An industrial perspective on coal R+D

Dr Mike Farley
Director of Technology Policy Liaison
Company update

- Doosan Babcock Energy Limited is a subsidiary of Doosan Heavy Industries and Construction of South Korea, part of the Doosan Group, and a market leader in gas, coal, nuclear power generation and desalination. Orders in 2007 totalled 7 Bn USD.

- Doosan Babcock Energy remains committed to all forms of power generation, including clean coal, nuclear, gas and renewables.

- Doosan Heavy offers Pre and Post combustion and Oxyfuel carbon capture technologies.

- Doosan Babcock Energy has been designated the Doosan global Centre of Excellence and R+D Centre for Boilers (including Clean coal and Carbon dioxide capture).

- Doosan Babcock Energy’s sales territory is Europe, Americas, Southern Africa and China, but its boiler technology is used globally, including recent orders in India and Thailand.
A campaign for clean fossil power?

- Recognise that despite energy saving measures we will probably need more clean electricity if carbon targets for heating and transport are to be met
- Recognise that coal and gas cannot be avoided if people are to have sufficient energy and therefore that widespread implementation of CCS is urgent
- Recognise that while CCS technologies do not need to be invented they need progressive scale up, requiring a number of demonstration projects before wholesale implementation
- Seek ambitious programmes for implementation of CCS demonstrations *ie Multiple capture technologies, coal and gas*
- Ensure all other coal and gas plants are genuinely capture-ready and plan retrofit of CCS onto capture ready plant as soon as reasonable - will require incentives or regulation if C-price not sufficient soon enough
- Question whether one UK demonstration is sufficient in the context of 20 GW of new fossil plant in the UK (Conservatives are saying they would support at least 3)
- Do not discriminate against coal in favour of gas, such policy simply allows the UK to dodge the issue temporarily
Content of Presentation

• Importance of clean coal
  – Balance renewables
  – Lower cost low carbon option
  – Avoid further excessive dependence on gas
  – Set a global example

• Status of technologies

• Why are Carbon capture-ready (CCR) power plants and multiple CCS demonstrations needed?

• Current R+D and industrial activities

• Further R+D and Demonstration needs
Flexible fossil power needed to provide power on demand to balance intermittency of renewables and variations in demand.

Average day for Wind generation

Sources: VdN, UCTE
Relative costs of electricity generation (£/MWh)

- Recent evidence to the House of Commons Select Committee on Environmental Audit Committee by EON UK, a major developer of windfarms (onshore and offshore), gas-fired power stations and the proposer of the Kingsnorth clean coal project, quoted the following relative costs-of-electricity generation (£/MWh):

<table>
<thead>
<tr>
<th>£/MWh</th>
<th>Excluding cost of Carbon Allowances</th>
<th>Including Cost of Carbon Allowances €20/te</th>
<th>Including Cost of Carbon Allowances €40/te</th>
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</thead>
<tbody>
<tr>
<td>CCGT (gas)</td>
<td>44.3</td>
<td>51.8</td>
<td>59.3</td>
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<tr>
<td>Coal</td>
<td>41.7</td>
<td>56.4</td>
<td>70.8</td>
</tr>
<tr>
<td>Coal + CCS</td>
<td>67.7</td>
<td>69.2</td>
<td>70.7</td>
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<td>Nuclear</td>
<td>38.6</td>
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<tr>
<td>Onshore Wind</td>
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<td>75.0</td>
<td>75.0</td>
</tr>
<tr>
<td>Offshore Wind</td>
<td>107.0</td>
<td>107.0</td>
<td>107.0</td>
</tr>
</tbody>
</table>
Coal Forum Scenarios for UK – “Pessimistic for coal”

Scenario assumes
• No new coal by 2016
• 10 GW of opted-in coal plants close in 2016
• No CCS demonstration
• All new fossil plant are gas

Outcomes of model
• Generation capacity gap unless a further 2GW of Gas CCGT built by 2012 and 15GW by 2016 on top of 12 GW planned/under construction
• 75% dependence (GW) on gas during a cold still spell in winter (cf 36% now)
• 54% of generation (TWh) from gas, 17% from renewables in 2016
Clean Coal Technologies available now

