Doosan Babcock Energy

Clean Fossil Power generation in the 21st Century
- a technology strategy for carbon capture and storage

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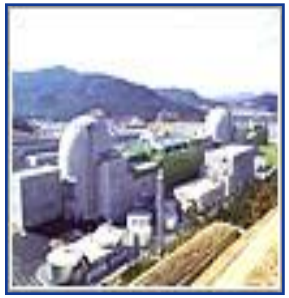
MEC Eng Doc Launch March 4 2009

APG TF

Company update – Doosan Babcock and Doosan Heavy


Nuclear


Thermal


Turbine & Generator


Desalination


Casting & Forging

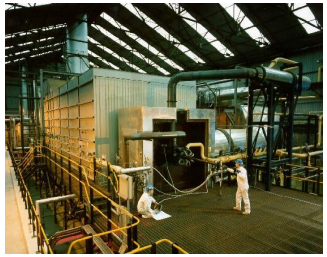

Construction

- **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**
- **The company offers Pre, Post combustion and Oxyfuel carbon capture as well as capture ready Advanced Supercritical Boilers**
- **Doosan Babcock Energy has been designated the Doosan global Centre of Excellence and R+D Centre for Boilers (including Clean coal and CCS)**

PostCombustion
Doosan Babcock offers amine capture technology to its global customer base from the UK.

OxyCoal™ 2

40MW pilot in UK



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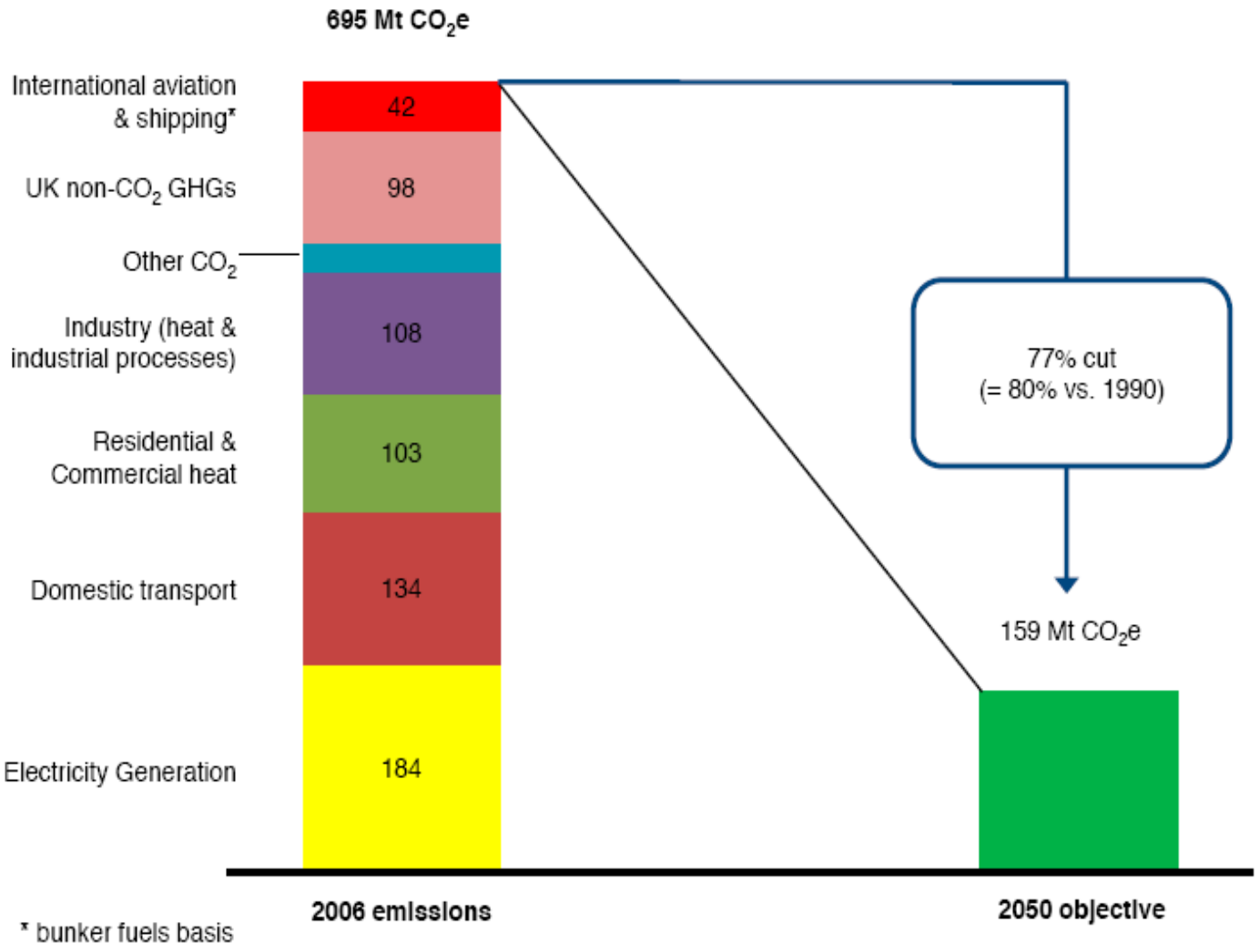
Outline of presentation

