CO_2 Post Combustion Capture: CASTOR Project

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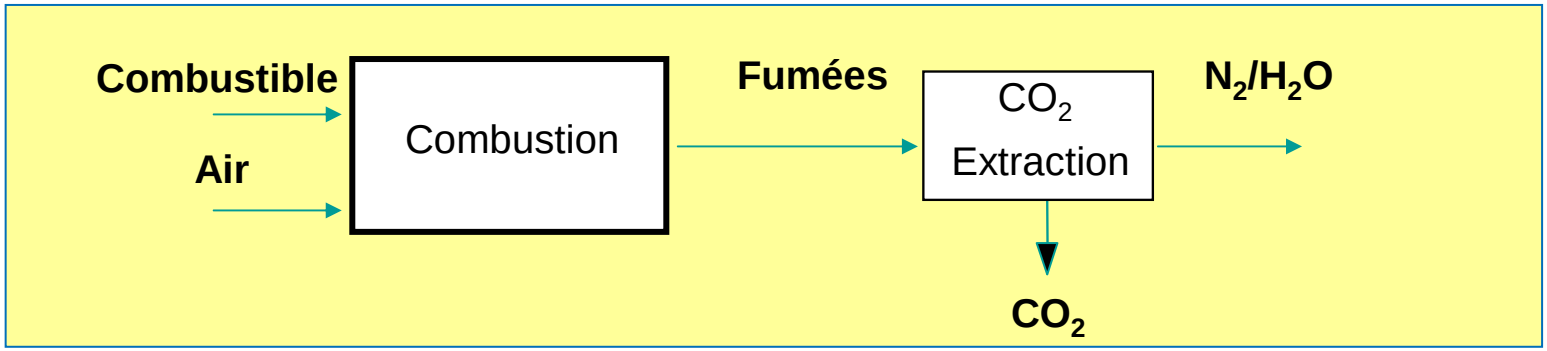
Outlook

- CASTOR Project
  - Objectives, Summary
- CO_2 Post-Combustion Capture
  - Principles and main issues
  - Process optimization :
    - Size of the plants : gas/liquid contactors
    - Heat of regeneration : new solvents
    - Model validation : DONG Energy pilot plant
- Exemples of innovative solutions (IFP Energies nouvelles)
  - new contactors, new solvents (DMX™)
- Conclusions / Perspectives

CASTOR Project

- Objectives :
  - The reduction of emissions of greenhouse gases by the development of CO_2 Post Combustion capture and geological storage
    - Capture, transport and storage feasibility
- Summary :
  - European project :
    - 28 participants : 12 research institutes + universities, 5 oil and gas companies, 6 electricity suppliers, 4 manufacturers, 1 solvent producer.
  - 15 800 k€ over 4 years (2004-2008), ~ 70% for capture
  - IFP Energies nouvelles = coordinator : P. Le Thiez, P. Broutin.

Post Combustion Capture (1/8)



