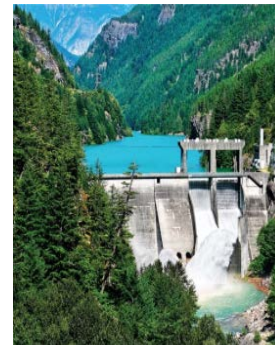


Driving Technology and Business Models Innovation for Storage and Demand Response

Robert Clover – Senior Director – FTI Consulting





Agenda - Business models and market drivers for Storage and DSR

Market Backdrop

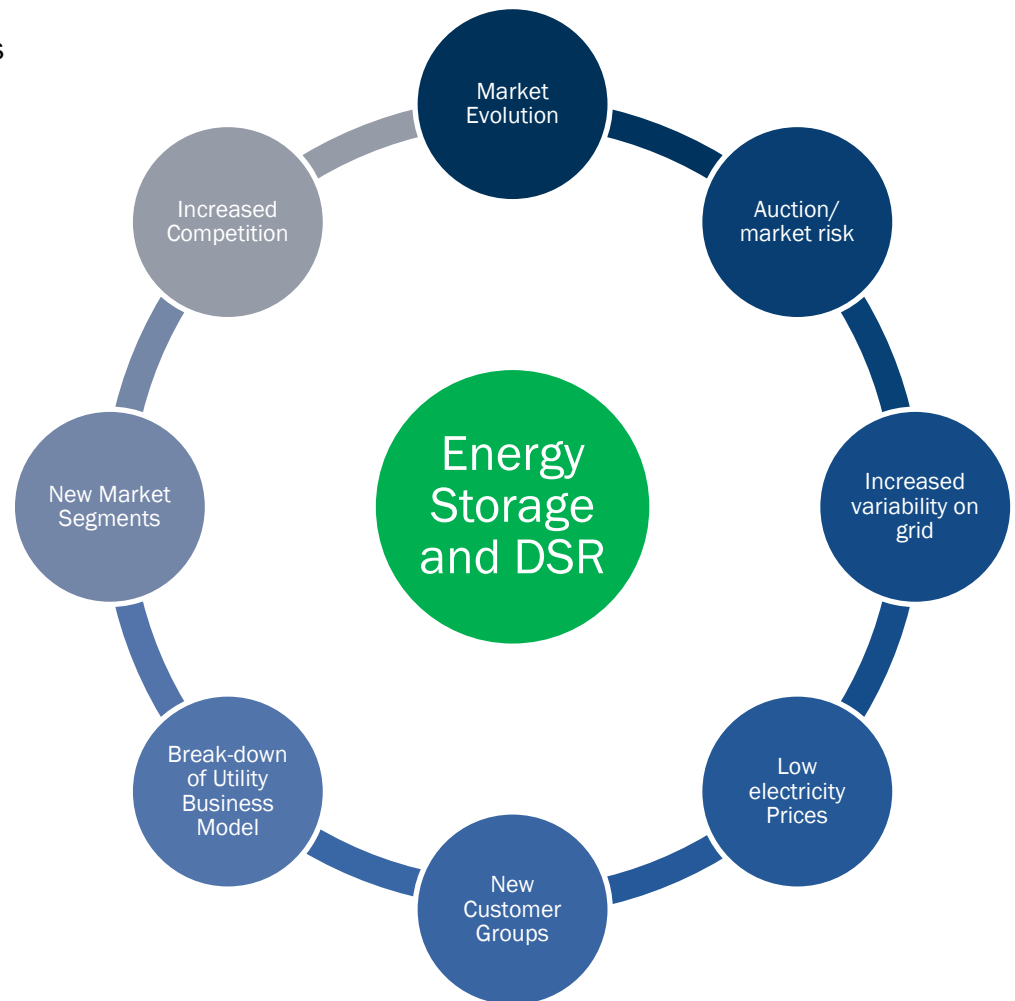
Business Model Assessment

Market Assessment

The market is changing.....

■ The sector is undergoing profound change:

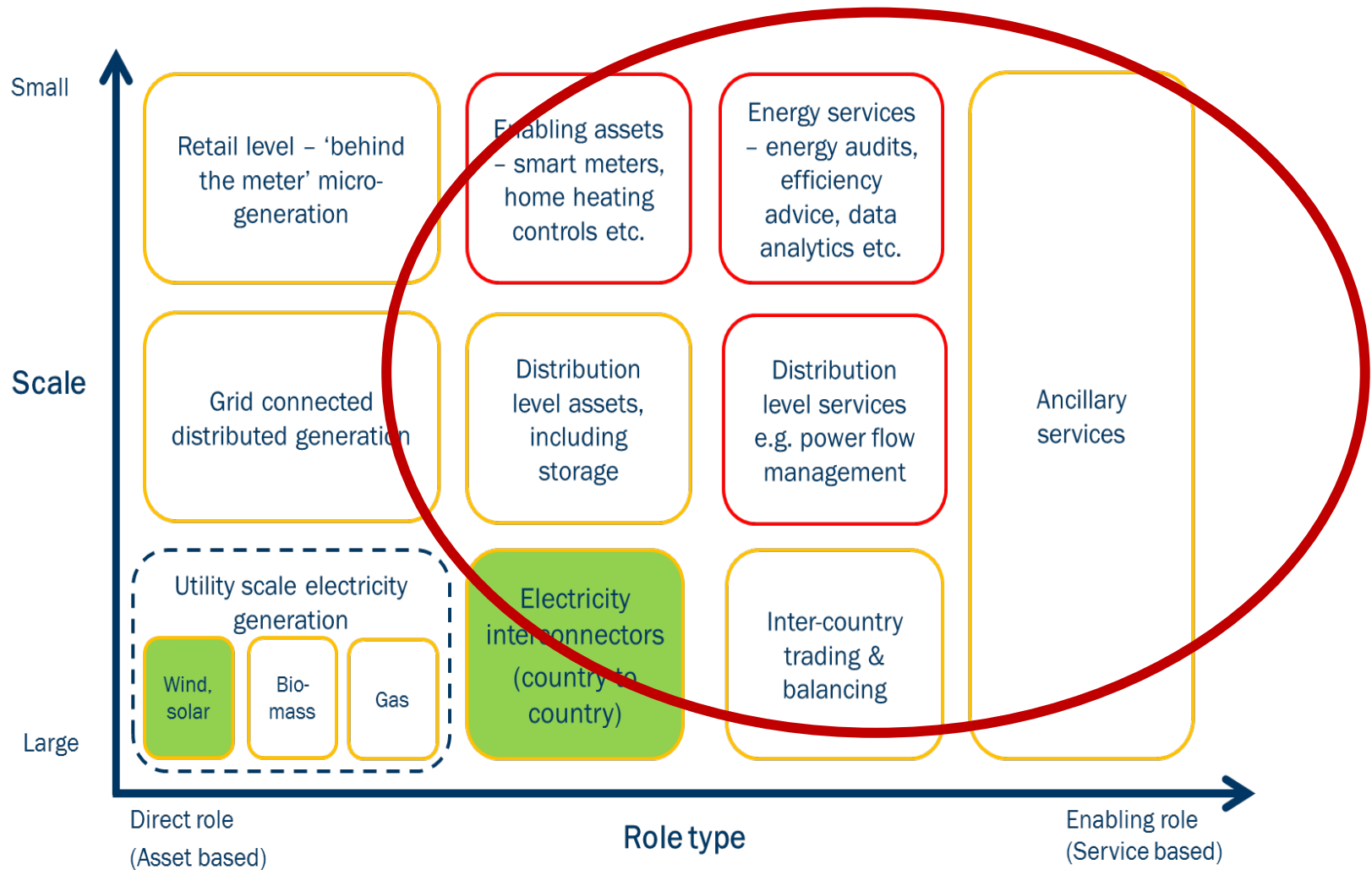
- **Significant regulatory change** is occurring across many markets as renewable energy is cost competitive and FiTs and other support mechanisms are removed and increasingly auction and other market-risk based systems are put in place
- Greater balancing requirements and consequently revenues available
- There is significant interest in **renewable energy infrastructure** as an asset class given the **relative return profile** of it versus other asset classes
- **New investors and capital** are being attracted to the sector as technology matures and costs come down
- **Customer groups are evolving** with strong growth in the corporate PPA market and prosumers
- **Advanced PPAs** in the form of synthetics are making an entrance
- **New technologies** are emerging due to **cost reductions** and new markets opening up – e.g. storage in capacity and ancillary services markets
- **Breakdown in the utility business model** continues driven by regulation, changes in customer habits and poor cash flows
- **Storage and Demand Response** is a key focus, among others including asset light business models in contrast to the conventional utility model.



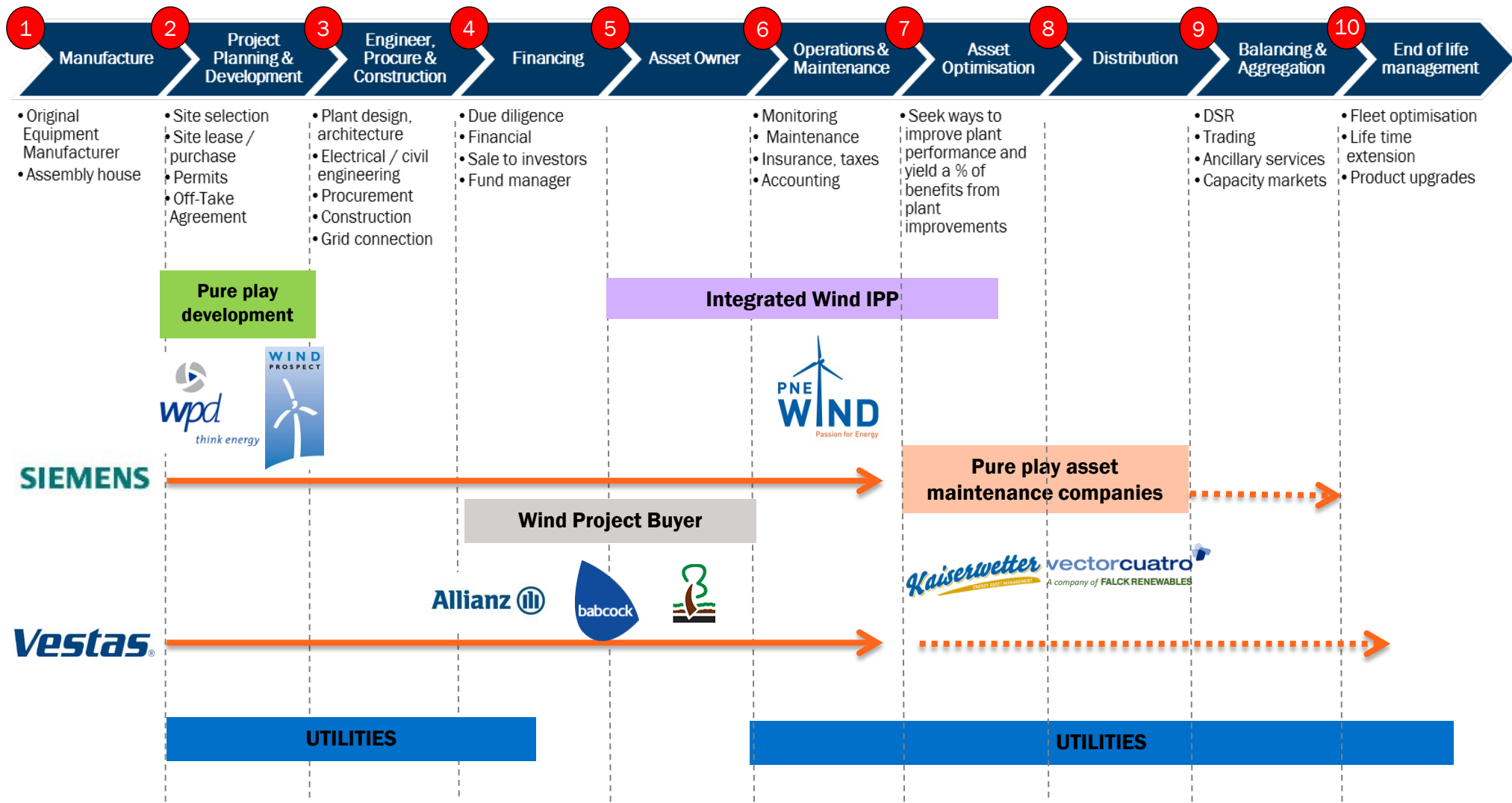
Business models and the market are rapidly changing

