ERRA 21st Annual Conference
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Energy Regulatory Commission
Office of the Energy Regulatory Commission

Session II:

IMPACT OF CLEAN ENERGY SOURCES ON THE GRIDS AND SYSTEM STABILITY

Addressing technical challenges from high penetration of variable renewables

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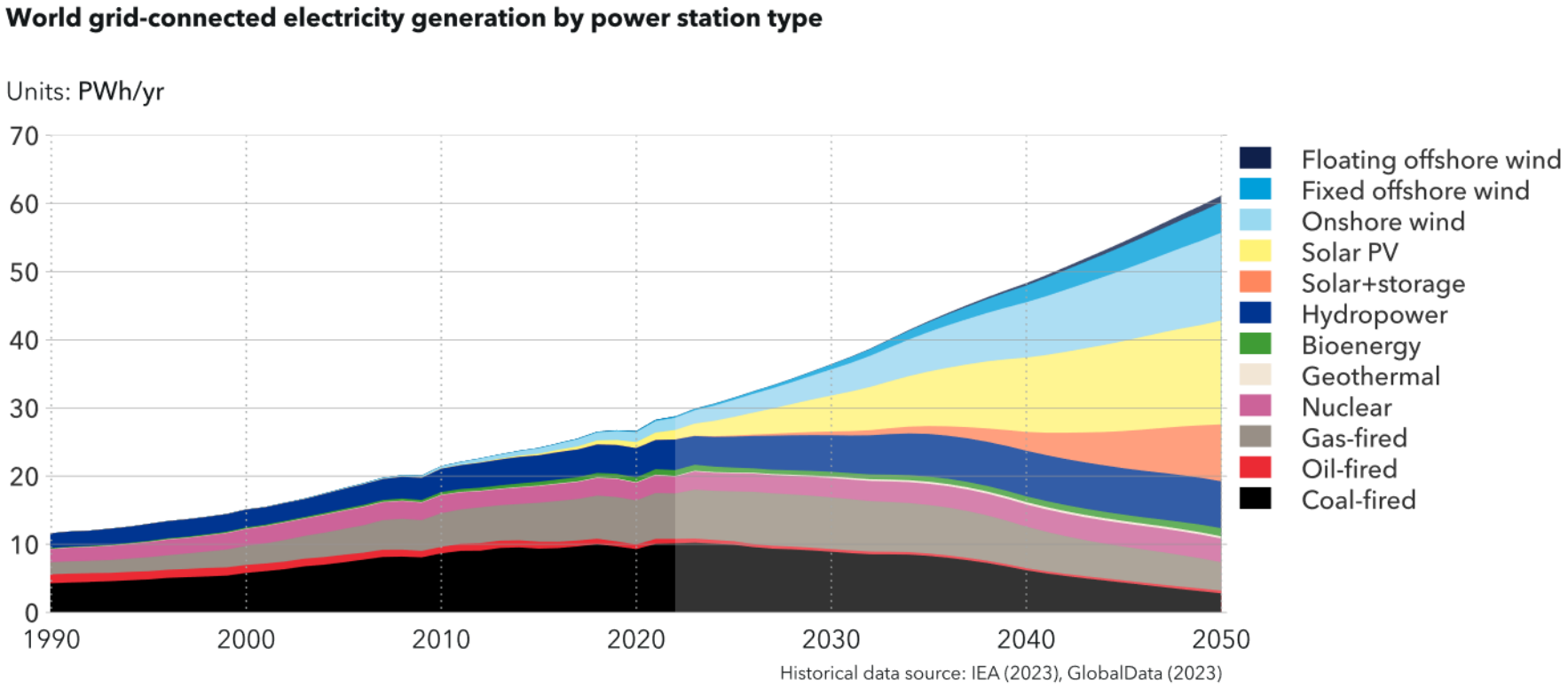
Renewables are the backbone of clean energy systems



- A massive shift in the electricity mix – Almost 70% of electricity will come from solar and wind in 2050
- Increasing share of wind and solar PV requires greater flexibility to ensure the security of electricity supply
- Grid infrastructure (domestic and cross-border) and other flexibility resources are key to integrate wind and solar
  - Grid, transmission and distribution, will both double in length

