IMPACTS

Project no.:
308809

Project acronym:
IMPACTS

Project full title:
The impact of the quality of CO_2 on transport and storage behavior

Collaborative large-scale integrating project

FP7 - ENERGY.2012-1-2STAGE

Start date of project: 2013-01-01
Duration: 3 years

D 4.2.3
Annual report on dissemination activities 2014

Due delivery date: 2014-12-31
Actual delivery date: 2015-03-15

Organisation name of lead participant for this deliverable:
SINTEF Energi AS

Project co-funded by the European Commission within the Seventh Framework Programme (2012-2015)		
Dissemination Level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential , only for members of the consortium (including the Commission Services)	

Deliverable number:	D 4.2.3
Deliverable name:	Annual report on dissemination activities
Work package:	WP 4.2 Project dissemination
Lead participant:	SINTEF ER

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Abstract

This deliverable reports the dissemination activities performed in IMPACTS during 2014. The dissemination activities are organized under the work package (WP) 4.2 Project dissemination, but dissemination also occurred in other WPs, for example as journal publications, presentations, meetings and workshops or courses and summer schools.

TABLE OF CONTENTS

1 INTRODUCTION

IMPACTS is a collaborative project co-funded by the European Commission under the 7th Framework Programme. The objective of IMPACTS is to develop the CO_2 quality knowledge base required for defining norms and regulations to ensure safe and reliable design, construction and operation of CO_2 pipelines and injection equipment, and safe long-term geological storage of CO_2. By this, IMPACTS supports the objectives of the Innovation Union and contributes to the implementation of large-scale CCS and the competitiveness of the European CCS industry.

The dissemination activities of IMPACTS are organized under work package (WP) 4.2 Project dissemination. Typical activities are development of the project website, newsletters, meetings and workshops, courses, summer schools, deliverables from the project and publications and media contributions. Even though WP4.2 has the overall responsibility for dissemination in the project, many activities will also be performed by the other WPs, such as journal publications, presentations, meetings and workshops or courses and summer schools.

This deliverable gives an overview dissemination activities performed in IMPACTS for 2014.

IMPACTS GOAL:

To develop the CO_2 quality knowledge base required for defining norms and regulations to ensure safe and reliable design, construction and operation of CO_2 pipelines and injection equipment, and safe long-term geological storage of CO_2

2 WEBSITE

As a part of the running dissemination activities a website for the IMPACTS project was established in 2013. The website is an information channel and a source of public project information and results. The web-address is http://www.sintef.no/impacts

Information about the project like objectives, project overview, activities and participants are given here. The website has been continuously updated with public information about project news, reports and publications.

The original website was launched in January 2013. During 2014 a major reorganization of the IMPACTS web site was performed and the new version of the web site was issued in December 2014. Two example pages from the website are shown in the figures below.

Figure 1: IMPACTS website (start page) as per December 2014.

Figure 2: Example from results section of IMPACTS web page 2014

2.1 Blog

A new addition to the IMPACTS web site during 2014 was the IMPACTS blog. The plan is for all the WP leaders in IMPACTS to contribute to the blog. During 2014 three IMPACTS blogs were published. They can be found on the IMPACTS web site and are also reprinted here.

2.2 Blog: Why is Mr. Petrov so engaged?

Posted on 17. oktober 201414. november 2014 by BIGCCS

Blogger: Mona J. Mølnvik

In a small room “hidden” in a laboratory at Gløshaugen in the city of Trondheim, Norway, a meeting took place this week between the PhD student Snorre Foss Westman from NTNU, Researcher Sigmund E. Størset from SINTEF Energy Research and Scientific Officer Mr. Petrov from the European Commission.

Mr. Petrov was visiting to discuss the mid-term evaluation of the EU project IMPACTS under the 7th Framework Programme. One objective of IMPACTS is to develop the CO_2 quality knowledge base required for defining norms and regulations to ensure safe and reliable design, construction and operation of CO_2 pipelines and injection equipment.

Since Mr. Petrov already was visiting Trondheim, he wanted to see relevant laboratory activities. The test-rig that Mr. Petrov inspected, is found in a slightly worn room. This does not go for the equipment that will generate data on phase equilibrium of CO_2 mixtures. This equipment, which holds more “Rolls Royce standard” is not possible to buy anywhere, it had to be developed by the researchers, and the hurdles to overcome to achieve the desired accuracy have been many and challenging.

From left SINTEF researcher Sigmund Ø. Størset, scientific officer at the European Commission Petre Petrov, and doctoral student Snorre Foss Westman. (Photo: SINTEF)

What makes Mr. Petrov is so engaged is that he has just learned that the equipment developed in the KPN project CO2Mix under the FME BIGCCS, can probably provide the most accurate data for the phase equilibrium of CO_2 mixtures world-wide.

This means that when Snorre has made his data-sets for a specific mixture and temperature, it is not necessary to repeat them. It is perhaps a little sad, but not when you consider how many possible mixtures of CO_2 there are.

And what do we need such data for? In a future where much of the CO_2 emissions must be addressed, i.e. they must be collected, transported and injected into the subsurface, it is crucial that this is done in a safe and efficient manner. Knowledge of the state of gas mixes – i.e. if the mixture is in the gas phase or the liquid phase at different pressures and temperatures will be critical for designing efficient and safe transport of CO_2.

