International Energy Agency

Electricity Security and Renewables Integration

Electricity Security Advisory Board (ESAB), 17 September 2024

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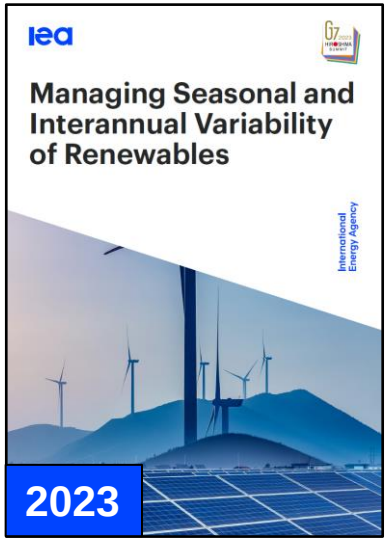
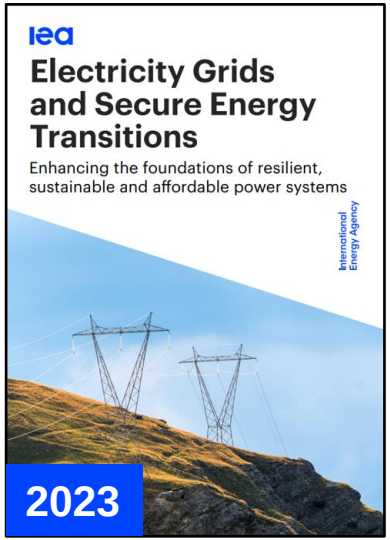
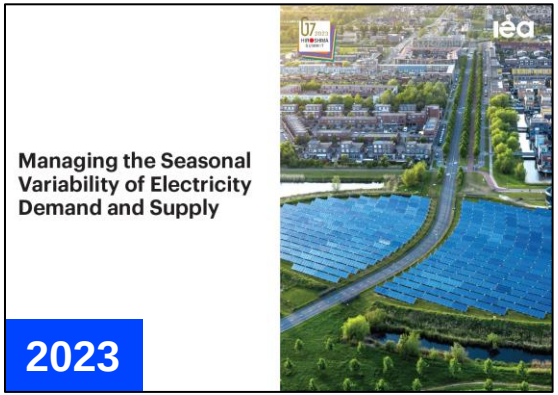
Electricity Security at the heart of IEA's mandate



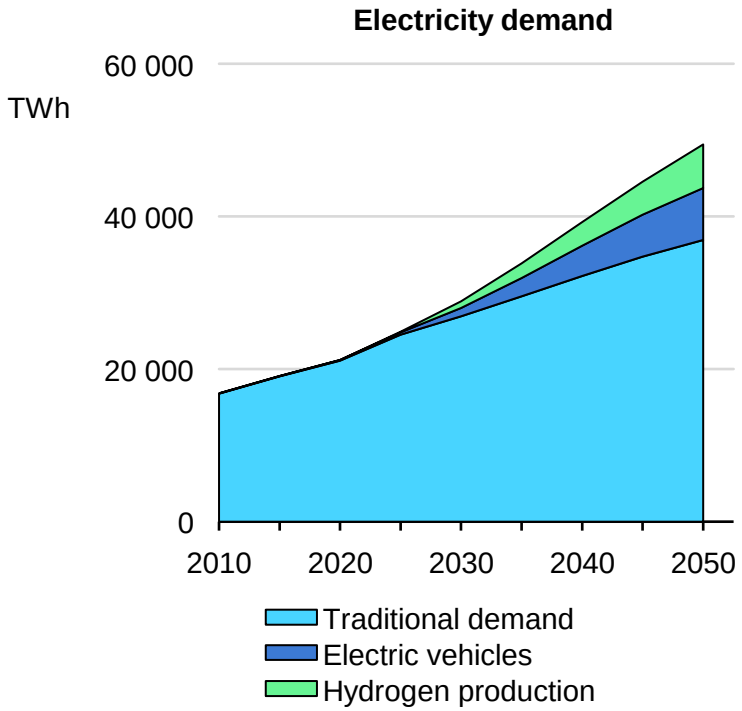


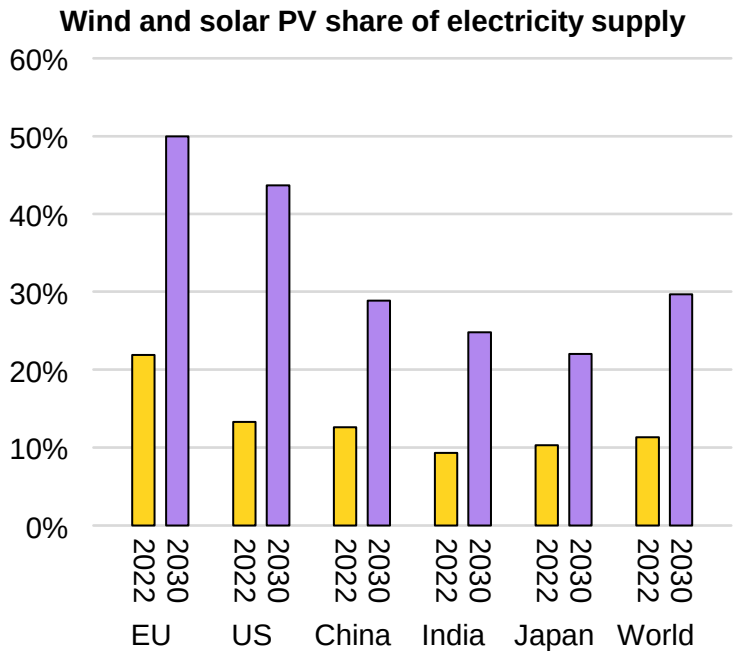


(upcoming)
Ireland 2024
Energy Policy Review

2024

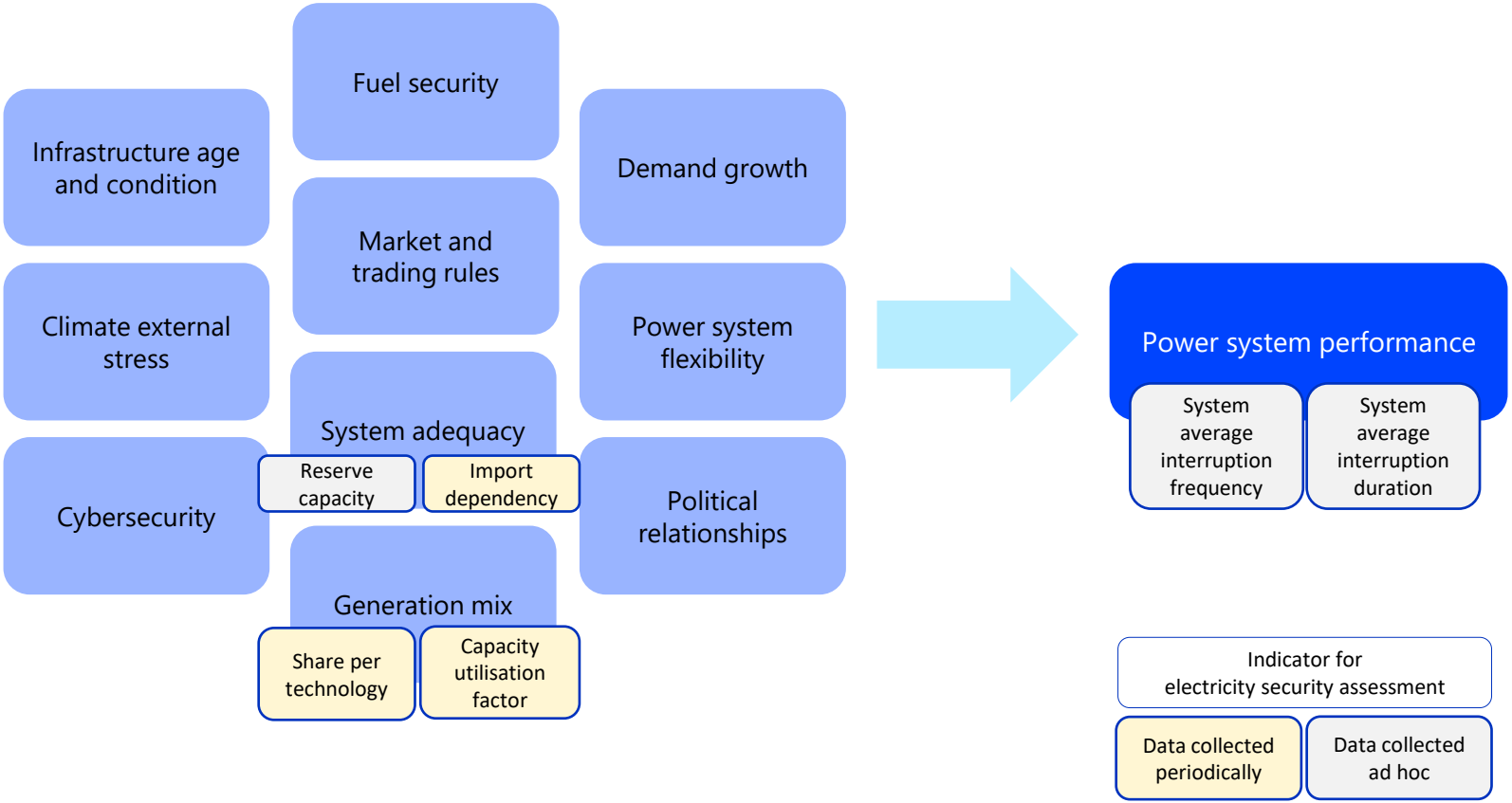
The nature of electricity systems is changing



