Global Strategy to Accelerate Battery Storage Development

Sarah Fairhurst

15 October 2018

THE LANTAU GROUP

Early reports on storage continue making headlines…

BRIEF

South Australia's grid service costs slashed 90% by Tesla batterv

BUSINESS NEWS FEBRUARY 16, 2018 / 2:14 AM / 6 DAYS AGO

U.S. regulator moves to clear market barriers for energy storage technology

The Energy Revolution Of 2018: Electricity Storage

Bain Insights, CONTRIBUTOR
We are a global business consulting firm. FULL BIO
Opinions expressed by Forbes Contributors are their own.

Batteries stabilise energy grid: regulator

Battery storage leaves fossil fuels and regulators in state of inertia

One-third of companies in the UK have installed on-site battery storage

Coal beaten out as gas, battery storage and DSR are winners in UK's Capacity Market

Storage Might Solve Some Big Grid Problems, but Not the Ones You Think

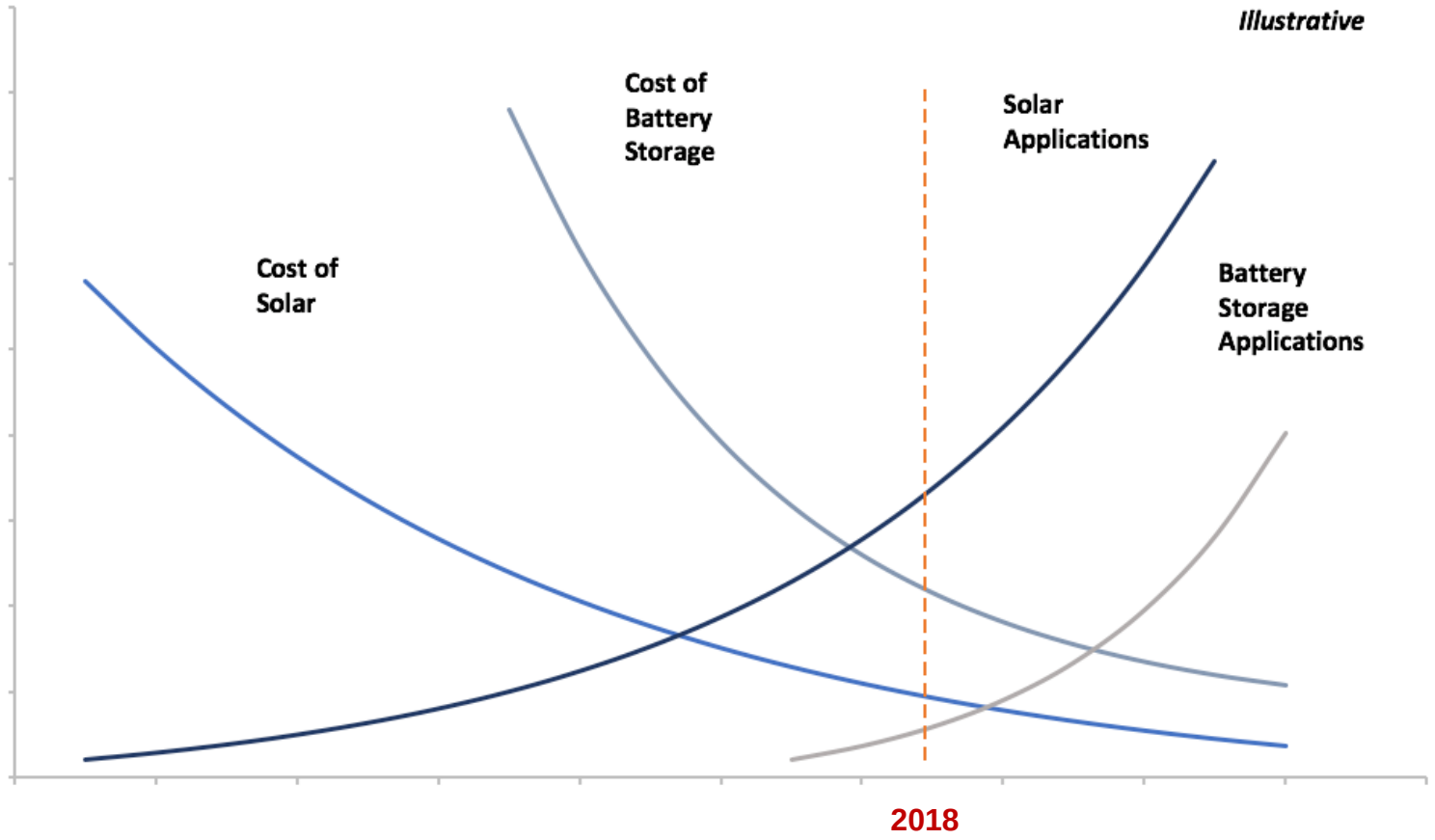
A new wholesale market participation model for energy storage may help other inverter-based or distributed energy resources.

MARK AHLSTROM | MAY 15, 2018

Duke Energy to Invest $500 Million in Battery Storage Over 15 Years

THE LANTAU GROUP

Driven partially by improving economics



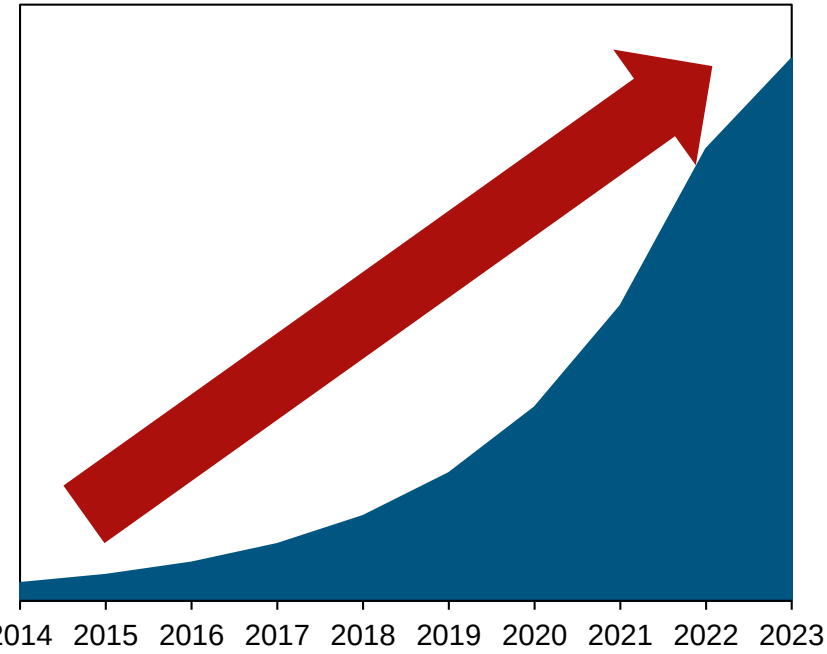
How will this develop? What will drive success? And what applications will work in Southeast Asia?

High expectations – but in which application?

Analysts see rapid growth and big impacts

- Core component of energy transformation
- Ability to make RE ubiquitous
- Peak reduction
- Bring energy to places without access
- Improving transmission systems
- Improving reliability
- Reducing energy bills

Energy Storage Revenue Growth

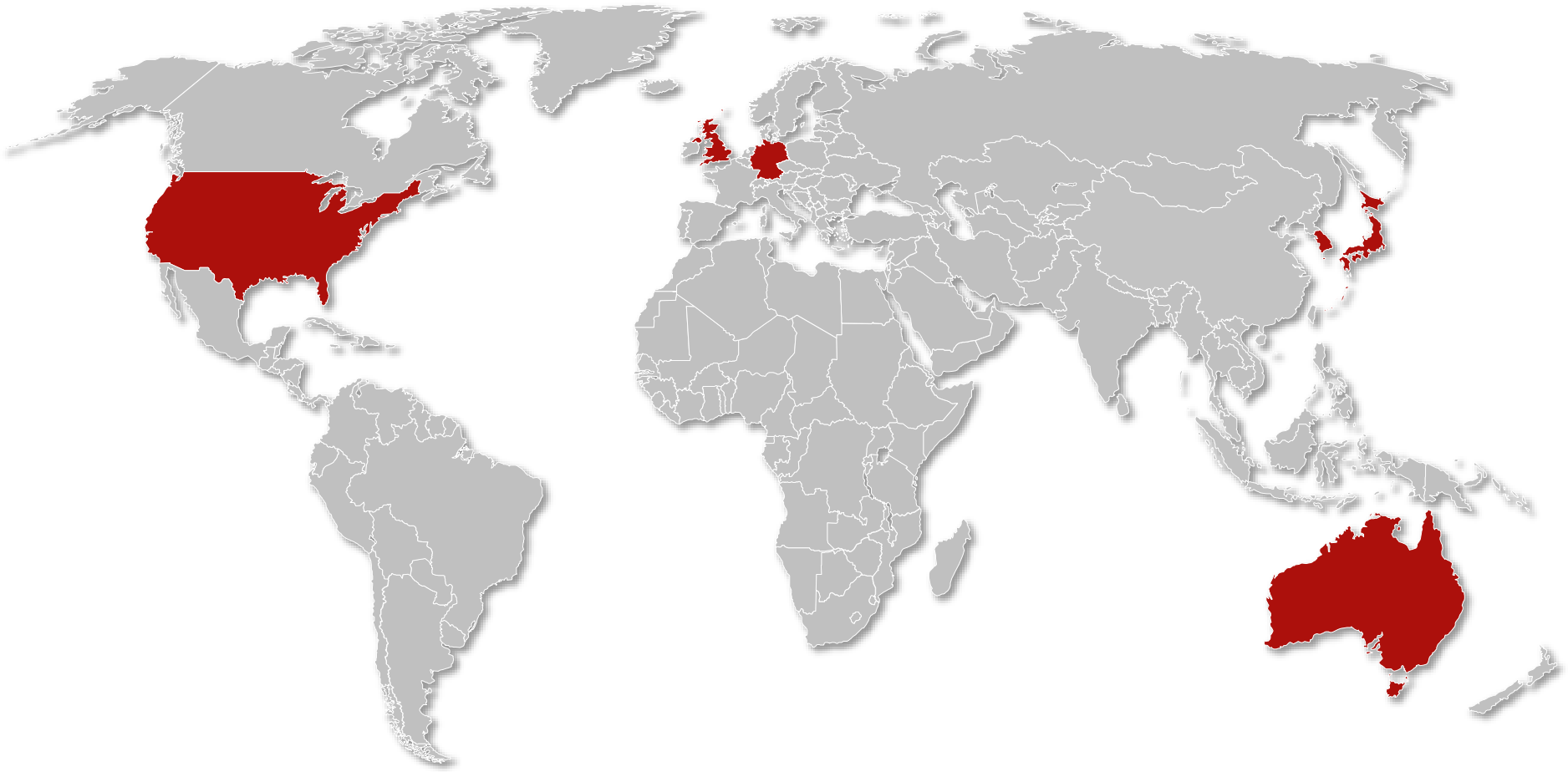


Sources: Lux Research

But this involves multiple applications, business models, locations, market structures and regulatory regimes
There isn't a single global strategy for battery storage adoption!

