



Department of Energy



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The Vanadium Flow Battery: Supply, Ancillary Services, & Smart Grid Application

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E-Power Mo

Tuesday, 24 April 2018.

Hotel Supreme Convention Plaza, Baguio City.

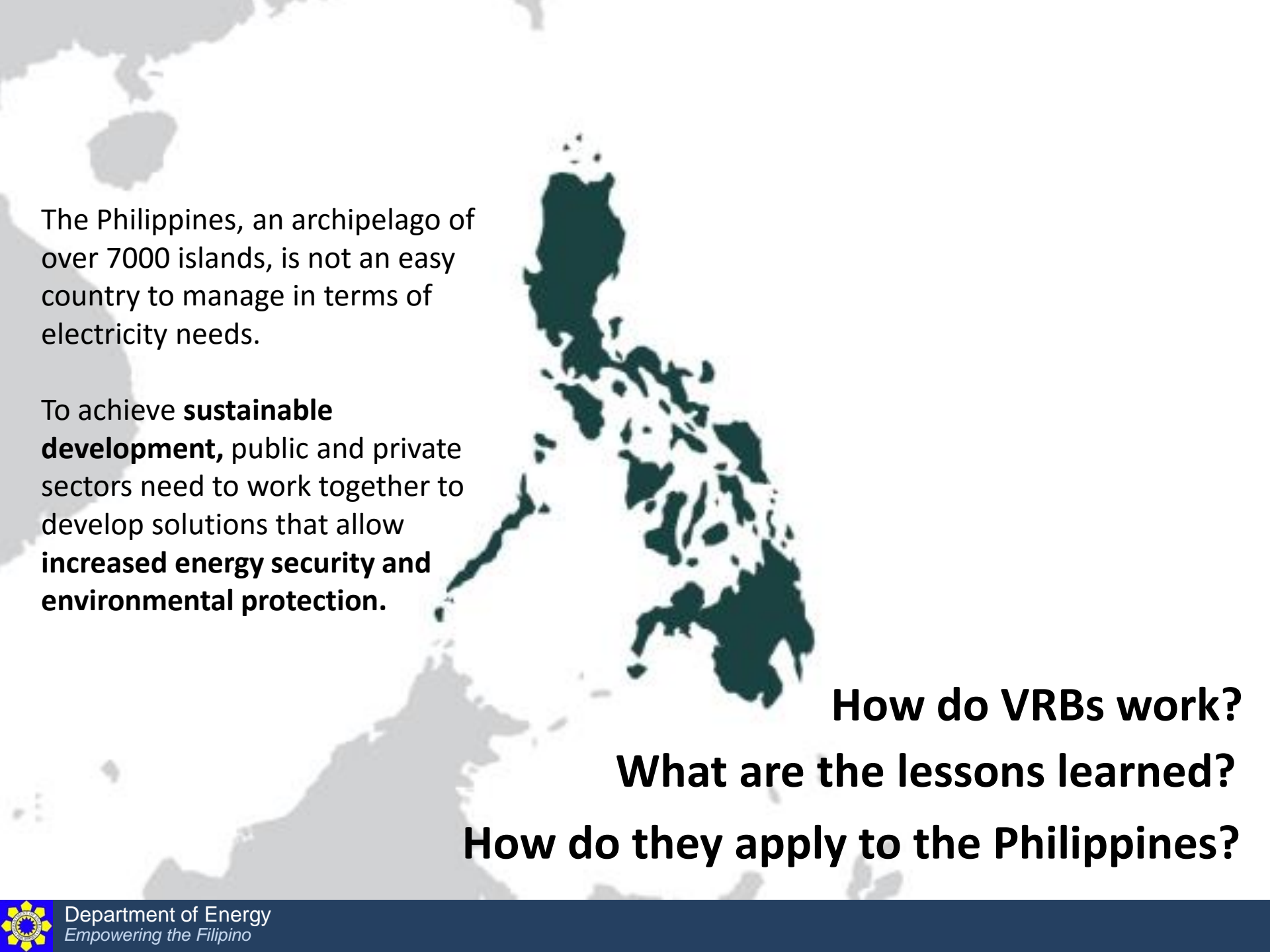




SOUTH AUSTRALIA



TAIWAN



The Philippines, an archipelago of over 7000 islands, is not an easy country to manage in terms of electricity needs.

To achieve **sustainable development**, public and private sectors need to work together to develop solutions that allow **increased energy security and environmental protection**.

How do VRBs work?

What are the lessons learned?

How do they apply to the Philippines?



OUR COMPANY

Introduction





SEN TEK ENERGY SOLUTIONS INC.

- A. Our **mission** is to create energy sustainable communities, through innovative solutions.
- B. Our **vision** is to become the world leader in pioneering renewable energy solutions.



SEN TEK ENERGY

AUSTRALIA



- 50MW Solar PV with **200MWh vanadium flow batteries**
 - Arbitrage model and PPA.
 - Ancillary services.
- USD 300million project.
- South Australia, Australia.

