Engineering of Air Separation and Cryocap™ units for large size plants

Oxyfuel Combustion Conference (OCC3), 9-13th September 2013, Ponferrada, Spain

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Agenda

- Design ASU for oxy-combustion
  - eXtra Large ASU → Air Liquide Engineering ability to build very large plants
  - eXtra Low Energy ASU→ New improved design adapted to new specifications
  - ALIVE™ Concept
  - Example of the Endesa FEED: Basic engineering of ASU designed for oxy-combustion

- Design of Cryocap™ Oxy for industrial size
  - Air Liquide experience through pilots
  - The FutureGen 2.0 pre-FEED
  - Looking forward: FutureGen 2.0 project

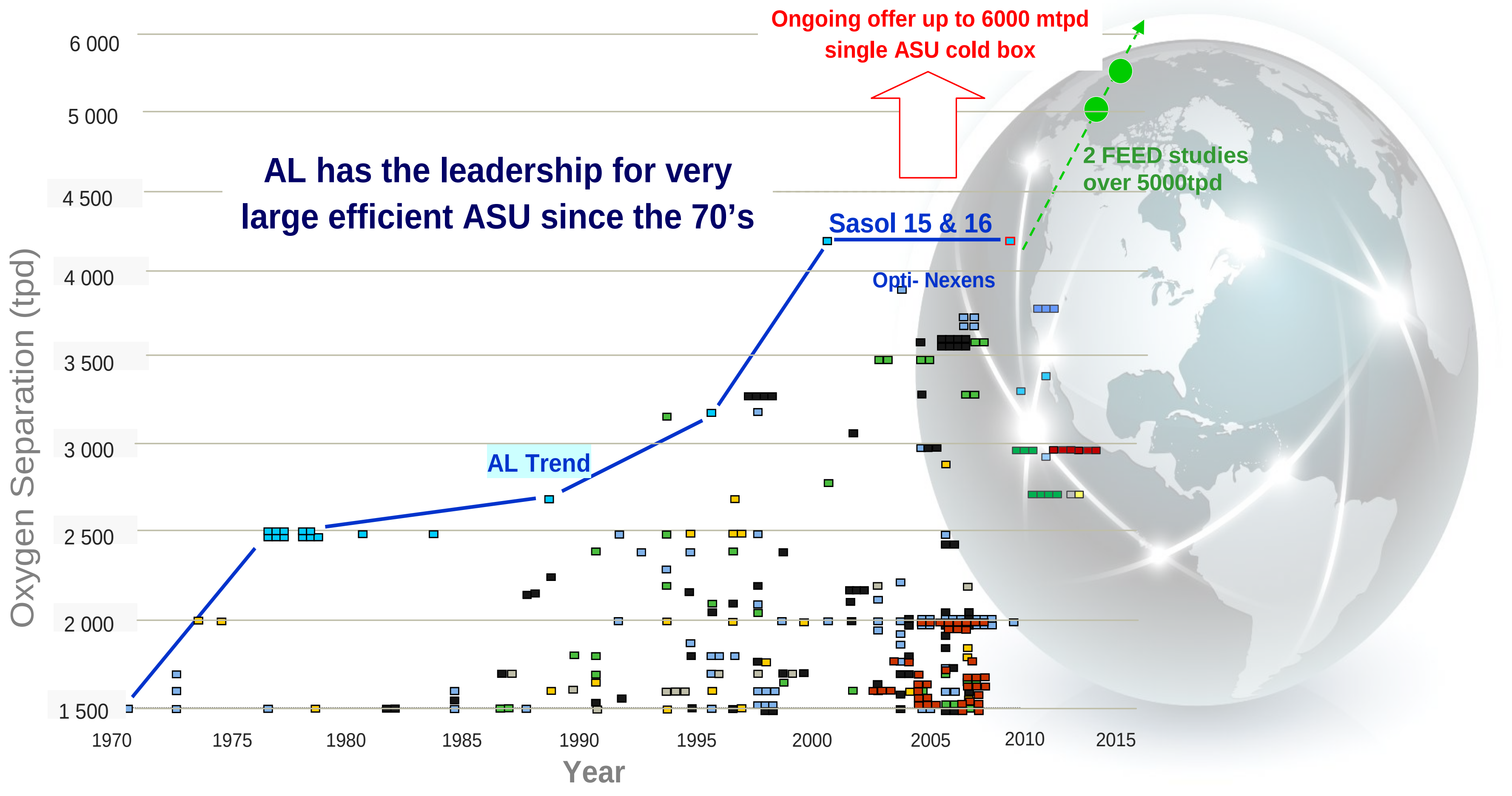
Engineering Design of ASU for oxy-combustion

