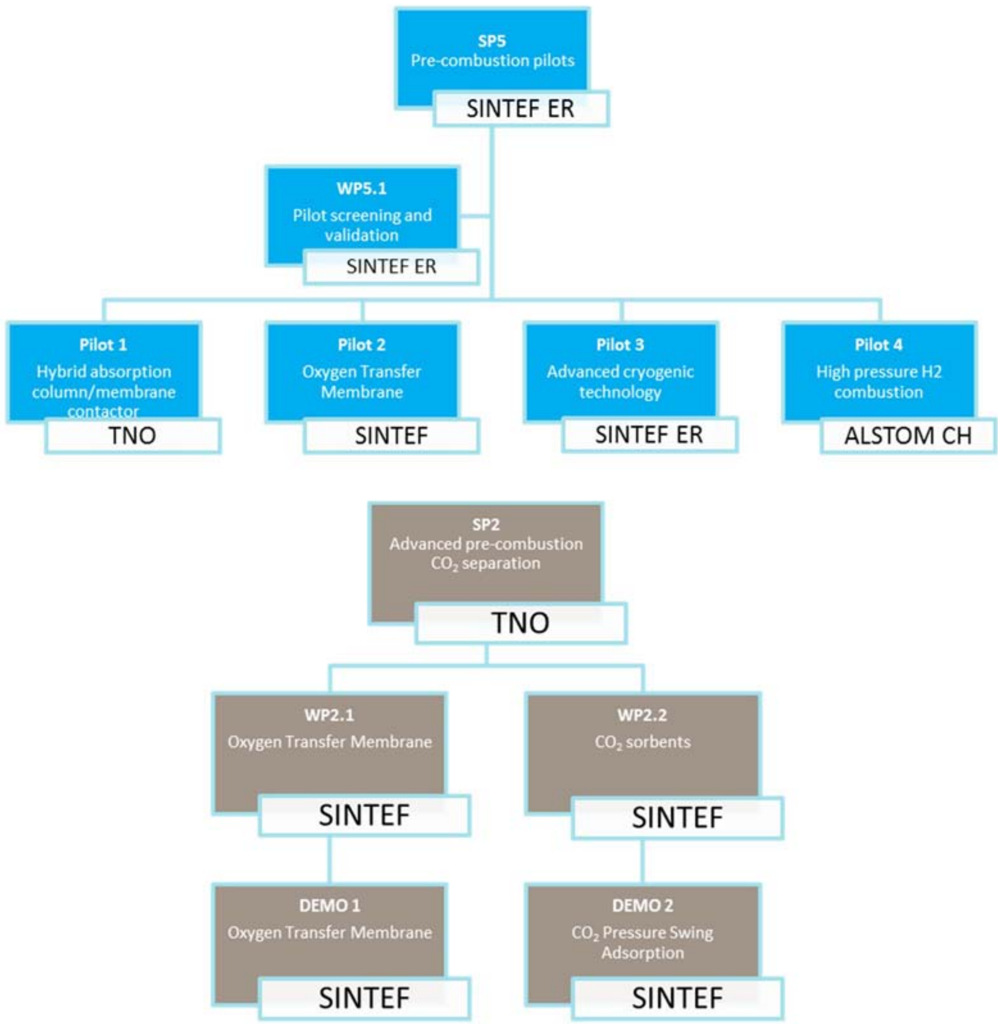
Newsletter
1-2010

DECARBIT progress medio 2010

DECARBit responds to the urgent need for further research and development in advanced pre-combustion capture techniques to substantially reduce emissions of greenhouse gases from fossil fuel power plants. The project will accelerate the technology development and contribute to the deployment of large-scale carbon capture and storage (CCS) plants, in line with the adopted European policies for emission reductions. The project focus is to pursue the search for improved and new pre-combustion technologies. DECARBit is designed as a Collaborative Large-scale Integrating Project.

