



Doosan Power Systems
Carbon Capture Global One Team

Advanced Coal Combustion Technology

McIlvaine Company Hot Topic Hour

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OxyCoal™ Combustion Technology Road Map

2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
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Fundamental Research



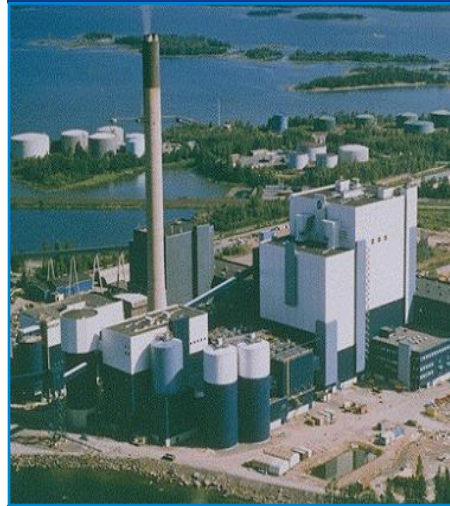
- Address technology gaps
- Operating experience

Combustion System Demonstration



- Retrofit the existing 70 MWt Clean Combustion Test Facility to operate and test a 40 MWt, commercial-scale OxyCoal™ burner
- Demonstrate optimized combustion
- Develop market proposition

Field Plant Demonstration



- Front End Engineering Design (FEED) activities
- Secure field demonstration project of 100-200 MWe
- Embed technology skills into organisation to support future full scale commercialisation

Commercialisation



- 1000 MWe OxyCoal™ power plant
- Continue development to drive efficiency gains
- Drive down costs and increase commercialisation

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

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

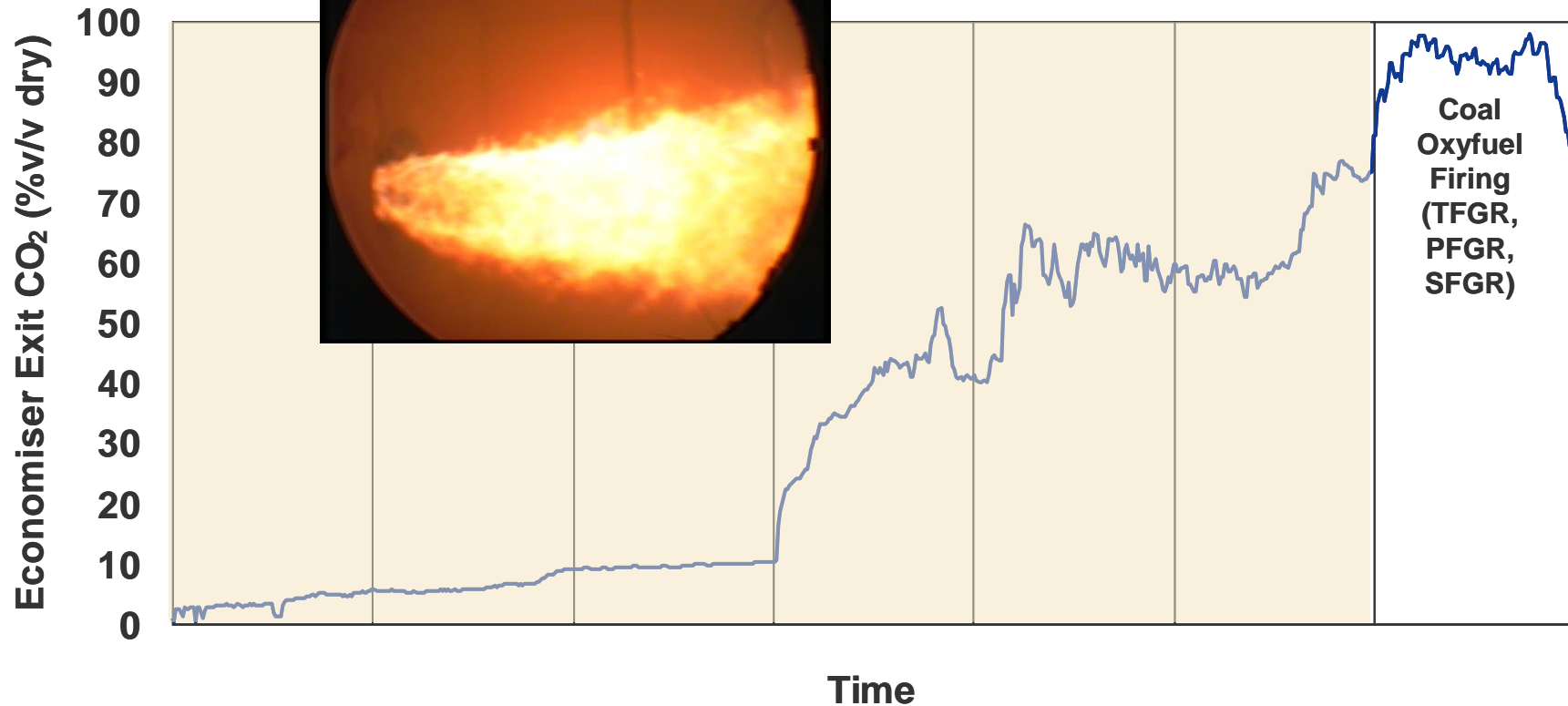


OxyCoal-UK: Phase 2 - Clean Combustion Test Facility (CCTF)