THE LANTAU GROUP

Early storage deployment concentrated in the US, Japan, Korea and Europe – countries developing storage technologies – while Australia is recently taking the lead

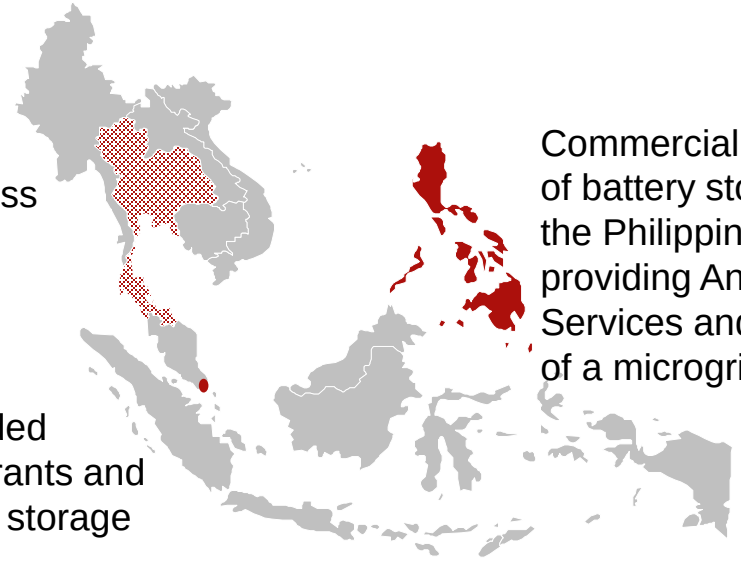


4 Source: DOE Global Energy Storage Database

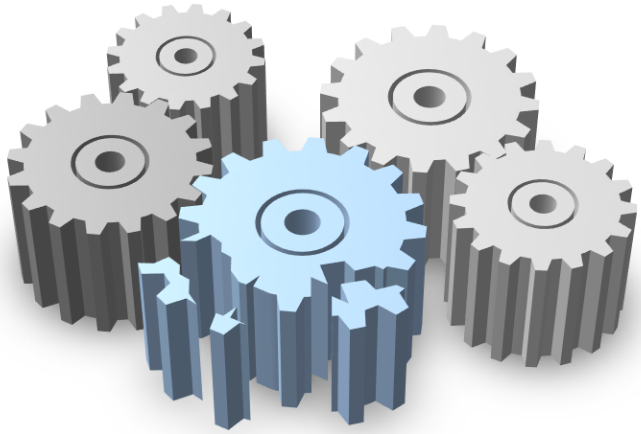
South East Asia is still a grey area for storage development

EGAT is in the process of procuring storage for testing as grid support

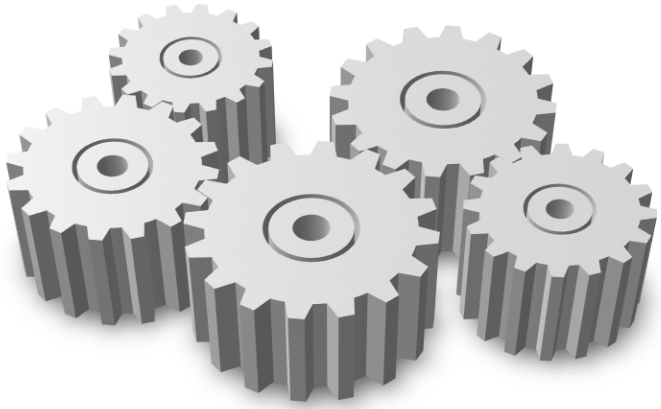
EMA awarded research grants and sandboxed storage operators



Commercial operations of battery storage in the Philippines providing Ancillary Services and as a part of a microgrid



How to make storage work in South East Asia?



Battery storage means different things to different people

There is no *“one size fits all”*

There is no *“one battery fits all”* either

There are multiple commercial opportunities – many few commercial success stories (yet)

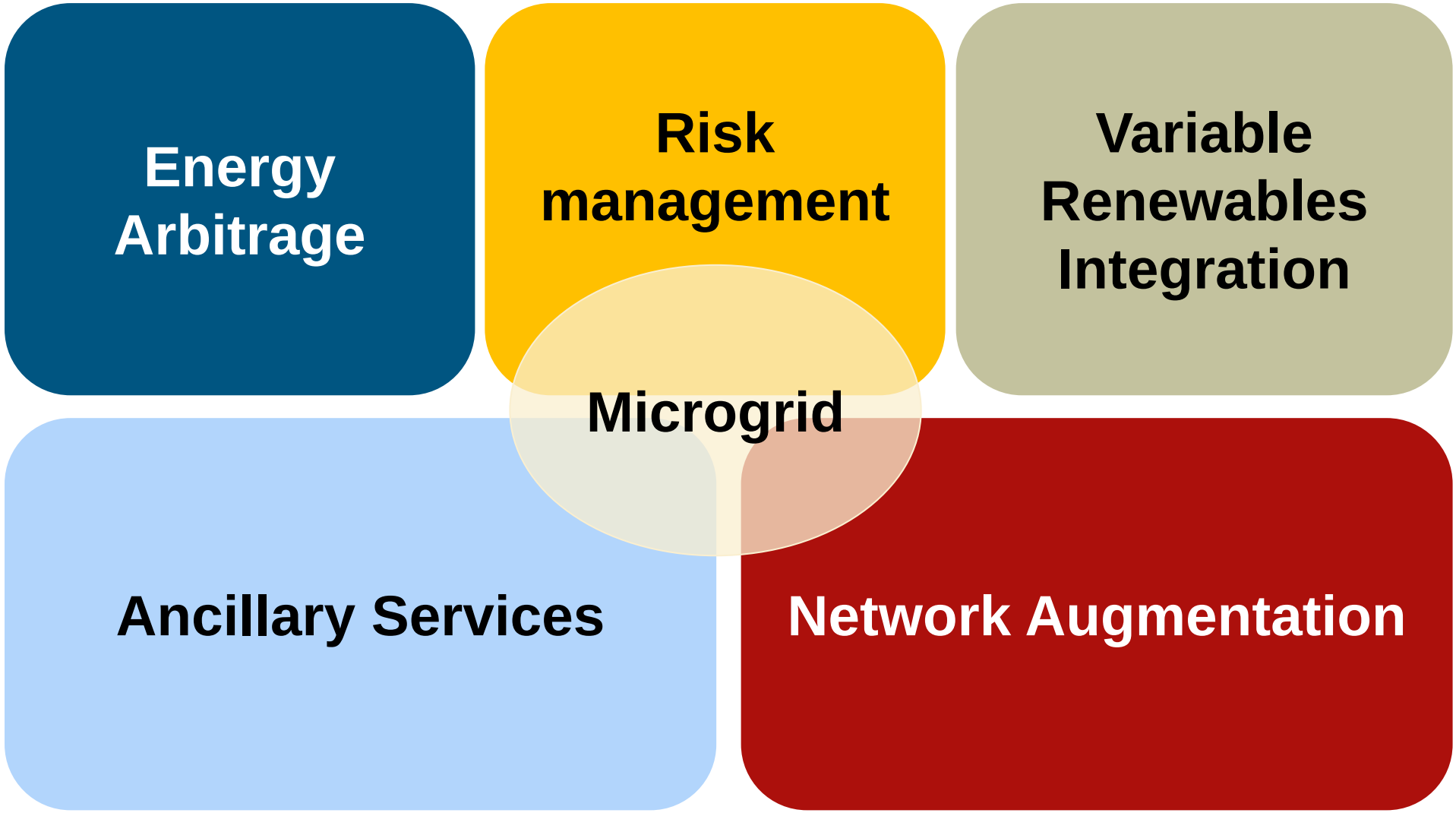
So let’s start at the beginning.

How storage can be used?

Overview of applications, business models and regional examples

THE LANTAU GROUP

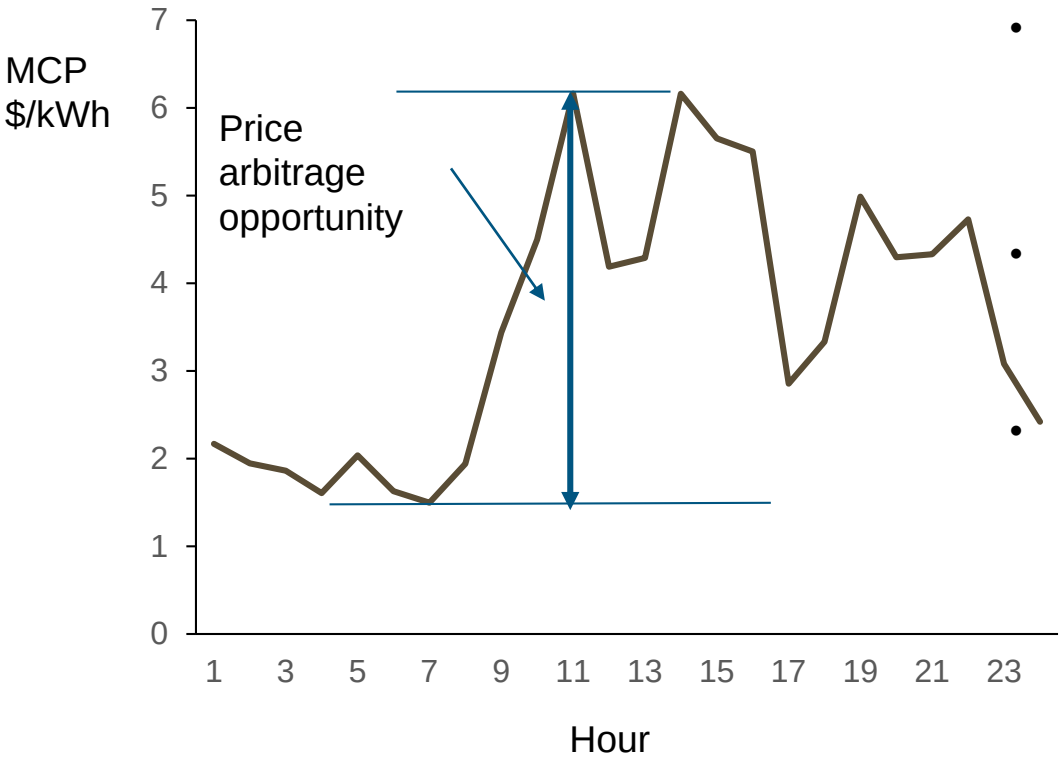
Six types of businesses that storage can do



THE LANTAU GROUP

Energy Arbitrage

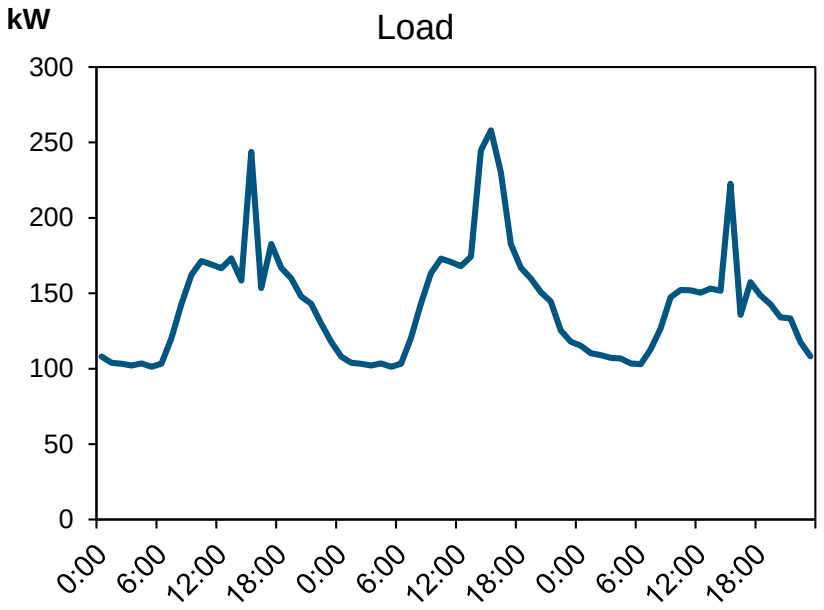
Energy Arbitrage



- Wholesale market price arbitrage is one of the most straightforward applications of storage
- The value storage brings is by replacing expensive peaking capacity
- This business model is the most similar to the load shifting application of storage that was traditional employment for pumped storage plants
- The size of the opportunity depends on the steepness of the merit order curve and is bounded in the long run by the LRMC of storage
- Similar business model can be build in the retail market in case of some types of tariffs

