System Operability Framework

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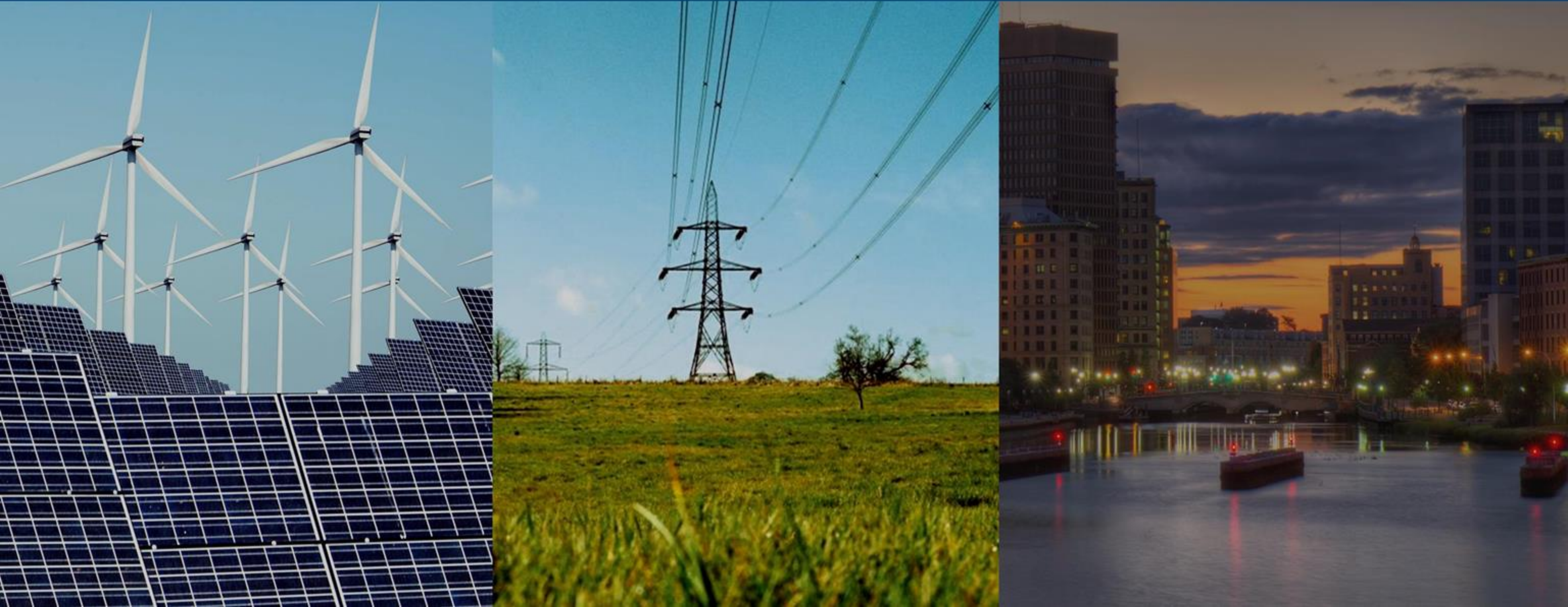
Welcome to the Pre-Assessment Industry Workshop



System Operability Framework Workshop

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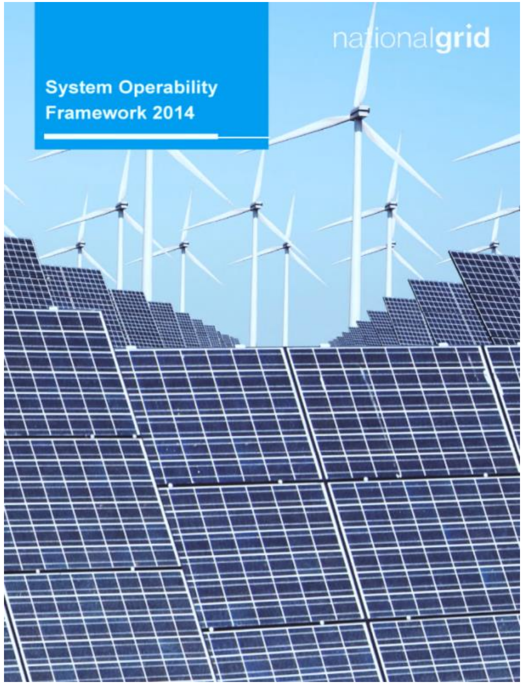

Vandad Hamidi

SMARTer System Performance Manager

Safety and Security

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- No planned fire alarm
  - Leave through nearest exit - You will be directed by Fire Marshalls
  - The muster point is outside the building in the car park
- Facilities
- Tea and Coffee
- Mobile phones

Agenda - Technical Session (Morning)

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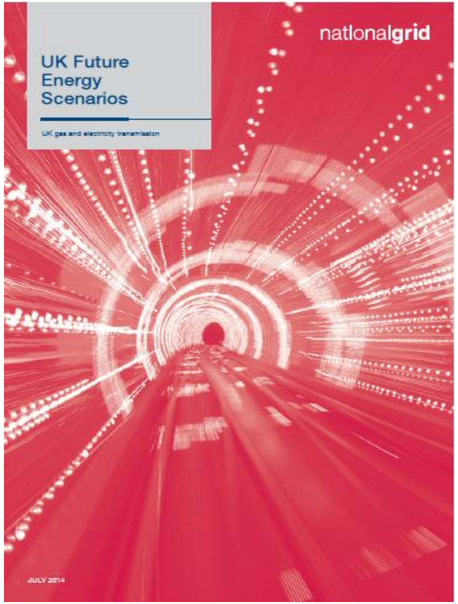
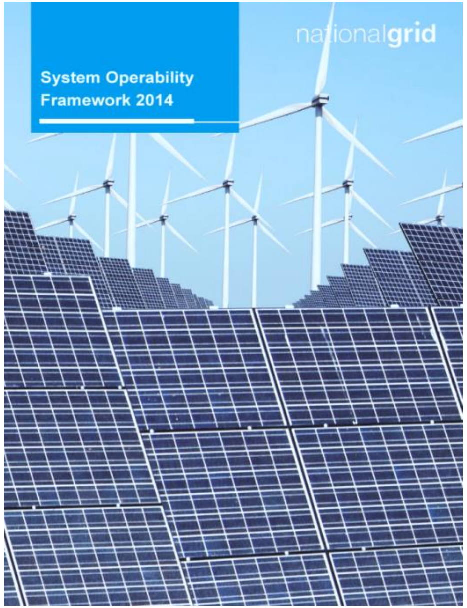
- **[10:00 - 10:10]** Welcome Note
- **[10:10 - 10:20]** Future energy landscape and system operability – Richard Smith
- **[10:20 - 12:30]** System Operability; internal and external perspective (Technical)
- **External Perspective:** Western Power Distribution (WPD), Scottish and Southern Energy (SSE) University of Lancaster
- **Introduction of System Operability Framework (SOF)**
- **Example of SOF; Impact of Embedded Generation on Transmission System and Opportunities**
- **[12:30 - 13:15]** Break (*business lunch*) and general Q&A

Agenda- Commercial Session (Afternoon)

- **[13:15 – 14:45]** System services; internal and external perspective (Commercial)
- **External Perspective:** DONG Energy, RenewableUK, Imperial College of London
- **Economic Appraisal of System Services**
- **Contracts for System Services**
- **[14:45 - 15:30]** System Operability Framework 2015 theme
- **[15:30 - 15:40]** Innovative new services
- **[15:40 – 16:00]** Next steps and future engagement

Future Energy Landscape and System Operability





Richard Smith

Head of Network Strategy

System Operability Framework Workshop

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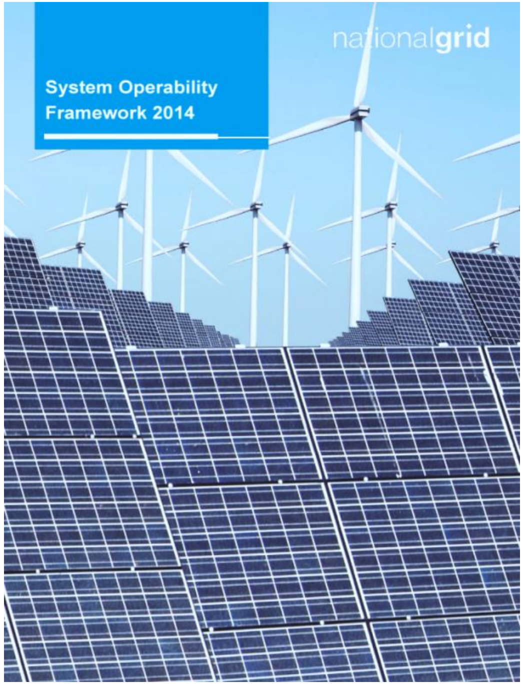
RESPONSIBLE BUSINESS OF THE YEAR 2014
BUSINESS IN THE COMMUNITY



Vandad Hamidi

SMARTer System Performance Manager

WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

SOF Workshop 9th April 2015

Nigel Turvey

Design & Development Manager

Challenges For Power Systems in GB

- Volume of DG connecting in some areas
  - e.g. summary for S West

Renewable Energy Type	Connected	Accepted	Offered	Grand Total
Biomass & Energy Crops (not CHP)	150	110,500	400	111,050
Hydro	3,677	141	50	3,868
Landfill Gas, Sewage Gas, Biogas (not CHP)	6,746	5,127	1,650	13,523
Large CHP (>=50mw)	-	0	0	-
Medium CHP (>5MW,<50MW)	-	5,650	49,999	55,649
Micro CHP (Domestic)	133	0	0	133
Mini CHP (<1MW)	2,400	716	-	3,116
Offshore Wind	-	-	-	-
Onshore Wind	190,286	181,351	12,147	383,784
Other Generation	353,105	142,626	106,400	602,131
Photovoltaic	778,875	1,255,794	559,251	2,593,920
Small CHP (>1MW, <5MW)	9,750	-	-	9,750
Tidal Stream & Wave Power	-	30,000	-	30,000
Waste Incineration (not CHP)	33,965	72,800	9,000	115,765
Grand Total	1,379,087	1,804,705	738,897	3,922,689

Winter Maximum Demand	2,530,000
Summer Minimum Demand	980,000

Challenges For Power Systems in GB

- Speed of build/deployment of DG – can be less than 6 months from planning consent for 5MW PV sites
- Peak output non-coincident with local demand in many locations. Becoming a seasonal rather than time of day issue resulting in DSR/Storage options offering little benefit
- At thermal/local voltage rise limits in many locations with significant reinforcements for further acceptances based on accepted offers
- Conversion rate of accepted to connected volatile and essentially unknown at present
- SoW process not designed for multiple small DG – currently resulting in conditions on Var absorption – difficult to get verification of whether Distribution Network Capacity or National Grid voltage control (Var absorption) is the limitation
- Unclear whether or when other 'SOF' issues will result in conditions on DG connections

‘Immediate’ actions needed

- What are the operational capabilities of the joint DNO/TO networks
- Hence what are the limits of the current system
- Understanding of the DG service capabilities e.g. ability to absorb Vars and whether this can be dispatched or is a fixed parameter
- Understanding of the commercial impact of these services so that a cost benefit can be assessed against network solutions
- Current ‘bulk’ SoW application process results in all generators in the application getting the same conditions – the application will have a range of generators with different application dates. Should the conditions ramp up with application date?
- More rapid turn around of SoW – not being able to give generators information on conditions or even whether they can connect until close to connection date is not sustainable

Expectations from System Operability Framework

- Understanding of the capabilities and limits on the Transmission Network
- Information presented in an easily understandable form to be able to explain to customers when limits are likely to be reached and the likely conditions/delay or contribution to costs that will result
- Simpler/quicker SoW process – as limits known in advance
- Clear understanding of the data transfer between DNO/TO recognising the limitations of the data available to the DNO from connecting DG

System Operability

An External Perspective

Bless Kuri
Scottish Hydro Electric Transmission plc

Scottish and Southern Energy
Power Distribution

Challenges/Opportunities for the future GB power system (1)

- **Increase in proportion of 'smart' demand**
  - Demand Side Response and Storage devices
  - Changing system characteristics (dynamic behaviour, reactive demand…)

- **Increase in renewable generation**
  - Connected through power electronics
  - Low short circuit contribution
  - Low system inertia
  - Weak systems and connections to islands

Scottish and Southern Energy Power Distribution

Challenges/Opportunities for the future GB power system (2)

- **Combination of distributed generation resources and active demand + storage**
  - Resource/information management
  - Island grid operation
  - Conditions for ‘combinatorial innovation’
  - Addressing existing and emerging system requirements

- **Conducive market structure and commercial arrangements**
  - Encourage innovation, research and development
  - Support technological developments

Scottish and Southern Energy
Power Distribution

Actions and Expectations

- **Actions by National Grid/Industry**
  - Progress solutions to currently known issues to enhance system operability
  - Identify and address immediate future issues
    - SOF 2014 is a good staring point
    - Address skills requirements
  - Fundamental systems review based on a holistic approach

- **Expectations from SOF and National Grid**
  - Industry involvement in determining the scope of the SOF
  - Clear articulation of challenges and possible solutions
  - Assessment of solution blockers/enablers
    - Commercial arrangements
    - Policy…

Scottish and Southern Energy
Power Distribution

System Operability

An External Perspective

Bless Kuri

Scottish Hydro Electric Transmission plc

Scottish and Southern Energy
Power Distribution

National Grid, System Operability Framework

Workshop 9 April 2015

Challenges to the GB power system

Professor Roger Kemp

Lancaster University

The questions:

- What do you see as challenge(s) for the future power system in GB?
- What “immediate” actions you believe are needed (By National Grid, and by the industry)?
- What are your expectations from System Operability Framework and National Grid?

Prior work


The Royal Academy of Engineering
Generating the Future:
UK energy systems fit for 2050
The Royal Academy of Engineering
Heat: degrees of comfort?
Options for heating homes in a low carbon economy
ROYAL ACADEMY OF ENGINEERING
GB electricity capacity margin
A report by the Royal Academy of Engineering for the Council for Science and Technology
October 2013
IET The Institution of Engineering and Technology
Electricity Networks
Handling a Shock to the System
IET technical report on the whole system challenges facing Britain's electricity network
www.theiet.org/pnjv
IET The Institution of Engineering and Technology
Transforming the Electricity System:
How other sectors have met the challenge of whole-system integration
Executive Summary
A report from the IET expert group: Power Network Joint Vision
www.theiet.org/pnjv
ROYAL ACADEMY OF ENGINEERING
WIND ENERGY
implications of large-scale deployment on the GB electricity system
April 2014

Challenge 1: Rebuilding the electricity system

while maintaining adequate capacity

Climate Change Act 2008

Environmental commitment:
80% reduction in CO_2 by 2050

CCC target to reduce emissions from electricity from 450 g/kWh to 50 g/kWh by 2030

Coal-fired power stations

Fiddler's Ferry

Picture: Webb Aviation

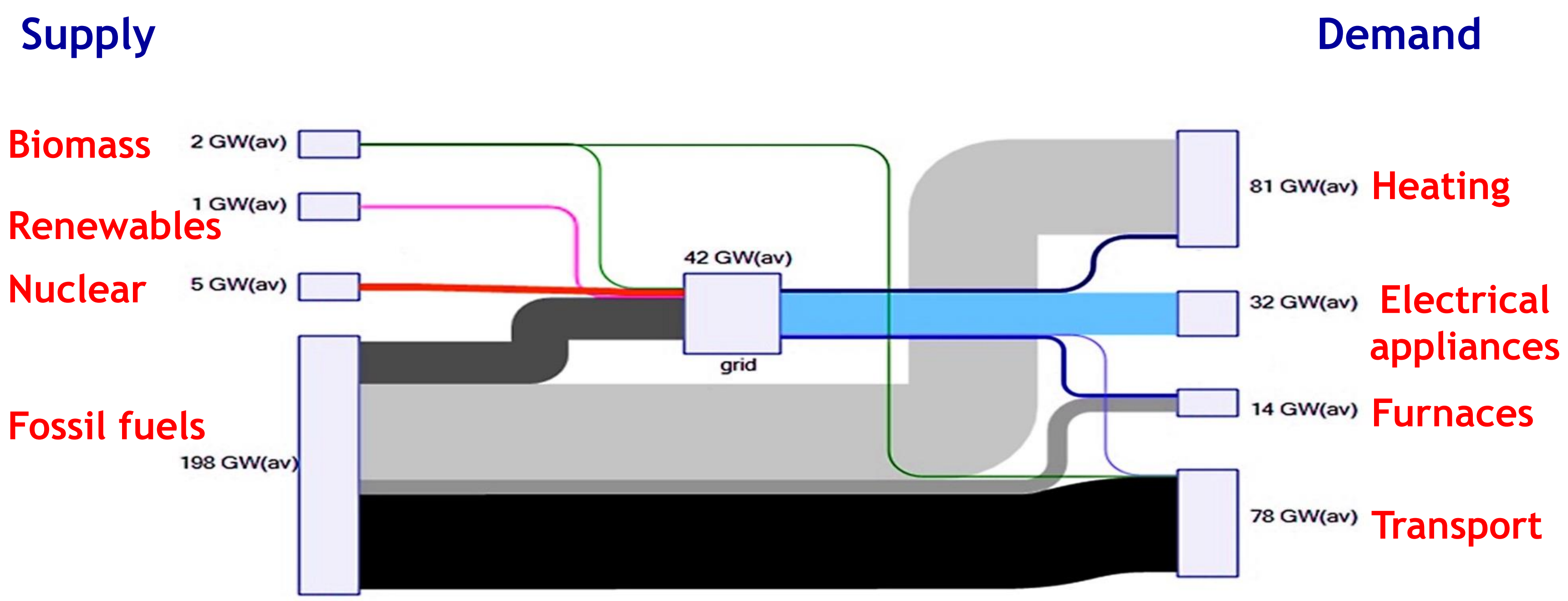
- Last month coal provided 25 GW base load (33% of demand)
- Most plants have been in service since the 1970s and will close in the next decade

Nuclear power

- Of the existing fleet of nuclear stations, only Sizewell B will still be operating in 10 year's time

