International Energy Agency

Status of Power System Transformation:

The Energy Transition to boost system flexibility

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System Integration of Renewables, IEA

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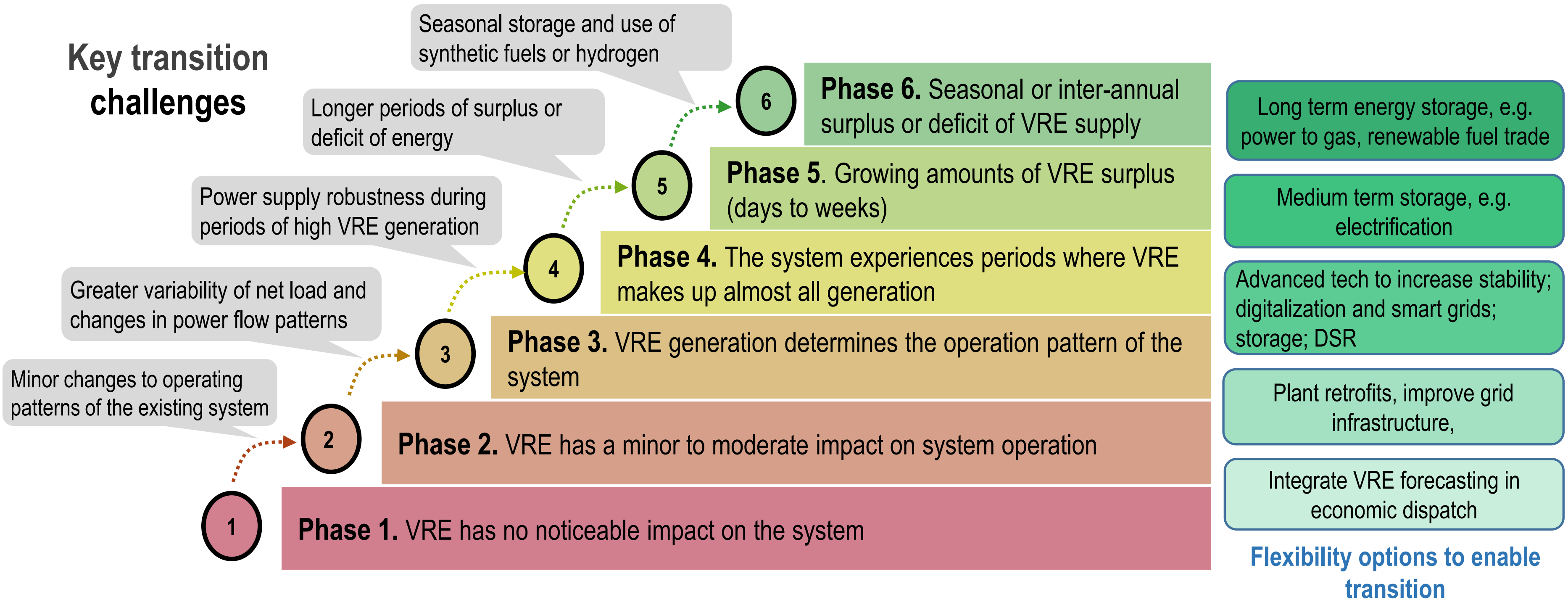
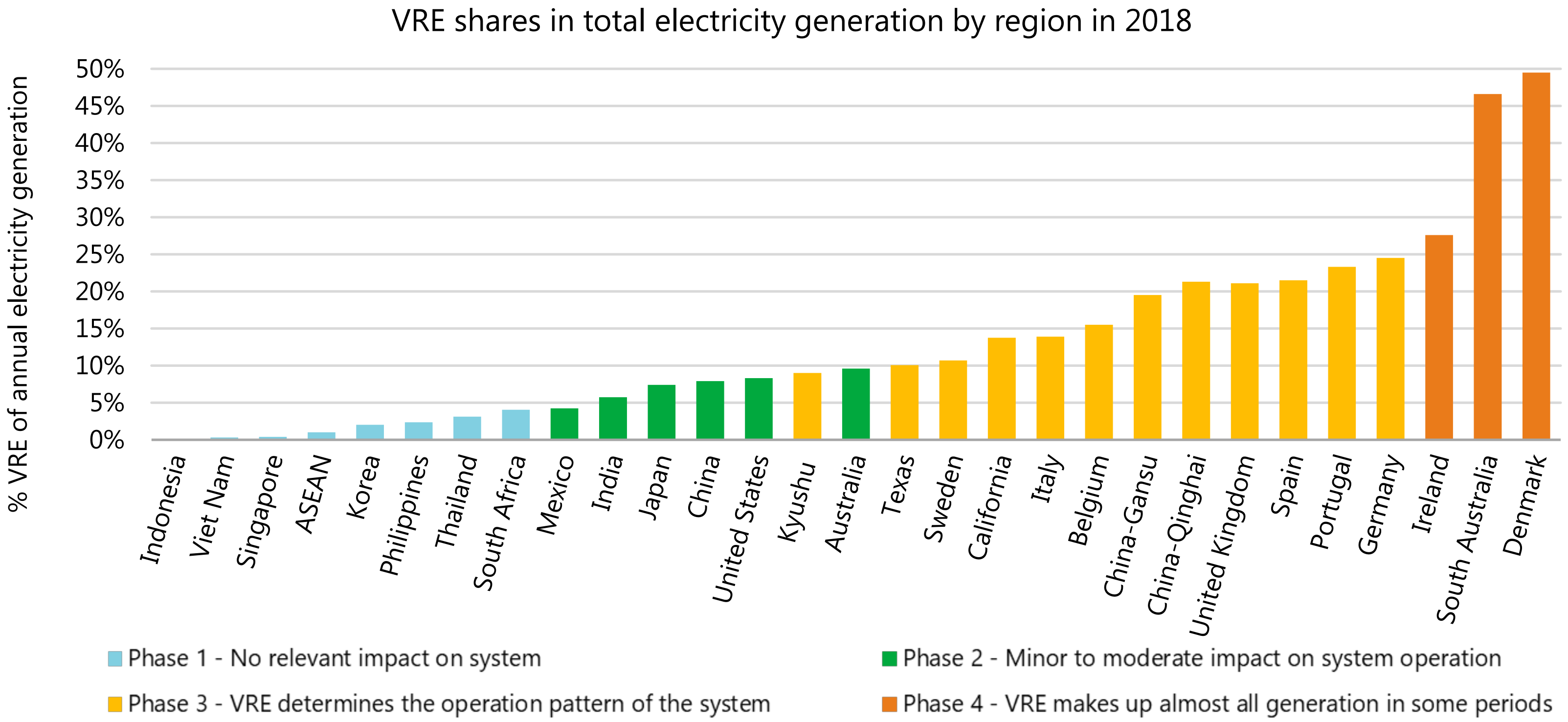
Characteristics in different phases of system integration of VRE



