Opportunities for Battery Storage

The Lantau Group

November 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

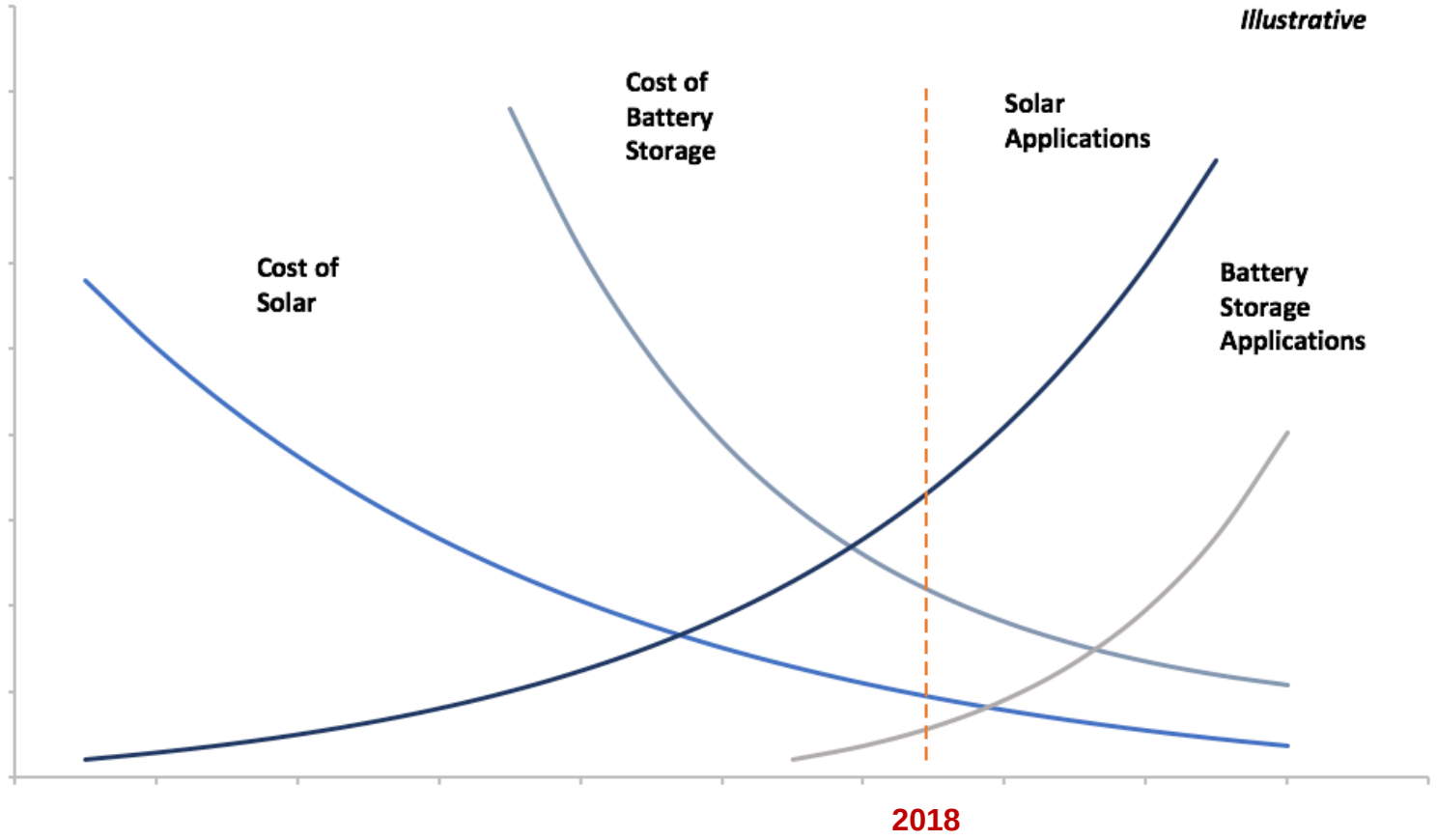
A new wholesale market participation model for energy storage may help other inverter-based or distributed energy resources.

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



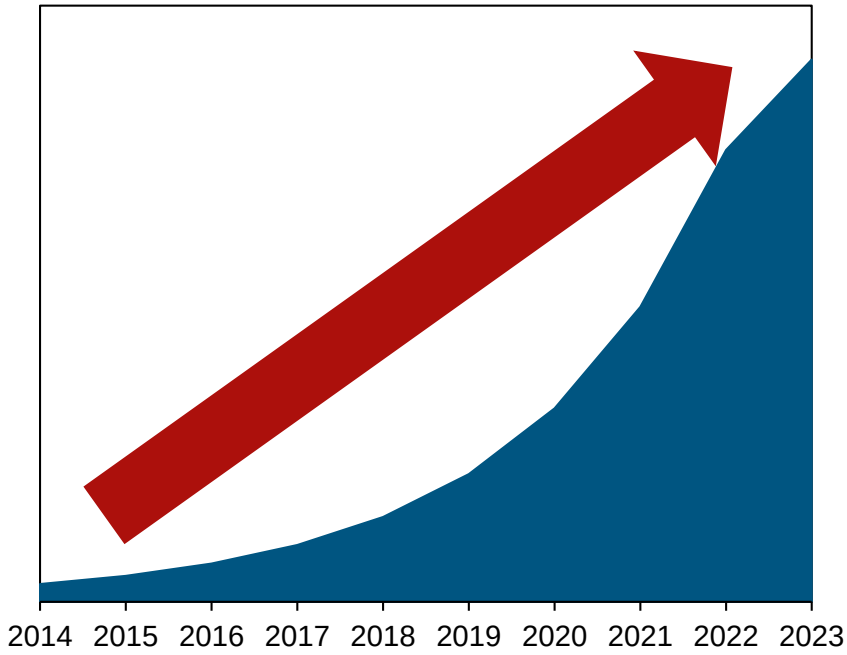
But also by demand side economics, regulations, and new business models

High expectations – but what will be viable first?