2010-2011 -> The PILOT phase

DECARBit is now well into Y3. Pilot selection has passed and construction of each of the four pilots and lab-scale demos proceeds according to schedule. Four main pilots and two smaller lab-scale demonstration systems have passed the criteria for being selected.



PILOT news

Pilot 2 - Oxygen Transport Membrane

Oxygen production by use of Oxygen Transport Membranes (OTMs) is for many applications a promising alternative to cryogenic distillation, in particular when integrated in high temperature systems. The main objective of DECARBit WP3.1 – Oxygen Transport Membranes – is to develop and characterize OTMs for high temperature air separation with both high oxygen flux and sufficient chemical/thermal/mechanical stability under defined conditions. Asymmetric tubular membranes (thin dense selective membranes coated on mechanically strong porous supports) are under development and these are planned assembled into smaller modules and tested as part of DECARBit – Pilot 2. A set-up for measuring oxygen flux of single-tube membrane modules is depicted in Figure 1 with the tubular membrane and housing components. The prepared module is currently being tested and evaluated for symmetric (dense) tubular membranes using silver-based air braze to seal the membrane to the alloy caps/steel gas piping.

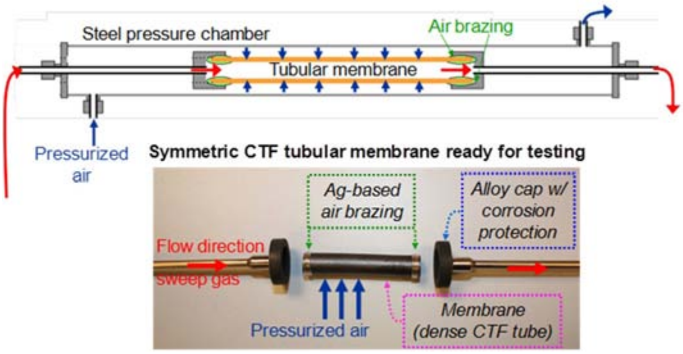


Figure 1: Scheme of set-up for testing of single-tube membrane modules (top) and prepared components (below).

In parallel to the membrane development in WP3.1 work has been initiated for the approved pilot application on OTMs, Pilot 2. One main goal in this pilot is to assemble a multi-tubular membrane module. Currently a module assembly is being designed. Initial membrane module illustration is presented in Figure 2. High temperature alloy is selected for the housing material and silver based air brazing, as investigated in WP3.1, for sealing.

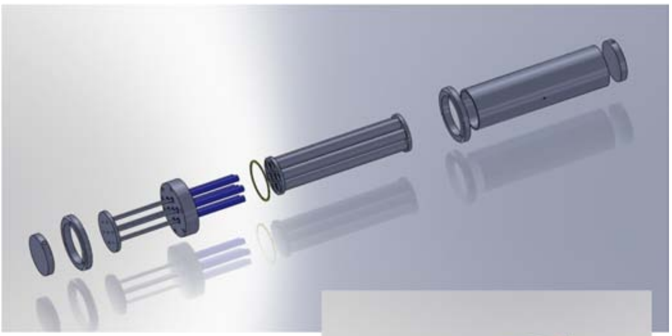


Figure 2: Illustration of multi-tubular OTM module assembly (a) opened and b) assembled) currently being designed within DECARBit Pilot 2.

Project news

Work package 2.3 - Novel Solvent Systems, is a co-operation between TIPS RAS (Moscow), SINTEF (Trondheim), TU Delft (Delft) and TNO (Delft).

The main task is to integrate an absorption step with a new regeneration step. For the regeneration step so-called membrane gas desorption (MGD) is being evaluated. The idea is to keep the absorption liquid pressurized and that the regeneration of the solvent takes place in a membrane contactor by CO_2 permeation across the membrane. To study the desorption from the liquid phase different types of membrane materials (high permeability glassy polymer) have been synthesized at the A.V.Topchiev Institute for Petrochemical Synthesis (TIPS RAS). Flat sheet membranes are available that can be applied in a membrane contactor for pre-combustion CO_2-H_2 separation at elevated pressures and elevated temperatures.

