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Draft Strategy and Action Plan for the Implementation of Multi-national Programmes on Clean Fossil Energy

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CO	Confidential, only for members of the consortium (including the Commission Services)	

Executive Summary

The purpose of this report is to develop a draft strategy and action plan for the implementation of multi-national programmes on clean fossil energy. It has done this by:

a. Defining the areas where action is needed to deploy fossil ETP-ZEP technologies and types of activity needed (eg. R&D, pilot plant, full-scale demonstration) in each of these action areas.
b. Defining the time line required for taking forward these activities with the aim of having ZEPs available for general deployment from about 2020.
c. Identifying the combination of action areas and activities where transnational cooperation through joint programmes will be most beneficial and cost effective.
d. Identifying key actions needed to establish a durable system for agreeing and implementing joint actions.

The report also gives a set of recommendations for finalizing the strategy and action plan.

Recommendation 1 - The strategic interim proposals should be tested in a workshop drawing in a wider representation of EU Member State funding agencies.

The success of a joint programme of activities on ZEPs depends on the support of the organizations from business and the research community. In particular these organizations need to support the strategic focus proposed herein.

Recommendation 2 – The strategic interim proposals should be tested in a workshop involving industry and research community stakeholders.

For both workshops the NFAs are to take the initiative. If applicable, the FENCO-ERA Management Board will support organization and management of the workshops on behalf of the NFAs.

The action plan sets out 10 actions that are needed to establish a durable framework for implementing multi-national programmes. This plan focuses on systems needed to deliver annual calls for proposals based on the view on priorities held by individual Member States. In other words the plan for joint actions is driven by a sharing of national visions for future development rather than single integrated vision developed. The timescale envisaged to deliver these actions is in the order of 1-2 years.

Recommendation 3 – The FENCO-ERA Management Board should check that the actions listed will be delivered in order to finalise the strategy and action plan (see D 4.1.1).

It is vital to establish a durable system to deliver joint actions after the current FENCO-ERA initiative is completed. The action plan envisages this being achieved by an informal process in which the organizational burden is taken in turns by NFAs. The NFAs should decide whether to follow this informal process or some other.

Recommendation 4 – Further discussion is needed between NFAs and the Ministries sponsoring work on ZEPs to determine whether they are willing to make a more firm commitment to a system for establishing joint actions. For example a commitment to participate for 3-5 years with further activity subject to review (see D 4.4.1 and D 5.4.2).

Recommendations 3 and 4 are strongly linked and again the NFAs are to take the initiative. In case that the NFAs agree to further support the FENCO-ERA Management Board will attend these activities on behalf of the NFAs.

Content

1. Introduction

Zero emission fossil energy technologies are a group of devices and processes that can considerably reduce (>90%) or even totally eliminate the emissions associated with fossil fuel combustion. Foremost amongst these is carbon capture and storage (CCS), in which the carbon dioxide (CO_2) produced during fossil fuel combustion is first separated and then committed to geological storage. CCS is currently the subject of considerable worldwide interest because it opens up the option of continuing to use fossil fuels while considerably reducing energy related CO_2 emissions, one of the main causes of the increase in atmospheric greenhouse gas concentrations.

Zero emission fossil technologies are most suited for application to large combustion or process plant that offer appreciable economies of scale. This is particularly true for CCS, which in addition to the CO_2 capture process, requires a transport infrastructure to move millions of tonnes per year of CO_2 to suitable geological stores. Consequently most attention has focused on the development of Zero Emission Fossil Fuel Power Plants (ZEPs) since power stations represent a high proportion of large combustion plants, and they are particularly suited for the development of standardised technologies and designs. The European Technology Platform for Zero Emission Fossil Fuel Power Plants (ETP-ZEP)[1] has drawn together stakeholder groups to formulate and propose integrated strategies for the research and development, full-scale demonstration and deployment of ZEPs including CCS. Also the European Council and Parliament have made provision to financially assist up to 12 large-scale CCS demonstration projects from 2013 through the New Entrant Reserve of the EU Emission Trading Scheme[2].

These initiatives show the EU's determination to drive forward the development of ZEPs, including CCS, and give a unique opportunity for EU business stakeholders to become global leaders in the provision of ETP-ZEP equipment and services. However, large scale demonstration of CCS needs to be considered as part of an integrated strategy for ZEPs that also aims to improve the technologies both technically and commercially through a parallel programme of research and development. Here the picture is less encouraging with considerable fragmentation between EU and Member State efforts. Several Member States support R&D related to ZEPs, and the European Commission's Framework Programmes continues to encourage collaborative projects amongst Member State organisations. However, much of this activity is driven by national or regional strategies, or by the priorities of a limited group

[1] http://www.zero-emissionplatform.eu/website/
[2] http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML%2BTA%2B20081217%2BSIT%2BDOC%2BWORD%2BV0//EN&language=EN

of business stakeholders, with little opportunity to gain synergistic benefits through broader collaboration and coordination.

The Fossil Energy Coalition Energy Research Area Network (FENCO-ERA NET) was established as a Coordinated Action under the EU's ERA-NET initiative with the objective of establishing a durable network for the development and promotion of ZEPs across Europe. FENCO-ERA is composed of the national funding agencies (NFAs) charged with managing Member State programmes for the development of fossil energy technologies, and therefore can have a strong influence in delivering greater cooperation between national programmes.

In this document the FENCO-ERA team present a draft strategy and action plan for enhancing cooperation between Member State programmes and for engaging the broad range of stakeholders needed to deliver ETP-ZEP technologies. The document takes account of the European Commission's views expressed in its Strategic Energy Technology Plant (SET) as well as the views of the ETP-ZEP. It is intended that this document will form the basis for a series of consultation workshops with stakeholders drawn from government, business and the research community within the next one to two years, to consider how Member States could formulate and organise their programmes to encourage and support wider cooperation and the establishment of joint actions.

2. Scope of the strategy and action plan

The scope of the strategy and action plan needs to be sufficiently broad to encompass all the elements needed to achieve the successful delivery of fossil fuel ZEPs. Generally Member State programmes directed at ZEPs have evolved from earlier programmes aimed at the development of cleaner fossil fuel technologies. As a consequence they tend to encompass a wide range of devices and enabling technologies that are mainly concerned with power generation plant, and may be grouped under four broad categories:

- **Efficiency improvement** – developments that improve the combustion and conversion efficiency of fossil fuel plant, thereby reducing the amount of fuel burned and emissions associated with the production of a given quantity of electricity.
- **Emission reduction** – processes aimed directly at reducing the emissions of atmospheric pollutants (eg. sulphur and nitrogen oxides, particulates and heavy metals) associated with fossil fuel combustion.
- **Reduced carbon intensity** – co-firing with nominally carbon neutral biomass can reduce the CO_2 emissions from fossil fuel plant, but the affect of their combustion products on advanced boiler systems requires further investigation.

- **Carbon dioxide capture and storage** – CCS is the key to achieving truly zero emission fossil fuel plant, and is the most challenging development because it requires the establishment and linked operation of a novel chain of devices covering capture, transport and storage.

While all four of the above categories are important and can make a useful contribution to reducing the emissions of fossil fuel plant, it needs to be recognised that only CCS gives the radical step change essential for delivering true ZEPs. The other three categories listed above give evolutionary improvements that contribute towards CCS and ZEPs and therefore can be regarded as a subset of CCS. For example efficiency improvements yield two-fold benefits. Firstly it reduces generating cost by lowering fuel demand. Secondly, it reduces environmental burden due to reduced coal input.. Biomass co-firing would be needed to enable a CCS plant to achieve 100% CO_2 abatement by using carbon neutral fuel to offset the ~10% of CO_2 still released from current CO_2 capture equipment.

Accordingly this strategy takes the development and deployment of CCS as its central objective, while recognising that the other categories listed above remain important, with efficiency improvement being the most important.

This focus on CCS brings in the transport and storage of CO_2, which introduces new developments that go well beyond traditional cleaner fossil fuels. The ETP-ZEP has specified five areas requiring action, namely[3]:

- Advanced fossil plant and CO_2 capture
- CO_2 use and storage
- Infrastructure and environment
- Market and regulatory policy
- Communication and public acceptance.