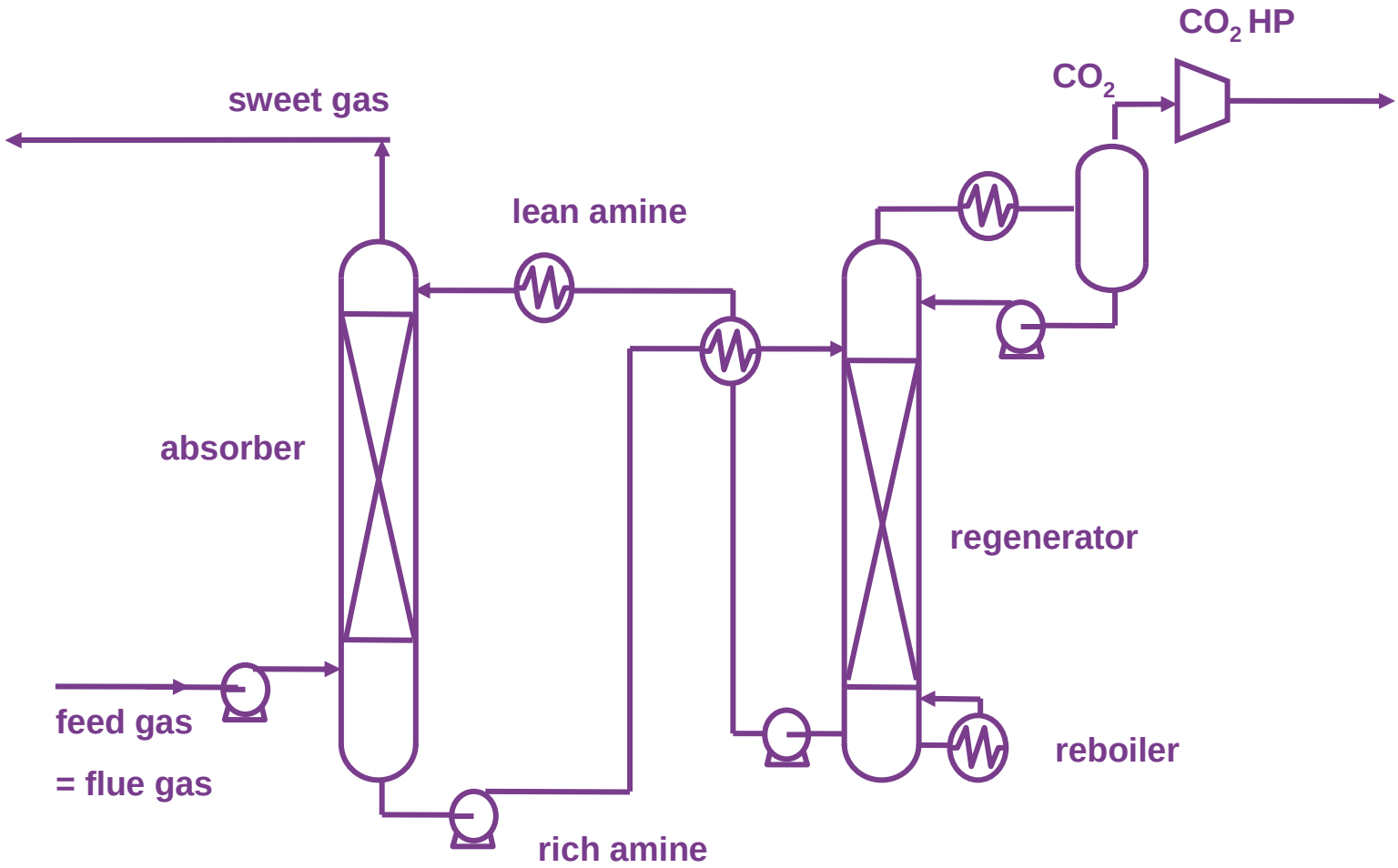
- **Huge gas flowrate at low pressure and with low CO_2 concentration :**

  600 MWe coal = 1 800 000 Nm^3/h ; P_{CO2} = 0.15 bar

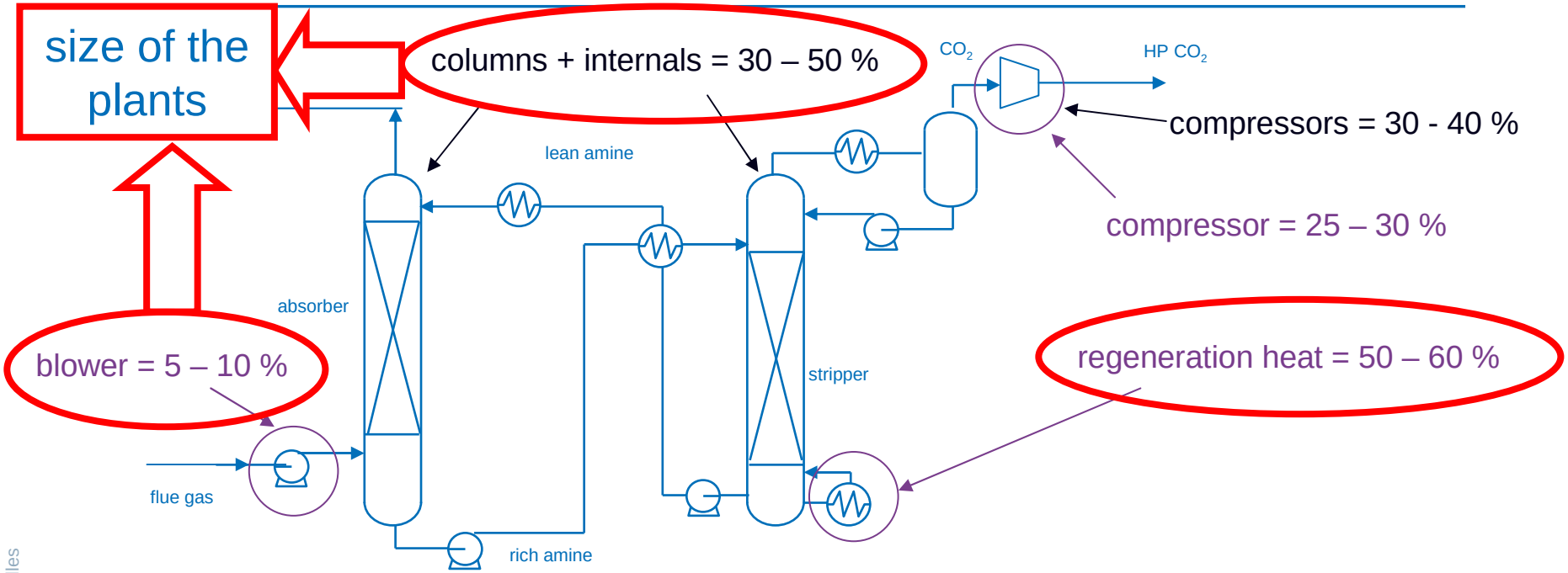
- **The more mature way to capture CO_2 emitted, the way to reduce existing power plants emissions**

