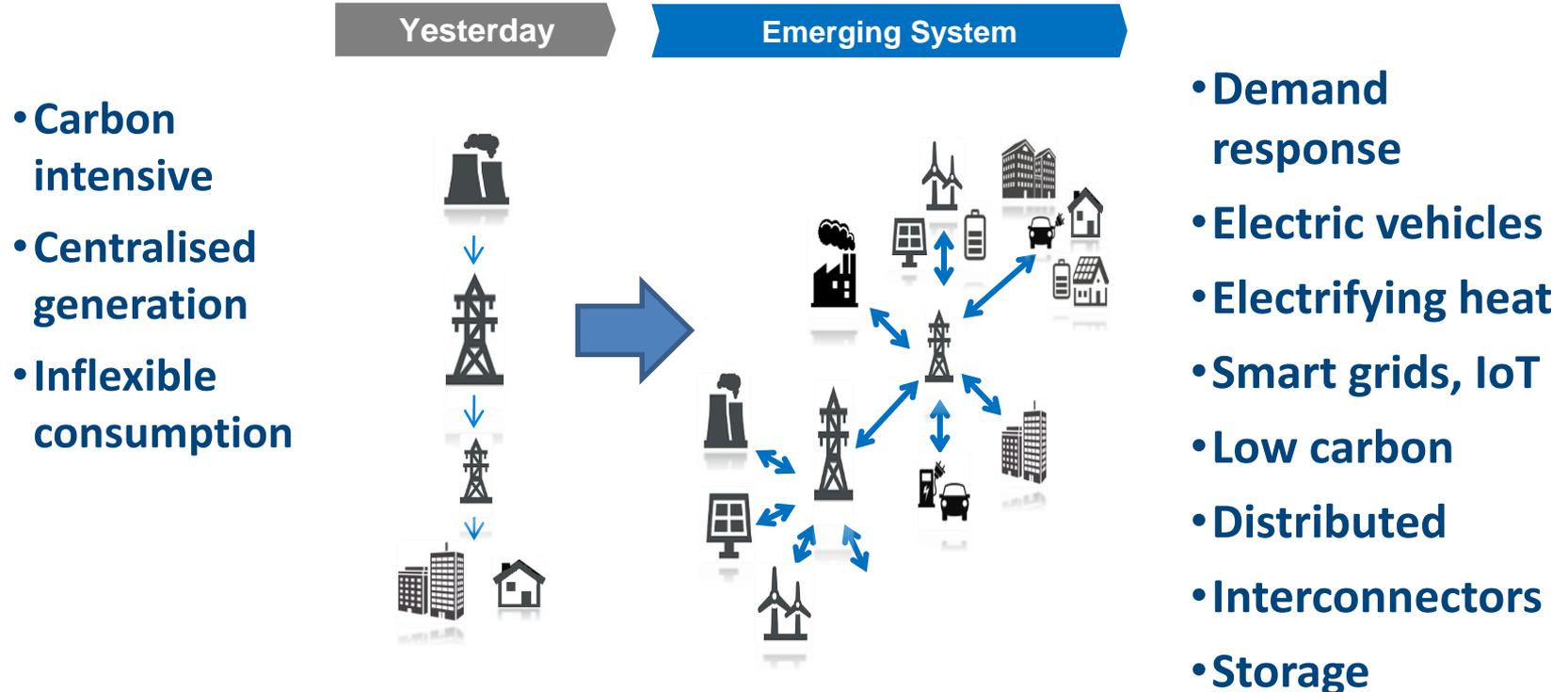


Energy Storage: Integrating into the UK electricity system

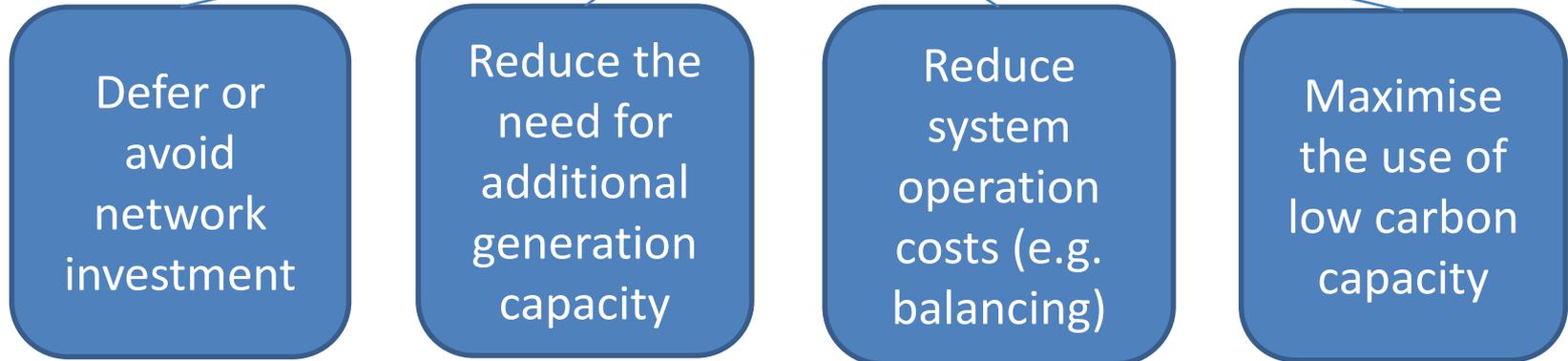
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Smart energy and Flexibility in the UK Electricity System



What is the value of Smart and Flexible technologies to the UK electricity system?

