Impacto operación recursos energéticos distribuidos

Francisco Gafaro, Team lead power sector transformation,
IRENA IITC

Congreso de Energia MEM - Octubre 30 2025

IRENA in brief

The International Renewable Energy Agency

IRENA
International Renewable Energy Agency

- Established in 2011
- Headquarters in Masdar City, Abu Dhabi, UAE
- IRENA Innovation and Technology Centre (IITC) – Bonn, Germany
- Permanent Observer to the United Nations – New York, USA
- 169 Members + EU and 15 States in Accession

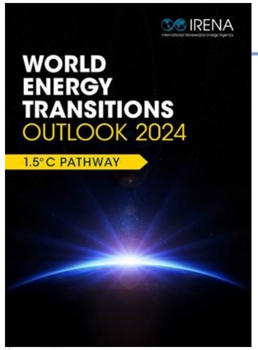
Mandate

To promote the widespread adoption and sustainable use of
all forms of renewable energy worldwide

Bioenergy | Geothermal Energy | Hydropower | Ocean Energy | Solar Energy | Wind Energy

IITC Flagship Publications and Events

Innovation Landscape Report

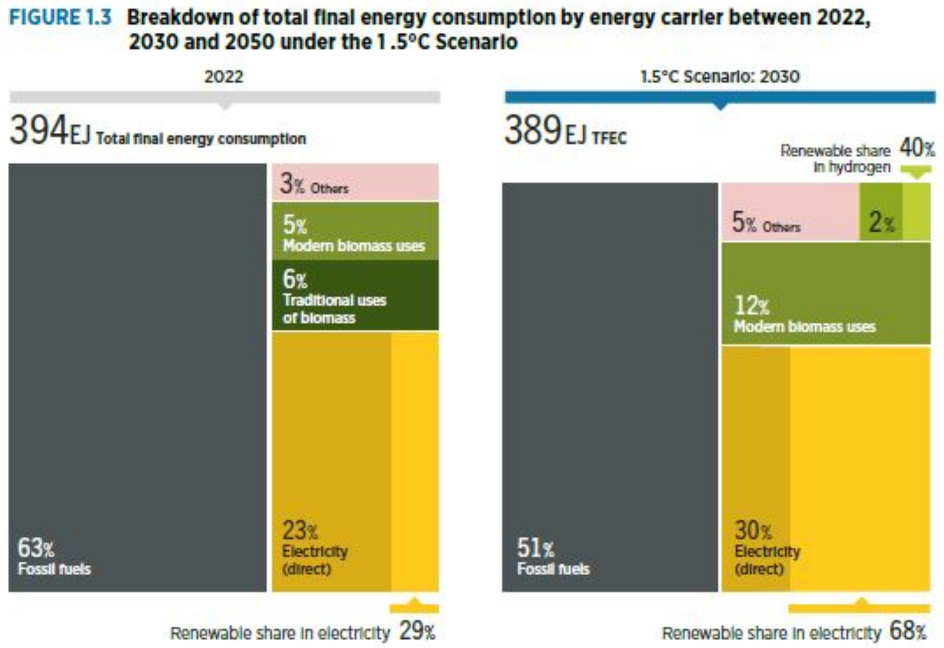


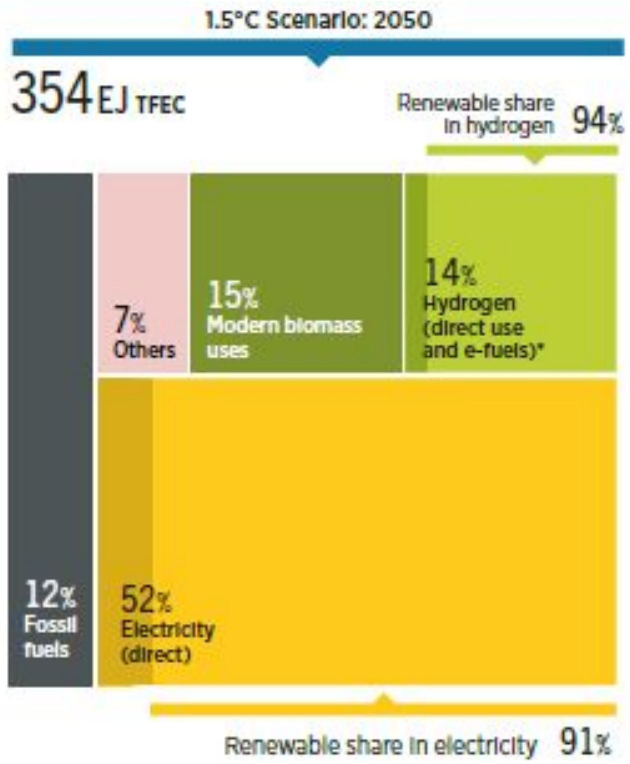
World Energy Transitions Outlook

Renewable Power Generation Costs

DER in the energy transition

The power sector is at the heart of the energy transition



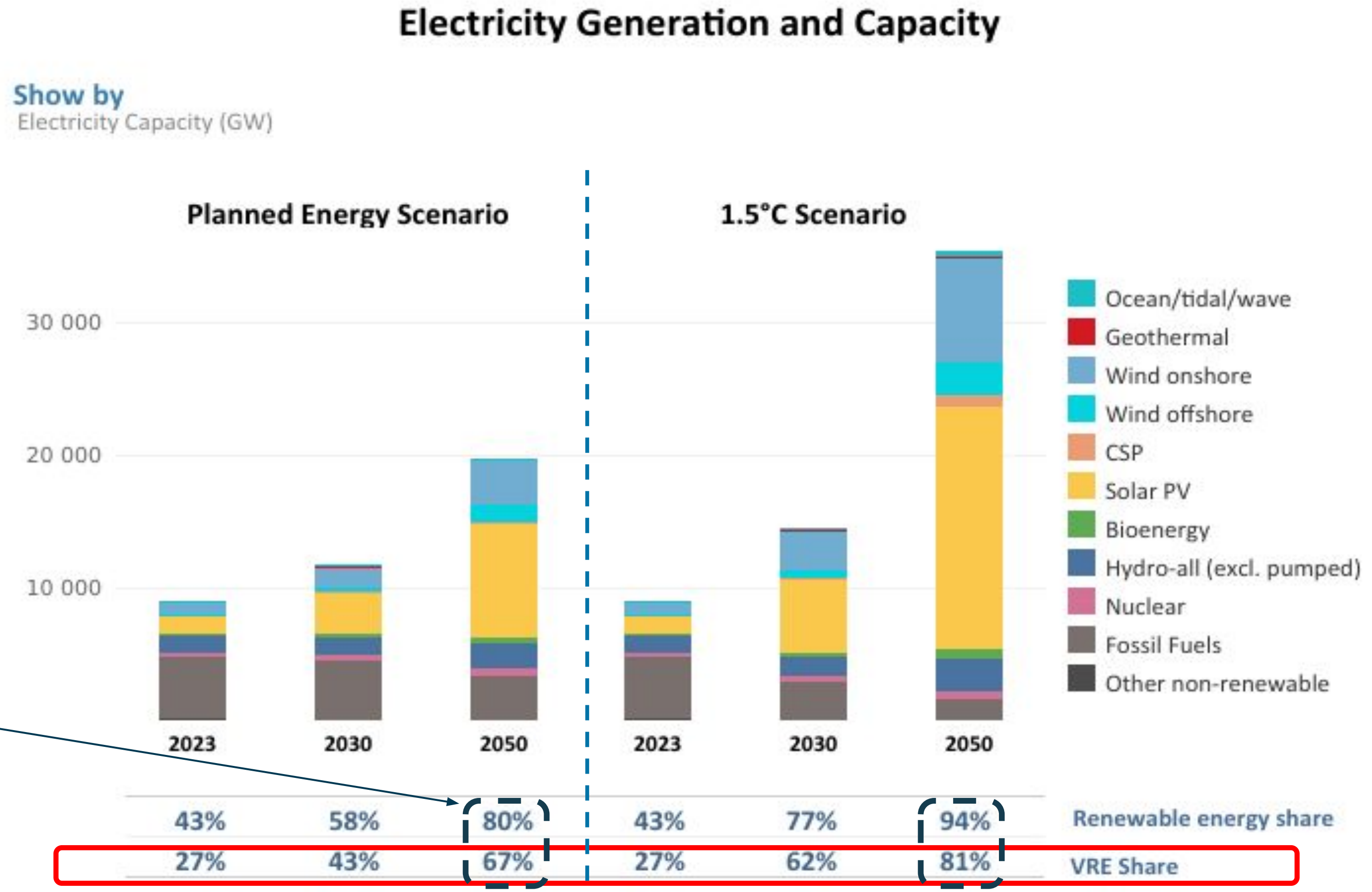


In decarbonization scenarios Electricity would become the main energy carrier in 2050

- **Renewable energy** deployment, improvements in **energy efficiency** and the **electrification** of end-use sectors contribute to this shift
- More significant roles of **modern biomass** (15%) and **hydrogen** (14%) in 2050
- **94% of hydrogen** consumption in 2050 from **renewables**

We are moving toward a power system dominated by solar and wind

Even in non-decarbonized scenarios VRE resources would predominate



Source: IRENA (2024), World Energy Transitions Outlook 2024: 1.5°C Pathway, International Renewable Energy Agency, Abu Dhabi.
https://www.irena.org/Publications/2024/Nov/World-Energy-Transitions-Outlook-2024