  => 5.6 Mt of CO_2 emitted /year

Post Combustion Capture (2/8)



Post Combustion Capture (3/8)



	Base case	With CCS (MEA)
Net Efficiency	45 %	34.5 %
capture cost CO_2 (indicative)		61 €/t

Post Combustion Capture (4/8)

- Size of the plants / gas-liquid contactors :
  - High capacity contactors : gas velocity > 2 m/s to reduce columns diameter / number
  - High efficiency contactors : high interfacial area to reduce column height (90% of the CO_2 should be captured)
  - CASTOR Project :
    - Two Commercial contactors selected by IFP Energies nouvelles (Random packing IMTP 50, structured packing M252Y)
    - IFP Energies nouvelles => characterization tests => model for capture plants with MEA => validation with pilot plant measurements

Post Combustion Capture (5/8)

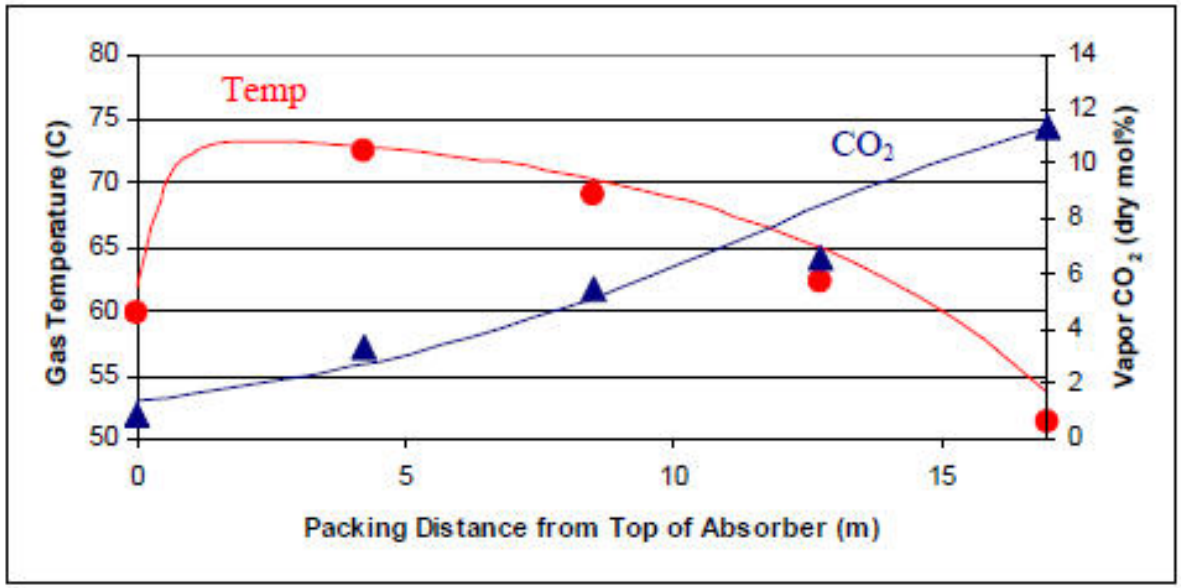
- Regeneration heat : new solvents
  - Heat of regeneration
    - L/V equilibrium, heat of reactions, ...
  - Kinetics :
    - chemical reactions => absorber height
  - Thermodynamics :
    - capacity => liquid flowrate (pumps, pipes, etc)
    - driving force = absorber height
  - Degradation, foaming, corrosion
    - materials, additives...
    - degradation products => corrosion ?
    - NOx, SOx impact ? => deNOx-deSOx upstream ?
  - ....

