Power System Flexibility Challenge

Decarbonization, VREs & Electrification

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What is Power System Flexibility

Cochran et. al (2014) definition of flexibility:

"… the power system's ability to respond to both expected and unexpected changes in demand and supply"

International Energy Agency (IEA) (2018), definition of flexibility:

"… the ability of a power system to reliably and cost-effectively manage the variability and uncertainty of demand and supply across all relevant timescales."

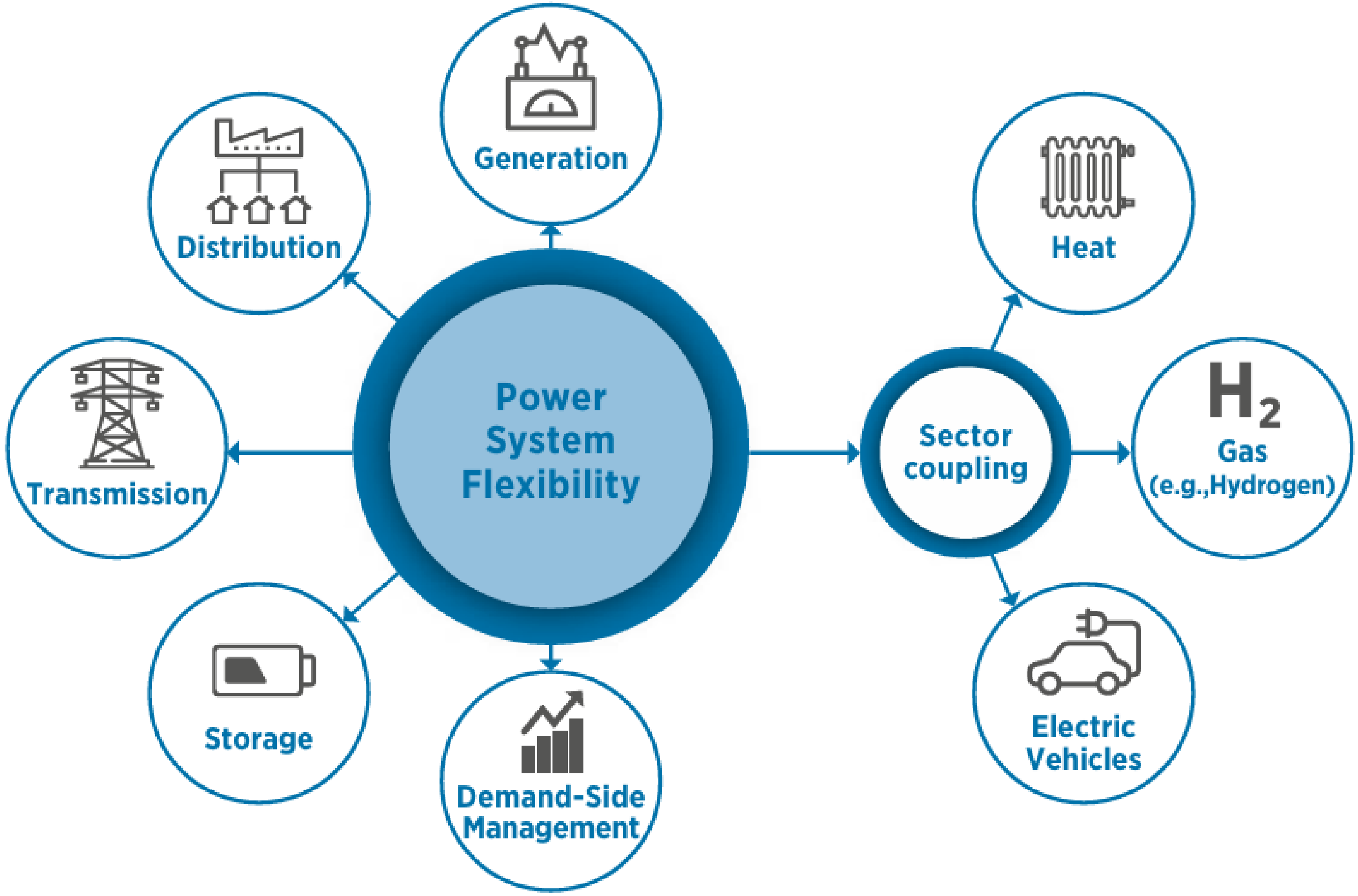
Cochran, J. et al. (2014), Flexibility in 21st Century Power Systems, US National Renewable Energy Laboratory, Golden, Colorado. doi: 10.2172/1130630.
IEA (2018), Status of Power System Transformation: Advanced Power Plant Flexibility, International Energy Agency, Paris. doi: 10.1787/9789264278820-en.