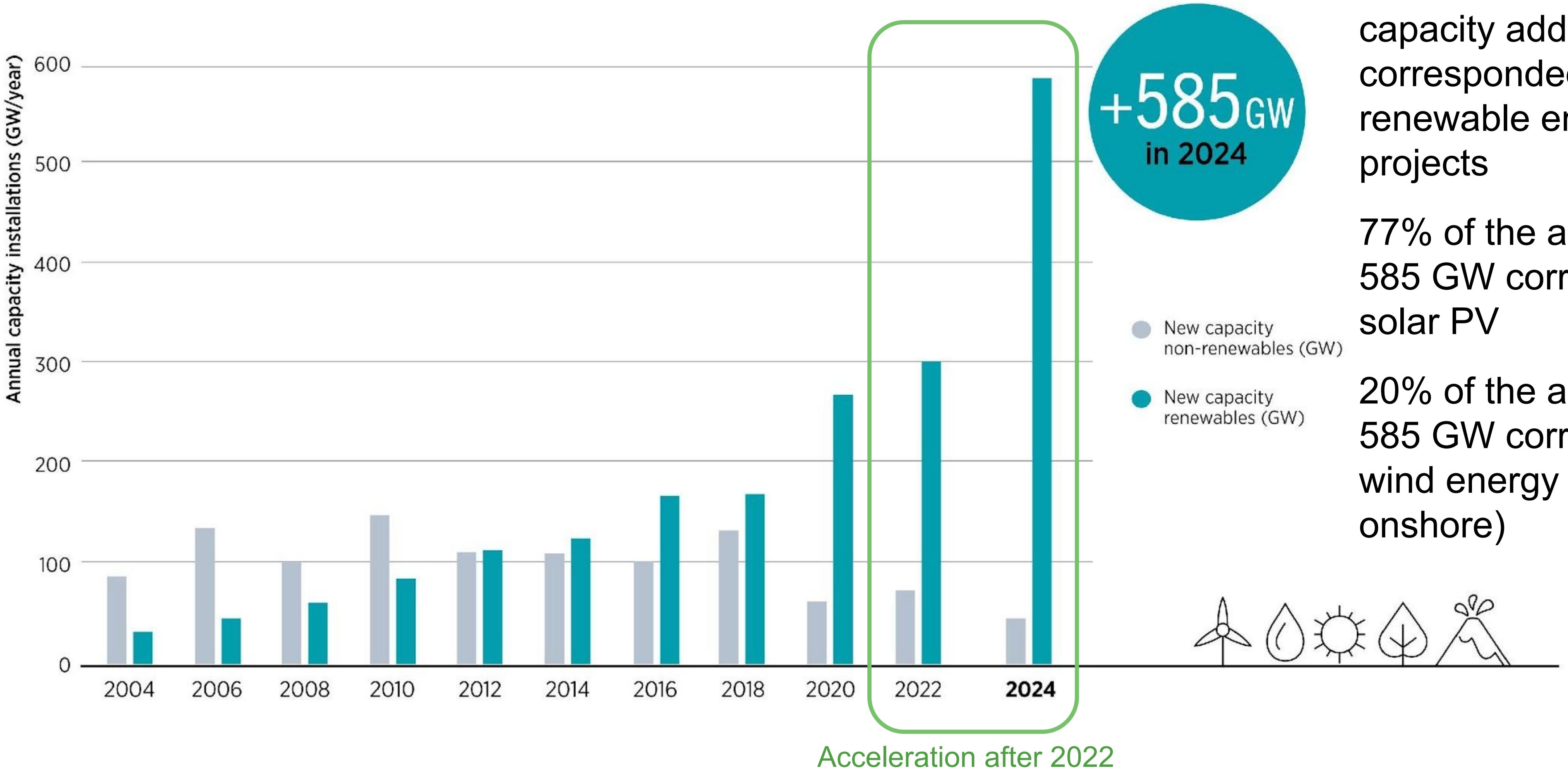
Last update: 07 January, 2024

Solar and Wind: Driving the Transformation with Lowest Costs

In 2024, solar PV projects were on average 41 percent cheaper than the lowest-cost fossil fuel alternatives, while onshore wind projects were 53 percent cheaper.

In 2024, 91% of all newly commissioned utility-scale renewable projects delivered electricity at a lower cost than fossil fuel-fired alternatives

Solar and Wind: Driving the Transformation



Around 92% of new capacity additions corresponded to renewable energy projects

77% of the additional 585 GW corresponds to solar PV

20% of the additional 585 GW corresponds to wind energy (95% onshore)

Solar and Wind: Driving the Transformation

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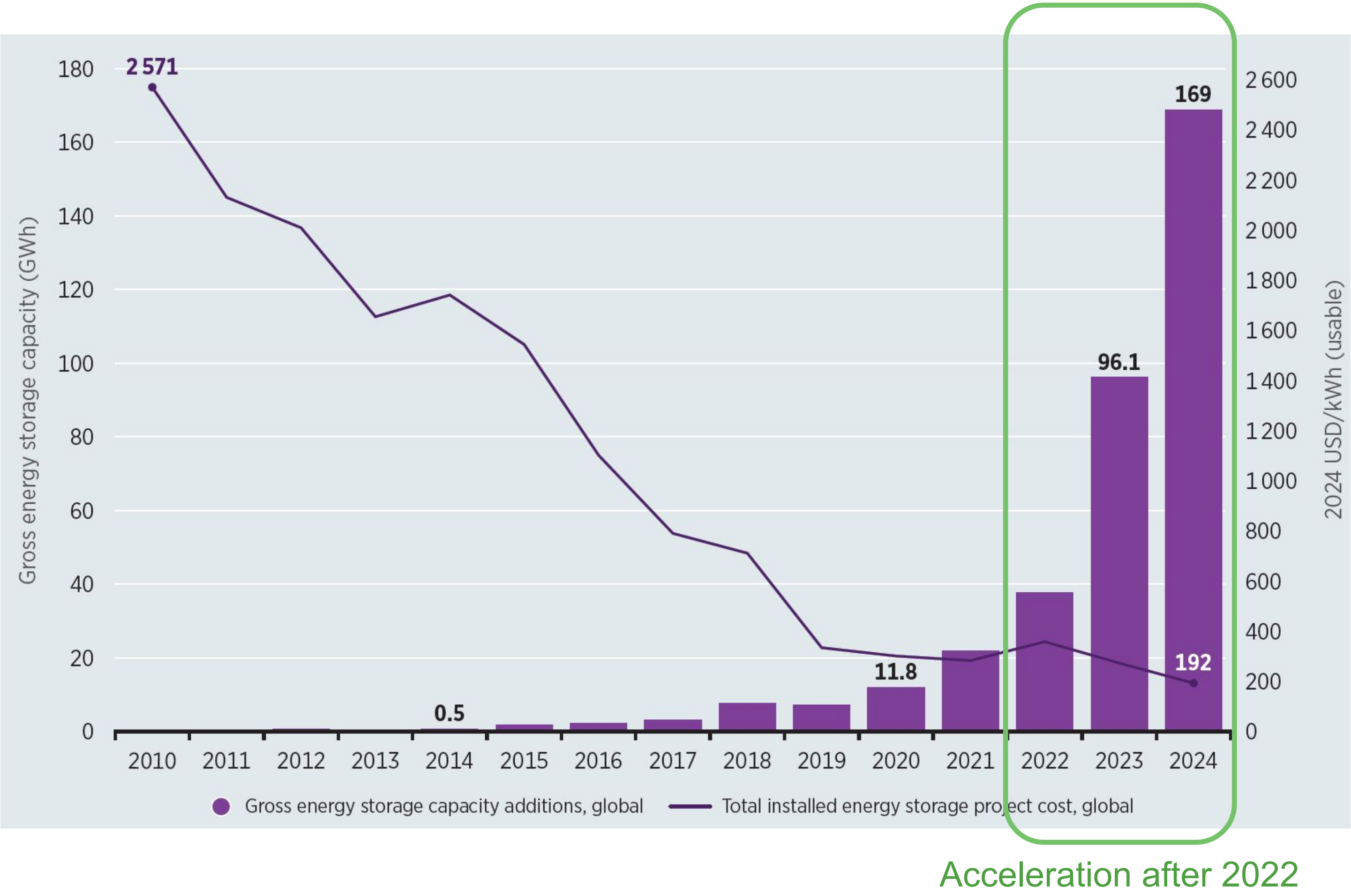


Between 2010 and 2024, the costs of battery storage projects declined 93%,

- Technological advancements in battery chemistries
- Materials efficiency improvements, manufacturing scale-up
- Increased market competition.

