REINHOLD ENVIRONMENTAL Ltd.

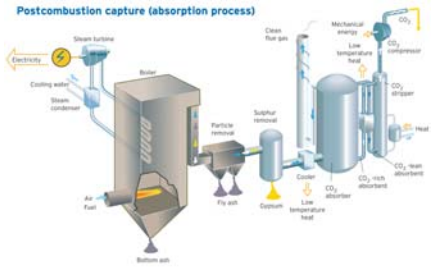
2011 NOx-Combustion Round Table & Expo Presentation

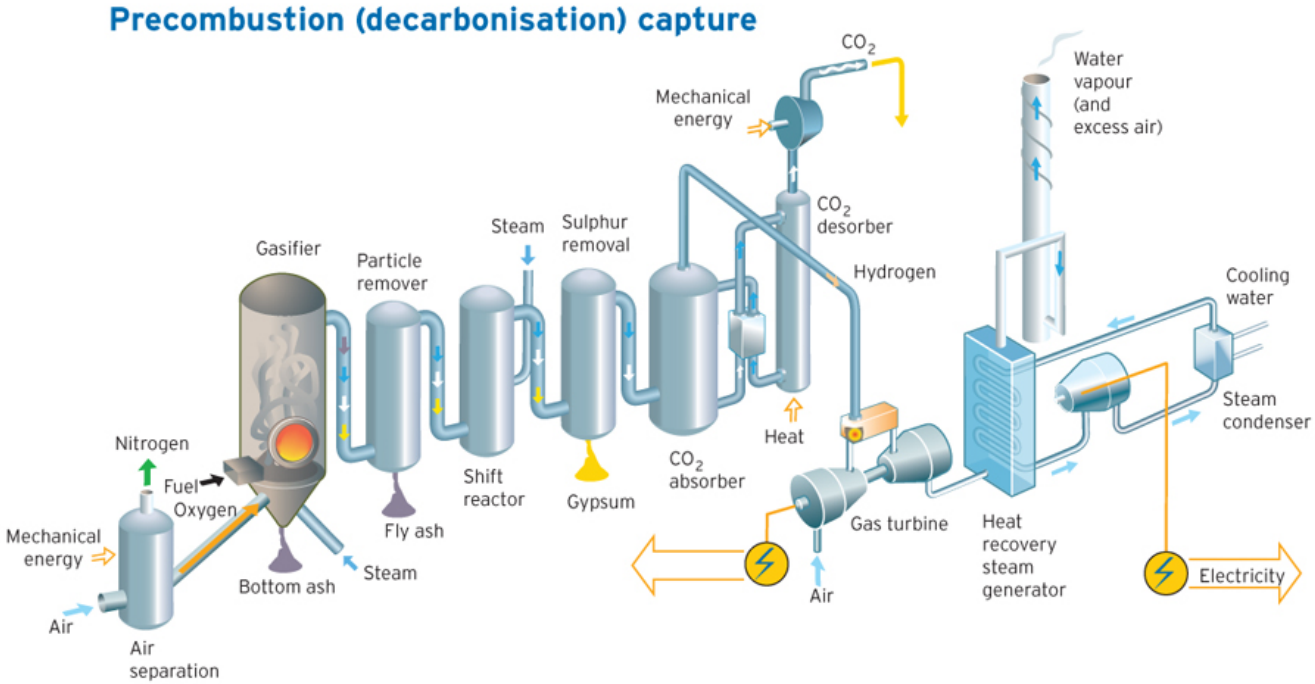
February 7-8, 2011, in Birmingham, AL / Hosted by Southern Company

Agenda

- Introduction to Doosan Power Systems
- Carbon Capture Technologies in Development
  - Pre-Combustion Capture
  - Oxy-Combustion Capture
  - Post-Combustion Capture
- Utilization/Storage of CO_2
- Key Challenges Associated with Development and Commercialization
- Conclusions

Three Technologies for Carbon Capture

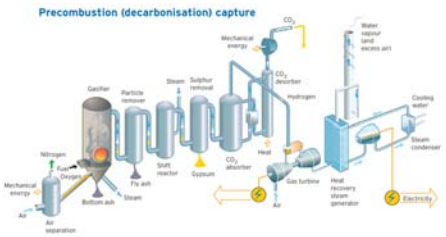


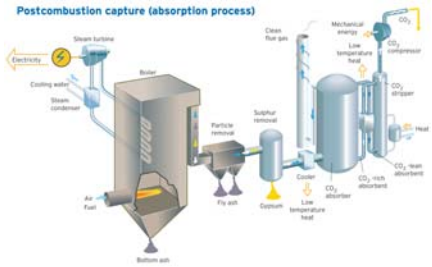


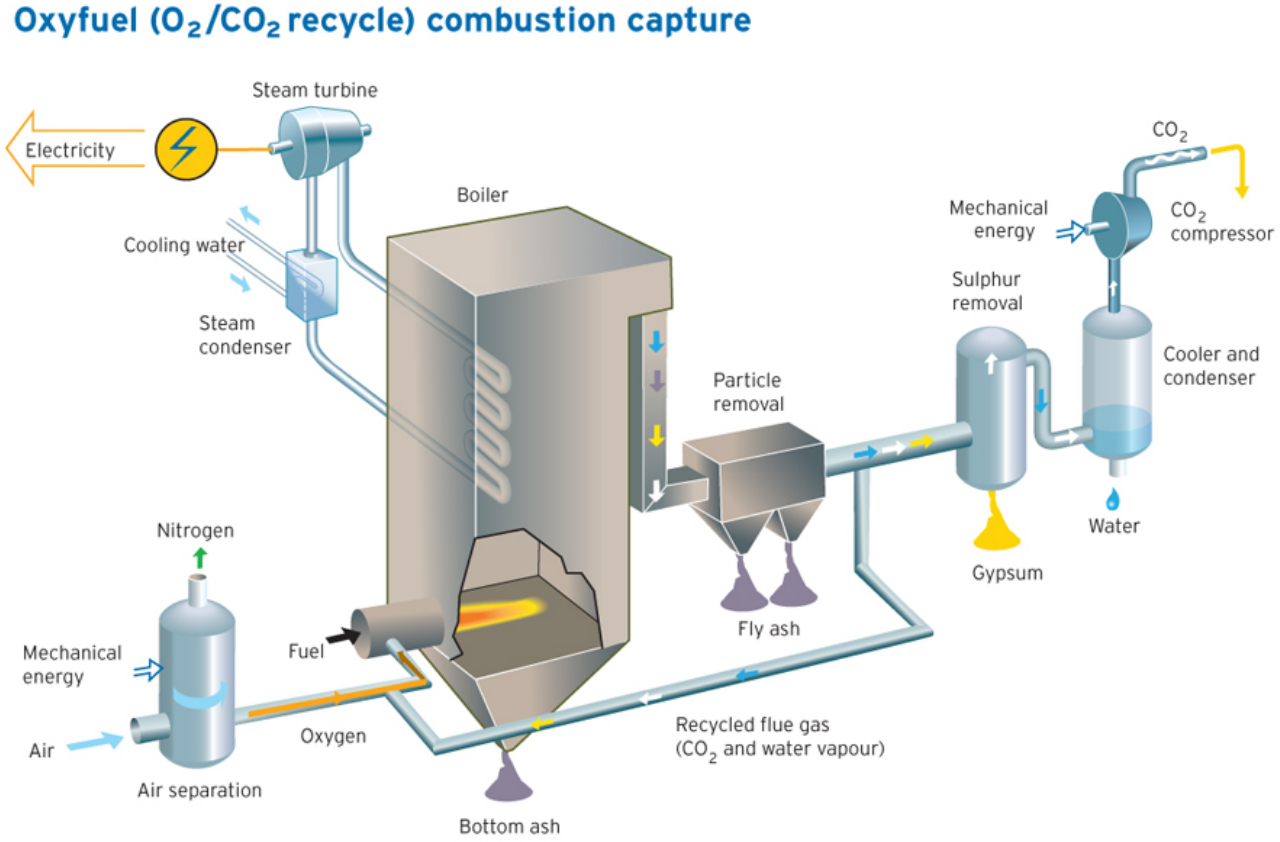
Pre-Combustion Capture
(Integrated Gasification Combined Cycle or 'IGCC')
Turns the coal into a gas, then removes the pollutants prior to combustion.

