DEVELOPMENT AND DEMONSTRATION OF OXY CFB FOR POWER PLANTS WITH CO₂ CAPTURE

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- Development of Flexi-Burn CFB technology
- The 300 MWₑ demonstration project of ENDESA and CIUDEN

"Flexi-Burn™" is trademark of Foster Wheeler AG
Introduction: Oxy CFB boiler

- Benefits of Oxyfuel combustion in CFB
- Flexi-Burn CFB boiler
- Challenges for the development
Oxyfuel CFB Technology
Main Benefits

- The established CFB advantages exist also in CFB oxycombustion: low furnace temperatures, hot circulating solids, long solid residence time.
- Multi-fuel capability (coal, petroleum coke, lignites, biomasses), simple feed systems – capability to utilize cheap fuels emphasized due to CCS efficiency penalties.
- NO\(_x\) and SO\(_x\) reduction without back-end cleaning.
- Good fuel burnout and sorbent utilization.
- Efficient heat transfer and uniform heat flux.
- Enables Flexi-Burn CFB boiler design: the same boiler can be operated in air firing or oxy firing mode with CCS.

Further potential to use high O\(_2\) contents

- Reduce boiler size
- Limited capability for air firing
Flexi-Burn CFB Power Plant

- 1st generation OXY CFB with oxygen content of the oxidant close to air firing
- Boiler designed to be capable for both oxy and air firing
- Oxy-ready design for subsequent implementation of CCS
- The plant can be built in functional stages
- Retrofit possibility
Challenges of Oxyfuel CFB technology

- Understand the significant change in gas atmosphere in OXY mode
  - Changes in hydrodynamics
  - Behaviour of materials
  - Emissions prediction
  - Adaptation of design tools
- Achieve high gross efficiency to minimize penalty
  - Aim at steam parameters $> 600 \, ^\circ\text{C}$, 270 bar
- Reduce oxygen production costs
- System-level integration to reduce investment costs and to improve efficiency

Oxy-fuel CFB is considered technically viable

- Experiments in bench scale and pilot test facilities combined with modelling required to confirm the process performance and material behaviour in the CO$_2$ rich atmosphere
- Demonstration in 10’s of MW scale and commercial scale required to proof the concept - design, performance and economics
Development of Flexi-Burn CFB technology

- Roadmap for Oxy CFB development
- Piloting (laboratory scale, CANMET, CIUDEN)
- Feasibility studies
Development of OXY CFB Technology
Integrated Experimental and Modeling Work for Scale-Up

**Bench scale**  
**Pilot scale**  
**10 MW scale**  
**Boiler scale**

**EXPERIMENTAL SCALES**

**MODELS AND DESIGN TOOLS**

Models for phenomena  
1-D process models (stationary, dynamic)  
1-D design model  
3-D process model
Development of Flexi-Burn CFB
Main Activities

• Of the main CCS technology options, Foster Wheeler is mainly focusing on oxy-fuel combustion, having been developing it since 2003:
  • Knowledge and design tool development
  • Test activities (VTT bench scale & small pilot CFB)
  • Conceptual and feasibility studies (boiler design)

• Pilot test activities at larger scale facilities
  • ~0.1 MW\text{th} (current) $\rightarrow$ ~1 MW\text{th} CANMET (2009) $\rightarrow$ 30 MW\text{th} CIUDEN (2010-11)

• In parallel, scale-up of air-fired CFB boilers has continued. The world largest and first SC-OTU CFB at PKE’s Lagisza plant in Poland is in commercial operation and and FW has developed the OTU CFB boiler concept further up to 600-800 MW\text{e} size with 600 °C steam temperature.