- Higher efficiency / lower emissions than current coal, better than LCPD standards
- Lower cost electricity than gas or renewables
- Suitable for UK or imported coal
- Suitable for Carbon Capture and Storage (CCS) - 90% capture
- ASC Pulverised Coal offers Capture-Ready Retrofit options
- IGCC offers Hydrogen options
- 95% of current orders are for Pulverised Coal
Carbon-Abated Clean Coal Power Plant

Advanced Supercritical Pulverised Coal Boiler /Steam Turbine
350-1000MW

- Best Available Technology now 46/47% efficient (290 bar/600C/610C), cf 35%
- Advantages are proven Availability (>95%), Load Flexibility (20-100%) and wide fuel range (inc Biomass cofiring up to 20%)
- Matches any other coal technology for emissions, easily meets LCPD limits
- Can be built now, designed to be “capture ready” and fitted with economical CO₂ capture when CCS is possible
- Can be retrofitted to existing UK stations
- Technology of choice for vast majority of new build orders
- Doosan Babcock building 2 x 800MW ASC in Germany and tendered for Kingsnorth
Integrated Gasification Combined Cycle (IGCC)

Integrated Gasification
Combined Cycle
250-900MW

• New technology for New-Build claimed attractive because of potential for hydrogen generation and CO₂ capture
• Total of 4 units in operation worldwide on coal and some plans for further plants
• Challenges are poor availability, high cost, lack of flexibility, lack of EPC guarantees
• Latest designs attempt to improve availability with consequences on cost and efficiency
• Main challenge for CCS is the GT (has to fire natural gas, syn gas and hydrogen in turn)
• IGCC projects are being developed in UK, Europe and USA, some with CCS, but few are certain to go ahead. Futuregen on hold.
• Powerfuel were proposing to build a capture ready IGCC at Hatfield
Main Steam
  281 bar
  602.45°C

Reheat Steam
  605 °C

International traded Bituminous Coal with 3 specified guarantee coals plus 100% oil firing

Boiler Efficiency (100% load LHV)
  95%

O₂ at economiser outlet
  2.84%

Boiler HP steam flow
  578.65 kg/s

Pressure drop (bar)
  HP
  27
  RH
  2.4

SCR inlet NOx (worst coal)
  <450 mg/Nm³

SCR outlet NOx (all coals)
  200 mg/Nm³

CO at econ outlet
  <200 mg/Nm³

800MW 46% efficiency advanced supercritical boiler
800MW 46% efficiency advanced supercritical boiler

Main Steam
- Pressures: 281bar, 602.45°C
- Reheat Steam: 605°C

International traded Bituminous Coal with 3 specified guarantee coals plus 100% oil firing

Boiler Efficiency (100% load LHV): 95%

O2 at economiser outlet: 2.84%

Boiler HP steam flow: 578.65 kg/s

Pressure drop (bar)
- HP: 27
- RH: 2.4

SCR inlet NOx (worst coal): <450mg/Nm³
SCR outlet NOx (all coals): 200mg/Nm³

CO at econ outlet: <200mg/Nm³

Ordered in Germany

Suitable for UK (eg for Kingsnorth, Tilbury, Longannet)

Can be designed capture ready

Suitable for new build or retrofit

800MW 46% efficiency advanced supercritical boiler

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Doosan Babcock Energy
Near Zero Emissions Power plant – CO₂ capture options

Three options:

- **Post Combustion Capture (PCC)** –
  - Amine or Ammonia scrubbing
  - Oxyfuel firing

- **Precombustion – IGCC**

Numerous studies show these are similar in resulting efficiency and cost of electricity and competitive amongst low carbon technologies.

No clear winner but PCC and Oxyfuel needed for retrofit to plants currently being built around the world (including China and India).

All three capture technologies proved in pilot plants but need scale up and Demonstration on full-size plants.

Post Combustion Capture selected for (initial) BERR competition, amine scrubbing likely to be picked if nothing else because of the terms of the competition.