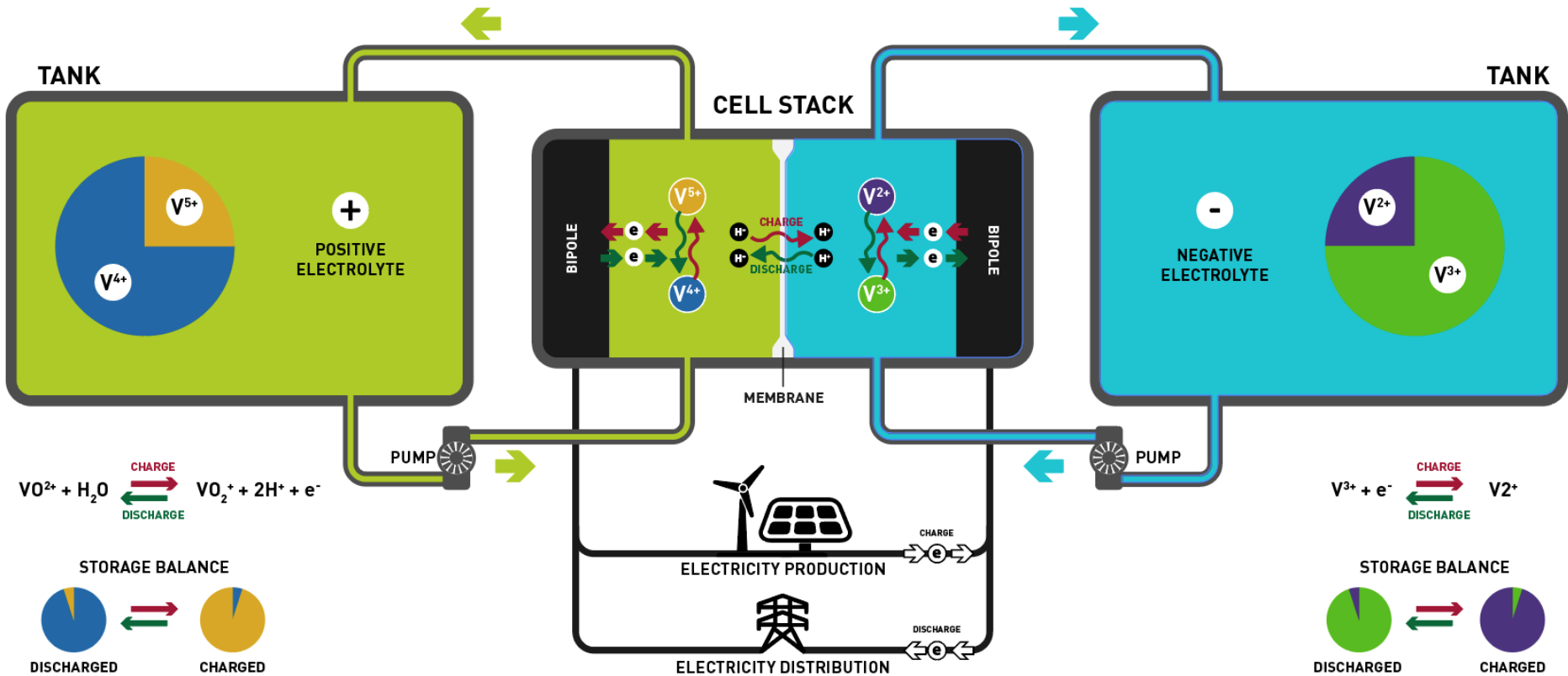




VANADIUM FLOW BATTERIES

Chemistry
Advantages

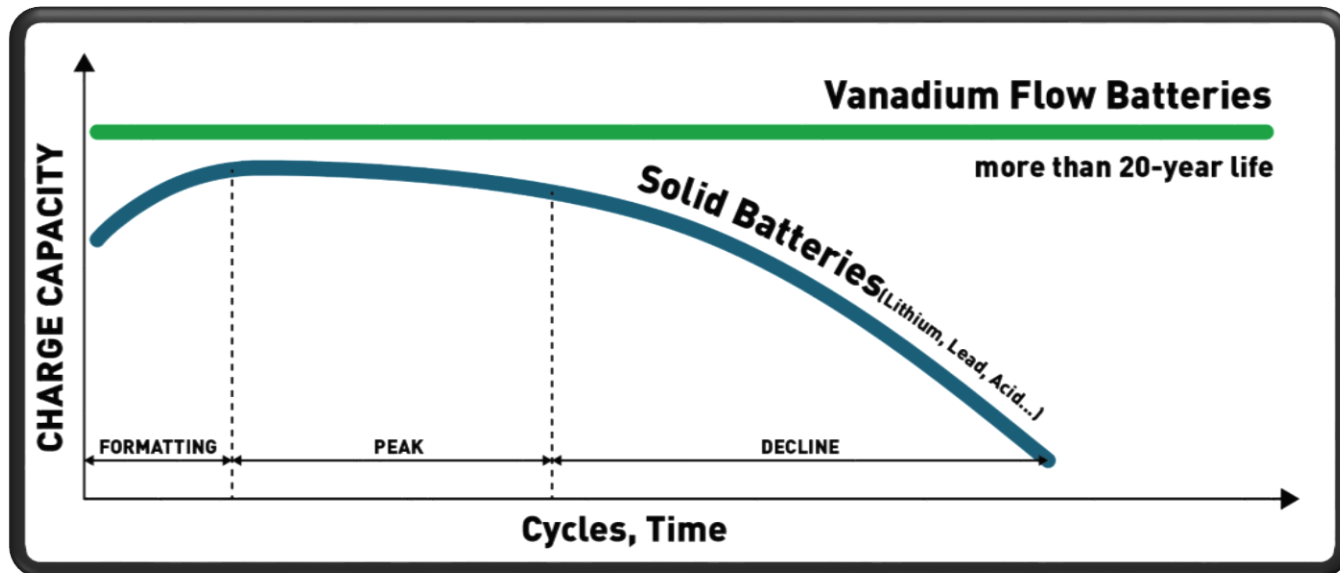
VANADIUM FLOW BATTERIES



VANADIUM FLOW BATTERIES

LONG LIFE

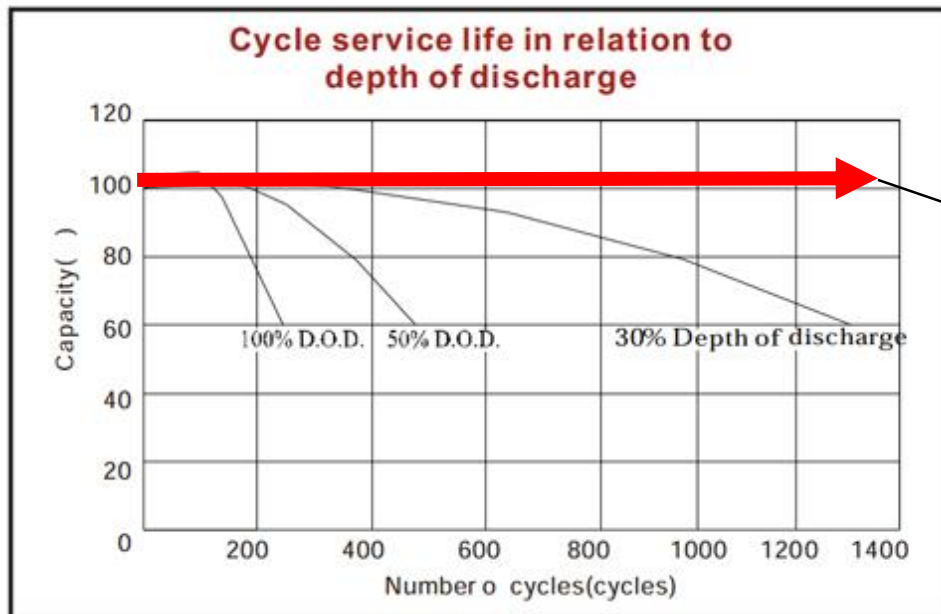
- While the lifetime of lithium-based batteries is limited, vanadium redox technology **can be drained over an almost unlimited number of charge and discharge cycles** without wearing out.
- The electrolyte solution in VRB is inert to charge discharge cycling, and is **theoretically limitless**.



VANADIUM FLOW BATTERIES

FLEXIBILITY

- Lithium batteries require a partial charge or discharge profile, otherwise, there is a significant decline of life of batteries.
- Vanadium energy storage batteries **do not experience a degradation in efficiency**, and allow for **100% full depth of discharge**.

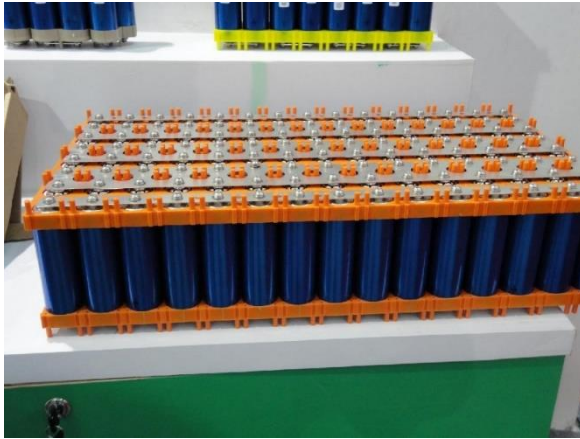


For VRB, there is no limitation on how much capacity you can discharge, and how many times.



VANADIUM FLOW BATTERIES

SCALABLE



VS



- **Lithium** batteries store their energy in relatively **small, self-contained cells** that get hot with use. But in a grid scale storage system, you need hundreds of thousands of them together. This results in **thermal runaway**.