Deploying **smart, flexible technologies**, such as storage and demand-side response, **can save the UK up to £40bn** across the electricity system to 2050.*



* When compared against electricity systems that do not deploy additional flexibility technologies. Upgrading Our Energy System: Smart Systems & Flexibility Plan (July 2017).

Smart Systems & Flexibility Plan 2017

Enabling greater DSR participation among domestic / non-domestic consumers

- Enabling Half Hourly Settlement and time of use pricing / tariffs
- Delivering smart meters
- Standards for smart appliances
- ADE's voluntary code of conduct for aggregators
- Assessing cyber security & consumer risks

Ensuring markets can allow the best flexible solutions to flourish & compete fairly

- Improving access to markets (e.g. Balancing Mechanism & Ancillary Services) for distributed energy resources
- National Grid's System Needs & Products Strategy
- DNO-DSO transition - market based approaches
- New markets for local flexibility
- Enable value stacking from different markets
- Regulations on 'relevant balancing services'

Removing barriers to smart technologies



Smart homes and businesses

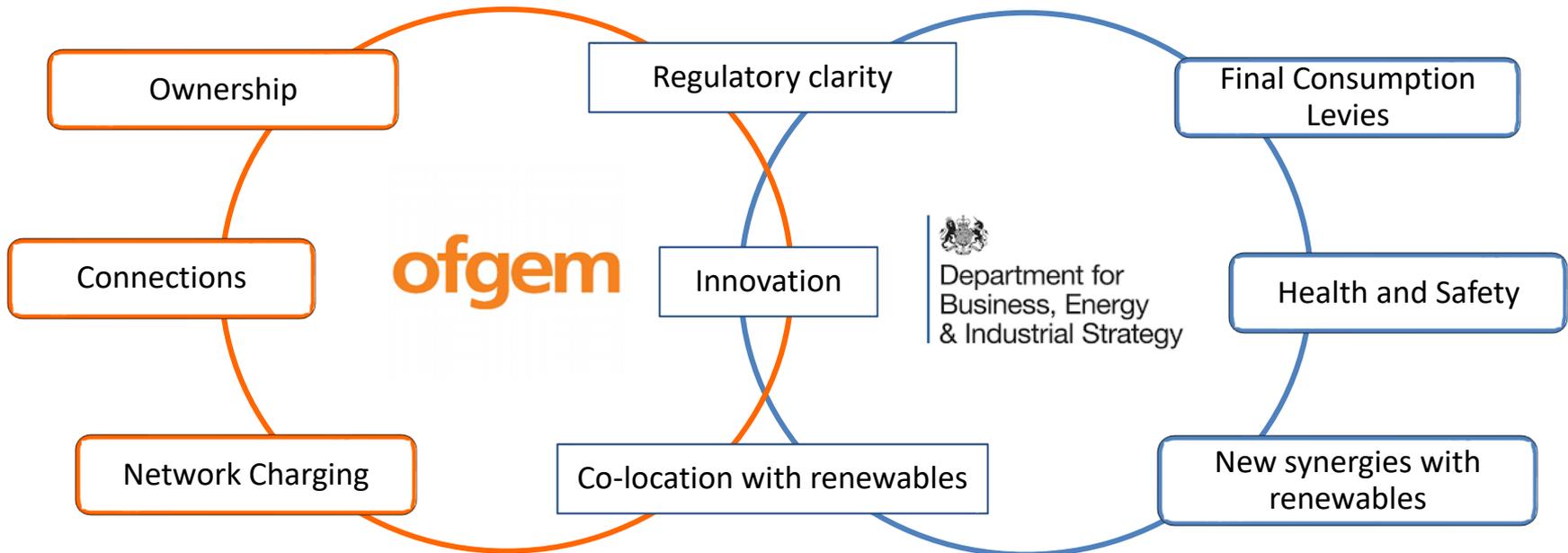


Markets that work for flexibility



Removing barriers to storage: 9 actions

Our aim is to **create a level playing field, so that energy storage can compete fairly** with other forms of flexibility and more traditional energy solutions



Regulatory Clarity & Final Consumption Levies

Regulatory Clarity

- Define storage as subset of generation in primary legislation when parliamentary time allows
- Ofgem consulting on modifying generation licence to include storage – live by Summer 2018



Planning process

- Confirmed storage to be treated as generation
- Review this treatment – guidance & threshold



Final consumption levies

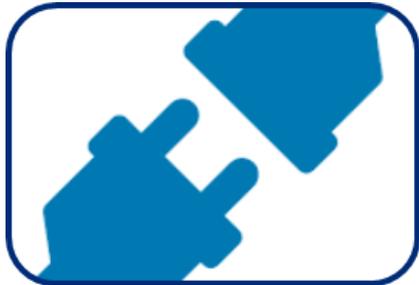
- Supply to licence holders excluded from calculations of supplier obligations
- Clarified that certain storage facilities can be CCL exempt

