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"CCS for members of Clean Fossil programme advisory committees"

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SenterNovem

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

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2 Introduction

All FENCO members run national programmes in the field of Fossil Fuels, very often including CCS. The organisational structure around these national FF/CCS programmes includes the deployment of an advisory committee that gives guidance to programme development and priority setting. They form the prime target group for this workshop. Furthermore, observers from other FENCO participant countries were invited. See participants list in Chapter 5.

The purpose of the workshop was to

- identify and analyse the typical issues related to the first CCS demonstration projects from the perspective of an advisory committee
- exchange information and insights concerning headlines, process, procedures and substance of the individual advisory committees, and
- identify areas where there is scope for a common European approach.

The workshop started by exchanging information and insights through five country presentations on national CCS programmes. The agenda was as follows:

- CLIMIT, Norway, T. Riis
- COORETEC, Germany, Prof. dr. -ing A. Kather
- CAT R&D, United Kingdom, F. La Porta
- Captage et Stockage du CO_2, France, A. Ehinger
- CATO & EOS, the Netherlands, H. Schreurs

The participants were then divided into two discussion groups:

- Group 1 discussed headlines, processes, procedures and substance of the individual advisory committees (Moderator: Dr. H. Höwener)
- Group 2 discussed typical common issues and research gaps related to the first CCS demonstration projects from the perspective of an advisory committee (Moderator: H. Schreurs)

During the final plenary, round table, session at the end of the workshop, the concluding remarks and recommendations were analysed, defined, and agreed upon.

3 Concluding remarks

This section summarises the concluding remarks. Full details on the issues discussed can be found in the appendices as presented in Chapters 6, 7 and 8.

CONCLUDING REMARK I: All participants observed that there are considerable *differences regarding national CCS programmes and programming*. Harmonisation of the national programmes (in order to pursue transnational cooperation) will be a challenge, but is not impossible.

Looking at funding schemes shows that, in some countries, CCS has to compete with other technologies such as renewable, efficiency improvements, energy savings, biofuels, etc., while others have earmarked special CCS budgets.

Countries not only differ in their approach to CCS from a technology perspective or ways of funding, but also in the national laws (or lack thereof) that they have passed, defined policy priorities (or lack thereof), or way they handle (or do not handle) private intellectual property rights. In the case of CO_2-capture, intellectual property rights are even seen as a potential obstacle to transnational cooperation. It is therefore advised to start with pure chimney CO_2 (94 vol%), intellectual property issues are in this case less relevant.

From a technology point of view, it will become easier to get transnational support and cooperation on issues related to CO_2 transport and storage, than to make fundamental choices related to CO_2 capture spearheads and focal points. But one should bear in mind that although the CCS organisation and strategies differ between countries, most of the elements are more or less covered by all nations.

CONCLUDING REMARK II: *The way the 7th Framework Programme is organised, does not tackle problems such as the hurdle of harmonising national programmes and funding schemes*. The main issue is that EU-Framework Programming takes a long time to identify spearheads and implement R&D or demonstration projects. For example, formulating a programme takes approximately four years, plus another six years for (tendering) procedures and project implementation. The throughput time must be speeded up because ongoing technology developments and new insights require a faster response and better programme flexibility in order to make appropriate adjustments.

CONCLUDING REMARKS III: The following typical common and distinct issues and research gaps related to the first CCS demonstration projects were mentioned:
(A) *CO_2 capture should be the top priority for improvement*. The costs need to be a lot lower and the technology has to achieve market readiness. Capture efficiency improvements are also necessary in order to improve the performance of the entire CCS chain. All participants agreed that a clear focus is required in order to find a breakthrough technology for CO_2 capture. Future R&D should aim at this. The implementation of existing research projects teaches us that the improvement steps achieved so far are simply too small: at this point in time we need real capture innovations.

(B) *Reliable models for calculating capacity for all types of storage* (aquifers, gas fields, oil fields, CBM) *are lacking*. This particularly hampers the development of aquifers as a storage method.

(C) *The transnational infrastructure for CO_2 is important*, because not all EU countries have CO_2 storage capacity for their emissions. At this point in time it seems very difficult, and even impossible, to realise cross-border CO_2 transport. Therefore, it is necessary to develop some kind of EU regulation in legislation that makes transnational transport possible. General problems in laying a pipeline include public acceptance and NIMBY.

(D) *Gaps also exist in Monitoring Measurement & Verification (MM&V), risk assessment, trapping mechanisms, and the behaviour of CO_2*. This not only involves issues to keep CO_2 in the storage facilities, but also its reactions to water, cap rock, or even a combination of chemicals, are relevant to further investigation. For example, CO_2 can form acids (in reaction with other materials) and will this then stay trapped?

