



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

PRESENTER



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

A man and a woman are working together in an office. The man, wearing a blue sweater, is leaning over the woman's shoulder. The woman, wearing a striped sweater, is looking at a computer screen. They are both focused on their work. The background shows a modern office environment with large windows and a desk with a keyboard and other office supplies.

- 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

RAMBOLL MULTI FUELS EXAMPLE

Avedøre, Unit 2

Ultra super critical boiler

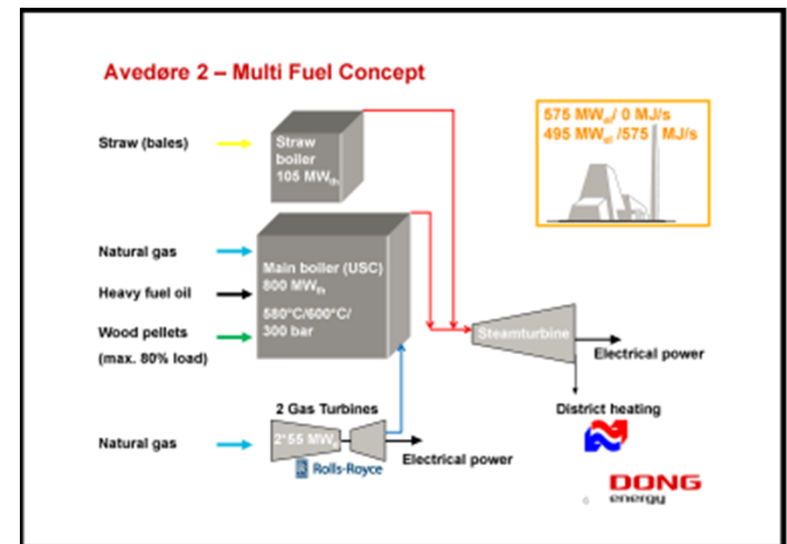
- Live steam: 1067 t/h, 305 bar, 582 ° C
- Reheat steam: 84 bar / 600 ° C

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

Feedwater boosting with 2 gas turbines

District heating supply

Flexible and efficient power plant 49 % (LHV)



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

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GLOBAL PERSPECTIVE

Paris Agreement

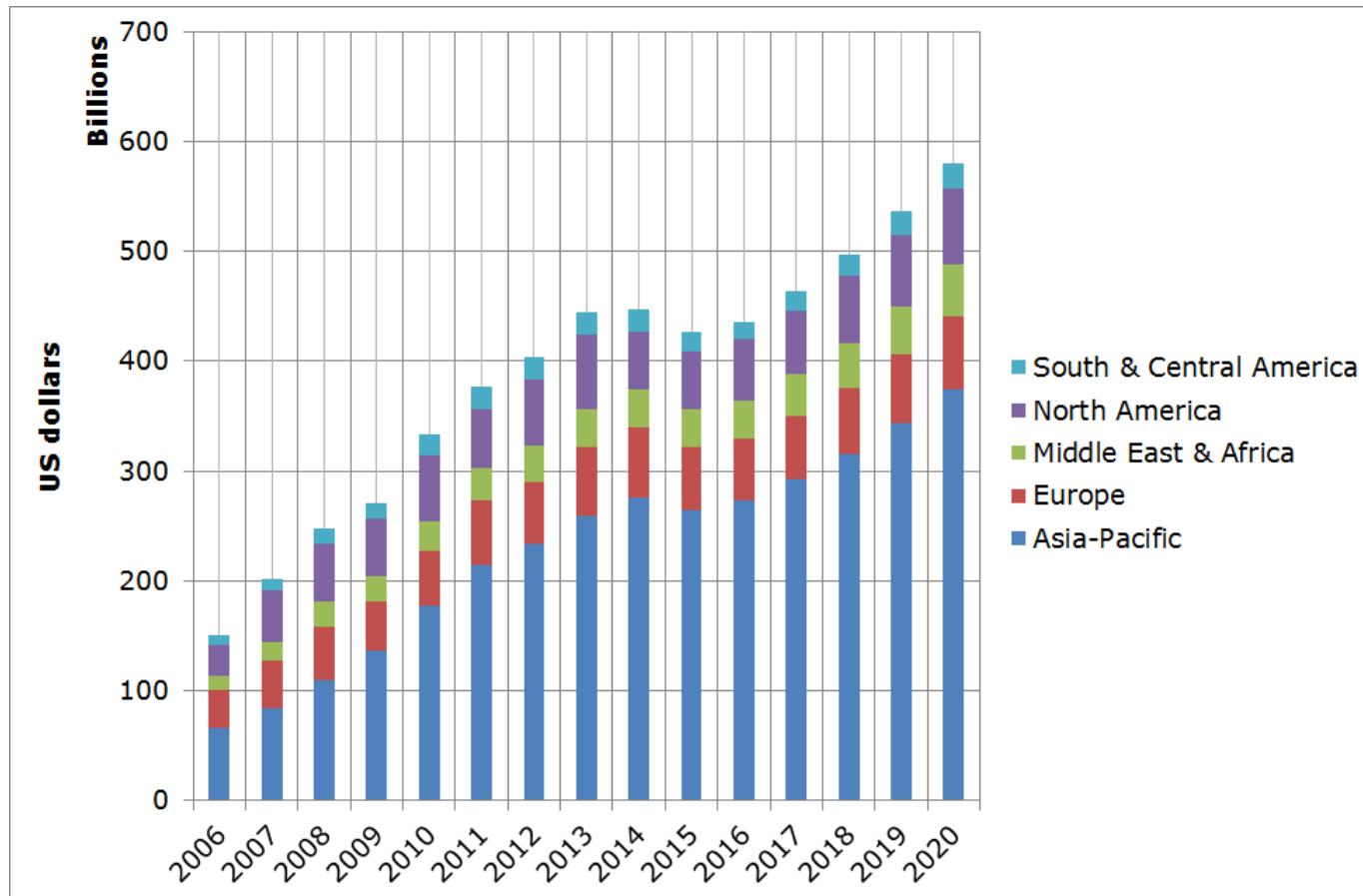
- Entered into force 4th November 2016
- Article 2 states:
 1. Holding the increase in the global average temperature to well below 2°C above pre-industrial levels; and
 2. Pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.
- 115 Parties out of 197 have ratified Agreement
- **International pressure from Governments and funding agencies to reduce CO₂ emissions**



