INTERNATIONAL vs UK PERSPECTIVE
ROLE OF FOSSIL FUELS IN THE POWER GENERATION MIX

APGTF WORKSHOP – IET, SAVOY PLACE, LONDON 6 DECEMBER 2016
EMILY AGUS, STEVE LOYD & MIKE WHEELER
Michael Wheeler
Global Market Director, Power - Ramboll

- 30 + years in power generation industry
- 10 years with OEM
- 20 years in Power Generation Consultancy
  - 17 years with PB Power (Generation Director)
  - 3 years with Ramboll
- 2007 to 2010
  - Lead Technical Adviser for UK 300 MW CCS Demo (DECC)
- 2010 to 2013
  - Project Director on Rabigh 2400 MW and PP12 2800 MW projects (Saudi Arabia)
- 2013 to present (Ramboll)
  - Lynemouth 3 x 140 MW coal-fired to biomass conversion project
  - Muzaffargarh 660 MW coal-fired project (Pakistan)
  - Development support on numerous UK power projects
Ramboll Group

- Leading engineering, design and consultancy company
- Founded in Denmark in 1945
- 13,000 experts
- 300 offices in 35 countries
- Significant presence in Scandinavia, North America, United Kingdom, Central and southern Europe, India and the Middle East
- Over 10 billion DKK in revenue
- Owned by the Ramboll Foundation

Ramboll works within:
- Buildings
- Transport
- Planning & Urban Design
- Water
- Environment & Health
- Energy
- Oil & Gas
- Management Consulting
ENERGY

- Among top 10 energy consultancies in Europe
- 45 years of experience in planning, design and implementation of energy solutions
- Expertise on full spectrum of technologies
- Expertise ranging from production over transmission to distribution

- Revenue (m€): 117
- Employees: 800
- Sector focus:
  - Wind energy
  - Waste-to-energy
  - Thermal power
  - District energy
  - Power transmission
  - Asset management
  - Renewable energy
  - Energy planning
Avedore, Unit 2

Ultra super critical boiler
- Live steam: 1067 t/h, 305 bar, 582 °C
- Reheat steam: 84 bar / 600 °C

Multi fuelled: Gas, oil, coal, wood pellets, straw

Feedwater boosting with 2 gas turbines

District heating supply

Flexible and efficient power plant 49 % (LHV)
CONTENTS

• PART 1: GLOBAL PERSPECTIVE
• PART 2: FOCUS – UK PERSPECTIVE
• PART 3: UK – ROLE OF FOSSIL FUELS IN THE POWER GENERATION MIX
CONTENTS

• PART 1: GLOBAL PERSPECTIVE

• PART 2: FOCUS – UK PERSPECTIVE

• PART 3: UK – ROLE OF FOSSIL FUELS IN THE POWER GENERATION MIX
GLOBAL PERSPECTIVE
Paris Agreement

• Entered into force 4th November 2016

• Article 2 states:
  1. Holding the increase in the global average temperature to well below 2°C above pre-industrial levels; and
  2. Pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.

• 115 Parties out of 197 have ratified Agreement

➢ International pressure from Governments and funding agencies to reduce CO₂ emissions
GLOBAL PERSPECTIVE
New Construction – Electricity and Power: 2006 to 2020

Source: Timetric
FOCUS: ASIA-PACIFIC
Power Project Pipeline 2015 (MW): By Country and Type

Source: Timetric
FOCUS: EUROPE
Power Project Pipeline 2015 (MW): By Country and Type

Source: Timetric
CONTENTS

• PART 1: GLOBAL PERSPECTIVE

• PART 2: FOCUS – UK PERSPECTIVE

• PART 3: UK – ROLE OF FOSSIL FUELS IN THE POWER GENERATION MIX
UK – CURRENT SITUATION (2015)
Installed Capacity / Electricity Supplied

- **Installed Capacity (GW):**
  - Fossil Fuels: 52 GW (54%)
  - Nuclear: 9 GW (9%)
  - Biomass: 3 GW (3%)

- **Electricity Supplied (TWh):**
  - Fossil Fuels: 162 TWh (49%)
  - Nuclear: 62 TWh (19%)
  - Biomass: 31 TWh (9%)
UK – CURRENT SITUATION (2015)
Installed Capacity / Electricity Supplied – Hierarchy of Dispatch