Demand charges – risk management behind-the-meter

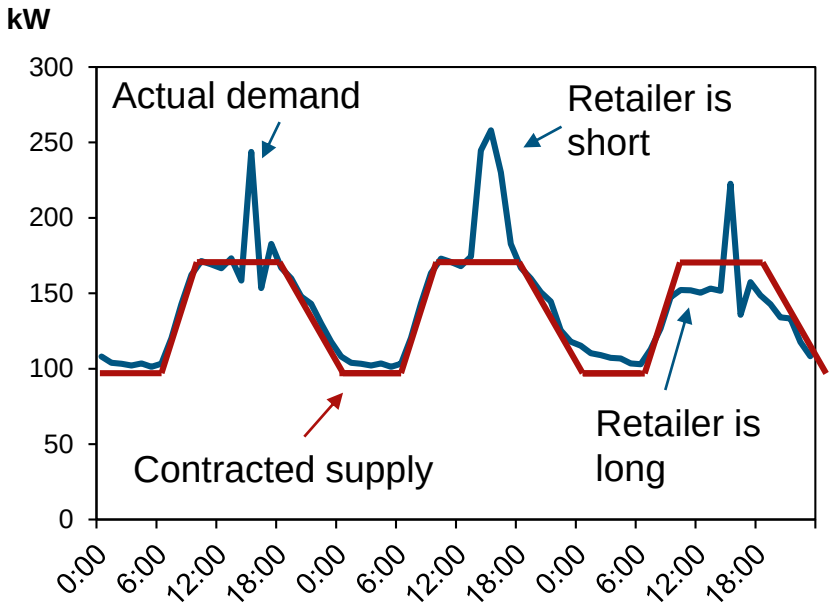
Demand charges



- An interesting business model for storage can be build in the Behind-the-meter application scenario
- Storage can be used to manage the electricity bill in multiple way, depending on the tariff structure
- One of the simple applications is to lower peak demand and therefore reduce the demand charges of the end-user
- In such scenario, end-user has an electricity bill composed of two elements. Usage charge, denominated in $/kWh and demand charges, denominated in $/kW
- Such application of storage is highly valuable in case when end-user experiences occasional high surges in demand
- Another type of such BTM application is when combining storage with a time-of-use tariff

Retailer hedging – risk management at the utility scale

Retailer hedging

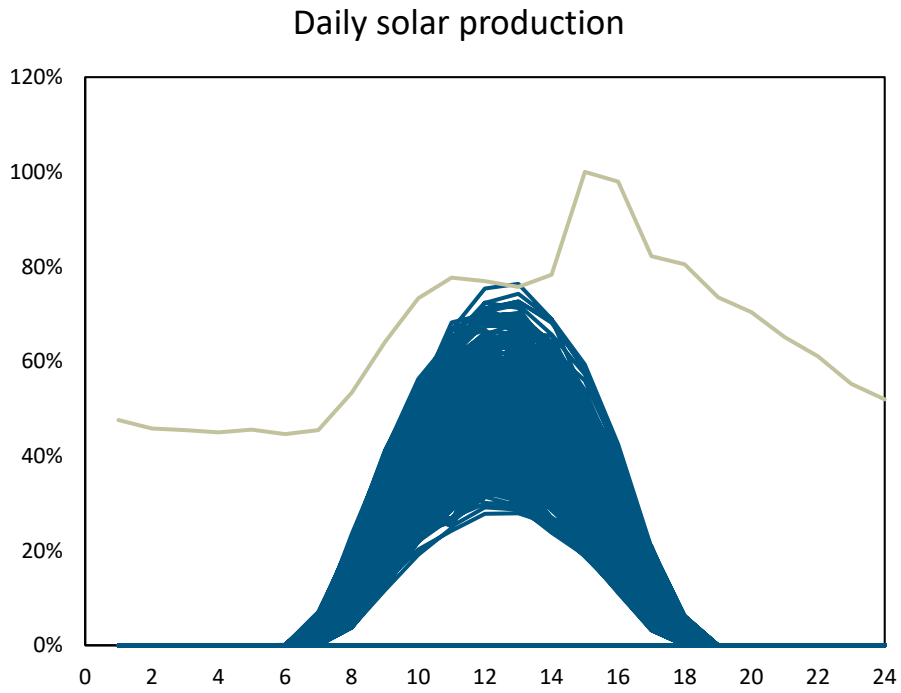


- Electricity retailers face two types of risks while performing their basic operation of retailing energy. The price risk and the quantity risk. Both are interdependent.
- Retailer needs to forecast specific demand profile for its customer base in specific locations and meet their instantaneous demand via self-generation, forward purchase contracts and balancing market purchases^
- To minimize its value-at-risk, the retailer needs to engage in multiple hedge strategies at various time scales.
- Financial hedges does not always offer optimal solution, while physical hedges are not always allowed in a market (e.g. due to unbounding).
- Storage can offer an opportunity to build a physical hedge at an intra-day scale. Studies show, such hedge has a significant value in a case of price inelastic demand.

^ specific portfolio of financial and physical hedges depends on the market structure in given jurisdiction

VRE Integration

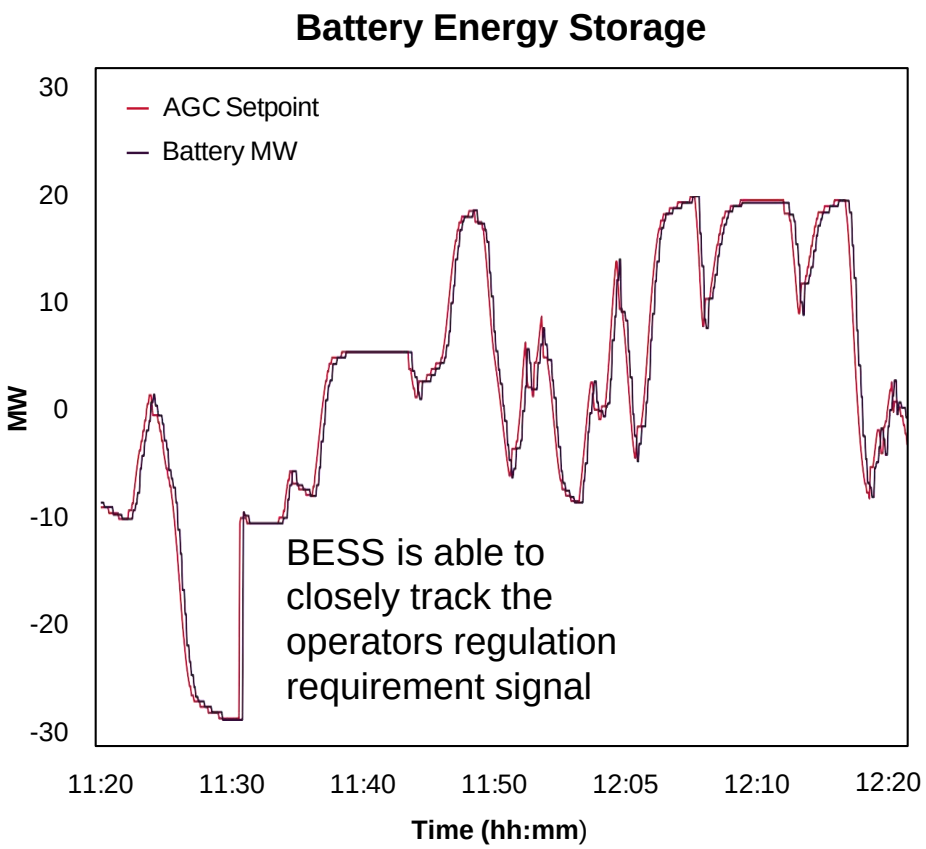
Variable Renewable Integration



- Production from photovoltaic cells and wind mills is known to be highly variable and generally non-dispatchable
- Given that growing penetration of RE depresses prices at times of high production probability, the ability to dispatch such generators is going to bring increasing value
- Additionally, some jurisdictions require specific generation profile for the PSA/PPAs that cannot be assured for a typical variable generation asset unless a balancing market is present or storage is adopted to assure the specific generation profile
- In some countries, high penetration of RE leads to the curtailment of these resources
- While the prices of RE and storage continue to drop, combination of the two can supply baseload power

Ancillary Services

Ancillary Services



- Ancillary Services are grid services that assure instantaneous matching of supply and demand, preserve the frequency and voltage within the system and correct for the power factor
- Storage systems are particularly suitable for supplying high flexibility frequency regulation services. They can also be used to supply black start capabilities
- Albeit, the current AS types do not require so stringent performance as storage can offer, increasing penetration of VRE is likely to change this. Some regulators are currently considering tightening the performance standards for AS supply that may favor some types of storage

Network Augmentation

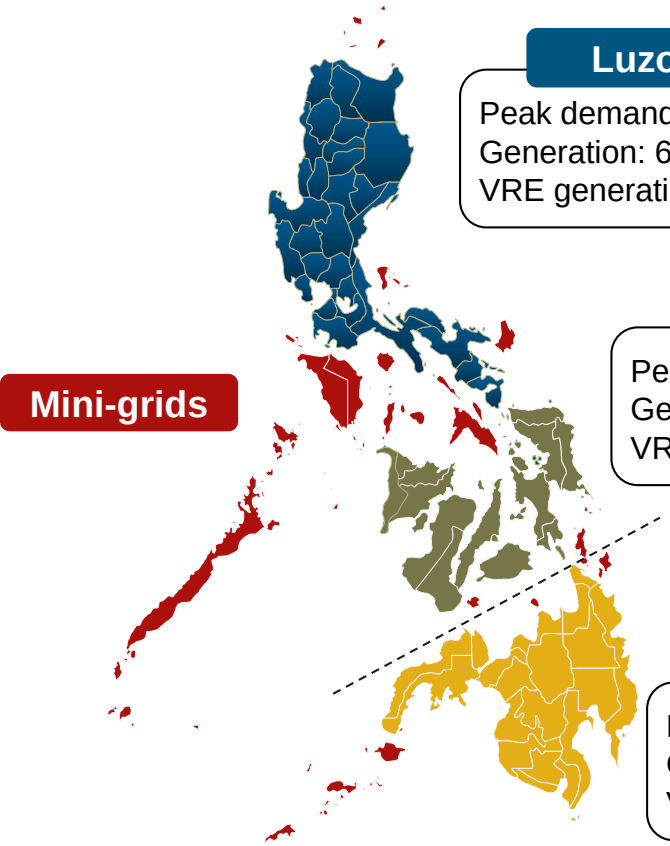
Network Augmentation

- As the demand grows in radially connected load centers, the network throughput upgrades may be needed to serve the peak demand
- Often such upgrade may be deferred by strategic installation of the storage asset to unload the overloaded substation
- Strategically located storage can either supply peak demand downstream from the overloaded segment or shift the injection from VRE to a less congested time period
- The values that storage captures here is the investment deferment and also smoothening out of interregional price spreads due to congestion