Generation is changing: the choice on new assets depends on capability, regulation, location and economics

There are a range of contiguous asset classes that may also warrant exploration in the near future:



The value chain is lengthening: search for returns in a market-risk based environment





Introduction

Business Model Assessment

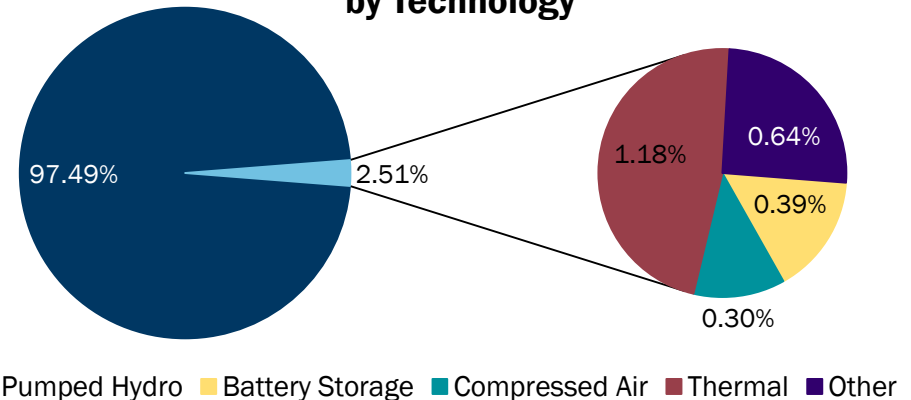
Market Assessment

What are we talking about – Storage and DSR?

Energy Storage

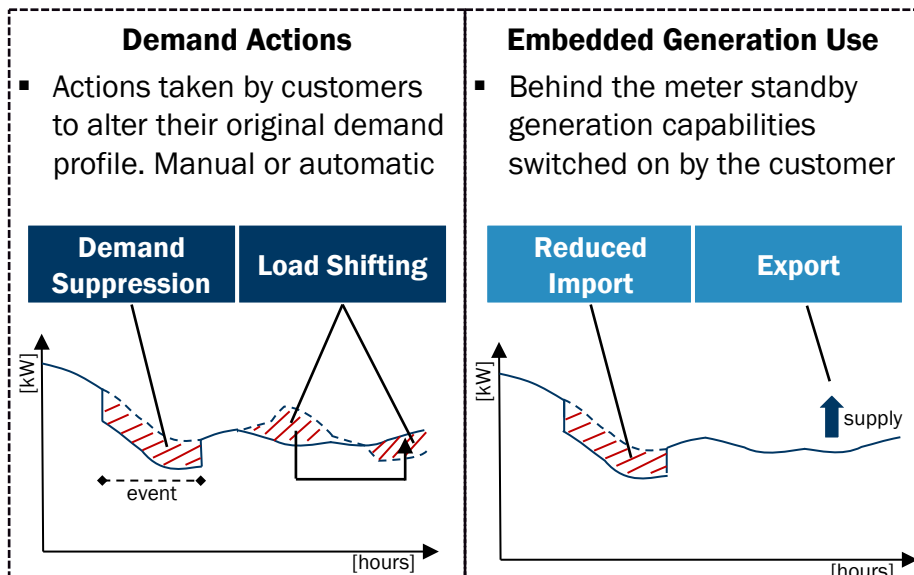
- Storing electricity for to enable use when there is significant demand or a reduction in generation
- Can be long or short term typically with high response rates
- Multiple revenue opportunities

Breakdown of Installed Energy Storage Projects by Technology



Source: DOE Energy Storage Database

Demand Response

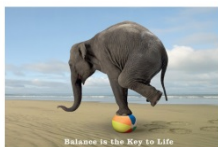


- Demand Response offers flexibility though the adjusting of electricity usage from the normal profile in response to incentives to meet the needs of the electricity system. There are three main offerings:
 - Turn down response
 - On-site generation turn on
 - Turn up response
- Supply deficit
- Supply surplus

We see 5 key opportunities to monetise storage and DSR

Capacity

- Load reduction & storage capacity is bid into capacity markets as a replacement for conventional generation
- Reducing or augmenting generation capacity requirements during peak demand hours



Keeping the transmission system balanced

Energy

- Wholesale market price compensation (Arbitrage)
- Providing/avoiding energy use at peak times



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Improve grid

Environment

- Optimising energy mix to reduce CO2 intensive electricity
- Ensuring maximal efficiency from new and existing conventional generating assets through consistent running



Keeping the lights on

Flexibility

- Providing modifications in electricity demand or supply to a TSO or energy supplier to provide additional ancillary services (e.g. frequency, voltage etc.)