(E) *Standards regarding the impurity of CO_2 are also missing*. When establishing a national or transnational transport infrastructure, CO_2 from different sources will probably be mixed. In order to allow industry to add CO_2 to the transport system, the gas mixture should consist of a certain purity level within a range of set standards.

(F) *Sharing non-commercial information concerning the entire chain (between countries) has not yet been established*. A CO_2 supplier should also know what type of CO_2 is required and what the demands are from a storage point of view. CCS knowledge is disseminated throughout Europe. Capacity building is required for the entire chain, also for the lower levels in order to facilitate public acceptance.

4 Recommendations

Chapter 3 presents the main hurdles to the exchange of information and identifies the typical CCS issues highlighted during the workshop. This chapter details the various recommendations.

RECOMMENDATION I: In order to overcome existing differences regarding national programmes and subsidy schemes (CONCLUDING REMARK I), *it is important that CCS European Flagship projects and capacity building come into effect*. This initiative should focus on similarities and will be the catalyst for exchanging widespread CCS knowledge. These transnational networks can focus, for example, on differences in national laws, common technology issues, harmonisation spearheads, public acceptance topics, tendering procedures, national differences between know-how and know-why (also at lower levels), chosen national R&D priorities related to intellectual propriety rights, pursuing continuous research and development, etc.

RECOMMENDATION II: In order to improve transnational cooperation and tackle the problem of long throughput times of European programmes (CONCLUDING REMARK II), *a CCS development vehicle or intermediary level should be installed between the individual countries and the European Commission*. This should help to speed up CCS development. Such a vehicle would shorten the time taken to select CCS topics that need to be boosted. This is necessary because technology development and/or new insights require more programme flexibility in order to make appropriate adjustments. Such an intermediate level could be operated by FENCO, which should be able to respond quickly to the fast-changing environment and needs.

As a starting point, the group unanimously recommended *organising a two-day workshop to share thoughts about developing and organising an intermediary level between European countries and the European Commission*.

RECOMMENDATION III: After identifying the typical common and distinct issues and research gaps related to the first CCS demonstration projects (CONCLUDING REMARK III), all participants agreed upon the following ranked recommendations:

1) *Develop breakthrough CO_2 capture technology* in order to decrease costs and increase efficiency of the chain
2) *Develop reliable storage capacity estimation techniques and calculation methodologies*
3) In order to *improve transnational cooperation,* CCS information and knowledge should be shared more intensively. There is a real gap in the level of understanding between countries and the knowledge that is disseminated. Improvement can be realised through capacity building projects and establishing European Test Centres
4) *Pursue transnational cooperation* with a clear focus on a *European CO_2 infrastructure*, bringing CO_2 supply and demand together and improving transnational regulation
5) Develop techniques and methodologies for *Monitoring Measurement & Verification* (MM&V)

It is vital that, when developing monitoring and/or storage estimating techniques and methodologies, the European countries agree upon standardisation. For transnational cooperation and the development of a European CO_2 infrastructure, it is important that outcomes and data can be compared in an unbiased manner.

5 Appendix, list of participants at the FENCO workshop

Name	Affiliation	Origin	Group
Trygve U. Riis	The Research Council of Norway	NO	2
Tore Torp	StatoilHydro	NO	1
Prof. Dr. –Ing A. Kather	TUHH	DE	1
Dipl.-Ing. A. Schimkat	ALSTOM Power Gen. AG	DE	2
Ms. Filomena La Porta	TSB	UK	1
Nick Otter	Alstom Power Ltd.	UK	2
Andreas Ehinger	Agence Nationale de la Recherche	FR	1
Ms. L. van Rijn-Vellekoop	MER Commision	NL	1
Nikolaos Koukouzas	CERTH	GR	1
Harry Schreurs (Moderator group 2)	SenterNovem	NL	2
Dr. Hubert Höwener (Moderator group1)	PTJ	DE	1
Peter Versteegh (Assistant to moderator group 1)	SenterNovem	NL	1
Ms. Lydia Dijkshoorn (Assistant to moderator group 2)	SenterNovem	NL	2
Peter Sage	AEA	UK	2
George Marsh	BERR	UK	1
Ms. Fotini Ziogou	CERTH	GR	2
Bert Stuij (Chairman)	SenterNovem	NL	1/2
Jan Willem Dijk (Secretary)	DConsult	NL	2
Maarten Maresch (Secretary)	DConsult	NL	2