Key challenges in each phase that should be addressed for moving up to higher levels of integrating VRE in the power system

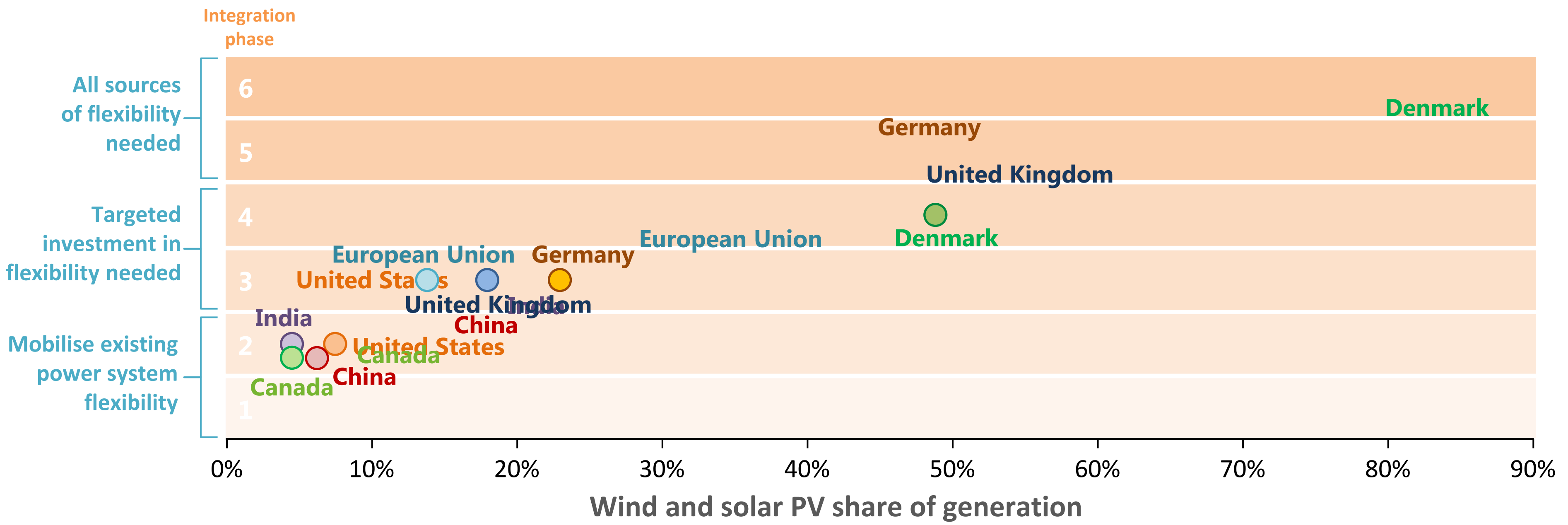
System integration can be classified into different phases



Specific power system regions can be at higher VRE integration phases due to limited interconnection and VRE penetration. Many countries/regions are still in Phase 1 and 2 of system integration.

Flexibility is the cornerstone of tomorrow's power systems

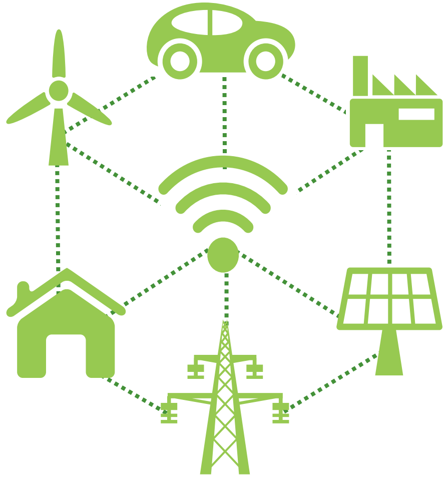
Phases of integration with variable renewables share, 2017 to 2030



Very high shares of wind & solar PV require reforms to attract investment at unprecedented level in grids & interconnections, flexible power plants, affordable storage & demand-side response

System flexibility: Identifying and engaging with the right actor is key

Institutions and actors ("Who")	Policy, market and regulatory frameworks ("How")	Hardware and infrastructure ("What")
Typical decision makers	***Categories of interventions***	***Flexibility Asset types***
Energy ministry	*Energy strategies* *Legal frameworks* *Policies and programmes*	
Regulatory agency	*Regulatory frameworks and decisions* *Power sector planning exercises* *Retail electricity pricing*	
System operator, electric utility, standards body	*Power market rules and codes* *System operation protocols* *Connection codes*	



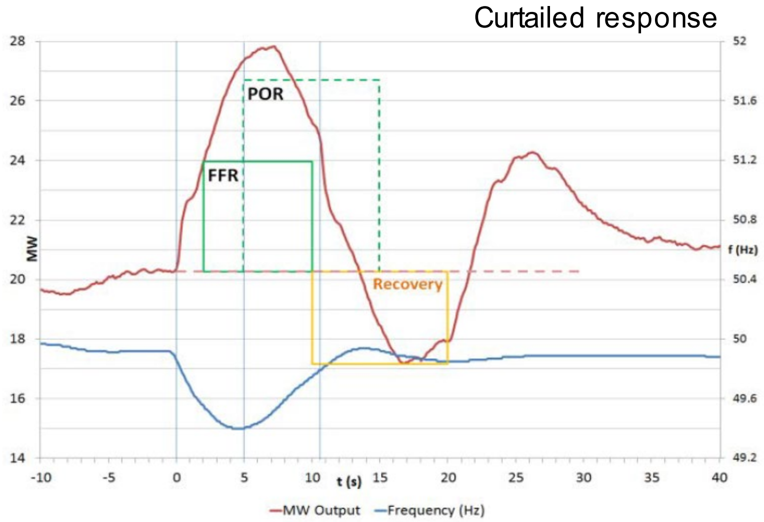
Source: Status of Power System Transformation 2019

A range of approaches to enhance power system flexibility are available at different levels of decision making. The institutional context defines the set of instruments available to boost system flexibility.