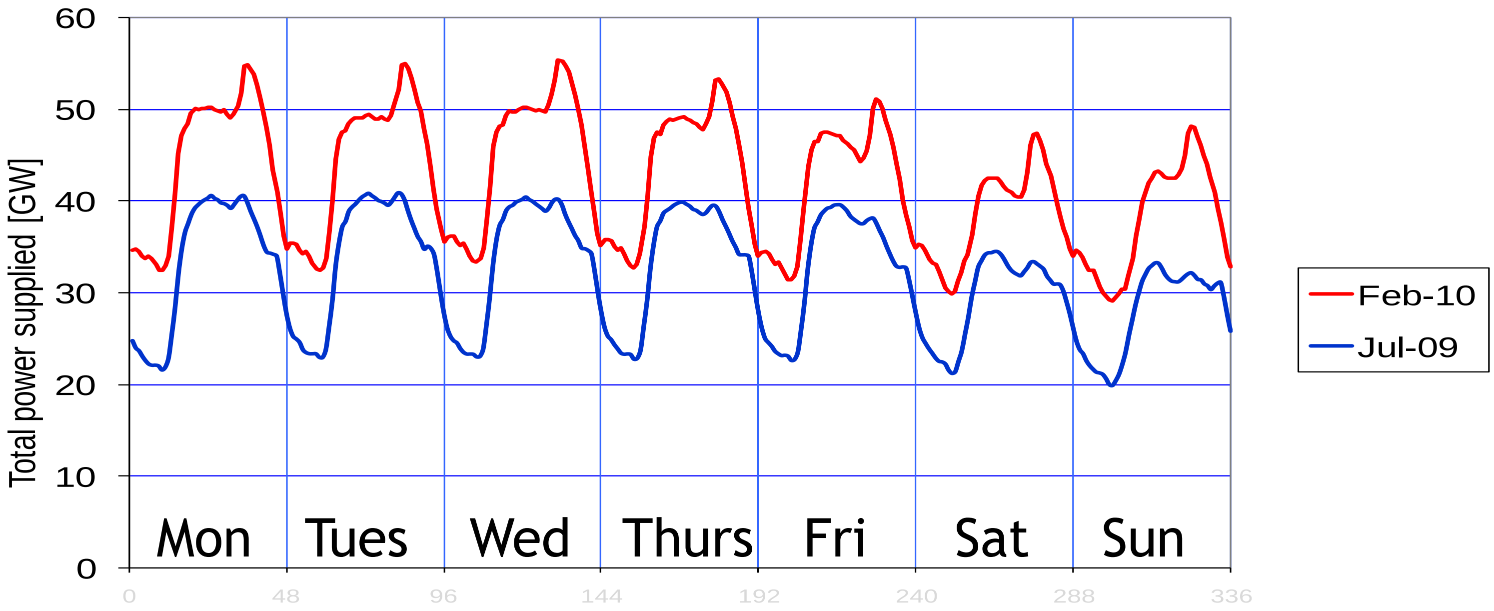
Heysham 1 & 2

Challenge 2: Decarbonisation of heat and transport



Source: Generating the Future, RAEng

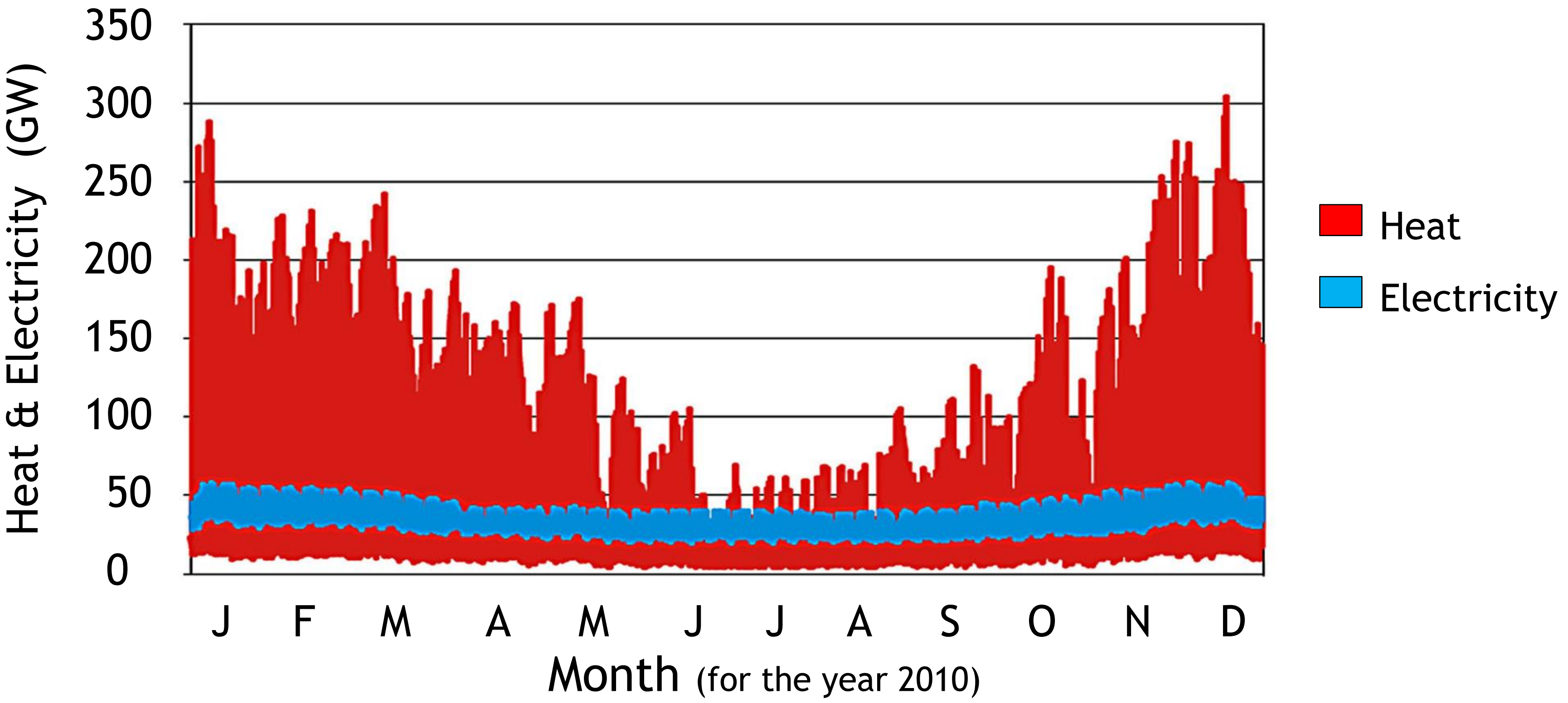
Daily demand on the electricity grid



Source: NETA website

GB use of heat and electricity

(Domestic and commercial sectors)

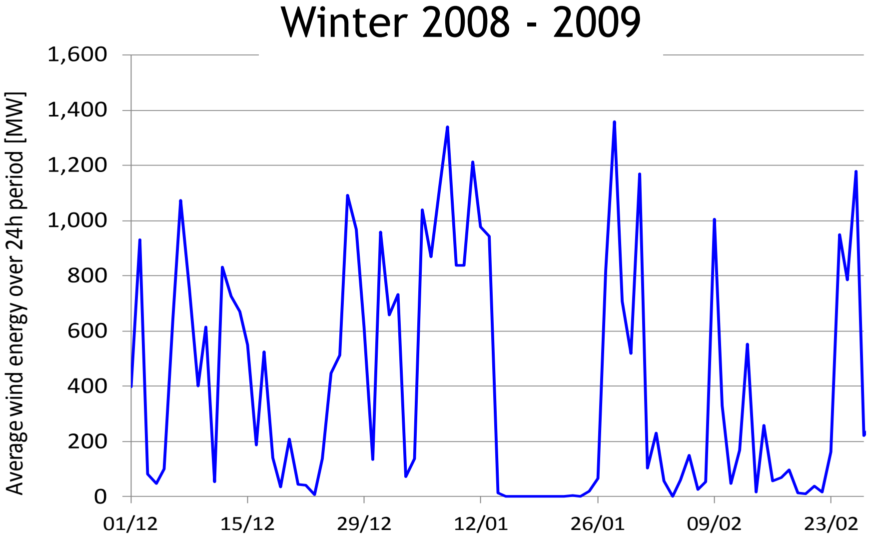


Source: The future of heating, DECC and Imperial College

Transferring heating load to electricity

- Heat pumps replaces gas boilers
- Transfers load from the gas grid to the electricity system
- Peak load (winter evenings) additional to existing system maximum
- Risks extra generation and transmission assets being unused all summer

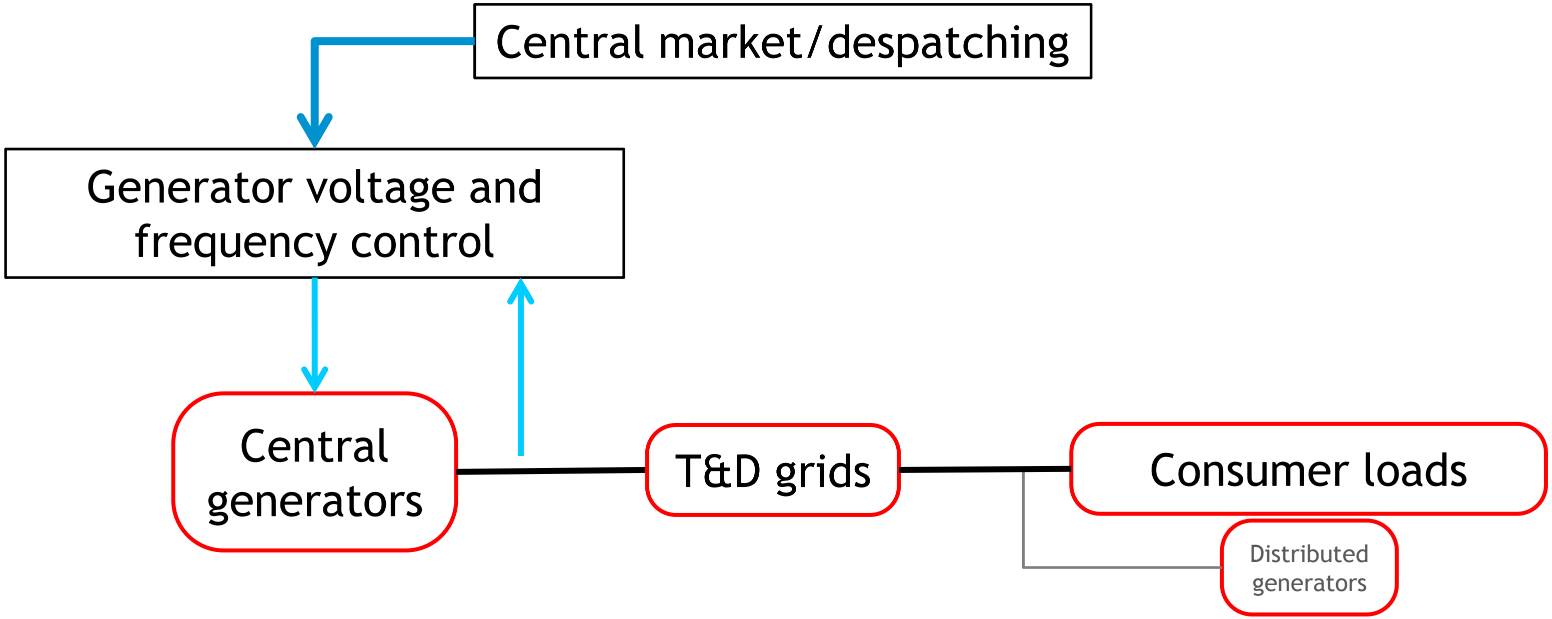
Challenge 3: Intermittency



Data for grid-connected on-shore wind farms from NETA

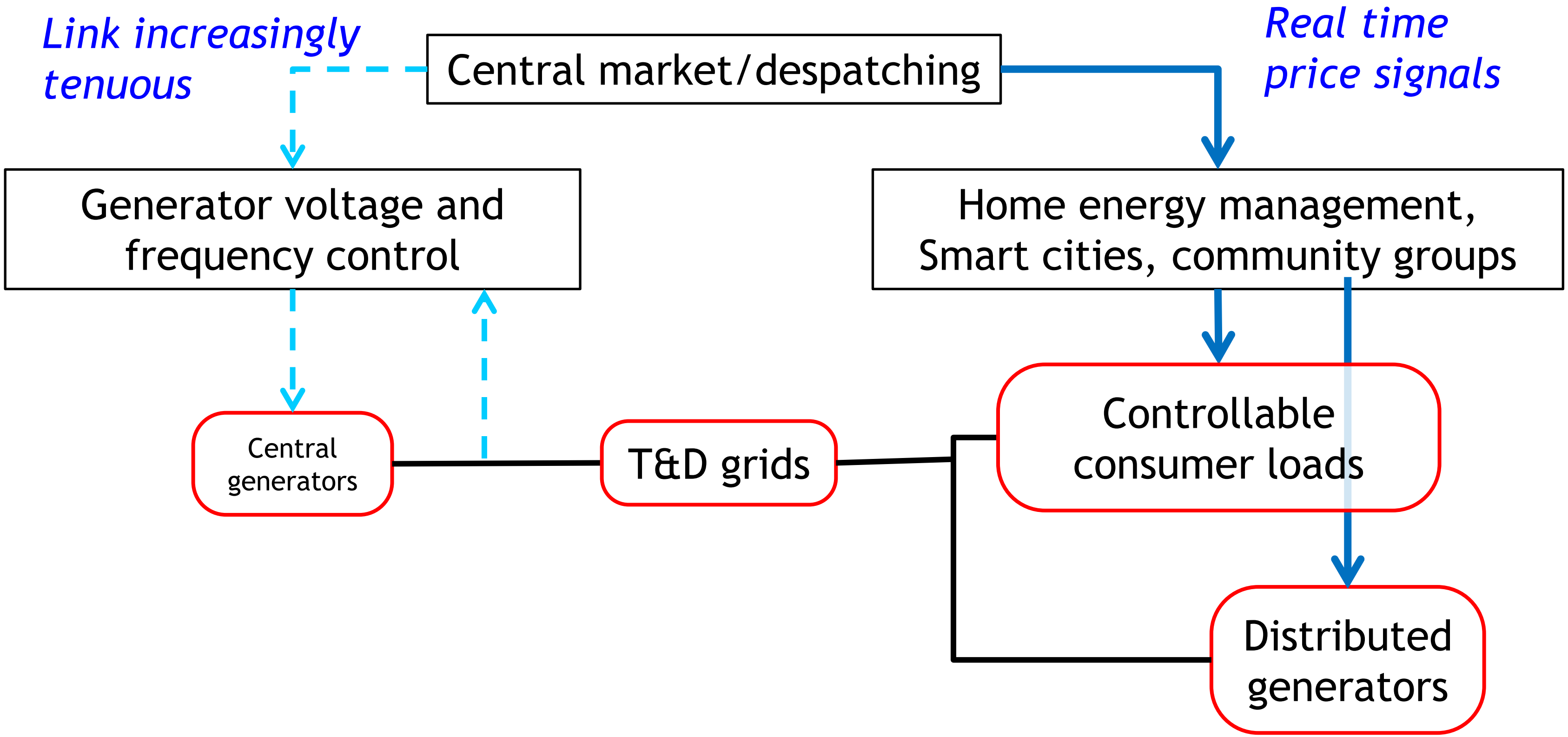
Challenge 4: system control

(2015 – CO_2 emission 450 g/kWh)



Challenge 4: system control

(2030 - CO_2 emission 50 g/kWh)

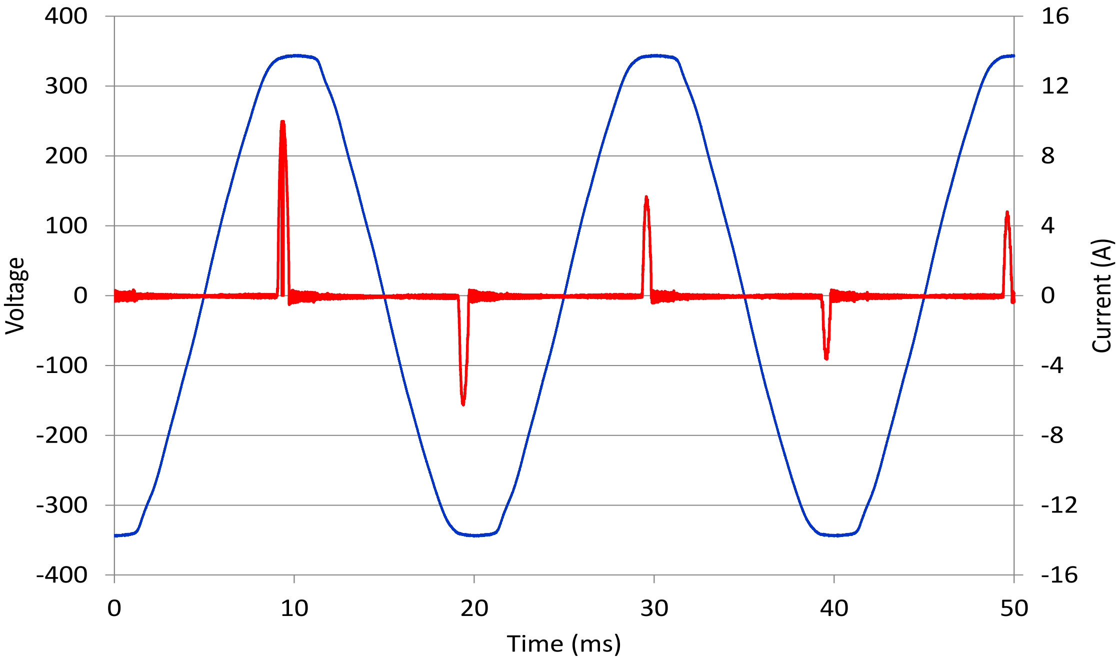


Challenge 5: Power quality

- **Reduced frequency stability** – due to lower system inertia and lower proportion of plant under frequency control
- **Reduced fault level** – difficulty in operating protection, commutation failure in current-source inverters, more severe voltage transients
- **Higher non-50 Hz spectrum** – heating in transformers, and other equipment, electrical interference
- **Voltage and reactive power management**

and others!

Consumer electronics



Ringing frequency 16 kHz

Challenge 6: Economics and the market

2005

- Cost of electricity dominated by fuel
- Most generating plant fully depreciated
- Market price, based on £/MWh, was closely related to real costs

2025

- Cost of electricity dominated by CAPEX of nuclear and renewable plant
- Fuel cost very low, or zero
- Market price, based on £/MWh, bears little relationship to costs which are related to £/MW.

Challenge 7: Loading on distribution networks

Top speed: 125 mph
0 – 60 mph: 3.7 sec

Battery 53 kWh, 88% charge/discharge efficiency
∴ to charge in 8 hours requires 7.5 kW (average)

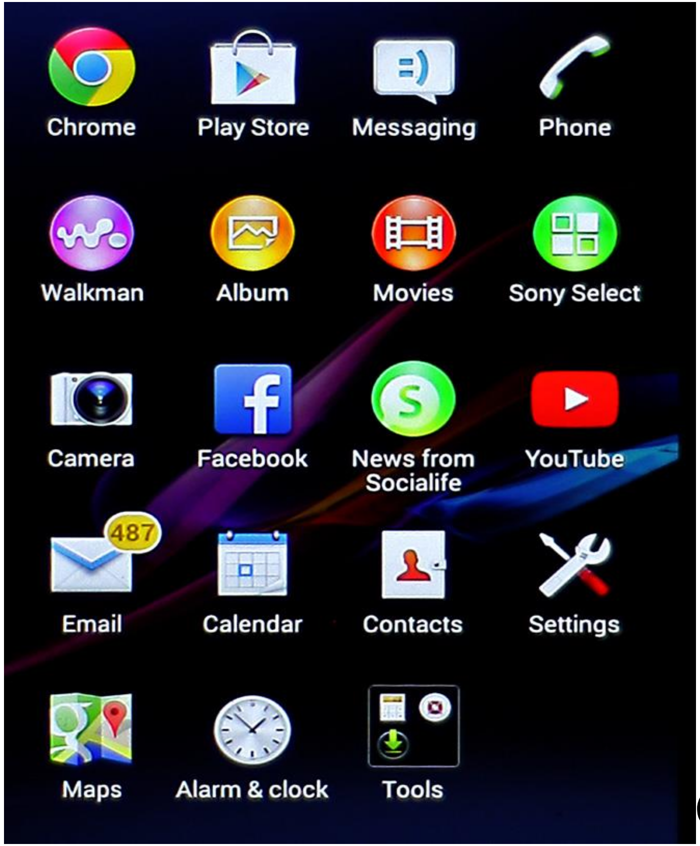
Photo: Tesla Roadster

Challenge 8 - “smart” electricity system for consumers

- Controls electric heating to provide adequate comfort
- Manages EV charging to ensure cars are ready when needed
- Minimises consumers’ bills
- Enables CO_2 targets to be met
- Reduces need to replace cables in the street
- Provides load reduction ability to cope with loss of generation capacity
- Uses existing smart meter network; avoids obsolescence
- Works with all intelligent white goods, GSM interface, etc.
- Secure against hacking, fraud, sabotage, … … (SIL 3 or 4?)
- Proof against “herd behaviour”
- Does not destroy economic case for low-carbon generation
- Easy to understand

Challenges: integration with IT & telecoms

- Google, Apple, Microsoft and others developing home automation apps
- Integration with smart cities, home and community energy networks and DNOs
- Herd effects?
- Cyber-crime, sabotage, … … …



Challenge 9 - new stakeholders

Community energy groups

Smart city developers

Smart meter DCC

Smart phone app developers

Grid-connected generators

Transmission system operator

Distribution system operators

PV installers & users

White goods manufacturers

Building automation suppliers

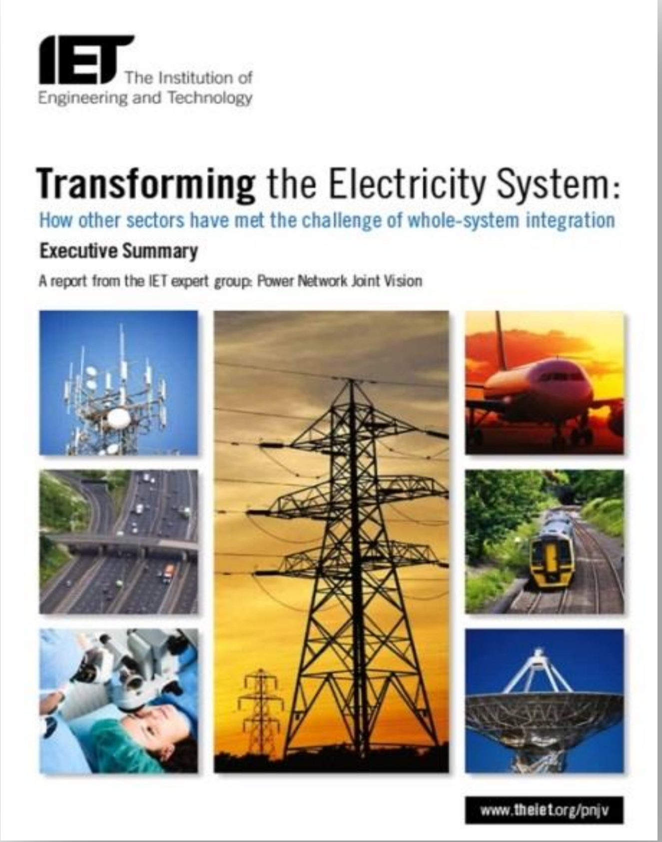
Heat pump system designers

Electric vehicle manufacturers

Car park operators etc.