Co-location, Charging & Ownership



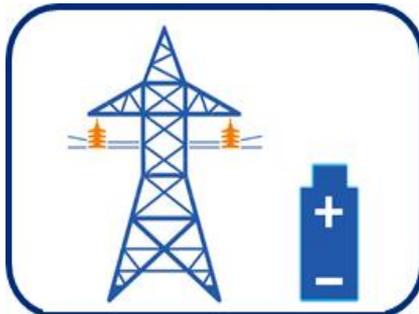
Co-location with Renewables

- Ofgem E-Serve published new guidance on how storage can be co-located with generation under FIT & RO schemes in December 2017
- Govt. has outlined a position on how storage should be treated under the Contracts For Difference scheme



Network Charging

- Ofgem has confirmed storage should not pay for certain aspects of network charges – i.e. non-locational aspects of demand charges, and both sets of balancing system charges



Ownership by Network Operators

- Ofgem recently consulted on regulating ownership/operation - ensuring storage sufficiently separated from network business
- Ambition is for DNO-DSO transition to bring market based solutions for network owners to procure services

Removing Barriers to Storage: UK Smart Innovation Funding

The Plan announced **up to £70 million to support innovation** in storage and other smart technologies up to 2021.

In January 2017, Gov. launched two energy storage competitions:

1. up to £9m **cost reduction** of energy storage technologies; and
2. a further £600k for feasibility studies for a first-of-a-kind, **large scale future storage demonstrator**.

The Industrial Strategy Challenge Fund (ISCF) includes the **'Faraday Challenge'** – **£246m** to ensure the UK becomes a world-leader in the development and manufacture of batteries principally for electric vehicles. The second wave of ISCF includes **'Prospering from the Energy Revolution'** that intends to develop world-leading smart energy systems that deliver cheaper and cleaner energy across power, heating and transport.



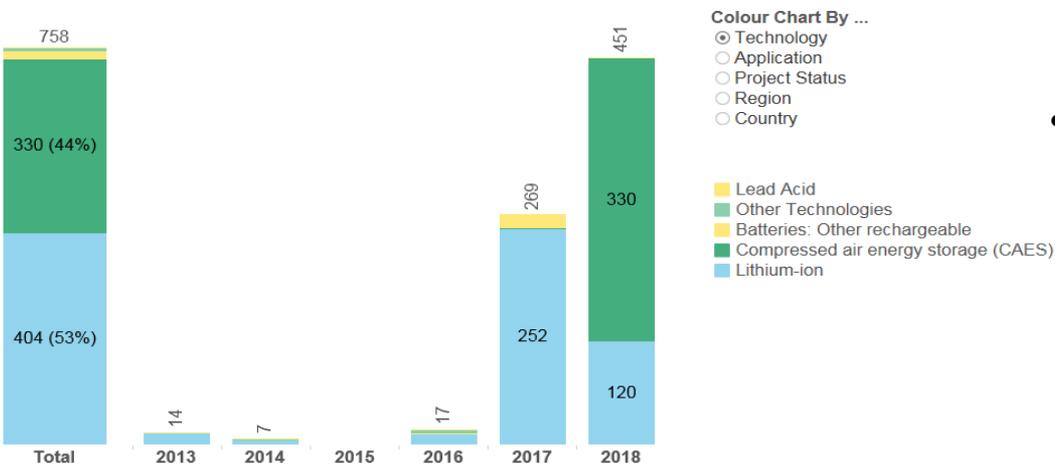
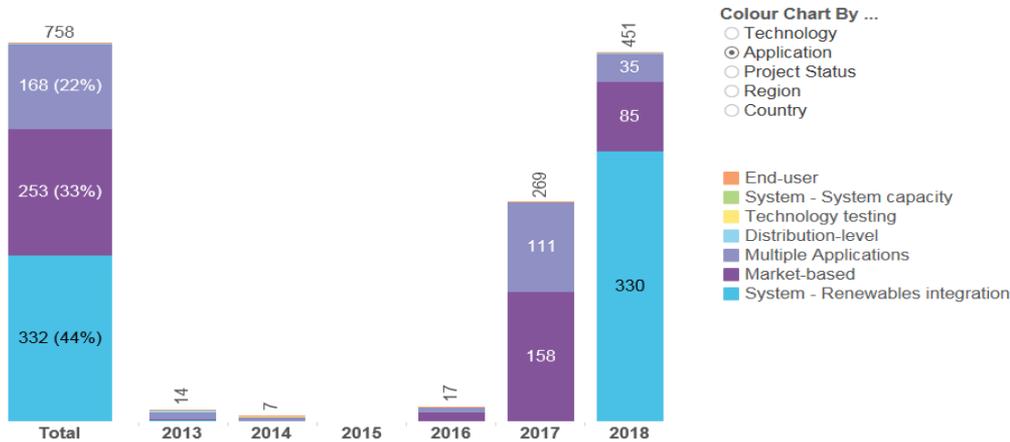
There are numerous storage technologies used in the UK