Illustration by www.kjell-design.com

Three Technologies for Carbon Capture



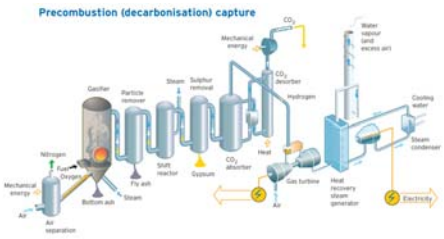


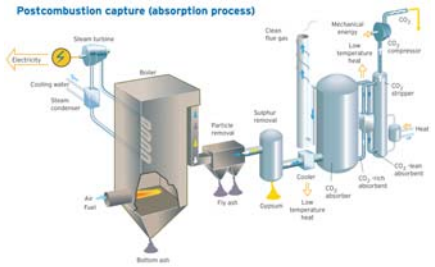


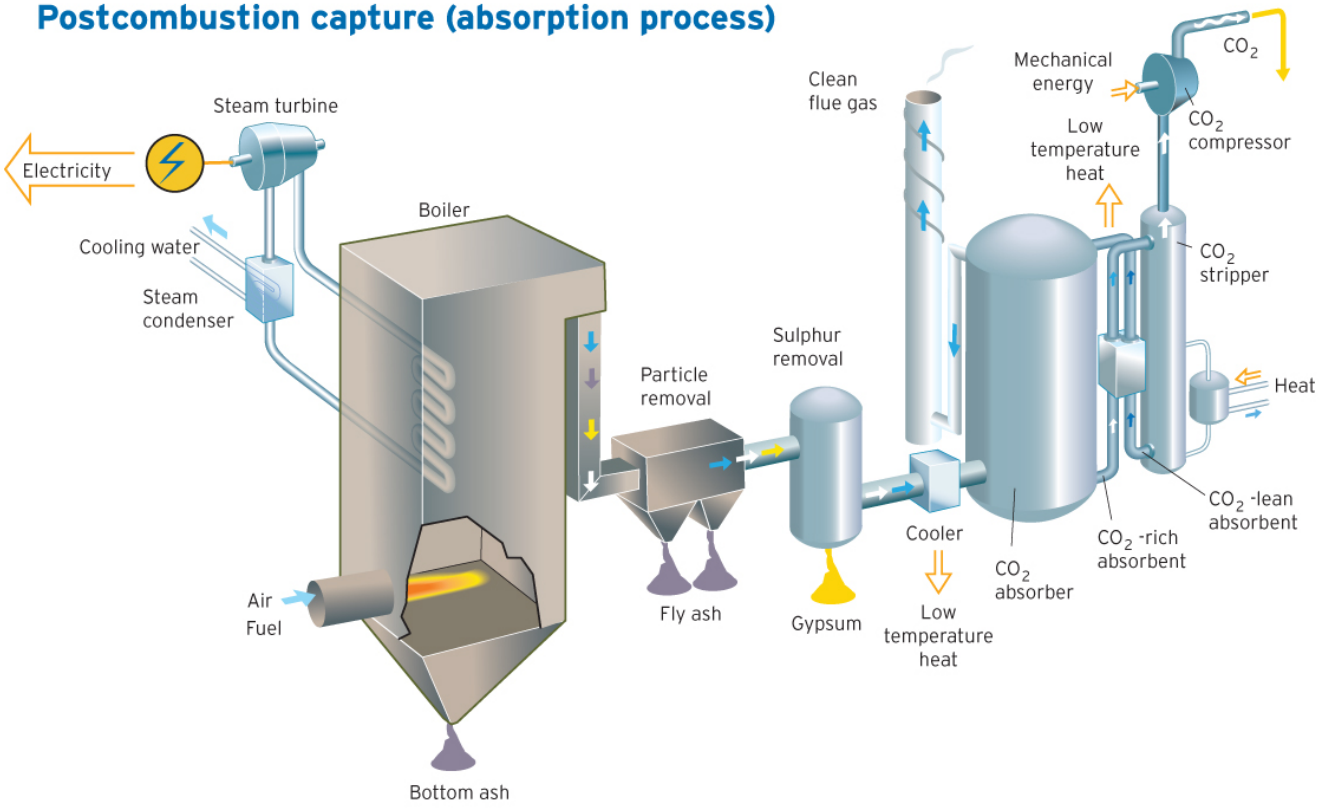
Oxyfuel Capture
Combustion of the fuel with oxygen and recycled flue gas to yield a high CO_2 concentration product stream that can be purified.