These groupings recognise that CCS is not simply a new fossil power generation technology, but that it introduces new challenges including transnational networks, safety, regulation and public acceptance, all of which require new knowledge and know-how if they are to be addressed successfully. This strategy and action plan, with two modifications, uses the same areas for action to facilitate continuity and shared dialogue between FENCO-ERA and the ETP-ZEP. One exception is that the first action area has been separated into two (a) Advanced fossil plant and (b) CO_2 capture. This has been done to simplify consideration of State Aid regulations (see below). The second exception is to include safety as part of the “Infrastructure and environment”

[3] Strategic Research Agenda, The European Technology Platform for Zero Emission Fossil Fuel Power Plants, September 2007. (http://www.zero-emissionplatform.eu/website/library/index.html)

activity area, which is also assumed to include transport related issues. Therefore FENCO-ERA has considered six areas for action:

1. Advanced fossil plant
2. CO_2 capture
3. CO_2 use and storage
4. Infrastructure, environment and safety
5. Market and regulatory policy
6. Communication and public acceptance.

The acquisition of the knowledge and know-how referred to above will require action at a number of levels:

a) R&D in support of first large/full-scale deployment,
b) Pilot trials on new/alternative technologies
c) Large/full-scale demonstration
d) Longer term R&D for more advanced systems

These activities mainly concentrate on technical work but additionally comprise economic, legal and social studies. Essentially a matrix of areas for action can be envisaged as illustrated in Table 1. This recognises that research and development will not stop with the attainment of the first phase of large/full-scale deployment, but that there will be a need to improve the technology for second and third generation plant (Action d). For example technical advances are needed to reduce the energy used for CO_2 capture, and to reduce manufacturing and operating costs. Similarly it will be beneficial to improve long term monitoring and modelling techniques for CO_2 stores to enhance confidence in their integrity or give early warning of any potential problems.

This strategy and action plan is concerned with identifying the areas within this matrix in which enhanced cooperation and collaboration between Member State programmes will deliver most added value and benefit. It also considers how such collaboration may be implemented most effectively within the constraints placed on national programmes.

Table 1 Matrix of areas for action needing to covered for the development of fossil ZEPs

Action Area / Activity	Advanced fossil plants	CO_2 Capture	CO_2 use and storage	Infrastructure, Environment and Safety(1)	Market Regulation and Policy	Communication and Public acceptance
R&D to support full-scale deployment						
Pilot plant trials to support scale-up						
Full-scale demonstration						
R&D in support of second and third generation systems						

1. Includes CO_2 transport.

3. Timeline of the strategy and action plan

In developing a strategy and action plan for ZEPs a key question is when will these technologies be needed for commercial deployment and therefore over what timeframe do the research, development and demonstration activities need to be delivered? The answer to this question differs depending on the action areas defined in Section 2. Specifically Action Area 1 – Advanced Fossil Plants differs from the other action areas (2 to 6), which are mainly concerned with CCS.

3.1. Advanced fossil plant

It is arguable that there is already a "market pull" to encourage innovation and development of advanced fossil plants. The choice between coal fired steam cycle power plant based on supercritical and advanced supercritical technology will be made by balancing the additional capital cost of advanced supercritical against the lifetime fuel cost savings that the greater fuel efficiency offers compared to more basic supercritical technology. Increasingly stringent environmental regulations are already driving the development of better and cleaner combustion systems.

The justification for the provision of EU and Member State support for advanced fossil fuel plant is "knowledge leakage" since the rules regarding IPR are not clearly defined in this area. In other words the equipment suppliers who would be expected to finance the development of advanced fossil plant may be deterred from such investments because the knowledge gained will "leak" away to competitor organisations. This is the established justification for EU and Member State funding of research and development, and pilot plant trials of advanced fossil fuel technologies. However, this does not justify similar support for large/full-scale demonstration projects because at this stage equipment suppliers have other options open to them to protect their intellectual property (e.g. patents).

This line of reasoning shows public support for advanced fossil plant should be confined to research, development and pilot scale testing, and that this is an on-going process without any specific deadlines other than those set by commercial and environmental considerations.

3.2. CCS related action areas

Unlike advanced fossil plant the other action areas are mainly concerned with CCS, which is a set of technologies that are designed exclusively to deliver carbon abatement from fossil fuelled combustion plant. Therefore the drivers that will determine the timing for CCS deployment are the policy measures at EU and Member State levels aimed at carbon abatement rather than existing "market pull". The main such policy measure is the EU's Emission Trading Scheme (ETS), and the European Parliament and the Council have recently agreed changes that will permit plants fitted with CCS to participate in the

scheme[4,5,6]. However, this measure alone is unlikely to facilitate commercial deployment of CCS before 2020 and possibly much later. There are two reasons for this, firstly the EU's target to reduce carbon emissions by 20% by 2020 is not expected to generate an ETS allowance price sufficient to make CCS commercially viable, and secondly because early CCS plant are likely to attract a risk premium making the technology even less cost competitive. To illustrate, it has been estimated that the ETS allowance price in 2020 will be between €35-47/tCO_2 depending on assumptions for fossil fuel prices and the impact of the EU's renewable energy targets[7]. In comparison the cost of early CCS demonstration projects has been estimated to be €60-90/tCO_2 abated[8]. Later CCS plants are projected to attain abatement costs more comparable to the ETS allowance price, but these costs will only be attained after the experience of the large scale demonstrations.

Early deployment of CCS will cost more than later plants because it involves a number of technical, commercial and regulatory uncertainties that represent appreciable additional risks to potential investors. Important examples are:

Scale-up – While it is generally agreed that the combination of technologies and processes needed for the first implementation of CCS are all at a mature stage of development, there is a need to scale up some processes to power station size (eg amine scrubbers for post combustion capture of CO_2).

Operational reliability – CCS technologies have not been operated at full-scale on a power station, so there is greater uncertainty over their reliability compared to conventional generation plant. For the same reason equipment suppliers will be reluctant to give the same guarantees that come with conventional plant.

Planning uncertainty – Although a regulatory framework has now been fixed for CCS at the EU level there is still uncertainty over how this will be implemented with specific projects, and public acceptance of CCS is uncertain given the current low awareness of the technology. Further there is currently widespread public concern regarding any new coal fired power plant.

[4] Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emissions allowance trading system of the Community, COM(2008)16, January 2008.
[5] http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML%2BTA%2B20081217%2BSIT%2BDOC%2BWORD%2BV0//EN&language=EN
[6] http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML%2BTA%2B20081217%2BSIT%2BDOC%2BWORD%2BV0//EN&language=EN
[7] Model based analysis of the 2008 EU policy package on climate change and renewables, P. Capros, L. Mantzos, V Papandreous and N. Tasios, PRIMES Model, NTUA, Athens, June 2008.
[8] Carbon capture and storage: assessing the economics, McKinsey and Company, September 2008, (http://www.mckinsey.com/clientservice/ccsi/pdf/CCS_Assessing_the_Economics.pdf)

Long term ETS allowance prices – There is uncertainty over the development of the ETS beyond 2020. This makes it unattractive to invest in CCS plants that will need a stable and buoyant carbon market going well beyond 2020 to ensure a reasonable payback on the capital deployed.

It could be argued that the ETS carbon price will increase after 2020 to make CCS more commercially attractive, but this is uncertain because the EU's target for carbon abatement beyond 2020 is yet to be agreed. Moreover, even with a more ambitious abatement target after 2020, the ETS price could be depressed by other policy decisions (e.g. the inclusion of more Clean Development Mechanism (CDM) credits). Nonetheless there is a growing consensus that fossil ZEPs have a major role to play in achieving the reductions in greenhouse gas emissions needed to limit climate change to tolerable levels. For example a range of modelling studies both at national and global levels have shown that CCS needs to be deployed in addition to energy efficiency and renewable energy technologies from 2020-25 in order to follow an abatement trajectory that reduces CO_2 emissions to 60% of 2000 levels by 2050[9],[10],[11].

Consequently there are two market failures that justify the provision of EU and Member State support for CCS related development work. Firstly "knowledge leakage" as for advanced fossil fuel plant, but more significantly the difficulty of the carbon market being able to provide a reliable signal to encourage the development of CCS at full-scale. This justifies intervention to support full-scale demonstration in addition to research, development and pilot plant trials. This was recognised by the European Commission in its communication on sustainable power generation from fossil fuels which proposed that all new fossil power generation should from 2020 be required to have CCS fitted[12]. More recently the European Parliament and the Council have agreed on a package of measures to facilitate the deployment of CCS, which includes financial support for up to 12 large/full-scale demonstration projects through the New Entrant Reserve of the ETS Phase III[13].