And what does it mean? Yes, that means that this work helps scientists make large-scale implementation of CCS possible.

2.3 Blog: IMPACTS and BIGCCS visit partners in Bochum in Germany

Blog: IMPACTS and BIGCCS visit partners in Bochum in Germany

Posted on 11. november 2014 by BIGCCS

Blogger: Sigmund Størset

Ruhr Universität Bochum has over 40,000 students and 4,500 permanent employees. Here you can study everything from film, language and African culture, through history, engineering and astrophysics, to gases' thermophysical properties. And precisely because of this last thing were participants of the EU project IMPACTS gathered in Bochum two days in the end of October.

The host for the visit was Professor Roland Span, professor within the field called thermophysical properties.

Late October this year, the IMPACTS project met for a technical workshop and board meeting in Bochum, and we had the opportunity to visit his very interesting laboratories. SINTEF researcher Halvor Lund listens closely to what Professor Roland Span, the man behind the Span-Wagner equation of state, has to tell. (Photo: SINTEF/Sigmund Størset)

Late October this year, the IMPACTS project met for a technical workshop and board meeting in Bochum, and we had the opportunity to visit his very interesting laboratories.

Posted on 11. november 201414. november 2014 by BIGCCS

Latest news

- BIGCCS contributions at the CLIMIT Summit 2015
- Why good models are important for safe and efficient CO2 transport
- Record interest in TCCS-8
- SINTEF and NTNU CCS Award – Seeking nominations
- Trondheim CCS Conference – TCCS-8

Monthly archive

- mars 2015
- februar 2015
- desember 2014
- november 2014
- oktober 2014
- august 2014
- mai 2014
- april 2014
- mars 2014
- oktober 2013

The IMPACTS project concerns pipeline transport of CO_2 as an integral part the CO_2 capture and storage concept. During such transportation, knowledge of CO_2 gas properties such as thermal conductivity, viscosity, pressure and temperature of transition between the phases (solid-liquid-gas) and other are important and essential.

This has been Professor Roland Spans' area of research for many years, both in determining these properties accurately in the laboratory and predicting the properties by developing equations that say something about how CO_2 will behave under different pressures and temperatures.

Professor Span is also one of the researchers behind the Span-Wagner equation of state. This is an equation which predicts the behavior of pure CO_2 very accurately, and which is widely used for us who work with CO_2 capture, transport and storage.

Professor Roland Span and his research group are partners of the IMPACTS project and they contribute with both experimental and theoretical research.

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IMPACTS is a large European research project under the 7th Framework Programme coordinated by SINTEF Energy Research. The project deals with the transport of CO_2 in pipelines as an intermediary between CO_2 capture and CO_2 storage. More specifically, the project will work on identifying how the impurities of gases other than CO_2 affect how the CO_2 behaves during transport in a pipeline. This is important to know in order to avoid gas mixtures that may form solid phases which could block the pipeline, or mixtures which provide such high pressure that the pipe can crack open.

Several of SINTEF researchers participating in the IMPACTS project are also key researchers in BIGCCS and have gained significantly from research in the center. Professor Roland Span also contributes to the BIGCCS centre.

Del

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NTNU

Blogger: Sigmund Størset

from research in the center. Professor Roland Span also contributes to the BIGCCS centre.

3 NEWSLETTERS

An electronic newsletter is distributed via email to the IMPACTS consortium and another 300 recipients in the SINTEF CCS email list every six months. The IMPACTS participants are also encouraged to further spread the newsletter in their networks. The third newsletter appeared in June 2014 and the fourth newsletter appeared in December 2014. The newsletters are prepared by TNO with input from all participants, and summarize the project progress, events, meetings and publications in the last six month period.

The Front page of Newsletter 3 is shown in Figure3. The newsletter can be found on the IMPACTS web page at the following link: http://www.sintef.no/globalassets/project/impacts/impacts-newsletter-3---july-2014.pdf
Newsletters 3 and 4 who were issued in 2014 are also shown in their entirety as Attachment 1 to this report.

3rd Newsletter, July 2014

Dear reader,

Before you is the third edition of the IMPACTS newsletter, covering the period January – Juli 2014. The newsletters inform partners and stakeholders on the developments in the EU FP7 IMPACTS project[1]. You can navigate through this document by clicking on the elements of the content list (below).