Post Combustion Capture (6/8)

- DONG Energy Pilot Plant:
  - Coal power plant (Esbjerg, DK)
    - 1x400 MWe
  - Amine scrubbing
    - flue gases = 5000 Nm^3/h (0.5%)
    - 1 T/h de CO_2 treated (1 MWe)
  - Random packing IMTP50
  - Solvents : MEA 30%wt, CASTOR 1 & 2
  - Absorber :
    - D=1.1 m, H= 34 m
  - Regenerator :
    - D=1.1 m , H= 26 m

Post Combustion Capture (7/8)

- Absorber modelling :
  - Rate based model (mass transfer, chemical react., thermo,...)



  - Good agreement for MEA 30%wt (CO_2 and T profils)
  - Heat of regeneration = [3.7 ; 4] GJ/t of CO_2 for MEA ; 3.8 GJ/t for CASTOR 1 ; 3.5 GJ/t for CASTOR 2

Innovative Solutions : new contactors (1/3)

- Gascogne Project (ANR)
  - IFP Energies nouvelles, LGC Toulouse and SPS (SAFRAN)
  - Carbon / Carbon 4D internal

+ IFP Energies nouvelles : IFPACC contactor (patent)
⇒ also very promising
⇒ in progress

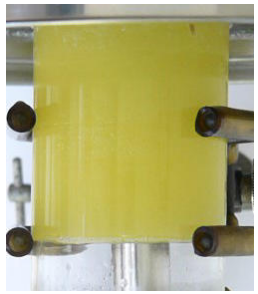
  - Summary :
    - very high interfacial area vs. a lower capacity than commercial packings => promising, to be confirmed at a bigger scale
      => economic study

Innovative Solutions : DMX™ (2/3)

Two phases are generated when the solvent reacts with CO_2 :

=> top phase = amine

=> bottom phase = water + products of reactions



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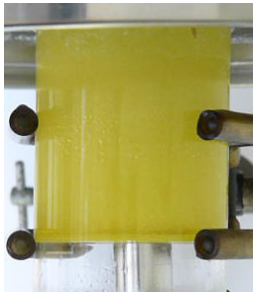
(arrêt de l'Ultra-Turrax)



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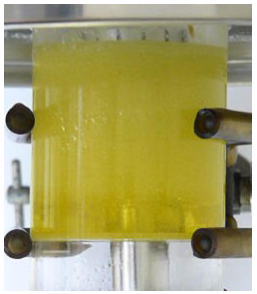

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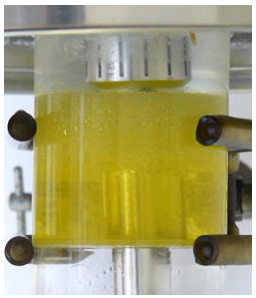
phase supérieure

lit dense

phase inférieure



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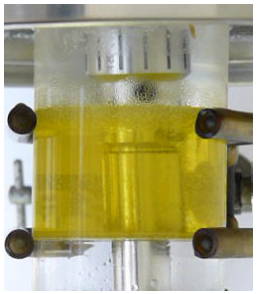

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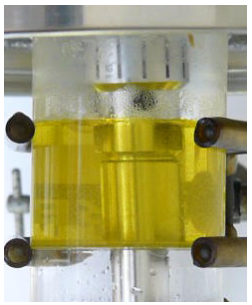

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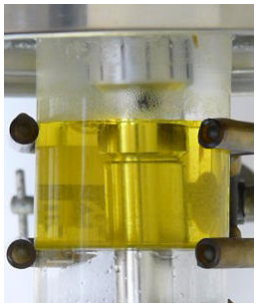

