

# System Operability Framework

nationalgrid

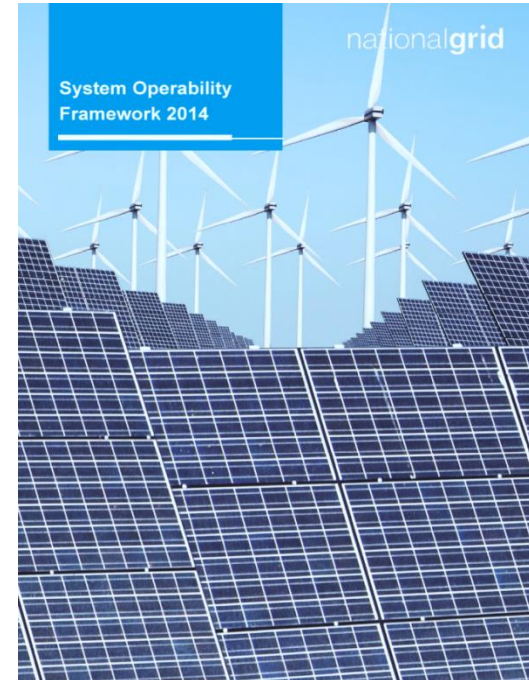
Welcome to the Pre-Assessment Industry Workshop





Vandad Hamidi

SMARTer System Performance Manager



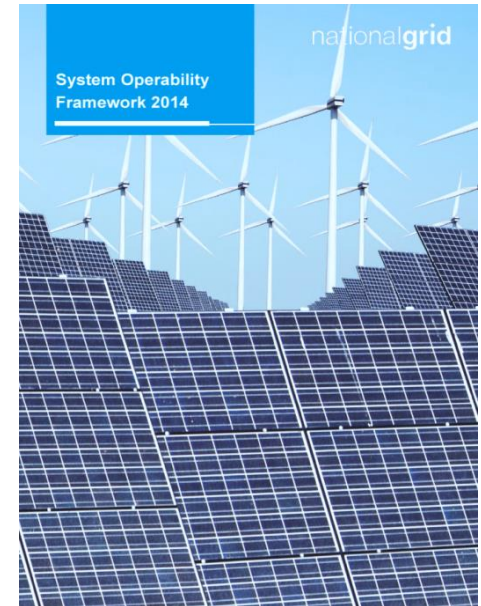
- No planned fire alarm
  - Leave through nearest exit - You will be directed by Fire Marshals
  - The muster point is outside the building in the car park
- Facilities
- Tea and Coffee
- Mobile phones

- **[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



Richard Smith

Head of Network Strategy

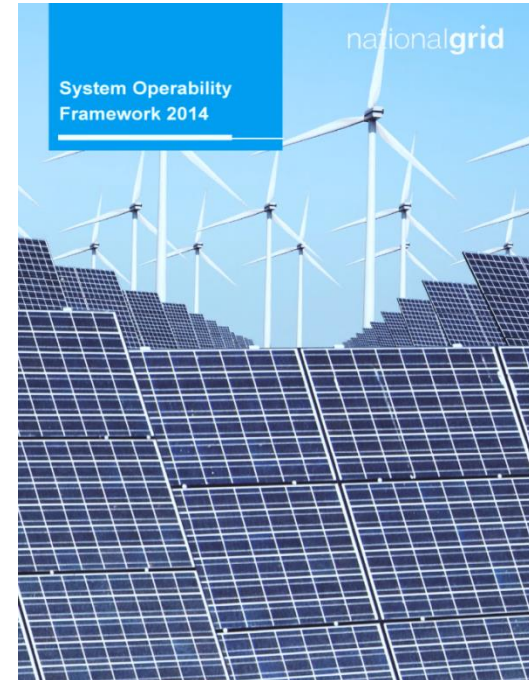






Vandad Hamidi

SMARTer System Performance Manager





*Serving the Midlands, South West and Wales*

# **SOF Workshop 9<sup>th</sup> 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

# 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

# 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



# 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 starting 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...

# System Operability

## An External Perspective



Bless Kuri

Scottish Hydro Electric Transmission plc

National Grid, System Operability Framework  
Workshop 9 April 2015

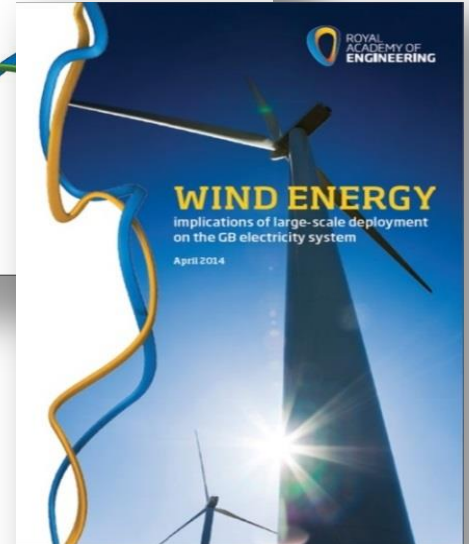
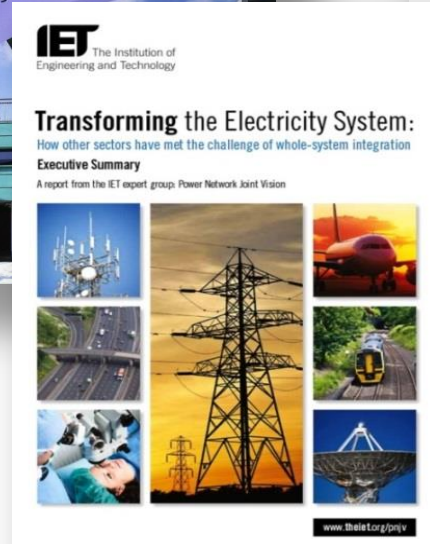
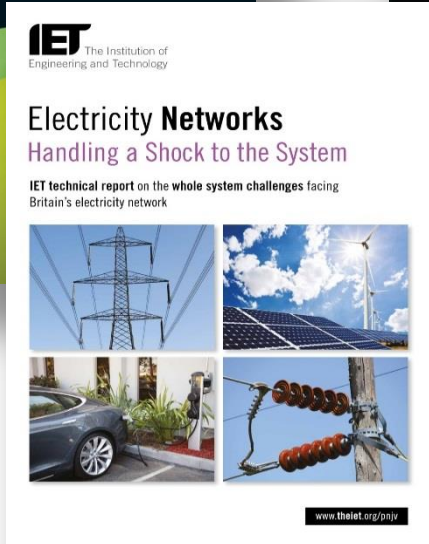
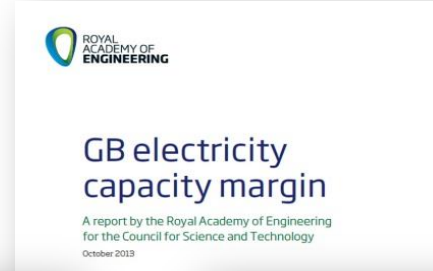
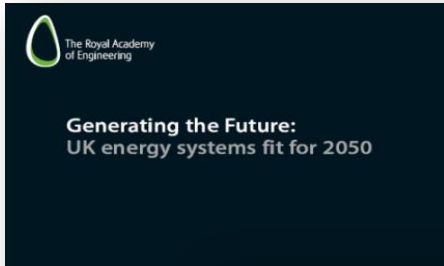
# Challenges to the GB power system

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





# Challenge 1: Rebuilding the electricity system

while maintaining adequate capacity



Climate Change Act 2008

Environmental commitment:  
80% reduction in CO<sub>2</sub> 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*

- 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

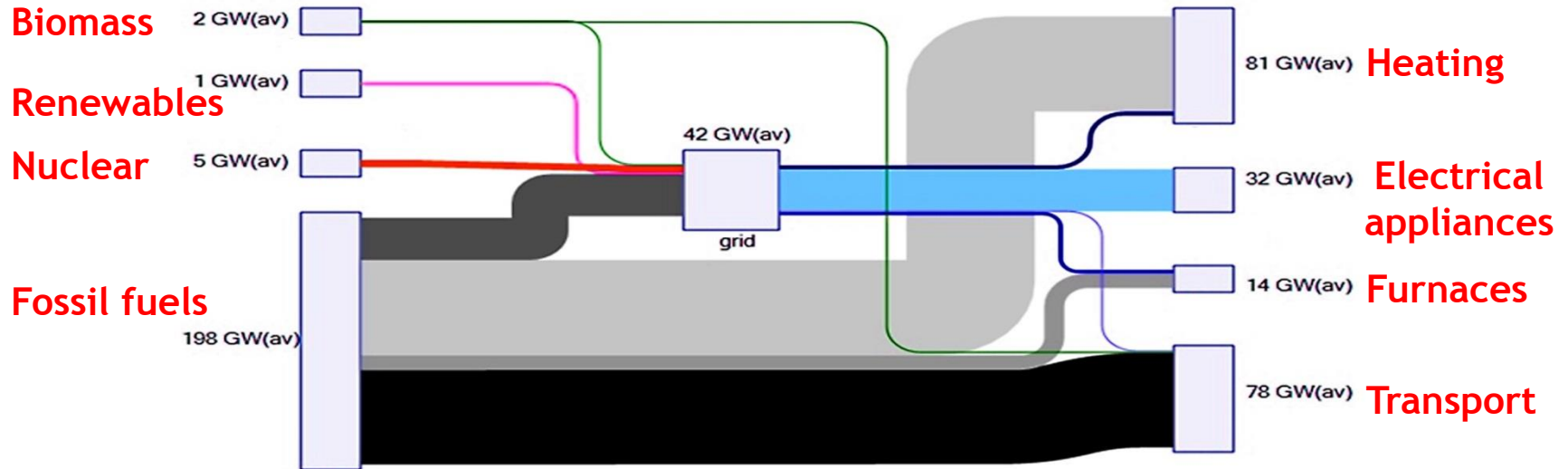


*Heysham 1 & 2*

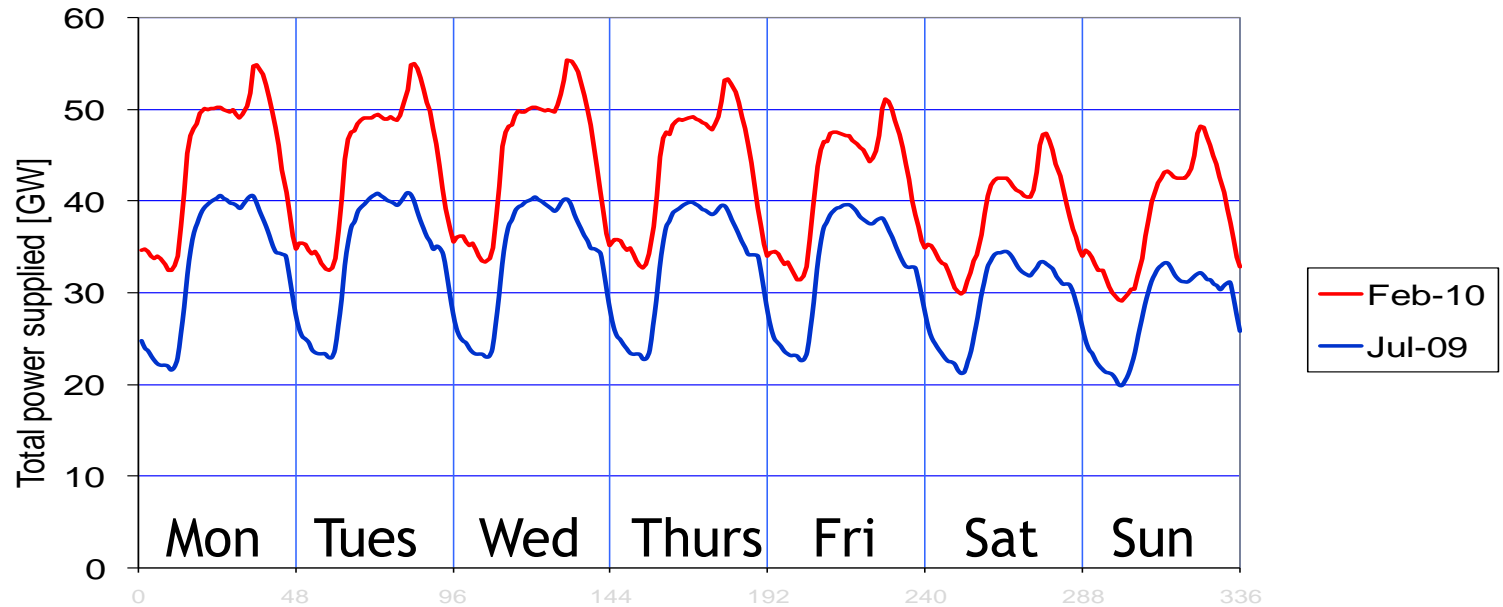
# Challenge 2: Decarbonisation of heat and transport

## Supply

## Demand

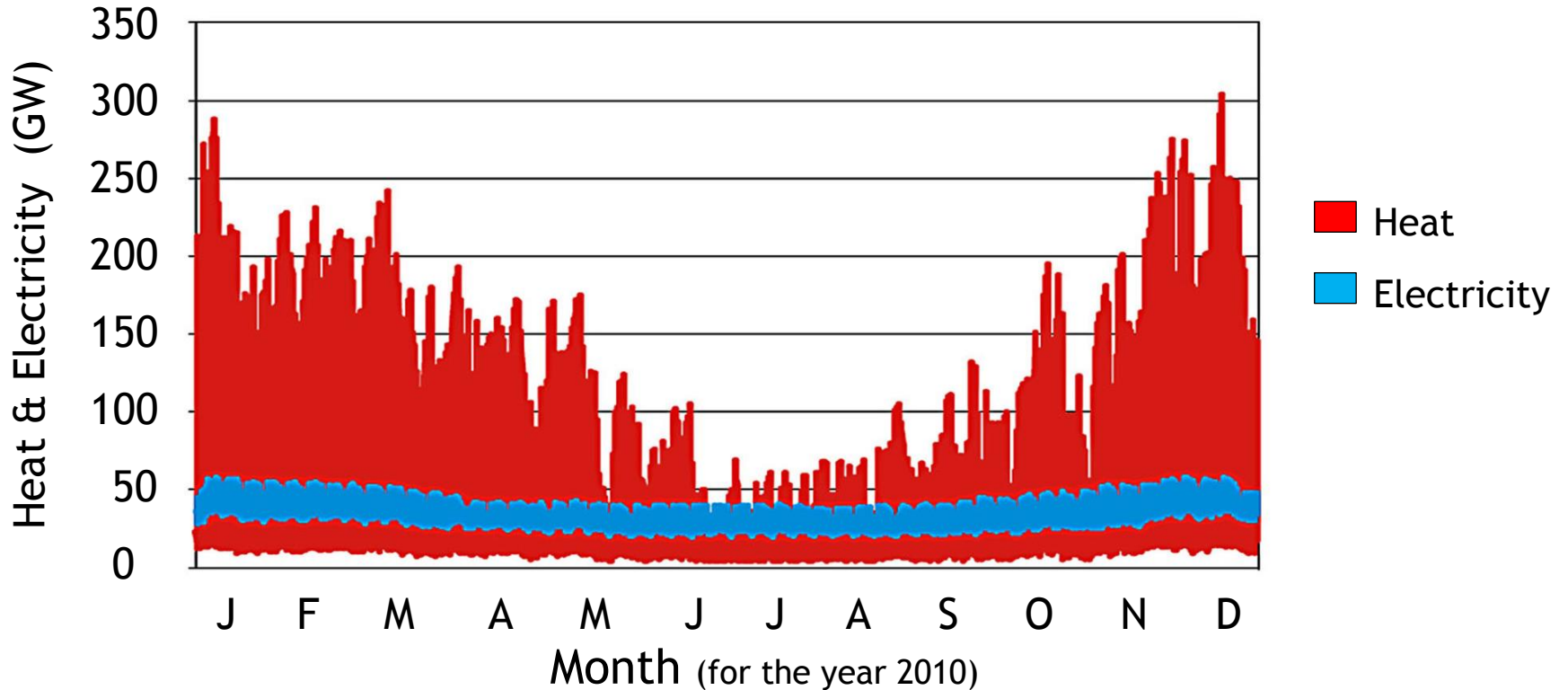


# Daily demand on the electricity grid



# GB use of heat and electricity

(Domestic and commercial sectors)



Source: *The future of heating*, DECC and Imperial College

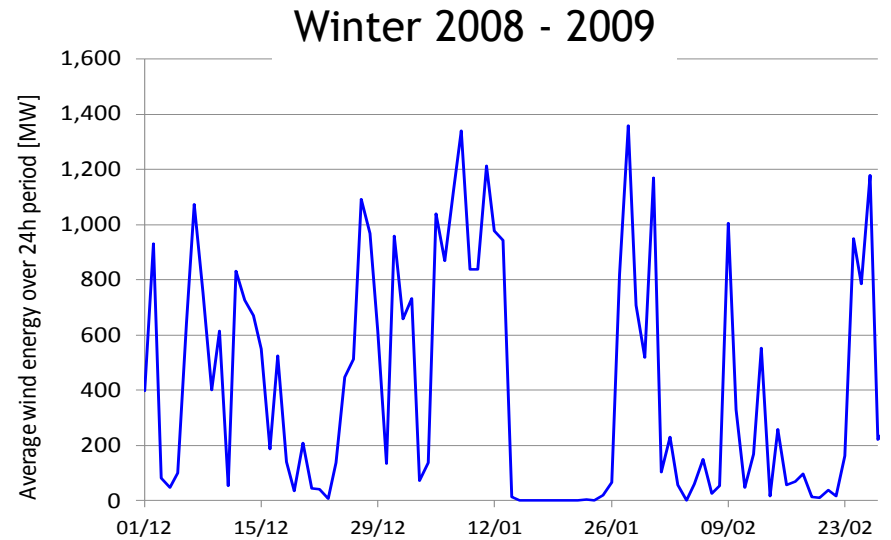
# Transferring heating load to electricity



