Delivering a smart energy system

The role of energy storage on the network

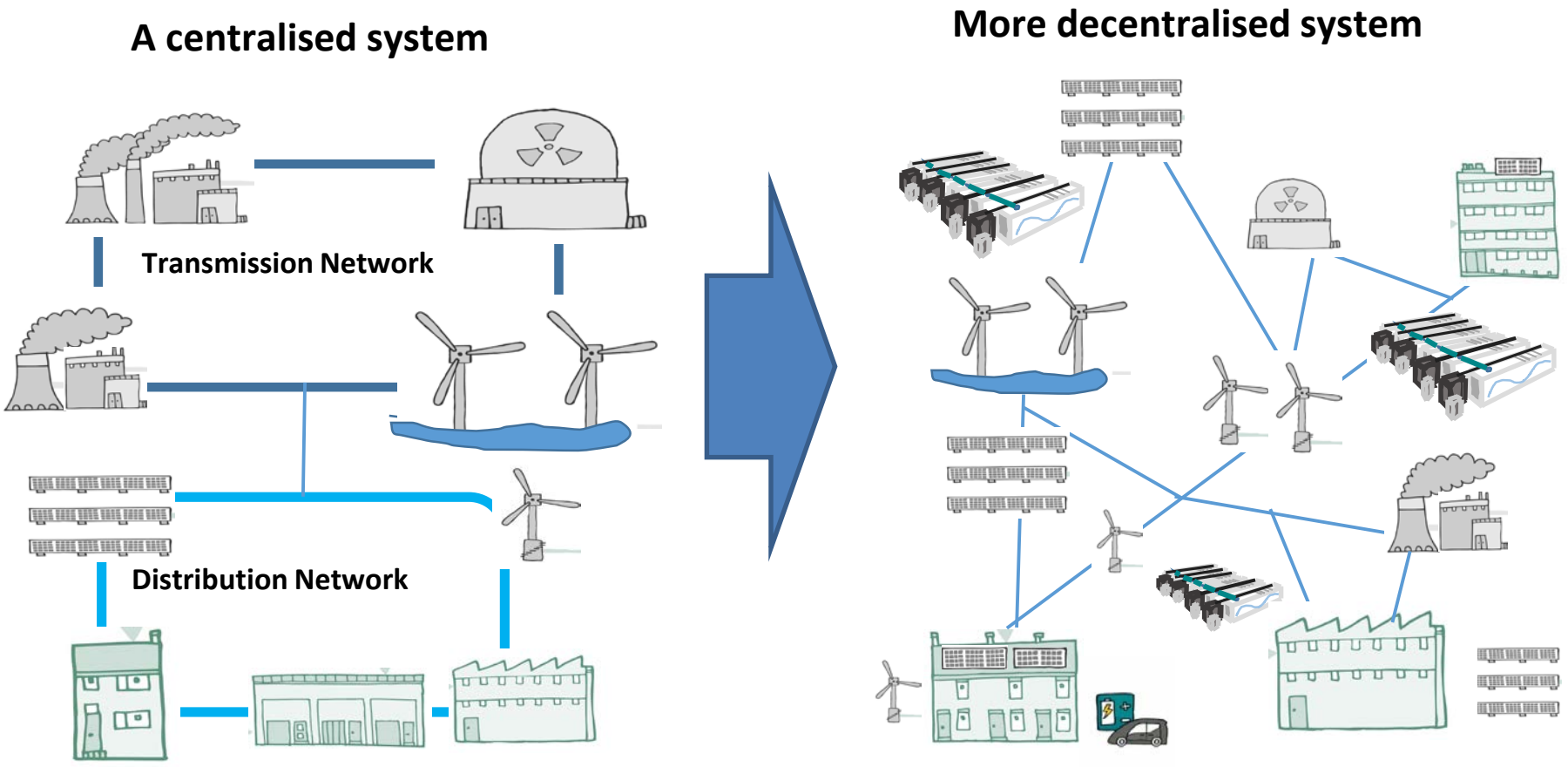
Bath University

4th July 2017

Johnny Gowdy

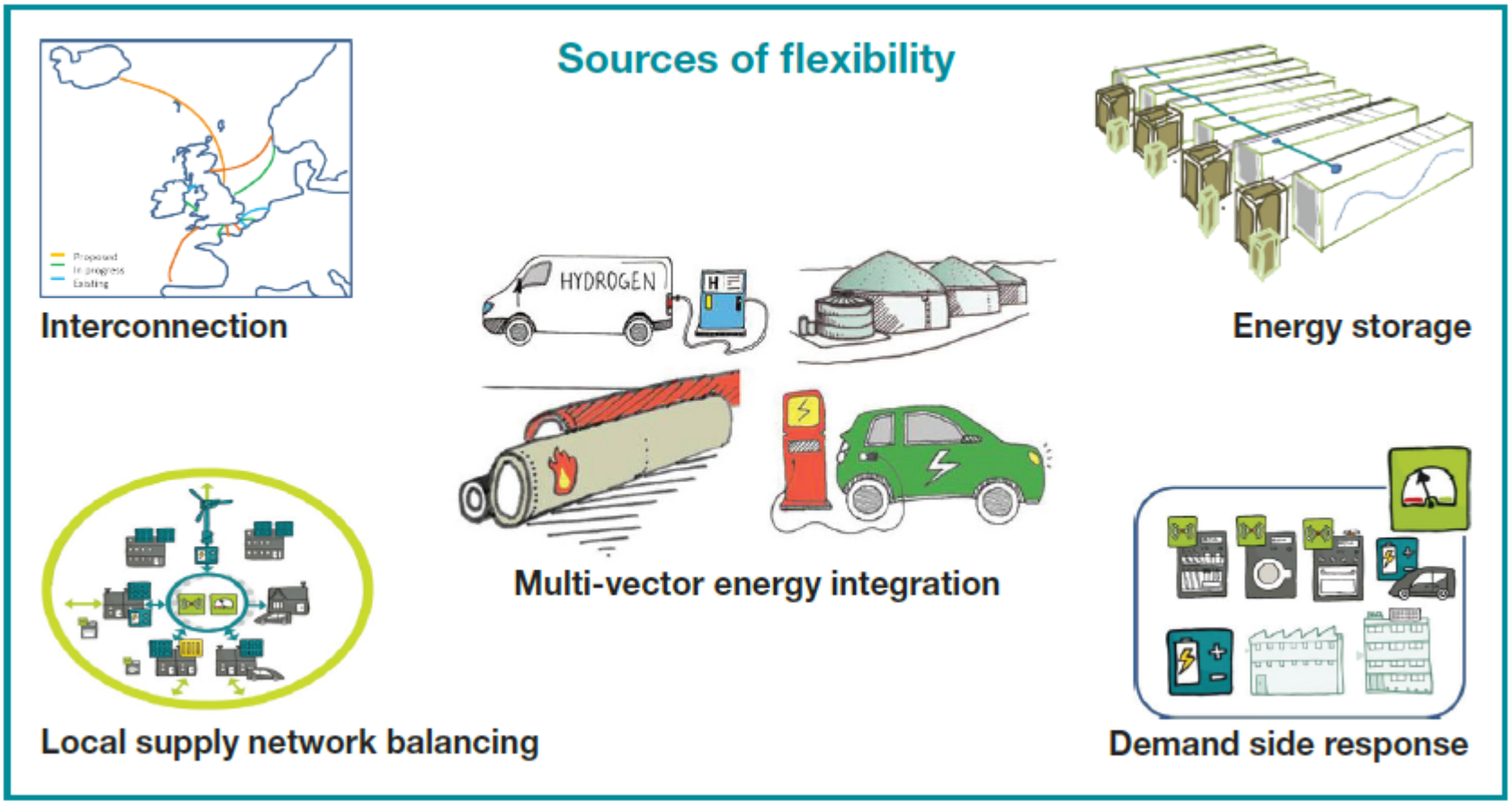
regen
transforming energy

Energy system structural changes



"Our engineers say that 2015 was the last year we operated the system in the way it has operated for the past 50," he says. "The way we are operating now is fundamentally different." John Pettigrew Chief Exec. National Grid

Value of flexibility

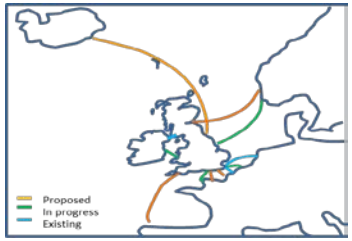


"Three innovations will help us deliver greater flexibility – interconnection, storage, and demand flexibility – which have the potential to displace part of the need for new generating capacity, save money for businesses and domestic consumers and help the UK meet its climate reduction targets. The saving could be as large as £8 billion a year by 2030".

Lord Andrew Adonis, Chair, The National Infrastructure Commission[10]

New market potential

Interconnection

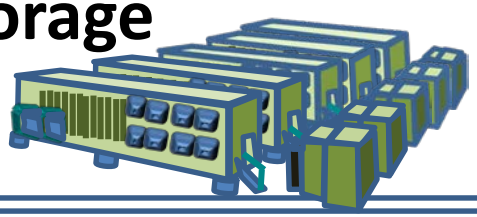


10-15 GW

New links planned to France, Norway, Ireland, Denmark and Belgium.

European Energy Market

Storage



10-12 GW

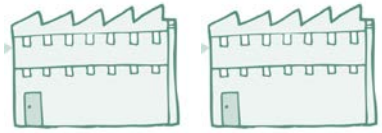
Large and small scale storage from pumped hydro, commercial and small scale battery storage

Peak demand shift

1-2 GW?

