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OCTAVIUS:

A New FP7 Project Demonstrating CO_2 Capture Technologies

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Abstract

The OCTAVIUS project (Optimisation of CO_2 Capture Technology Allowing Verification and Implementation at Utility Scale) has started on March 1st 2012 for a period of 5 years, as part of the 7th Framework Programme of the European Commission. Gathering 15 European and 2 South African partners, OCTAVIUS was conceived as contributing to demonstration of integrated concepts for zero emission power plants covering all the components needed for power generation as well as CO_2 post-combustion capture and compression facilities.

This paper presents the objectives of the project, its main expected outcomes and the results obtained within the first six months period.

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Keywords: CO_2 Post-Combustion Capture, Demonstration, Operability, Flexibility, DMX Process, Energy Penalty and Costs Reduction

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1. Introduction

CO_2 Capture and geological Storage is now recognised as being one of the pathways that can be implemented to reduce CO_2 emissions and fight against global warning.

Among all the possible technologies for CO_2 capture from flue gases generated at power stations, first generation post-combustion processes using amine-based solvents appear now as the most developed for middle term industrial deployment.

Full scale demonstration projects planned in Europe such as the ROAD and Porto Tolle projects will implement such first generation processes which were studied within the previous FP6 and FP7 projects CASTOR [1] [2] [3] and CESAR [4]. Within these projects, process upgrades and novel solvents were evaluated at pilot-scale [5].

The new FP7 project OCTAVIUS [6] proposes to continue these developments on first generation CO_2 post-combustion processes. Operability and flexibility of these CO_2 capture processes will be demonstrated on 3 pilot plants in order to prepare the first full scale demonstration projects that will start in 2015-2016. OCTAVIUS will establish detailed guidelines for operational issues and provide particularly relevant data on emissions.

OCTAVIUS will also consider the demonstration of the DMX^{TM} process [7], [8] which represents an essential step prior to commercialisation of this capture process. A first full scale demonstration project based on this second generation process allowing important reduction of energy penalty and costs could be launched at the end of OCTAVIUS.

Firstly, in the present paper a summary of the project, its objectives and its organisation are given. Then, the technical content of each technical sub-project and the main achievements during the first 6 months of the project are presented.

2. The OCTAVIUS Project

2.1. OCTAVIUS in Brief

- FP7 Demonstration Project call ENERGY 2011
- Starting Date: 01 March 2012
- Kick-off Meeting: 13-14 March 2012
- Duration: 60 Months
- Total Budget: 13.7 M€
- EU funding: 8 M€
- 17 partners (see Table 1)

Table 1. List of Participants

Organisation	Type	Country
IFPEN (Coordinator)	R&D Organisation	France
TNO	R&D Organisation	Netherlands
SINTEF	R&D Organisation	Norway
NTNU	University	Norway
INERIS	R&D Organisation	France
DTU	University	Denmark
TUHH	University	Germany
E-ON	Power Utility	UK
EnBW	Power Utility	Germany
Doosan Power Systems	Supplier	UK
ENEL	Power Utility	Italy
ESKOM	Power Utility	South Africa
Laborelec / GDF SUEZ	R&D Organisation	Belgium
EDF	Power Utility	France
PROSERNAT	Engineering Company	France
EcoMetrix	SME	South Africa
TIPS	Supplier	Russia

2.2. Objectives and Organisation

The objectives of the OCTAVIUS project are the following:

- to demonstrate operability and flexibility of first generation post-combustion processes on pilot plants in preparation of full scale demonstration projects such as the ROAD and Porto Tolle projects. Experimentation will be carried out on 3 different industrial pilot plants (TNO pilot at Maasvlakte, ENEL pilot at Brindisi, EnBW pilot at Heilbronn). Based on the results of the pilot campaigns, OCTAVIUS will establish detailed guidelines with relevant data on emissions, operability, flexibility and cost aspects as well as HSE issues, for first generation CO_2 capture processes.
- to demonstrate the DMX^{TM} process on the ENEL pilot plant at Brindisi which will be retrofitted. This second generation capture process issued from IFPEN researches uses phase change solvents and aims at an energy consumption of around 2.3 MJ/kgCO_2 captured. So, it can enable a substantial reduction in the energy penalty and operational costs. The demonstration is an essential step before the first full scale demonstration envisaged to be launched at the end of OCTAVIUS. Application to coal power stations but also NGCC will be considered within OCTAVIUS.
- to establish guidelines for commercial scale demonstration units in South Africa. Participation to the project of ESKOM and EcoMetrix will help these South African companies to envisage the appropriate frame for such demonstration units in South Africa through exchange with the European partners.

In order to fulfil these objectives, the project has been divided in 3 technical sub-projects as presented in Figure 1. Each sub-project is described in more detail in the following sections starting with SP2.

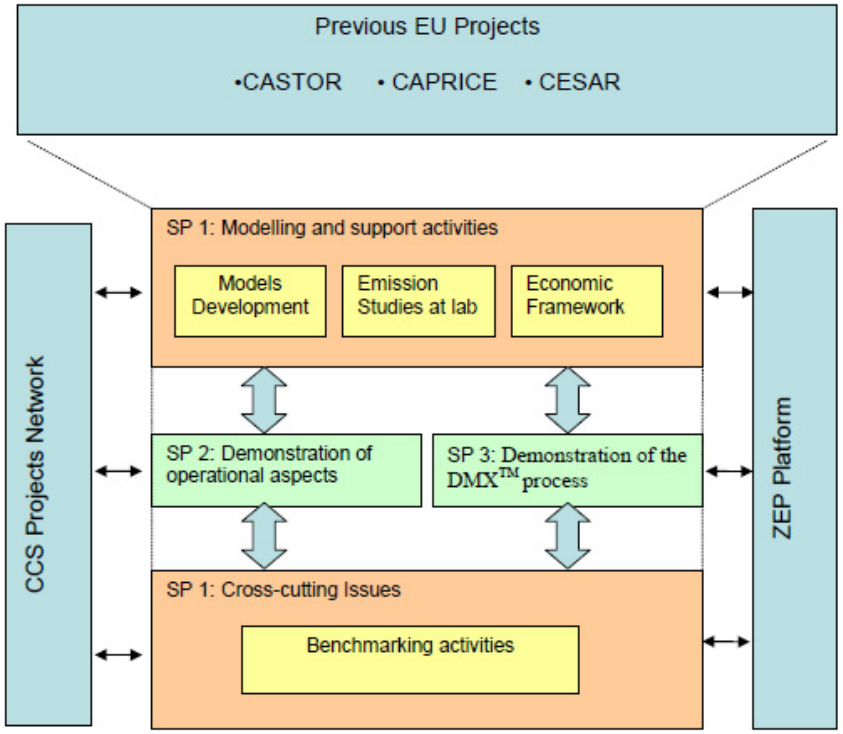

Figure 1. OCTAVIUS Work Plan

2.3. Subproject SP2 on First Generation Processes Demonstration

SP2 contains the demonstrations aspects for first generation post-combustion processes by using three different pilot plants fed on side-stream from coal power station flue gases (pilots operated by TNO, ENEL and EnBW see Figures 2,3, and 4 respectively).

SP2 will use dedicated pilot plant testing campaigns on the three pilot plants to provide the following:

- demonstration of emission control options including novel countermeasures;
- demonstration of solvent life time aspects and key dependencies;
- demonstration of operability and flexibility options to determine operability limits;
- demonstration of process analytical techniques and control options (including dynamic response);
- demonstration of alternative materials.