Previous newsletters:

- Newsletter 1, January – July 2013
- Newsletter 2, July- December 2013

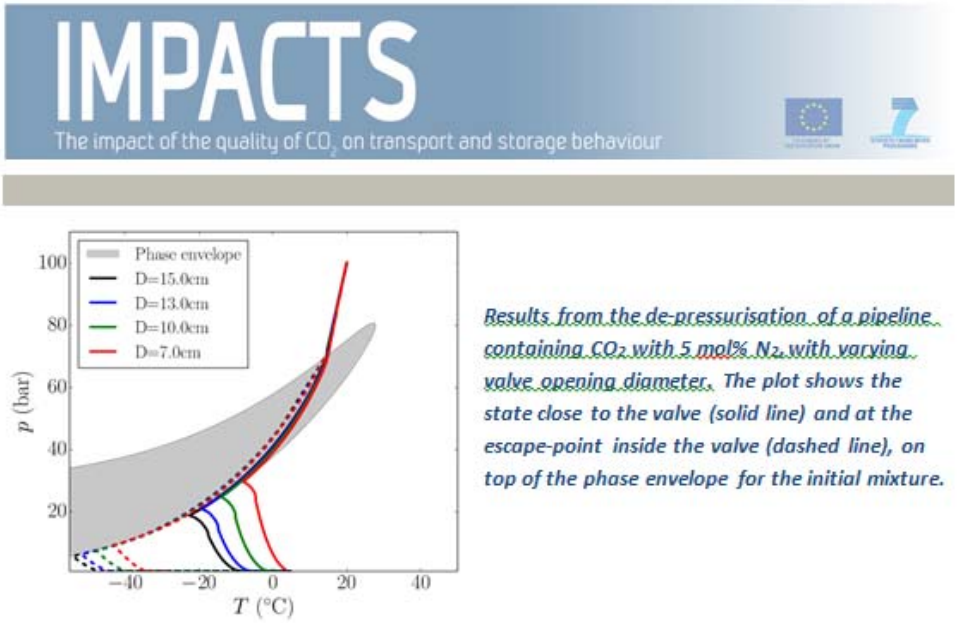
Contents of this newsletter

- About IMPACTS
- Events & meetings
- Current activities
- Publications
- Contact information

About IMPACTS

IMPACTS is a collaborative project co-funded by the European Commission under the 7th Framework Programme. The goal of the IMPACTS project is to close knowledge gaps related to transport and storage of CO_2-rich mixtures from various CO_2 sources to enable realisation of safer and more cost-efficient solutions for CCS. The results of IMPACTS will help to ensure safe and reliable design, construction and operation of CO_2 pipelines and injection equipment, and safe long-term geological storage of CO_2. The project started on 1 January 2013 and has a duration of three years. It has 12 research performing partners and 5 funding partners. You can find more information on the project website.

Figure 3: IMPACTS newsletter 3 -June 2014



Results from the de-pressurisation of a pipeline containing CO_2 with 5 mol% N_2 with varying valve opening diameter. The plot shows the state close to the valve (solid line) and at the escape-point inside the valve (dashed line), on top of the phase envelope for the initial mixture.

The second report contains a benchmark of three different simulation tools for CO_2 pipeline: The commercial simulator OLGA, ANSYS Fluent with CSM's thermodynamic library CO_2 GASMISC, and SINTEF Energy Research' in-house code. Both steady-state flow and depressurization and filling of a pipeline were considered, with impurities typical for various capture processes. Especially for depressurization and filling some discrepancies were found between the various tools. The report shows that simulation of two-phase flow of CO_2 with impurities still requires more research.

WP1.4 Corrosion potentials in CO_2 infrastructure

Corrosion and test corrosion tests are ongoing. Three different pipeline materials have been selected for the testing activity:

- Grade X60
- Grade X65
- Grade X70

The test corrosion testing activity will include measurements on samples cut out form a girth weld. All the samples have been machined. All the testing activity will finish in the first months of 2015.

WP1.5 Chemical and physical effects of impurities on CO2 storage

Within the last months the work performed in WP1.5 made a great step forward towards understanding the physicochemical effects of an impure CO_2 stream in the deep subsurface during injection and subsequent storage. Reservoir engineering simulations were conducted, considering mixture of gases, like CO_2 and SO_2, and assessed the influence of the various impurity concentrations in the CO_2 stream on e.g. the pressure development and storage capacity. In addition, the presence of CO_2 and additional substances has varying influences on chemical fluid-rock interactions and results most notably in dissolution of primary minerals and the precipitation of newly formed phases, causing changes in porosity and permeability. By using geochemical modelling tools we showed that the presence of SO_2 may have a significant influence on the porosity evolution of the

The newsletter in its entirety can be found on the IMPACTS web page here:
http://www.sintef.no/globalassets/impacts-newsletter-4---december-2014.pdf

Figure 4: Excerpt from IMPACTS Newsletter # 4 December 2014

4 PUBLIC MEETINGS AND WORKSHOPS

4.1 Visit to the CO2Quest project, 14-15 April at University College London

The coordinator of the EU FP7 project CO2QUEST invited the IMPACTS project to an open dissemination workshop on the 14 and 15 April 2014, hosted at University College London. Other EU FP7 projects related to CCS were invited to participate and give a presentation:

- IMPACTS
- OCTAVIUS
- CO2 MUSTANG
- CO2 Panacea
- CO2 PipeHaz
- IOLICAP
- CO2 TRUST

The SP1 and SP2 leaders, Alexandre Morin and Charles Eickhoff were given the opportunity to present the IMPACTS project as a whole, the work within modelling of flows in pipeline and the techno-economic analysis of the CCS chains. The agenda, as well as a report of the event are available at the UK CCS Research Centre website.