Smart meters and Time of Use Tariffs. Heat pump and EV charging off-peak. Smart appliances

Demand side Response (DSR)



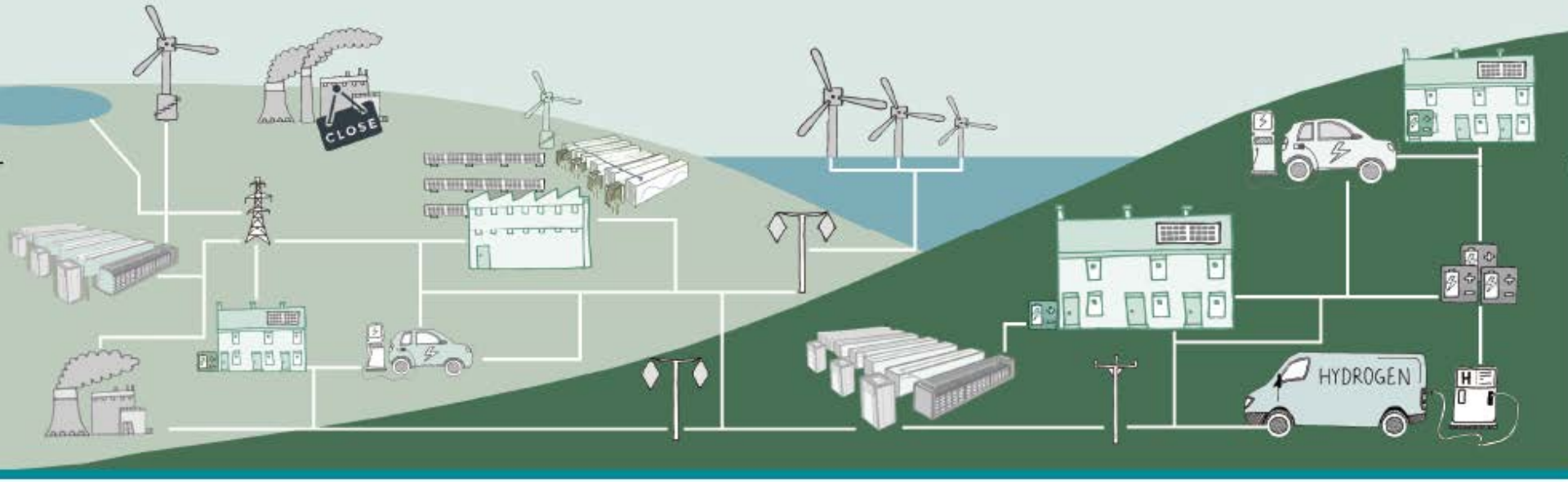
2-4 GW

Contracted DSR – energy user peak demand reduction and demand turn up as needed

regensw
delivering sustainable energy

Pathways to Parity - Market insight series

Energy Storage - Towards a commercial model



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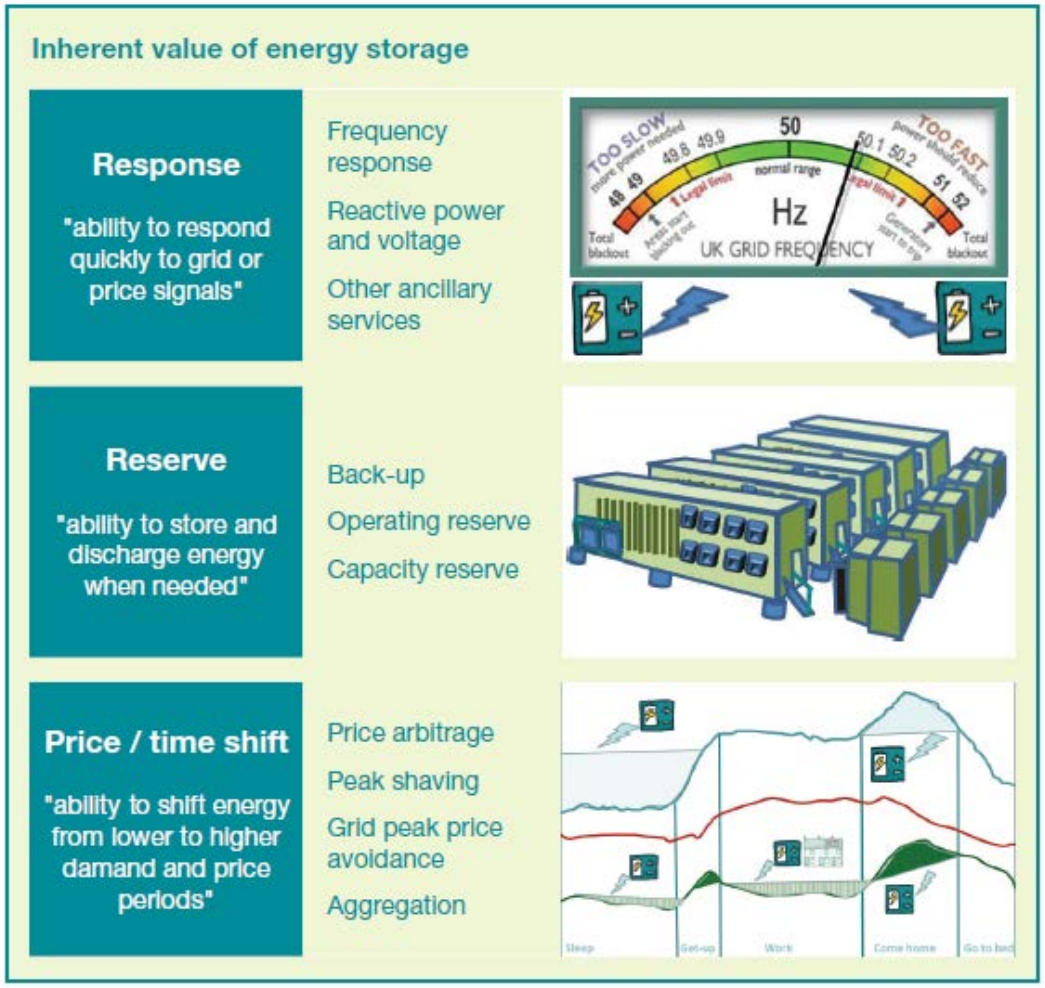
GREEN HEDGE

Triodos Bank

The role of energy storage

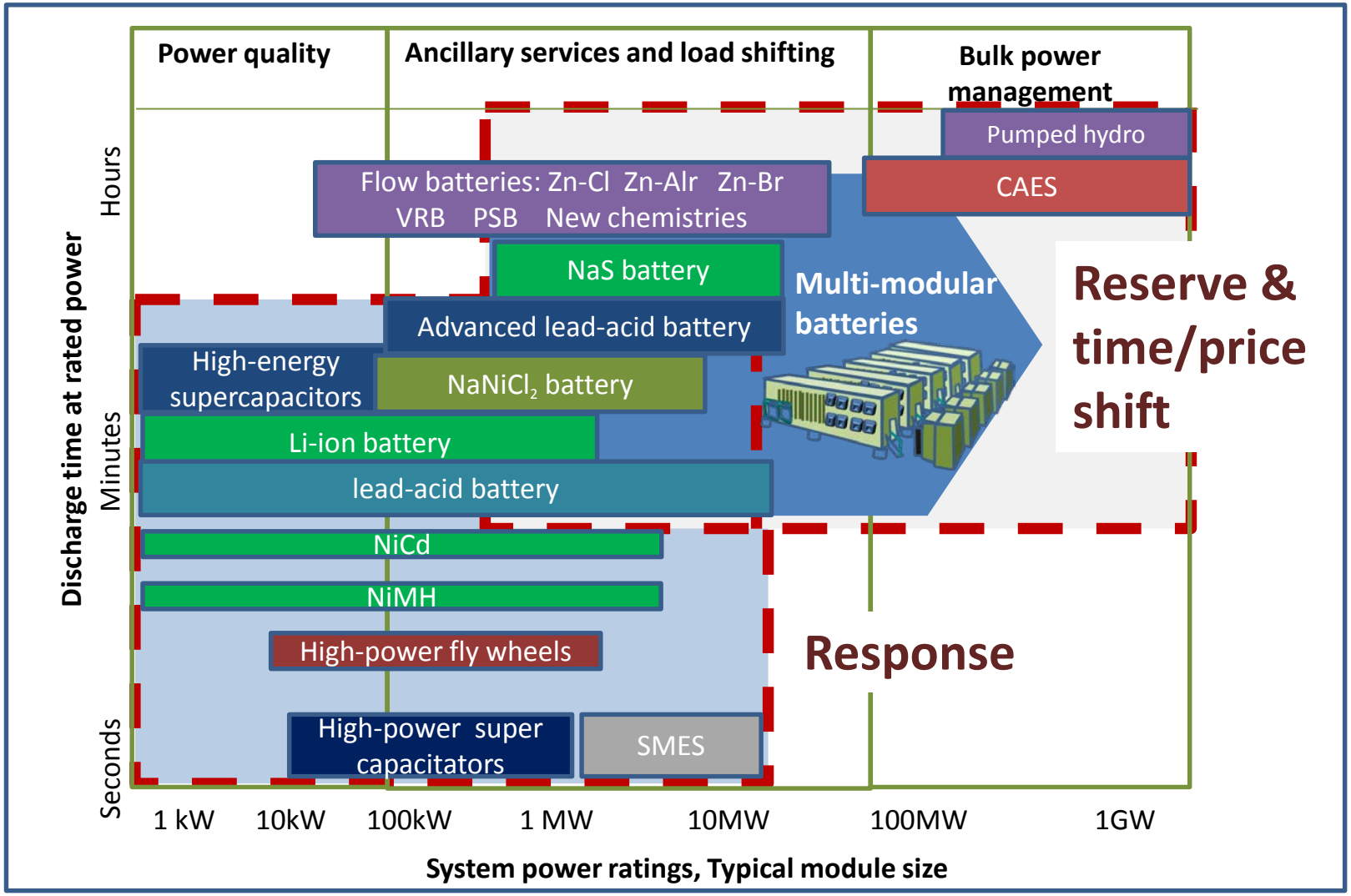


Response: The ability to respond quickly (milliseconds – minutes) to grid, frequency and/or price signals. Potential applications include the provision of ancillary network services such as frequency response and voltage support.

Reserve: The fundamental property of energy storage that enables the storage of energy to be used at a time when it is required. From a simple back-up capability for use as an alternative source of energy, to large scale capacity reserve and Short Term Operating Reserve.

Price and time shift: The capability to shift energy from lower to higher price/cost periods. A more sophisticated application of both reserve and response functions, allowing energy users and suppliers to take advantage of price variance (price arbitrage), avoid peak transmission and distribution costs and/or to recover energy that would be lost due to grid or other constraints.