6 Appendix, summary of a number of European national CCS programmes

6.1 Conclusions

The workshop started by exchanging information and insights through five country presentations on national CCS programmes. The agenda was as follows:

- *Norway*, Trygve U. Riis, CLIMIT
- *Germany*, Prof. Dr.-Ing. A. Kather, COORETEC
- *United Kingdom*, Filomena La Porta, Technology Strategy Board
- *France*, Andreas Ehinger, ANR
- *The Netherlands*, Harry Schreurs, SenterNovem

(Conclusion 1) From the aforementioned presentations, participants learned that the five *national CCS programmes differ in approach and organisation*:

1) The Dutch programmes have always started with very structured and well-defined topics (CATO). The Netherlands has now made a shift to (EOS) more large-scale projects and a flexible operating structure. In the Netherlands, the (EOS) programme only has one Task Force and advisory committee, and one implementing body (SenterNovem) for all CCS topics.
2) The Germans have identified specific areas of research and focus, but only for a few topics. Those topics are all covered by one of the five working groups with advisory power: 1 Steam power post-combustion capture; 2 NGCC; 3 IGCC + CO_2 capture; 4. Oxyfuel; 5 CO_2 Storage. There are therefore five advisory committees. PTJ is the implementing body.
3) The Norwegians have defined specific CCS areas that need to be investigated, and have a lot of off-shore aquifer storage experience. They have two implementing offices bundled within the CLIMIT, with Gassnova dealing with Demonstrations and the Research Council of Norway dealing with R&D.
4) The French have open calls for tenders and do not specify policy spearheads concerning CCS technology stimulation. There is only one implementing body in France, namely ANR.
5) The UK has divided CCS and CAT innovation phases in four parts, namely: TRL 1-3 Fundamental R&D: managed by Research Councils; TLR 3-6 Applied R&D: managed by TSB (CAT) and ETI (CCS); TRL 6-7 Demo: managed by ETF (Capital grants, CAT); TRL 7-9 Deployment: managed by CCS Demonstrator.

(Conclusion 2) The *technology focus differs considerably between the different countries*. This is due to the different types of storage opportunities, geographical location of storage, academic expertise, and predominate fuel type.

(Conclusion 3) *The tendering procedures and funding schemes also differ*. One country tenders with open calls for all types of New Energy Technology, while another prescribes specific technology areas. This makes transnational cooperation complicated.

(Conclusion 4) There seems to be a gap in (public, political, etc.) know-how and know-why between countries. Knowledge of CCS is spread over the EU. There is also a clear difference between levels of experience related to certain technologies between the countries identified. Capacity building activities should come into place, also at the lower levels and for public relations.

(Conclusion 5) *Continuity in policy and subsidy schemes* is based on the industry of importance. It is not just research that should be stimulated, but the gap to deployment should be bridged. This is lacking at the moment in some countries.

(Conclusion 6) All countries *lack experience concerning public acceptance processes*.

(Concluding remark) The different national approaches, experience, and organisational methods *hamper a uniform European CCS approach* in all EU-27 Member States. Transnational cooperation will be complicated, but not impossible.

6.2 *Overview of five European national CCS programmes*

The following three tables summarise the presentations of five national CCS programmes. The presentations were compared based on the following criteria:

- National *CCS organisation* of the CCS activities
- National *CCS policy strategy*
- Main *CCS programmes in progress*
- *CCS opportunities* as seen by a country
- Broad *conclusions and recommendations*

The criteria were set after the presentations had been given.

	Organisation	**Policy strategy**
Norway Trygve U. Riis CLIMIT	Since 2005 there are two executing offices for CCS activities, namely: ▪ Gassnova: public enterprise for carbon capture and storage (€250mln via open calls): - Technology development - Adviser to the Government - Project developer ▪ Research Council of Norway - For 2007 budget €6mln to R&D and €10mln Demo.	▪ Gas power with CO_2 capture and storage (CCS) - a national priority ▪ Necessary to develop sustainable energy systems. CCS is a solution - in addition to other measures such as energy efficiency and increased use of renewable energy sources ▪ All new gas-fired power plants shall as a rule be based on technology for CO_2 capture ▪ The Norwegian Government intends to: - cooperate with the industry - provide public funding ▪ Make widespread use of CCS a reality
Germany Prof. Dr.-Ing. A. Kather COORETEC	▪ Defined 80 CCS areas; selected 5; and established 5 related working groups. In every working group 1 member of industry and 1 academic lead the party. ▪ The working groups fall under the COORETEC Advisory Council and focussed on are: 1 Steam power post-combustion capture; 2 NGCC; 3 IGCC + CO_2 capture; 4. Oxyfuel; 5 CO_2 Storage ▪ R&D COORETEC of the Federal ministry of Economics and Technology ▪ Projects can be presented to each of the working groups. A group of 30-80 specialists define an advice. The ministry decides on the themes and programmes and PTJ decides on the individual projects ▪ Programme Geotechnologieen also relevant for storage.	▪ Eliminating nuclear installed base. Replacement by 50% of renewable and 50% of natural gas ▪ Without fossil fuels – and especially without coal – it won‘t work, either for German or worldwide electricity generation ▪ 25% of funding to efficiency improvements, 75% to CCS technology

