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Energy Storage Market Place

ReGen SW Exeter

Siemens Financial Services
Energy Management – Funding discussion
Introduced by Ian Tyrer, Head Of Sales – Energy Finance

March 2017

Impact of the changing Energy Landscape

Different solutions for different market stages

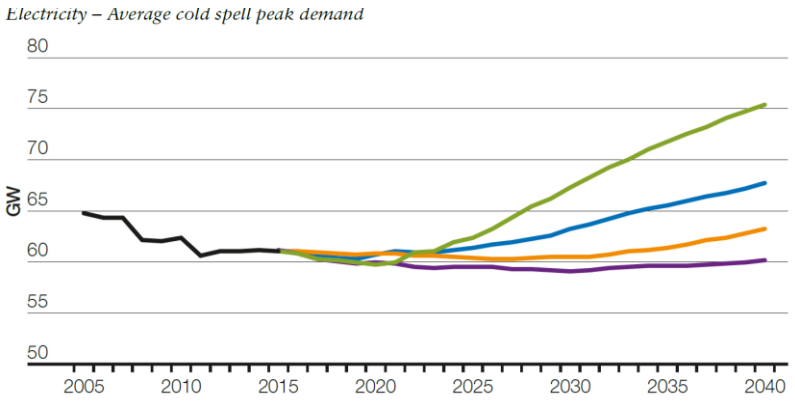
<10%	20+%	40+%	60+%	80+%
Traditional mix	**System integration**	**Market integration**	**Regional autonomous system**	**Decoupled generation and consumption**
– Fossil (coal, gas, oil) – Nuclear – Renewables (mainly hydro)	– Fossil (coal, gas, oil) – Renewables (wind, PV, hydro)	– Capacity markets etc.	– Predictable regional “area generation” (topological plants)	– Interaction of all energy carriers
– Efficiency – LCC reduction – Availability / reliability / security	– Decreasing spot market prices – Subsidized economy – Increasing redispatch[1)] operation	– Power2Heat, CHP increasing – Demand side management – ***First storage solutions*** – HVDC/AC overlay	– Regional plants, cellular grids – HVDC overlay and meshed AC/DC systems – ***Power2Chem /*** – Stability challenge	– Complete integration of decentralized power generation – ***Storage systems/*** – Return of gas power plants?
Past	**Today**	**Mid-term**		**Long-term**

1) Corrective action to avoid bottlenecks in power grid

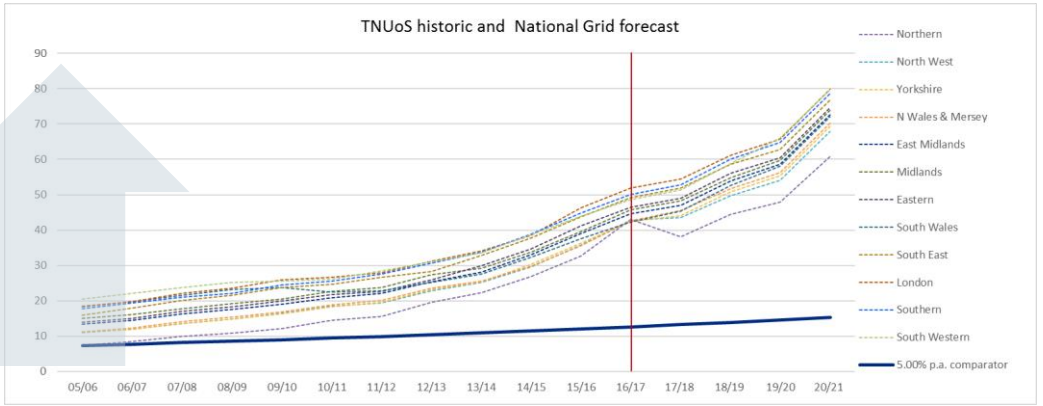
Prices and Charges

The only way is up!!