If further Demonstrations are supported then other technologies should be encouraged.
Near Zero Emissions Power plant – CO₂ capture options

Specific Investment costs (Euro/kw)

Net Cycle Efficiencies (%LHV)

From joint paper with Jacobs at Powergen 2006

Cost of Electricity (Eurocents/kwh)

5 -6.2 Euro/kwh for New build, <5 Euro/kwh for retrofit
Post-combustion Carbon Capture
– Flue Gas Scrubbing on Pulverised Coal Plant

![Diagram of CO₂ Capture Plant]

- **Flue Gas**
  - **Flue gas treatment**
  - **CO₂ separation**
  - **Remaining flue gas**

- **Coal**
  - **Boiler**
    - **Steam**
    - **Steam turbine**
      - **Electricity**

- **SOₓ, NOₓ, (O₂), particles**
  - **CO₂**
  - **CO₂ compression**
  - **CO₂ to transport and storage**

- **Mechanical energy**
- **Low temperature heat**
Scale up of Post Combustion Capture for Coal power plants

Many R+D scale – pilot plants using power station flue gases by 2010

More than 5 pilot scale demonstrations in the 10 – 30MW range for operation by 2008 - 2012

More than 6 industrial scale demonstrations 60-250MW planned, for operation 2009 -2012

300 - 400 MWe UK Competition demonstration 2014

Target is “Commercialised by 2020”

UK project is a major step up, 2x 800MW commercial units would be a step too far

| Powerspan | Basin Electric Beulah, ND | 2012 | 120MW slipstream | Coal
| MHI      | E.ON Germany            | 2010 | 6-25 MW          | Coal
| Fluor    | E.ON Wilhelmshaven      | 2010 |                | Coal
| Cansolv  | E.ON Heyden             | end 2009 | 10MW approx   | Coal
| Alstom   | Kertshavn               | 2008 | 5MWe             | Oil/gas
|          | EON/Electrabel/HitachiEu | 2009? |                | Coal
| A.S.F.   | RWE Niederaussem        | mid 2010 | 0.33MW          | Coal
| ?        | RWE Aberthaw            | 2010 | 1MW              | Coal

| HTC      | Searles Valley Minerals | 2009 | 50MW             | Coal
| CSIRO    | Huaneng Beijing        | 2009 | 175MW            | Coal
| ASEP     | AEP Oklahoma           | 2011 | 233MW            | Coal
| ASEP     | NRG WA Parish          | 2012 | 125MW            | Coal
| (HTC)    | Sask Power             | 2011 |                | Coal
| HTC      | BCOR Genese            | 2010 |                | Coal
| HTC & EESTech | Loy Yang | - | 60MW | CEM
Many pilot plant R+D scale – pilot plants using power station flue gases by 2010

More than 5 pilot scale demonstrations in the 10 – 30MW range for operation by 2008 - 2012

More than 6 industrial scale demonstrations 60-250MW planned, for operation 2009 -2012

300 - 400 MWe
UK BERR
Competition demonstration 2014

2 x 800 MWe
New power station/retrofit

<table>
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<tr>
<th>Project</th>
<th>Contractor</th>
<th>Year</th>
<th>Capacity</th>
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<td>CSIRO - Huaneng Beijing</td>
<td>2009</td>
<td>175 MW</td>
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<tr>
<td>Alstom</td>
<td>AEP Oklahoma</td>
<td>2011</td>
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<td>125 MW</td>
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<tr>
<td>HTC</td>
<td>Boundary Dam</td>
<td>2012</td>
<td>100 MW</td>
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<td>HTC</td>
<td>Boundary Dam</td>
<td>2011</td>
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<tr>
<td></td>
<td>(HTC &amp; EESTech) Loy Yang</td>
<td>-</td>
<td>60 MW</td>
</tr>
<tr>
<td>Powerspan</td>
<td>Basin Electric Beulah, NC</td>
<td>2012</td>
<td>20MW sideline</td>
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<tr>
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<td>EON Germany</td>
<td>2010</td>
<td>6-25 MW</td>
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<tr>
<td>Fluor</td>
<td>EON Wilhelmshaven</td>
<td>2010</td>
<td>Coal</td>
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<td>EON Heyden</td>
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<td>Kehlshain</td>
<td>2008</td>
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<td>Mitsubishi</td>
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<td>BASF</td>
<td>RWE Niederausen</td>
<td>mid 2010</td>
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</tr>
<tr>
<td>?</td>
<td>RWE Aberthaw</td>
<td>2010</td>
<td>1 MW</td>
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</tbody>
</table>
Carbon Capture by Oxyfuel firing on Pulverised Coal Plant