All power system assets can provide flexibility, including VRE

- Appropriate policy, market and regulatory frameworks can enable participation from a broad range of power system assets.

Fast frequency response from a wind plant during a trial period in Ireland

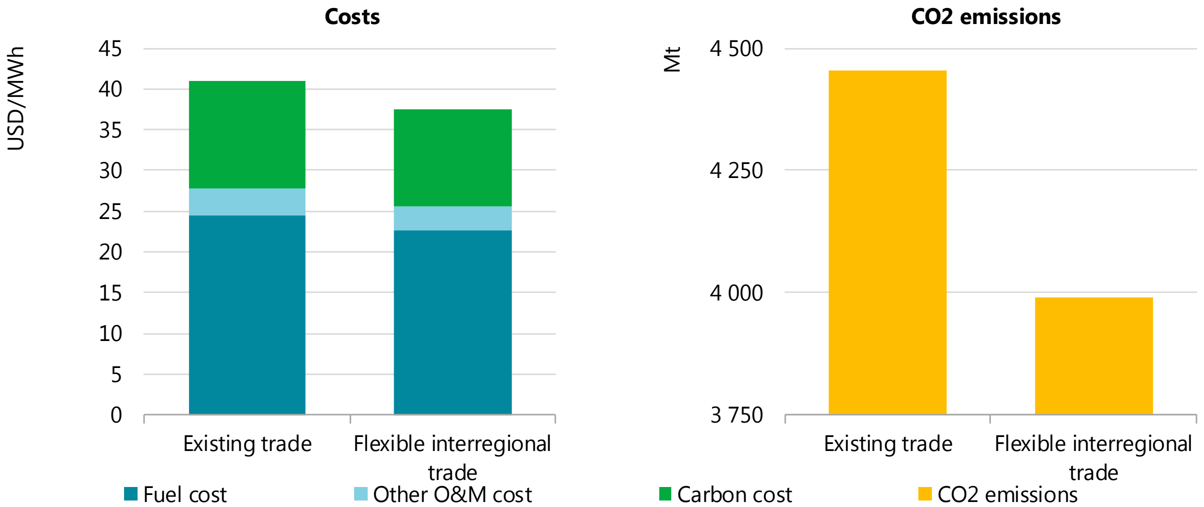


Redefining grid codes, ancillary service requirements and remuneration schemes are needed to tap into the flexibility potential from VRE. This strongly depends on the institutional framework

Electricity networks remain a critical enabler of system flexibility

- Inter-regional transmission interconnections and international coordination can yield significant economic benefits
  - *Example: IEA China Power System Transformation study (NPS scenario, 2035)*

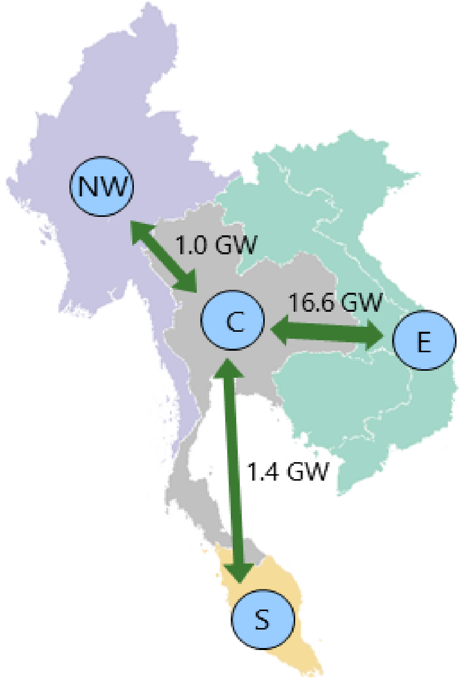
Potential for yearly USD 9 bn operational cost savings with inter-regional trading