	Technology	Expected Life (Years)	Maturity	Cycle Efficiency	Response Time	Cost (\$/kW)	Cost (\$/kWh)
Solid State	Lead/acid	5-15	Demo to Mature	75-80%	Milliseconds	400-600	150-300
	Lithium-ion	5-15	Demo to Mature	80-94%	Milliseconds	400-600	300-450
	Sodium-sulphur	5-15	Demo to Deploy	75%	Milliseconds	400-600	300-400
Flow State	Flow batteries (Vanadium redox /Zinc bromide)	15-20	Develop to Deploy	60-70%	Milliseconds	800-1200	150-300
Mechanical	Pumped hydro	30-50	Mature	80-82%	Seconds to minutes	1,500-2,700	138-338
	Compressed air (Underground)	15-40	Demo to Mature	65-75%	Seconds to minutes	2000-3000	<i>Low, site dependent</i>

Source: IHS (2016), ECOFYS, Norton Rose Fulbright,

UK Storage by Application and Technology

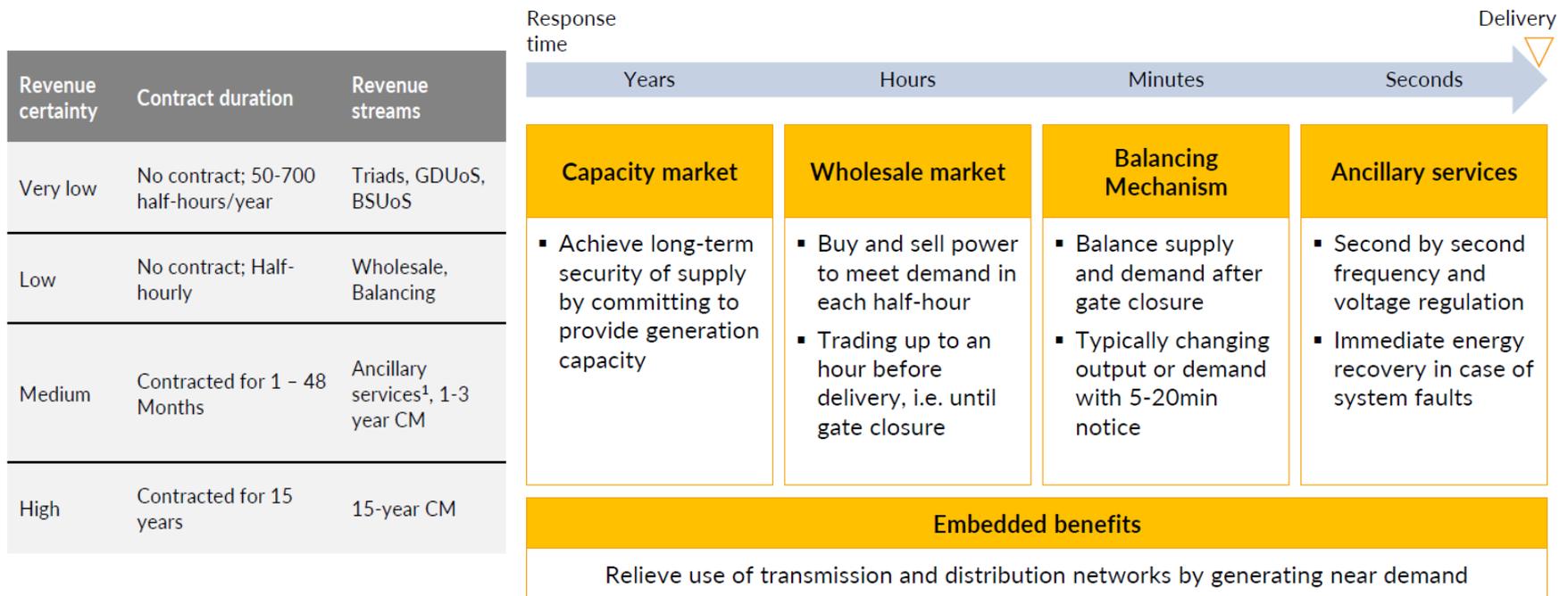
Total Energy Storage by Power Output (MW) and Commissioning Date



- The large chunks of capacity in both charts relate to the 330MW (CAES) project located in Northern Ireland and funded by the Connecting Europe Facility (CEF)
- The aim is to use this CAES facility to store curtailed wind power for periods of peak demand
- The majority of projects being delivered in 2017/18 are Li-ion batteries designed to provide Enhanced Frequency Response (EFR)

Source: BNEF (2017)

Storage can operate in a number of UK markets



- Profitability balanced with contract length and revenue certainty
- Diversification spreads risk and can improve overall revenues

Batteries can technically offer a range of services

Market	Service
Energy Market	Capacity Market
	Wholesale Market
	Balancing Market
Ancillary Services	Enhanced Frequency Response (EFR)
	Fast Frequency Response (FFR)
	Fast Reserve
	Short Term Operating Reserve (STOR)
	Demand Turn-Up
	Black Start
	Voltage management
Embedded Benefits	TNUoS Avoidance
	GDUoS Avoidance

Stacking revenues is important to investors

		Frequency Regulation (EFR)	Frequency Regulation (FFR)	Energy Reserve (Fast Reserve)	Energy Reserve (STOR)	Energy Trader
Energy Markets	Wholesale/ Balancing					✓
	Capacity	✓	✓	✓	✓	✓
Ancillary Services	EFR	✓				
	FFR		✓			
	Fast Reserve			✓		
	STOR				✓	
Embedded Benefits	TNUoS					
	GDUoS					

Source: Aurora (2017)

Embedded and Transmission

Embedded Only

Primary Function: ✓

Final remarks

- The Plan is an important first step, and we know there will be more to be done. Technology and commercial models continue to evolve.
- We will implement the Plan and continue our close engagement with industry to understand what more is needed.



