



CO₂ Capture Project

Technical Report

NGCAS (*CO₂ Next Generation Capture And Storage*)
Project

Funded by the EU 5th Framework Programme & the CCP JIP

Demetrios V. Yannimaras

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Prepared by BP, operator on behalf of the CCP JIP

Storage Monitoring & Verification

NGCAS

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Description & Work Scope

The subject project is cooperatively funded by the European Union (EU) and the CO₂ Capture Joint-Industry Project (CCP), with a total budget of ~€1 MM. It has a multiplicity of objectives related to CO₂ capture and geological storage, summarized under the acronym NGCAS (CO₂ Next Generation Capture And Storage) and best understood by perusing the project participants' objectives shown below. The project includes technology transfer obligations arising out of NGCAS-developed technology and is also funding publication of the Clean Coal Technology (CCT) Newsletters. Project participants are listed below in alphabetical order, together with their work objectives.

BP (BP Exploration Operating Company Limited), UK

Technical oversight and participation, project coordination, financial, reporting.

CIEMAT (Centro de Investigaciones Energeticas Medioambientales Y Technologies), Spain

Publication of the EU-funded Clean Coal Technology Newsletter.

ECLT (ECL Technology), UK

Numerical modelling of CO₂ storage in hydrocarbon reservoirs & concomitant risk assessment.

FZJ (Forschungszentrum Juelich GmbH, Juelich), Germany

Publication of the EU-funded Clean Coal Technology Newsletter.

GEUS (Geological Survey of Denmark), Denmark

Basin Modelling to determine long term changes, if any, to safe storage of CO₂ in hydrocarbon reservoirs.

IEA-GHG (IEA Greenhouse Gas R&D Programme), UK

Workshops for project technology transfer & publication of the EU-funded Clean Coal Technology Newsletter.

IFP (Institute Francais du Petrole), France

Basin Modelling to determine long term changes, if any, to safe storage of CO₂ in hydrocarbon reservoirs.

NERC/ BGS (National Environ. Res. Council, British Geological Survey), UK

Study storage into suitable nearby geologic formations of the CO₂/flue gas emitted from the Grangemouth (UK) petrochemical complex.

STATOIL (Den Norske Stats Oljeselskap A.S.), Norway

Self-funded participant; also participates in the over-arching CCP JIP.

Highlights this month

NGCAS Technical Audit by the European Commission Technical Officer. The 09Jan NGCAS Technical Audit by Dr. V. Kougionas (Euro. Commission) went very well. Only one item of an administrative nature was flagged-up (notice of change of participant for ECL Technology's purchase of AEAT Winfrith business) & which is being addressed by our legal advisor J. Hargrove. In attendance were: D. Yannimaras, T. Espie, H. Kerr, S. Cawley (UTG-Aberdeen), & V. Kougionas. The following e-mail was received from the technical officer following the meeting: "Thank you very much for your very interesting presentations. The organisation of the meeting at BP was excellent."

23 January NGCAS Semi-Annual Technical Meeting. This meeting is to be hosted by the British Geological Survey at their Keyworth offices, UK (near Nottingham). Progress on all technical items will be discussed and administrative issues will be addressed.

Risk Assessment Work for the Reservoir Storage of CO₂ by ECL Technologies. ECLT attended 4 December 2002 Eutrecht FEP meeting and participated in FEP elicitation process. Attended Weyburn FEP meeting in Canada as part of effort to coordinate activities. Discussions with Ton Wildenborg at the TNO Utrecht meeting on rationalising approaches so as to achieve a consistent risk assessment methodology. Ton will be producing a first pass note on this. Work to understand the Weyburn and TNO FEP methodologies has been initiated with the objective of achieving as common an approach as possible.