- **Vanadium flow batteries** store their energy in **tanks**. The electrolyte — the fluid that transfers charges inside a battery — flows from one tank through the system back to the same tank.



VANADIUM FLOW BATTERIES

SAFE



- The vanadium electrolyte is **non-toxic** fluid per UN regulations.
- Unlike other large battery systems, our VRB contains no heavy metals such as lead, nickel, Zinc or cadmium.
- The electrolyte is **non-flammable**.

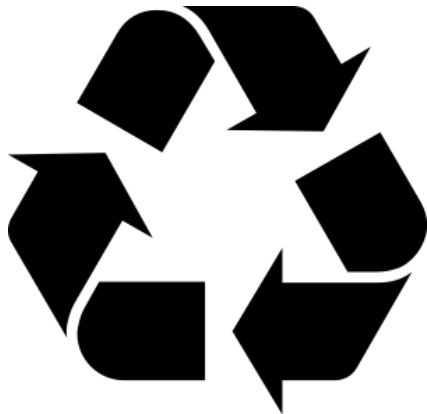


VANADIUM FLOW BATTERIES

RECYCLEABLE



- The electrolyte is **100% reusable**, with high residual value.
- Upon decommissioning, vanadium electrolyte can also be safely **recycled** through a filtration process, making it ready to be used again.
- Therefore, theoretically the asset life of the energy storage is unlimited.



EMBEDDED SUPPLY

Peak shaving

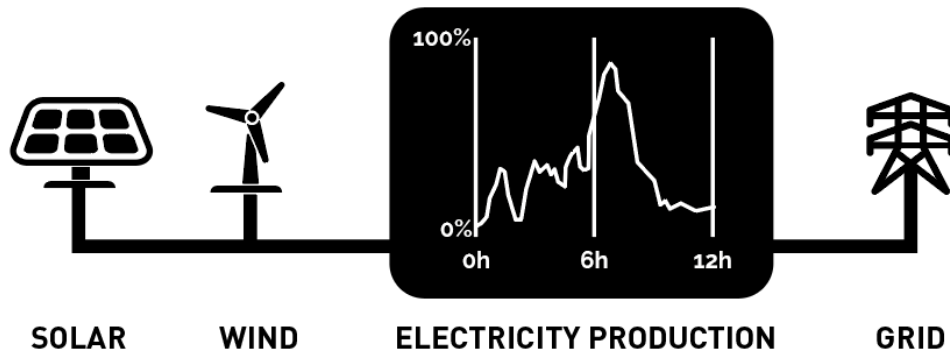
RETs as baseload



EMBEDDED SUPPLY

RET – Intermittent generators

Renewable energy generators such as solar and wind system, are **unable to generate energy on a continuous and uninterrupted basis**, making it difficult to satisfy energy demands consistently.