Energy storage technologies



Rapidly falling technology costs

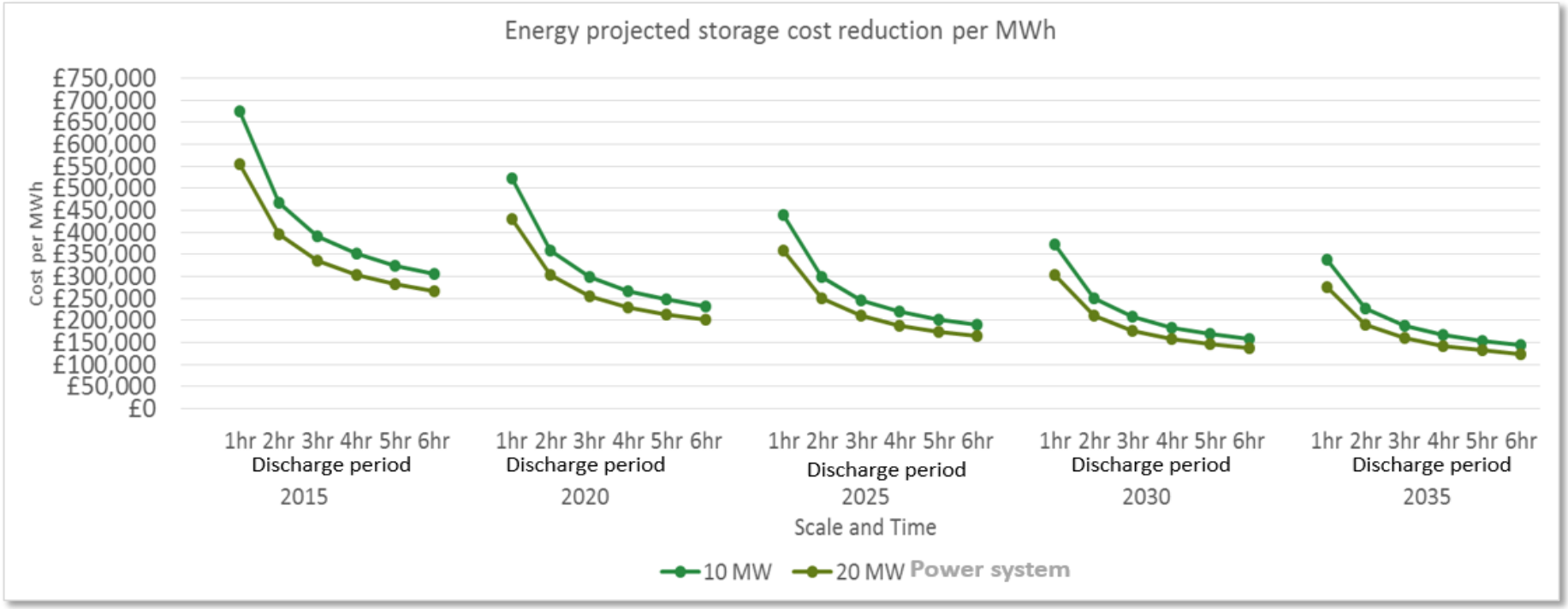
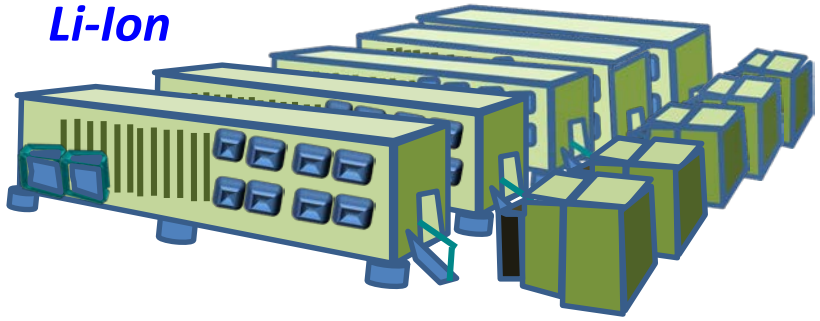


Image credit: Tesla Gigafactory, [Tesla 2017]

Falling solid state battery costs

Li-Ion



Potential revenue streams

regen transforming energy

	Major revenue stream	Route to market	Relative value	Market size*	Location options
Response	**Enhanced Frequency Response**	Tender (Auxiliary service)	High	200-700 MW	
Response	**Firm Frequency Response (generation or demand reduction)**	Tender (Auxiliary service)	High	2000-3000 MW	
Response	**Frequency Control by Demand Management (FCDM)**	Tender (Auxiliary service)	Med/high	??	
Reserve	**Fast Reserve**	Tender (Balancing service)	Med/high	250-600 MW	
Reserve	**Consumer backup power**	Contract	Variable	??	
Reserve	**Short Term Operating Reserve (generation or demand reduction)**	Tender (Balancing service)	Med	2-4 GW	
Reserve	**Capacity Market**	Tender - Capacity Auction	Med	GWs	
Time/price shift	**Transmission cost avoidance**	Market mechanism/cost avoidance	Med/high	GWs	
Time/price shift	**Distribution cost avoidance**	Market mechanism/cost avoidance	Med/high	GWs	
Time/price shift	**Generator "Own Use" (Domestic and non-domestic)**	Market via price/cost avoidance	Low	GWs	
Time/price shift	**Generator grid curtailment**	Market via price & subsidy revenue gain/reinforcement avoidance	Low/mid	GWs	
Time/price shift	**Price arbitrage (& peak shaving)**	Market via price variance/trade	Low	GWs	