4.2 IMPACTS Contributions at GHGT-12, Austin Texas, Oct 4-9, 2014.

Impacts was represented with 2 posters:

- IMPACTS: economic trade-offs for CO_2 impurity specification
  Charles Eickhoff a*, Filip Neeleb, Morten Hammerc, Massimo DiBiagiod, Cor Hofsteeb, Marielle Koenenb, Sebastian Fischere, Anastasia Isaenkof, Andy Browna, Timea Kovacs

- N_2-CO_2 co-injection field test at Ketzin pilot CO_2 storage site, Dr Sebastian Fischer - GFZ German Research Centre for Geosciences - GERMANY

4.3 IMPACTS Informational Workshop at GHGT-12

October 7th, 2014, *14:15-15:55*

A public IMPACTS informational workshop was held during the GHGT 12 meeting in Austin on October 7th, 2014. Marit Mazzetti gave an overview presentation of IMPACTS. Marie Bysveen also from SINTEF gave an overview of the EERA CCS project. Then all the work packages gave a presentation Jacob Stang from SINTEF represented WP1 talking about impact of impurities in CO_2 transport. And Sebastian Fischer from GFZ showed results from the important CO_2/N2 injection experiments at Ketzin. Filip Neele presented the work to be performed in WP3 as that has just now started. There was great interest in the techno economic assessment and the tools that are under development in WP3. The techno-economic tool aims to study the relation between CO_2 quality and the cost of constructing and operating a CCS system (including capture, transport and storage).

There was also an interesting guest lecture by Rebecca Hollins from CO_2 Global, USA. As Texas has the longest experience with operating CO_2 pipelines in the world, it was interesting to learn from the US Experience of impact of impurities in CO_2 pipelines.

The US has an extensive network of CO_2 pipelines as can be seen from the picture from Dr. Hollis's presentation shown below. The US pipelines are regulated by the US Department of Transportation. The CO_2 pipelines are not hazardous. A 90% molar purity is required for supercritical. Pressure rating is 2-3000 psig, about 3 times that of natural gas pipelines.

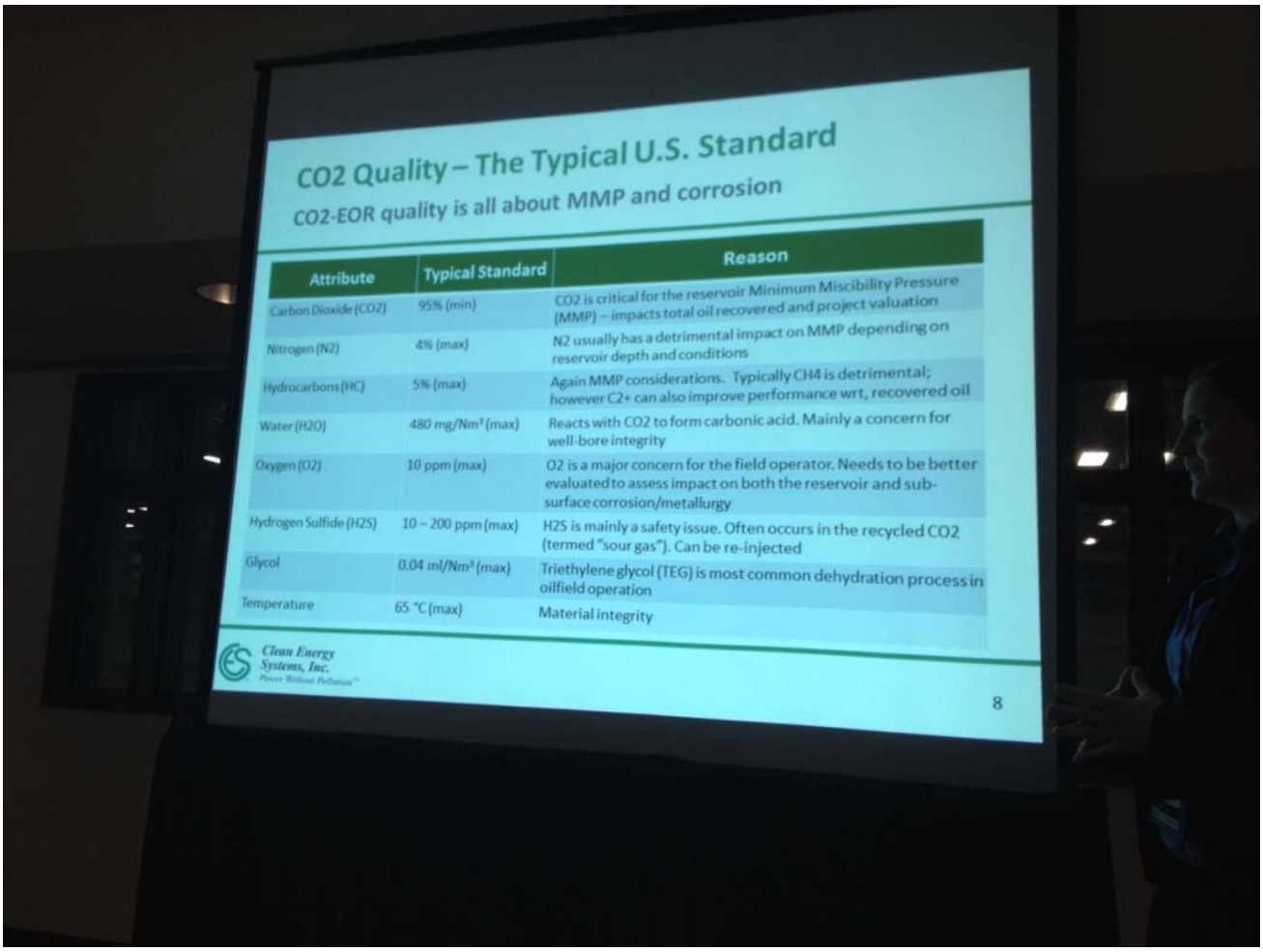
The standard in the US has been CO_2 for use in EOR. The CO_2 quality is therefore all about corrosion and MMP (Minimum Miscibility Pressure) which impacts total oil recovered and project valuation. The CO_2 is set to 95% purity. The nitrogen is limited to 4 % as it usually has a detrimental impact on MMP depending on reservoir depth and conditions.