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

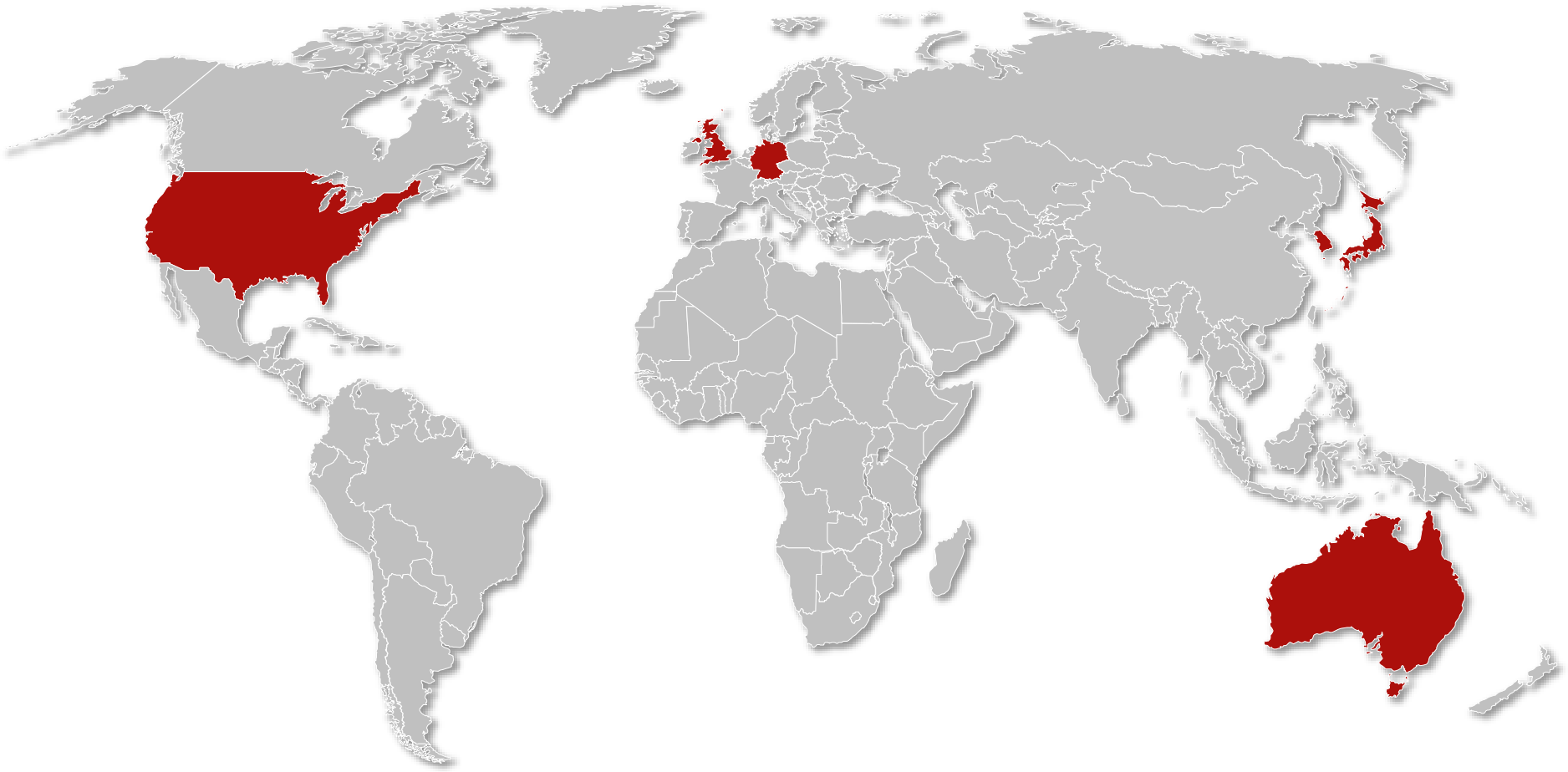


Sources: Lux Research

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

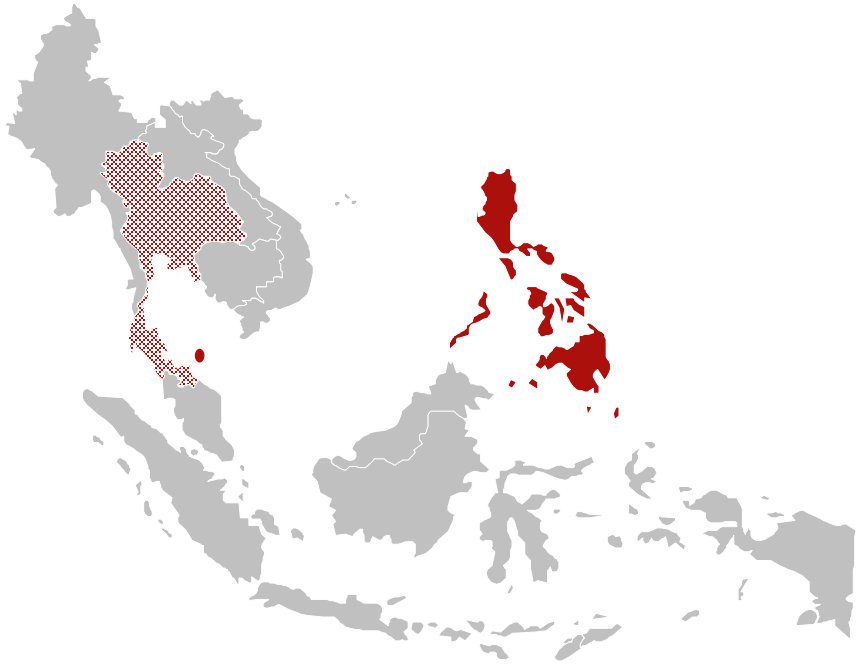
THE LANTAU GROUP

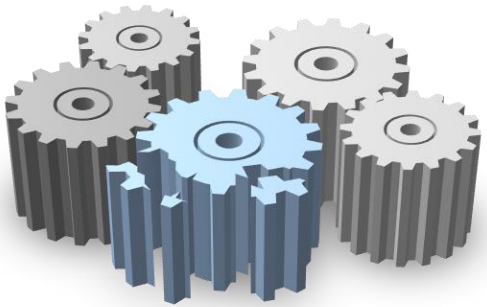
Energy storage deployment started in the US, Japan, Korea and Europe – countries developing storage technologies – while Australia has come on strong



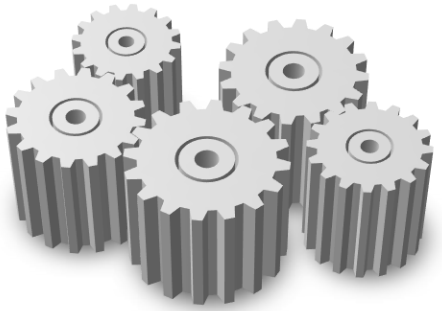
4 Source: DOE Global Energy Storage Database

South East Asia is still in the early days of energy storage development





How will storage be deployed in Southeast Asia



THE LANTAU GROUP

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.