Annex

Funding Innovation: BEIS Competitions

**BEIS Smart Energy Innovation Programme:
Up to £70m**

Energy Storage Competitions (£10m):
Focused on cost reduction of larger scale technologies

Demand Side Response Competitions (£24m):
Engaging domestic & commercial consumers with innovative DSR applications

Vehicle-to-Grid Competition (£20m):
Innovative technology and business approaches to harness vehicle-to-grid services

Flexibility Markets Competition (£0.6m):
Innovative approaches to value and trade flexibility at local levels

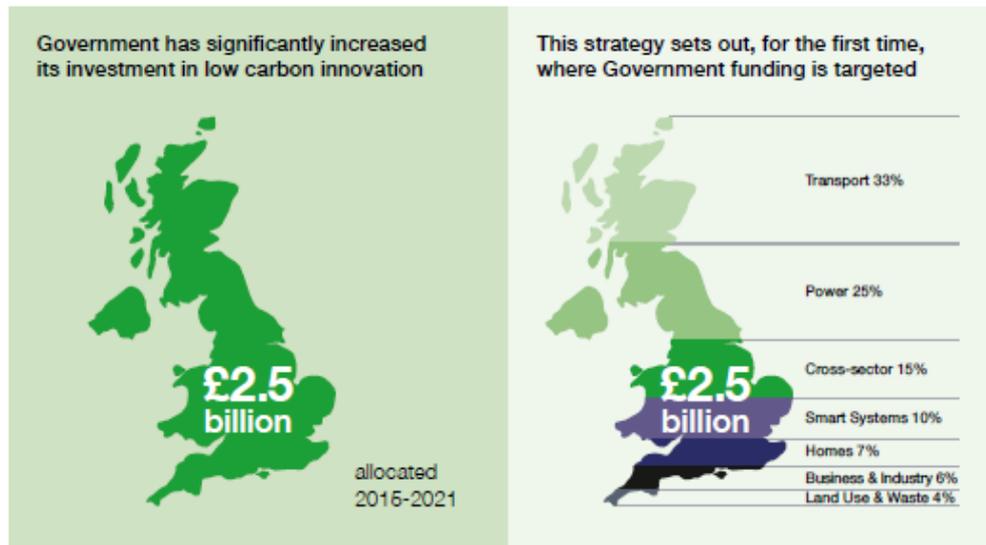
Funding Innovation: Total Spend on Smart

The [Clean Growth Strategy](#), published by BEIS in October 2017, confirmed total UK innovation funding allocation for Smart Systems to 2021 is £265 million*

INVESTMENT IN INNOVATION FOR CLEAN GROWTH

To achieve the clean growth we want, the UK will need to nurture low carbon technologies, processes and systems that are as cheap as possible.

It is only through innovation that we will see new technologies developed and the cost of clean technologies come down.



*across government, industry and academia

Addressing Barriers to Smart Tech (1)

Regulatory clarity

- **Govt.** to define storage as subset of generation in primary legislation, *when parliamentary time allows*
- **Ofgem** consulting on modifying gen. licence – to be *ready by Summer 2018*
- **Govt.** has reaffirmed position that storage is treated as generation for planning, and will review planning framework to ensure it is appropriate for storage

Final Consumption levies

- **Ofgem** Consultation clarifies that certain requirements in the licence conditions may not apply to small-scale storage, making the framework suitable for small providers as well.
- **Industry** operators holding the licence will not pay towards RO, FIT, CFD, CM
- **Govt.** has clarified that certain storage facilities can be exempt from CCL (certain conditions apply)

Ownership

- **Ofgem** consulting on regulating ownership/operation by network operators.
- This seeks views on steps to ensure that storage assets are sufficiently separated from network businesses, and to monitor those which own storage.
- Announcement in Q2 2018

Network Charging

- **Ofgem** has confirmed that storage should not pay for certain aspects of network charges – i.e. the non-locational aspects of demand-based network charges, and it should not pay twice towards charges for balancing the system.
- Now expected that **industry** will raise code modifications to enact these changes.

Addressing Barriers to Smart Tech (2)

Synergies with Renewables

- **Govt.** will develop synergies between smart energy and future renewables policies - *ongoing*
- This will seek to realise the full benefits of storing electricity for self-consumption and export to the grid, potentially involving ability for generators to take advantage of time-of-export tariffs

Network Connections

- **Network operators** expected to start work to improve network connections, clarify the process for developers and implement better queue management.
- **Ofgem** will use their Incentive on Connections Engagement process to assess how this is being realised

Co-location

- **Ofgem E-Serve** published new guidance on how storage can be co-located with generating stations under the Feed in Tariff and Renewable Obligation schemes (end of 2017).
- In January 2017 **Govt.** outlined how a position on how storage should be treated by generators supported under the Contracts for Difference scheme. Govt. will continue to engage with industry and monitor progress.