FIRST PRIORITY
Continuous Low Carbon / Continuous Renewables
UK – CURRENT SITUATION (2015)
Installed Capacity / Electricity Supplied – Hierarchy of Dispatch

- Continuous Low Carbon
- Continuous Renewables

12% Installed Capacity → 28% Electricity Generated

- Intermittent Renewables

30% Installed Capacity → 16% Electricity Supplied
UK – CURRENT SITUATION (2015)
Installed Capacity / Electricity Supplied – Hierarchy of Dispatch

Fossil Fuels used as back-up when Intermittent Renewables are unavailable
THE ENERGY ‘TRILEMMA’…
And the Future Power Generation Mix

Ensuring Security of Supply…

...Whilst Decarbonising...

...And Containing Costs.
THE ENERGY ‘TRILEMMA’…
And the Future Power Generation Mix

Bad reactions
France’s nuclear-energy champion is in turmoil

Retiring nuclear power stations and a planned coal phase-out could leave the UK facing a huge electricity supply gap by 2025,

Winter power crunch fears arise

Ensuring Security of Supply...

UK power supply ‘tight but manageable this winter’
THE ENERGY ‘TRILEMMA’…
And the Future Power Generation Mix

Carbon Ambitions:
Climate Change Act 2008 - Mandatory reductions in carbon emissions
Overall target of 80% reduction by 2050 (from 1990 levels)

Renewable Energy Ambitions:
EU Renewable Energy Directive - Targets for renewable energy generation
European Union overall target is 20% energy from renewables by 2020
UK target is 15% energy from renewables by 2020.
THE ENERGY ‘TRILEMMA’...
And the Future Power Generation Mix

"Cold" households were fearful of high energy costs over winter

...And Containing Costs.

Why aren't my energy bills coming down?

UK households used 14% less energy last year but still paid more

Reduction in energy bills 'long overdue' says MP

29% of young households borrowing to pay the heating bills

Energy cost problems result in manufacturer jobs threat
THE ENERGY ‘TRILEMMA’

The future power generation mix needs to be:

Secure...

Low Carbon...

...AND Low Cost.

“We now have an electricity system where no form of power generation, not even gas-fired power stations, can be built without government intervention. And a legacy of ageing, often unreliable plant.

Amber Rudd, Energy and Climate Change Secretary November 2015
CONTENTS

- PART 1: GLOBAL PERSPECTIVE
- PART 2: FOCUS – UK PERSPECTIVE
- PART 3: UK – ROLE OF FOSSIL FUELS IN THE POWER GENERATION MIX
NATIONAL GRID PROJECTIONS / TRENDS

Scenario comparison

- **Heating**
  - 1 million heat pumps
  - **Gone Green**
  - **Slow Progression**
  - **No Progression**
  - **Maximum expected by 2040**
  - **NET 10 million**

- **Transport**
  - 4 million electric vehicles
  - **Gone Green**
  - **Slow Progression**
  - **No Progression**
  - **Maximum expected by 2040**
  - **NET 10 million**

- **Electricity generation**
  - First new nuclear power station commissioned
  - **Gone Green**
  - **Slow Progression**
  - **No Progression**
  - **Maximum expected by 2040**
  - **15 GW (total nuclear)**

- **Electricity storage**
  - 1 GW of new electricity storage technology
  - **Gone Green**
  - **Slow Progression**
  - **No Progression**
  - **Maximum expected by 2040**
  - **NET 15 GW**

- **Electricity interconnection**
  - 13 GW of electricity import capacity
  - **Gone Green**
  - **Slow Progression**
  - **No Progression**
  - **Maximum expected by 2040**
  - **NET 23 GW**

- **Gas supplies**
  - 5 per cent of gas from onshore production
  - **Gone Green**
  - **Slow Progression**
  - **No Progression**
  - **Maximum expected by 2040**
  - **NET 54 per cent**

- **Environmental targets**
  - 2020 Renewable Energy Directive target met
  - **Gone Green**
  - **Slow Progression**
  - **No Progression**
  - **Maximum expected by 2040**
  - **NET**

**ROLE OF FOSSIL FUELS IN THE POWER GENERATION MIX**

2016/12/06
UK PROJECTIONS TO 2040

Electricity Supplied

The diagram shows the projected electricity supplied (TWh) from different energy sources across various scenarios and years (2020, 2030, 2040). The energy sources include Coal, Gas, Nuclear, Biomass, and Other.
Electricity Supplied 333 TWh
- Coal – 58 TWh (17%)
- Gas – 104 TWh (31%)
- Nuclear – 62 TWh (19%)
- Biomass – 31 TWh (9%)

