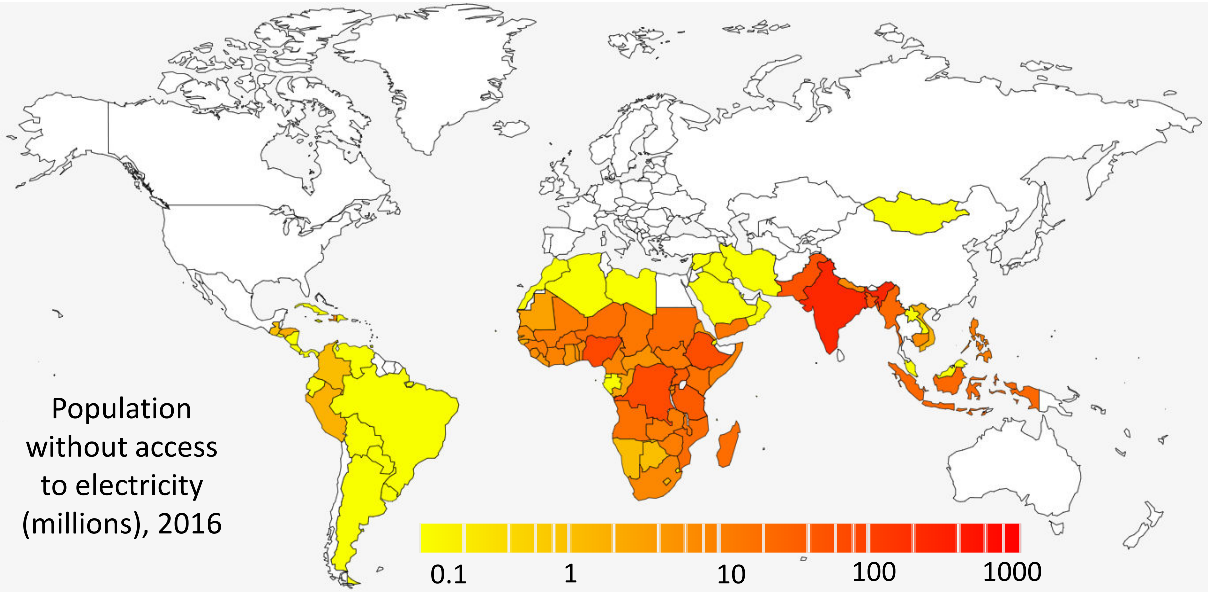
Energy Optimisation and Storage

Energy Institute

28 March 2019

Relevance

- Energy systems across the world are transitioning with a clear trend towards cleaner, low carbon, sustainable and reliable electricity.
- Renewable generation has the potential to displace thermal generation, however, addressing intermittency and infrastructure shortcomings are essential
- At present, approximately 1.1 billion people do not have access to electricity, mainly in sub-Saharan Africa, the Indian sub-continent and Southeast Asia.



1: Energy Access Outlook: World Energy Outlook 2017 Special Report: Electricity Access Database. (2017). Available at: https://www.iea.org/energyaccess/database/

System Level Considerations

Commercial and Regulatory Framework

- Government and Policy
- Payment Reflecting Value
- System Operators and Charges

Energy System Architecture

- Technical Design
- Grid vs Off-Grid
- Capacity Planning

Flexibility and Balancing

- Aggregators
- Virtual Power Plants
- Comms Infrastructure

Regulation and policy affecting the wider roll out of storage

- Regulations and government policies directly affect the competitiveness of energy storage by dictating its value in the current market.

- In the UK energy storage participates in EFR, FFR, balancing mechanism, standby reserve and in any arbitrage opportunities.

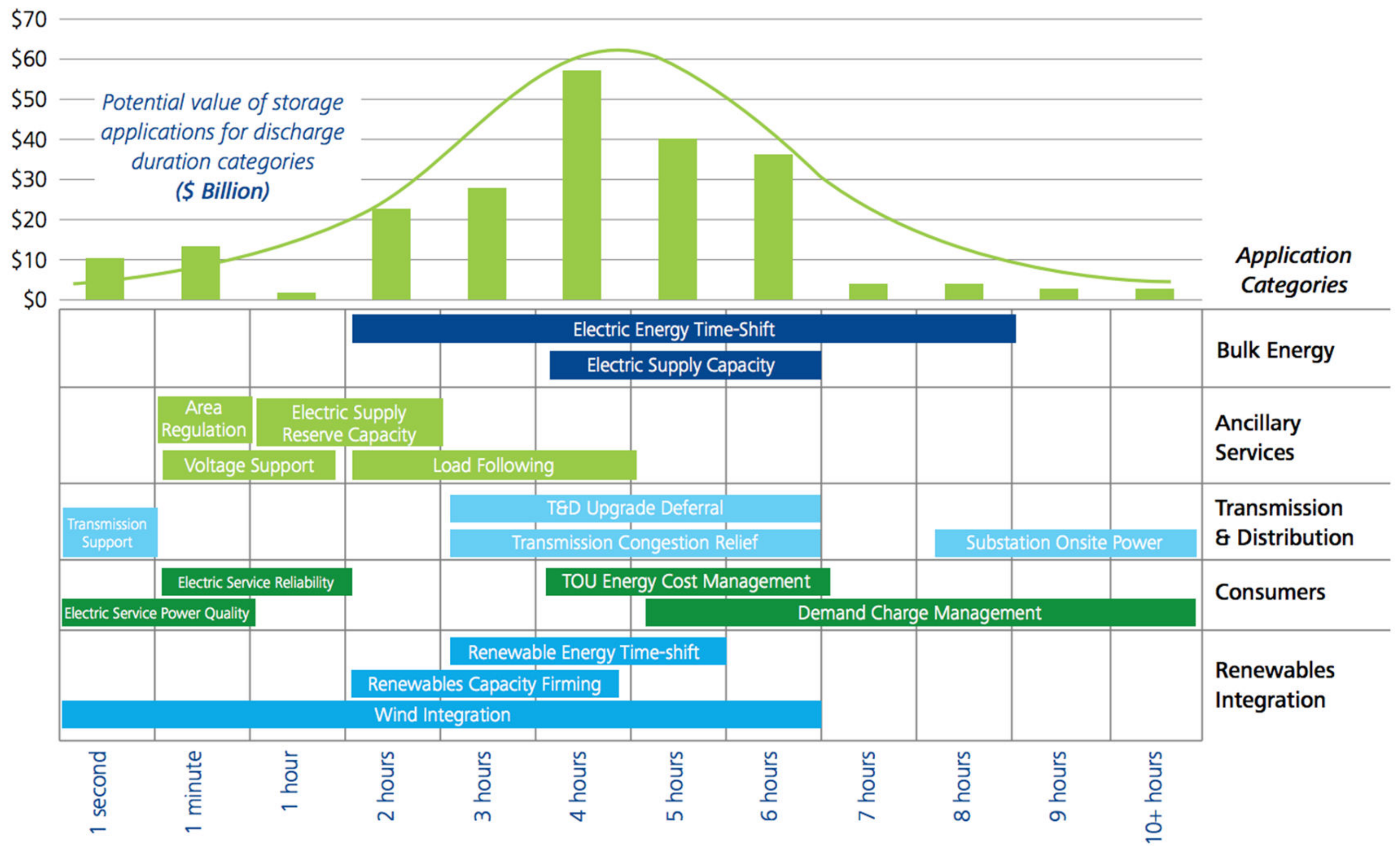
- Recent ruling on the Capacity Market have caused uncertainty for this revenue stream.