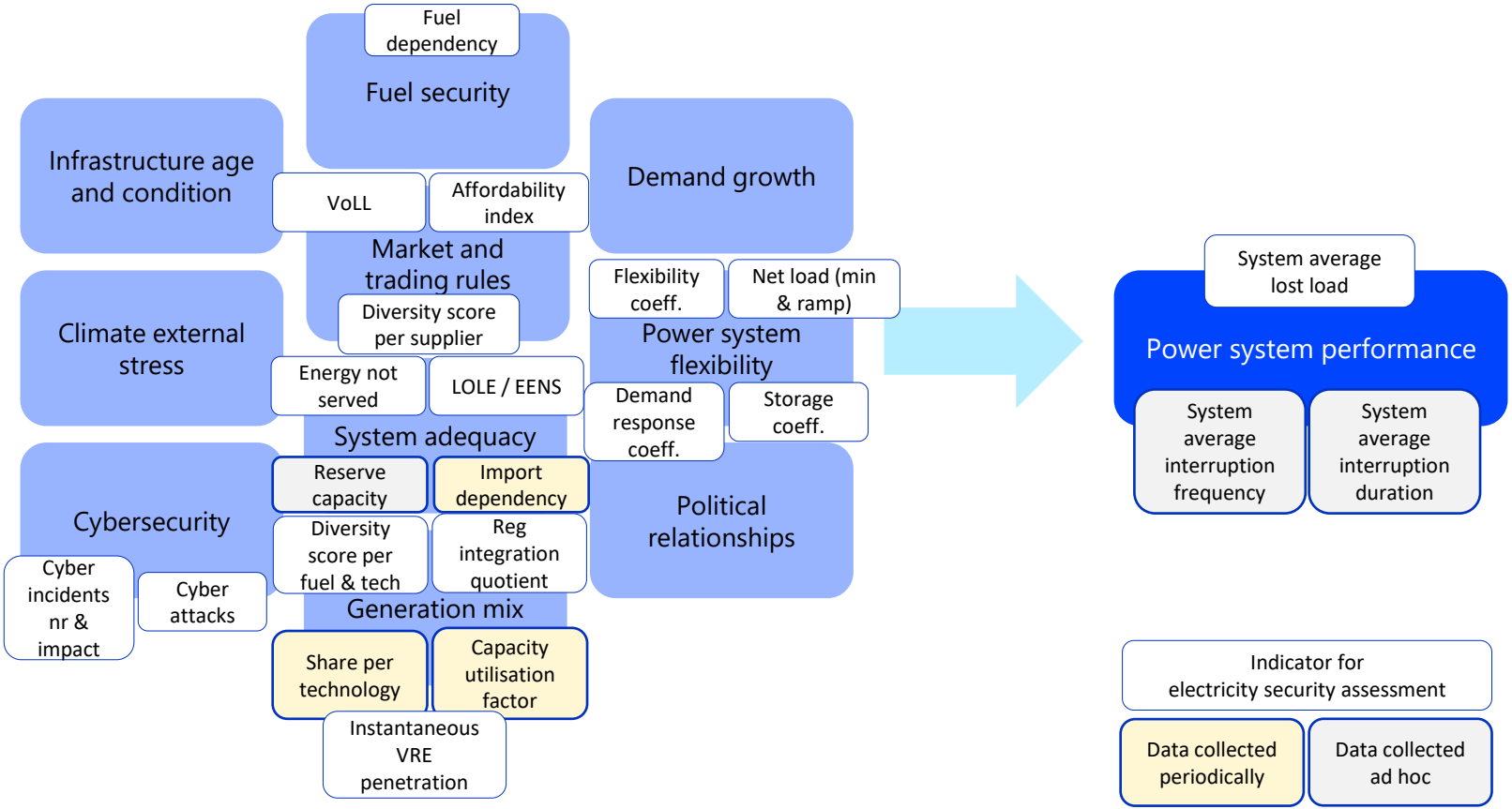


The transformation of demand and supply are shaped by policies addressing decarbonisation and industrial strategies

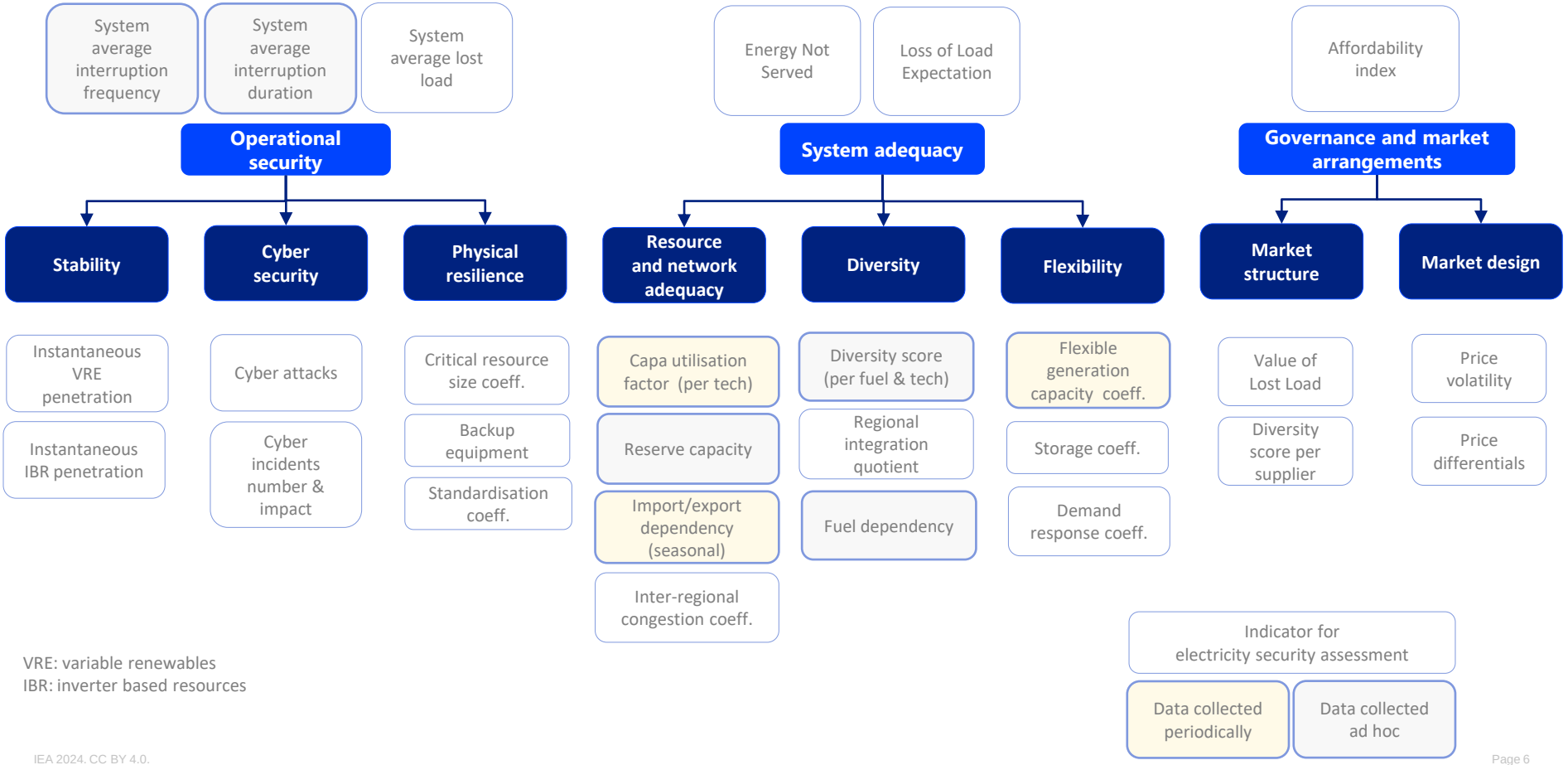
The typical definition of security is too narrow and very technical