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

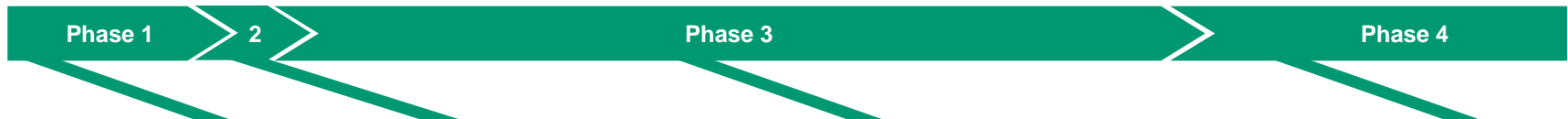
Oxyfuel firing tests to demonstrate transition from air firing to oxyfuel firing on oil and on coal



Post Combustion Capture Road Map (2007 – 2017)



Technology transferred



1. Acquire technology

The diagram shows three parallel process flows for CO₂ capture. Each flow starts with 'Fuel' and 'Air' entering a 'Power & Heat' block. In the first flow, 'Flue gas' goes to 'CO₂ separation', which outputs 'N₂, O₂, H₂O' and 'CO₂'. In the second flow, 'Gasification or partial oxidation shift + CO₂ separation' produces 'H₂' and 'CO₂', while 'Air separation' provides 'O₂' and 'N₂'. The 'CO₂' then goes to 'CO₂ dehydration, compression, transport and storage'. In the third flow, 'Air separation' provides 'O₂' and 'N₂', and 'Recycle (CO₂, H₂O)' is fed back into the 'Power & Heat' block.

- Market evaluation
- Technology selection

2. Product & market development

A photograph showing the interior of an industrial facility with large yellow storage tanks, pipes, and workers in hard hats.

- Carry out technology transfer and document processes
- Provide support to early

3. Demonstration & optimization

A photograph of an industrial facility at night, illuminated by yellow lights, showing a complex structure of pipes and scaffolding.

- Secure FEED work
- Secure commercial part of new build EPC

4. Commercialization

A photograph of an industrial facility exterior, showing tall towers and a complex network of pipes against a blue sky.

- Secure commercial part of new build EPC

CCS Global One Team for Post Combustion Capture



- ❑ Boiler OEM with over 160 GW of references
- ❑ Significant expertise executing major projects in coal, nuclear and natural gas power plants
- ❑ Specific expertise in petrochemical and chemical projects; relationships with major companies
- ❑ Global reputation delivering major chemical process columns and equipment through Doosan Mecatec
- ❑ Global team, based in Renfrew, Scotland, is developing dedicated expertise, leveraging the capabilities throughout Doosan to push boundaries in CCS