In 2050, the electricity system will be dramatically different than today

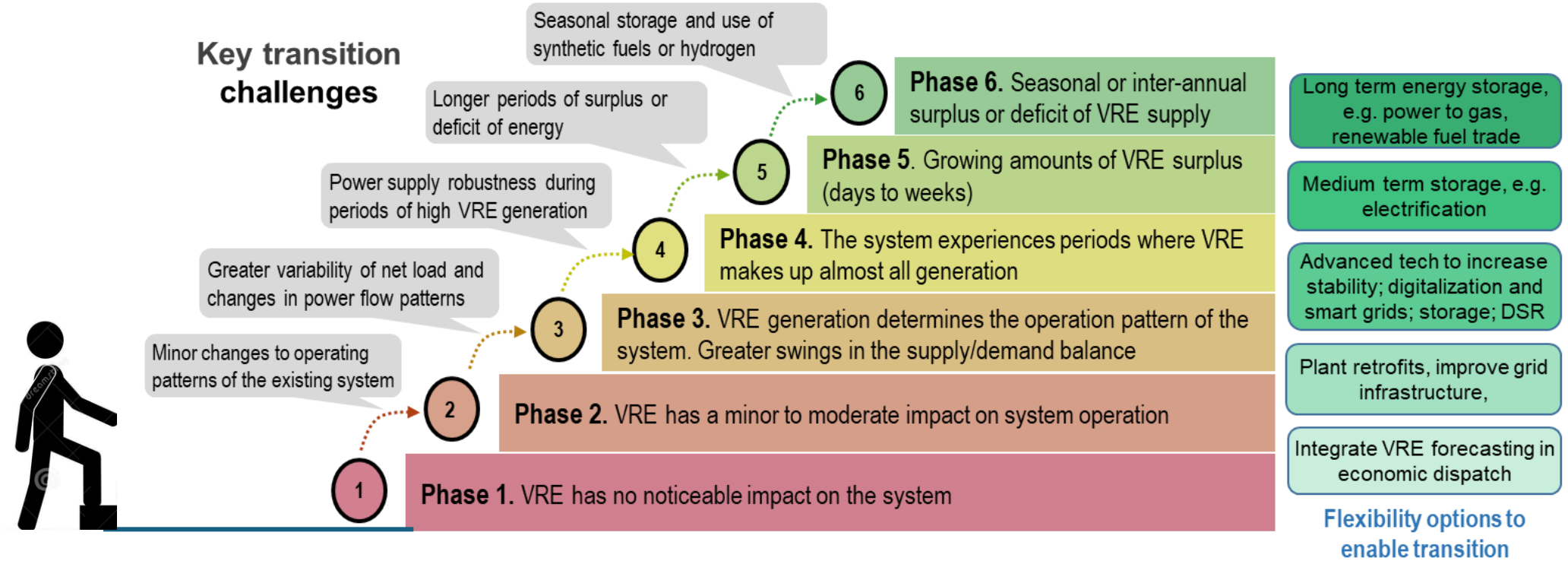
55,000
utility scale PV plants

12,000
onshore wind farms

5,000
offshore wind farms

1.3 billion
passenger electric vehicles

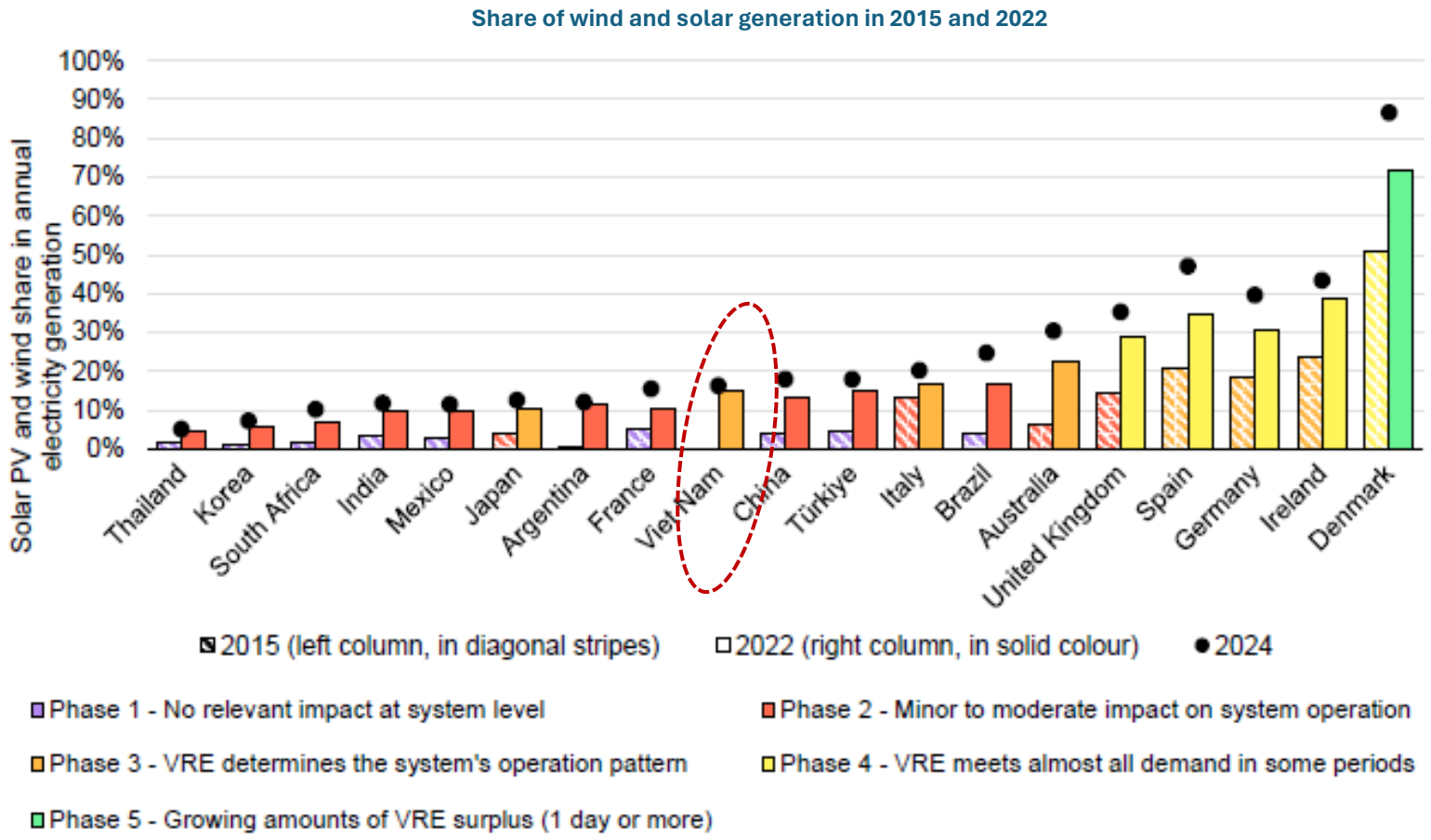
High VRE penetration raises integration challenges



Source: IEA 2019, Status of Power System Transformation 2019

- Integration of VRE might become a challenge since no or limited market-based mechanisms are available
- Expansion of variable renewables require a more flexible power system
- The growth of renewables has not been homogenous across countries (liberalized markets leading)
- No one-fits-all solutions: different power sector structures, liberalization level and VRE integration challenges

Impact of high wind and solar penetration



Source: IEA 2023, Renewable Energy Update

- Impact of high VRE penetration
  - **Technical** – operational challenges and energy security
  - **Economic** – Congestion leads to the risk of low-cost RE curtailment and drive up costs.
  - **Regulatory** – market design, incentives for flexibility resources
- Viet Nam leads the growth of renewables but facing challenges
  - Wind and solar capacity increased from **0.5 GW in 2015** to **25 GW in 2022**
  - Operational and regulatory challenges become the main issue in a short timeframe.