Renewable energy sector challenges

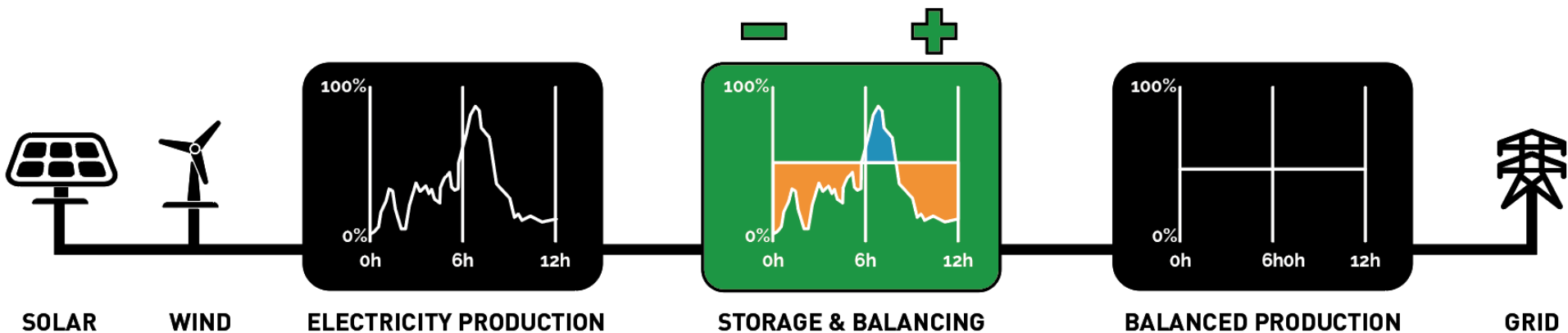
- **Inflexible:** Cannot increase power supply on demand.
- **Wasteful:** Energy waste has been increasing in line with the share of renewables.



EMBEDDED SUPPLY

Peak shaving

Peak shaving is a technique that is used to reduce electrical power consumption during periods of maximum demand on the power utility. Thus saving substantial amounts of money due to peaking charges.



EMBEDDED SUPPLY

RETs as baseload

Table 1 South Australian local electricity supply breakdown for 2016–17

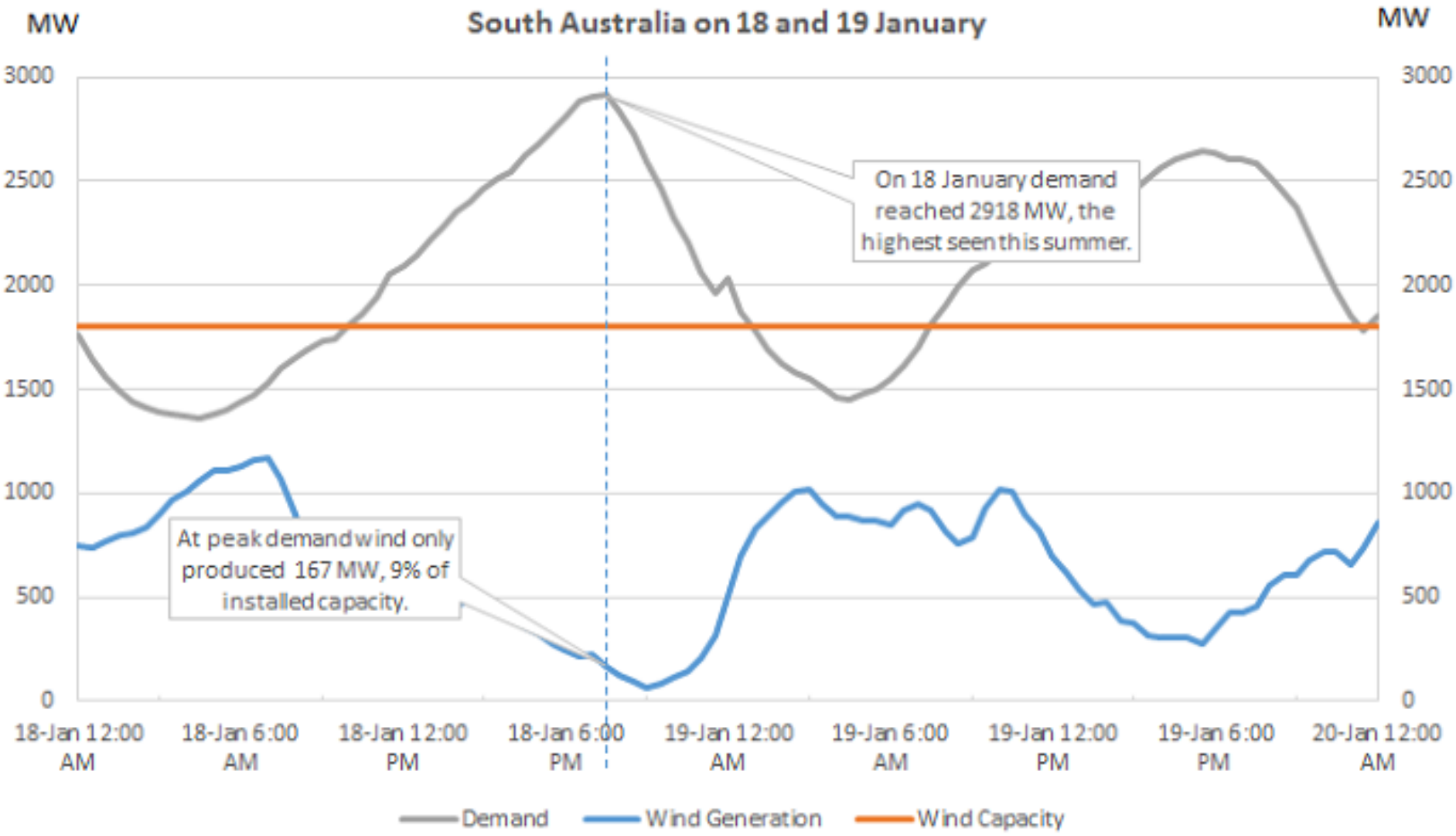
Local generation	Generation in GWh	Share of total
Gas	5,596	50.5%
Wind	4,343	39.2%
Coal	0	0.0%
Rooftop PV	1,016	9.2%
Diesel and small non-scheduled generation*	122	1.1%
Combined interconnector flows	Flow in GWh	
Imports to South Australia	2,889	
Exports from South Australia	164	