- Some of the key challenges have been surrounding the definition of energy storage as it sits as both a generator and consumer in most regulations; and

- Stakeholders in the energy storage industry need to actively engage with regulators and governments, to ensure a level playing field is in place for all technologies and that revenue streams are not constantly changed, rather price reflects value.

Price versus value

- Storage and optimisation can provide a wide variety of services, many not conceived of in current system design, certainly not from one source. Linking price to value is key:



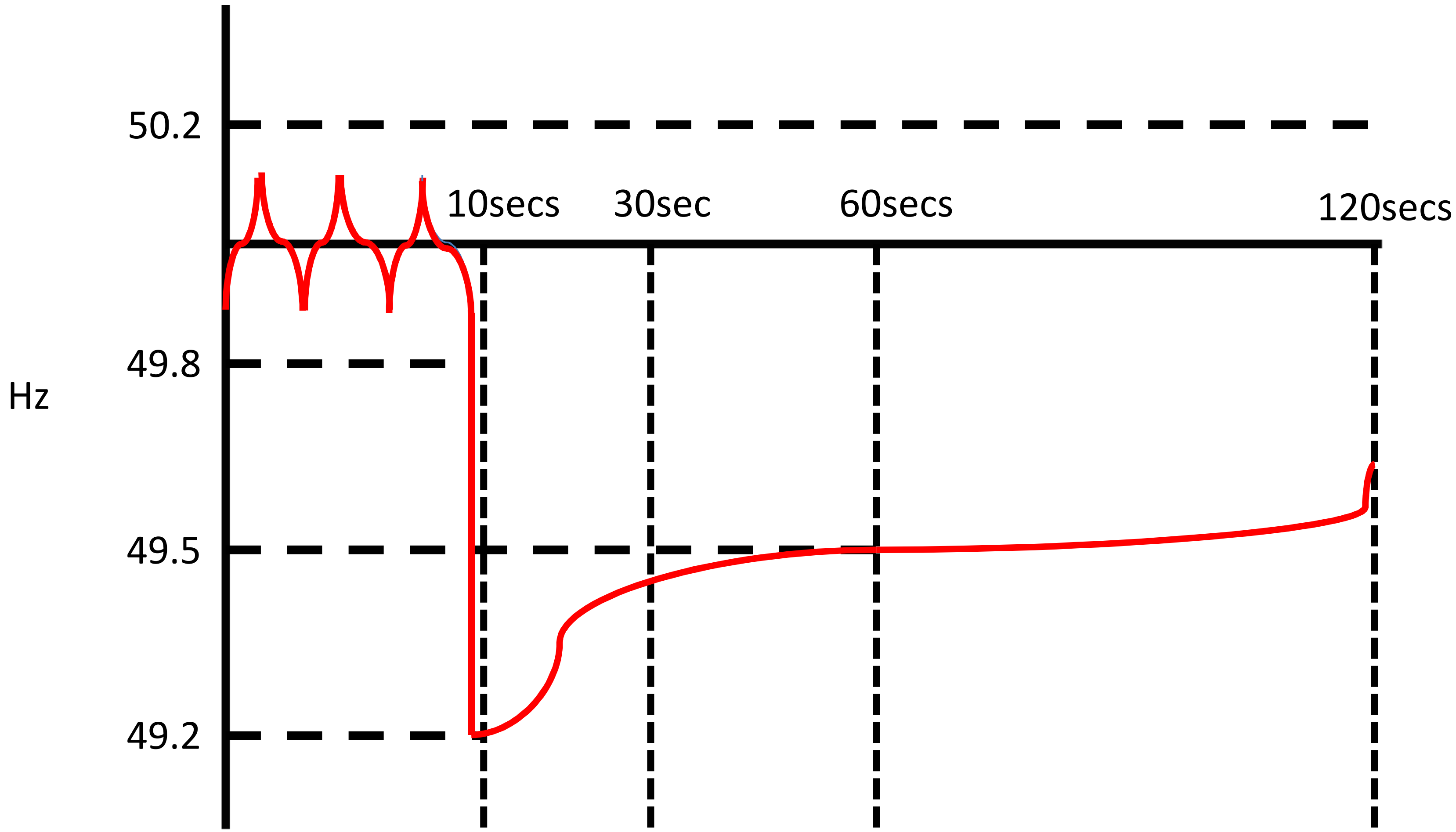
https://www2.deloitte.com/content/dam/Deloitte/no/Documents/energy-resources/energy-storage-tracking-technologies-transform-power-sector.pdf

Role of the network operators

- UK is currently at the forefront of the debate on whether network operators should own energy storage assets:
  - CapEx versus OpEx a factor;
  - Market competitiveness highly relevant;
  - Impact on cost for consumers;
  - Ability of network operators to innovate and adapt; and
  - Policy/regulation currently keeps generation separate.

- Opportunity in SE Asia to observe pros and cons of what other countries/regions have experienced and implement what is optimal for the future energy system.

System balancing services – Example



System balancing services

Generators and battery storage asset owners get paid based upon:

- Speed of response;
- Size of response in MW;
- Hold time i.e. how long can the battery or generator run for;
- How often the asset can be called; and
- Energy produced in MWh.

The TU benefits by:

- Avoiding using dirtier coal fired power stations;
- Avoiding the import of higher priced energy;
- Limiting exposure to short term volatility;
- Maintaining system security and reducing the risk of black/brownouts; and
- Increasing the use of renewable generation.