Providing Flexibility in a "Conventional System"

Inflexible Generation	Flexible Generation	Highly Flexible Generation
- Nuclear - Coal - Geothermal	- CCGT - Flex. Coal - Biomass - Biogas - CSP	- Reservoir Hydro - Combustion Engines - Aero-derivative gas

Gonzalez-Salazar, Miguel & Kirsten, Trevor & Prchlik, Lubos. (2017). Review of the operational flexibility and emissions of gas- and coal-fired power plants in a future with growing renewables. Renewable and Sustainable Energy Reviews. 82. 10.1016/j.rser.2017.05.278.

Increased Complexity in Power Systems



IRENA (2018), Power System Flexibility for the Energy Transition, Part 1: Overview for policy makers, International Renewable Energy Agency, Abu Dhabi.

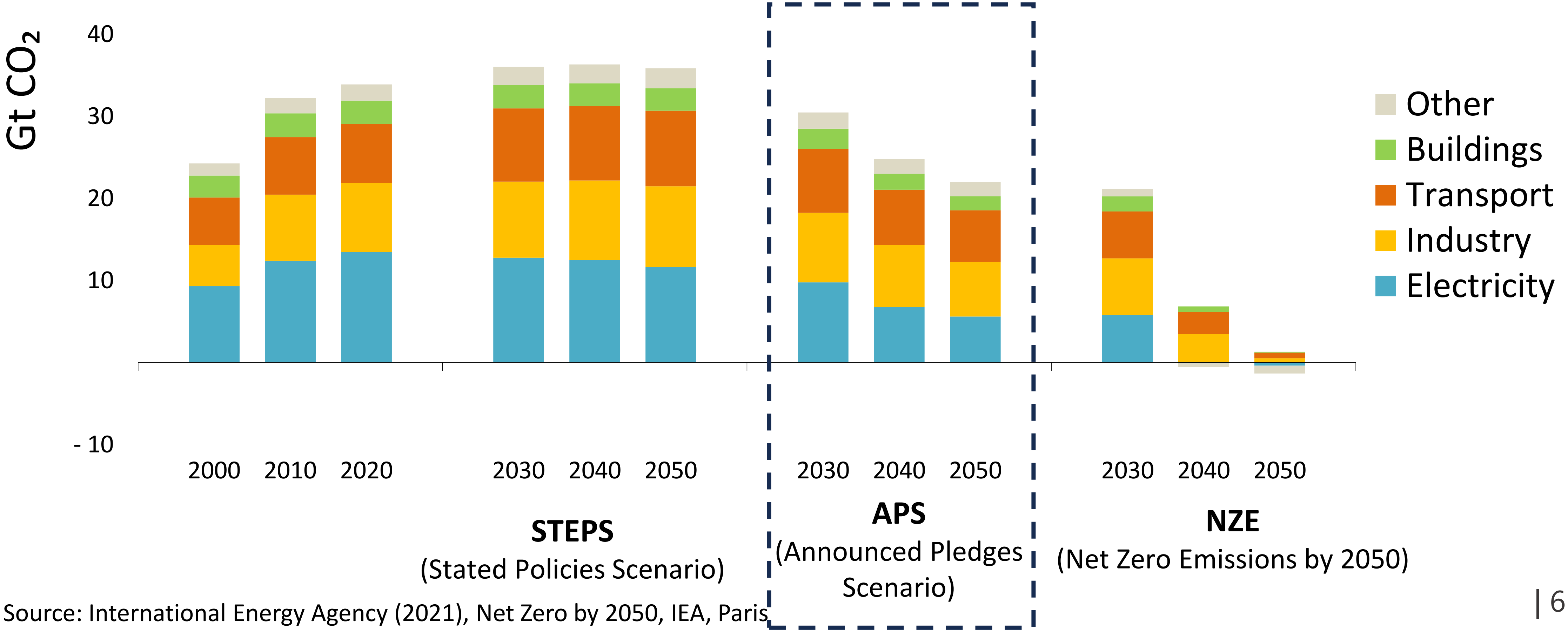
New challenges to power flexibility

Main new drivers/challenges leading to an increased need for flexibility:

- Decarbonization
- Variable Renewable Energy (VREs)
- Electrification

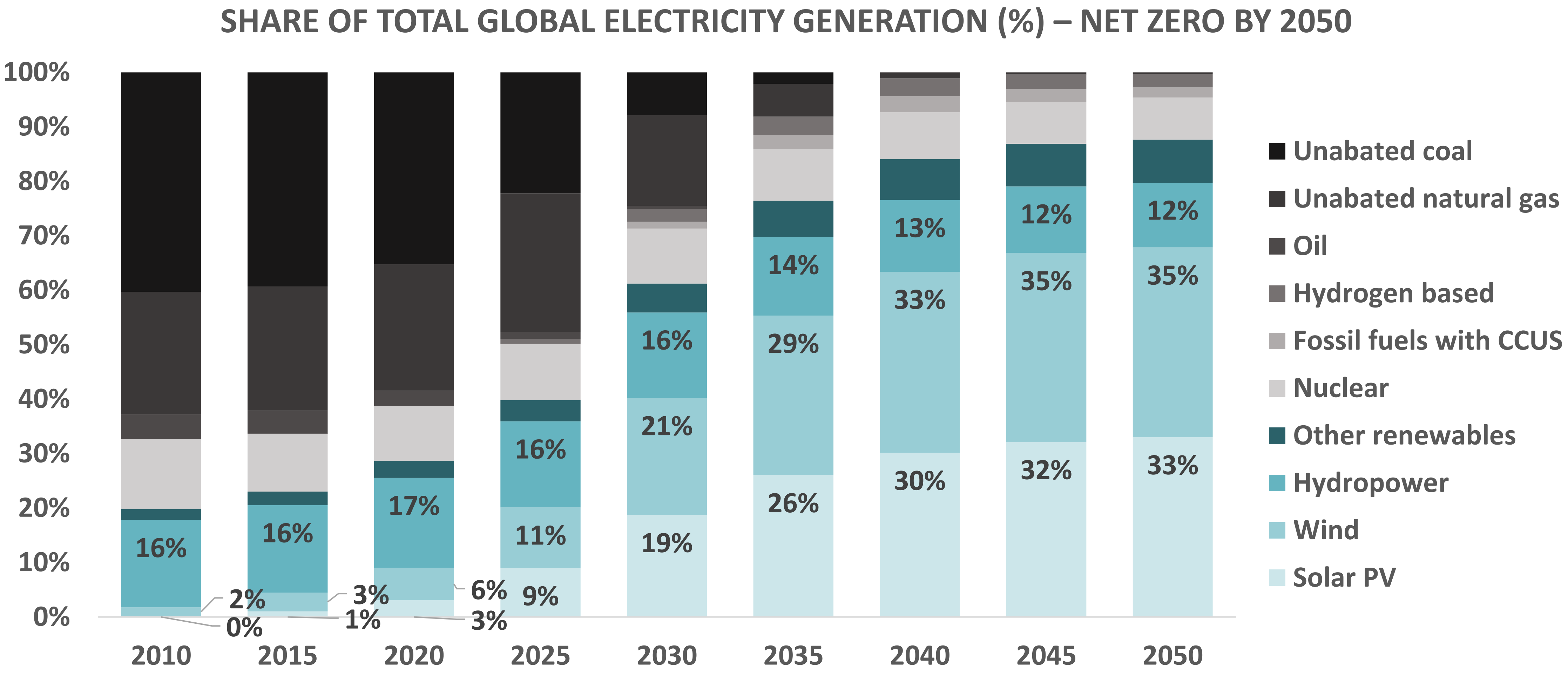
Decarbonization - Targets

Electricity generation was the largest source of emissions in 2020.
APS emissions of electricity drop by 60% until 2050.