 Transmission grid connected

 Distribution grid connected

 Potential demand side response or behind the meter

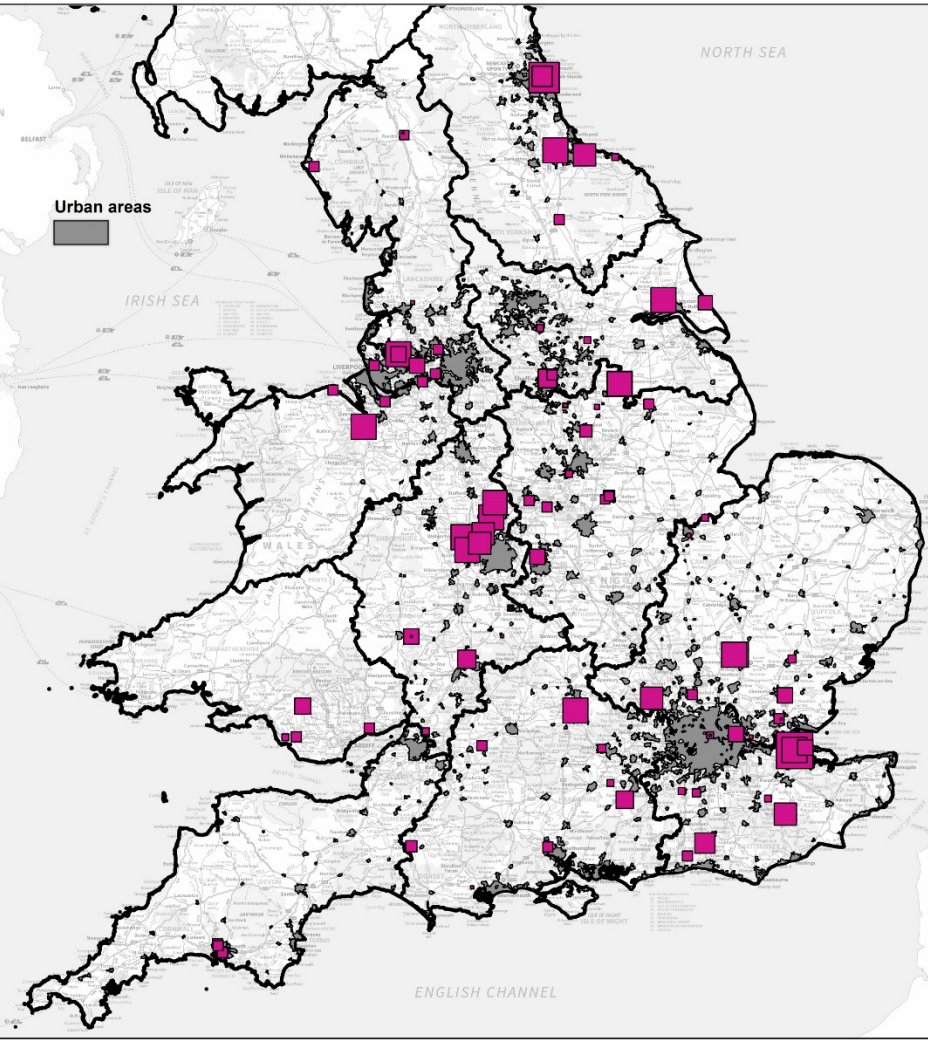
 Co-location with renewables benefits

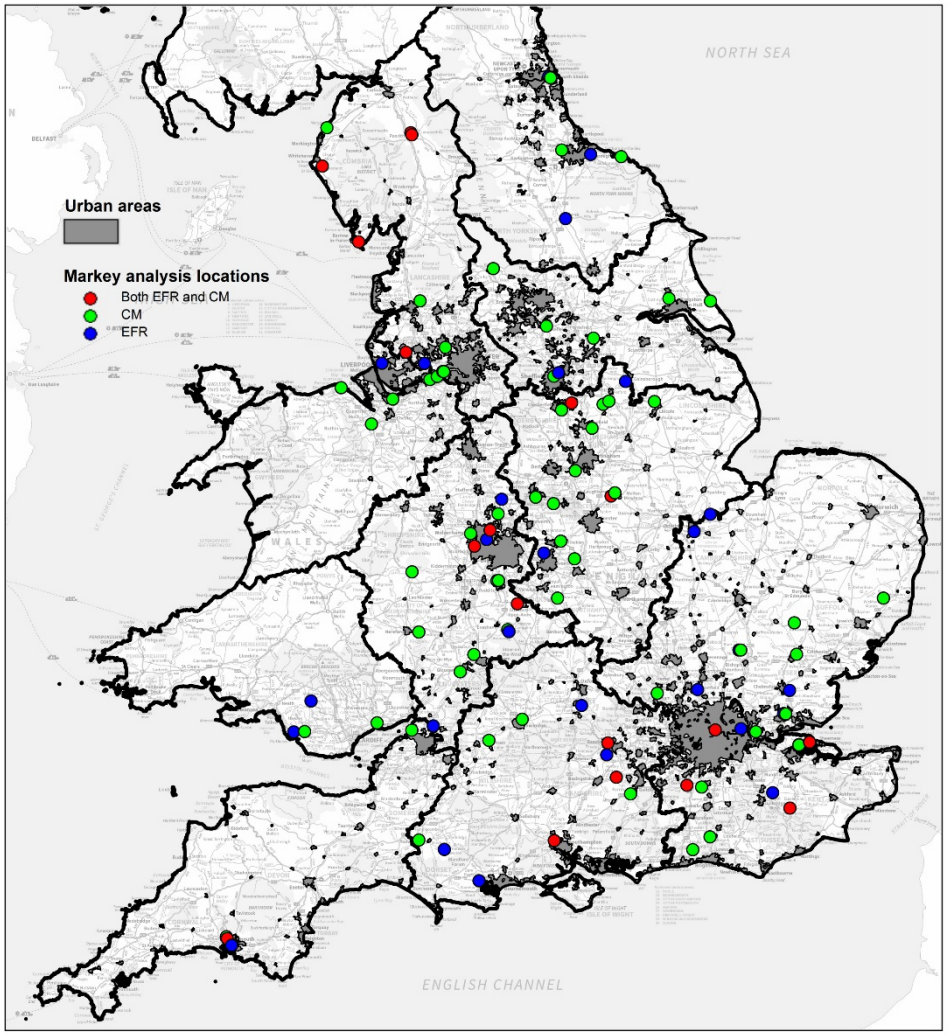
Table adapted from a number of sources including National Grid Future Energy Scenarios 2016

Emerging business models

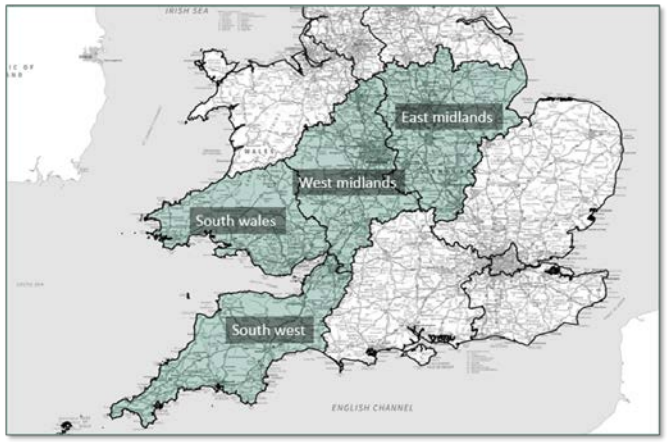
1. Response service	*Providing higher value ancillary services to transmission and distribution network operators, including frequency response and voltage support (EFR, FFR, ERPS)*
2. Reserve service	*Specifically aiming to provide short/medium term reserve capacity for network balancing, such as the Capacity Market, Short Term Operating Reserve (STOR) and Fast Reserve*
3. C&I high energy 'prosumers'	*Located with a higher energy user (with or without on-site generation) to avoid peak energy costs, and peak transmission and distribution charges while providing energy continuity*
4. Domestic and community 'own-use'	*Located with a higher energy user (with or without on-site generation) to avoid peak energy costs, and peak transmission and distribution charges while providing energy continuity*
5. Generation co-location	*Storage co-located with variable energy generation in order to a) price/time shift or b) peak shave to avoid grid curtailment or reinforcement costs*
6. Energy trader	*The business model that references the potential for energy supply companies, local supply markets and/or generators using storage as a means of arbitrage between low and high price periods - likely aggregated - and peak shaving.*

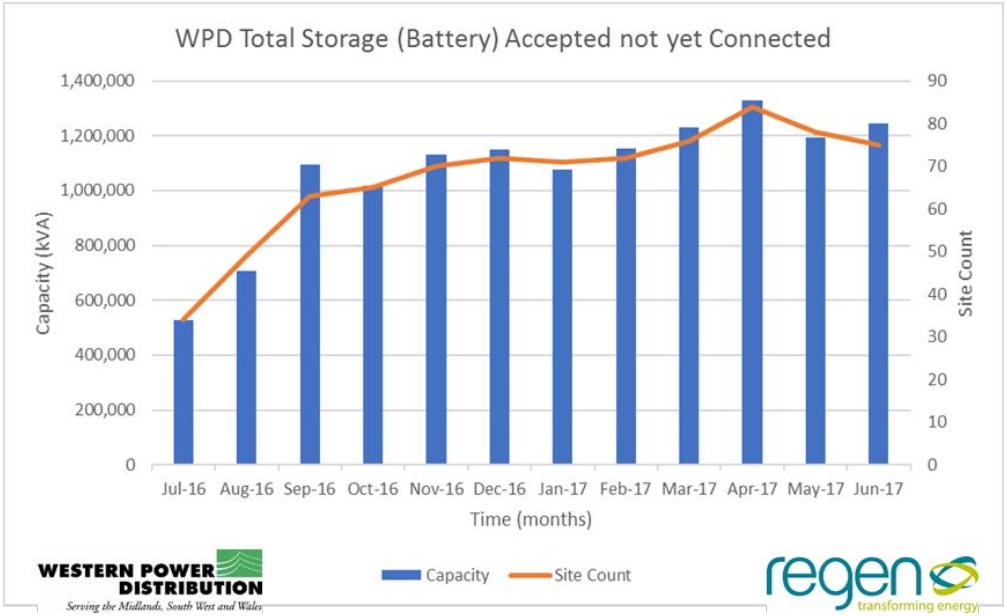
Storage projects bidding into EFR and capacity market auctions





Grid Connection Applications Surge





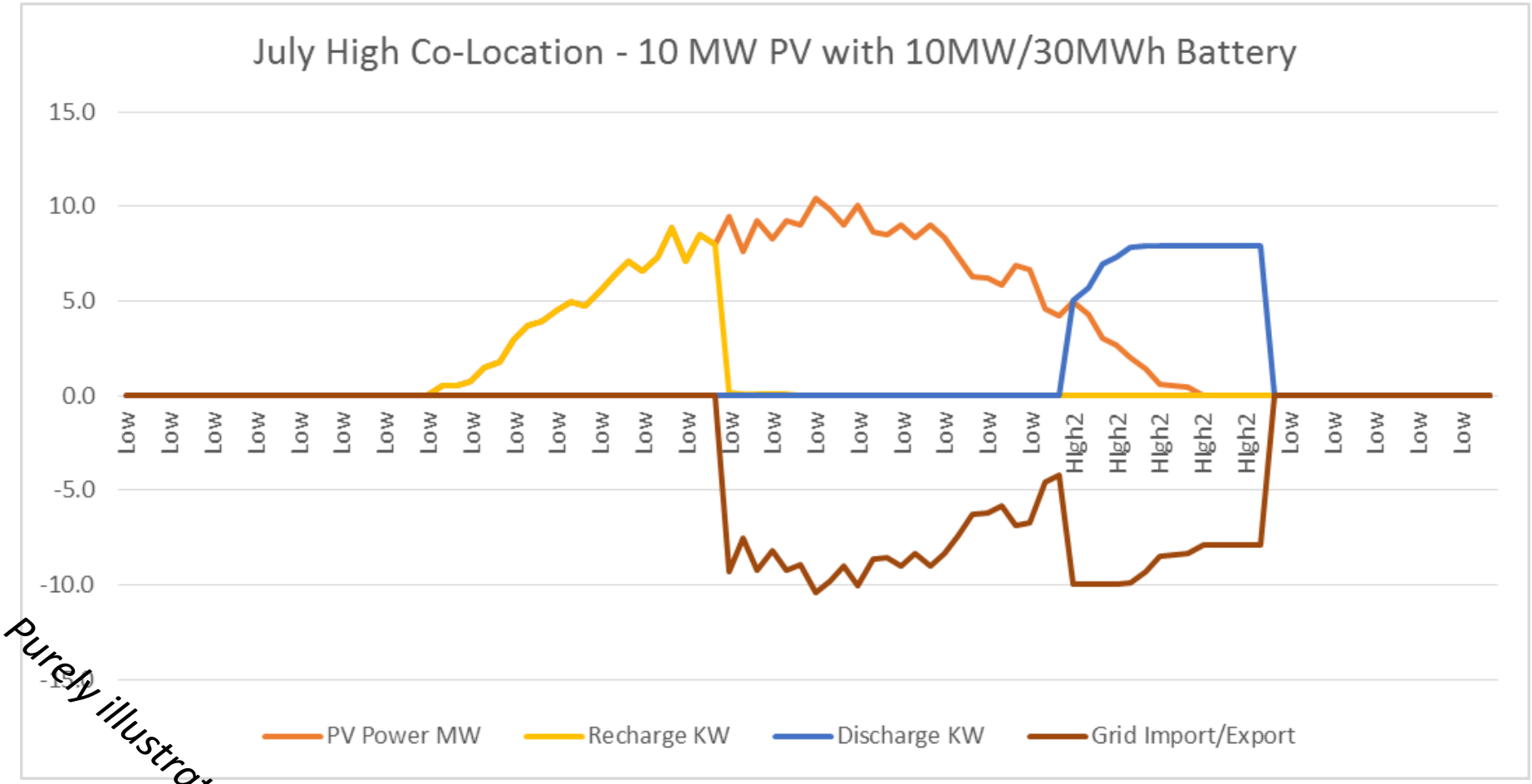
Western Power Distribution

- 140 projects
- 2.5 GW capacity applications
- 1.3 GW accepted applications

	Battery Storage Capacity					
	Connected		Accepted		Offered	
WPD Supply Area	Number of Sites	Capacity (MVA)	Number of Sites	Capacity (MVA)	Number of Sites	Capacity (MVA)
West Midlands	1	3	45	744	15	348
East Midlands	0	0	20	268	19	464
South Wales	0	0	4	101	1	5
South West	0	0	17	217	19	430
TOTAL	**1**	**3**	**86**	**1,330**	**54**	**1,247**