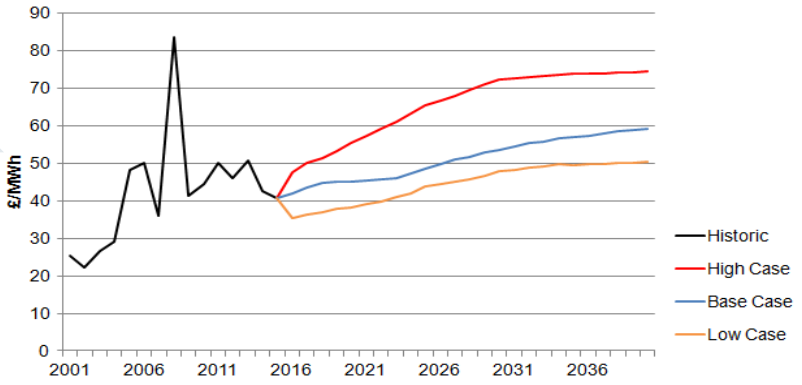
Demand



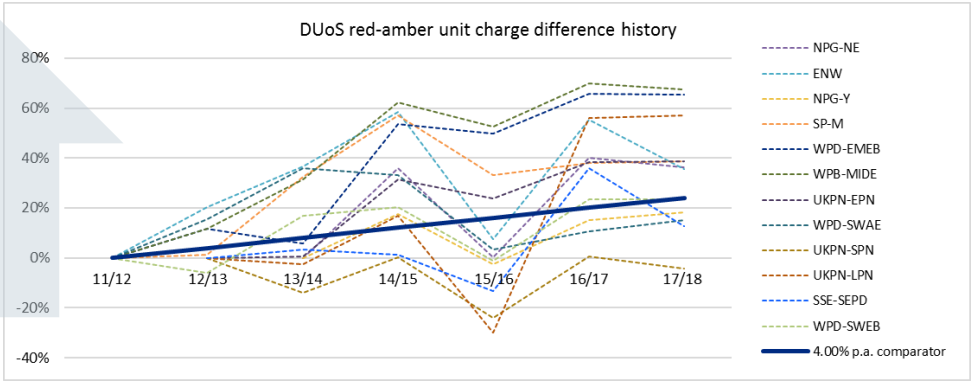
Transmission Charges



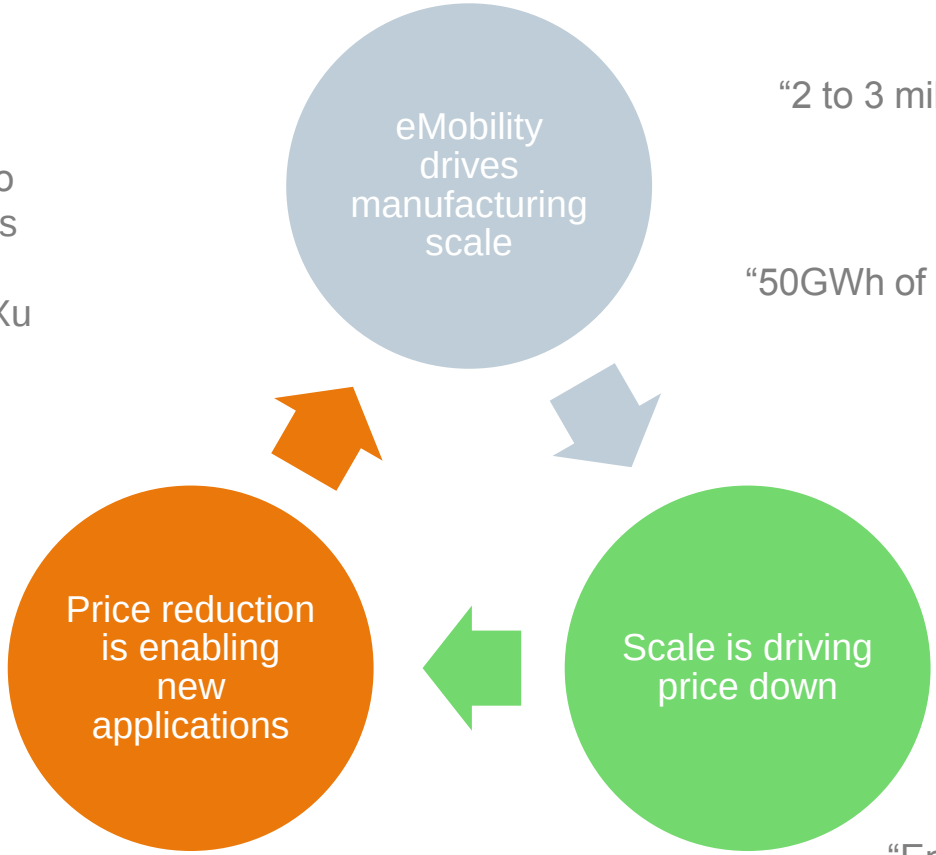
Wholesale unit prices



Distribution Charge



Li-ion market driven by eMobility scale and new applications



"Shenzhen has set a target to make its fleet of 16,000 buses all powered by batteries by 2017, according to its mayor Xu Qin." SCMP Jul 2016

"2 to 3 million all-electric cars a year by 2025". Volkswagen June 2016

"50GWh of capacity by 2018". Tesla June 2016

550MW BESS in 2016 T-4 CM Auction

200MW Enhanced Frequency Response (National Grid)