THE LANTAU GROUP

Microgirds

Microgrid



Luzon

Peak demand: 10.1GW
Generation: 68.5TWh
VRE generation: 2.0%

Visayas

Peak demand: 2.0GW
Generation: 14.1TWh
VRE generation: 5.9%

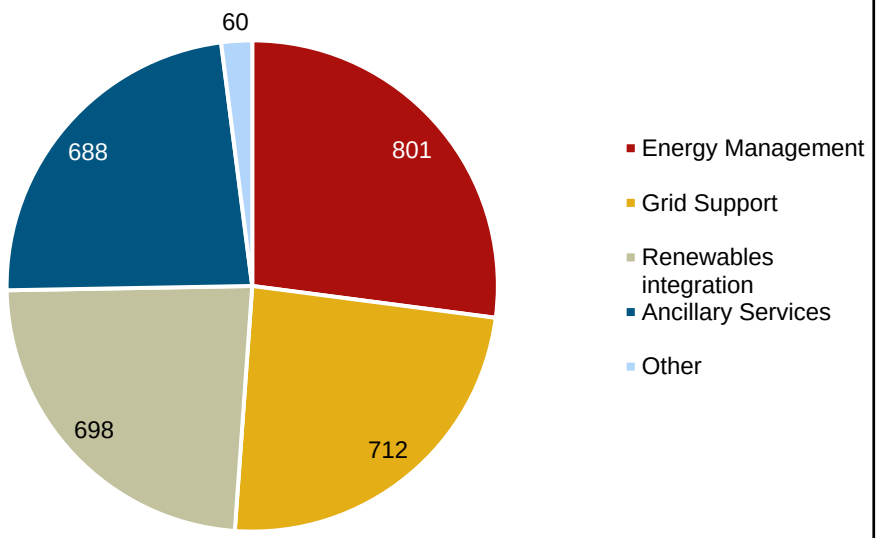
Mindanao

Peak demand: 1.8GW
Generation: 11.8TWh
VRE generation: 0.7%

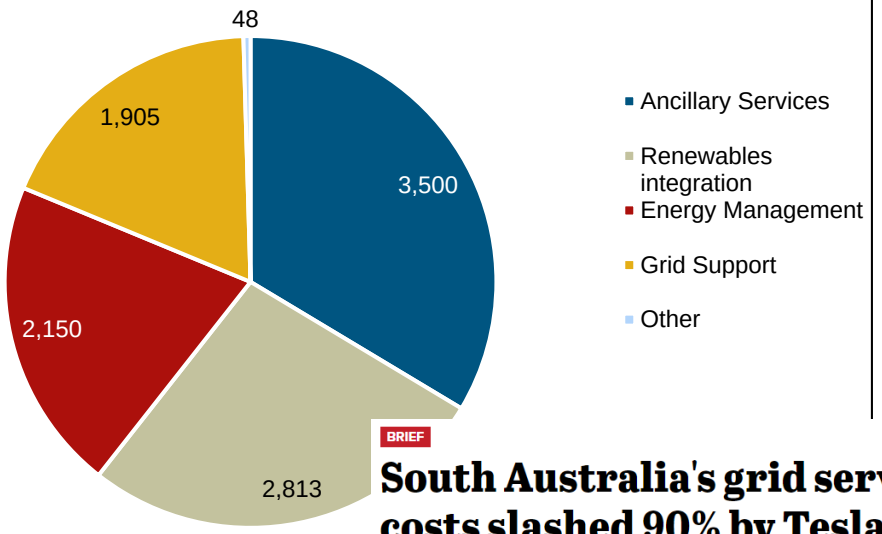
- To illustrate the value that storage creates for microgrids, one may view microgrid as a normal power system, but without the benefits of the scale. Thus the lowered costs due to optimal capacity mix are typically not realized. In fact, microgrids often operate on diesel engines that can provide enough flexibility at small scale
- Storage can be used in combination in small scale VRE to lower the aggregate LCOE of such system by tapping into low cost, but unreliable VRE supply
- Opportunity for storage in the microgrid application is typically scattered and limited by the grid size, albeit strong economic fundamentals support the multiple adoption of storage in this type of applications globally

The largest investment in storage globally thus far is for Ancillary Services provision, contributing 1/3rd of total capacity

Number of storage plants by use case



Reported capacity of storage by use case
(MW)



BRIEF

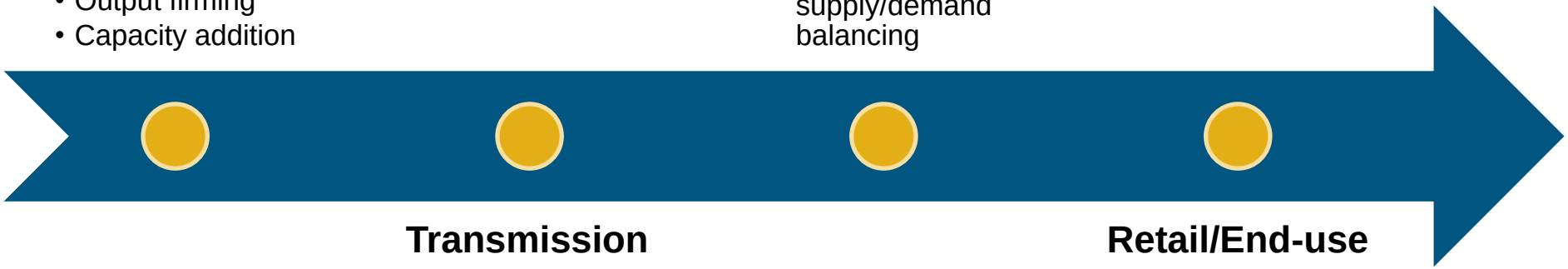
South Australia's grid service costs slashed 90% by Tesla battery

Ancillary services, followed by renewables integration and energy management are the major applications for storage

16 Source: US Dept of Energy global energy storage database

THE LANTAU GROUP

Notwithstanding, storage can provide multiple services from a single facility, however regulations often do not allow such operations



Generation

- Load shifting
- Output firming
- Capacity addition

Distribution

- Infrastructure expansion
- Distributed supply/demand balancing

Transmission

- Ancillary Services
- Infrastructure expansion

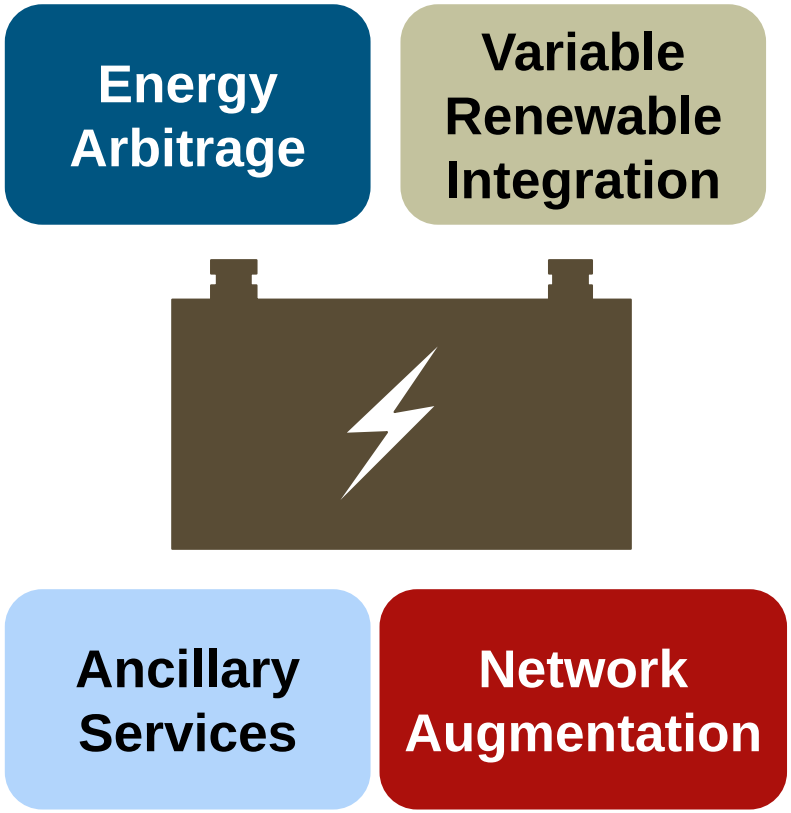
Retail/End-use

- Price arbitrage
- Behind-the-meter generation firming

- In theory, storage can provide multiple services at once
- However, reliability requirements and provisions enacted to set-up power market may require physical unbundling of services provided by a single facility
- Locational demand for some services may be the technical reason for such limitation

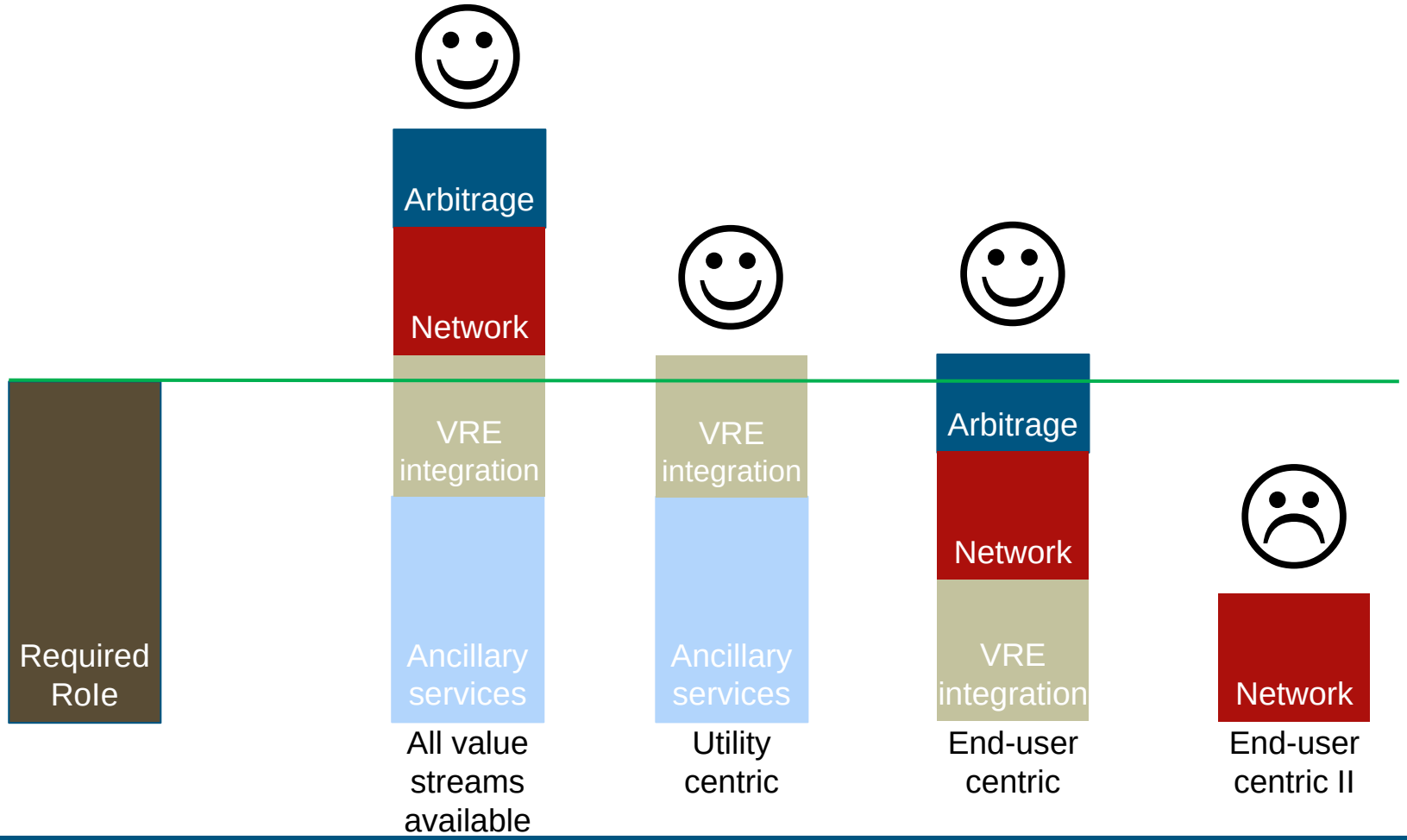
Regulatory developments hint that utility-scale storage facilities may be required to provide single service only – but the jury is still out

Stacking services



- Storage devices has an ability to supply multiple services at the same time, the microgrid application is a perfect example of combining several of the value streams in one
- Besides allowing tapping into multiple value streams, the stack-ability is also a way to manage risks by building a business case on a portfolio of value streams
- An example is the Tesla battery in South Australia (Hornsdale Reserve) that participates in Ancillary Services provision, price arbitrage and integrates the Hornsdale wind farm
- Multiple other examples can be drawn from Australia where business case stack-ability is tested

“STACKABILITY” of energy storage



Maximizing the realizable value of energy storage requires finding “use cases” where multiple value sources are compatible

THE LANTAU GROUP

Dalrymple Energy Storage Project – Pushing the boundaries of regulated businesses

Owner: ElectraNet - South Australia Transmission Network operated (regulated network business)

Project size: 30 MW/8MWh

Funding: ElectraNet (18 mil) and ARENA (12 mil grant)

Developer: Consolidated Power Projects

Technology supplier: Samsung (lithium-ion battery), ABB (BoP)

Operator: ElectraNet for Regulated Network Services and AGL for Contestable Market Services

Business Models:

- *Network Services:* Supply Fast Frequency Response to stabilize the grid and Heywood interconnect (SA-VIC).
- *Microgrid:* Islanding Yorke Peninsula in case of loss of transmission event;
- *Arbitrage:* Market caps trading (derivative product in NEM)
- *Ancillary Services:* provision of Frequency Control Ancillary Services.