United Nations
Framework Convention on
Climate Change

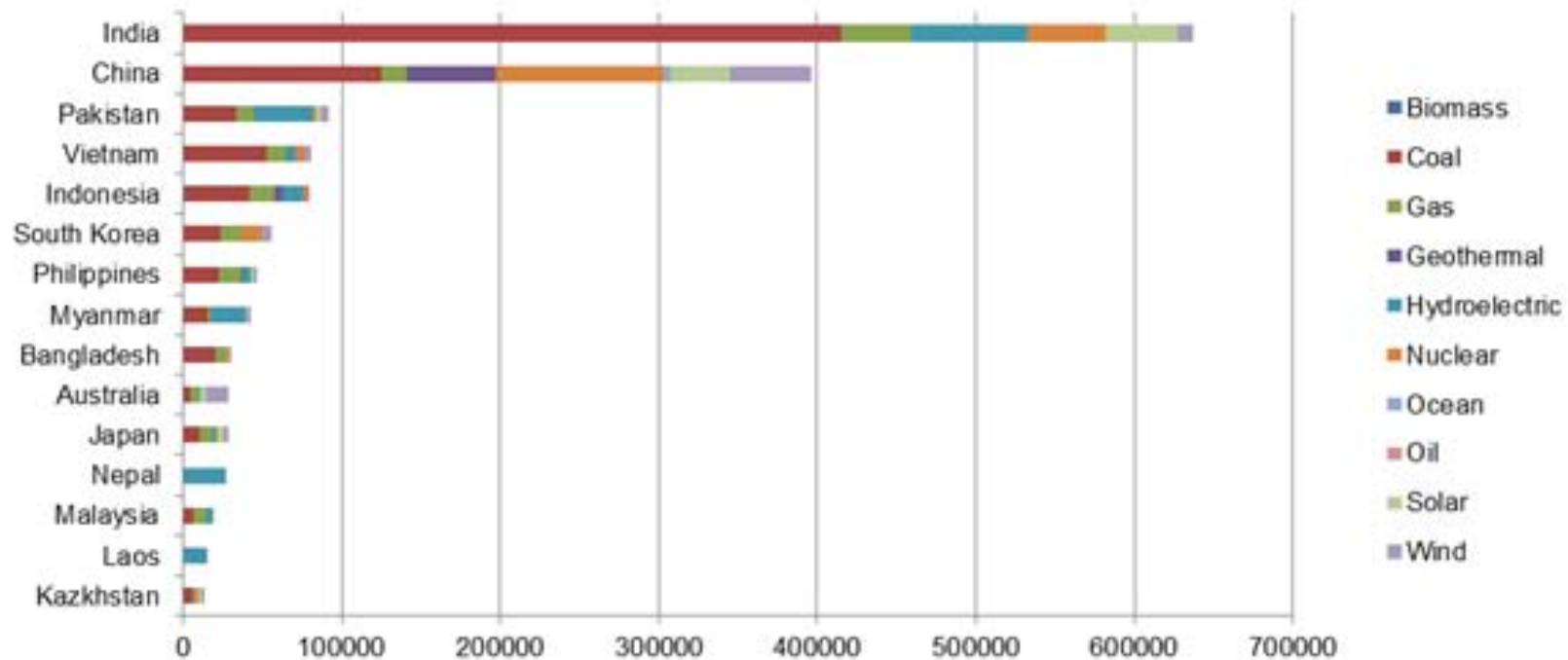
GLOBAL PERSPECTIVE

New Construction – Electricity and Power: 2006 to 2020



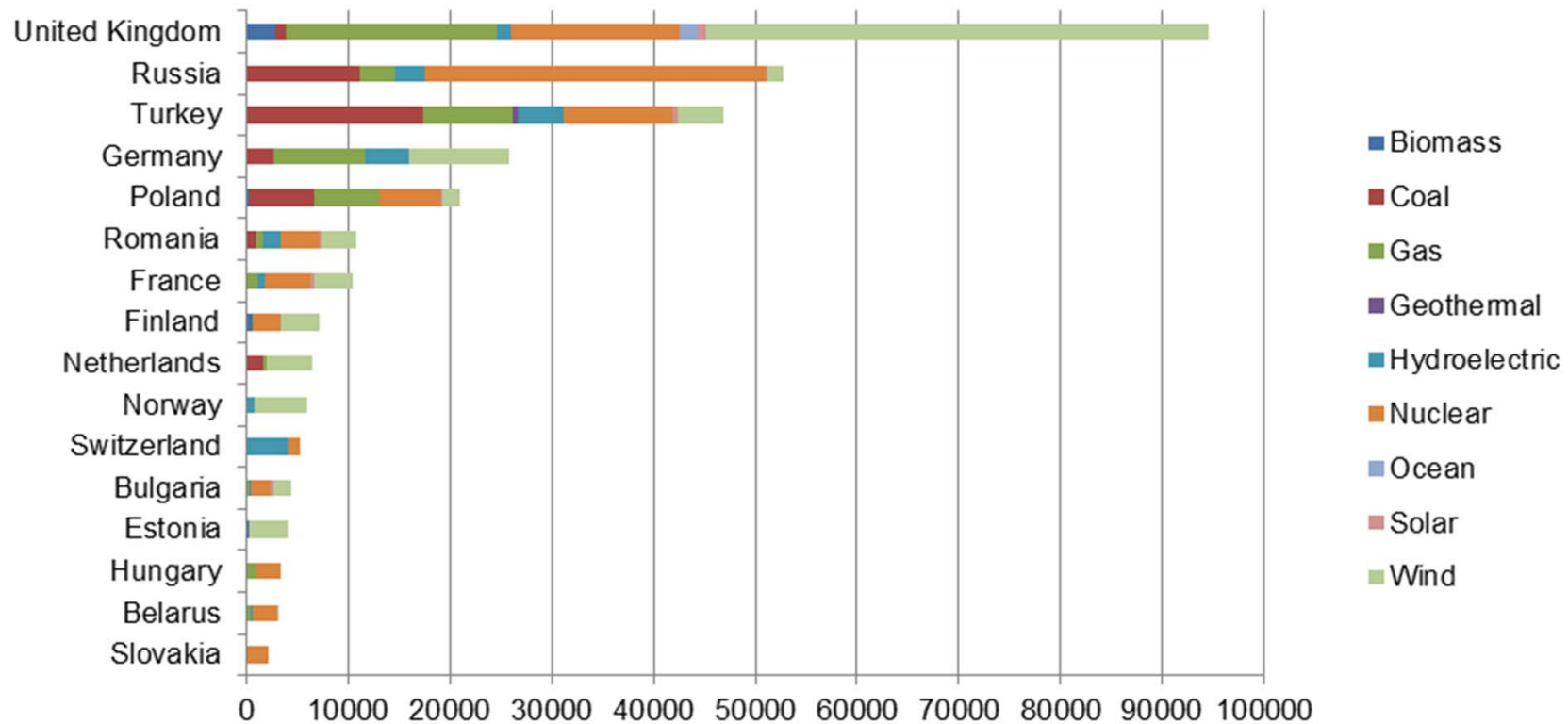
FOCUS: ASIA-PACIFIC

Power Project Pipeline 2015 (MW): By Country and Type



FOCUS: EUROPE

Power Project Pipeline 2015 (MW): By Country and Type

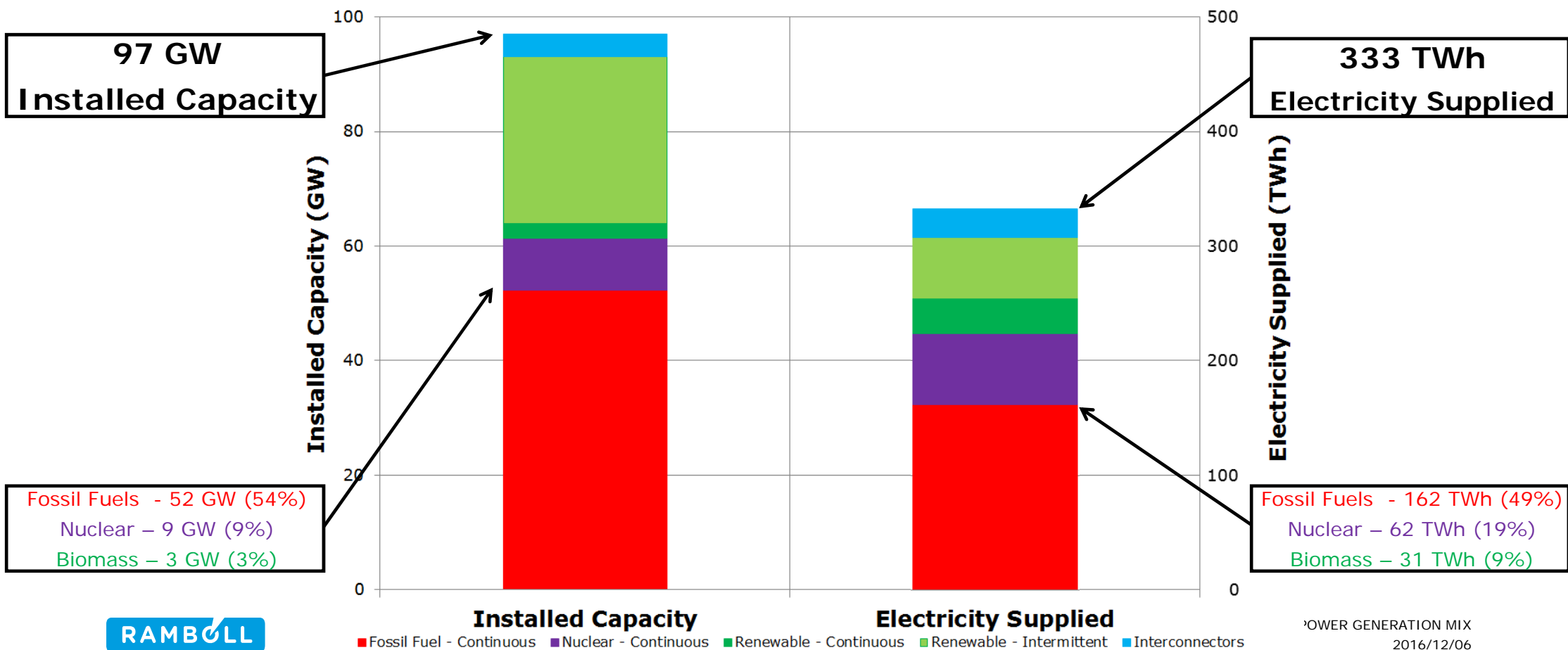


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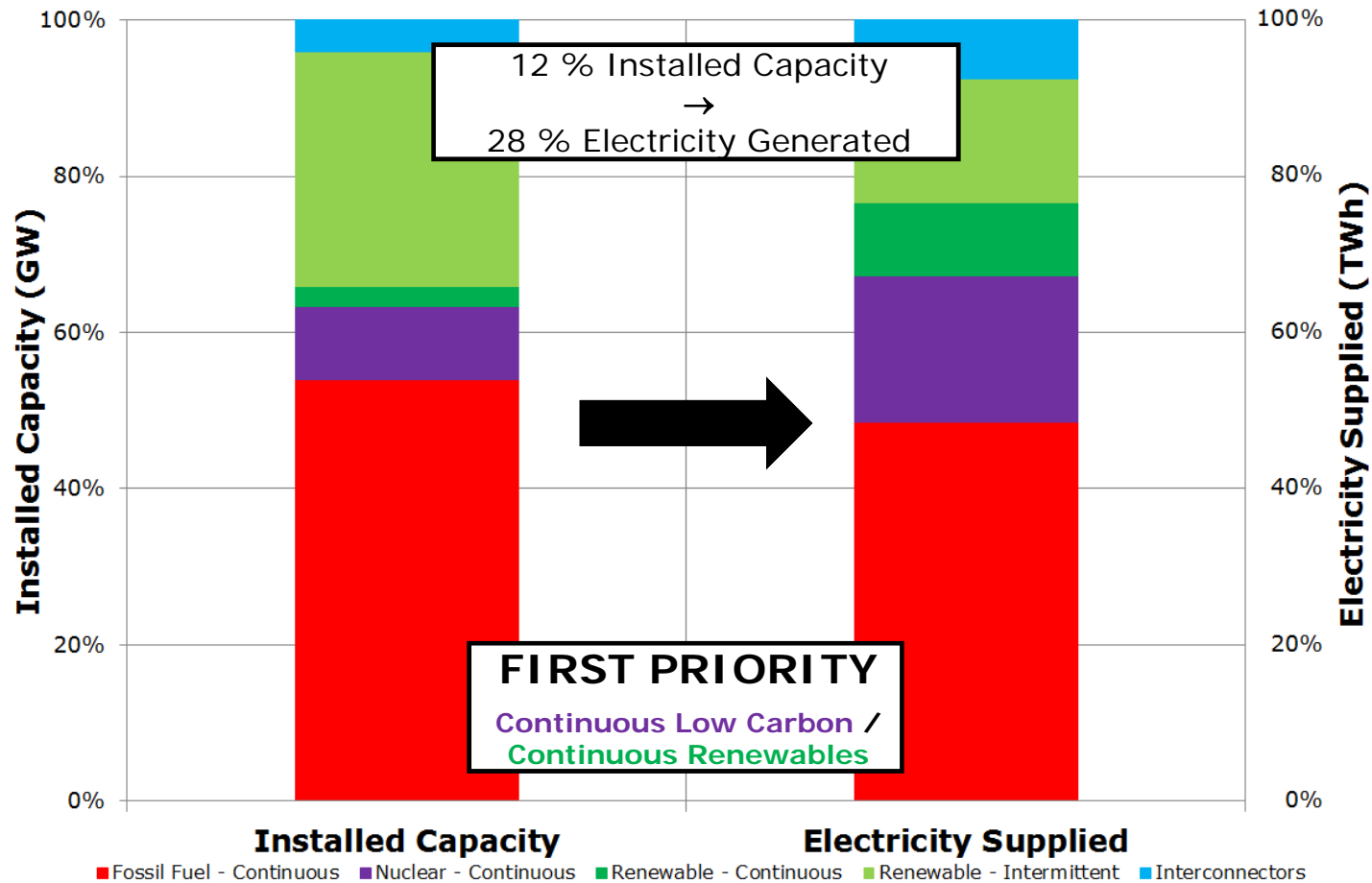
UK – CURRENT SITUATION (2015)