Based on draft APGTF strategy document in pack

- Why we need a Strategy
- Objectives
- Status of key technologies
- Current programmes and activities
- The APGTF RD&D strategy
- Demonstrations, Pilots and R+D needed
- Priorities, timescales, funding
- Way forward

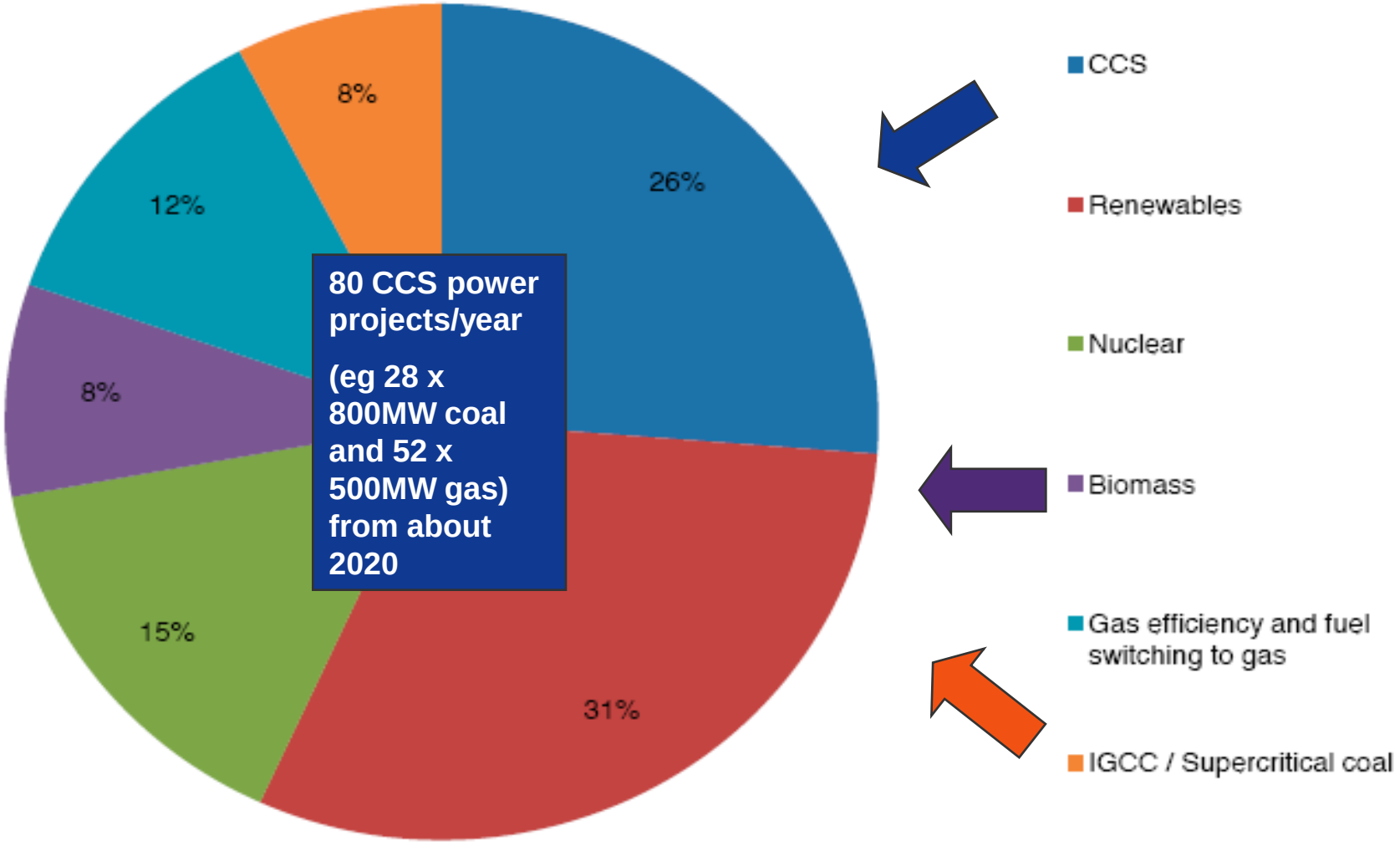
The scale of the challenge for target emissions reductions (UKCCC)