Source: International Energy Agency (2021), Net Zero by 2050, IEA, Paris

Variable Renewable Energy – Targets

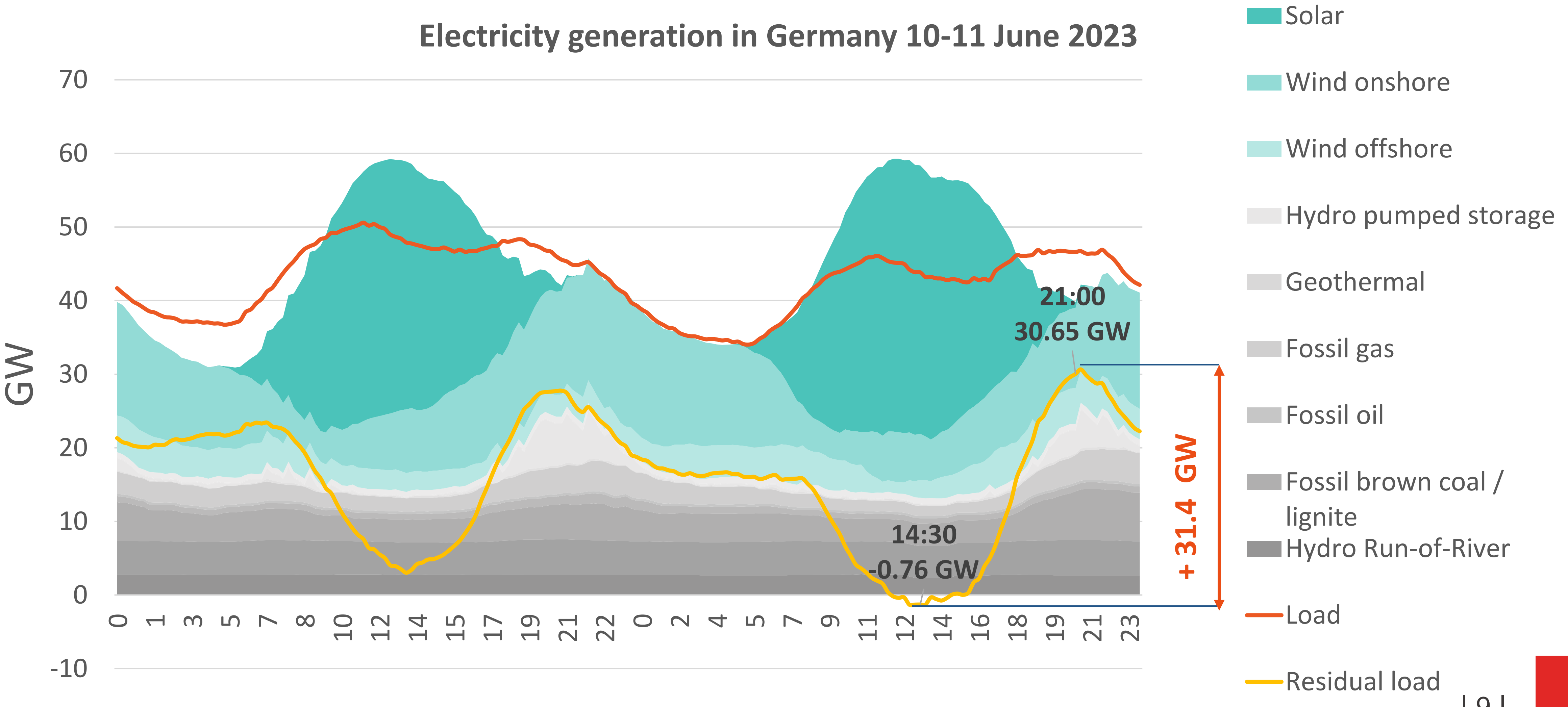


Source: International Energy Agency (2021), Net Zero by 2050, IEA, Paris

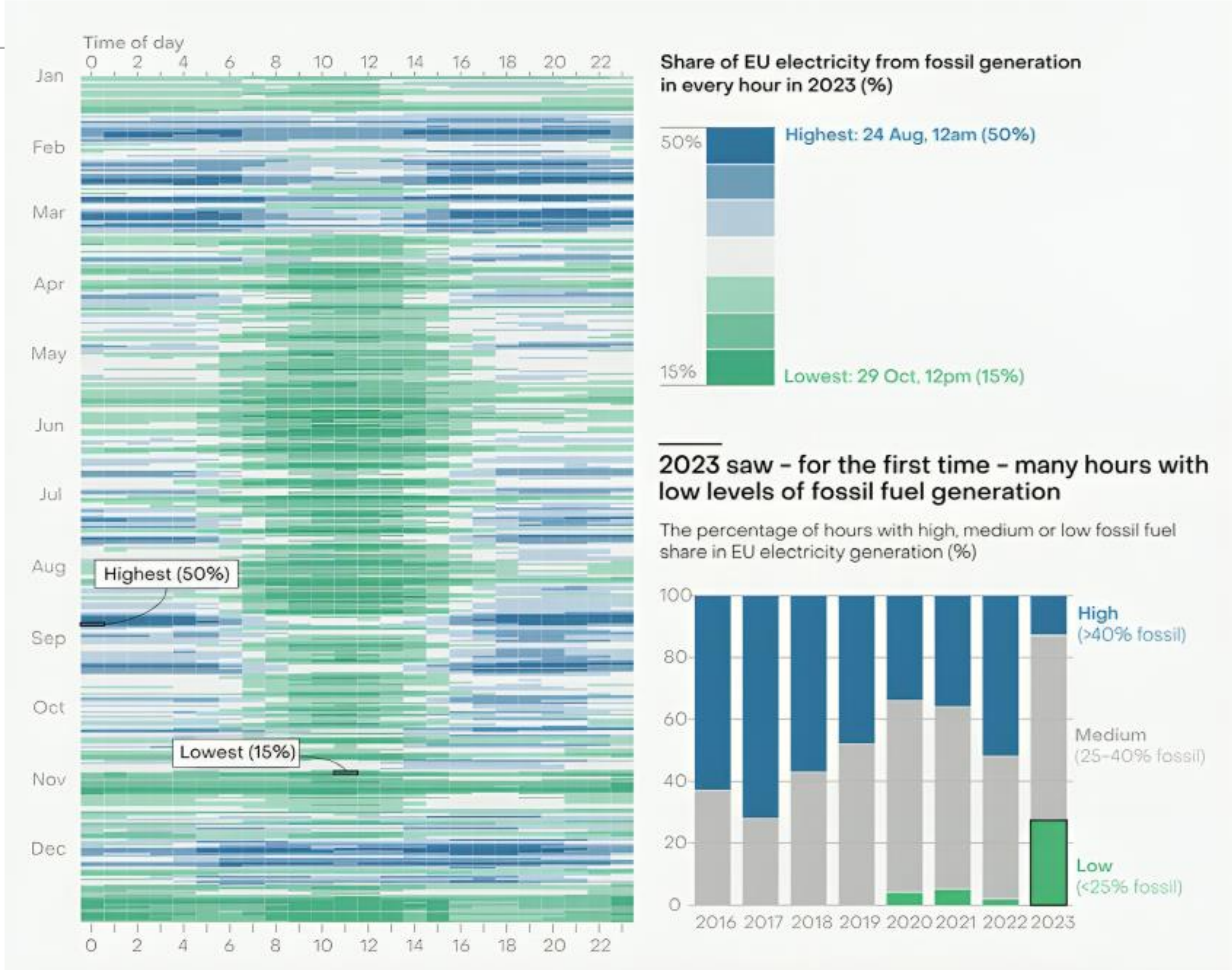
VREs – Effects to the grid and flexibility

	Transmission Level	Distribution Level
Grid Operations	- Increase in required reserve capacity and ramp capabilities - Increase in minimum generation of conventional units on stand-by - Decrease in system inertia - Over generation risks from RES leading to curtailment	- Voltage Flickers/Changes - Frequency Changes - Harmonic Distortions
Grid Planning	- Increase in flexibility costs (balancing) due to higher flexibility demand - Increase in cost of maintaining conventional units at idle state - Challenges in planning of flexibility needs and related procurement (flexibility markets)	Distribution upgrades: - Additional capacity requirements - Uncertainty in generation forecasting - Opportunities for distributed PV + storage