- 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



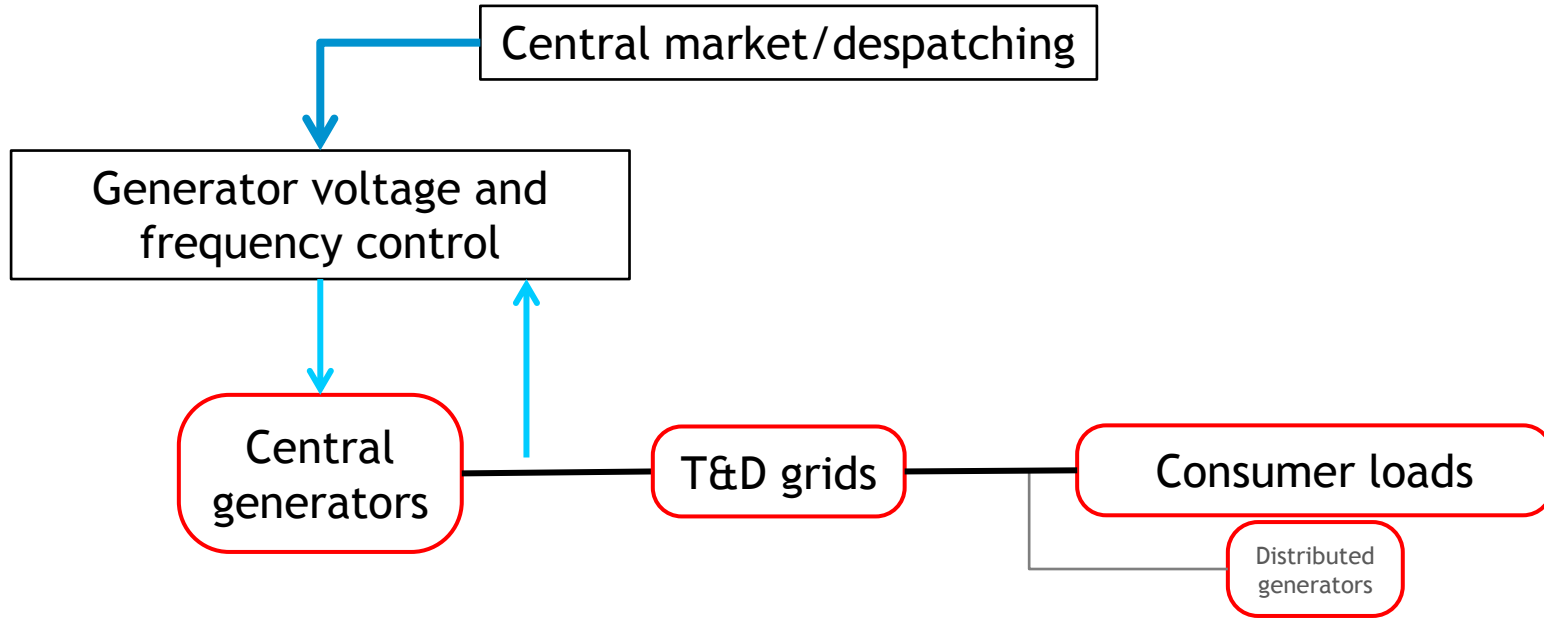
# Challenge 3: Intermittency



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

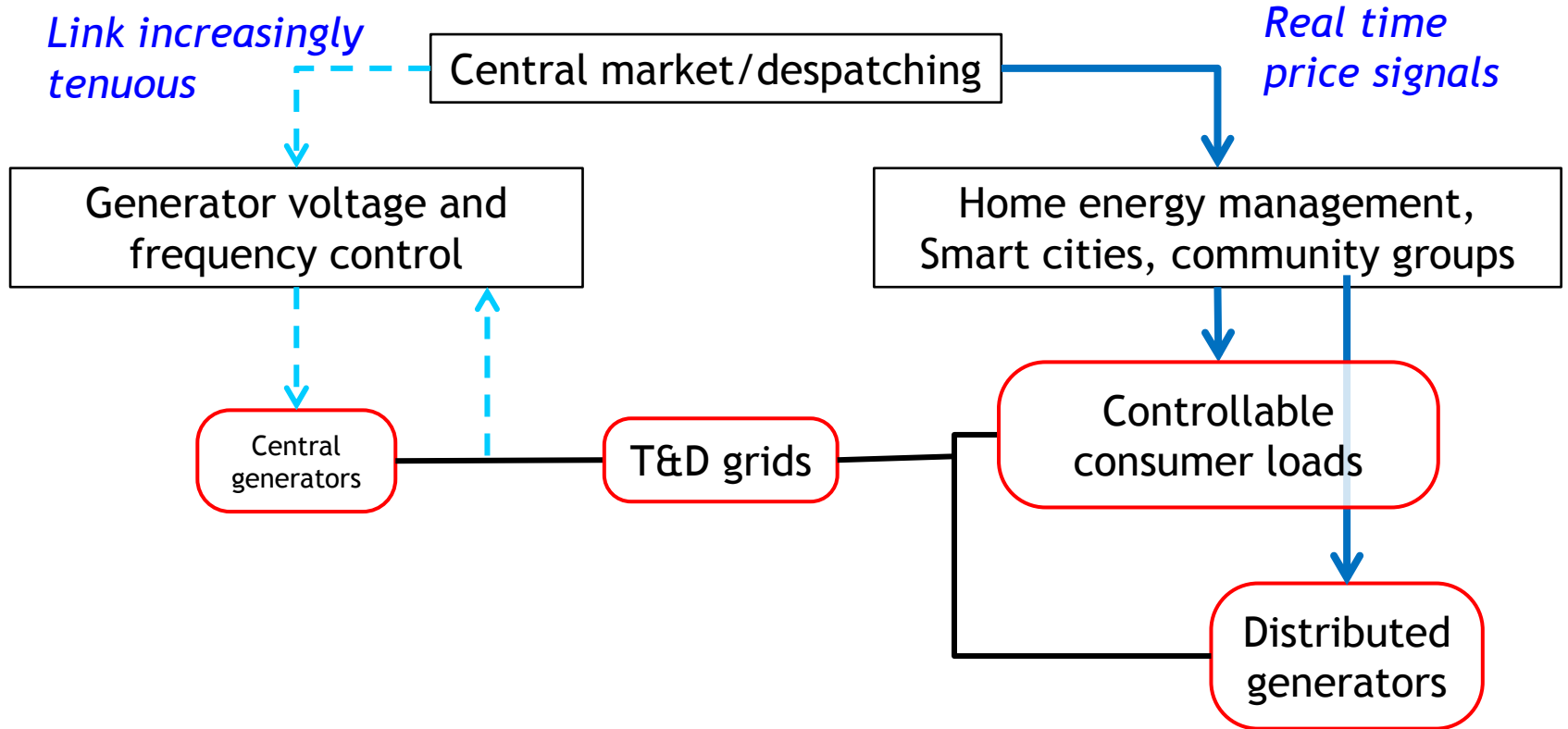
# Challenge 4: system control

(2015 - CO<sub>2</sub> emission 450 g/kWh)



# Challenge 4: system control

(2030 - CO<sub>2</sub> emission 50 g/kWh)

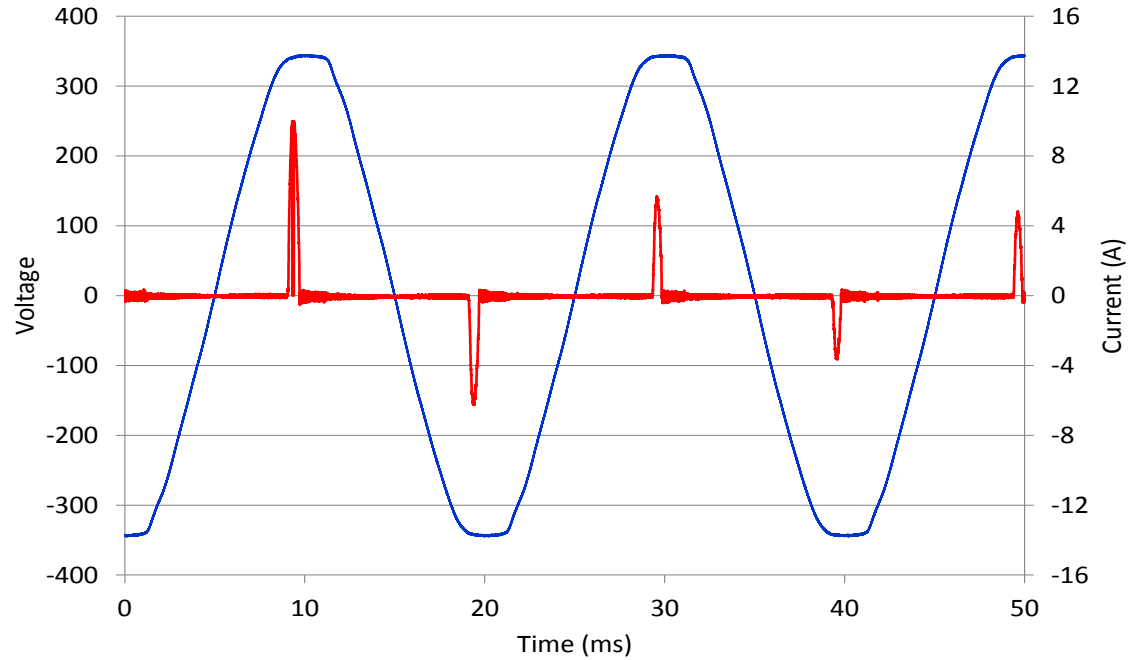


## Challenge 5: Power quality

- **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



Ringling 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)

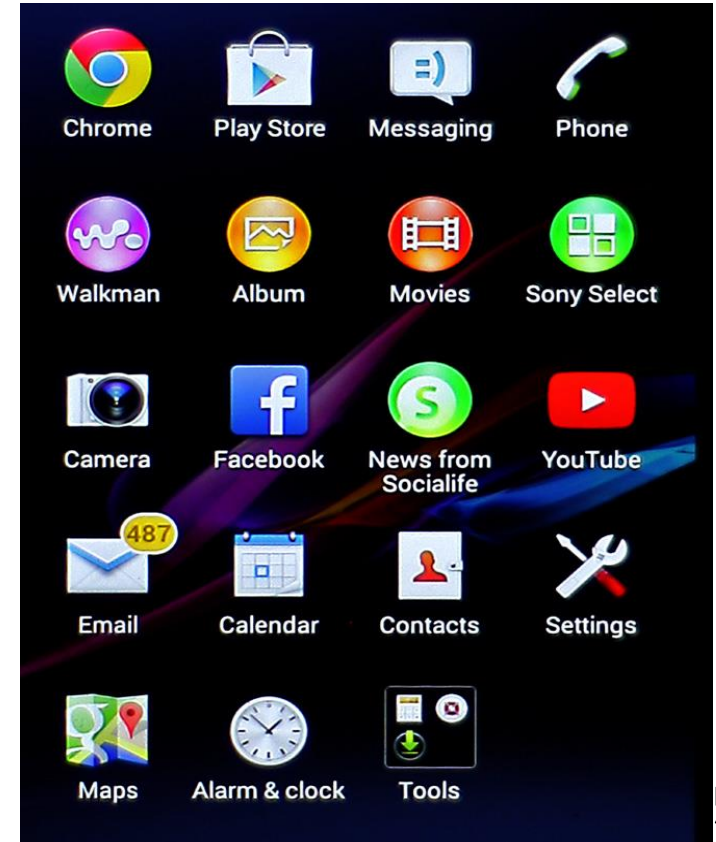
*Photo: Tesla Roadster*

## 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<sub>2</sub> 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 ... ..

**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](http://www.theiet.org/pnjv)

## “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



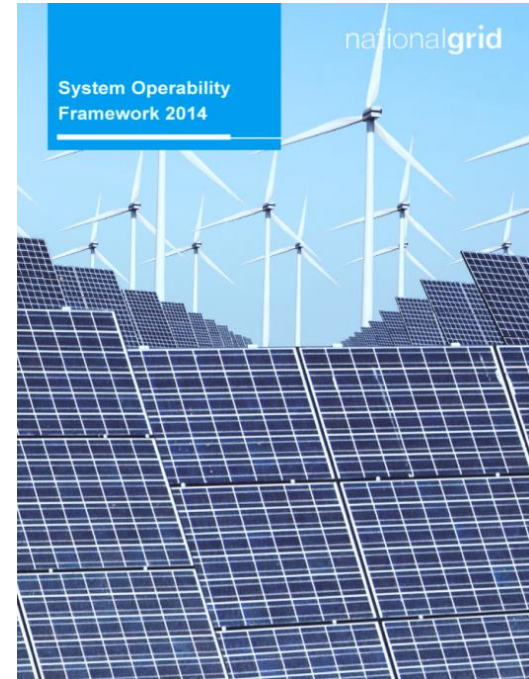
# Expectations of SOF and NG

	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



Liena Vilde

SOF Project Team



## Islanded AC power system

## Changes in the energy landscape

### Generation

Increase in non-synchronous generation

Closure of conventional plants

Increase in Embedded non-synchronous generation

### Demand side

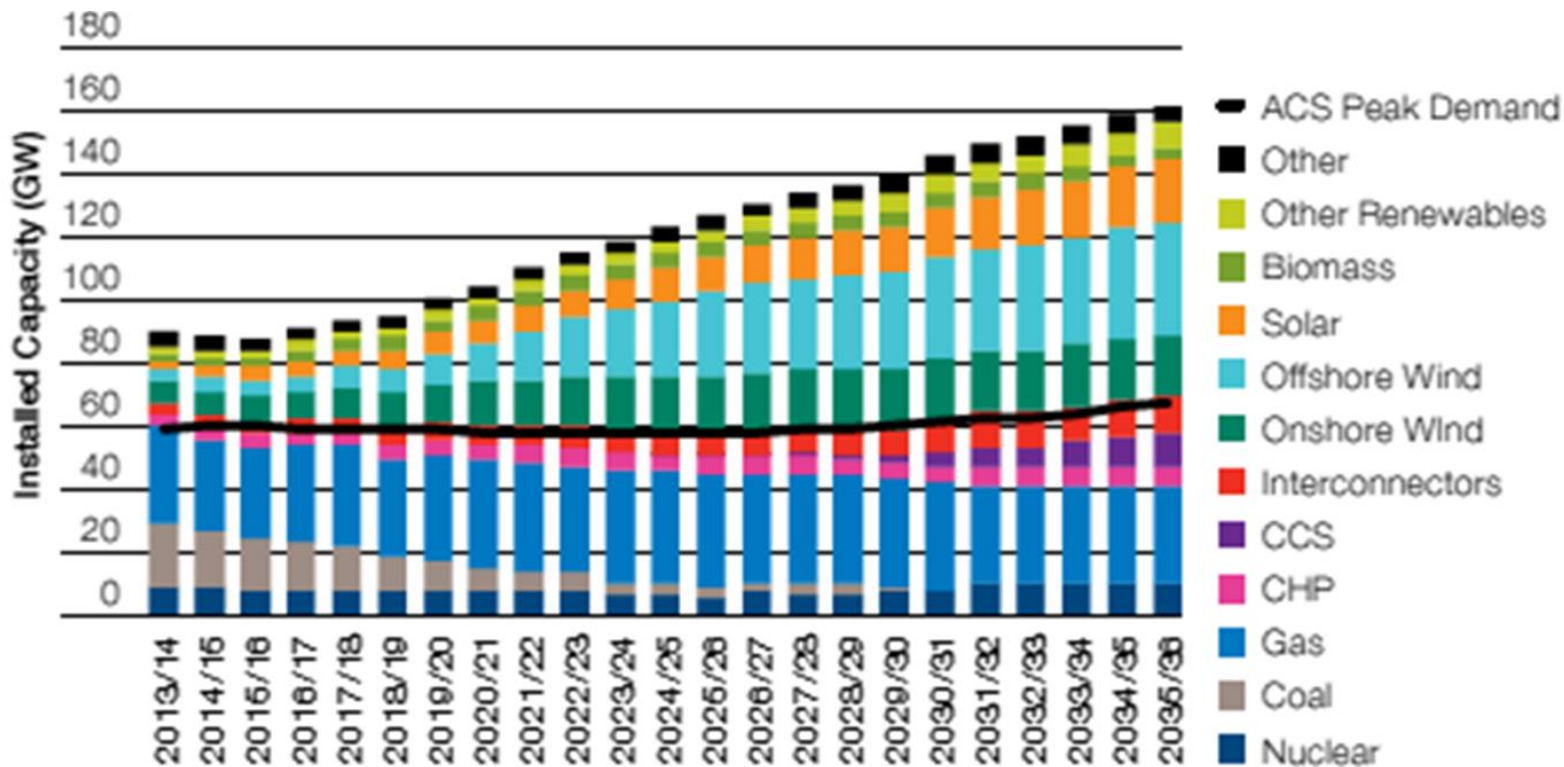
Change in Demand type (LED lights – Heat Pump)

### Network

First Embedded HVDC Link (parallel to AC)