Saving or generating money

Network

- Active electricity management at the local level through demand adjustments or storage to
 - Limit capital investments in the network through peak avoidance
 - Reduced congestion and improve reliability



Reduce emissions

A variety of value streams are available and revenue opportunity is highly dependant on location

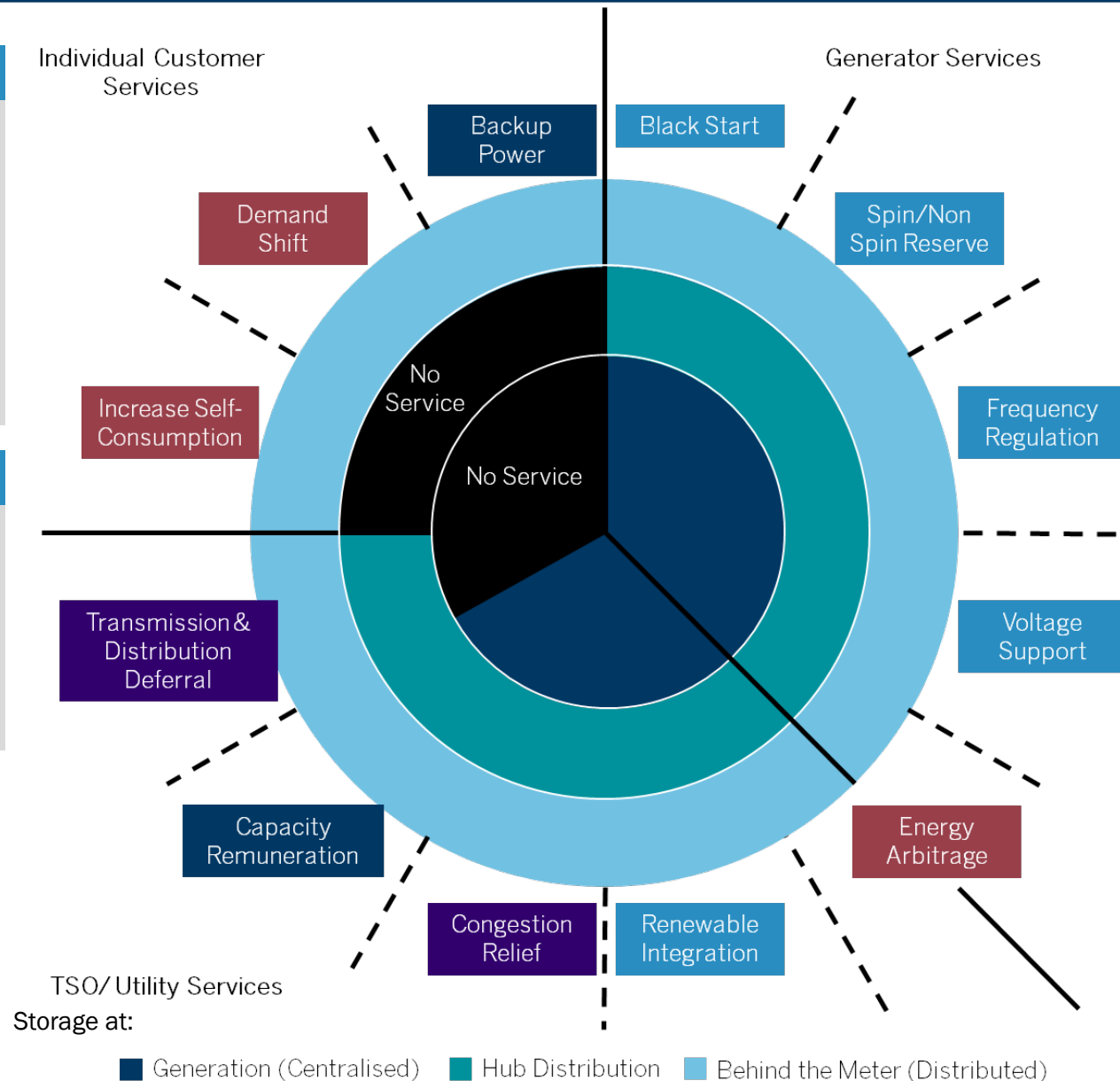
Energy Storage Revenue Potential

- 12+ sources of revenue opportunities
- Revenue streams are dependent on technical and regulatory constraints.
- Location is important to access specific revenues

Demand Response Revenue Potential

- Can access most of the revenue opportunities that storage can.
- Location is more important for demand response.

- Capacity Value
- Flexibility Value
- Energy Value
- Network Value
- Environmental Value



What kind of spend are we talking about in the UK?

Capacity

- UK Capacity Auction 2015 (for 2019/2020 delivery) = £830Million.

Energy

- Hard to predict But we reckon about £1-2bn

Flexibility

- £800m roughly in 2015

Network

- National Grid UK electricity transmission capital expenditure is over £1Billion

Environmental

- There is currently no spend in the UK on environmental benefits from storage and DSR.

Retail

- 27.5M domestic & > 2M I&C customers with a total use of almost 300TWh¹. >4.5GW of capacity of distributed generation¹.