Installed Capacity / Electricity Supplied



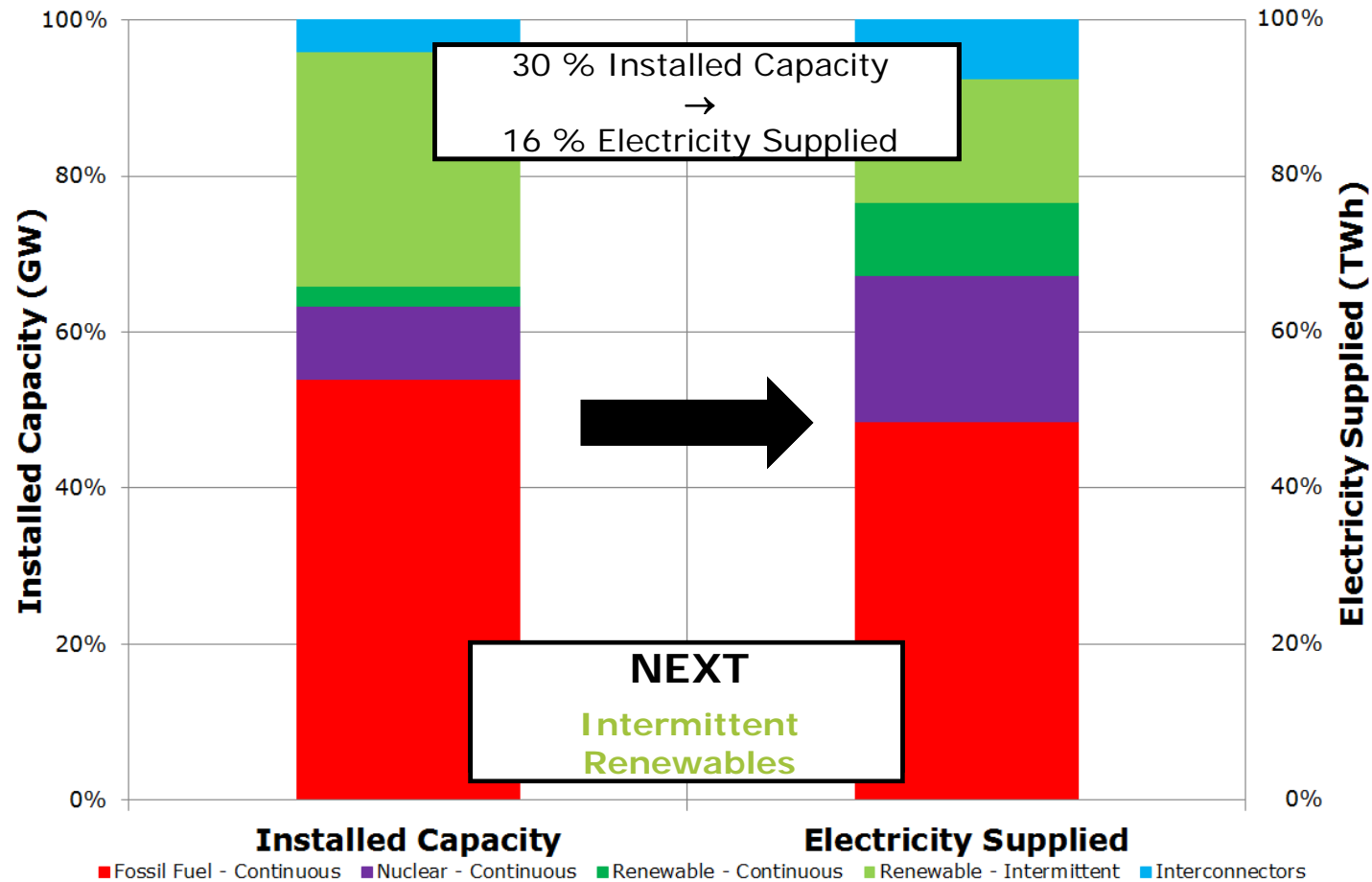
UK – CURRENT SITUATION (2015)

Installed Capacity / Electricity Supplied – Hierarchy of Dispatch



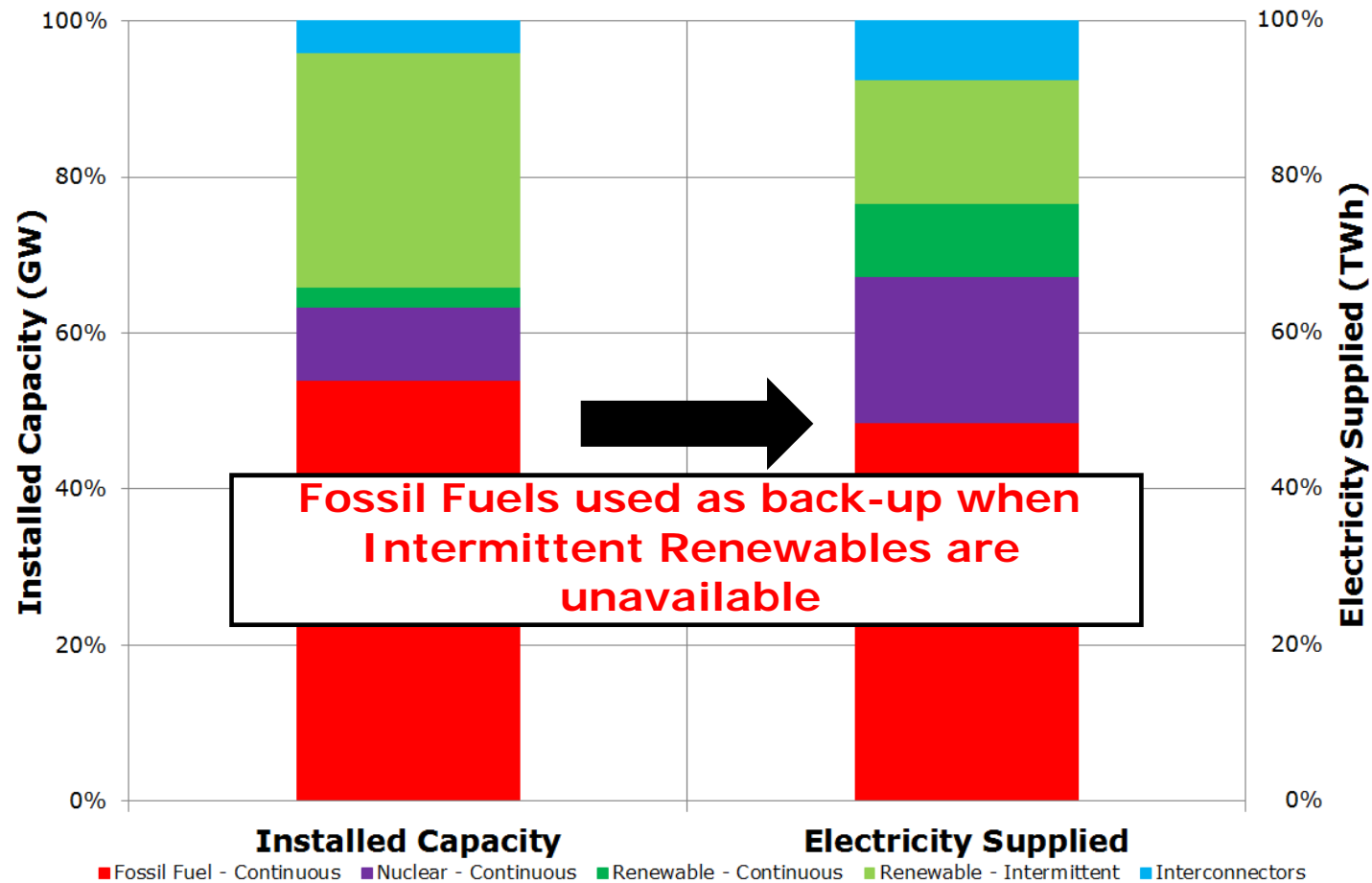
UK – CURRENT SITUATION (2015)