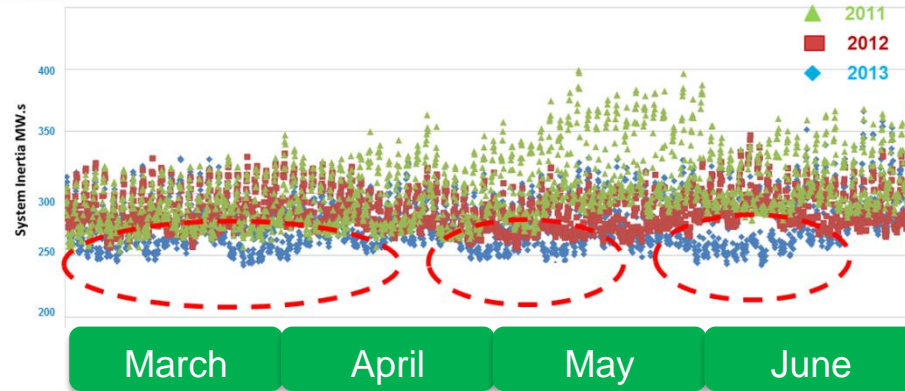
Thyristor Controlled Series Compensation (TCSC)

# Why do we need a System Operability Framework in GB?

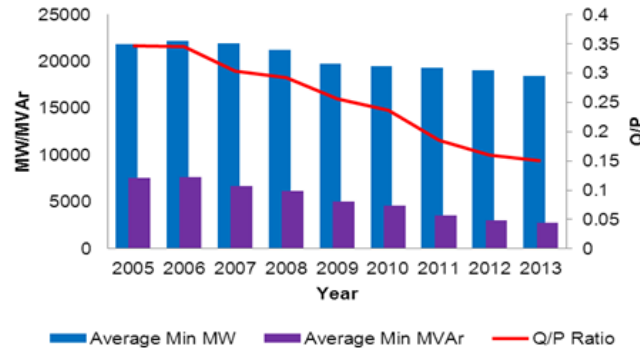


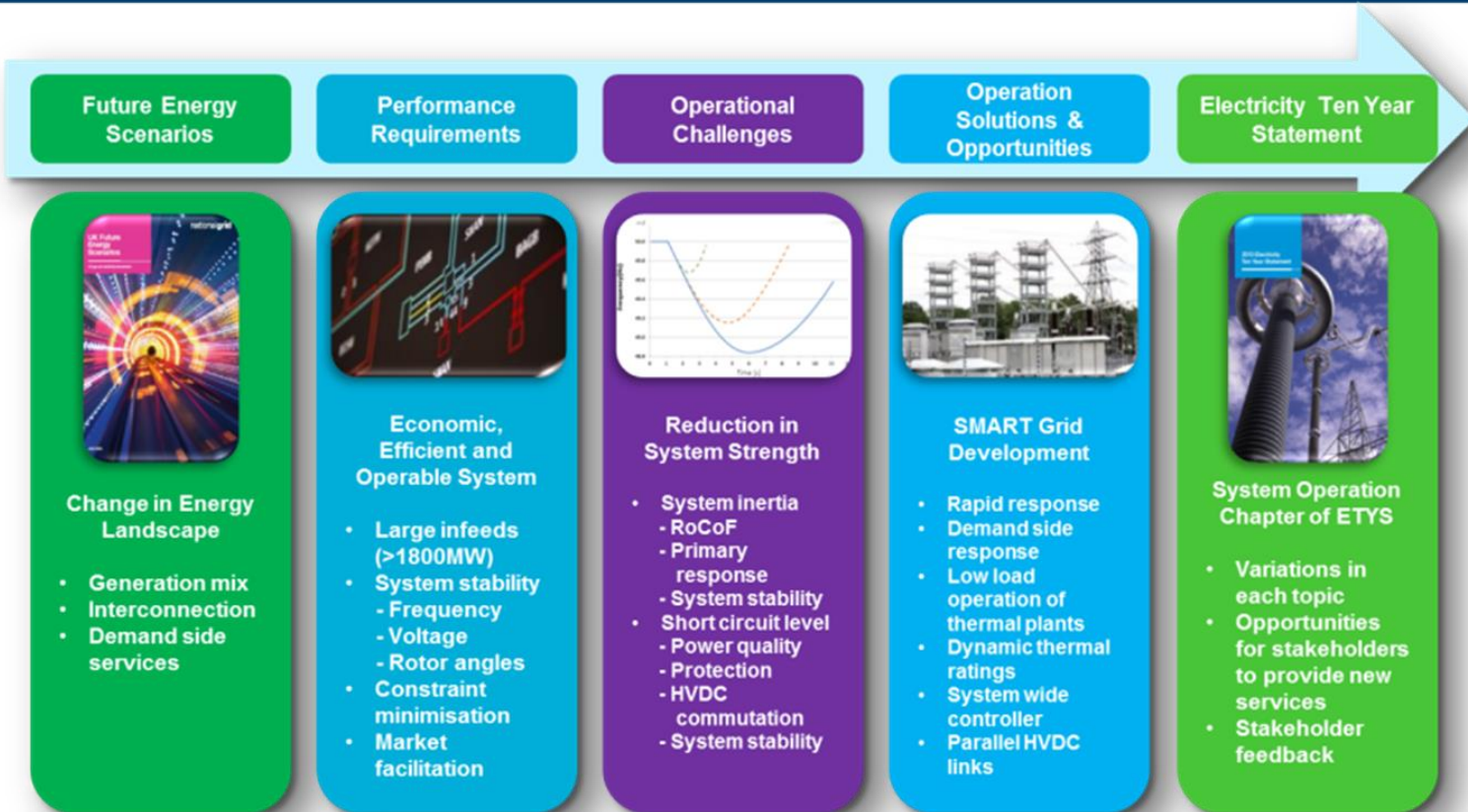
# And the impact?

System Inertia

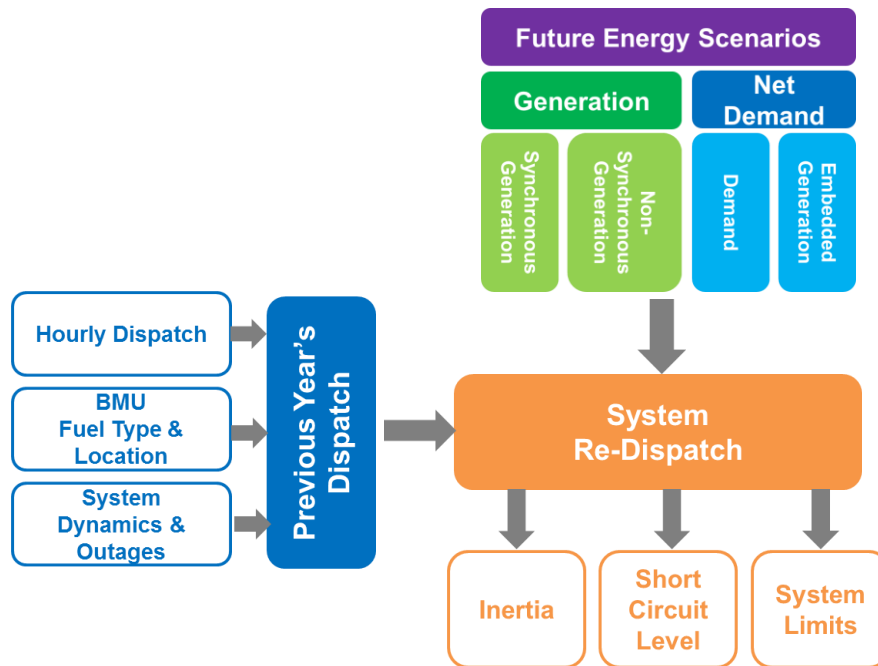


MVAr Demand





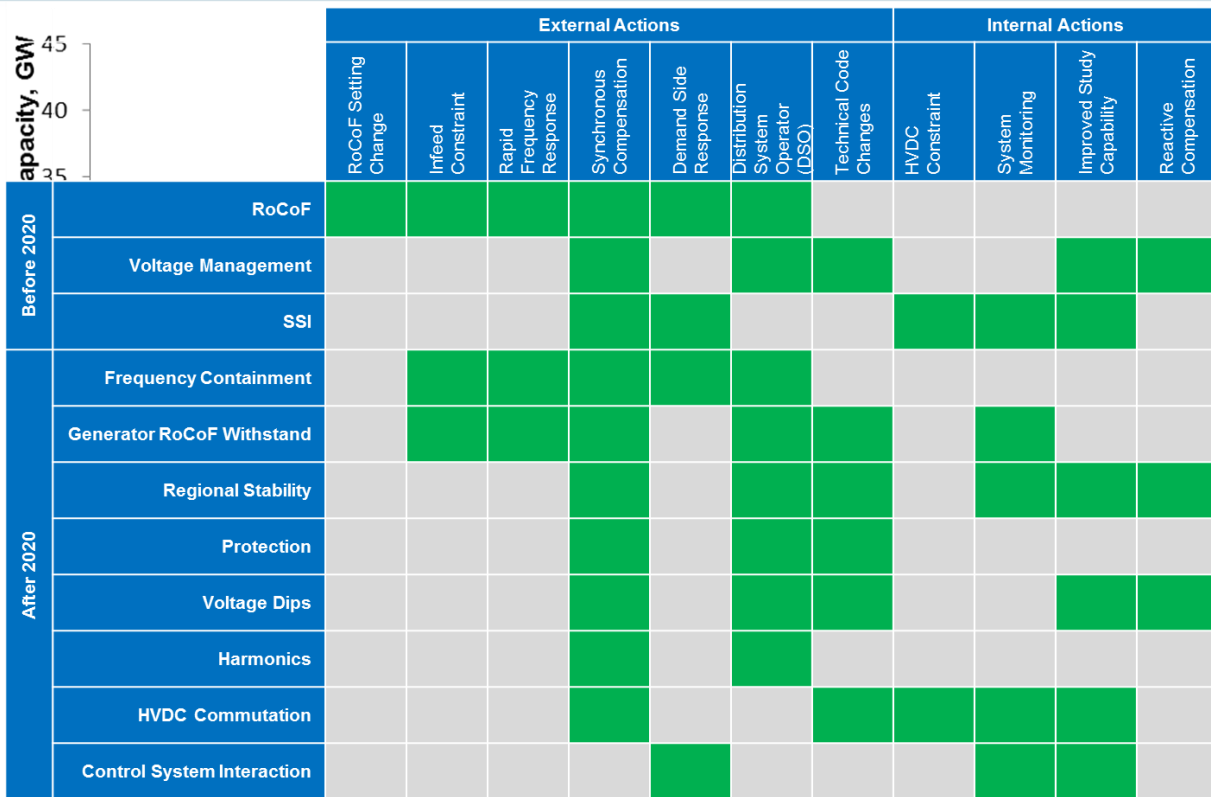




## Topics

## Timeline

## Solutions



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

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

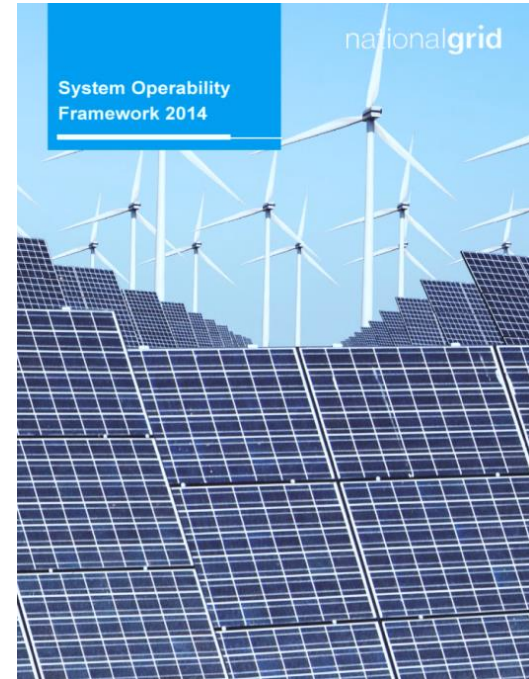
# Impact of Embedded Generation on the Transmission System and Potential Opportunities

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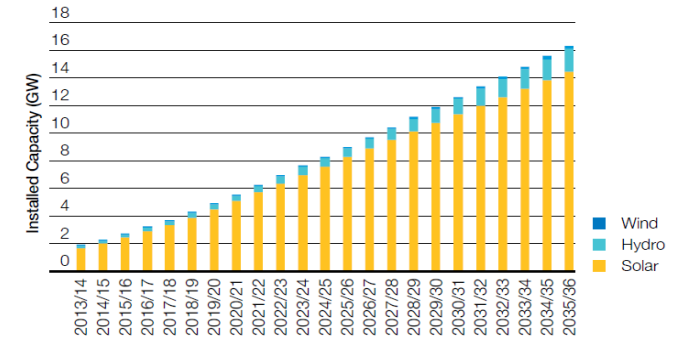
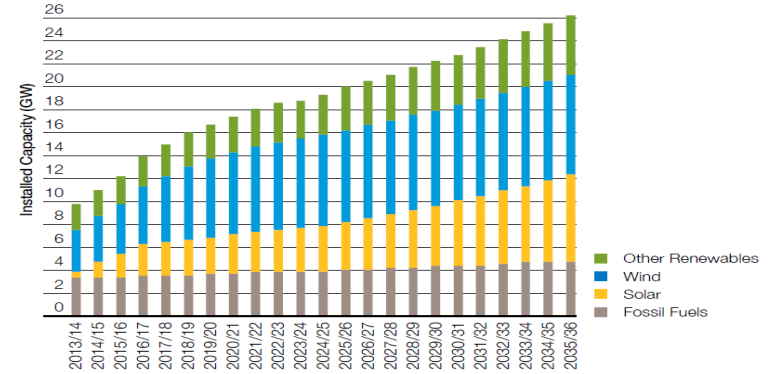
**Nikola Gargov**

**SOF Project Team**



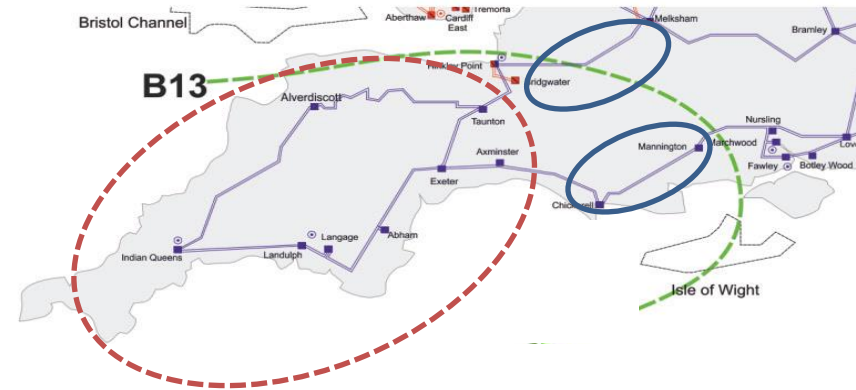
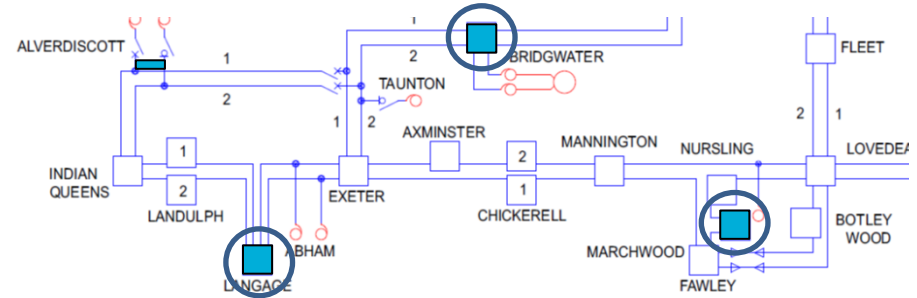
## Future Energy Scenarios predictions for Embedded and Micro Generation:

- Embedded Generation: generation with installed capacity above 1MW
- Micro Generation: generation with installed capacity below 1MW



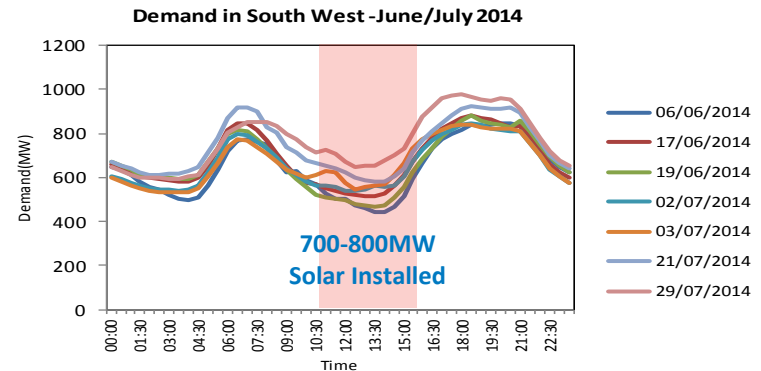
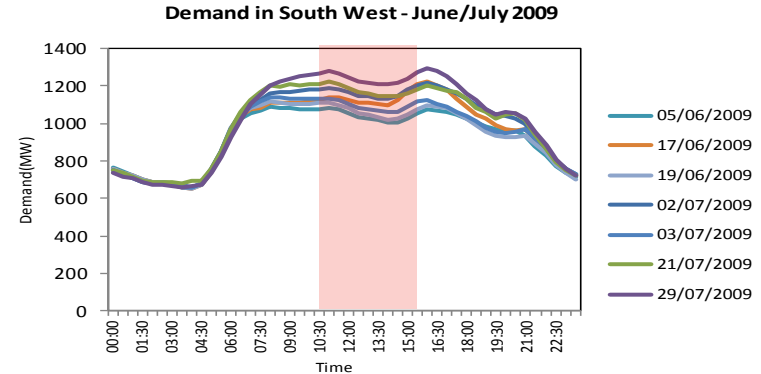
## Background:

- 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)



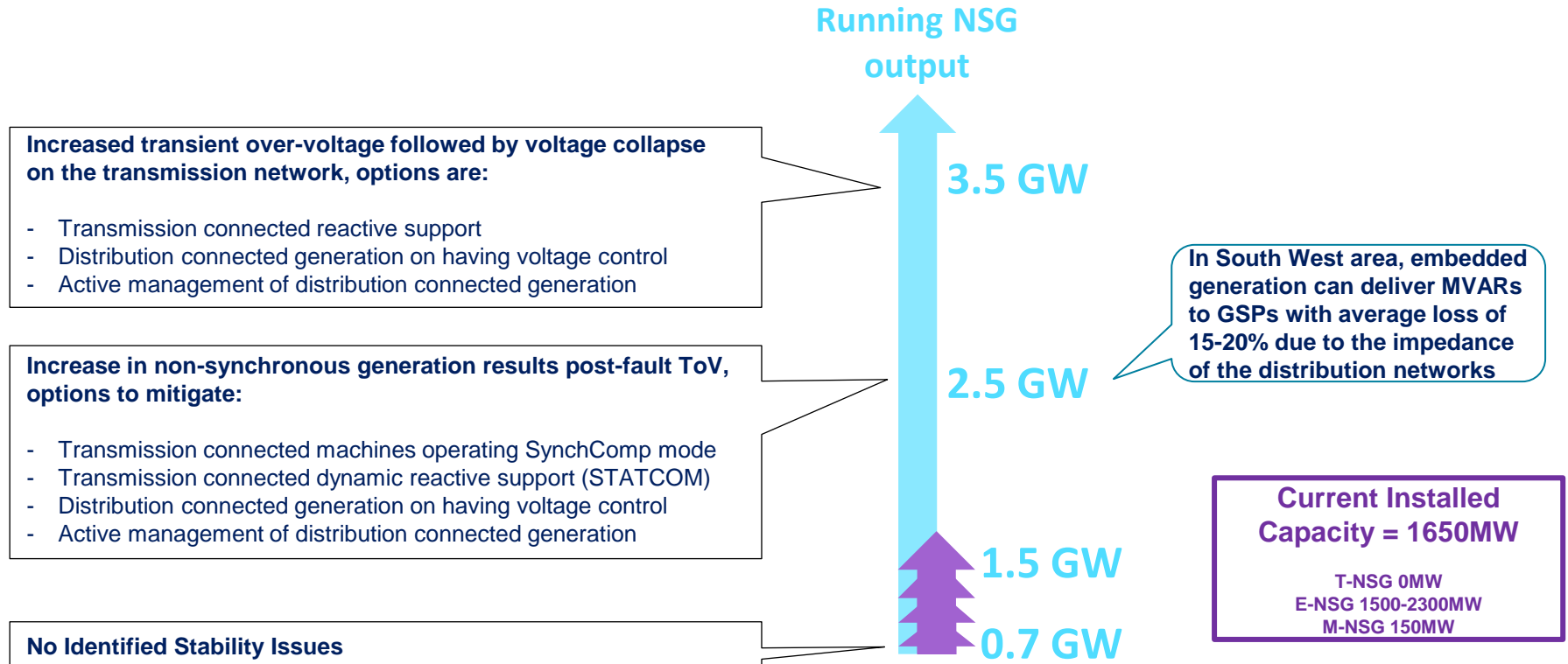
## How large volumes of Embedded Generation could affect the operation of the transmission system:

- 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



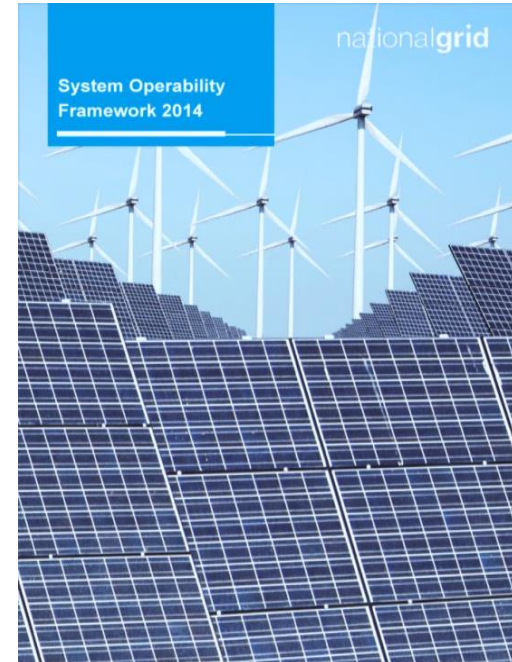


# Impact of Embedded Generation on the Transmission System and Potential Opportunities



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**

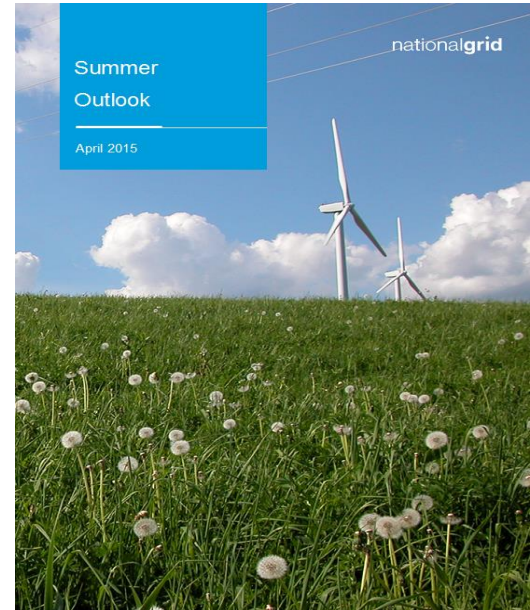


- **[13:15 – 14:45]** System services; internal and external perspective (Commercial)
- **External Perspective:** DONG Energy, RenewableUK, Imperial College of London
- **Economic Appraisal of System Services**
- **Contracts for System Services**
- **[14:45 - 15:30]** System Operability Framework 2015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



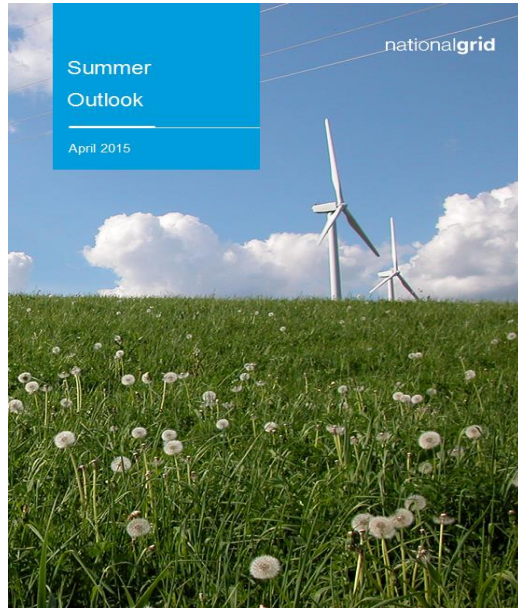
Chris Thackeray

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

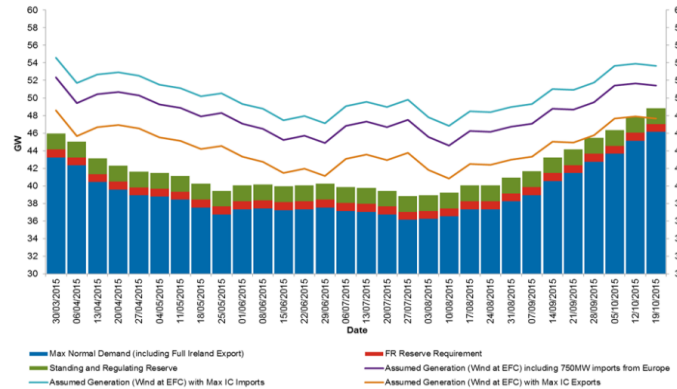
Fresh approach with a focus on making it interesting and relevant

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/](http://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

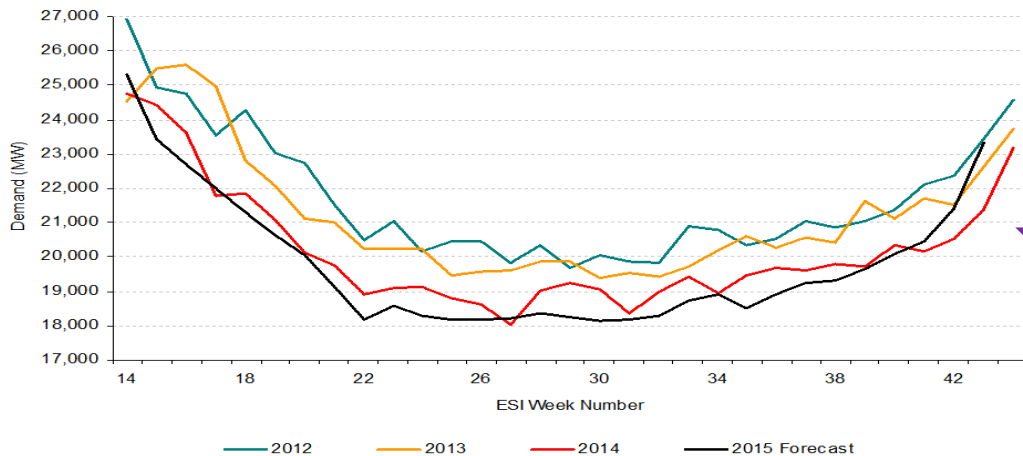
Maximum forecast demand in high summer

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...

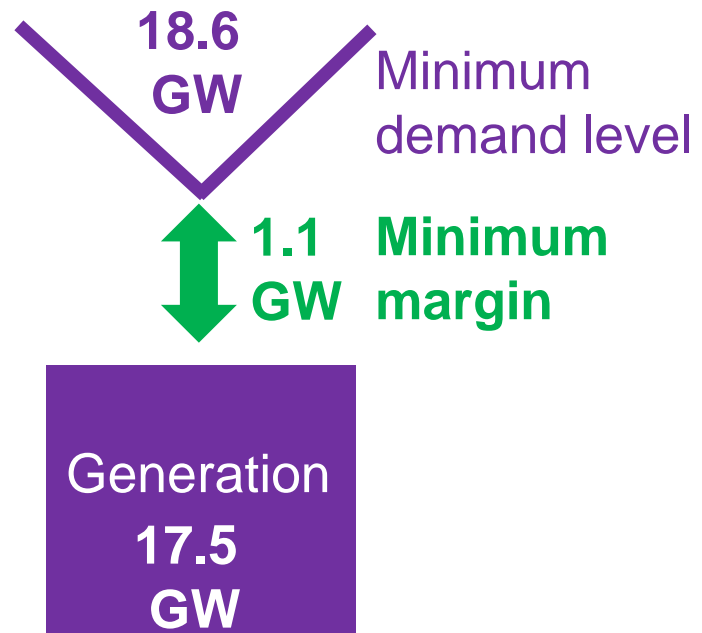
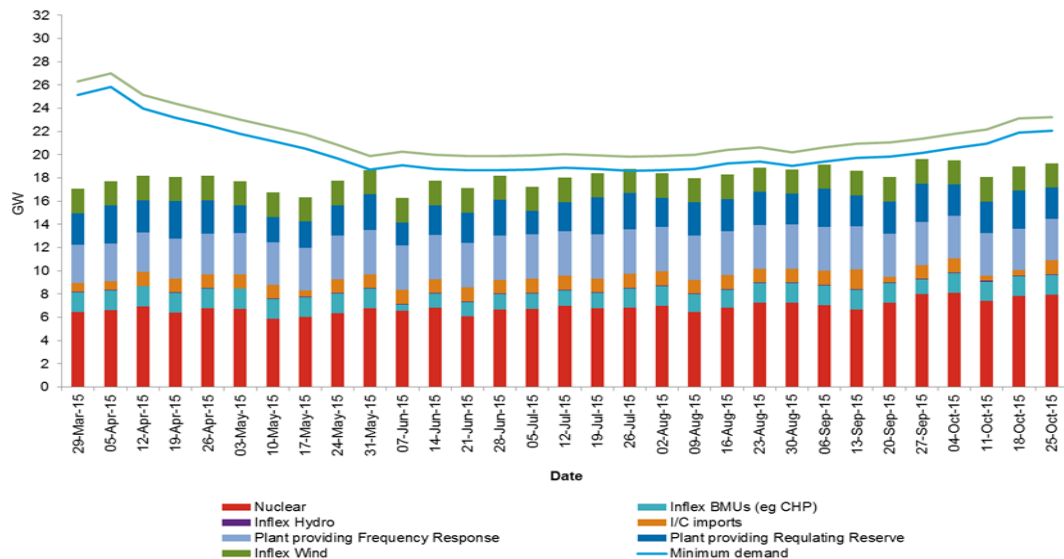


↓ Increase in embedded generation  
Energy efficiency

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

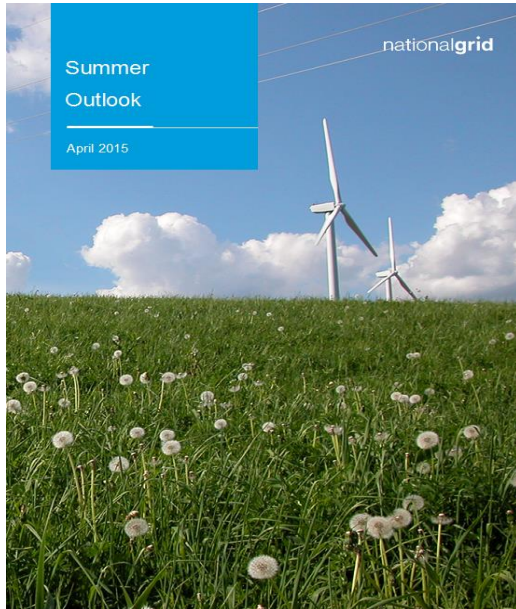


# System operability is the main focus for us as the System Operator this summer...



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

nationalgrid



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/](http://www.nationalgrid.com/UK/Industry-information/Future-of-Energy/FES/summer-outlook/)

# System Operability Framework pre-assessment workshop – 9<sup>th</sup> April 2015

Hannah McKinney



**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...*

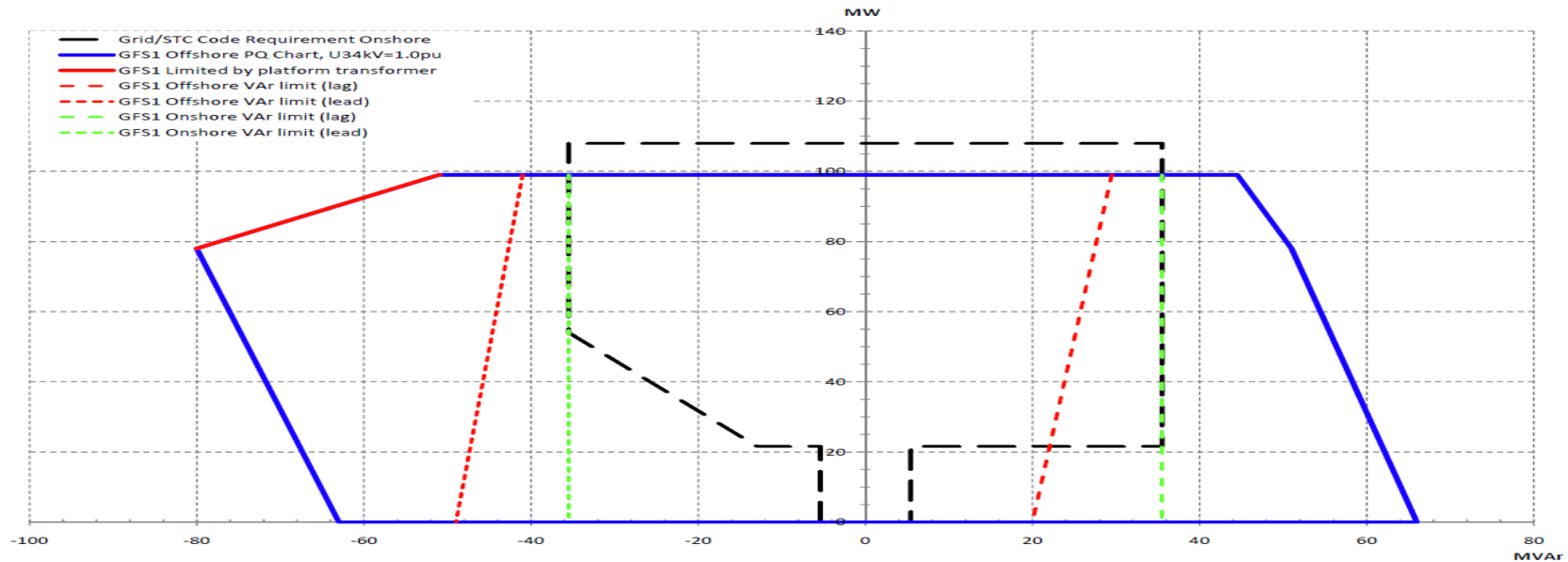
- Voltage Management
- Stabilising network deviations faults/voltage dips
- need for more Reactive/Voltage support