Illustration by www.kjell-design.com

Three Technologies for Carbon Capture





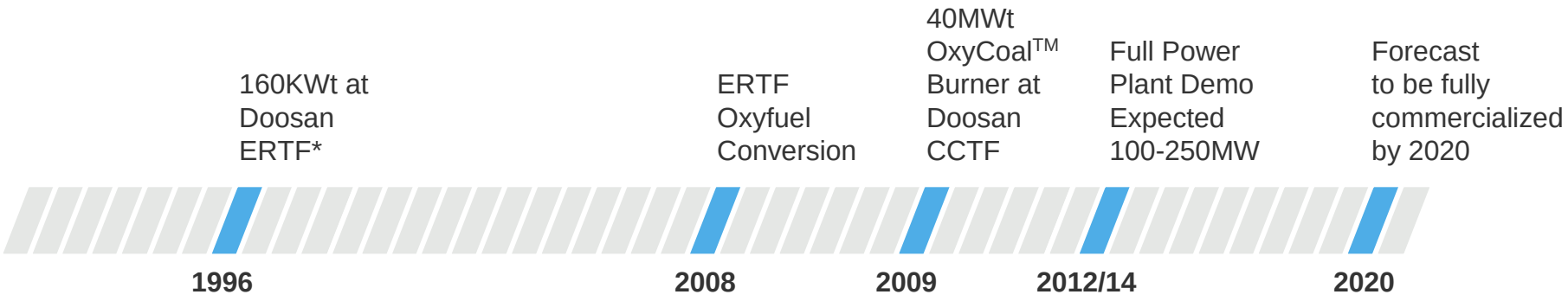


Post-Combustion Capture
Separation of the CO_2 from the flue gas stream, utilizing a chemical scrubbing process.

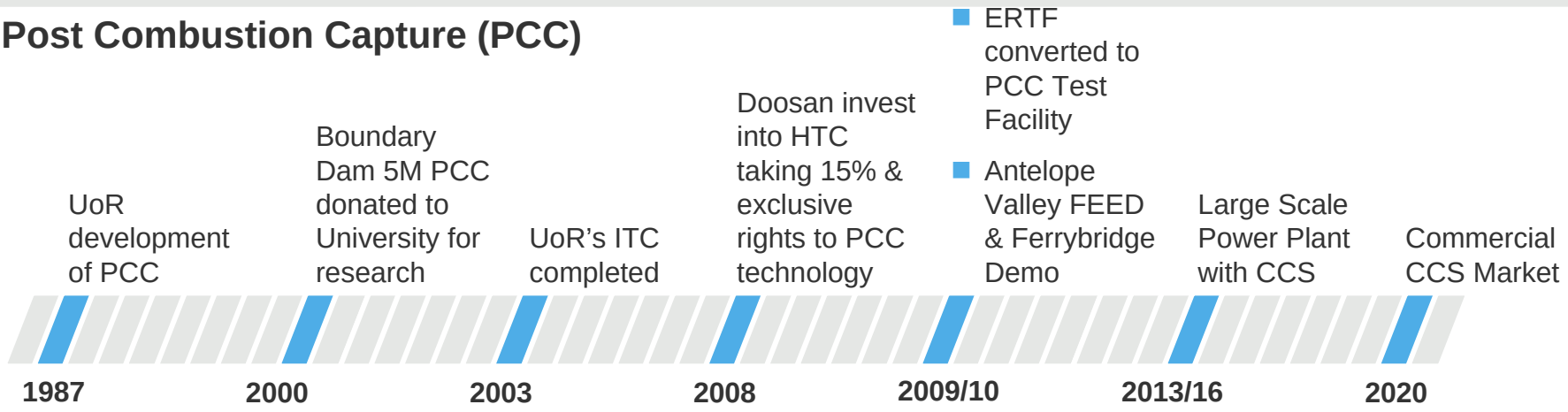
Illustration by www.kjell-design.com

Doosan Carbon Capture Technologies

Oxyfuel



Post Combustion Capture (PCC)

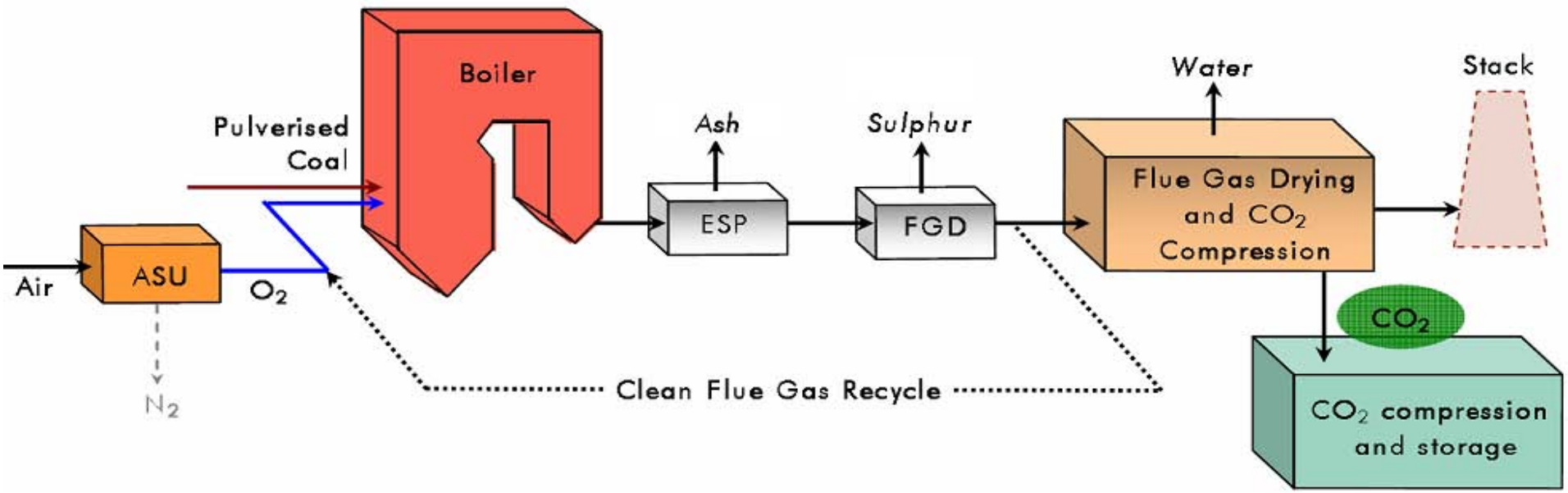


Over 20 years of experience in carbon capture

Oxyfuel Carbon Capture

Doosan Power Systems

Oxyfuel Carbon Capture Technology - Introduction



Air Separation Unit (ASU) to supply nearly pure O_2; N_2 is removed from the process prior to combustion to produce a flue gas that is mostly CO_2 and H_2O

Fuel burned in O_2/CO_2 atmosphere, Flue Gas Recycle (FGR) mitigates high temperatures from combustion in pure O_2 to maintain combustion and boiler thermal performance

