First results of the 2.25 t/h post-combustion CO$_2$ capture pilot plant of ENEL at the Brindisi coal power plant with MEA from 20 to 40 %wt

P.A. Bouillon (IFPEN)
E. Lemaire (IFPEN)
A. Mangiaracina (ENEL)
C. Tabasso (ENEL)
Agenda

- IFPEN & ENEL's CCS strategies
- Pilot Plant Presentation
- MEA 30%wt tests
- MEA 40%wt preliminary results
- Conclusion
ENEL - Post Combustion CO$_2$ Capture Project

ZEPT - Zero Emission Porto Tolle

Project goal

To retrofit one 660 MW$_{e}$ coal fired unit, of Porto Tolle power station, with CO$_2$ post combustion capture equipment and start CO$_2$ underground storage in an off-shore saline aquifer by 2015

Project supported by the EEPR grant agreement with European Commission
ZEPT- Zero Emission Porto Tolle

**Lab**
- Advanced diagnostic
  - Lab pant (Brindisi)
  - Flue gases: 2 Nm³/h
  - CO₂: 0.4 kg/h

**Pilot**
- Pilot plant Brindisi Sud
  - Flue gases: 10,000 Nm³/h
  - CO₂: 2500 kg/h

**Demo**
- Porto Tolle
  - Flue gases: 810,000 Nm³/h
  - CO₂: 180,000 kg/h

**Mathematical modelling**
- Process testing
- Analytical methodologies development
- Performance testing
- Emissions measurement
- Innovative concepts testing
- Development and testing modelling tools

**Commercial application**
- Pre-commercial demo
- Technology scale-up
- Know how transfer to Engineering & Construction → costs and risk reduction
IFP Energies nouvelles

5 complementary strategic priorities

- Renewable energies
- Eco-friendly production
- Innovative transport
- Eco-efficient processes
- Sustainable resources

ENERGY DIVERSIFICATION

REDUCING THE ECOLOGICAL IMPACT

ENERGY EFFICIENCY

SECURING SUPPLIES

DECARBONATION

CLIMATE CHANGE: CUTTING CO₂ EMISSIONS

SUSTAINABLE DEVELOPMENT

Producing fuels, chemical intermediates and energy from renewable sources
Producing energy while mitigating the environmental footprint
Developing fuel-efficient, environmentally-friendly transport
Producing environmentally-friendly fuels and chemical intermediates from fossil resources
Providing environmentally-friendly technologies and pushing back the current boundaries of oil and gas reserves
IFPEN solutions for CO$_2$ capture

- **1$^{st}$ generation process**: HiCapt+™
  - MEA at 40% wt improved with inhibitors

- **2$^{nd}$ generation process**: DMX-1™
  - Needs for a collaboration for an industrial pilot
  - 2013-2015: pilot test campaign

- **3$^{rd}$ generation process**...
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Pilot plant presentation
Pilot plant presentation

Brindisi Federico II coal fired power plant

4 units x 660 MWe

Site of CO₂ capture pilot plant
Pilot plant presentation – Project planning

- Engineering phase
  - July 2008 – May 2009

- Construction phase
  - March 2009 – June 2010

- Start-up phase
  - June 2010 – July 2010

- Validation phase: MEA 20%wt
  - September 2010

- MEA 30%wt & 40%wt campaigns
  - November 2010 – May 2011
Pilot plant presentation – Project planning

- Mid 2010: start-up of the Brindisi's CCS pilot plant
- End 2010: Start of first test campaign

~ 2 years between start of engineering & start up of the unit
Pilot plant presentation – Construction
Pilot plant presentation – Construction
Pilot plant presentation – Construction
Pilot plant presentation – Characteristics

Flue gas conditioning

- Flue gas Blower
  - Flue gas flowrate: 3,000 to ~14,000 Nm$^3$/h

- DeSOx unit
  - Spray tower
  - SO$_2$ inlet up to 400 mg/Nm$^3$
  - Efficiency min: 95%

- WESP
  - 2 series / parallel WESP
Pilot plant presentation – Characteristics

CCS unit – Main equipments

- **Absorber**
  - i = 1 500 mm / H<sub>LT</sub> = 45 000 mm
  - packing: 3 x 7,35m M250X + 1 x 4m M250X
  - 3 stages solvent inlet