Organizational Aspects

Organizational Meeting & Coordinator Change: On 27 February 2002 a project organizational meeting took place at BP's Sunbury, Middlesex, UK offices. Every participant discussed the project objectives pertaining to his work and outlined organizational & personnel capabilities. Dr. Tony Espie, BP, gave an overview of project inception, technology aims, relationship to EU & CCP, and project finances. He also advised that the formal project start date was 1 Oct. 2001 and that the undersigned, Demetrios V. Yannimaras, BP, will be the new BP coordinator. A short seminar on the use of the collaboration website created by the software package "QuickPlace" (discussed in more detail below) was presented. It was decided to hold the next meeting in September, the exact date to be arrived at by polling the participants.

12 September 2002 Meeting: The semi-annual NGCAS meeting was held on 12 September 2002 at the ECL Technology offices, in Winfrith, Dorset, UK. Results presented by the technology providers are discussed in the relevant section of this document.

Collaboration Website

Lotus "QuickPlace" is a software package used to create secure websites, accessible internally via company intranet and externally via the Internet. The project has its own website, at the address shown below. The purpose of the project website is to (a) provide information about the project, (b) enable participants to upload reports and summaries, and (c) offer information exchange & communications.

The original NGCAS QP site was updated significantly in May 2002, while still under the CCP one. It was migrated to a new, independent site in August & September 2002. The technical work for this migration was done by Mrs. Meryl Yates, with the IT services firm Kaleidoscope (YatesM1@bp.com, ...+44 (0) 19327 64848), in cooperation with the author (& project coordinator).

To access the project website, first double-click on the following link:

https://qp2.bp.com/QuickPlace/ngcas_2002_07/Main.nsf/

noticing the underscores “ngcas_2002_07”. Input userID and Password in the login panel that appears to bring up the main NGCAS site (Figure 1).

If you wish to be included in the collaboration site, please notify the author at the address shown at the end of this document.

ECLT: Maximize CO₂ Storage in HC Reservoirs & Risk Assessment

NOTE: In 2002 ECL Technology acquired the subsurface engineering business unit of AEA Technology. The subsurface engineering business unit includes the Decision Risk Management team. Thus, the technology provider for this item changed name, although almost all of the technical personnel working in this area remained the same.

After consideration of alternatives & technical discussions with the coordinator, the Forties offshore UK hydrocarbon reservoir was selected as the test-bed for studying CO₂ geologic sequestration. A number of modelling issues were raised and resolved by adopting BP's latest Forties reservoir segment model. A Landmark VIP (commercial reservoir simulator) license was obtained by the coordinator on behalf of AEAT under the BP corporate licensing arrangement. After successful installation of the software, AEAT project personnel ran test cases for familiarization and got in touch with the Aberdeen BP model expert (R. Skinner) for discussion on a number of reservoir engineering points. AEAT attended the NGCAS meeting at Sunbury on 27/02/02, the June 2002 Aberdeen basin modeling meeting, and the risk-assessment workshop in May 2002.

Currently AEAT is working on CO₂ WAG (Water Alternating Gas) injection into Forties and on interfacing with the basin modeling effort on calculations of risked CO₂ release profiles. In the Forties CO₂ WAG IOR/sequestration modeling, initially, some numerical stability problems were experienced in running the BP sector model for >1 slug of gas injection. These have been resolved sufficiently to enable the model to run, albeit slowly for some cases.

A series of cases has been run, changing the reservoir sweep rate and well completion strategy. Realistic operating constraint limits have been estimated on the basis of the sector model case received from BP, the 29 April e-mail received from Roger Skinner and general comments and information shared by BP at the 18/19 June Aberdeen meeting and the 25 June DTI IOR seminar.

As presented in the 12 Sep. 2002 Meeting, the results obtained by ECL Technology for storing CO₂ in A Forties-type sector model lead to: (a) increased oil recovery of of 8-10% over the base waterflood case, (b) CO₂ sequestration of approx. 50 % HCPV (Hydrocarbon Pore Volume), (c) optimising CO₂ storage aids oil recovery, and (d) fluid redistribution after shut-in shows gas migration to top and under shales.