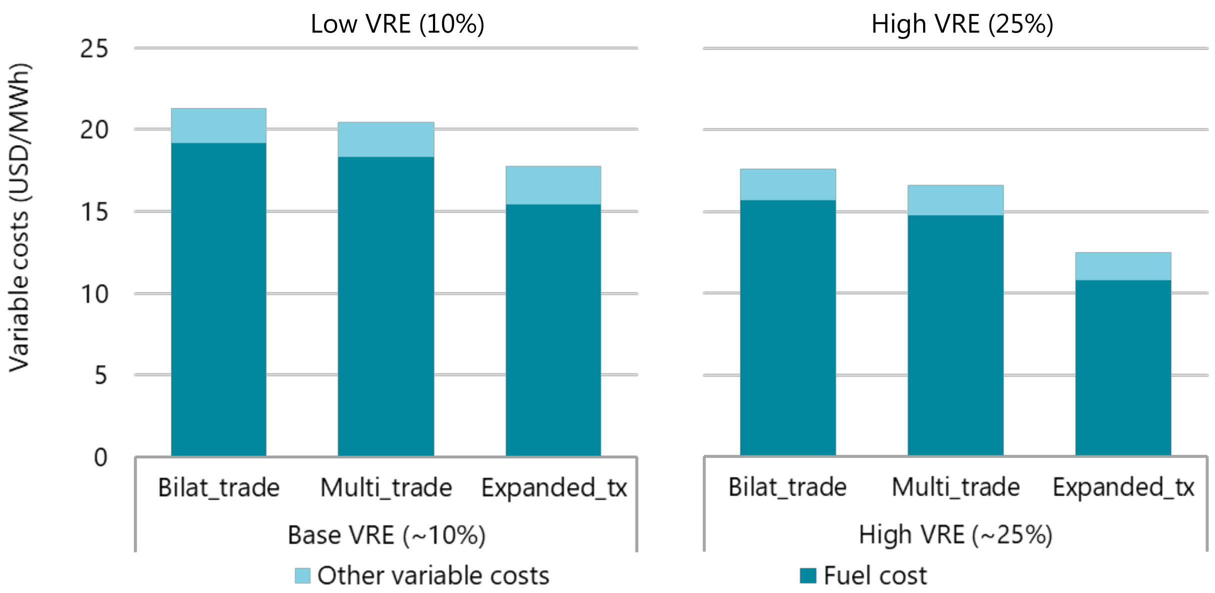
Enhanced trade across regions can bring substantial cost savings and emission reductions by sharing flexibility resources more widely.