Storage technologies - critical to get this selection right for storage projects..... HELLO BATTERIES

Technologies

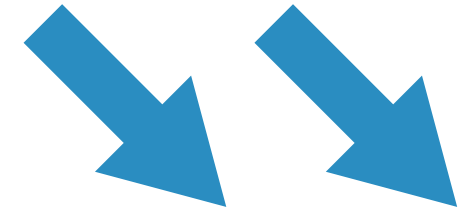
- Wide range of technologies – Traditionally Pumped Hydro has been used.
- Recently battery technology has developed quickly with a range of solutions becoming viable including lithium ion batteries and flow batteries.
- The primary technology limitations are on storage capacity – Pumped hydro can store GWh of electricity, however there are huge space requirements.

	Capacity Opportunity	Energy Opportunity		Flexibility Opportunity				Network Opportunity
	Capacity Market	Arbitrage	Load Levelling	Frequency Response	Reserves	System Security	Reactive Power Services	Investment Deferral
Solid State Batteries								
Flow Batteries								
Capacitor								
Pumped Hydro								
Thermal								
CAES								
Demand Response								

Storage Costs are coming down rapidly but is still an issue

Costs & Trends

- Costs for different applications are very different due to the differing technical requirements.
- For example costs will be higher for residential applications due to consumer requirements.
- Costs have been declining significantly and are expected to continue declining over the next 5 years by approximately 5-60% depending on technology over the period.



Technology	Capital Costs (\$/kWh)		Levelised Cost	
	2015	2020	2015	2020
Pumped Hydro	\$213-313	\$200-300	\$188-274	\$180-270
Compressed Air	\$171	\$150-180	\$192	\$180-200
Lithium Ion	\$422-1,700	\$211-1530	\$347-1363	\$211-1135
Flow Battery	\$307-2400	\$130-2060	\$248-1657	\$196-1254
Lead Acid	\$533-2,542	\$220-2400	\$402-1692	\$335-1316

Source: IRENA Estimates

Range of business models with combos possible to maximise revenue

Energy Storage & Demand Response

Asset/ Technology Developer

- The owner and developer of a specific technology. Creating revenue from selling products or licensing rights.
- Engineering developers, creating assets on the site on a project specific basis



Asset Owner

- The ownership of storage or generation asset(s).
- This asset may then be used to operate in the energy, balancing and ancillary markets as decided by the owner.



Aggregator Optimiser



- Uses DSR, generation and storage capacity from a number of customers (May be large or small)
- This capacity is then controlled by the aggregator.
- Optimisers provide technology and services to maximise revenue from capacity



Energy Service Provider

- Aim to provide optimisation for customers energy consumption.
- The use of all technology types including smart meters, intelligent software, energy storage and generating assets.



The most active business models are asset owner and developers, followed by energy service providers. Globally, aggregators and optimisers are less utilised

Business Model

Key Factors

Key Regions

Key Companies

Asset Owner

- Asset owners can be from any industry & Asset developers may also own assets
- Other renewable asset owners are more likely to own storage assets.
- Capital intensive



Asset Developer

- Companies operate globally.
- A wide range of companies offer different technical expertise.



Energy Service Provider

- Typically dominated by existing local players.
- Both small companies and large utilities are competing in this market.







Aggregator / Optimiser

- Highly dependant on regulation and open markets.
- Technological requirements are high.
- Difficult to transfer business model into new markets.
- Many more I&C aggregators than R/D aggregators.



Key barriers to storage/DSR

	Specific Barrier		Current Mitigation
Market Barriers	<ul style="list-style-type: none"> Low arbitrage value/IRRs Balancing services/ products must be available to operate Must be contracted from TSO/ DSOs. 		<ul style="list-style-type: none"> Increased range of balancing services offered at higher market prices enabling the profitability of assets. This is highly dependant on the location.
Regulatory Barriers	<ul style="list-style-type: none"> Double charging (storage) (e.g. UK & France) The allowance of aggregation (e.g. Allowed in UK & France, not allowed in Germany) Ability to stack certain revenue streams. 		<ul style="list-style-type: none"> Regulatory review (e.g. Australia, and Recent changes in the UK).
Technical Barriers	<ul style="list-style-type: none"> Power and energy capacity limitations Response times Ongoing degradation of storage assets Difficulties of operating aggregated capacity (software/meters). 		<ul style="list-style-type: none"> Existing technologies are improving. New technologies are being developed. Operational optimisation algorithms are being developed.
Cost Barriers	<ul style="list-style-type: none"> Current high cost of storage across all technology types. Higher specific requirements increase costs. 		<ul style="list-style-type: none"> Battery costs are falling dramatically.

What do revenues look like and what can they look like?