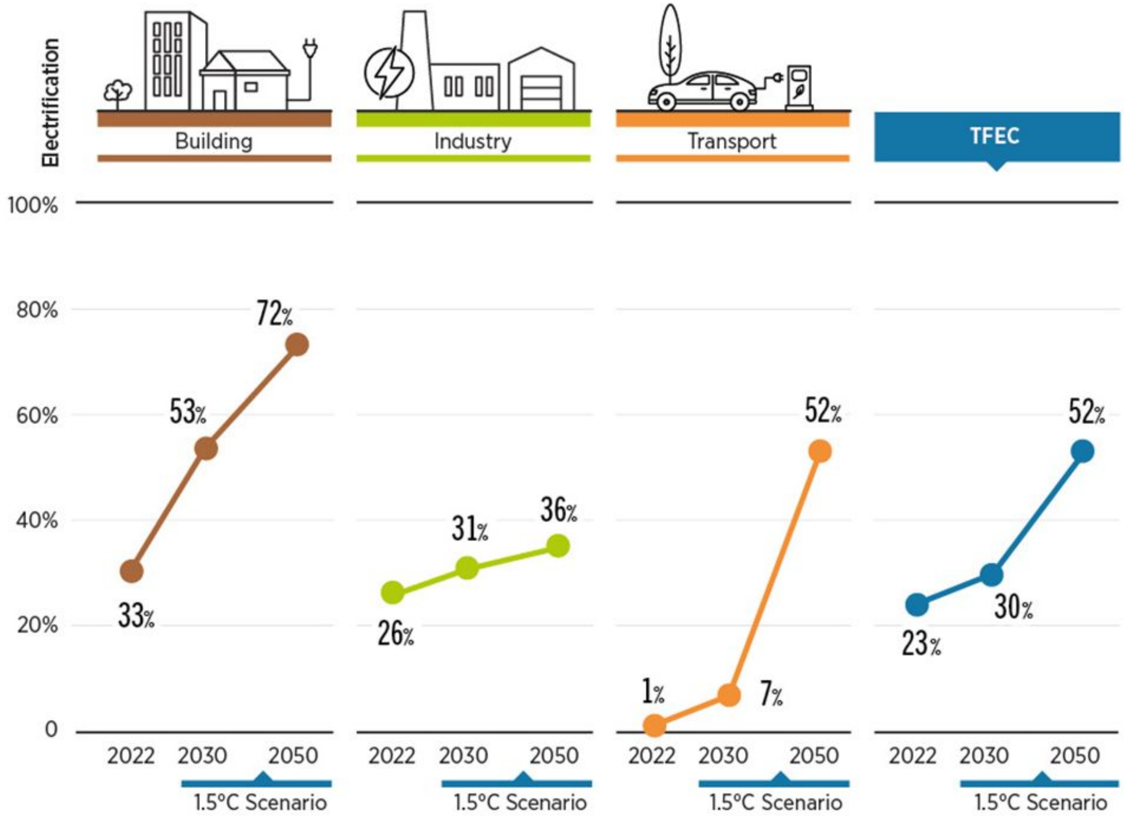
Annual capacity additions for chemical battery storage increased from 0.1 GWh gross capacity in 2010 to 169 GWh gross capacity in 2024.

Energy shifting is the main application of electricity storage, accounting for 68% of the total added capacity in 2024

In 2024 around 40% of battery investments were at the customer side

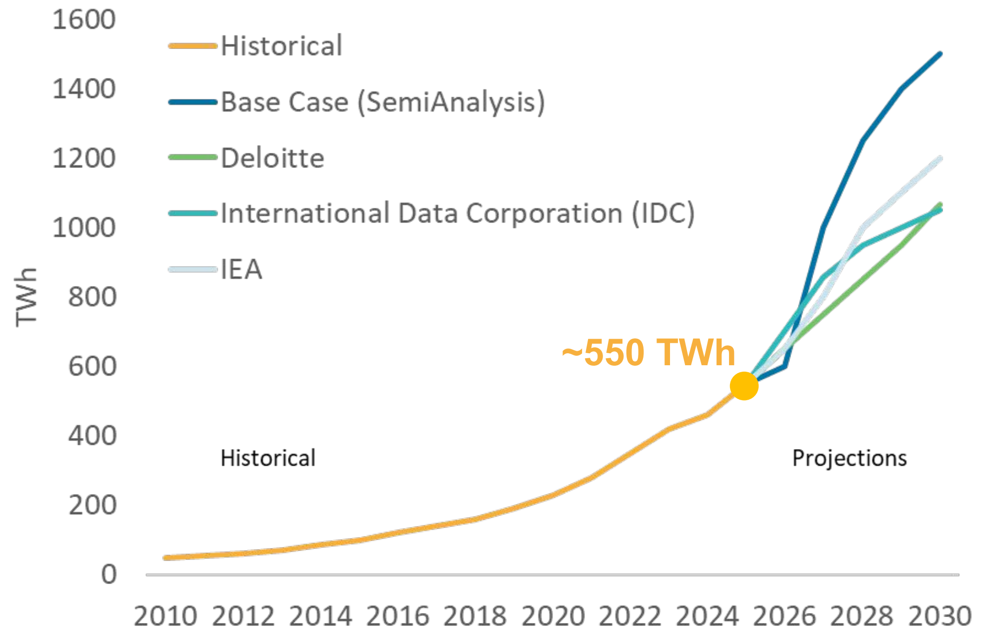
Electrification - Evolving Demand for the Energy Transition

Global electrification in end-use sectors and TFEC, 2022, 2030 and 2050 under the 1.5°C Scenario



Source: IRENA – World Energy Transitions Outlook 2024

Range of scenarios of electricity demand for data centres globally (TWh)



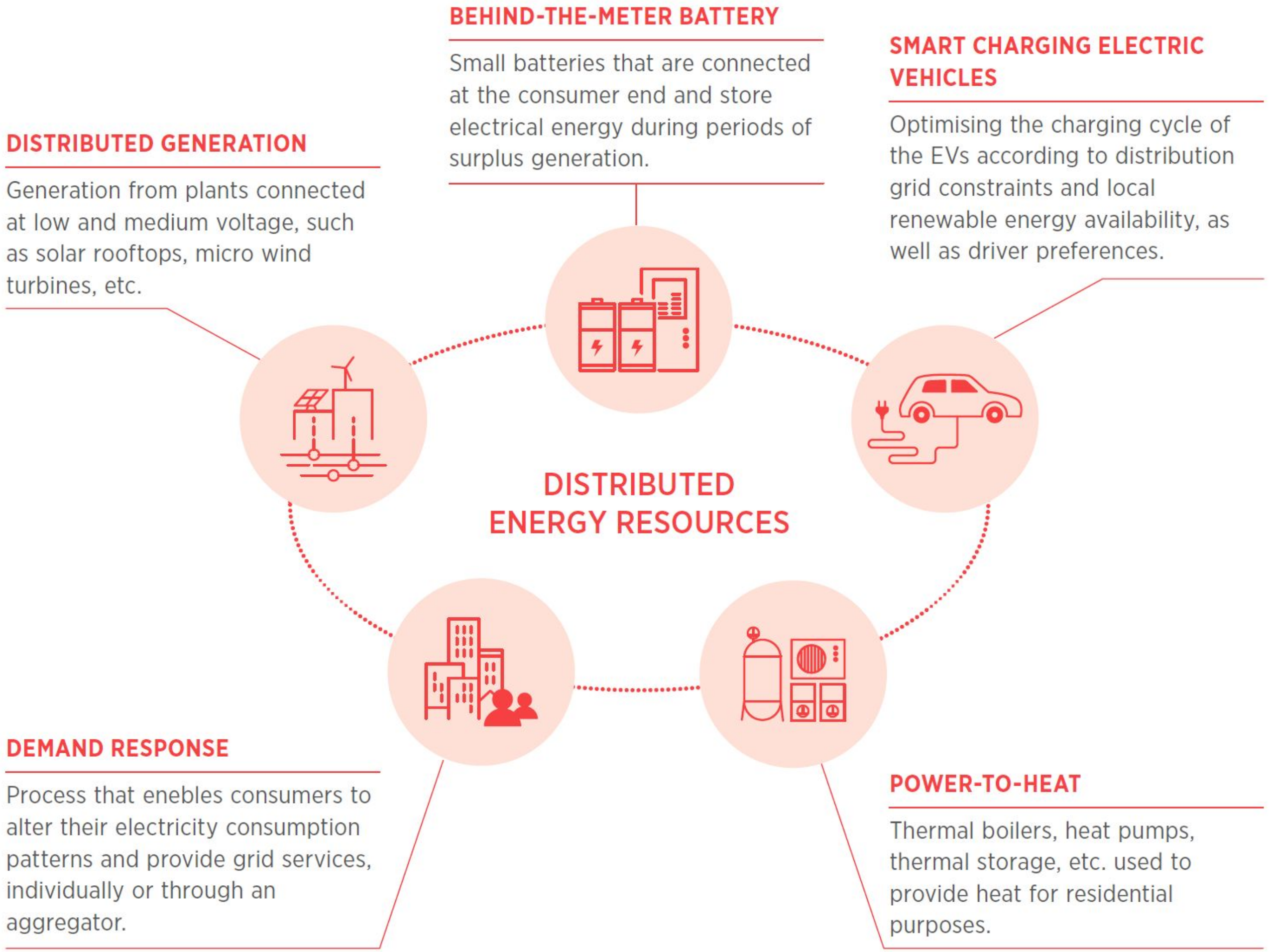
Source: IRENA calculations based on Bloomberg BNEF data, 2025