Installed Capacity / Electricity Supplied – Hierarchy of Dispatch



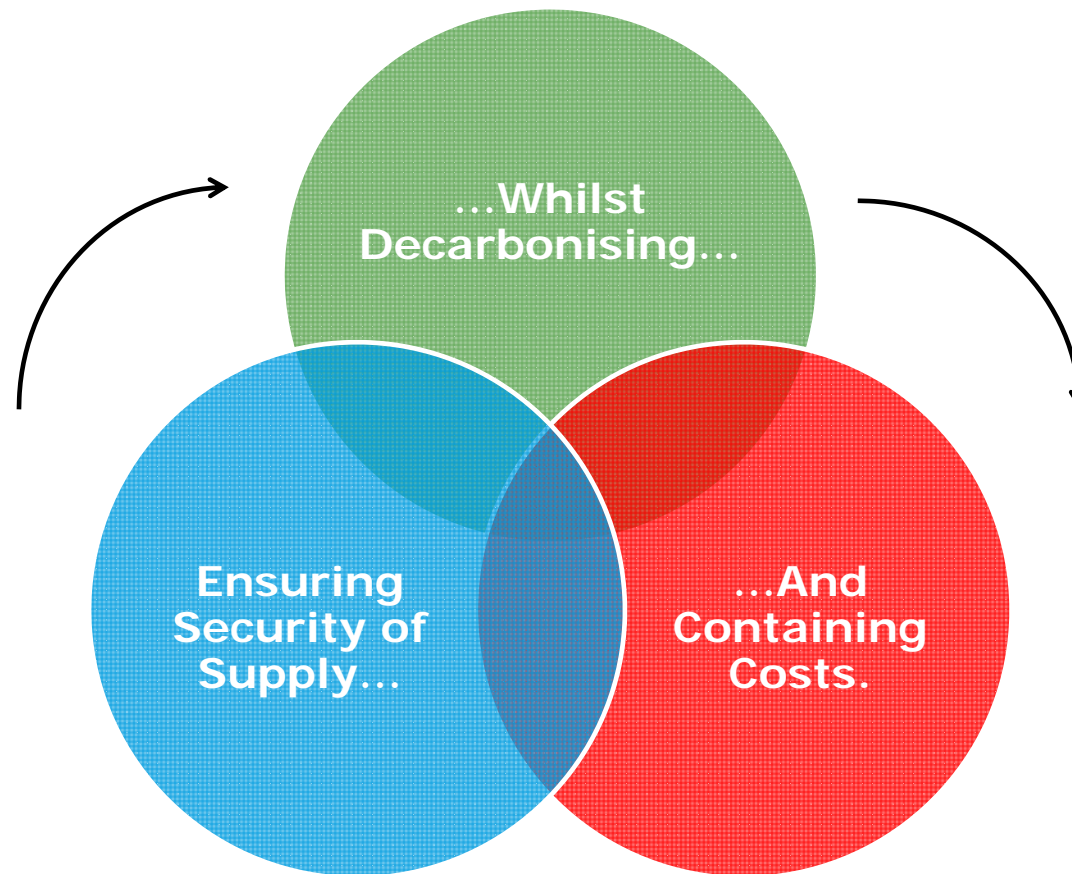
UK – CURRENT SITUATION (2015)

Installed Capacity / Electricity Supplied – Hierarchy of Dispatch



THE ENERGY 'TRILEMMA'...

And the Future Power Generation Mix



THE ENERGY 'TRILEMMA'...

And the Future Power Generation Mix

Bad reactions

France's nuclear-energy champion is in turmoil

Electricité de France has had to shut down 18 of its 58 nuclear reactors
Dec 3rd 2016 | PARIS

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

Business
Winter power crunch fears a

Cold snap warning of power problems

November 22, 2016

Ensuring
Security of
Supply...

Power crisis looms at

UK power supply 'tight but manageable this winter'

Dec 04, 2016 | Jessy Dainoff | Infrastructure & Generation | 0

Capacity problem looms a

RAMBOLL

ROLE OF FOSSIL FUELS IN THE POWER GENERATION MIX
2016/12/06

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

Shows that 6 million households turned off

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

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29% of young households borrowing to pay the heating bills

...And
Containing
Costs.

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.

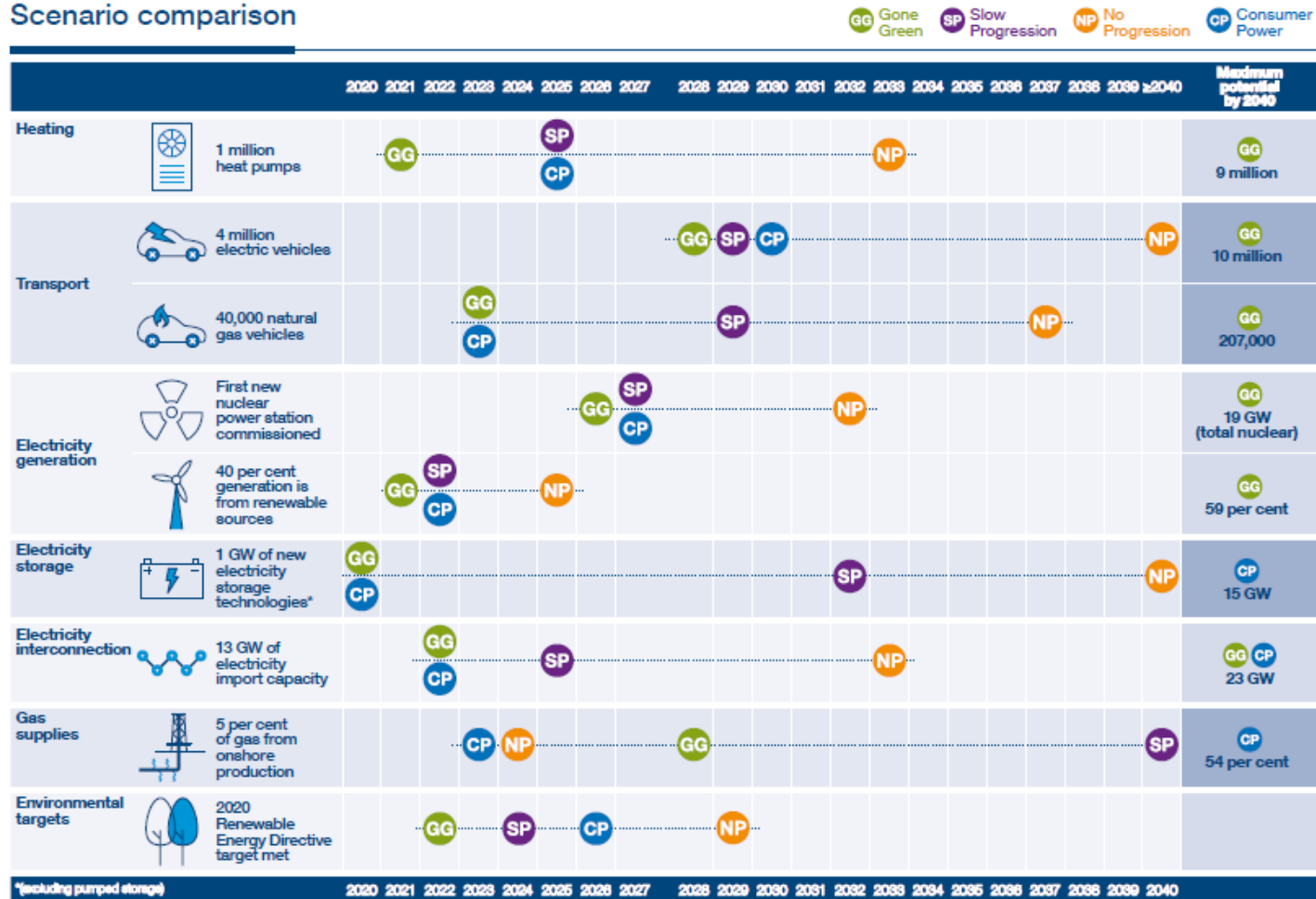
Amber Rudd, Energy and Climate Change Secretary November 2015