The MGD process uses high permeability glassy polymer membranes in combination with amine based solvent. At SINTEF CO_2 absorption with different amine-based solvents is being studied. The optimal conditions for both pure amine systems and mixtures of amines have been evaluated. In parallel to the solvent development at SINTEF, the Technical

University of Delft (TU Delft) is developing an infrastructure for rapid screening and benchmarking of solvents. In the next phase the different processes, membrane gas desorption and CO_2 absorption using an amine-based solvent, will be combined.

SP4 - Summing up results so far Y1-3

The objective of DECARBit SP4 is to develop low-NO_x H_2 rich gas turbines. This work is split into two work packages where the first is on developing the combustor itself. Here Alstom CH perform design, optimization and experimental development of a hydrogen burner operating in premixed mode, while SINTEF obtain numerical combustion models that will aid the burner development. The second work package focus on developing the fuel system leading from the gas separation unit into the combustor. Here SIEMENS and ENEL will optimize the design of H_2 fuel system based on numerous results obtained throughout the project.

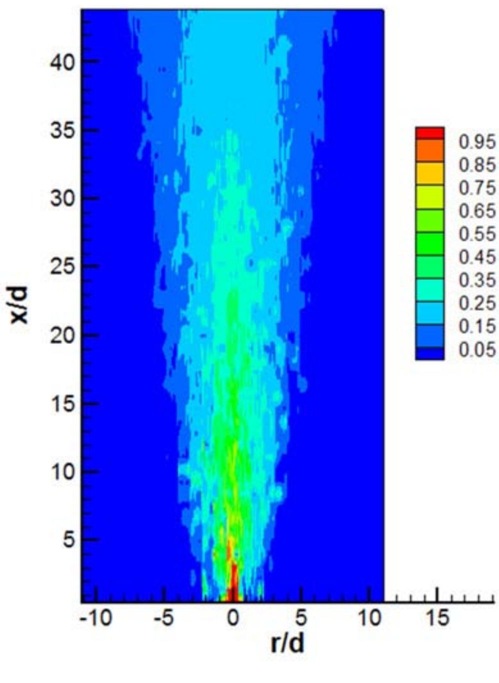


Figure 1: Fuel jet mixture fraction using 3DLEM

By using Direct Numerical Simulations (DNS) the turbulent flame speed has been investigated by SINTEF at conditions relevant for the H_2 rich version of Alstoms GT24/26 gas turbine. The turbulent flame speeds have been compared with the much more easily obtainable laminar flame speeds, and the results are used for determining flashback conditions in a real gas turbine combustor. Using DNS is very accurate but also very CPU intensive, and therefore not yet applicable for simulating full scale industrial combustors. For this reason a much less CPU intensive, but still very accurate, simulation strategy is being developed by SINTEF. This is the so called three-dimensional Linear Eddy Model (3DLEM), where the smallest scales of the combusting flow are fully resolved only in one-dimensional sub domains. These sub domains are then embedded into a full three dimensional CFD code, yielding a code with resolution comparable to DNS but which can be used to simulate full scale applications. At the current stage a relatively simple version of the 3DLEM is being coupled to the commercially available Fluent code.

Alstom CH is developing a second stage combustor for H_2 rich fuel in premixed mode for their GT24/26 gas turbine. In this gas turbine the main flow passes the first combustion chamber (EV combustor), wherein a part of the fuel is combusted. After expanding at the high-pressure turbine stage, the remaining fuel is added (SEV combustor). Both combustors contain premixing burners, as NO_x emissions depend on the mixing quality of the fuel and the oxidizer.