Energy Storage Applications & Business Models

THE LANTAU GROUP

Storage has four primary applications

Energy Arbitrage/Energy management

Variable Renewables Integration

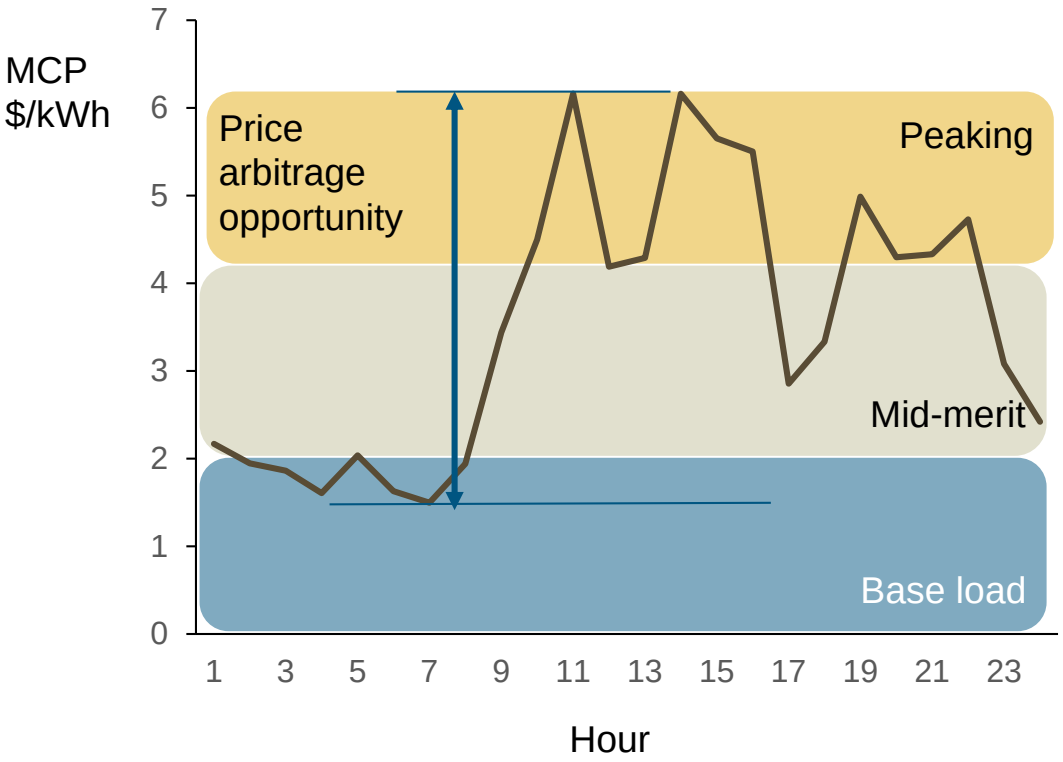
Ancillary Services

Network Augmentation

All of the typical applications of storage cumulate in the microgrid application

Energy Arbitrage

Energy Arbitrage



Storage replaces the peaking capacity and improves utilization of baseload

The steeper the merit order curve (highly peaky demand, e.g. due to hot and but short summer) the more value storage brings

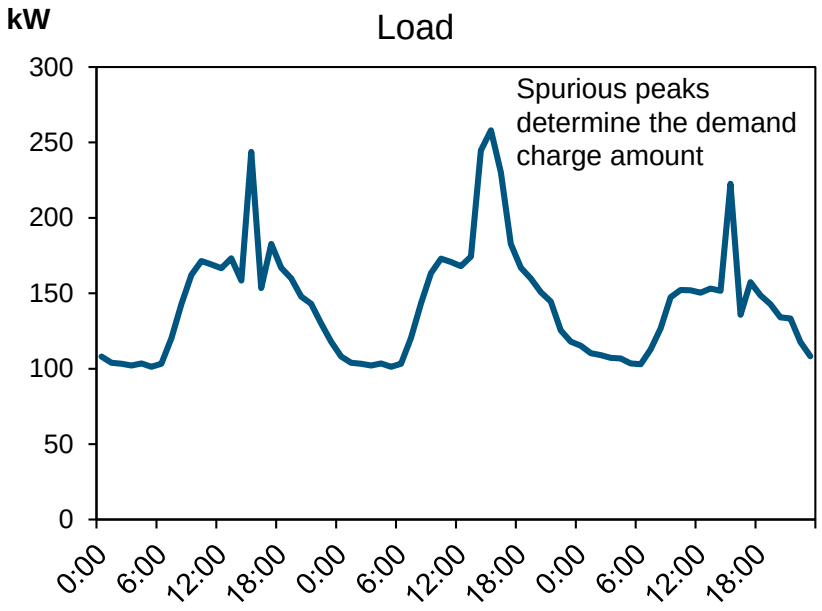
In the long term, the revenue opportunity for price arbitrage will tend towards the LRMC of storage

Storage can also bring value to retailers by offering an ability to self balance offtake profile

Energy arbitrage can also be executed at the retail level in case of time-of-use tariffs