Flexibility resources are key to integrate VRE

Electricity Grid

- Cross-border interconnections
- FACTS devices, special protection schemes, DLR

Generation

- Inertia, fast frequency response, primary response
- Cycling and quick start;

Storage

- Battery (short-term), Pumped Storage Hydro (medium term)
- Hydrogen (long-term)

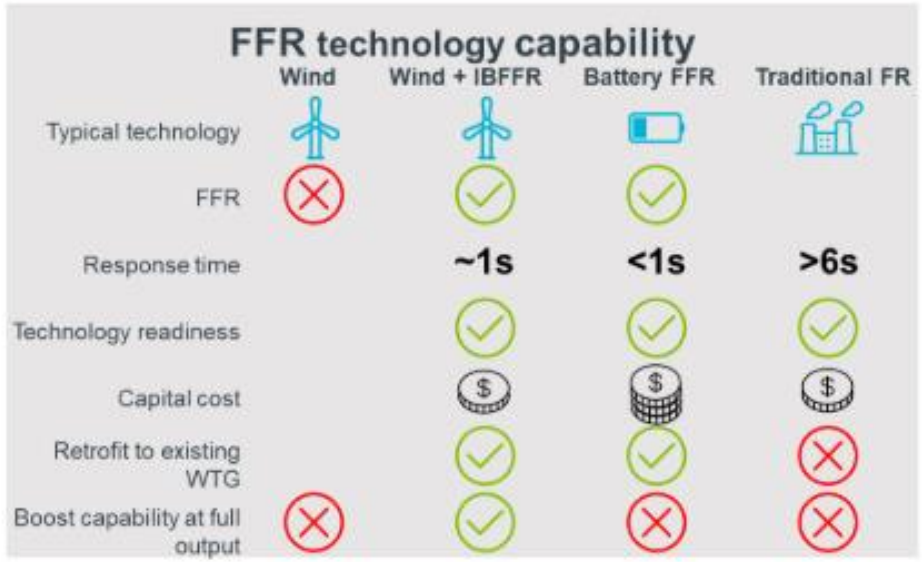
Demand response

- Demand side options (e.g. load shifting)
- Smart meters

- Appropriate policy, market and regulatory frameworks can enable participation of flexibility resources
- Grid codes, ancillary service requirements and remunerations are needed

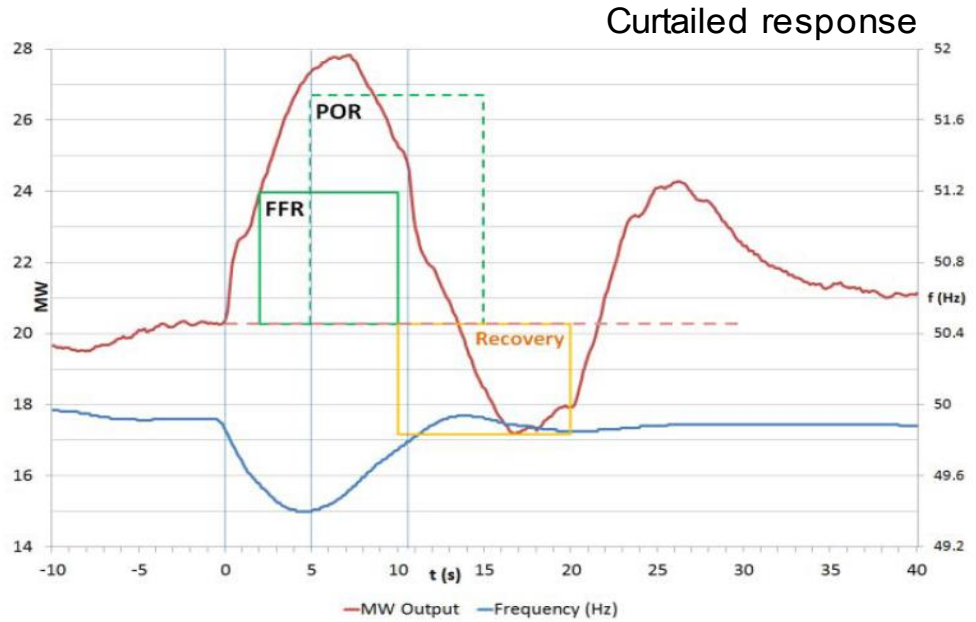
All generation technologies can provide flexibility

Fast frequency response capability of different generation technology



Source: AECOM (2020):e demonstration of Inertia Based Fast Frequency Response

Frequency response from a wind plant in Ireland



- Generating plants (conventional and VRE) are technically capable to provide flexibility – i.e. frequency response
- Market frameworks and regulations are key to enable participation from all power system assets to provide system services (primary, secondary response)
  - Regulations - Grid connection codes
  - Market incentives - Ancillary service markets