Seasonal constraints – Southeast Asia

- Southeast Asia suffers from large seasonal variations.
  - For example, in Cambodia, the beginning of Khmer New Year sees regular brownouts due to peak pick up in cooling as the hot and wet season begins;
  - To reinforce the network for the 10-14 week period of elevated demand would be too costly; and
  - Resultantly, diesel generators and very expensive imported electricity is used to cover the period, or as often is seen, wide scale outages occur.

- Using storage instead of diesel and imported electricity can improve the situation.
  - Not only does storage offer a means to support these peaks more smoothly, but there can now be a year-round fault restoration system in place to continue helping with pre-/post-fault outages; and
  - Whilst the commercial case is harder to design, the alternative is vast and expensive reinforcement.

Optimisation in action: Project FALCON

FALCON was a UK project specifically looking at the transition to a lower carbon economy through a number of techniques, all designed to support the DU networks across different voltages. The techniques were all evaluated alongside traditional reinforcement and stringing techniques so as to free up capacity, and apply ancillary service methodology for procurement:

- £17m invested to defer reinforcement costs and maintain system security and resilience to optimum levels;
- Dynamic asset rating - the ongoing reassessment of the capacity of assets, based on environmental and operating conditions they are actually experiencing, or are forecast to experience;
- Automatic load transfer – the implementation of alternative network open point locations to change power flow along feeders, aimed at increasing feeder capacity headroom, and also to improve other operational parameters (losses, and voltage);
- Meshed networks – the closure of normal open points on the network to change power flows and alleviate constraints. This technique also involved the provision of additional circuit protection to maintain/improve connected customer resilience to faults;

Optimisation in action: Project FALCON

Continued…

- **Energy Storage** – the installation of equipment that effectively time-shifted demand, from periods of potential system constraint, by discharging energy into the system. The stored energy is then recharged at periods of lower demand. Such equipment may also improve other network parameters and providing (commercial) ancillary services;
- **Control of distributed generation** – to increase capacity on the 11kV network using innovative commercial arrangements; and
- **Control of customer demand** – to increase capacity on the 11kV network through the use of innovative commercial arrangements.

The project overall was deemed a great success by trailblazing new techniques in an older market to support the GB systems.

VPPs and comms essential

Deployment

Generation

Transmission connected:

- Predominately thermal fossil fuel
- Challenging to adapt to demand changes
- Long term trend to decrease
- Baseload equivalent needed

Distribution connected:

- Increasingly from renewable sources
- Integrates easily alongside various technologies
- Intermittency is main challenge
- Rapid to deploy and scalable

Micro-grid, Off-Grid and Islands

- Typically hybrid installations
- Broad range of system sizes and demand profiles
- Security of supply is main challenge
- Rapid to deploy and scalable

Demand

- Continual growth across residential and industrial customers
- Grid unreliability necessitates onsite generation (typically diesel) or no power
- Demand profile remains an untapped resource

Hybridised systems

- Hybridisation – combine an energy storage system with a demand or generating asset, such as:
  - Solar;
  - Solar + wind;
  - Solar + diesel;
  - Hydro;
  - Gas, or any other fuel mix.

- Leads to longer battery life, increased generating asset efficiency and reduction in intermittency. Reducing long term costs;

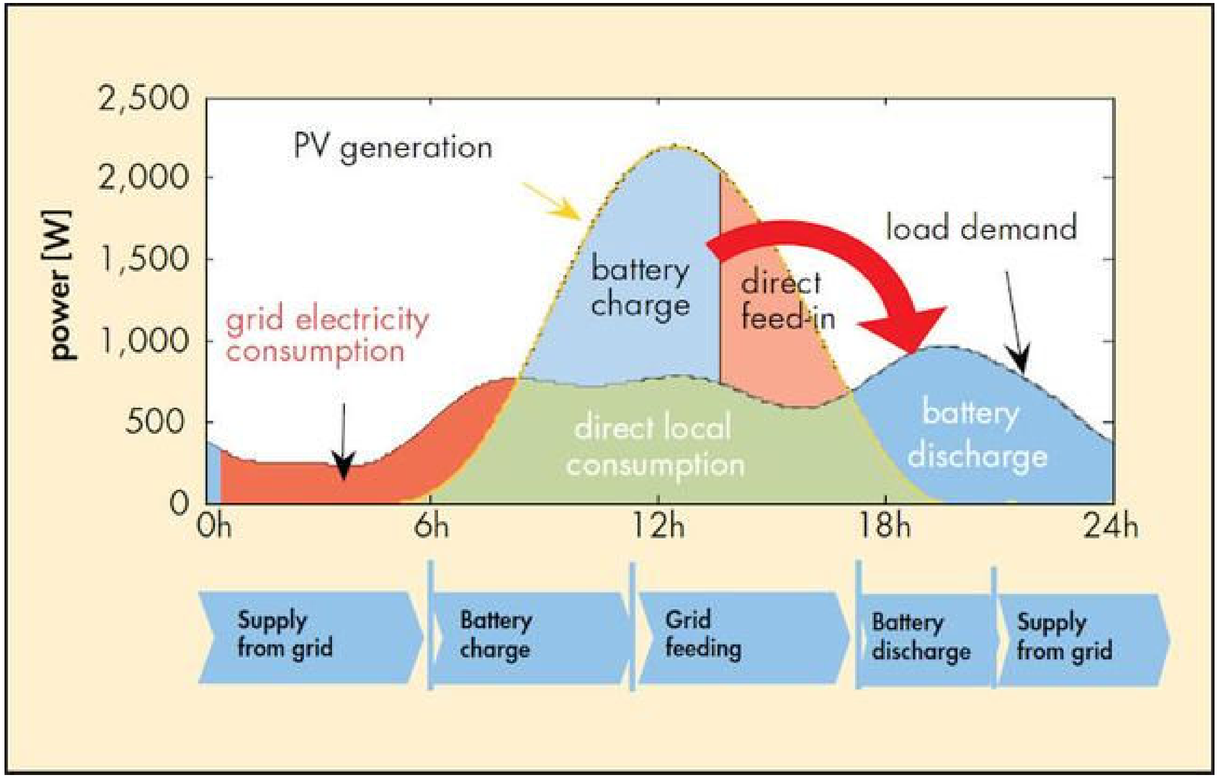
- Not necessary to be co-located given advanced aggregation and VPP technologies;

- Could also contribute to lower capital costs asset by spreading startup CapEx across multiple generation facilities (e.g. part subsidised); and

- Temporary installations to allow for infrastructure development.