So the current position is one in which the need for ZEPs is being increasingly recognised and the EU has taken the first steps for provide financial support for large demonstration projects. Also this EU support can be supplemented by support from Member States, so a framework is emerging for joint action and

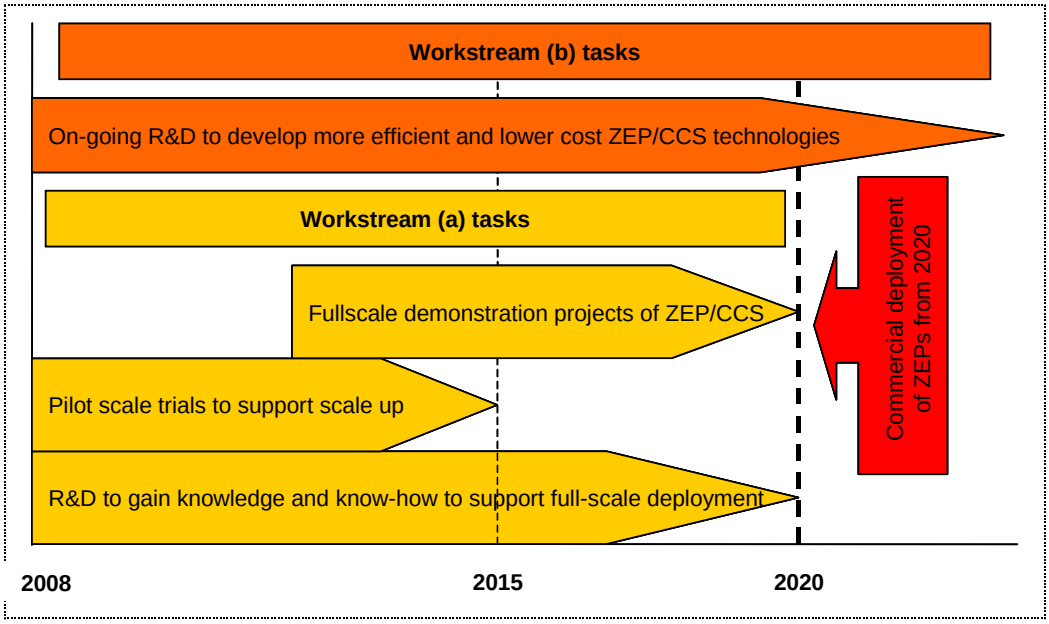
[9] Scenarios and Sensitivities for long term UK carbon reductions using the UK MARKAL and MARKAL-MACRO energy systems models, UKERC Report RR/ESM/2008/002. February 2008 (http://www.ukerc.ac.uk/Downloads/PDF/S/Scenariosreport.pdf).
[10] Ref IEA Energy Technology Perspectives
[11] IPCC Special Report on Carbon Dioxide Capture and Storage, IPCC Working Group 3, 2005
[12] Communication from the Commission to the Council and European Parliament – Sustainable power generation from fossil fuels: aiming for near-zero emission from coal after 2020, COM(2006)1723.
[13] http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML%2BTA%2B20081217%2BSIT%2BDOC%2BWORD%2BV0//EN&language=EN

collaboration across the EU for large/full-scale demonstration activities. However, this leaves an on-going requirement for innovation covering two types of activity:

a. Firstly R&D and pilot demonstration work needed in order to provide the knowledge and know-how to support the deployment of ZEPs both at the demonstration and early commercial levels.
b. Secondly to undertake longer term R&D to develop more efficient, less expensive and more flexible second and third generation ZEPs, and to enhance capabilities for long term monitoring and modelling of CO_2 stores.

These two work streams have different timelines. Workstream (a) should be geared to supporting wider deployment of ZEPs from about 2020 and therefore needs to be compressed into the 2008-2020 period. In contrast Workstream (b) is concerned with longer term development and will be a continuing process extending beyond 2020. These timelines are illustrated in Figure 1.

Figure 1 Illustrative timeline for the two innovation workstreams needed to support the implementation of ZEP technologies



The FENCO-ERA strategy and action plan needs to consider both of the above workstreams with their different timelines. However, with the growing concern to move to large/full-scale demonstration of CCS by 2014[14], with the aim of advancing to first commercial deployment by about 2020 the shorter term work streams needed to support such deployment are likely to demand priority.

[14] http://www.berr.gov.uk/energy/sources/sustainable/ccs/ccs-demo/page40961.html

4. Status of Member State Programmes

Another important input to the development of a strategy and action plan for cooperation and collaboration between Member State programmes is the current status and objectives of these programmes. As mentioned above most Member State programmes on ZEPs have evolved from earlier programmes on cleaner fossil fuel technology, with increasing priority being given to CCS.

Information on Member State ZEP programmes and initiatives have been gathered from FENCO-ERA participants, through the questionnaire process undertaken by Work Package 2, which was designed to gain insights on the rationale and objectives for their national programmes. The information has been grouped under the six activities identified in Section 2, namely:

i. Advanced fossil plant
ii. CO_2 capture
iii. CO_2 use and storage
iv. Infrastructure, environment and safety
v. Market regulation and policy
vi. Communication and public acceptance.

The questionnaire has also shown that work on fossil fuel ZEP technologies varies in scope and significance between Member States. This probably reflects a range of national factors such as the relative importance of fossil fuels within different national contexts, differing levels of national resources for advancing the technologies and the role perceived for fossil fuel ZEP technologies within national climate change strategies. The questionnaires have shown that Member State's activities can be placed into one of four categories representing increasing levels of commitment to the development of ZEPs:

- **Watching brief –** mainly concerned with maintaining awareness of developments and establishing a knowledge base to make more informed judgments of the ZEP technologies. This may be combined with some basic research to hold open the option of becoming more actively involved with the development of the technology at a later date. Generally programmes of this type are not stand alone, but are one theme within much broader cross cutting programmes on science and technology or industrial innovation.
- **R&D –** actively supporting R&D on ZEP technologies with the objective of being an "informed buyer", "informed regulator" and to build up national expertise and capacity. This level of activity may be linked to possibly moving to larger pilot or demonstration projects at a later stage. Generally programmes of this type are stand alone in nature with separate budgets and defined timescales and objectives.
- **R&D and pilot demonstration –** this activity includes R&D but with a larger budget to support pilot demonstration projects covering either the

full CCS chain or key components (e.g. Germany's oxy-fuel 30MW prototype capture plant and the Berlin CO_2-Store project).

- **R&D, pilot and full-scale demonstration** – this activity goes one step further with support for R&D, pilot demonstration and one or more full-scale demonstrations of CCS. Because of the high cost of a full-scale CCS demonstration the support for such projects tends to be provided by special measures lying outside of national innovation programmes. Norway and the UK are the only countries to have committed to supporting full-scale demonstrations, but others have indicated that it is under consideration (e.g. Germany).

Member State's and their programmes are grouped according to this classification in Table 2.

The table shows that, of the Member States covered by the FENCO-ERA questionnaire, Austria, Portugal, Poland and Latvia currently have only small activities concerned with zero emission fossil fuel and CCS (i.e. watching brief). However, some, notably Austria, have a growing interest in the subject, which could lead to an extended R&D programme in the future. Other Member States including Germany, Denmark, The Netherlands, Spain and the UK have significant R&D programmes that extend to include support for pilot plant scale demonstration activities. As member of this group Germany's present position (of BMWi) is not to support a full-scale demonstration of CCS, but the future position may be different depending on further agreements between BMWi and BMU. At present only Norway and the UK have formally declared support for such a project

The table shows some clustering of interest in the development of CO_2 capture technology and in the assessment and monitoring of CO_2 storage options. There is a developing activity on assessing the infrastructure implications and potential environmental impacts of CCS, and on market regulation and public acceptance. This includes work on the safety aspects of handling and transporting large quantities of supercritical CO_2 in populated areas, and the long term integrity of CO_2 stores. It will be noted that there is no Member State funding of full-scale demonstration of advanced fossil plant. This is consistent with the discussion in Section 3.1, which concluded that such activities were incentivised by market drivers and should be left to equipment suppliers and plant operators. Table 2 also makes reference to 'Communication and public acceptance' activity within member states. A summary of recent work in this area is presented in Annex 2.