* Small non-scheduled generation is approximate, and is based on a larger list of generators than in the 2016 SAER. It includes data from selected non-scheduled generators less than 30 megawatts (MW) capacity, including PV non-scheduled generation

- Close to 40% renewable energy generation.
- There is volatility in electricity prices reflecting the amount of wind power generation.



EMBEDDED SUPPLY

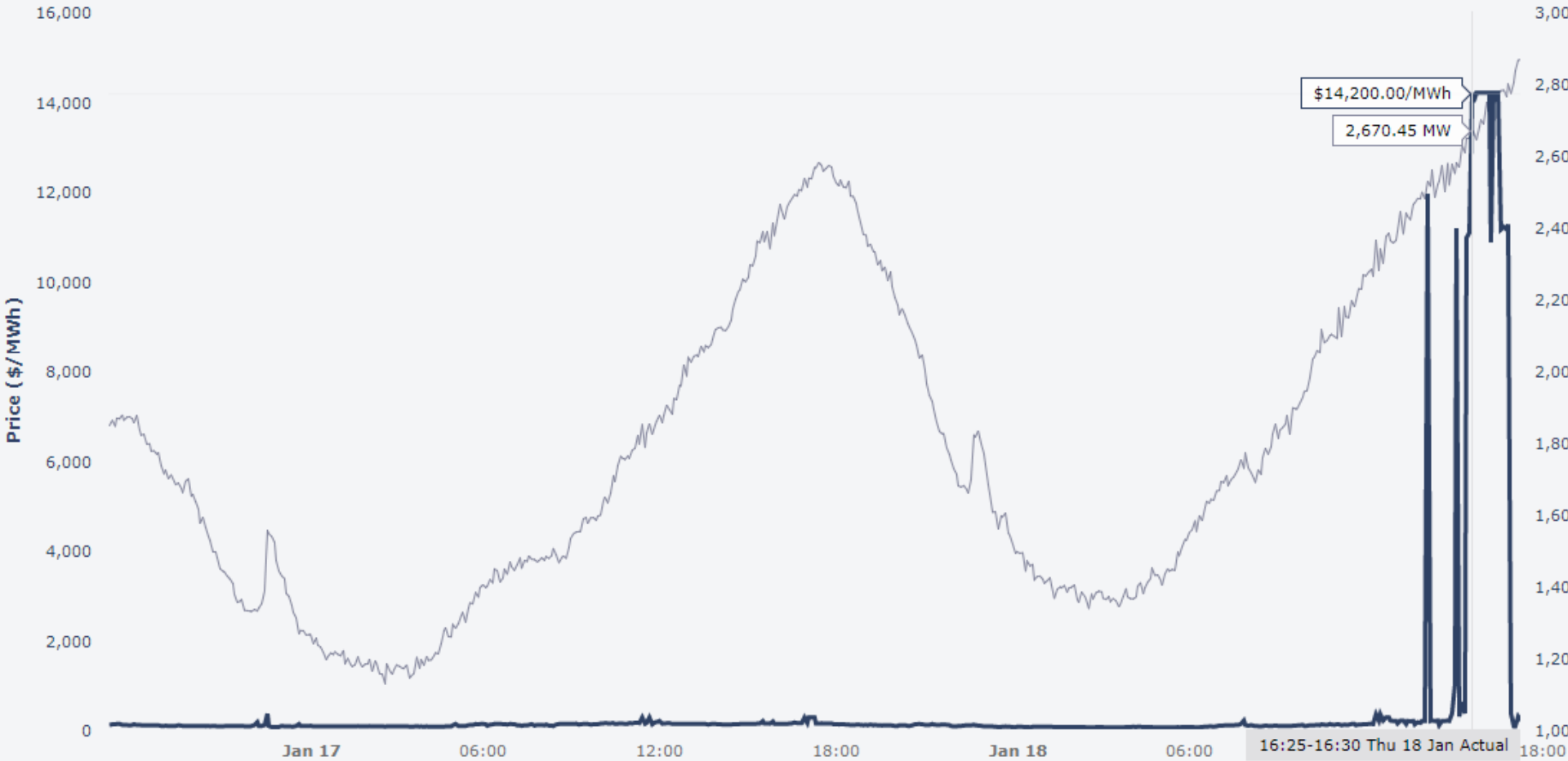