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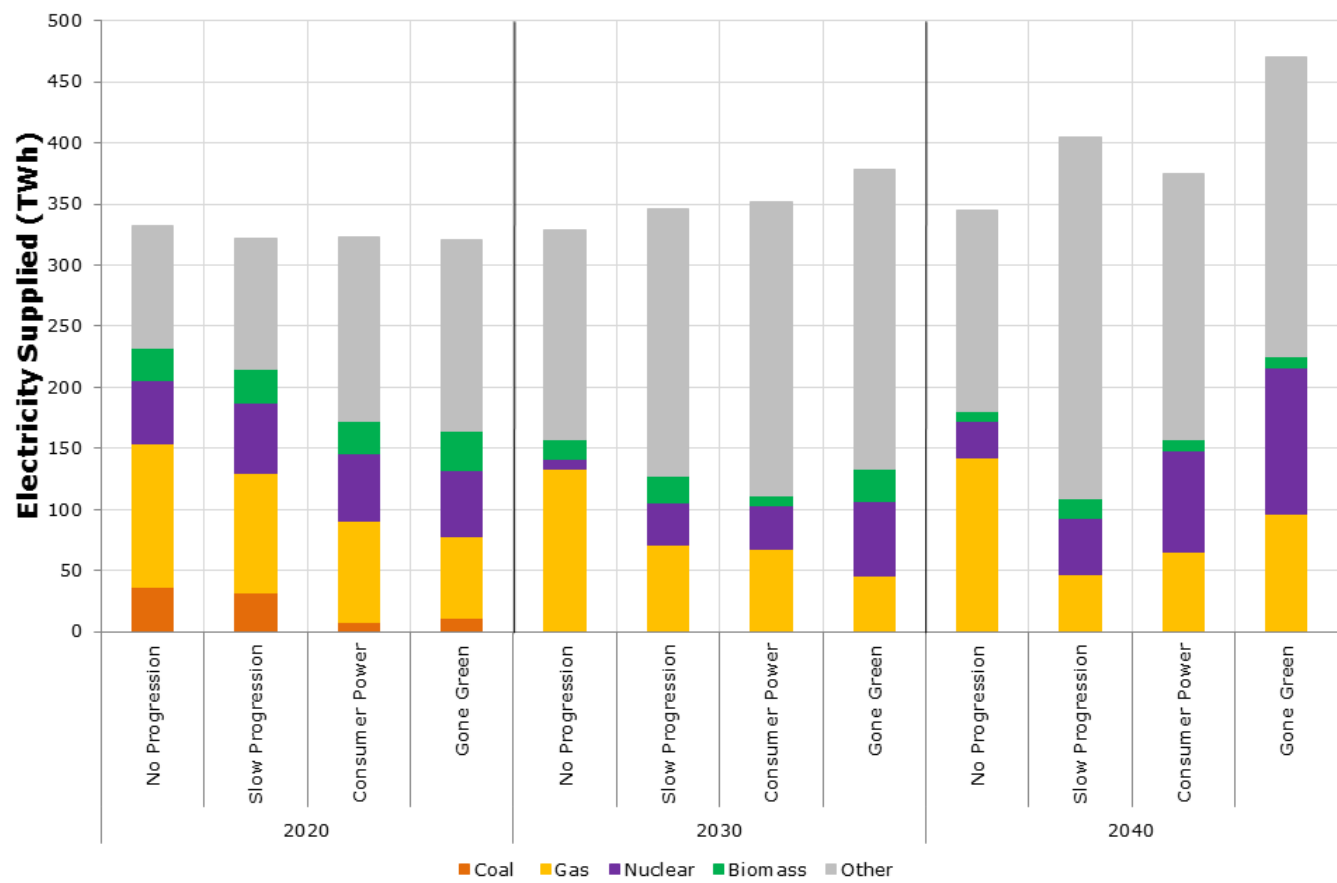
NATIONAL GRID PROJECTIONS / TRENDS

Scenario comparison



UK PROJECTIONS TO 2040

Electricity Supplied



THE POWER GENERATION MIX
2016/12/06

2015

Electricity Supplied 333 TWh

Coal – 58 TWh (17%)

Gas – 104 TWh (31%)

Nuclear – 62 TWh (19%)

Biomass – 31 TWh (9%)

VISIONS TO 2040

2020

Coal – 36 TWh (11%)

Gas – 118 TWh (36%)

Nuclear – 51 TWh (15%)

Biomass – 27 TWh (8%)

2030

Coal – 0 TWh (0%)

Gas – 134 TWh (41%)

Nuclear – 8 TWh (2%)

Biomass – 16 TWh (5%)

2040: No Progression

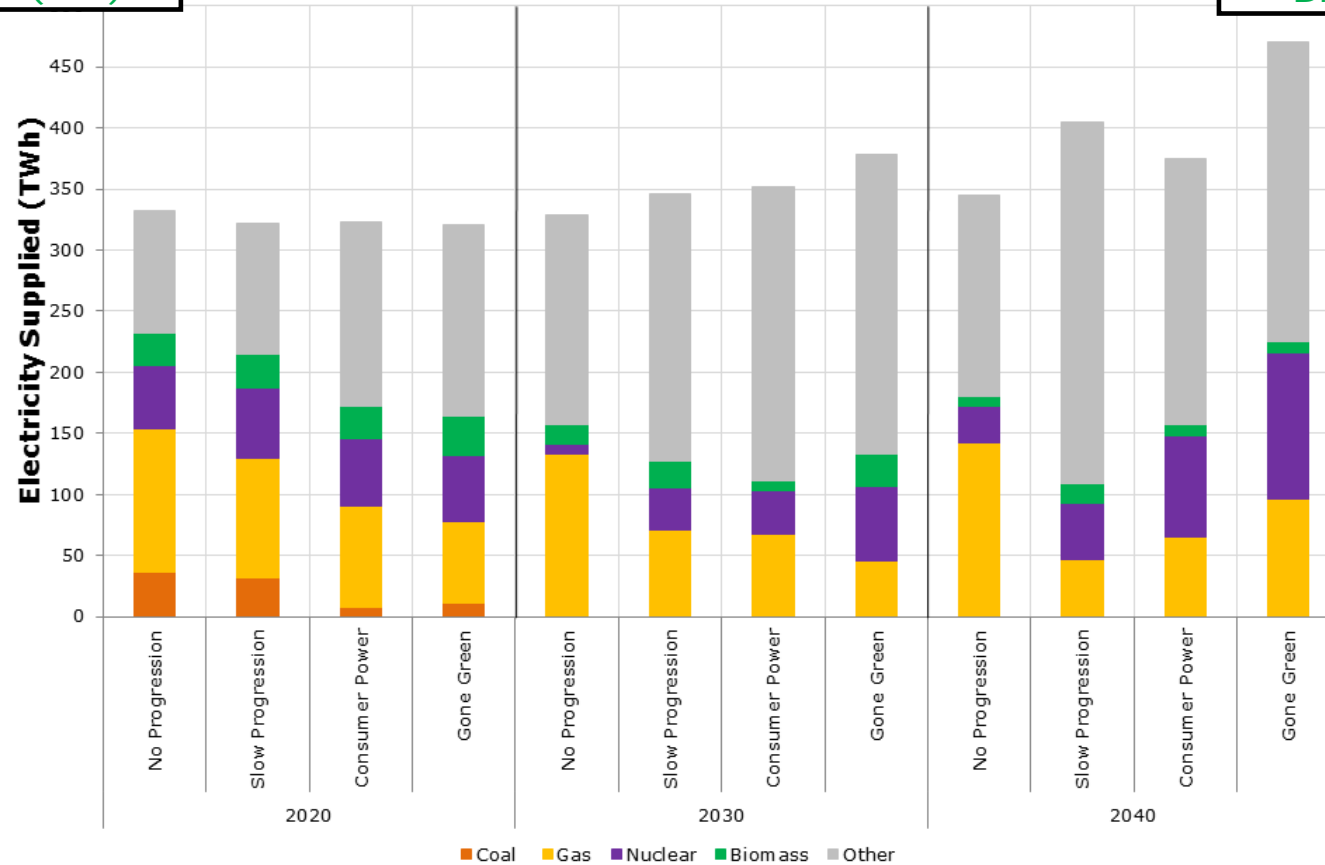
Electricity Supplied 471 TWh

Coal – 0 TWh (0%)

Gas – 142 TWh (41%)

Nuclear – 31 TWh (9%)

Biomass – 8 TWh (2%)



THE POWER GENERATION MIX
2016/12/06

2015

Electricity Supplied 333 TWh

Coal – 58 TWh (17%)

Gas – 104 TWh (31%)

Nuclear – 62 TWh (19%)

Biomass – 31 TWh (9%)

2020

Coal – 11 TWh (3%)

Gas – 67 TWh (24%)

Nuclear – 55 TWh (17%)

Biomass – 32 TWh (10%)

2030

Coal – 0 TWh (0%)

Gas – 46 TWh (12%)

Nuclear – 61 TWh (16%)

Biomass – 26 TWh (7%)

2040: Gone Green

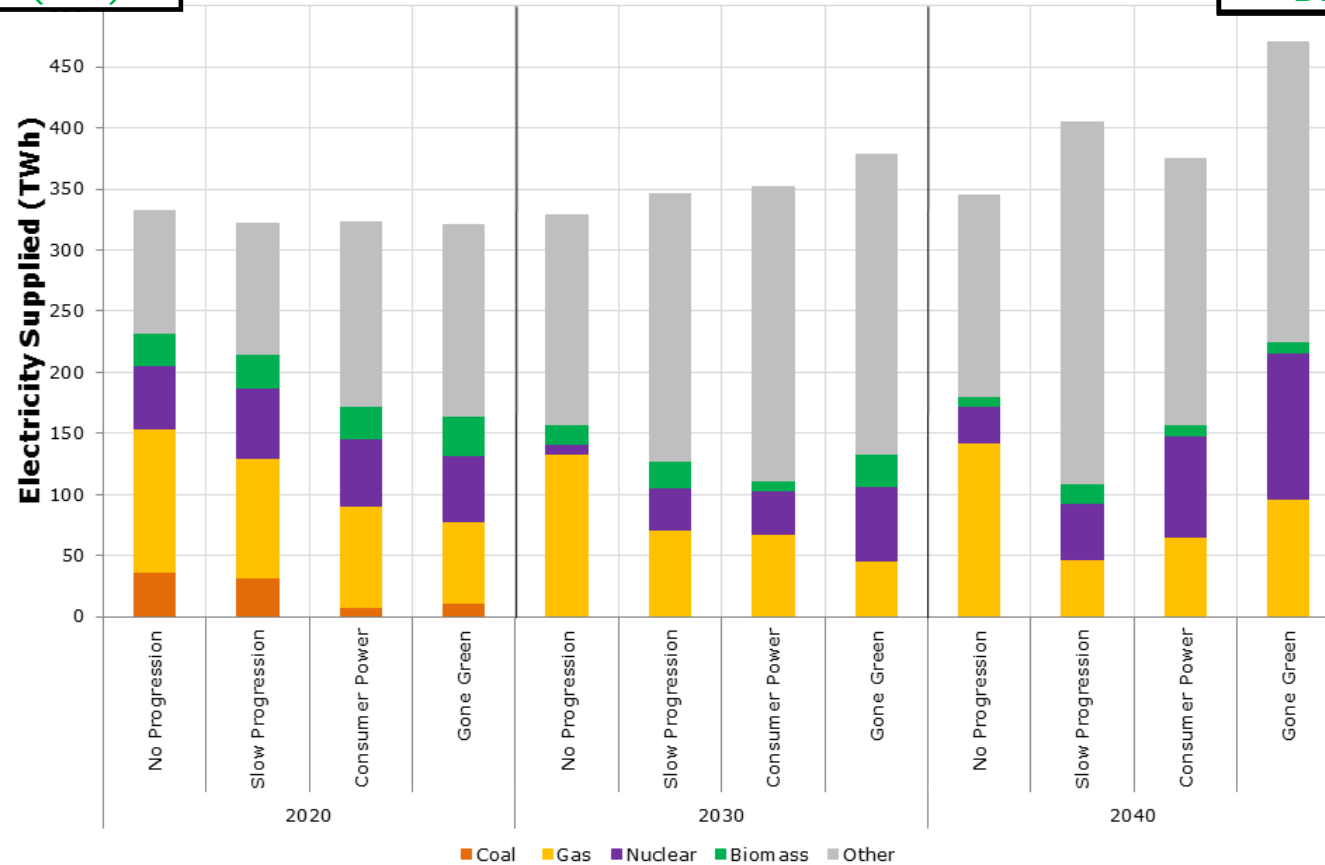
Electricity Supplied 471 TWh

Coal – 0 TWh (0%)

