UK - Integrating Renewable Energy

A System Operation Perspective

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Agenda

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Background - UK power system

Impact of renewables on System Operation

What have we learned?

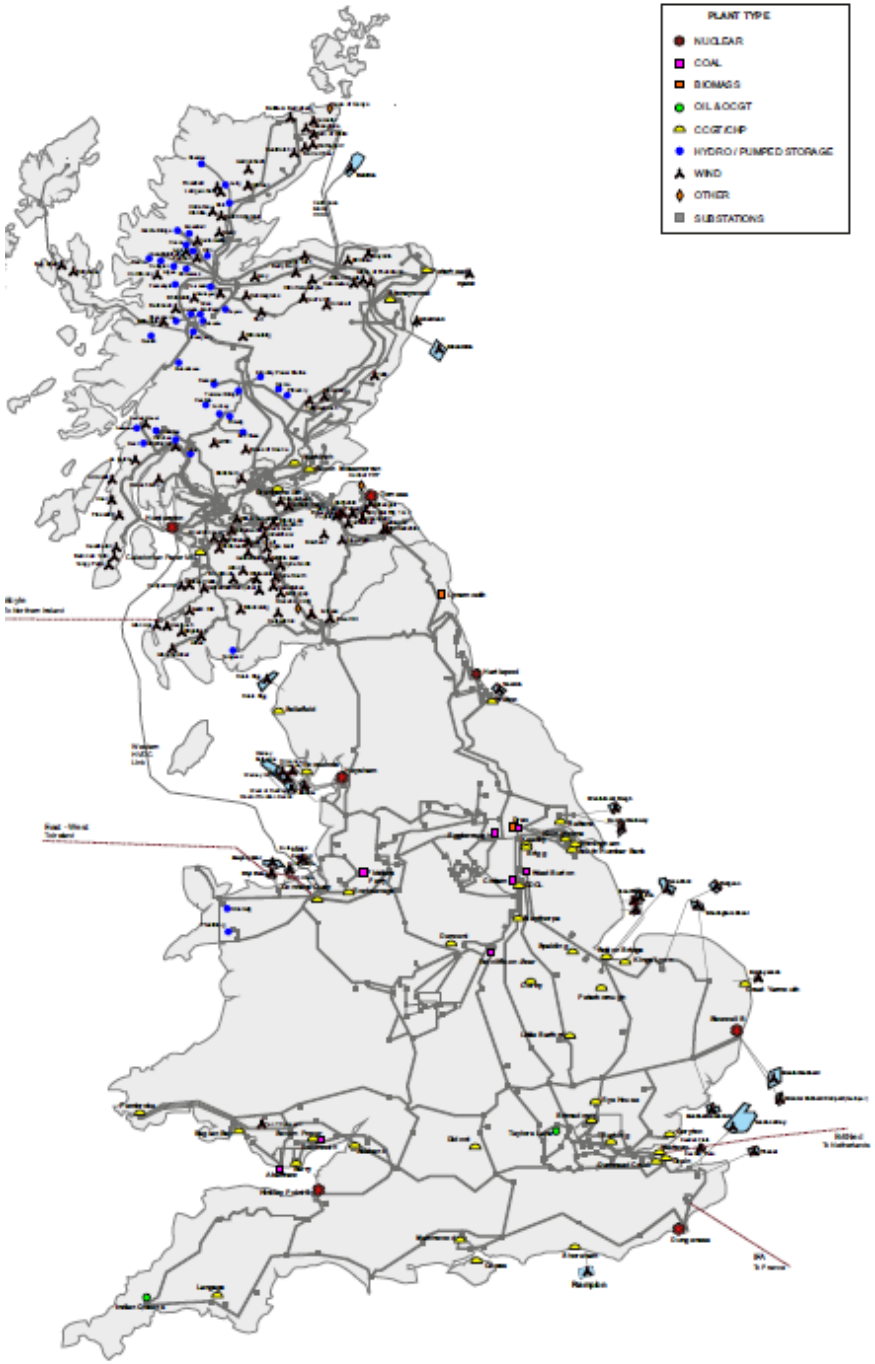
Future challenges

1. Background: The UK electricity system - 2018

Key characteristics

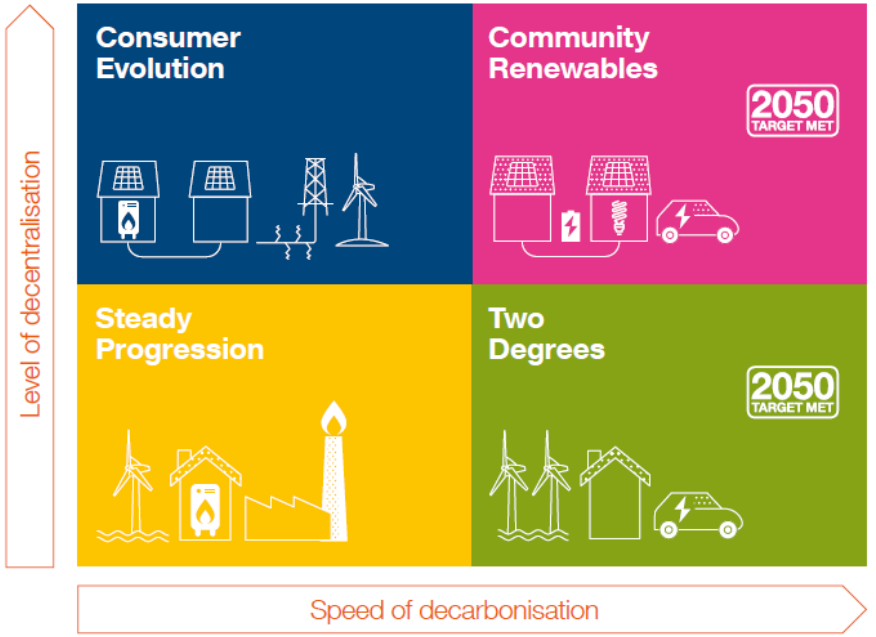
- 3 onshore transmission companies
- 14 distribution companies
- System Operator
- Regulator - Ofgem
- Governance through licences and codes (self governance)
- Peak demand = 60 GW
- 108 GW of total generation capacity
- 43 GW of renewable generation, generating 111 TWh (about 1/3 of total generation)
- Power flows and system constraints are changing
- Carbon free days of operation expected by 2025

2018	
Technology	**Actual GW**
Interconnectors	4
CCUS	0
Nuclear	9
Thermal	48
Solar	13
Wind	21