<table>
<tr><th></th><th>Organisation</th><th>Policy strategy</th></tr>
<tr><td>United Kingdom
Filomena La Porta
Technology Strategy Board</td><td>▪ The UK finances projects through national and EU subsidy schemes with a focus on innovation, climate change, and security of supply
▪ The UK divided CCS and CAT innovation phases in 4 parts, namely:
- TRL 1-3 Fundamental R&D: managed by Research Councils
- TLR 3-6 Applied R&D: managed by TSB (CAT) and ETI (CCS)
- TRL 6-7 Demo: by ETF (Capital grants, CAT)
- TRL 7-9 Deployment: by CCS Demonstrator</td><td>The UK focuses on four policy aspects:
▪ Technology development
▪ Regulatory framework
▪ Policies towards deployment
▪ International

Spearheads:
▪ Combination of R&D, Component Demonstration and full-scale demonstration
▪ Aim to have CCS commercially viable by 2020</td></tr>
<tr><td>France
Andreas Ehinger
ANR</td><td>Old approach:
▪ General priorities fixed by government
▪ Grand Steering Committee (SC) proposes programmes and trends
▪ For each programme (e.g. CCS) a SC helps define calls for projects
▪ The evaluation is performed by an scientific Evaluation Committee (EvC), by at least two independent experts
▪ Good proposals are transmitted from the EvC to the SC
▪ SC proposes a list of projects to be financed to ANR

New approach:
▪ Advisory committee (ministries, funding agencies and qualified individuals) expresses opinions
▪ Steering committee (ministries) validates
▪ ADEME implements subsidy schemes</td><td>Projects 2006-2012:
▪ No specific technology choices were made in previous programmes
▪ Three area’s selected: Capture; Acceptability; Storage
▪ Global Climate Change now high on political agenda
▪ Set-up of a specific fund for research pilots €1,000mln in 4 years; €400mln for New Technologies such as: 2nd- and 3rd-generation biofuels; CCS; renewables; buildings; networks; vehicles</td></tr>
<tr><td>The Netherlands
Harry Schreurs
SenterNovem</td><td>▪ Task Force on CCS: Industry and government working together to stimulate development of projects
▪ Formation of a government CCS-team cooperation between MoEA, MotE, MoF and MoT to remove hurdles (laws, regulation)
▪ Advisory committees advises on projects to be subsidised
▪ SenterNovem as ‘mid-fielder’</td><td>White paper 'Clean and Efficient': CCS is part of the system development with earmarked funding
▪ CATO was very structured; projects now require more flexibility and the focus has moved to large-scale demo projects</td></tr>
</table>