Current Opportunity

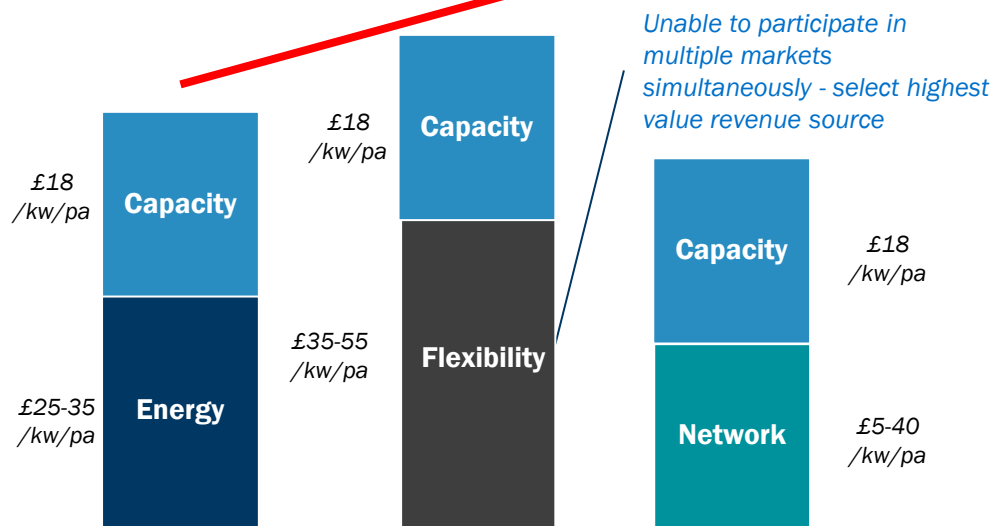
- Largest revenue opportunity is within ancillary services (specifically frequency response).
- Limited revenue stacking is available.

Future Opportunity

- Greater opportunity for revenue stacking.
- Enhanced Frequency Response.

Estimate

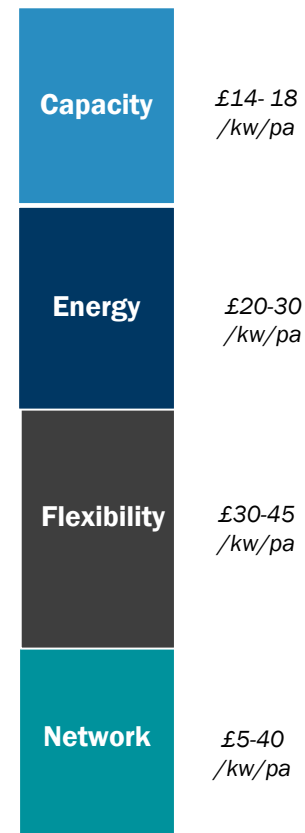
Maximum current opportunity estimated in the region of £75/kW/Annum



Estimate

Maximum future opportunity estimated in the region of £70-120/kW/Annum

Individual revenue streams are reduced with multiple uses, but overall revenues are maximised.