Challenge 10 - Joined-up thinking

- IET has put forward the case for a *system architect* for the electricity system
- We need joined-up thinking for all energy policy issues:
  - Renewables
  - Nuclear power
  - Storage
  - Gas vs electricity heating
  - Transport … … …



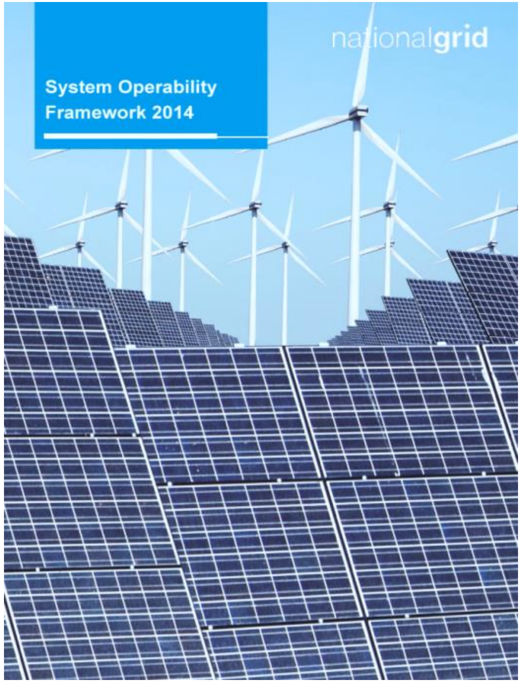
“Immediate” actions needed

- Ensure all parties (including DECC & Ofgem) have a shared understanding of the above 10 issues
- Establish an industry structure and culture capable of addressing them

Expectations of SOF and NG

		NG	DECC	Ofgem	DNOs
1	Replacing retiring generation		X		
2	Decarbonisation of heat and transport		X		
3	Intermittency	X	X		
4	System control	X			
5	Power quality	X			
6	Economics & market		X	X	
7	Loading on distribution feeders	X			X
8	Smart system for consumers		X	X	
9	New stakeholders	X	X	X	X
10	Joined-up thinking	X	X	X	X

System Operability Framework Background



Liena Vilde

SOF Project Team

Why do we need a System Operability Framework in GB?

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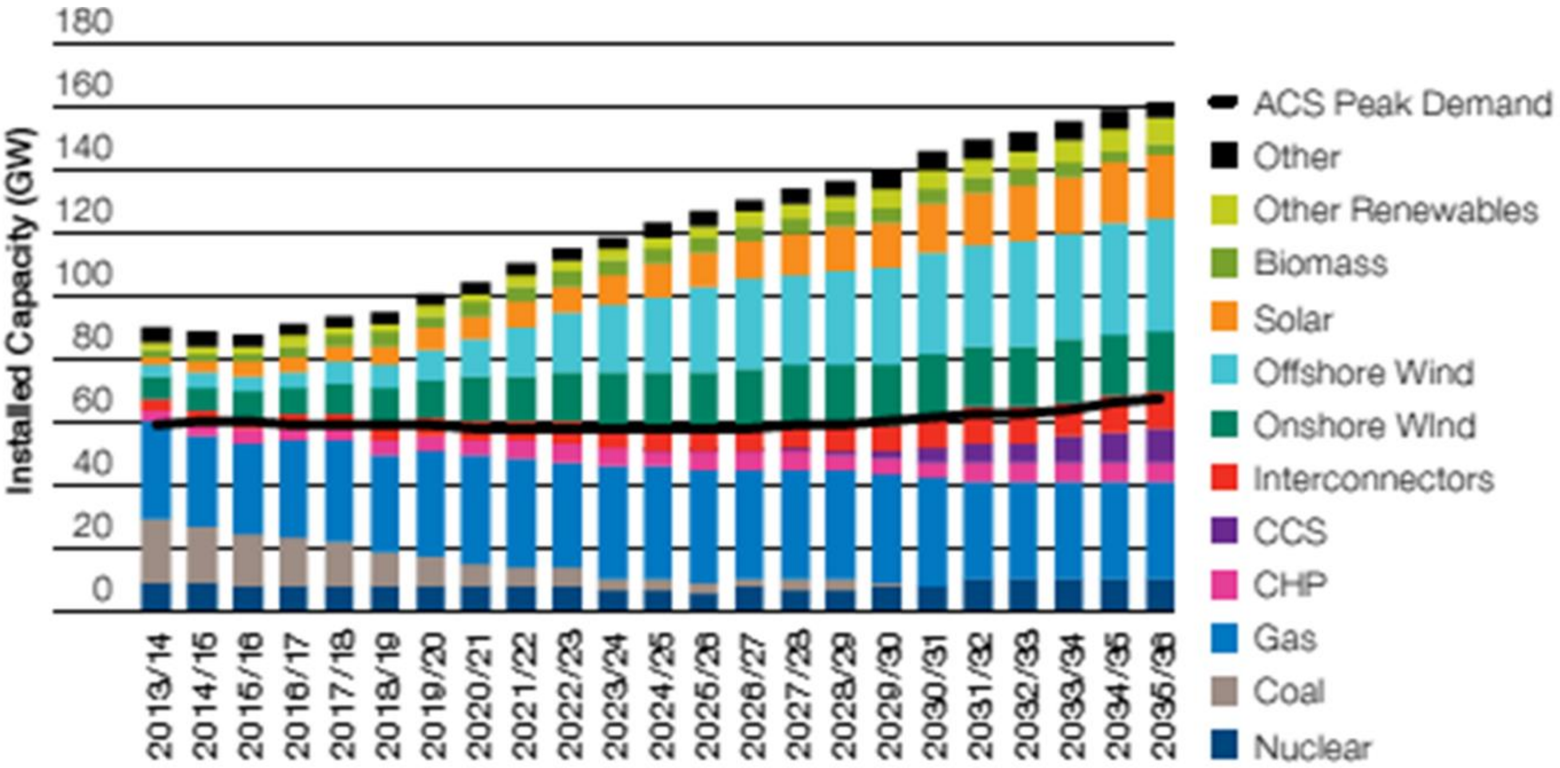
Islanded AC power system

Changes in the energy landscape

Generation		Demand side		Network	
Increase in non-synchronous generation	Closure of conventional plants	Increase in Embedded non-synchronous generation	Change in Demand type (LED lights – Heat Pump)	First Embedded HVDC Link (parallel to AC)	Thyristor Controlled Series Compensation (TCSC)

Why do we need a System Operability Framework in GB?



And the impact?

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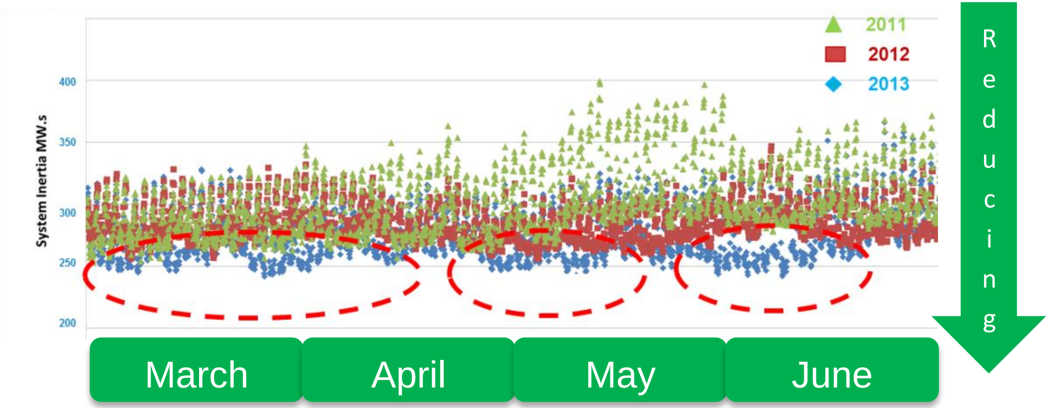
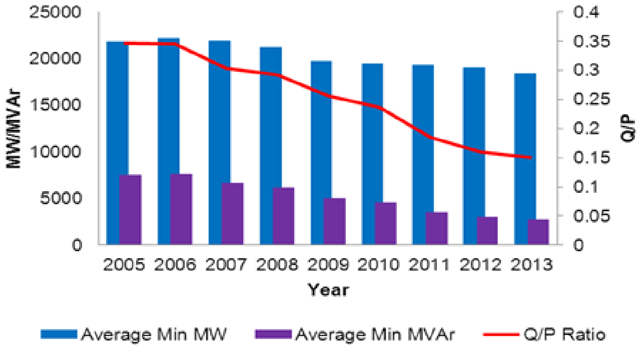
System Inertia



MVAr Demand



System Operability Framework (SOF)

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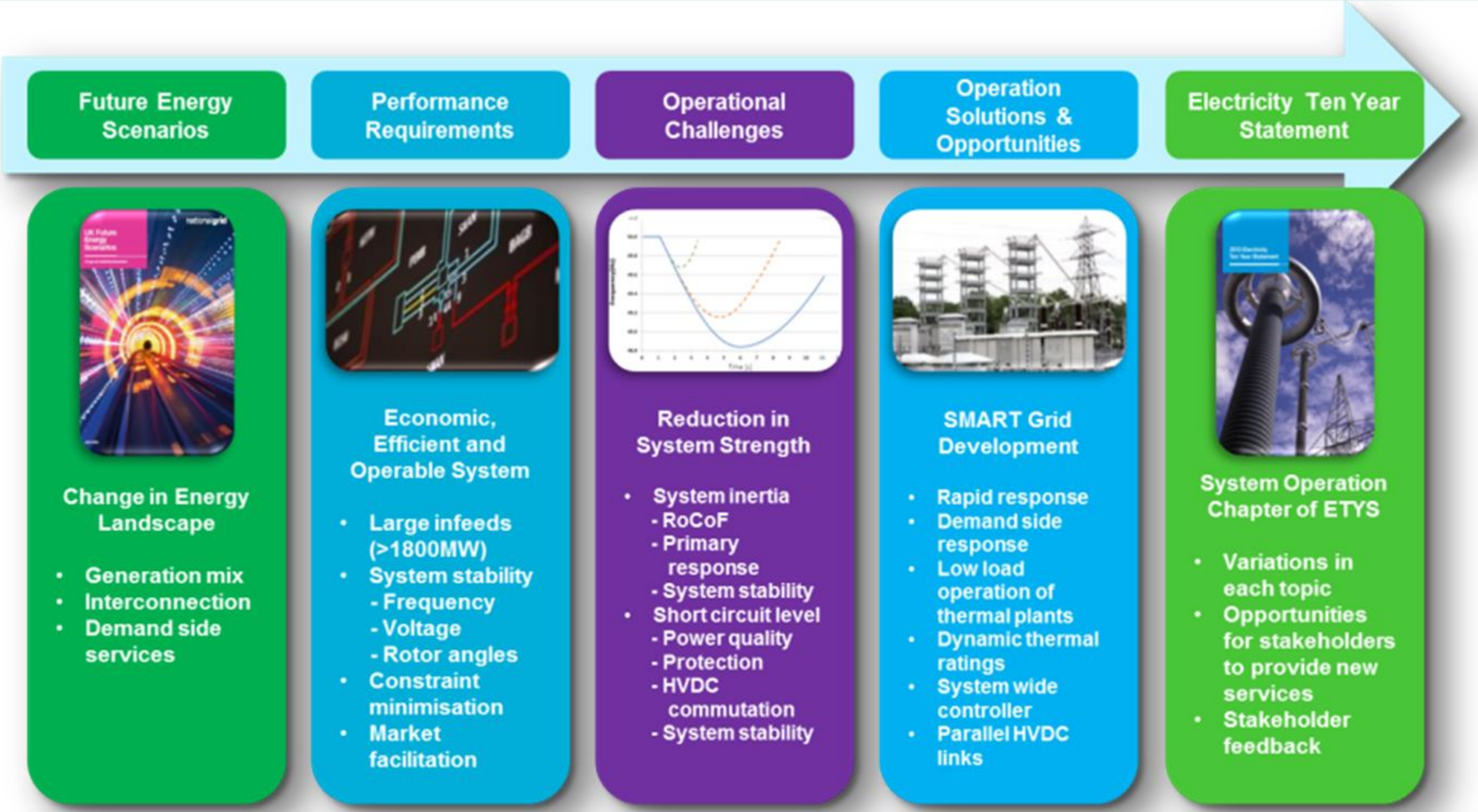
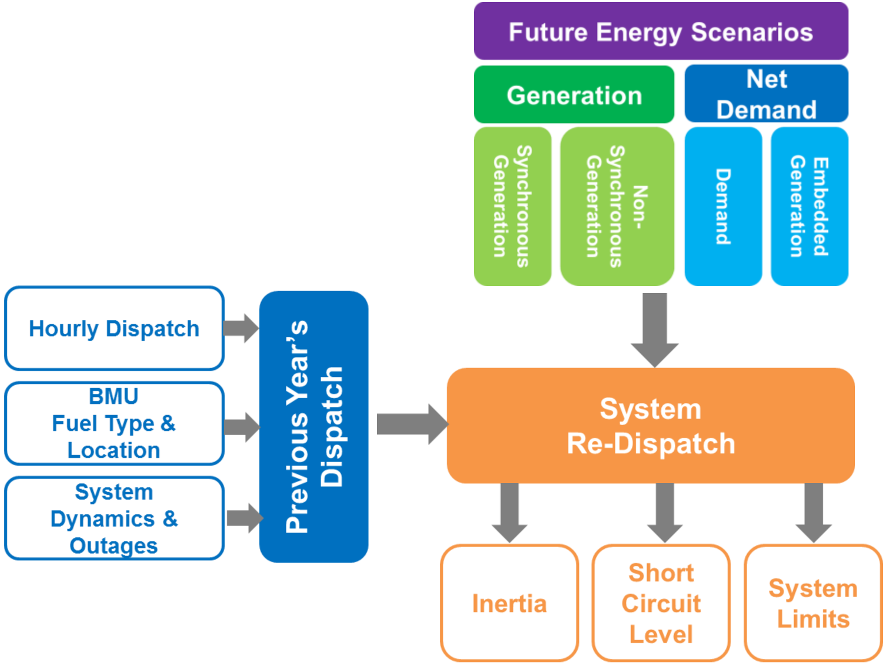


SOF methodology



SOF 2014

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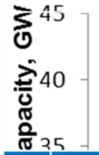
Topics

Timeline

Solutions



		External Actions							Internal Actions			
		RoCoF Setting Change	Infeed Constraint	Rapid Frequency Response	Synchronous Compensation	Demand Side Response	Distribution System Operator (DSO)	Technical Code Changes	HVDC Constraint	System Monitoring	Improved Study Capability	Reactive Compensation
Before 2020	RoCoF	X	X	X	X	X	X					
	Voltage Management				X		X	X			X	X
	SSI				X	X			X	X	X	
After 2020	Frequency Containment		X	X	X	X	X					
	Generator RoCoF Withstand		X	X	X		X	X		X		
	Regional Stability				X		X	X		X	X	X
	Protection				X		X	X				
	Voltage Dips				X		X	X			X	X
	Harmonics				X		X					
	HVDC Commutation				X			X	X	X	X	
	Control System Interaction					X				X	X	

SOF interactions

Who? / How?	Service Providers (Generators, Aggregators, Interconnectors)	Onshore and Offshore Transmission Owners	Distribution Network Operators	Manufacturers and Technology Providers
Design of the new balancing services	Future revenue streams	Future compliance	DSO services	Future products / Compliance
Coordinate the use of existing capability	Additional incentives	Coordination of resources	Coordination of resources	Retrofit vs new design
R&D and joint innovation projects	Collaboration and engagement	Collaboration and engagement	Collaboration and engagement	Collaboration and engagement

SOF will provide the technical inputs into commercial and regulatory frameworks to ensure future grid operability

Impact of Embedded Generation on the Transmission System and Potential Opportunities

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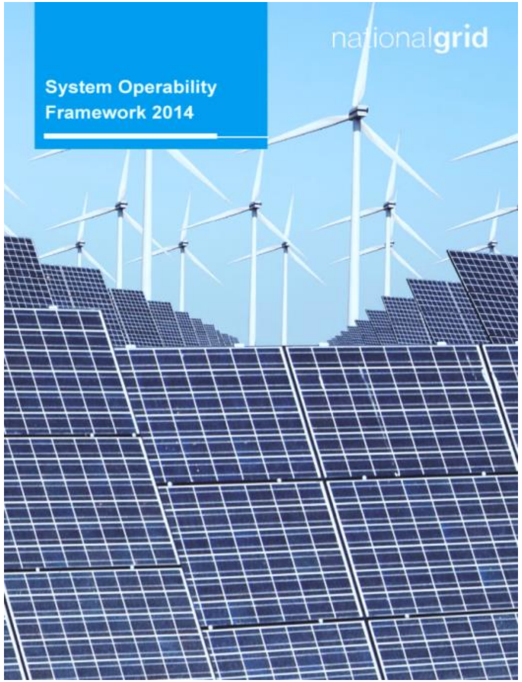


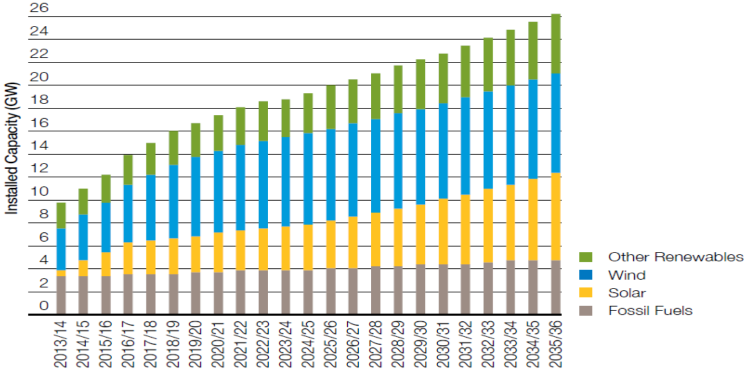
Nikola Gargov

SOF Project Team

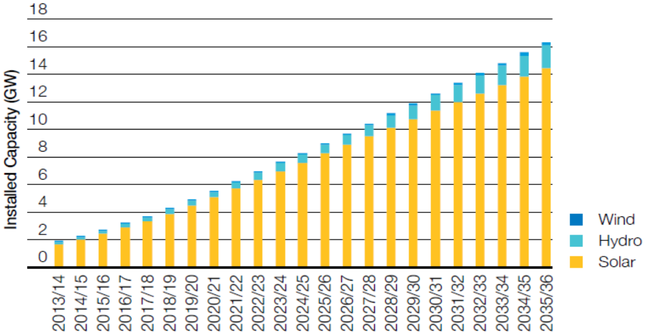
Increase of Generation in the Distribution Networks

Future Energy Scenarios predictions for Embeddedd and Micro Generation:

- Embedded Generation: generation with installed capacity above 1MW



- Micro Generation: generation with installed capacity below 1MW



Example in South West

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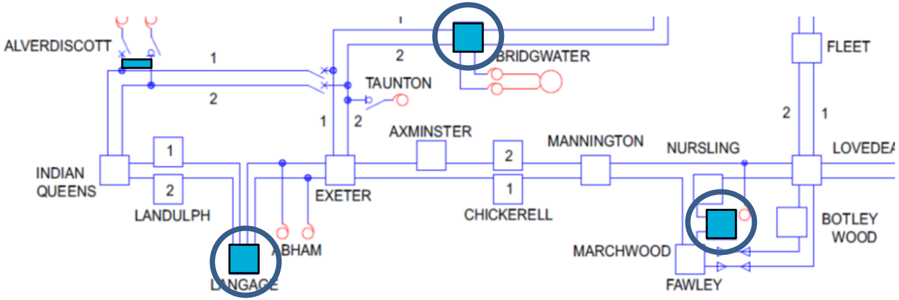
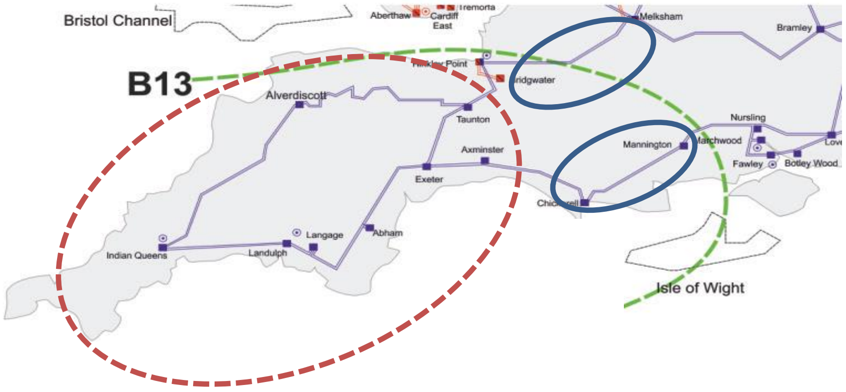
Background:

- Two transmission double circuits connecting South West with the rest of the system
- Potential for large volumes of Embedded Generation being connected in the DNO networks
- Several large synchronous generators in the area
- Relatively long transmission circuits (high impedance)





Embedded Generation and Effect on the Steady State Operation

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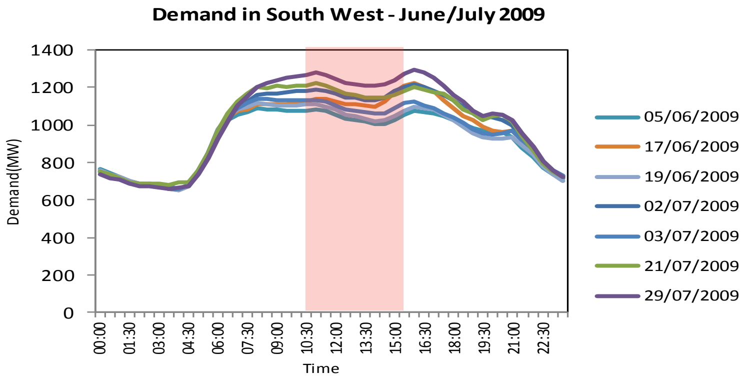
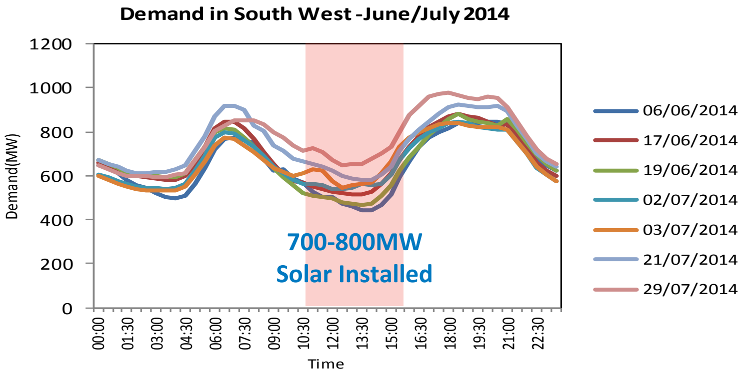
How large volumes of Embedded Generation could affect the operation of the transmission system:

- Lower the power transfers on the transmission network
- This may result in difficulties in managing the voltages on the transmission system in steady-state
- Need for reactive compensation sufficient to maintain the voltages within operation limits





Main System Background Assumptions

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System Background Assumptions	Justification
Demand Background 1. All system demands are dispatched from DEAF database at 21GW	**Demand Background** 1. Typical summer minimum total system demand
Generation Background 1. Summer minimum ranking order 2. Large size generators have voltage/reactive and frequency response capability 3. HVDC is modeled with full PowerFactory models 4. Embedded and Micro generation has been modelled in the DNO networks within the area of study	**Generation Background** 1. Officially released by Energy Strategy and Policy team 2. Grid Code requirement 3. The latest HVDC models available are used 4. This assumption will provide better degree of modeling the system and will allow new opportunities to be explored
System and generator outages 1. Typical summer outage pattern is used 2. Summer generator outages are taken in account	**System and generator outages** 1. The typical outage pattern has been provided by Offshore team END (Appendix 1) (as outlined in BP-078) 2. Summer nuclear plant outages are taken into account in the Summer Ranking Order released by ESP team
System Dispatch 1. The studies start from Y1 and additional NSG is being added in the region of study 2. In the region of study the all generation is dispatched to their rated capacity	**System Dispatch** 1. This approach has been chosen in order to save study time and manage the project within its timeline 2. Assuming the worst case scenarios (to be consistent with NDP and ETYS process) where all non-synchronous generators inside the area of study are dispatched to 100% of their rated capacity

Main Modelling Assumptions

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Modelling Assumptions	Justification
System Fault 1. The worst N-D contingency highlighting the stability limit is assessed for every region 2. Fault is selected to be three-phase solid short-circuit on a double-circuit line having zero impedance for 140ms duration	**System Fault** 1. Communication within SMARTER System Performance and Network development Strategy teams regional engineers 2. A conservative fault clearance time has been considered to represent the worst case scenario
Generators 1. Embedded generators has the possibility to provide voltage support (considered as a potential solution in some cases)	**Generators** 1. Communication with engineers in Smarter System Performance and Network Design
Pre-fault voltages 1. Pre-fault voltages to be between 1-1.025pu	**Pre-fault voltages** 1. Historical data suggests that voltages between 1-1.025pu as expected during summer minimum periods with high levels of wind and solar generation
Reinforcements 1. Voltage Stability: Fast reactive compensation, dynamic compensation, synchronous machines operating in SynchComp mode, Reactive support from EG 2. Frequency Stability: additional inertia on the system, synchronous machines operating in SynchComp mode 3. Rotor Angle Stability: Power System Stabilizers	**Reinforcements** 1. Some MSCs have capability to provide fast MVAR support, some current generators can operated in SynchComp mode 2. The studies conducted last year suggest that additional inertia on the system, synchronous machines operating in SynchComp mode improve stability

Impact of Embedded Generation on the Transmission System and Potential Opportunities

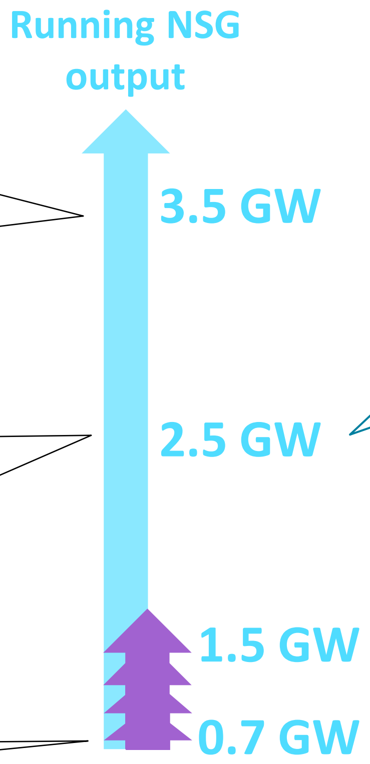
Increased transient over-voltage followed by voltage collapse on the transmission network, options are:

- Transmission connected reactive support
- Distribution connected generation on having voltage control
- Active management of distribution connected generation

Increase in non-synchronous generation results post-fault ToV, options to mitigate:

- Transmission connected machines operating SynchComp mode
- Transmission connected dynamic reactive support (STATCOM)
- Distribution connected generation on having voltage control
- Active management of distribution connected generation

No Identified Stability Issues



In South West area, embedded generation can deliver MVARs to GSPs with average loss of 15-20% due to the impedance of the distribution networks

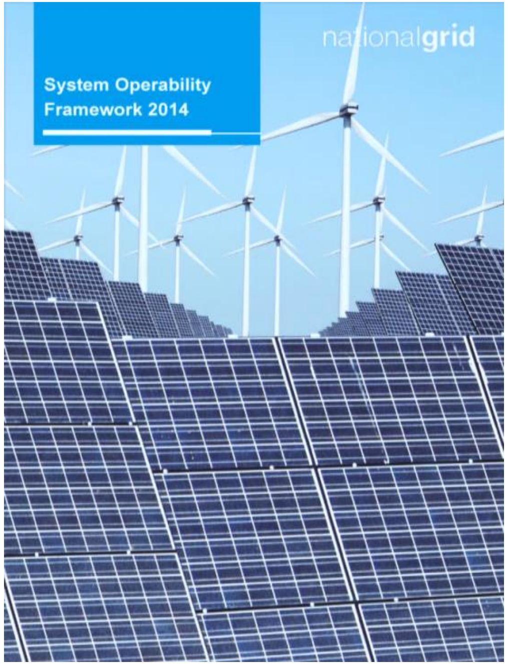
Current Installed Capacity = 1650MW

T-NSG 0MW
E-NSG 1500-2300MW
M-NSG 150MW

Key Learning for South West

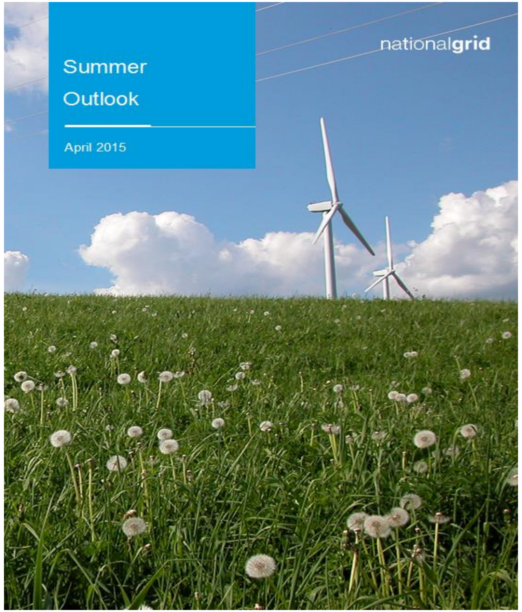
Based on the analysis done as part of SOF, National Grid and Distribution Network Operators are working closely in identifying potential mitigations of the future challenges. The possible options include:

1. **Use of transmission connected generators in SynchComp mode**
2. **Use of fast acting static reactive support**
3. **Use of dynamic reactive support**
4. **Active control of transmission and embedded generation**
5. **Active network management**



Summer Outlook 2015

nationalgrid

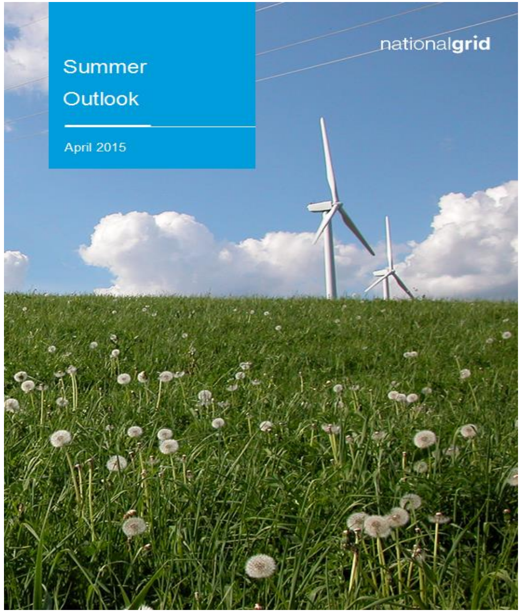


Chris Thackeray

Energy Strategy and Policy

The Summer Outlook Report has been published on our website today…

nationalgrid



Listened to our stakeholders through meetings, a survey and events

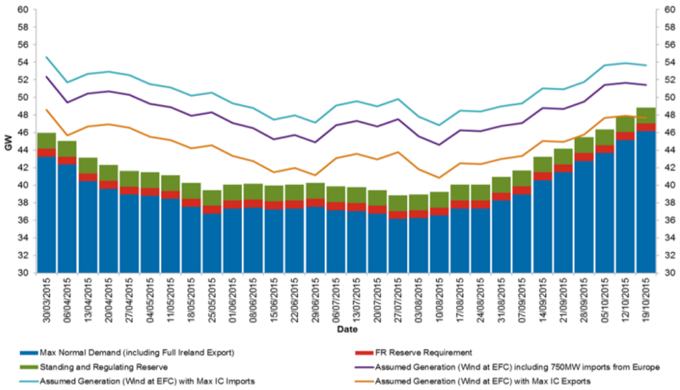
Fresh approach with a focus on making it interesting and relevant

Interesting case studies to bring relevant issues to life

Operability is the focus for summer 2015 for both gas and electricity

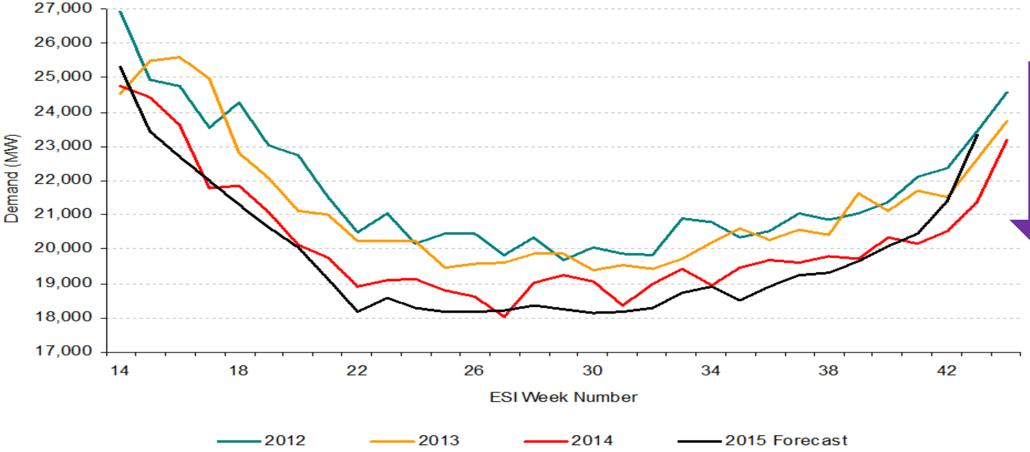
www.nationalgrid.com/UK/Industry-information/Future-of-Energy/FES/summer-outlook/

Margins are currently forecast to be at a comfortable level over the summer...



Current generator capacity	73.5 GW
De-rated generator availability when demand is forecast at its highest	42.4 GW
Maximum forecast demand in high summer	37.5 GW
Forecast margin when demand is forecast at its highest	4.9 GW

Summer demand is falling year on year but the minimum is comparable with last year…



Increase in embedded generation

Energy efficiency

High summer demand forecast (GW)	2014 outturn	2015 forecast
Highest demand	38.4	37.5
Minimum demand	18.6	18.6

System operability is the main focus for us as the System Operator this summer…

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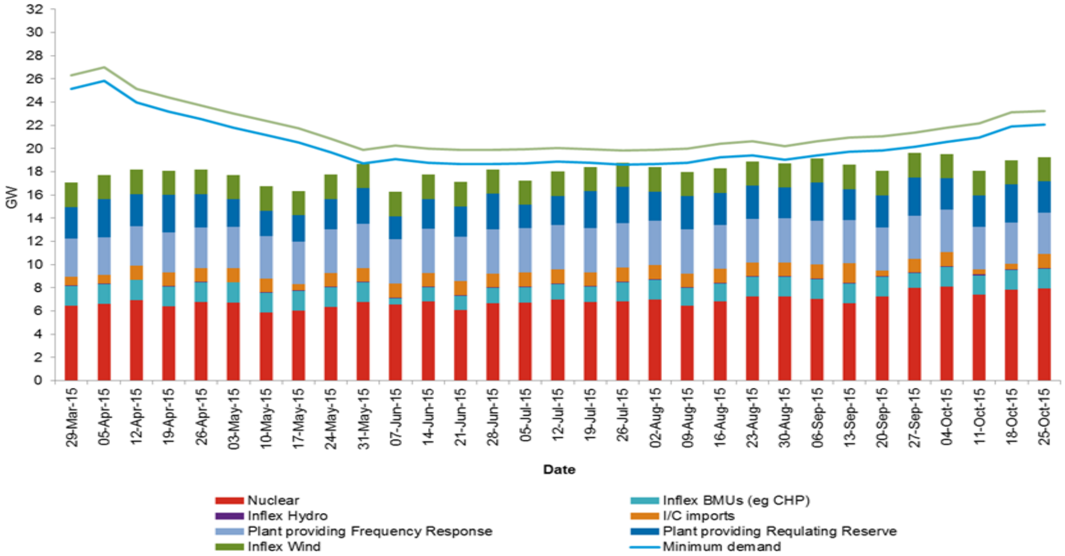


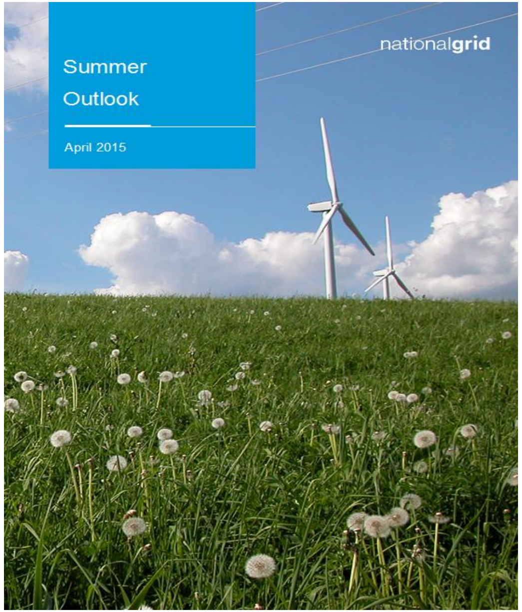
18.6 GW Minimum demand level

1.1 GW **Minimum margin**

Generation

17.5 GW

The Summer Outlook Report has been published on our website today…



Listened to stakeholders and acted on their feedback.

Margins are currently forecast to be at a comfortable level over the summer.

Summer demand is falling year on year but the minimum is comparable with last year.