[From the final report by ECL Technology: Modelling of CO₂ Storage in the N. Sea Forties Oil Reservoir (09/2002). The objective of the study was to investigate the optimisation of incremental oil recovery and the sequestration of CO₂. It was conducted using numerical simulation to represent a sector of the Forties Charlie sand. The model was initially waterflooded and then was subjected to WAG (Water Alternating Gas) with CO₂ being the injection gas. A range of simulations were performed to investigate various effects including different WAG strategies, timing of initiation of postflush gas injection, well placement and well completions. The initial model contained approximately 21 MMrB of single-phase reservoir fluid oil and 5 MMrb of water.

Conclusions drawn from this study: (a) increased oil recovery of 8-10% over the base waterflood case, (b) CO₂ sequestration of approx. 50 % HCPV (Hydrocarbon Pore Volume) can be achieved, (c) techniques to optimise the CO₂ storage also aided oil recovery, (d) the use of WAG accelerated oil production and (e) significant fluid redistribution occurred after the reservoir was shut-in, with gas migration to the top of the reservoir and under shales.

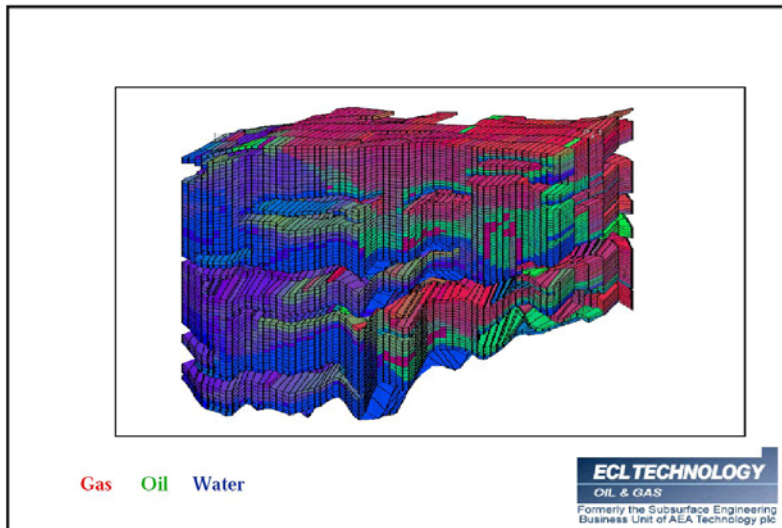
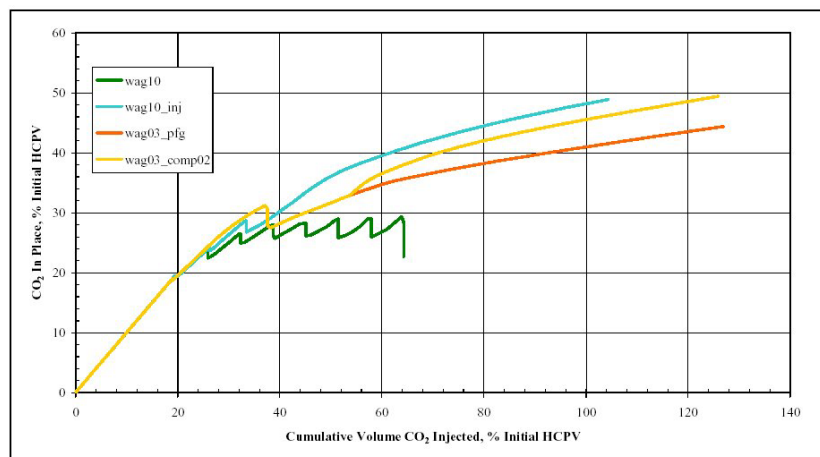


Figure 27: Fluid Redistribution at 2150 (Case : wag03_comp01)



ECL TECHNOLOGY
OIL & GAS
Formerly the Subsurface Engineering
Business Unit of AEA Technology plc

Storage of CO₂ in Depleted Petroleum Reservoirs Using Equilibrium Modelling. A prototype study of CO₂ injection and subsequent geologic storage has been carried out on the Forties Field, UKCS, using the MPath petroleum migration toolkit, by J. Bunney, Permedia Research Group. The primary objectives of the study were to validate the simulation approach, develop a time-realistic work flow to assess potential storage volumes and key risks to retention, illustrate the relative storage capacity of a reservoir to the petroleum fluid versus dense CO₂, and to develop a risking model to identify key data short-comings and potential failure modes.

