Work Plan of the Group of Experts on Cleaner Electricity Production from Fossil Fuels for 2014-2015

Activity A and Provisional Agenda Item 5

Possible inclusion into the Draft Outline for the Recommendations (Chapter II, par. C – *Status of CCS Deployment in 2014-2015*)

DRAFT

A Survey of Carbon Capture and Storage (CCS): Landscape, Recent Developments and Principal Stakeholders in an Intergovernmental Context

Introduction

This paper explains what carbon capture and storage (CCS) is, identifies what the major drivers of CCS are, and provides an inventory of relevant international stakeholders.

Fossil fuel accounts for a significant portion of electricity production and industrial processes. Coal accounts for 42% of the world's electricity, and combined with other fossil fuels, generates over 2/3 of the world's electricity.[1] At current production levels, proven coal reserves are estimated to last 118 more years and proven oil and gas reserves around 46 and 59 years respectively.[2]

Table 1 - Countries heavily dependent on coal fired electricity

COUNTRY	DOMESTIC COAL FIRED POWER
South Africa	93%
Estonia	91%
Poland	90%
China	79%
Kazakhstan	70%(80)
Serbia	70%
India	69%
Israel	63%(67)
Czech Rep.	56%(61)
Greece	55%(56)
USA	45%(49)
Germany	44%(47)

Source: World Coal Association 2011, via UNECE Energy Week 2011; IEA data 2005-2011 averages

Energy from fossil fuels such as coal, oil and natural gas is released in the combustion (burning) process, which also results in the emission of CO2 as a by-product. The combustion of coal was responsible for more than 45% of global energy-related CO2 emissions in 2011[3]. About 1,200 coal-fired power plants are currently planned for construction in 59 countries over the next five years.[4]

CCS presents a mitigation solution that gives effect to the long term isolation of emissions from atmosphere by capturing CO2 from power plants and industrial sources, transporting and storing the captured CO2 into appropriately sited geological formations. This can dramatically reduce global emissions from fossil-energy use. A power plant with CCS could reduce CO2 emissions to the atmosphere by approximately 80–90% compared to a plant without CCS.[5] The International Energy Agency (IEA) identifies that in order to limit average global temperature rise below 2°C compared to pre-industrial levels between 2015 and 2050, almost half of the CO2 that needs to be captured is from the power sector (coal and gas) and half from industrial applications (refineries, cement plants, and steel mills that emit exhaust gases with a relatively high concentration of CO2).[6]

[1] World Coal Association (2012), *Coal – Energy for Sustainable Development*, p. 10. www.worldcoal.org

[2] Nitrogen & Syngas 2012 Conference, *Coal Gasification Technology for Ammonia Plant. http://www.kbr.com/newsroom/publications/whitepapers/coal-gasification-technology-for-ammonia-plants.pdf*

[3] International Energy Agency (2012) *Global carbon-dioxide emissions increase by 1.0 Gt in 2011 to record high* http://www.iea.org/newsroomandevents/news/2012/may/name,27216,en.html

[4] World Resource Institute (2012) *Global Coal Risk Assessment* http://www.wri.org/publication/global-coal-risk-assessment

[5] IPCC SR-CCS SPM, page 4

[6] International Energy Agency (2013) *Technology Roadmap: Carbon Capture and Storage 201*

Capturing the CO2 is the first step in an integrated CCS solution. There are three basic types of CO2 capture: post-combustion, pre-combustion and oxyfuel with post-combustion. Post-combustion processes separate CO2 from combustion exhaust gases. CO2 can be captured using a liquid solvent. Once absorbed by the solvent, the CO2 is released by heating to form a high purity CO2 stream. Pre-combustion processes convert fuel into a gaseous mixture of hydrogen and CO2. The hydrogen is separated and can be burnt without producing any CO2; the CO2 can be compressed for transport. The fuel conversion steps required for pre-combustion are more complex than the processes involved in post-combustion, making the technology more difficult to apply to existing power plants. Pre-combustion capture is used in industrial processes but has not yet been demonstrated in large power generation projects. Oxyfuel with post-combustion processes use oxygen rather than air for combustion of fuel. This produces exhaust gas that is mainly water vapour and CO2 that can be easily separated to produce a high purity CO2 stream. After the CO2 is captured at the point source, it needs to be transported by either CO2 pipeline (most typical), truck and/or rail and/or by ship to an appropriate geological site for injection and storage, typically in into rock formations deep underground. The formations are typically saline aquifers[7] that are selected for their high capacity to store and retain the injected greenhouse gases indefinitely. In general, depths greater than 800 metres are desired to keep the CO2 in the compressed or dense state.

CCS can be a complicated process that involves not only the field of chemical engineering but geology, economics, atmospheric chemistry and industrial engineering. The vast amount of considerations that need to be taken into account have resulted in varying opinions on the feasibility of using CCS as a means to effectively reduce emissions. By many accounts, capturing and storing CO2 from commercial scale power plants is a safe and proven means to avoid CO2 emissions. At the same time there are opposing views that consider the technology and process to be a risky undertaking due to the cost, liability and questions about the process.

In 2005, the Intergovernmental Panel on Climate Change (IPCC) delivered a Special Report on CCS[8] that concluded while components of CCS are in various stages of development: 1) Complete CCS systems can be assembled from existing technologies that are mature or economically feasible under specific conditions; 2) It is likely that there is a technical potential of at least about 2,000GtCO2 of storage capacity in geological formations 3) The economic potential of CCS amounts to between 15–55% to the cumulative mitigation effort worldwide until 2100 and 4) The inclusion of CCS in a mitigation portfolio could reduce the costs of stabilizing global CO2 concentrations by 30% or more.

There remains localised considerations of CCS projects in regards to conditions underpinning the granting of 'social licenses to operate', engineering scale and scope, and subsequent regulatory compliance of CCS components – these include such things as the optimal power plant design to facilitate carbon capture (due to its associated energy penalty); the design of and 3rd party access to distribution infrastructure to transport the CO2 (for which pipelines are generally government owned and/or operated as natural monopolies); and the selection criteria for geological storage sites to accommodate the large scale injection of CO2 streams over decadal timeframes and the appropriate trapping

http://www.iea.org/publications/freepublications/publication/technology-roadmap-carbon-capture-and-storage-2013.html

[7] IPCC defines Saline formations as sedimentary rocks saturated with formation waters containing high concentrations of dissolved salts (IPCC Special Report on CCS Summary for Policy Makers p3).

[8] IPCC (2005) IPCC Special Report on CCS Summary for Policy Makers https://www.ipcc.ch/pdf/special-reports/srccs/srccs_summaryforpolicymakers.pdf

mechanisms for assuring that stored CO2 remains permanently isolated from the atmosphere.

Currently, the main challenges for CCS are not technical, but financial. A power plant equipped with a CCS system (with access to geological or ocean storage) would need roughly 10-40% more energy than a plant of equivalent output without CCS, of which most is for capture and compression.[9] The loss of power output resulting from capturing the CO2 means that plants need to increase their fuel intake to replace the lost electricity generating capacity as well as water use will be expected to increase.[10] These factors increase the operating cost of a CCS power plant over a conventional power plant considerably. The levelised cost of energy (LCE) for a power plant fitted with CCS can range from about $116/MWh to $151/MWh depending on the type of facility and application. This compares to a levelised cost of $85/MWh for a new supercritical pulverized coal plant or $27/MWh for existing power plants.[11]

However, while LCE is an important metric when considering the commercial viability of an offtake, 'avoided CO2' can be a superior indicator of the cost-effectiveness of mitigation outcomes. When CCS is compared to many alternate large-scale baseload renewable technologies such as concentrated solar thermal with storage or offshore wind, CCS remains competitive within the context of delivering on ever deepening ambitions to give effect to decarbonising centralised energy systems[12]. When compared to unabated fossil technologies, the economic cost of decarbonizing the global energy system and industrial processes will be much higher without CCS. Estimates from the IEA suggest that the additional investment needs in the electricity sector to limit average global temperature increase to 2°C would increase by 40% if CCS technology is not available, with a total extra cost of $2 trillion over 40 years.[13]

While CCS is relatively more expensive than conventional coal fired power technology, there are opportunities to generate revenues from selling the captured CO2 for processes such as enhanced oil recovery (EOR). This can help offset the increased cost associated with capture (which represents the largest cost component of a CCS system) and encourage advances in CCS technology. EOR is a process where captured CO2 from CCS is injected into existing, partially depleted oil wells to access the approximately 60% of oil that is "stranded' in the well. Without CO2 injection this oil would not be produced. In this case, the use of CO2 can also generate commercial value by increasing oil production from existing wells. The economics of CCS for EOR therefore are not primarily driven by the carbon removal objective. CCS for the purpose of onshore EOR has already been in operation commercially at small scale.

The public acceptability issues of safety, dependability of CCS operations and micro-seismicity rank as high priorities in the public domain, specifically in regards to underground storage of CO2 and the potential for leakage. Despite the public concerns, there is industry experience with the underground storage of CO2. There are currently 22 industrial-scale storage projects that are operational or under construction injecting up to 400ktCO2 annually for industrial facilities and 800kt CO2 annually for power plants. The Sleipner and Snøhvit CCS projects have injected and stored about 23MtCO2 in the North Sea since 2006 with no reports of seepage (escape out of the reservoir) or leakage

[9] IPCC SR-CCS SPM, page 4
[10] *Ibid.*
[11] National Energy Technology Laboratory / U.S. Department of Energy, *DOE/NETL Carbon Dioxide Capture and Storage RD&D Roadmap* *http://www.netl.doe.gov/File%20Library/Research/Carbon%20Seq/Reference%20Shelf/CCSRoadmap.pdf*
[12] Global CCS Institute (2013) *The Global Status of CCS*, pg 172 http://www.globalccsinstitute.com/publications/global-status-ccs-2013
[13] IEA, 2012a, Energy technology perspectives: Pathways to a clean energy system, OECD/IEA, France

(escape to atmosphere) incidents. Underground storage of CO2 has also existed for decades in the oil and natural gas industry through EOR and other technologies. In most of these operations the CO2 is recycled and will remain in the reservoir indefinitely.[14] The success of these projects and the increasing number of research demonstrations have provided considerable confidence in the potential to store large quantities of CO2 underground safely, securely and for very long periods. The IPCC has also concluded (which has been recently re-affirmed by the CDM's inclusion of CCS as an eligible project level activity) that with appropriate site selection, monitoring programme, and regulatory system the local health, safety and environment risks of geological storage are comparable to the risks of current activities such as natural gas storage, EOR and deep underground disposal of acid gas.

While challenges still exist for large-scale integrated CCS systems, the technology is increasingly being deployed around the world. According to the Global CCS Institute, the world has 12 fully operational large-scale carbon-capture projects and 10 projects under construction. In October 2014, the world's first coal-fired plant with CCS project (Boundary Dam) was opened in Canada; it cost $1.2 billion and will capture and store about 1MtCO2 per year. Two large demonstration projects for CCS power generation in North America are also expected to be operational by 2016. With construction and operating experience at scale, the relative merits of pre-combustion, post-combustion, and oxyfuel CCS technologies for specific applications, emissions requirements, and economic conditions will be better understood.

A number of international, national, and nongovernmental organizations are working towards better understanding and facilitating CCS technology implementation and deployment from all over the world. A detailed list of these organizations, contacts and their main functions are presented in Annex I.

Status of CCS Deployment in an Intergovernmental Context

China

China is launching CCS schemes faster than any other nation, and the country is unique in its determination to address the emissions from coal-fired plants.

The Chinese government faces twin imperatives: lifting people out of poverty and avoiding the worst consequences of industrialization. As a result CCS technologies will be very important and will be deployed in both the power and industry sectors at scale in 2050. It is expected that CCS will be developed and demonstrated from 2020 and deployed at a commercialized scale from 2030. Both CO2 utilization and geologic storage have a high potential in China.

China has significant investments in CCS/CCUS and is allied with US to investigate CCS with a clean development mechanism (CDM) agenda. China is more inclined to work bilaterally with the US than to push CCS under an international convention framework.

The United States and China in July 2014 signed eight partnership agreements to cut greenhouse gases, bringing the world's two biggest carbon emitters closer together on climate policy.[15]

[14] Global CCS Institute *How CCS Works - Storage* http://www.globalccsinstitute.com/content/how-ccs-works-storage

[15] Valerie Volcovici, *Reuters, U.S., China ink coal, clean energy deals in climate cooperation*, http://uk.reuters.com/article/2014/07/08/usa-china-climatechange-idUKL2N0PJ20920140708

In one of the memoranda of understanding (MOUs), China's Huaneng Clean Energy Research Institute, a subsidiary of state-owned power company China Huaneng and Washington-based Summit Power Group agreed to share information on clean coal power generation technology. Huaneng is part of a Chinese consortium operating a 400MW pilot integrated gasification combined cycle plant in Tianjin.

Under the MOU, Huaneng will share information with Summit Power, which is expected to soon break ground on a similar project in Texas after it secures engineering and procurement support from Petrochina and the Chinese engineering firm Huanqiu Contracting and Engineering. Summit, in turn, will share information and technology for recovering oil from captured carbon.

"This [partnership between Summit and Huaneng] accelerates sharing of information on carbon capture and storage for power," said Julio Friedmann, deputy assistant Secretary for Clean Coal for the US Department of Energy.

Another coal state university, the University of Kentucky, will partner with Shanxi Coal International Energy Group and Air Products and Chemicals Inc. on a project feasibility study of a 350MW supercritical coal-fired power plant that can capture 2 million tonnes of CO2 annually.

Germany

Germany has had a consistently rigorous view on climate change, with an aggressive goal of reaching 50-80% renewables within 30 years. The resulting increase in both cost and emissions, coupled with a decline in the quality of energy, has caused several German firms to relocate to the US. Due to the perception that CCS is synonymous with coal, and given that Germany's recent increase in coal use will be short lived, CCS will not likely be a priority. Additionally, there is incredibly strong opposition to geological sequestration of any kind in Germany.

United Kingdom

The UK government has announced plans to become a market leader in CCS innovation and technology. It estimates the CCS industry – including the transfer of CCS technology to developing nations – will be worth £6.5 billion to the UK by 2030.[16] CCS technology is currently the only means by which fossil fuels can be maintained within the UK generation mix, whilst meeting 2050 carbon targets (a detailed summary of the survey of CCS in the UK is presented in Annex II to this document).

The technical CO2 storage capacity of the UK is up to 70 billion tonnes – sufficient to store 100 years' worth of current emissions from the energy sector. CCS also represents a major green growth opportunity for the UK. Export opportunities for UK based firms have been estimated to be between £3 - 6.5 billion a year by the late 2020s. CCS could be lopping $50 billion off Britain's annual energy bill by 2050, according to the Energy Technology Institute. The UK has also world-class engineering capability within the power sector and is well represented in manufacturing sectors likely to be important for CCS, including large-scale compressors, pipelines and air separation plants.

Currently in the UK there are plans for 4 new coal-fired power plants with CCS and one gas fired plant to be retrofitted with CCS. In 2011-12 two CCS projects were cancelled due to concerns about their commercial viability. The White Rose CCS project under development by Capture Power Limited, is a new

[16] Department for Energy and Climate Change, *Clean coal: an industrial strategy for the development of carbon capture and storage across the UK*, https://ukccsrc.ac.uk/system/files/publications/ccs-reports/DECC_CCS_153.pdf

oxyfuel supercritical coal-fired power station that was confirmed in 2014 by the European Commission to be in line to win the 300million euros. The project is a new 426MW (gross) clean coal power plant with full CCS capability. The demonstration plant would have the potential to co-fire biomass and would provide enough safe, reliable and clean electricity to meet the typical demands of more than 630,000 homes as well as capturing approximately 90% of all the CO2. White Rose would be the first power station to employ oxyfuel combustion . The captured CO2 would be transported from the White Rose site through National Grid's proposed Yorkshire and Humber CCS Project pipeline for safe and permanent storage in geological formations deep beneath the North Sea.

In July of this year, the UK's opposition Shadow Ministry, led by Baroness Bryony Worthington released a Position Paper setting out their vision for CCS under a potential future Labour Government. The paper stresses the importance of CCS to both the energy and industrial sectors. Industrial CCS receives a significant amount of focus in the paper – which also stresses the crucial role of regional clusters of industrial and power users, making use of shared transportation and storage infrastructure.

UK is a host country to a number of international organizations working on CCS:

International Energy Agency (IEA) Clean Coal Center (CCC) - London

IEA Clean Coal Centre is a major provider of impartial information, analysis and research on all aspects of coal with a team of experienced professionals gathering, analyzing and distributing information and knowledge on the efficient and clean use of coal. IEA publishes Carbon Capture and Storage Legal and Regulatory Review (CCS Review), a regular review of CCS regulatory frameworks worldwide. It collates contributions from national and regional governments, as well as leading organizations engaged in CCS regulatory activities, to provide a knowledge-sharing forum to support CCS framework development.

The Carbon Capture and Storage Association (CCSA)

The CCSA aims: to encourage the development of CCS in the UK and internationally; to provide advice to policy makers on regulatory issues and potential incentive mechanisms associated with CCS; to promote industry priorities on financial, technical, research and policy issues related to CCS; and to provide a forum to encourage information exchange, networking and enhanced capability in relation to CCS. The CCSA is not a technical forum, professional institute or an environmental or climate campaign group.

International Petroleum Industry Environmental Conservation Association – London

IPIECA is the global oil and gas industry association for environmental and social issues. IPIECA was formed in 1974 following the launch of the United Nations Environment Programme (UNEP). IPIECA helps the oil and gas industry improve its environmental and social performance by:

- Developing, sharing and promoting good practices and solutions;
- Enhancing and communicating knowledge and understanding;
- Engaging members and others in the industry.

World Coal Association (WCA) – London

WCA is a global coal network, which provides a voice for coal in international energy, environment and development forums, presenting the case for coal to key decision-makers, including ministers, development banks, NGOs, international media, the energy industry, business and finance and research bodies. WCA produces material that improves understanding of the vital role of coal, organises workshops, holds meetings

with senior policy-makers, and develops policy positions to inform international policy discussions in bodies such as the European Commission, European Parliament, United Nations Framework Convention on Climate Change, UN Environment Programme, World Bank, World Economic Forum and national governments.

World Energy Council – London

Formed in 1923, WEC is the UN-accredited global energy body, representing the entire energy spectrum, with more than 3000 organisations located in over 90 countries and drawn from governments, private and state corporations, academia, NGOs and energy-related stakeholders. Platform for global energy issues exchange.

World Petroleum Council

The World Petroleum Council's (WPC) main purpose is to catalyse and facilitate dialogue amongst internal and external stakeholders aimed at seeking solutions to key technical, social, environmental and management challenges in global energy issues for the benefit of mankind. In doing so, the WPC will contribute towards sustainable growth. The WPC provides a forum where the solutions to key challenges can be addressed.