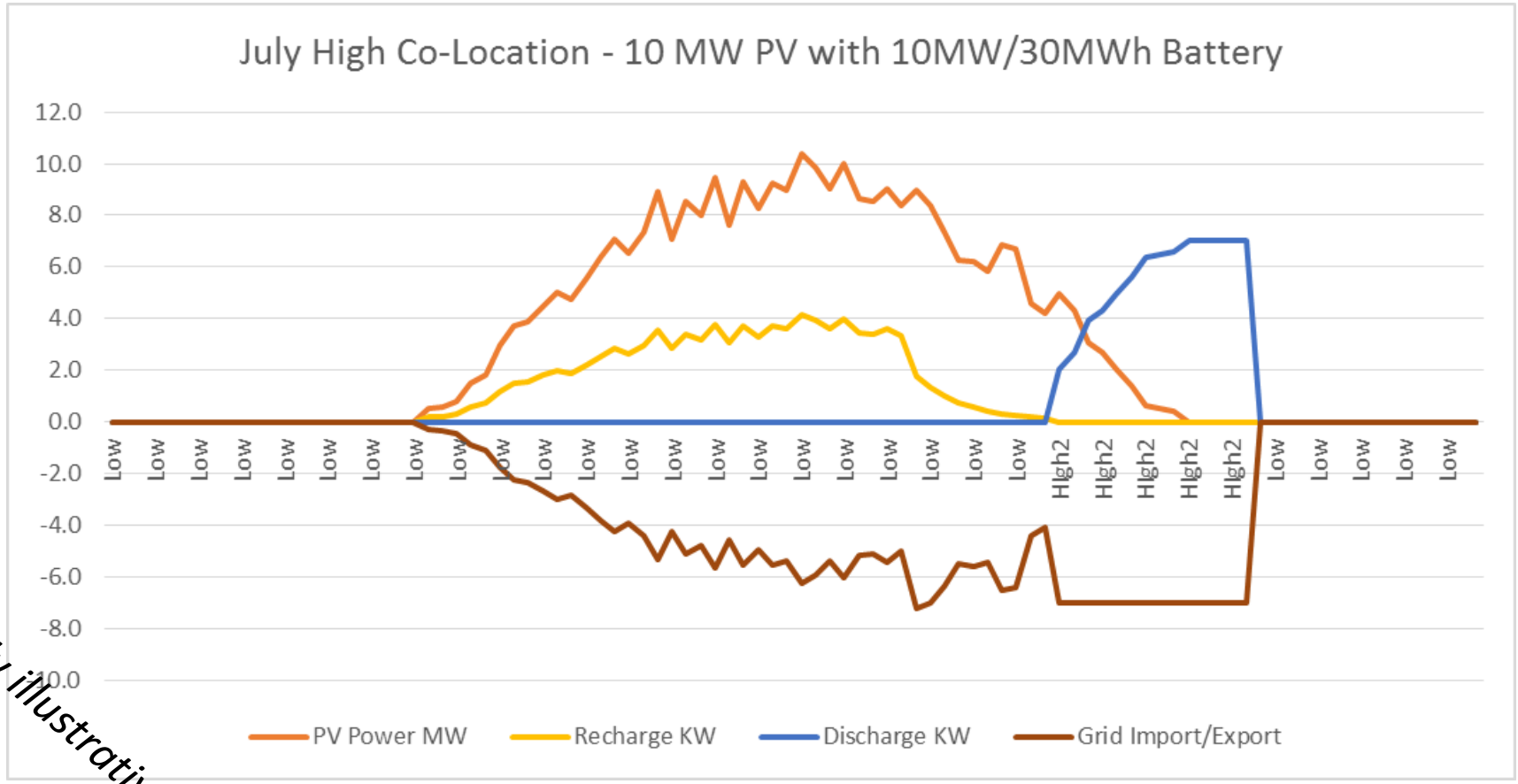
Figure 4 – WPD Generation Capacity Register data for storage, dated 3rd April 2017

How will storage assets operate? Simplistic co-location with PV model



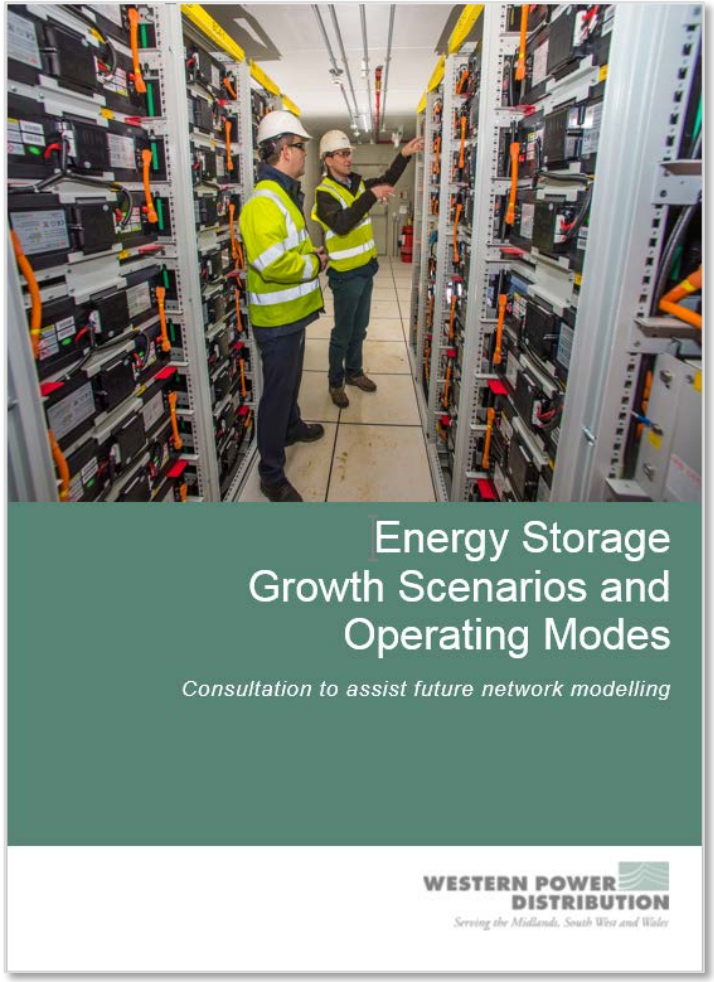
Purely illustrative numbers

How will storage assets operate
Peak shave with local 7 MW grid constraint



Purely illustrative numbers

WPD Consultation on energy storage



WPD is seeking to understand:

- *The potential scale of growth of energy storage within its distribution network*
- *The type of energy storage assets/projects that are likely to be deployed within its network and their business models*
- *The typical operating behaviour of storage assets, how they are likely to be used and their typical modes of operation*

Working with

Storage Operating Modes

Operating Mode	Summary Definition
i) Network Auxiliary services only	*Operating under direct contracted response services such as frequency, Voltage / Reactive Power. This mode is for battery systems that are dedicated to being available for these response programmes 24hrs a day*
ii) Network Auxiliary services + Network Peak	*As above, but carving out a small window of operation (2-4hrs) to discharge in peak network charge + commodity price periods.*
iii) Reserve service standby only	*Operating mode reflecting operation under balancing service contracts, effectively operating to be available for STOR, Fast Reserve, CM etc. - idle operation awaiting triggers/alerts*
iv) Reserve service + Network Peak	*Operating under balancing services contracts as above, but also carving out a window of operation to discharge during peak network charge + commodity price periods*
v) Network Peak Charge Avoider Only	*A mode of operation designed predominantly for behind the meter classes of project, whereby a battery system has been implemented to supply a demand load during network peak charges. Battery charging is during lowest price periods.*
vi) Cost Sensitive Self-consumption	*A mode where a demand user with generation is maximising self-consumption, but discharging during high commodity/delivery charge periods. This could currently be a C&I user with generation, subject to cost sensitivity or smaller users with Time of use Tariffs*
vii) Max Self-Use	*A mode where the maximisation of self-usage is not sensitive to high/low price thresholds (i.e. domestic solar with a flat electricity import tariff). Charging when solar is generating, discharge when energy is needed.*
viii) Generation Peak Shaving	*Mode of operation where storage is co-located with a stand alone generation, diverting proportion of generation into storage, so as to bypass grid export limitations. Likely to also discharge during network peak.*
ix) Generation Time & Price Shift	*Mode as above, but whereby there is no grid export limitation restriction and the co-located storage is simply shifting the time of some exported volume into more beneficial times - i.e. evening network peak*

WPD Storage operating mode model overview

Business Models

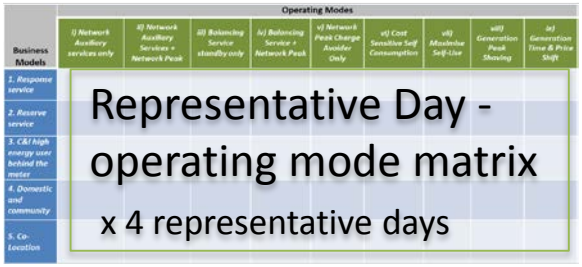
X 6 models

1) How much power/capacity of each storage type or asset class is deployed

Operating Mode

X 9 generic modes

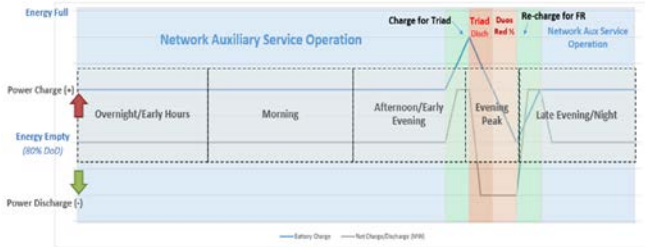
2) How a storage asset likely to be is used expressed as a discharge/charge profile



3) How many (MW and MWh) storage assets are operating under each mode on a representative day – winter peak, summer generation, autumn and Spring