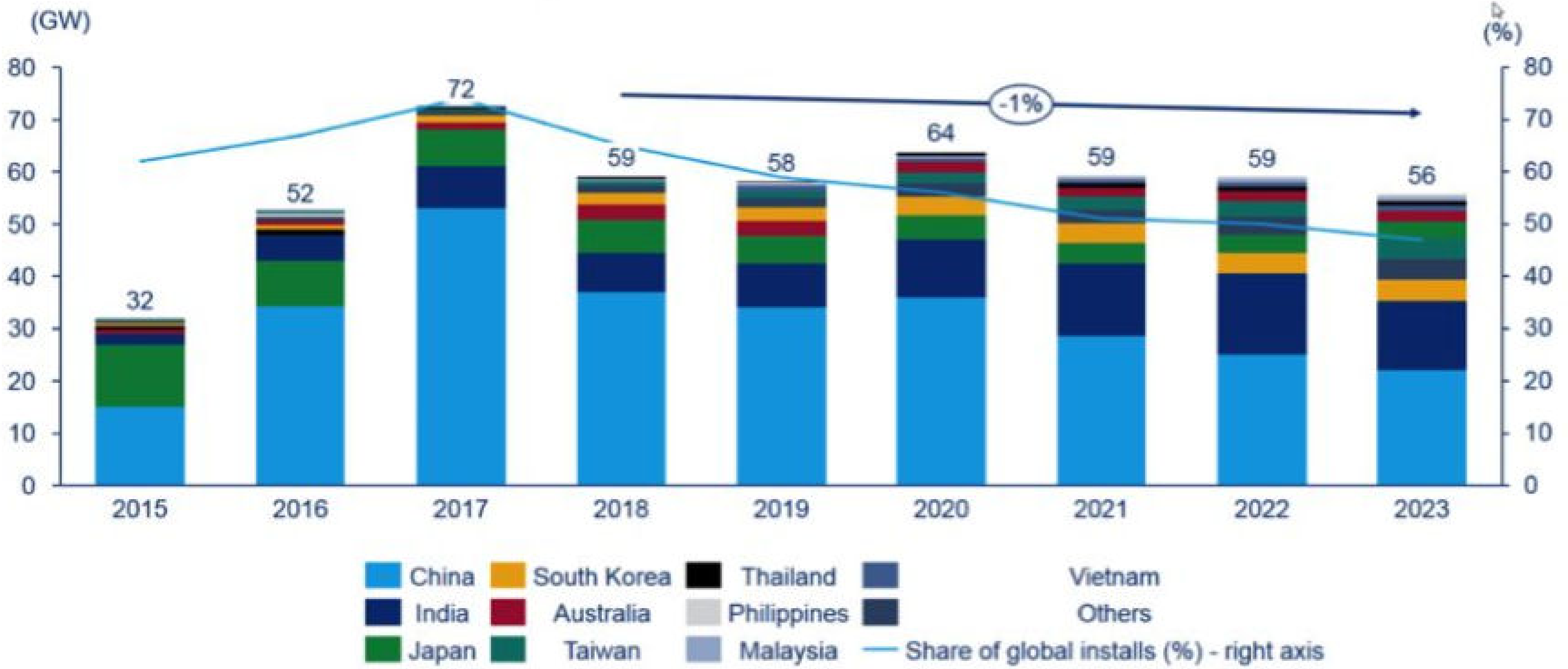
Connected but curtailed solar PV

- There are situations where network operators have operational solar PV connected to their networks, often at large scale, however it is regularly curtailed, often completely, due to network challenges and resiliency issues.
- Utilising a variety of solutions, the level of curtailment currently being experienced could be vastly reduced by adopting energy storage as the basis.



Solar PV growth – boosted by storage?

- APAC market will account for circa 55% of global annual installation.
- Growth in emerging markets will counter decline in China and Japan.
- Energy storage will underpin ability for solar PV to deliver baseload.



Source: Wood Mackenzie

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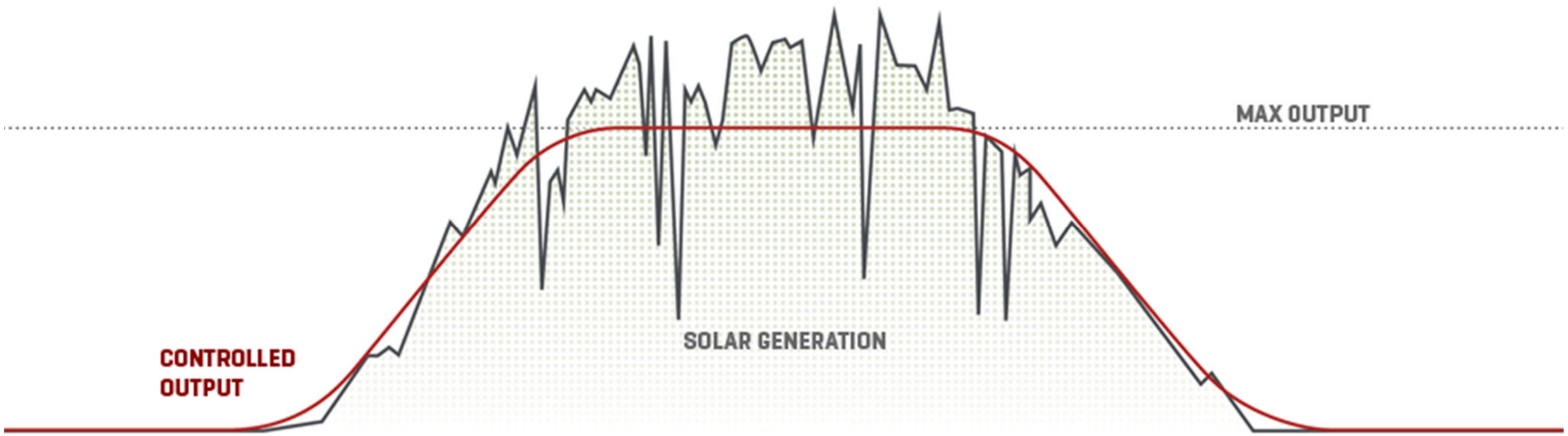
Reducing curtailment of connected solar PV