Cross-border network can facilitate VRE integration in ASEAN

Capacity of the interconnectors

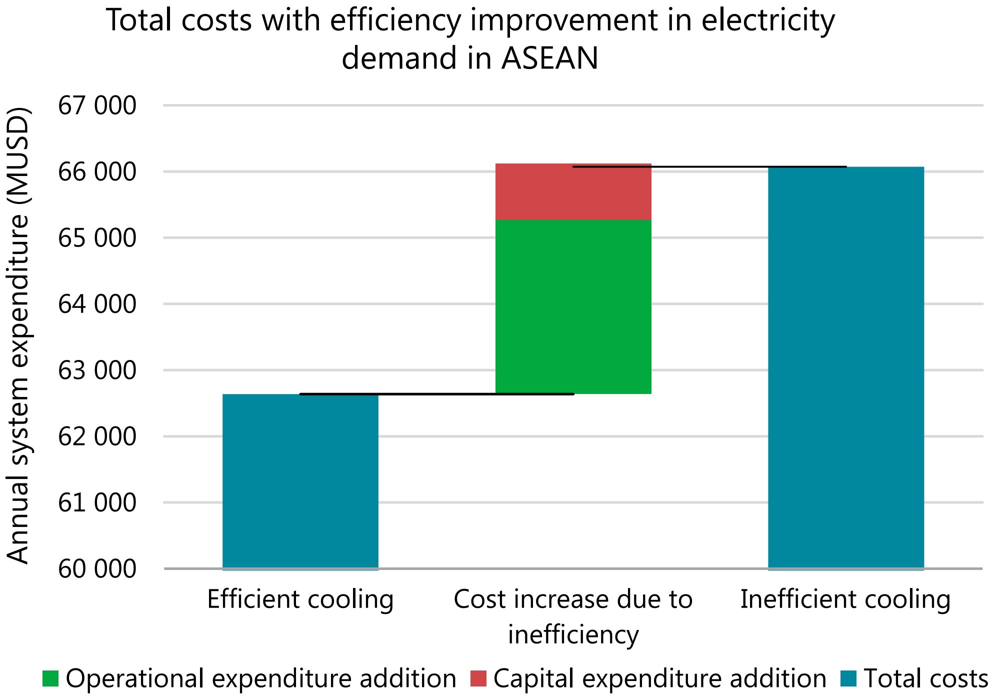


Annual operation cost



Expanding interconnectors can lead to operational cost savings. It enables the integration of higher share of VRE that provides economic and environmental benefits

Demand-side resources offer significant flexibility potential



- Cooling demand is the fastest growth demand in ASEAN.
- The value of energy efficiency is evaluated to demonstrate the key role of energy efficiency to provide energy services cost effectively.
- Efficient cooling appliances not only reduces electricity consumption, but also allows the power system to burn less fossil fuels during peak periods

Demand-side resources reduce total costs as a result of lower peak demand therefore less generation capacity is required.

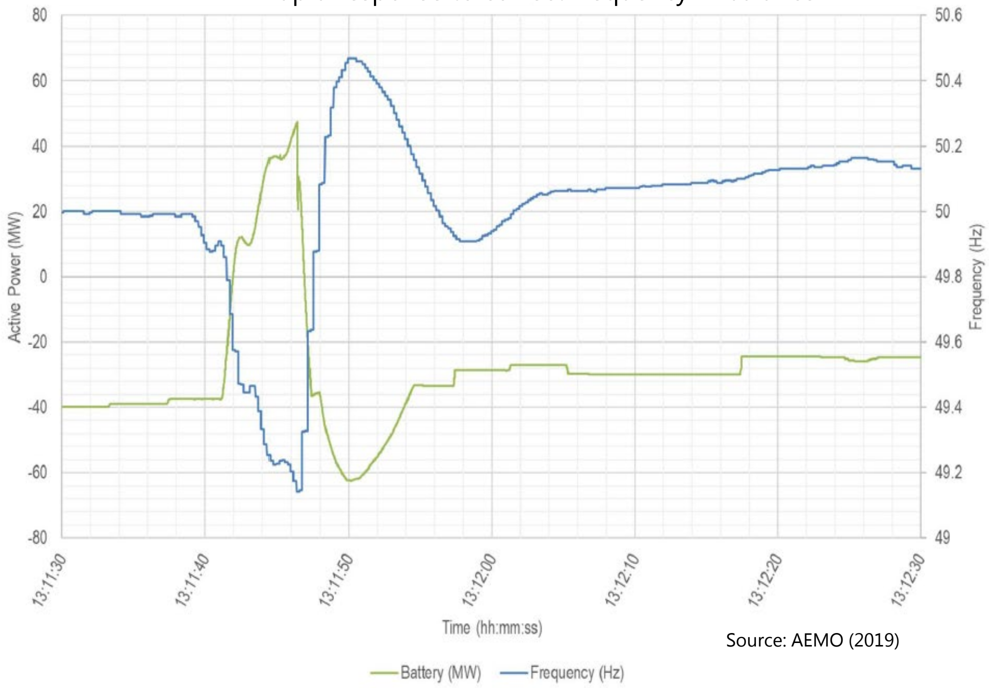
Batteries are becoming a cost-competitive flexibility provider

- Changes to connection codes and market rules **enable participation** by energy storage resources.

- Regulatory innovation is needed to **unlock multiple benefit streams** for storage resources in a system-effective manner.