Storage Growth Scenario Dataset

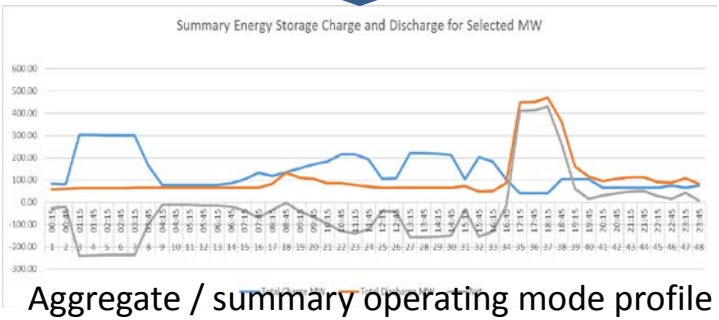
Operating Mode
i) Network Auxiliary services only
ii) Network Auxiliary services + Network Peak
iii) Reserve service standby only
iv) Reserve service + Network Peak
v) Network Peak Charge Avoider Only
vi) Cost Sensitive Self-consumption
vii) Max Self-Use
viii) Generation Peak Shaving
ix) Generation Time & Price Shift



24 hr operating profiles x 9 modes

			Selected Year MW
Business Model	Scenario	ESA	2030
Response service	Gone Green	ALL East Midlands Licence Area	279
Reserve service	Gone Green	ALL East Midlands Licence Area	150
High energy commercial and industrial	Gone Green	ALL East Midlands Licence Area	266
Domestic and community own use	Gone Green	ALL East Midlands Licence Area	237
Generation co-location	Gone Green	ALL East Midlands Licence Area	208

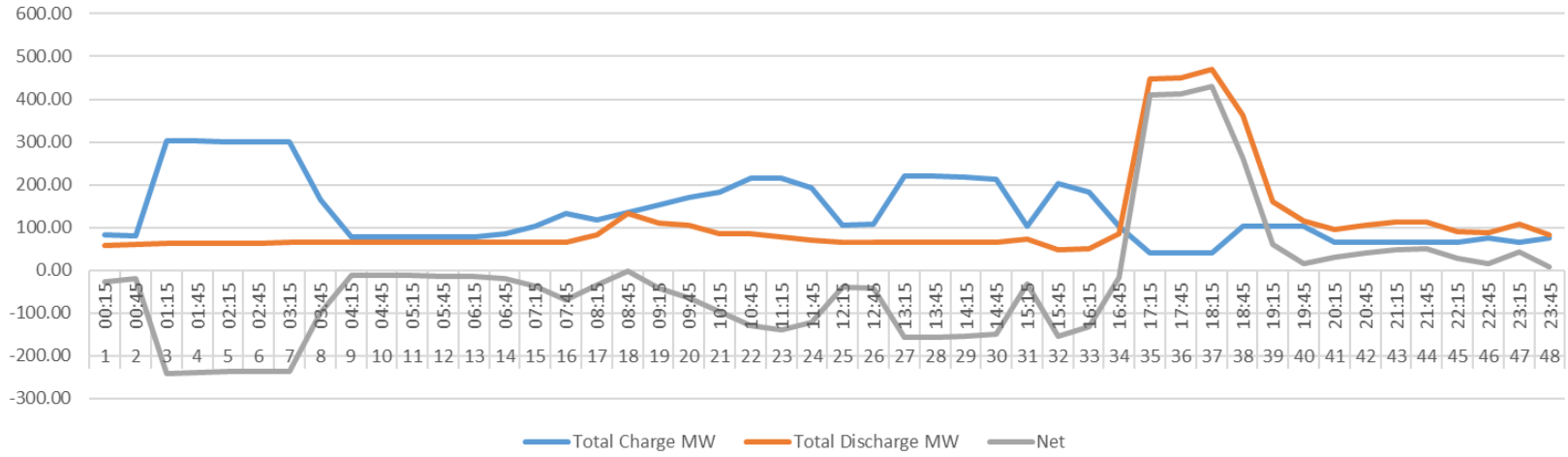
Selected Data for given ESA, Scenario, Year



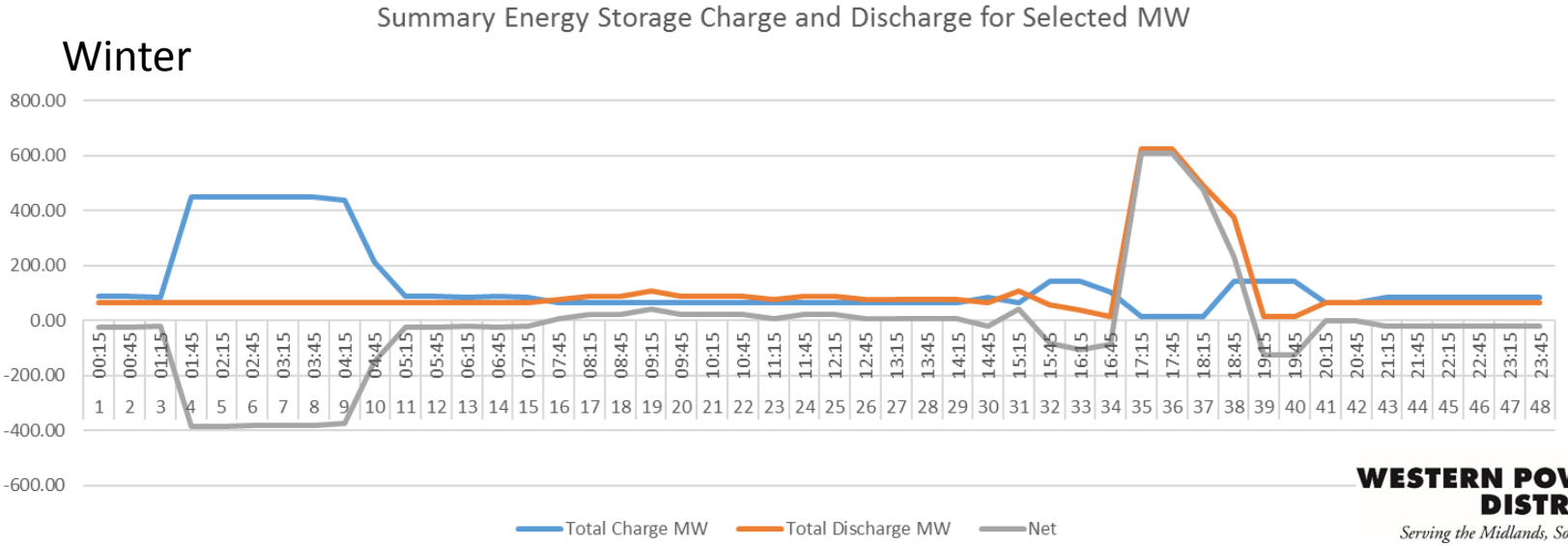
Aggregate / summary operating mode profile