Decentralization - Consumers at the center of the transition

Distributed energy resources (DERs) are

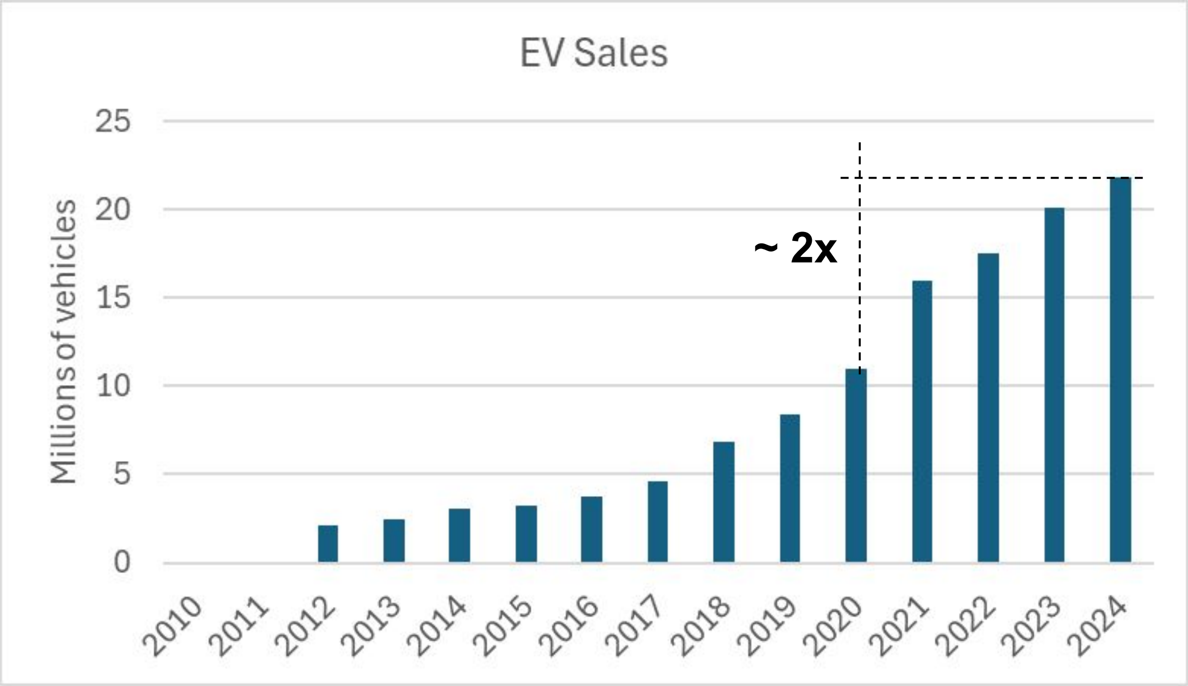
- They are small and medium-sized power sources connected to the distribution network, that can potentially provide services to the power system
    - DERs include distributed generation, energy storage (small scale batteries) and controllable loads, such as electric vehicles (EVs), heat pumps or demand response.

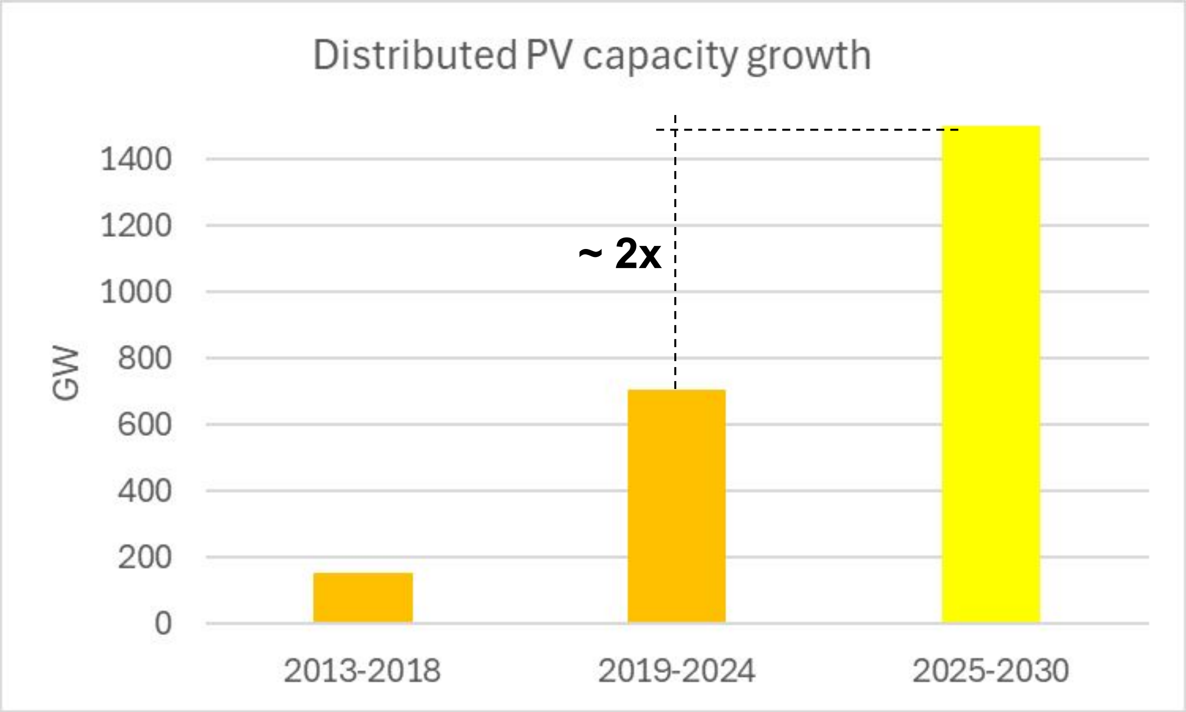
The new consumer is also producing, storing, trading energy and managing own load



Source: IRENA (2019) Innovation landscape brief: Market integration of distributed energy resources