South Africa

CCS technology is supported in South Africa, although disposal sites have not been identified yet despite the considerable efforts that have been devoted to their exploration. A government decision has been taken to not pursue ocean storage; geological storage is still being investigated and could provide additional reduction potentials, notably in the industrial sectors. At present CCS is not considered seriously by South Africa due to the costs associated with CCS/CCUS. South Africa is currently looking at efficiency and distributed generation but from an R&D focused and applied agenda, CCS/CCUS is unlikely to happen.

India

India is supportive of CCS/CCUS technology but is heavily focused on equity and is looking at opportunities for financial transfers. Since nobody will pay them to do CCS projects, there is no incentive on their part to pursue it. Political play in recent negotiations has also not been helpful. The scale of the potential for geological carbon sequestration in India is still uncertain.

Australia

Australia was historically aligned with US on CCS/CCUS, but since the election has been backing away from all bilateral efforts, and thus is no longer a strong ally.

Australia is a host country to the following organizations working on CCS:

The Global Carbon Capture and Storage Institute (GCCSI)

The Global Carbon Capture and Storage (CCS) Institute is an independent, not-for-profit company registered under the (Australian) Corporations Act 2001 (Cth). The Institute accelerates the development, demonstration and deployment of CCS globally through our knowledge sharing activities, fact-based influential advice and advocacy, and works to create favourable conditions to implement CCS. The Institute has around 370 Members from more than 40 countries, and offices in Australia, Belgium, China, Japan and the United States. Members include national governments, global corporations, small companies, environmental non-government organizations, research bodies and universities. The Institute is an accredited observer to

the UNFCCC, Green Climate Fund, member of the Climate Technology Centre's Network, and Intergovernmental Panel on Climate Change (application pending).

Commonwealth Scientific and Industrial Research Organization (CSIRO) - Australia

CSIRO is developing efficient and low emission coal technologies for energy generation, new technologies for oil and gas exploration and production to support a clean and secure energy future.

Cooperative Research Centre for Greenhouse Gas Technologies (CRC) – Australia

CO2CRC is a joint venture comprising participants from Australian and global industry, universities and other research bodies from Australia and New Zealand, and Australian Commonwealth, State and international government agencies. CO2CRC activities include:

- Undertaking leading research into and development of technologies for carbon dioxide capture and geological storage.
- Decreasing commercial risks by demonstrating the practical application of carbon dioxide capture and storage technologies to reduce carbon dioxide emissions.

Japan

Japan is interested in options for CCS but there is little momentum to move the system, which is inherently more reactive than proactive. Poor international reception of Japan's CCS/CCUS efforts (e.g., perceived damage to biodiversity) is also a deterrent.

Canada

Canada is very active with CCS and CCUS. There are seven active projects in the country including the Boundary Dam Project which is the first grid scale coal-fired power plant to be retrofitted with a CCS system.[17]

Canada is a strong ally and is a host country to the following CCS organizations:

Carbon Capture and Storage Research Consortium Nova Scotia- Canada

Carbon Capture and Storage Nova Scotia Research Consortium's mandate is to research the feasibility of storing condensed CO2 emissions in suitable geological formations that exist about one kilometer underground.

Canadian Clean Power Coalition- Canada

The CCPC is completing its third phase of study on emerging technologies to reduce emissions from coal plants.

PHASE I - Feasibility studies to reduce emissions from coal plants

PHASE II - Study of post combustion, oxyfuel and gasification technologies

PHASE III - Study of advances in technologies to reduce GHG emissions

PHASE IV - Canadian Clean Power Coalition Phase IV Workplan

Russia

Although CCS has been tested in pilot projects around the world, the technology is not commercial yet, and it is uncertain if it will be available under competitive costs in Russia.

United States

CCS projects in the United States appear to be making progress. The Expanding Carbon Capture through

[17] John Kemp, *Reuters, Beyond Boundary Dam, carbon capture costs must come down: kemp,* http://www.reuters.com/article/2014/10/04/us-carboncapture-canada-kemp-idUSKCN0HT00X201410048

Enhanced Oil Recovery Act of 2014 (S. 2288) was recently introduced in the US which expands tax credits for carbon sequestration.

The US is a host country to the following CCS organizations:

Carbon Sequestration Leadership Forum – USA

CSLF is a Ministerial-level international climate change initiative that is focused on the development of improved cost-effective technologies for the separation and capture of carbon dioxide (CO2) for its transport and long-term safe storage. One of the most successful initiatives of the CSLF is to analyze in depth the situation worldwide and identify priorities on the most urgent actions to be implemented for using CCS to mitigate global warming. The CSLF advances technological capacity through collaborative efforts with all the stakeholders to address key technical, economic, regulatory and environmental obstacles to CCS development and deployment.

United States Energy Association (USEA) - USA

The United States Energy Association (USEA) is the U.S. Member Committee of the World Energy Council (WEC). USEA is an association of public and private energy-related organizations, corporations, and government agencies. USEA represents the broad interests of the U.S. energy sector by increasing the understanding of energy issues, both domestically and internationally.

Carbon Sequestration Council- USA

The U.S. Carbon Sequestration Council (USCSC) is a non-profit coalition of scientists, engineers, academics, environmentalists, and leaders from the business and the public sectors. These individuals, from 40 U.S. States and 4 Canadian Provinces, have pledged their time, their money, and their ingenuity to develop something of lasting value to our society: a source of low cost and pollution-free energy.

Clean Air Taskforce- USA

CATF was launched in 1996 with a single goal: to enact federal policy to reduce the pollutants from America's coal-fired power plants that cause respiratory death and disease, smog, acid rain, and haze.

US Carbon Capture & Storage Association- USA

The Carbon Capture & Storage Association () was launched in March 2006 to represent the interests of its members in promoting the business of capture and geological storage of carbon dioxide) as a means of abating atmospheric emissions of carbon dioxide and tackling climate change.

Norway

The Norwegian Government has an ambitious environmental policy, with the goal of becoming carbon neutral by 2050 (or 2030 depending on global agreement). The Norwegian Government has stated that CCS is one of the 'three pillars' of its energy policy, announcing that all new gas-fired power plants will be required to implement CCS – a step further than the requirement of 'CCS ready' introduced by the EU. A detailed summary of the survey of CCS in Norway can be found in Annex III of this document.

Despite a number of years of dedicated support for CCS, the Government does not have specific legislation or regulations regarding CCS.

In the North Sea, the storage capacity is estimated at about 72 Gt of CO_2.. With regard to EOR, a study by the European Commission suggested that Norway could recover an additional 4.2 billion barrels of oil, while storing 6.2 Gt of CO_2.

Norway has extensive experience in storage of CO2 in geological structures. Since 1996, one million tonnes of CO2 per year have been separated from gas production on the Sleipner Vest field in the North Sea for storage in Utsira, a geological formation 1000 metres below the seabed.

There are currently two operational storage projects in Norway. From 2007-2009 three projects were cancelled in Norway due to concerns about their commercial viability.

The Snøhvit CO2 Storage Project is an operating LNG development in the Barents Sea offshore of Norway. The development consists of a fully subsea offshore development in water depths of 250-350 metres / 820-1,150 feet. The CO2 removal process captures 0.7 million tonnes of carbon dioxide annually when the Snøhvit LNG facility is at full capacity.[18]

Industrikraft Möre AS Norway was a newly built 250 MWe natural gas-based power plant with carbon dioxide (CO2) capture (post-combustion) where more than 1.4 million tonnes per annum (Mtpa) of CO2 would be captured at the plant using Sargas's own 'Stargate 250' post-combustion capture technology but the project has been put on hold

Norway has recently cancelled a final investment decision on the building a full-scale CCS centre at Mongstad power station on cost grounds.

Norway is a host country to the following CCS organizations:

[18]Global CCS Institute Snøhvit CO2 Storage Project http://www.globalccsinstitute.com/project/sn%C3%B8hvit-co2-injection

Technology Centre Mongstad – Norway

Technology Centre Mongstad is the world's largest facility for testing and improving CO2 capture technologies, a vital part of the CCS value chain. TCM focuses on testing and improving CO2 capture technology and taking technology development one step further.

The main ambitions of the Technology Centre are to:

- Test, verify and demonstrate CO2 capture technology owned and marketed by vendors
- Reduce cost, technical, environmental and financial risks
- Encourage the development of the market for carbon capture technology
- Aim at international development

The Zero Emissions Resource Organization- Norway (20% funding from government)

Zero Emission Resource Organization (ZERO) is a Norwegian based environmental foundation. ZERO is a non-profit environmental organization dedicated to reducing climate change by demonstrating and gaining acceptance for zero emission energy solutions. ZERO works with a wide range of sources for greenhouse gas emissions. Below follows a list of their major fields of focus:

- CO2-capture and storage
- Electric power for the offshore sector
- Wind energy
- Biofuels for road transport, ships and heating

Kazakhstan

In Kazakhstan the vast majority of power generation comes from coal-fired power plants, concentrated in the north of the country near the coal producing regions. In 2013, Kazakhstan became the first country in Central Asia to launch an economy-wide carbon emissions system to cap emissions from its biggest emitters in the

energy, coal, oil and gas extraction sectors. A detailed summary of the survey of CCS in Kazakhstan can be found in Annex IV to this document. Energy companies have expressed interest in developing CCS tin Kazakhstan such as:

- Samruk Energo which has shown interest in enhanced oil recovery in Kazakhstan.
- Shell released a statement in 2010 outlining opportunities and interest for the company to develop CCS.

There is a technical capacity to perform CCS demo projects at existing sites due to a number of potential geological formations in the country that can be used to store captured CO2 in the future. There also is a political will to develop innovation in the energy sector and the potential to establish a Regional Centre of Advanced Energy Technologies and Innovation. Oil and gas legislation for promoting clean technologies has also been adopted. Kazakhstan has a significant number of oil and gas deposits, both continental and offshore and the possibility of other geological formations suitable for CO2 storage. However, carbon capture and storage projects are at an early development stage in Kazakhstan due to political, economic and mostly financial reasons. At present there are no existing CCS projects in Kazakhstan.

Azerbaijan

Azerbaijan's fossil fuel power plants account for around 86% of total power generation. Currently the country is lagging behind in lying the groundwork for the deployment of CCS once the technology is mature. Azerbaijan has CO2 point sources and potential storage sites that could make CCS feasible such as depleted oil or gas fields. However, little electricity is generated using coal, so CCS would more likely be applied to natural-gas power plants or industrial processes. There is the potential for the private sector deployment of CCS technologies in the future emerging from energy companies using CCS for EOR or for CO2 storage.

Currently there are no CCS projects in Azerbaijan. A detailed summary of the survey of CCS in Azerbaijan can be found in Annex V to this document.

Annex I

Principal Stakeholders from Government and Nongovernmental Sectors, Academia and International Organizations

United Nations Organizations

1. UN Economic Commission for Europe	The Committee on Sustainable Energy is the principal intergovernmental body at the UN Economic Commission for Europe (UNECE) responsible for promoting international cooperation in the field of energy. Key areas: • Industry restructuring • Market liberalization • Energy pricing The sustainable energy work programme has five major components centered on promoting convergence in the overall legal, regulatory and policy framework, including: • The development of classification systems and guidelines; • Promoting energy efficiency and conservation, notably in economies in transition; • Encouraging the greater use of natural gas as a "transitional" fuel to bridge the gap until "new" environmentally benign energy sources are developed and commercialised; • Greening the coal-to-energy chain • Addressing issues related to electric power network system interconnections. **Contact:** Mr. Scott Foster, Director Tel.: +41 22 917 24 44 E-mail: scott.foster@unece.org
2. UN Foundation	The United Nations Foundation links the UN's work with others around the world, mobilizing the energy and expertise of business and non-governmental organizations to help the UN tackle issues including climate change, global health, peace and security, women's empowerment, poverty eradication, energy access, and U.S.-UN relations. Key energy-related areas of work: • Climate change • Energy efficiency • Universal access to energy **Contact:** United Nations Foundation, 801 Second Ave Suite 900 - New York, NY 10017. Tel.: 212.697.3315
3. UN Framework Convention on Climate Change	In 1992, countries adopted the United Nations Framework Convention on Climate Change (UNFCCC) as a response to the problem of global warming. Five years later, they adopted the Kyoto Protocol, which strengthens the Convention by setting legally binding emission reduction requirements for 37 industrialized countries. Contact : UNFCCC Secretariat Platz der Vereinten Nationen 1, 53113 Bonn, Germany Tel.: (49-228) 815-1000. Fax: (49-228) 815-1999 http://unfccc.int
4. UN-Energy	UN-Energy, the United Nations' mechanism for inter-agency collaboration in the field of energy, was established in 2004 to help ensure coherence in the United Nations system's multidisciplinary response to the World Summit on Sustainable Development (WSSD), and to support countries in their transition to sustainable energy. The core fields of access to energy, renewable energy and energy efficiency - UN-Energy's clusters. UN-Energy's work is organized around three thematic clusters, each led by two United Nations organizations:

	• Energy access: led by UN DESA and UNDP, in partnership with the WorldBank • Renewable energy: led by FAO and UNEP, with support of UNESCO • Energy efficiency: led by UNIDO and the IAEA **Contact**: From the webpage only http://www.un-energy.org/contact
5. United Nations Environment Programme	UNEP work encompasses: • Assessing global, regional and national environmental conditions and trends • Developing international and national environmental instruments • Strengthening institutions for the wise management of the environment **Contact:** United Nations Avenue, Gigiri, PO Box 30552, 00100, Nairobi, Kenya. Tel: (254-20) 7621234. General information: unepinfo@unep.org Regional offices by country: www.unep.org
6. United Nations Industrial Development Organization	UNIDO has long recognized that environmental issues must be addressed and cleaner production methodologies must be promoted at a systemic level in industrial development. UNIDO promotes use of sustainable industrial energy strategies that include adoption of renewable energy sources, as well as energy efficiency, and are thus key for addressing climate change through moving economies onto a lower-carbon path. UNIDO provides assistance in the following areas: • Resource-efficient and low-carbon industrial production • Clean energy access for productive use • Capacity building for the implementation of multilateral environmental agreements **Contact:** UNIDO HQ.Vienna International Centre,Wagramerstr. 5 P.O. Box 300 , A-1400 Vienna, Austria. Tel.: +43 (1) 26026-0, Fax: +43 (1) 2692669 Geneva Office: Le Bocage, Pavillion I. Room 77-82 Palais des Nations, Avenue de la Paix 8-14.CH-1211 Geneva 10 Switzerland. Tel.: +41 (22) 917 1423,Fax: +41 (22) 917 0059
7. United Nations Office for Disaster Risk Reduction	UNISDR advocates for DRR as an instrument for sustainable development. We advocate for the importance and necessity of linking disaster risk reduction with sustainable development initiatives. Our focal point is Ms. Elina Palm (palm@un.org). **Contact:** Palais des Nations, CH1211, Geneva, Switzerland Tel.: +41 229178907-8, Fax: +41 229178964. Email: isdr@un.org

International Governmental Organizations

8. Carbon Sequestration Leadership Forum	CSLF is a Ministerial-level international climate change initiative that is focused on the development of improved cost-effective technologies for the separation and capture of carbon dioxide (CO2) for its transport and long-term safe storage. **Contact:** CSLF Secretariat,U.S. Department of Energy,FE-27 1000 Independence Ave., S.W.Washington, DC 20585 U.S.A. E-mail: CSLFSecretariat@hq.doe.gov
9. Global Environmental Facility	The Global Environment Facility (GEF) unites 183 countries in partnership with international institutions, civil society organizations (CSOs), and the private sector to

	address global environmental issues while supporting national sustainable development initiatives. GEF provides grants for projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants. **Contact:** GEF Secretariat, 1818 H Street, NW, Mail Stop P4-400 Washington, DC 20433 USA, Tel.: (202) 473-0508, Fax: (202) 522-3240/3245. Email: secretariat@thegef.org
10. IEA Clean Coal Center	IEA Clean Coal Centre is a major provider of impartial information, analysis and research on all aspects of coal. A team of experienced professionals gather, analyse and distribute information and knowledge on the efficient and clean use of coal. **Contact:** Park House, 14 Northfields, London, SW18 1DD, UK Tel.: +44 (0)20 8877 6280 Email: mail@iea-coal.org http://www.iea-coal.org
11. IEA Greenhouse Gas R & D Programme	The IEA Greenhouse Gas R&D Programme (IEAGHG) is an international collaborative research programme established in 1991 as an Implementing Agreement under the International Energy Agency (IEA). The role of the Programme is to evaluate technologies that can reduce greenhouse gas emissions derived from the use of fossil fuels. **Contact:** Cheltenham Office Park, Hatherley Lane, Cheltenham, Glos.GL51 6SH UK. Tel.: +44 (0)1242 802911. E-mail: mail@ieaghg.org
12. IEA Working Party on Fossil Fuels	The objectives of the Working Party on Fossil Fuels (WPFF) are to encourage energy security and environmental protection by monitoring fossil fuel technology-related policies and trends of IEA member and key partner countries. The WPFF has been instrumental in bringing carbon capture and storage (CCS) and clean coal technologies to the forefront of policy debates. It works closely with the IEA Coal Industry Advisory Board, the Global Carbon Capture and Storage Institute and the Carbon Sequestration Leadership Forum. Implementing Agreements (IAs) in the fossil fuel portfolio include: • Enhanced Oil Recovery (EOR IA) • Fluidised Bed Conversion (FBC IA) • Clean Coal Centre (CCC IA) • Gas and Oil Technologies (GOT IA) • Greenhouse Gas R&D (GHG IA) **Contact:** Tel.: +33 1 40 57 65 00, fax: +33 1 40 57 65 09 http://www.iea.org/aboutus/standinggroupsandcommittees/cert/wpff/
13. Intergovernmental Panel on Climate Change	The Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts. The IPCC is a scientific body under the auspices of the United Nations (UN). It reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change. **Contact:** IPCC Secretariat C/O World Meteorological Organization 7 bis Avenue de la Paix C.P. 2300,CH- 1211 Geneva 2, Switzerland Tel.: +41-22-730-8208/54/84, Fax : +41-22-730-8025/13
14. International Energy Agency	The IEA is an autonomous organisation which works to ensure reliable, affordable and clean energy for its 29 member countries and beyond. The IEA's four main areas of focus are: energy security, economic development, environmental awareness, and engagement worldwide.