VREs – Effects to the grid and flexibility

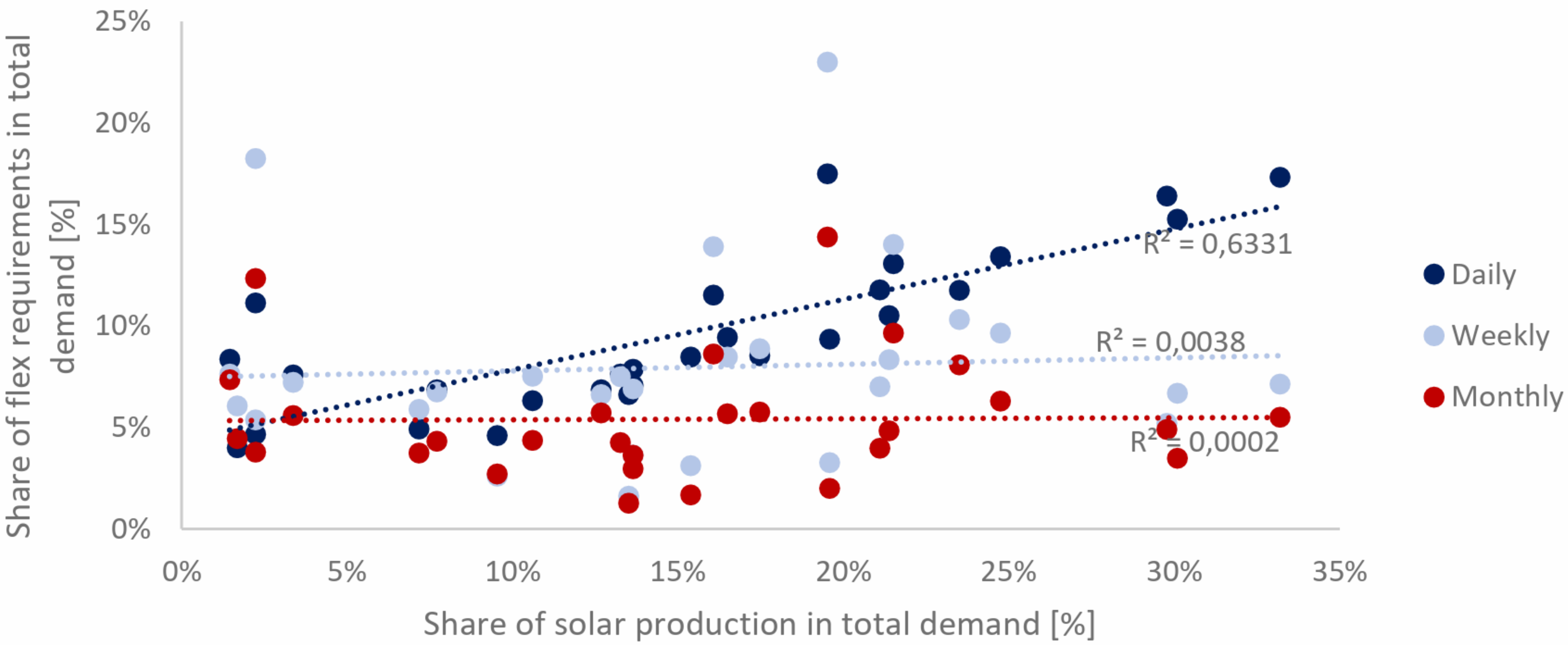


VREs – Effect to markets and conventional power plants



Source: EMBER (2024), European Electricity Review.

Projection of flexibility demand



Koolen, D., De Felice, M. and Busch, S., Flexibility requirements and the role of storage in future European power systems, EUR 31239 EN, Publications Office of the European Union, Luxembourg, 2023, ISBN 978-92-76-57363-0, doi:10.2760/384443, JRC130519.

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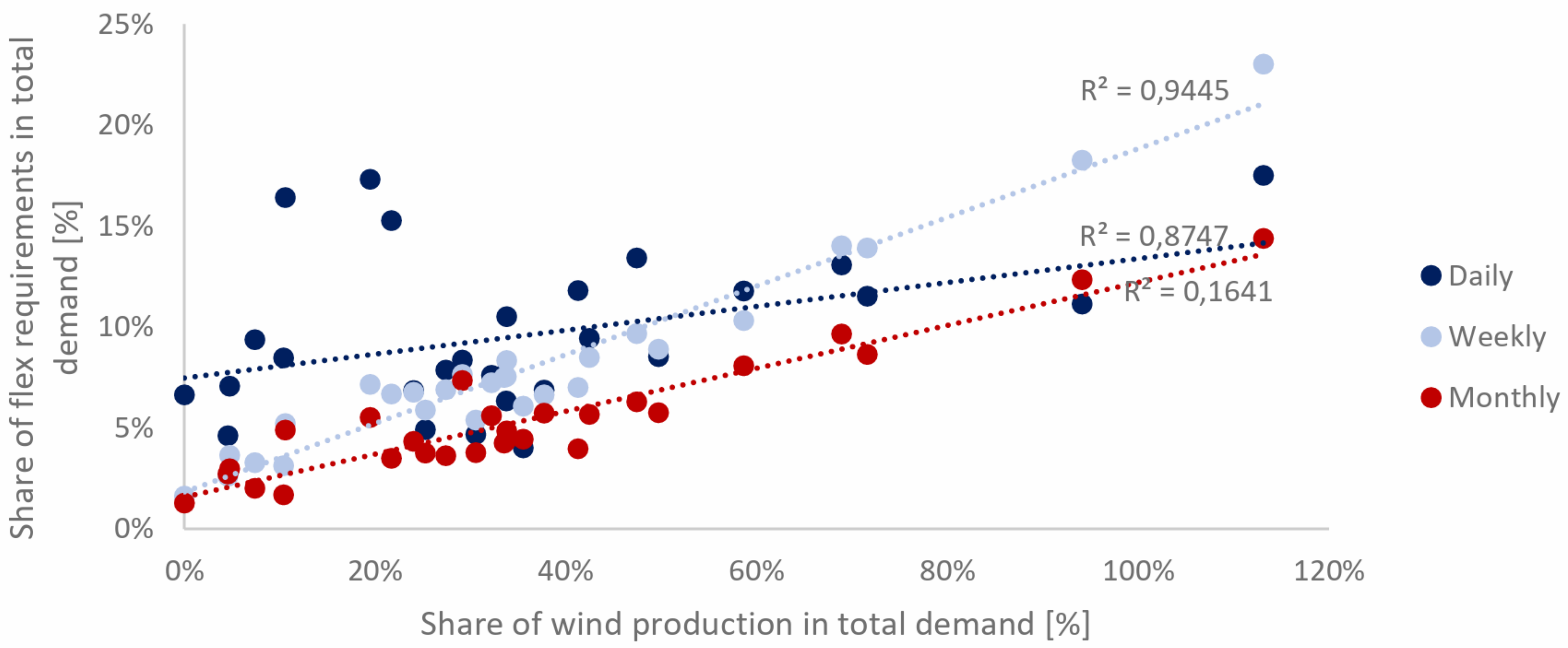