Battery is now the main flexibility provider

Figure 68 Batteries further grew FCAS market share

FCAS volume market share by technology – Q4 2023

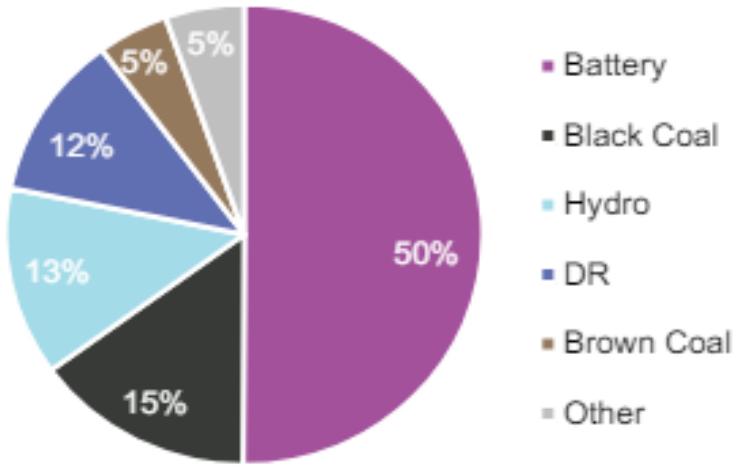
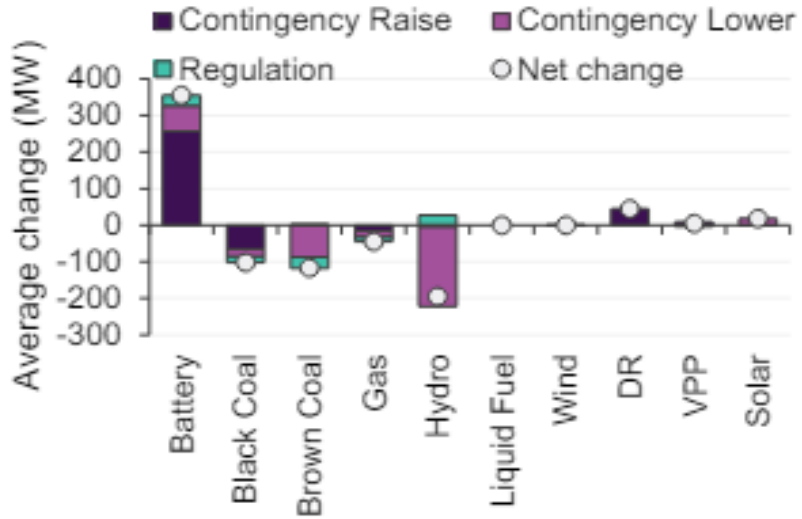