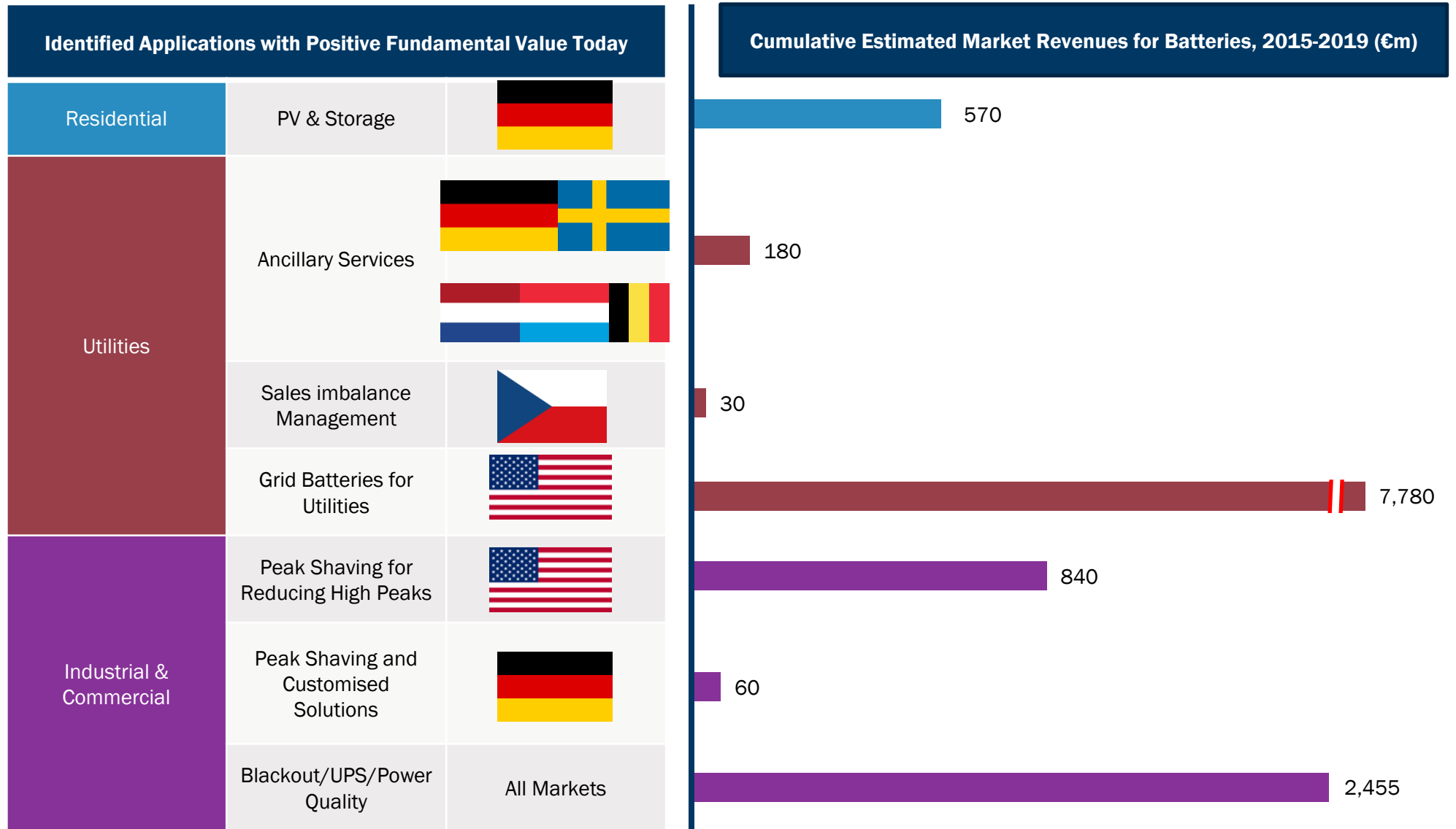


Introduction

Business Model Assessment

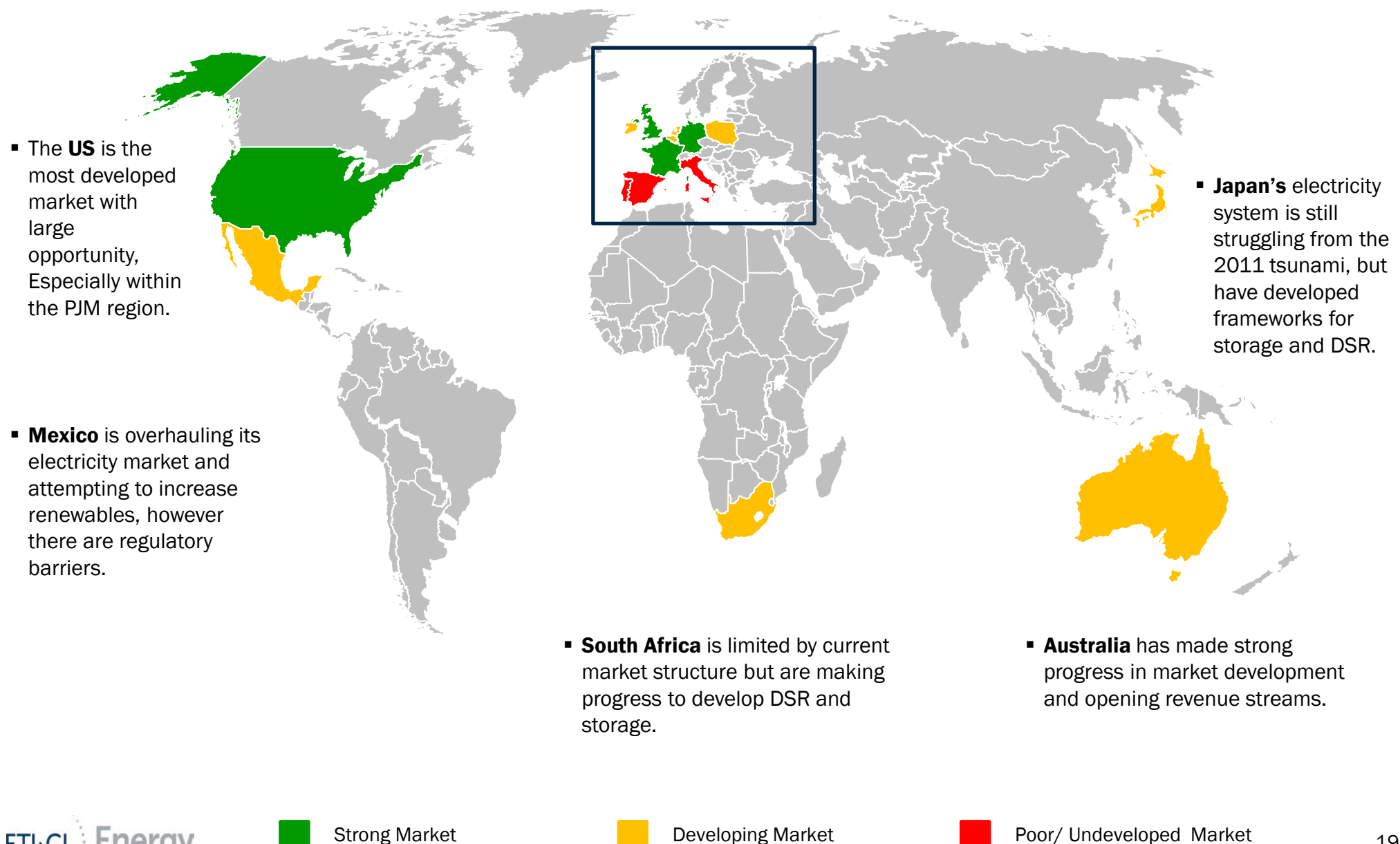
Market Analysis

€12 Billion of revenue from storage by 2019 with the majority of opportunity within the US.