	Contact: International Energy Agency 9, rue de la Fédération 75739 Paris Cedex 15 France Tel.: +33 1 40 57 65 00, Fax: +33 1 40 57 65 09 Website: www.iea.org Mr. Juho Lipponen Head of CCS Technology Unit juho.lipponen@iea.org
15. International Energy Forum	The 87 Member Countries of the Forum are signatories to the IEF Charter, which outlines the framework of the global energy dialogue through this inter-governmental arrangement. Covering all six continents and accounting for around 90% of global supply and demand for oil and gas, the IEF is unique in that it comprises not only consuming and producing countries of the IEA and OPEC, but also Transit States and major players outside of their memberships, including Argentina, Brazil, China, India, Mexico, Oman, Russia and South Africa. Sitting alongside other important developed and developing economies on the 31 strong IEF Executive Board these key nations are active supporters of the global energy dialogue through the IEF. The IEF is the neutral facilitator of informal, open, informed and continuing global energy dialogue. Recognising their interdependence in the field of energy, the member countries of the IEF co-operate under the neutral framework of the Forum to foster greater mutual understanding and awareness of common energy interests in order to ensure global energy security. The Forum's biennial Ministerial Meetings are the world's largest gathering of Energy Ministers. **Contact:** IEF Secretariat Saudi Arabia, P.O. Box 94736, Diplomatic Quarter, Riyadh-11614, Tel.: +966 11 4810022 | Fax: +966 11 4810055 Email:info@ief.org
16. International Monetary Fund	http://www.imf.org/external/np/exr/contacts/contacts.aspx (link to regional contacts) IMF is not directly involved with energy issues, but can support least developed countries with technical assistance on ad hoc basis.
17. The UN Commission on Sustainable Development	The UNCSD was established by the UN General Assembly in December 1992 to ensure effective follow-up of United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit. At its eleventh session in 2003, the Commission decided on a multi-year work programme consisting of review and policy years. Since its establishment in 1992, the Commission has greatly advanced the sustainable development agenda within the international community. **Contact:** Division for Sustainable Development Department of Economic and Social Affairs, United Nations Secretariat Building, 405 East 42nd Street. New York, NY 10017, USA Fax: + 1 212 963 4260 or via the website contact form http://sustainabledevelopment.un.org/account.php?menu=1727
18. World Bank Group	The World Bank Group provides financial services and project financing on sustainable energy and clean energy, energy-efficiency. Each activity varies from the range of country-approved activities, so better look into the country specific program. **Contact:** HQ, The World Bank,1818 H Street, NW, Washington, DC 20433 USA, Tel.: (202) 473-1000, Fax: (202) 477-6391 Country offices: http://www.worldbank.org/en/about/contacts
19. World Trade Organization	The World Trade Organization (WTO) deals with the global rules of trade between nations. Regarding CCS, WTO deals with technologies, patents, rules of trade, legal aspects of technology transfer.

	Contact: Centre William Rappard, Rue de Lausanne 154, CH-1211 Geneva 21, Switzerland. Tel.: +41 (0)22 739 51 11, Fax: +41 (0) 22 731 42 06
20. United Kingdom CCS Development Forum	The Carbon Capture and Storage (CCS) Development Forum facilitates the development of commercial CCS by bringing government and major CCS stakeholders together to remove barriers to deployment. Following the successful completion of the work of the CCS Cost Reduction Task Force in 2013, the Energy Minister Michael Fallon decided to re-launch the CCS Development Forum, in a revised format, to continue engagement but with a focus on industry and accelerating commercial deployment. **Contact:** 3 Whitehall Place, London, SW1A 2HD. Mr. Ashley Ibbett CEO, Office of Carbon Capture and Storage Department of Energy and Climate Change (DECC) Email: occs@decc.gsi.gov.uk

International Non-Governmental Organizations

21. Bellona	The Bellona Foundation was founded in 1986. They currently have 65 employees, working at the main office in Oslo and their three international offices in Brussels (Belgium / EU) Murmansk (Russia) and St. Petersburg (Russia). Areas of expertise: • Nuclear Issues • Fossil fuels • Russian human rights issues • Arctic • Climate Change • CCS • Renewable Energy • Energy Efficiency **Contact:** Magnus Borgen, Head of Communication Tel.: +47 977 28 476. Email: magnus@bellona.no
22. CCS Alliance	The CCS Alliance's purpose is to promote development of positions and policy by the private sector, states, the federal government, nongovernmental organizations, and others to appropriately address risks associated with the development and deployment of CCS technologies. **Contact:** Frederick R. Eames, Partner, Hunton & Williams LLP Phone: 202.778.2245.E-Mail: feames@hunton.com Andrew Paterson, Principal - Energy Finance. Tel.: 619.807.3267 E-Mail: adpaterson@gmail.com
23. CE.Si.S.P (Interuniversity Centre for the Development of Product Sustainability)	Through research, training and scientific collaboration in the product sustainability sector, CE.Si.S.P. aims at promoting and coordinating research methodological activities applied to the following fields: • Carbon Management and Trading • Life cycle of the products (LCA, EPDs, ECO-Design) • Integrated Product Policies (IPP) • Sustainability Innovation and Marketing • Building Energy Efficiency Standards **Contact:** Via all'Opera Pia 15; I-16145 Genoa; Italy Tel.: +39 010 353.2909, Fax: +39 010 353.6596,

	Email: cesisp@cesisp.unige.it http://www.cesisp.unige.it/eng/index.htm
24. Climate Works	Climate Works operates under the auspice of the Monash Sustainability Institute (MSI), which brings together the best minds from multiple fields of endeavour in world-leading cross-disciplinary programs and centres of excellence. They pull together scientists, lawyers, economists, psychologists, biologists, engineers, health professionals, training experts and more to nut out the 'wicked' problems. Australian NGO working under 3 sectors: land, power and energy efficiency. **Contact:** Anna Skarbek, Tel.: +61 3 9902 0741. Email: Anna.Skarbek@climateworksaustralia.org
25. CO2GeoNet - The European Network of Excellence on Geological Storage of CO2	CO2GeoNet is the European scientific authority dealing with all aspects of geological storage of CO2. They are durably engaged in enabling the safe and efficient deployment of the CO2 Capture and Storage (CCS) technology in order to mitigate climate change and ocean acidification. The network joins together 24 partners from 16 European countries, ranging from national geological surveys and research institutes, through to universities and associated "spin out" research companies, all with a high international profile and critical mass in CO2 geological storage research. **Contact:** Via the webform only : http://www.co2geonet.com/ContactUs.aspx?section=32
26. Global Carbon Capture and Storage Association	The Carbon Capture and Storage Association (CCSA) aims: • To encourage development of CCS in the UK and internationally • To provide advice to policy makers on regulatory issues and potential incentive mechanisms associated with CCS. • To promote industry priorities on financial, technical, research and policy issues related to CCS. • To liaise with other industry and professional groupings with interests in energy conservation and CCS. • To provide a forum to encourage information exchange, networking and enhanced capability in relation to CCS. • The CCSA is not a technical forum, professional institute or an environmental or climate campaign group. **Contact:** 10 Dean Farrar Street, London SW1H 0DX. Tel.: +44 (0) 20 3031 8750, Fax: +44 (0) 20 7222 4253. Email: info@ccsassociation.org
27. International Gas Union	The International Gas Union (IGU) was founded in 1931. It is a worldwide non-profit organisation registered in Vevey, Switzerland with the Secretariat currently located in Oslo, Norway. The mission of IGU is to advocate gas as an integral part of a sustainable global energy system, and to promote the political, technical and economic progress of the gas industry. The more than 120 members of IGU are associations and corporations of the gas industry representing over 95% of the global gas market. Current task forces: • Exploration & Production of Gas; • Gas storage; • Transmission of Gas; Distribution of Gas; Utilisation of Gas; • Sustainable Development; • Strategy, Economics and Regulation; • Developing Gas Markets; • LNG; • Marketing of Gas; Research, Development and Innovation • Task Force on Human Capital; Task Force on Gas Advocacy **Contact:** Office of the Secretary General, c/o Statoil Box 3 N – 1330 Fornebu, Norway. Tel.: +47 51 99 00 00. Fax +47 67 80 56 01

28. Petroleum Industry Environmental Conservation Association	IPIECA is the global oil and gas industry association for environmental and social issues. IPIECA was formed in 1974 following the launch of the United Nations Environment Programme (UNEP). IPIECA helps the oil and gas industry improve its environmental and social performance by: • Developing, sharing and promoting good practices and solutions; • Enhancing and communicating knowledge and understanding; • Engaging members and others in the industry. **Contact:** 209-215 Blackfriars Road, London SE1 8NL,United Kingdom. Tel.: +44 (020) 7633 2388 Fax: +44 (020) 7633 2389 http://www.ipieca.org/contact
29. The Climate Group	The Climate Group is an award-winning, international non-profit. Their goal is a prosperous, low carbon future. They aim towards a 'clean revolution': the rapid scale-up of low carbon energy and technology. They are present in Greater China, North America, India and Europe. **Contact:** Via the web form http://www.theclimategroup.org/contact-us/
30. Underground Coal Gasification Association	The Underground Coal Gasification Association benefits from close working relationships with an impressive array of energy sector professionals and support service. They work proactively with governments and energy authorities to develop regulatory frameworks for UCG to safely operate and influencing energy policy developments at international level. Though UCG is seen by many as a relatively new technology - it is ready to be deployed today. **Contact:** Julie Lauder, Chief Executive Officer Tel.: +44 1252 661978 http://www.ucgassociation.org/index.php/home
31. World Coal Association	WCA is a global coal network, which provides a voice for coal in international energy, environment and development forums, presenting the case for coal to key decision-makers, including ministers, development banks, NGOs, international media, the energy industry, business and finance and research bodies. WCA produces material that improves understanding of the vital role of coal, organises workshops, holds meetings with senior policy-makers, and develops policy positions to inform international policy discussions in bodies such as the European Commission, European Parliament, United Nations Framework Convention on Climate Change, UN Environment Programme, World Bank, World Economic Forum and national governments. **Contact:** Heddon House,149 - 151 Regent Street London,W1B 4JD,UK. Tel.: 44 (0) 20 7851 0052, Fax: 44 (0) 20 7851 0061 info@worldcoal.org http://www.worldcoal.org/
32. International Standards Organization	The ISO develops international standards, including key areas of sustainable development and energy-efficiency, technology safety which can be related to CCS technologies use. **Contact:** ISO Central Secretariat1, ch. de la Voie-Creuse CP 56 CH-1211 Geneva 20, Switzerland E-mail: central@iso.org Tel.: +41 22 749 01 11. Fax : +41 22 733 34 30 http://www.iso.org/iso/home.htm
33. World Energy Council	Formed in 1923, WEC is the UN-accredited global energy body, representing the entire energy spectrum, with more than 3000 organisations located in over 90 countries and drawn from governments, private and state corporations, academia, NGOs and energy-related stakeholders. The council acts as a platform for global energy issues exchange.

	Contact: 5th Floor – Regency House, 1-4 Warwick Street, London W1B 5LT, United Kingdom. Tel: +44 (0) 207734 5996. Fax: +44 207734 592. www.worldenergy.org
34. World Environmental Center	Founded in 1974, the World Environment Center is an independent, global, non-profit, non-advocacy organization that advances sustainable development through the business practices of member companies and in partnership with governments, multi-lateral organizations, non-governmental organizations, universities and other stakeholders. WEC's mission is to: • Promote business and societal value by advancing solutions to sustainable development-related problems; • Foster leading edge ideas about economic development, environmental protection and social responsibility through roundtables and other forums that engage the leadership of a diverse number of organizations; and • Recognize performance excellence by companies that advance sustainable development. **Contact:** WEC European Office, Bodenseestrasse 4, 81241 Munich Germany Tel.: +49 (0) 89.1892.0563 Email.fwerner@wec.org
35. World Petroleum Congress	Global Petroleum Event The 21st World Petroleum Congress, held from 15th to the 19th June, 2014, brought together 10,198 attendees from 119 countries around the world. With 34 Ministers and 692 speakers, the Congress managed to address all aspects of the oil and gas industry including the upstream and downstream sector, natural gas and renewables and the sustainable management of the industry. **Contact:** Tel/fax: +7 495 739 2854, Email: info@21wpc.com
36. World Petroleum Council	The World Petroleum Council's (WPC) main purpose is to catalyse and facilitate dialogue amongst internal and external stakeholders aimed at seeking solutions to key technical, social, environmental and management challenges in global energy issues for the benefit of mankind. In doing so, the WPC will contribute towards sustainable growth. The WPC provides a forum where the solutions to key challenges can be addressed. **Contact:** Suite 1, 4th Floor, 1 Duchess Street, London, W1W 6AN Tel.: +44 (0)20 7637 4995 Email: info@world-petroleum.org http://www.world-petroleum.org/
37. World Steel Association	WSA represents approximately 170 steel producers (including 17 of the world's 20 largest steel companies), national and regional steel industry associations, and steel research institutes. WSA members represent around 85% of world steel production, addressed various issues of steel production and trade, including sustainability issues. **Contact:** Rue Colonel Bourg 120, B-1140 Brussels Belgium Tel.: +32 2 702 89 00.F: +32 2 702 88 99. Email: steel@worldsteel.org http://www.worldsteel.org/steel-by-topic/sustainable-steel.html
38. The Global Carbon Capture and Storage Institute (GCCSI)	The Global Carbon Capture and Storage (CCS) Institute is an independent, not-for-profit company registered under the (Australian) Corporations Act 2001 (Cth). The Institute accelerates the development, demonstration and deployment of CCS globally through our knowledge sharing activities, fact-based influential advice and advocacy, and work to create favourable conditions to implement CCS. With around 370 Members from more than 40 countries, and offices in Australia, Belgium, China, Japan and the United States. Members include national governments,

	global corporations, small companies, environmental non-government organisations, research bodies and universities. Objectives: • Authoritative knowledge sharing • Fact-based influential advice and advocacy • Create favourable conditions to implement CCS Outcomes: • Increased public understanding and acceptance of CCS • Increased commercial opportunities for CCS • Equal treatment of CCS with other clean energy technologies in energy and climate change policy The Institute is an accredited observer to the UNFCCC, Green Climate Fund, member of the Climate Technology Centre's Network, and Intergovernmental Panel on Climate Change (application pending). **Contact:** PO Box 23335 Docklands VIC 8012 Australia Tel.: +61 3 8620 7300 Email: info@globalccsinstitute.com http://www.globalccsinstitute.com/

National Non-Government Organizations

39. CEPAC – Brazilian Center of Excellence in Research and Innovation in Petroleum, Mineral Resources and Carbon Storage	CEPAC offers services of chemical analyses, mineral characterization and imaging (among others), through the center facilities. **Contact:** CEPAC - Carbon Storage Research Center Av. Ipiranga, 6681, Prédio 96J CEP 90619-900, Porto Alegre - RS - Brasil Tel.: +55.51.33203689, Fax: +55.51.33538350 http://www.pucrs.br/cepac/index_e.php
40. Canadian Clean Power Coalition-Canada	Association on electricity producers in Canada. Key activities: The CCPC is completing its third phase of study on emerging technologies to reduce emissions from coal plants. PHASE I - Feasibility studies to reduce emissions from coal plants PHASE II - Study of post combustion, oxyfuel and gasification technologies PHASE III - Study of advances in technologies to reduce GHG emissions PHASE IV - Canadian Clean Power Coalition Phase IV Workplan **Contact:** Davia Butler, Email: dave.butler@cleanerpower.ca Tel.: (403)606-0973, Fax (403)256-0424 http://www.canadiancleanpowercoalition.com/index.php
41. Carbon Capture and Storage Research Consortium Nova Scotia- Canada	Carbon Capture and Storage Nova Scotia Research Consortium's mandate is to research the feasibility of storing condensed CO2 emissions in suitable geological formations that exist about one kilometre underground. It started our research in 2009 by reviewing existing data. That data led to assume that the Sydney Sub Basin has the greatest potential for onshore storage of condensed CO2. However, a deeper understanding and greater certainty is needed. Between 2013 and 2014, we will conduct 2D seismic testing and drill wells so that we can know more about the Sydney Sub-Basin. **Contact** Via website http://www.ccsnovascotia.ca/

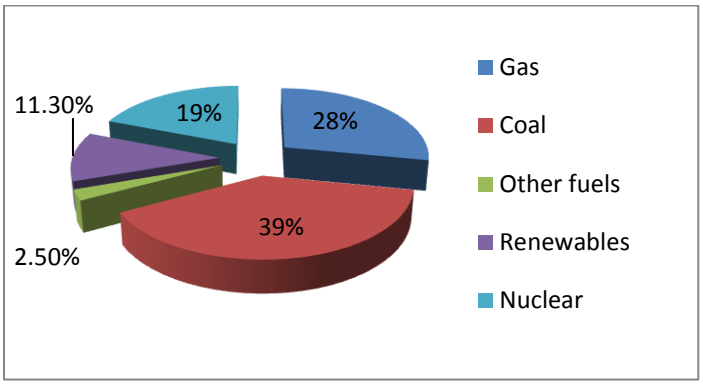
42. Carbon Sequestration Council- USA	The U.S. Carbon Sequestration Council (USCSC) is a non-profit coalition of scientists, engineers, academics, environmentalists, and leaders from the business and the public sectors. These individuals, from 40 U.S. States and 4 Canadian Provinces, have pledged their time, their money, and their ingenuity to develop something of lasting value to our society: a source of low cost and pollution-free energy. **Contact:** Tel.: 703.475.7787. Email: info@uscsc.org http://www.uscsc.org/default.asp
43. Clean Air Taskforce-USA	CATF was launched in 1996 with a single goal: to enact federal policy to reduce the pollutants from America's coal-fired power plants that cause respiratory death and disease, smog, acid rain, and haze. When CATF began its efforts, polls showed that a majority of Americans believed most of their power came from hydroelectric dams and very little from coal. The gap between reality and perception was alarming: in fact, coal power in 1996 and still today provides roughly 50% of U.S. electricity, while hydropower provides only 7%. **Contact :** 18 Tremont Street, Suite 530, Boston, MA 02108 Tel.: 617-624-0234 | Fax: 617-624-0230
44. Coal Utilization Research Council-USA	The Coal Utilization Research Council (CURC) is an industry advocacy group that promotes the efficient and environmentally-sound use of coal. **Contact:** Ben Yamagata, Executive Director. Coal Utilization Research Council 1050 Thomas Jefferson Street, NW, Washington DC 20007. Email. bny@vnf.com Tel.:202-298-1850 http://www.coal.org/index.asp
45. Commonwealth Scientific and Industrial Research Organization-Australia	CSIRO is developing efficient and low emission coal technologies for energy generation, new technologies for oil and gas exploration and production to support a clean and secure energy future. **Contact:** Tel.: 1300 363 400, Alt Phone: +61 3 9545 2176, Email: Enquiries@csiro.au http://www.csiro.au/
46. Cooperative Research Centre for Greenhouse Gas Technologies (CRC) - Australia	CO2CRC is a joint venture comprised of participants from, global industry, universities and other research bodies from Australia, New Zealand, Australian Commonwealth, State and international government agencies. CO2CRC activities include: • Undertaking leading research into and development of technologies for carbon dioxide capture and geological storage. • Decreasing commercial risks by demonstrating the practical application of carbon dioxide capture and storage technologies to reduce carbon dioxide emissions. **Contact:** Tel. : +61 2 6120 1600 , fax +61 2 6273 7181 Email. info@co2crc.com.au http://www.co2crc.com.au/about/
47. Electric Power Research Institute-USA	The Electric Power Research Institute, Inc. conducts research, development and demonstration (RD&D) relating to the generation, delivery and use of electricity for the benefit of the public. An independent NGO. **Contact:** Jeff Brehm, Communications Manager. Tel.: 704-595-2521. Email: jbrehm@epri.com, http://www.epri.com/Pages/Default.aspx