Figure 69 Increased enablement for batteries and DR

Change in FCAS enablement by technology – Q4 2023 vs Q4 2022

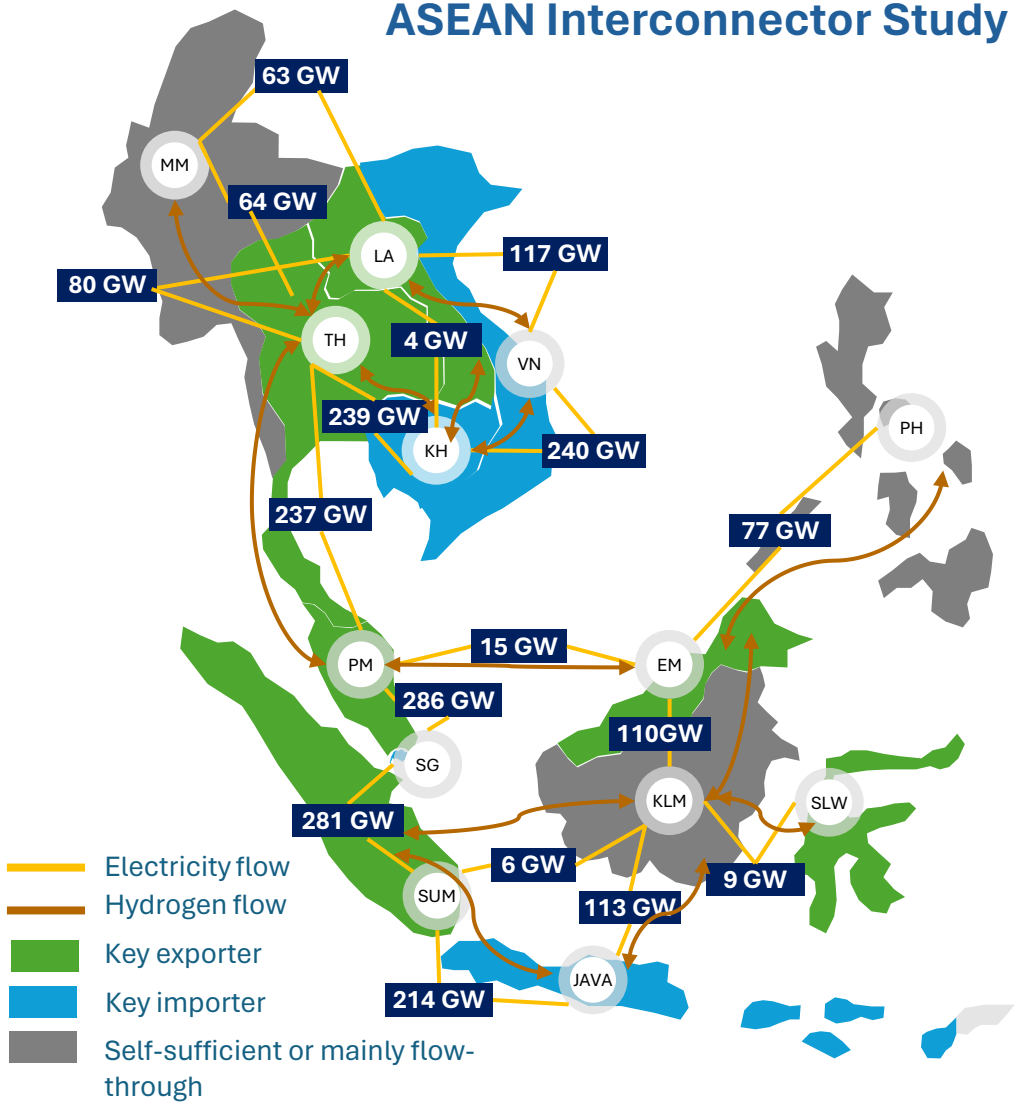


Source: AEMO (2024), Quarterly Energy Dynamics Q4 2023

- Changes to connection codes and market rules **enable participation of** energy storage resources.
- Regulatory innovation is needed to **unlock multiple benefit streams** for storage resources in a system-effective manner.
- In the Australian National Electricity Market (NEM), battery is the main source of Frequency Control Ancillary Services (FCAS)
- Prequalification requirements and the design of system services are key to incentivize and enable the services from battery

Regional interconnection plays a key role to support RE integration and decarbonisation