Source: UK National Atmospheric Emissions Inventory (2008).

UK CCC Page 38, Figure 2.1

Global power generation abatement in 2050 (IEA BLUE Map scenario)



Page 71, Figure 2.23

Power sector abatement: 18.3 $GtCO_2$

Vision commensurate with global and UK objectives

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1) Adoption of a target for the successful deployment of CATs and in particular CCS, in the UK with a target of **10% of UK power generation (approximately 40 TWhr) being from fossil-fuel plant fitted with CCS by 2020**

2) A capability for CCS is created in the UK, so that CCS can make a major contribution to the targets of 80% CO_2 emission reduction by 2050 (against a 1990 baseline)

3) The **UK is positioned for success in the global markets** and influence in the EU and global policy dialogue.

Vision and Objectives

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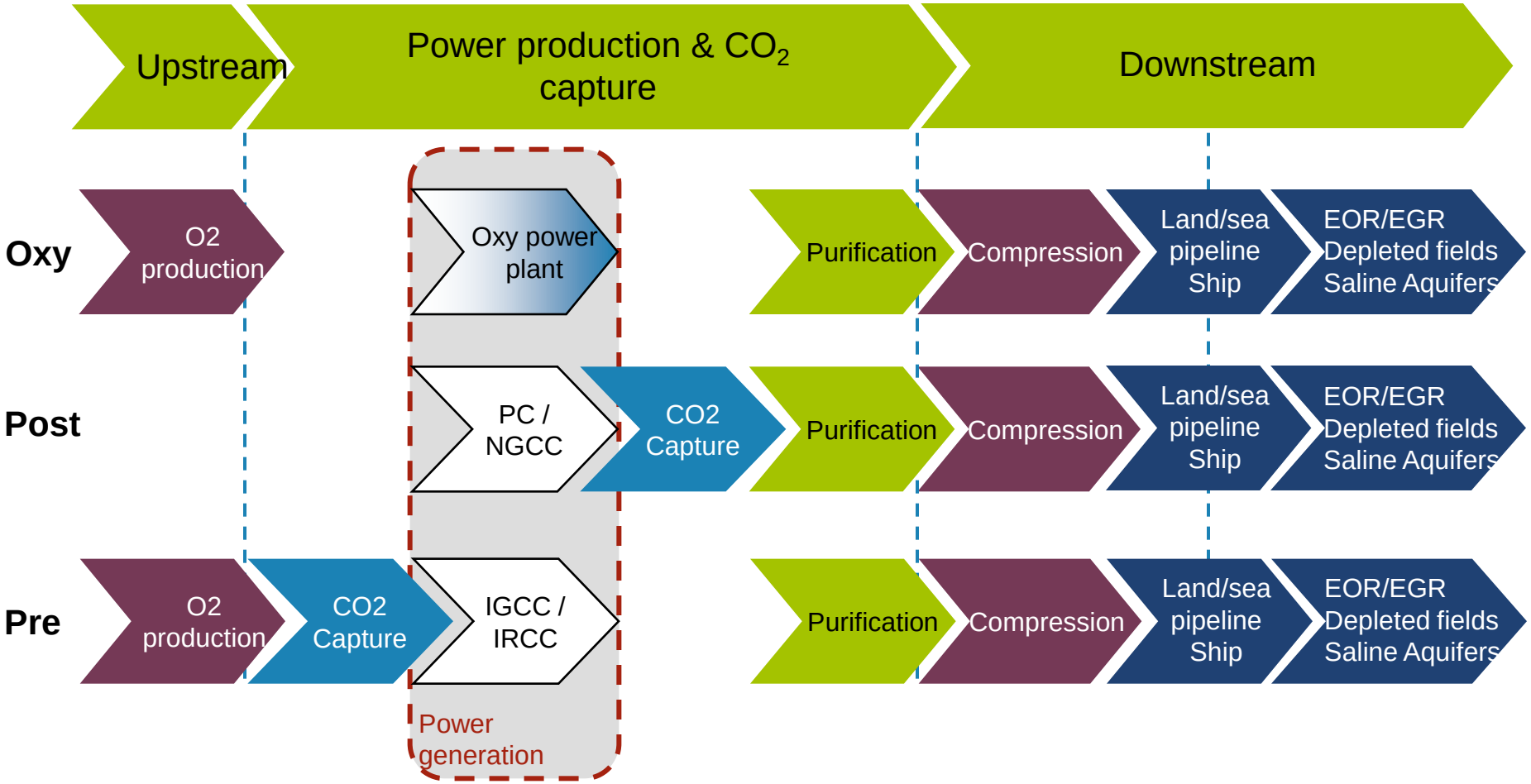
Objectives for RD&D strategy:

- Support the demonstration programmes, which should be part of the CAT strategy
- Ensure that CATs and in particular CCS are affordable, acceptable and commercially available by 2020.
- Ensure that the next generation of fossil fuel power plant technologies including technologies which today are regarded as novel, are successfully brought to the market place by 2030+ so that the 2050 targets can be met in the most affordable and acceptable way.
- Ensure the necessary skills and competencies are available to develop and support the future fossil fuel power technologies

Overview of the Technology Blocks Along the CO_2, Capture, Transport and Storage Value Chains



Current programme

- **Support by DTI, BERR, TSB , and the Research Councils has laid a good foundation and we have now the opportunity to build on this**
- **Culminated in full scale UK demonstration of post-combustion CCS**
- **UK has been up with the leaders, now in danger of falling behind**
- **Detail in the document and in tomorrow's sessions**

Next stage:

- Achievement of our Vision!

(eg 10% of UK generation fitted with CCS by 2020)

Doosan Babcock partnership with HTC Purenergy and University of Regina

In September 2008, Doosan Babcock signed an agreement with HTC Purenergy of Canada to licence University of Regina technology for post-combustion capture of CO_2.

Doosan Babcock will offer the technology to its customer base in the UK, Europe, the Americas and China and will take advantage of the series of demonstration projects in which HTC and UoR are involved

Coal fide gas demonstration - Test Facilities at Boundary Dam

ITC - Natural gas flue gas capture Centre

CCS1000 Modular Design

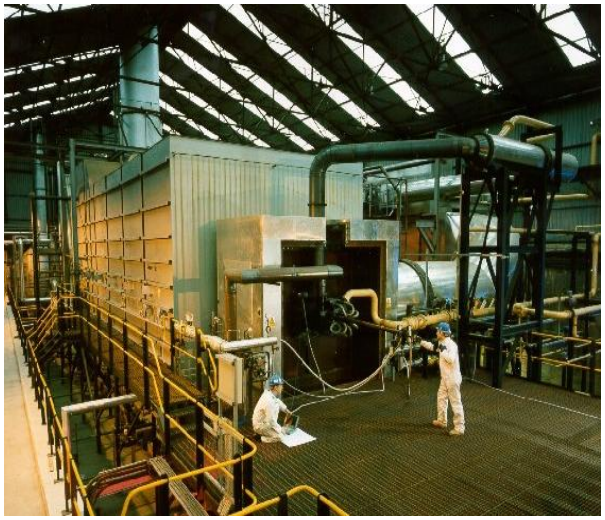
Absorption Column, 14 ft-6 in ID x high 119 ft

Stripper Column, 12 ft-6 in ID x 77 ft high

2008 Demonstration at SV Minerals - 50MW, includes new solvent (RS1), new packing material strategy, steam reduction

OxyCoal 2 - Demonstration of OxyCoal™ combustion system

- £7.4M project
- 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 %CO_2 recycle and excess oxygen
  - Start-up, shut down, transition from air to oxyfuel, load change



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Research, Development, Demonstration needs