Status: Commissioned in September 2018

Source: Press releases, TLG Research

Tesla's Virtual Power Plant – combining behind-the-meter with contestable market services

Owner: Tesla

Project size: planned 250 MW/650 MWh (about 5.5 MW/15 MWh planned by end of 2019, completed 1/10th as of Sep 2018)

Funding: Tesla (~800 mil) & State Funding (2 mil grant and 30 mil loan)

Developer: Tesla

Technology supplier: Tesla

Operator: Unknown

Business Models: The project is financed by the Owner and costs are to be recovered through per kWh rate imposed on project participant, no upfront cost is to levied on the end-users

- *BTM:* Energy management
- *VRE integration:* 13.5 kWh battery pack to be combined with 5 kW solar panel
- *Ancillary Services:* provision of Frequency Control Ancillary Services.
- Arbitrage: Supplying peak demand to the NEM

Status: Phase 1 in progress (total three phases to be completed by 2022)

AES's BESS – providing ancillary services to the grid under an Ancillary Services Procurement Agreement (ASPA) with NGCP

Owner: Masinloc Power Partners Co. Ltd. (SMC, formerly owned by AES and EGCO)

Project size: 10 MW (energy capacity in MWh is not disclosed)

Funding: Unknown

Developer: Masinloc Power Partners Co. Ltd.

Technology supplier: Fluence (Siemens and AES JV)

Operator: Unknown

Business Models: The Masinloc BESS project has signed a 5-year Ancillary Services Procurement Agreement with NGCP (National Grid Corporation of the Philippines) to provide regulating reserve services (load following and frequency regulating reserve). Regulating reserve capacity is allocated to cover inter and intra-hour variations in supply and demand.

- *Ancillary Services:* provision of Regulating reserves

Status: Operational and certified/accredited by NGCP to be able to provide ancillary services in the form of regulating reserves to the grid

 Source: DOE, ERC, media sources

Solar Philippines Solar/Battery/Diesel Microgrid – providing reliable power to Paluan in Mindoro which suffered from outages that could last days

Owner: Solar Para Sa Bayan (Solar Philippines)

Project size: 2 MWh (power capacity in MW is not disclosed)

Funding: Unknown

Developer: Solar Philippines

Technology supplier: Tesla

Operator: Unknown

Business Models: No commercial details of the project are available, but the project is a hybrid project involving solar PV, batteries and back-up diesel. The Paluan municipality in Occidental Mindoro operates its own self generation and distribution system

Solar Philippines is seeking franchise rights for Solar Para Sa Bayan that would enable it to construct, install, establish, operate and maintain distributable power technologies and minigrid systems throughout the Philippines. Known as House Bill 8179, the proposed franchise Bill was approved by the House committee on legislative franchises and supported by some consumer groups and remote municipalities (where Solar Philippines is proposing to develop minigrids), but is opposed by electric cooperatives as well as some of the renewable energy developers

Status: Operational

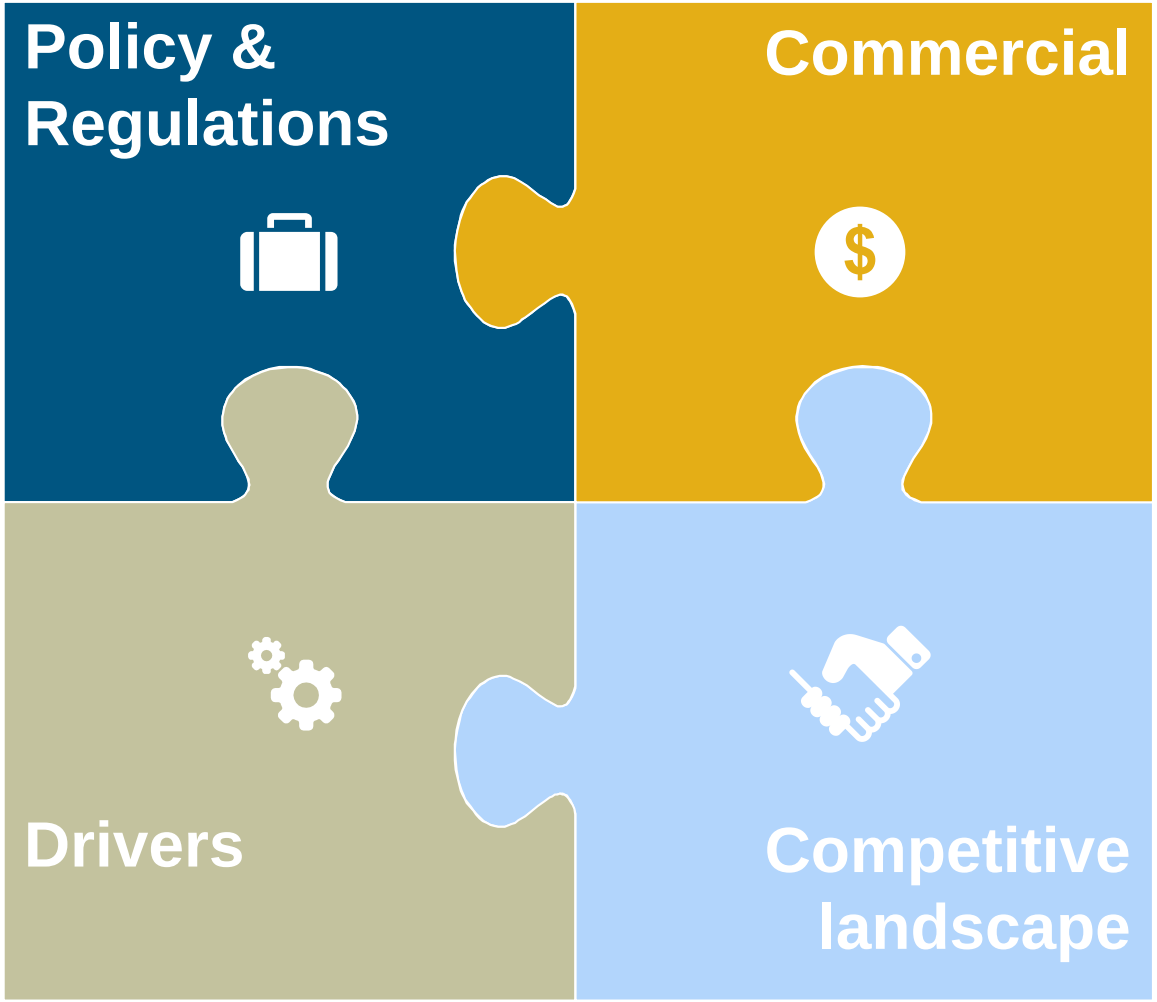
 Source: Solar Philippines, media sources

How to find opportunity for storage ?

THE LANTAU GROUP

Four “lenses” framework

- **Drivers**
  - RE penetration
  - Power quality
  - Grid topology
- **Policy & Regulations (enabler or barrier?)**
  - Is storage allowed to participate?
  - What market segments are there for storage to participate?
- **Commercial enablers and barriers**
  - Tariff structure & contestability
  - Wholesale/AS market spreads
- **Competitive landscape**
  - Are there any assets or plans?
  - Who are the competitors?



THE LANTAU GROUP

Mapping these lenses to issues allows us to answer key questions

Regulatory overview	Temporal price spreads	Are there any grid locations with oversized storage	Existing ESS
Market structure	Availability of low cost charging, spare RE energy	Penetration of RE behind the meter	Planned ESS
Can storage participate?	Looming demand for additional AS	Is the local community open to invest in storage	Are these pilot plants or commercial plants?
Is storage recognized as separate asset type?	High out-of-solar-hour peak	How well is the grid integrated?	Who are the technology providers/operators?
How does storage operator pays for grid usage?			

Australia is one of the few markets with a strong bottom up interest in the storage technologies combined with the strong fundamentals

Regulatory

- Australia's states have various regulations pertaining participation of storage in the energy market. Western Australia currently does not allow it, albeit it is considering changes, while Eastern states allow participation of storage
- Storage can participate in wholesale as well as Ancillary Service markets
- Storage can be used by grid operators in whole Australia to improve power quality in remote locations
- Australia has two power markets, WEM and NEM. NEM is bigger energy only market, while WEM is smaller energy + capacity market
- WEM is looking to co-optimise AS with energy, while this is already done in NEM

Commercial

- Australia has a significant market opportunity in the wholesale and retail price arbitrage
- The wholesale price spread in some location reaches 90 AUD/MWh while some of the customers opt in for ToU tariff with significant price differential forming an interesting opportunity for bill management and price arbitrage
- Likewise, regulatory change with ancillary services is expected to lead to more refined definitions of Ancillary Service and likely unprecedented market niche for storage
- Flawed design of FiT for residential customers resulted in significant amount of end-user with solar overcapacity not being compensated for their grid exports, thus creating ESS opportunity

Drivers

- Australia enjoys high penetration of renewable energy driven largely by positive outlook of local community but also by impact investors
- This high penetration of RE combined with thinly laid out electric grid poses significant challenges for managing variability in the grid and thus creating demand for ESS technologies, either stabilising the output from RE or providing AS
- Multiple remote habitats are potentially cheaper to supply as microgrids than by long radial grid expansion thus creating opportunity for ESS
- Across multiple offgrid areas in the Australia's outback the mining industry is a noteworthy potential user of the ESS

Competitors

- Australia has by far the largest number of storage assets installed and under construction with diverse portfolio of competitors including the conglomerates like Samsung, Siemens, Tesla, AES, etc.
- A quick scan of recent additions reveals about 450 MW of existing and planned capacity with ~1000 MWh of storage playing multiple roles from energy arbitrage, AS provision (frequency and contingency) to grid strain relief and technology testing
- South Australia and Victoria are the major states for capacity additions.
- ARENA provided funding for majority of the installations

Low electricity tariffs along with modest RE penetration, and a lack of clarity over energy storage regulations or policies means the opportunity for batteries is highly uncertain in Malaysia

Regulatory

- Peninsular Malaysia and Sabah are subject to national energy supply laws and are regulated by ST, whilst Sarawak has its own energy laws and regulator
- PPAs/SLAs between TNB and IPPs remain the status quo, but the introduction of NEDA (New Electricity Dispatch Arrangement) has provided a mechanism for generators to offer capacity on a merchant basis.
- The need for new generation capacity is assessed by ST, and procured via competitive tenders by the Single Buyer
- There appears to be no specific regulations for battery energy storage in Malaysia yet

Commercial

- Electricity tariffs in Malaysia, among the lowest in the region, will remain low for domestic consumers as the new administration recently announced subsidies to shield them from the rising fuel costs.
- Ancillary services, which are procured under PPAs/SLAs and dispatched by the GSO (Grid System Operator), may offer a possible opportunity for energy storage, but there are no known precedents (of using battery technology in Malaysia) so there is considerable uncertainty as to how it is viewed by ST, Single Buyer and the GS

Drivers

- The level of RE penetration in Malaysia is still modest, with about 358MW of grid-connected PV as of 2017
- Solar PV development in Peninsular Malaysia and Sabah is supported by Large Scale Solar (LSS) and Net Energy Metering (NEM) programmes, which have quotas of 1,000MW and 500MW respectively
- There are planned transmission augmentations projects in Peninsular Malaysia to relieve system constraints
- RE policy in Sarawak, which experience high levels of precipitation, is more focused on hydro. Sarawak's heavy reliance on hydro would indicate that there is limited scope of other forms of storage
- Albeit microgrid application in remote regions of Sarawak and Sabah could be potentially interesting

Competitors

- The Secretary-General of the Ministry of Energy revealed in 2015 that discussions were underway to implement a national energy storage system, but there have been few signs of progress from the Government
- Some private sector collaborations have been announced such as the tie-up between Cypark Resources Bhd with the German 21st Century Clean Energy GmbH & Co, and Sunway Berhad of Malaysia with Comtec Solar Systems Group of China.