Figure 2: TNO pilot plant in Maasvlakte (Netherlands) / Capacity: 0.25 TCO_2 captured/h

Figure 3: EnBW pilot plant in Heilbronn (Germany) / Capacity: 0.3 TCO_2 captured/h

Figure 4: ENEL pilot plant in Brindisi (Italy) / Capacity: 2.25 TCO_2 captured/h

A significant amount of operational data will be collected from the demonstration campaigns and then used to validate and verify the models developed within OCTAVIUS. These models shall provide insight into methods required to address the issues facing demo projects in the near future. The work carried out within SP2 will conclude by preparing detailed guidelines for the demonstration scale units, containing relevant data on emissions and emission minimisation, HSE, operability and flexibility aspects. In this respect the pilot scale demonstration activities within OCTAVIUS SP2 will complement and support the successful integration and operation of early commercial scale demonstration capture projects.

2.4. Subproject SP3 on DMX™ Process Demonstration

Sub-project SP3 will demonstrate a new CO_2 capture process with low energy penalty. This IFP Energies nouvelles process called DMX™ [7],[8] is based on the particular property of demixing solvents to form, for specific CO_2 loadings or temperature conditions, two immiscible liquid phases respectively characterised by different densities and different CO_2 loadings. The heavier phase has a particular high CO_2 loading, while the lighter phase is almost free of CO_2. The difference in densities and the further possibility of separation by decantation, allow an important decrease in solvent mass flow at regeneration. Indeed, the use of a decanter, preferably positioned downstream the amine/amine heat exchanger, enables to take advantage of the liquid/liquid separation property of the solvent with the simultaneous effect of CO_2 charge and heat. Only the dense phase having a high CO_2 concentration is fed to the regenerator. The light phase is mixed with the regenerated solvent coming from the stripper and injected to the absorber as can be seen from the simplified process flow diagram given in Figure 5.

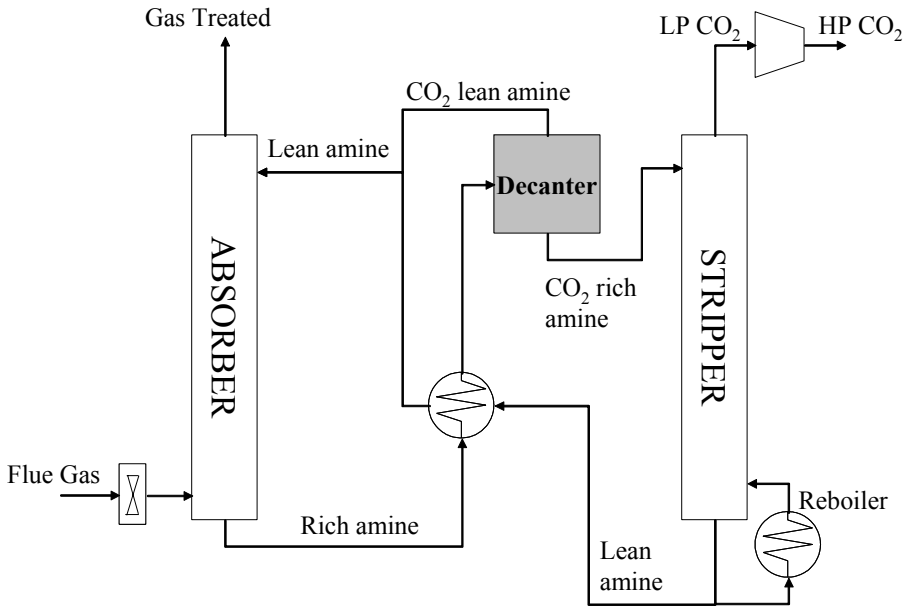

Figure 5: Simplified process flow diagram of the DMX™ process.

The solvent used in the DMX™ process is characterised by excellent thermodynamic properties which, when combined with the demixing advantage, further induce an energy consumption at reboiler as low as 2.3 GJ/tCO_2 captured compared with ~3.7 GJ/tCO_2 for a reference 30 wt. % MEA capture process. The low energy consumption combined with smart, integrated, process design solutions (e.g. high pressure regeneration) will evolve in a technology that has the potential to reach a 20 % cost reduction per ton of CO_2 captured when compared with today's technology.