EMBEDDED SUPPLY

NSW QLD VIC SA TAS

30 Min

Dispatch Price (5min) \$210.00/MWh
Scheduled Demand (5min) 2,867.57 MW



OTHER APPLICATIONS

Ancillary services

Smart grid application

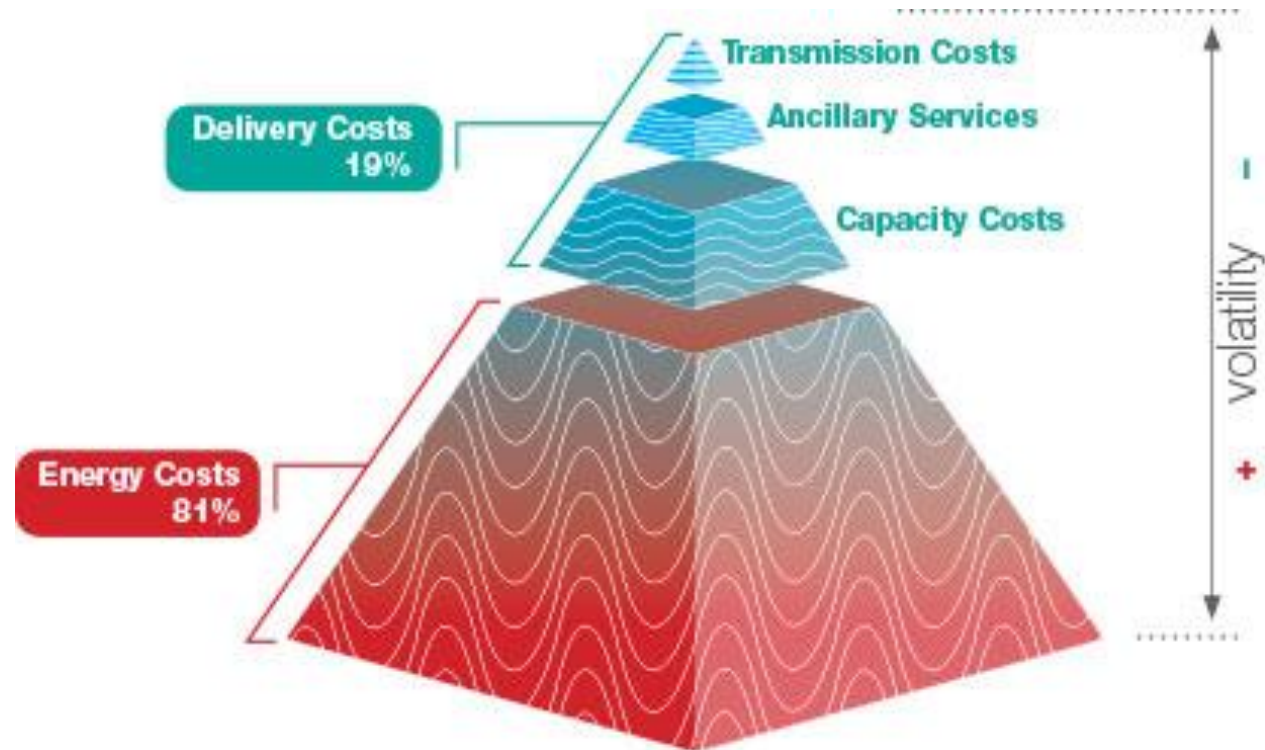


ANCILLARY SERVICES

Ancillary or grid support services

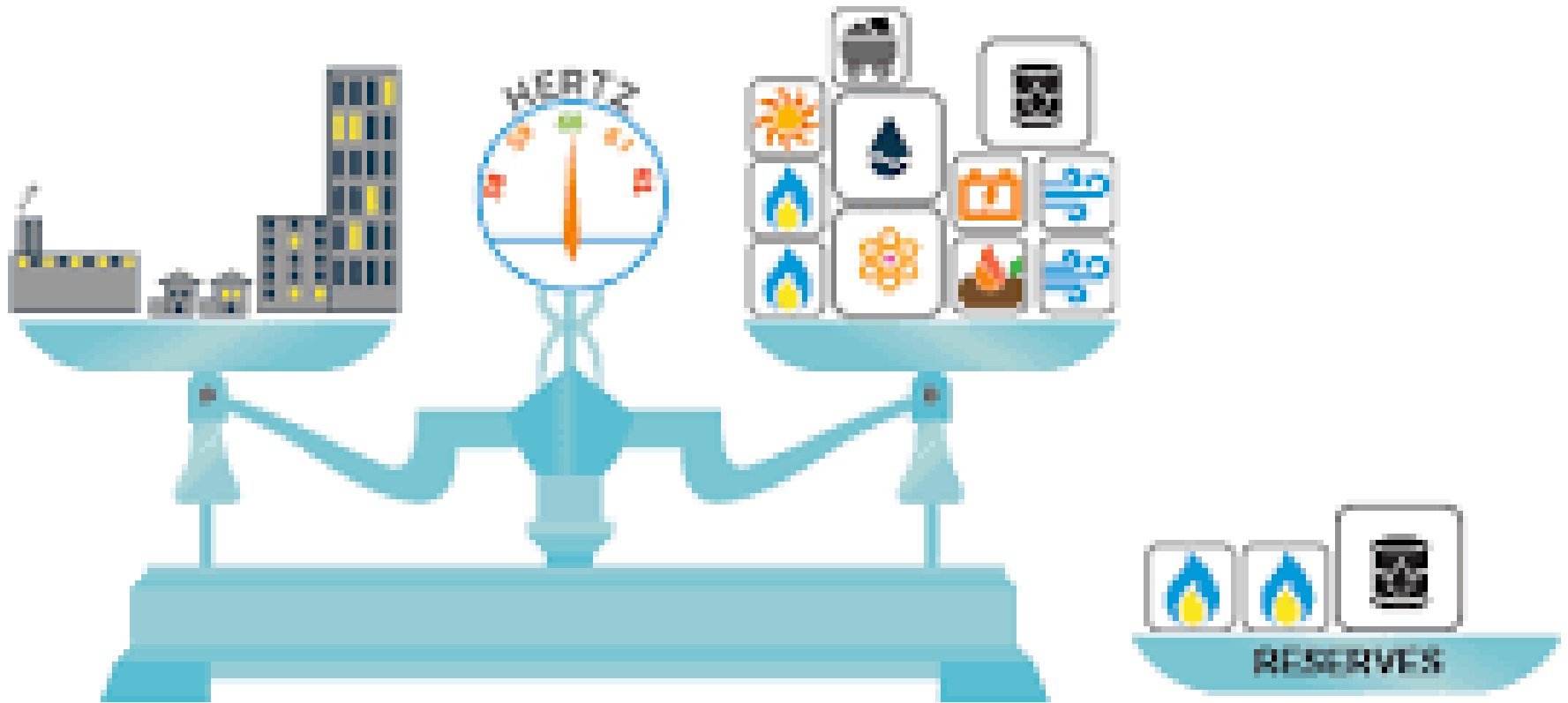
Ancillary services are those services necessary to support the transmission of electricity, given the demand and generation supply.