Health & Safety

- **Govt.** working with **industry** to review, consolidate and update standards on H&S for storage (*ongoing*)
- This will build on work led by **British Standards Institute & Institute of Engineering & Technology**

Smart Systems Plan – Key actions on storage:

Our aim is to **create a level playing field, so that energy storage can compete fairly** with other forms of flexibility and more traditional energy solutions

Network Charging

- Stopping the double-charging of storage so that it is not treated both as demand *and* generation.

Definition & Planning

- Creating a storage license to get rid of planning barriers.

Final Consumption Levies

- Reducing certain policy costs for storage developers.

Co-location with Renewables

- Increasing guidance to enable colocation of storage and renewables.

Smart Systems Plan – Key actions on storage:

Network Connections

- Faster connections where storage may add value to the networks

Health & Safety

- Government will update the health and safety standards for storage

Ownership

- Ofgem will set-out whether network companies should be allowed to own storage.

Simplifying the ancillary services markets

- National Grid are reforming the ancillary services markets and trialling new approaches such as real-time markets.

Distribution networks to use more smart flexibility.

- Distribution networks are encouraged to use more storage / demand side response in the stead of tradition network solutions.

Frequency Response Model

- 4-year reliable revenue stream
- Batteries suitable for rapid response

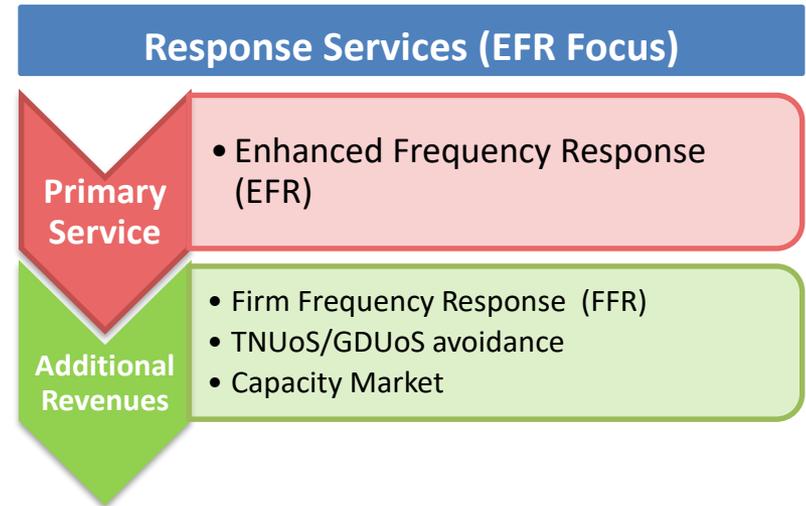
Case Studies

Low Carbon (2 schemes, total 50 MW)

- Opted to exclude potential Triad periods
- **Primary:** EFR, **Additional:** Triads, CM

Element Power (25 MW)

- EFR project as an opportunity to gain experience
- Will seek diversification after the contract
- **Primary:** EFR

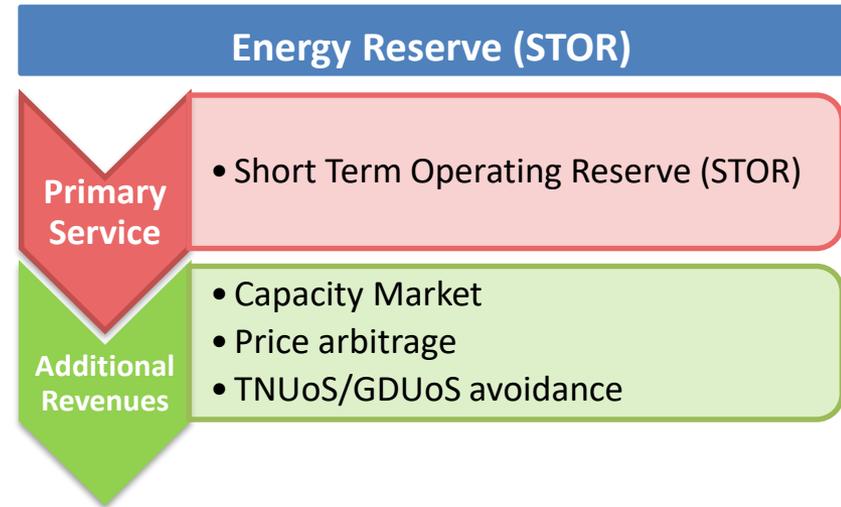


Company	Capacity (MW)	Tender price £/MW per EFR hr
EDF ER	49	7
Vattenfall	22	7.45
Low Carbon	10	7.94
Low Carbon	40	9.38
E.ON UK	10	11.09
Element Power	25	11.49
RES	35	11.93
Belectric	10	11.97