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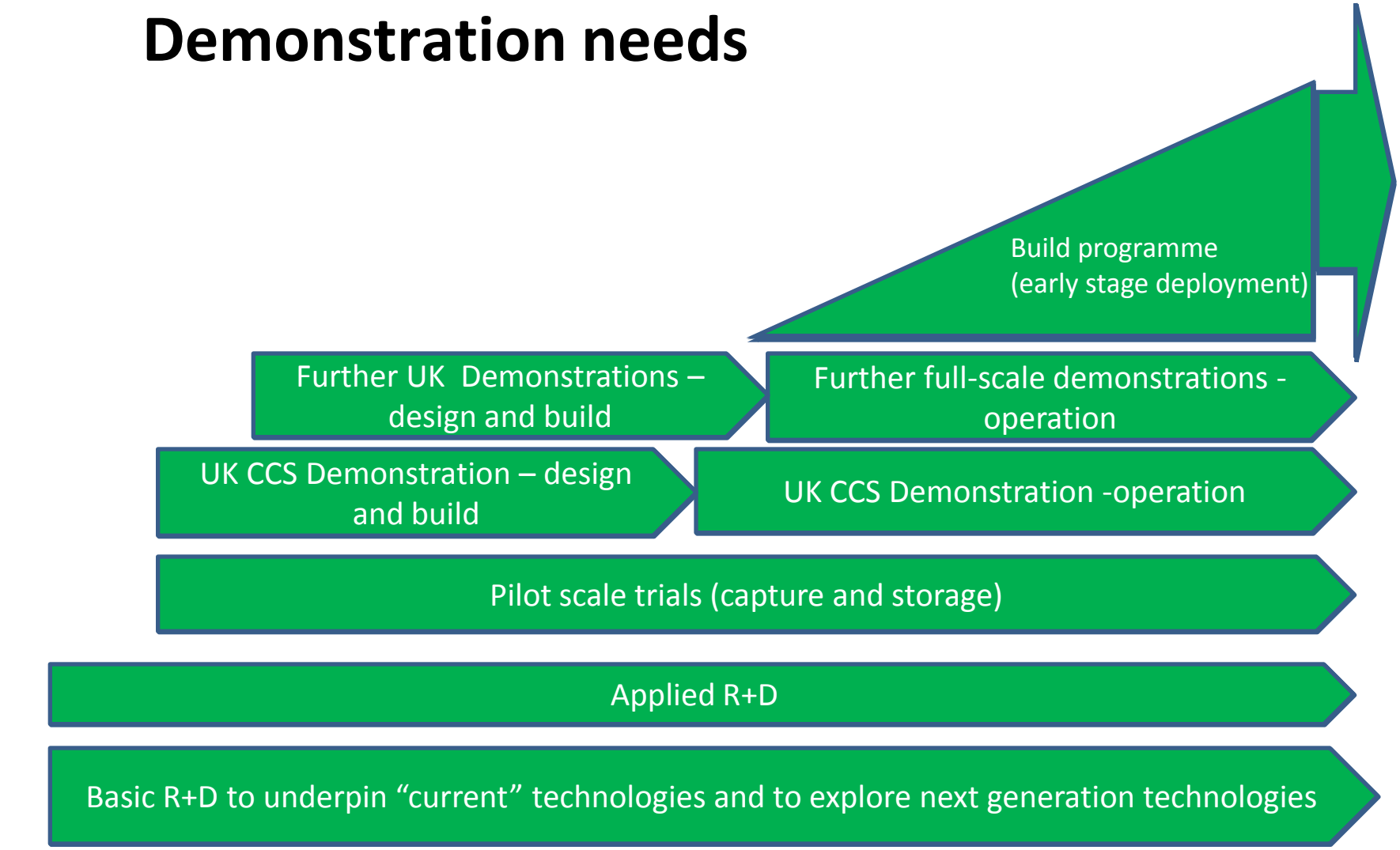