48. Energy Valley Foundation- Netherlands	Energy Valley Foundation is an NGO in Netherlands which deals with energy projects including biofuels, sustainable energy and decentralized energy. **Contact:** 11073, 9700 CB Groningen, Nederland Tel.: +31507890010, Fax +31507890010 http://www.energyvalley.nl/startpagina (website is in Dutch)
49. Engineering Advancement Association of Japan- Japan	The Engineering Advancement Association of Japan (ENAA)is a non-profit organization established in 1978 with the support of the Ministry of International Trade & Industry (the present Ministry of Economy, Trade and Industry (METI)) to aim at developing diversified activities such as advancement of technological capabilities and promotion of technical development. **Contact:** 3-18-19 Toranomon, Minato-ku, Tokyo 105-0001, Japan Tel.: 813-5405-7201 Fax:813-5405-8201 https://www.enaa.or.jp/EN/index.html
50. Geological Survey of Ireland- Ireland	GSI is responsible for providing geological advice and information, and for the acquisition of data for this purpose. GSI produces a range of products including maps, reports and databases and acts as a knowledge centre and project partner in all aspects of Irish geology. It is a division of the Department of Communications, Energy & Natural Resources (DCENR) and has about 50 multi-disciplinary staff. **Contact:** Tel.: +353-1-678 2000, Fax +353-1- 668 1782 http://www.gsi.ie
51. Japan CCS Co., Ltd – Japan	Business entity responsible for implementation of demonstration projects for Carbon-dioxide Capture and Storage (CCS) in Japan, comprehensive investigations of CCS technologies and its relating subjects. **Contact:** Tel.: +81 (0)3 6268 7610. http://www.japanccs.com/?lang=en
52. Korea CCS Association (KCCSA) – South Korea	KCCSA objectives: • To support research, development and deployment of CCS technology in Korea • To facilitate strategic planning and assessment of R&D programs for demonstration, commercialization, and industrialization of CCS, • To enhance the distribution of knowledge and technology among members. **Contact:** 599 Kwanak-ro, 311-414, Chemical Process Institute, Seoul National University, Kwanak-ku, Seoul, Korea. Tel.: 82-2-888-1022, Fax: 82-2-888-1026 Email: kccsa@kccsa.or.kr, http://www.kccsa.or.kr/Englishpage
53. National Mining Association-USA	The National Mining Association (NMA) is U.S. mining's advocate in Washington, D.C. and beyond. NMA is the only national trade organization that represents the interests of mining before Congress, the administration, federal agencies, the judiciary and the media—providing a clear voice for U.S. mining. NMA's mission is to build support for public policies that will help America fully and responsibly utilize its coal and mineral resources. **Contact:** Tel.: (202) 463-2600. http://www.nma.org/index.php
54. Southern States Energy Board-USA	The Southern States Energy Board (SSEB) is a non-profit interstate compact organization created in 1960 and established under Public Laws 87-563 and 92-440. The Board's mission is to enhance economic development and the quality of life in the South through innovations in energy and environmental policies, programs and technologies.

	Contact: Southern States Energy Board, 6325 Amherst Court, Peachtree Corners, GA 30092 Tel.: 770.242.7712, FAX I: 770.242.9956, FAX II: 770.242.0421 E-mail: sseb@sseb.org, http://www.sseb.org/
55. The Clinton Foundation- USA	Partnership of NGOs which has one of work areas in sustainable energy **Contact:** Only via website form. http://www.clintonfoundation.org/
56. The Zero Emissions Resource Organization- Norway (20% funding from gov't)	Zero Emission Resource Organization (ZERO) is a Norwegian based environmental foundation. ZERO is a non-profit environmental organization dedicated to reducing climate change by demonstrating and gaining acceptance for zero emission energy solutions. ZERO works with a wide range of sources for greenhouse gas emissions. Below follows a list of our major fields of focus: • CO2-capture and storage • Electric power for the offshore sector • Wind energy • Biofuels for road transport, ships and heating **Contact:** http://www.riscs-co2.eu/ via the website form.
57. United States Energy Association	The United States Energy Association (USEA) is the U.S. Member Committee of the World Energy Council (WEC). USEA is an association of public and private energy-related organizations, corporations, and government agencies. USEA represents the broad interests of the U.S. energy sector by increasing the understanding of energy issues, both domestically and internationally. **Contact:** Tel.: (202) 312-1230, Email: reply@usea.org
58. US Carbon Capture & Storage Association- USA	The Carbon Capture & Storage Association (CCSA) was launched in March 2006 to represent the interests of its members in promoting the business of capture and geological storage of carbon dioxide (known as Carbon Capture and Storage, or CCS) as a means of abating atmospheric emissions of carbon dioxide and tackling climate change. **Contact:** Carbon Capture and Storage Association, 6th Floor,10 Dean Farrar Street London SW1H 0DX, Tel.: +44 (0) 20 3031 8750, Fax: +44 (0) 20 7222 4253 Email: info@ccsassociation.org, http://www.ccsassociation.org/
59. Technology Centre Mongstad - Norway	Technology Centre Mongstad is the world's largest facility for testing and improving CO2 capture technologies, a vital part of the CCS value chain. TCM focuses on testing and improving CO2 capture technology and takes technology development one step further. The main ambitions of the Technology Centre are to: • Test, verify and demonstrate CO2 capture technology owned and marketed by vendors • Reduce cost, technical, environmental and financial risks • Encourage the development of the market for carbon capture technology • Aim at international development The realisation of TCM depends on close cooperation between the owners and technology suppliers. The success criteria include increased competition among the suppliers, strengthening the development of a market. **Contact:** CO2 Technology Centre Mongstad (TCM), 5954 Mongstad

	Tel.: + 47 56 34 52 20 (Reception at TCM, Mongstad) Managing Director Frank Ellingsen Tel.: Mobile: +47 905 47 505 http://www.tcmda.com/en/
60. Demos EUROPA - Poland	Polish NGO which is involved in research, including energy issues. **Contact:** Pavel Wieboda, Director. Tel.: +48 22 401 70 26, f: +48 22 401 70 29 Email.pawelswieboda@demoseuropa.eu http://www.demoseuropa.eu

Annex II: A Survey of Carbon Capture and Storage (CCS): landscape and recent developments in the United Kingdom



Fuel used for UK electricity generation in 2012
Source: GOV. UK
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/279546/DUKES_2013_Chapter_5.pdf

United Kingdom

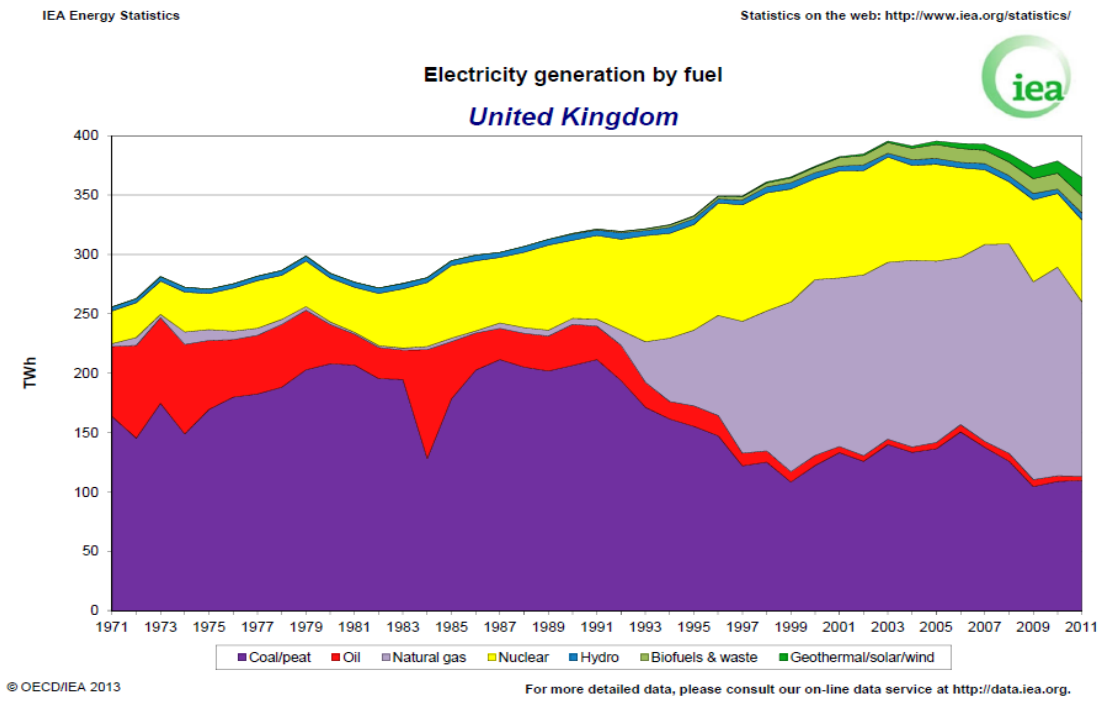
Electricity generation from fossil fuels accounts for the majority of electricity produced in the UK, with coal occupying the top spot among all sources. Renewable energy, especially wind, continues to grow and reached almost 15% of total generation in 2013. The UK government has announced plans to become a market leader in CCS innovation and technology. It estiates the CCS industry – including the transfer of CCS technology to developing nations – will be worth £6.5 billion to the UK by 2030. CCS technology is currently the only means by which fossil fuels can be maintained within the UK generation mix, whilst meeting 2050 carbon targets.

1. Capacity building for cleaner energy

- The Government has initiated widespread reform of the electricity market with the aim of providing a framework that will facilitate low carbon investment, including in CCS to create a market in which there is a clear commercial model for CCS in the UK, provided it can demonstrate the ability to compete with other low carbon technologies.
- Working with other leading Governments, the Global Carbon Capture and Storage Association and the European Commission to ensure that knowledge and lessons learned in the UK and overseas are shared to inform a best practice approach.
- Working with the industrial sector to identify the current state of innovation on CCS and the potential for Government interventions to enable deployment.

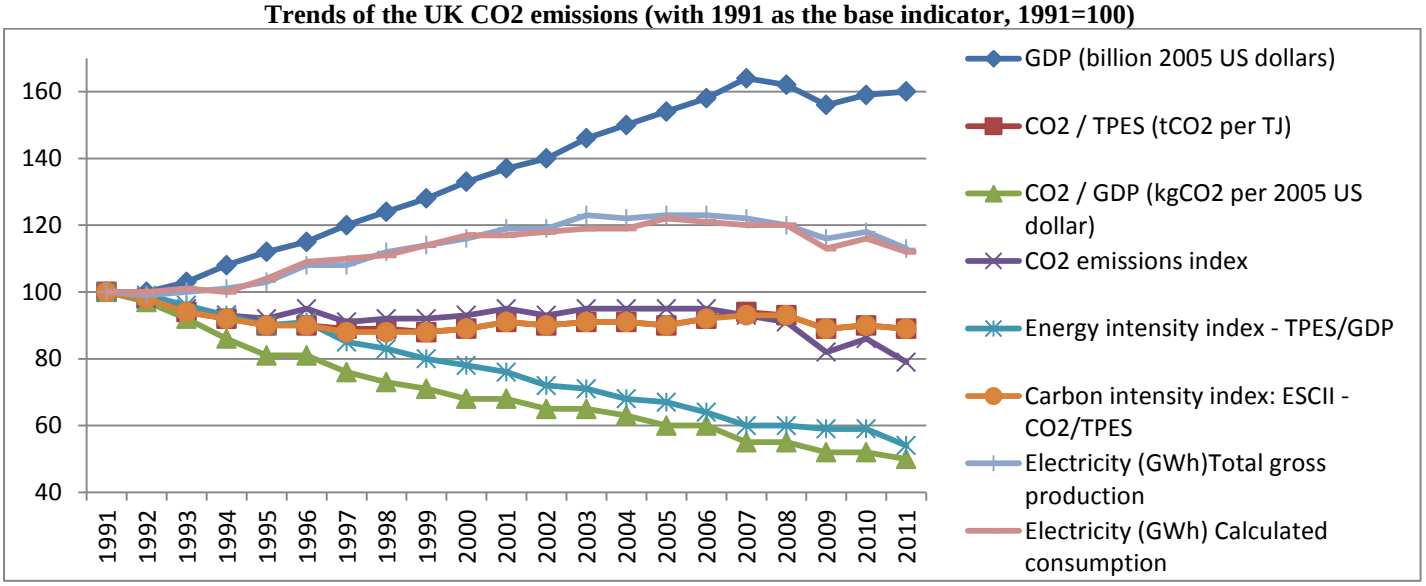
2. Clean energy policies and legislation

- The UK has endorsed both the Kyoto Protocol and the Copenhagen accord. The need to reduce emissions of CO2 is recognized by the Government in the Climate Change Act of 2008, which sets legally binding targets for the UK to reduce emissions of CO2 and other greenhouse gases by 80% from 1990 levels, by 2050.
- In 2010, the UK Parliament transposed provisions of the Energy Act of 2008 and the CCS Directive into national law. The law defines "CCS Ready" and requires all new power plants over 300MW, implemented under Section 3 of the Electricity Act 1989, to be CCS Ready.
- In 2012 the UK introduced the CCS Roadmap, setting out the steps that the government is taking to develop a new world-leading CCS industry in the 2020s. A plan for a new UK CCS Research Centre.



Source: International Energy Agency. http://www.iea.org/stats/WebGraphs/UK2.pdf

Trends of the UK CO2 emissions (with 1991 as the base indicator, 1991=100)



Source: Data for this chart was taken from the International Energy Agency. http://wds.iea.org/WDS/ReportFolders/reportFolders.aspx

3. Clean energy technologies and potential

- The technical CO2 storage capacity of the UK is up to 70 billion tonnes – sufficient to store 100 years' worth of current emissions from the energy sector. CCS also represents a major green growth opportunity for the UK. Export opportunities for UK based firms have been estimated to be between £3 - 6.5 billion a year by the late 2020s.
- CCS could be lopping $50 billion off Britain's annual energy bill by 2050, according to the Energy Technology Institute.
- The UK has world-class engineering capability within the power sector and is well represented in manufacturing sectors likely to be important for CCS, including large-scale compressors, pipelines and air separation plants.
- Britain has a wealth of underwater engineers.
- Technology used: post-combustion, pre-combustion and oxyfuel combustion.

4. Readiness to introduce CCS

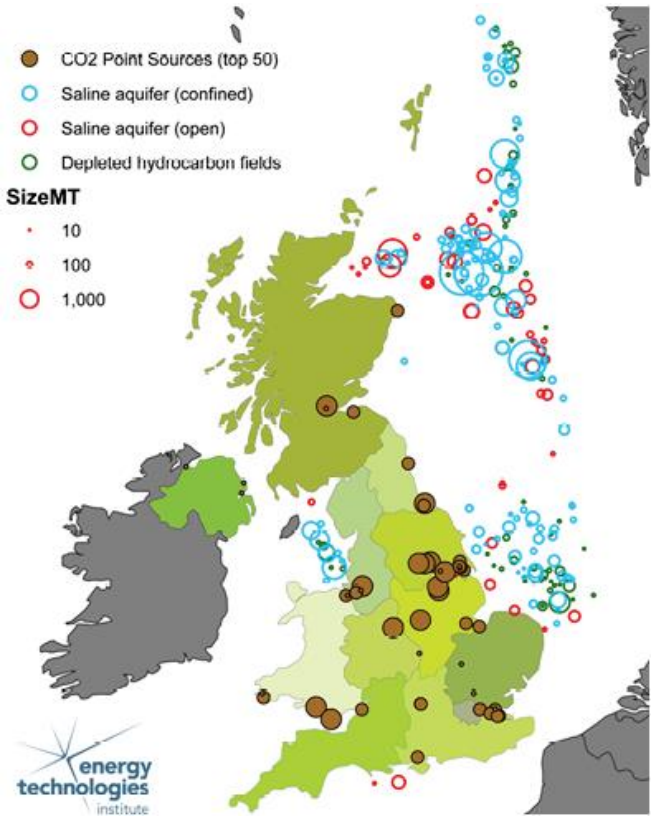
The deployment of CCS is at an early stage. The UK has developed programmes to help create a new CCS industry:

- A Commercialization Programme with £1 billion capital support focused on learning by doing and sharing knowledge to reduce the cost of CCS so that it can be deployed in the early 2020s
- Delivering a £125m, 4-year, coordinated R&D and innovation programme covering fundamental research and understanding through to component development and pilot-scale testing
- Reforming the electricity market to enable investment in low carbon power generation
- Developing long-term contracts which recognize the potential contribution of CCS to a balanced low carbon electricity system
- Exempting power stations with CCS from the Carbon Price Floor in proportion to the CO2 captured and stored
- Exempting CCS projects from the Emissions Performance Standard Programme.