Other renewables	9
Storage	4
Peak demand	**60**



1. Background: expected future growth profile

- The 2019 GB Electricity System Operator Future Energy Scenarios show significant renewable energy growth
- These were based on 80% decarbonisation target by 2050 – a new NetZero target has recently been set



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2030			
CR	**TD**	**SP**	**CE**
17	20	15	12
0	1	0	0
5	5	7	3
23	31	42	43
30	23	16	19
53	54	43	38
14	12	10	10
12	12	8	7
57	**64**	**63**	**60**

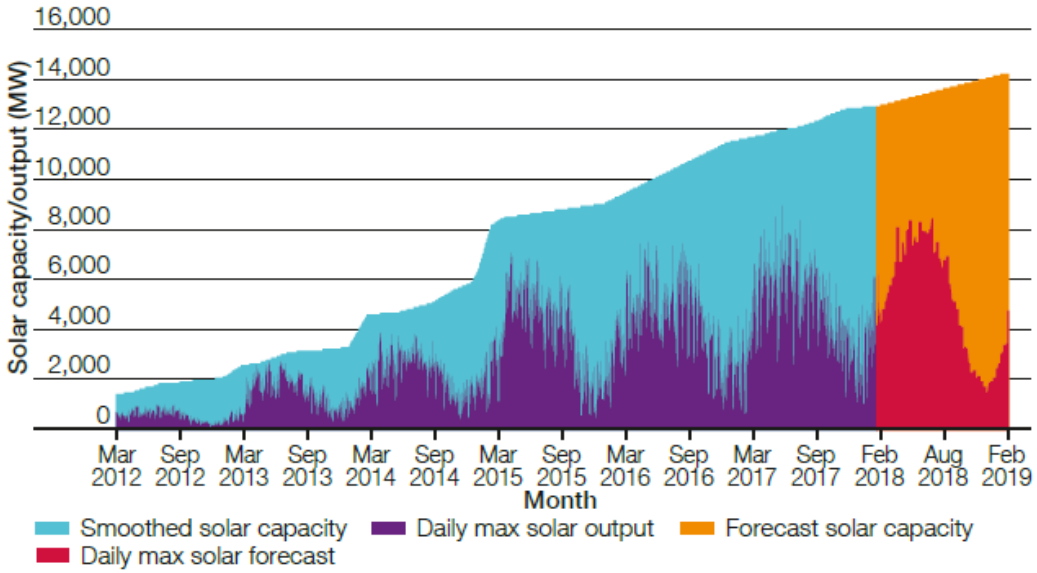
2050			
CR	**TD**	**SP**	**CE**
17	20	15	12
0	12	7	0
8	17	10	5
17	13	33	36
52	42	26	35
87	79	56	53
14	13	7	9
28	23	14	18
72	**83**	**75**	**69**

2. Impact on system operation

Distributed energy growth

Historically, the distribution networks have always imported. However, the connection of around 13 GW of solar capacity has meant that some of these networks are often exporting during the daytime.