Similar to Australia, the bottom up demand for storage is obvious in the Philippines, albeit combined with lower development level the country merits a separate marketing strategy

Regulatory

- Exact regulatory treatment of energy storage has not been determined yet. The DOE issued a draft circular in August 2018 requesting the ERC to address key issues pertaining to cost recovery mechanism, pricing structure and delivery charges, etc.
- All energy is dispatched through an 'energy only' spot market (WESM) including contracted plants with PSAs
- Ancillary services are procured by the transmission system operator NGCP, though plans exist for regulating and contingency reserves to be co-optimized with energy in the WESM (delayed by NGCP inaction)
- ERC recently approved a battery Ancillary Services Procurement Agreement application between Advancion (AES subsidiary) and NGCP

Commercial

- Price arbitrage opportunities persist in Visayas where daytime prices are depressed by solar penetration, while evening peak is at times met by expensive diesel gensets
- However, low market price caps in the WESM dampen the value of storage and peaking services
- There is an acute shortage of ancillary services particularly in Visayas, where some forms of reserve are outsourced to Luzon.
- Despite existence of the NEM program with some of the retailers, the 100 kW cap and bureaucratic difficulties play in hand of ESS developers

Drivers

- The development of RE in the Philippines has been promoted via policy instruments introduced by the RE Act (2008) including the FIT, net-metering of RE, Renewable Portfolio Standard (RPS), Renewable Energy Market (REM) and RE Certificates, among others
- The FIT led to a short term thrust in RE development, but future RE investments will likely benefit from the proposed 35% target energy mix envisaged in the RPS
- Localised solar penetration with limited transmission capacity (in Visayas) and slow transmission development may present opportunities for energy storage application
- Small islands and offgrid areas, which traditionally relied on expensive diesel generators with unreliable fuel supplies, are ripe for RE and storage deployment though offtaker credit risk will be high and dealing with the incumbent NPC Small Power Utilities Group for off-grid regions is known to be difficult
- Multiple storage plants are potential competitors for ESS in provision of AS

Competitors

- There is a limited number of operational storage projects along with many proposed ones in the Philippines, with the largest existing project being the 10MW Masinloc energy storage project by Advancion (AES).
- Solar Philippines, the largest solar developer in the Philippines, has an existing 2MW solar, 2MWh and 2MW diesel-back-up microgrid project in Paluan, Mindoro
- Other proposed projects exist by players such as Aboitiz, Marubeni, Sonnen, and Silay Global Energy Solutions
- Solar Home Systems are being piloted in numerous remote sites as an alternative to the expansion of the distribution grid

Singapore is a price example of a top down approach to the energy market, with the demand for ESS driven and managed by the government authorities

Regulatory

- Singapore allows ESS participation in the wholesale market
- Singapore is the most advanced energy/ancillary services market in the SEA including the electricity futures trading
- Singapore is trailing full contestability in the Jurong region and is planning to expand island-wide
- Some of the retailers also own ESS
- Local grid operator/SOLR is considering investing in storage under regulatory sandbox
- EMA granted two grants to RES to procure and testbed energy storage in Singapore

Commercial

- Singapore is at the verge of opening up full retail contestability with a pilot program run in the Jurong island
- Retail offers to contestable markets are of two types, flat tariff or NEMS-indexed tariff with ceiling and floor price
- Present tariff structure offer limited opportunity for storage
- The NEMS has a flat merit order curve dominated by gas units, albeit there is significant market power being exercised leading to occasional price peaks that could be arbitraged by a storage operator
- NEMS situation can be summarised as unhealthy thus hinting to expected market changes that may increase market volatility

Drivers

- Singapore is a fairly compact power system with a few outlying islands depending on diesel generators
- The main grid has one of the highest reliability standard
- There is limited penetration of renewable energy with some CSR projects (including SolarNova) pushing for the adoption of the rooftop solar panels
- The country targets capacity of 1 GW post 2020, albeit is not on track of trajectory to meet this target anytime before 2035

Competitors

- Two storage projects are currently being commissioned in Singapore, the CW Group lithium ion battery and Red Dot Power's vanadium flow battery (4.4 MW/4.4 MWh)
- The companies owning the assets received grants for test bedding the technology from the EMA. The assets are to be operational through the end of 2022.
- The companies are also RES, albeit without any generation assets thus offering energy supply solely based on wholesale market trading and storage.
- Suppliers include Wartsilla and Younicos

Thailand’s storage potential is limited by regulatory regime and relatively small sophistication in retail tariff pricing

Regulatory

- Enhanced single buyer electricity market structure does not enable easy access to the grid
- Policy-makers currently making substantial revisions to national Power Development Plan
- Proposed net-metering scheme could compete with storage
- High potential for distribution reforms that would allow greater ability for corporate users to buy RE across the grid
- Completed PPA award program for firm renewable energy, which favored biomass based generation, but could be a platform for a future RE hybrid PPA program

Commercial

- Relatively low electricity costs, demand charges and peak-off peak spreads, making storage variability difficult
- Looming large LNG dependency has the potential to substantially increase electricity costs
- Although rooftop solar PV is less expensive then retail power
- Utility-scale is not substantially less expensive than conventional generation, making an RE-hybrid program unlikely
- Existing RE generators have uncertain supply profile thus forming issues as PPAs require predictable supply

Drivers

- Centralized market and extensive grid provide access to almost all users and adequate power quality to industry
- Largest quantity of installed variable RE is SEAsia with almost 3MW of utility scale and a rapidly growing rooftop
- Intermittent RE generation regarded as a problem by utilities
- Demand charge and sophisticated metering applied to large subset of industry
- No off-grid or micro-grid opportunities

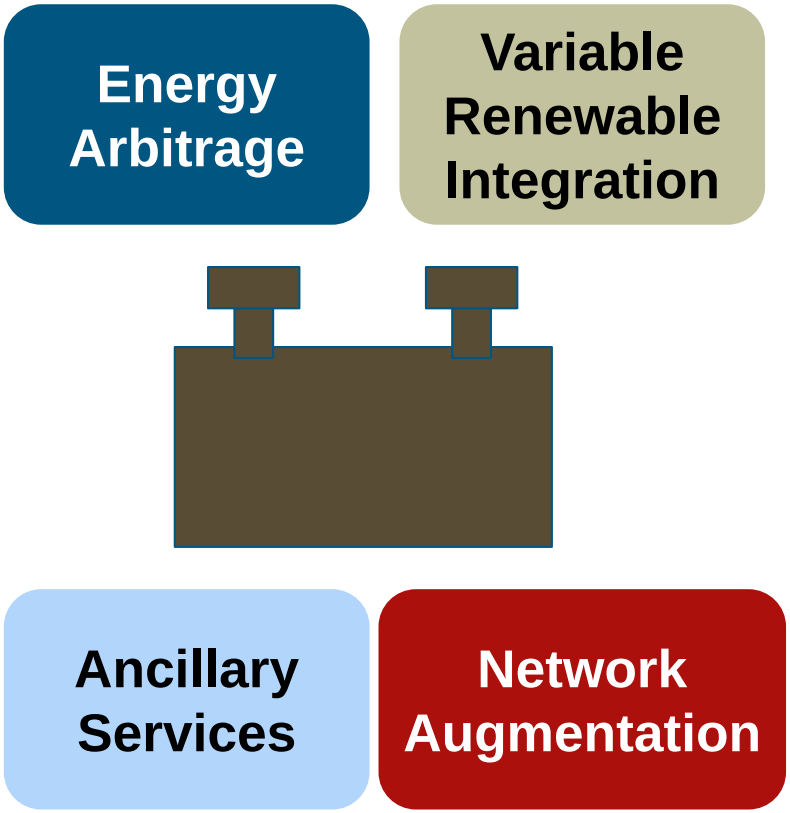
Competitors

- EGAT is currently installing three grid-based battery pilot projects, two of which are designed to manage grid impacts of RE. The third provides access to a remote province, but is unlikely to be replicable
- Current energy plans emphasize technology, including storage – although this is largely aspirational
- EGAT mandated not to compete with private sector
- Capable local industry with domestic and international RE assets

What about Vietnam?

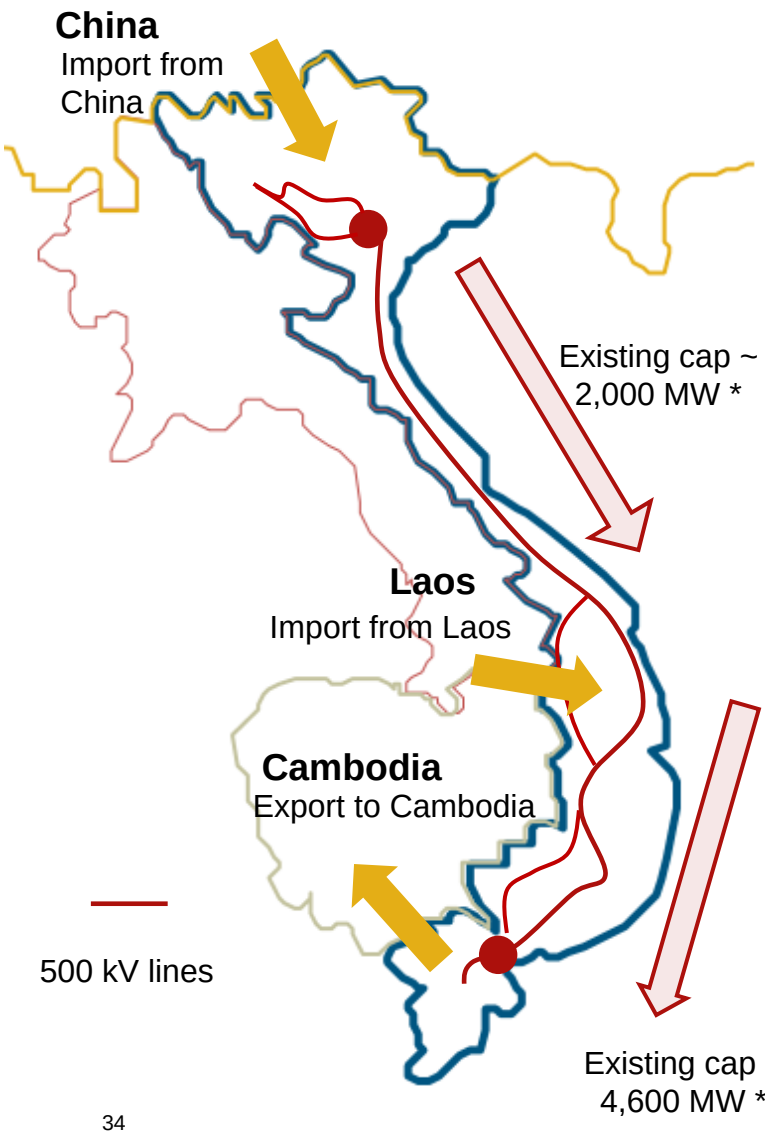
THE LANTAU GROUP

Does Vietnam need battery energy storage?

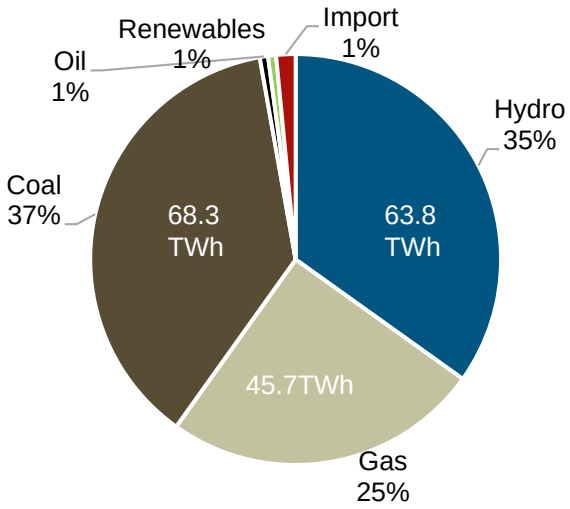


- Penetration of variable renewable energy sources is low (though this may change – see later slide)
- Large amounts of hydro (including imports) as well as gas-fired capacity are available, which can be dispatched flexibly
- Tariffs are low relative to regional countries (see later slide)
- The aging and overloaded transmission system is being upgraded to address some bottlenecks. Given the centralized nature of most generation now, batteries have limited scope to replace this

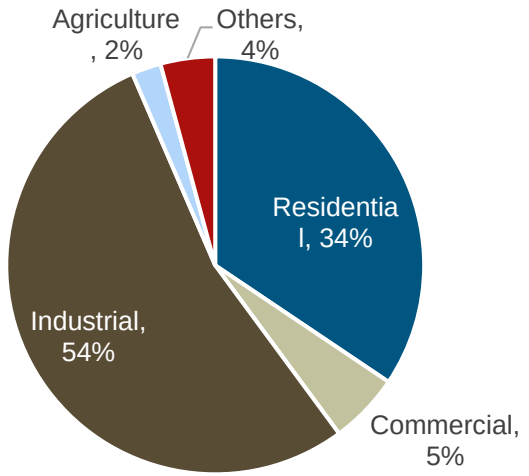
Vietnam's rapid power demand growth has been met by coal, hydro and gas resources, with different proportions in each region