The model was then 'filled' with the observed petroleum fluid, and the emplacement timing and spatial distribution were observed. A number of scenarios were developed to approximate the geologic sourcing of the petroleum e.g. did it fill the reservoir from a number of geographically diverse source points or from a single direction? The petrophysical properties of the top seal were systematically varied and the dependant volumetric capacity of the reservoir was quantified. A very good match was identified for one of the filling scenarios, the known oil in place and the distribution of the known oil within the reservoir.

The fluid properties were then changed from a reservoir oil to a dense CO₂ fluid, and the filling scenarios repeated. The trend in injected fluid volumes and saturation distribution follows the direction expected when substituting in a slightly more buoyant fluid with a lower interfacial tension. In this way, equivalent CO₂ storage volumes were determined for each scenario and a possible storage volume 'envelope' was produced.

BGS: Sequestering CO₂ from Grangemouth Complex

BGS is examining the potential to sequester the CO₂ underground in the Midland Valley of Scotland and nearshore areas off the east coast of Scotland. Tasks completed to date include:

1. Geological map of the Midland Valley and surrounding areas showing 100 km circle round Grangemouth refinery/petrochemical complex. Completed and entered into ArcView
2. Map showing distribution of seismic data in the Midland Valley. Completed and entered into ArcView
3. Generalized depth contours on the base of the Carboniferous. Completed and entered into ArcView
4. Generalized depth contours on top of Lower Carboniferous. Completed and entered into ArcView
5. Generalized depth contours on base Coal Measures. Completed and entered into ArcView
6. Map showing location of PEDL's and Mining Licenses, existing coal mines, abandoned deep mines, location of Airth CBM project. Deep mines abandoned between 1947 (nationalisation) and present entered into ArcView.

BGS is examining alternatives to sequestering the CO₂ from the Grangemouth refinery/petrochemicals complex in the Forties field. In more detail, BGS is examining the potential to sequester the CO₂ underground in the Midland Valley of Scotland and an area off the east coast of Scotland between 55° 50' N, 57° 20' N, the inshore limit of the Zechstein at approximately 2° 24' W and 0° 00'. BGS is also interpreting 2 regional seismic lines to form the basis of 2D models of natural fluid flow in the Tertiary strata from the Forties area towards the Scottish coast. Work completed in November: The text of the draft report on the potential to sequester CO₂ in the Midland Valley of Scotland, due end December 2002, is being edited and the figures are being drafted. The first cross section from the Forties area towards the Scottish coast has been delivered to GEUS for comment & further development.

IFP+GEUS: Basin Modelling

June 2002 Aberdeen Meeting: During 18-19 June 2002 GEUS, IFP, GEUS, AEAT & BP personnel met in Aberdeen to crystallise the project's data requirements and deliverables timing. The meeting was organized by Steve Cawley, BP, Aberdeen. The objectives of the meeting were to bring the various participants together and see demonstrations of the basin modelling software which will be used by participants, give the BP Forties Business Unit subsurface staff an idea of data demands for project work, get a workflow and plan together, and study the results of reservoir CO₂ storage using the equilibrium-relations software employed by Permedia Research & funded by BP. Details of all presentations are to be found at the project's QP collaboration site.