Building large size ASUs for oxy-combustion

- Typical coal oxy-power plant oxygen need: 5 000 – 15 000 Tonnes/day of O_2 (~20 tpd O_2 / MWe)

- Challenges
  - Large size project management
  - Ability to maximize size of single train unit (XL ASUs)
    - Transport constraints
    - Acceptable size of equipment
    - Limits of cold box (diameter of columns…)
  - Ability to handle multi-train

Air Liquide Capabilities in XL ASUs



Air Liquide Capabilities in XL ASUs

Largest O2 site in the world

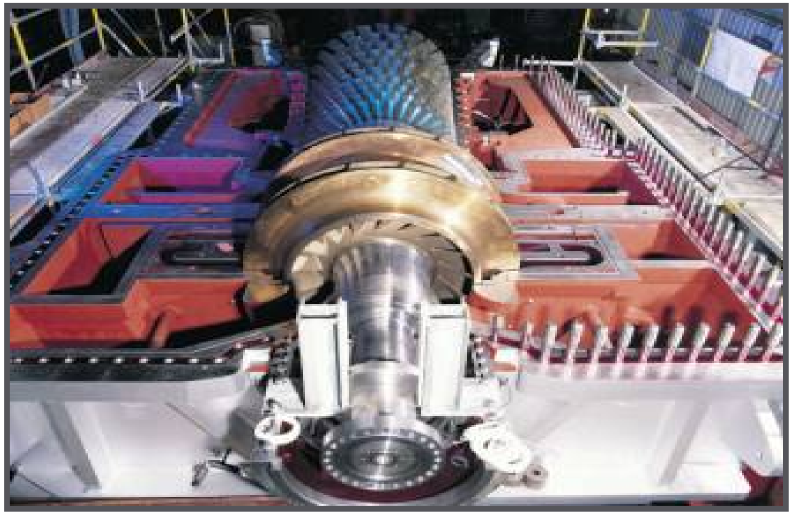
42 000 mTPD - SASOL

Largest ASU trains in the world

4 200 TPD (at MSL) – SASOL T15

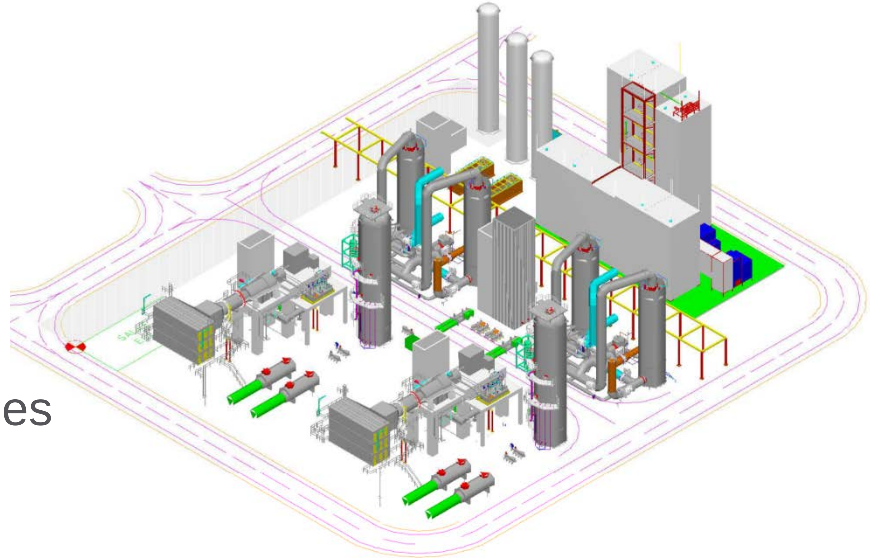
Largest air compressor in the world

700,000 m3/h



FEED of Endesa OxyCFB300

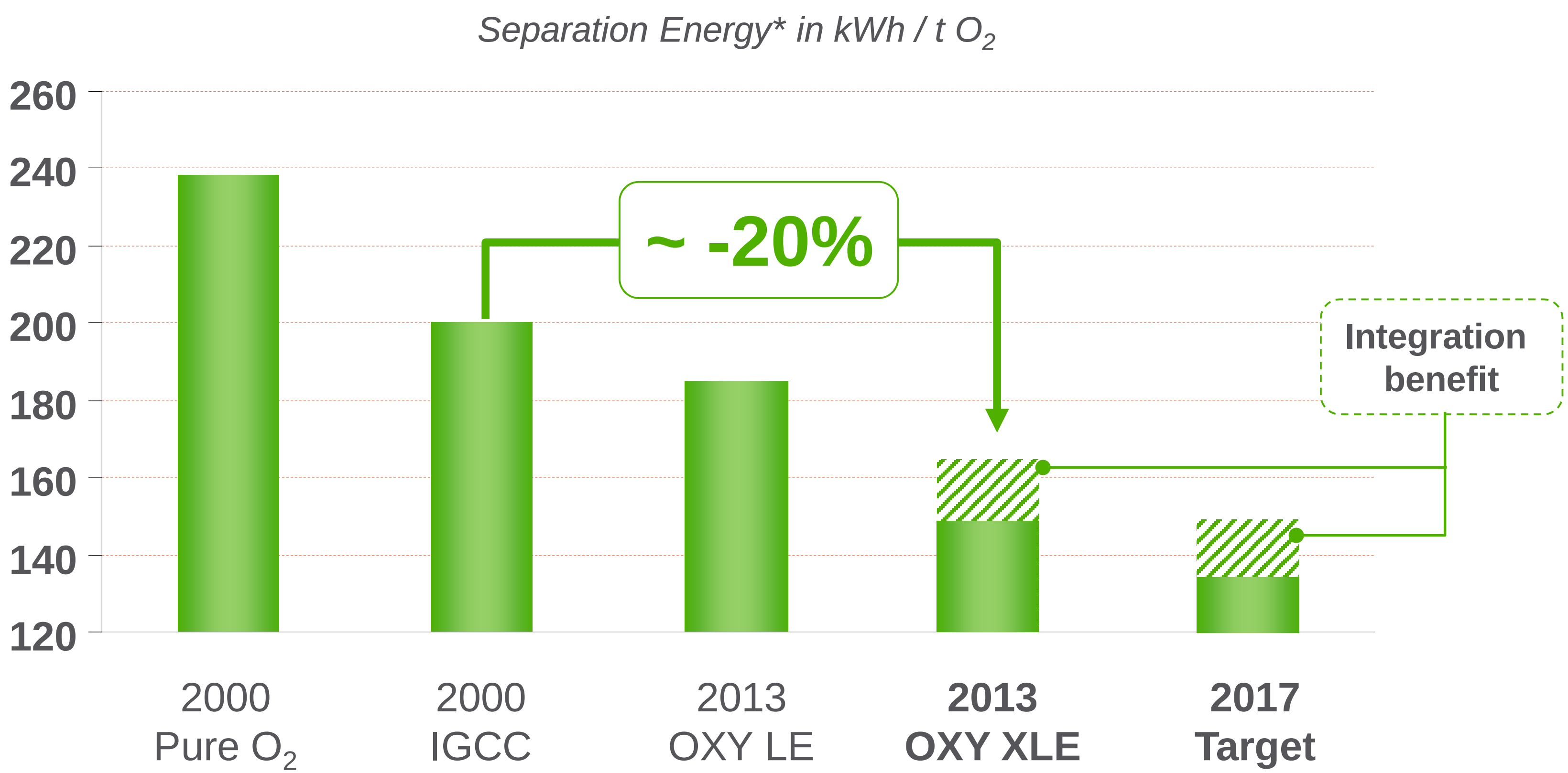
- OxyCFB300 Context
  - 330MWe gross oxy-power with CFB technology
  - EERP funding
- One large size ASU
  - > 5000 mtpd