	Main programmes in progress		Opportunities
Norway Trygve U. Riis CLIMIT	▪ CCS projects in progress; - Test Centre Mongstad - Large-Scale Facility Mongstad - Large-Scale Facility Kårstø ▪ Storage - Sleipner (11 years) - Snøhvit	Established a dedicated state-owned company - Gassnova SF - to administer the government's participation in the CCS-projects	▪ Gas-fired power with CO_2 capture and storage ▪ Stimulate development of cost-effective technologies ▪ Coordinate the various activities and phases in the innovation chain (R&D, demo, commercial) for CCS - RCN responsible for R&D - Gassnova: Responsible for pilot and demo - Proactive work ▪ Participate in financing projects with a clear commercial potential and market-based business plan
Germany Prof. Dr.-Ing. A. Kather COORETEC	200 projects were financed totalling €93 mln in public funding (total project value €161 mln). The research topics are: gasification; materials; turbo machinery lignite engine; CO_2 Storage; 3rd-generation gas turbine; hybrid power plant; IEA; Membrane; Oxyfuel; post-combustion	▪ innovative potential of universities, research laboratories and industry is accounted for by prioritising collaborative R&D projects ▪ industry participates in financing projects	Efficiency Development of Fossil Fuel Power Plants: Near-zero-emission technologies might be an important option, such as Power Plant with CO_2 Capture
United Kingdom Filomena La Porta Technology Strategy Board	▪ Low-carbon energy technologies portfolio through Collaborative R&D from 2004 to 2007 (~£75M investment) ▪ BERR Demo £100mln ▪ £10-20mln storage project identified ▪ ETI £1.1bn 50:50 basis public:private	16 CAT projects- total value ~£11m (2004-07): 1 Retrofitting Carbon Abatement; Technologies to existing fossil plant; 2 700°C steam power plant developments; 3 Advanced burners for coal-fired boilers; 4 Biomass co-firing; 5 Oxyfuel firing; 6 CO_2 separation & storage; 7 Hydrogen combus.	Proposed programme elements for the UK: Capture test facility ▪ Advanced capture technology ▪ Storage capacity appraisal and development of monitoring and verification tools ▪ System modelling
France Andreas Ehinger ANR	▪ started in 2005 (as did ANR) ▪ 4 consecutive calls for proposals (2005-2008); project length 2-4 years; programme duration 2006-2012 ▪ Overarching objectives: cost and energy efficient capture and safe storage ▪ 33 projects selected; €27mln	Subjects: ▪ Capture and transport ▪ Storage and MM&V ▪ Risk, security, regulation ▪ Innovative / breakthrough concepts ▪ Socio- and technical-economic studies, social acceptability Cover the complete CCS value chain	Bridge the gap between lab-scale and industrial scale / deployment

	Main programmes in progress		Opportunities
The Netherlands Harry Schreurs SenterNovem	CATO: € 26 mln R&D(&D) programme, running for 5 years now: 1 System analysis & Transition; 2 Capture of CO_2; 3 Storage of CO_2; 4 Mineralization; 5 Monitoring, safety and regulations; 6 Communication; 7 Management and knowledge transfer ▪ Capture Pilot Maasvlakte/CATO	EOS subsidy schemes: ▪ Innovation Subsidy on Cooperation Projects ▪ Tender CO_2 storage €60 mln: government will pay €/ton stored as a service price ▪ Tender CO_2 Capture €30 mln ▪ Tenders R&D on focal area's	▪ NUON IGCC coal gas side stream €45 mln ▪ ENECOGEN cryogenic capture total €37 mln ▪ SEQ 50 MWe Oxyfuel plant total €60 mln ▪ Transport: CO_2 hub nationwide ▪ A Rotterdam Climate Initiative business scenario

	Conclusions and/or Recommendations	
Norway Trygve U. Riis CLIMIT	▪ Significantly reduce the cost of capturing CO_2 ▪ Build trust in CO_2 storage ▪ R&D activities on CCS technologies important Emphasis on experience	Make use of experience gathering during storage of CO_2 on the Sleipner field since 1996 – Snøhvit in 2007
Germany Prof. Dr.-Ing. A. Kather COORETEC	▪ Germany has a strong research focus on carbonate looping. The UK and Norway also have a strong tendency towards this technology Emphasis on capture technology	
United Kingdom Filomena La Porta Technology Strategy Board	▪ CCS and CAT have priority for the UK ▪ Cannot be taken forward by one organisation ▪ High level of cooperation is required ▪ Activities should be planned across all 'TRL' levels Emphasis on communication chain	Technology strategy board priorities: ▪ Higher efficiency conversion process to reduce the amount of fuel consumed and the associated CO_2 emissions. ▪ Carbon Capture and Storage (twin-track with higher efficiency). ▪ Fuel switching to lower carbon alternatives - such as natural gas and co-firing with biomass. ▪ Underpinning technologies ▪ Lower TRL CCS technologies? (e.g. taking from 2-3)
France Andreas Ehinger ANR	The approach taken by France is comparable to that taken in Norway. France works with open calls, all different types of technology compete.	

	Conclusions and/or Recommendations	
The Netherlands Harry Schreurs SenterNovem	▪ Storage on shore has its own problems; public communications, pipelines ▪ Question still exist as to whether there is enough capacity (aquifers??) ▪ Storage under the sea bed is attractive ▪ The North Sea offers an excellent opportunity, starting with EGR ▪ Build up of European Transport Infrastructure should come high on the list ▪ Industry is not willing to participate if regulation is not right Emphasis on infrastructure and capacity	▪ The CO_2-Hub should be developed ▪ There must be a 'stimulating' environment for investors ▪ Legal and regulatory hurdles for investors need to be taken up by the government and resolved in a practical way ▪ Monitoring and risk assessment must be item #1 ▪ Talking to the public living near by ('on') the site must be item #1 (NiMBY)

7 Appendix, CCS headlines, processes, procedures, and substance

7.1 Institutional and procedural aspects of all inter-related groups dealing with first CCS projects

The discussion in Group 1[1] was mainly based on a comparison of the roles and functions of the advisory committees within the systems used in Norway, the UK, Germany, France and the Netherlands. The moderator asked the participants to take into account whether they could agree on their national approach and system and whether suggestions could be made for improvement.