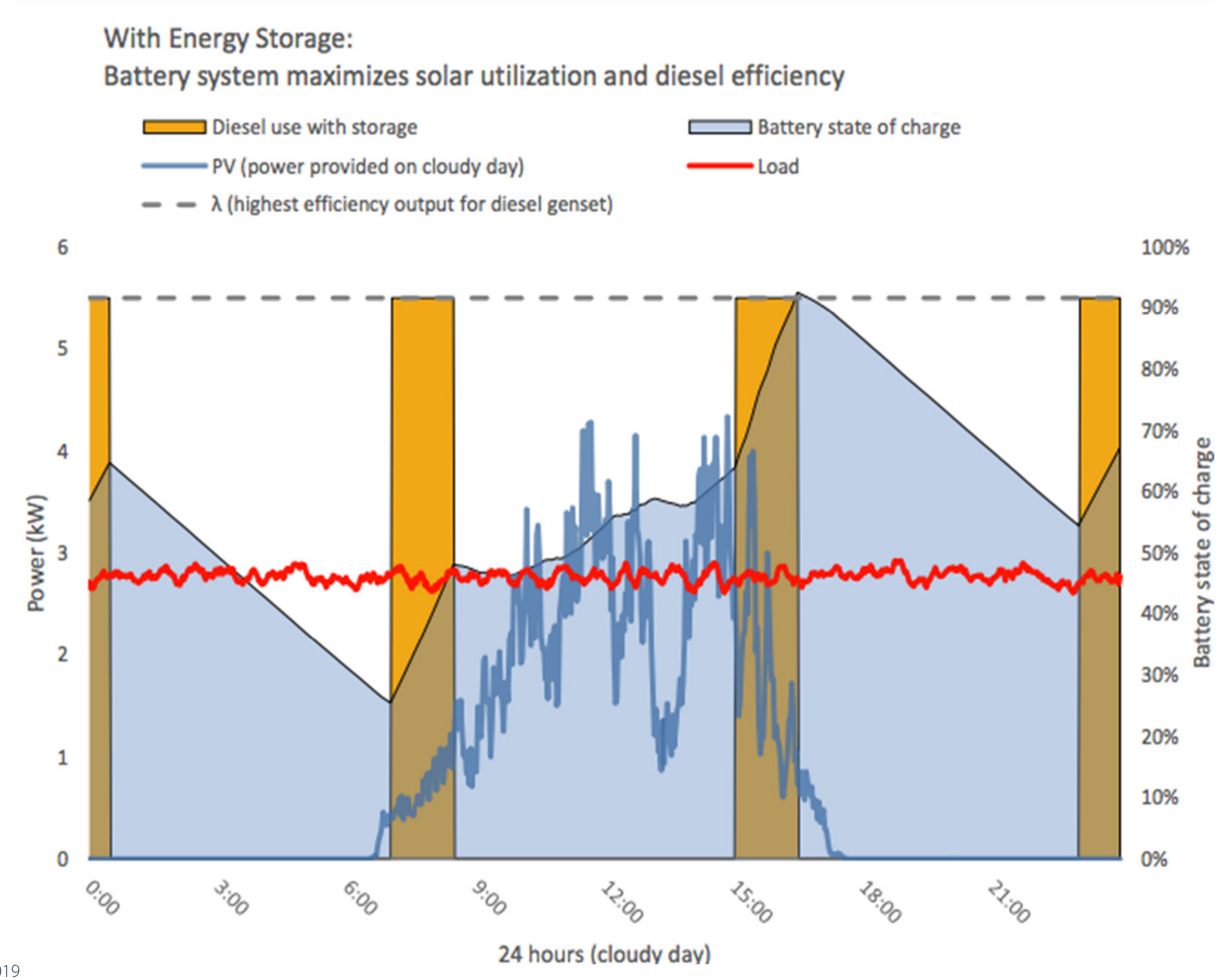
- Co-locating energy storage directly with solar PV sites enables control over the supply profile of the energy generated.
- Controlling when power is exported smooths the supply profile, creating predictable output, and allowing a higher proportion of generated power to reach the grid.
- Easier for networks to receive power generated from renewable sources.



Optimisation at all network levels

Optimisation at all network levels

Diesel + PV + storage



Achieving Scale

Capital Investment to Maximise Asset Utilisation

Oversized Centralised Grids?

Adapt to Changing Demands?

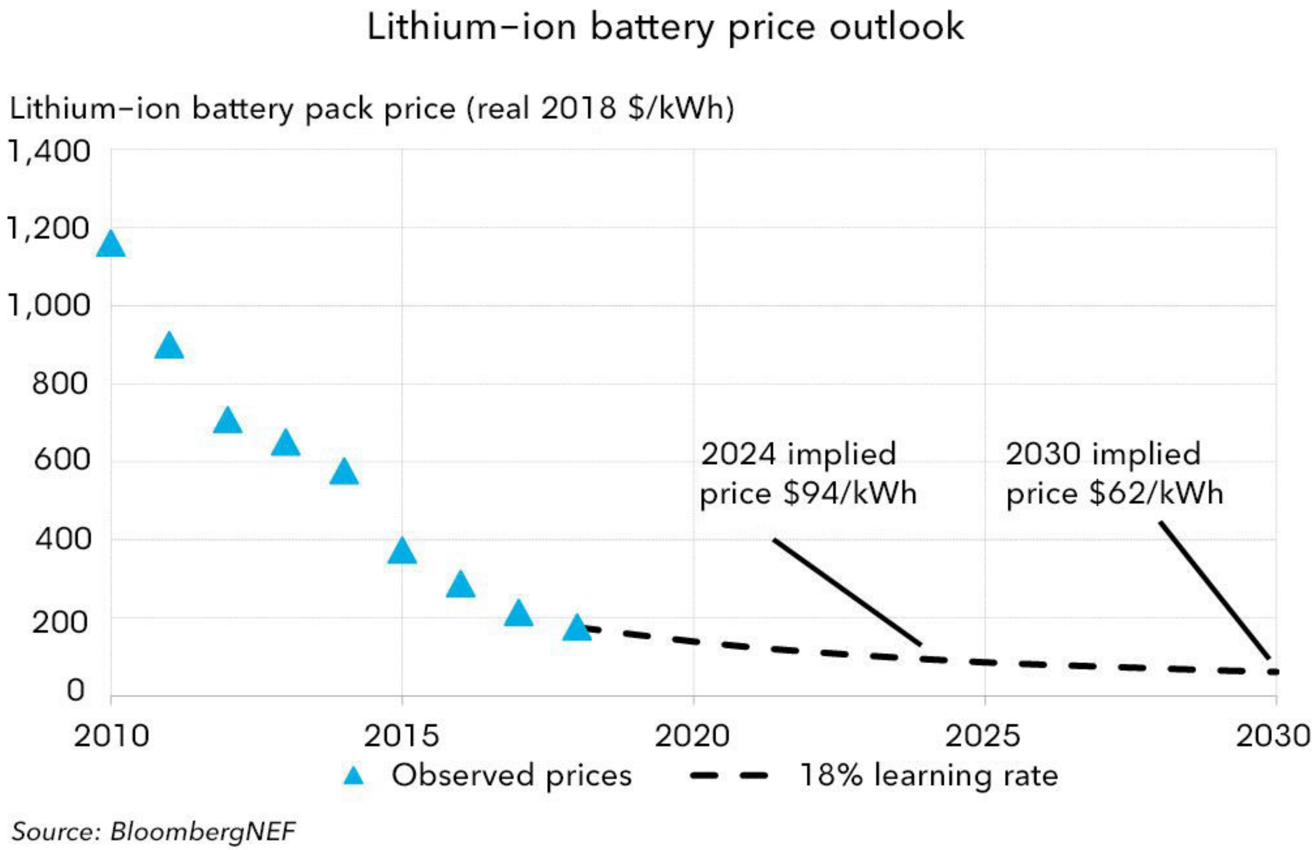
Avoid Stranded Assets?