100MW – 400MWh peak-plant replacement (Southern California Edison Co/AES Corp)

Prices are down 70% in the last 18 months" STEM June 2016 (GTM Research)

"Entering 2016 GM said its cells cost $145 per kilowatt-hour, and by late 2021, they could be at the $100 mark." GM Global Business Conference 2015

UK Storage Market

Potential to exceed 10GW by 2030 vs. recent estimates of 1.5GW
£500bn market considering ~£500/kW

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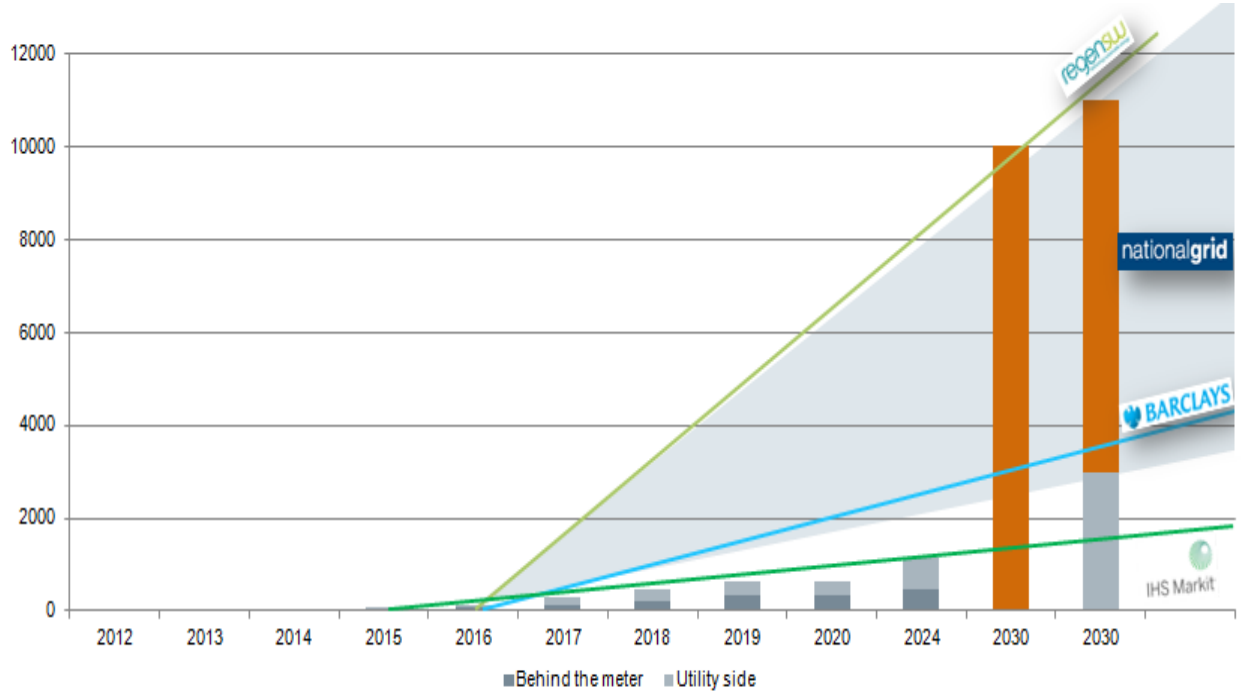
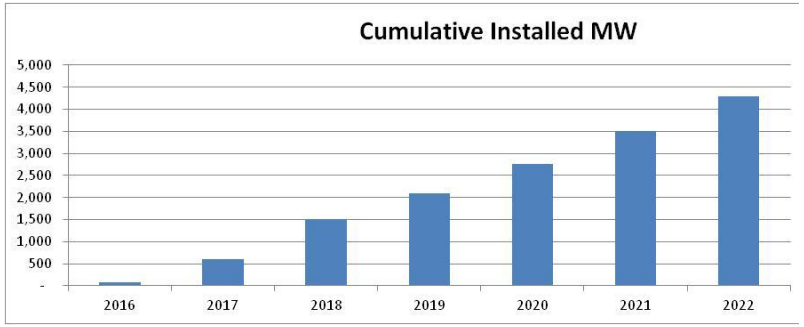
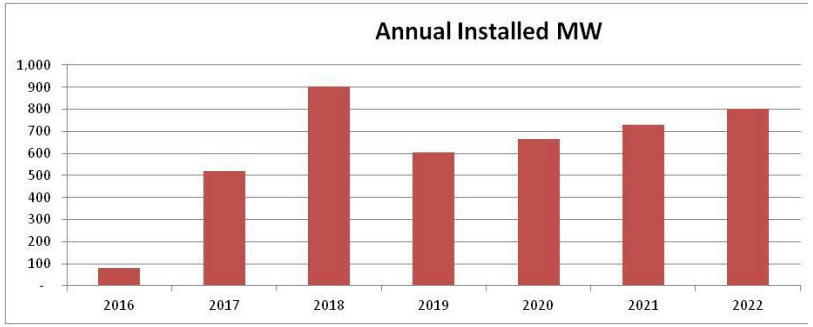
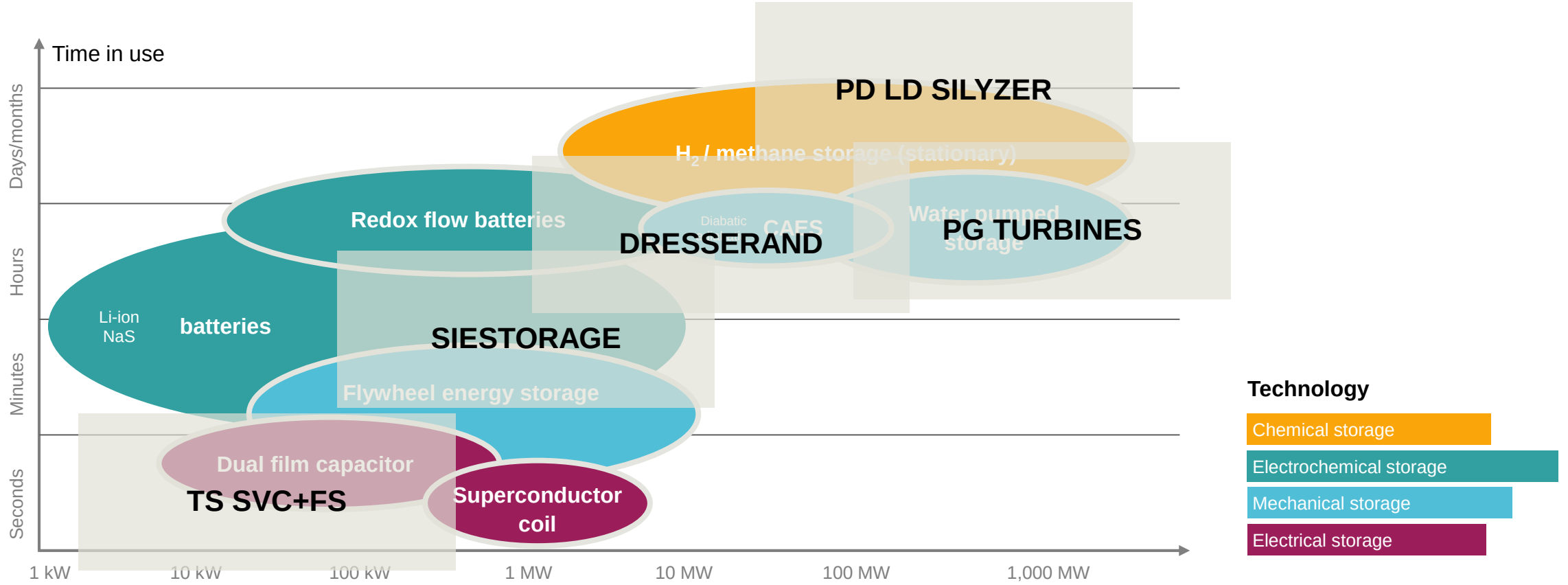
- National Infrastructure Commission states storage to be 1 of the 3 pillars of infrastructure development for the UK.
- National Grid EFR call for 200MW results in unexpected price drop <400/kW making storage financially viable for many more applications.
- National Grid Future Energy Scenarios (FES) estimated between 3 (for slow progress) and 11GW (for gone green) by 2030
- BEIS now also includes 3GW storage in energy system planning.
- OFGEM flexibility paper calls for evidence on how to release storage as a solution for DNO solutions expected to be the 1st step towards DSO model.
- EireGrid launches DS3 with fast services similar to EFR and FFR
- Sites with Gas Turbines providing operating reserve considering adding storage to access faster/higher revenue grid services.
- Solar developers converting PV sites to storage as a result of FiT end.
- Dec 2016 Capacity Market Auction disrupted by 550MW BESS
- Cost of funding reducing.
- Large energy consumers (behind the meter) seek ways to reduce energy costs (grid charges)
- SSE CMZ 3rd attempt