Aggregate storage operating profile for a representative day

Summer



Winter



WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

Next wave of commercial storage
Key drivers

regen transforming energy

Auxiliary grid and network services

Future of Balancing Services

50Hz

power responsive

nationalgrid

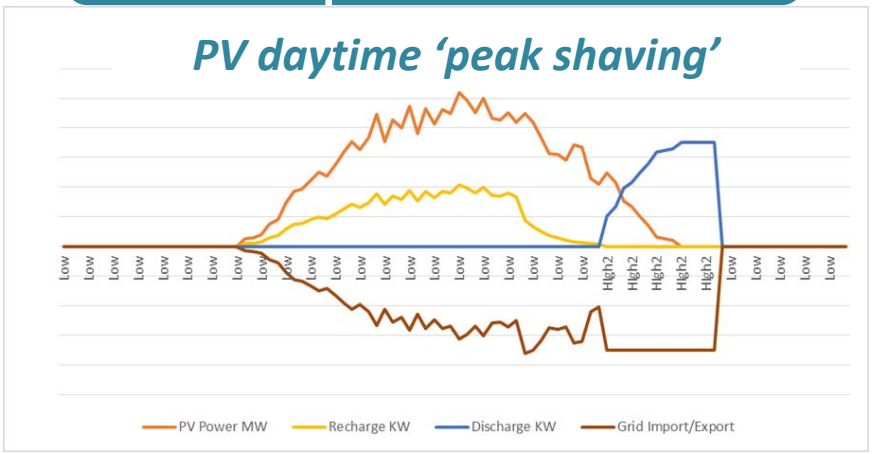
Transmission

&

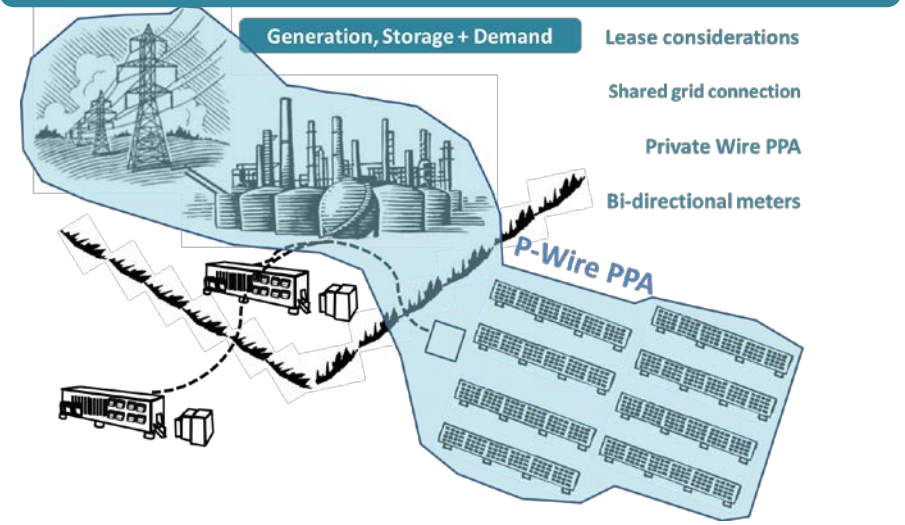
Distribution

Network charge avoidance + credits

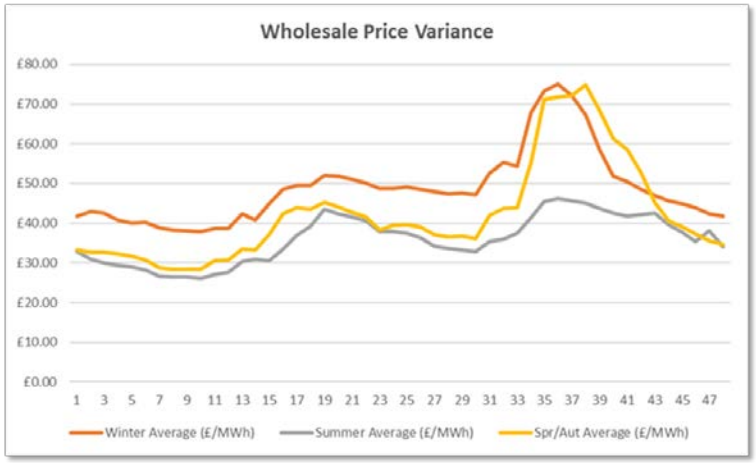
Generation/network asset optimisation



Commercial and industrial co-location

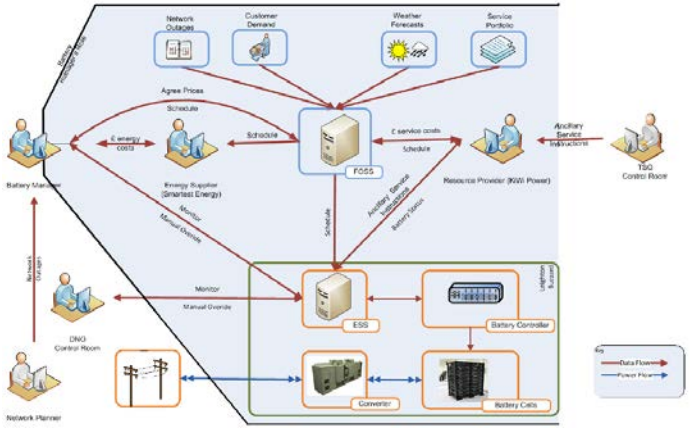


Trading and Price arbitrage



Enabled by new technology

Storage Control Systems



Source: UKPN Leighton Buzzard LADD document

Network Interfacing Devices

Argand Solutions Grid GEM™

ABB PMU

green acorn EMMA
ENERGY STORAGE & BACK UP SYSTEMS

POWERFLOW
Export Limitation Module

Aggregation Platforms & Tech

limejump

KiWiPOWER
demand management

REstore

upside

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

Flexible Power
By Western Power Distribution

e·on Virtual Power Plant

Bitcoin / Blockchain

Image credit: https://solarcoin.org/

Image credit: Microgrid Media

National Grid
System Needs and Product Strategy

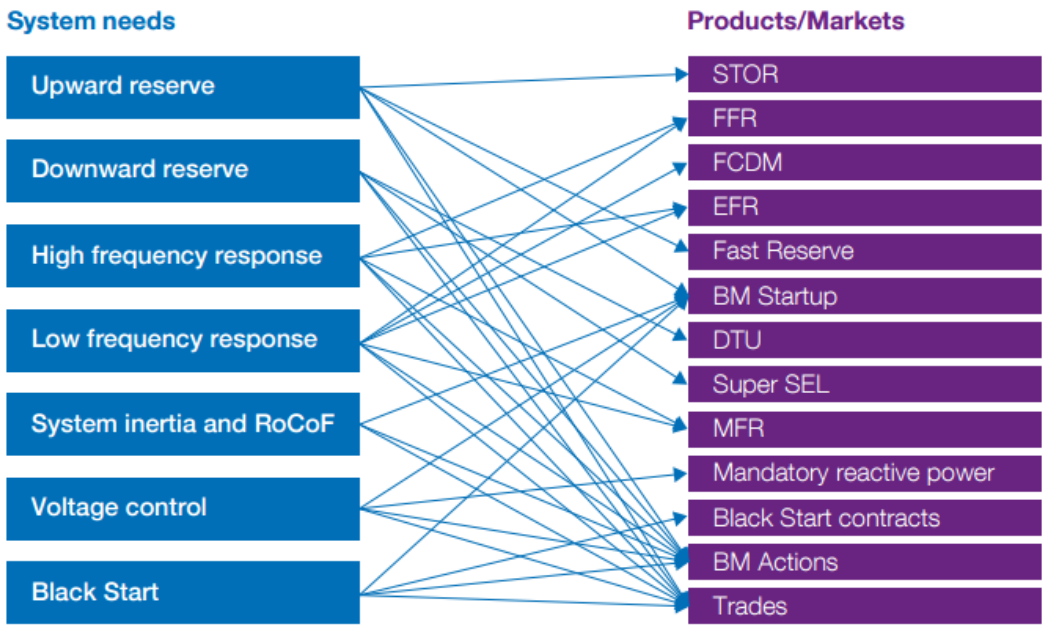
Streamlining of programmes (24 at present)

Consistency of technical requirements

Focus on non-frequency other programmes (Fast Reserve, FDCM)

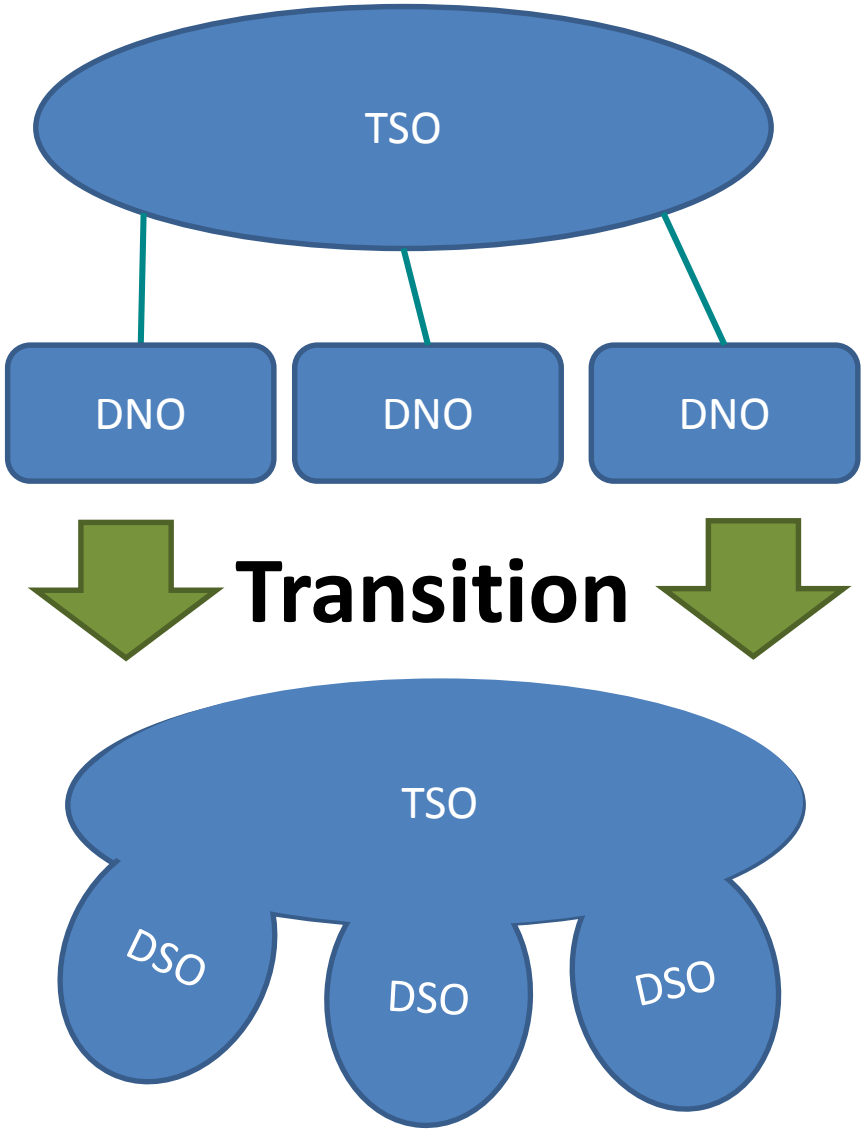
System inertia is also key

power responsive



Could this drive a move behind the meter?

TSO/DSO model
Opportunities for innovation



- Smarter network solutions
- Voltage, thermal and power flow management
- Multi-purpose capabilities – frequency, voltage, balancing
- Data and analytics
- Modularity and flexibility
- Alternative non-network solutions – investment deferral
- Flexibility trading (platforms)
- Managing uncertainty
- Inter system (EU) integration
- New markets and new partners




Regen, Innovation Centre, Rennes Drive, Exeter, EX4 4RN
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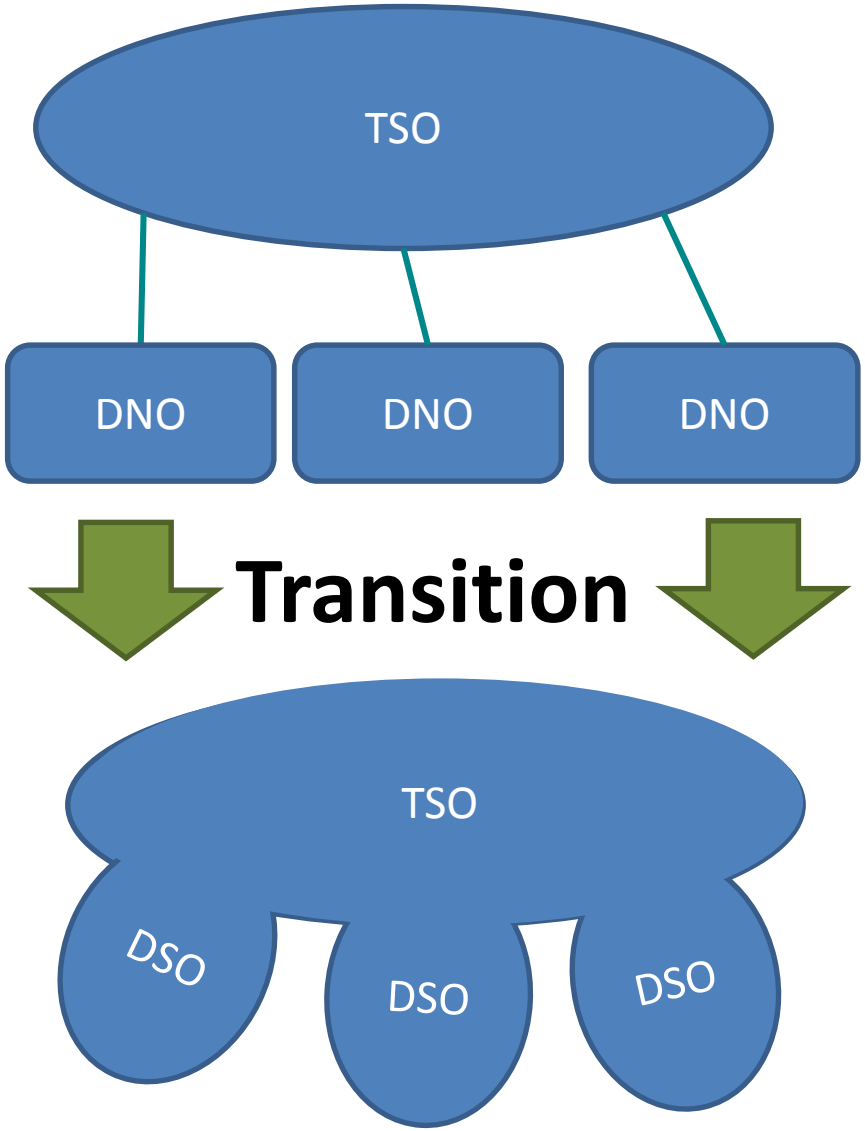
Shift from TSO to a more holistic TSO/DSO model