Gas – 97 TWh (21%)

Nuclear – 119 TWh (25%)

Biomass – 9 TWh (2%)



THE POWER GENERATION MIX
2016/12/06

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?

Flamanville: France's beleaguered forerunner to Hinkley Point C

Finns deeply worried about French nuclear industry

TVO power group concerned over fate of EPR technology

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

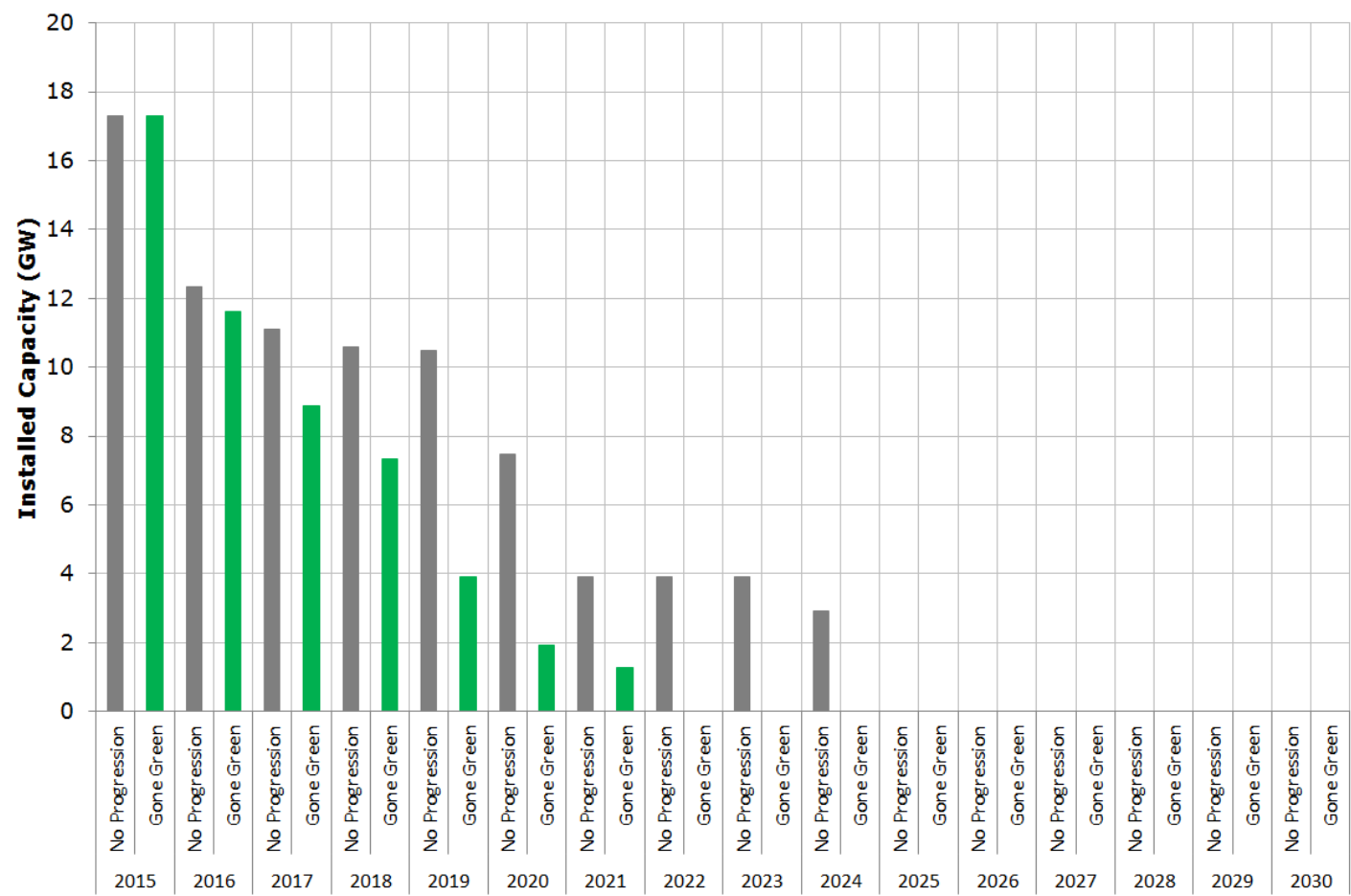
Policy objectives  reduced CO2 emissions

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



THE POWER GENERATION MIX
2016/12/06

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

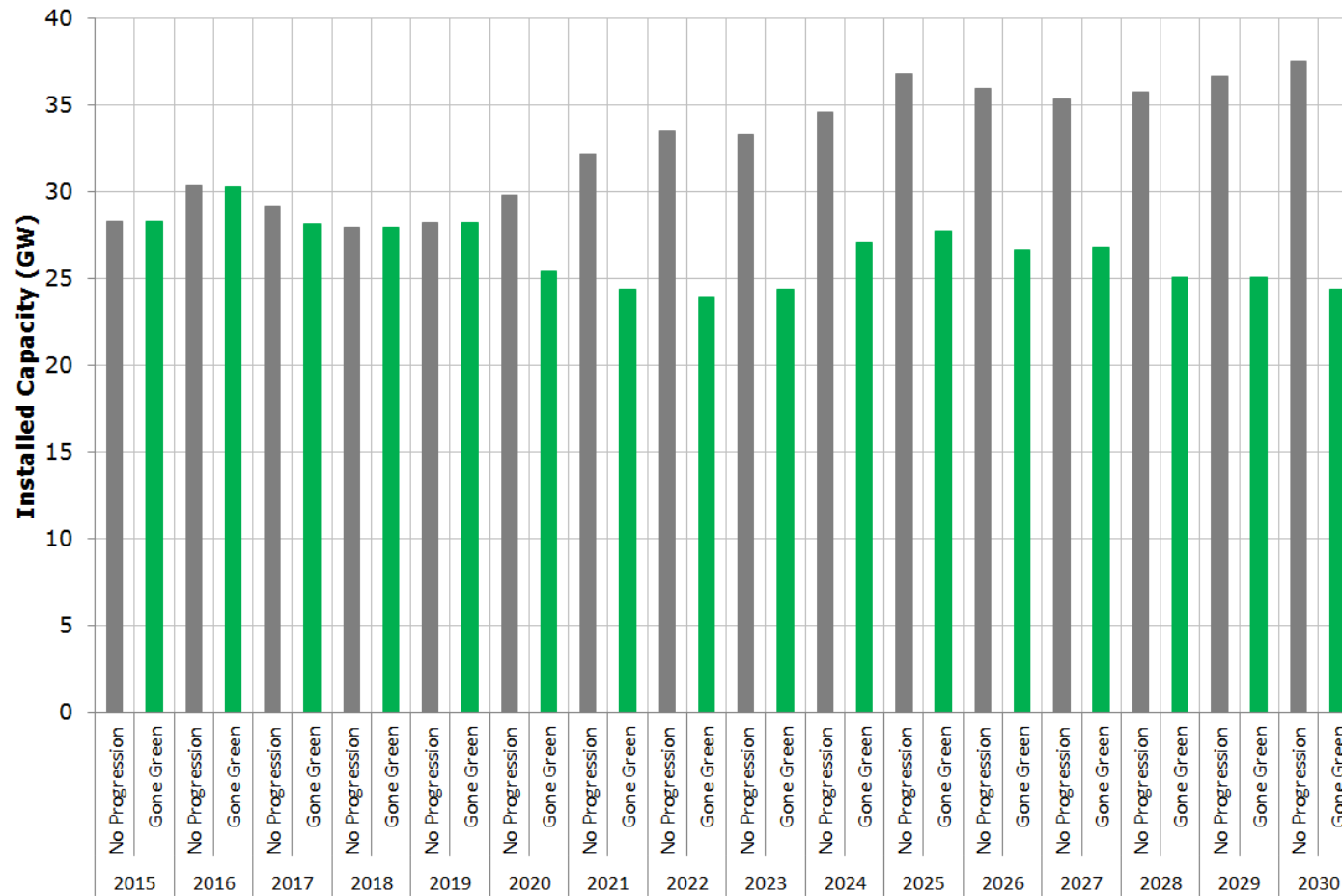
“One of the greatest and most cost-effective contributions we can make to emission reductions in electricity is by replacing coal fired power stations with gas”

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...