DER Evolution over time

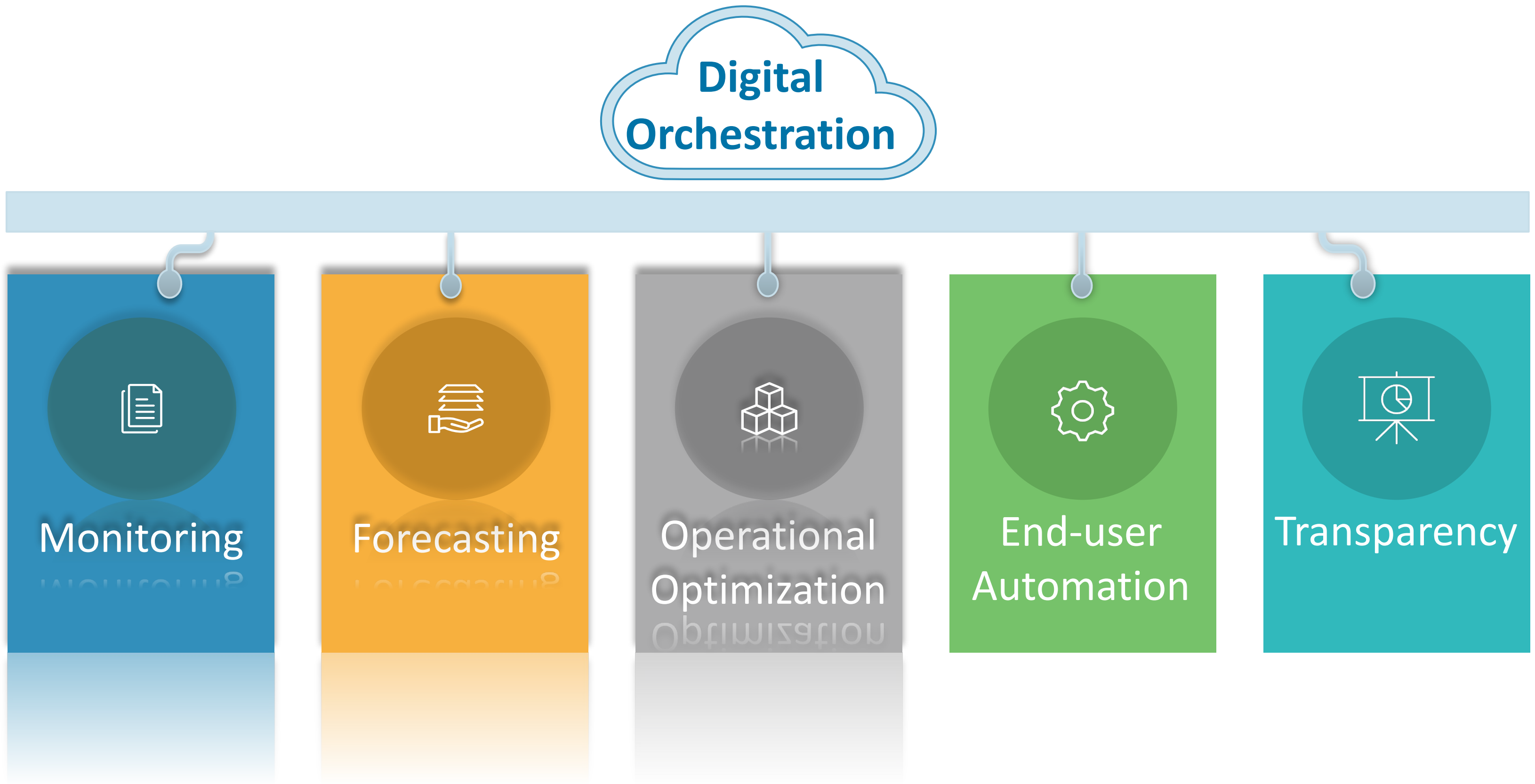




EV include Cars, Vans, Buses, Trucks and 2 and 3 wheelers

Digitalisation and AI

Converting Data into value for the power system



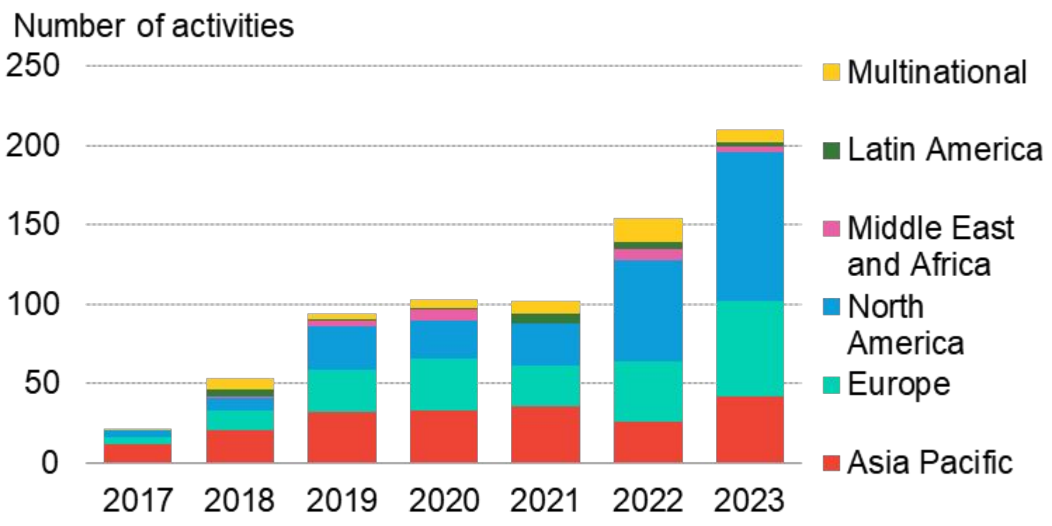
Decentralization:
New assets on the supply side

Electrification:
New loads and load profiles

- Monitoring, management and control crucial for the success of the energy transition
- **Digitalization is an amplifier of the energy transition**

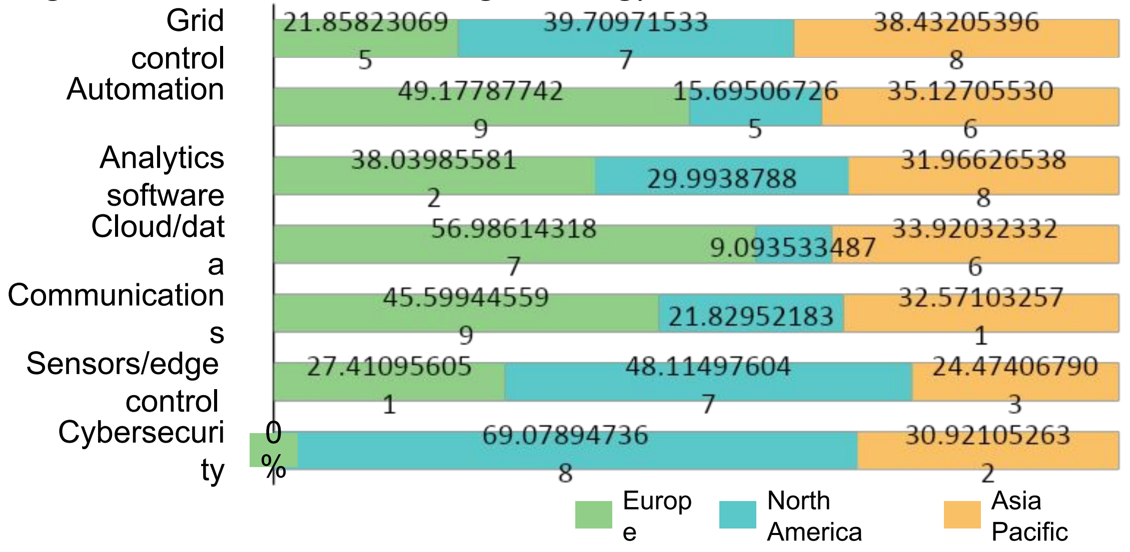
Growing awareness leading to investments

Number of digitalisation activities in Power sector



Note: Data activities are pilots, project, and product announcements;
Source: Bloomberg BNEF

Regional Investment Focus in Digital Energy, 2023



Distributed Energy Resources a change in paradigm

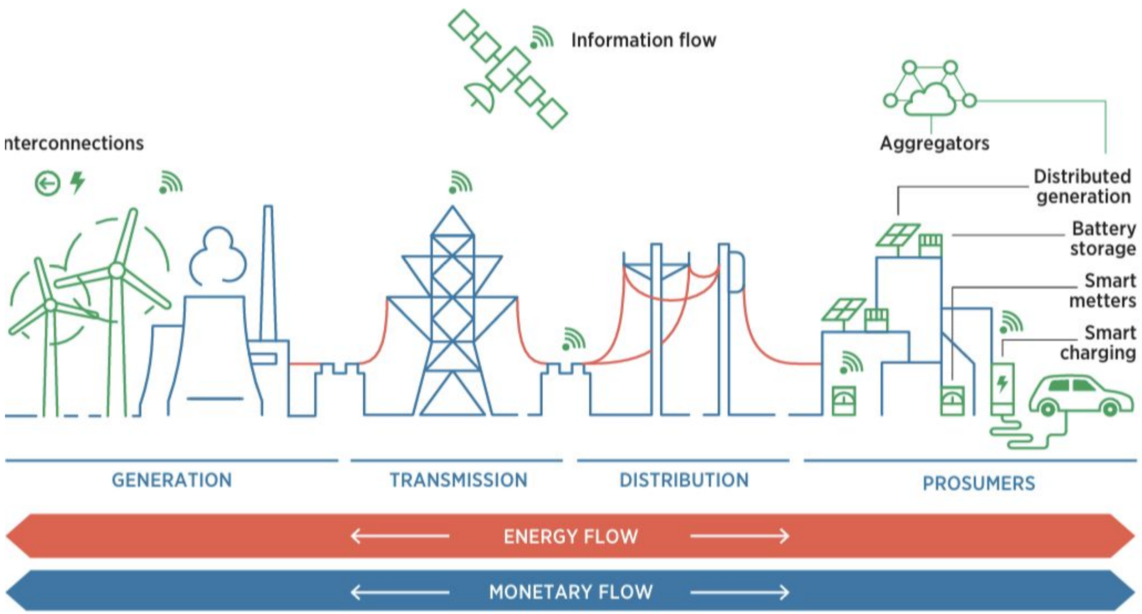
The growth of distributed energy resources reflects deep transformations across the energy transition, as generation becomes more distributed, energy use becomes increasingly electrified, and digital technologies enable new forms of control and coordination

- Electrification of end-use sectors is an emerging solution to **maintain value and avoid curtailment of VRE**, and help decarbonize other sectors

- The increasing deployment of Distributed Energy Resources (DERs) turns the consumer into an active participant, **fostering demand-side management**.

- Digital technologies enable **faster response, better management of assets** by **connecting devices, collecting data, monitor and control**