Most Member States are taking a holistic view of CCS and are aiming to be involved in all six areas for development action covered in Table 2.

Table 2 Summary of Member State interests and subjects being considered for action on zero emission fossil fuel technology

Activity	Advanced fossil plants	CO_2 Capture	CO_2 use and storage	Infrastructure, Environment and Safety(1)	Market Regulation and Policy	Communication and Public acceptance
Watching brief	AT, PT, LV, PO	PT, LV, PO	LV, PT, PO	AT, EL	AT, EL	AT, PT
R&D	DE, EL, ES, UK	AT, ES, EL, FR, DK, NL, NO, DE, UK	A, EL, ES, FR, NO, NL, DE, UK	DE. DK, FR, NO, NL, UK	DE, DK, FR, NL, NO, UK	FR, NL, UK, NO, DE
R&D and pilot plant demonstration	DE, ES, UK	ES, FR, DK, NL, NO, DE, UK	ES, FR, NO, NL, DE, UK	?	N/A	?
R&D, pilot and full-scale demonstration	N/A	NO, UK	NO, NL?, DE( ), UK	N/A	N/A	?

1 Includes CO_2 transport.
( ): activities outside the programme
N/A Not applicable, it is unlikely that demonstration projects will be needed advance these areas, although they may benefit from demonstration projects aimed at the other development areas (e.g. CO_2 capture).
? Indicates some uncertainty over the need for support.

5. Rationale for joint programmes

Collaboration and cooperation between countries on research, development and demonstration to overcome fragmentation should not be regarded as an end in itself. Joint programmes are only justified if they deliver additional benefits over and above separate national programmes, and the value of these benefits exceeds the additional costs of operating a joint programme. The benefits of joint programmes may be wide ranging, and occasionally unique to the subject involved, but some of the main benefits include:

a. **Assembling the necessary skills** - In subjects covering a wide range of disciplines, and consequently requiring a substantial team of specialists, it may not be possible to assemble a complete team in one country.
b. **Achieving a critical sized programme** – National resources may not be sufficient to support all the work needed to be done within a limited timeframe.
c. **Accelerating progress** – Similar to (b) above except this is concerned with the required pace of development. Cooperation between rival teams may induce a desire to drive work forward more quickly.
d. **Tackling trans-national issues** – Some issues that need to be resolved using the knowledge and know-how coming from R&D and demonstration are likely to require agreement at an international level (e.g. regulation, monitoring and verification, safety standards). In such cases there are advantages if the knowledge base is assembled through collaborative work engaging the parties concerned.

Programme options that capture these benefits could merit consideration for some form of joint action. However, determination of the nature of this action must also consider the costs involved. Experience from FENCO-ERA's pilot joint call shows that the cost to the national agencies of organizing and administering such an exercise is of the order of 100k€. Therefore a full formal joint call procedure would only be justified for programmes exceeding about 1M€ (i.e. administrative costs should not exceed 10% of the programme budget). For smaller actions the cost of running a full joint call cannot be justified, and a more informal network for cooperation and information exchange would seem to be a more cost effective approach.

6. A strategic focus for joint actions

Previous sections of this report have defined:

i. The general scope of work needed to develop and deploy fossil ZEPs.
ii. The timelines for this work.
iii. Criteria for assessing where transnational joint actions will be most beneficial.

This section applies this information to set out the strategic focus for transnational joint actions.

Joint actions will be supported with Member State funds that generally are derived from taxation or possibly some form of levy on the consumer. As discussed in Section 3, the use of such funding is normally targeted to address some form of "market failure", since otherwise there would be no justification for government intervention. This same requirement also arises through the EU's State Aid regulations that again seek to prevent interventions in normal market mechanisms except where a market failure can be identified. Consequently before identifying priority topic areas for joint action it is essential to consider how this choice may be affected by national and EU State Aid requirements.

Government support for R&D is normally justified on the basis that the work is pre-competitive and that commercial organizations are deterred from investing in such work because it is not possible for them to capture the full benefit of their investment (i.e. a market failure). For example, much of the knowledge gained from R&D "leaks" from the organization funding the work either through the publication of technical reports or the loss of staff to competitor organizations. Of course companies can take measures to protect the intellectual property rights (IPR) they gain from R&D directed at the specific development of products and devices. However, this only applies to R&D close to commercial exploitation (near market), which would not qualify for national or EU level support.

Government support for pilot and full-scale demonstration projects is more difficult to justify because clearly this is aimed at a specific product or device and therefore could constitute a market intervention. In the case of ZEPs however, this can be justified because of another market failure, in this case the failure of the market to deliver an adequate financial reward for the CO_2 abated. However, invoking this market failure means that governments should only provide financial support for the parts of the pilot or demonstration plant that are concerned with CO_2 capture and storage. Demonstrations of technologies that improved conversion efficiency or advance biomass co-firing would not be justified because these are not subject to the same market failure. Of course this does not mean that, for example, a full-scale demonstration of a fossil ETP-ZEP involving advanced conversion and co-firing could not gain government support. However, this support would need to be confined to the CO_2 capture elements of the project, with the commercial stakeholders carrying the full cost of any aspects of the project that would gain market rewards (eg reduced fuel costs through higher conversion efficiency), and therefore are not subject to a market failure.

Drawing these considerations together a set of criteria can be specified for choosing action areas for developing and implementing ZEPs that would merit and benefit from trans-national joint programmes. These are:

A. Need for larger or wider effort
B. Need for a larger team with a wider range of expertise.
C. Need to accelerate progress
D. Addresses a transnational issue
E. Can be set up cost effectively
F. Conforms with national and EU State Aid requirements.

A preliminary assessment of the matrix of action areas and types of development activity described in Section 2 (Table 1) has been made using the above criteria. This is shown in Table 3 in which the symbols A, B, etc are included to show that a particular action area/activity combination is judged to meet that particular criterion for a transnational initiative. Action areas that are judged not to conform with State Aid regulations have been exclude.

This preliminary assessment shows that near term R&D activities in all action areas would benefit from multi-national programmes. Action areas for which programmes should extend beyond R&D to pilot and fullscale demonstration are "CO_2 capture" and "CO_2 use and storage". "Infrastructure environment and safety" could also benefit from pilot scale projects, and full-scale demonstration could be justified but is unlikely to be needed in practice.

R&D work on "Market and Regulatory Policy" and "Communication and Public Acceptance" are also priority areas for transnational actions, but it is likely that programmes will be relatively small (i.e. less that 1M€) and therefore it would not be cost effective to set up a formal process for joint calls and programmes. Instead, these activity/action area combinations could be covered through more informal networks and cooperation systems.

Longer term transnational collaborative R&D is also justified principally to improve the performance and reduce the cost of CCS for second and third generation ZEPs. These actions should cover R&D on Advanced Fossil Plant, CO_2 capture and CO_2 use and storage. These joint programmes should not extend beyond R&D because second and third generation ZEPs should not be subject to the market failures that currently impact on current ETP-ZEP CCS technologies. A market based system to fully reward CO_2 abatement should be in place by the time second generation ZEPs are ready for deployment. Longer term cooperation is unlikely to be required on "Market Regulation and Policy" or "Communication and Public acceptance" since these issues will have been addressed and resolved through the deployment of first generation ZEPs.

With regard to geographical focus, joint programmes could be EU wide or could address subjects specific to a limited number of Member States. For example countries around the North Sea rim may have specific interests in sub-sea CO_2 storage, while another grouping could be concerned with capture from lignite fired plant.