Oxygen is set at 10 ppm max. It is a major concern for the field operator. It needs to be better evaluated to assess impact on both the reservoir and sub-surface corrosion/metallurgy. There is a H_2S requirement set at 10-200ppm (max.). It is a safety issue. It can be re-injected however. Points brought up for further consideration was:

- There is extensive experience with $CO_2$for EOR, however there is little compatibility with this and the requirements for storage in Deep Saline Formations (DSF)
    - DSF is more related to criteria for environment and safe drinking water
- There also remain challenges for defining CO_2 quality criteria with various capture technologies that require differing downstream CO_2 processing and clean-up.

Overall it was an interesting workshop with great interaction and discussions among the participants.

IMPACTS Information workshop, GHGT12



Summary of the US Standard for CO2 Quality by Rebecca Hollins, Clean Energy Systems, USA

Impacts Informational Workshop Programme

14:15-14:30: Welcome and Introduction to the IMPACTS project
Marit Mazzetti, SINTEF

14:30-14:40: The EERA CCS project
Marie Bysveen, SINTEF

14:40-15:00: EOR requirements for CO_2 quality and composition- Experience from US Projects
Rebecca Hollis, Clean Energy Systems

15:00-15:15: Impact of impurities on CO_2 transport
Jacob Stang, SINTEF

15:15-15:30: Results from CO_2/N_2 injection experiment
Sebastian Fischer, GFZ

15:30-15:45 Techno-economic evaluation in Impacts
Filip Neele, TNO

15:45-15:55: Discussion and Wrap-Up

5 EVENTS & MEETINGS

5.1.1 Consortium technical meeting, March 25 2014, Burgos, Spain

The second EB meeting (see below) was used to organise a project-wide technical meeting. All work packages presented the work done so far in the project, informing all partners of successes reached and of the planning for the next period.
Part of the meeting was a visit to the Hontomín research site. Part of the IMPACTS consortium combined the visit to Burgos with a site visit of the Ponferrada site, to see the CIUDEN CO_2 transport rig where the dynamic tests of IMPACTS are going to be held.

The IMPACTS team at the Hontomín site

IMPACTS consortium at the CO_2 Transport Test Rig in Ponferrada

5.1.2 Executive Board meeting, March 26 2014, Burgos, Spain

The second EB meeting was held in March, in Burgos, hosted by CIUDEN, immediately following the consortium technical meeting on the day before.

5.1.3 Workshop on September 23-24 at TNO, Utrecht, The Netherlands

Following the workshop in June, 2014, also held at TNO in The Netherlands, a second workshop was organized to further discuss the translation of results from the work done in the 'technical work packages' to input for the techno-economic model of CCS chains. The technical work packages focus on the study of CO_2 mixtures in such areas as fluid properties and behavior, corrosion and transport and injection. In IMPACTS, the results from these studies are to be used to reach conclusions about the relation between the quality of the CO_2 stream and the design and