The initial R&D phase in Norway is based on guidelines from the deputy minister of petroleum and energy. These guidelines are based on (earlier) advice by relevant companies and respected professors. In practice, about 90% of the advice is followed by the minister and given to the research council who, in turn, define specific projects. Then it turns out that the size of the projects may become problematic. The ministry and the industry finance the projects.

The advisory committee in France is performing well in setting up demonstration programmes. The deployment phase also includes socio- and technical-economic studies. However, there are no specific technology choices. The funding of CCS demonstration projects is based on earmarked budgets for new energy technologies (such as CCS, biofuels, renewables etc.). The Steering Committee defines programmes, with a specific steering committee helping each programme to define the calls for projects. Proposal evaluation is performed by a scientific Evaluation Committee and is based on peer reviews by at least two independent experts per proposal. Acceptable proposals are then transferred from the Evaluation Committee to the Steering Committee. The Steering Committee makes a list of projects. No specific technology choices have been made within the CCS programme. Like Norway, everyone involved in either committee is fully informed concerning any proposal.

In Germany, there is a significant need for new power plant capacity. The Federal Ministry of Economics and Technology is supporting the development of innovative technologies with the COORETEC (CO_2-reduction technologies) research and development concept, which aims to realise low-emission power plants based on fossil fuels. COORETEC is coordinating R&D activities (including demonstration). The Advisory Board supports ongoing assessment and recommends new priorities. The Board meets once a year at the invitation of the German Ministry of Economics. In Germany, the Steering Committee makes the ultimate decisions and is advised by the advisory boards. Proposals submitted to the Advisory Committees can only be approved when the R&D proposal is supported by industry (because industry will pay 50% of the costs) and meet the criteria mentioned in the COORETEC Lighthouse concept. The implementation of research funding is based on the Advisory Council, which has decided to favour five main technologies and is advised by five Working Groups. Each working group represents one of the five chosen technologies.

In the Netherlands, CCS is part of a specific governmental agenda (known as 'Clean & Efficient'). There is also a Task Force on CCS, a governmental CCS group and advisory committees. All are advising on projects requiring subsidy. The Netherlands does not favour any specific technologies.

In the UK, BERR (Department of Business Enterprise and Regulatory Reform) focuses on improving and sustaining the UK's economic performance. The R&D for fundamental Academic Research is funded by the Government and implemented by the Research Councils. The Energy Technologies Institute (ETI) deals with applied R&D. ETI is a public/private partnership, which was created to accelerate the development and commercial deployment of a portfolio of energy technologies. Funding of the projects is based on multiple schemes: European support, National support, and Industry support. Private organisations can therefore maximise their external non-commercial funding.

[1] Participants Group 1: Tore Torp (NO), Prof Dr. –ing. A. Kather (DE), Filomena La Porta (UK), Andreas Ehinger (F), Leni van Rijn-Vellekoop (NL), Dr. Hubert Höwener (DE), George Marsh (UK), Peter Versteegh (NL), and Maarten Maresch (NL)

7.2 Differences between national systems and the consequences for CCS value chain development

7.2.1 Different national approaches to set R&D priorities and the intellectual property gap

Comparing the different national systems:

- One can distinguish two different approaches:
  - R&D programme-based projects (Germany, COORETEC Lighthouse Concept) versus
  - Tender-driven R&D projects.
- There are structural differences that are larger than schemes suggest
- There are some common aspects in view of technological phases
- There are differences in funding, decision-making and initiatives
- The countries have different legal systems and do not apply the same regulations. Specifically for transport; storage; monitoring, measurement and verification these differences may become critical for integrating the CCS value chain
- All stakeholders have insight into the national R&D policy and project proposals. Some stakeholders can even have several different advisory roles. All national schemes make use of scientific advice. There is a distinction between public and company information, and of course classified company information will remain confidential.

Participants concluded that the tender-driven approach is seen as more flexible ('there is no single solution'), but is less open. However, it is not easy to say whether the tender-driven procedure is favourable. Germany feels that R&D is actually investing in the development of intellectual property and is of strategic interest for individual companies. Therefore, the willingness to cooperate diminishes when one has to share findings.