NEW PARADIGM OF THE ENERGY SUPPLY CHAIN

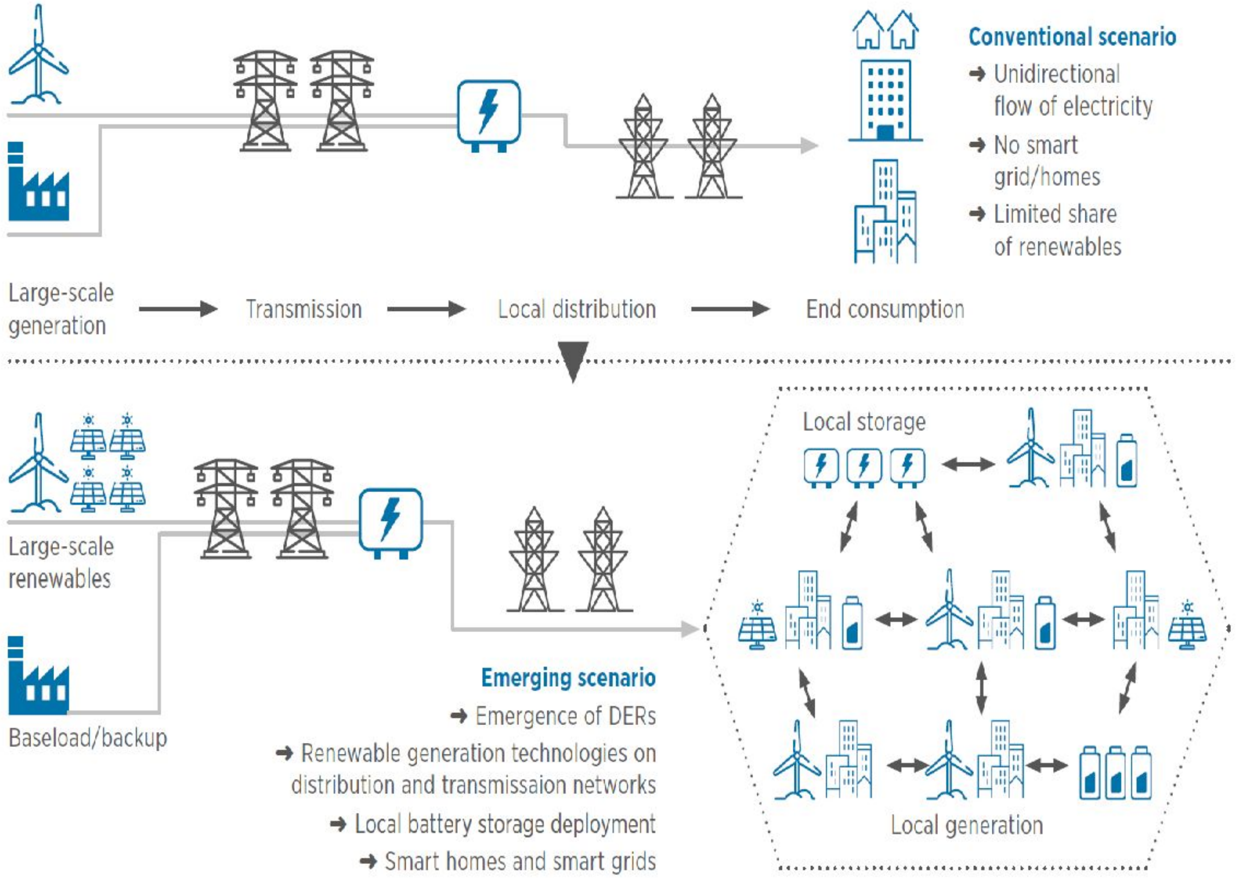


Change in the Paradigm

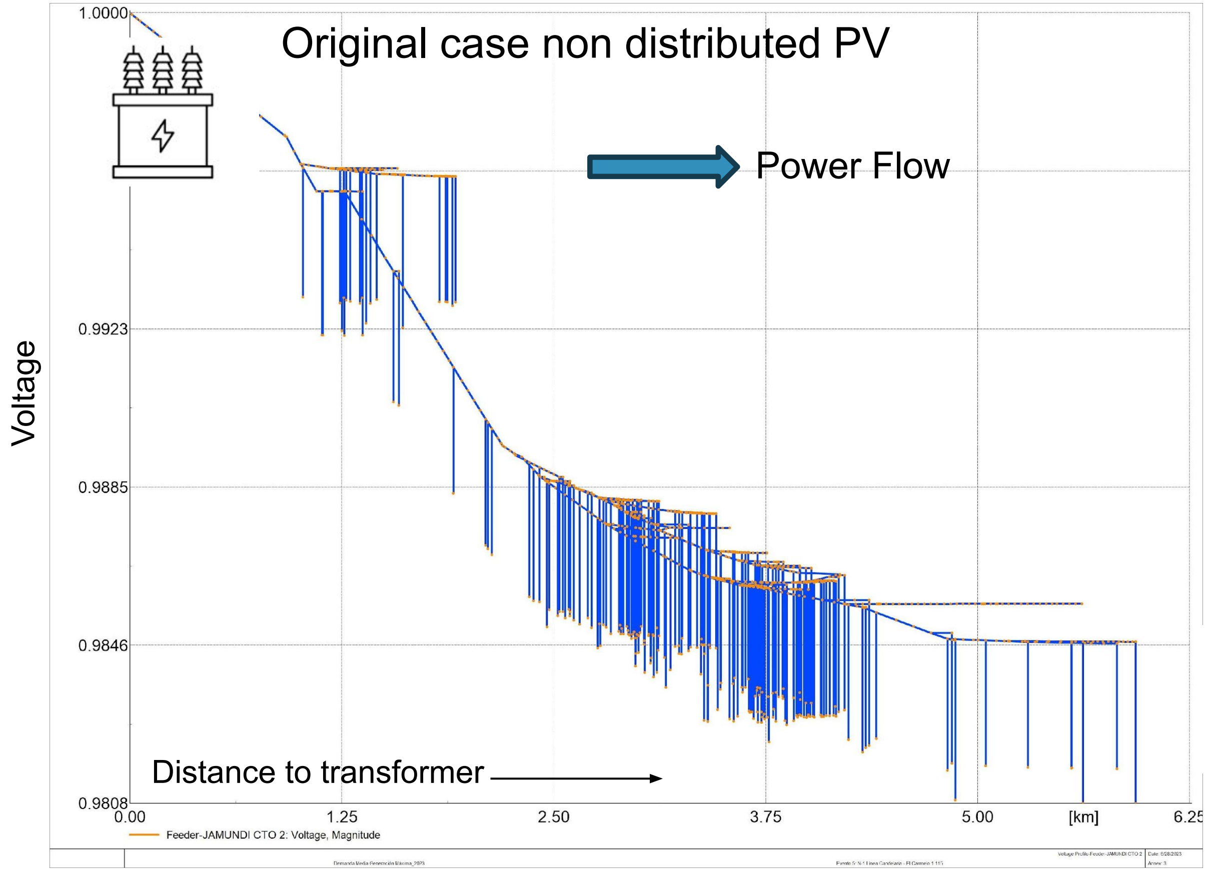
Impacts on the operation - Opportunities and challenges

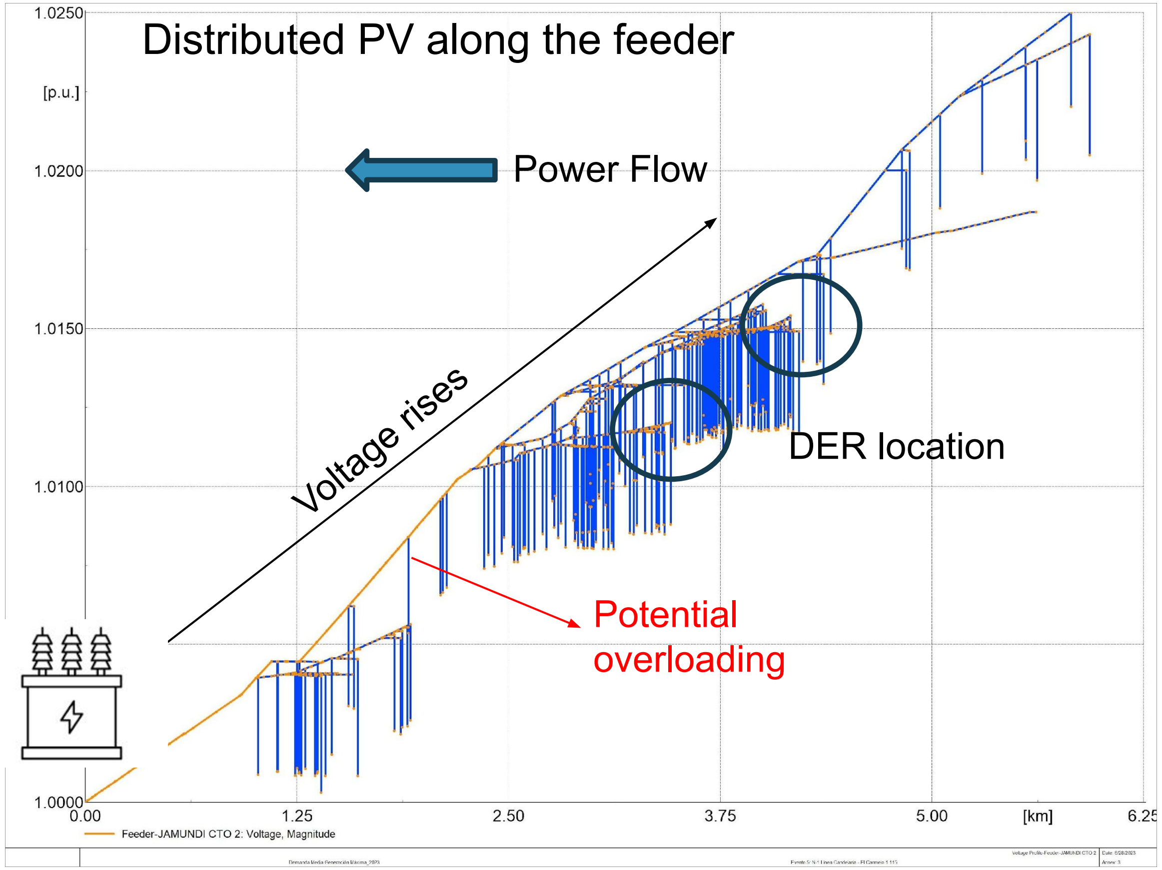
Challenges to integrating DERs – Distribution Grid

- Grid Integration and bi-directional power flows:
  - less predictable and reverse flow of power in the system, which can affect the traditional planning and operation of distribution and transmission networks.
  - Can cause congestion in distribution grids
  - Distribution networks were typically built to accommodate gradually falling voltages, with power flowing in one direction from substation to customer, and substation voltage being stepped up to prevent it from dropping below the lower limit after traversing a long power line.



Challenges – Distribution Grid Hosting Capacity





In a distribution feeder installed DER capacity may have a limit associated with voltage and loading of the circuits unless grid reinforcements take place

Challenges System Level– Security of operation

Massive deployment of DERs without adequate coordination or technical compatibility can compromise frequency stability, voltage control, and protection schemes, threatening overall system reliability.