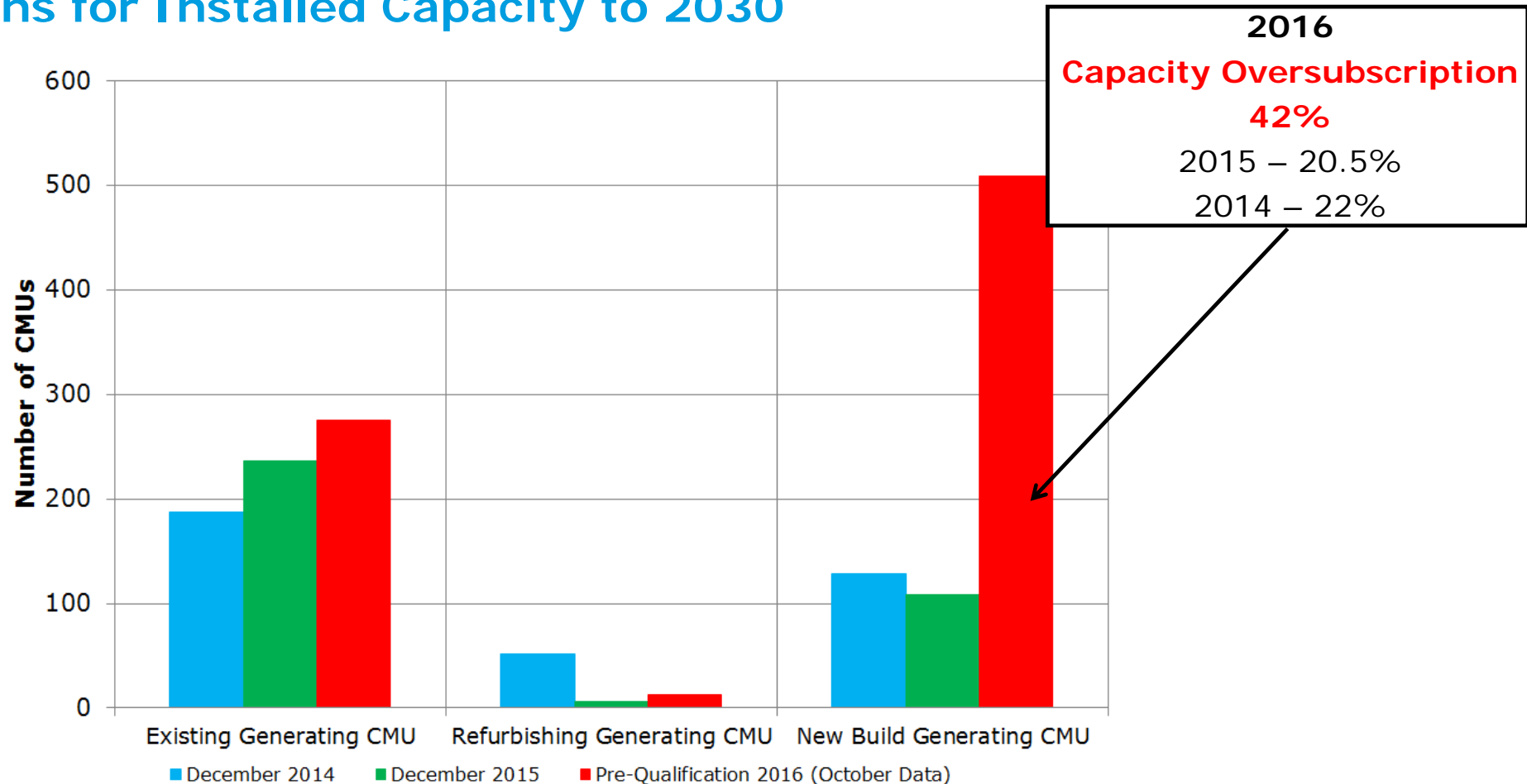
Projections for Installed Capacity to 2030



THE POWER GENERATION MIX
2016/12/06

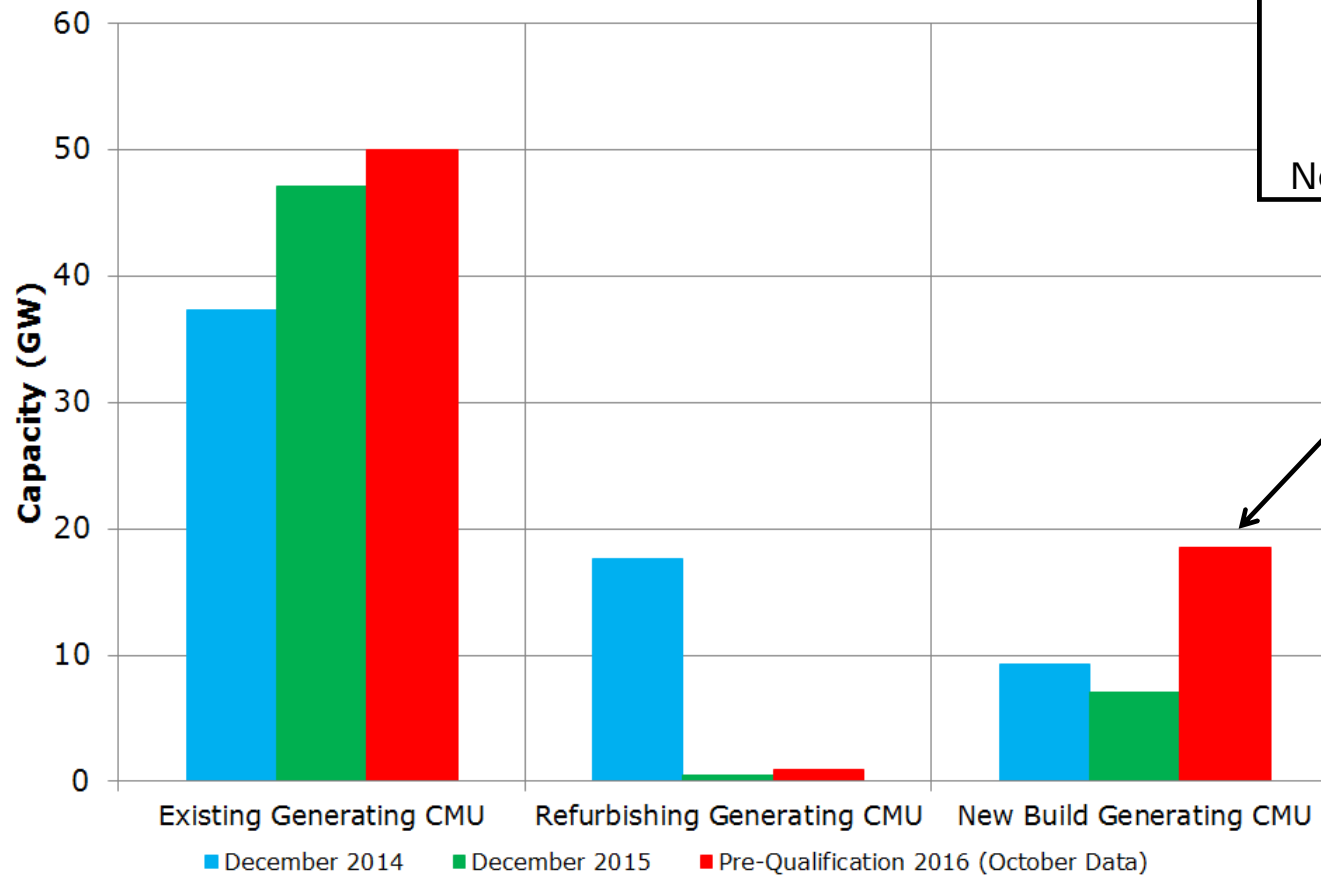
VARIABILITY IN THE ROLE FOR GAS...

Projections for Installed Capacity to 2030



VARIABILITY IN THE ROLE FOR GAS...