- Basic Engineering Deliverables
  - Detailed mass balance & PFDs, utilities
  - Single Line Diagram
  - Process control, Sensitivity analysis
  - Plot optimization, Bill of Quantities
- Implementation of the ALIVE™ concept

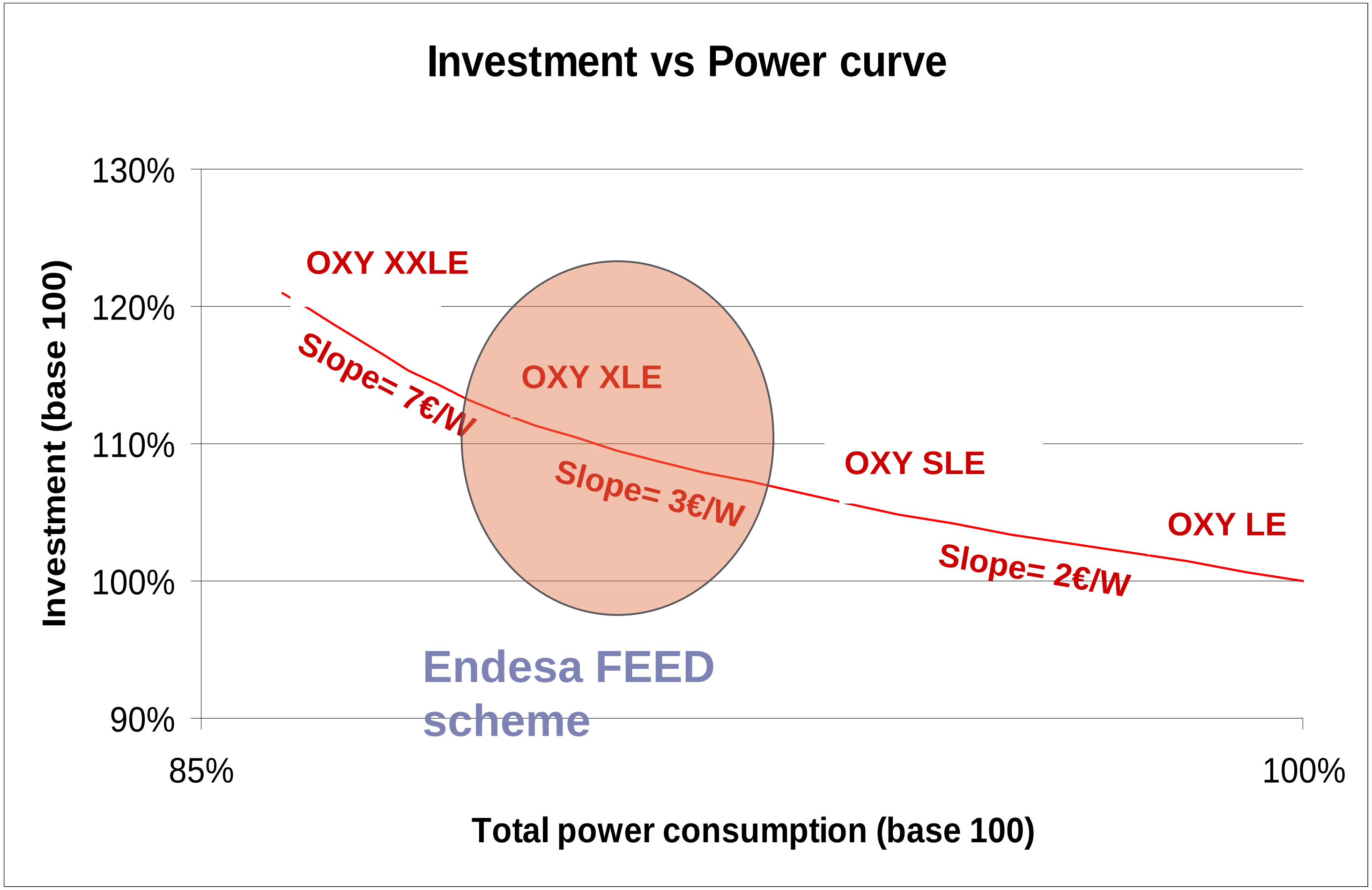
High efficiency ASU for oxy-combustion

- Oxy combustion
  - ASU design = air distillation at lowest possible pressure (< 4bara)