System operability is the main focus for us as the System Operator this summer.

www.nationalgrid.com/UK/Industry-information/Future-of-Energy/FES/summer-outlook/

System Operability Framework pre-assessment workshop – 9th April 2015

Hannah McKinney

standardisation
accountability
THE SAFE WAY OR NO WAY
efficiency

DONG energy

1. What do you see as challenge(s) for the future power system in GB?

Maintaining system strength with increasing volumes of NSG capacity & NSG/Demand ratio

- Decreasing System Inertia

RoCoF, Frequency containment

need for more Rapid Frequency Response

We see a growing need and opportunity and could deliver…

- Voltage Management

Stabilising network deviations faults/voltage dips

need for more Reactive/Voltage support

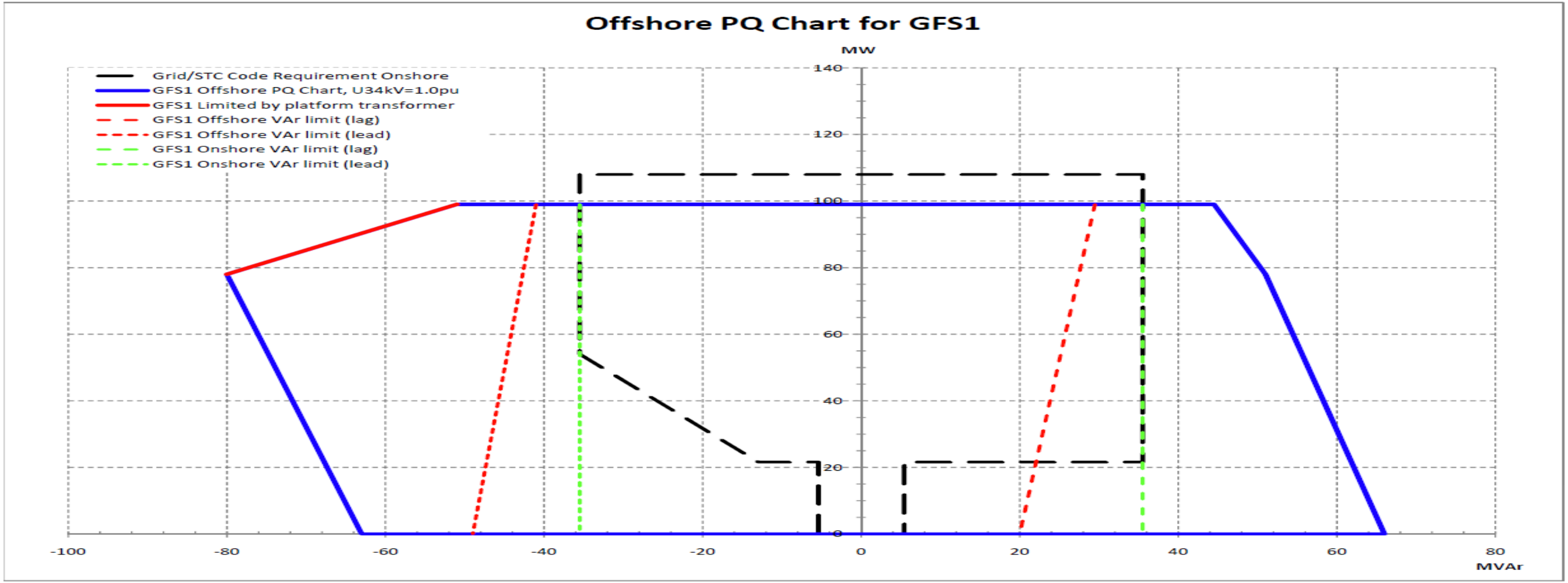
We see a reducing opportunity for providing additional reactive power/voltage control services….

DONG energy

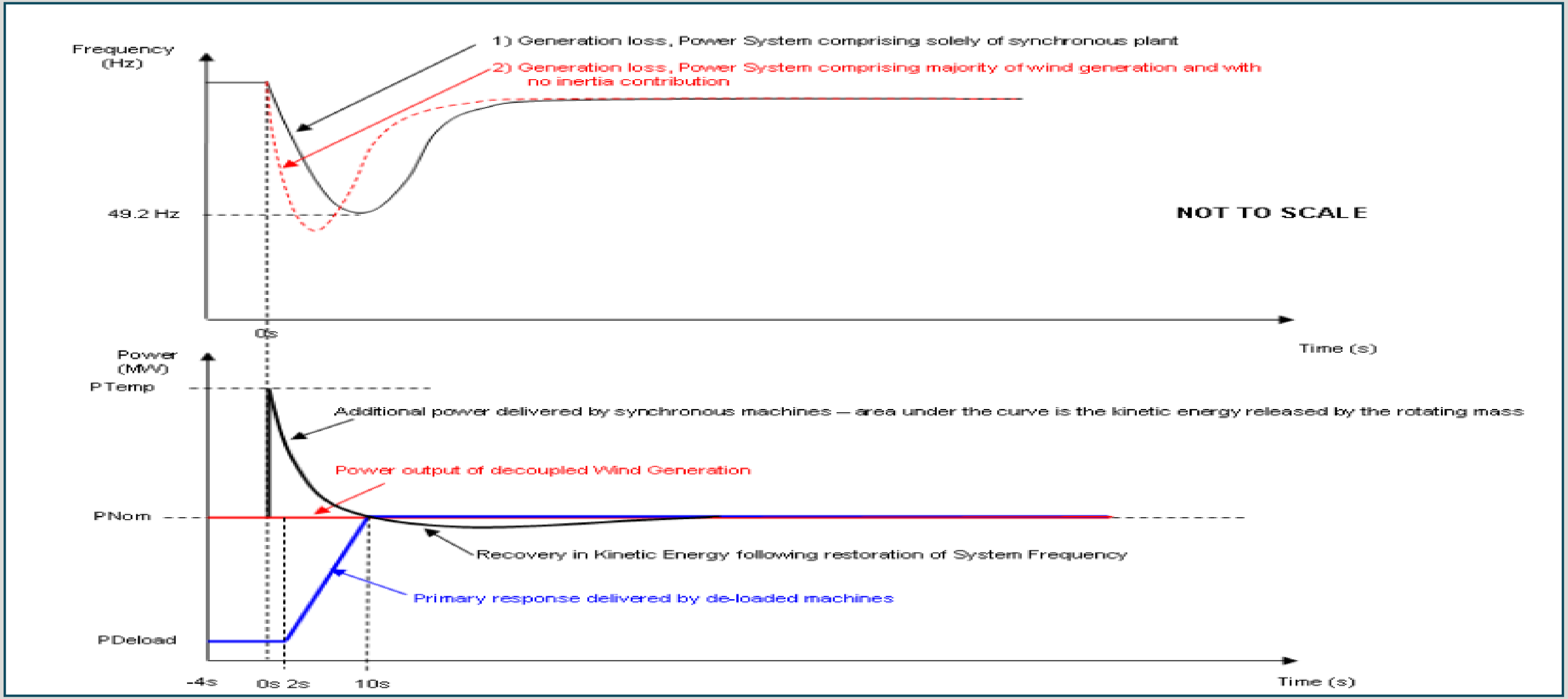
1. Challenges cont…in particular, the challenge of managing Voltage

- Modern offshore wind turbines normally have AC converter machines (if they 're not DC),
- Capable of delivering significant volumes of reactive power at all levels of active power production

- Early projects relied on wind turbines to provide the majority of voltage control requirements
- As projects move further from shore and increase in size, the use of STATCOMs onshore is becoming common



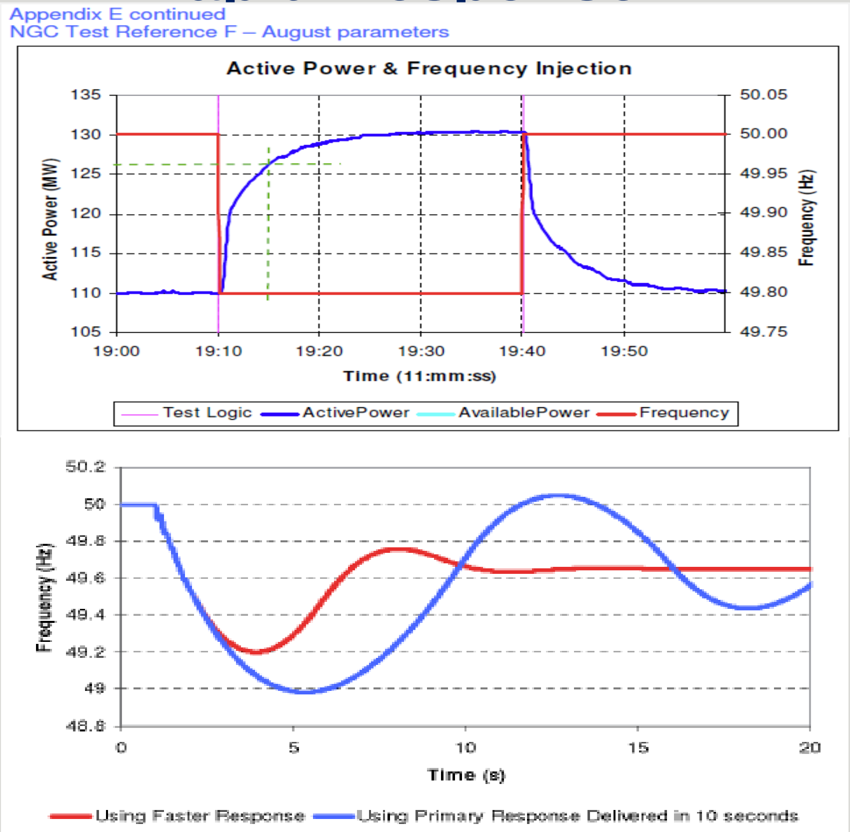
1. Challenges cont…in particular, the challenge of managing RoCoF



DONG energy

1… Challenges but real opportunity for NSG – RFR technically capable

Rapid Response

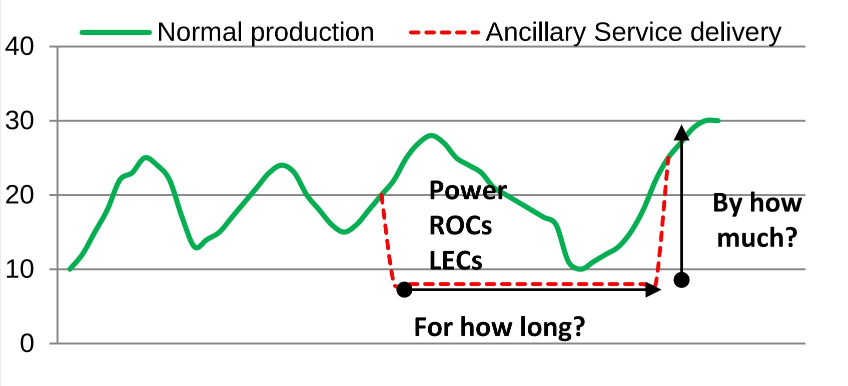


DONG energy

2. What "immediate" actions you believe are needed (By National Grid, and by the industry)

- What we need?

- Positive business case! - mitigate risks to:
  - Our JV projects – both industrial and financial partnerships
  - ensure return on CAPEX (Grid Code Compliance) currently limited realised return? *why…*
- Requires upfront pricing of deliveries both uncertain in duration and magnitude



- What NGET and Industry can do?

- Clear direction re: actual utilisation – making progress with NGET account managers
- change existing settlement mechanisms eg., Frequency Response (CMP 237) an important step/in the right direction!
- Wind could then be more competitive vs conventional!
- Improved awareness of the additional complexities with Offshore Wind projects – all have a role to play

DONG energy

3. What are our expectations from System Operability Framework and National Grid?

- Looking ahead - DONG Energy prospects for delivering Ancillary Services
  - Prepared to progress developing A/S (eg., RFR) from selected wind farms on the basis of such activities **being profitable!**
  - **Demonstrate financial viability** (in terms of incoming cash flows and overall profitability) to our JV partners
  - Enter into **pilot project(s) for new A/S (e.g., RFR)** such that that DONG Energy remain whole in terms of lost output for the duration of the exercise

- SOF can be used as the technical justification behind pursuing changes:
  - To the existing settlement mechanisms (CMP 237)
  - Use historical operational data about delivery patterns to determine likely duration and magnitude of net production losses ~ may reduce (but not remove) the uncertainties .
  - Potential lowering of risk premium to the benefit of both SO (lower price) and wind generators (eg, more efficient and competitive prices), and
  - Pilot projects

DONG energy

THANK YOU

renewableUK
The voice of wind & marine energy

RenewableUK previously: BWEA

System Operability Framework – A Perspective

Zoltan Zavody
Head of Grid

RenewableUK

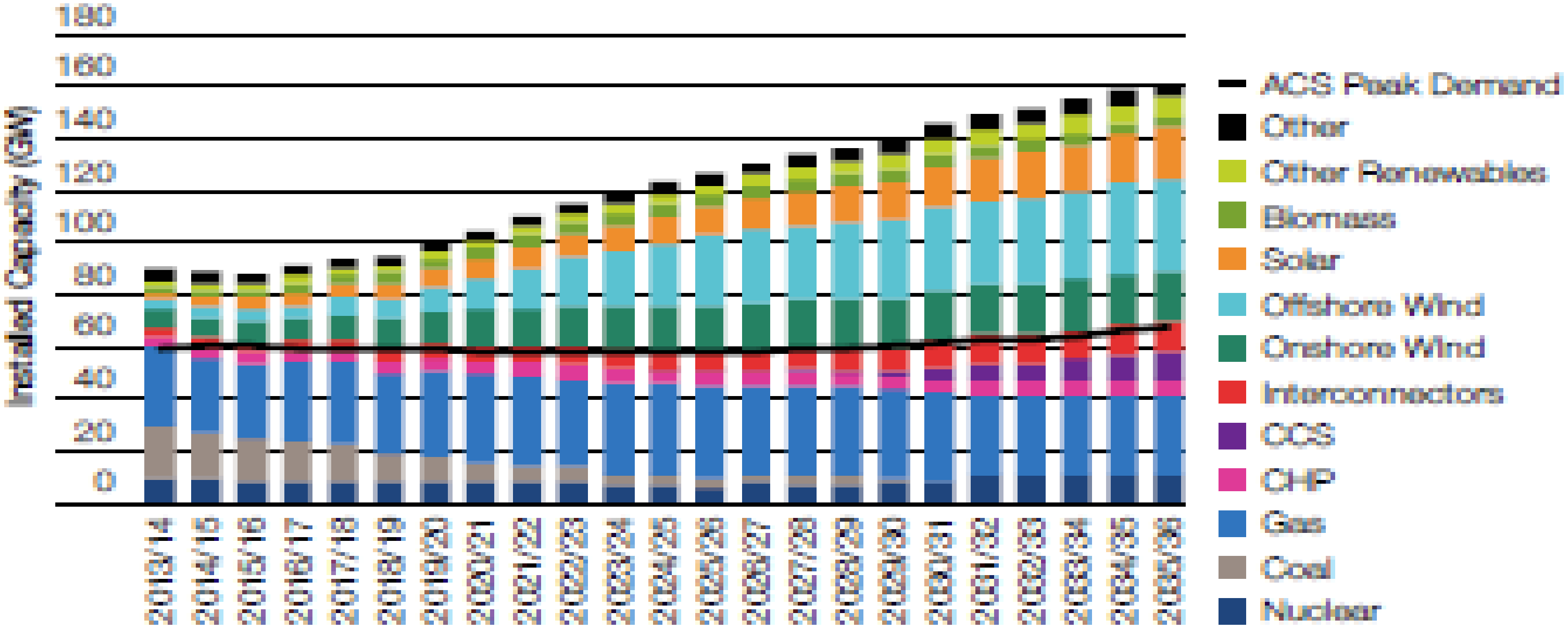




"The voice of wind and marine energy"

- ❑ industry forum
- ❑ represents industry to Government
- ❑ media resource
- ❑ public campaign

Gone Green Generation Scenario

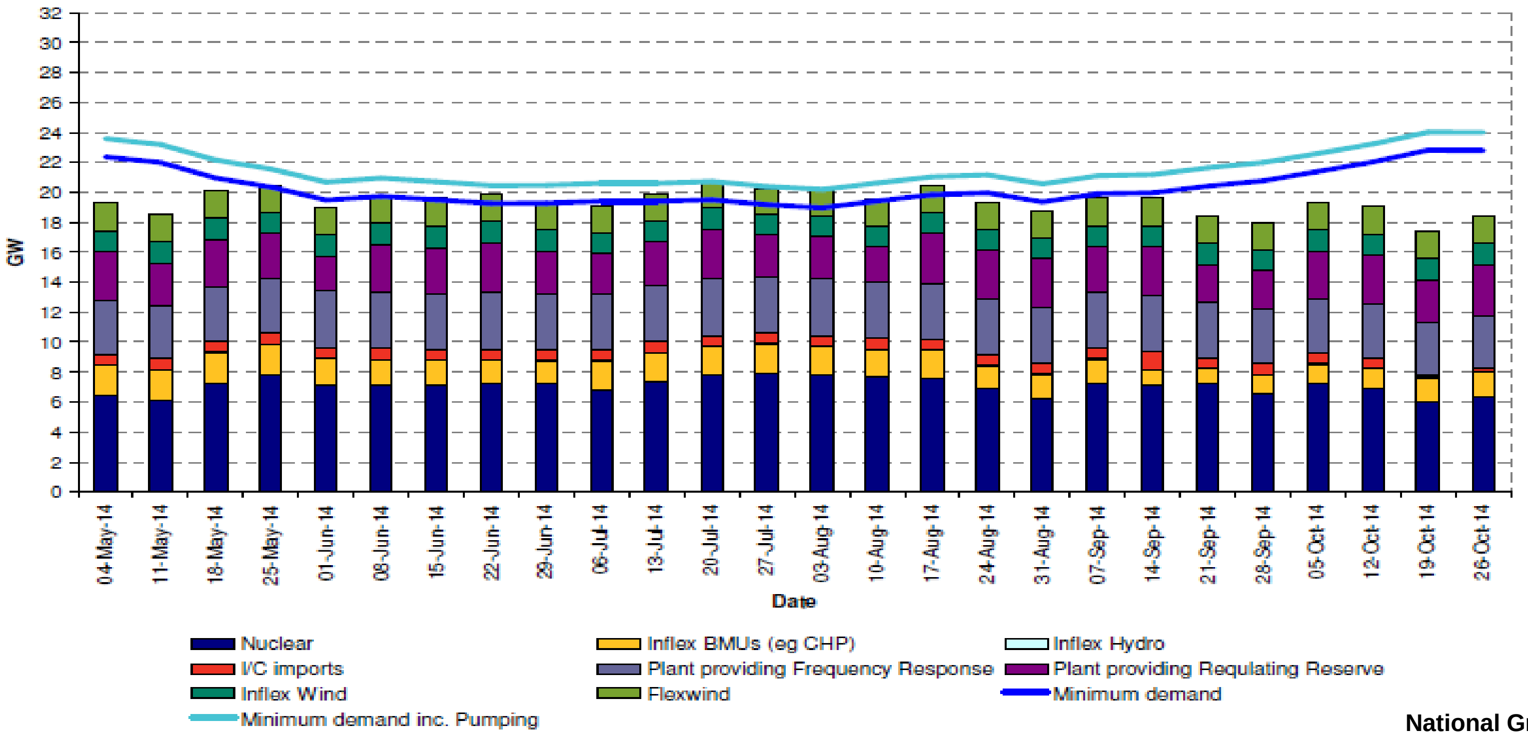


National Grid, Future Energy Scenarios 2014

renewableUK
The voice of wind & marine energy

RenewableUK previously: BWEA

Minimum Summer Nighttime Demand 2014



National Grid, Summer Outlook 2014

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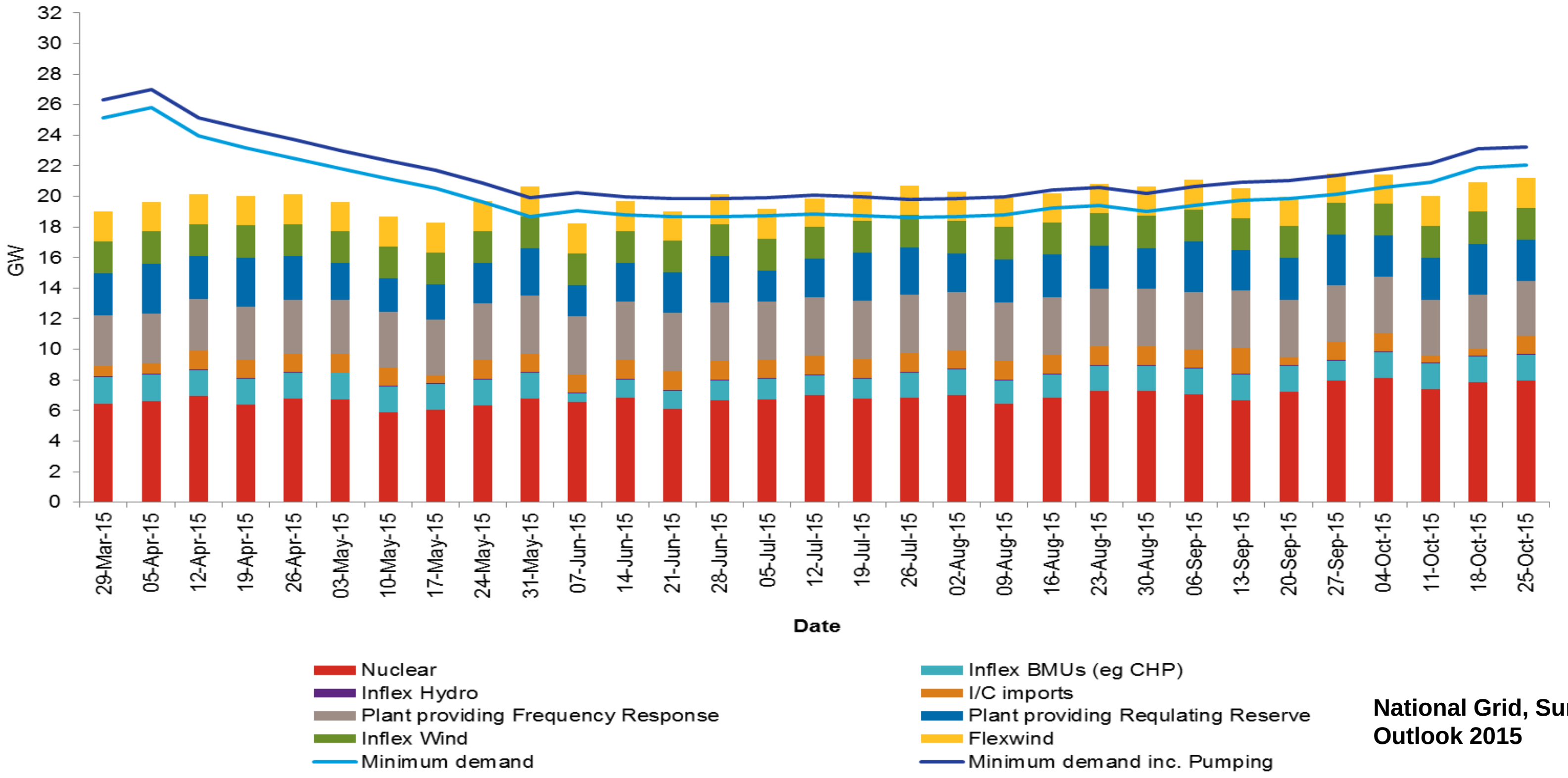
Minimum Summer Nighttime Demand 2015