- voltage control, fast frequency response, system restart, network loading control, black start, demand response, and spinning reserve.



ANCILLARY SERVICES

Balanced Load & Generation



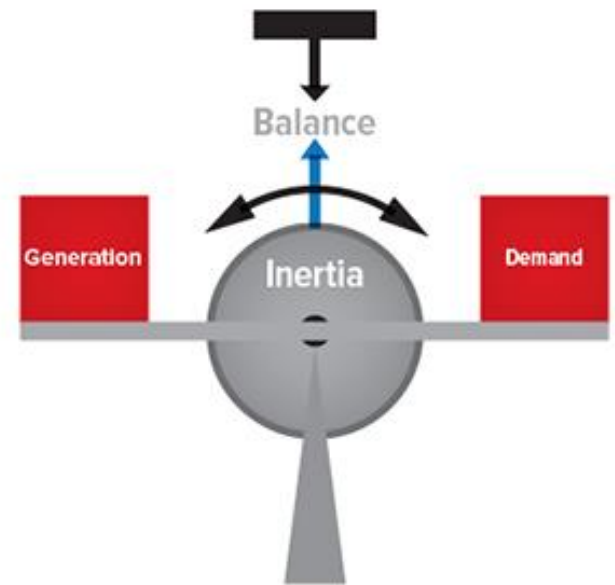
ANCILLARY SERVICES

RE lack inertia, VRB provides

Traditional generators create **inertia** to allow the dispatch of their electricity, as well as, provide ancillary services which to maintain the reliable operations of transmission systems.

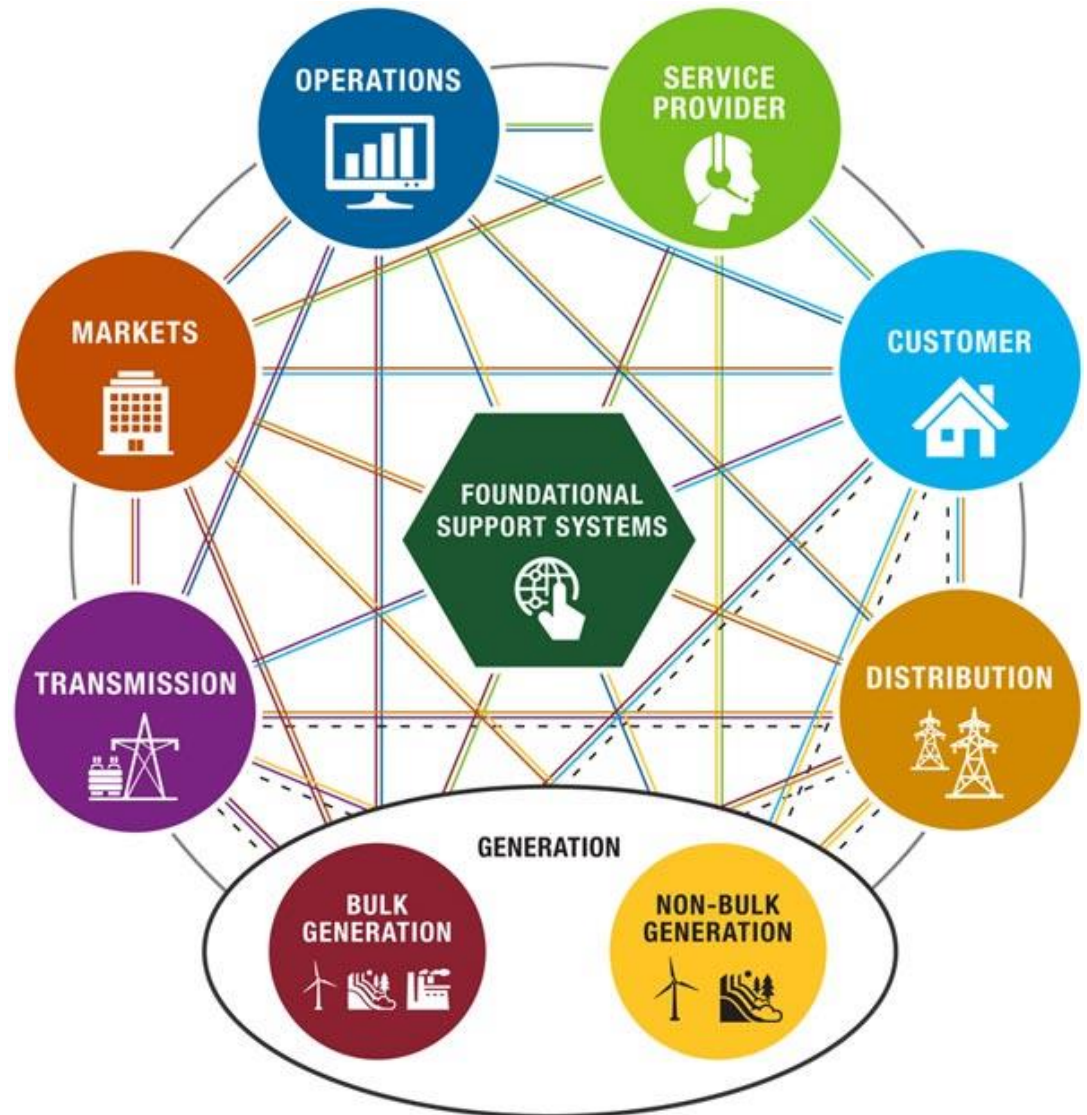
But RETs are **asynchronous** – the inertia produced is dependent on strength of the RE source.