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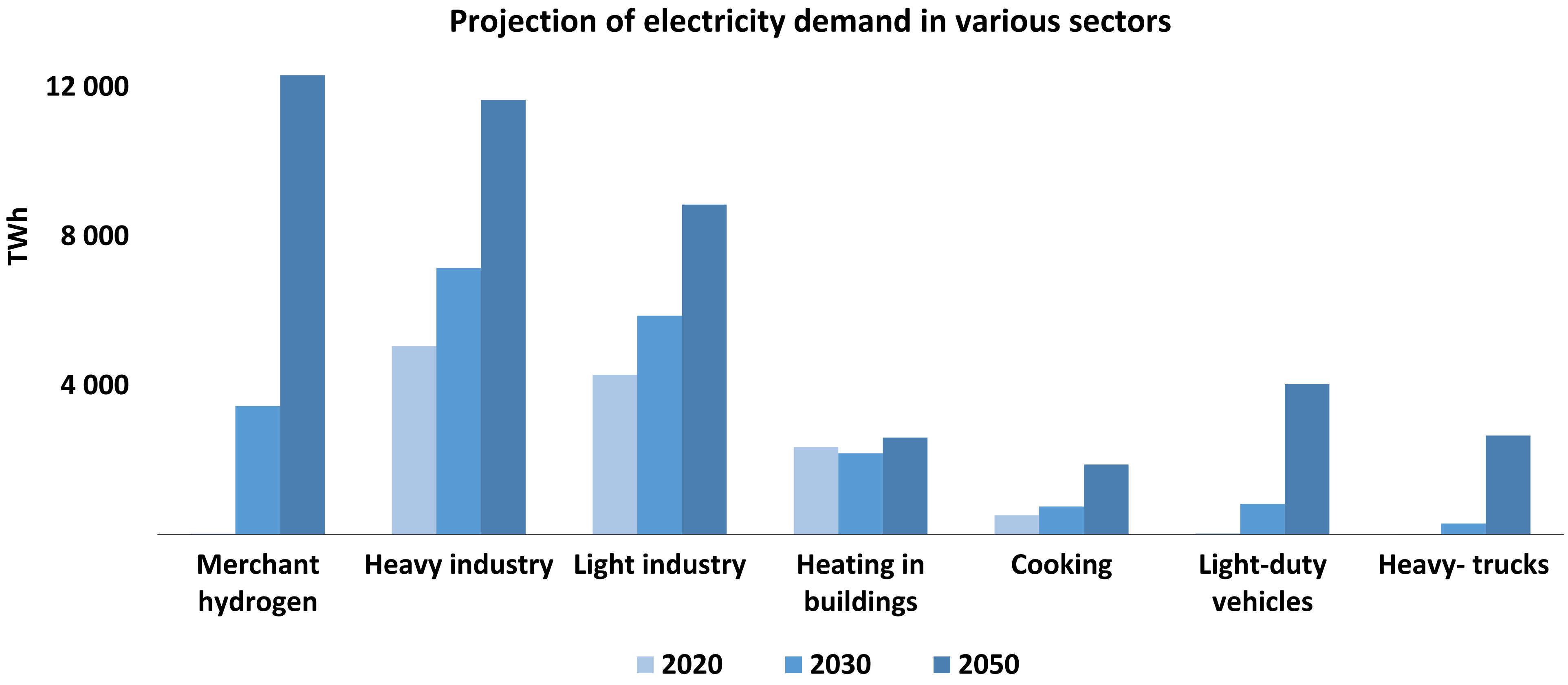
Electrification - trends