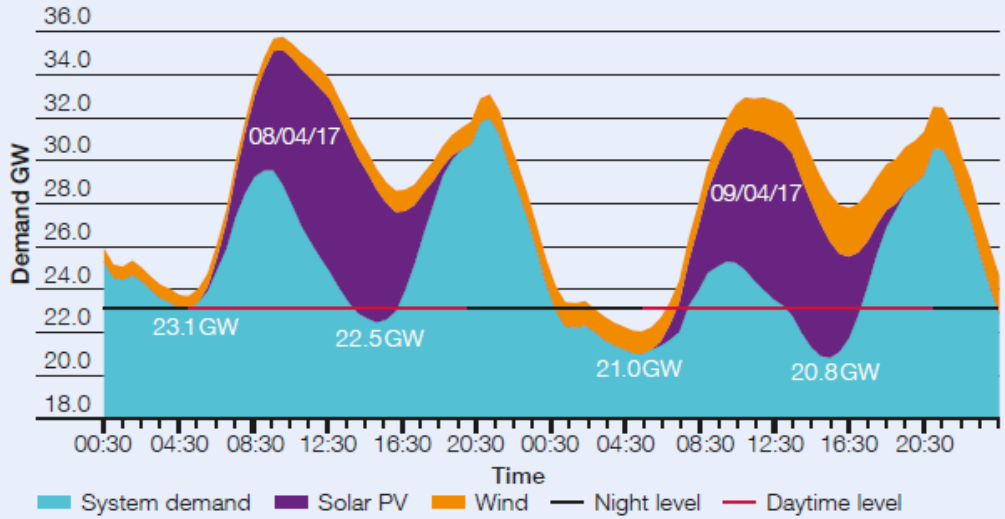
Historic and forecast PV capacity and daily maximum output



Change to demand profile

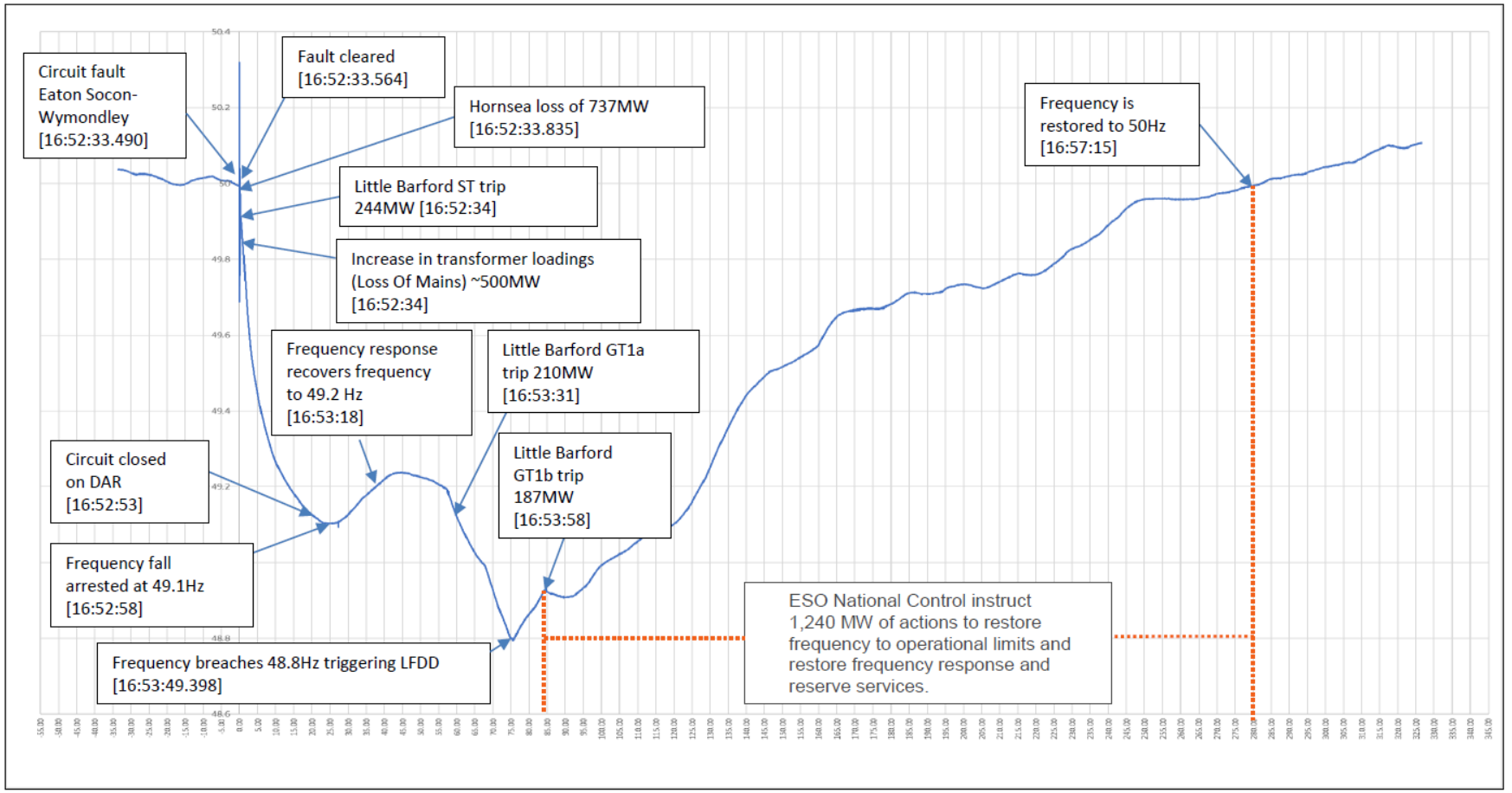
Historically, lowest demand on the transmission system has occurred overnight. However, growth of renewable generation has meant that lower demands may occur in the daytime.