On the other hand, the theoretical space is too large



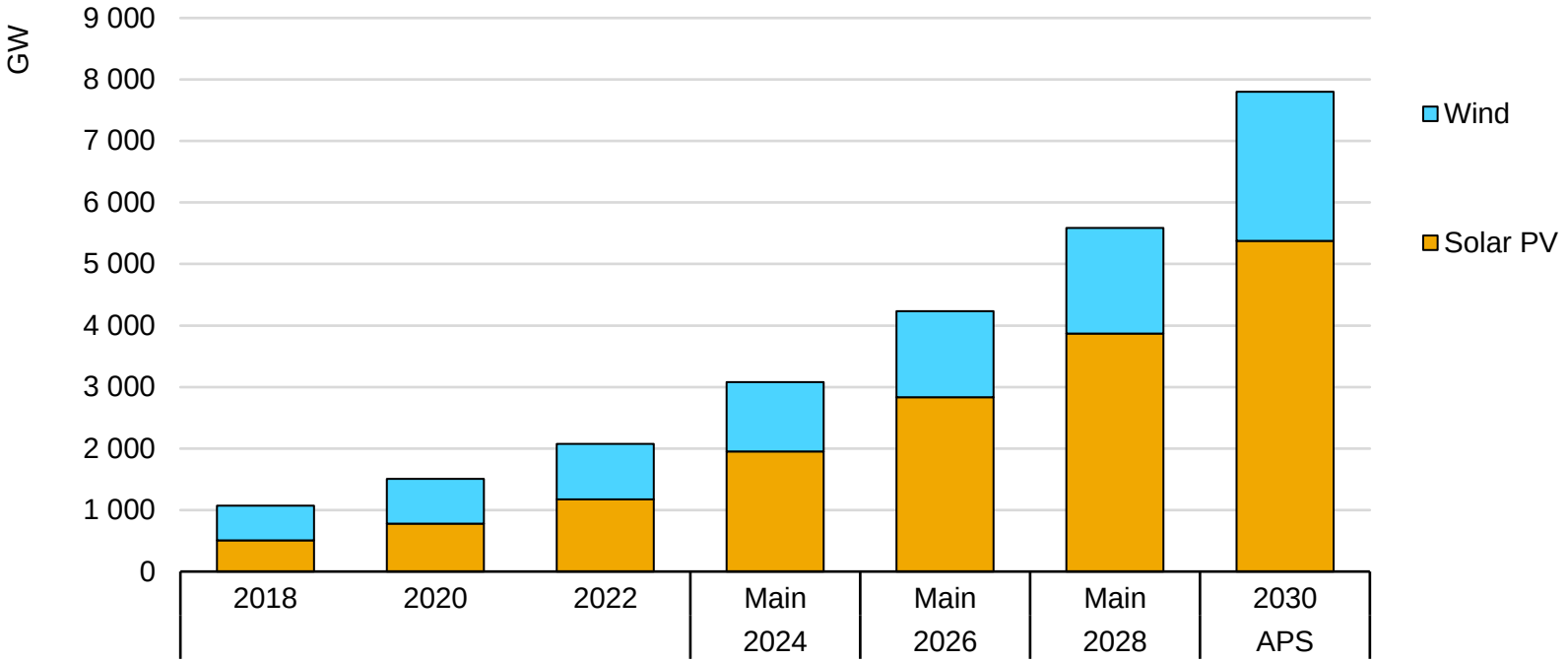
Towards a modern, comprehensible and actionable framework



VRE: variable renewables
IBR: inverter based resources

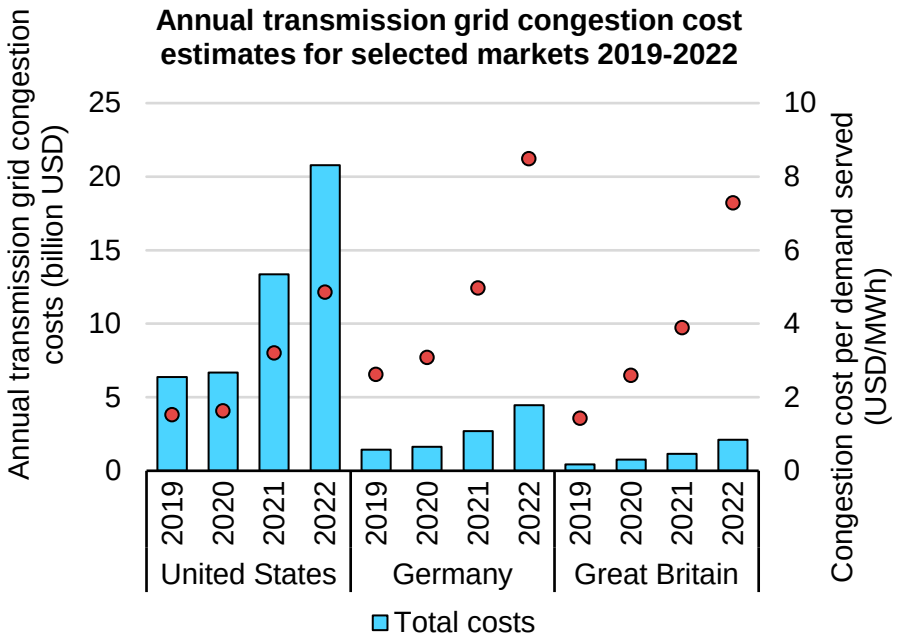
Solar PV and wind are set to grow further towards 2030

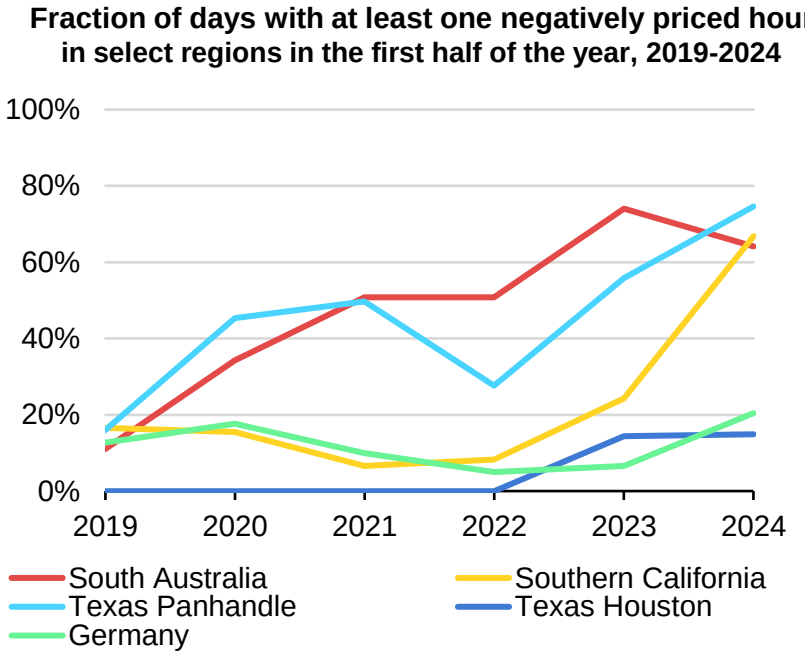
Historical and future cumulative solar PV and wind capacity in the Renewables 2023 main case (2024-2028) and APS (2030)



Governments are positioning solar PV and wind as key pillars for decarbonising the energy sector.