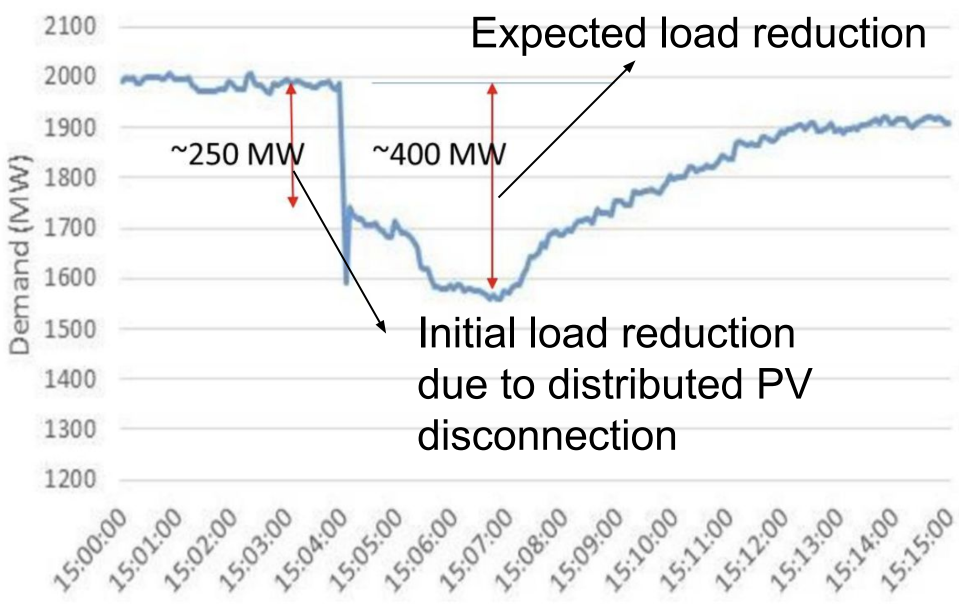
- Limited visibility increases operational uncertainty
- Lack of compatibility undermines supply security

- **Connection requirements and modelling as a safeguard**
  ✔ Standardised interconnection rules, inverter performance criteria, and communication protocols ensure DERs support rather than disrupt system operation

• **Information and standards as enablers of secure integration**

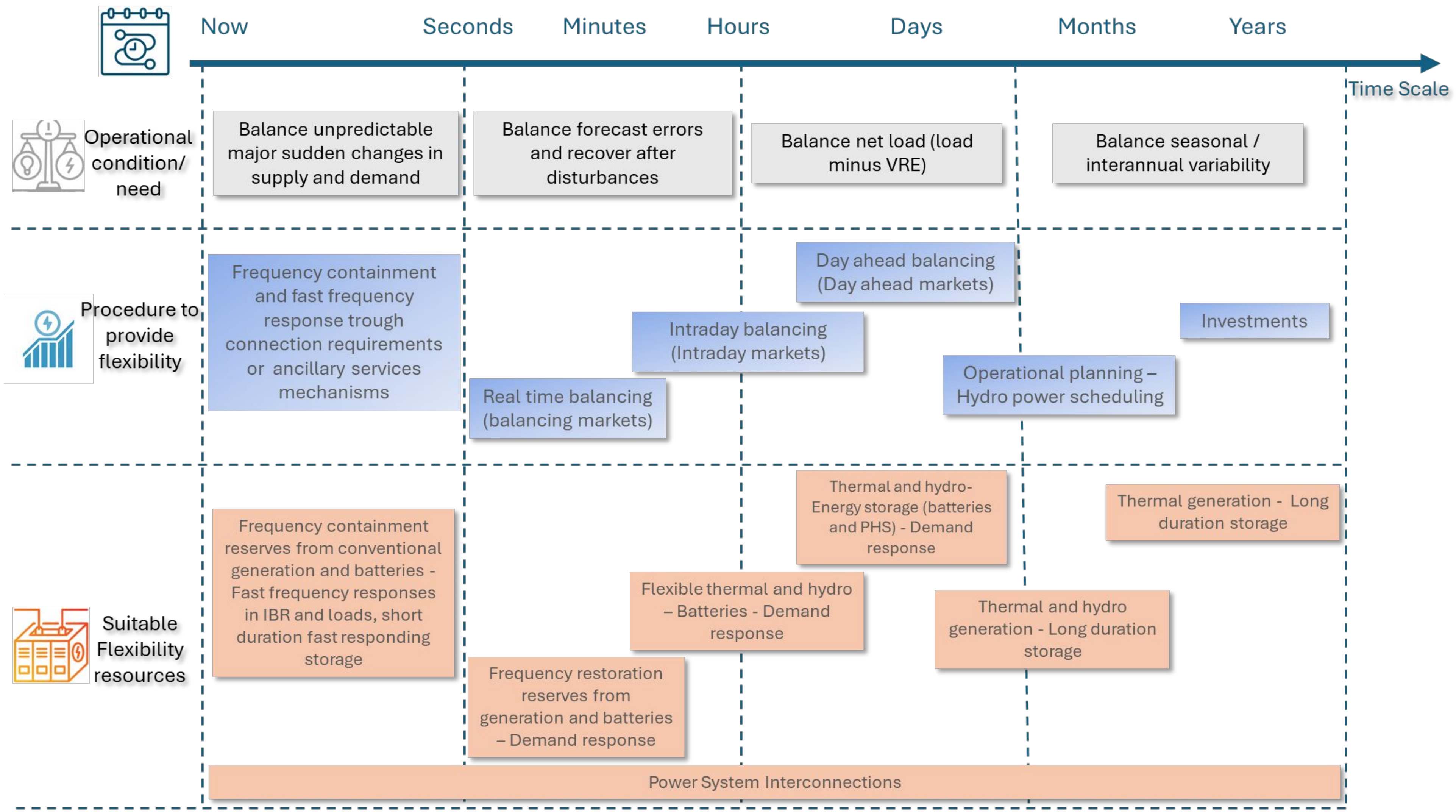
✔ Comprehensive DER registration, data exchange, and compliance verification allow operators to maintain reliability as distributed resources scale up

Figure 5 Demand in South Australia, 3 March 2017

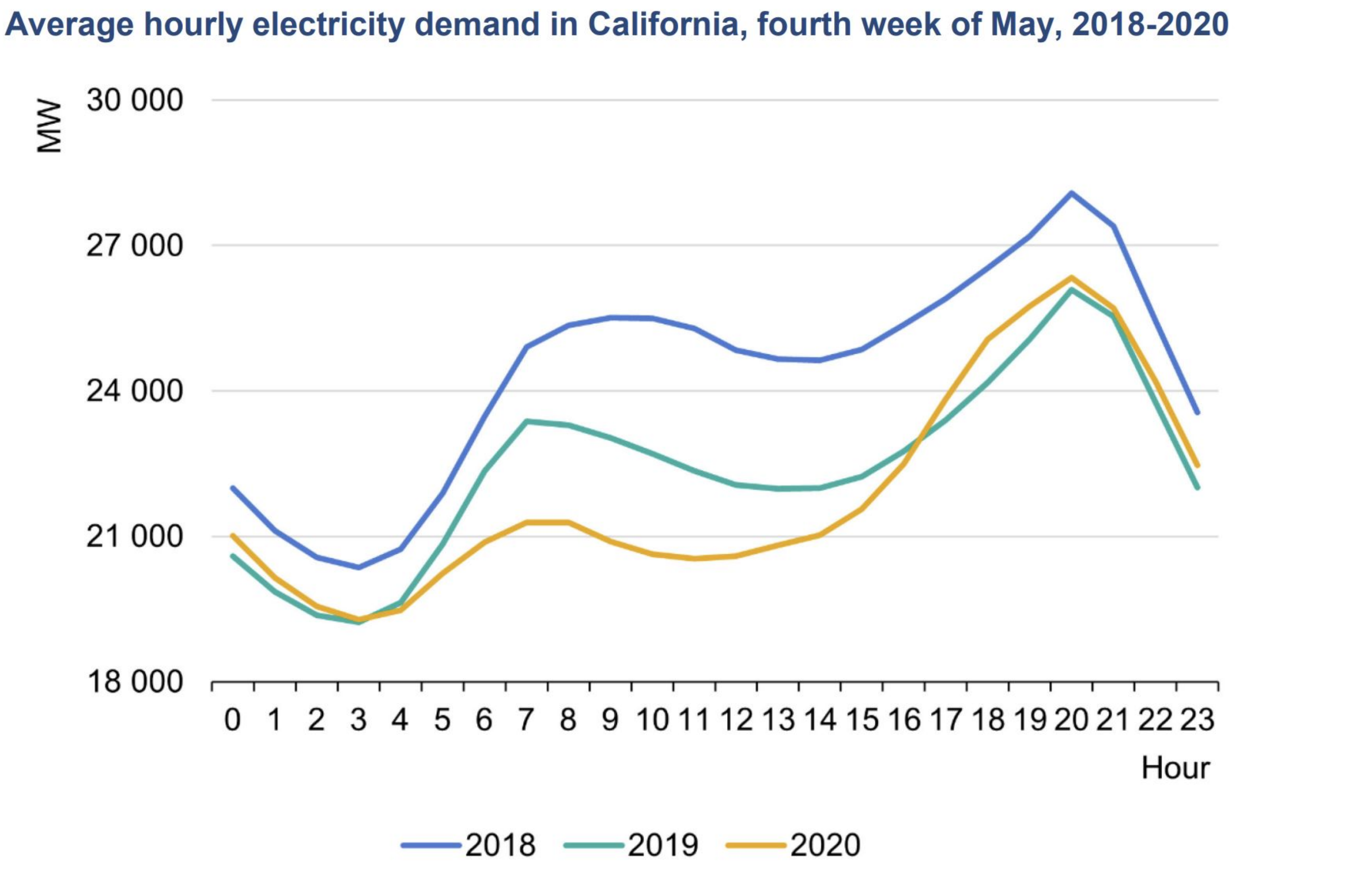


Example Australia DER disconnection impacted effectiveness of Load Shedding Scheme

Challenges System Level - The need for flexibility



The need for flexibility Potential DER Impacts



DER can alter the load profile adding uncertainty and variability to the around both supply and demand

Impact the System Operator task of maintaining the balance

Needs for flexibility may increase

Aprovechar los recursos energéticos distribuidos como activos del sistema eléctrico

Distributed energy resources can contribute to system flexibility, alleviate grid congestion through load management, defer network expansion, and strengthen reliability

- **Establish clear connection and interoperability requirements**
  Ensuring technical compatibility and communication between DERs and grid operators is the foundation for secure and coordinated operation at scale.