O₂/CO₂ recycle (oxyfuel) combustion capture

Figure courtesy of Vattenfall
Scale up of Oxyfuel firing for coal power plants

160KW tests at Doosan Babcock 1996

1MWt tests at E.ON 2008/9

30 MWt full chain demonstration at Schwarze Pumpe 2009

40 MWt full size Oxycoal2 burner test at Doosan Babcock 2009

0.5 MW tests at RWE npower 2008/9

100 - 250 MWe full power plant demonstration by 2012/2014

Vattenfall Janschwalde 2015 250MWe Lignite

Alstom Lacq 2009 30MWth Oil?
Alstom Schwarze Pumpe 2008 30MWth Lignite
IHI Calide 2010 30MWe
B+ W B+ W CEDF 2008 30MWth Coal
Alstom Alstom CE 2010 15MWth Coal
Doosan Babcock Doosan Babcock 2009 40MWth Coal

By the end of 2009 there will have been at least two industrial scale demonstrations of the full process and the Doosan Babcock full size burner demonstration which should give a high level of confidence in going to the next step, an intermediate demo at 100-250MWe

Target is “Commercialised by 2020”
Scale up of Oxyfuel Firing for coal power plants - Doosan Babcock road map

160KW tests at Doosan Babcock 1996

1MWt tests at E.ON 2007-8

30 MWt full chain demonstration at Schwarze Pumpe 2009

40 MWt full size burner test at Doosan Babcock 2009

100 MWe full power plant demonstration by 2012

500 MWe full power plant demonstration 2015

Opportunities in USA, Korea, and UK?

By the end of 2009 there will have been at least two industrial scale demonstrations of the full process and the Doosan Babcock full size burner demonstration which should give a high level of confidence in going to the next step.
### CO₂ storage options

<table>
<thead>
<tr>
<th></th>
<th>Cost</th>
<th>Capacity</th>
<th>When</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil – fields with EOR</td>
<td>Higher cost but offset from EOR</td>
<td>Limited capacity</td>
<td>Earliest opportunities</td>
</tr>
<tr>
<td>Depleted oil and gas fields</td>
<td>Lower cost</td>
<td>Limited capacity</td>
<td>Early opportunities</td>
</tr>
<tr>
<td>Saline Aquifers</td>
<td>Lowest cost</td>
<td>Massive capacity</td>
<td>Long term main capacity globally</td>
</tr>
</tbody>
</table>

**Storage technologies are being demonstrated now at 1 Mtonnes/year scale in USA, Canada, Norway and Algeria.**
Scale-up of CCS capacity needed to commercialise CCS by 2020

IEA Energy Technology Perspectives
In support of the G8 Plan of Action
“Scenarios and Strategies to 2050”
“Blue Map Scenario” has CCS on power plant responsible for 19% of CO₂ savings in 2050

55 CCS projects/year
(35 x 500MW coal and 20 x 500MW gas)
from about 2020

5.6 Gt/y

x1000

25 Mt/y

20 full scale CCS demonstrations globally, operational by 2015

More than 6 industrial scale demonstrations 60-250MW planned, for operation
2009 - 2012