Network charges - what do these indicate?

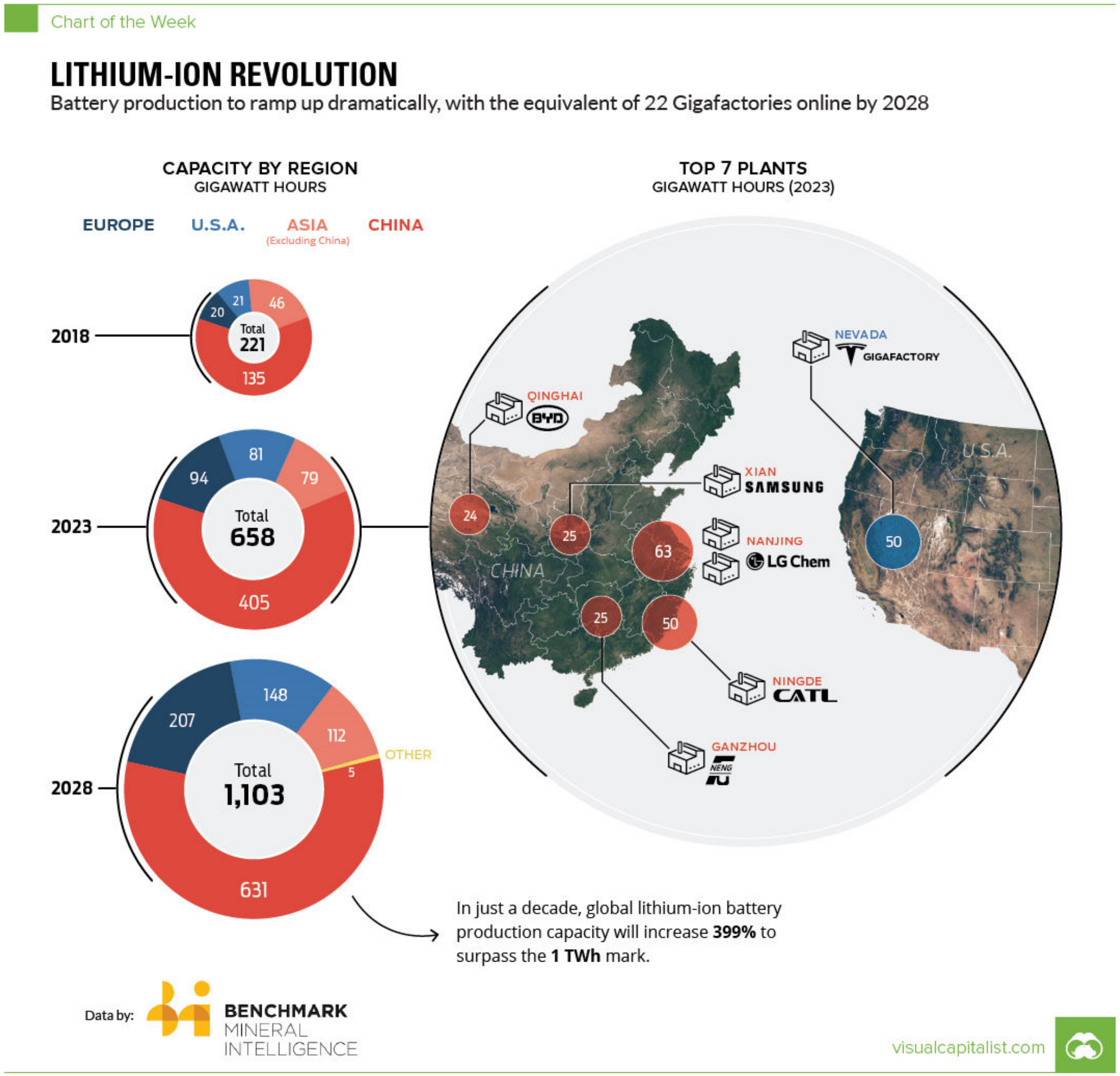
- TUs and DUs charge congestion fees in the UK, with a premium being paid by all energy users for energy used at peak times;
- This type of tariff mechanism charges over £2bn per annum in the UK per year and is levied against suppliers to pass through to consumers;
- This is an entirely zonal payment, based on area in the country, but can be avoided;
- It encourages major energy users (factories, manufacturing etc) to shift energy use to outside peak hours;
- In the South East of England, this charge is nearly £50k/MW/year; and
- The NHS, printing companies and water utilities use behind the meter generation, battery storage and demand response, to avoid this charge; and

Utility scale underpinned by EV growth

- Lithium-ion price is continuously falling driven by the increased uptake of EV vehicles;
- Forecasts predict the price to continue dropping; and
- BNEF predicts prices of $62/kWh in 2030. (Same analysis from 2017 predicted $73)