• The Spanish government has decided on investment for the CIUDEN 30 MW\text{th} class pilot CFB facility, which provides a full experimental CCS platform for the demonstration and validation of oxy/air fuel combustion in sufficient scale to allow continuation to commercial scale.
Development of Flexi-Burn CFB
Main Activities

• The Oxy-CFB 300 MW_e project of ENDESA and CIUDEN aims to be one of the 10-12 CCS commercial size demonstration plants in Europe.
  • FW prepared a feasibility study for the 500 MWe Oxy CFB Power plant with CCS
  • FW will provide the technology for the CFB boiler

• Feasibility studies with other utilities
  • Vattenfall 500 MWe CHP power plant with Oxyfuel CFB
  • PVO 500 MWe multifuel Oxy ready CFB plant (biomass cofiring)
• EU FP7 project “FLEXI BURN CFB” aiming at the development of technology to be ready for demonstration

• FW participates in the development of 50 MW_e Oxy-CFB demonstration project at Jamestown plant in New York state and the 78 MW_e Oxy-CFB project developed by Praxair and New Holland Board of Public Works.
Development of Flexi-Burn CFB
Scale-Up Path

Existing know-how
- Supply of over 300 CFB boilers up to 460 MW<sub>e</sub>
- Long-term development of design tools

Lagisza 460 MW<sub>e</sub> OTU CFB
- Scale-up information from the world's largest CFB
- Experiences of the world's first SC OTU CFB
- Design model validation

CIUDEN - demonstration of Flexi-Burn CFB
Air- / oxy-fuel combustion with fuel flexibility
- CO<sub>2</sub> separation

Commercial scale Flexi-Burn Oxy CFB technology demonstration in <500 MW<sub>e</sub> size by 2015

- Background for engineering
- Scale-up criteria
- Air- / oxyfiring + CCS expertise

Flexi-Burn Oxy CFB technology commercial up to 800 MW<sub>e</sub> size by 2020
The 300 MWe demonstration project of ENDESA and CIUDEN

- ENDESA Generación and CIUDEN are promoting a CCS integral Commercial Demonstration Project, including CO2 capture, transport and storage, based on a circa 323 MWe Circulating Fluidised Bed (CFB) supercritical oxycombustion plant, with CO2 storage in a saline aquifer.

- The main target of this Demo project is to validate, at commercial plant size, a CCS technology that will allow the renovation of the existing fossil thermal plants from 2020, using a wide range of domestic coals, as well as imported fuels (coals, pet coke...), and biomass.

- The proposed project programme has been divided in two periods: Technology Development and FEED studies (2009-2011) and the construction of the Demo project infrastructure including capture transport and storage concepts (2012-2015).

- The schedule of the proposed project considers that the Final Investment Decision (FID) of the integrated project will be taken by the end of 2011, once all the final studies (technical, economical, risks, etc.), financial and permitting issues are finally cleared.
The 300 MWe demonstration project of ENDESA and CIUDEN

ENDESA has signed (2007) cooperation agreement with FOSTER WHEELER ENERGIA SA (FWESA) to participate in the scale-up validation program as well as on the expected construction of the Commercial Demo Plant.

ENDESA and CIUDEN have agreed to establish a Joint-Venture to start the development of the Commercial Demo Plant jointly with Foster Wheeler

• The technology provider is the Finland based FOSTER WHEELER ENERGIA Oy, responsible of the basic design of CFB units.

• In order to support the development, CIUDEN is constructing an Integrated CCS Technology Development Plant in Compostilla featuring a 30MWth Oxy-CFB using exactly the same technology to be incorporated by the commercial scale demo plant.
A complete test program will be carried out in this plant, with the aim of validating the full chain of processes from fuel preparation to CO₂ purification, producing an stream ready for transport and storage in order to obtain enough data for scaling-up the technology.

The TDP is located next to the Compostilla power plant.
The TDP has been engineered to test the integrated operation of:

- the coal and limestone preparation and feeding, biomass in the 2nd phase
- circulating fluidised bed oxycombustion,
- flue gas recirculating/mixing and heating devices,
- flue gas cleaning
- CO2 compression and purification units and
- auxiliary services, to provide the necessary technical support for its application in the OXY-CFB-300 power plant.

- The TDP also incorporates a PC oxyboiler
Summary

• CFB is very well suited for Oxy-firing

• The benefits of air-fired CFB technology are available for Oxy operation

• Flexi-Burn CFB allows operation of the plant both in oxy and air mode

• The Oxy-CFB development targets to have the commercial scale CCS demonstration plant in operation in 2015
Thank You!