Pilot scale demonstrations in the 10 – 40MW range for operation by 2012

5 Mt/y

CO₂ Stored

20 CCS projects over 7 years

CCS projects/yr

x5
Scale-up of CCS capacity needed to commercialise CCS by 2020

IEA Energy Technology Perspectives
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- Pilot scale demonstrations in the 10 – 40MW range for operation by 2012
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- 20 full scale CCS demonstrations globally, operational by 2015
- 55 CCS projects/year
- 5Mt/y CO₂ Stored

- 55 CCS projects/year (35 x500MW coal and 20x500MW gas) from about 2020
- 5.6 Gt/y

- 20 full scale CCS projects over 7 years
- 20 CCS projects/year in 2015
- 100 full scale early stage deployment projects – build up from 20/yr to 40/yr, each committed by 2015, operational by 2020
- 100Mt/y

- 20 CCS projects/year in 2020
- 40 CCS projects/year for 30 years
- 55 CCS projects/year for 30 years
IEA scenario presented to G8 requires 35 coal (800MW) and 20 gas (500MW) CCS power plants per year

Clean coal and gas power plant - CCS or CCR (Carbon Capture Ready) ?

- **Our objective:**
  
- **Timing and scale of introduction of CCS is restricted by the pace of**
  - pilot/demonstration projects
  - introduction of regulations and
  - market conditions/incentives …dependent on the carbon price under the ETS
- “Capture ready (CCR)” is therefore very important since new power plants are needed in UK and globally on a scale larger and on a timescale faster than it is feasible to adopt CCS
- We conclude that we need *both* CCR and multiple CCS demonstrations
- We can set an excellent global example by building power plants capture ready and in parallel accelerating the demonstration of CCS
CAT Strategy twin – track approach – Cleaner coal now and near-zero emissions power commercialised by 2020

Track 1: BAT efficiency

- 23% reduction possible now
- 90-95% reduction by 2020

Track 2: Carbon capture and storage (CCS)

- 12 full scale CCS demos in EU by 2015, some new build, some retrofit

Possible Now 2010 Medium Term 2020 Long Term

CCR plants
CAT Strategy twin – track approach –
Cleaner coal *now* and near - zero emissions power commercialised by 2020

**Track 1: BAT efficiency**
- 23% reduction
- Possible Now
- Medium Term: 2010
- Long Term: 2020

**Track 2: Carbon capture and storage (CCS)**
- 90 - 95% reduction
- 12 full scale CCS demos in EU by 2015, some new build, some retrofit
- Retrofits of CCS
- 12 full scale CCS demos in EU by 2015, some new build, some retrofit
- CCR plants
CAT Strategy twin – track approach – Cleaner coal *now* and near – zero emissions power commercialised by 2020

**Track 1: BAT efficiency**

**Track 2: Carbon capture and storage (CCS)**

- **Carbon Dioxide Reduction**
  - 90 - 95%
  - 23%

- **Possible Now**
  - 2010
  - 2020

- **Medium Term**
  - 2010

- **Long Term**
  - 2020

- **12 full scale CCS demos in EU by 2015, some new build, some retrofit**

- **CCR plants**

- **Retrofits of CCS**

- **Commercialisation of CCS by 2020, All new build with CCS, from 2020? Rapid retrofit of CCR plant, by 2025?**
What is CCR? Stages of Capture-Readiness

- **Capture un-ready**
  (ie CCS not feasible)

- **Capture ready**
  (ie CCS feasible and recognised in the power plant design with adequate space provided for a feasible capture option and route for transport of CO2 identified)

- **Capture and Storage ready**
  (ie CCS feasible and recognised in the power plant design with adequate space provided for a feasible capture option, route for transport of CO2 identified and suitable store identified)

- **Capture and Storage Qualified**
  (ie CCS feasible and recognised in the power plant design with adequate space provided for a feasible capture option, route for transport of CO2 identified and suitable store qualified)

- **Capture and Storage ready to implement**
  (ie Capture plant installed, pipeline built, storage equipment installed)

- **CCS implemented**

**Build Capture-ready power plant**

**Implement CCS project**

Many new gas and coal power plants could be in this category.

Relatively easy and inexpensive to implement on new high efficiency power plant.

Proposed IEA definition referenced in BERR consultation.

Longer to implement.