- *Example: Hornsdale Power Reserve participates in regulation, contingency reserve and energy markets in South Australia*

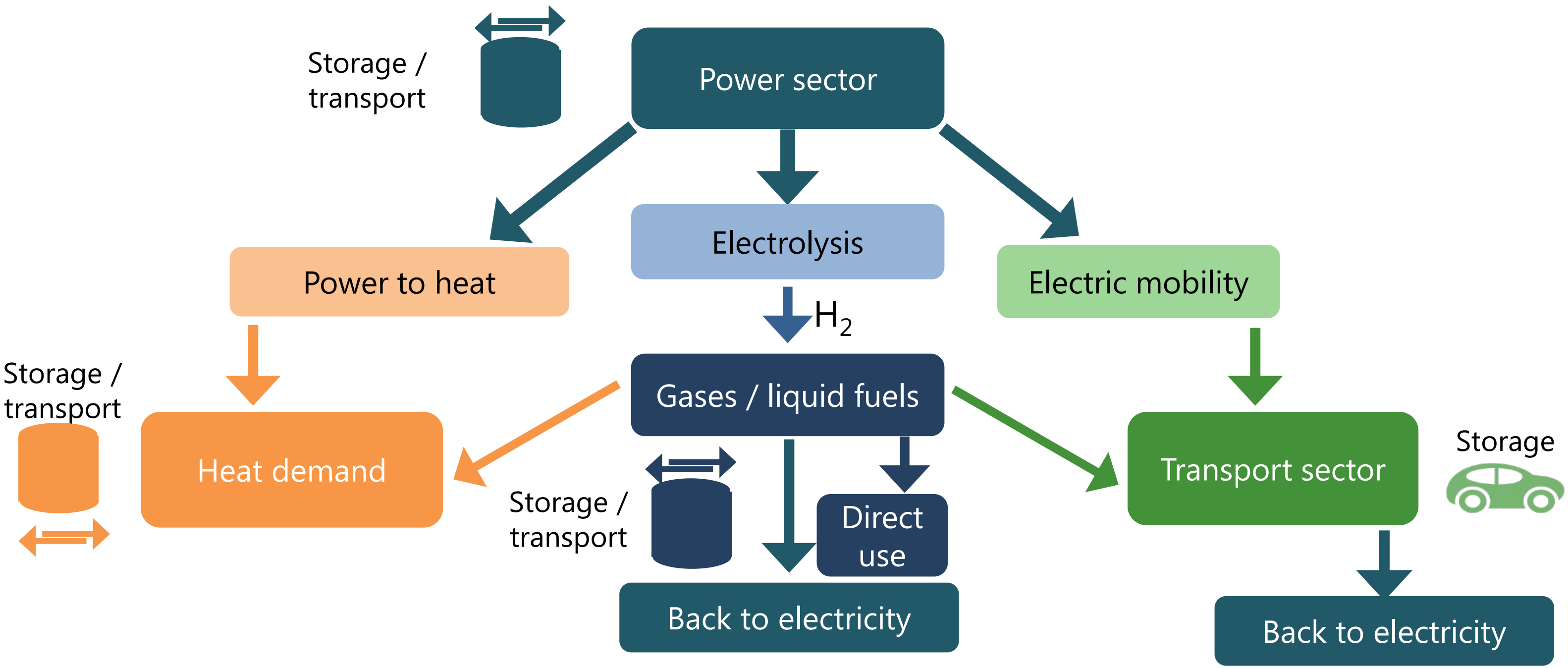
Rapid response to correct frequency imbalance



Source: AEMO (2019)

Prequalification requirements and the design of flexibility services are key to enable battery storage in flexibility services. Benefit stacking can increase financial viability but requires further regulatory review.

Sector Coupling addresses wider energy system decarbonisation



Sector coupling can create flexible electricity demand, dispatchable clean supply, open new ways of energy storage / transport and facilitate decarbonisation via direct use of carbon free synthetic fuels.

Summary and the way forward

- Power system flexibility is essential with increasing VRE penetration
  - Different flexibility requirements and resources depending on the context

- Integrating flexibility resources – *VRE, grids, storage and DER* – goes beyond the typical remit of policy makers. Engagement of regulators, system operators and industry is key.

- Policy maker engagement with actors across the power system is a priority to unlock latent flexibility potential and de-risk investments.

- In regulated contexts, regulatory innovations are key to recognise the value of flexible operations and new system resources as alternatives to conventional investments.

- Integrated power system modelling/studies are essential with high VRE
  - Prioritise modelling studies in accordance with time horizon and VRE phases (and penetration levels)