Demonstration of the DMX™ process will be done on the ENEL pilot plant in Brindisi (Italy) which treats flue gases from a coal fired power station (see Figure 4).

2.5. Subproject SP1 on Modelling and Benchmarking

The relevant research needed for the demonstration activities in OCTAVIUS will be covered by Sub-project SP1. It will include the necessary research activities and provide a basis (necessary data, models, tools, and simulation results) for the demonstration activities in SP2 and SP3. Thus in SP1 the following main topics will be addressed: solvent degradation and emission control, flexibility and operability.

As a starting point the results of previous projects (CASTOR and CESAR) and open literature will be used. This will enable a well-focused project with a flying start. There will also be a link from SP2 and SP3 to SP1 regarding updating of models based on validation in pilot plants.

Furthermore, SP1 will include the benchmarking activities based on inputs from SP2 and SP3 in terms of performance of the different processes or technical solutions to be demonstrated.

3. Preliminary Results

As the project has just started, only first results can be presented here.

Important work has been carried out within Sub-project SP1 in order to evaluate and select the simulation tools to be used within OCTAVIUS. For steady state simulations, the tool EBSILON®Professional will be used for the power-plant, and both Aspen Plus™ with the RateSEP column model and CO2SIM (SINTEF/NTNU in-house tool) will be used for the capture plant. Some in-house tools will be used for cost estimation. For dynamic simulations the K-spice tool will be used.

A common methodology for measurement of gas and liquid emissions has been established. This methodology will be tested during the first campaign to be carried out on the TNO pilot plant.

A common methodology for benchmarking of large scale capture plant has also been developed. Such common methodology will allow an objective comparison of first and second generation processes.

Within SP2, base cases were defined corresponding to 3 European and 2 South African power stations. For each case, battery limits, user requirement, interface aspects and operating windows were established.

A lot of activities in SP2 have been concentrated around the design and realisation of the acid wash column at the TNO pilot plant at the Maasvlakte coal power station. The new column has been installed and commissioned in September. The Maasvlakte campaign started in the first week of October.

Work has also started on sub-project SP3 dedicated to the demonstration of the DMX™ process. The basic design of the ENEL minipilot to be built in Brindisi was completed. This new pilot plant should be in operation in January 2013. The IFPEN minipilot in Solaize is being retrofitted and should also be in operation in January 2013. Both minipilots will be used to prepare the demonstration on the ENEL Brindisi pilot plant which has to be revamped in 2013 – 2014. Then the demonstration of the DMX™ process could be realised in 2015.

DMX HSE related issues have been discussed and ENEL will provide to local authorities the permitting documents needed for retrofit and operation of the Brindisi pilot plant by the end of 2012.

Main action carried out in term of dissemination, is the preparation of the OCTAVIUS workshop to be held next year in South Africa. This workshop co-organised by EcoMetrix and ESKOM will have the following objectives:

- to present the results of OCTAVIUS;
- to share experiences about other CCS projects in EU and SA on CO_2 capture but also CO_2 storage;
- to create synergies on CCS between R&D and industrial companies from Europe and South Africa.

Note this international event in your diaries:

- Dates: 13 to 15 February 2013
- Place: ESKOM Academy of Learning in Midrand (near Johannesburg)
- Programme & Registration Procedure to be downloaded at www.octavius-cO2.eu

4. Conclusions

This new FP7 project will improve and achieve demonstration readiness for first generation capture technologies. With participation of technology suppliers and end-users, OCTAVIUS is ideally positioned to prepare the full scale demonstration projects to be in operation in Europe near 2015 – 2016.

Testing campaigns on 3 different pilot plants will demonstrate for these first generation processes:

- emission control options including novel countermeasures;
- solvent life time aspects, key dependencies and reduction of operational costs;
- operability and flexibility options to determine operability limits;
- performance of alternative materials that can reduce capital costs.

In addition, within OCTAVIUS, a second generation phase change solvent based capture system will be demonstrated. This new system should allow important savings on energy consumption and by consequence on the operating cost of the CO_2 capture process.

Acknowledgements

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