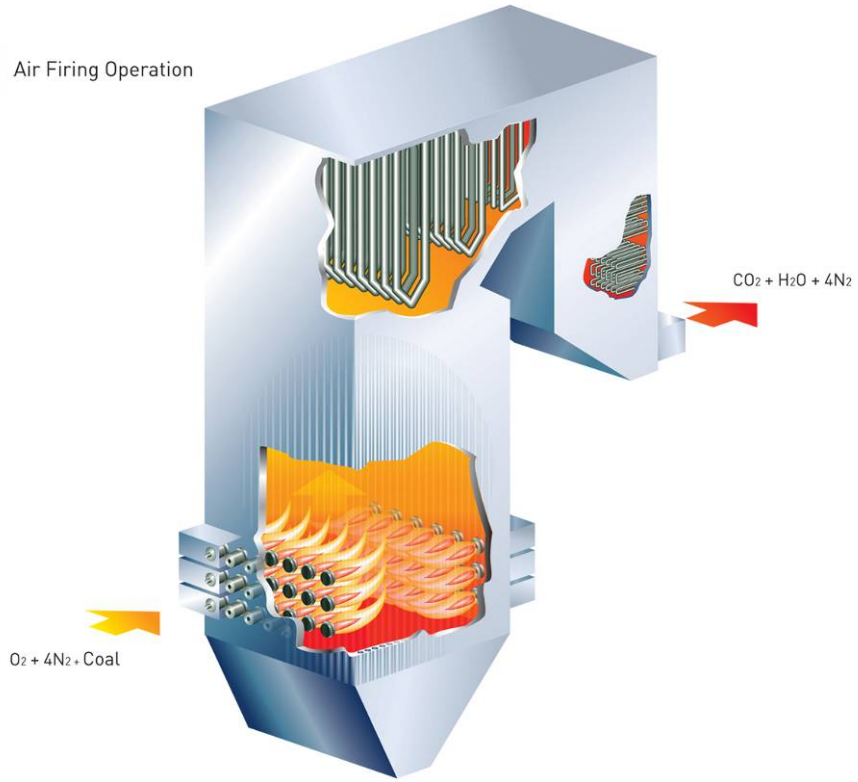
High CO_2 content allows simple compression cycle for CO_2 purification and capture

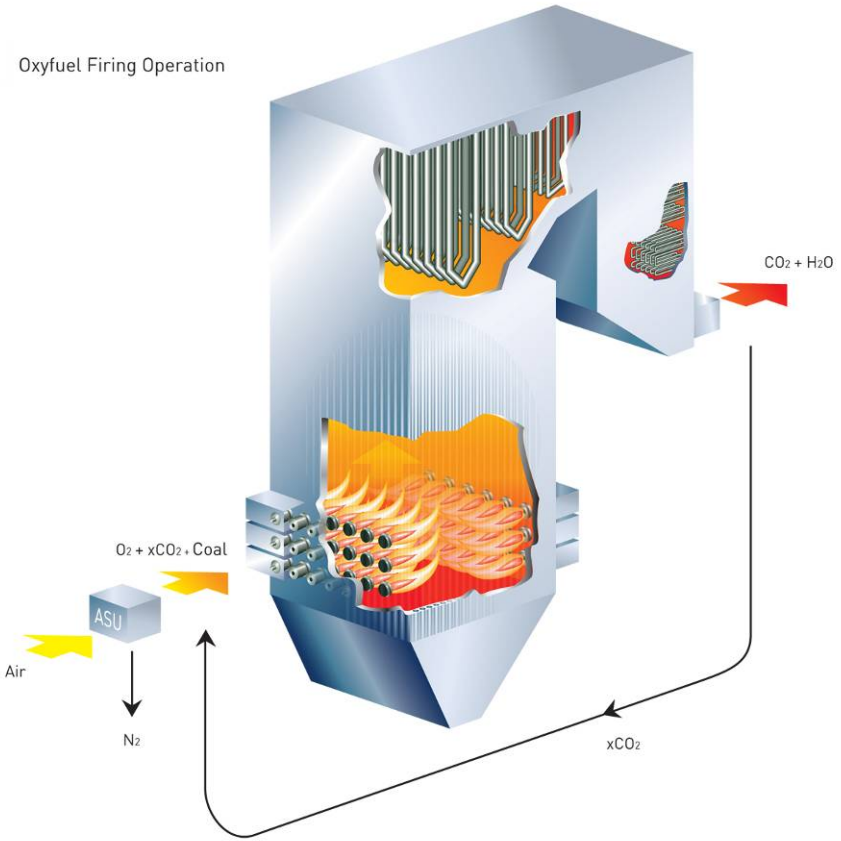
Air Firing versus Oxyfuel Firing Technology

Pulverized fuel combustion produces a flue gas CO_2 concentration…

Air firing typically 15%v/v dry basis.

Oxyfuel firing typically >75%v/v dry basis.





Doosan Power Systems

OxyCoal-UK: Phase 2 – Demonstration of an Oxyfuel Combustion System

The OxyCoal-UK: Phase 2 collaborative project was led by Doosan Power Systems and supported by the Department of Energy and Climate Change.

DOOSAN Doosan Power Systems

Lead Company

Scottish and Southern Energy

Prime Sponsor

Imperial College London | The University of Nottingham

University Participants

DEPARTMENT OF ENERGY & CLIMATE CHANGE

UK Government Support

EDF ENERGY | AIR PRODUCTS | UK COAL | SCOTTISHPOWER | VATTENFALL | DONG energy | Drax Power Limited | e·on

Sponsors

Diagram of the Clean Combustion Test Facility (CCTF)