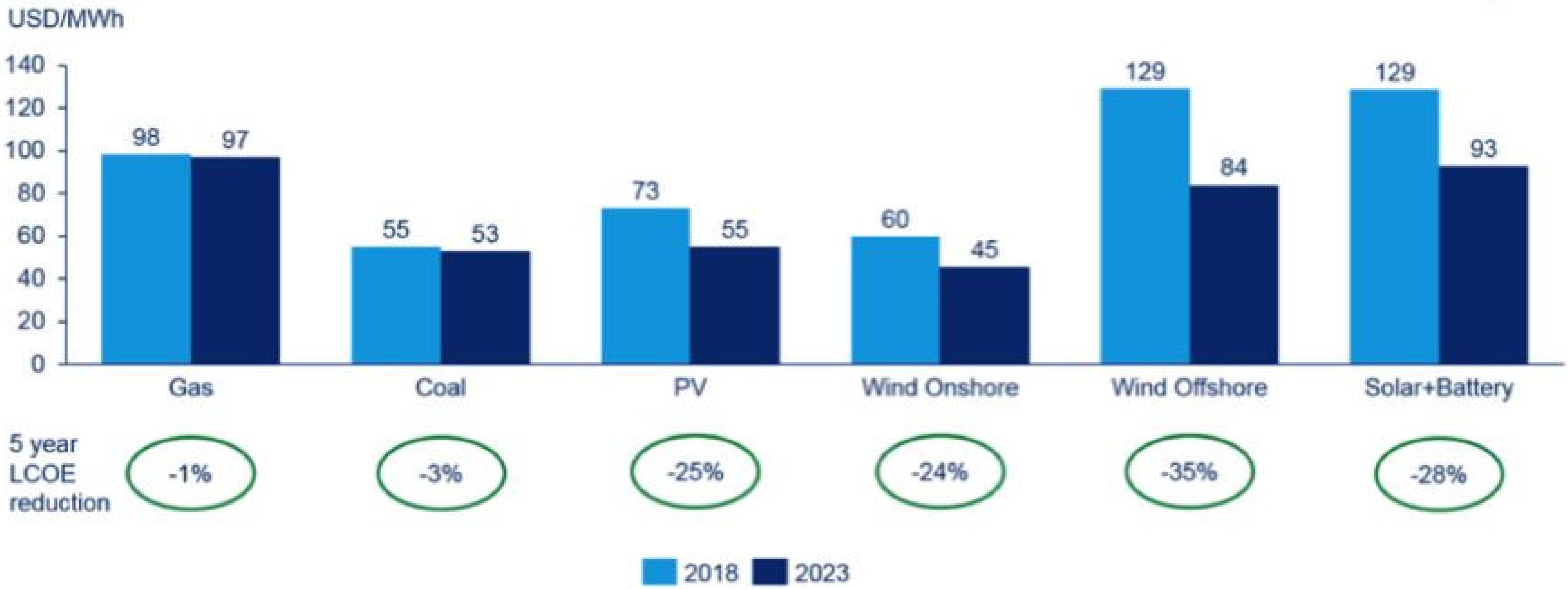


Production growth locked in



Reinforcing competitiveness

- LCOE of renewables is already competitive versus traditional baseload.
- Onshore wind and PV already competitive versus gas.
- PV plus battery expected to be so by 2023.



Source: Wood Mackeznie, Note: Average utility-scale solar LCOE for APAC region shown

Technology Considerations

Current and potential future technologies

Storage

- Batteries
  - Lithium-ion;
  - Sodium sulphur;
  - Sodium ion;
  - Redox flow;
  - Solid state; and
  - Lithium sulphur.
- Gases
  - Hydrogen;
  - Power to gas; and
  - Liquid air.
- Mechanical
  - Flywheels; and
  - Gravitational systems.

Optimisation

- Technology
  - SCADA and monitoring;
  - LV switching and
  - Auto load transfer;
  - Smart meters;
  - IoT devices;
  - EV integration;
  - Communications connectivity;
  - Monitoring;
  - Control systems; and
  - Supply / demand balancing.

Main storage technology groups

Electro-Chemical

(Flow battery / Lithium Ion)

Mechanical

(Flywheel)

Bulk Mechanical

(CAES)

Thermal

(Ice / Molten Salt)

Bulk Gravitational

(Pumped Hydro)

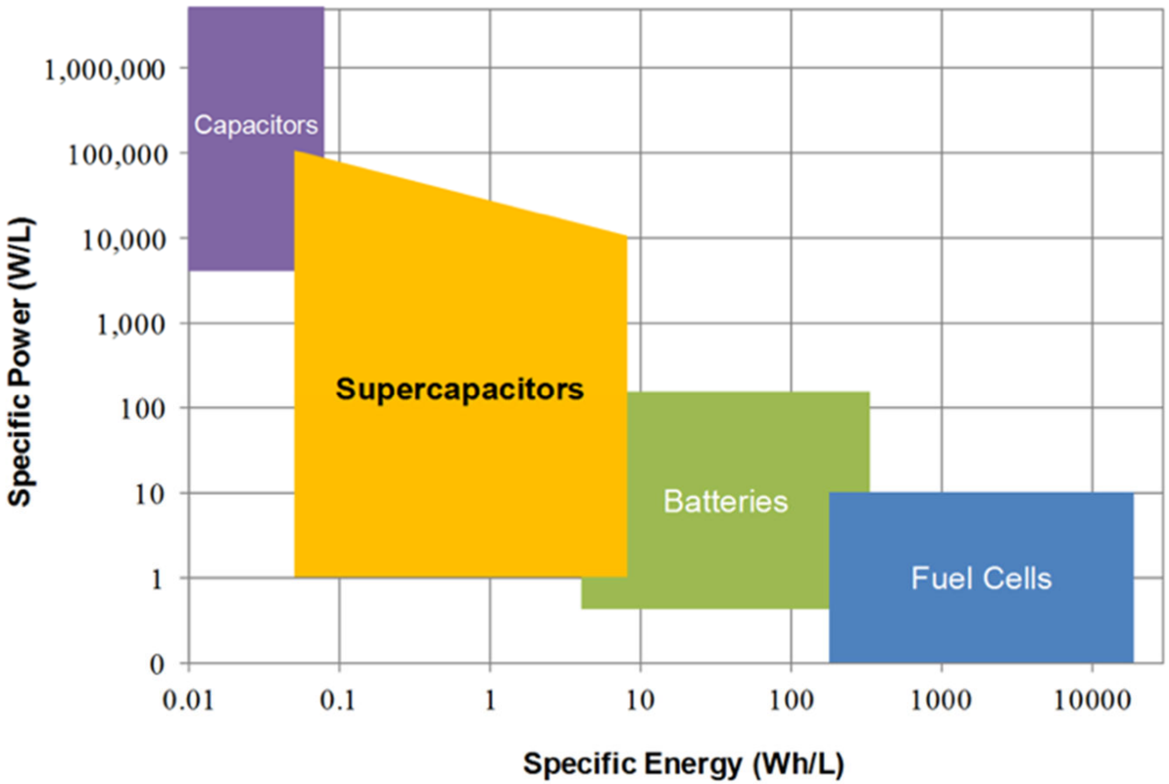
Transportation

(Electric Vehicles)