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

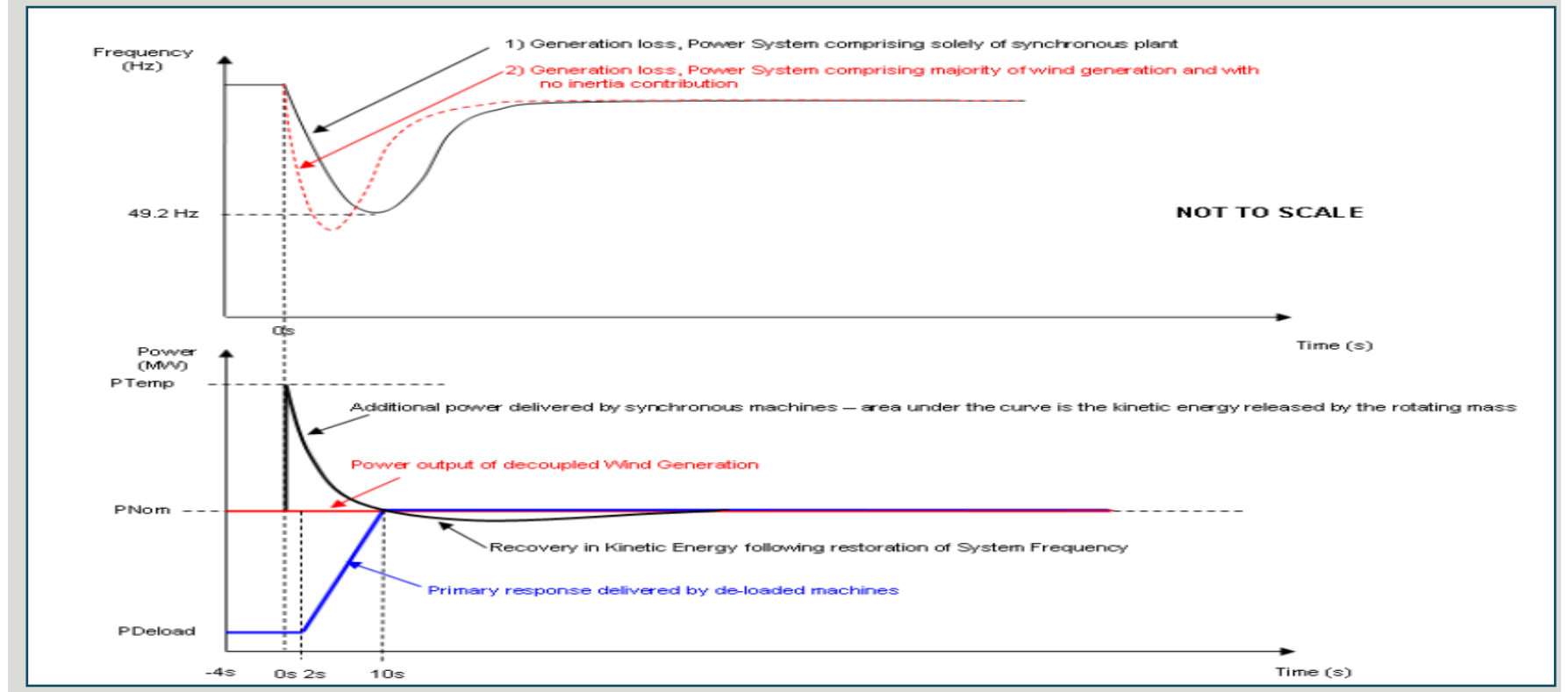
# 1. Challenges cont...in particular, the challenge of managing Voltage

- 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

Offshore PQ Chart for GFS1



# 1. Challenges cont...in particular, the challenge of managing

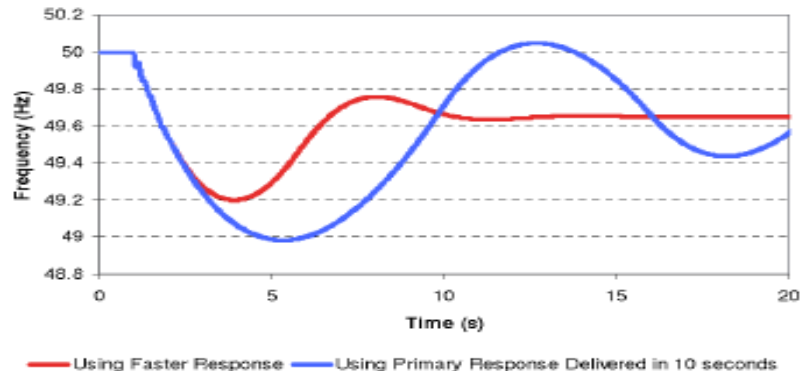
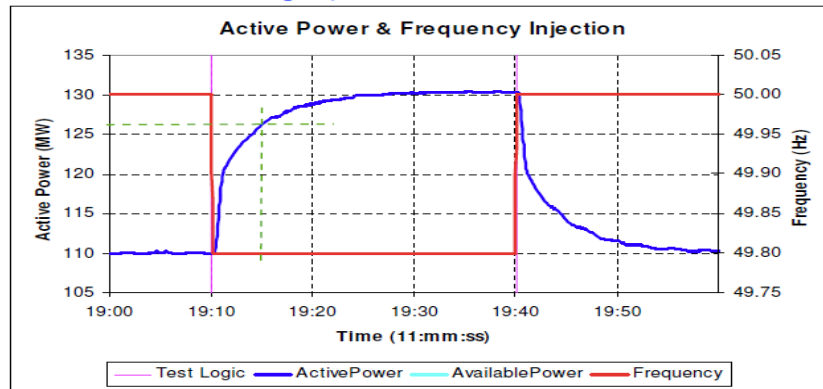


# 1... Challenges but real opportunity for NSG – RFR technically capable

## Rapid Response

Appendix E continued

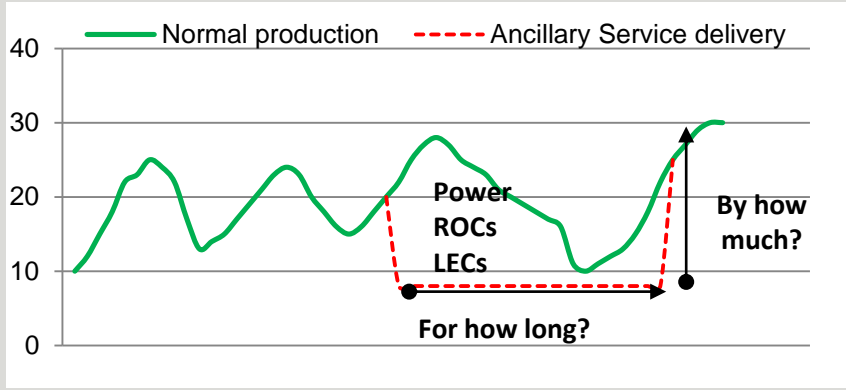
NGC Test Reference F – August parameters





## 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

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

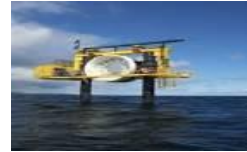
- Looking ahead - DONG Energy prospects for delivering Ancillary Services
  - Prepared to progress developing A/S (eg., RFR) from selected wind farms on the basis of such activities **being profitable!**
  - **Demonstrate financial viability** (in terms of incoming cash flows and overall profitability) 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

THANK YOU

# System Operability Framework – A Perspective

**Zoltan Zavody**  
**Head of Grid**

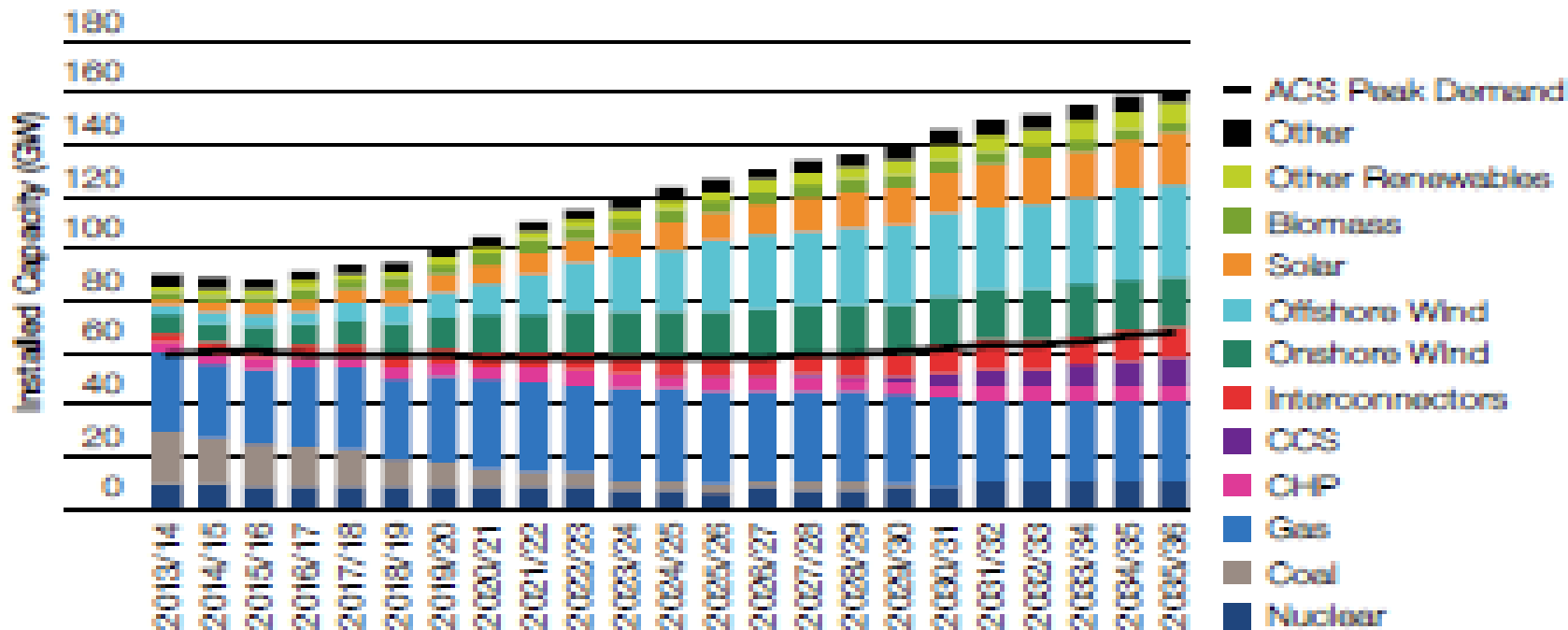
# RenewableUK



“The voice of wind and marine energy”

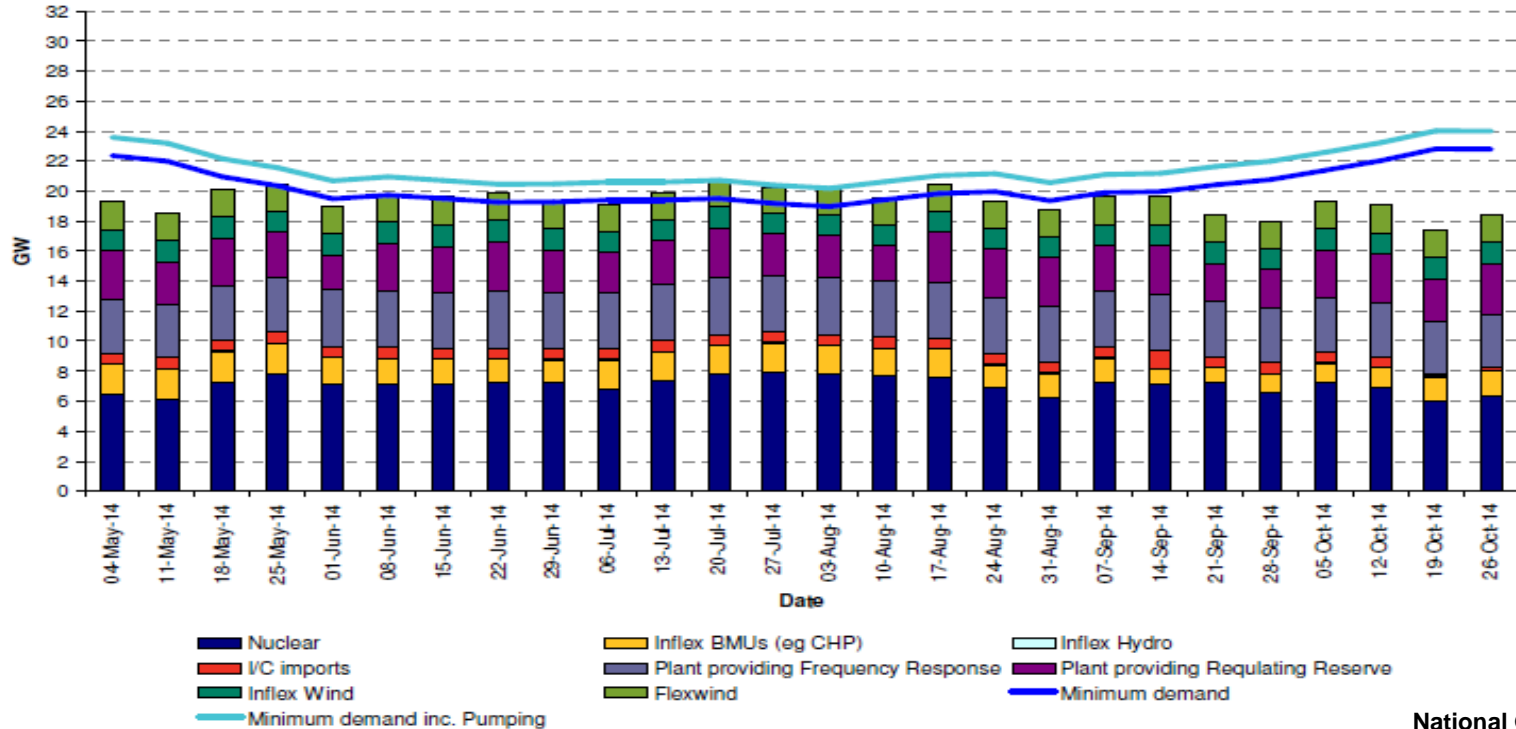
- industry forum
- represents industry to Government
- media resource
- public campaign

# Gone Green Generation Scenario



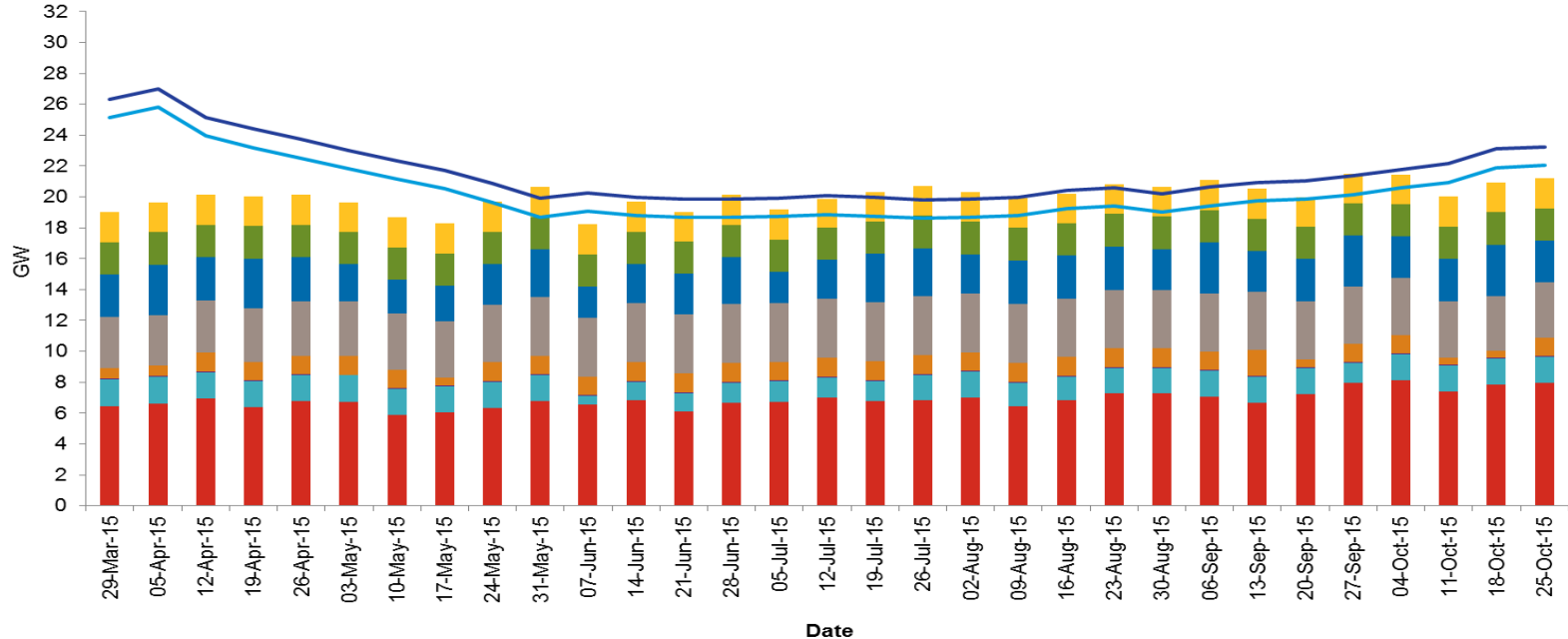
National Grid, Future Energy Scenarios 2014

# Minimum Summer Nighttime Demand 2014





# Minimum Summer Nighttime Demand 2015



- Nuclear
- Inflex Hydro
- Plant providing Frequency Response
- Inflex Wind
- Minimum demand

- Inflex BMUs (eg CHP)
- I/C imports
- Plant providing Regulating Reserve
- Flexwind
- Minimum demand inc. Pumping