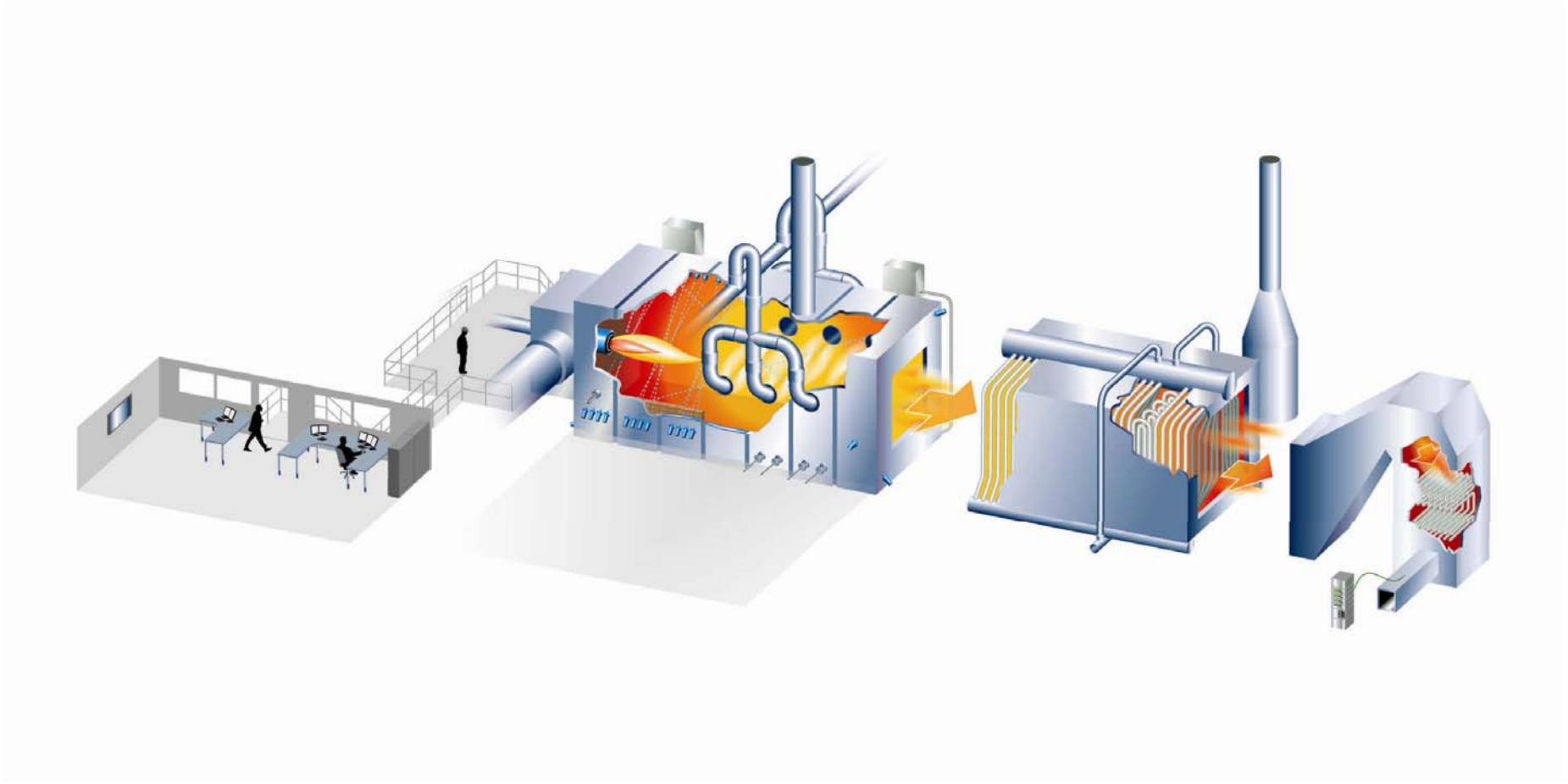
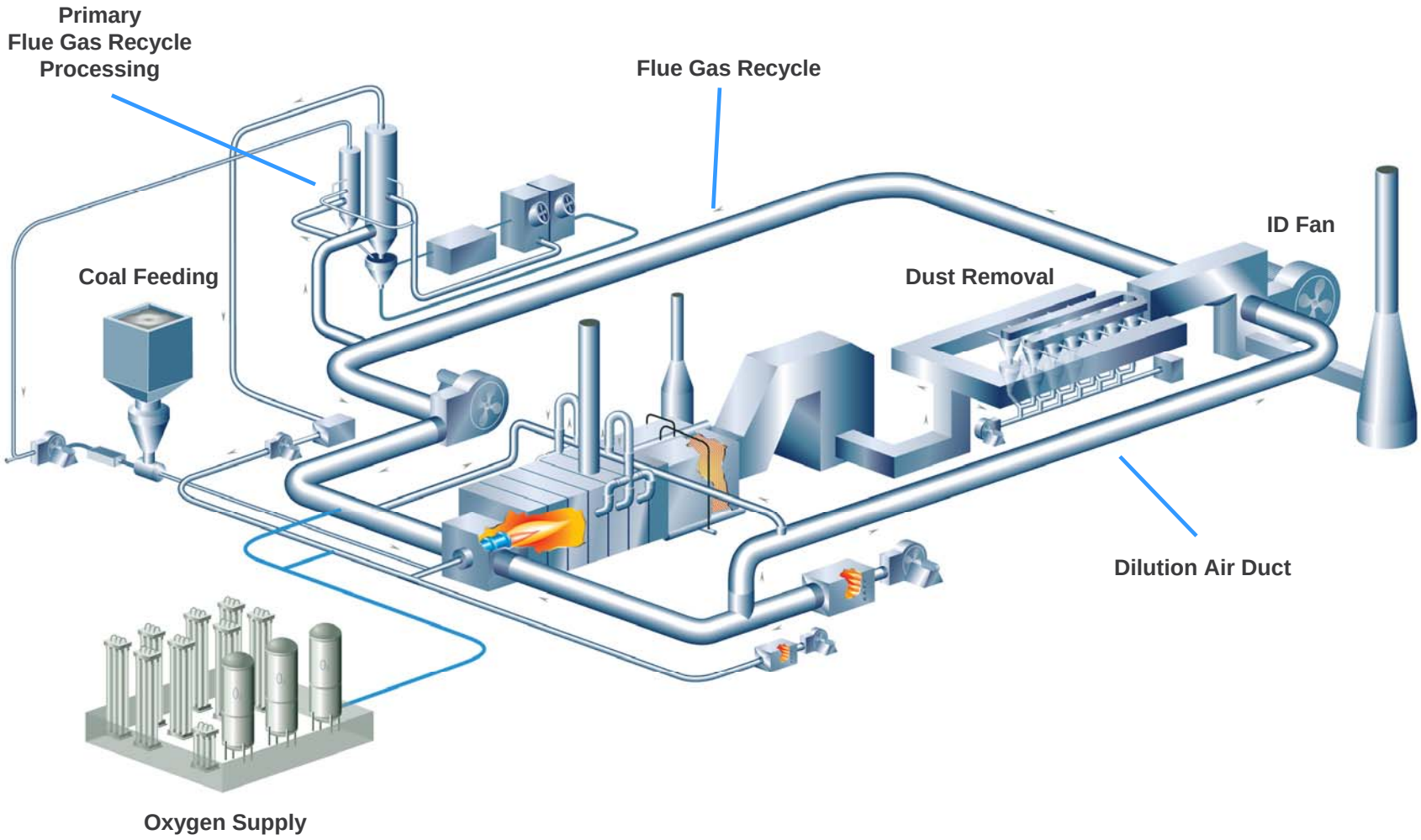


Diagram of CCTF Modified for the OxyCoal 2 Demonstration Program



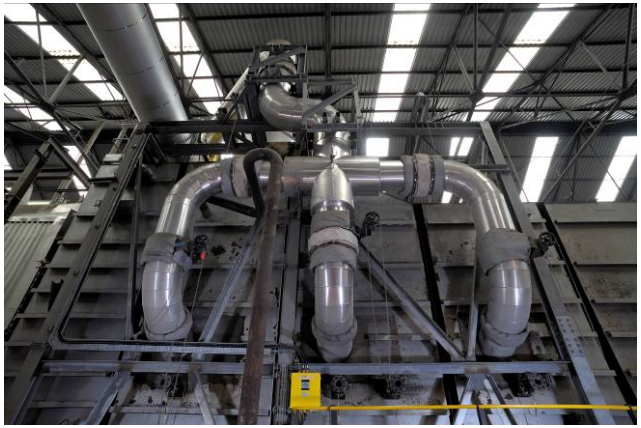
OxyCoal™ At The Renfrew Test Facility

OxyCoal 2 – Program Objectives

Testing a burner of the type and size applicable to new build and retrofit coal-fired boilers.