Daytime minimum demand vs overnight demand



2. Impact on system operation: 9 August 2019

- Low frequency demand disconnection event
- Around 1 GW of customers disconnected
- Investigations underway by Government & Ofgem
- Questions include
  - Adequate reserve?
  - Adequate inertia?
  - Performance of distributed generation?
  - Performance of renewables?
  - Protection settings?
  - Prioritisation of demand loss?



3. What have we learned?

System needs

- System Inertia – as levels of wind, solar and interconnection increase, system inertia is decreasing
- Frequency response – is influenced by system inertia and the size of the greatest generation or demand loss
- Rate of Change of Frequency – desensitising protection will allow system to operate at lower levels of inertia
- Reserve – flexible upward and downward reserve needed
- Reactive power – mandatory reactive market does not properly value the reactive power capability
- Black start – system restoration to reflect new generation mix, including distributed generation

Network development

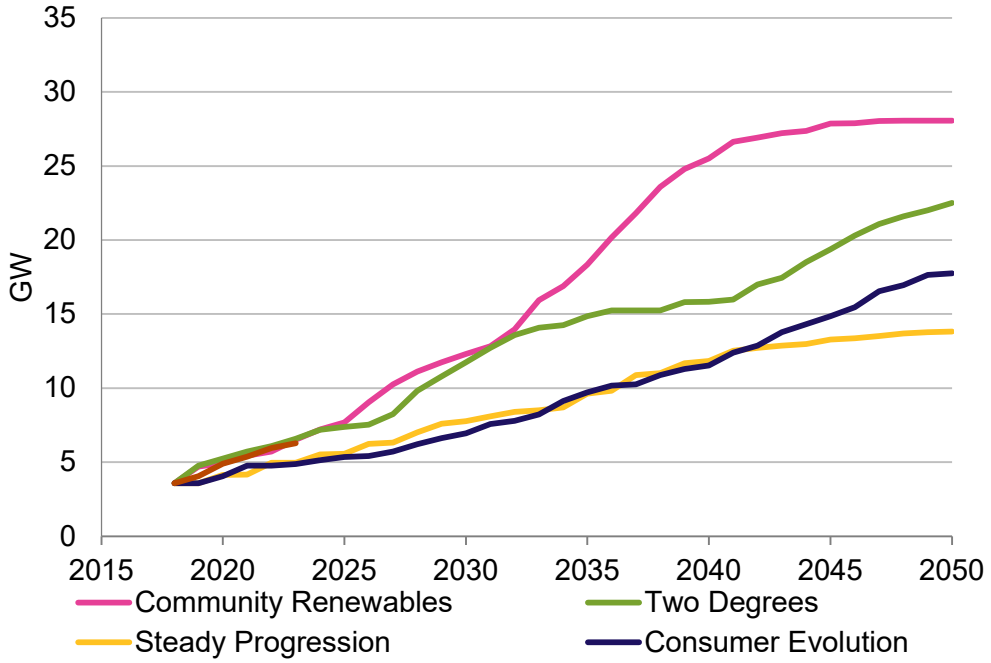
- Growth of new network capacity – funding of new network reinforcements
- Growth of transmission and distribution new connections – offering firm and non-firm access
- Competition for new network investments
- Network charging and access arrangements – ensuring fair and predictable charges access for generation and demand