Strategen Consulting 2016

Power vs energy storage applications

- Some applications require fast and high power response for short durations. This is ideal for high power, low energy technologies like supercapacitors and flywheels; and
- Other applications require slow and low power response for longer durations. This requires technologies which have a higher energy capacity.



http://www.plug-in.com/wp-content/uploads/Energy-Density-Chart.jpg

Energy Institute:
Sub-committee for Energy Optimisation and Storage

Why?

- Identifying key topics of our time within the energy sector and region;
- Leadership role as a catalyst to support development and adoption of solutions to address these key topics;
- Facilitating an industry led approach to expand knowledge base, technical guidance as a resource and channel global best practices from within the region; and
- Engage with key stakeholders in a unified, coherent manner, thus increasing possibility of accelerating market development and the low carbon transition.

ion Ventures

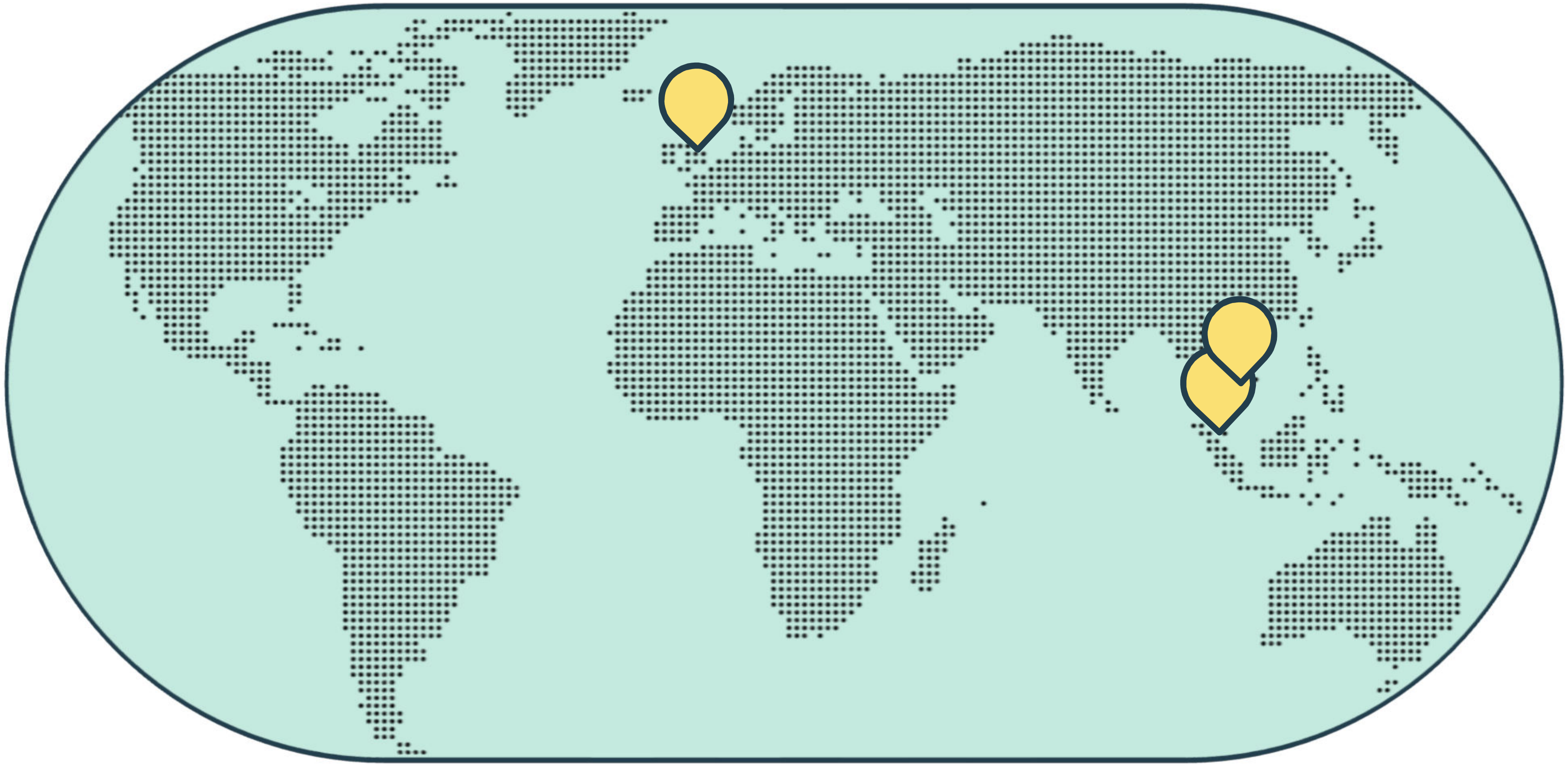
ion Ventures

ion Ventures is an expert advisor, partner and developer to emerging market electrification schemes via developers, utilities and network owners or operators, and boasts the following:

- Deploys a combination of its existing hybrid systems to deliver cleaner grid applications, both on and off grid;
- A proven skillsets in using new energy storage technology to mitigate emissions via localised diesel, fuel oil and gas generation;
- A developer-led mindset having built and commissioned 100s of MWs of renewable power, gas, diesel, working as the originator, financier and operator of the assets, allowing a full set of expertise to be deployed appropriately;
- The team is sized and scoped to be nimble enough to provide support in key Asian countries, as well as maintaining regional HQs in London and Singapore;
- Well-versed in unlocking investment (equity and debt) to facilitate deploying technologies/projects at scale;
- Experienced in addressing risks as necessary to meet criteria of insurers and funders, with particular emphasis on warranties;
- Strong relationships with leading suppliers enabling optimised pricing and lead times.

ion Ventures in Southeast Asia

- ion Ventures operates internationally, with a focus on Europe and Southeast Asia.
- With a regional HQ in Singapore, and a subsidiary in Cambodia, ion Ventures is actively engaged within Southeast Asia.



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