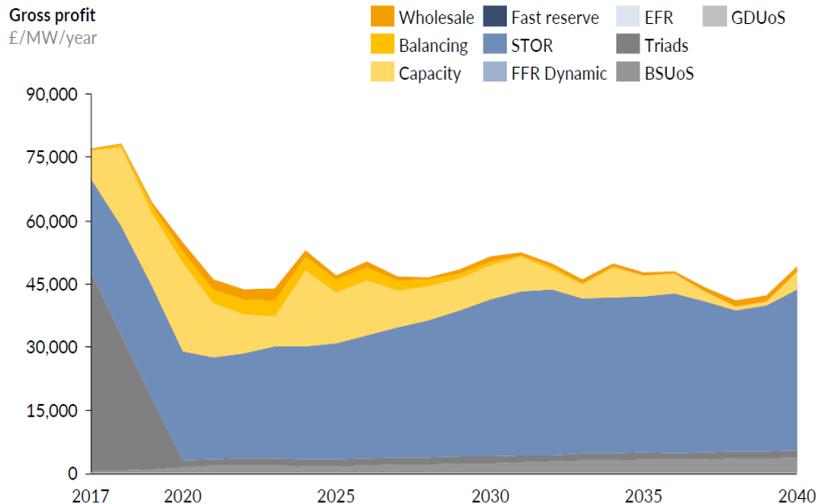
Source: KPMG (2017)

Energy Reserve Model

- Revenues cannot be stacked, specific STOR periods must be carved out
- 2-hour commitment unsuitable for batteries
- Relatively low value service

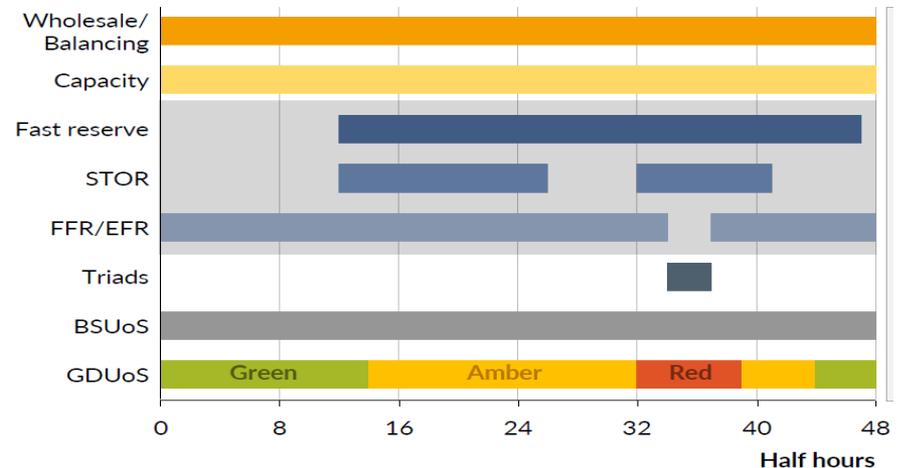


Battery (Li-ion) - STOR model



Source: Aurora (2017)

Average 2017 winter weekday
Half-hourly revenue streams



Source: Aurora (2017)

Arbitrage / Energy Trader Model

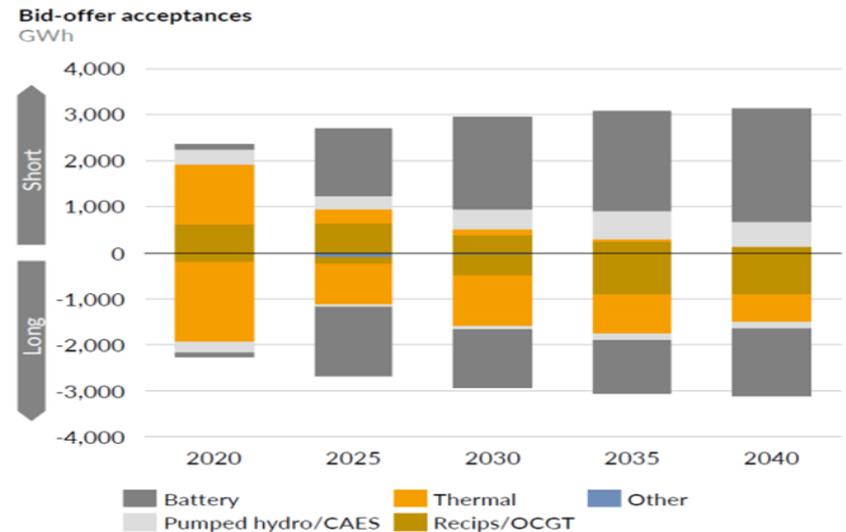
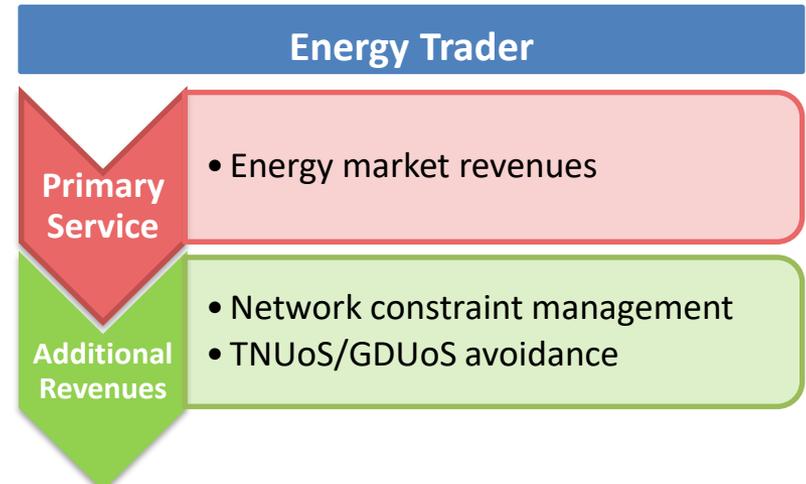
- Arbitrage between high and low price periods
- Majority of revenue from the balancing mechanism