Demonstrate operational envelope and successful performance of the OxyCoal™ burner:

- Flame stability
- Turndown
- Start-up
- Shutdown
- Transition between air and oxyfuel firing



Obtain baseline performance data for air firing on coal

Demonstrate transition from air to oxyfuel firing on oil and coal

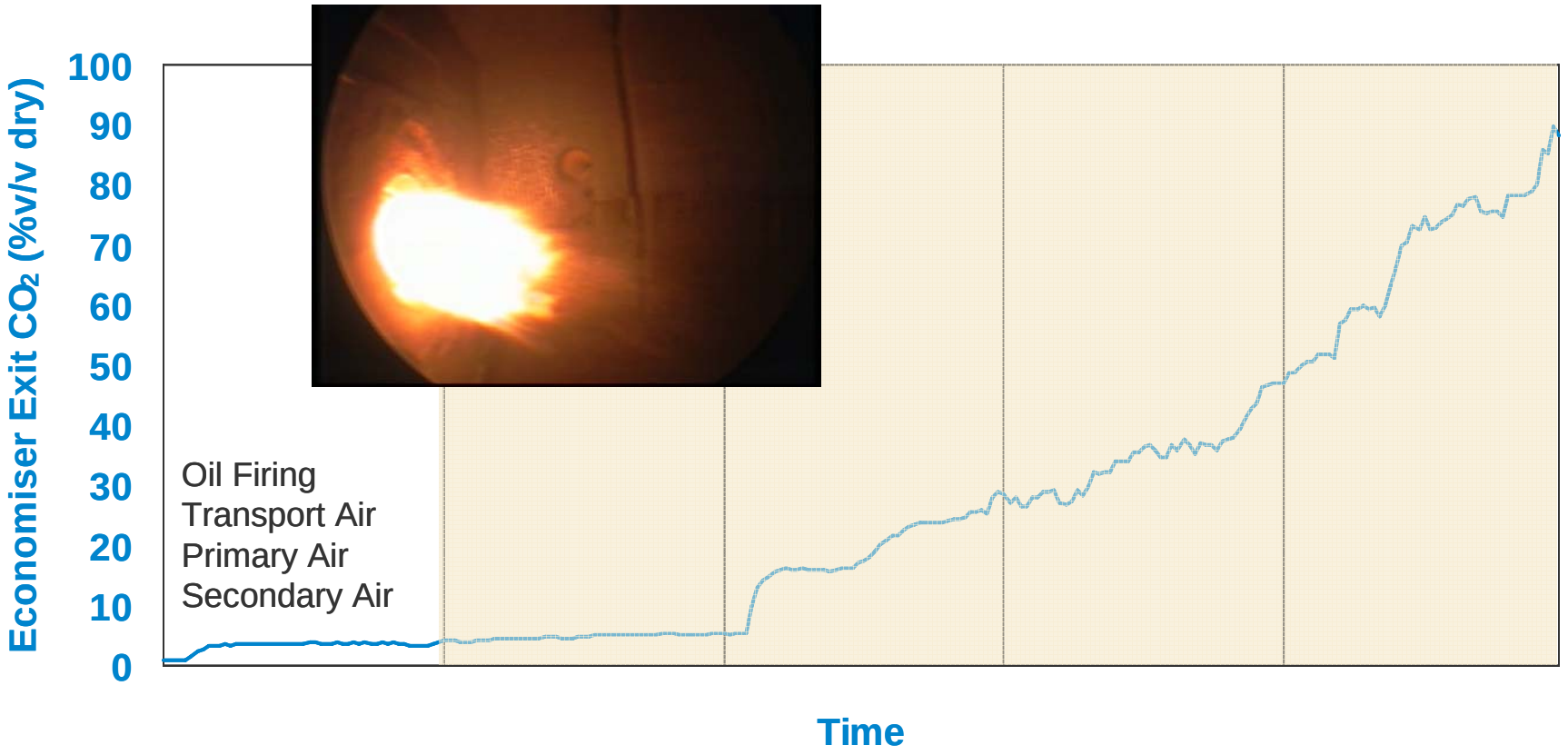
Measure air infiltration during oxyfuel firing on oil and coal

Obtain performance data for varying flue gas recycle rates and burner stoichiometry

Investigate sensitivity to primary and secondary flue gas recycle oxygen content

OxyCoal-UK: Phase 2 – Demonstration of an Oxyfuel Combustion System

Oxyfuel firing tests to demonstrate transition from air firing to oxyfuel firing on oil and on coal.



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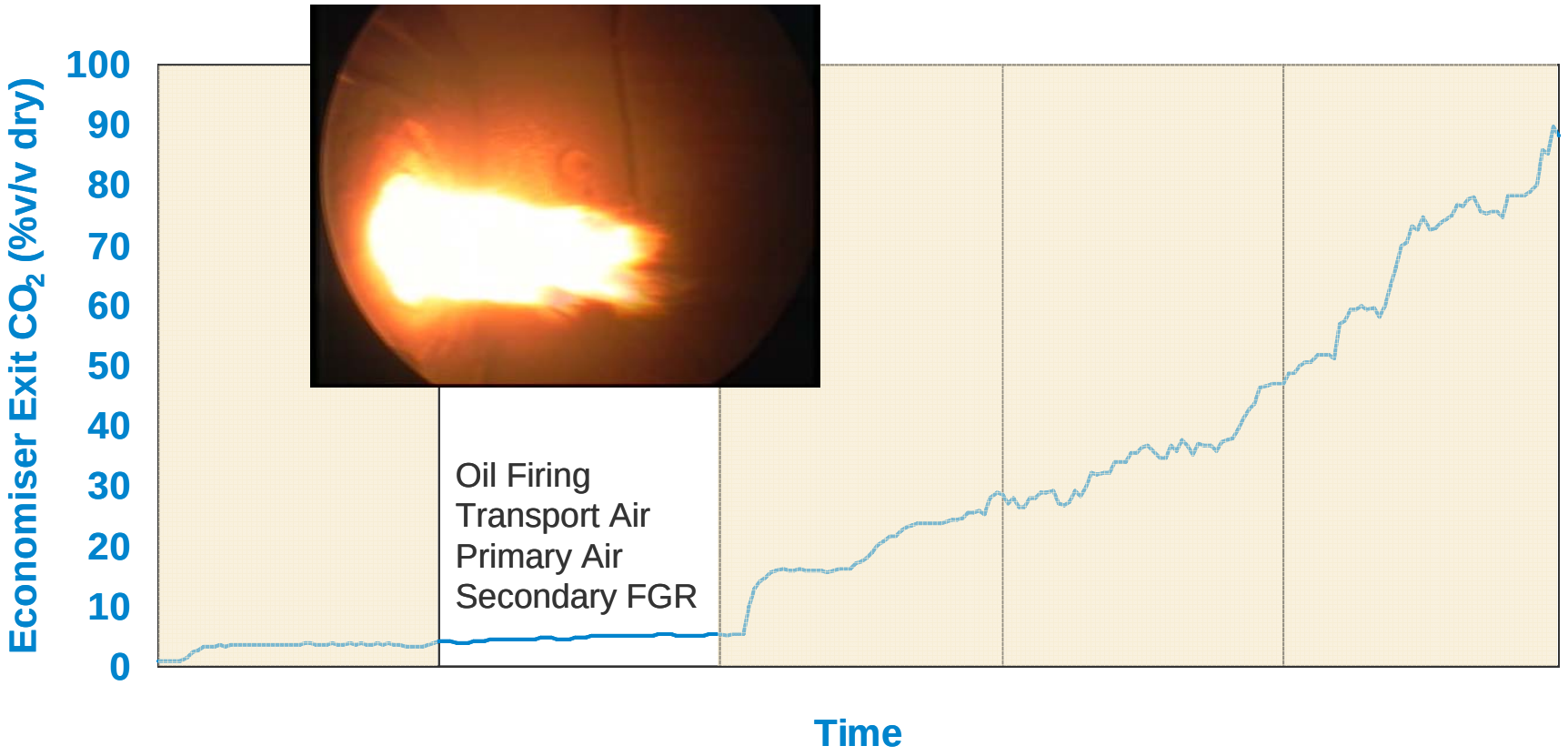