Power generation type in 2016

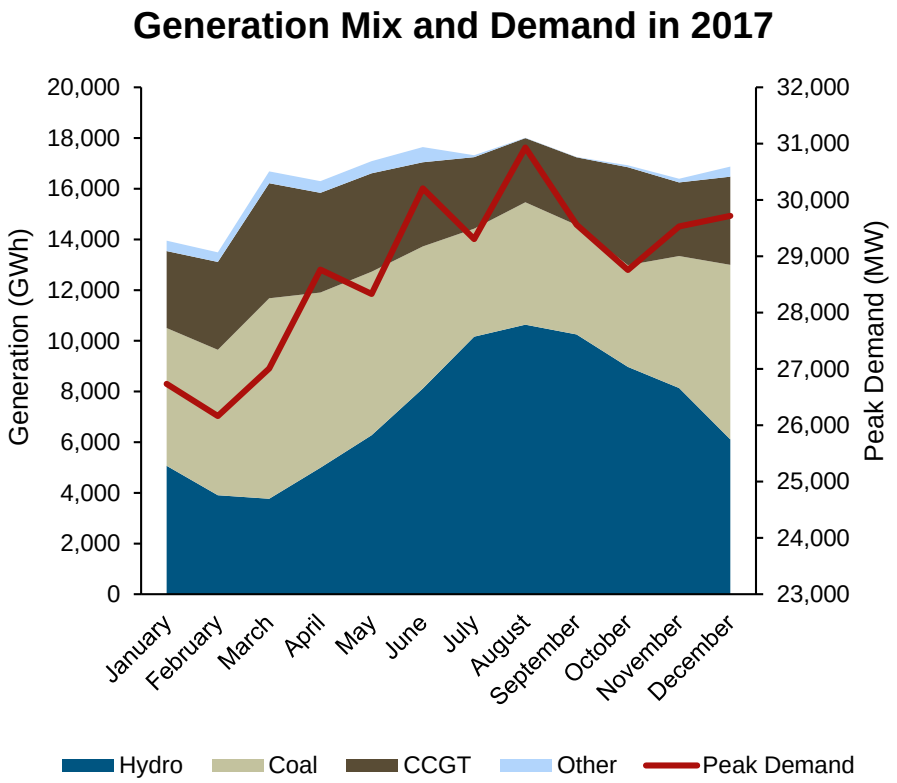


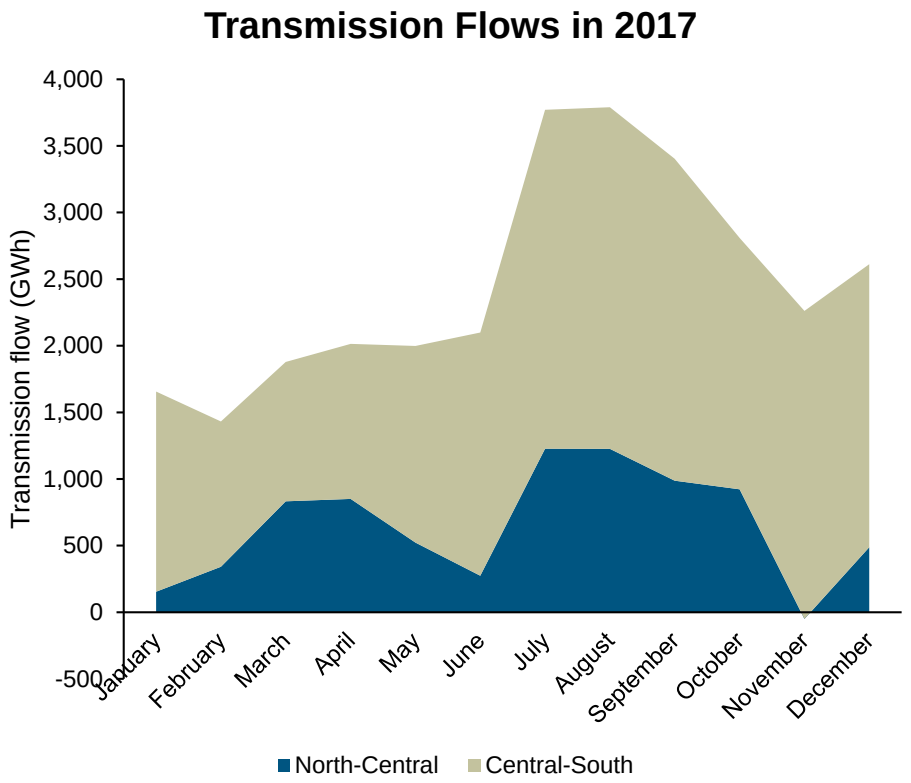
Demand by sector in 2016



- The Vietnamese electricity system is long and skinny with a 500kV transmission backbone that traverses the country
- Demand has been growing rapidly, led by the industrial and residential sectors. 2005-2017 peak demand CAGR was 11.8 percent
- Vietnam has regional generation mix differences, with the Northern region heavily reliant on coal and hydro, the Central region dependent on hydro, and the Southern region relying mostly on gas along with some coal and hydro
- Vietnam's electricity supply and the flow of power is influenced heavily by the seasonality of hydro

Vietnam's electricity sector is heavily influenced by the seasonality of its hydro resources which influence the level of transmission flows from North to South





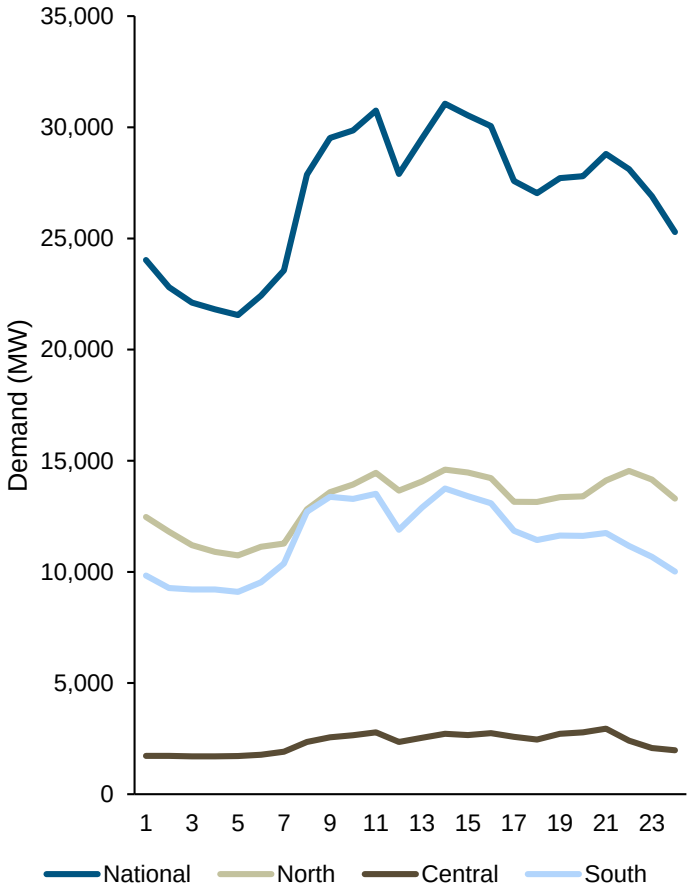
- Overall power demand is high in summer time. However, as the country's total supply relies on hydropower, peak demand growth is constrained by supply shortage in dry season (typically from December to April) when most of the hydro capacity is not able to operate at full capacity
- As the north region is predominated by hydro power and was impacted more seasonally. The region has more than self-sufficient power generation during wet season (May to September), and will export to Central and South region

Source: NLDC

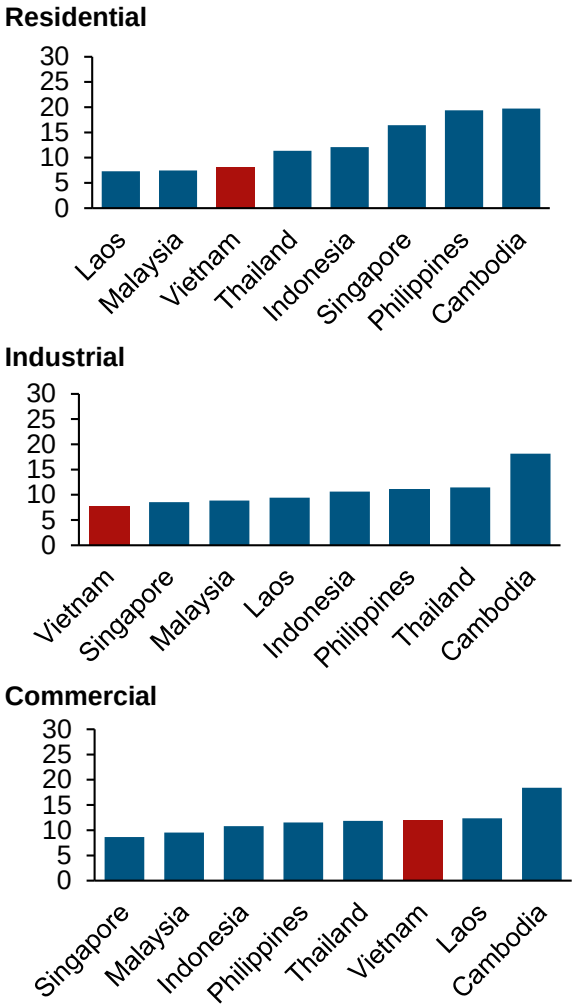
THE LANTAU GROUP

Vietnam's diurnal profile shows significant variations, and whilst the country has separate peak and offpeak prices for C&I customers, tariffs remain low

2017 Peak Demand Diurnal Profile



End User Electricity Cost (US¢ / kWh)



- Vietnam has low end-user electricity tariffs in the region, which supports its industrial base
- Vietnam's electricity consumption is extremely high compared to peer nations considering consumption per capita and GDP per capita
- C&I consumers face different peak and off-peak tariffs, but low tariffs may be insufficient to encourage the adoption of behind-the-meter storage

Source: NLDC
Note: Electricity tariffs are from September 2017. Peak demand is from August 11 2017

THE LANTAU GROUP

Vietnam's favourable solar conditions, and the model PPA and FiT announced in September 2017 triggered a strong interest in solar PV projects in Vietnam

4E project, jointly implemented by GIZ, EREA and MoIT (24 January 2018)

Economic potential of ground-mounted solar in Viet Nam reaches 7 Gigawatt until 2020

VietnamNet (27 January 2018)

Vietnam's solar potential to reach hundreds of GW in near future

Vietnam's solar power generation capacity will reach several hundred Gigawatts once the market starts growing.

PVTech (8 June 2018)

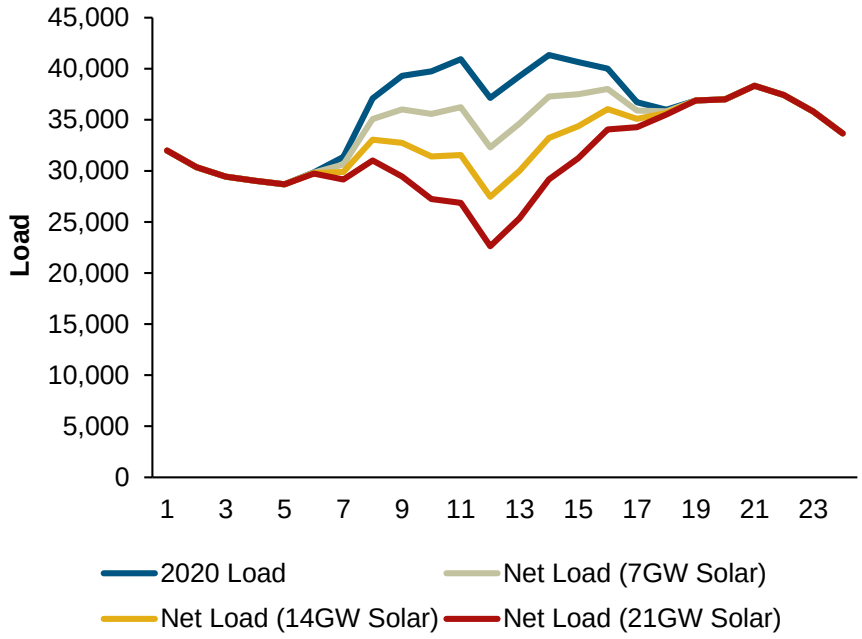
Sunseap begins construction of 168MW Vietnam solar project

PV-Magazine (25 June 2018)

Construction underway on 350 MW of solar in Vietnam

Grimm Power and Xuan Cau began construction on two solar PV plants in the southern province of Tay Ninh.