Build Capture-ready power plant

Implement CCS project
UK companies are participating in EU, UK govt and international R+D projects on High Efficiency Boiler/Steam Turbine, biomass cofiring and CO$_2$ Capture, Transport and Storage.
What’s happening in the CATs field in UK industry?

- EU Research projects on Efficiency (COST 536 Materials for Advanced Plant, COMTES 700), Capture (ENCAP, CASTOR, CESAR, ASSOCOGS, ECOSCRUB) and Storage

- DTI Projects (largely complete)
  - Retrofit of Gasifier to CCGT, DTI Project 407 - Retros of Boiler/Turbines with CO₂ capture, DTI - 366 ‘Future CO2 Capture Technology Options for the Canadian Market’, High pressure coal gasification, DTI Project 410 - Materials and fabrication for 700degC power plant,

- BERR/TSB projects underway:

- Devolved Administrations/RDAs
  - Yorkshire Forward CO₂ network study
  - Scottish CCS Study

- International R+D
  - Vattenfall Oxyfuel demonstration
  - E.ON Collaborative Pilot R&D activities (University of Texas, ITC Canada) and Bilateral Development of pilot plants (up to 5MW scale) with Alstom, Siemens
  - Involvement in Futuregen 275MWe Project Development
  - RWE npower is an industrial sponsor of the pilot amine scrubbing research facility of University of Texas at Austin (and is building its own 1MW pilot at Aberthaw)
Oxycoal2 - Demonstration of Oxycoal combustion system for coal fired power plants

- Convert Doosan Babcock’s full-scale burner test facility to oxyfuel firing
  - Oxygen supply
  - Flue gas recycle system (fans, ducts, cooler, heater, etc.)
  - Instrumentation
- Design and build full-scale utility Oxycoal burner (40MW)
  - Derived from air-firing experience, CFD modelling and Oxyfuel R+D
- Demonstrate a full-scale utility Oxycoal burner
  - Flame stability, combustion efficiency, emissions, flame shape, and heat transfer characteristics as function of %CO₂ recycle and excess oxygen
  - Start-up, shut down, transition from air to oxyfuel, load change
The substantial contributions of:

- the Prime Sponsor

- Sponsors

- University participants

are acknowledged by Doosan Babcock
Ambitions:
What we should be aiming for if UK is to be a leader in Carbon abatement technologies for fossil fuels

Priorities for R+D and Demonstration:
Based on discussions at APGTF
Efficiency improvement for Power Plant with CCS

Ambition:
• a high efficiency coal power plant (efficiency 50% before CCS and >43% with CCS), designed for CCS, and integrated with a heat utilisation scheme
• operating in the UK by 2016

Priorities for R+D and Demonstration:
• Materials, fabrication, inspection, monitoring and life assessment technologies for progressive increases in steam temperature and pressure to 350 bar and 750°C
  – Particular issues relating to high nickel alloys
• Optimisation of cycles recognising
  – Carbon capture
  – Large scale CHP, utilisation of waste heat
  – Double reheat (towards 50% efficiency without nickel alloys)
Biomass cofiring with CCS

Ambitions:
- a biomass cofired 600deg coal power plant (efficiency >45 %), designed for CCS, integrated with a heat utilisation scheme, with 20% cofiring of a wide range of biomass fuels
- operating in the UK by 2016

Priorities for R+D and Demonstration:
- Advanced cofiring or co-gasification (up to 20% or more by heat input), including corrosion, slagging and fouling issues
- Efficient preparation and processing of sustainable biomass energy crops (e.g. pelletisation, torrefaction)
- Better understanding of availability of sustainable biomass resources for cofiring
- Impact of biomass cofiring on precombustion, post combustion and oxyfuel carbon capture processes
Ambitions:
- a 600deg coal power plant (efficiency >45 % before CCS and >36 % with CCS), initially capture ready by 2013, then with 400MW Post combustion capture, operating in the UK by 2014
- a 400MW CCGT with CCS operating in the UK by 2015
- several smaller scale pilots/demonstrations of competing scrubbing technologies eg up to 100MW slip stream
- capacity of industry built up to match market needs