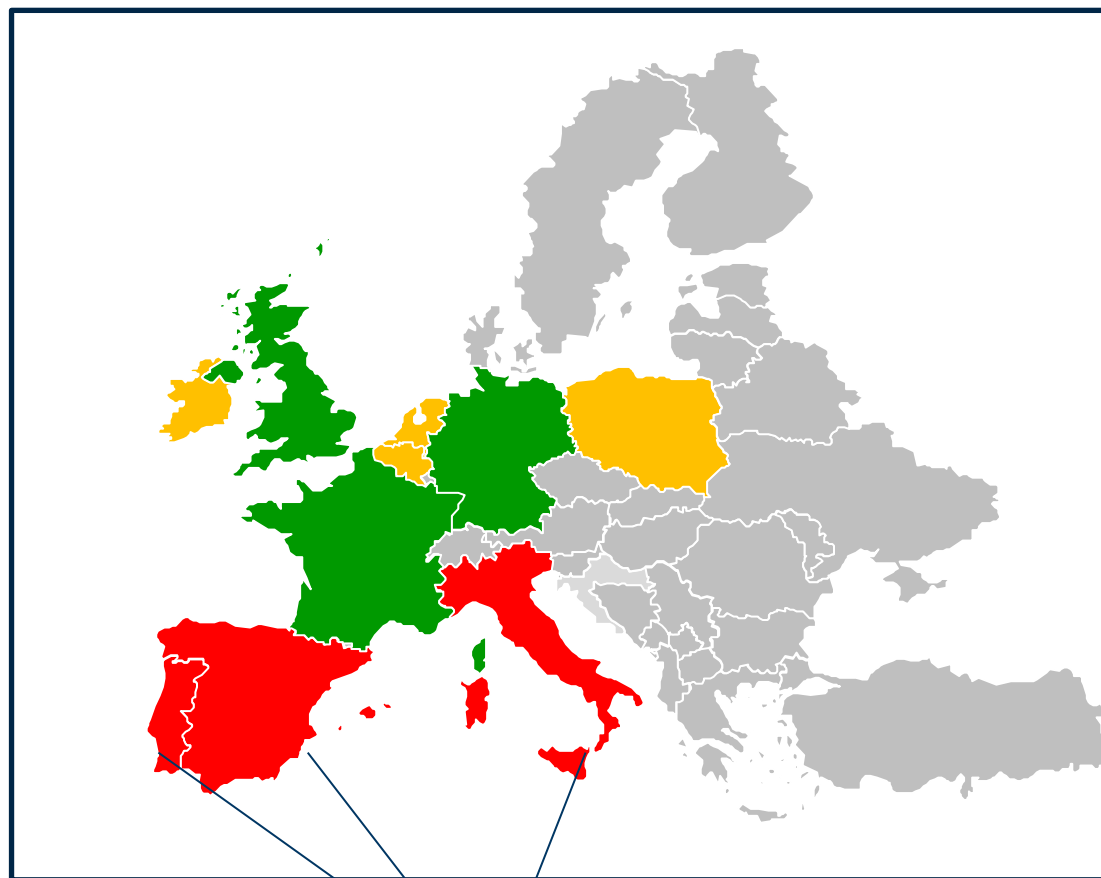
Total Revenue Opportunity – €11,915 Million

Current Key Markets for Storage and Demand Response



Current Key Markets for Storage and Demand Response

- The **UK** has limitations but has many revenue opportunities and a developed market and is currently the most attractive in Europe
- **Ireland** are overhauling their energy regulation and market with strong renewable goals.
- The **Netherlands** has relatively little market opportunity for storage, but the regulatory framework is developing
- **Belgium** is exploring the benefits of demand response and is facing future difficulties in the energy market for which storage will help.
- **France** is leading in Europe for demand response policy with a strong regulatory environment. However there are limitations for storage.
- **Germany** is leading Europe in Renewable generation, however there are barriers for demand response and storage aggregation.
- **Poland** is developing its renewable energy market, however there is currently limited regulatory clarity for storage and DSR.



- **Spain, Italy and Portugal** are hampered by poor regulation and government views on storage and DSR.

When looking at specific projects, it is clear that there are differences between customers, applications and countries.

Residential Customers	Applications	Technology	Countries
<ul style="list-style-type: none"> Behind the meter Distributed services through aggregation 	<ul style="list-style-type: none"> Demand shift Increase self-consumption Storage plus RES Smart metering/DSR Demand Response Schemes 	<ul style="list-style-type: none"> Demand Response Storage <ul style="list-style-type: none"> Lithium Ion 	<ul style="list-style-type: none"> France Germany US UK All Regions
Wholesale/Utilities/TSO&DSO			
<ul style="list-style-type: none"> Storage at generation Grid level distributed storage. 	<ul style="list-style-type: none"> Capacity Ancillary services – Frequency Response, Voltage support, Black Start, etc. Energy arbitrage Balancing services T&D investment deferral 	<ul style="list-style-type: none"> Demand Response Generation Storage <ul style="list-style-type: none"> Lithium Ion Flow Batteries Capacitors & Flywheels 	<ul style="list-style-type: none"> UK US France Germany Australia
Industrial & Commercial			
<ul style="list-style-type: none"> Behind the meter Aggregated demand response Aggregated storage Storage onsite DSR onsite. 	<ul style="list-style-type: none"> Peak shaving/demand shift Increase self-consumption Back-up power Black-out UPS High integrity power usage. Demand response schemes 	<ul style="list-style-type: none"> Demand Response Generation Storage <ul style="list-style-type: none"> Lithium Ion Flow Batteries Thermal 	<ul style="list-style-type: none"> US UK France Australia All regions

FTI have identified the 4 most interesting applications for storage and demand response and identified key technologies and markets for these business models.

Utility Scale Energy Storage – Ancillary Services

- The analysis of a large scale energy storage asset implemented to provide a variety of services and to interact within wholesale energy, balancing and ancillary services markets.

Key Technology

- Battery Storage – Lithium Ion

Utility Scale Energy Storage – Renewable Generation

- The analysis of a large scale energy storage project linked to a renewable energy project. This asset could also provide ancillary services.

Key Technology

- Battery Storage – Lithium Ion
- Thermal Storage – Molten Salt

Residential Scale Energy Storage – Renewable Generation

- The analysis of smaller scale (industrial, commercial and domestic) storage linked with the use of energy storage to maximise the benefits.

Key Technology

- Battery Storage linked with PV

Demand Response Aggregation

- The analysis of a demand response aggregator operating in a variety of markets with the ability to provide ancillary services in addition to demand response.

Key Technology

- Demand Response – Industrial and Commercial



Critical Thinking at the Critical Time TM

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