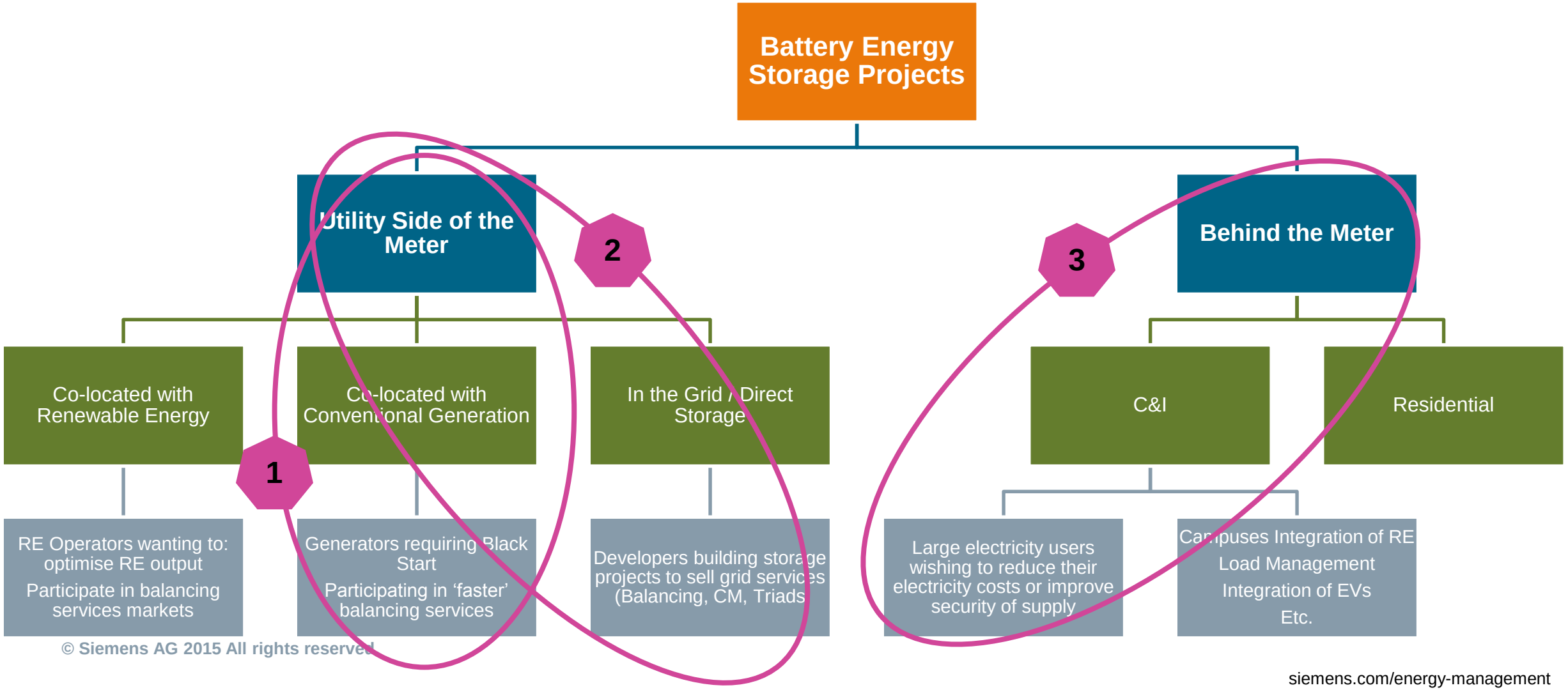


Energy storage technologies & Siemens



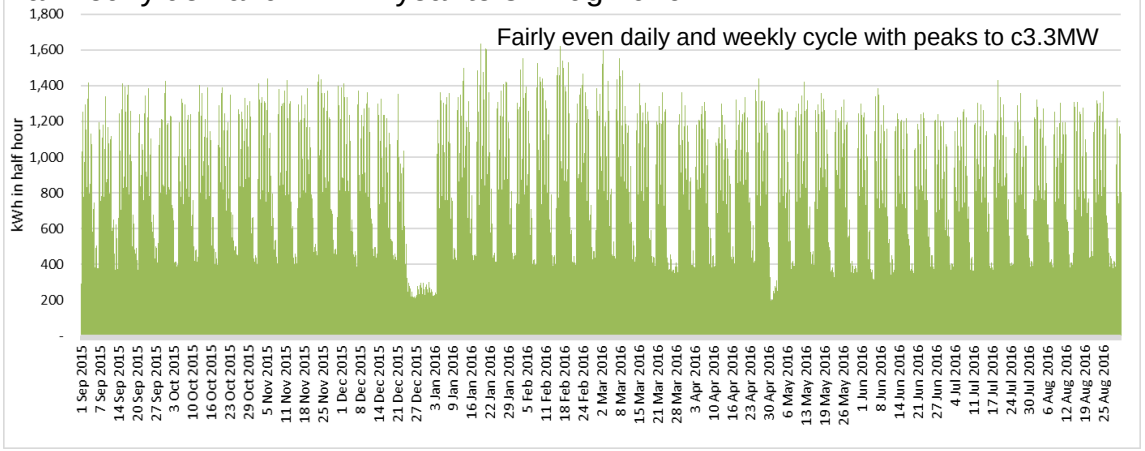
Source: Study by DNK/WEC “Energie für Deutschland 2011“, Bloomberg – Energy Storage technologies Q2 2011
CAES – Compressed Air Energy Storage