Projections for Installed Capacity to 2030

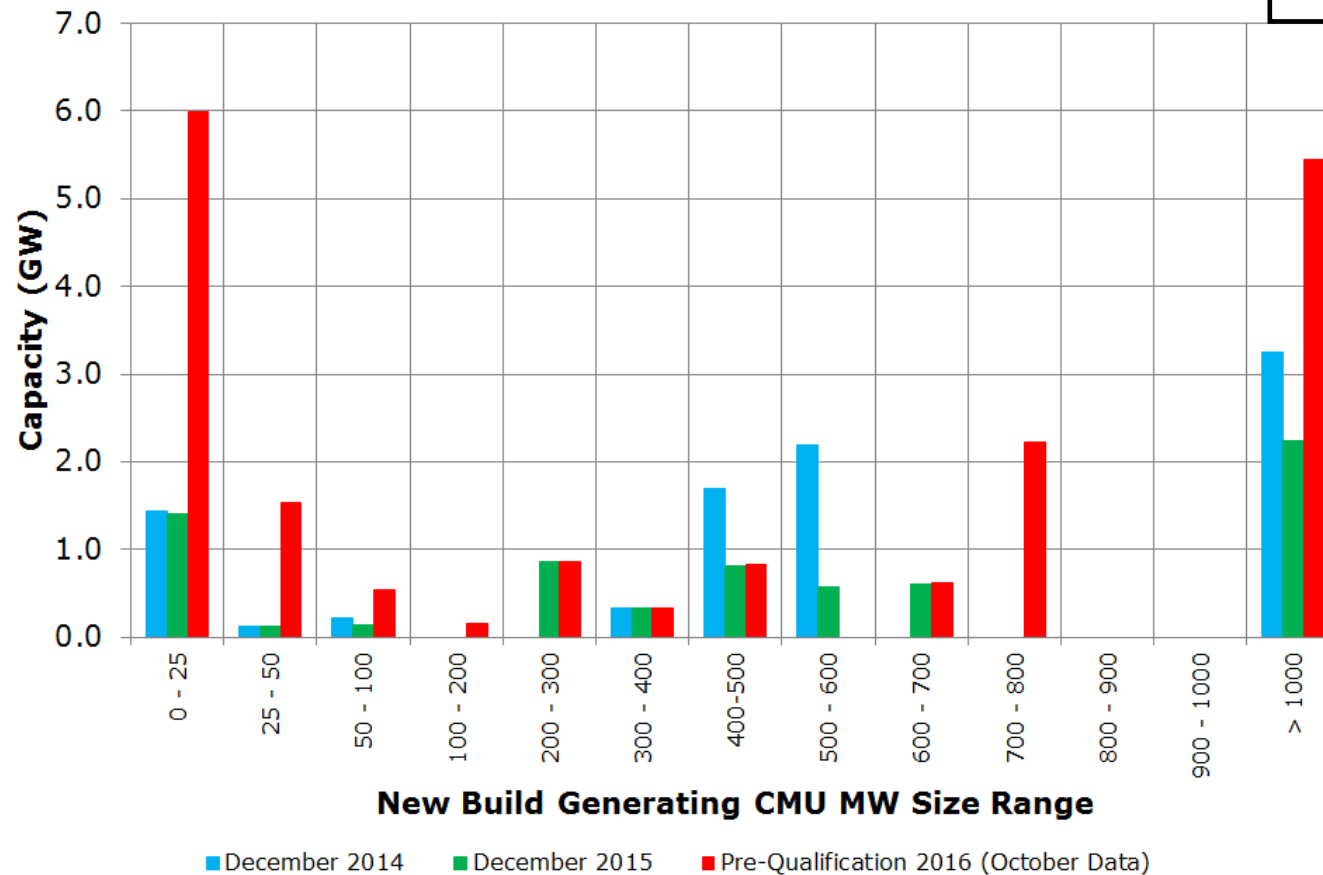


Mostly Driven by
**10 GW
Increase
in Capacity**
of
New Build Generating CMUs

VARIABILITY IN THE ROLE FOR GAS...

Projections for Installed Capacity to 2030

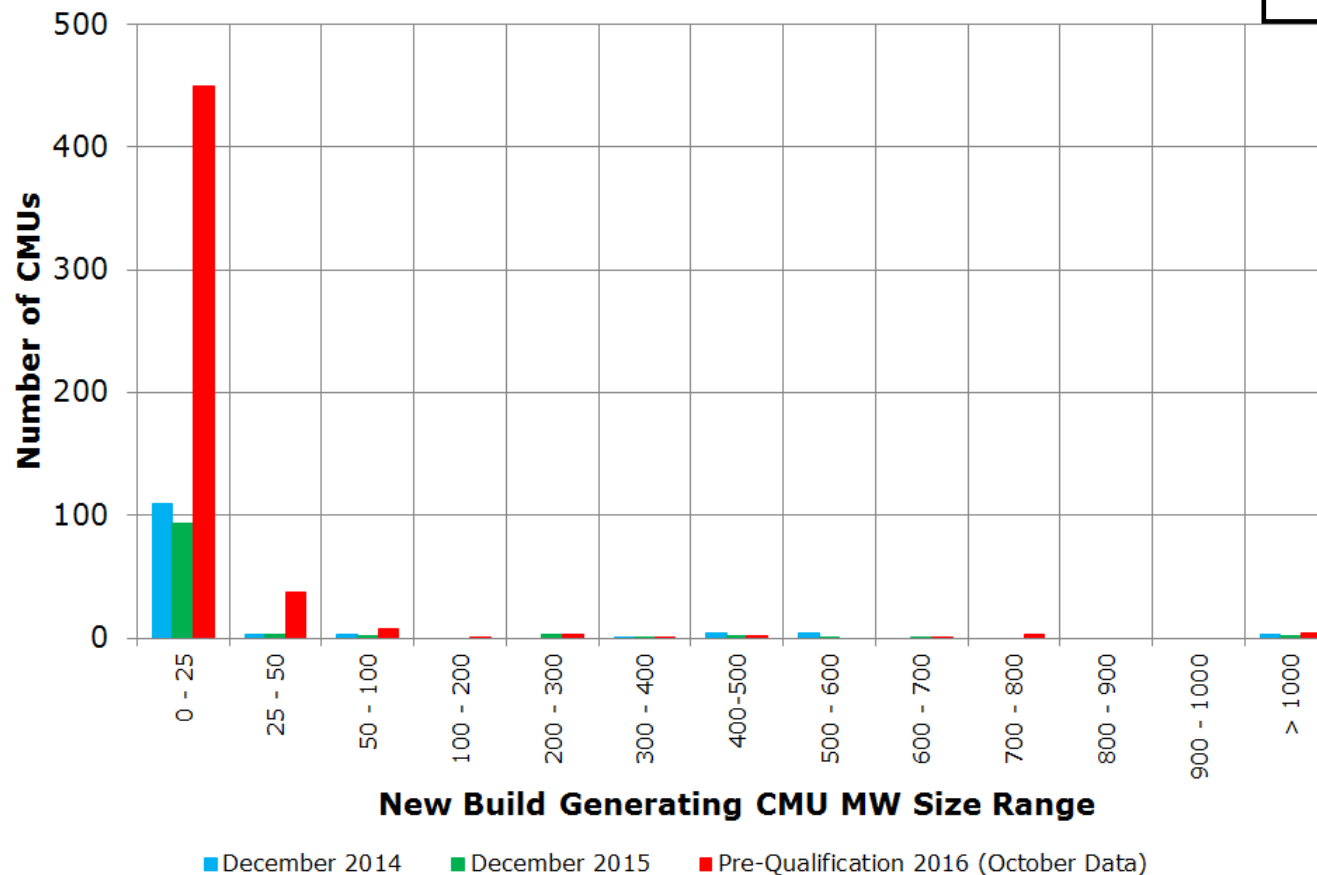
Whilst
Pre-Qualified **Capacity**
shows **Increases**
across all
MW Size Ranges



VARIABILITY IN THE ROLE FOR GAS...

Projections for Installed Capacity to 2030

Distortion Caused By
Large **Increase** in
Pre-Qualified **Number**
of
0 – 25 MW Units



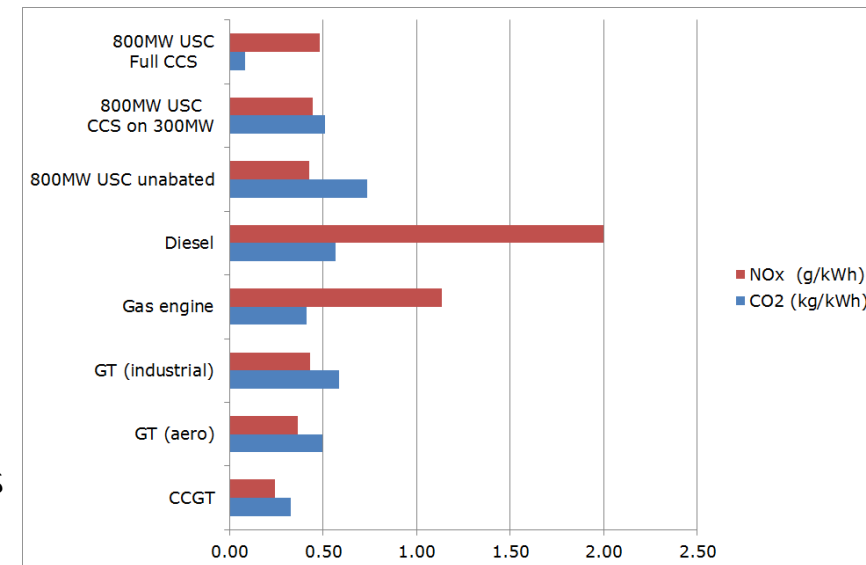
VARIABILITY IN THE ROLE FOR GAS...

Projections for Installed Capacity to 2030

- 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?

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Typical power plant emissions (NO_x & CO₂)



ROLE OF FOSSIL FUELS IN THE POWER GENERATION MIX
2016/12/06

VARIABILITY IN THE ROLE FOR GAS...

Projections for Installed Capacity to 2030 and Beyond...

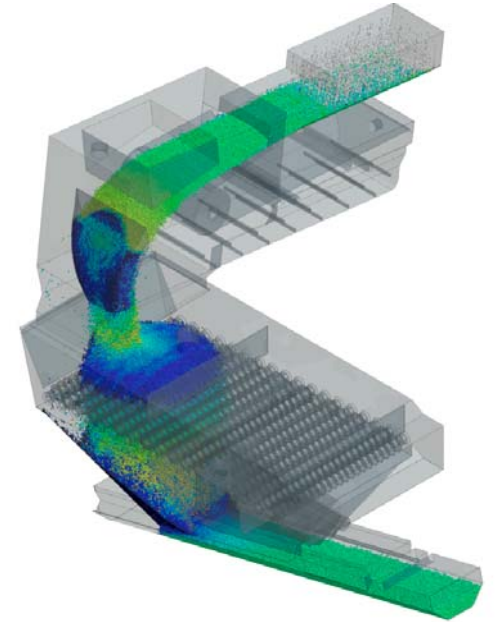
- The distortion highlighted 'disjoint' in environmental requirements for small-scale units:
 - Established and Implemented requirements of IED for large-scale units:
 - Registering / permitting requirements
 - Stringent Emission Limits
 - Demonstrate the use of Best Available Techniques
 - Regular monitoring / 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?**

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