National Grid, Summer Outlook 2015

RenewableUK previously: BWEA

Summary

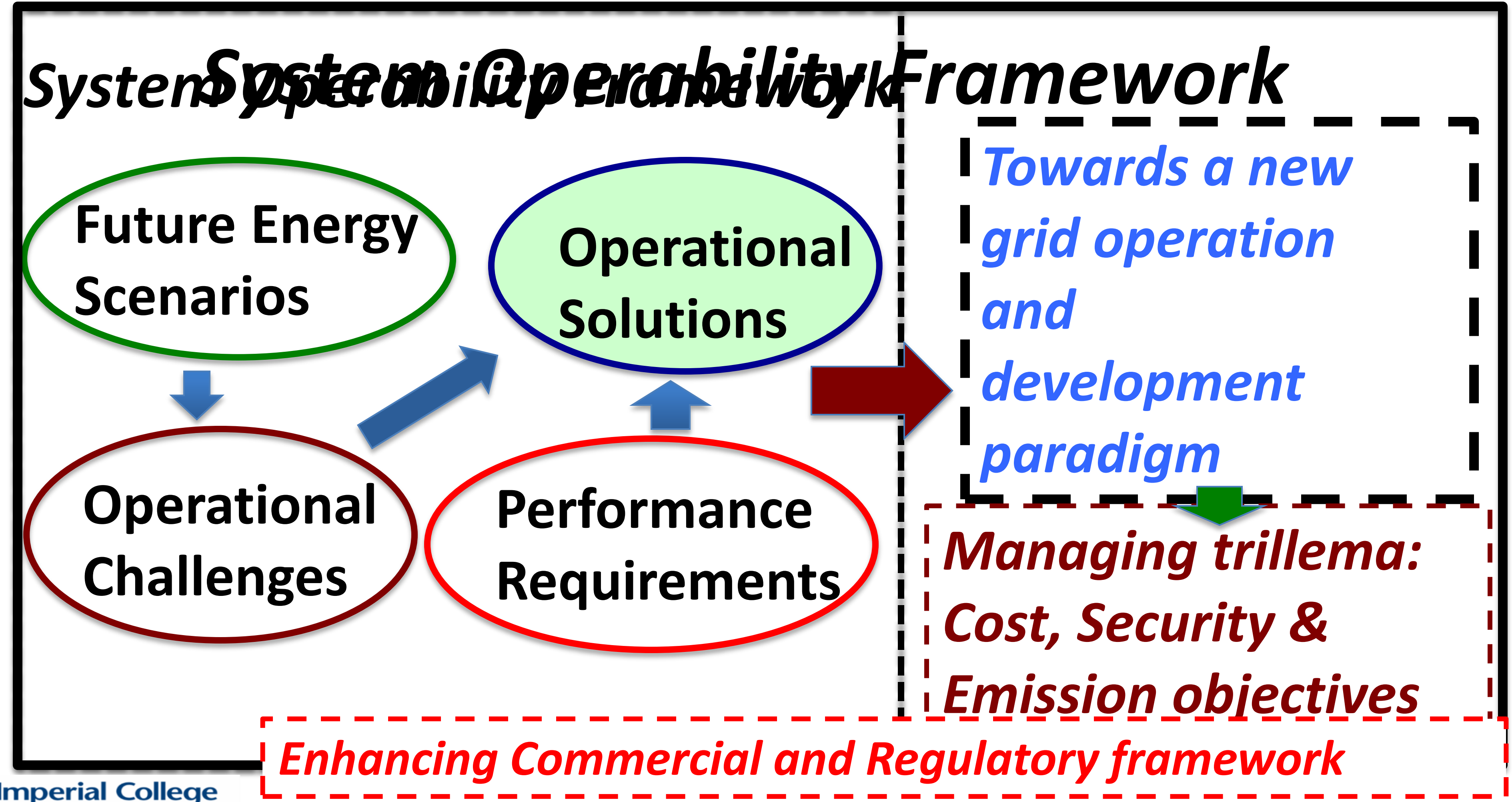
- Windfarms have the capability to provide the voltage and frequency services described in SOF
- Summer nighttimes will inevitably necessitate services from wind – but how and when?
- Need to demonstrate how tomorrow’s need will be met by commercial arrangements
- Need explicit dialogue on range of potential service providers and long-term arrangements

Imperial College London

System Operability Framework

Towards a new grid operation and development paradigm

Goran Strbac



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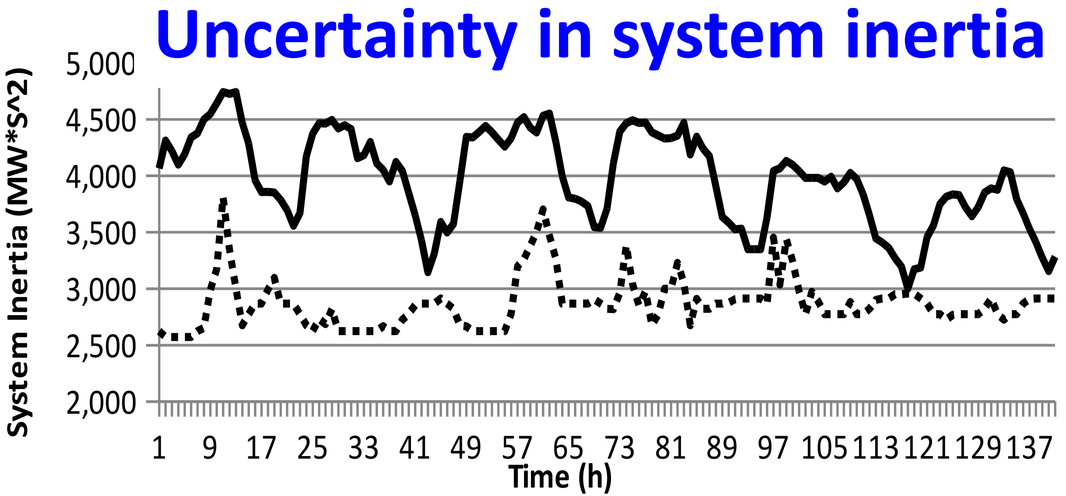
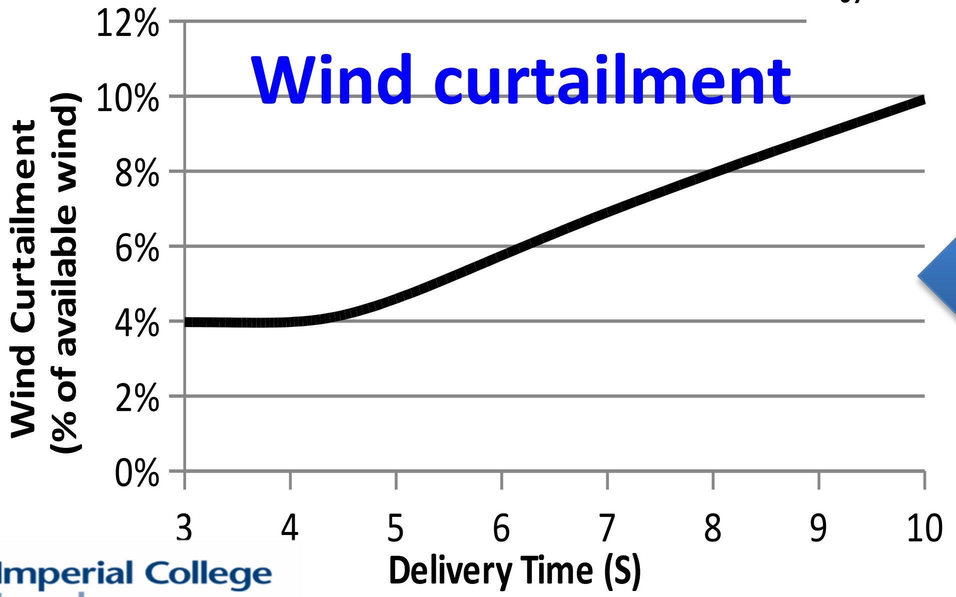
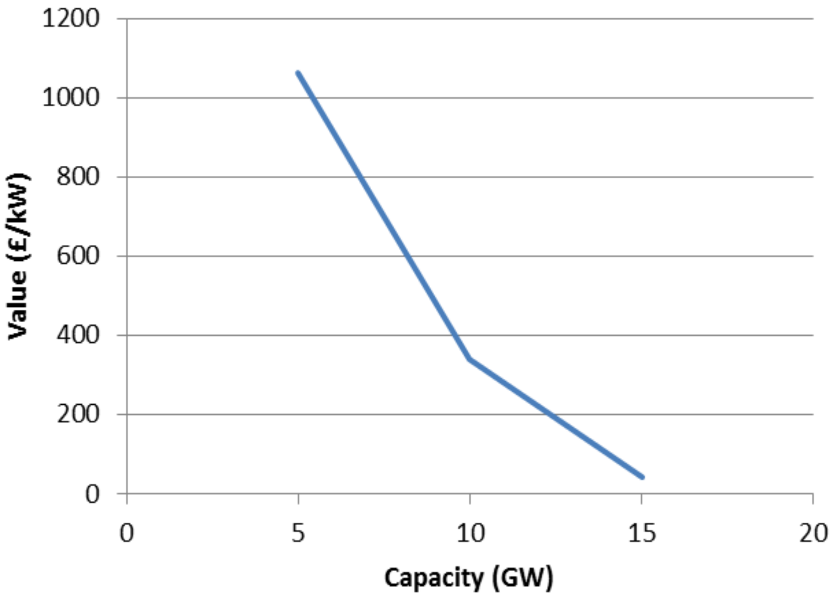
Example: *system value of new services*

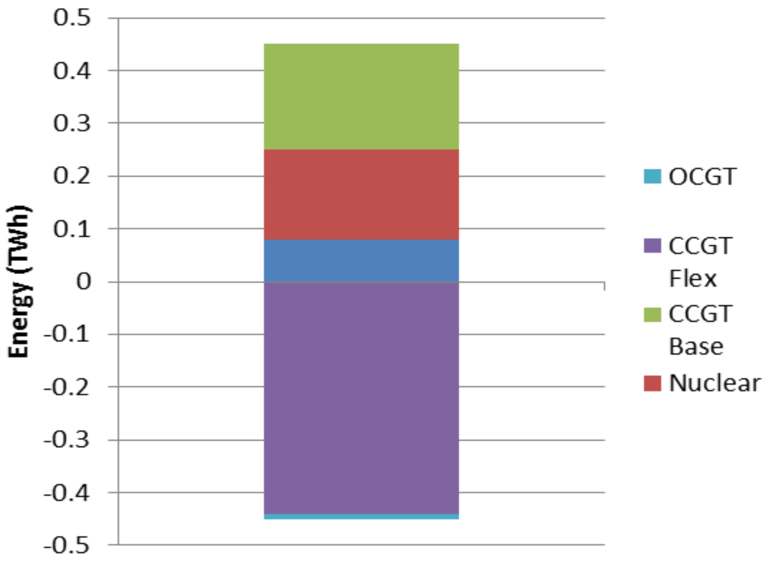




Enhancing the ability of the system to integrate RES by reducing response delivery time

Investment in flexibility ?

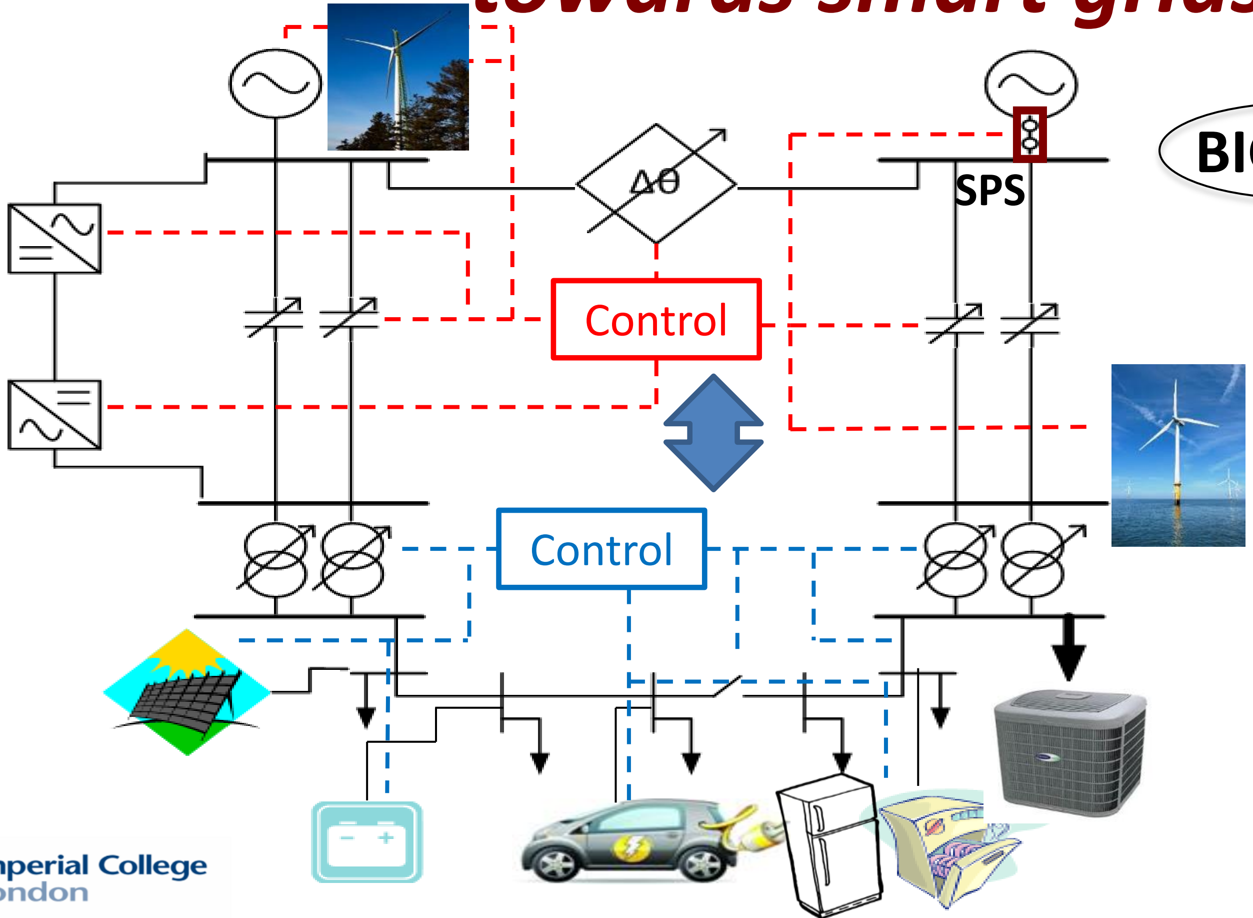


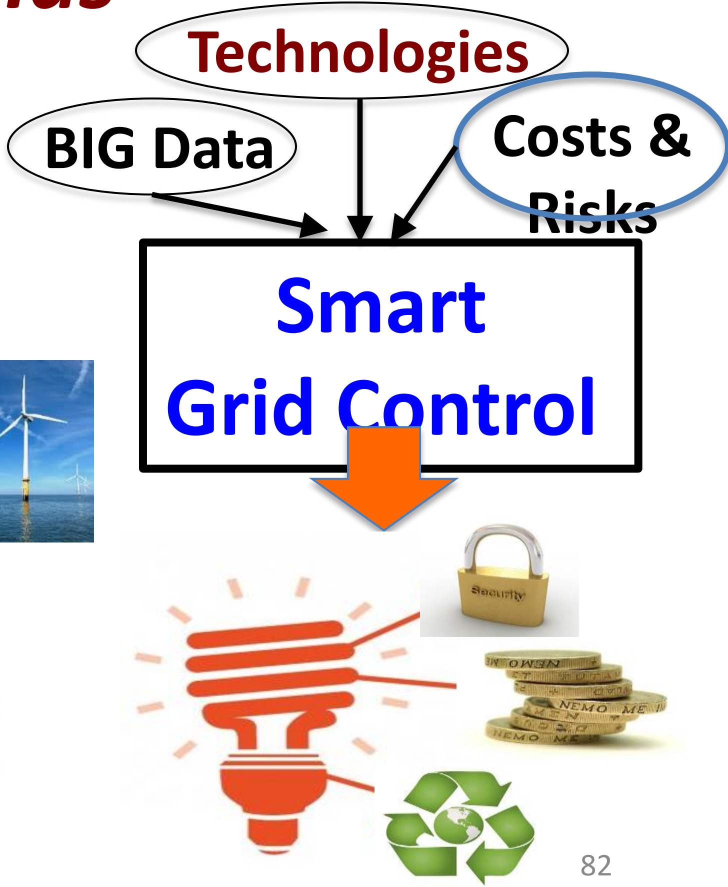


System value of enhanced flexibility of CCGTs will be significant

How about the value to investors?

Operational challenge: *paradigm shift towards smart grids*





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Balancing Services

nationalgrid

Leon Walker

Commercial Development Manager

Alignment of Balancing Services with SOF: Internal Perspective

- Required portfolio of Balancing Service products has been historically stable
- Historic change such as CAP047 [1st October 2005] which introduced cost reflectivity in frequency response
  - Mandatory Response provision changed
  - Development of commercial Firm Frequency Response Service
- We are developing our current processes to align with System Operability Framework (SOF)

Alignment of Balancing Services with SOF: Development of Internal Process

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Identify Future Areas for study	• Prioritisation of activities
Understand Requirements	• Identify available actions within current market framework (if any) • Define relationship between new product and available actions • Future view of system dynamics • Characteristics of the future requirement
Define Mechanisms to resolve issue	• Understand the potential cost implications
Stakeholder Engagement	• Understand the capability of future technology to provide service • Investment Challenge?