Table 3 Preliminary assessment of ETP-ZEP action areas and activities that would most benefit from transnational joint actions

Action Area / Activity	Advanced fossil plants	CO_2 capture	CO_2 use and storage	Infrastructure, Environment and Safety(1)	Market Regulation and Policy	Communication and Public acceptance
Activities aimed at supporting first generation deployment						
R&D to support first full-scale deployment	A, B, C, D, E, F	A, B, C, E, F	A, B, C, D, E, F	A, B, C, D, E, F	A, B, C, D, F	A, B, C, D, F
Pilot plant trials to support scale-up		A, B, C, E, F	A, B, C, D, E, F	A, B, C, D, E, F	N/A	N/A
Full-scale demonstration		A, B, C, E, F	A, B, C, D, E	N/A	N/A	N/A
Activities aimed at developing improved devices and processes						
R&D to improve ETP-ZEP efficiency and reduce costs	A, B, C, D, E, F	A, B, C, E, F	A, B, C, D, E, F	N/A	N/A	N/A

1. Includes CO_2 transport.

Notes

- Action areas/activities coloured grey and marked N/A indicates that there is no requirement for joint action in this area and/or activity.
- Action areas/activities coloured red indicate they are likely to be precluded by State Aid regulations.
- Action areas in which a formal transnational programme is judged not to be cost effective are shaded amber.
- Areas where a formal transnational programme is judged to be beneficial and cost effective are shaded green

The clustering of areas for joint action are broadly in line with the recommendations of the ETP-ZEP, which has given a more detailed breakdown of potential subjects for work in each of the activity/action areas (Annex 1).

The schedule for initiating these joint actions can be derived from the discussion of ETP-ZEP timelines in Section 3:

- R&D in support of the deployment of first generation ZEPs needs to initiated as soon as possible.
- Pilot scale projects to aid the scale up of ZEPs should also start as soon as possible.
- Longer term R&D aimed at developing improved second and third generation ZEPs should proceed as an on-going process.

Realistically full-scale demonstration of ZEPs cannot commence before about 2014[15] although design and planning will need to start soon to meet such a start up schedule. Such projects are likely to each require several hundred million Euros of financial support, even when support is confined to the CCS elements and receives a contribution from the recently announced EU scheme. Because of the cost, and also the complexity of organizing, managing and regulating such projects, it seems likely that the first few demonstrations at least will be initiated by individual Member States, possibly with the European Commission through its project network providing a coordinating role. It is therefore uncertain if any additional transnational action of the type considered by FENCO-ERA is needed. However, there may be a role for separate transnational actions that utilize one or more full-scale demonstration projects as hosts or test beds for the FENCO-ERA areas identified in Table 3(e.g. R&D to develop advance methods for monitoring CO_2 stores).

7. Preliminary action plan for taking forward joint programmes

The action plan for taking forward joint programmes needs to address a number of issues including:

1. How to identify the priority areas and activities that would benefit most from joint action at any particular time.
2. How to sustain the drive for joint activities after the FENCO-ERA initiative concludes.
3. How, and at what stage, to engage stakeholders (e.g. from the business and research communities).
4. How to coordinate joint activities with EU level actions (e.g. through the framework programmes, SET, etc.).
5. How to undertake a call for participation in joint actions.
6. How to assess, manage and monitor joint actions.

[15] http://www.berr.gov.uk/energy/sources/sustainable/ccs/ccs-demo/page40961.html

7. How to share and disseminate the knowledge and insights gained through joint actions.

A key factor underlying many of these issues is coordination, and this applies at a number of levels:

- Coordination between Member States in agreeing the activity/action areas for which they agree should have priority for joint actions.
- Coordination between Member States and business and research community stakeholders to gain the views of the latter on which activity/action areas they are prepared to participate in through joint actions.
- Coordination between Member States, stakeholders and EU level initiatives that could contribute to joint actions. For example the EU Framework Programme, EU Structural Funds for innovation, etc.

The following table lists actions envisaged to establish an on-going system for organizing joint actions. Responsibility for the actions will rest with FENCO-ERA during its lifetime, NFAs and the Commission's SET Plan.

Table 4 Actions envisaged to establish an on-going system for organizing joint actions

	Actions
1	Agree proposed arrangements for annual workshop of NFAs to identify subjects for joint actions.
2	Run first annual workshop of NFA's to identify subjects for joint actions (to include NFAs not represented in FENCO).
3	Run first annual workshop of other stakeholders to review and prioritise subjects for joint action identified in NFA workshop.
4	Identify the NFA to run the second annual workshop of NFAs
5	Identify the NFA to run the second annual workshop of stakeholders
6	Fix coordination arrangements between joint call process and EU level programme activities
7	Establish a generic collaboration agreement for all joint actions which can be reused in each annual round.
8	Establish the level of monitoring needed for joint actions.
9	Agree a framework for sharing knowledge from joint actions with third parties.
10	Agree an informal framework for smaller policy related joint actions.

8. Conclusions and Recommendations

This report has set out an interim strategy and action plan for the implementation of multi-national programmes on clean fossil energy. The proposals and recommendations are based on a survey of current innovation priorities in Member State clean fossil programmes and one to o ne feedback from the national funding agencies participating in FENCO. The strategy has identified topic areas and activities most suited for joint actions, and has proposed a timeline for their implementation.

Recommendation 1 - These strategic interim proposals should be tested in a workshop drawing in a wider representation of EU Member State funding agencies.

The success of a joint programme of activities on ZEPs depends on the support of the organizations from business and the research communitiy. In particular these organizations need to support the strategic focus proposed herein.

Recommendation 2 – The strategic interim proposals should be tested in a workshop involving industry and research community stakeholders.

For both workshops the NFAs are to take the initiative. If applicable, the FENCO-ERA Management Board will support organization and management of the workshops on behalf of the NFAs.

The action plan sets out 10 actions that are needed to establish a durable framework for implementing multi-national programmes. This plan focusses on systems needed to deliver annual calls for proposals based on the view on priorities held by individual Member States. In other words the plan for joint actions is driven by a sharing of national visions for future development rather than single integrated vision developed.

Recommendation 3 – It is vital to establish a durable system to deliver joint actions after the current FENCO-ERA initiative is completed. The action plan envisages this being achieved by an informal process in which the organizational burden is taken in turns by NFAs (see D 4.1.1).

Recommendation 4 – Further discussion is needed between NFAs and the Ministries supporting work on ZEPs to determine whether they are willing to make a more firm commitment to a system for establishing joint actions. For example a commitment to participate for 3-5 years with further activity subject to review (see D 4.4.1, D 5.4.2).

Recommendations 3 and 4 are strongly linked and again the NFAs are to take the initiative. In case that the NFAs agree to further support the FENCO-ERA Management Board will attend these activities on behalf of the NFAs.

Annex 1 Possible subjects for projects in each of the action areas identified in the strategy

Action Area 1 – Advanced Fossil Fuel Plant
Activity – R&D

Increase the efficiency of steam power plant to over 50%
Develop new high temperature materials
Develop new protective coatings
Improve fabrication methods for increased integrity and cost reduction
Develop novel steam turbine designs
Advanced design codes and tools
Improved NDT and defect detection
New seals
Increase the efficiency of gas combined cycle plant to over 63%
Improved optimization of gas turbines, boilers and steam turbines
Improved high temperature materials for gas turbines
Advanced high temperature coatings
Improved aerodynamic design for gas turbines
Improved seals
Advanced low emission technologies and processes
Life time extension with modeling and condition monitoring
Increased fuel flexibility
Cross cutting themes for gas and steam plant
Improved instrument and control systems
Gasification development for IGCC
Improve part load efficiency
Advanced fuel processing and multi-fuel capability

Action Area 2 – Carbon dioxide capture
Activity – R&D

Post Combustion
New and less energy intensive solvents
Solvent degradation mechanisms
Process optimization and integration (heat and gas path)
Retrofit concepts
Adsorbents and membranes for separation
Methods to reduce the impact of flue gas contaminants
Advanced process and equipment models
Pre-combustion
Up scaling gasifiers to 1200-1500MWth
Improved gas clean up
Conversion technologies with oxygen membranes
Improved shift catalysts
Improved solvents for separation
Membranes for separation
Develop larger turbines capable of burning hydrogen
Hybrid cycles involving fuel cells
Process integration and optimization
Membranes for oxygen separation
Oxyfuel combustion
R&D into oxy-combustion, heat transfer, slagging, fouling and corrosion
Develop design tools for scale up
R&D of oxy-fuel gas turbines and combined cycles
Chemical looping
Flue gas cleaning technologies
R&D of the degradation of materials for handling oxy-fuel flue gases
Materials for high efficiency boilers operating with oxy-fuel environments