So VRB are needed to provide the adequate **synthetic inertia**.

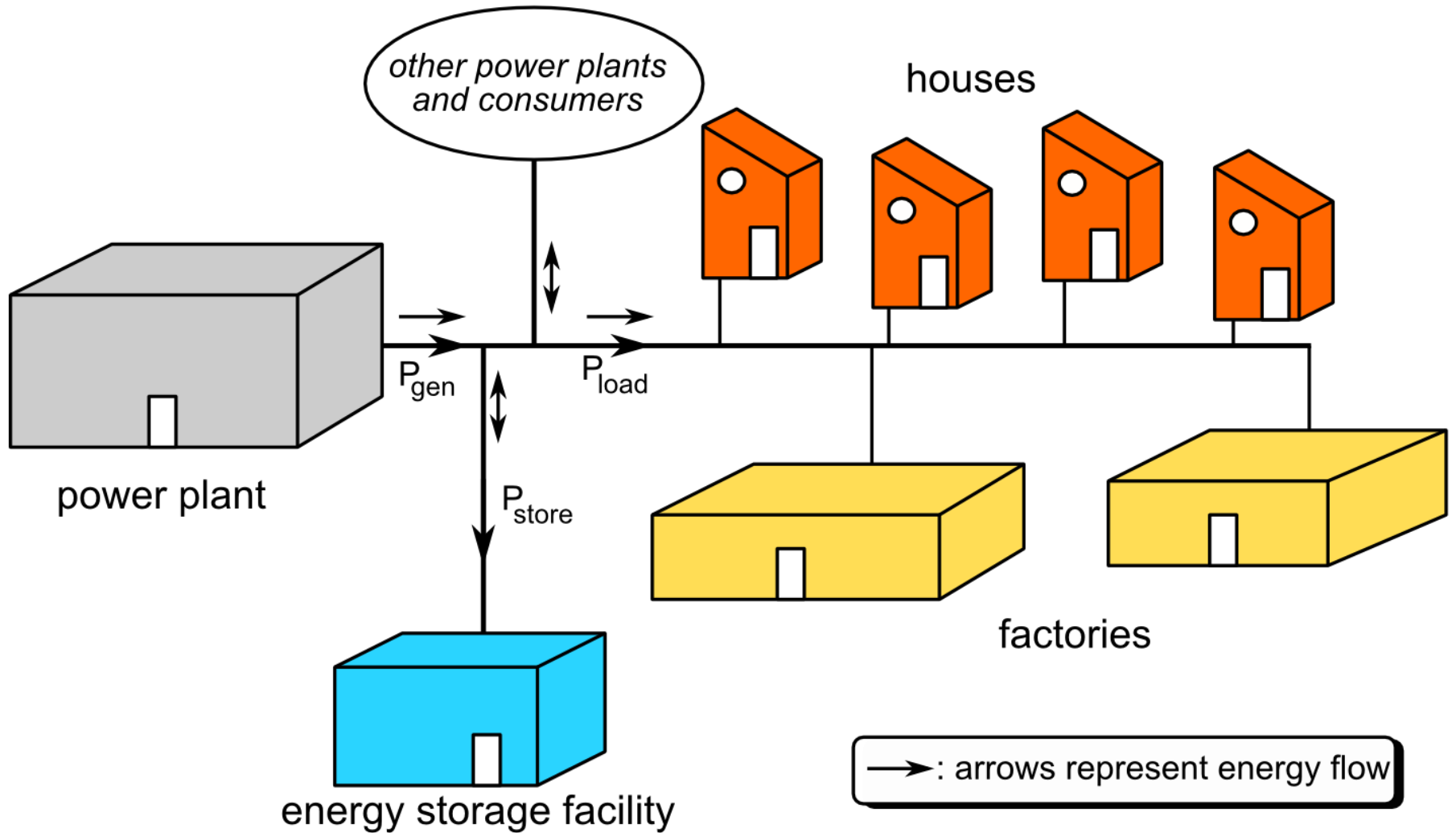


SMART GRID APPLICATION

Smart grid is an idealized grid where there is increased use of digital technology allowing for communication between participants.



SMART GRID APPLICATION



SMART GRID APPLICATION

VRB responses instantaneously



- VRBs are in a **'ready'** state.
- Stacks are primed with reactants, so they can increase from zero to full output within a few **milliseconds**.



CONCLUSION

We need to invest in a mix of solutions to **increase energy security and environmental protection.**

Energy Storage is able to address a lot of the needs for an improved grid.

SUPPLY.

ANCILLARY SERVICES.

SMART GRID APPLICATION.

Since **Vanadium Flow Batteries** represent the next generation in terms of energy storage, **VRBs will be at the forefront** of this electricity revolution.

**JOIN THE
REVOLUTION!**



Thank You!



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