Future Developments

- Aurora forecast a growing role for batteries, replacing thermal generation in BM activity
- Challenge: capital investment required to store significant energy capacity to effectively price arbitrage

Case Study: EDF & Flexibility

- 49 MW battery in West Burton
- **Primary:** EFR, **Additional:** CM
- Currently a full-time EFR provider
- Model able to evolve after the current contract has expired
- Intention to stack revenues or diversify after the 4-year contract

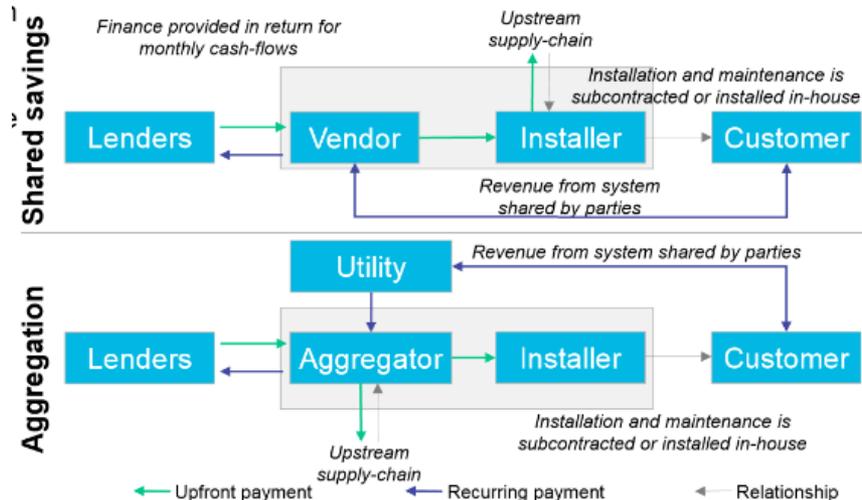


Source: Aurora (2017)

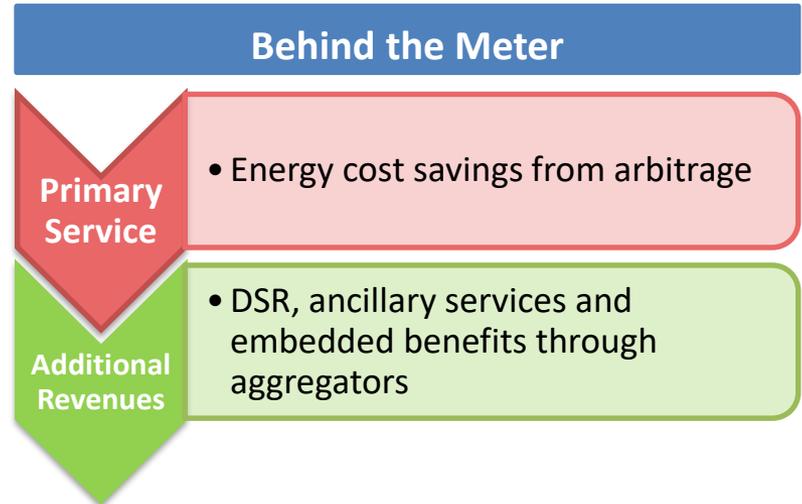
Behind the Meter Model

- Currently not a common business model in the UK – but forecast to grow
- Smart Systems and Flexibility Plan is looking to set out measures to support development of smart technologies in homes and businesses – including small scale battery storage

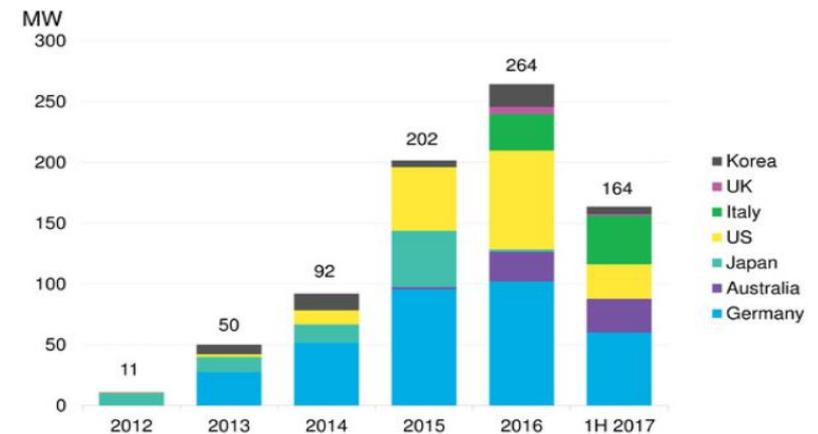
Prevalent business models for behind-the-meter storage



Source: BNEF (2017)



Annual installations of behind-the-meter storage



Source: BNEF (2017)