- **Stripper**
  - i = 1 300 mm / H<sub>LT</sub> = 31 000 mm
  - packing: 3 x 3,70m iRing 50 + 1 x 3m iRing 50
  - Reboiler: Kettle type ~ 1 to 3 MWth

- **Solvent / Solvent cross heat exchanger**
  - Plates type
Pilot plant presentation – Characteristics

CCS unit – annex equipments

- **Filtration section**
  - 2 mechanical filters
  - 1 carbon filter 15 m³

- **Solvent Storage**
  - 2 x 100m³ tanks
  - Solvent hold up ~ 65 m³

- **Cooling water section**
  - External loop sea water
  - Industrial Cooling water loop
  - Sea water / cooling water heat exchanger (TEMA)
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MEA 30%wt campaign

- 4 months campaign
  - November 2010 - February 2011

- Parametric studies – Process optimization
  - Regeneration pressure
  - Lean loading

- Aspen+ Model validation
  - L/G variations – hydrodynamic correlations
  - Packing height – kinetics equations

- Long run test = 500 hours
  - Performances validation
  - Emission measurements
  - Solvent degradation
MEA 30%wt campaign – Performance test

![Graph showing flue gas flowrate and CO2 levels over time.](image)

**Date - heure**

**Flue gas flowrate (Nm³/h)**

- Flue gas flowrate
- CO2 in
- CO2 out

**CO2 (%vol.)**

- Flue gas flowrate
- CO2 in
- CO2 out
MEA 30%wt campaign – Performance test

Date - heure

CO₂ / Steam (kg/h)

CO₂ production
Steam flowrate
MEA flowrate

ME (m³/h)
MEA 30%wt campaign – Performance test

Long run test main results

- Operating conditions
  - Flue gas: 9,825 Nm$^3$/h
  - MEA: 28 m$^3$/h
  - Pstripper: 1,8 bar(a)

- Results
  - CO$_2$ prod.: 1,730 kg/h
  - Loadings: $L = 0.22 \Rightarrow R = 0.515$
  - Efficiency: 83.2%
  - Energy: $\sim 3.35 \text{ GJ/t}_\text{CO}_2$
  - Degradation: 1.4 – 1.5 kg$_\text{MEA}$/t$_\text{CO}_2$
MEA 30%wt campaign – Performance test

ASPEN+ model

- Good representitivety
- Errors < 5%
  - T° profiles, CO₂ profiles
  - CO₂ prod, steam consumption...
Agenda

- IFPEN & ENEL's CCS strategies
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- MEA 30%wt tests
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MEA 40%wt campaign

- 3 months campaign
  - March 2011 - May 2011
  - Tests under progress

- Parametric studies
  - Process optimization
  - Aspen+ model upgrade to MEA 40%wt

- Long run test = 500 hours
  - Performances validation
  - Emission measurements
  - Solvent degradation
MEA 40%wt campaign – First results
MEA 40%wt campaign – First results

- **Process optimization**
  - lean optimum $\sim 0.22 - 0.24$ mol/mol
  - $E_{\text{reg}} \sim 3 - 3.15$ GJ / t\(CO_2\)

- **Aspen+ model**
  - Good prediction for hydrodynamic
  - Kinetics tests to be completed with packing height variation

- **To be completed**
  - Degradation
  - Emissions
MEA 40%wt campaign – First results

ASPEN+ model

- **Good representitivity**
  - T° profiles, CO₂ profiles
  - CO₂ prod, steam consumption...

![Graphs showing temperature, CO₂ vapor, and absorbent concentration profiles](image-url)
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Conclusions - perspectives

- ENEL's Brindisi CCS pilot plant is representative of industrial units

- More than 2,000 hours of continuous operation already done

- Qualification with MEA 30%wt has been done successfully

- MEA 40%wt campaign already gave good results... Test campaign to be completed in the next month.

- Aspen+ model updated appears to be robust for MEA 20 to 40%wt
Questions?

p-antoine.bouillon@ifpen.fr
angela.mangiaracina@enel.com