UK CCS Demonstration projects needed

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Carbon dioxide capture (coal) **•Post-combustion**	**600°C coal power plant with Post combustion capture, operating in the UK by 2014**
•Oxyfuel	**Full-scale 100-250MWe oxyfuel CCS demonstration by 2015**
•Pre-combustion	**A 4-800MW_e UK IGCC demonstration based on UK OEM capability by 2016**
Carbon dioxide capture (gas)	**State of the art gas fired power plant with post combustion capture operating in the UK by 2017** Demonstration of high efficiency gas turbine working on very high H_2 content fuel (international collaboration) Demonstration of pre-combustion capture with a natural gas combined cycle power plant (possibly retrofit)
Carbon dioxide transport	**Development of onshore transport network linked to several capture sites by 2015/17**
Carbon dioxide storage	**Multiple storage demonstrations in by 2015, including EOR, depleted gas and oil fields and saline aquifers**

UK Pilot scale projects needed

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Proven	Up to 2012	2014
Post combustion capture		
0.25-2 MW scale	Pilot scale demos at 1-20 MWe scale	Full scale power plant, at least 300MWe
Oxyfuel capture		
0.1 to 1MWscale	Demo of full size single burner(40MWth)	Full scale power plant,eg 100 -250MWe
	Demo of CO2 purification	
Pre-Combustion		
		Full scale power plant, at least 300MWe
CO2 storage in Saline acquifers		
1 million T/Yr into a very large aquifer with limited monitoring	CO2 development store with extensive monitoring to better understand interaction of CO2 with sub-surface structures. Single well. Near shore site preferred Injection around 100,00T/Yr	Further R&D using development store with multiple wells and extensive monitoring. Injection around 1million T/Yr
CO2 Stored in Depleted Gas Fields		
Limited test injection of CO2 currently underway, but limited information available	Test injection of around 100,000 T/Yr, from tanker With extensive monitoring	Increased injection of around 1 million T/Yr either from tanker or pipeline

Applied R+D

Basic R+D to underpin “current” technologies and to explore next generation technologies

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- Document covers
  - detailed needs
  - priorities
- Focus on
  - **Power plant** : focus on cost and increasing efficiency, biomass cofiring
  - **Capture technologies**: focus on cost, efficiency penalty, waste heat utilisation
  - **Storage**: focus on security, monitoring and verification
  - **Transport**: focus on logistics and transport network
  - **Whole system**: focus on risks, transient capability
  - **Advanced and novel capture technologies**
  - **Underpinning technology support**

Recommendations - Coordinated UK R, D & Demonstration Programme

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- It is vital that each area of technology (Capture, Transport, Storage) is taken forward and that there are no gaps

- In order to realise the vision, all of these key areas and the challenges within them need to be addressed in a managed and timely way across all the relevant government departments (including DECC, BERR, DIUS, UKFCO and Treasury) and funding agencies, tying in with key milestones as illustrated in the Route Map figure and driving towards and beyond the widespread roll out of CCS by 2020

- A Coordinated UK R, D& Demonstration Programme is required covering the full innovation chain and involving DECC, industry and all of the bodies which support R,D and Demonstration - including the Research Councils, the Carbon Trust, the Technology Strategy Board , the Energy Technologies Institute, Environmental Transformation Fund, the RDAs/Devolved Administrations and Government- supported Demonstrations.

- The programme needs longevity (the product life cycle time with such components and plant being up to several decades in duration) and should be subject to regular review.

Recommendations

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1) APGTF recommends that 10% of UK power generation capability (approximately 40 TWh/y) would be provided by fossil-fuel plant operating with CCS by 2020.

2) **The UK should be hosting three coal and one gas large scale CCS demonstration projects, to be operational by 2015**. A range of storage options should also be tested by these projects.

3) A sustained programme of RD&D, supported by Government and industry is needed to 2020 and beyond, to support and underpin the demonstration programmes and to develop new technologies. **A strategic programme of skills development is needed - the MEC Industrial Doctorate Centre is central to this**

4) There should be a **Coordinated UK R,D&D Programme** involving Government, funding agencies and industry. The programme needs longevity and should be subject to regular review.

5) The Coordinated programme should include: a **Basic R&D Programme**; an **Applied RD&D Programme**; a **Technology Transfer and Export Promotion Programme**. The **Government/EU- supported Full Scale Demonstrations** should also be an integral part

6) **The APGTF should be fully engaged with the proposed Coordinated UK RD&D Programme**.

How to deliver clean and secure power and set an example of global relevance

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

We can set an excellent example to other countries which will build fossil fuel power plant if we insist on building all coal and gas plants capture and storage ready in parallel with actions to demonstrate, and then implement, properly regulated and monitored CCS

Thank you for your attention