Development of the DMX™ process within the OCTAVIUS project

Matthieu Dreillard
Outline

- DMX™ process
- The OCTAVIUS Project
  - Sub-Project 3
- Main results (SP3)
  - Mini-pilots results
  - Process evaluation on a full scale power plant
  - FEED study
  - Go/no Go meeting
Outline

- DMX™ process

- The OCTAVIUS Project
  - Sub-Project 3

- Main results (SP3)
  - Mini-pilots results
  - Process evaluation on a full scale power plant
  - FEED study
  - Go/no Go meeting
Demixing solvents concept

1) High capacity solvent
2) Low reaction heat
3) Regeneration of the CO$_2$ rich phase only

High potential of energy saving
DMX™ Process

- Flue Gas
- Gas Treated
- CO₂ lean amine
- CO₂ rich amine
- LP CO₂
- HP CO₂
- Decanter
- Reboiler

CO₂ lean phase
CO₂ rich phase
Decantation tests - Laboratory

- Tests in an high rotation speed Ultra-Turrax (11,000 rpm)
- Input data for CFD simulation models

Decantation is fast
Degradation tests - Laboratory

- Little impact of CO₂/O₂ (DMX-1 vs 17 molecules)
- Very low thermal degradation of DMX-1 solvent

- Low solvent consumption
- Possibility to increase stripper temperature (and therefore pressure)
Other aspects

- Corrosion tests in a laboratory test rig
  - complete loop
  - comparison of solvents (qualitative)

  Carbon steel shows good behavior towards DMX-1 solvent

- Kinetic tests

  Kinetic of CO₂ absorption in DMX-1 is slower than MEA
First DMX™ process evaluation on a coal power station case (660 MWe)

2.3 GJ/ton CO₂ (-38% !)  
+ 2 pts net efficiency gain  
- 25 % in CO₂ total cost

Ref = MEA 30wt% case

Needs to be validated at a representative pilot scale!
Outline

- DMX™ process
- The OCTAVIUS Project
  - Sub-Project 3
- Main results (SP3)
  - Mini-pilots results
  - Process evaluation on a full scale power plant
  - FEED study
  - Go/no Go meeting
OCTAVIUS Organisation

- Two main technical Sub-projects (SP2 and SP3)
  - SP2: demonstration of operability and flexibility aspects of first generation processes (ROAD and Porto Tolle Project)
  - SP3 dedicated to the demonstration of DMX™ process
  - SP2 and SP3 are independent

- One supporting Sub-project (SP1)
  - Benchmarking activities

- SP3 Participants
  - ENEL, GDF SUEZ, Prosernat, IFPEN and TOTAL (Sponsor)
DMX™ process Demonstration (SP3)

- Scheduled on ENEL pilot plant at Brindisi (Italy)

- Implemented on a Coal fired power plant
  - Brindisi Frederico II
  - 4 x 660 MWe

- Capacity 2.25 tCO$_2$/h

- Already operated with HiCapt and HiCapt+ processes (2010-2011)
  - HiCapt = MEA 30wt%
  - HiCapt+ = MEA 40 wt%

- Revamp is needed to operate DMX process
SP3 Program: Demonstration of DMX™ process

- **Phase 1 (0 – 18 month)**
  - Experimentation on ENEL & IFPEN mini-pilot
  - Experimentation & CFD study on decantation
  - Techno-economic study on a coal case
  - FEED + estimation on the ENEL pilot plan revamp

- **Go/no Go decision (technical + economical criteria)**

- **Phase 2 (18-60 month)**
  - Revamp & Commissioning of the ENEL pilot plant
  - Demonstration of the DMX™ process (2015-2016)
  - Full techno-economic study on 2 coal cases (ENEL + GDF SUEZ)
  - Full techno-economic study on a NGCC case (GDF SUEZ)
Outline

- DMX™ process
- The OCTAVIUS Project
  - Sub-Project 3
- Main results (SP3)
  - Mini-pilots results
  - Process evaluation on a full scale power plant
  - FEED study
  - Go/no Go meeting
DMX™ Process mini-pilots tests

- **2 Mini-pilots**
  - At ENEL research center in Brindisi
  - At IFPEN in Solaize (Lyon)

- **Possibility to study**
  - Performances
    - CO₂ capture rate
    - Emissions
    - Corrosion
    - Degradation
  - Operability/flexibility
U544 mini-pilot at IFPEN

- Continuous pilot (24/24 & 7/7)
- Capacity
  - \( \sim 0.15 \text{ kgCO}_2/\text{h} \)
  - 0.5 - 2.5 L/h of solvent
- 1 absorber
  - \( \varnothing 50 \text{ mm}/1 \text{ m packing} \)
  - \( P=1-4 \text{ bara} \)
- 1 regenerator
  - \( \varnothing 50 \text{ mm}/1 \text{ m packing} \)
  - \( P=1-10 \text{ bara} \)
  - \( T \text{ up to 170°C} \)
- 1 vertical decanter
- Inline Gas analysis (FTIR)
U544 Simplified scheme (DMX™ configuration)
Mini-pilot tests within Octavius project