National Grid, Summer Outlook 2015

# 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

# *System Operability Framework*

*Towards a new grid operation and  
development paradigm*

Goran Strbac

# System Operability Framework

Future Energy Scenarios

Operational Solutions

Operational Challenges

Performance Requirements

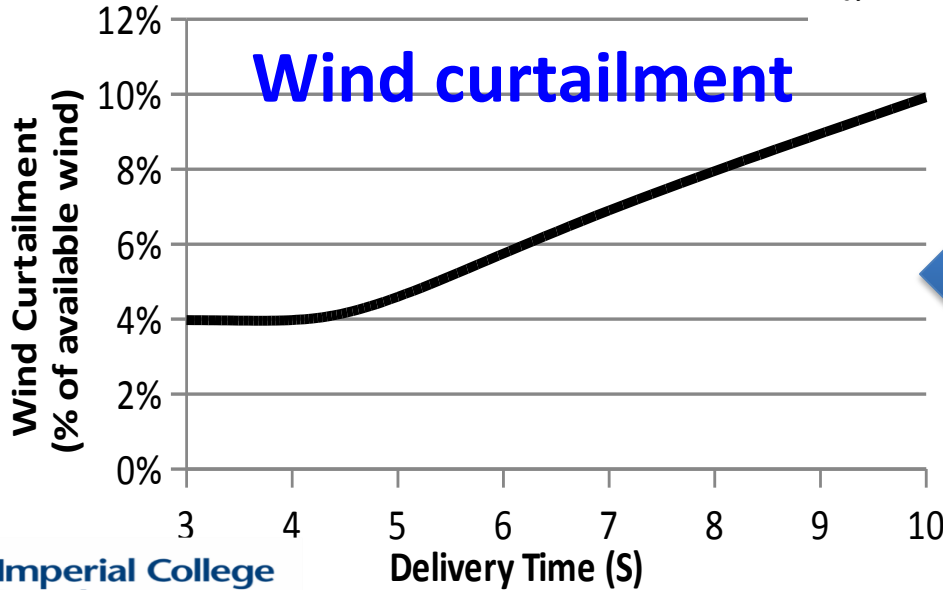
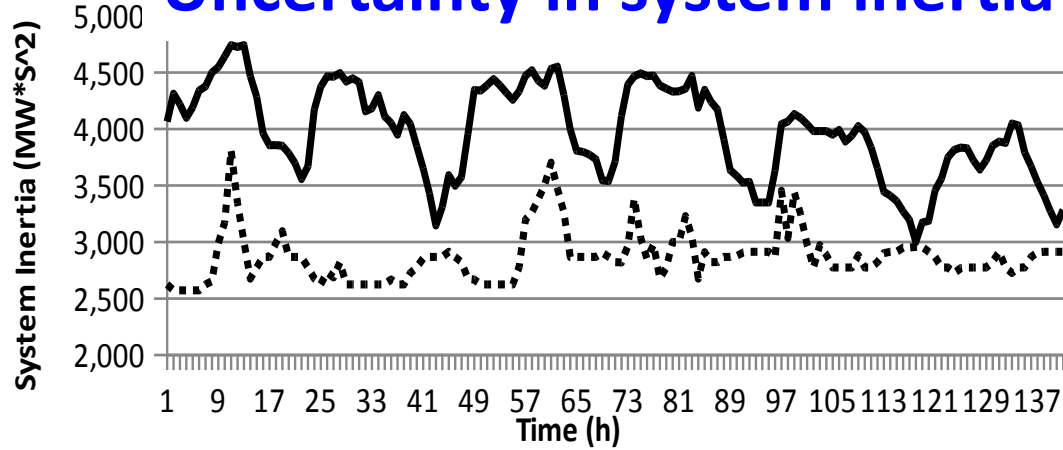
*Towards a new grid operation and development paradigm*

*Managing trillema: Cost, Security & Emission objectives*

*Enhancing Commercial and Regulatory framework*

# Example: *system value of new services*

## Uncertainty in system inertia

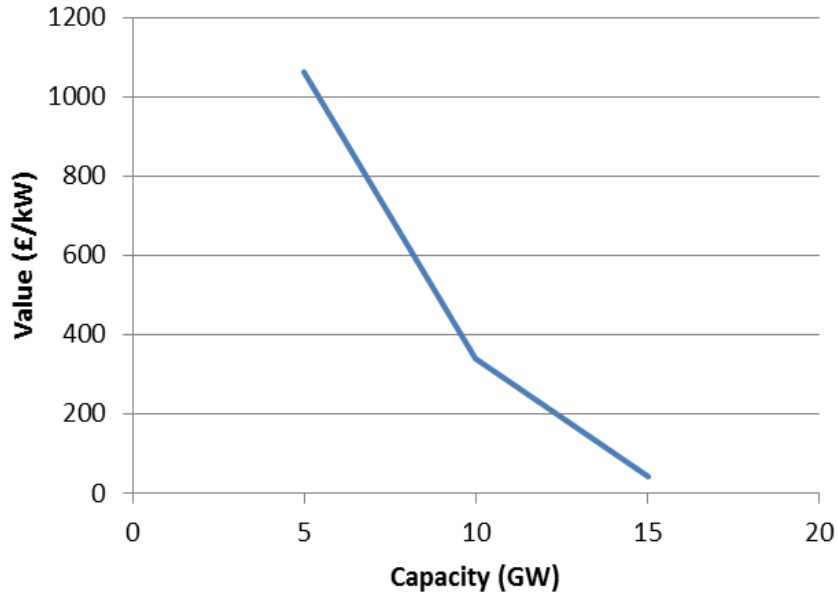


**Wind curtailment**

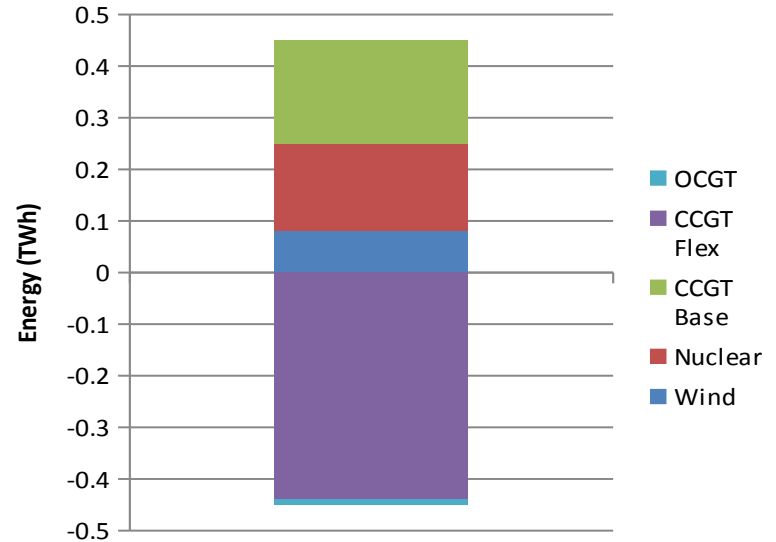
**Enhancing the ability of  
the system to integrate  
RES by reducing  
response delivery time**



# Investment in flexibility ?

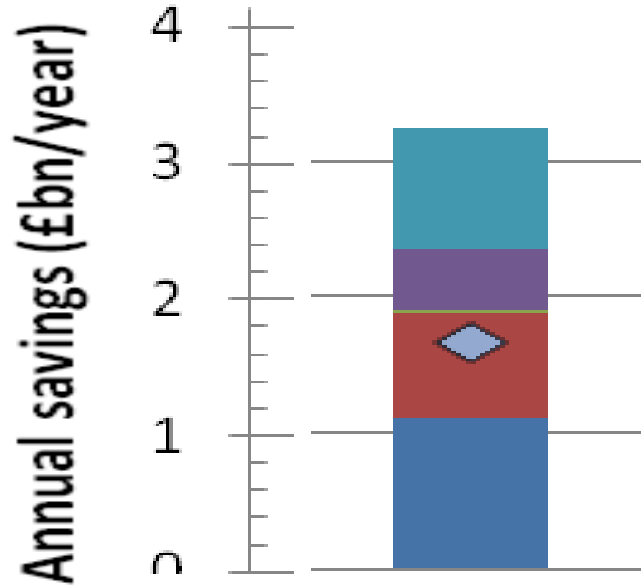


**System value of enhanced flexibility of CCGTs will be significant**

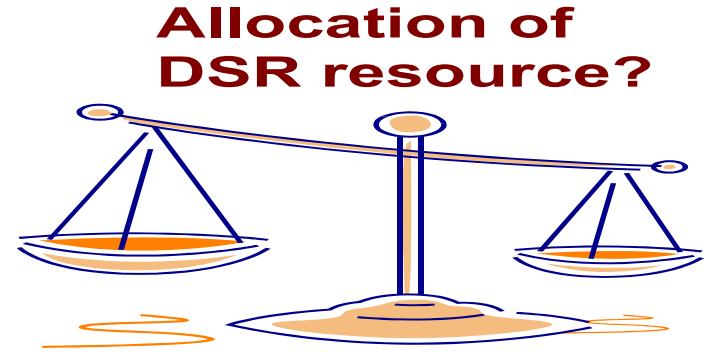


**How about the value to investors?**

# Complexity of energy storage and demand response: *Split benefits*



■ OPEX ■ G CAPEX ■ T CAPEX ■ IC CAPEX ■ D CAPEX



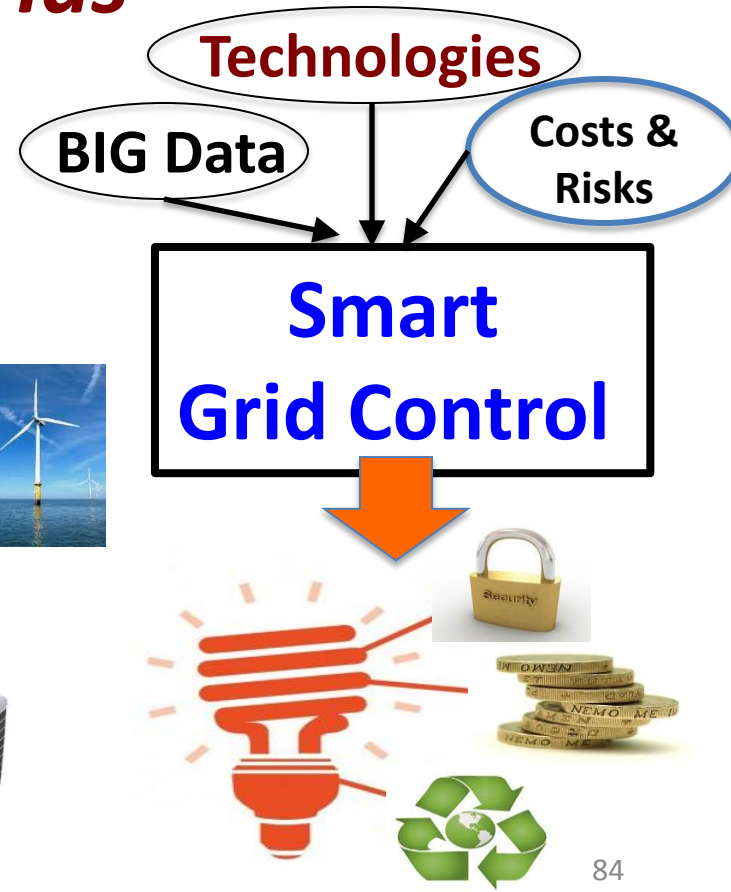
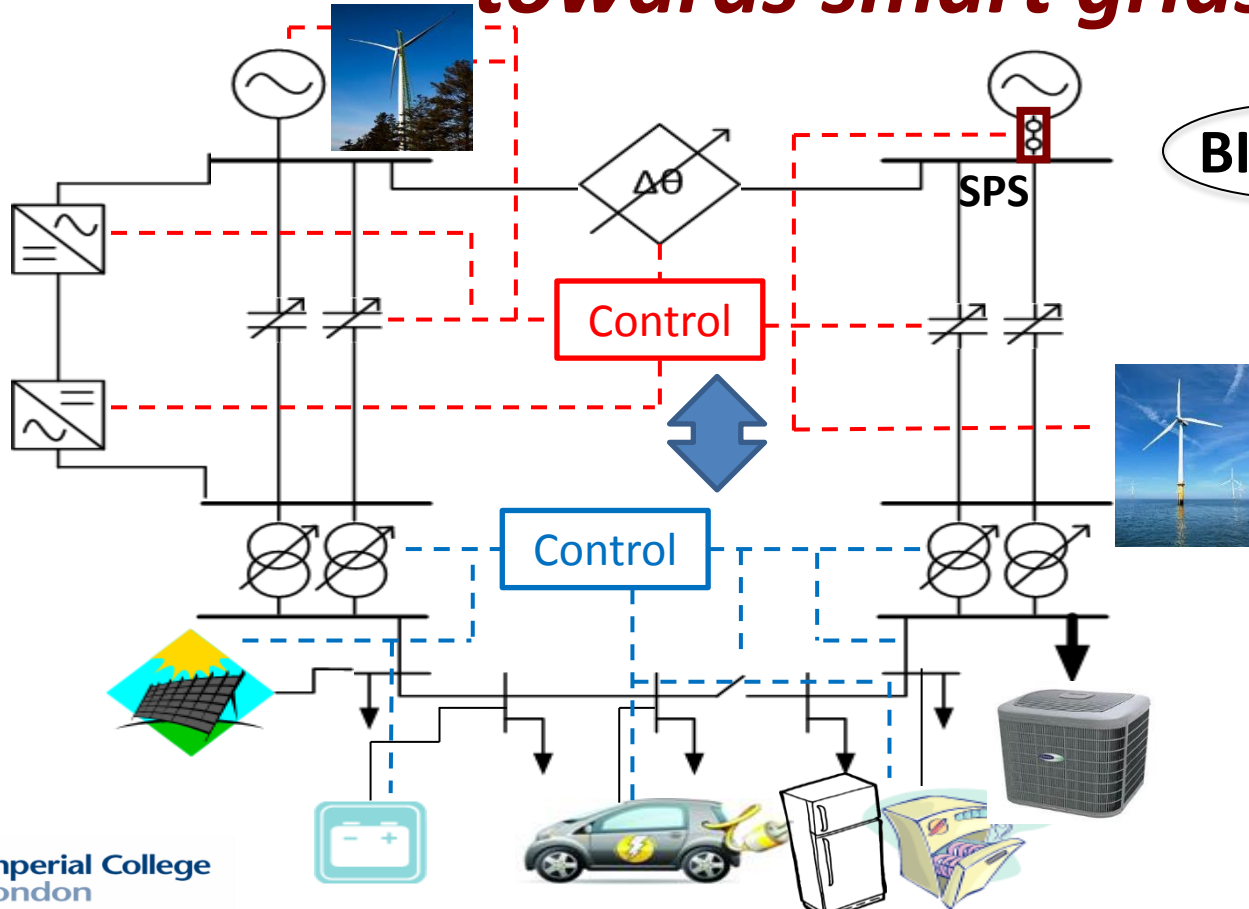
**National  
Balancing  
Services**

**Local  
Network  
Control**

**Can the market facilitate this?**



# Operational challenge: *paradigm shift towards smart grids*



# ***Improving current regulatory & commercial regime /1***

***(1) Strengthening the incentives for development & implementation of cost effective smart grid measures – from the stick to a carrot approach – e.g. linking rate of return with cost effectiveness***

***(2) Whole systems approach to network operation and design - from silo to whole systems concept based network operation and planning***

## **Improving current regulatory & commercial regime /2**

**(3) Facilitate investment under uncertainty** From scenario only driven investment to dealing with uncertainty - option value of smart and traditional investment

**(4) Facilitate strategic investment investment in smart T&D networks** - Need to coordinate existing and future users needs: balance strategic and incremental investment

**(5) Enhancing market integration** – Ensure that DER flexibility can access their whole-system value by providing services across different sectors and timescales (operation & investment)

# ***Improving current regulatory & commercial regime /3***

***(6) Recognise increased risk and complexity associated with innovation and deployment of new technologies*** - Need to establish provisions to allow network operators to account for increased risks

***(7) Role of the Regulator***

*From acting as a buyer of network services to developing appropriate incentive mechanisms*

# *System Operability Framework*

*Towards a new grid operation and  
development paradigm*

Goran Strbac



Leon Walker

Commercial Development Manager

- Required portfolio of Balancing Service products has been historically stable
- Historic change such as CAP047 [1<sup>st</sup> 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

## 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

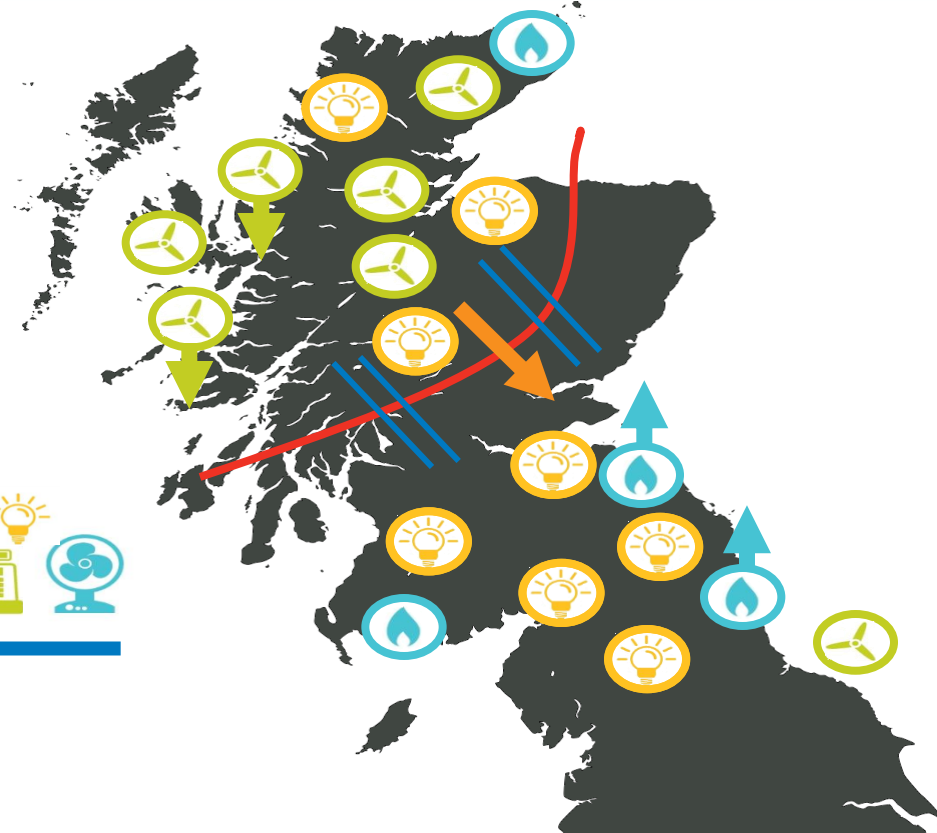
- Understand the capability of future technology to provide service
- Investment Challenge?