Action Area 2 – Carbon dioxide capture
Activity – Pilot Plant

Post Combustion
Solvent trials
Pre-combustion
Hybrid cycle trials
Oxygen membrane separation
Hydrogen gas turbine trials
Oxyfuel combustion
Pulverised coal burner trials
CO_2 clean up trials
Circulating fluidized bed with oxy-fuel trial

Action Area 3 – Carbon dioxide use and storage
Activity – R&D

Physical, chemical and biological behaviour of CO_2 in the subsurface
Fluid – rock interactions
Development of dynamic models of storage behaviour
Rock cap integrity and seal characterisation
Tools for reservoir design (well location, monitoring systems)
Modelling the long term evolution of CO_2 stores
CO_2 thermodynamics
New monitoring tools
R&D of well bore integrity
Leak detection and tracking
Leak mitigation techniques

Action Area 3 – Carbon dioxide use and storage
Activity – Pilot Trials

Field investigations of rock-fluid interactions
Pilot tests of seal integrity
Field trials of monitoring equipment
Well seal monitoring trials
Field laboratory for studying CO_2 migration in the over burden

Action Area 4 – Infrastructure, environment and safety
Activity – R&D

Corrosion properties of CO_2
Seals and valves for CO_2
Develop subsea dispersion models
Impact of CO_2 on terrestrial and marine ecosystems
Methods for mitigating leaks in the transport system
Safety implication of different sized leaks of gaseous and supercritical CO_2
Other potential environmental impacts of CCS (solvent leakage)

Action Area 3 – Infrastructure, environment and safety
Activity – Pilot Trials

Leakage impact tests with pressurized gaseous and supercritical CO_2

Action Area 6 – Communication and public acceptance
Activity – R&D

Research the perception of different stakeholder groups
How to build public trust
Develop risk communication strategies
Use full-scale demonstration projects to engage with the public and better understand their concerns

Annex 2 Review of Social aspects and Public Communication concerning CCS

Social Aspects and Public Communication of CCS

Public engagement is one of the key activities within the scope of non-technical matters involved in successful deployment of new pilot and large-scale technologies. History shows examples of problems and subsequent costs as a result of poorly communicated plans for new technologies[16]. Such experiences have made project developers more aware of the importance of engaging with key stakeholders and the public. Projects introducing new technologies now seek to involve and incorporate social aspects from the outset to help mitigate potential risks associated with non-engagement.

All European projects dealing with CCS are aware of the importance and necessity of public communication and have identified task forces in their workplans. During 2004, the first research studies appeared on the topic of social aspects and public communication of CCS. The leading scientific platforms in this respect are the biennially International Conference on Greenhouse Gas Control Technologies (GHGT) and different Clean Coal Conferences and their associated journals. Other relevant scientific journals are Environmental Impact Assessment Review, Journal of Environmental Management, Energy Policy, and Environmental Science & Policy.

The European CCS projects and platforms themselves published several studies and reports on social aspects and public communication as well as studies commissioned by governmental departments and NGOs. These are summarized below.

Many of representative papers on social aspects of the European programmes like CATO, COORETEC, CLIMIT, etc. are already covered by the analysis in the Wuppertal Study, the key conclusions of which are translated into English below. Meanwhile the Tyndall Report from 2004 was one of the first European studies on the topic of public acceptance of CCS. A Communications and Public acceptance project was initiated through the1st FENCO-ERA Joint Call for proposals. The other studies and reports presented below have been published at the same time or later than the Wuppertal study.

- **UK Tyndall Report 2004:** The Public Perceptions of Carbon Capture and Storage. Simon Shackley, Carly McLachlan, Clair Gough. Tyndall

[16] For example see the consequences of falire of engage with local residents during BP's Hornchurch Hydrogen Filling Station well documented here http://www.createacceptance.net/fileadmin/create-acceptance/user/docs/CASE_20.pdf

Centre for Climate Change Research, Tyndall Centre Working Paper No. 44, January 2004. [http://www.tyndall.ac.uk/publications/working_papers/wp44.pdf 10.11.2008]

- **ACCSEPT Report 2007:** Summary of the Main Findings and Key Recommendations. Deliverable D5.1 from ACCSEPT. Final report from ACCSEPT. December 2007. [http://www.accsept.org/outputs/wp_5_2dec_2007_final.pdf]
- **French CIRED Study 2007:** A survey on the public perception of CCS in France. Minh Ha–Duong, Alain Nadai, Ana Sofia Campos, CIRED – Centre international de recherche sur l'environnement et le développement, December 2007. [http://www.centre-cired.fr/IMG/pdf/CIREDWP-200808.pdf 10.11.2008]
- http://www.fz-juelich.de/**International IEA Report 2007:** Public Perception of Carbon Dioxide Capture and Storage: Prioritised Assessment of Issues and Concerns. Summary for Policy–Makers. Commissioned by: International Energy Agency Working Party on fossil Fuels. IEA WPFF report dd. 23 March 2007. [http://www.zero-emissionplatform.eu/ → Library → Related documents 10.11.2008]
- **German Wuppertal Report 2008:** Socio–economic Research on Acceptance of Carbon Capture and Storage (CCS) at National and International Level. Wuppertal Institute, Research Centre Juelich, Fraunhofer Institute, and BSR Sustainability GmbH, 2008. [http://www.wupperinst.org/de/projekte/proj/uploads/tx_wiprojekt/Akzeptanz-CCS-Endbericht.pdf 10.11.2008, in German]
- **ZEP Communication Plan 2008–2010: ETP-ZEP** Task Force Public Communication, Brussels 2008. Communication Plan 2008–2010.
- **IEF-SET 2009** Scrutinizing the impact of CCS communication on the general and local public. Initiated through the1st FENCO-ERA Joint Call [http://www.fenco-era.net/Impact_of_Communication]

UK Tyndall Report 2004

The study has been carried out in 2002/2003 in Manchester, York and Liverpool International Airport (UK). Published: January 2004.

Aims of the study:

- Exploration of the public perception of CCS both when first presented with the idea and when more background information is provided.
- Exploration and understanding of the perception of key risks and concerns on CCS. Find out what information, policies and processes would make CCS acceptable to the public.

Methodology:

Two gender–related Citizen Panels were run, each Panel met for ten hours in total. Based on the findings of the Citizen Panels a questionnaire was devised which then was administered through face-to face interviews to over 200 respondents conducted in the departure area of the Liverpool John Lennon International Airport.

Summary of the study:
On first contact with CCS, most people are slightly against, neither for nor against it or say that they do not know. When provided with more information on CCS, it is generally recognised as a potentially important carbon mitigation option for the UK. Support for CCS is conditional on understanding the reasons for CO_2 mitigation. A necessary prerequisite for including CCS as a serious response option to climate change is the belief in, and concern about, human–caused climate change, plus recognition of the need for major CO_2 emission reduction. If more information about alternatives is presented, wind, wave, tidal and solar power, and energy efficiency measures are favoured over CCS.

Referring the question of appropriate policies, the public requires more certainty about the risks of CCS in the long-term. CCS as one within a portfolio of decarbonisation technologies, options and measures (e.g. other new technologies, lifestyle change), and as an explicit bridging strategy to a low-carbon energy system, would do much to increase its public acceptability. Enhanced Oil Recovery, combined with CCS will be regarded as an additional reason in support of CCS, rather than counting as a reason against. Regulation involving a partnership between Government, the Environment Agency, Environmental organisations and the energy industry would help to reassure the public. CCS should not be considered or presented as a „technical fix“. Ownership by the public is important.

ACCSEPT Report 2007

The Accsept–project ran from January 2006 to December 2007 and was funded by DG Research of the European Commission under the Sixth Framework Programme.

Aims of the project:
The project identified and analysed the main factors which have been influencing the emergence of CCS within the EU. One of the key clusters of factors are social acceptability issues.

Methodology:

Discussion in various work packages; two stakeholder workshops; Survey of stakeholder opinions across the EU through a large–scale questionnaire undertaken in 2006.