FLOW	2007	2008	2009	2010	2011
CO2 Sectoral Approach (Mt of CO2)	522.84	512.73	464.75	482.18	443.01
CO2 Reference Approach (Mt of CO2)	530.65	522.3	475.25	490.52	450.6
Total primary energy supply (PJ)	8833.84	8717.29	8226.42	8450.17	7874.28
Total primary energy supply (Mtoe)	210.99	208.21	196.48	201.83	188.07
GDP (billion 2005 US dollars)	2441.12	2417.49	2321.41	2363.18	2386.63
GDP PPP (billion 2005 US dollars)	2110.45	2090.02	2006.95	2043.06	2063.34
CO2 / TPES (tCO2 per TJ)	59.19	58.82	56.49	57.06	56.26
CO2 / GDP (kgCO2 per 2005 US dollar)	0.21	0.21	0.2	0.2	0.19
CO2 emissions index	95.19	93.35	84.61	87.79	80.66
GDP per population index	151.7	149.22	142.38	143.84	144.18
Energy intensity index - TPES/GDP	63.39	63.17	62.08	62.64	57.8
Carbon intensity index: ESCII - CO2/TPES	92.9	92.32	88.68	89.57	88.31
Total gross production of electricy (GWh)	396830	388990	376775	381771	367802
Elect.output-main activity prod. electricity plants (TWh)	349.32	342.54	331.07	336.79	321.41
CO2 per kWh of electricity (gCO2 per kWh)	506.36	498.51	452.92	457.29	440.67

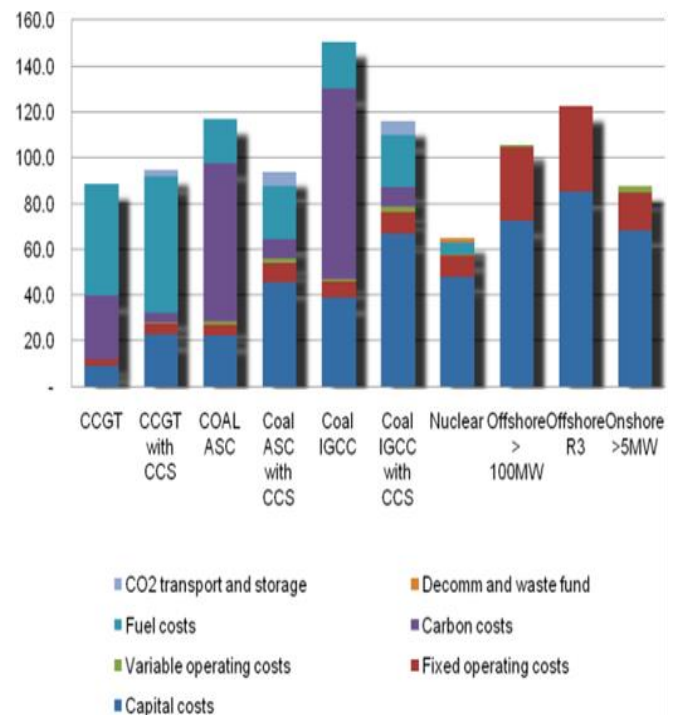
Source: International Energy Agency. http://wds.iea.org/WDS/ReportFolders/reportFolders.aspx

Proximity of the UK's largest industrial emitters to CO2 storage sites in the North and Irish Seas.

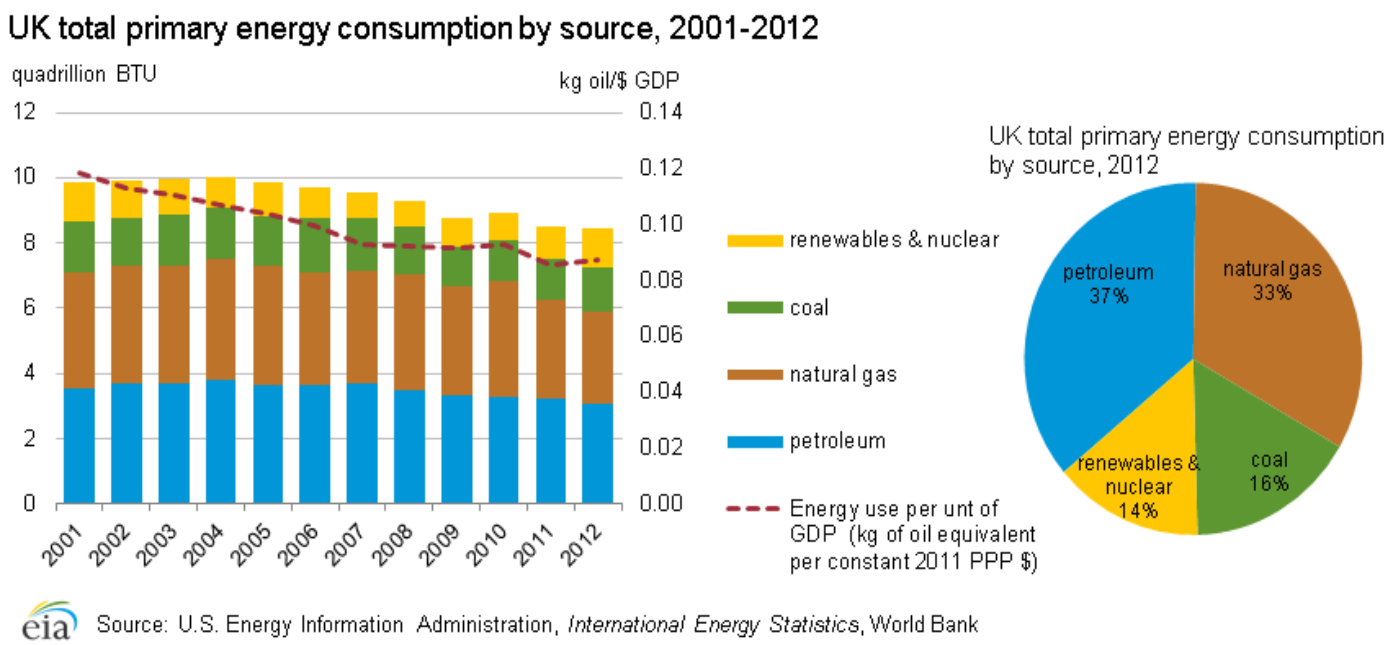


Source: CCS Map by DECC (UK). Map provided by the Energy Technologies Institute. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48317/4899-the-ccs-roadmap.pdf

Nth of a kind (NOAK) levelised cost estimates (£s per MWh) for generation technologies for projects starting in 2017



Source: Central estimates of construction, operation, fuel and carbon costs, 10% discount rate. Data from PB Power (2011) and Arup (2011).



The White Rose CCS Project

Source: The White Rose CCS Project
http://www.whiteroseccs.co.uk/about-white-rose

5. Case studies – current projects

Currently in the UK there are plans for 5 new coal-fired power plants with CCS and one gas fired plant to be retrofitted with CCS. In 2011-12 two CCS projects were cancelled due to concerns about their commercial viability. *White Rose, Capture Power Limited, North Yorkshire* – oxyfuel new supercritical coal-fired power station. In 2014, The European Commission has confirmed that the White Rose project is in line to win the 300million euros. A new 426MW (gross) clean coal power plant with full CCS capability. The demonstration plant would have the potential to co-fire biomass and would provide enough safe, reliable and clean electricity to meet the typical demands of more than 630,000 homes as well as capturing approximately 90% of all the CO2. White Rose would be the first power station to employ a CCS technology variant called oxyfuel combustion. The captured CO2 would be transported from the White Rose site through National Grid's proposed Yorkshire and Humber CCS Project pipeline for safe and permanent storage in geological formations deep beneath the North Sea.

6. Key challenges for CCS deployment

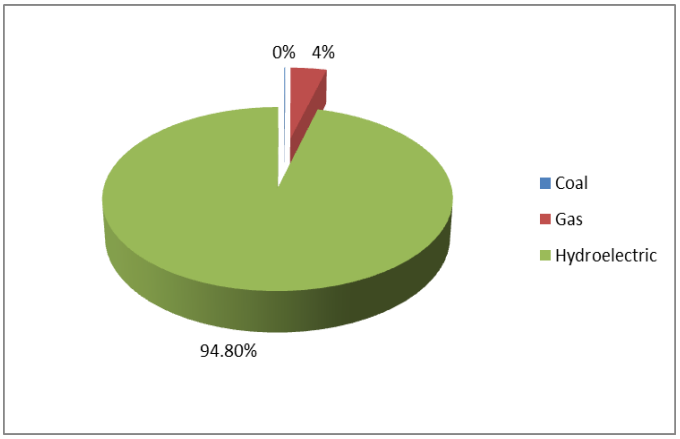
- Given the early stage of CCS development (there are no commercial scale full chain projects operating) there is great uncertainty in making cost projections.
- There is more certainty regarding the host plant costs (for super critical coal and CCGT, at least), although even here there are uncertainties about future capital costs as engineering, procurement and construction (EPC) markets have become commoditised (and subject to demand and supply pressures) and fuel prices are even more uncertain.
- Energy from the first CCS plants could cost 150-200 pounds per megawatt h our, four times the current wholesale price of power and more expensive even than offshore wind farms.
- There is uncertainty as to whether geological storage of CO2 will prove safe over long time periods, and about how the associated risks can be reliably assessed and managed.
- It is unclear how CCS systems will be integrated. Integration is a technical challenge, as well as an issue of organization and governance.

7. Key Stakeholders in the UK

Rt Hon Michael Fallon (Co-Chair)	Minister of State for Business and Industry	BIS / DECC
Michael Gibbons (Co-Chair)	Chairman	Carbon Capture and Storage Association (CCSA)
Lewis Gillies	Chief Executive	2CO Energy Ltd
Leigh Hackett	General Manager	Capture Power Ltd
Luke Warren	Chief Executive	Carbon Capture and Storage Association (CCSA)
Janice Munday	Director Advanced Manufacturing and Services	Department for Business, Innovation & Skills (BIS)
Ashley Ibbett	Chief Executive and Director OCCS	DECC
Patrick Dixon	Expert Chair, Office of Carbon Capture and Storage	DECC / Independent
Graeme Sweeney	Chairman	Zero Emissions Platform

David Clarke	Chief Executive	Energy Technologies Institute (ETI)
Nilay Shah	Professor of Process Systems Engineering	Imperial College London; UK CCS Research Centre
Peter Boreham	Director European Business Development	National Grid Carbon Ltd
Peter Whitton	Managing Director	Progressive Energy Ltd
Bill Spence	Head of CCS	Shell UK Ltd
Eric Redman	Chief Executive	Summit Power Group
Rob Hastings	Director of the Marine Estate	The Crown Estate & Storage Development Group
Dave Robson	Technical Development Manager	SSI UK Ltd
Graeme Sweeney	Chairman	Zero Emissions Platform (ZEP)
Leigh Hackett	Chief Executive	Capture Power White Project

Annex III. A Survey of Carbon Capture and Storage (CCS): landscape and recent developments in Norway



Fuel used for Norway electricity generation in 2010
Source: http://www.tradingeconomics.com/norway/fossil-fuel-energy-consumption-percent-of-total-wb-data.html

Norway

Norway is Europe's largest oil producer, the world's third-largest natural gas exporter, and an important supplier of both oil and natural gas to other European countries. Almost half of its domestic energy consumption is met by electricity and electricity is about 95% based on hydropower, leading to a high proportion of renewable energy in Norway's energy supply. In June 2012, government officials from Norway, Germany, and the United Kingdom confirmed their plans for subsea electric power interconnects between their countries to strengthen the northern European electricity grid and increase supply security.

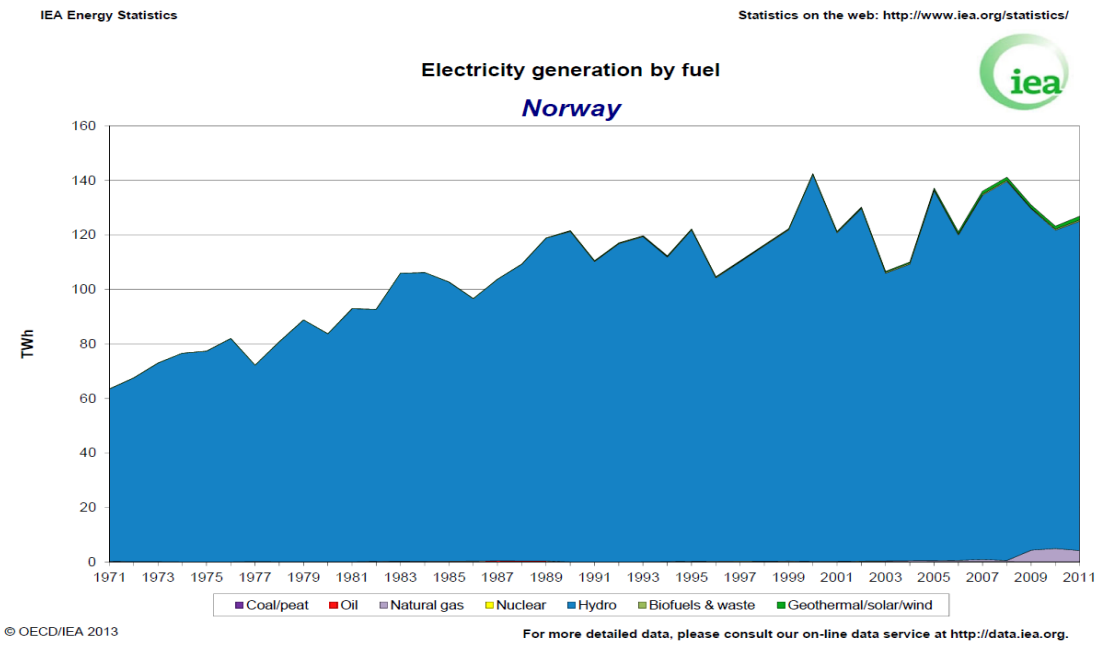
1. Capacity building for cleaner energy

- The Norwegian Petroleum Directorate developed a CO_2 Storage Atlas of the Norwegian part of the North Sea, and will develop a similar atlas for the Norwegian Sea in 2012.
- The Norwegian Government has an ambitious environmental policy, with the goal of becoming carbon neutral by 2050 (or 2030 depending on global agreement). The Norwegian Government has stated that CCS is one of the 'three pillars' of its energy policy, announcing that all new gas-fired power plants will be required to implement CCS – a step further than the requirement of 'CCS ready' introduced by the EU.
- Despite a number of years of dedicated support for CCS, the Government does not have specific legislation or regulations regarding CCS.

2. Clean energy policies and legislation

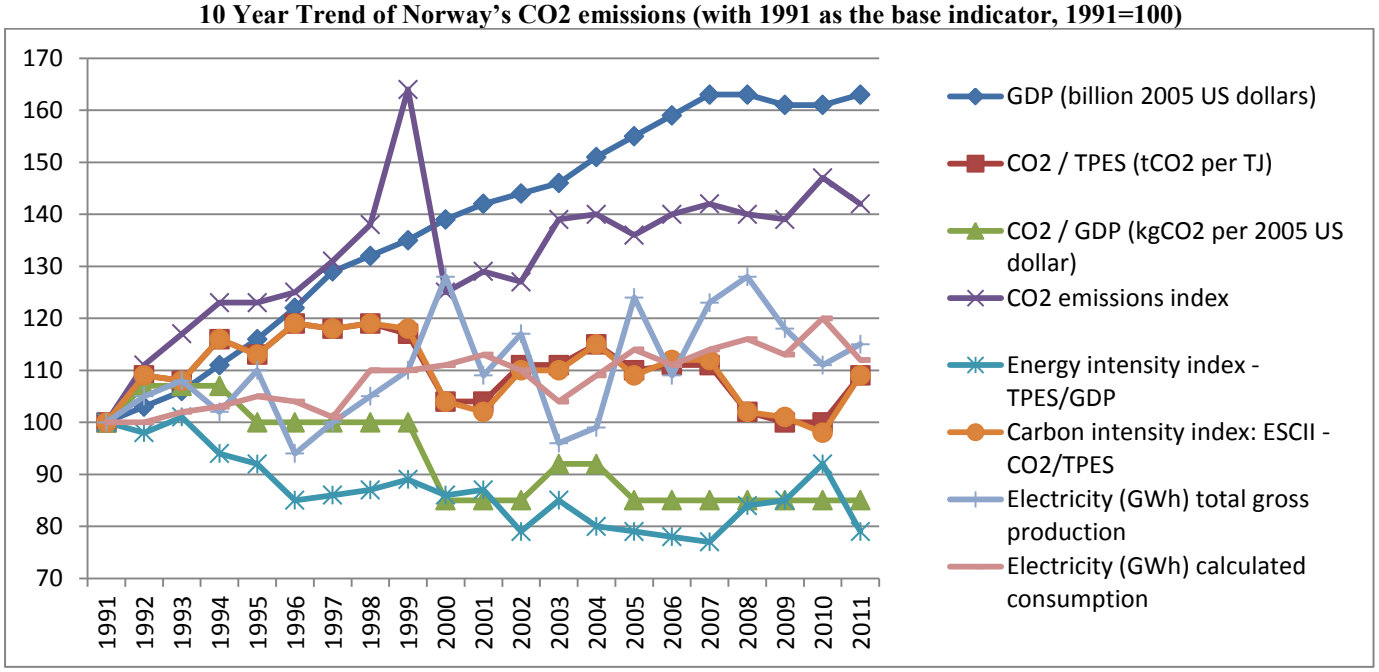
The following initiatives impact the development of CCS in Norway:

- The *Norwegian Act Pertaining to Petroleum Activities* (under the Ministry of Petroleum and Energy) and the *Pollution Control Act* (under the Ministry of Environment).
- *The Pollution Control Act is the* most relevant piece of legislation, covering the application and withdrawal of permits, the authority's responsibilities, inspection, provision of information, closure, and liability. The Act will also form the basis for CO_2 storage legislation.
- The building and operation of pipelines, exploration of offshore reservoirs for permanent storage, the need for an environmental impact assessment, monitoring, or third party access to pipelines or storage will fall under new regulations in the *Continental Shelf Act*.



Source: International Energy Agency. http://www.iea.org/stats/WebGraphs/NORWAY2.pdf

10 Year Trend of Norway's CO2 emissions (with 1991 as the base indicator, 1991=100)



Source: Data for this chart was taken from the International Energy Agency. http://wds.iea.org/WDS/ReportFolders/reportFolders.aspx

3. Clean energy technologies and potential

- In the North Sea, the storage capacity is estimated at about 72 Gt of CO_2. About 12-15 million tonnes of CO_2 have been injected into the Utsira Formation from the Sleipner project.
- In regard to enhanced oil recovery (EOR), a study by the European Commission suggested that Norway could recover an additional 4.2 billion barrels of oil, while storing 6.2 Gt of CO_2.
- Norway has extensive experience in storage of CO2 in geological structures. Since 1996, one million tonnes of CO2 per year have been separated from gas production on the Sleipner Vest field in the North Sea for storage in Utsira, a geological formation 1000 metres below the seabed.