- **Improve visibility and data exchange**
  Enhanced monitoring of behind-the-meter resources and distribution networks enables system operators to plan, forecast, and dispatch flexibility effectively.

- **Align DER operation with system needs**
  Through smart control and responsive operation, DERs such as EVs, batteries, and PV systems can support grid balancing rather than adding to peak demand.

- **Incentivise flexibility instead of expanding infrastructure**
  Rewarding DER owners for shifting consumption or exporting energy at strategic times can be more cost-efficient than reinforcing the grid.

Aprovechar los recursos energéticos distribuidos como activos del sistema eléctrico

- **Coordinate interests among stakeholders**
  Aligning incentives and responsibilities between DER owners, aggregators, and system operators ensures mutual benefit and reliable service provision.

- **Leverage DER proximity to consumers**
  Positioned within distribution networks, DERs can relieve local congestion, manage voltage levels, and strengthen resilience.

- **Build from the foundation upward**
  With technical standards, visibility, and aligned incentives in place, DERs evolve from consumer assets into active service providers that enhance power-system flexibility and stability.

Aprovechar los recursos energéticos distribuidos como activos del sistema eléctrico - Vision

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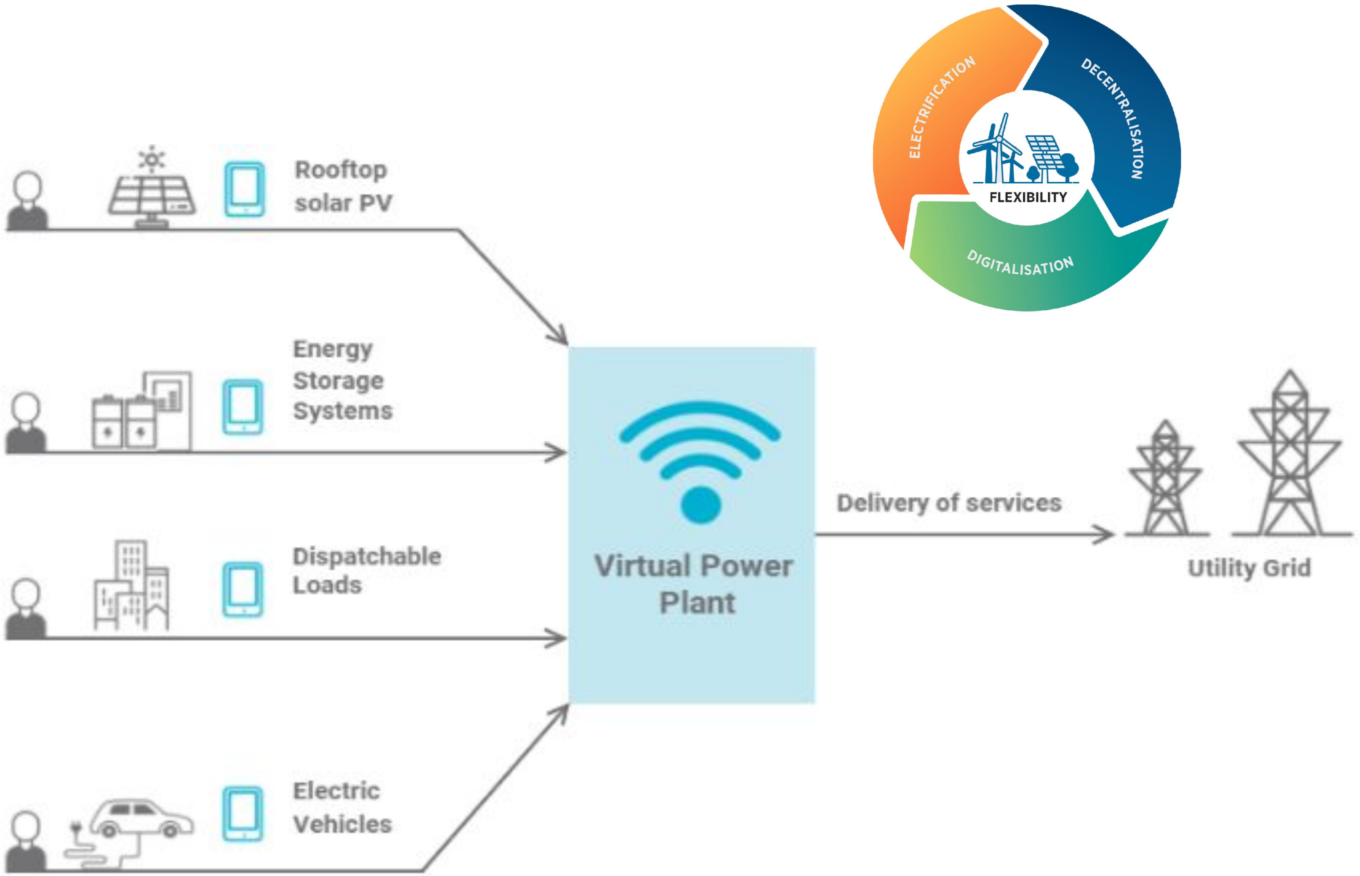
Aggregators

Innovative Business Models

Aggregators bundle DERs to engage as a single entity – a virtual power plant (VPP) – in power or service markets.

Aggregators are a new market player that can optimise the use of distributed energy resources.



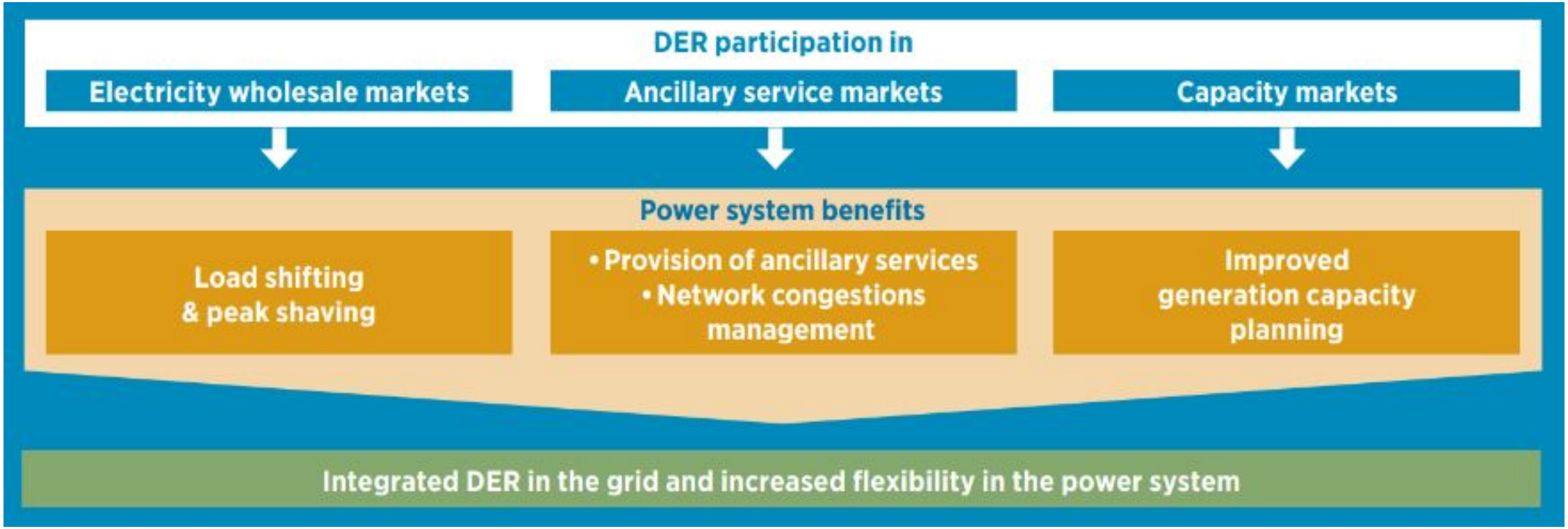
Aggregators can provide:

- Load shifting
- Balancing services to TSOs
- Local flexibility to DSOs

Source: IRENA (2019) Innovation landscape brief: Aggregators

Aprovechar los recursos energéticos distribuidos como activos del sistema eléctrico - Vision

Market Integration of Distributed Energy Resources



Participation in wholesale and ancillary service markets exposes DERs to market prices and enable demand-side flexibility via explicit demand response

Source: IRENA (2019) Innovation landscape brief: Market integration of distributed energy resources

Muchas gracias