Demand charges – a special case of arbitrage

Energy management/ Demand charges



Retail opportunity for storage

Demand charge management

Tariff = **highest instantaneous consumption** + total consumption

Time-of-use arbitrage

Tariff = peak consumption + off-peak consumption

Enables or Demand Side Management

Tariff = Consumption – DSM provision

THE LANTAU GROUP

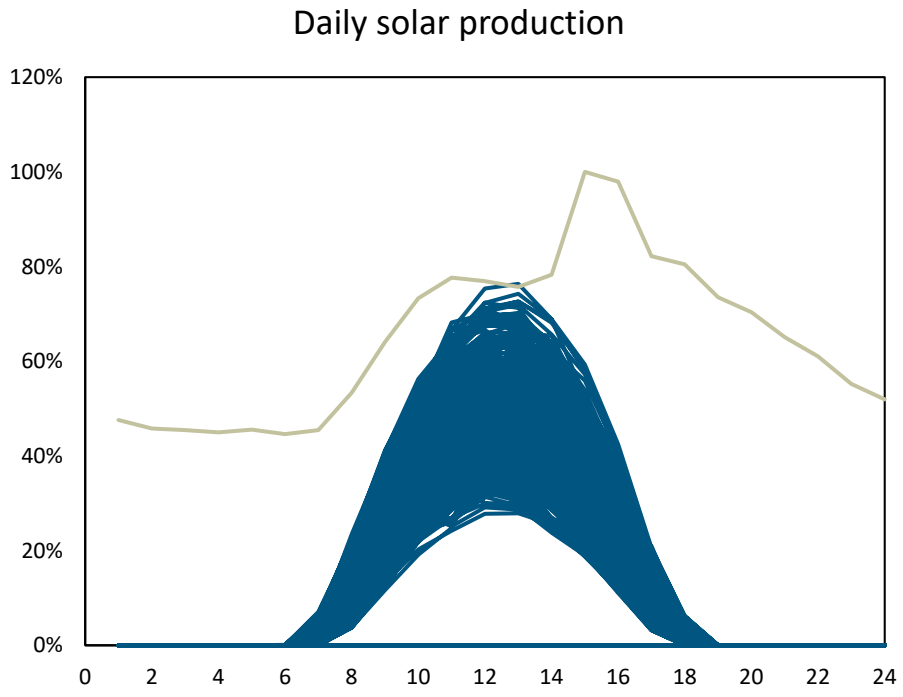
VRE integration

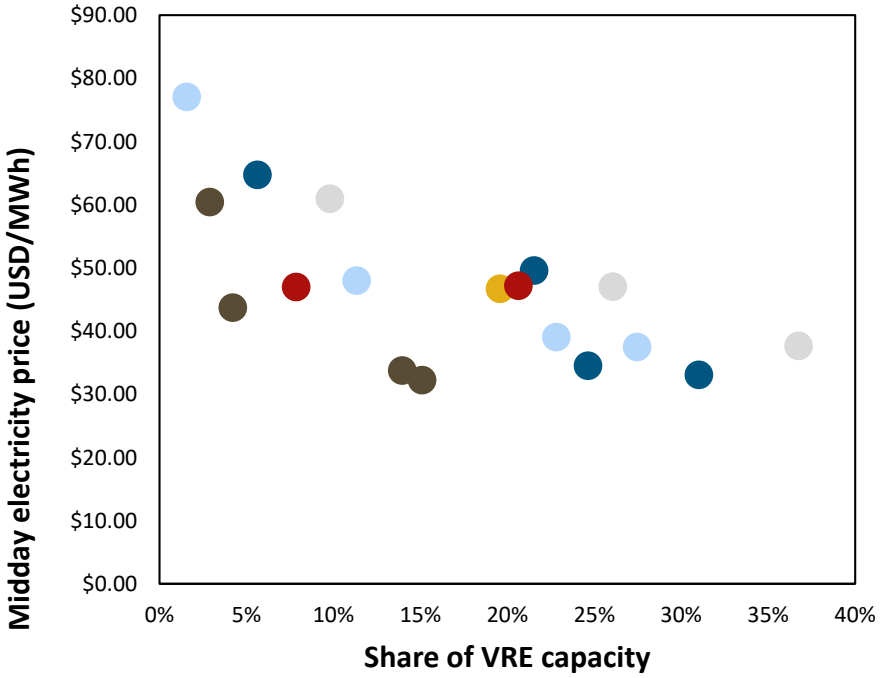
Variable Renewable Integration

- **Dispatchability**
- **System stability**

Lack of ability to dispatch VRE will lead to reducing profitability of VRE project of similar generation profile. Combining VRE with storage can give an opportunity to charge the storage at hours of high generation and dispatch during the hours of high price.

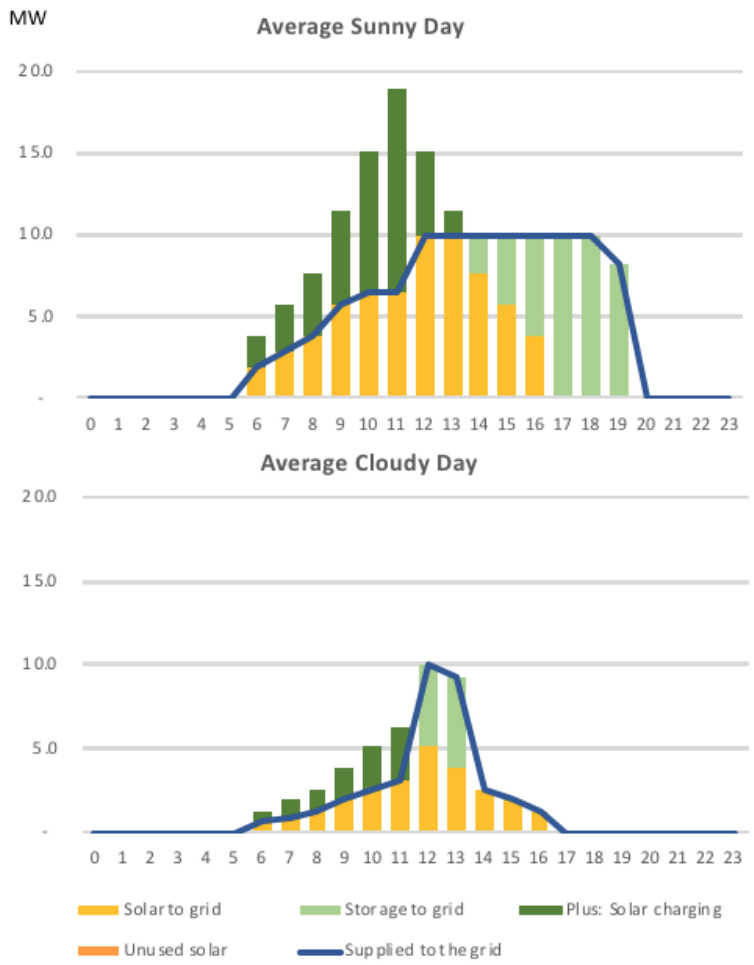
VRE is a source of additional supply-demand variability and as such it creates additional demand for Ancillary Services. Storage can reduce the output variability of VRE.





THE LANTAU GROUP

Combining solar and storage “behind the meter”



Solar PV has a set of characteristics that can make it extremely attractive for industrial facilities:

- Lower cost of electricity
- Can be a good match with peak demand
- Energy price hedge
- CSR and supplier criteria

And a set of drawbacks:

- Intermittent supply means it is not as effective in reducing the demand curve
- Solar PV application may have to be sized close to lowest match in demand profile

Energy storage can optimize solar PV, allowing:

- A larger quantity of solar PV
- More efficient use of solar power

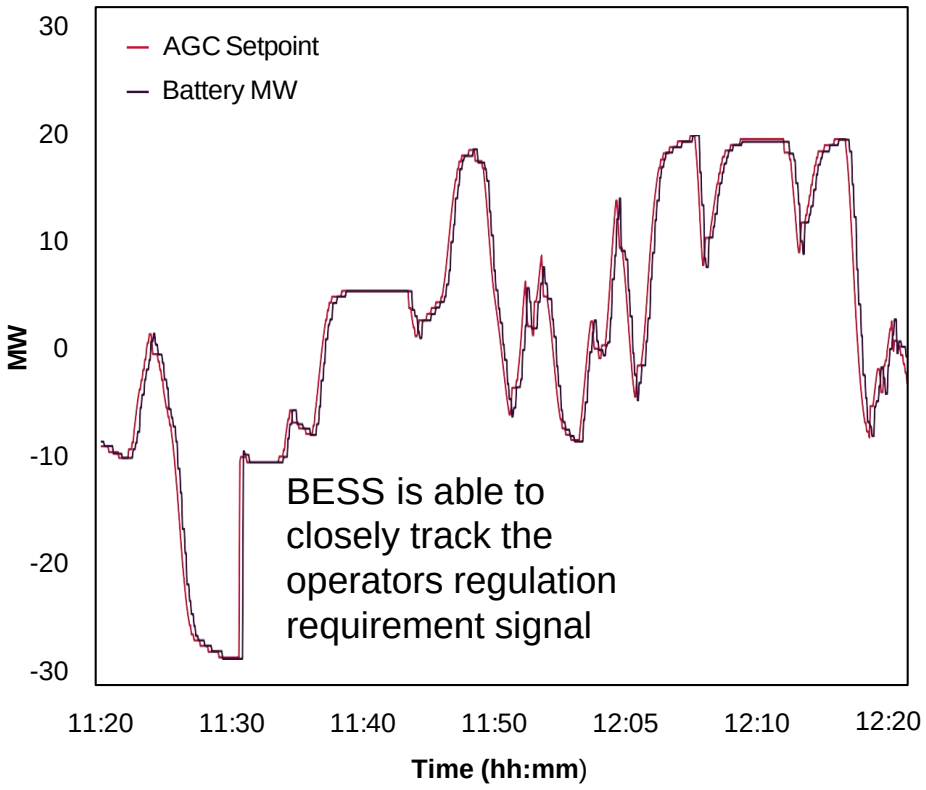
THE LANTAU GROUP

Ancillary Services

Ancillary Services

Grid Services that are needed to keep the power system safe and reliable

Battery Energy Storage



Growing penetration of the VRE creates additional demand for Ancillary Services to instantaneously match the supply and demand

The suitability of existing Ancillary Services technologies is being more and more put to test with increasing penetration of VRE

Storage technologies offer superior flexibility characteristics as compared to conventional Ancillary Services technologies, albeit such flexibility is currently not being remunerated

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.

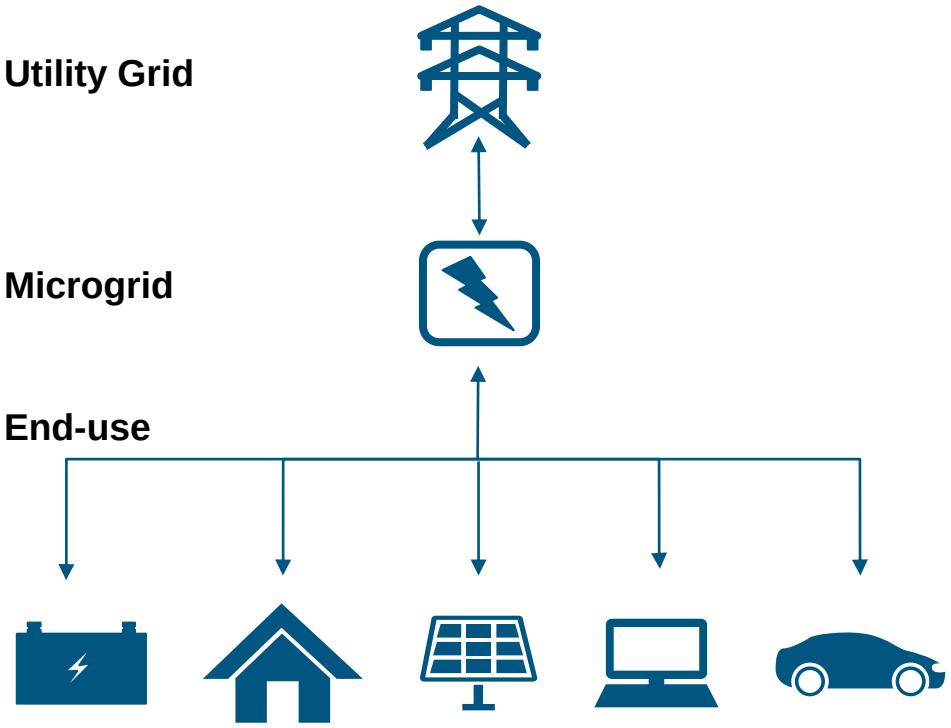
Strategically located storage can either supply peak demand downstream from the overloaded segment or shift the injection from VRE to a less congested time period.

The values that storage captures here is the investment deferment and also smoothening out of interregional price spreads due to congestion.

THE LANTAU GROUP

Microgrids

Microgrid



- 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.
- Additionally, storage can be used as an alternative to replacement of existing aged generating units.
- 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.

How solar and storage adds value to the microgrid areas

Fuel consumption reduction

Genset microgrid

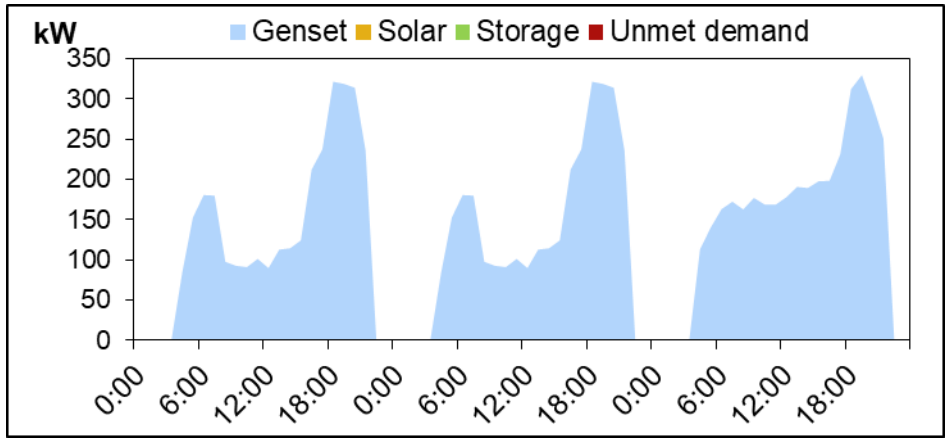
Service hours extension or capacity replacement