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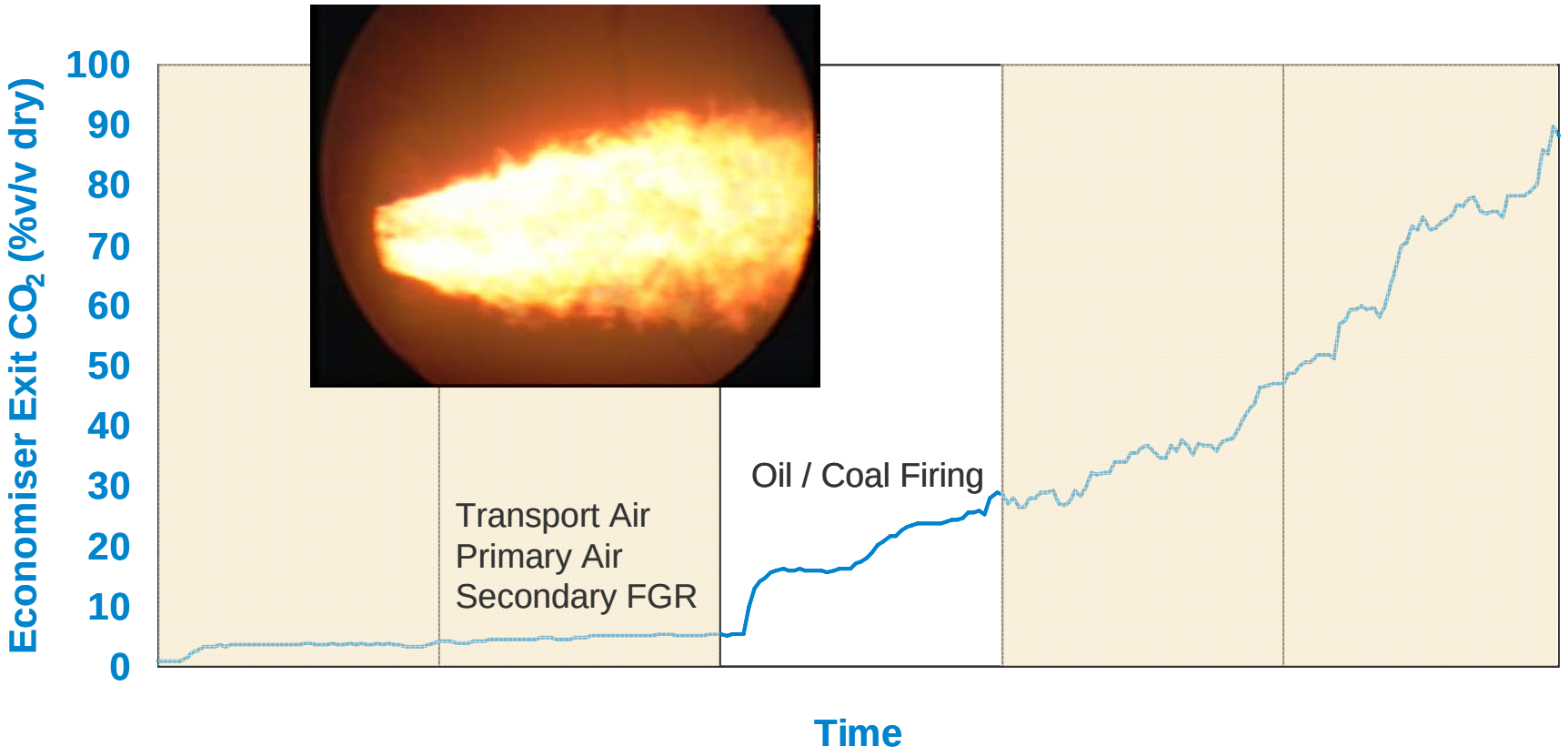