The "data mining" project in Aberdeen - to collect the necessary input data for the basin modelling studies – was finished in August 2002; it was supervised by Steve Cawley (BP) and carried out by RML (BP contractor). In September IFP & GEUS received the following data for the area of interest (approximately 50 x 50 km encompassing part or all of the following blocks surrounding the Forties main-field area):

1. **Structure maps** : in time (TOP CHALK, BASE CHALK, TOP ALBA, TOP PALAEOCENE, TOP FORTIES), in depth (mbmsl) (BASE UPPER JURASSIC)
2. **BGS Maps:** Solid geology and sea bed sediment
3. **THEMIS data:** MEDICA grids (horizon and structural maps)
4. **Logs** : all available

In the Sept. 2002 meeting IFP discussed the following work plan methodology:

1. THEMIS output (water velocity, reservoir and its relevant surrounding layers cap-rock /aquifer) as boundary conditions for SIMUSCOPP.
2. MPATH (Permedia Res. Software) output as initial conditions for SIMUSCOPP.
3. SIMUSCOPP a reservoir-like (coarse grid) flow simulation of CO₂ behavior at end of CO₂ injection to quantify CO₂ migration out of the reservoir (mostly through aquifer hydrodynamics).

Risk Assessment Workshop for the Geological Storage of CO₂. To review the approaches used for risk assessment of various modes of geological storage of CO₂, the NGCAS project organized a risk assessment workshop, in direct alignment with the AEAT & BGS deliverables and as one of the workshops promised under the technology transfer obligations. The workshop was held 29-30th May 2002 at the British Geological Survey offices at Keyworth near Nottingham, UK, with 35 delegates attending.

The project groups agreed that a considered auditable approach to risk assessment was essential and that the risk assessment methodology developed for the nuclear waste industry should be drawn upon. The projects agreed to share data, to assist in avoiding duplication and work towards building common features & databases and to promote information dissemination.

An article on NGCAS was submitted for publication in the "Greenhouse Issues" published by the IEA Greenhouse Gas R&D Programme.

Publication of the Clean Coal Technology Newsletter. In summary:

- Collected the latest information about "Operational Experience" of the ELCOGAS IGCC Plant in Puertollano.
- Analysed the possible Newsletter structure: Puertollano plant experience, interview of ELCOGAS General Manager, interview of Dr. de Sampaio Nunes, News about NGCAS.
- The de Sampaio interview could be about the relationship of NGCAS/IGCC and about the situation of the VI FP.
- The N°16 Newsletter could be printed by November/December. The second newsletter (N°17), would be printed one year later, and could incorporate in more extended space the situation of NGCAS project. - The N°17 Newsletter will be more direct responsibility of FZJ.

In detail & as reported by CIEMAT: The main objective of this activity is the promotion of Clean Coal Technologies for large-scale power generation and projects results to inform to all the target audience about the state of the art of such topics. The aim of this action is also to continue with the series publication of CCT NEWSLETTER, which has been published since 1992: 20 Newsletters. The Newsletter offer relevant information on European CCT Projects to a wide range of decision-makers: Utilities R&D Centres, Financial Services, Technical Groups. Etc.

For this action we have considered the following three working packages (WP):

WP1: Kick-off-Meeting.

WP2: CCT Newsletter N° 16

WP3: CCT Newsletter N° 17

1.- Kick-off-Meeting

This meeting was held in BP Sunbury site bldg 200, in occasion of the general Kick-off-meeting of the Global CLUSTER-Project, in order to define the contents, layout, possible evolutions and modifications, collaborations, etc. There were indicate that the services of a professional journalist will be used for:

Avoid too technical details without omitting important technical issues.

Use a crisp language and make the Newsletter attractive.

And the distribution is crucial, the Newsletter will be distributed by mail (OPET Net) and via INTERNET

There were considered the following main tasks:

Task-1: Collection of information, pictures and diagrams; interview; elaboration of text draft; layout; revision of final draft; Commission approval; document ready for printing.

Task-2: Printing of 4,000 copies of newsletters.

Task-3: Distribution by mail to selected entities in all countries (OPETs). The partners will distribute the newsletter in each own country.

Task-4: Preparation of texts for introduction into INTERNET

NEWSLETTER N° 16: IGCC of ELCOGAS in Puertollano and first news about the NGCAS of CO₂; and other possible project news.