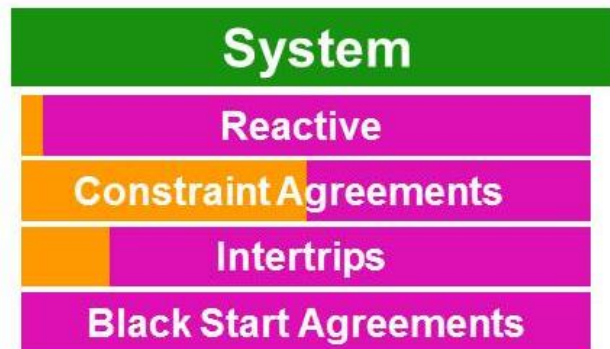


Neil Rowley

Senior Account Manager

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





\* In use from Nov 2014

\*\* In use from Nov 2015



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

- 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

- Rate of Change of Frequency

Forecast Inertia

Monitor Inertia

Largest loss

Constrain Stations

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

Additional Inertia Available?

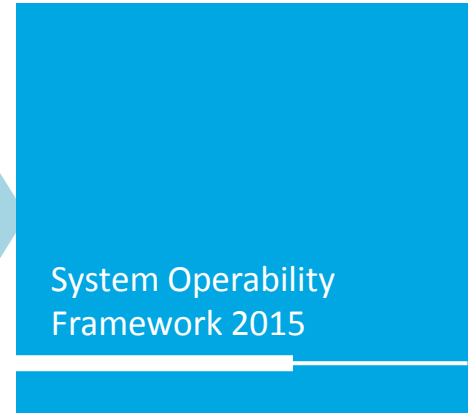
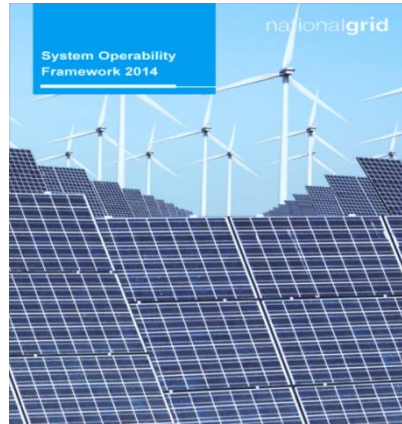
Combined Services?

Economic?

- 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



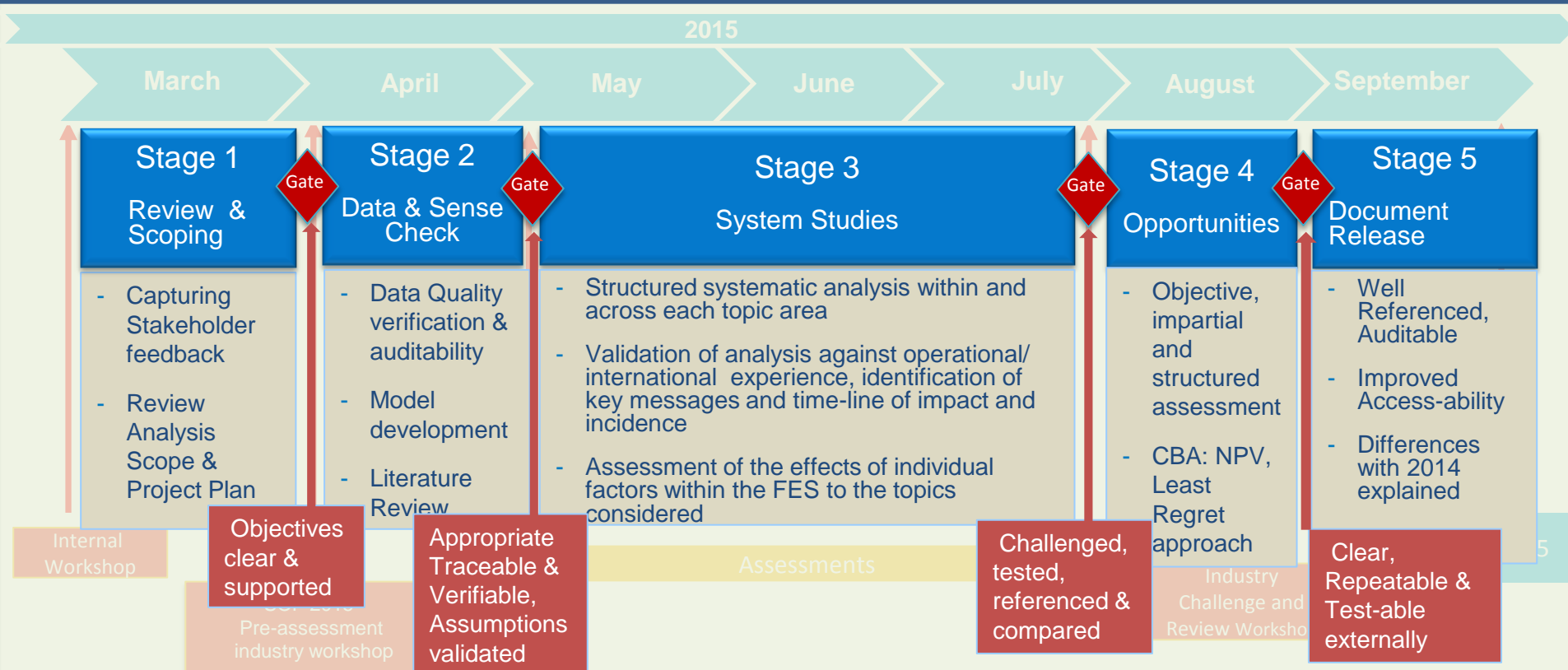
- The market is changing
- The SOF is going to help provide a valuable tool to understanding some of the challenges
- How does GB meet the future system needs?



Paramjit Sihre, Ben Marshall and Jordan Darley

SOF Project Team

# Systemic Approach Proposed in Developing SOF 2015

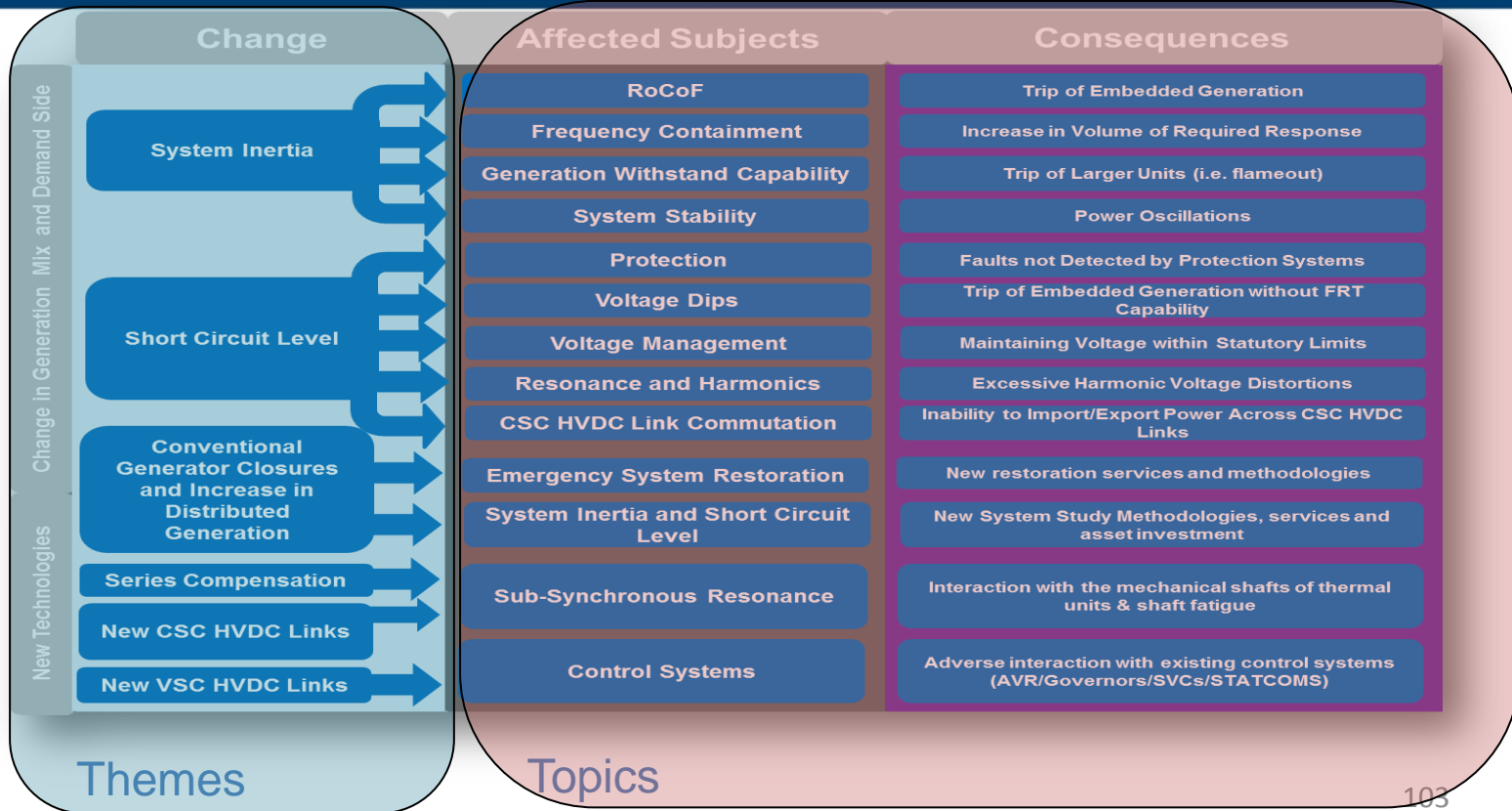


- The Themes and Topics for 2014 and how we got to them
- Feedback from stakeholders on the 2014 report, and its Topic areas
- New themes arising in 2015
- Our Initial thoughts on 2015 topics & responding to stakeholder feedback received today
- Consulting on our next steps - how we would take topic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

# Recap on 2014:- Themes and Topics

*Were we missing anything Last time?*

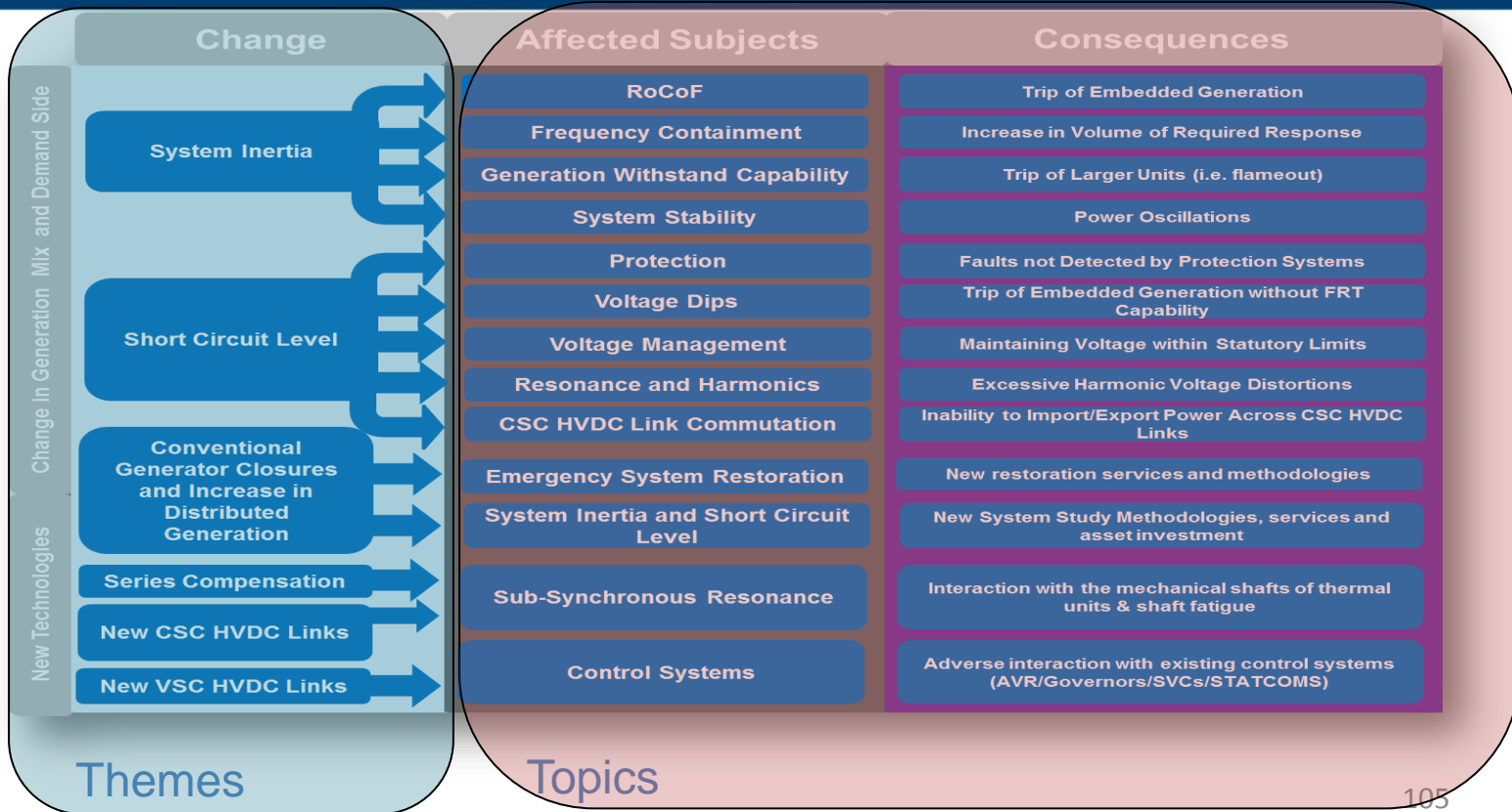
*If So What?*

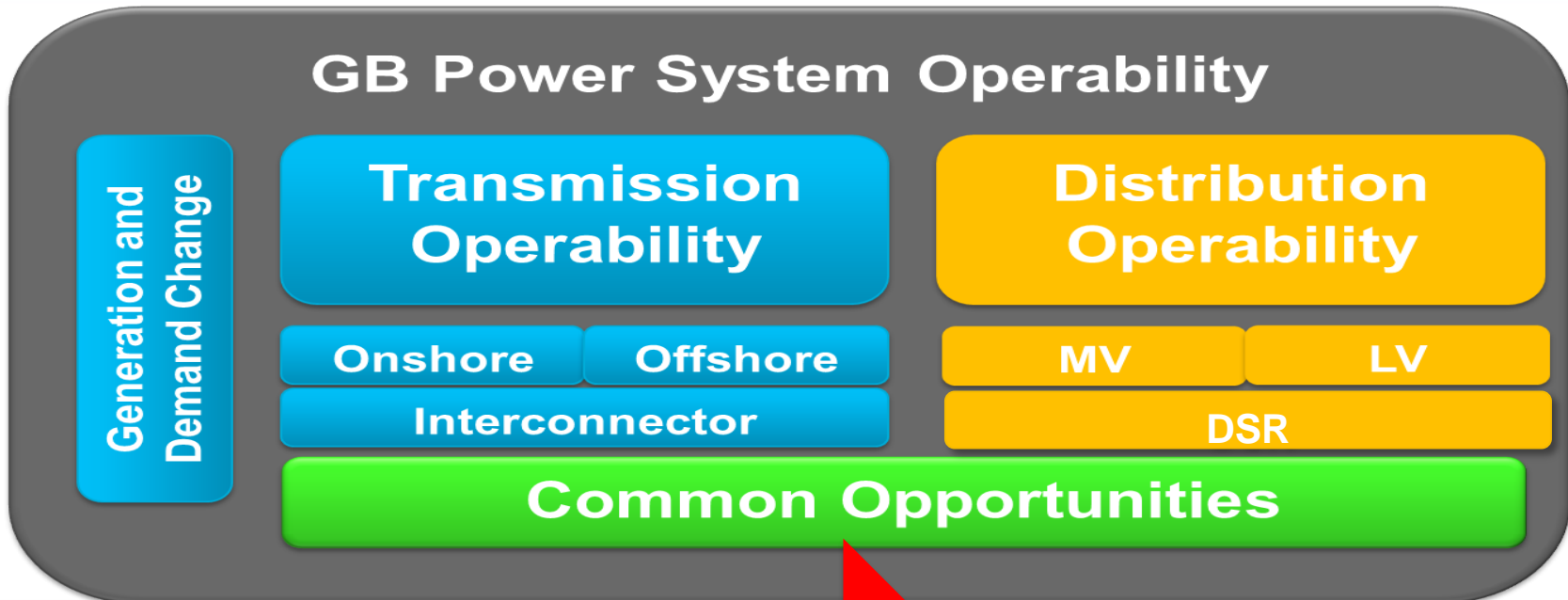


- Generally positive (very good engagement)
- SOF Topics
  - Number comments indicated the impact of change at the distribution level needs to be better articulated, i.e. DSR, EVs, etc.
- SOF Solutions
  - Better balance between market based products (i.e. wherever the technology is already capable), 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?