Priorities for R+D and Demonstration:
- Process optimisation/ heat integration (including utilisation of waste heat)
- New and less energy intensive solvents (e.g. amines, carbonates, ammonia)
- Avoidance of solvent degradation
and for the longer term
- Improved capture technologies
Ambitions: UK demonstration and UK OEM capability

Priorities for R+D and Demonstration:
- Gasification: process integration/optimisation, improved availability, biomass cogasification
- Gas cleaning: improved reliability
- Gas conditioning:
  - CO₂ capture: integration and optimisation of shift conversion and CO₂ capture processes
  - Conditioning of H₂ fuel gas stream for GT
- Gas turbine: Premix burners for hydrogen requiring
- Air separation unit: Process optimisation, improved absorbents for contaminant removal, high efficiency packing for distilling fluids close to supercritical conditions
Carbon Dioxide Capture Technologies - Oxyfuel combustion

Ambitions:
• a 100 -200 MWe Demonstration of an Oxyfuel power plant on hard coals by 2012

• a 500 MW Demonstration CCS project by 2017

Priorities for R+D and Demonstration:
• Process optimisation, including start-up/shut-down/flexibility
  - Combustion chemistry and kinetics, Heat transfer prediction
  - Materials for oxyfuel environment, corrosion issues, ash properties
  - FGD performance, Flue gas cleaning to meet CO₂ specifications
  - ASUs (including membranes)
  - 40MW demo of new burners, more coal types
  - a 100 -200 MWe Demonstration of Oxyfuel power plant on hard coals
Ambitions:
• early stages of a transport network linked to one or more storage sites and several capture sites by 2015/7

Priorities for R+D and Demonstration:
- Crack formation and growth, major high pressure leaks
- Corrosion behaviour of pipelines as a function of material, temperature, etc and content of CO2 stream
- Alternative materials, joining technologies, sealing technologies
Carbon Dioxide Storage

Ambitions:
• multiple storage demonstrations in UK by 2015, including EOR, depleted gas and oil fields and saline aquifers

Priorities for R+D and Demonstration:
• Site appraisal: methods to assess aquifer injectivity, aquifer seal performance
• Saline aquifers: improve estimation of storage ability e.g. atlas of seal and injectivity properties
• Site stability: subsurface remote sensing of geomechanical stability during re-pressurisation
• CO2 mobility:
  – improved validated software for reservoir and region
  – develop measuring, hi-resolution monitoring, modelling and verification techniques
• Site performance: reduce impact of sub-surface uncertainty on performance prediction and risk
• CO2 physical properties: experimental data at different groundwater salinities
• Geochemical impact:
  – major reactions of minor contaminants in CO2 stream
  – validated database of equilibrium and kinetic data for modelling
• ECBM /UCG - capacity of coal as function of depth and permeability
• Support by DTI, BERR, TSB, and the Research Councils has laid a good foundation and we have now the opportunity to build on this
• Need to be open to capabilities and opportunities available overseas and leverage these
• Need to join up environmental, energy and enterprise and research objectives – consistent with global roll out of the technologies
• Need targeted research as headlined above but also require underpinning R+D in cross cutting areas such as coal science, modelling, environmental impact etc
• R+D in Universities also has an important role in creating the skilled people which industry needs for the future and specialist laboratory facilities – EPSRC Doctorate Training initiatives welcome
• EPSRC/EON Strategic Partnership - Call for University proposals, very timely (deadline 6 Nov) and appropriately targeted
  – APGTF volunteering to organise subject groups of parties interested in the seven topics to work with Research Councils, TSB, ETF, and ETI
• ETI (autumn), TSB (next year) and BERR ETF(?) expected to call for proposals in this topic area – all will encourage involvement of the Research community in what will be industry-led projects
Doosan Babcock are committed to development and global implementation of cleaner power plants - clean coal, clean gas, nuclear and renewables as rapidly as the market allows.

Thank you for your attention

mfarley@doosanbabcock.com