Variable renewables need to be integrated as they are deployed





Concerns over symptoms of integration challenges, such as grid congestion and negative prices are sending cautionary signals to investors in solar and wind.

Timely integration requires addressing challenges at different phases

Phases of VRE integration framework

Low phases

Phase 1: VRE has no significant impact at the system level

Phase 2: VRE has a minor to moderate impact on the system

Phase 3: VRE determines the operation pattern of the power system

High phases

Phase 4: VRE meets almost all demand at times

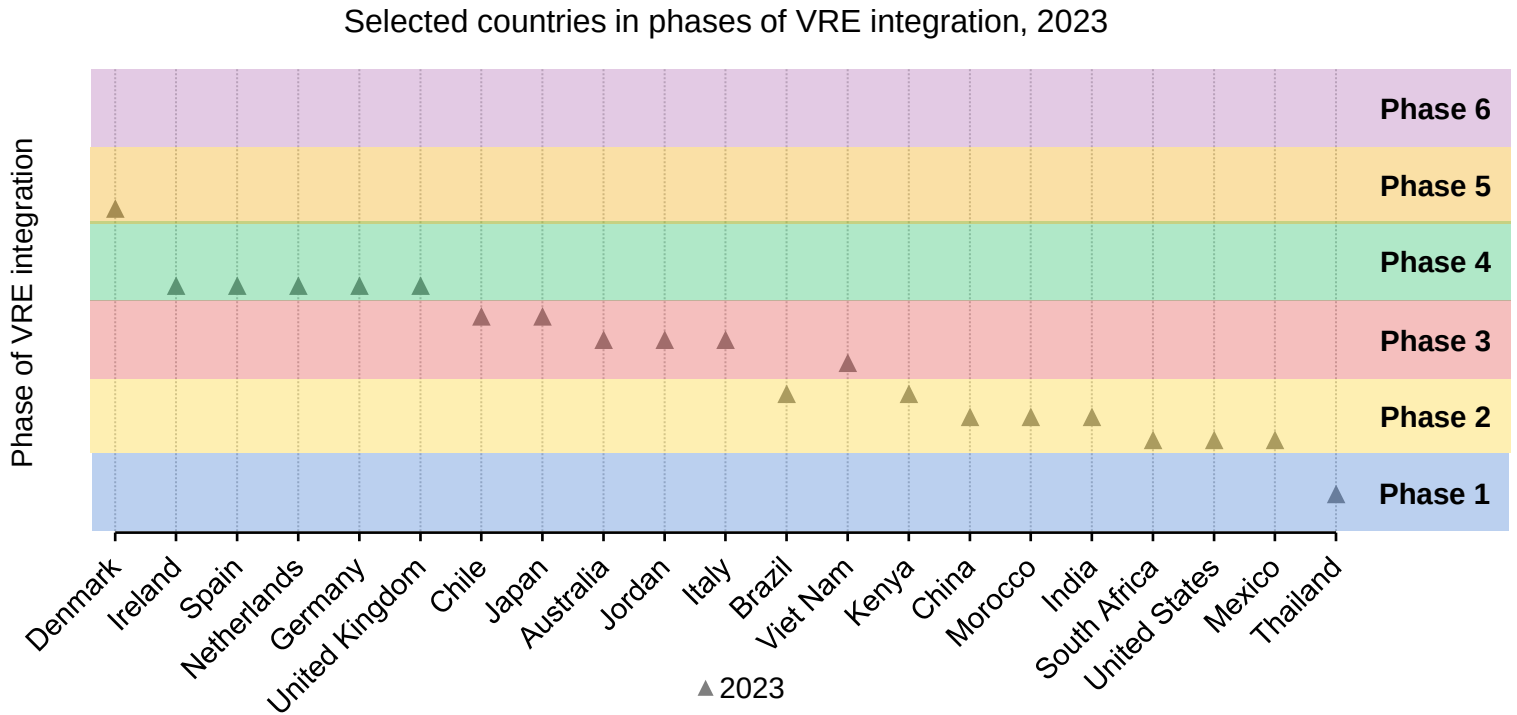
Phase 5: Significant volumes of surplus VRE across the year

Phase 6: Secure electricity supply almost exclusively from VRE

VRE = variable renewable energy

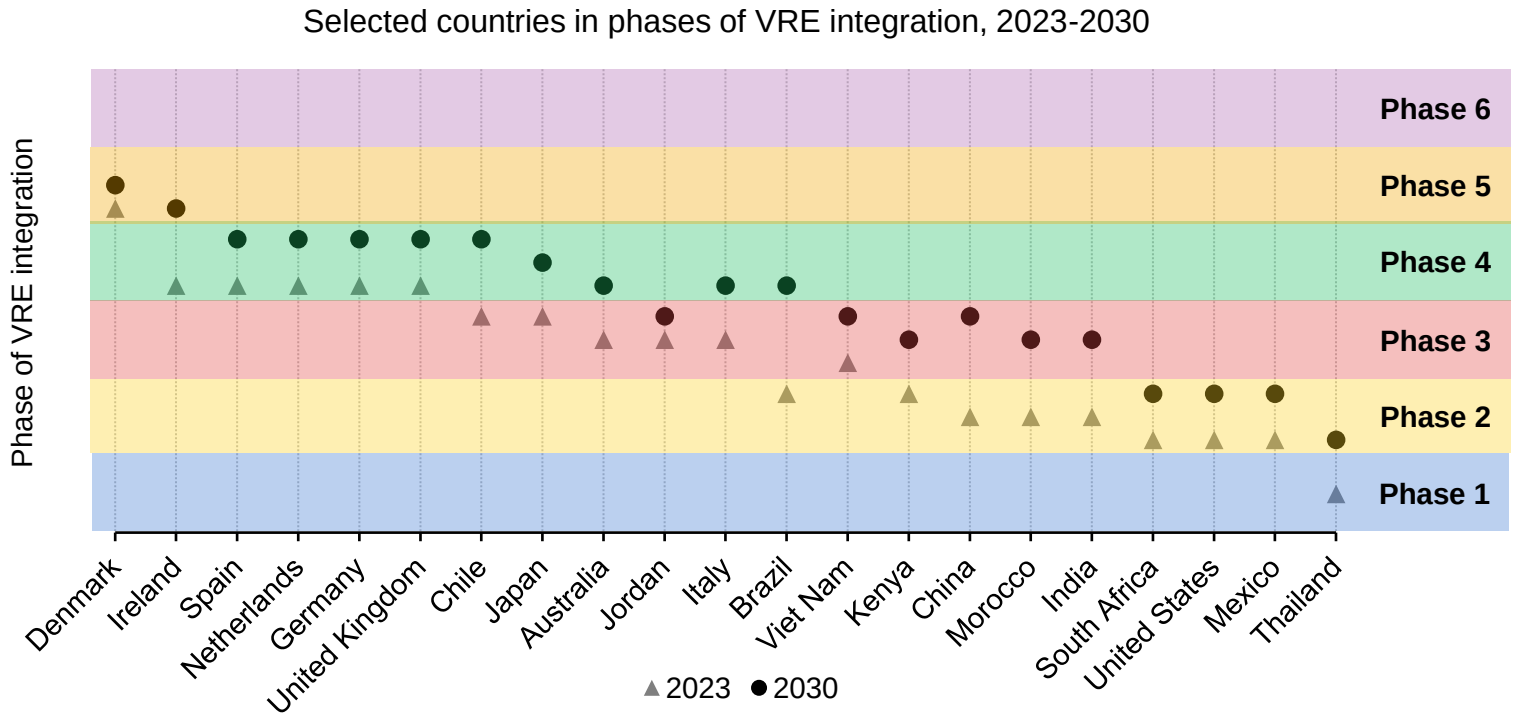
The framework allows policy makers to identify VRE integration measures that need to be prioritised at each phase to ensure its timely implementation.