Consequently, the question is: how do intellectual property aspects influence the development of the value chain of CCS?

7.2.2 Intellectual property and the CCS value chain development

The German participant stated that CO_2 capture technology is becoming more common. The delegate from Norway mentioned that the storage technology (and, to a lesser extent, transport + injection) will probably be less problematic in respect to intellectual property. In addition, based on Norwegian experience, storage will become more time-problematic and will probably become the most difficult part of the value chain. Transport is seen as less of a technological problem.

The Norwegian delegate felt that demonstration projects are needed - to convince bigger industries before they decide to make further investments - and will need to have a certain acceptable impact. These projects will be expensive and not affordable by just one country, although the impact can be of great value for Europe and the development of the entire value chain.

The German representative mentioned that: 'when countries have to fund, and their funding is substantial, then countries normally want to recover their investment, in some way or another. Actually, for CCS, intellectual property rights will then mostly be built up and will be of commercial value to countries and organisations. Therefore, if the EU wants to benefit, then the EU has to finance. And, in addition, everything needs to be open: intellectual property rights cannot be claimed by any single commercial organisation or single country.'

In response the UK delegate stated: 'but there is competition and there will always be competition.' The Norwegian delegate repeated: 'when Europe has nothing to offer, then nothing will happen.'

7.2.3 The need for a new vehicle

Based on the remarks concerning flexibility versus a programme-driven R&D approach, the intellectual property issues, the fundamental research problems related to storage and financing of demonstration projects, the group suggested developing a European development vehicle. This should be an instrument placed between national groups and institutions that must be faster, easier and more flexible than the Framework Programme.

8 Appendix, typical CCS issues and research gaps

During the break-out session in the afternoon, Group 2[2] discussed typical issues and research gaps related to the first CCS demonstration projects, from the perspective of an advisory committee. This chapter is split up in four parts: the first section details the common aspects, the second discusses the distinct issues, the third focuses on several gaps in understanding, techniques and methodologies, while the fourth concludes with a ranked list of the issues and gaps to be tackled.

8.1 Typical common CCS issues

The group identified a number of **typical common issues** related to the first CCS demonstration projects. These issues are presented in a random order below.

(Issue A) The UK participants emphasised the necessity of *up-scaling CCS* R&D to demonstration projects. R&D work should not fade out, but efforts should be pinpointed towards deploying the new technology.

(Issue B) As indicated by the Norwegian delegates, *environmental issues* should form an important part of up-scaling R&D efforts to demonstration projects, and should be *investigated* in more detail. Hazardous risks such as (amino? red.) reactions, saline behaviour, etc. should be investigated in further detail.

(Issue C) All participants discussed the approach of *full chain integration* if a pilot plant or CCS demonstration is built. It is important, for example, that if CO_2 capture is realised, that transport, injection, and storage also become available. The Norwegian delegates warned the other group members that an early preparation of storage is vital. Their experience with Sleipner and others shows that arranging storage will take a lot more time than predicted. Necessary seismographic investigations, for example, take a lot of time (2-3 years plus).

(Issue D) *Increasing* total *efficiency* of the system and *reduction* of *total costs* (particularly for capture) were identified and analysed as typical common issues related to the first CCS demonstration projects. The members of the advisory committee unanimously adopted these as the top priority issues.

(Issue E) The delegate from Greece stated that the *assessment* of the *storage capacity* of aquifers is of major importance to her country. The Dutch delegation backs this up for gas fields as well. Less is known about the storage capacity of different layers. Before starting the investments in the chain, actual data on capacity has to be known upfront. Based on experience, the delegates stated that they do not know for sure the capacity of an assigned storage field or aquifer. This is important, in order to prevent disinvestments if the actual storage capacity turns out badly.

(Issue F) All delegates agreed upon another concern that deals with the assessment of the *required quality of the chain,* particularly keeping it in shape. The chain in this case concerns capture, transport, injection, and storage. The purity of CO_2 determines, for example, the level of corrosion, but can also cause chemical reactions (in cap rocks, etc.), if toxics are still part of the gas mix. The composition of the gas mixture is also influenced by the capture technique used: take for example the effects of membrane usage on purity levels.

The delegate from Greece also raised research questions such as: '*which materials should we use*?', or '*what are the security and safety consequences of using different types of materials*?'
Another issue that came to mind was whether it is possible to mix several types of CO_2 gas blends, and what is then the implication for the quality of the chain?