Summary of key recommendations (concerning public communication):

- In order to implement CCS on a large scale, widespread public support will be required. Important targets are national and European parliamentarians, journalists, environmental pressure groups and representatives of civil sciety.
- It is important to ensure communication in a dialog, not one way: establishing an information campaign about CCS is not without danger. It requires the advice of professional agencies.
- The budget for an outreach campaign is estimated around € 250.000,- per country.
- Regular monitoring of the public reaction and responding when necessary. The Eurobarometer survey instrument could be used.
- An information and communication campaign needs to be supplemented by public and stakeholder engagement activities. The aim of engagement is not to „win over“ or change the opinions of sceptical groups. At the same time, information should be provided that informs and raises the level of the debate over the energy future. It should be emphasised that stakeholders and the public will not judge CCS in isolation, but relative to the alternatives and complementary options.

French CIRED Study 2007

The study has been carried out in April 2007 throughout France.
Published: December 2007.

Aim of the study:
To explore the variability of opinions (information and semantics) on CCS by a survey on awareness and approval of or opposition to the use of CCS in France.

Methodology:
The study was conducted by a professional survey institute in France. About 1000 persons were questioned, using the quota method on sex, age, head of household, profession/social category. The selected individuals are a representative cross section of the population throughout France. The design of the survey was a split–sample, before/after experiment. CO_2–sequestration and CO_2–storage were questioned separately. The surveyors explained briefly CCS. The multiple choice questionnaire contained twelve questions specifically

related to CCS, followed by eleven questions addressing the social and demographic characteristics of the respondent, and six additional variables describing the respondent's neighbourhood were taken from in a national database.

Summary of the study:
About a third of the population has heard about CCS, 6 % of the respondents could define the technology. The key question about 'approval of or opposition to' the use of CCS in France was asked twice, first after presenting the technology, then after exposing the potential adverse consequences. The approval rate decreased from 59 % to 38 %. The study reveals that French public is not strictly opposed to CCS, but rather suspicious than supportive.

International IEA Report 2007

The report was encouraged by the G8 Gleneagles summit in 2005.
Published in March 2007.

Summary of the report (concerning public acceptance):
Perceptions and issues were surveyed by region (North America, Europe, Australia/New Zealand, Japan, China, India and South Africa) and by stakeholder group (NGOs, public, government, industry, and R&D organisations). The stakeholder groups will ultimately be critical in determining the viability of CCS. Without broad acceptance, CCS will be seen as a technically feasible but politically unrealistic climate change mitigation opportunity.

Building public acceptance includes: raising awareness of CCS; identifying perceptions and concerns; developing and implementing responses (ideally with the help of those who raise the concerns); communicating with the public (public relations as a one–way instrument for sharing information often confuses the public).

The role of CCS as part of a portfolio of solutions to climate change has to be clarified. The public acceptance of CCS is positively correlated to the perception that CCS provides a pathway for transition to a cleaner energy economy, but assigning timelines for transition is difficult. Most people agree that CCS alone will not solve the climate change problem.
Increased support for demonstration projects is required, because there is solid evidence that engaging the public on the topic of energy technologies, when set in the context of climate change, generally improves attitudes towards CCS. In addition, an informed media will help to educate the general public about CCS.

The media will need to be engaged in discussions about CCS to ensure the information they provide is accurate and up to date.

German Wuppertal Report 2008

The study has been carried out from April 2006 to December 2007 in Germany. Published: February 2008.
This study is a comprehensive information source for several topics concerning social aspects and public communication, containing a number of annotated references.

Aims of the project:

- Assessment of the status quo of CCS.
  Which general and detailed assessments do already exist?
- Assessment of potential hazards and risk perception.
  Which hazards have to be taken into consideration and how are risks and hazards perceived by different stakeholders and the broad public?
- Presentation of historic and current media coverage of CCS.
  Which aspects of CCS are of relevance in media coverage? Which media cover CCS, and how? What are the basic trends in media coverage?
- Analysis of acceptance of CCS.
  Which factors influence public acceptance in general?
  What is the current level of public acceptance?
- Development of a communication concept.
  Which criteria have to be met for objective, transparent and credible information campaigns in Germany?

Methodology:

- Overview and analysis of existing international studies on acceptance of CCS.
- Demonstration and discussion of general methods for research on public acceptance, their opportunities and weaknesses and how they can be transferred to the case of CCS.
- Empirical study, multiplier consultations: ~35 in–depth interviews (60 % telephone interviews, 40% written interviews), ~230 written international expert interviews.
- Content analysis of German language print media (~300 articles: news agencies (7 %), national daily newspapers 39 %, weekly magazines 3 %, national weekly papers 3 %, professional journals 27 %, local journals 21 %), international media (internet research: ~140 articles out of 4 weekly papers, 24 daily newspapers), and 8 brochures of CCS.

Summary of the study's core statements:

Status quo on research on public acceptance and CCS:

- The research on public acceptance becomes important for rolling out new technologies. Acceptance cannot be assumed as a fact in high engineered societies.
- Because of technical research gaps and the low public awareness level of CCS it is difficult to define boundary conditions for an acceptance survey.
- Individuals living near to a CO_2–storage facilities or CO_2–pipeline will be more critical as it is common for any other new technology. But it weighs more because of the expected large new pipeline infrastructure.
- The population has much confidence in NGOs and partly in the scientific references.
- Acceptance and communication of CCS is covered by the international research agenda, e.g. FENCO-ERA Era–Net and the EU 7th Framework Programme, and the Netherlands' CATO–programme.

Experiences with other energy technologies:

- Increasing of the safety arrangements for nuclear power plants does not decrease the risk perception of the population.
- Public discussions on wind energy can not be compared with CCS. As it is the case for nuclear energy the discussion of CCS is affected by the question if large–scale technology can be controlled generally.
- On the one hand there has to be a balance between the local hazard and the higher–ranking climate protection. On the other hand the potential plant operators will be the big companies of the energy industry.
- The public discussion on natural gas storage facilities is not comparable with CO_2 storage facilities. The former are used as short–time storage facilities and have much less storage capacity.
- More comparable is the resistance to CO–pipelines. In the public opinion CO_2 is as negative patterned as CO in spite of the difference of the direct human impact. CO_2 is also referred to as „climate toxin".

Risk potential, risk perception and legal placement:

- Working out the details of potential hazards and risk assessment allows the conclusion that there are no safety risks that lead to the exclusion of CO_2 sequestration, transport, and storage.
- Compared with other industrial sectors the incidence rate of accidents and the measure of damage will normally be little. There exist monitoring systems and emergency plans which can be transferred to CCS.
- The publicity of the EU–directive on CO_2–storage can stabilise the public awareness of CCS. Solutions on considerably points of criticism regarding waste and water legislation are provided.
- There is a lack of regulation regarding long–term responsibilities of storage facilities.
- In general the public has not developed yet risk awareness of CCS. Therefore future trends should be accompanied by targeted risk communication.

Media analysis on CCS:

- Up to now no fundamental reporting on CCS or the potential role of CCS in the future took place in the media.
- Articles concerning CCS refer to economic and political stakeholders. Furthermore journalists use scientific resources. The opinion of NGOs is rarely mentioned.

Empirical survey and acceptance of CCS in Germany:

- Consultations of multipliers show that the positions on the necessity and value of CCS are far diverging.
- Even within social groups the positions are not consistent. In particular NGOs have different positions from strict refusal to the necessity of critical review and mentoring.
- The negative attitude of several NGOs is based on the direct connection of CCS and use of coal, and not on the CCS–technology itself. The additional power for CO_2–sequestration and storage would increase the problems of coal mining.
- The CCS–technology can only be implemented at large–scale. Therefore it counteracts the required decentralising of the power supply structure. The fear is that the CCS–technology acts as a pretext for legitimating building new coal–fired power plants.
- The way even multipliers see it, public acceptance could be a tilt effect of CCS–technology.
- The public doesn't know much about CCS, this technology is not yet negative patterned, like e.g. nuclear energy. Therefore multipliers could still influence the public acceptance.

- Experts expect negative public attitudes on CCS, while the public itself is mainly neutral to positive. Experts judge public acceptance, economical reasons and financing as main barriers to roll out CCS.
- CCS is seen as an interim solution or bridging technology to gain time for developing alternative energy sources and increasing efficiency. CCS is seen as important technology more on an international level than on a national level.
- At present public consultations are pointless due to very little knowledge about CCS by the public. This may be changed by more research and demonstration plants.