Focus Segments
(Not Limited To)

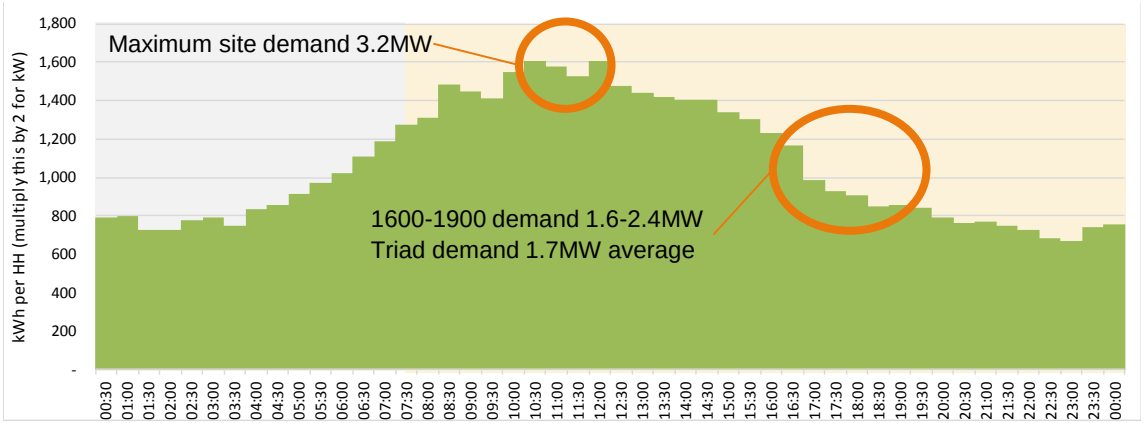


Siemens Lincoln
Site characterisation

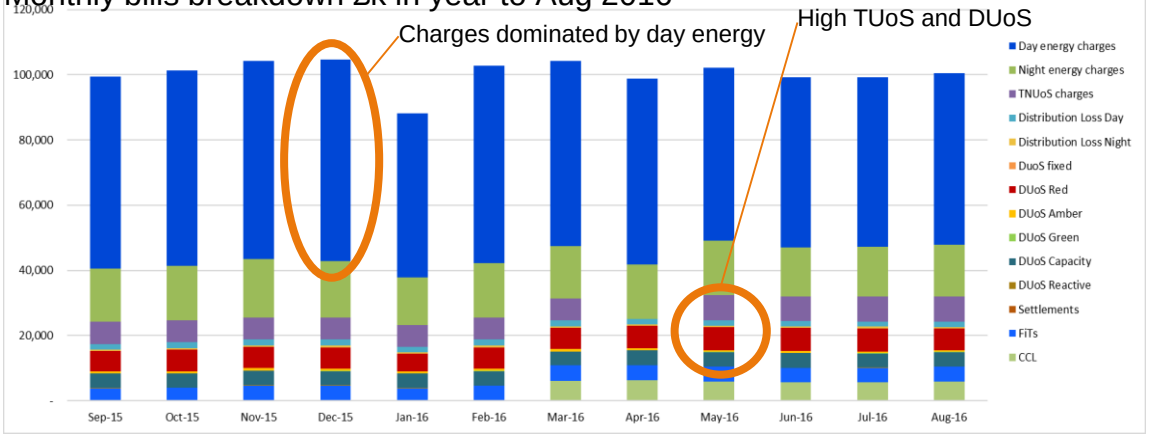
Half hourly demand kWh in year to 31 Aug 2016