** Compression energy not included, calculated at 15 ° C, 1 atm, 60% humidity*

ASU scheme selection for the OxyCFB300 Project



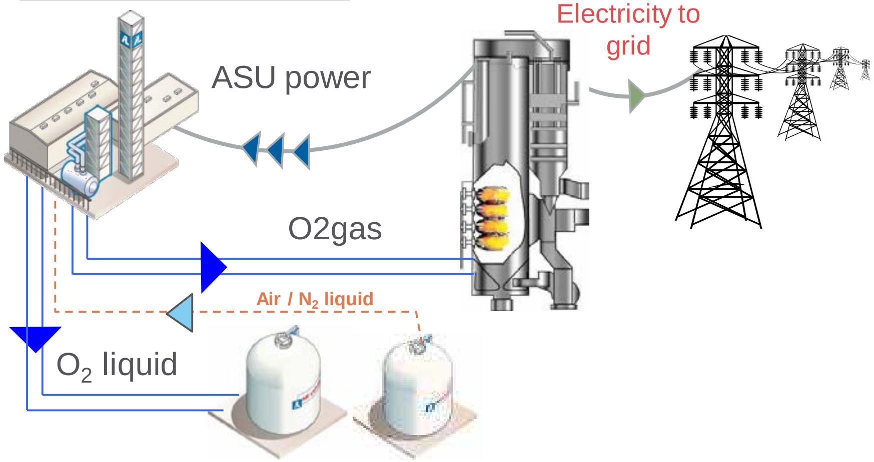
Implementation of Alive™ Concept

ALIVE - AL Innovative Variable Energy

Off-peak: low electricity prices – O_2 storage –

Cheap power is valued by generating O_2

Minimum output is sold to the grid



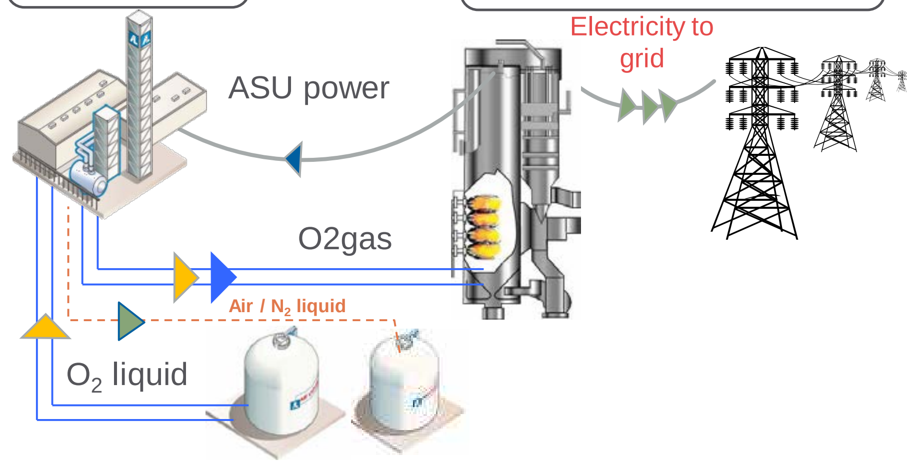
Surplus of O2 is stored

Cheap generation of O_2 to storage

Peak: high electricity prices – O_2 consumption –

ASU run at minimal power

Maximum output is sold to the grid



Stored O2 supply for additional power generation

Maximum power sale to the grid

Swinging plant –ALIVE Concept

- Implementation on the Endesa FEED
  - ASU and boiler are in phase opposition
  - Extra O_2 separation energy consumed during off peak (night) is recovered during peak time (day) by reducing ASU load
  - O_2 liquefaction energy is transferred to other fluids and vice versa → Almost no energy losses
  - Globally Energy storage efficiency is greater than 95%
  - Specificities linked to local economic environment
  - Energy storage capacity ~ 200 - 300MWh

Engineering Design of Cryocap™ Oxy

AIR LIQUIDE

Cryocap™ Oxy: Proof of concept

- CO2 delivery from oxy-combustion plant requires additionnal steps
  - Cleaning of impurities
    - N_2, Ar, O_2
    - H_2O
    - NOx, SOx, Hg
  - Pressurisation
    - Compression
    - Supercritical CO_2 pumping
- Technological bricks identified / schemes developped
  - Process simulations
  - Litterature review
  - Definition of proprietary AL solution
  - Lab tests

☺ Done by 2005

Cryocap™ Oxy: pilot plants