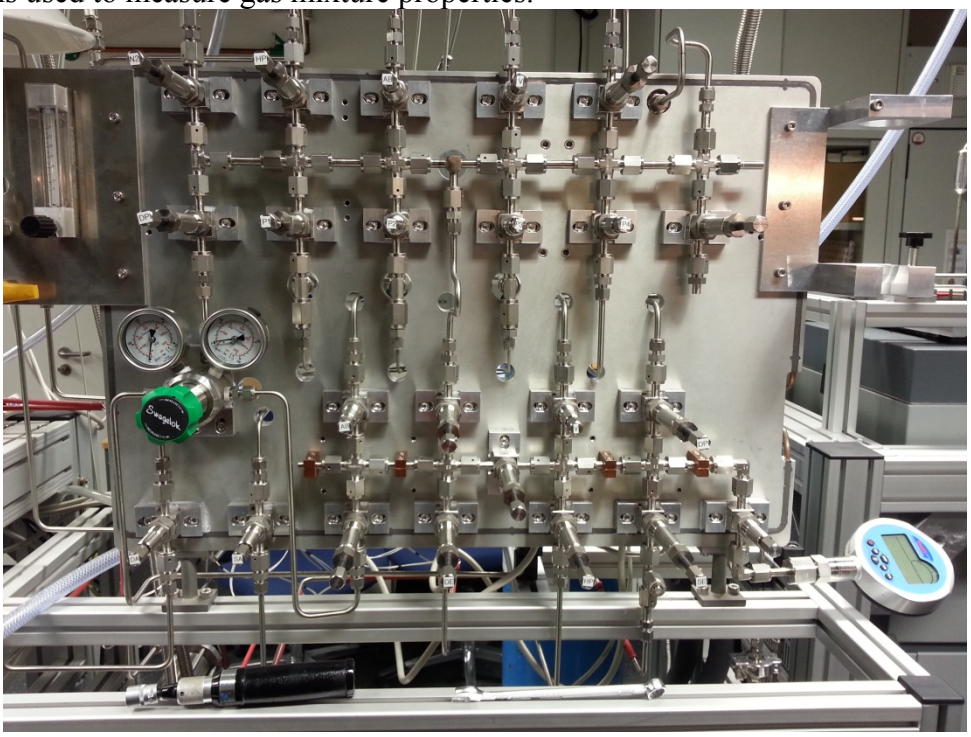
operation of CCS chains –in terms of safety, technology and economics. The project's goal is a series of studies of the trade-offs between mixture quality and the costs of building and operating a CCS chain in various different circumstances.
The workshop concluded with identifying how each of the main categories of expected impurity influences were going to be "translated", what kind of result could be anticipated in each case and (importantly) who was going to provide what. This information is held in a document commonly known as the SP2 Shopping List.

5.1.4 Executive Board meeting, October 20, 2014, Ruhr Universität Bochum, Germany

The third EB meeting was held in October, in Bochum, hosted by the Ruhr Universität.

5.1.5 Consortium technical meeting, October 21, 2014, Ruhr Universität Bochum, Germany

A technical meeting was held on the day following the Executive Board meeting. The meeting was attended by most IMPACTS participants and used to update the group on the progress of work in the various work packages. The other objective was to look ahead and make plans for 2015, the final year of the project, and to prepare for dissemination activities like conference attendance and workshops.
After the meeting the lab facilities of the research group of Prof. Span were visited, to view the installations used to measure gas mixture properties.



Equipment for mixing of gases in the labs of Ruhr University

5.1.6 WP1.2 Thermophysical behaviour of CO_2 mixtures

In September 2014 Ruhr-University Bochum in Denmark organized an international workshop addressing algorithms for the evaluation of multi-parameter mixture models. 22 scientists from six countries (including the USA and Japan) joined the workshop, which was closely related to

the goals addressed in WP1.2 in Impacts. The whole team working on thermodynamic property models in IMPACTS attended the workshop.

Participants of the modelling workshop in Denmark

Results of the work in Impacts were presented on the workshop "CO_2 Properties and EoS for Pipeline Engineering" organized by the UKCCS Research Centre in York in November.

The experimental work at Tsinghua and Ruhr-Universität continues. The data generated at both laboratories are directly utilized in the development of improved property models. Mutual visits have strengthened the cooperation between both groups. From October 2014 to March 2015 Xiaoxian Yang, a young researcher working on the Impacts project at Tsinghua University, stays at Ruhr-University as guest researcher to further intensify the cooperation.

6 DELIVERABLES

In order to disseminate the results from the project, all deliverables will be published on the project website: http://www.sintef.no/Projectweb/IMPACTS/Results/

Restricted deliverables will published with title, authors and public introduction only, whereas the full public deliverables will be made available on the website. All deliverables are available for the IMPACTS consortium on the IMPACTS eRoom.

7 PUBLICATIONS

IMPACTS is encouraging popular science articles, conference presentations and journal publications from the project and gives this topic high priority in the PMT meetings.