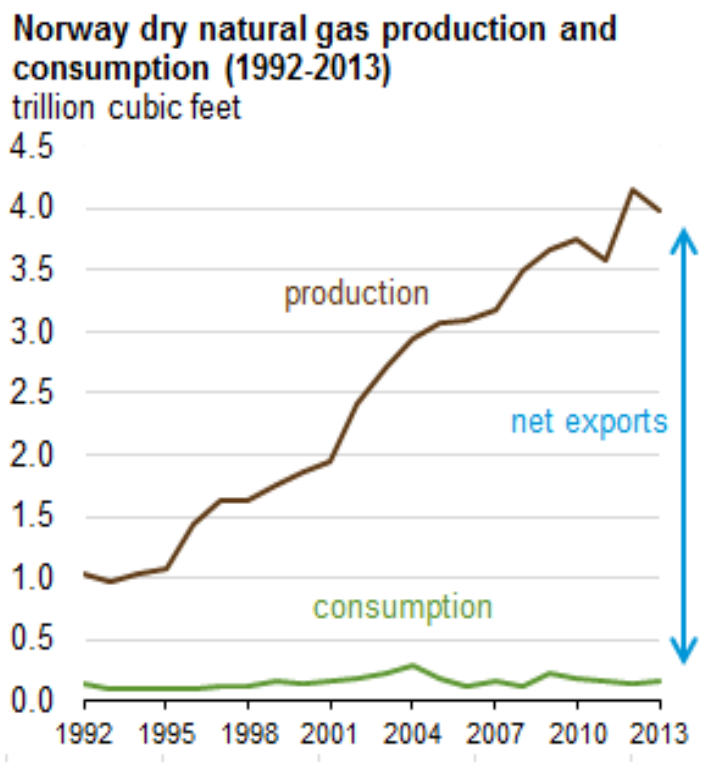
4. Readiness to introduce CCS

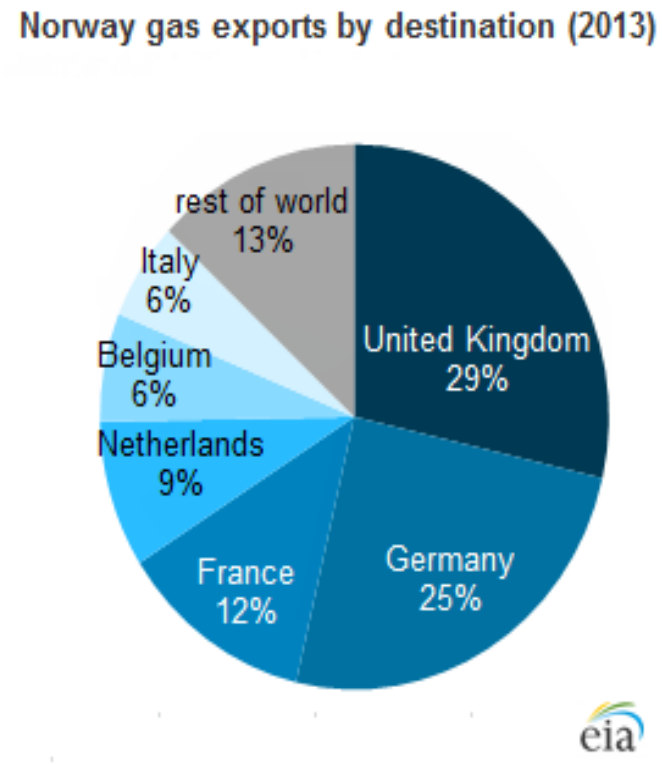
In 2008, the Ministry of Petroleum and Energy launched a national strategy for energy research and development, called Energi21. Its mandate is limited to stationary energy production/consumption and carbon capture, and there are twin aims; the development of 'climate-friendly' energy systems while creating economic value and internationally competitive expertise. The strategy was revised in 2011 and recommended focusing activities in priority areas:

- Solar cells (industrial development in the supply chain for the export market);
- Offshore wind power (industrial development and use of domestic resources);
- Use of domestic resources to provide grid balancing services to the European market;
- CCS technology to safeguard the future economic value of Norwegian gas resources;
- Flexible energy systems: smart grid operation and the integration of renewable sources.

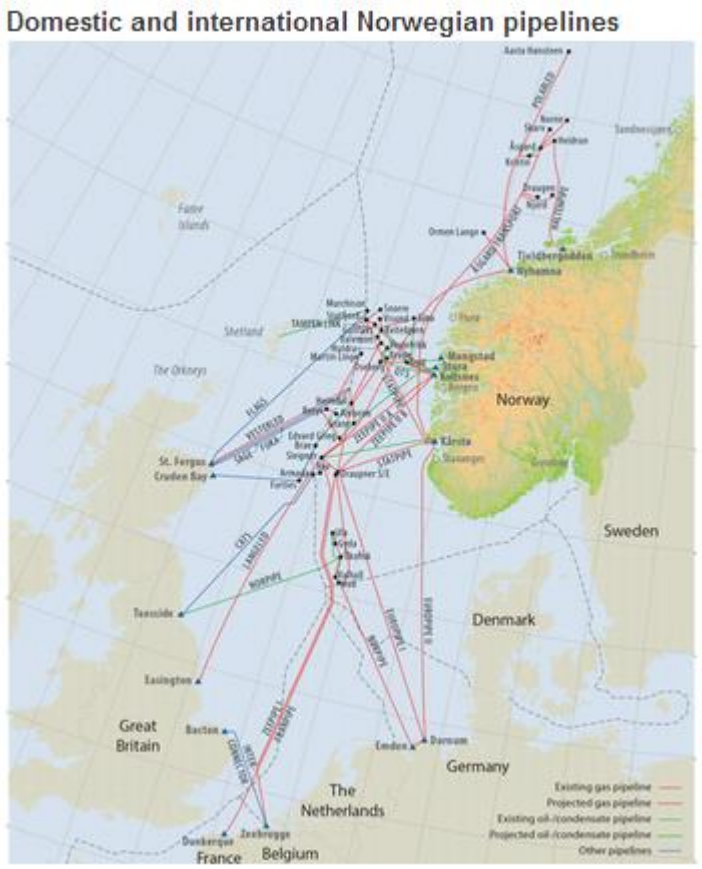
Flow	2007	2008	2009	2010	2011
CO2 Sectoral Approach (Mt of CO2)	37.99	37.55	37.07	39.38	38.1
CO2 Reference Approach (Mt of CO2)	39.01	44.81	46.95	51.38	41.66
Total primary energy supply (PJ)	1153.35	1247.88	1246.63	1353.94	1178.03
Total primary energy supply (Mtoe)	27.55	29.81	29.78	32.34	28.14
GDP (billion 2005 US dollars)	319.3	319.52	314.29	315.8	319.64
GDP PPP (billion 2005 US dollars)	231.23	231.38	227.6	228.69	231.47
Population (millions)	4.71	4.77	4.83	4.89	4.95
CO2 / TPES (tCO2 per TJ)	32.94	30.09	29.74	29.09	32.34
CO2 / GDP (kgCO2 per 2005 US dollar)	0.12	0.12	0.12	0.12	0.12
CO2 emissions index	134.32	132.76	131.05	139.23	134.69
Population index	110.96	112.45	113.82	115.28	116.79
GDP per population index	151.81	149.9	145.68	144.52	144.39
Energy intensity index - TPES/GDP	77.86	84.19	85.5	92.42	79.44
Carbon intensity index: ESCII - CO2/TPES	102.41	93.56	92.44	90.43	100.54
Electricity (GWh) total gross production	137192	142134	131773	123640	128148
Electricity (GWh) calculated consumption	114214	115920	112620	119709	111668

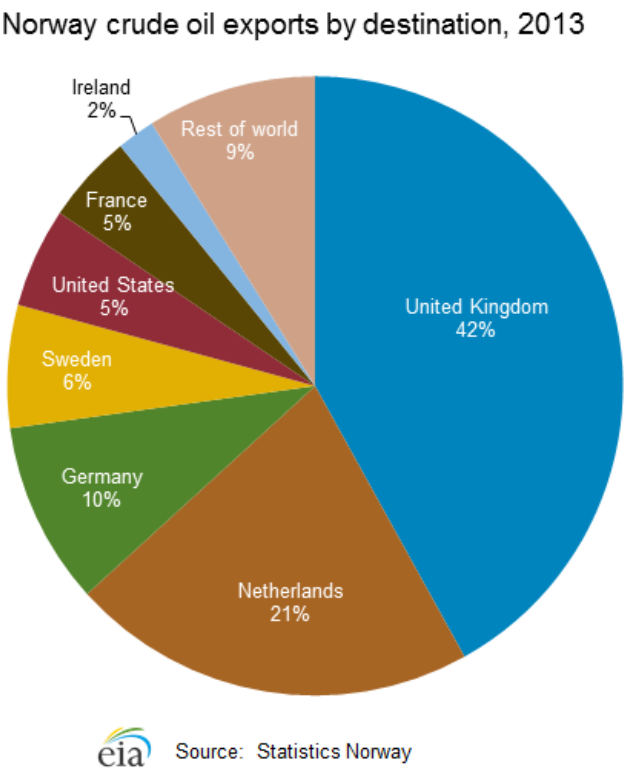
Source: International Energy Agency. http://wds.iea.org/WDS/ReportFolders/reportFolders.aspx



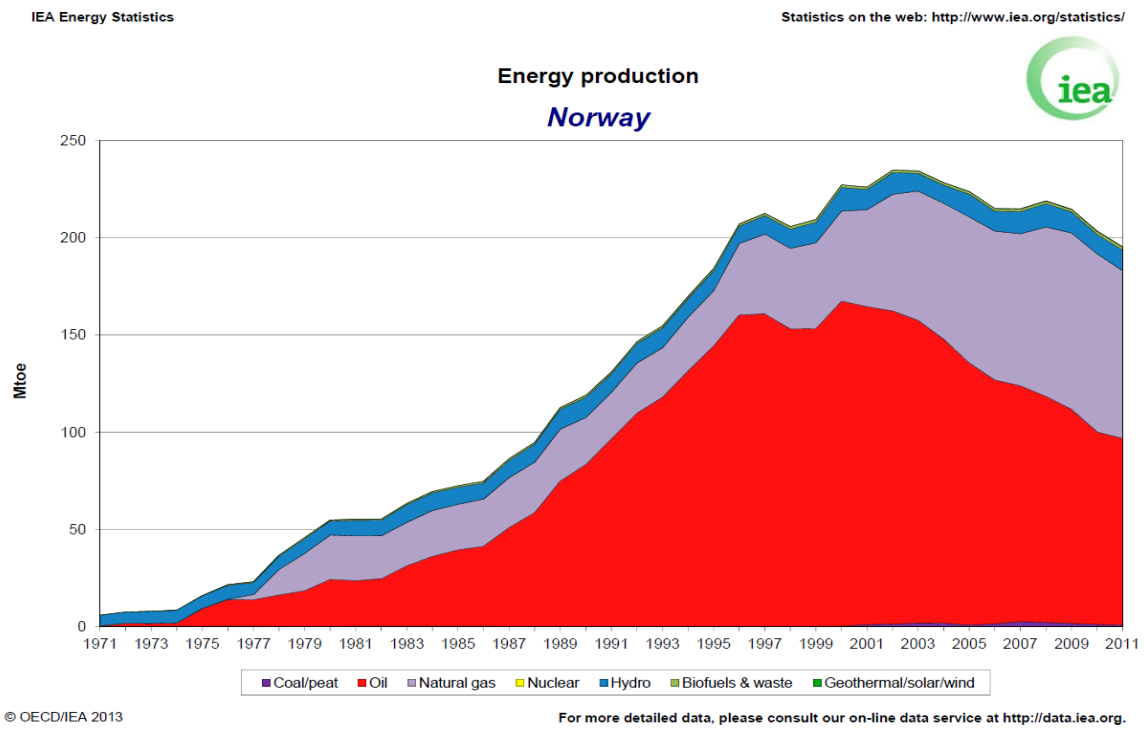


Source: U.S. Energy Information Administration. http://www.eia.gov/todayinenergy/detail.cfm?id=16311





Source: U.S. Energy Information Administration, with permission from the Norwegian Petroleum Directorate. http://www.eia.gov/todayinenergy/detail.cfm?id=16311



Source: International Energy Agency. http://www.iea.org/stats/WebGraphs/NORWAY3.pdf

5. Case studies – current projects

. From 2007-2009 three projects were cancelled in Norway due to concerns about their commercial viability. Norway is home to three large-scale CCS projects – including two operational storage projects and one project on hold:

Industrikraft Möre AS Norway – on hold

- New built 250 MWe natural gas-based power plant with carbon dioxide (CO_2) capture (post-combustion)
- More than 1.4 million tonnes per annum (Mtpa) of CO_2 would be captured at the plant using Sargas's own 'Stargate 250' post-combustion capture technology.

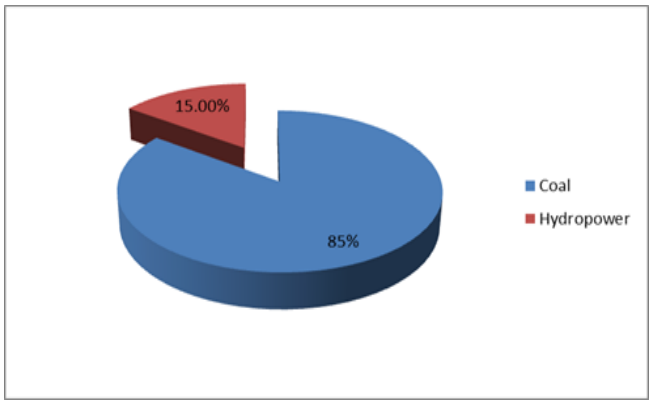
6. Key challenges for CCS deployment

- Current costs levels and technology risks are a serious barrier to large scale commercial deployment of CCS.
- Worley Parsons modelling, as part of the 2009 Strategic Analysis of the *Global Status of CCS, determined that the* cost of CCS for power generation, based on the use of commercially available technology, range from $62 to $112 per tonne of CO2 avoided or $44 to $90 per tonne of CO2 captured. For projects to be economic, it is therefore crucial to reduce CCS costs and raise permit prices.
- Norway has recently delayed a final investment decision on the building a full-scale CCS centre at Mongstad power station on cost grounds.

7. Key Stakeholders in Norway

Mr.	Torstein	Indrebø	Deputy Director General	Ministry of Petroleum and Energy of Norway
Mr.	Jostein	Dahl Karlsen	Senior Advisor, Technology and Industry Department, Research Technology Section	Ministry of Petroleum and Energy
Mr.	Henrik O.	Madsen	DNV GL Group CEO	DNV GL
Mr.	Åsmund	Bøe	Chief Technology Officer	Aker Solutions
Dr.	Espen	Hamborg	Technology Manager	CO2 Technology Centre Mongstad (TCM)
Mr.	Tore	Amundsen	CEO of Gassnova SF	Gassnova

Annex IV: A Survey of Carbon Capture and Storage (CCS): landscape and recent developments in Kazakhstan



Fuel used for Kazakhstan electricity generation in 2013
http://www.eia.gov/countries/cab.cfm?fips=KZ

Kazakhstan

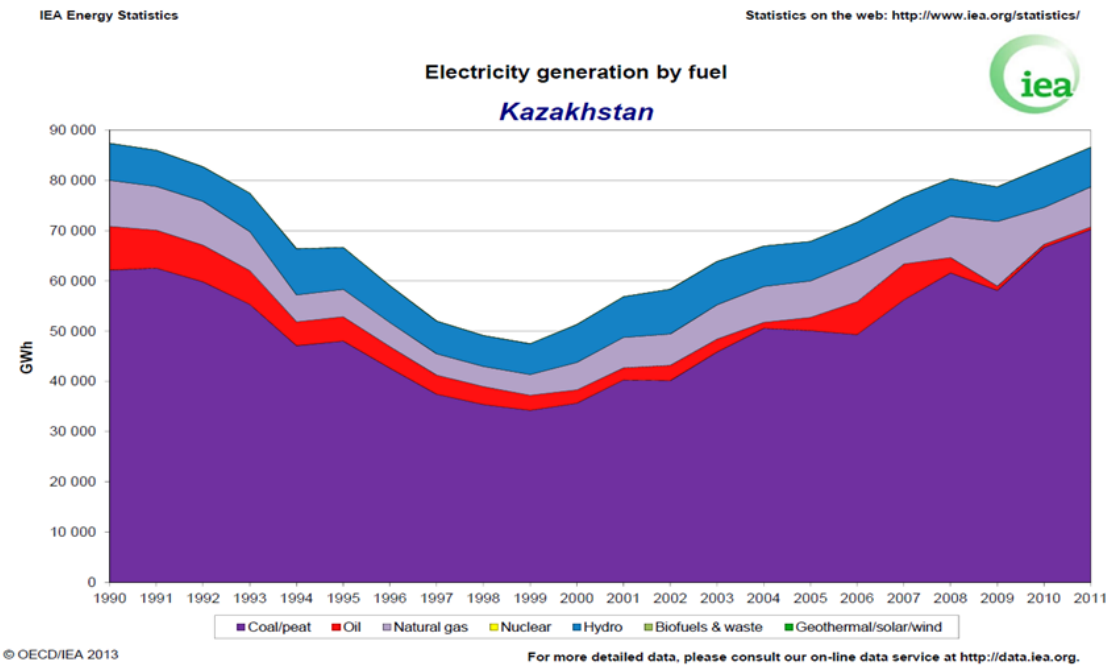
Key sectors of economy are oil, gas, coal production, uranium and mining with historically coal being the cheapest resource. The vast majority of power generation comes from coal-fired power plants, concentrated in the north of the country near the coal producing regions, 70% of which are either outdated or need modernization. Kazakhstan's total installed generating capacity is 85% coal-fired power with the remaining 15% generated from hydropower. In 2012 Kazakhstan's electric power production rose by 4.6% to 90.5 billion kWh. The electric power industry remains a key factor in industrial development and economic growth as electric power generation accounts for about one-tenth of all industrial output.

1. Capacity building for cleaner energy

- In 2013, Kazakhstan became the first country in Central Asia to launch an economy-wide carbon emissions system to cap emissions from its biggest emitters in the energy, coal, oil and gas extraction sectors.
- Some support work for developing capacity for green mechanisms in Kazakhstan has already been done by international organizations:
  -Capability mapping for clean development mechanisms (USAID)
  -Enhancing capacity project (Norwegian MFA)
  -PETER project Phase 1 and 2 (EBRD)
- Energy companies expressed interest to develop Carbon Capture and Storage in Kazakhstan as a long-term:
  -Samruk Energo interest in enhanced oil recovery
  -Shell issued a statement in 2010 outlining opportunities and interest for Shell to develop CCS as a perspective activity.