Most power systems in the world are currently in low phases…



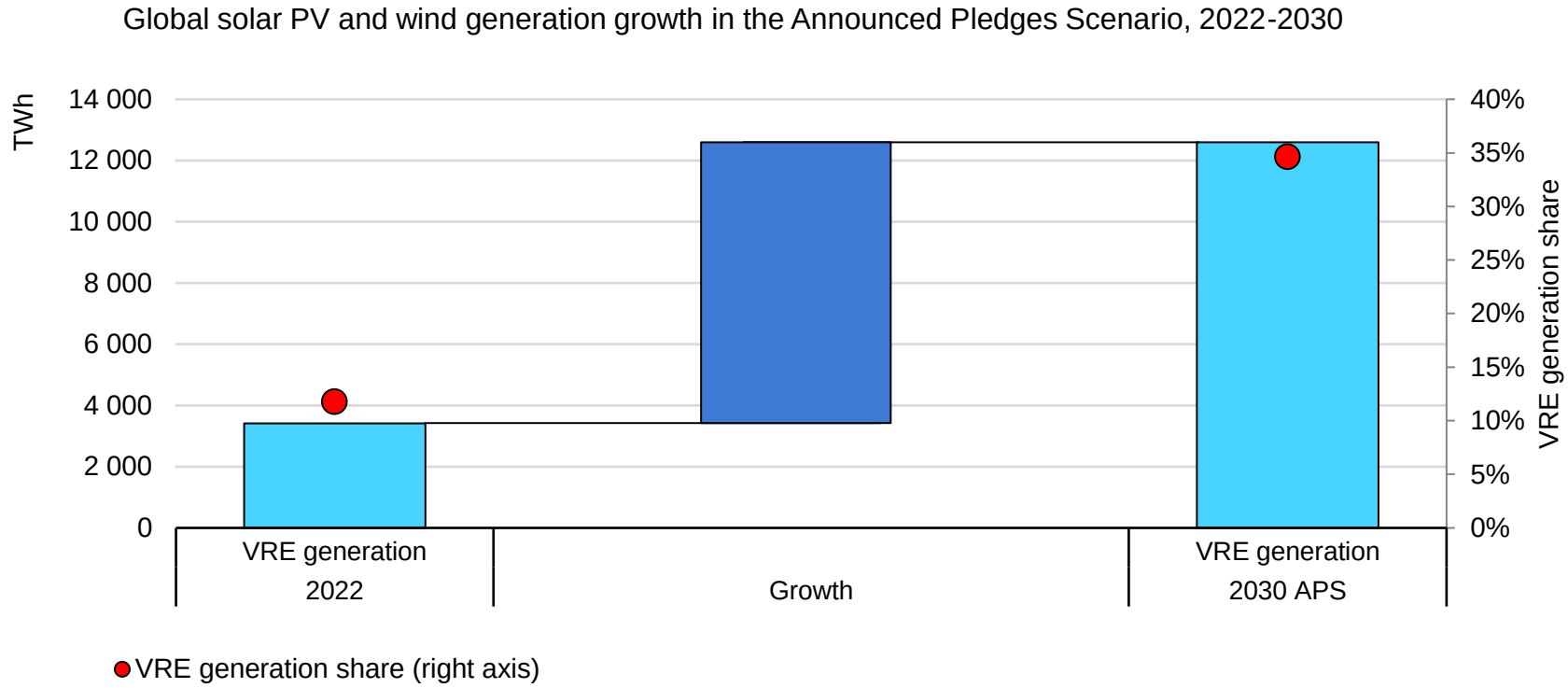
Several countries with different geographies and levels of economic development reached Phase 3 by 2023, indicating that there is a wealth of global experience to manage the challenges in low phases.

…but more systems will be at higher phases by 2030



Some countries are currently classified at high phases with high wind penetration, but more systems will be at high phases by 2030 driven by solar PV penetration.

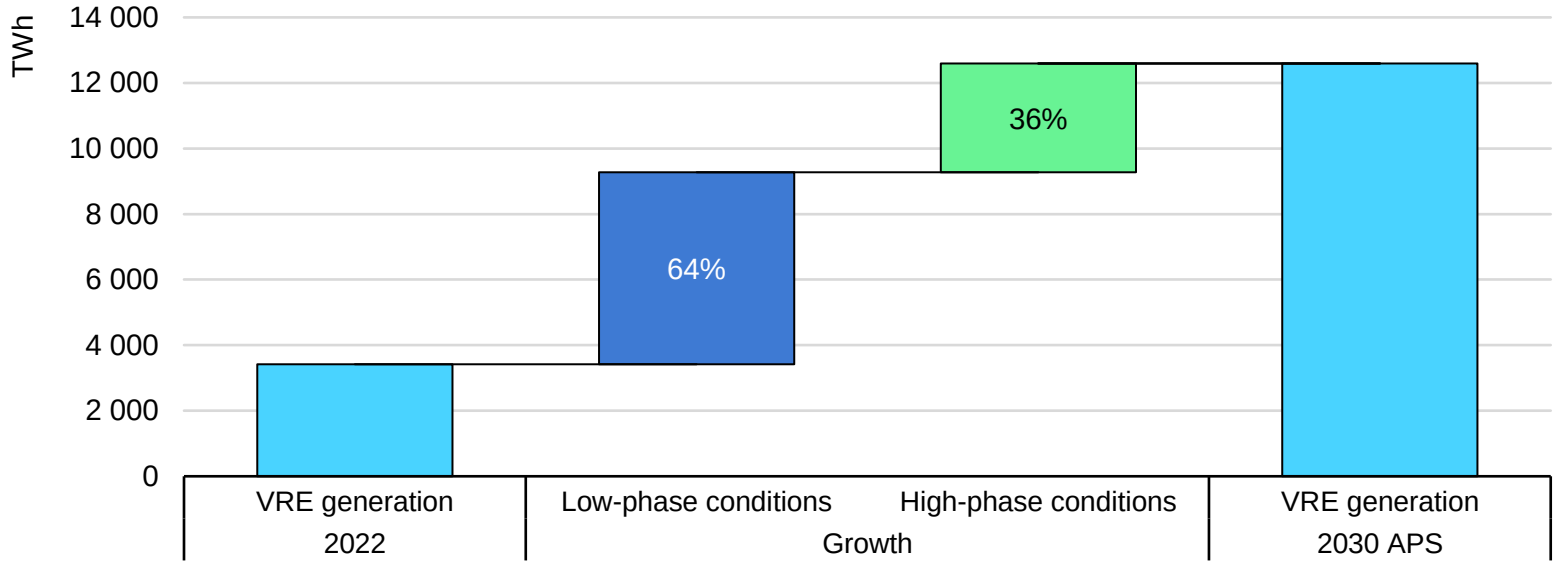
VRE generation in 2030 needs to grow almost four times that of 2022



Global growth in VRE to meet APS 2030 would result in 4.2 Gt of carbon dioxide (CO_2) emissions reductions.