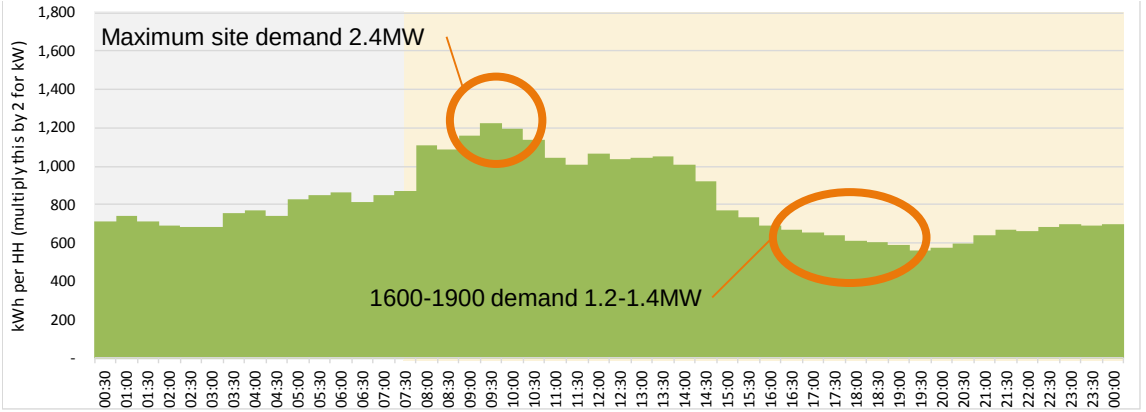
One day demand 21 Jan 16 – highest demand day



Monthly bills breakdown £k in year to Aug 2016



One day demand 5 Jul 16 – typical summer day



Innovation not only happens at the cell level
Battery Management and Operation in the Cloud

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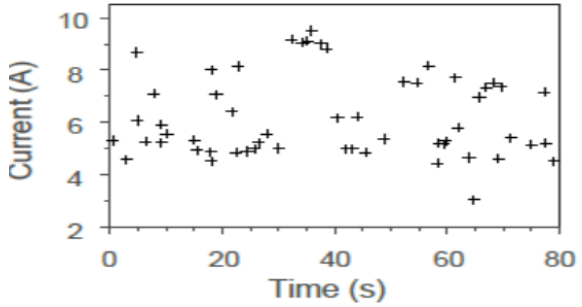
Physical models of the battery are used to inform data analytics working on large data sets through the connectivity provided by Mindsphere

Increasing Connectivity

Raw Data

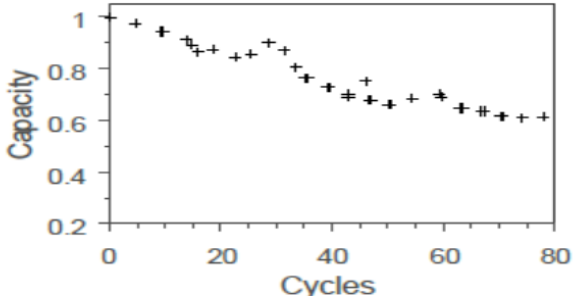
Raw waveforms (e.g. Current, voltage, temperature) from operated device



Battery sensors
(voltage, current, temperatures, EIS, RF)

Diagnostics

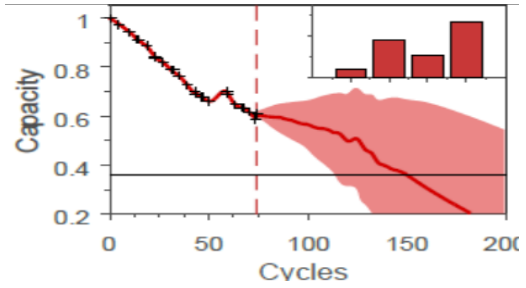
Physical models of the battery are used to determine SOH indicators



Physical
Battery Modelling
(Kalman Filter, reduced order electrochemical.....)

Prognostics

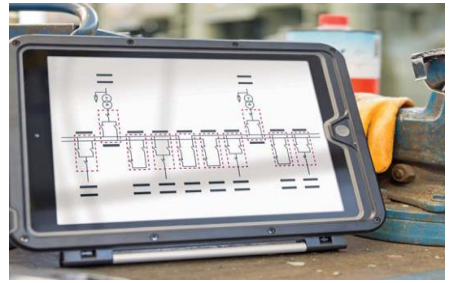
Data driven analytics are used to predict future health of the battery



Data Analytics
(Machine Learning, Neural Networks)