Electricity Supplied 471 TWh
- Coal – 0 TWh (0%)
- Gas – 142 TWh (41%)
- Nuclear – 31 TWh (9%)
- Biomass – 8 TWh (2%)
### UK Projections to 2040

<table>
<thead>
<tr>
<th>Year</th>
<th>Electricity Supplied (TWh)</th>
<th>Coal</th>
<th>Gas</th>
<th>Nuclear</th>
<th>Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>333</td>
<td>58 TWh (17%)</td>
<td>104 TWh (31%)</td>
<td>62 TWh (19%)</td>
<td>31 TWh (9%)</td>
</tr>
<tr>
<td>2020</td>
<td>471</td>
<td>0 TWh (0%)</td>
<td>142 TWh (41%)</td>
<td>31 TWh (9%)</td>
<td>8 TWh (2%)</td>
</tr>
<tr>
<td>2030</td>
<td>471</td>
<td>0 TWh (0%)</td>
<td>134 TWh (41%)</td>
<td>8 TWh (2%)</td>
<td>16 TWh (5%)</td>
</tr>
<tr>
<td>2040: Gone Green</td>
<td>471</td>
<td>0 TWh (0%)</td>
<td>97 TWh (21%)</td>
<td>119 TWh (25%)</td>
<td>9 TWh (2%)</td>
</tr>
</tbody>
</table>

### Notes
- **2015**
  - Electricity Supplied: 333 TWh
    - Coal: 58 TWh (17%)
    - Gas: 104 TWh (31%)
    - Nuclear: 62 TWh (19%)
    - Biomass: 31 TWh (9%)

- **2020**
  - Electricity Supplied: 471 TWh
    - Coal: 0 TWh (0%)
    - Gas: 142 TWh (41%)
    - Nuclear: 31 TWh (9%)
    - Biomass: 8 TWh (2%)

- **2030**
  - Electricity Supplied: 471 TWh
    - Coal: 0 TWh (0%)
    - Gas: 134 TWh (41%)
    - Nuclear: 8 TWh (2%)
    - Biomass: 16 TWh (5%)

- **2040: Gone Green**
  - Electricity Supplied: 471 TWh
    - Coal: 0 TWh (0%)
    - Gas: 97 TWh (21%)
    - Nuclear: 119 TWh (25%)
    - Biomass: 9 TWh (2%)
NUCLEAR & SECURITY OF SUPPLY

• Nov 2016
  • Britain is exporting electricity to France for the first time in four years after safety concerns forced the closure of 18 French nuclear reactors
  • Flamanville 3 (France) 1,650 MW
    • construction commenced 2007 - to be online in 2013
    • Costs tripled to more than €10.5bn
    • Commercial operation delayed...2018?
  • Olkiluoto 3 (Finland) - €3bn, 1,600 MW; to be online in 2009 ......
    • 3 times over budget – now due in 2018?
  • Hinkley Point - £18bn, 3,200 MW
    • When / if?
COAL - UK GOVERNMENT RECENT TIMELINE

• 2007
  • Start of 300 MW CCS demo competition
  • New USC coal plants in development (viable in UK Market)

• 2009
  • Any new coal power station in England and Wales to demonstrate CCS from day one on 300MW; expectation of retrofit CCS to full capacity by 2025

• 2010
  • UK CCS 300 MW demo cancelled

• 2016
  • 2nd UK CCS demo project cancelled
  • Unabated Coal to be phased out by 2025

Policy objectives reduced CO2 emissions
Consequence
  • No investment in high efficiency (USC) coal plant
  • Old inefficient (sub-critical) plant remaining in operation (average of 47 years old!)
LIMITED ROLE FOR COAL?...
Projections for Installed Capacity to 2030
LIMITED ROLE FOR COAL?...
Projections for Installed Capacity to 2030

- Majority of Fleet have secured Capacity Market Agreements for 2018 / 2019 and 2019 / 2020
- Majority of these generating under the IED’s Transitional National Plan
  - Annual Emissions Allocation within declining overall UK Maximum Emissions Ceiling
  - From July 2020 must either meet IED Emission Limit Values, Close or be Limited to 1,500 hours / year
- Indications of post-2020 (post-TNP) role for unabated coal (and remaining fleet) through Capacity Market Auction?
- Based on planned unabated coal phase out, does this limit investment in pollution / carbon abatement?
VARIABILITY IN THE ROLE FOR GAS...
Projections for Installed Capacity to 2030