Since the second combustor is fed by expanded exhaust gas of the first combustor, the operating conditions allow auto ignition (spontaneous ignition) of the fuel air mixture without additional energy being supplied to the mixture. To prevent ignition of the fuel air mixture in the mixing region, the residence time therein must not exceed the auto ignition delay time. This criterion poses challenges in obtaining appropriate distribution of the fuel across the burner exit area.

For natural gas (NG) and oil the design of the SEV combustor is the result of an optimization process. The optimization process took into account various burner performance criteria, such as NO_x emissions, reliability, pulsations, etc. Unfortunately, some of the burner performance criteria compete with each other. Consequently, implementing pre-combustion CCS technologies must contain trade off studies for various burner performance criteria for hydrogen rich fuel types. The tradeoff studies must be constrained with respect to the operating conditions to keep the scope limited. The goal of this activity is to be able to run the SEV combustor with a fuel composed of 70% H_2 and only 30% N_2 for dilution. At the last high pressure test campaign Alstom CH was already able to run the combustor at medium to high hydrogen content.

In the hydrogen rich fuel supply system the hydrogen will typically be diluted with nitrogen from the air separation unit and possibly also with steam. This introduces several complicating issues. One important issue here is the remaining oxygen concentration in the nitrogen stream. If the oxygen concentration is too high in the nitrogen stream, unacceptable amounts of parasitic fuel consumption will occur when pre-mixing with the hydrogen stream. The worst imagined scenario is if the oxygen concentration is allowed to reach such a level that sustained combustion is possible. SIEMENS has been in charge to study, both numerical and experimentally, the limiting values of the oxygen concentration in the diluents which allows for safe and economical operation.
Another important issue related to safety is the material selection, both for the fuel supply piping and the welding material of such. Issues like hydrogen embrittlement, hydrogen leakages through the seals and corrosion due to the dilution with steam are particularly important. Based on the above constraints such a selection has been successfully done by SIEMENS, and in addition to this, the positioning of the components of the fuel supply system has been optimized for running with hydrogen rich fuels.

Finally, an evaluation of safety risks and on existing regulations for hydrogen pipelines has been performed by SIEMENS and ENEL, ending up with a discussion of possible worst case scenarios in addition to an upper level for the amount of H_2 to be transported in existing natural gas pipelines.

Two major achievements from DECARBit SP4 so far are; Alstom CH have made great progress towards the goal of running their GT24/26 gas turbine with a fuel blend of 70% H_2 and 30% N_2 in premixed mode, and; SIEMENS have finalize a detailed design for a H_2 rich fuel supply system.

News from the European Benchmarking Task Force (EBTF)

The work performed under SP1 by the European Benchmarking Task Force is closing up to finalization. This work provides an analysis of three test cases, each one by two of the three projects CAESAR, CESAR and DECARBit. In general, the agreement reached by the projects in the main results of these three cases is very good, considering that not only different teams have worked on the calculations but also that these teams have used different computer codes, often involving different models of processes and equipment. In particular, the efficiencies obtained for each case are in remarkable agreement. The work carried out by the European Benchmarking Task Force has achieved its objective in showing that similar results can be reached by different teams with different resources from a similar set of assumptions and parameters.

The final conclusions from this team will be publically available in the next DECARBit newsletter!