Relevant criteria of public acceptance:

- Mass media can be seen as the main source for opinion making. Generally they are the first information source for the public and they influence the first image of CCS.
- Depending on the arguments the CCS technology chain will be seen as a social benefit or not. These arguments and the social context of the multipliers will influence the acceptance of CCS.
- Depending on the particular stakeholder, positve factors of increased acceptance of CCS technologies are the opportunity to cleave to the central power supply structure, to provide new jobs by constructing new CCS–power plants and retrofitting with CCS, and the technology transfer e.g. to China or India. On national level it provides security of supply by domestic coal–fired plants in spite of the requirements on climate protection.
- Multipliers valuate the benefit of CCS on a global level significant higher than for Germany or Europe. Therefore broad international use of CCS will increase public acceptance.
- Risk awareness of CCS will be an important factor of public acceptance. Upcoming fears concerning CCS have to receive attention. It has to be taken into account that there will be conclusions by analogy even they are not justified. To provide clarification in this respect is an important task of communication strategies.
- CCS–technologies could be seen as a trigger for higher energy prices and therefore reduce the acceptance without relating cause (share in climate protection) and effect.
- Power plants with CO_2–sequestration need considerable more station auxiliary power than plants without CO_2–sequestration. This impact on environment and landscape (higher coal demand) could reduce public acceptance.
- Conventional coal–fired power plants cause civil opposition, particularly in regions where new coal–fired power plants are planned. Missing

acceptance on conventional coal–fired power plants will affect on CCS–technologies.

Recommendations for a concept of an information campaign

- In the future it is important to focus on the communication task to increase the public information level on CCS.
- Up to now there has not been a broad information campaign on CCS. Although there are several brochures on CCS of different stakeholders and the media reporting increases, but there are no stakeholder–spanning reports yet.
- The public debate on selective topics of CCS has begun, but several other topics and aspects of CCS–technology are not or insufficiently covered yet. To ensure a broad discussion on CCS an information basis shout be provided covering the whole complexity of CCS.
- On the part of energy economics and plant design there is an attempt to inform comprehensive and neutral about CCS together with other stakeholders (e.g. science) by the information centre for climate friendly coal–fired plants. Critics are in doubt about the objectivity because of the chosen structure and sponsorship of the centre. Critical groups, e.g. NGOs, are not involved in this kind of information campaign. If there has been reached a leading decision for CCS it is possible that at least a few NGOs collaborate constructively in the process of finding a location.
- Multiplier statements and experiences from abroad show that the communication of benefits and risks of CCS needs the intervention of a neutral arbitrator. These could be well known and high reputed individuals or the science. Attributes such as competence, social standing, trustworthiness, and the professional background of the communicator are decisive factors for acceptance.
- Because of research gaps an information campaign on CCS should communicate transparently that several open questions on CCS can’t be answered at present.
- Above all the population located near a CCS construction project (plant, pipeline, storage facility) should be informed at an early stage, that means in the planning and placing stage of a pilot or large scale project. The appropriate instrument is face–to–face communication with the located population in the framework of a dialogue process.

- Risk communication at an early stage provides the opportunity to bring topics carrying negative connotations (CO_2 transport and storage) and false conclusions by analogy to an objective level. Risk communication is suitable for locally concerned persons.
- To address many sectors of the population (e.g. interested laypersons, persons concerned) and multipliers (e.g. media, organisations) an information campaign should be designed and presented target group aligned.
- An essential task of providing information is to organise an open and fair dialog between the relevant stakeholders. Therefore adequate stuctures have to be established with transparent sponsorship and cleary documented independence.

ZEP Communication Plan 2008–2010

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Objectives of ETP-ZEP Communication Plan:
ZEP, as a unique body composed of industry, NGO, researchers, and science claims its role to become the authoritative, trusted voice on CCS [in Europe]. The objective is to engage key stakeholders in an open dialogue using holistic communications and targeted, effective platforms to educate and positively influence their perceptions of CCS, energy and climate change.

Key Messages and planned actions:
CCS provides a key solution for combating climate change. CCS recognizes the reality of fossil fuelled power today, while building towards the truly sustainable energy system of tomorrow. CCS has been tested safely and successfully, on a small scale, world–wide.
ZEP states to explain and establish ZEP, to set the scene, to clarify the issues, and to inspire, involve, inform the right audiences.

Depending on the future budget, ETP-ZEP plans the creation of 4 short films of key issues of CCS to use at events, on websites, for educational purposes and media, and advertising campaigns. Further ETP-ZEP plans a stakeholder research. If ETP-ZEP can generate an optimal budget it plans a Print/TV advertising campaing in pan–European media to increase reach and awareness of CCS, print creation, pre–/post–test analysis, content translation into 5 languages, and media events.

Conclusions

The level of information on CCS is still low but the number of people who "heard about" CO_2 storage is increasing. All studies concluded that CCS should be communicated in the context of climate change mitigation as one essential factor in a portfolio of solutions. The public require more certainty about the long-term risks and responsibilities of CCS

Successful widespread deployment CCS will require public support. Therefore well designed communication strategies involving all stakeholders are needed.

There are a number of governmental working groups in different countries dealing with CCS on a national level. It would be useful to create an information platform where the results of national studies are available (in English) to enhance knowledge sharing and experience and minimise duplication of effort.

Having identified research gaps and considering the results of the comparison of the national programmes (D3.1.) FENCO-ERA set out the 1st call with topics "Economic modelling for roll-out strategies" and "Acceptance and public communication". The following IEF-STE 2008 project was adopted after the evaluation in 2008.

IEF-STE 2008 (FENCO-ERA)

Objectives and assumptions

The central objective of the project "Impact of communication" is to compare different approaches to CCS communication with respect to their effectiveness. The main assumption is that information on CCS should enable the public to develop well-informed and well-considered opinions on the technologies. If people's opinions are not well-informed or well-considered, it can be assumed that the opinions are of a low quality, which means that they are unstable, inconsistent and not based on conviction. Furthermore, opinions of a low quality are worthless for predicting future public support or opposition to CCS.

Hence, the pivotal research question of the project is how information on CCS should to be communicated in order to increase the quality of public opinion, which in turn will allow us to better predict future public approval or non-approval of the technologies. For this purpose, the project involves a comparative study of the communication of CCS in six European countries:

Germany, Greece, the Netherlands, Norway, Romania and the United Kingdom. The aim is to develop recommendations for the communication of CCS enabling the public to develop their own informed opinions.

Research approach

The research approach of the project “Impact of communication” is based on two main methods to be applied in all countries involved:

1. A study comparing the effectiveness of two CCS communication methods: a) oral presentation of information by experts to a small group of lay persons who will have the opportunity to extensively discuss CCS (focus group), and b) written presentation of the same expert information to a number of individual lay persons (who cannot interact) using an instrument helping them to make use of the information provided to form opinions on CCS (Information-Choice Questionnaire, ICQ). The main objective of this comparison is to investigate how opinion quality varies depending on the communication method used.
2. A survey of a representative sample of citizens. The main objective is to collect data on public awareness and knowledge of climate change, energy policy and CCS in general, as well as on public awareness and knowledge of local demonstration initiatives and existing CCS information materials and campaigns. To ensure comparability between all countries, a set of core question on CCS awareness will remain the same for all countries.

The data collected from the comparative study of communication methods and from the representative surveys will be evaluated and compared to enable conclusions to be drawn concerning the question of how CCS technologies should be communicated so that the resulting public attitudes can be used as indicators for measuring the degree of public approval.

Current status of the project implementation

The project consortium consists of 11 partners from six countries led by Forschungszentrum Jülich GmbH, Institute of Energy Research, Systems Analysis and Technology (IEF-STE). During the kick-off meeting at the 20th-21st of January 2009 in Jülich the first steps of the project implementation and the basic principles concerning the cooperation were discussed in-depth. Afterwards, the necessary materials for the focus groups and a general model for the representative surveys were developed. They were discussed amongst all partners during the first mid-term meeting which took place in Bucharest at the 27th-28th of April 2009. Furthermore, a time schedule for the implementation

of the focus groups, the ICQ surveys and the representative surveys were fixed for each country. According to this time schedule, Germany is the first country which carries out the focus groups. They have been implemented during May 2009. The other partners will start their focus groups during June 2009. The ICQ surveys and the representative surveys will be carried out until summer 2009.

Information on the project is posted on the project website (http://www.lignite.gr/CCS/index.htm)