Add solar PV

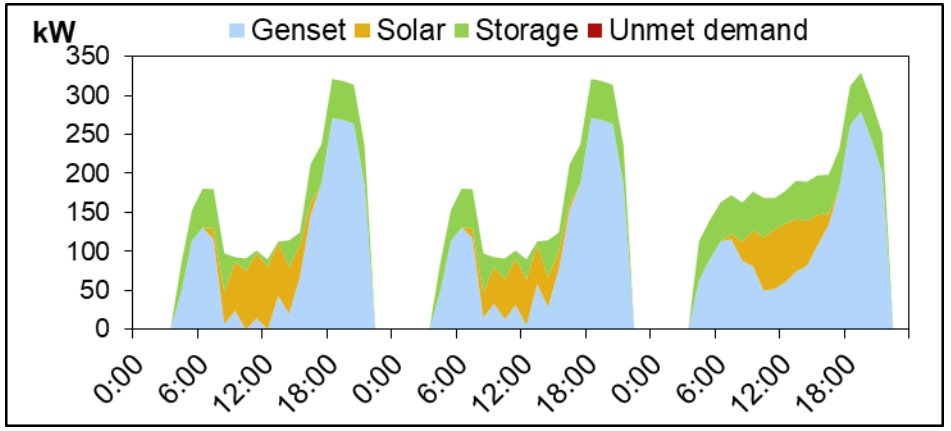
Add solar + storage

If solar profile does not match demand

Add storage



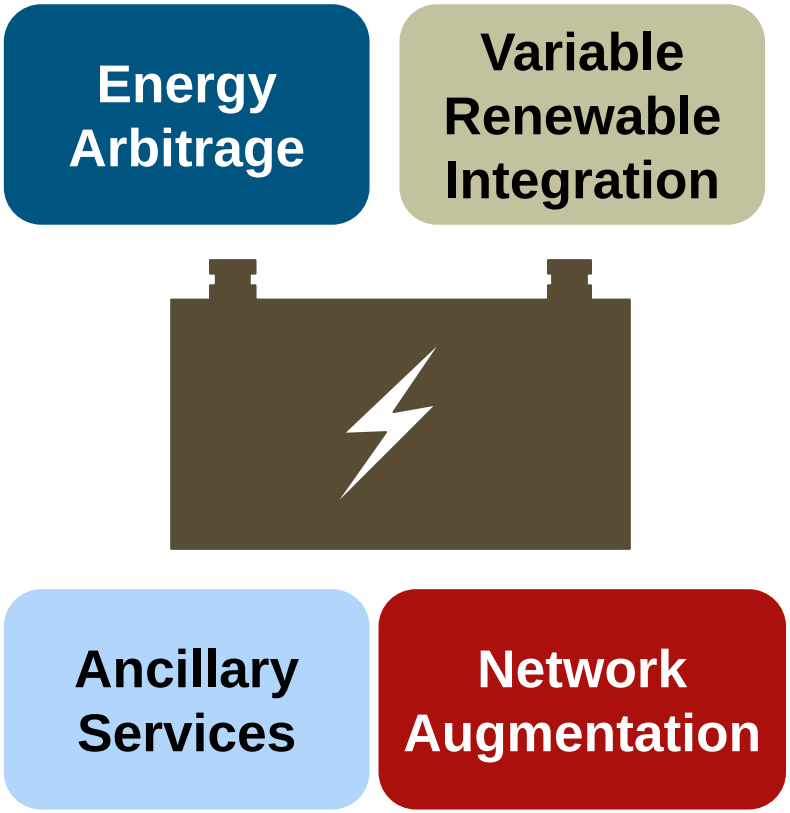
37% reduction in fuel cost



Managing fuel supply chain is challenging in the remote areas. Furthermore, diversifying the supply options away from liquid fuel improves the resiliency of the remote communities.

THE LANTAU GROUP

Stacking services

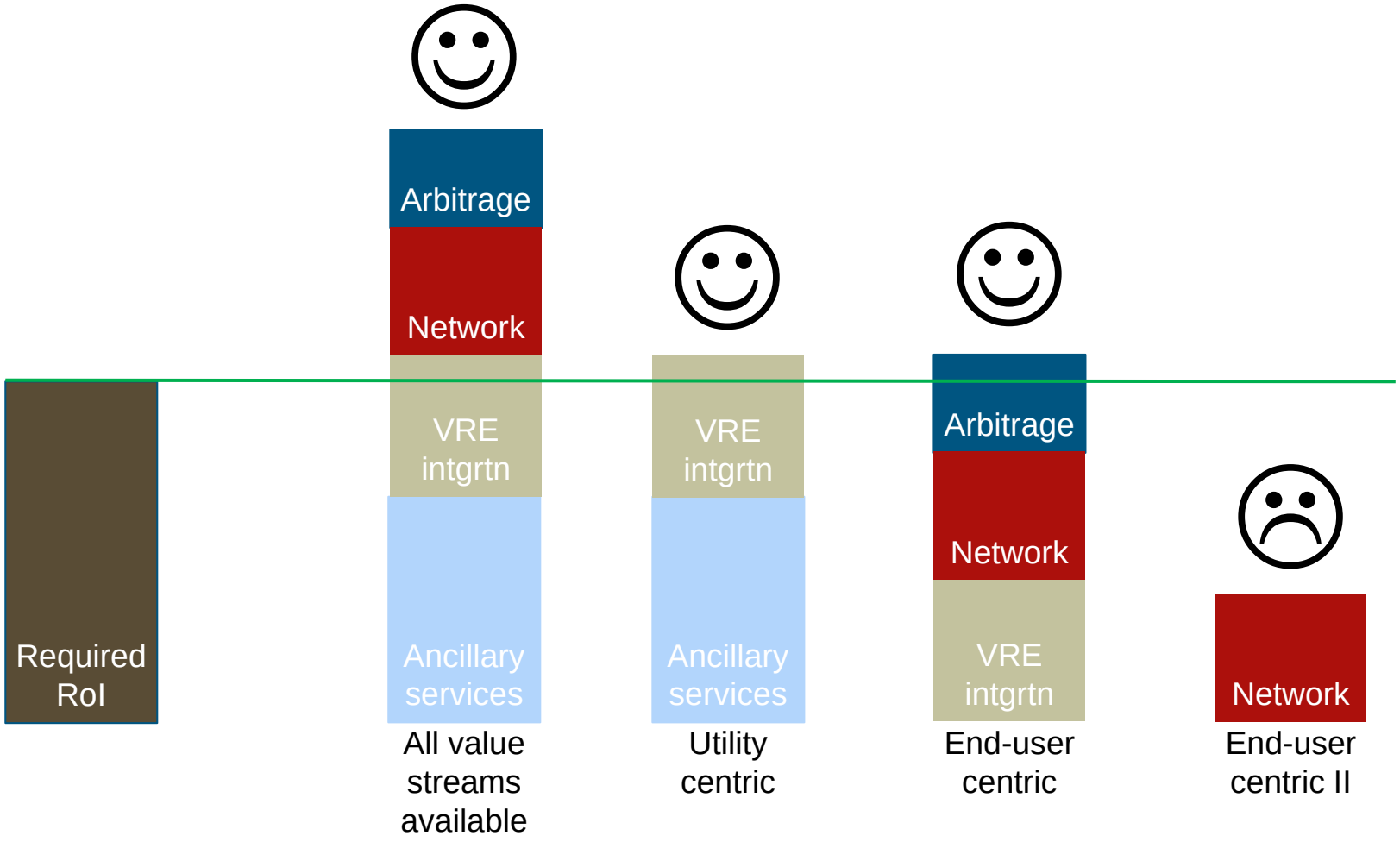


Storage devices have an ability to **supply multiple services at the same time**, the microgrid application is a perfect example of combining several of the value streams in one.