7.1 Conference presentations - 2014

7.1.1 GHGT-12, Austin Texas, Oct 4-9, 2014.

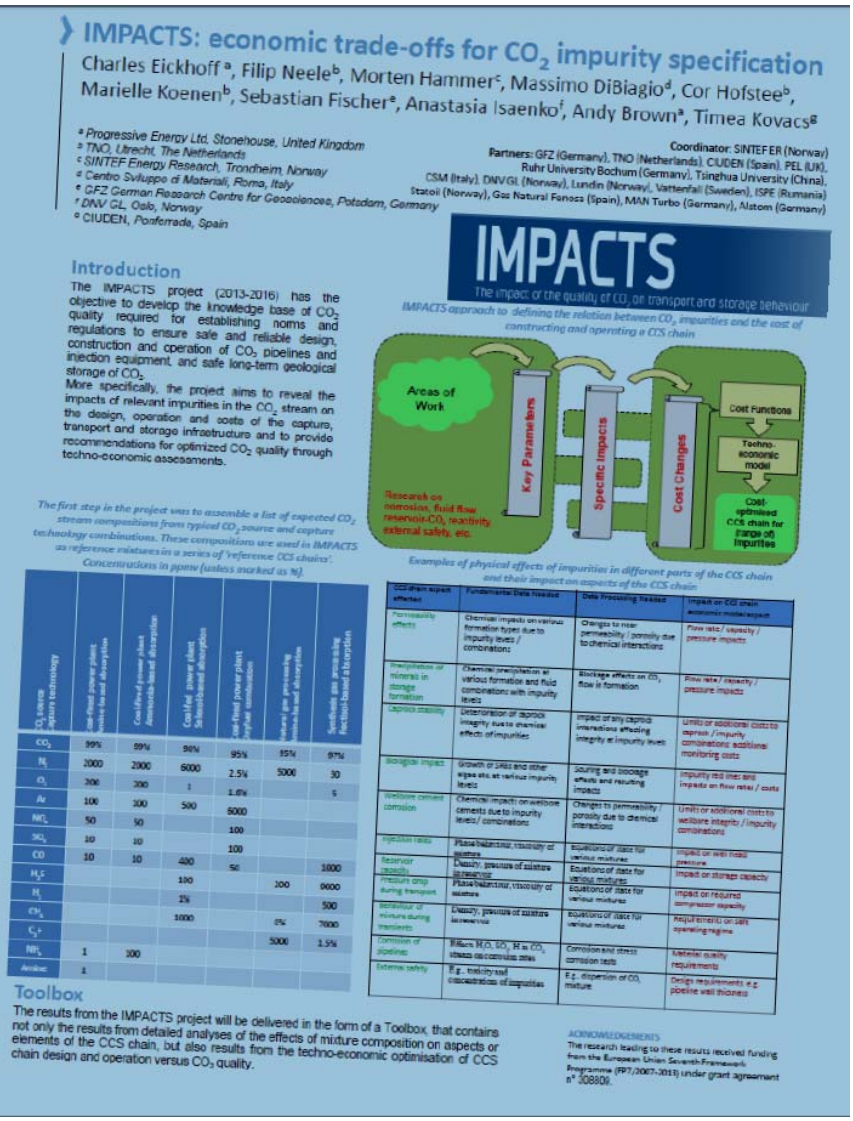
Impacts was represented with 2 posters:

- IMPACTS: economic trade-offs for CO_2 impurity specification
  Charles Eickhoff a*, Filip Neeleb, Morten Hammerc, Massimo DiBiagiod, Cor Hofsteeb, Marielle Koenenb, Sebastian Fischere, Anastasia Isaenkof, Andy Browna, Timea Kovacs, Progressive Energy Ltd, and TNO.

- N_2-CO_2 co-injection field test at Ketzin pilot CO_2 storage site, Dr Sebastian Fischer - GFZ German Research Centre for Geosciences - GERMANY

Poster at GHGT12 conference (October 2014, Austin TX), *IMPACTS: economic trade-offs for CO_2 impurity specification* by Charles Eickhoff (PEL), Filip Neele (TNO), Morten Hammer (SINTEF), Massimo DiBiagio (CSM), Cor Hofstee (TNO), Marielle Koenen (TNO), Sebastian Fischer (GFZ), Anastasia Isaenko (DNV-GL), Andy Brown (PEL), Timea Kovacs (CIUDEN)

The poster gives an overview of the IMPACTS project, with a focus on the techno-economic analysis that aims to analyse the trade-off between efforts at the capture side to deliver pure CO_2 and investments in transport and storage to deal with CO_2 with impurities.



7.1.2 CO_2 Properties and EoS for Pipeline Engineering, 11th November 2014

Thermodynamic Property Models for Transport and Storage of CO2 - Roland Span, Ruhr-Universitat Bochum, Germany **-Keynote lecture,**

7.2 Conference Presentations and Abstracts Submitted in 2014 for 2015 Publication

7.2.1 CO2QUEST CCS workshop, Athens, March, 2015

International Forum on Recent Developments of CCS Implementation, Athens, Greece, 26th – 27th March 2015,

- Thermophysical Properties for Transport and Storage of CO_2-rich Mixtures – Contributions by IMPACTS, Roland Span, University of Bochum.
- Measurements on Volumetric Properties of binaries and ternaries of Carbon dioxide, Nitrogen, and Argon at Supercritical State by Single Sinker Densimeter Xiaoxian Yang*, Zhe Wang, and Zheng Li, *Xiaoxian Yang, Tsinghua University.
- IMPACTS: Economic Trade-offs in Establishing CO_2 Impurity Specifications

C.Eickhoff*[1] and F.Neele[2], *Presenting author's email: charles@progressive-energy.com
[1] *Progressive Energy, Stonehouse, GL10 3RF UK*
[2]*TNO, Utrecht, Netherlands*

7.2.2 14th Annual Carbon Capture, Utilization and Storage Conference, Pittsburgh, Pennsylvania from Tuesday, April 28 – Friday, May 1, 2015.

- IMPACTS: The Impact of the Quality of CO2 on Transport and Storage Behaviour- Presentation Sigmund Ø. Størset[a], Marit J. Mazzetti[a], Morten Hammer[a] Charles Eickhoff[b], Filip Neele[c], Daniël Loeve[c.] [a]SINTEF Energy Research, Norway. [b]Progressive Energy, UK. [c]TNO, Netherlands.