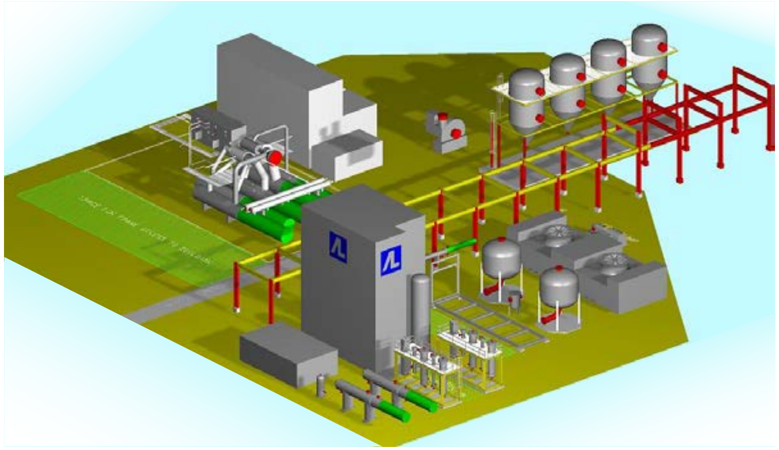
- Early phase necessary for new technology: qualification through industrial pilots (details in other AL presentations)
  - Lacq
    - Dryers
    - Oxy-gas burners (AL technology)
  - Callide & CIUDEN
    - Cryocap™ Oxy technology
    - Up-scalable

Done by 2009-2013

AIR LIQUIDE

Cryocap™ Oxy: pre-FEED phase

- Next phase: pre-FEED → validation of ability to design large size plants (including technical risk analysis)
  - FutureGen 2.0
    - Scheme selection and validation that maturity level allows entering next phases of the project
    - Main deliverables:
      - Block Flow Diagrams
      - Utilities Flow Diagram
      - Emissions and Effluents Summary
      - Tie in list
      - Main equipment list
      - Electrical consumer list
      - Heat and mass balance
      - Plot plan



Achieved in 2012

Path Forward for Cryocap™ Oxy

- Air Liquide able to handle FEED for large size Cryocap™ Oxy & project realization

- First industrial size project on-going: FutureGen 2.0 FEED phase from Q1 2013 to Q2 2014
  - Basic & detailed engineering

- Project execution of FutureGen 2.0 project to follow

General conclusions

- Air Liquide is ready for commercial deployment of oxy-combustion technology
  - ASU
    - Challenge of large size and high efficiency ASUs → AL ability demonstrated through ASU FEED phases performed
  - Cryocap™ Oxy
    - Proof of concept performed
    - Pilot phase done
    - Pre-FEED level achieved
    - First true FEED on-going

FutureGen ALLIANCE

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End of presentation

Thank you for your attention

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