NEWSLETTER N° 17: The whole issue devoted to the NGCAS - CO₂, as the most important target to be considered at present; and other possible projects news, included IGCC-Puertollano.

2.- Follow-up General CLUSTER Project.

Our activity about the global Cluster Project has been only the gathered of the information produced, mainly via Internet.

3.- Permanent contacts with ELCOGAS Technical Personnel.

In order to maintain the knowledge about the new results of the operation of the IGCC Puertollano Plant, we have been continuously in contact with the more relevant technicians of the ELCOGAS company. With this practices we have no got only all the main information about the evolution of the IGCC Process running and results, but also we have got the information about all the new improvements that the ELCOGAS Engineering and R&D Department have implemented along all this period of time. As consequence, we have gathered interesting information for writing the fist draft of the Newsletter.

4.- Doctoral Thesis about IGCC Process.

As consequence of the important technological development activities carry out in the IGCC process of Puertollano Power Plant, it has been possible to take advantages of that for the realisation of a doctoral level work, named: *"Gasification of Solid Fuels: Phenomenology and Parameterisation of Performance and Behaviour of the Mineral Matter"*. The Doctoral Thesis, consider the following chapters about the themes:

The gasification role for electric generation and gas sources from coal.

Future energy scenery and the necessary increasing of the coal consumption in the electricity production.

Phenomenology and basic concepts and characteristics of the gasification process.

The IGCC Puertollano process and its special innovations, as reference plant. Environmental conditions.

Mineral matter behaviour. Fouling and slagging problems. Slag applications.

Results of experimental trials and deposits characterisation.

Consideration of other applications in the world, and the challenge of the IGCC systems: Availability, flexibility, and cost reductions.

Discussion of results, conclusions, future developments and improvements

This new type of information could be also taken into account for our objective, in order to enrich the content of the newsletter, in some way.

5.- Consolidated Report.

As a process of updated mentioned information, we have got a consolidated report that can be considered as fundamental base for the content of the newsletter n°16. This report has the following scheme:

OPERACIONAL EXPERIENCE OF THE PUERTOLLANO IGCC PLANT

ELCOGAS DESCRIPTION AND TECHNOLOGICAL STRUCTURE

- Shareholders and main suppliers contributions
- Fuel and clean gas data
- Environmental achievements
- Gasifier main equipment
- Gas turbine main equipment

POWER PLANT RELEVANT MILESTONES

- Synchronisation of turbines
- Commercial operation of combined cycle with natural gas
- First switch over from natural gas to syngas in the gas turbine
- 3.10⁶MWh with coal gas as IGCC

OPERATIONAL DATA

- Fuel mode

- Gross and net production
- Gross and net efficiency
- Variable production costs in favour of coal gas

IMPROVEMENTS FOR FUTURE IGCC PROCESS

- Equipment and system
- Potential efficiency improvements
- Investment cost reductions
- Operational costs reductions

THE FUTURE OF THE PUERTOLLANO IGCC TECHNOLOGY

6.- First approach of newsletter structure.

In connection with the technological experienced journalist, in order to agree the layout of the newsletter, we have considered the following improvements of the basic mentioned report, as questions:

1. What is the front cover story about?
2. What would the interview subject for ELCOGAS representative?
3. What would be the interview subject for COMMISSION representative?
4. What is new and worth reporting about the Project Updated?
5. What is interesting new learning about the IGCC technology?
6. What does ELCOGAS have to say that is interesting to stakeholders?
7. What diagrams, photographs, illustrations, logos need to be gathered?

We can get it in more or less extended way from the consolidated report, but now is the moment for to decide the best considerations from ELCOGAS and from the COMMISSION. We have asked them about.

7.- New ELCOGAS last contacts.

Transmission to ELCOGAS the last idea of the possible newsletter structure in order, both, to get their approval and to take more updated information. Now, people of the Technological Centre of ELCOGAS, is working in this subject.