Combining multiple value streams helps **strengthen the business case** of storage project while at the same time offering a risk management tool based on **revenue source diversification**.

Australia is currently a key country in the region where service stackability is being tested.

“STACKABILITY” of energy storage



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

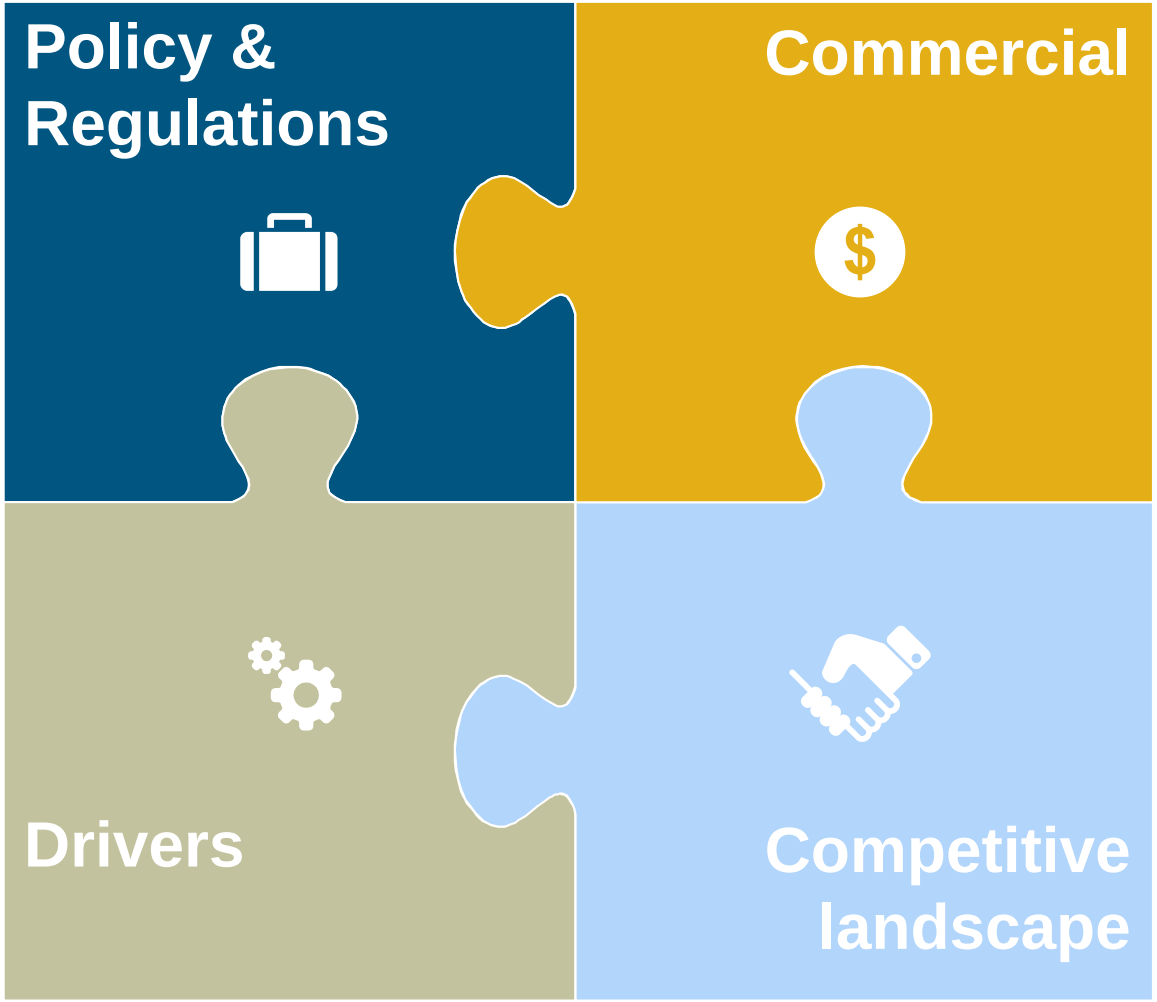
THE LANTAU GROUP

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?			

Example: 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

For a more detailed analysis of specific opportunities, we use our battery model

Key results metrics

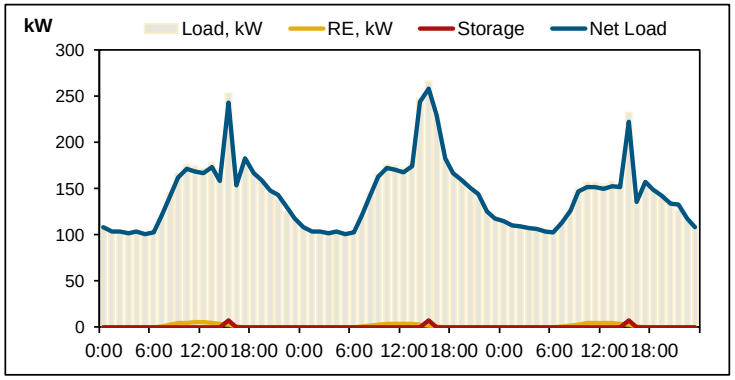
TLG's Time-frame Capacity Factor Model (The Philippines)