Indicative Net Load under different Solar Entry Scenarios

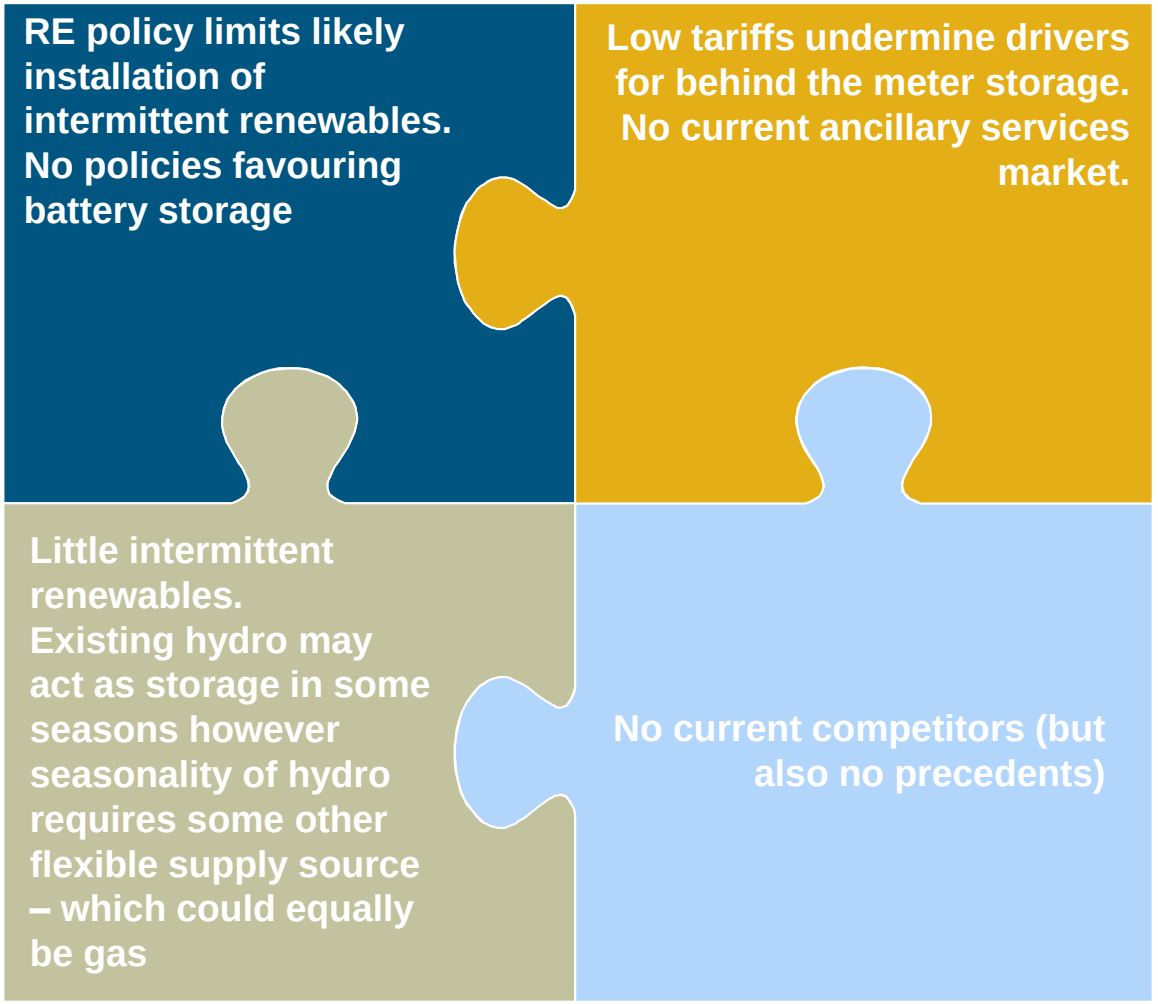


Note: based on 2017 peak demand date and grown at 10%/p.a. to 2020. Net load profiles assume different amounts of solar entry (as multiples of 7GW which was estimated as the economic potential under the 4E project)

Will large amounts of solar enter Vietnam, opening up opportunities for battery systems? How much VRE is required to make batteries attractive, and will regulations be an enabler or a hinderance?

Source: media sources (PVTech, PV-Magazine, Vietnam Net), GIZ, NLDC

In summary Vietnam has low current potential but possible in future depending on how renewable build-out goes and whether LNG enters



THE LANTAU GROUP

Barriers to storage adoption around the world

THE LANTAU GROUP

Barriers to Storage Adoption (1 of 2)

Lack of storage specific technical standards and procedures

- There are currently no agreed approach on how to reuse, recycle, and dispose of batteries at the end of their life span
- There is currently no enforceable standard for the product safety of lithium ion batteries
- The lack of standardization amongst battery suppliers adds to complexity, and therefore costs throughout the value chain. The lack of standardization could lead to a significant roadblock to further deployment
- The clear technical guidelines for battery deployment are yet to be decided

Inefficient market procedures and underdeveloped retail market

- Frequency of MCP calculation hinder the opportunities for fast-acting charging and discharging of battery storage and prevents the market signal of energy from being as effective as it could be
- Current ancillary market regulation doesn't support the fast and effective responsiveness of storage capacity
- The financial compensation for energy curtailment within some states is discouraging the adoption of energy storage
- Market price caps prevent storage from performing price arbitrage
- Prevalence of real-time pricing is limited thus reducing opportunity for batteries behind-the-meter
- Priority dispatch for non-dispatchable resources limits the opportunity for storage
- Cost pass-through to customers limit the demand for storage from retailers

Barriers to Storage Adoption (2 of 2)

Lack of government support

- Few governments are currently supporting feed-in tariffs compensating for social benefit of storage that would reward consumers who provide electricity from their storage during peak hours

Flawed regulations

- T&D companies are not required to publish information about the grid assets expansion or replacement that could be provided by storage operators
- Asset-base T&D regulation discourages effective investment in storage for network augmentation
- Storage is often categorized as generation asset thus preventing T&D companies from owning or operating it as a replacement to network assets
- Classification of storage as generation units, often prevents stack-ability of revenue streams and participation in some markets/services
- Lack of regulatory framework for energy storage has caused some states to impose double grid fees on storage systems, while other states are proposing direct taxation on self-consumed and stored energy
- Lack of regulatory framework for storage is causing investment uncertainty
- The inconsistency of regulation across the multiple markets that developers of energy storage devices would like to enter into make it more complex for developers to apply their technology to a wide range of uses.

Devising a strategy for storage adoption

Identifying and implementing succesfull strategy requires a clear framework and is a multi-step endevour

Step 1

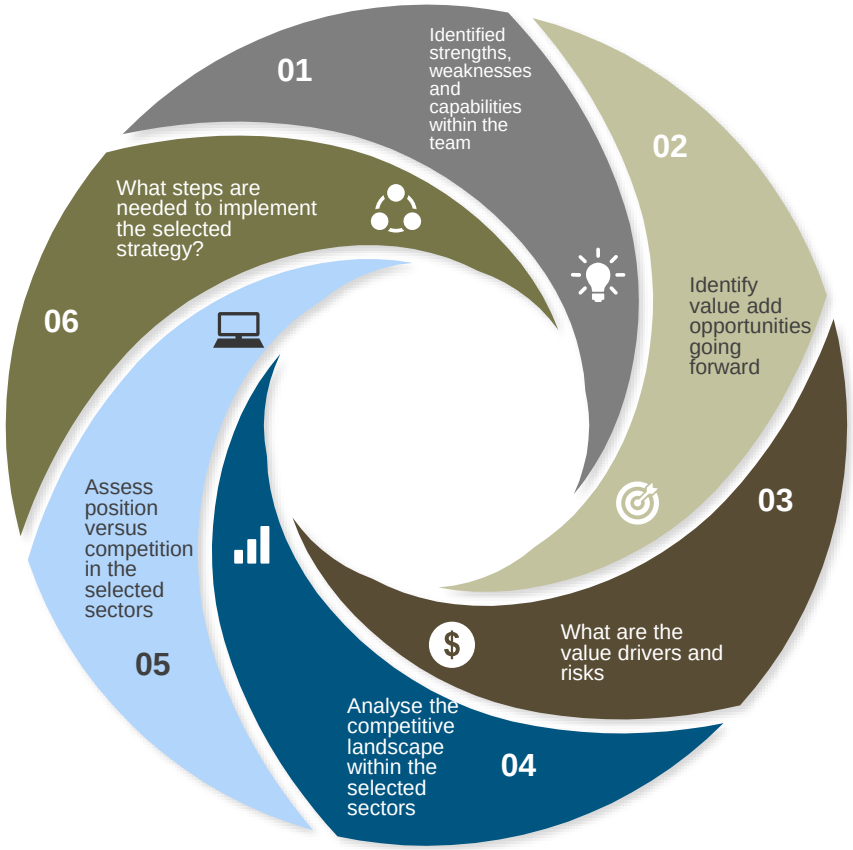
Identified strengths, weaknesses and capabilities within the team

Step 2

Identify value add opportunities going forward

Step 3

What are the value drivers and risks



Step 4

Analyse the competitive landscape within the selected sectors

Step 5

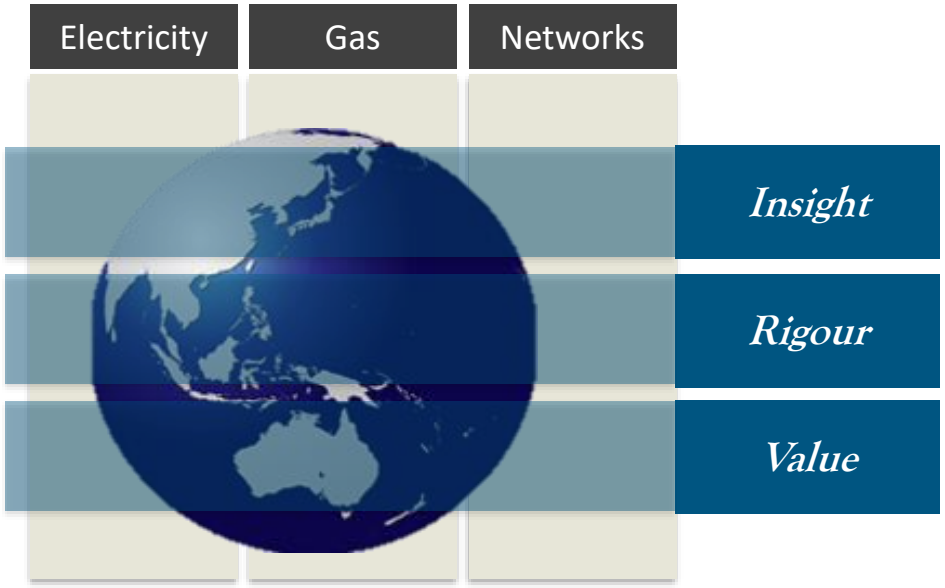
Assess position of TeaM versus competition in the selected sectors

Step 6

What steps are needed to implement the selected strategy? What core competences needs improvement?

THE LANTAU GROUP

Contact Us



By email
General Capabilities Inquiries
projects@lantaugroup.com

Direct Communications
mthomas@lantaugroup.com
sfairhurst@lantaugroup.com
jooi@lantaugroup.com

By phone
+852 2521 5501 (Hong Kong office)
+65 6957 1458 (Singapore office)

By mail
The Lantau Group (HK) Limited
4602-4606 Tower 1, Metroplaza
223 Hing Fong Road,
Kwai Fong, Hong Kong

The Lantau Group (Singapore) Pte Ltd
24 Raffles Place, #25-01
Clifford Centre
Singapore 048621

Online
www.lantaugroup.com

THE LANTAU GROUP