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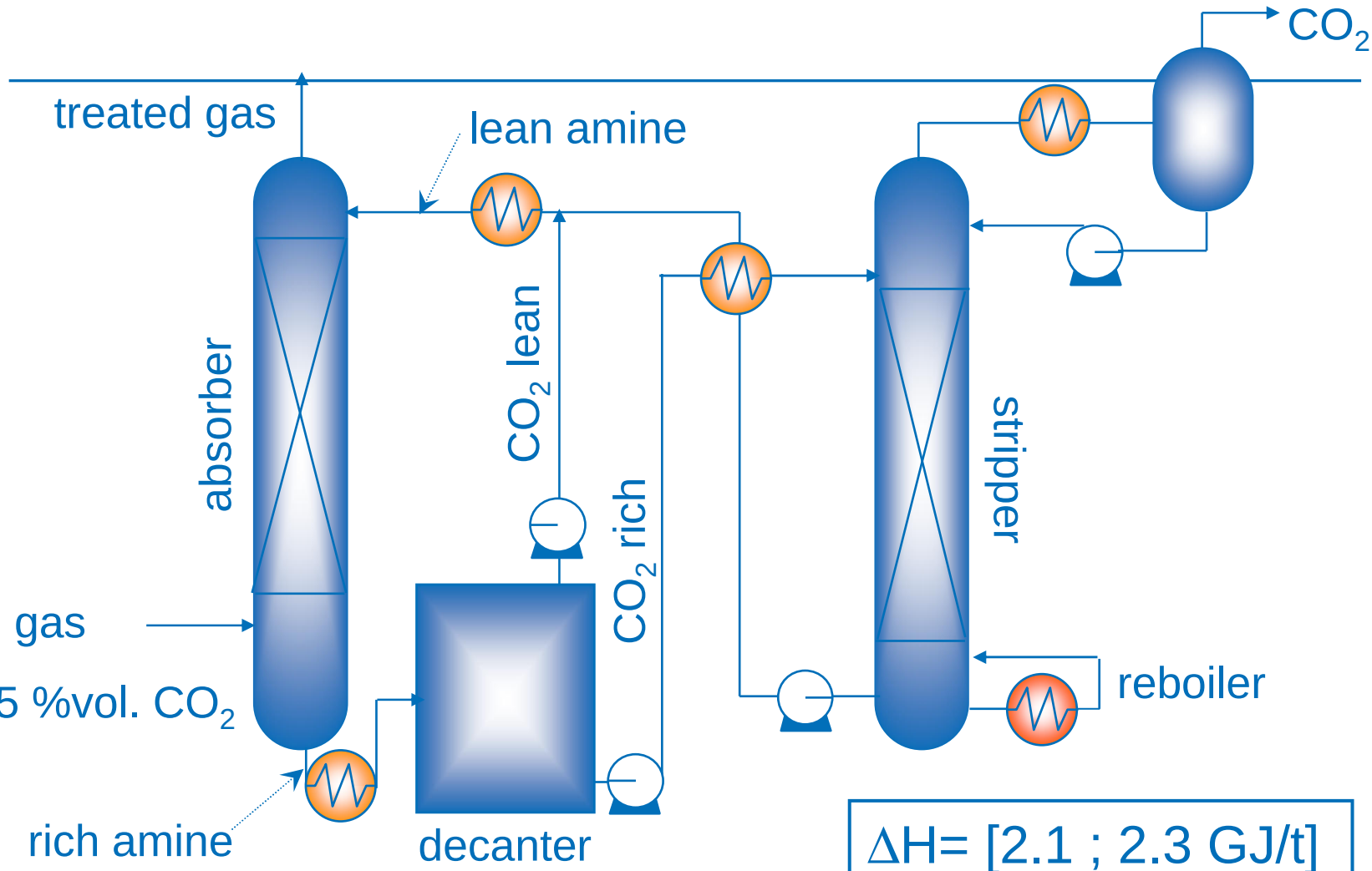
Innovative Solutions : DMX™ (3/3)



Conclusions/perspectives (1/2)

- Post Combustion Capture :
  - to reduce existing and new power plants emissions
  - heat of regeneration reduction => new solvents + process optimization
  - size of the plants and booster fan consumption reductions => high capacity and efficiency contactors
  - CASTOR Project => feedbacks, network,...
  - IFP Energies nouvelles develops innovative solutions : 4D, IFPACC, DMX™,...
- European Project Cesar (=>2010) :
  - DONG pilot plant modifications => structured packing, solvents = CESAR 1 & CESAR 2 (in progress)

Conclusions/perspectives (2/2)

- Piccaso ("grand emprunt")
  - Facilities to develop processes (solvents, techno, etc)

- Project with ENEL
  - Coal power plant (Brindisi, IT) :
    - 4x660 MWe
  - Structured packing
  - Hi-Capt+ (optimized MEA)
  - Started in june 2010
  - Flue gases flowrate: 12 000 Nm^3/h
  - Treated CO_2 : 2,25 T/h
  - Absorber : H 46m Ø 1,5m
  - Regenerator : H 32m Ø 1,3m