8.- Journalistic arrangements.

We have been in contact with the Journalist, specialised in technical articles, in order to agree the habitual conditions for this kind of works, costs, activity schedule, etc.

We have considered all the actions it is necessary to do, as:

Fist newsletter draft

Travel to Brussels

Interview to the Commission representative

Travel to Madrid and Puertollano

Interview to ELCOGAS representative

Prepare the printing maquette in printing office

Publication design

And finally we have got the total budget for all this works.

9.- Commission contacts.

We have made the adequate contacts in the Commission, through the corresponding project manager official, in order to get the approval and dates for the Commission representative interview.

10.- ELCOGAS interview.

Preparation of the ELCOGAS representative interview scheme and possible dates of celebration.

Coordinator's Particulars



Demetrios V. Yannimaras, PhD

BP

UTG, Reservoir Engineering

Compass Point 3/73

79-87 Kingston Road

Staines, Middlesex TW18 1DY, UK



yannimdv@bp.com



local: 01932+762673

international: ...+44+1932+762673

Fax: ...+44+(0)1932+744833

Table I. Total Project Budget & Sources of Funding.

NGCAS (Next Generation Capture and Storage) CO2 Consortium Budget

2-Year CCP Summary, \$US 1=Euro 1							
<i>Participant Name</i>	<i>Total Costs</i>	<i>% EU</i>	<i>EU Contribution</i>	<i>Total CCP Contribution</i>	<i>EU Payments Received</i>	<i>Participant's First EU Payment</i>	<i>2002 CCP Contribution</i>
BP UTG is coordinator					On 03May02 EU paid € 155,137.20		
Total co-ordinator costs	€ 330,712	50.0%	€ 165,356	€ 165,356	which is (£1=euro1.63)	€ 49,606.8	€ 82,678
AEAT	€ 178,437	50.0%	€ 89,219	€ 89,218	0.30	€ 26,765.7	€ 44,609
IFP	€ 100,000	50.0%	€ 50,000	€ 50,000	of total.	€ 15,000.0	€ 25,000
NERC (BGS)	€ 100,000	50.0%	€ 50,000	€ 50,000		€ 15,000.0	€ 25,000
GEUS	€ 99,928	50.0%	€ 49,964	€ 49,964		€ 14,989.2	€ 24,982
IEA GHG	€ 99,426	50.0%	€ 49,713	€ 49,713		€ 14,913.9	€ 24,857
STATOIL	€ 20,000	50.0%	€ 10,000	€ 0		€ 3,000.0	€ 0
CIEMAT	€ 48,552	68.5%	€ 33,273	€ 15,280		€ 9,981.8	€ 7,640
FZJ	€ 28,600	68.5%	€ 19,600	€ 9,100		€ 5,879.9	€ 4,550
Check Sums			€ 517,124	€ 995,755			
TOTAL	€ 1,005,655	51.0%	€ 517,124	€ 478,631		€ 155,137.2	€ 239,316