Optimal Operation

Multi-parameter application opimisation e.g. eBus fleet range optimisation



Optimal
Control Theory

Figures courtesy of David Howey & Robert Richardson, University of Oxford

Projects and references in Europe

Finland

2015 Helsinki; Renewable Integration Test Plant; 118 kVA / 45 kWh

UK

2015 Manchester; Research & Test Plant; 236 kVA / 180 kWh

Germany

2015 Sindelfingen; Renewable Integration; 360 kVA / 180 kWh

2015 Flein; Renewable Integration; 118 kVA / 135 kW

2015 Eisenhuettenstadt; Black Start; 2.8 MVA / 720 kWh

Italy

2015 Expo Milano; Smart Grid Test Plant; 354 kVA / 135 kWh

2015 Roma; Renewable Integration & Smart Grid; 118 kVA / 45 kWh

2015 Ventotene; Island/Microgrid Application; 500 kW / 600 kWh

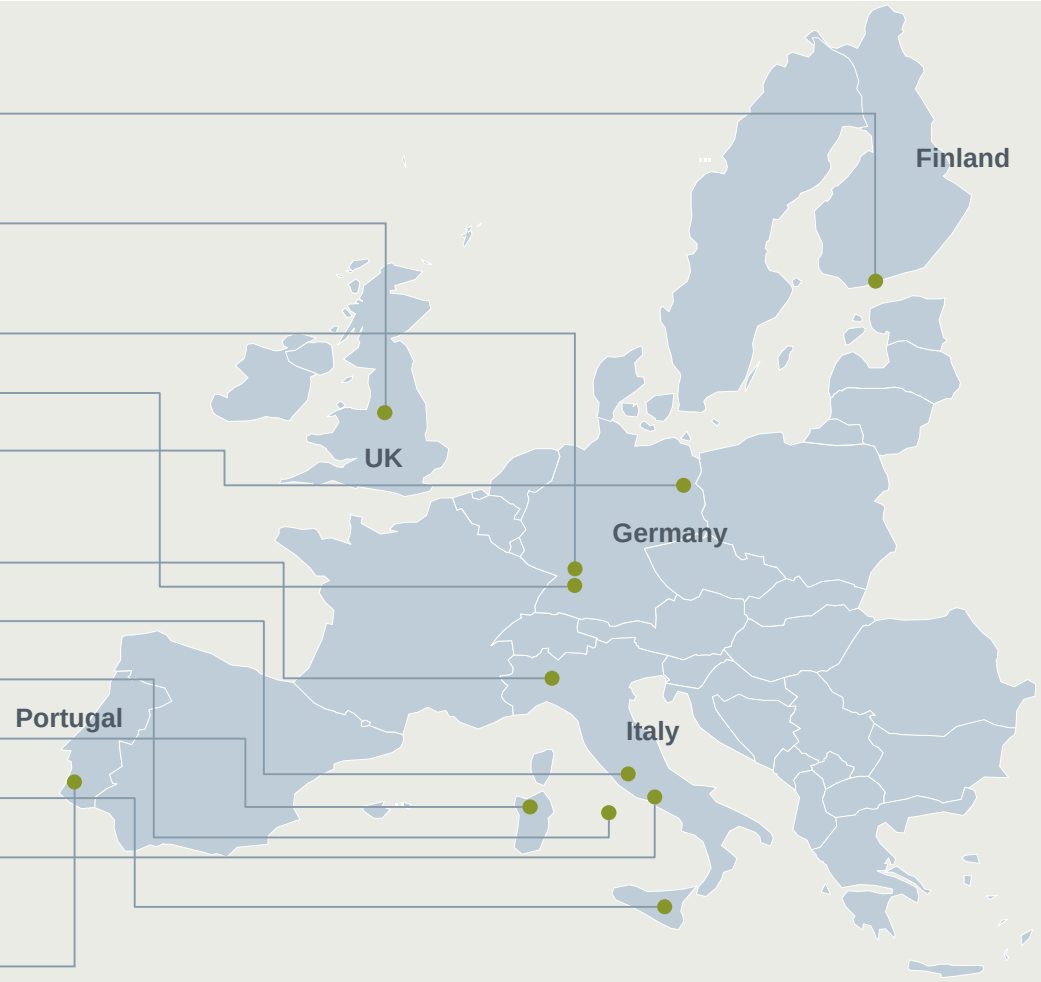
2015 Sardinia; Storage Lab Test Plant; 1 MVA / 500 kWh

2014 Sicily; NAS Storage Test Plant; 12 MW / 82 MWh

2012 Isernia; Smart Grid Test Plant; 1 MVA / 500 kWh

Portugal

2015 Evora; Smart Grid Integration; 472 kW / 360 kWh



- **~ 20 MW storage projects**
- **Variety of customers:**
  Grid operators, utilities, industries and ports
- **Variety of applications:**
  Islands, Diesel offset, renewable, integration, black start, shore-to-ship connection

Thank You For Your Attention

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