Most VRE growth occurs in low phase conditions

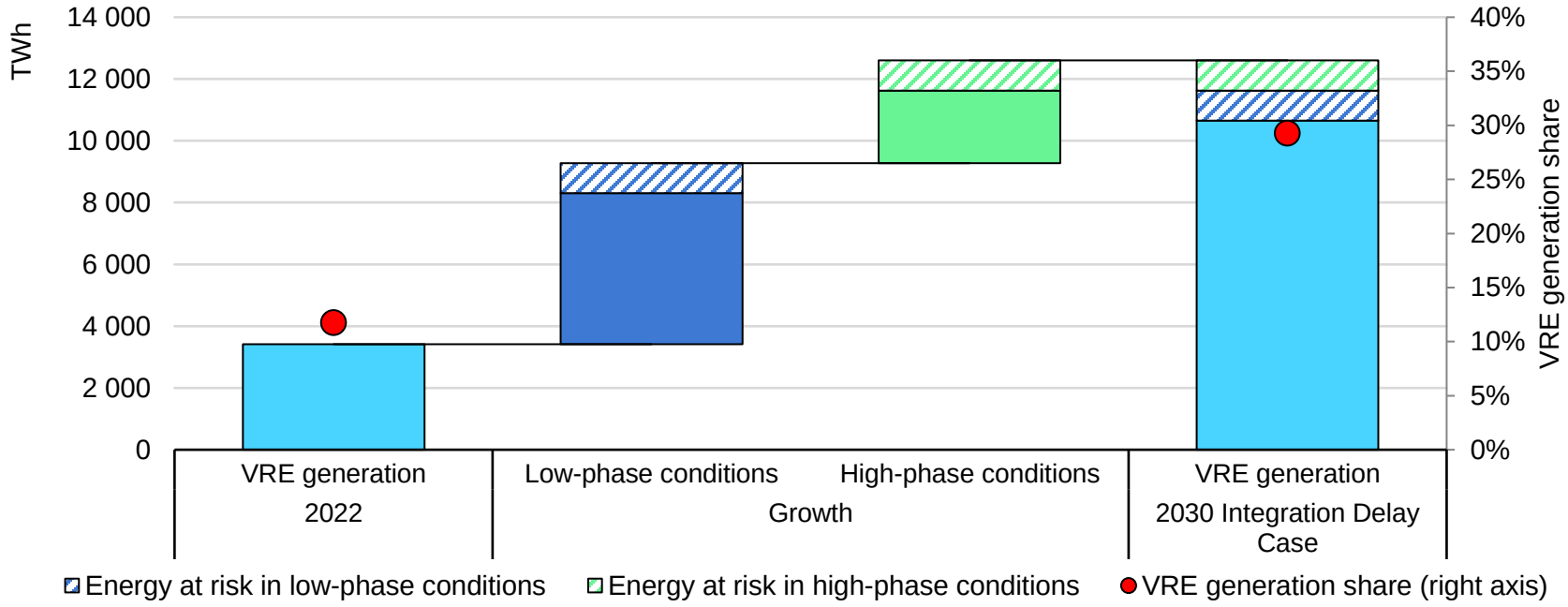
Global solar PV and wind generation growth in conditions of low and high phases of VRE integration in the Announced Pledges Scenario, 2022-2030



64% of growth is in systems in low-phase conditions and 36% in systems in high-phase conditions.

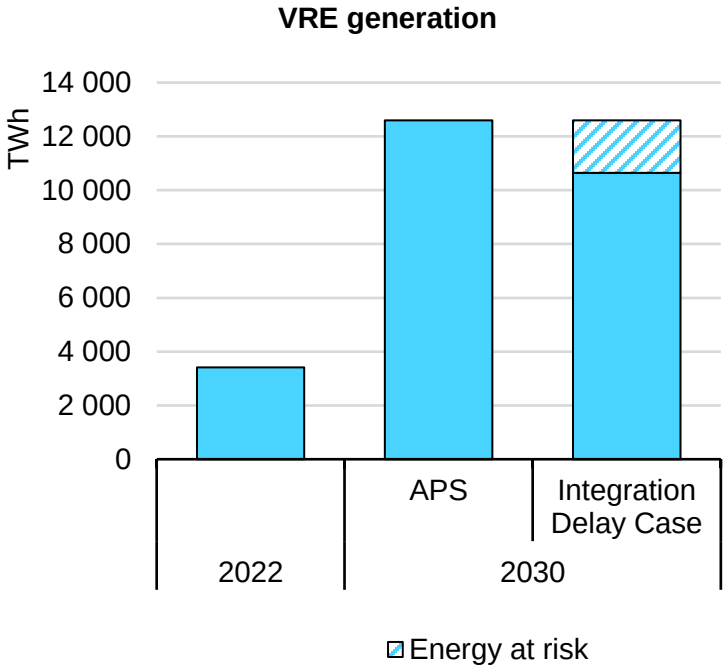
Delaying integration risks VRE growth

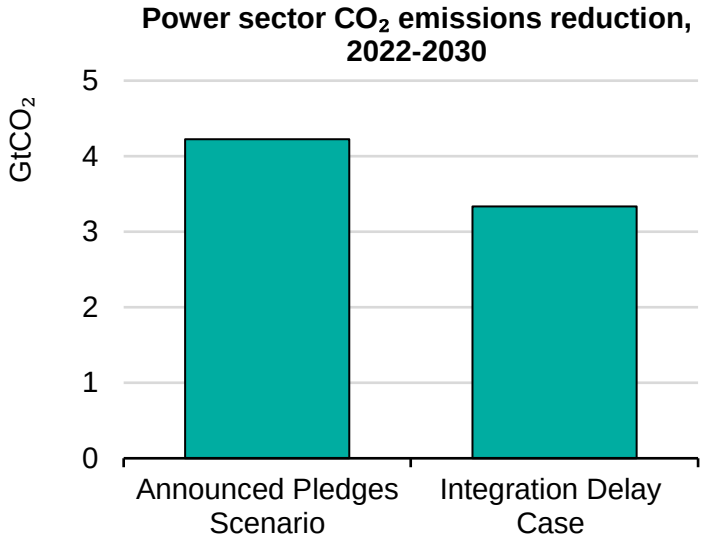
Global solar PV and wind generation at risk in the Integration Delay Case and the Announced Pledges Scenario, 2022-2030



Delaying the implementation of measures to support integration could result in electricity from solar PV and wind being 15% lower in 2030.

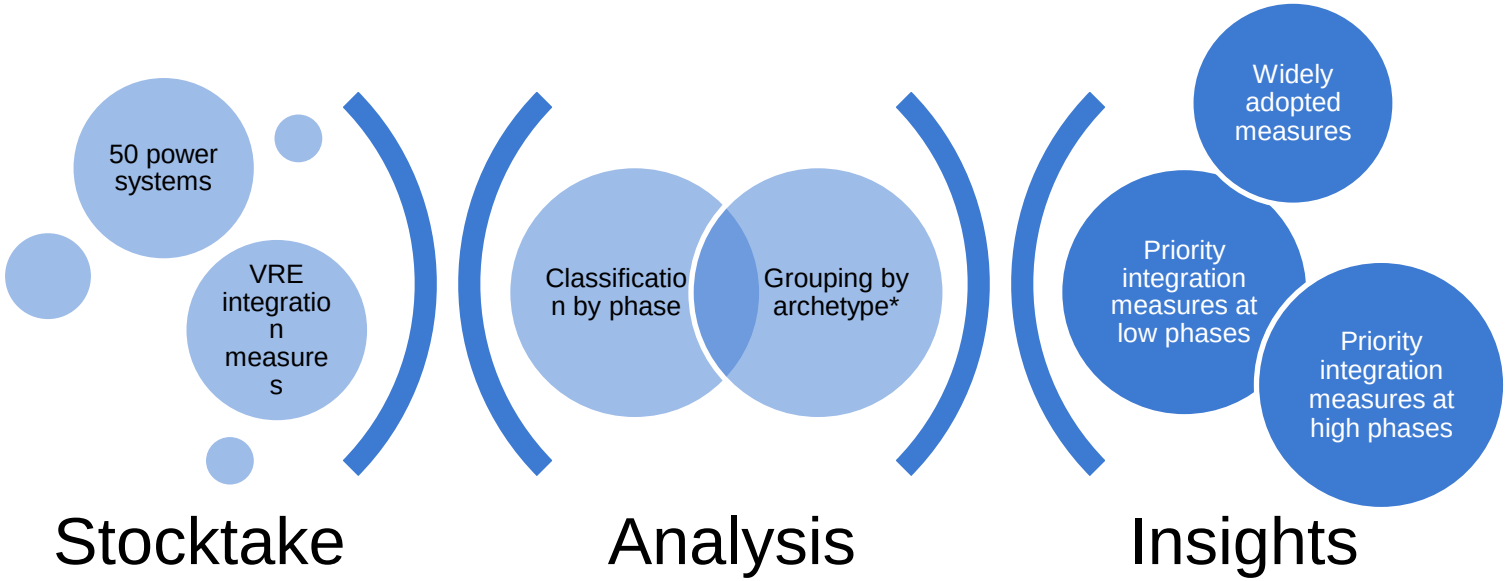
Potential consequences of delaying VRE integration