*Is anything from 2014 not needed this time?*





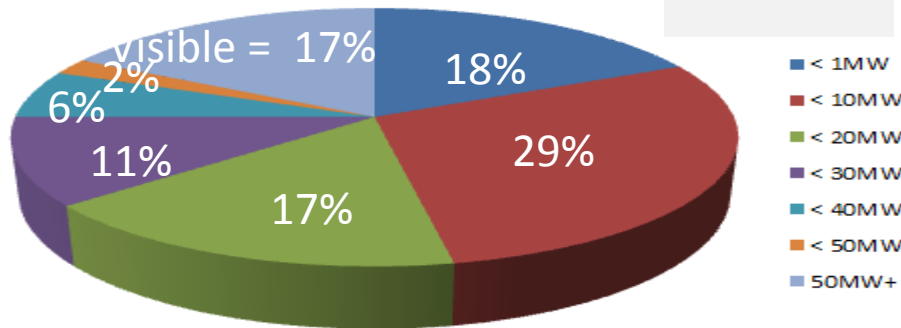
Review 2014 Themes for future SOF+ new ones of "Controlability" and "Demand Side Response"?

DNO & other network Engagement?



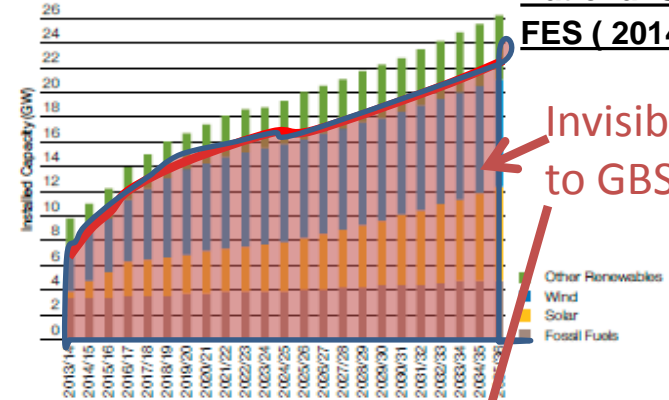
# Reduction in Control-ability?

Current % Of Embedded Generation by size ( Dec 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?

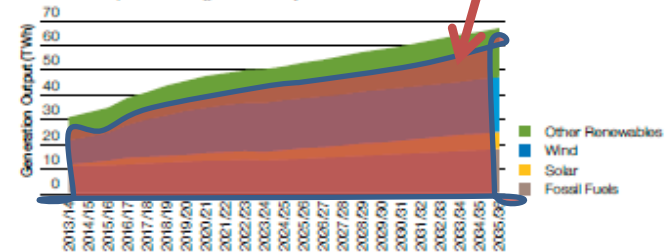
Figure 94  
Low Carbon Life distributed generation installed capacity

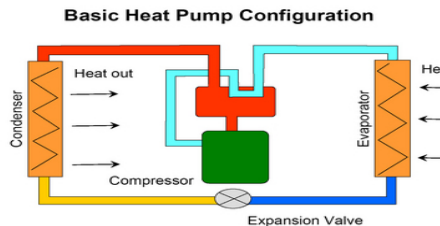


**National Grid  
FES ( 2014)**

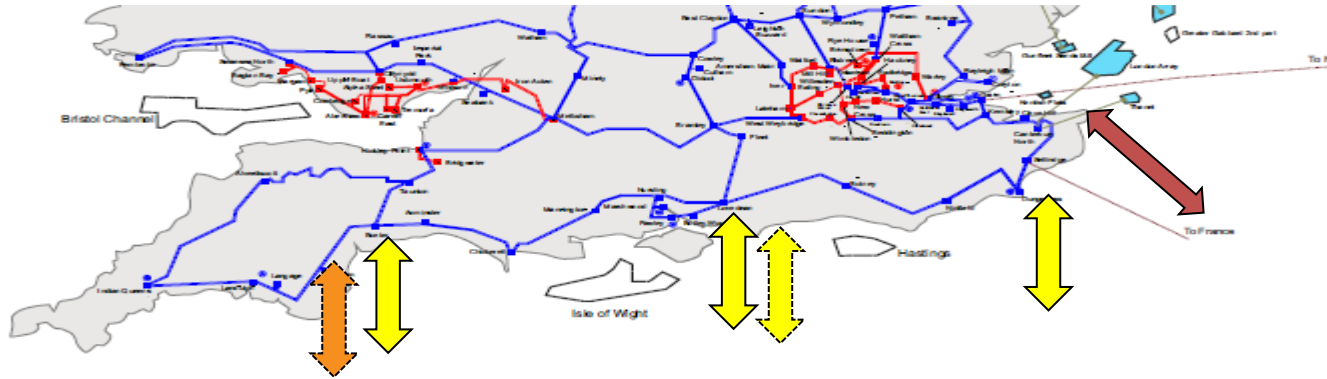
Invisible  
to GBSO

Figure 95  
Low Carbon Life distributed generation output



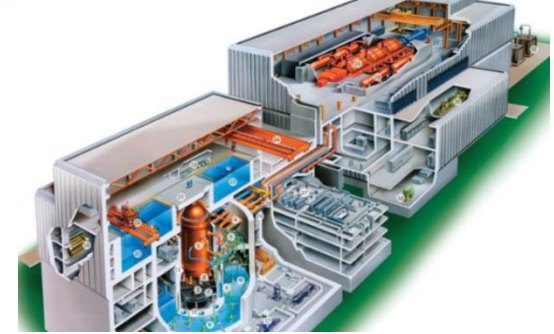


- In SOF 2014; considered as a service opportunity, but is it more than that?
- In SOF 2015; in addition we propose a broader consideration of the role of DSR, capturing various strands of *Network Innovation Allowance* and other work in these fields-
  - contrasting the effects of organic and directed 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?

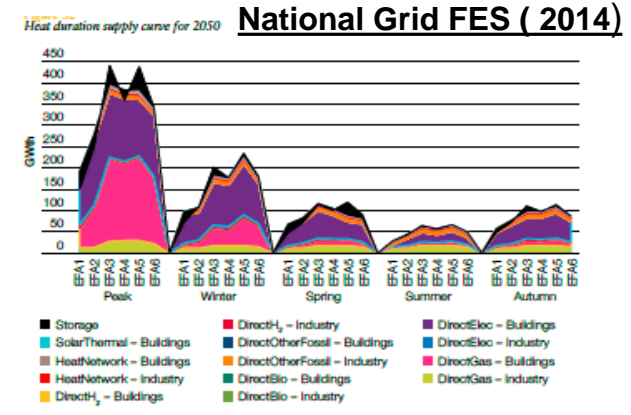


- In 2014 considered only in HVDC Technology risk but where is the power coming from/ going to?
- Scale of overall interconnection- more rapid changes due to market/ system/ or continental environmental effects?
- Common mode failures/ impacts, e.g. voltage dips on continent leading to RoCoF in GB?

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



- New 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?



- 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?

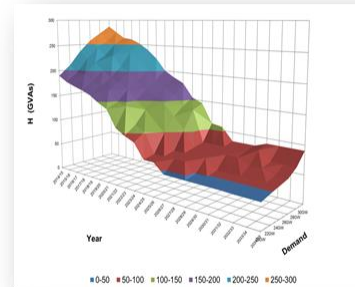
	Change	Affected Subjects	
Changes in Generation Mix and Demand	System Inertia	RoCoF Frequency Containment Generation Withstand Capability System Stability	
	Short Circuit Level	Protection Voltage Dips Voltage Management Resonance and Harmonics LCC HVDC Commutation	
	Reduction on Controlability	Supply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



New Topics & Themes

- 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?





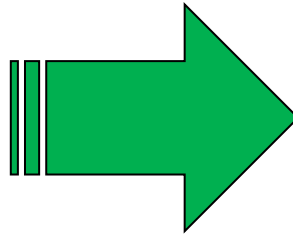
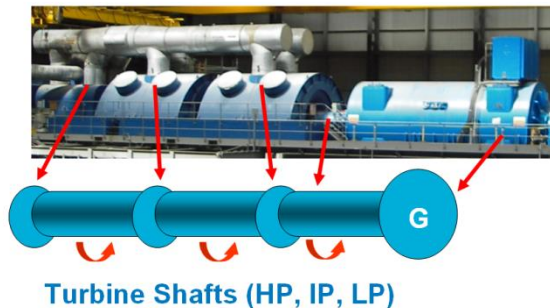
Charlotte Grant

SOF Project Team



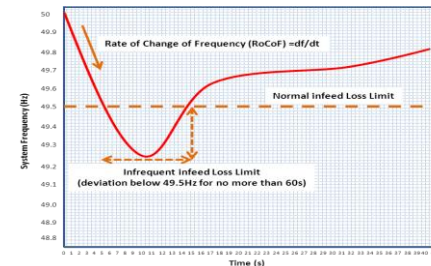
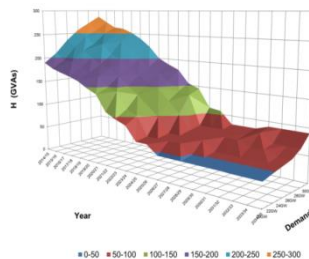
- Changes to the Transmission System - system inertia challenge
- Why SMART frequency control?
- SMART Frequency Control Project overview
- Project partners & collaboration
- Industry engagement and knowledge dissemination

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



# Why SMART Frequency Control?

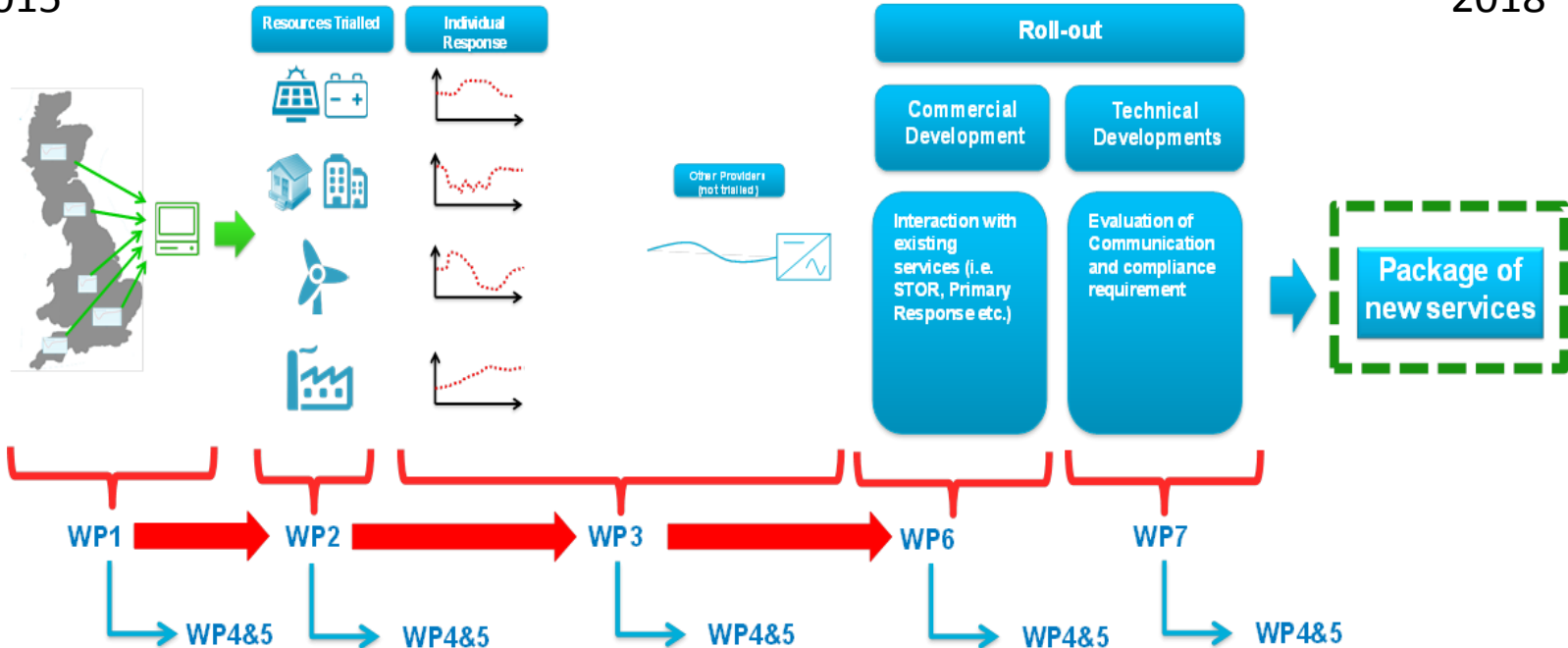
- Output from System Operability Framework....
  - Forecasted reduction of system inertia from 360GW/s to 150GW/s (by 2025 under Slow Progression or 2022 with Gone Green)
  - RoCoF increasing from 0.125Hz/s to 0.3Hz/s
- Increasing variability of system inertia
- Under Gone Green scenario, potential additional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



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

Jan  
2015

March  
2018



- **Work Package 1 - Control System**

- Event detection and control



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



- **Work Package 3 - Optimisation**

- **Work Package 4 - Validation**

- **Work Package 5 - Knowledge dissemination**



The University of Manchester



University of  
**Strathclyde**  
Glasgow

- **Work Package 6 – Commercial**

- Development of commercial frameworks

- **Work Package 7 – Communications**

- Control room interfaces



- SMART Frequency Control Project website
  - [http://www.nationalgridconnecting.com/The\\_balance\\_of\\_power/](http://www.nationalgridconnecting.com/The_balance_of_power/)
  - Publishing project updates, learning outcomes, events
  - Contact project team

nationalgrid

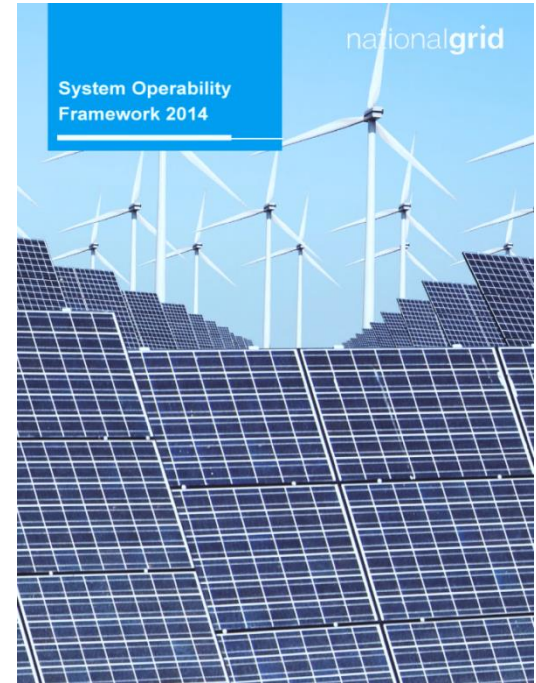
Connectingextra 



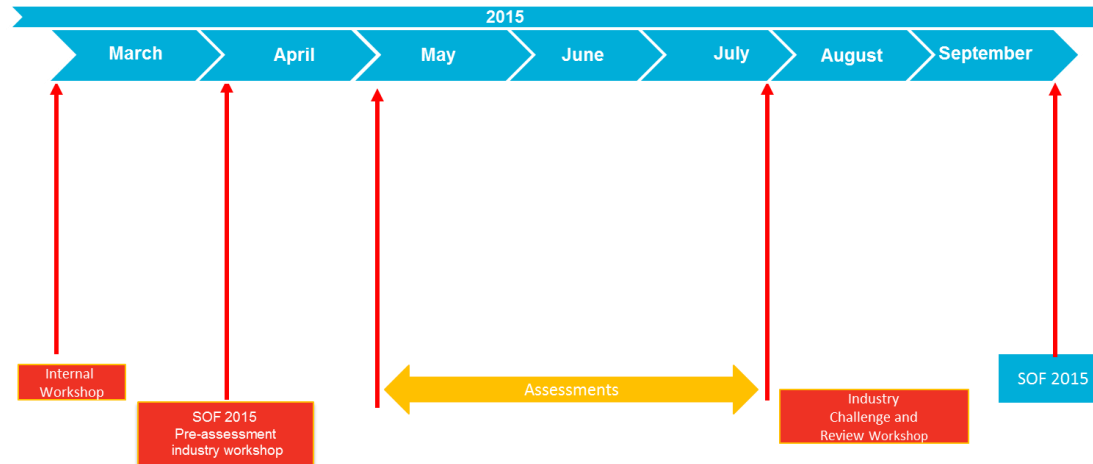


**Vandad Hamidi**

**SMARTer System Performance Manager**



- 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?





- 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)

**Thank you and have a safe journey back!**

**Email:**

**[box.transmission.sof@nationalgrid.com](mailto:box.transmission.sof@nationalgrid.com)**