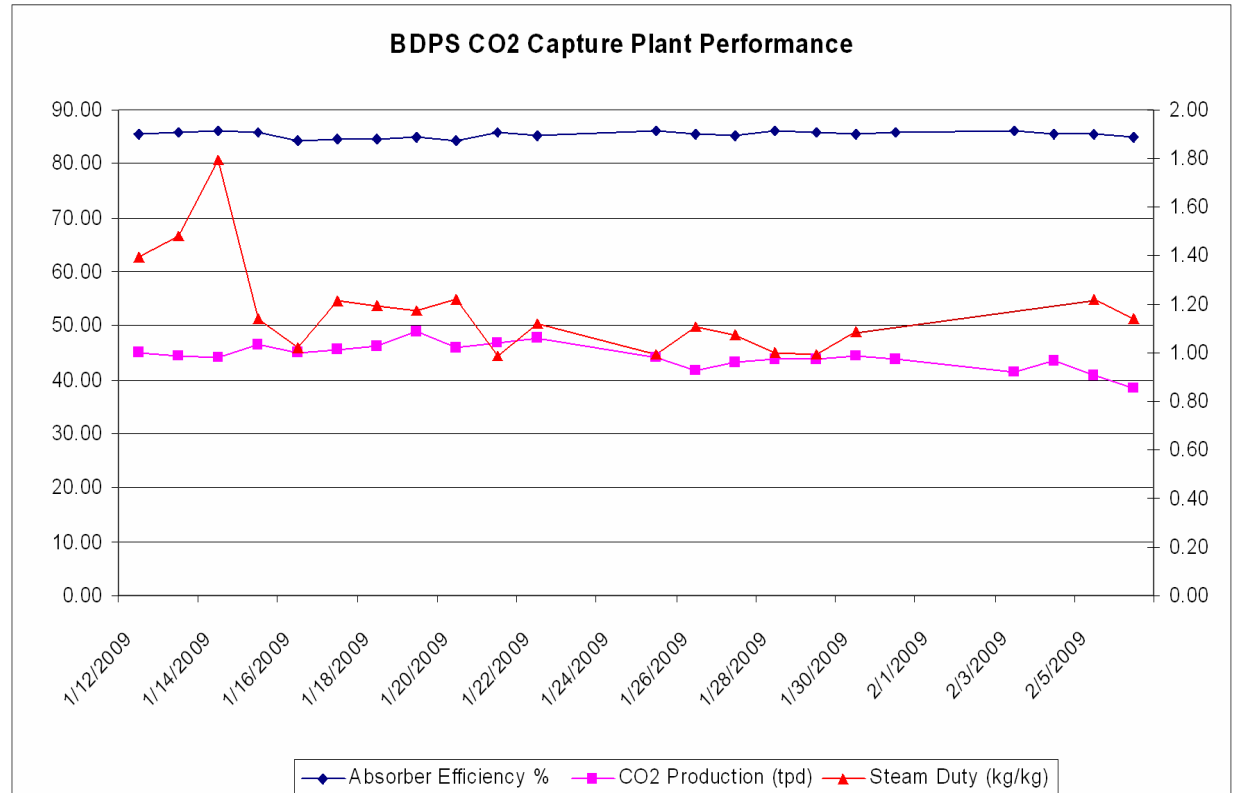


- ❑ Leading technology in the field of carbon capture, geologic profiling, oil field analysis and simulation and risk assessment
- ❑ World-class process technology and expertise
- ❑ Sophisticated process simulation models; developed over many years of pilot testing and validated against several, large-scale commercial facilities



Operation with TKO™ Configuration and RS-2™ Solvent

- Boundary Dam Field Pilot modified to operate with TKO™ advanced process flow scheme and RS-2™ solvent
- 1,400 hour test run demonstrated:
 - High absorption efficiency (~ 85% CO₂)
 - Low solvent degradation rate
 - Low steam consumption
 - <1.1 kg steam: 1kg CO₂ (~ 1,000 BTU/lb)



Process Technology Scale-Up

Doosan and HTC apply no less than three different models, which have each been developed and validated using extended bench-scale and field pilot testing, combined with actual operating data from commercial-scale plants.

HTC have developed a thorough understanding of:

- All physical and chemical properties (kinetics, diffusivity, etc.)
- Operating conditions
- Proper application of numeric modeling tools



Relative Size of CO₂ Absorber Column



International Test Center
1 TPD
Pilot plant treating exhaust
from gas turbine
RS-2 and MEA Solvent
TKO™ Flow Scheme



Boundary Dam Pilot
5 TPD
Pilot plant treating slip
stream from coal-fired power
plant
RS-2 and MEA Solvent
TKO™ Flow Scheme



150 TPD commercial CO₂
capture system treating
slipstream from coal-fired
power plant
MEA Solvent
Standard Flow Scheme



800 TPD (2 trains)
commercial CO₂ capture
system treating slipstream
from coal-fired boiler
MEA Solvent
Standard Flow Scheme

CCPilot100+

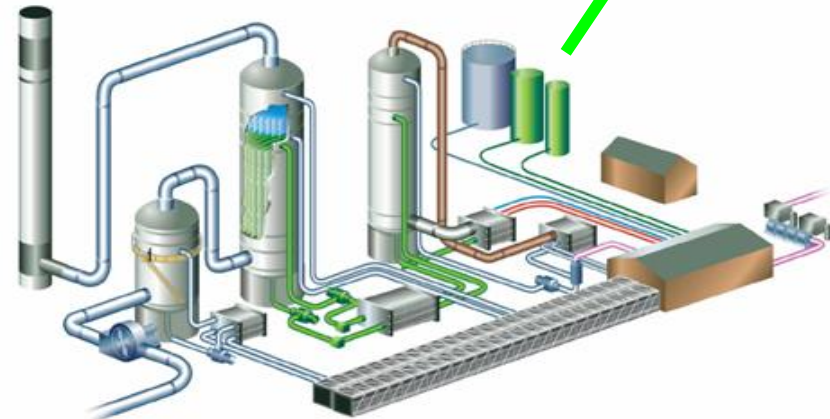
- Amine scrubbing pilot plant using Doosan Power System's technology
- 100 t/day slip stream on SSE's Ferrybridge Power Station
 - Largest PCC Demonstration in the UK
- Funding by the project partners, Scottish & Southern Energy, Vattenfall, Doosan Power Systems, TSB, DECC and The Northern Way
- Fast – track, operation in early 2011
- Two year test programme



Technology Strategy Board
Driving Innovation



**Moving Forward:
The Northern Way**



Basin Electric FEED



- Doosan Power Systems selected to develop a FEED for a commercial-scale, demonstration plant
 - Sized to capture 1.0 MM short tons per year of CO₂ from Basin Electric's Antelope Valley Power Plant
 - 3,000 short tons per day
 - Treating a 120 MW slipstream
- US Rural Utility Service has committed \$300 million in loan guarantees
- US DOE announced intention to enter into a cooperative agreement with Basin Electric for a \$100 million grant



Basin Electric Antelope Valley Station (in background) and Dakota Gasification Facility (in foreground)