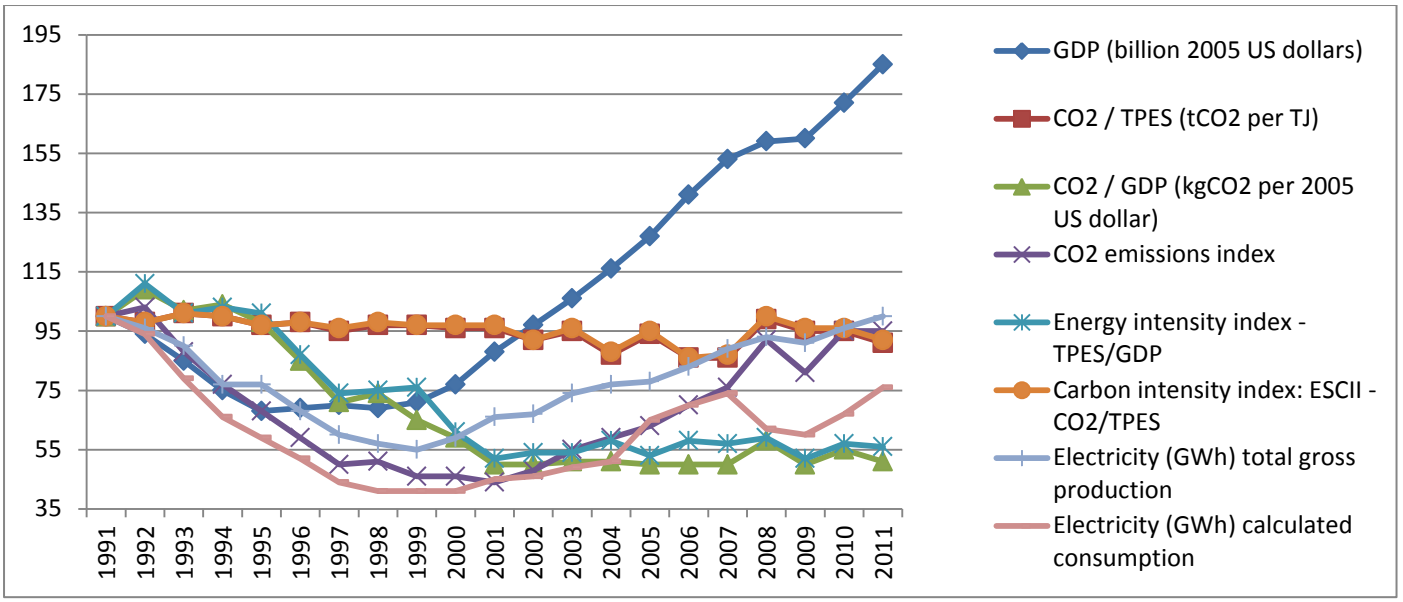
2. Clean energy policies and legislation

- The Kazakhstan government does not have specific legislation or regulations regarding CCS. In 2013, Kazakhstan adopted the Energy Efficiency 2020 Program that would reduce emissions 10% every year until 2015.
- As part of the Kyoto Protocol, Kazakhstan promised to reduce its emissions 5% relative to 1990 levels during 2013-2020. The energy sector's targets 3% emissions reduction below 2012 levels by 2015.
- 2013 – Adopted National Decree "On the concept of transition towards green economy":
  -Reduce current CO2 emissions in electricity production by 40% by 2050;
- 2012, Adopted "National Allocation Plan for GHG 2013":
  -Base year is 2010 using unverified reports from covered companies
  -Obligation for reduction in emissions - 0%.
  2014-2015, National Allocation Plan.



Source: International Energy Agency. http://www.iea.org/stats/WebGraphs/KAZAKHSTAN2.pdf

10 Year Trend of Kazakhstan's CO2 emissions (with 1991 as the base indicator, 1991=100)



Source: Data for this chart was taken from the International Energy Agency.http://wds.iea.org/WDS/ReportFolders/reportFolders.aspx

3. Clean energy technologies and potential

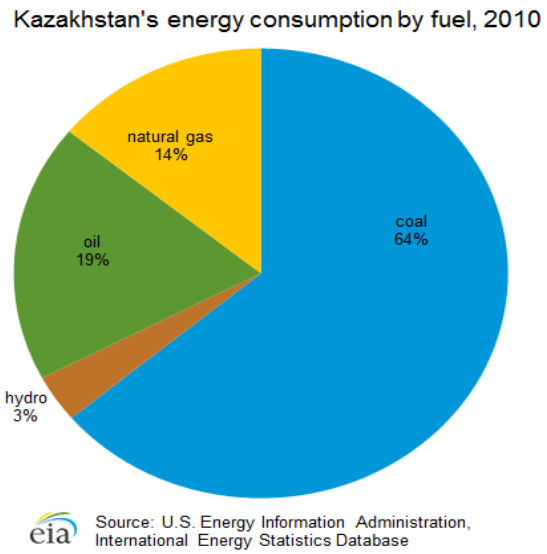
- There is a technical capacity to perform CCS demo projects at existing sites due to a number of potential geological formations in the country that can be used to store captured CO_2 in future.
- There is a political will to develop innovation in energy sector and potential to establish a Regional Centre of Advanced Energy Technologies and Innovation. Oil and gas legislation for promoting clean technologies is adopted.
- Availability and further development of coal-fired power plants;
- Significant number of oil and gas deposits – both continental and offshore ones;
- Possibility of other geological formations for CO2 storage; high level of population education and availability of highly qualified specialists in power.

4. Readiness to introduce CCS

- Carbon capture and storage projects are at an early development stage due to political, economic and mostly financial reasons.
- In Kazakhstan, there is no targeted financing of energy efficiency and renewable energy projects by local financial institutions.
- Lack of independent informational 'hub' for geological research and accumulation of knowledge at national level.
- Current taxation system does not stimulate optimization of the oil sites development and enhanced oil recovery that leads to resistance of companies for paying additional costs for EOR activities in Kazakhstan.
- At present there are no projects for CCS in Kazakhstan.

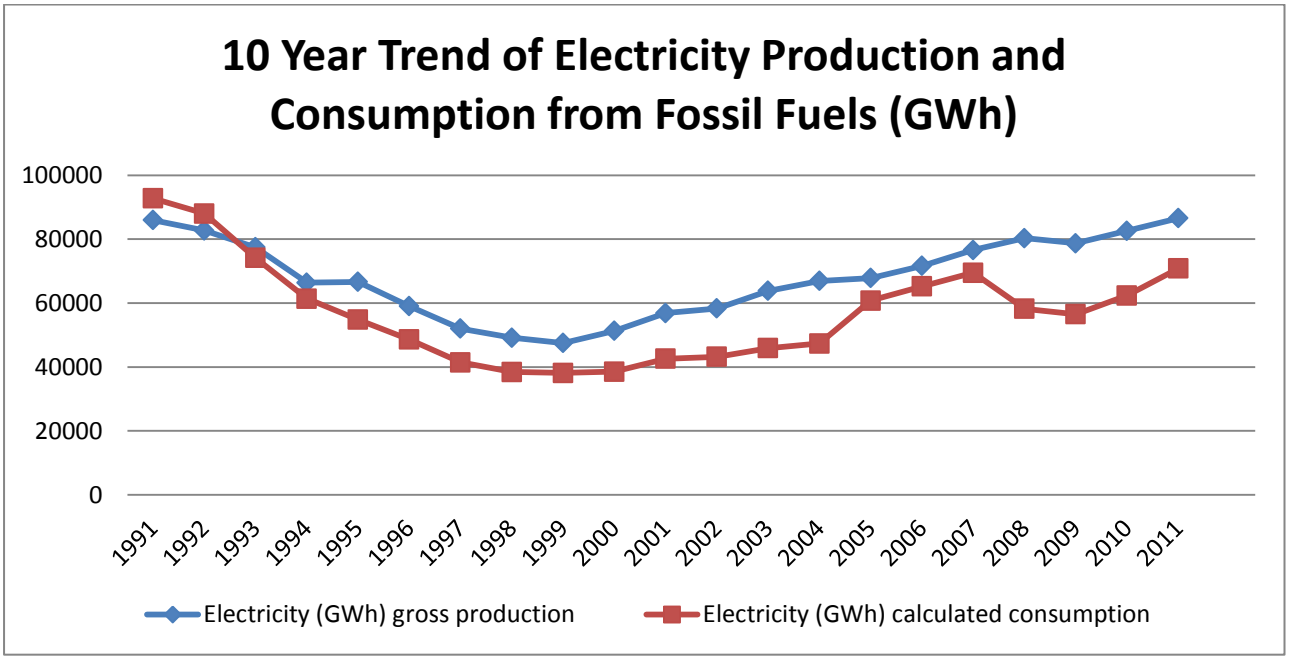
FLOW	2007	2008	2009	2010	2011
CO2 Sectoral Approach (Mt of CO2)	188.02	228.19	199.35	233.7	234.18
CO2 Reference Approach (Mt of CO2)	211.38	222.62	202.06	235.34	247.1
Total primary energy supply (PJ)	2772.94	2930.03	2655.14	3116.78	3269.94
Total primary energy supply (Mtoe)	66.23	69.98	63.42	74.44	78.1
GDP (billion 2005 US dollars)	68.86	71.14	71.99	77.25	83.04
GDP PPP (billion 2005 US dollars)	158.85	164.09	166.06	178.18	191.54
Population (millions)	15.48	15.67	16.09	16.32	16.56
CO2 / TPES (tCO2 per TJ)	67.81	77.88	75.08	74.98	71.62
CO2 / GDP (kgCO2 per 2005 US dollar)	2.73	3.21	2.77	3.03	2.82
CO2 emissions index	79.53	96.52	84.32	98.85	99.05
Population index	94.72	95.88	98.44	99.85	101.29
GDP per population index	144.71	147.67	145.56	153.98	163.18
Energy intensity index - TPES/GDP	65.79	67.3	60.26	65.92	64.34
Carbon intensity index: ESCII - CO2/TPES	88.2	101.3	97.66	97.53	93.15
Total gross production of electricity (GWh)	76598	80327	78710	82646	86586
Elect.output-main activity prod. electricity plants (TWh)	12.72	7.88	6.89	8.02	7.88
CO2 per kWh of electricity (gCO2 per kWh)	682.87	565.76	441.2	408.86	431.03

Source: International Energy Agency. http://wds.iea.org/WDS/ReportFolders/reportFolders.aspx



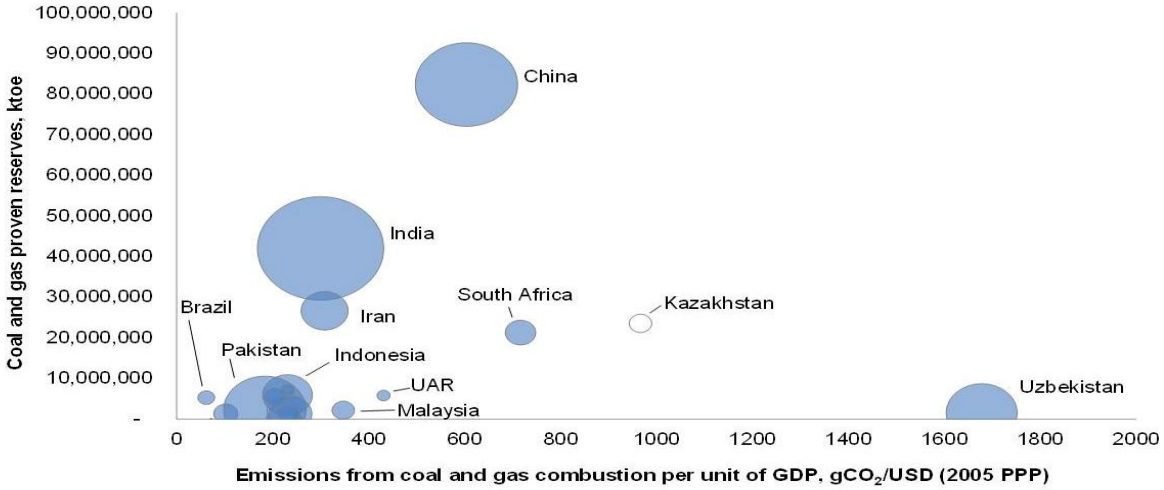
5. Key challenges for CCS deployment

- Lack of climate and sustainability education, awareness raising and communication.
- Lack of funding for RES/clean electricity demo projects. Current regulations do not imply feed-in tariffs or other political incentive for either renewables or innovation technologies. No government loans or grants
- Lack of technologies for CCS
- Lack of networking on CCS with local R&D institutions
- No legally binding agreement obliging to reduce CO2 in a short-medium term.
- Taxation schemes for oil companies are too tight.

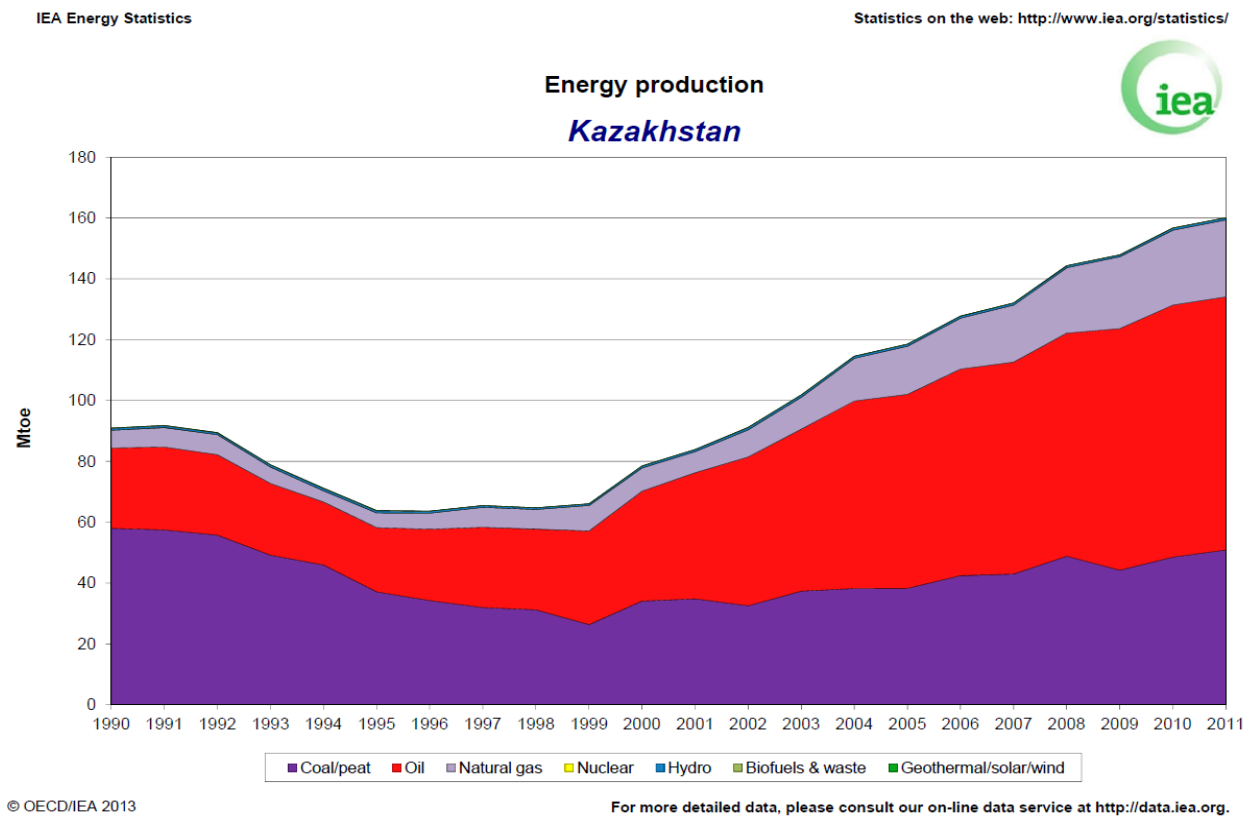


Source: Data for this chart was taken from the International Energy Agency. http://wds.iea.org/WDS/ReportFolders/reportFolders.aspx

Analysis to identify developing countries with greatest strategic interested in CCS deployment



Notes: Only countries with more than 2 quadrillion BTU are included in sample. Size of bubbles proportional to potential climate damages. Kazakhstan is predicted to benefit from climate change, and thus has "a negative size", indicated by shading.
Sources: The International Energy Agency IEA (2010a and 2010b) (imports, exports, domestic consumption of fossil fuel and of total energy); Wheeler (2011) (climate vulnerability). http://www.iea.org/publications/freepublications/publication/policy_strategy_for_ccs.pdf



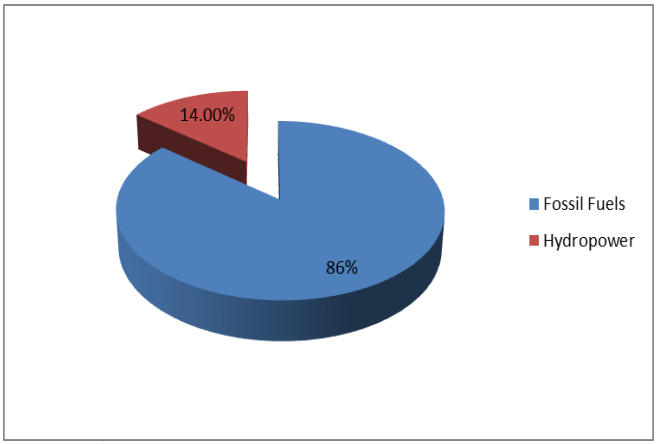
Country Fact Sheet: Kazakhstan

Installed power	
Total installed power, GW	19.1
Fossil fuel-fired plants, GW	16.8
Fossil fuel-fired plants, % of total	88
Annual Electricity Production	
Electricity generated, GWh	90.5
Electricity generated from fuel-fired plants, % of total	80
Energy intensity of the energy sector, TPES/GDP	64.34
Gas-fired electricity generation	
Gas-fired plants, installed power, GW	4.2
Gas-fired plants, % of fossil-fuel fired plants	25
Gas-fired plants, % of total	22
Average age of gas-fired power plants, years	10
Average calorific value of gas used, MJ/kg	38
Coal-fired electricity generation	
Coal-fired plants installed power, GW	12.6
Coal-fired plants, % of fossil-fuel fired plants	75
Coal-fired plants, % of total	66
Average age of coal-fired power plants, years	30
Average calorific value of coal used, MJ/kg	18.828 MJ / kg
Conversion efficiency of coal-fired power plants, %	41
CO2 emissions	
CO2 emissions from fossil fuel combustion, millions of tonnes/year	187
CO_2 emissions from coal, grams CO_2/kWh	488
CO_2 emissions from gas, grams CO_2/kWh	57.4

6. Key Stakeholders in Kazakhstan

Mr. Sergey Katyshev	Adviser to the President of Kegoc Kazakhstan Electricity Grid Operating Company JSC
Mr. Heinrich Wyes	Deputy Director The Regional Environmental Center for Central Asia (CAREC)
Mr. Tolegen Omarbekov	Director Department of New Technologies and Power Supply
Mr. Sungat Esimkhanov	Director Department of Energy and Coal Industry
Mr. Almasadam Satkaliev	Chariman of the Board JSC Samruk-Energy
Mr. Nurlan Mohamed-Rahimov	Chairman of the Management Board Almaty Power Stations JSC

Annex V: A Survey of Carbon Capture and Storage (CCS): landscape and recent developments in Azerbaijan



Fuel used for Azerbaijan electricity generation in 2013
Source: http://www.eia.gov/countries/cab.cfm?fips=AJ

Azerbaijan

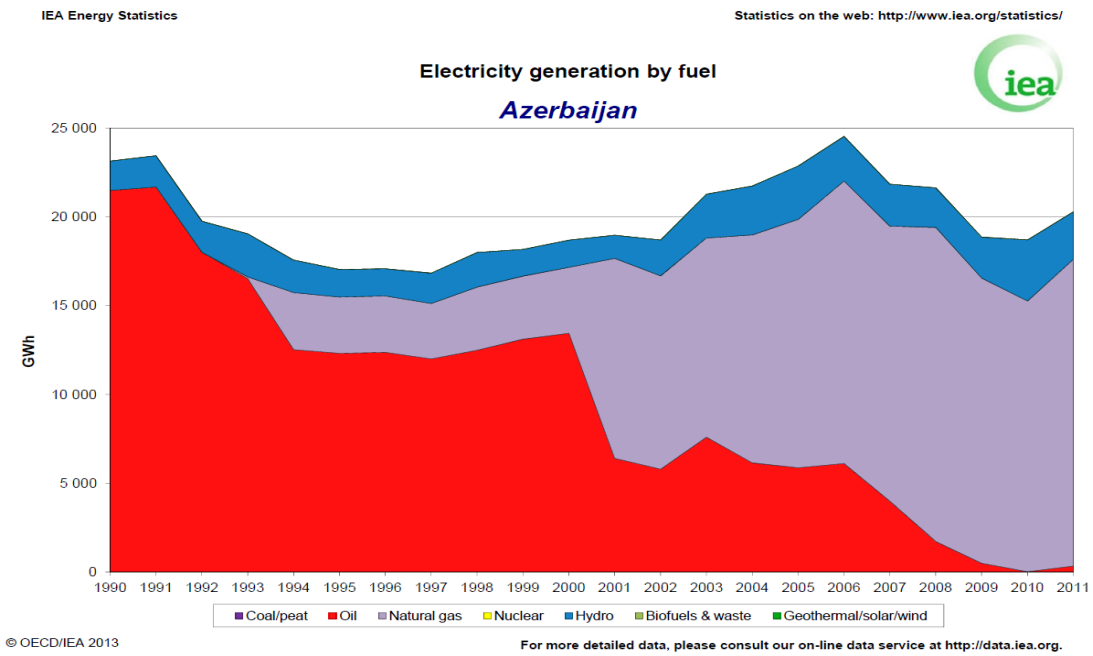
Azerbaijan has total installed electricity generating capacity of approximately 6 GW, but according to some sources, its actual generation capacity is closer to 5 GW because several of the country's largest power plants are old and operating below design capacity. The country's fossil fuel power plants account for around 86% of total power generation. The eight hydropower plants and a small amount of wind capacity account for the remainder of the country's installed generating capacity. A total of 13 fossil fuel power plants operate in Azerbaijan. Azerbaijan's electric power sector is in need of modernization, and there is a considerable effort underway to renovate and modernize the sector.