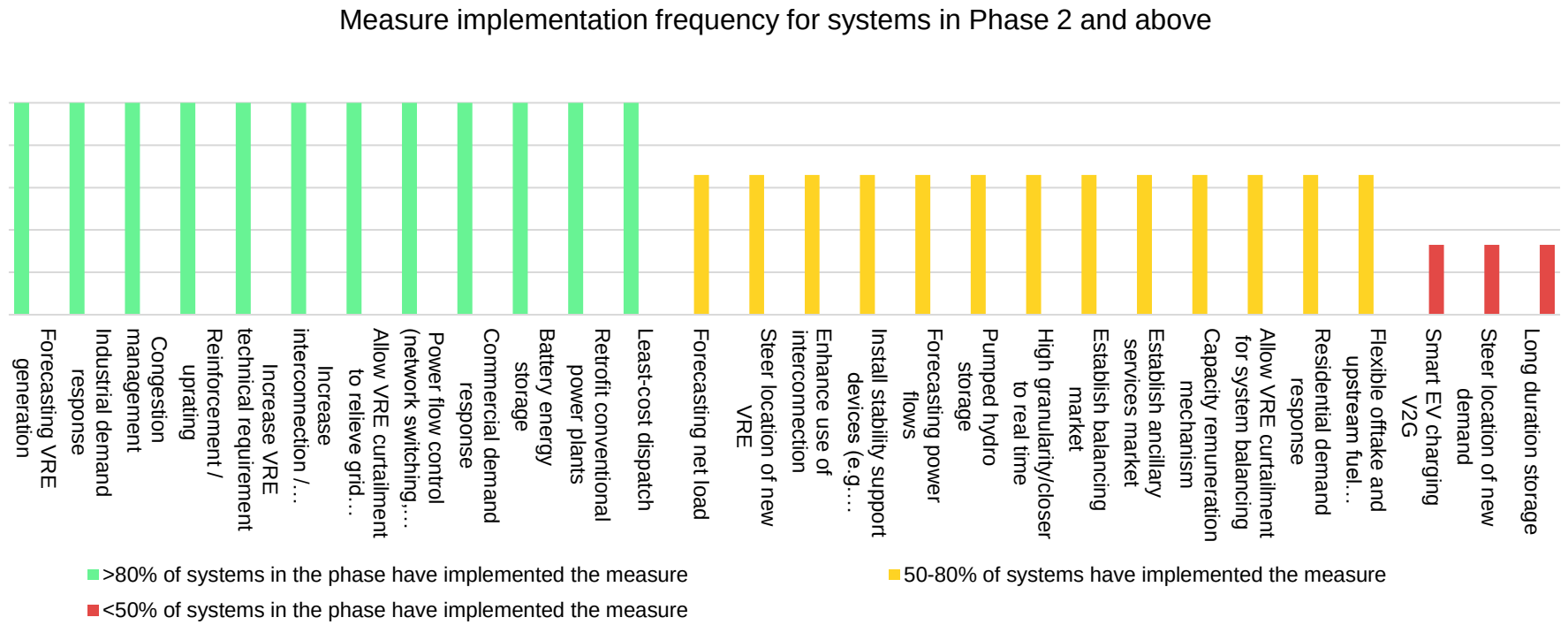
If this decrease is compensated by increased reliance on fossil fuels, it could lead to up to a 20% smaller reduction of CO_2 emissions in the power sector.

Stocktake of VRE integration measures



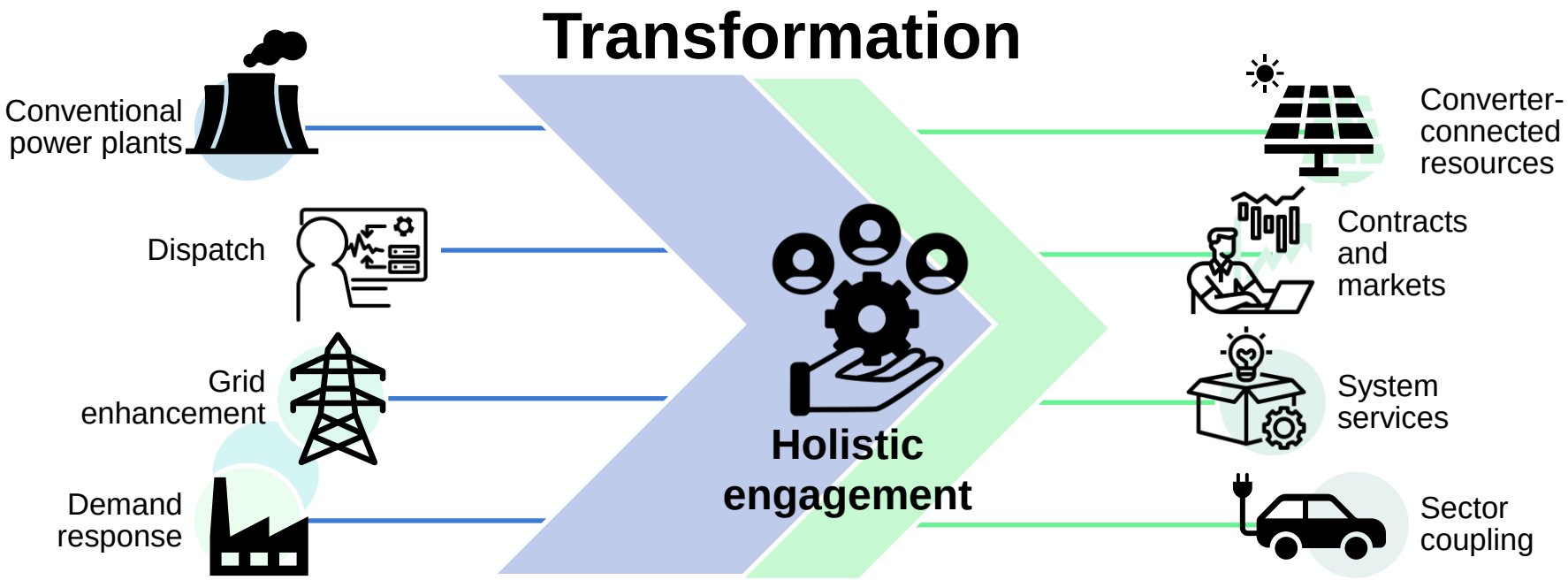
*Grouping together of systems sharing similar characteristics that affect their ability to deal with the challenges at each phase of VRE integration

Measures based on progressive and targeted adjustments can integrate most new capacity in low-phase systems



Countries that currently have low shares of VRE can typically boost deployment without enacting sweeping, system-wide changes. Well-known and tested measures – implemented gradually as the need arises – tend to be sufficient.

A strategic transformation ~~of energy systems~~ is required at high phases of VRE integration



New frameworks to extract further flexibility and system services from a wider range of sources, and new technologies to ensure stability and manage surplus energy, will need to be considered

Six key policy actions to accelerate effective VRE integration

Assess the system's preparedness for VRE integration by improving understanding of power system resources, identifying infrastructure needs, and gaps in funding, data and skills.

Ensure secure grid operation with clear requirements from VRE such as forecasting accuracy, asset visibility and controllability, and its reaction to disturbances.

Unlock flexibility from the existing power system to manage increasing variability by optimising dispatch, activating demand response, and making existing generation operate flexibly.

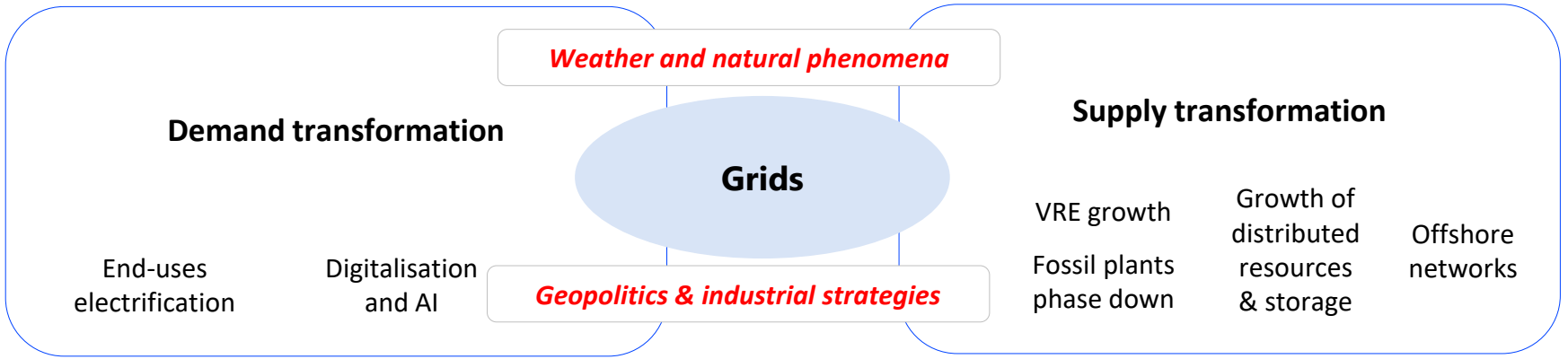
Design incentives to garner flexibility and system services from a wider range of sources by defining and quantifying the need and creating procurement frameworks.