Table II: NGCAS CONTACTS

Company	Name	E-Mail	Tel. No	Address
BP	Steve Cawley, Alba Gate AF26	cawleysj@bp.com	+44 (1224) 833 937	Bp Exploration Operating Co. Ltd Farburn Ind'l Est., Dyce Aberdeen, AB21 7PB, UK
BP	Tony Espie, 200 / 144	espjet@bp.com	+44 (1932) 763 780	Bp Exploration Operating Company Ltd
BP	Steve Hall	halls@bp.com	+44 (1932) 763 574	Chertsey Road, Sunbury upon Thames,
BP	Graham C. Perry	PerryGC@bp.com	+44 (1932) 739 603	
BP	Hargrove, John	hargrgj@bp.com	+44 (1932) 762393	
BP	Demetrios V. Yannimaras	yannimd@bp.com	+44 (1932) 762 673	Middlesex TW16 7LN, UK
ECL Technology				ECL Technology plc
	Laurence Wickens	laurence.wickens@ecl-winfrith.com	+44 (1305) 203 446	A31, Winfrith, Dorchester
	Sue Bridle		+44 (1305) 202 347	DT2 8ZE, UK
SERCO ASSURANCE	William Rodwell	william.rodwell@sercoassurance.com	+44 (1235) 432 039	Serco Assurance 4244 Harwell, Didcot
				Oxon, OX11 0QJ, UK
BGS	Sam Holloway	shol@bgs.ac.uk	+44 (115) 936 3190	(British Geological Survey)
	Dr. Nick Riley	njr@bgs.ac.uk	115 936 3312	Kingsley Dunham Centre Keyworth, Nottingham
				NG12 5GG, UK
	Mike Browne	maeb@bgs.ac.uk	+44 (131) 650 0289	BGS
	Sarah Arkley	slba@bgs.ac.uk	+44 (131) 650 0295	Murchison House West Mains Road, Edinburgh
				EH9 3LA, UK
IIFP	Etienne Brosse	Etienne.Brosse@ifip.fr	+33 (1) 4752 6816	Institut Francais Du Petrole
	Pierre Le Thiez	Pierre.Le-Thiez@ifip.fr	+33 (1) 4752 6723	BP 311
RF20, Div. Ing. de Resvoir	Yann, LeGallo	Yann.LE-GALLO@ifip.fr	33+(0)1+4752 6745	Fax: +33+(0)1+47 52 56 17
	Frederic Schneider	Frederic.Schneider@ifip.fr7001	1 & 4 Avenue de Bois-Preau
	Bernard Carpentier	Bernard.CARPENTIER@ifip.fr	+33 (1) 4752 6519	92852 Rueil-Malmaison Cedex - FRANCE
GEUS	Mr Niels Peter Christensen	npc@geus.dk	+45 (38) 142 153	Geological Survey of Denmark & Greenland
	Torben Bidstrup	tb@geus.dk	+45 (38) 142 501	Oster Voldgade 10
			switchboard: ... 2000	DK-1350 Copenhagen K, DENMARK
IEA-GHG	Mr John Gale	JohnG@ieagreen.demon.co.uk	+44 (1242) 680 753	IEA Greenhouse Gas R&D Programme Stoke Orchard Cheltenham, GL52 4RZ, UK
STATOIL	Ms Trude Sundset	Trude.Sundset@statoil.com		Den Norske Stats Oljeselskap A.S.
	Bjorn Berger	BBER@statoil.com	+47 480 34 885	Posttuttak
	Hans I. Almaas	HIAL@STATOIL.COM	+47 480 34 715	N-705 Trondheim, NORWAY
CIEMAT	Dr Marian Ferre	m.ferre@ciemat.es	+34 91 346 63 43	Centro De Investigaciones Energeticas,
	Dr Fernando Alegria	fernando.alegria@ciemat.es		Medioambientales Y Tecnologicas
				Avd. Complutense, 22
				Madrid, 28040, SPAIN
FZJ	Rainer Schneider	r.schneider@fz-juelich.de		Forschungszentrum Juelich GmbH PB 1913
				Leo Brandt Strase
				Juelich, 52425, GERMANY

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Welcome to the CO₂ **N**ext **G**eneration **C**apture **A**nd **S**torage Project

co-funded by the EU Fifth Framework Programme & the CO₂ Capture Project JIP .

This room is managed by Demetrios Yannimaras (yannimdv@bp.com) and Tony Espie (espieaa@bp.com). The site is intended to:

- Provide information about the project,
- Enable participants to upload reports and summaries, and
- Offer information exchange & communications

Please click on sidebar items (on the left-hand side) to access the site features.

Most participants will be accessing this 'Room' with 'Author' privileges; this means you can upload and edit your own documents only, and read all other documents. Before uploading new documents, please view the training documentation available on this site.

[Click here to view training documentation](#)

Participating Companies and Organisations

Figure 1. NGCAS Collaboration Site Opening Screen.