7.2.3 TCCS-8, Trondheim Norway, June 17-19, 2015

- Impact of CO_2 Quality on Transport and Storage- IMPACTS
  Marit Jagtøyen Mazzetti[1], Sigmund Østtveit Størset [1], Morten Hammer[1], Charles Eickhoff[2], Filip Neele[3], [1]SINTEF Energy Research, Norway, [2]Progressive Energy, UK, [3] TNO, Netherlands.
- Hydraulic characterization tests at Hontomin Technology Development Plant for CO_2 Storage. Experiences with brine, CO_2 and tracer injection; Daniel Fernandez-Poulussen (1), J. Carlos de Dios (1), Juan A. Marin, Fundación Ciudad de la Energia (CIUDEN). Avenida del Presidente Rodriguez Zapatero, 24492 Cubillos del Sil (León), Spain.
- Effects of impurities in a CO_2 transport experimental installation. First results and experiences at CIUDEN. Ruth Diego (1), Abraham Fernández (1), Miguel Ángel Delgado (1), Rosana González (1) (1) Fundación Ciudad de la Energia (CIUDEN). Avenida del Presidente Rodriguez Zapatero, 24492 Cubillos del Sil (León), Spain
- IMPACTS: Effect of CO_2 impurities on storage opportunities, Hanstock, D.J. & Eickhoff C.E., Progressive Energy Limited, UK
- Numerical modelling of physicochemical effects of discrete CO_2-SO_2 mixtures; potential cost effects for injection and storage of impure CO_2 in a sandstone aquifer, Svenja Waldmann, Cor Hofstee, Daniël Loeve, Mariëlle Koenen, Filip Neele, TNO, Princetonlaan 6, 3584 CB Utrecht, the Netherlands.

7.2.4 The international Thermophysical Properties Symposium in Boulder, Colorado (June, 2015)

- Accurate vapor-liquid phase equilibrium measurements on the binary CO_2-O_2 system, Snorre F.Westman, H. G. Jacob Stang, Sigurd W. Løvseth
- 2 presentations by Span's group at Bochum

7.3 Journal publications

7.3.1 Publications Issued in 2014

1. **Calculation of phase equilibria for multi-component mixtures using highly accurate Helmholtz energy equations of state,** Johannes Gernert, Andreas Jäger∗, Roland Span,, Ruhr-Universität Bochum, Gerrmany,
   Fluid Phase Equilibria 375 (2014) 209–218

2. **The IMPACTS project: The impact of the quality of CO_2 on transport and storage behavior.** Astrid Lilliestråle, Mona J. Mølnvik, Grethe Tangen, Jana P. Jakobsen,Svend Tollak Munkejord, Alexandre Morin and Sigmund Ø. Størset, Energy Procedia, 2014.

7.3.2 Submitted in 2014 for publication in 2015

3. **EOS-CG: A Helmholtz Energy Mixture Model for Humid Gases and CCS Mixtures** Johannes Gernerta,b and Roland Spana,1Thermodynamics, Ruhr-Universität Bochum, D-44801 Bochum, Germany

   Abstract

   An equation of state for the thermodynamic properties of humid gases, combustion gases and CO_2-rich mixtures typical for CCS processes, the EOS-CG mixture model, is presented in this work. This model uses the mathematical approach of the GERG-2008 equation of state by Kunz and Wagner [J. Chem.Eng. Data 2012, 57, 3032−3091] and presents new mixing parameters for mixtures of carbon dioxide, **Submitted to Journal of Chemical Thermodynamics, 2014**

4. Phase equilibria measurements of CO_2-N_2 and CO_2-O_2 system
   H. G. Jacob Stang, Sigurd W. Løvseth, Anders Austegard, Ingrid Snustad, Snorre F. Westman, Submitted in 2014
5. Accurate vapor-liquid phase equilibrium measurements on the binary CO_2-O_2 system, Snorre F. Westman, H. G. Jacob Stang, Sigurd W. Løvseth, Fluid Phase Equilibria, Submitted in 2014

8 COLLABORATION WITH OTHER PROJECTS

The CO2QUEST project coordinated by University College London (UCL), can be regarded as IMPACTS' sister project. Svend Tollak Munkejord, SINTEF ER, has been asked to join the advisory board of CO2QUEST, composed of members from industry and academia.

IMPACTS was working with CO2QUEST during 2014 planning meetings in 2015.

A second workshop is arranged by CO2QUEST in March 2015. The following abstracts were submitted from IMPACTS in November 2014:

International Forum on Recent Developments of CCS Implementation, Athens, Greece, 26th – 27th March 2015,

- **Thermophysical Properties for Transport and Storage of CO_2-rich Mixtures – Contributions by IMPACTS**
  R. Span

- **Measurements on Volumetric Properties of binaries and ternaries of Carbon dioxide, Nitrogen, and Argon at Supercritical State by Single Sinker Densimeter**
  Xiaoxian Yang*, Zhe Wang, and Zheng Li
  *Xiaoxian Yang: yxx06@mails.tsinghua.edu.cn

- Publication by Charles Eickhoff

9 ATTACHMENTS

9.1 A1- IMPACTS Newsletter #3

9.2 A2- IMPACTS Newsletter # 4