“One of the greatest and most cost-effective contributions we can make to emission reductions in electricity is by replacing coal fired power stations with gas”

Amber Rudd, Energy and Climate Change Secretary November 2015

- Under National Grid’s projections, large variability in the role for gas.
- Linked to uncertainties in nuclear / intermittent renewables role out.
- Gas will be required to provide Flexible / Dispatchable Capacity
- Current delivery through Capacity Market...
- But, Capacity Market created distortion...
VARIABILITY IN THE ROLE FOR GAS...
Projections for Installed Capacity to 2030
VARIABILITY IN THE ROLE FOR GAS...
Projections for Installed Capacity to 2030

2016
Capacity Oversubscription
42%
2015 – 20.5%
2014 – 22%
VARIABILITY IN THE ROLE FOR GAS...
Projections for Installed Capacity to 2030

Mostly Driven by 10 GW Increase in Capacity of New Build Generating CMUs

ROLE OF FOSSIL FUELS IN THE POWER GENERATION MIX
2016/12/06
VARIABILITY IN THE ROLE FOR GAS...
Projections for Installed Capacity to 2030

Whilst Pre-Qualified Capacity shows Increases across all MW Size Ranges
VARIABILITY IN THE ROLE FOR GAS...
Projections for Installed Capacity to 2030

 Whilst Pre-Qualified Capacity shows Increases across all MW Size Ranges, Distortion Caused By Large Increase in Pre-Qualified Number of 0 – 25 MW Units.
• Current Distortion has, in terms of New Build:
  - Driven delivery of small-scale gas / diesel units (i.e. reciprocating engines)
  - Limited delivery of large-scale gas (i.e. CCGT)
• Distortion being addressed through Capacity Amendments and Consultations
• But, in the meantime:
  - Has “contained costs”, but at what price to long term security of supply and Carbon / Renewable Ambitions
  - Provoked large number of CCGT to OCGT Variations
• Does this indicate a limited role for baseload large-scale gas?
• Associated rise in mid-merit / peaking gas?

Typical power plant emissions (NOx & CO₂)

Ramboll
VARIABILITY IN THE ROLE FOR GAS...
Projections for Installed Capacity to 2030 and Beyond...

- The distortion highlighted ‘disjoint’ in environmental requirements for small-scale units:
  - Established and Implemented requirements of IED for large-scale units:
    - Registering / permitting requirements
    - Stringent Emission Limits
    - Demonstrate the use of Best Available Techniques
    - Regular monitoring / reporting requirements
  - Versus requirements of MCPD still to be implemented for small-scale units
    - Little information in the public domain on small-scale units...
    - ...unlikely that Best Available Techniques (BAT) are being considered
IS THERE A ROLE FOR BIOMASS IN UK?
Projections for Installed Capacity to 2030

- Under Projections:
  - Installed capacity relatively consistent
  - Electricity supplied varies
  - Indicates variable role for biomass?
  - Associated requirements for flexibility...

- Ageing and inefficient coal plant fleet
  - Limited potential for further coal-to-biomass conversions?

- Uncertainty concerning future Government support schemes?
IS THERE A ROLE FOR CCS IN UK?

- Is there a future role for abated coal?
  - Under all projections, existing unabated coal phased out by 2025...
  - But, no coal with CCS...

- Is there a future role for abated gas?
  - Under most optimistic National Grid projection, gas with CCS late 2030s / early 2040s
  - But, gas required to be flexible / dispatchable capacity
  - Does the flexibility that will be required limit the application of CCS?

- Cancellation of two UK CCS Competitions – questions over consistent support / commitment?
CONCLUSION

- Many complex issues which impact upon the optimum future UK energy mix!

“We now have an electricity system where no form of power generation, not even gas-fired power stations, can be built without government intervention. And a legacy of ageing, often unreliable plant.

Amber Rudd, Energy and Climate Change Secretary November 2015

➢ But Government intervention often has unintended consequences!
THANK YOU
ANY QUESTIONS?

Michael Wheeler
Vice Director – Power, Ramboll Energy
michael.wheeler@ramboll.co.uk