Customer engagement

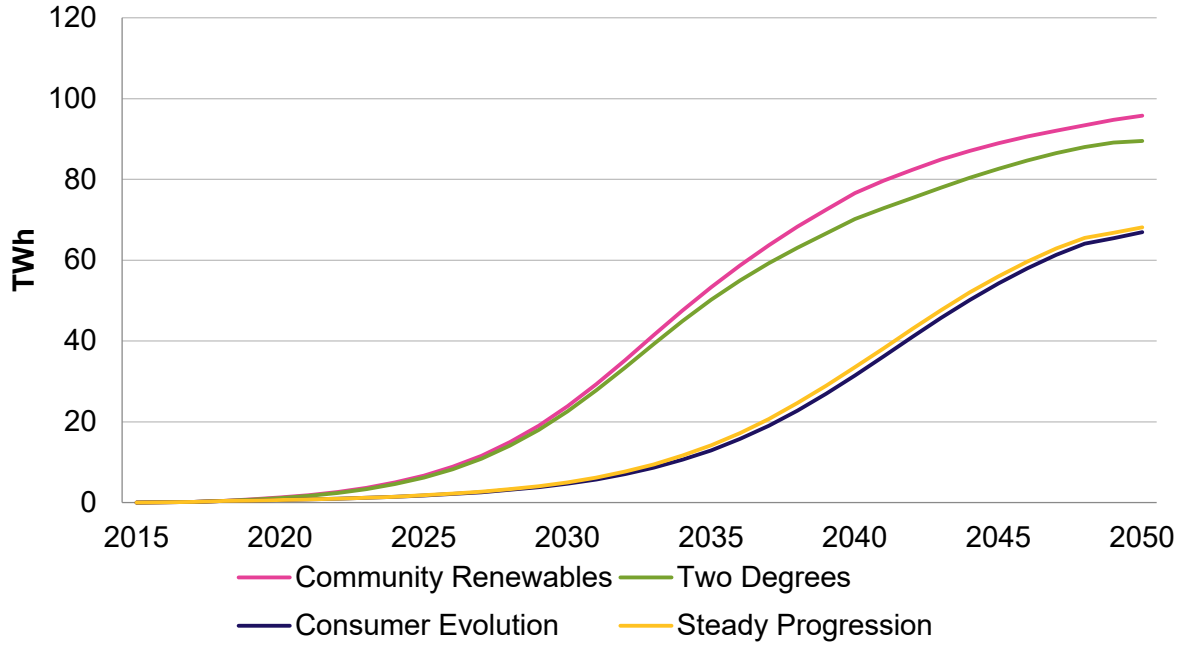
- Greater customer engagement through digitisation and media
- Increase in demand response
- Increase in new business models e.g. behind the meter
- Growth in electric vehicles, including vehicle to grid applications

3. What have we learned?

Flexibility: Forecast growth in energy storage



Uncertainty: Forecast growth in Electric Vehicle demand



3. What have we learned?

Positives

- Rapid growth in renewables can be achieved
- Power system reliability and security can be maintained
- Customers are becoming more engaged in the end to end ‘whole’ energy system

Negatives

- System needs, such as inertia are decreasing and must be replaced
- Greater flexibility e.g. storage will be needed to maintain reliability
- Uncertainty and opportunity – the ‘old’ governance and rules need to adapt more quickly in future

4. Future challenges

Technology

- Electricity storage
- Electric vehicles
- Digitisation/control
- Data
- Smart homes/cities

Speed of change

- Net Zero target
- Communications
- New business models and markets

Power system developments

- Decentralisation
- Inertia and flexibility
- Network capacity
- Grid defection

Industry governance

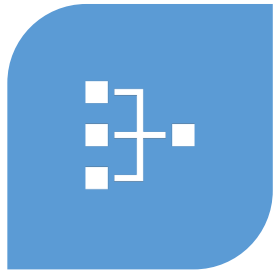
- Faster, simpler rule change
- Accessible to new entrants and new business models
- New responsibilities

4. Future challenges

UTILITY OF THE FUTURE?

CUSTOMER ENGAGEMENT?

POLICY DIRECTION?



SYSTEM OPERATION?

- Decarbonised
- Digitalised
- Decentralised

Thank You

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