System Services - Commercial

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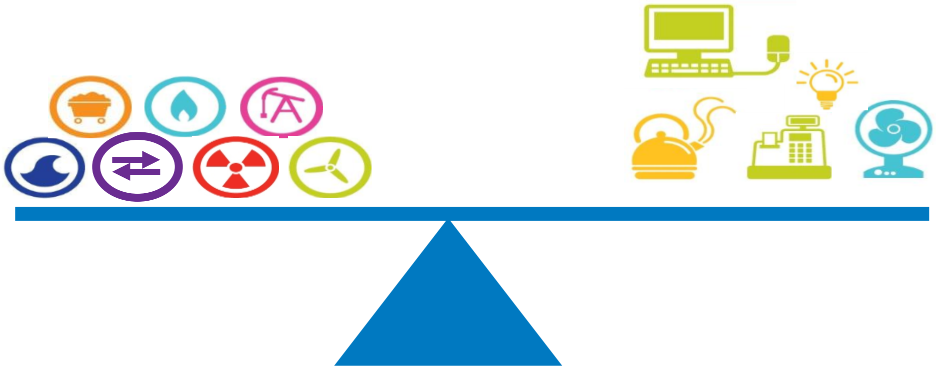
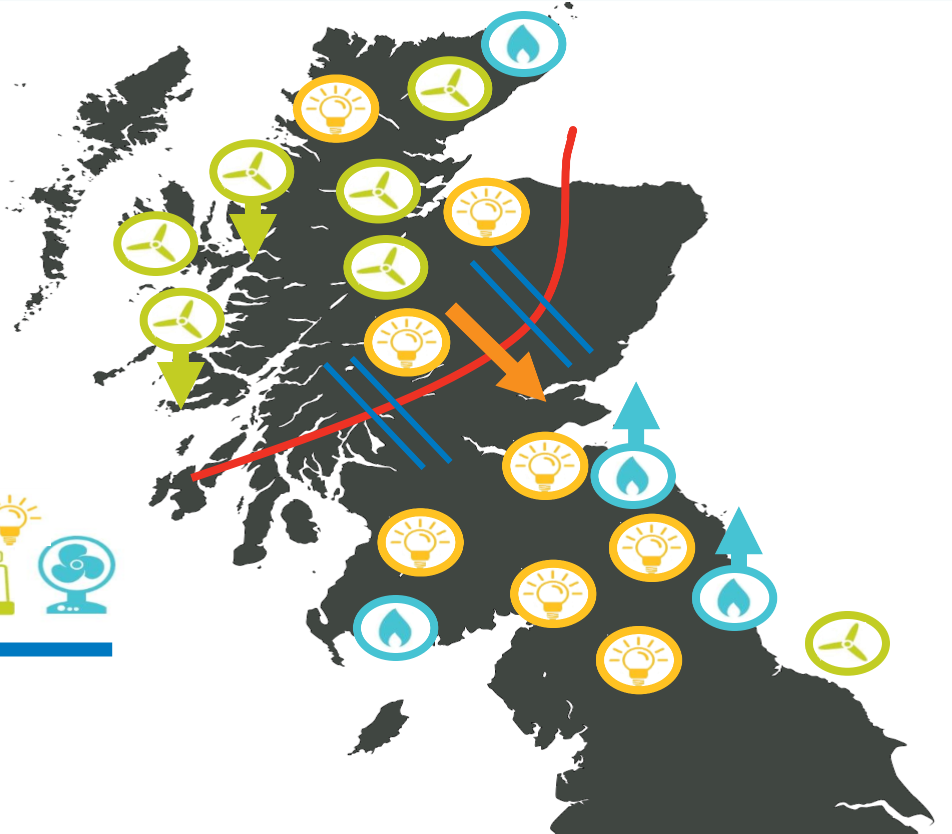
Neil Rowley

Senior Account Manager

Contract Services – What we do

- Provide Balancing Services contracts to help the SO;
  - Managing electricity flows across the networks
  - Balancing the generation and demand





The Services

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Energy

- STOR
- Firm Frequency Response
- Fast Reserve
- DSBR*
- SBR**
- Mandatory Frequency Response
- BM Start-Up
- Fast Start

System

- Reactive
- Constraint Agreements
- Intertrips
- Black Start Agreements

* In use from Nov 2014

** In use from Nov 2015

Market Tenders

Bilateral and Trading

SOF case study - Scotland Security

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- SOF identified risk of Longannet & Peterhead closing earlier than expected
- Detail studies then undertaken which identified System Operability risks
- Tender held and contract provided

SOF case study - Black Start

nationalgrid

- Black Start – contract to restore the system should any part of the transmission system need to shut now
- Typically been managed by contracting with an array of defined location thermal plants
- In the future, using the current model may make Black Start provision more difficult to contract
- Innovation funding being used to study potential commercial and technical solutions
- Output to feed input the 2015 SOF

SOF case study - Inertia

nationalgrid

- Rate of Change of Frequency

Forecast Inertia

Monitor Inertia

Largest loss

Constrain Stations

- Downward Regulation, Inertia and Voltage Evaluation (DRIVE) Tender

Additional Inertia Available?

Combined Services?

Economic?

SOF case study - Inertia

nationalgrid

- Current Options
  - Manage largest lost
  - Bring on plant with greater inertia
  - Commercial Rapid Frequency Response
- Potential Future Approaches
  - Improved signals for service requirements
  - Develop a market mechanism to reflect the value of inertia
  - Mandate inertia or frequency response requirements
  - Tenders for multi year contracts

To Conclude

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- The market is changing
- The SOF is going to help provide a valuable tool to understanding some of the challenges
- How does GB meet the future system needs?

System Operability Framework- Topics and Themes for 2015

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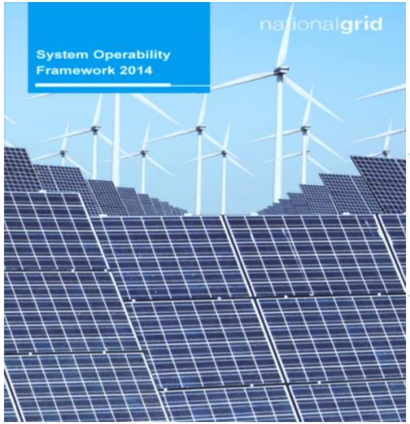
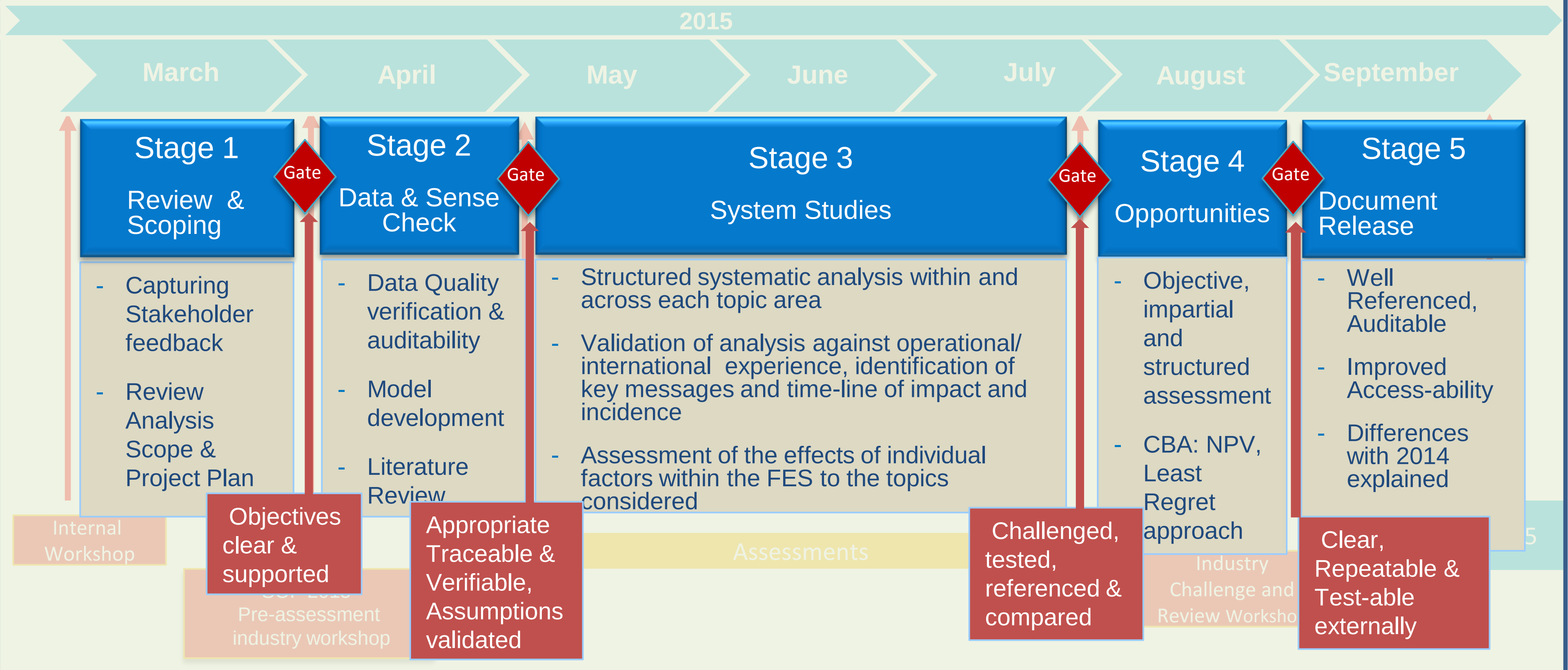


System Operability Framework 2015

Paramjit Sihre, Ben Marshall and Jordan Darley

SOF Project Team

Systemic Approach Proposed in Developing SOF 2015



Contents

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- The Themes and Topics for 2014 and how we got to them
- Feedback from stakeholders on the 2014 report, and its Topic areas
- New themes arising in 2015
- Our Initial thoughts on 2015 topics & responding to stakeholder feedback received today
- Consulting on our next steps - how we would take topic areas forward into assessment
- Anything else around these subjects - feel free to raise it!

Recap on 2014:- Themes and Topics

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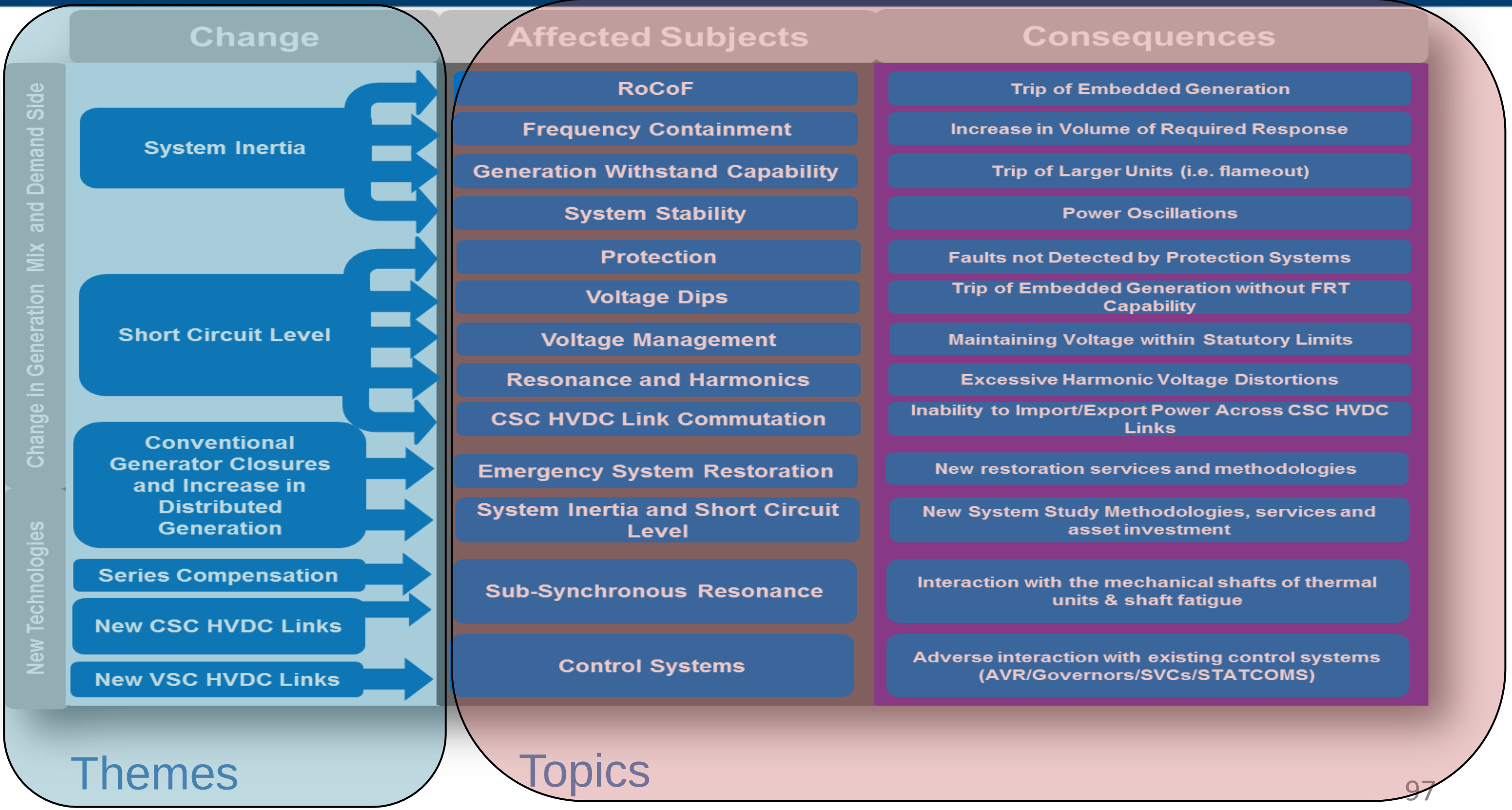
Were we missing anything Last time?

If So What?



Summary of 2014 Industry Consultation

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- Generally positive (very good engagement)
- SOF Topics
  - Number comments indicated the impact of change at the distribution level needs to be better articulated, i.e. DSR, EVs, etc.
- SOF Solutions
  - Better balance between market based products (i.e. wherever the technology is already capable), and new requirements
  - Solutions in long terms which require contract at early stages (i.e. synchronous compensator)
  - Solutions capable of providing number of services (i.e. Interconnectors, Storage)
- SOF Engagement
  - Strong desire to be involved at different stages of development of SOF, making it a GB Operability Framework

So onto 2015:- Themes and Topics?

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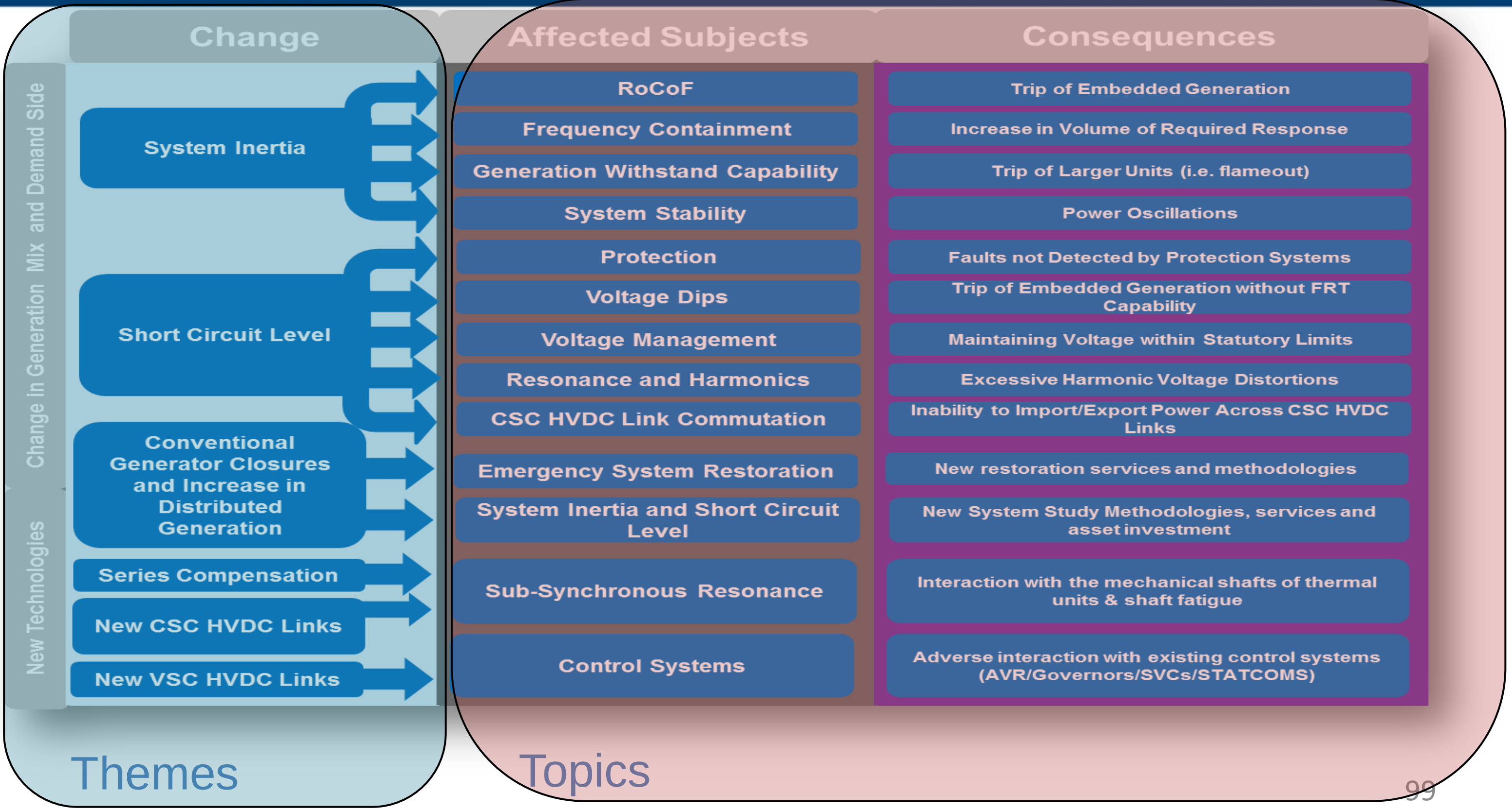
Is anything from 2014 not needed this time?



New Themes for 2015 - whole T&D system impact?

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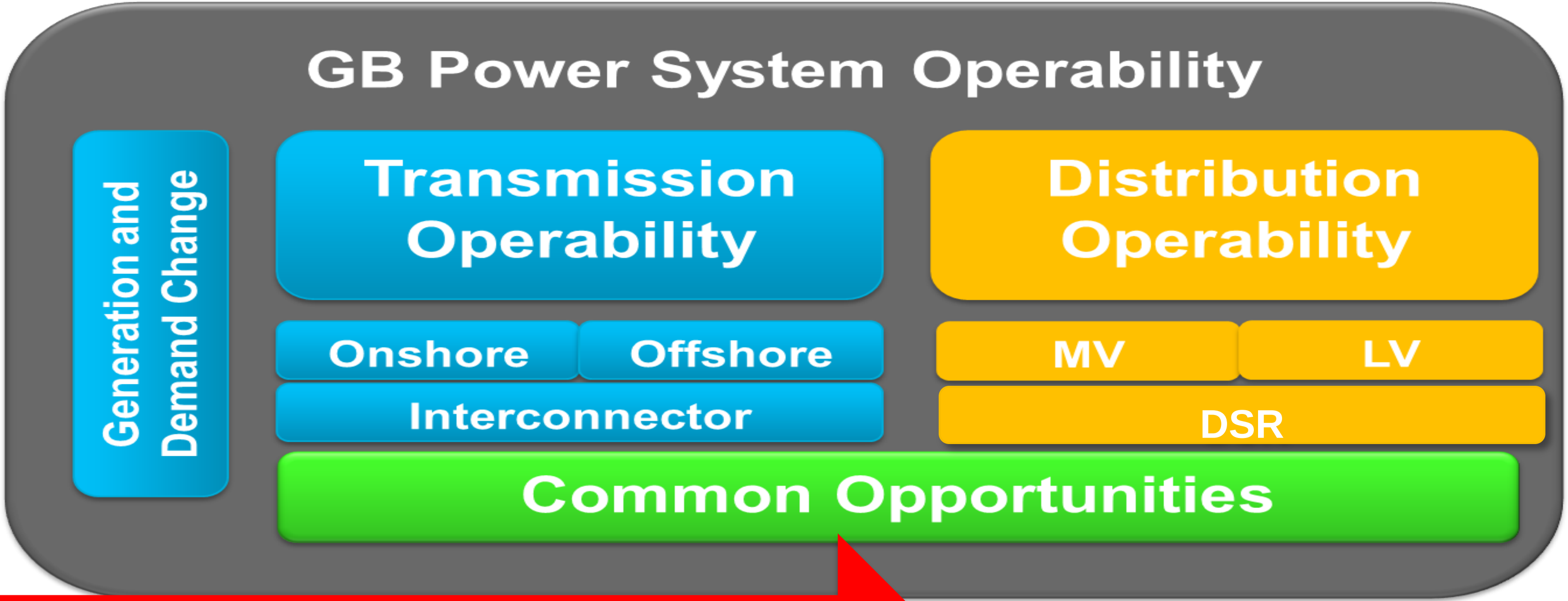

Review 2014 Themes for future SOF+ new ones of "Controlability" and "Demand Side Response"?