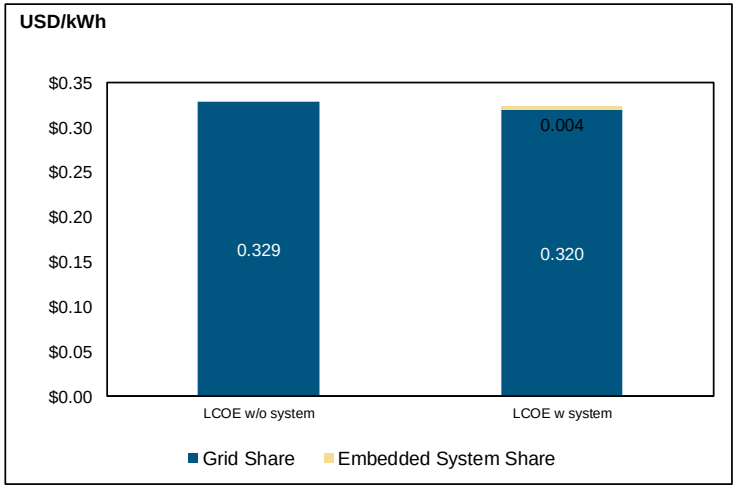
Inputs

Technical inputs		
Solar PV power rating	10	kW
Number of battery packs	10	
Storage capacity	20.00	kWh
Storage power rating	7.20	kW
Capex inputs		
Battery Cell Capex	$210.00	USD/kWh
Battery BoS Capex	$615.00	USD/kW
Battery Total Capex	$431.40	USD/kWh
Solar PV Capex	$850.00	USD/kW
Opex		
Battery Opex	$2.10	USD/kWh
Solar PV Opex	$63.75	USD/kWh
Electricity tariffs		
Tariff escalation	5.00%	
Years to escalate prices	25	
General		
Peak demand	200	kW
Senstivity (what if scenarios)		
Net Metering Limit	100	kW
Net Metering Rate	$0.10	USD/kWh
Demand Charge Multiplier	2	

Summary Results

Returns		
IRR	27.10%	
NPV	$29,243.56	$
Payback period	0.37	Years
Investment		
Investment costs	$21,402.27	$
Total O&M costs	$6,342.62	$
Peak demand and charges		
Peak - without system	297.34	kW
Peak - with system	286.80	kW
Charge - without system	$73,888.48	$/yr
Charge - with system	$70,939.60	$/yr
Electricity charges		
Reduced demand charges	$44,093.24	$
Reduced usage charges	$29,063.08	$
Total O&M costs	-$6,342.62	$
NEM income	$0.00	$
Total net savings	$66,813.70	$
Resulting electricity prices		
LCOE - without system	$0.329	USD/kWh
LCOE - with system	$0.325	USD/kWh
LCOE reduction	1.39%	

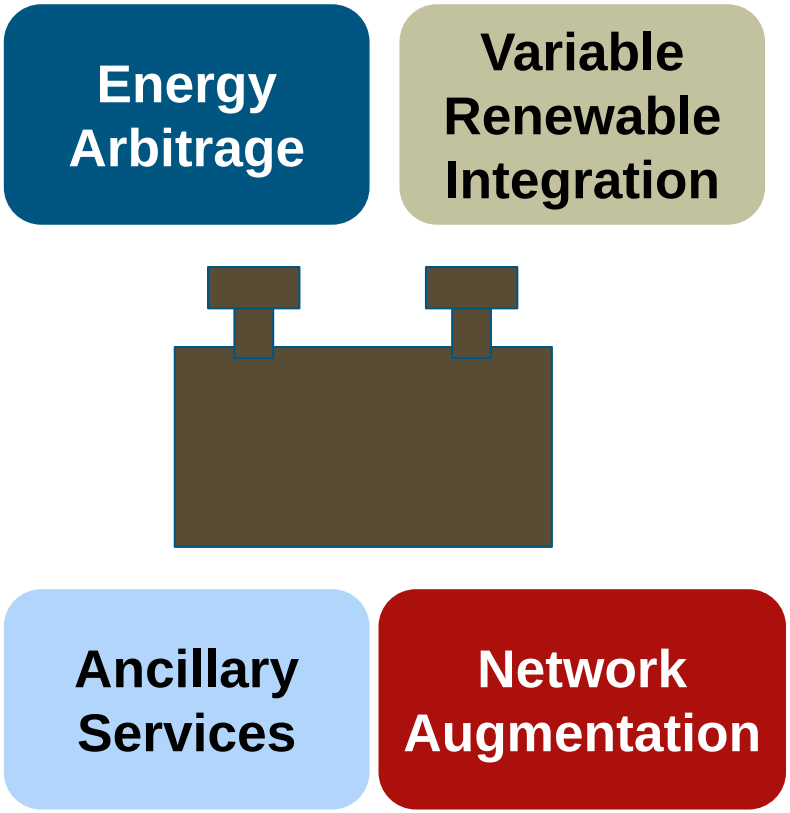




THE LANTAU GROUP
strategy & economic consulting

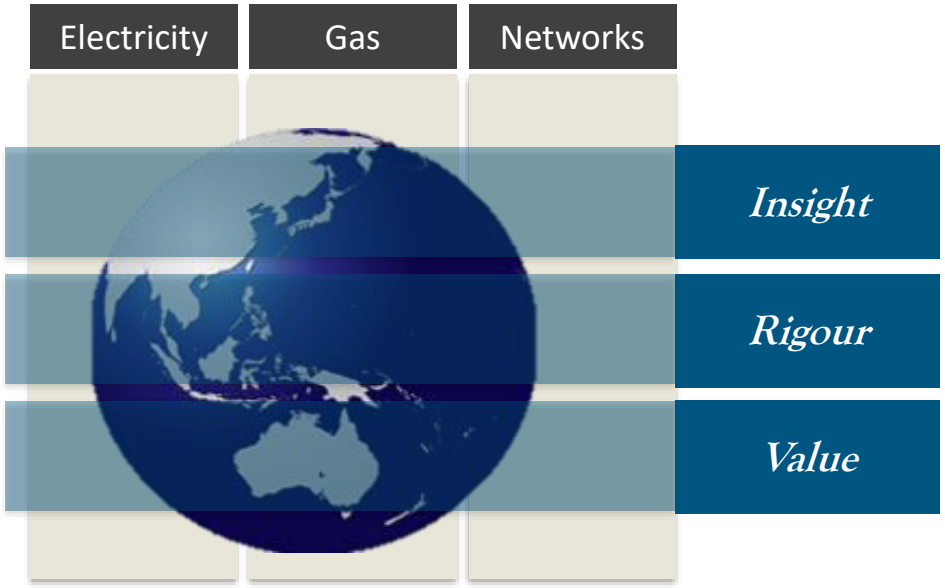
THE LANTAU GROUP

So what about Sri Lanka?



- Penetration of variable renewable energy sources is low (though this may change)
- Large amounts of hydro (and plans for gas-fired capacity) which can be dispatched flexibly
- Tariffs are low relative to regional countries (see later slide)
- A number of recent major blackouts suggests the grid may struggle to cope with new generation without significant investment meaning some storage may be prudently combined with rooftop solar

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 6818 6011 (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
Level 39, Marina Bay Financial Centre Tower 2
10 Marina Boulevard
Singapore 018983

Online
www.lantaugroup.com

THE LANTAU GROUP

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