CESAR progress

CESAR Website

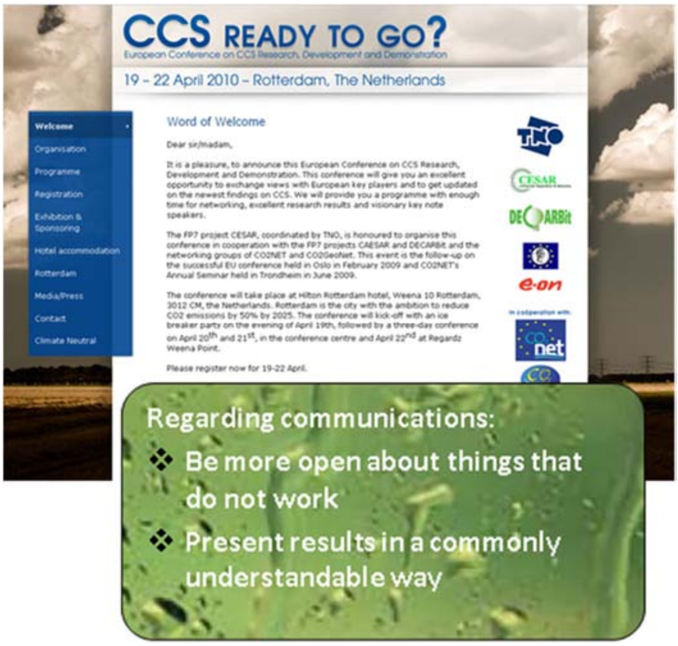
CESAR website is alive and continuously update with the latest news and facts (www.co2cesar.eu)

Dissemination

From April 19th until April 22nd the European CCS conference was held on behalf of the CESAR project. The conference was held at the Hilton Hotel in Rotterdam, the Netherlands. The conference was organized by the CESAR project, in close cooperation with CO2NET. Co-organizers were also the CEASAR project, the DECARBit project and CO2GEOnet.

The conference was very successful, although the organizing committee experienced quite some problems due to the fact that the conference took place during the eruption of the Iceland volcano. There were no flights possible within a great part of Europe during the conference. Despite this, about 155 people joined the conference and about 200 others watched (part of) the conference online over the internet. This facility was setup at Monday April 19th to be able to reach as many delegates as possible.

A special website was made for the conference for information exchange and for the delegates to subscribe to the event. Also the presentations held during the conference where uploaded to this website.



Lessons Learned:

- We should develop strategies for reducing carbon emissions; there are different solutions to be considered.
- Fossil fuels will continue to be an important energy source.
- The risk for full scale implementation is still high; more effort in R&D and financial founding is needed.
- See CO_2 as a product; look for specific decentralized solutions (Algae, greenhouses, Solar2Fuel activities).
- Lack of legislation in CCS delays implementation of projects.
- The need to share knowledge from pilot and demo plants
- Regulations need to be in place for companies to go forward
- Public acceptance and support is crucial

Recommendations:

- Research and industry need to work together
- There are network initiatives and new ones are coming up (CO2NET, CO2GEONET, EERA, etc.)
- Knowledge sharing already happens, but needs to be done more intensively, more 'open source' especially for demo sites
- Focus on more collaboration with emerging economies such as China, India and Brazil
- Education is very important (knowledge transfer)
- Avoid work duplication
- Improve communication, present activities in a broader context

Is CCS Ready to go?

- Current focus for CO_2 sources is mainly on electricity, other industries need to get involved.
- Europe: keep the lead and do not wait for others
- Europe should not push emerging economies
- Attach a price to CO_2, which makes it more realistic.
- Arrange licenses to operate (it is taking too long now to arrange permits)

CAESAR – CArbon-free Electricity by SEWGS: Advanced materials, Reactor- and process design

Starting date	1 January 2008
Duration	48 months
Budget	3.1 million €
EUcontribution	2.3 million €
Co-ordinator	Energy Research Centre of The Netherlands

CESAR – Enhanced separation & recovery

Starting date	1 February 2008
Duration	48 months
Budget	6 million €
EUcontribution	4 million €
Co-ordinator	TNO Science and Industry

DECARBit –Enabling advanced pre-combustion capture techniques and plants

Starting date	1 January 2008
Duration	48 months
Budget	15.5 million €
EUcontribution	10.2 million €
Co-ordinator	SINTEF Energy Research

Contact: Nils A. Røkke - nils.a.rokke@sintef.no
Editor: Marie Bysveen - marie.bysveen@sintef.no
Published by: SINTEF Energi AS (SINTEF Energy Research) - NO-7465 Trondheim - Phone: + 47 73 59 72 00 - www.sintef.no/energy