Accelerate technology integration and innovation with regulatory, market, and strategic support to rapidly scale up and develop technologies that are key for long-term decarbonisation.

Adopt a holistic approach to power system planning, by integrating cross-sectoral dynamics, incorporating resilience in addition to security and efficiency and leveraging global expertise.

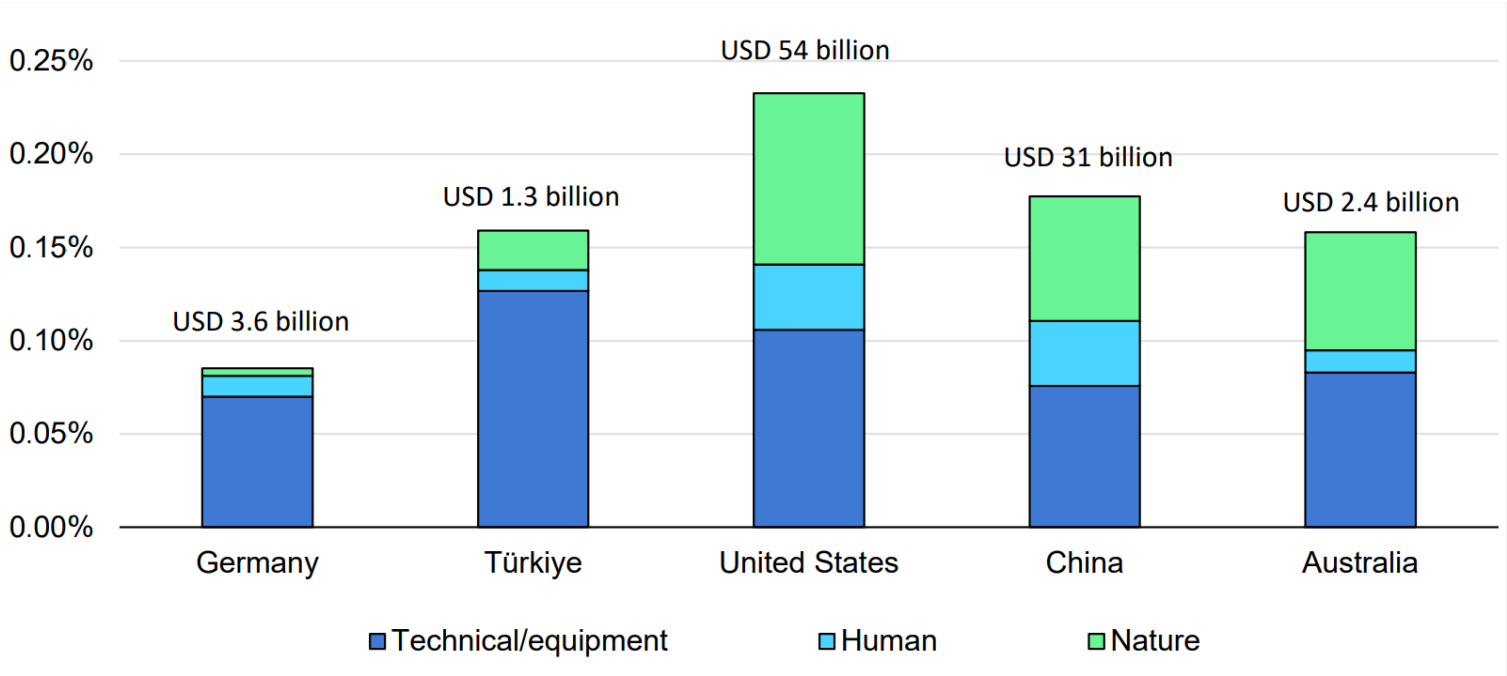
* System-friendly VRE refers to planning, operating or contracting solar and wind power plants in a way that supports the overall outcomes for the system.

A transforming power sector



Electricity security - Outages

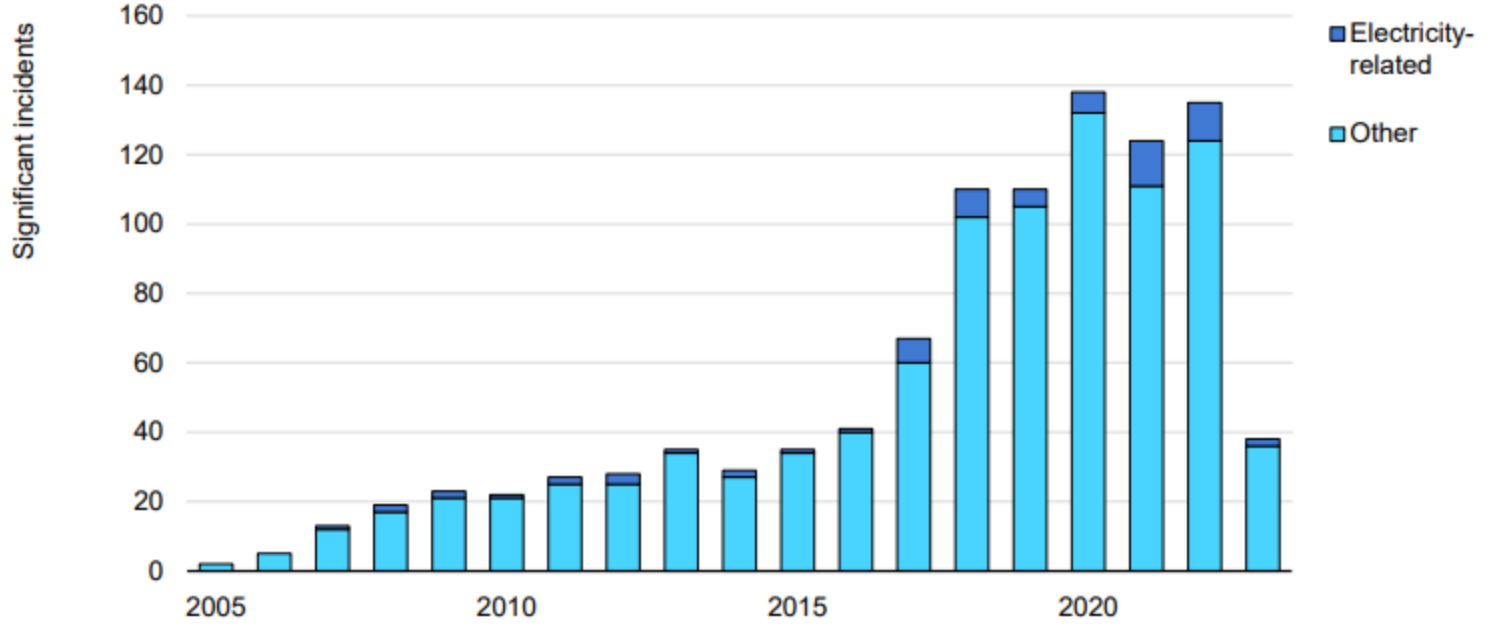
Estimated economic impact of grid-related outages by cause as a share of GDP in selected countries, 2021



Grid-related technical/equipment failures alone caused outages that amounted to a global economic loss of at least USD 100 billion in 2021, or 0.1% of global GDP.

Cyber security

Total and electricity-related significant cybersecurity incidents per year



Source: IEA analysis based on CSIS (2023).