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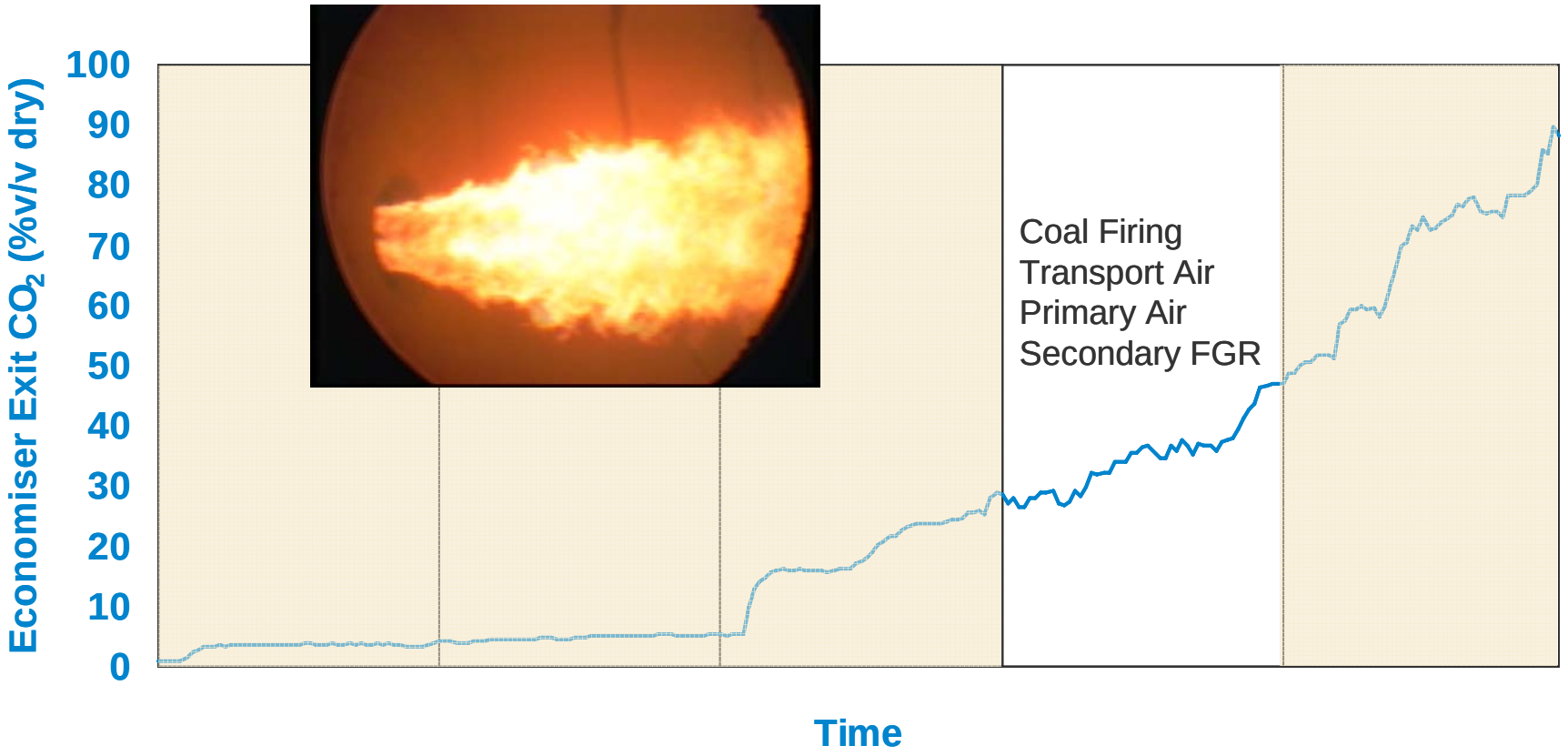

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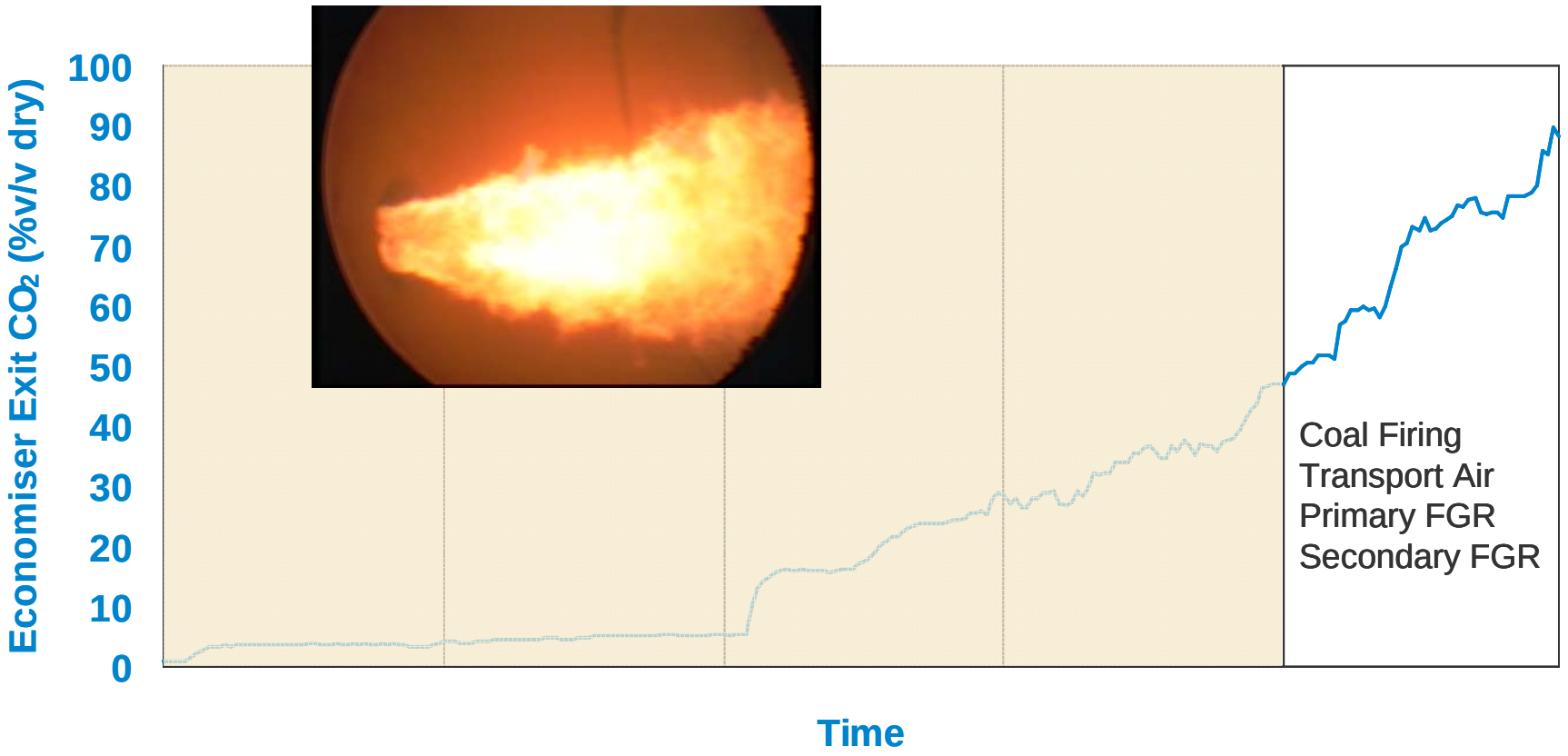

Oxyfuel - Key Costs

- CAPEX
  - ASU
  - CO_2 Compression, Purification and Dehydration
  - Flue gas recycle and incremental costs for boiler and burners
- OPEX
  - Auxiliary Load for ASU and CO_2 Compression, Purification and Dehydration
  - Incremental Operation and Maintenance Costs (Parts and Labor)