[2] Participants Group 2: Jan Willem Dijk (NL, secretary), Lydia Dijkshoorn (NL, assistant to the moderator), Nick Otter (UK), Trygre Riis (NO), Peter Sage (UK), Harry Schreurs (NL, moderator), Bert Stuij (NL), Dipl.-Ing. A. Shinkart (DE), Fontini Ziogou (GR)

8.2 Typical distinct CCS issues

This section presents typical **distinctive issues** related to the first CCS demonstrations, as analysed and identified by the participants.

(Issue G) The main distinctive issues concern ***types of storage*** and ***geographical location***. In addition to offshore storage opportunities the Netherlands also has onshore gas fields that become available. The UK participant said that they only look at offshore possibilities and that they also possess depleting oilfields. Greece and Norway focus more on offshore aquifers. Then again, storage is also possible in coal layers. All types of storage, including onshore or offshore locations, require their own research, development, and deployment.

(Issue H) The participant from Greece indicated that research into effects and ***implications of earthquakes*** on saline storage should be implemented before they can start with CCS demonstration projects.

(Issue I) Another element that differs from country to country, and that determines the research focus, is the ***predominant fuel*** (coal, gas, biomass, oil, etc.) used.

(Issue J) National differences in regulations will hamper the construction of a transnational pipeline. The UK is concerned that pipelines may have to be laid in populated areas. Studies are necessary to investigate issues in these ***transnational fields***. The Dutch delegates indicated the necessity for a transnational European CO_2 infrastructure, where supply meets demand, and also indicated that the method of financing projects differs a lot between countries. This could also hamper transnational cooperation.

To tackle the aforementioned distinct issues, it is important that countries join the focus research groups that are relevant for their particular country. For example the Netherlands and the UK could focus on offshore gas fields, while Norway and Greece could lead saline aquifer research offshore. For the Netherlands, oil field research (for example) is less important than onshore gas fields. European research groups should be larger than just 3-4 leading countries.

8.3 Gaps in CCS understanding

Group 2 identified significant **gaps in understanding** regarding techniques and methodologies. This is detailed further in the following section.

(Gap L) The delegates from the Netherlands, the UK and Norway stated that the general understanding of ***monitoring techniques and methodologies*** should be developed in depth. The understanding should cover the entire chain, from capture, transport, and injection through to storage. The gaps can especially be found in the ***Monitoring, Measurement & Verification*** (MMV) chain. A couple of issues to improve understanding were put forward e.g.:

- Storage mechanism, such as:
  - Chemical reaction of CO_2 with the surroundings (cap rocks, sand stone, coal-bed methane, salines, etc.)
  - Reactions in the marine environment
  - Trapping mechanism in aquifers, oil fields, gas fields, coal layers (CBM), etc. and the underground behaviour of CO_2 in storage facilities
- Ways to calculate storage capacity
- Risk assessment and safety issues

(Gap M) A main concern among the delegates is the lack of understanding concerning ***public acceptance***. How will the public react to having transport pipelines and storage facilities in their back yard? How are we going to convince them that these are acceptable?

(Gap N) A major problem for transnational cooperation is the different level of ***CCS understanding*** existing between ***countries***. It is therefore important that countries share information at lower levels.

According to the UK, Germany, and Norway, the best way to do this is through capacity building projects, for example via European test centres. The delegate from Greece emphasised that ways to deal with intellectual property should then be established.

8.4 Ranked main CCS issues and research gaps

After identifying the typical common and distinct issues and research gaps related to the first CCS demonstration projects, all participants agreed on the following ranked list of issues and gaps:

- *Develop breakthrough technology* in order to decrease the costs of CO_2 capture and increase efficiency of the chain (issue D)

- *Develop reliable storage capacity estimation techniques and calculation methodologies* (issues E and gap L) in order to prevent disinvestments.

- In order to *improve transnational cooperation,* CCS information and knowledge should be shared more intensively. There is a real gap in understanding levels between countries and of the knowledge that is disseminated. This can be improved through capacity building projects and European test Centres

- *Pursue transnational cooperation* with a clear focus on a *European CO_2 infrastructure*, bringing CO_2 supply and demand together (issues J, and gaps M and N) and improving transnational regulation.

- Develop techniques and methodologies for *Monitoring Measurement & Verification* –MM&V- (issues B, F, and gap L)

It is vital that, when monitoring and/or storage estimating techniques and methodologies are developed, the European Member States agree upon standardisation. For transnational cooperation and the development of a European CO_2 infrastructure, it is important that outcomes and data can be compared in an unbiased manner.