- **Objectives**
  - Get information about emissions, degradation, corrosion, operability in conditions that are representative of an industrial case

- **At ENEL research center**
  - 3 different tests
    - MEA sensitivity study
    - DMX sensitivity study an long run test
  - FTIR measurements performed by Laborelec (GDF SUEZ)

- **At IFPEN**
  - 2 different tests
    - MEA long run test (1500 h)
    - DMX long run test (1500h)
Main conclusions on DMX™ process from pilot tests (1/2)

- No decantation issue
  - Decantation is fast and easy to regulate

- Possibility to regenerate DMX solution @5bara
  - 147°C is set at the bottom of stripper

- Possibility to reach 90% CO₂ capture efficiency
  - Low loading is achievable (< 0.1 mol/mol)
  - High loading can be reached (> 0.7 mol/mol)

- Low emissions levels at absorber outlet (Ref = MEA 30%)
  - NH₃ emissions are very low (-85 % after 1500h of run)
  - -35% of solvent emissions
  - -75% of VOC emissions (after 1500h of run)
Main conclusions on DMX™ process from pilot tests (2/2)

- Low liquid degradation
  - No oxydative degradation detected
  - 60% of HSS compared to MEA 30% (after 1500h of run)
  - No significant loss of amine

- Corrosion
  - Regenerator @ 5.0 bara & 147 °C
  - Possibility to use CS with DMX (< 1µm/year)
  - CS coupons results after 1500h of run
  - Classical polymeric seals are degraded with DMX
  - PTFE seals is a proven solution
Outline

- DMX™ process
- The OCTAVIUS Project
  - Sub-Project 3
- Main results (SP3)
  - Mini-pilots results
  - Process evaluation on a full scale power plant
  - FEED study
  - Go/no Go meeting
Techno-economic study

- Process comparison of MEA 30% and DMX on a full-scale case in terms of:
  - Steam and electricity requirement
  - Energy penalty
  - Main equipments investment cost
  - Cost of electricity
  - Cost of CO₂ avoided

- Full-scale case selected
  - Grass root coal fired power plant
  - Net output power w/o CO₂ capture = 620 Mwe
Techno-economic study main results

- **Similar investment costs**
- **Considering optimized DMX case**
  - 22% reduction in terms of energy penalty
  - 23% reduction in terms of CO\(_2\) avoided cost
  - 48% increase in LCOE with DMX compared to 61% with MEA

<table>
<thead>
<tr>
<th></th>
<th>w/o capture</th>
<th>MEA ref</th>
<th>DMX case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net power</td>
<td>MWe</td>
<td>620</td>
<td>455</td>
</tr>
<tr>
<td>Net efficiency</td>
<td>%</td>
<td>44</td>
<td>32</td>
</tr>
<tr>
<td>Energy penalty</td>
<td>%pts</td>
<td>-</td>
<td>-11.6</td>
</tr>
<tr>
<td>Capture unit investment cost</td>
<td>M€</td>
<td>-</td>
<td>175.4</td>
</tr>
<tr>
<td>Cost of CO(_2) avoided</td>
<td>€/tCO(_2)</td>
<td>-</td>
<td>58.5</td>
</tr>
<tr>
<td>Cost of electricity</td>
<td>€/MWh</td>
<td>65.0</td>
<td>104.9</td>
</tr>
</tbody>
</table>

Similar investment cost (~176M€)

Significant reduction of CO\(_2\) avoided cost
Outline

- DMX™ process
- The OCTAVIUS Project

Main results (SP3)
- Mini-pilots results
- Process evaluation on a full scale power plant
- FEED study
- Go/no Go meeting
Preparation of the DMX™ Demonstration

- FEED for retrofit achieved
  - Collaboration between PROSERNAT, IFPEN & ENEL
  - Skid option was selected and fully designed
  - 3-D view of skid:

- Evaluation of the skid was performed
Outline

- DMX™ process
- The OCTAVIUS Project

Main results (SP3)
- Mini-pilots results
- Process evaluation on a full scale power plant
- FEED study
- Go/no Go meeting
Go/no Go meeting (1/2)

- Held in Brussel on the 11th December
- All technical criteria fulfilled
- DMX process is a promising CO₂ capture process
  - Low degradation and emissions observed during long test run (1 500 h)
  - Low corrosion confirmed: CS may be used with DMX
  - Reduces energy penalty (2.5 pts saved compared to MEA 30 wt%)
  - Same CAPEX as for MEA 30 wt% process
  - Reduced OPEX

23 % reduction in terms of CO₂ avoided cost
Go/no Go meeting (2/2)

- Nevertheless, financial criteria not fulfilled
  - Cost of pilot plant retrofit estimated at 6.68 > 4.00 M€

- Budget gap is too high

It was not possible to launch Phase 2 on Brindisi pilot Plant
Thank You for your Attention

Any questions?