Shift from a top-down centralised management philosophy

More collaboration with increased management at a network and local area level

A more holistic approach

But integration critical at a system and cross system (European market level)

and a big year for storage

EFR Auction

- 200 MW – 8 projects @£7.50-
- 1.2 GW of bids across 60 sites

2016 T4 Capacity Market

- 500 MW of new storage @£22

Pipeline ov

Embedded

- Ofgem op
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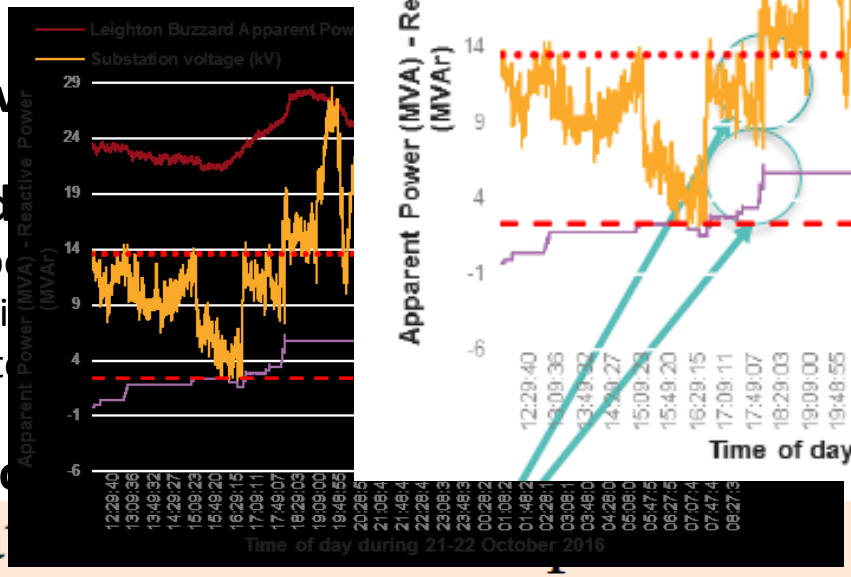
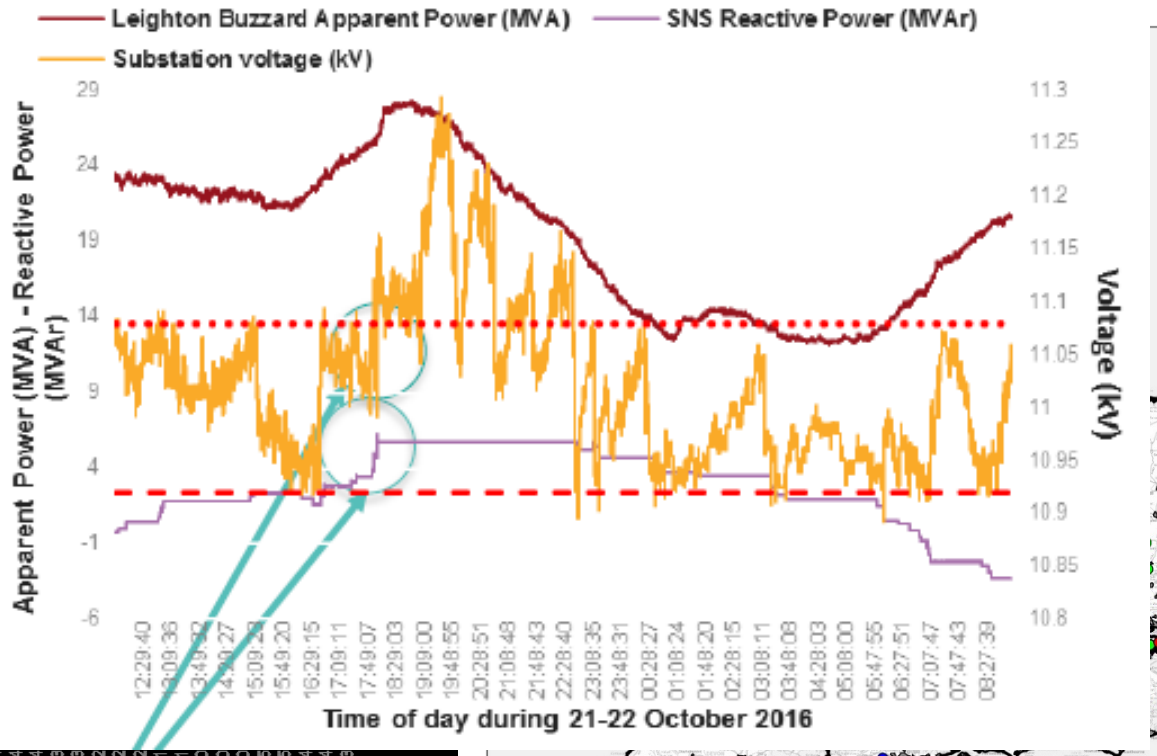
Consultati



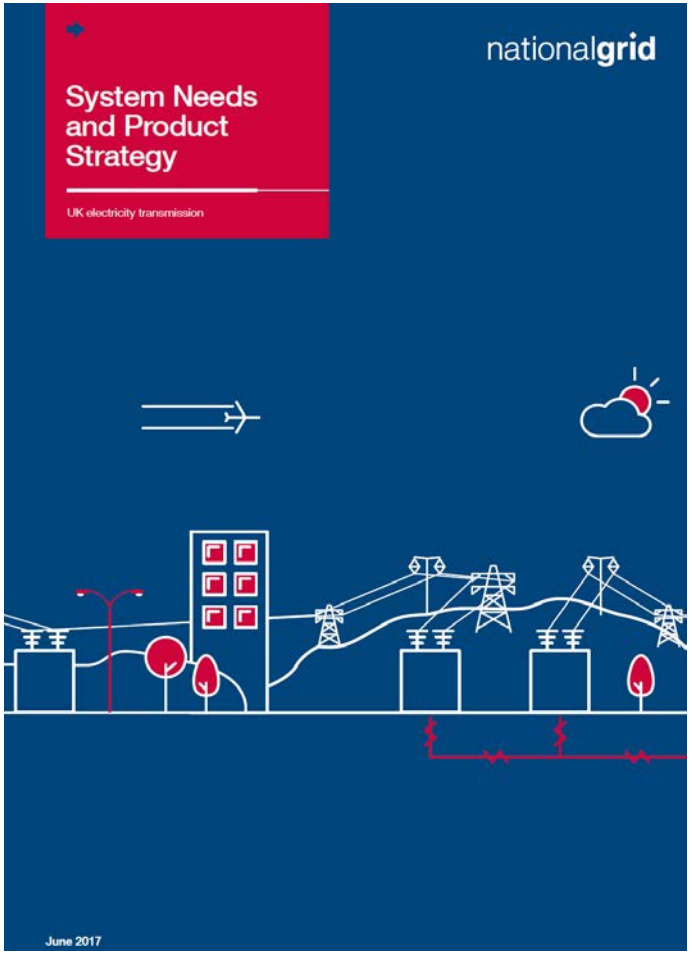


Why ba
than Brexit

Nick Butler's blog

FINANCIAL TIMES

National Grid – System Needs and Product Strategy



System need	What is the need?	Why is the need changing?	Where is the need?	How will we address the need?	When will we address the need?
System inertia/ Rate of Change of Frequency (RoCoF)	■ Inertia is required to ensure the Rate of Change of Frequency is manageable. ■ The number of occasions that the SO must act to manage inertia or RoCoF are increasing.	■ Less generation on the system providing inertia means that frequency changes happen more quickly.	■ General system need; while there is variation in the RoCoF across the system we currently need to manage system-wide and do not currently resolve on a locational basis.	■ Programme to desensitise RoCoF relays. ■ Reduce largest loss below RoCoF relay trigger points when required.	■ Ambition is to improve response products by March 2018. ■ RoCoF relay programme began in 2016 for >5 MW generation. Second phase currently being designed to address smaller generation.
Frequency response	■ Response needs become more volatile with greater extremes. ■ Increasing need for fast-acting sources of frequency response. ■ Tendered firm volumes remain fairly stable.	■ Less generation on the system providing inertia means that frequency changes happen more quickly.	■ General system need; no specific locational sensitivities.	■ New response product design which will include inertia and sub-second response. ■ Until launch, continue to contract for firm needs ahead of time in tendered markets and access close to real-time flexibility in BM through mandatory services.	■ Response product to be designed and launched by March 2018.
Reserve	■ Reserve needs become more volatile with greater extremes. ■ Increasing need for downward reserve when transmission demand is low. ■ Increasing need for close to real-time flexibility. ■ Tendered firm volumes remain stable.	■ Reserve needs increase due to uncertainty in weather-based generation and uncertainty of small-scale generation.	■ General system need; no specific locational sensitivities.	■ Standardise current reserve products to increase transparency of value. ■ New reserve product design to allow closer to real-time procurement of flexibility. ■ Flexibility accessed in BM through mandatory services.	■ Standardisation of current reserve products to be completed summer 2017. ■ New reserve product to be designed and launched in 18/19.

Electricity Price Arbitrage