1. Capacity building for cleaner energy

- Currently the country is lagging behind in laying the groundwork for deployment for CCS one the technology is mature.
- Due to the lack of capacity and legally binding agreement to reduce CO2 emissions in a short term, Azerbaijan is currently at the very low stage of development of it legal framework for sustainable energy and climate issues.
- Ratified the Kyoto Protocol but is not required to undertake quantitative obligations under the Protocol.
- As a non-Annex 1 Party to the Protocol and can participate in the Clean Development Mechanism.
- Climate Change and Ozone Centre was established within the Ministry of Ecology and Natural Resources in view to implement obligations under the Convention and coordination function.

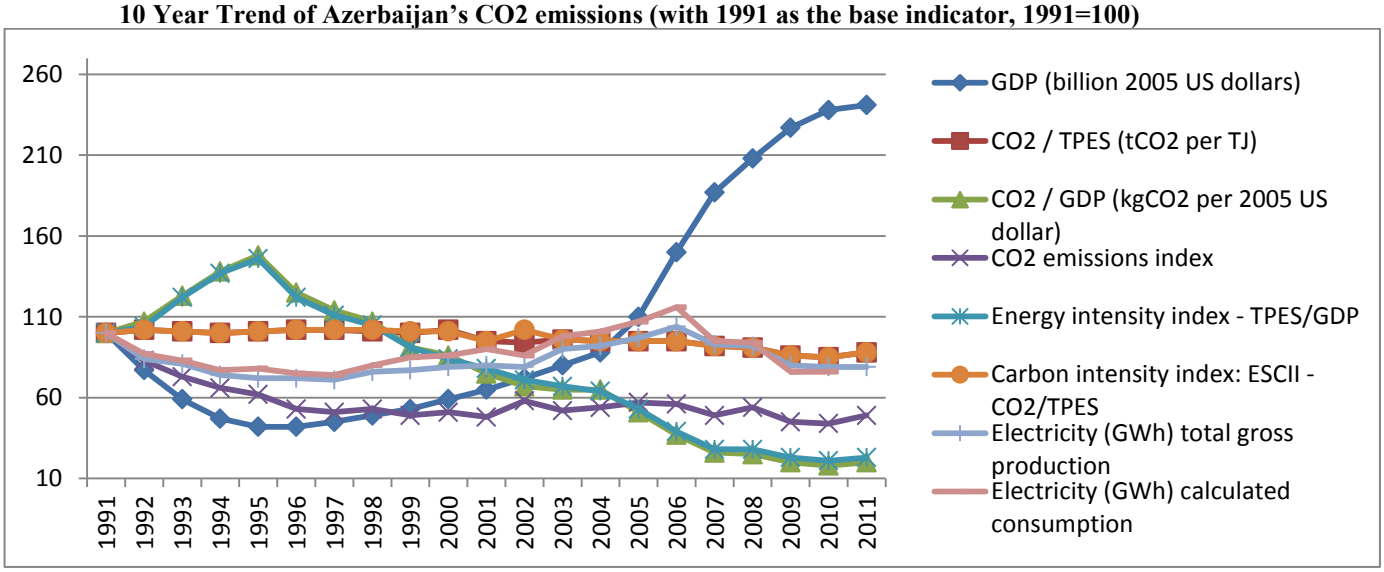
2. Clean energy policies and legislation

- Government does not have specific legislation or regulations regarding CCS.
- 2000,"Initial National Communications of Republic of Azerbaijan" to the Convention
- Clean technologies reducing GHGs were reflected in the second phase of "Initial national Communications of the Republic of Azerbaijan" project
- 2006,"Decree of President of the Republic of Azerbaijan on main directions of socio-economic development (highlights the importance of renewable energy in the energy mix, clean technologies and green practices in general)
- 2004, "National Program on the Use of Renewable Energy Sources in the Republic of Azerbaijan" (Sets targets for use of renewable energy as 20% till 2020. No subsidies or feed-in schemes are in progress.



Source: International Energy Agency. http://www.iea.org/stats/WebGraphs/AZERBAIJAN2.pdf

10 Year Trend of Azerbaijan's CO2 emissions (with 1991 as the base indicator, 1991=100)



Source: Data for this chart was taken from the International Energy Agency. http://wds.iea.org/WDS/ReportFolders/reportFolders.aspx

3. Clean energy technologies and potential

- Azerbaijan has CO2 point sources and potential storage sites that could make CCS feasible.
- Azerbaijan could use depleted oil or gas fields. However, little electricity is generated using coal, so CCS would more likely be applied to natural-gas power plants or industrial processes.
- Potential private sector for CCS technologies deployment in future would be energy companies, using CCS for EOR or for CO2 storage.
- Currently there are no projects for CCS in Azerbaijan.

4. Readiness to introduce CCS

- Some support work for developing capacity for green mechanisms in Azerbaijan has already been done by international organizations:
- EU TACIS Program – the project on technical assistance to South Caucasus states in the field of GHG reduction and design and implementation of two large-scale CDM projects
- INOGATE Program for international cooperation of the EU with Caspian states (funding and technical expertise for renewable energy legislation development, demo projects, first and secondary legislation).
- Regional project is implemented under the assistance of UNDP and GEF.
- Azerbaijan carries on negotiations with Japan, Germany and GHG reduction capacity building.

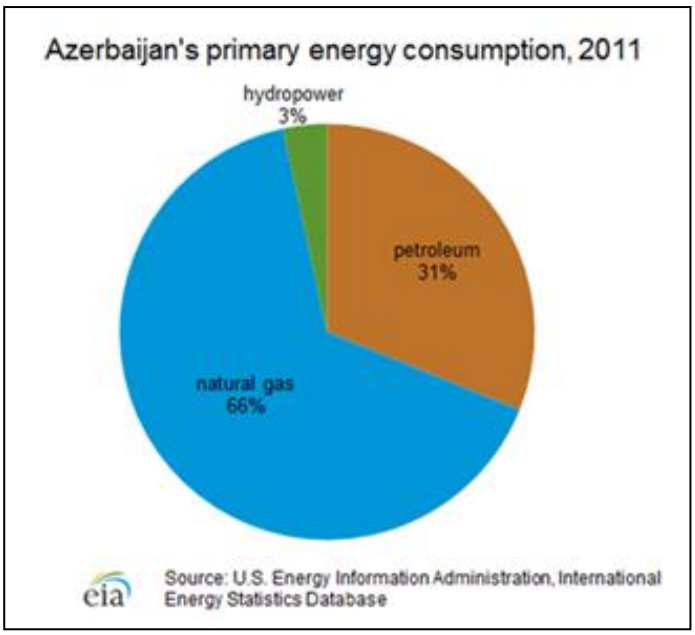
FLOW	2007	2008	2009	2010	2011
CO2 Sectoral Approach (Mt of CO2)	26.85	29.2	24.8	23.82	26.79
CO2 Reference Approach (Mt of CO2)	28.77	30.77	27.48	26.77	29.6
Total primary energy supply (PJ)	507.16	557.78	499.79	485.08	525.9
Total primary energy supply (Mtoe)	12.11	13.32	11.94	11.59	12.56
GDP (billion 2005 US dollars)	22.28	24.68	26.98	28.33	28.61
GDP PPP (billion 2005 US dollars)	63.46	70.31	76.85	80.7	81.5
Population (millions)	8.58	8.76	8.95	9.05	9.17
CO2 / TPES (tCO2 per TJ)	52.95	52.35	49.62	49.11	50.94
CO2 / GDP (kgCO2 per 2005 US dollar)	1.21	1.18	0.92	0.84	0.94
CO2 / GDP PPP (kgCO2 per 2005 US dollar)	0.42	0.42	0.32	0.3	0.33
CO2 / Population (tCO2 per capita)	3.13	3.33	2.77	2.63	2.92
CO2 emissions index	48.82	53.09	45.08	43.31	48.71
Population index	119.86	122.41	124.98	126.47	128.06
GDP per population index	155.57	168.79	180.69	187.48	187
Energy intensity index - TPES/GDP	28.67	28.45	23.33	21.56	23.15
Carbon intensity index: ESCII - CO2/TPES	91.33	90.3	85.58	84.72	87.87
Electricity (GWh) total gross production	24543	21847	21643	18868	18710
Electricity (GWh) calculated consumption	20613	16998	16760	13538	13543

Source: International Energy Agency. http://wds.iea.org/WDS/ReportFolders/reportFolders.aspx

Azerbaijan's power plants

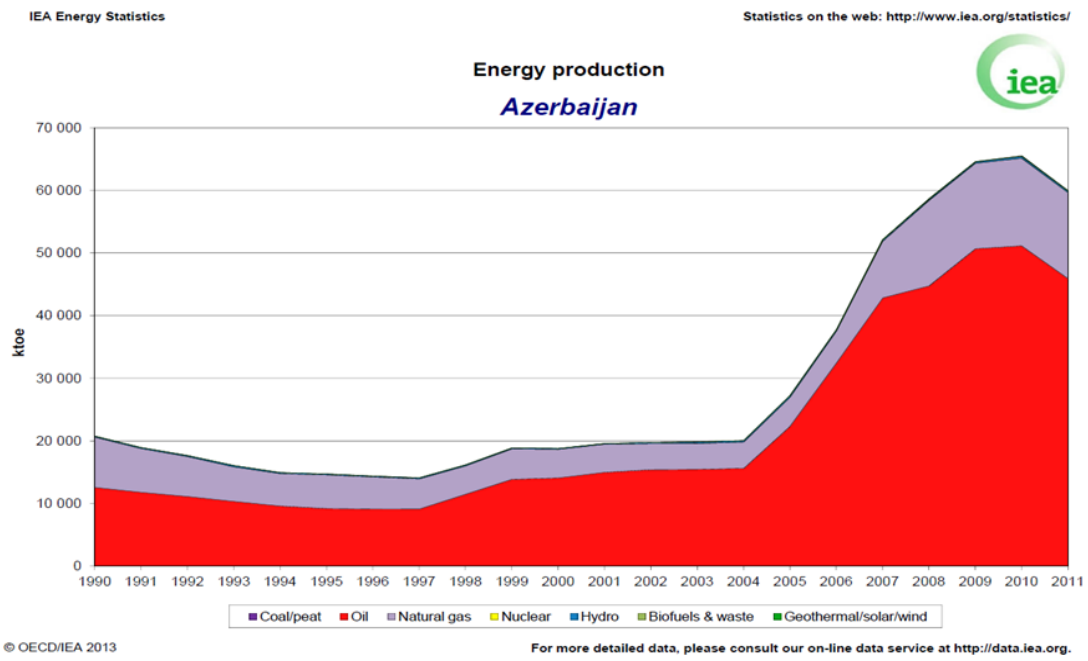
Plant	Installed capacity (MW)	Type
Ali Bayramli	1,050	Oil-fired, steam
Araz	22	Hydro
Astara	87	Gas-fired, turbine
Azerbaijan	2,400	Oil-fired, steam
Baku PP	105	Gas-fired, turbine
Baku TPC	106	Combined heat and power
Bilav	22	Hydro
Khachmaz	87	Gas-fired
Mingachevir	418	Hydro
Nakhchivan GTES	64	Gas-fired
Nakhchivan PP	87	Gas-fired
Sangachal	300	Multi-fuel
Shahdagh	105	Gas-fired
Shaki	87	Gas-fired
Shamkir	380	Hydro
Shimal	400	Gas-fired, combined cycle
Shirvan	900	Gas-fired, combined cycle
Sumgait	525	Gas-fired, combined cycle
Tartar	50	Hydro
Varvara	16	Hydro
Vaykhir	5	Hydro
Yenikend	150	Hydro
TOTAL	**7,366**	

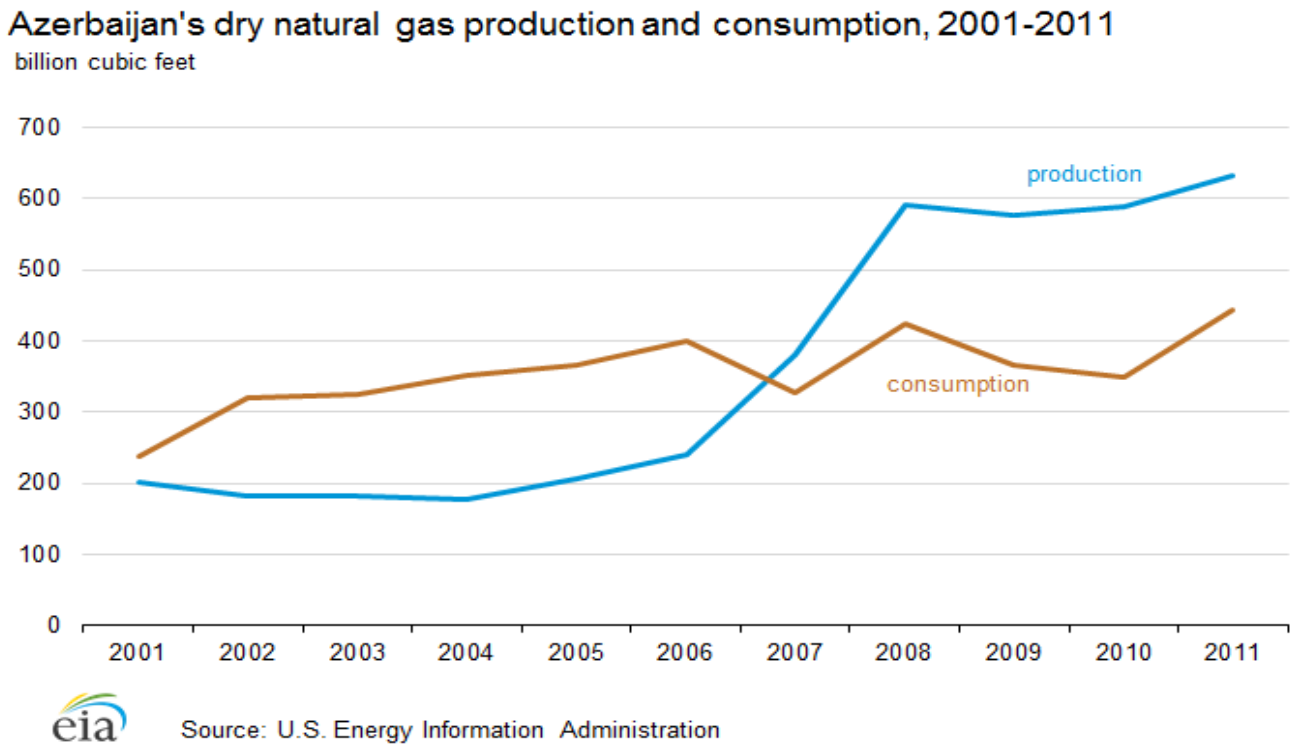
Source: Azerenerji, IHS Global Insight



5. Key challenges for CCS deployment

- No primary and secondary legislation in place for cleaner energy production
- Current socio-economic situation remains highly dependent on crude oil export which remains a substantive challenge.
- Production sharing agreements scheme is not stimulating foreign investors to put money into modernization and application of new technologies for CCS. Neither does legislative framework for energy companies.
- Non-existing technical and expert assistance with climate data verification, methodology, database arrangements and managements
- Lack of public awareness in energy efficiency
- No stimulations of taxation and custom duties for oil and gas companies for the use of renewable energy sources.





Source: U.S. Energy Information Administration. http://www.eia.gov/countries/cab.cfm?fips=AJ

6. Key Stakeholders in Azerbaijan

Mr.	Mutallim	Abdulhasanov	Head of Division	Ministry of Ecology and Natural Resources of Azerbaijan
Ms.	Matanat	Avazova	Deputy Head of Department	Ministry of Ecology and Natural Resources of Azerbaijan
Mr.	Issa	Aliyev	Director	REC Caucasus Azerbaijan Branch office
Mr.	Amin	Mammadov	Ecologist	Amin consulting
Ms.	Khatira	Abbasova	Consultant	Ministry of Industry and Energy of Azerbaijan
Ms.	Leyla	Isayeva	Consultant	Ministry of Industry and Energy of Azerbaijan
Mr.	Makhabbat	Mamedov	Director of State and International Programmes Department	Ministry of Energy and Industry of Azerbaijan
Mr.	Nariman	Rahmanov	Head of Energy Saving Centre	International Ecoenergy Academy
Mr.	Muslim	Imanov	President	Azerenergy JSC
Mr.	Mahmud	Kerimov	Vice-President	International Ecoenergy Academy
Mr.	Tofig	Gahramanov	Vice-President of Strategic Development	SOCAR