DNO & other network Engagement?

Reduction in Control-ability?

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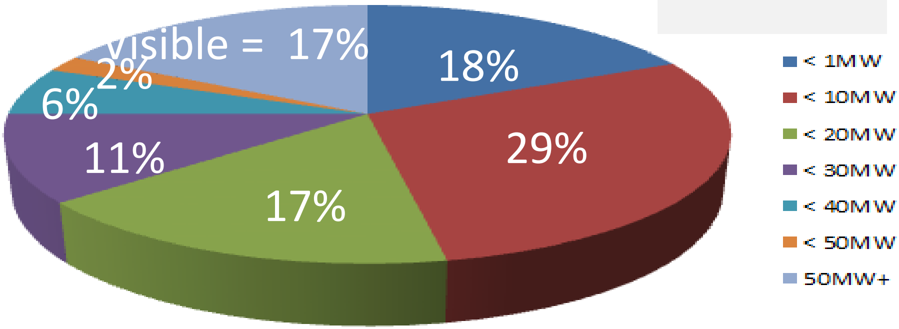
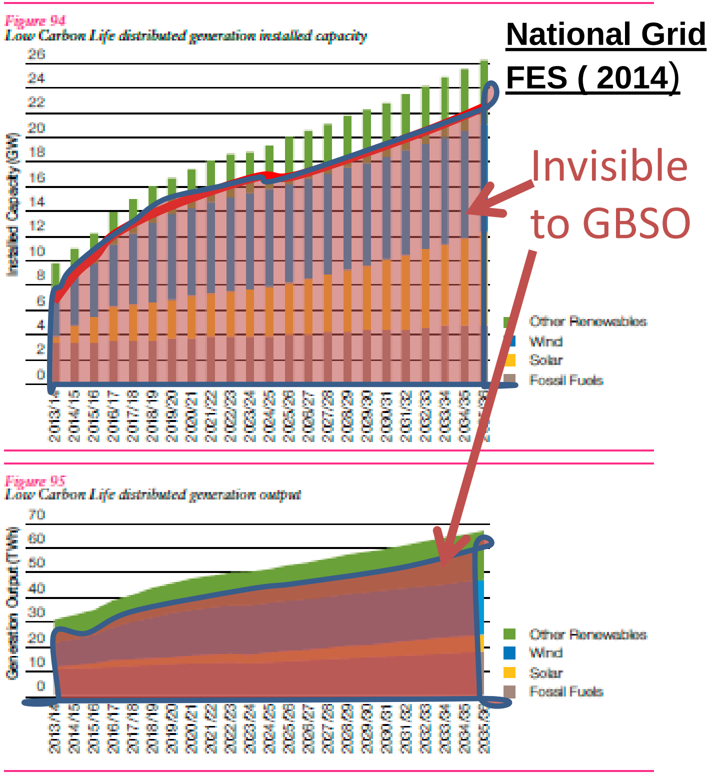
Current % Of Embedded Generation by size (Dec 2014)



National Grid FES (2014)



- Increasingly generation is smaller, less visible to GBSO & DNOs
- Intermittency, variety (Solar, wind, Hydro + CHP), Active Network Management,
- What is the raw demand underlying? Regionally- does export dominate?
- Given price sensitivity- is raw demand still diverse & traditionally predictable?
- Challenges to the operators range of control actions?

Demand Side Response?.

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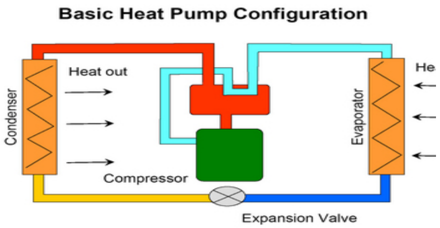

- In SOF 2014; considered as a service opportunity, but is it more than that?
- In SOF 2015; in addition we propose a broader consideration of the role of DSR, capturing various strands of *Network Innovation Allowance* and other work in these fields-
  - contrasting the effects of organic and directed DSR, and the different types of DSR available?
  - Capturing the impact of DSR on the load curve, the effects of rapid charging/ heating on DSR impacting devices with cyclical consumption?
  - considering the broader application of DSR in containment and demand control in emergency scenarios?

New Themes 2015- Reliance On External Systems?

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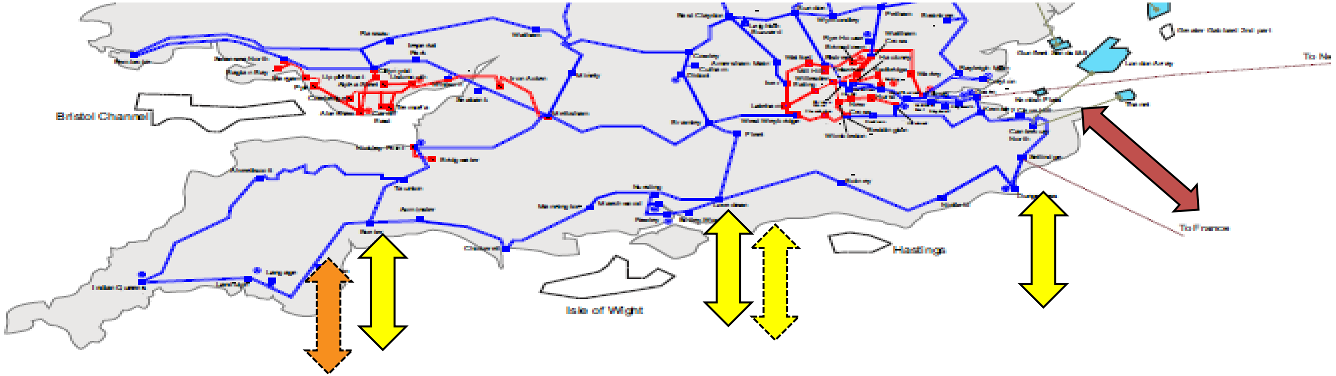

- In 2014 considered only in HVDC Technology risk but where is the power coming from/ going to?
- Scale of overall interconnection- more rapid changes due to market/ system/ or continental environmental effects?
- Common mode failures/ impacts, e.g. voltage dips on continent leading to RoCoF in GB?

How planning, operation and design are impacted when the external network becomes more significant?

New Themes 2015- New Nuclear Projects?

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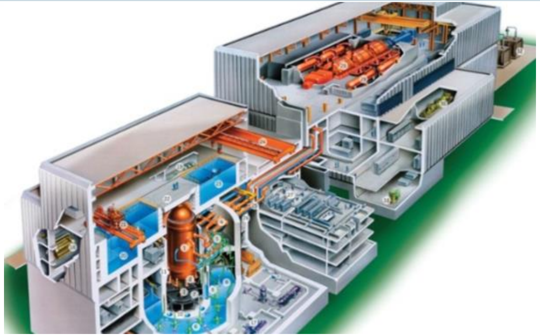

- New Nuclear will be the largest single units designed for the GB transmission system, Operationally what does this mean for us?
  - Against the context of an increasingly non-synchronous source system
  - Operating in extremes of high and low demand and transmission flow
- The characteristics, capabilities and opportunities arising from these developments may have particular relevance?

New Themes 2015- Electrification of Heating & Transportation?

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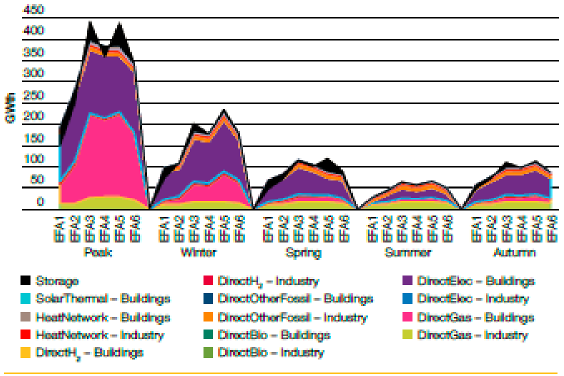
Heat duration supply curve for 2050

National Grid FES (2014)



- Based on the levels of electrification anticipated in the FES - are the levels of reliability and availability we traditionally expect from a transmission system still appropriate going forward?
- How do these expectations translate to operational planning, network design, management of emergency conditions? Is network & system resilience requirements related to these factors?

New Themes & Topics 2015- The Story So Far…

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	Change	Affected Subjects
Changes in Generation Mix and Demand	System Inertia	RoCoF Frequency Containment Generation Withstand Capability System Stability
	Short Circuit Level	Protection Voltage Dips Voltage Management Resonance and Harmonics LCC HVDC Commutation
	Reduction on Controlability	Supply and Demand Predictability
	Distributed Generation Increases Electrification of Heating and Transportation Demand Side Response	DNO-TSO Interaction
	Conventional Generation Closure New Nuclear Power Plant	Emergency System Restoration
Network Upgrades & New Technology	Increased Reliance on External Power Networks	System Resilience
	Series Compensation New CSC HVDC Links	Sub-synchronous Resonance
	New VSC HVDC Links	Control Systems

New Topics & Themes

Next Steps- how this informs assessment

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- Your Feedback on Topic areas will form context to our systematic SOF 2015 appraisal

- Should other approaches be considered- if so what?

- What is most effective approach to displaying results- load duration, impact magnitude, reference to system metrics- something else?

Network Innovation Competition:
SMART Frequency Control - (Enhanced Frequency Control Capability, EFCC)

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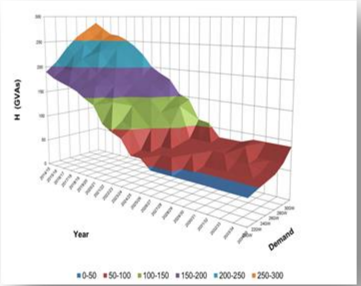

Charlotte Grant

SOF Project Team

Agenda

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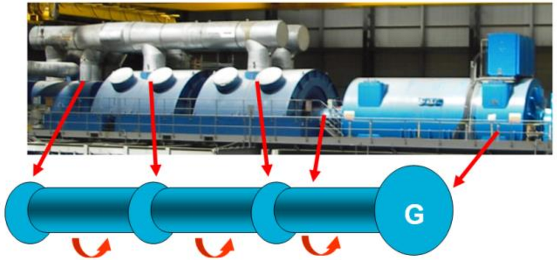
- Changes to the Transmission System - system inertia challenge
- Why SMART frequency control?
- SMART Frequency Control Project overview
- Project partners & collaboration
- Industry engagement and knowledge dissemination

Changes to the Transmission System

- Less synchronous and more asynchronous
- Wind and solar PV have very little or no natural inertia (no directly connected rotating mass)
- More Interconnectors



Turbine Shafts (HP, IP, LP)

Why SMART Frequency Control?

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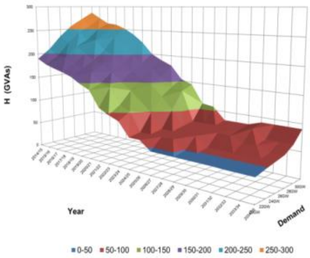
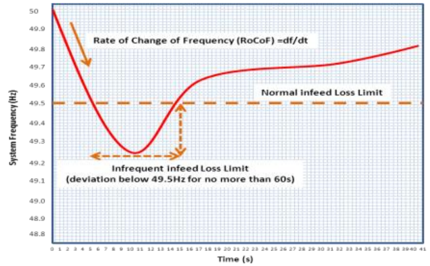
- Output from System Operability Framework….
  - Forecasted reduction of system inertia from 360GW/s to 150GW/s (by 2025 under Slow Progression or 2022 with Gone Green)
  - RoCoF increasing from 0.125Hz/s to 0.3Hz/s
- Increasing variability of system inertia
- Under Gone Green scenario, potential additional cost of ~£200m to carry larger volume of response reserve
- Fast frequency control to maintain operability and reduce cost
- Network Innovation Competition; Ofgem awarded **E**nhanced **F**requency **C**ontrol **C**apability November 2014 - SMART Frequency Control





	Solution
New Services	Enhanced Frequency Control (Fast Response)
	Low Load Operation of Thermal Plants
	Synchronous Compensator

SMART Frequency Control Project - Overview

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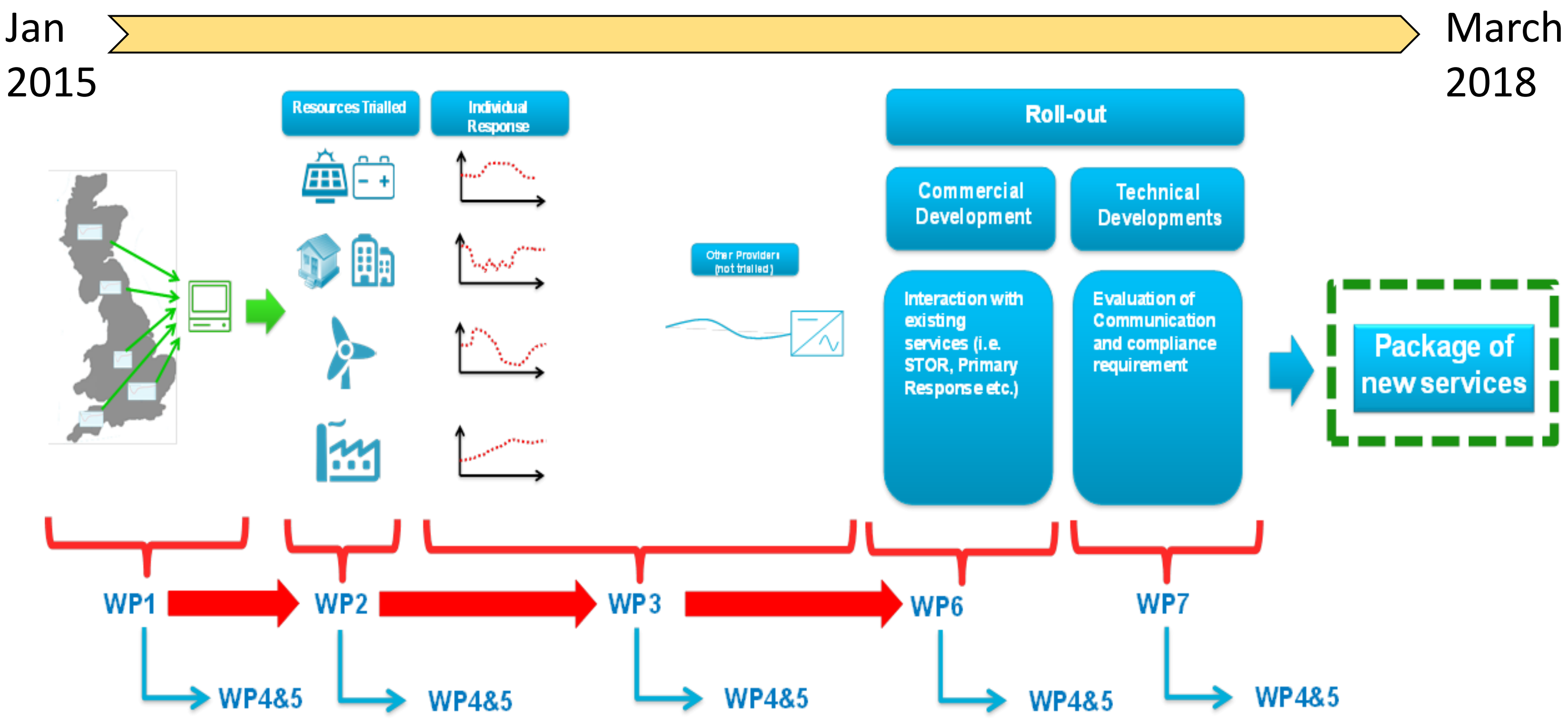

Project Partners & Collaboration

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- **Work Package 1 - Control System**
  - Event detection and control

ALSTOM

- **Work Package 2 - Assess response from service providers**

BELECTRIC™ centrica flexitricity Unlocking smart grid revenue

- **Work Package 3 - Optimisation**
- **Work Package 4 - Validation**
- **Work Package 5 - Knowledge dissemination**

MANCHESTER 1824 The University of Manchester

University of Strathclyde Glasgow

- **Work Package 6 – Commercial**
  - Development of commercial frameworks

nationalgrid

- **Work Package 7 – Communications**
  - Control room interfaces

ALSTOM

Industry Engagement & Knowledge Dissemination

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- SMART Frequency Control Project website
  - http://www.nationalgridconnecting.com/The_balance_of_power/
  - Publishing project updates, learning outcomes, events
  - Contact project team

System Operability Framework 2015 – Next Steps

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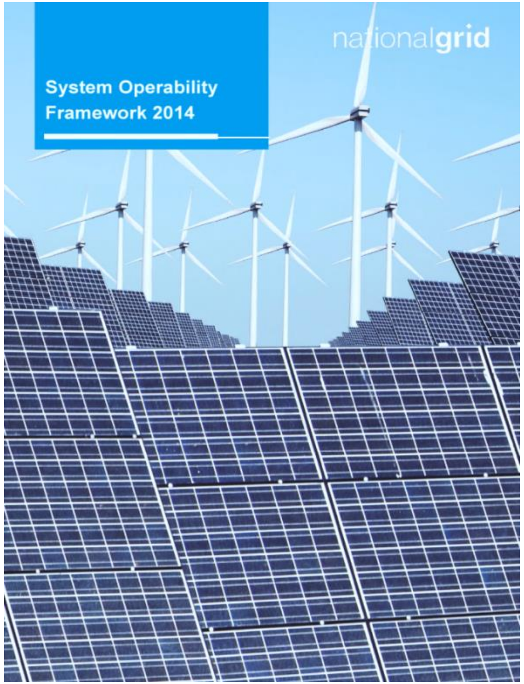
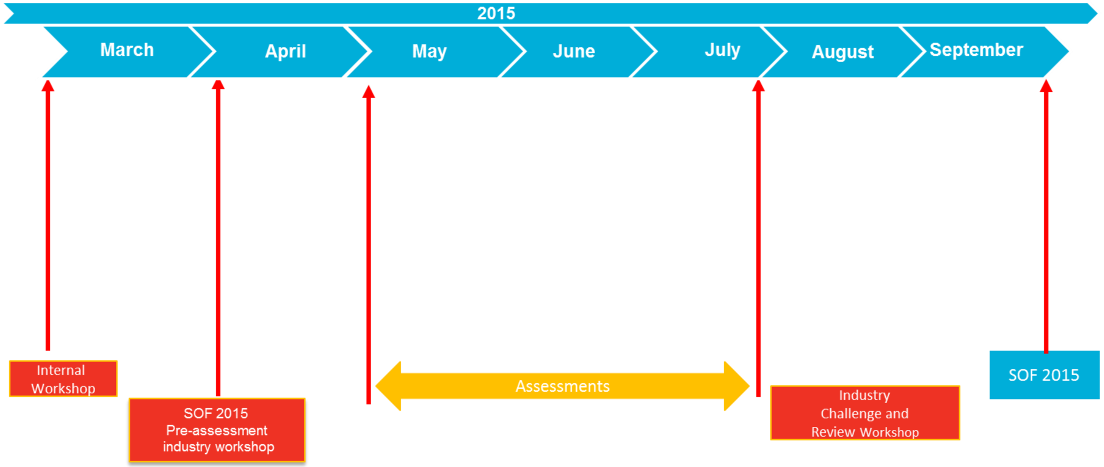


Vandad Hamidi

SMARTer System Performance Manager

System Operability Framework 2015 – Next Steps

- Your Feedback on Topic areas will form context to our systematic SOF 2015 appraisal…
- Challenge and review of the results: August-September; How?
- Do we need another workshop?



System Operability Framework 2015 – Next Steps

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- SOF Solutions and need for Innovation in some areas
- Capability that already exists/retrofit?
    - We would like to know and please get in touch with us
- Areas which require feasibility study/demonstration/innovation
    - Network Innovation Allowance (NIA)
    - Network Innovation Competition (NIC)

System Operability Framework

Thank you and have a safe journey back!

Email:
box.transmission.sof@nationalgrid.com