ASEAN Interconnector Study



The regional approach will require

3.75 mil km

of additional electrical infrastructure

The regional approach will reduce the need of

600 GW

less solar capacity to be installed

13%

footprint reduction

1.2 TWh

electricity storage

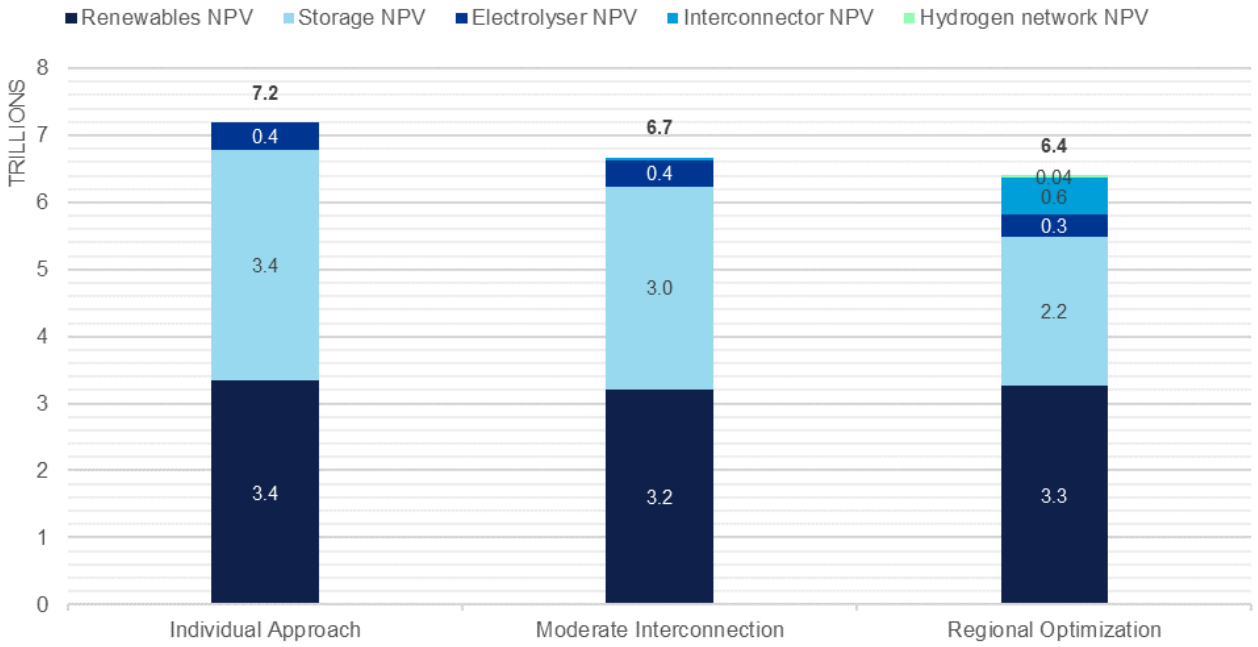
16 TWh

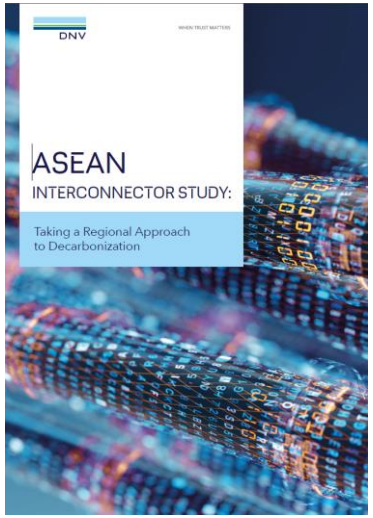
hydrogen storage

- **Regional cooperation in cross-border trading** plays a key role towards decarbonisation in 2050
- Sharing low-cost and low-carbon resources
- Significant economic and environmental benefits
  - Reduce resource requirements and footprints
  - Net-zero emission vision

Potential value of cross-border interconnections

Estimated costs for decarbonising ASEAN power systems





Download the report:

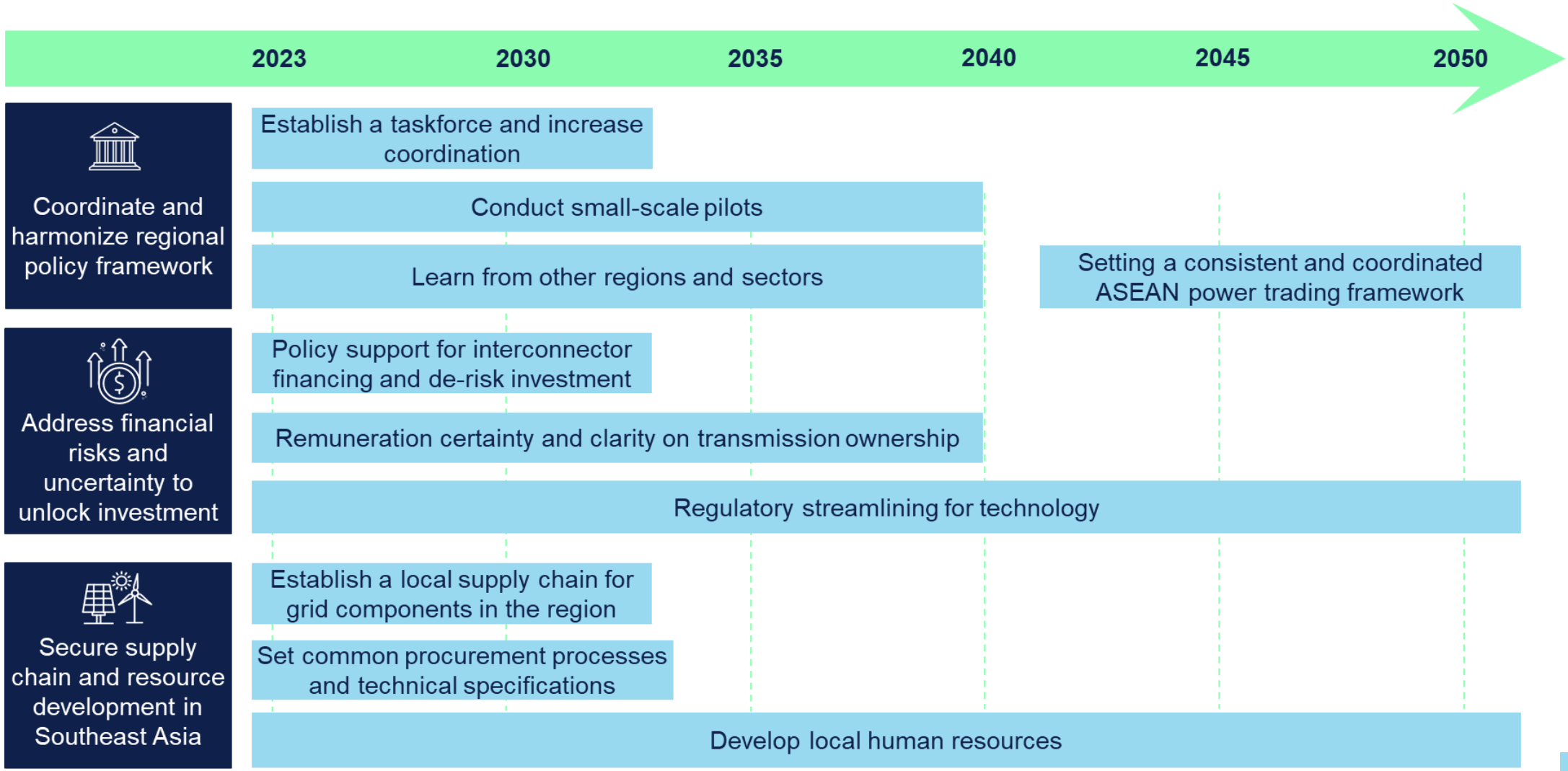
- **Economic benefits**
  - $600 million cost savings in decarbonisation
  - Savings in peak capacity needs
  - Allowing sharing of low-cost renewables and enabling power trade between the systems.

- **Enhance energy security**
  - Sharing of reserve between systems
  - Larger geographical spread can smooth the variability of overall VRE generation
  - Diversification of demand and generation patterns
  - Sharing of flexibility resources (i.e. storage)

Challenges to implement regional integration

Technical	• **Concerns over energy security** due to unreliable domestic grids • **Impact of high RE penetration** leading the country to prioritise domestic grid • **Limited technical expertise** in building and operating cross-border interconnections (both HVDC and HVAC)
Financial and economic	• **Uncertainties on funding source, ownership structure**, and remuneration. • **Vertically integrated market structure** - investment in power grids needs support from governmental and private stakeholders • **Limited financial resources** of electric utilities and governments to invest in grids, including cross-border interconnectors
Policy and regulatory framework	• **A diverse set of policies** and market structure among ASEAN countries • **Uncertainty in political will** and institutional arrangements • **Lengthy regulatory process** in permitting and licensing

Priorities to support regional integration in ASEAN



Key takeaway

- **Solar and wind will be the main source of electricity generation** as part of clean energy transition and decarbonisation
- **High penetration of wind and solar present challenges to the power system** due to their variability and uncertainty
- **Flexibility to facilitate renewable integration can be provided by all system resources** – generation, electricity grids, storage and demand response
- **Cross-border interconnections can provide significant benefits** and play a key role towards decarbonisation but challenging to develop and implement
- **Need harmonised regional policy** and regulatory framework.
- **Engagement of policymakers, regulators, system operators** and industry is key.

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