Source: International Energy Agency (2021), Net Zero by 2050, IEA, Paris

Electrification – effect to the grid

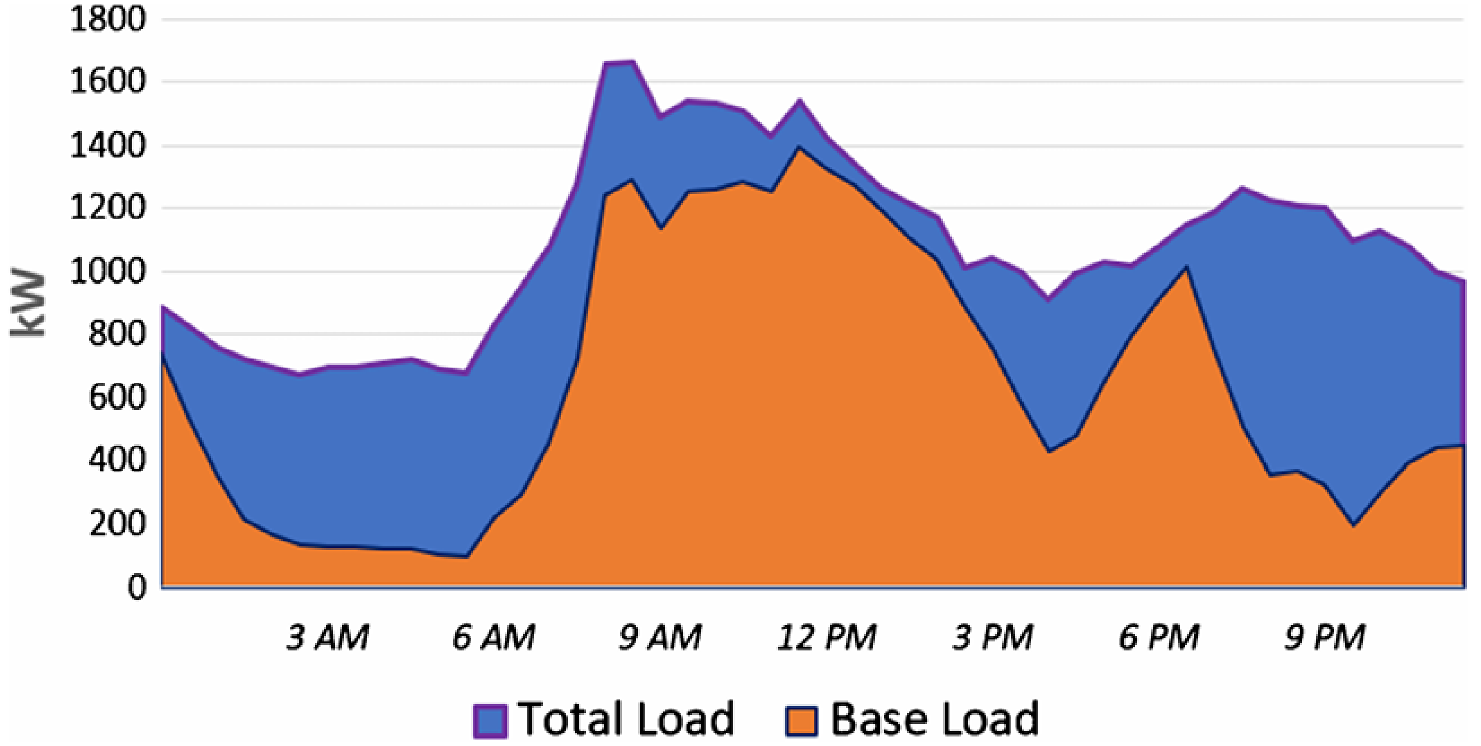
	Transmission Level	Distribution Level
Grid Operations	Peak capacity/economic dispatch: - Large changes in demand profile - Winter peaking in some areas - Opportunities for EV controller	Voltage regulation: - Lower voltages in distribution systems - Temporal and spatial variability of voltage
Grid Planning	Integrated resource planning: - Need for additional generation capacity - Need for new transmission lines for renewables - Opportunities for energy storage	Distribution upgrades: - Additional capacity requirements - Uncertainty in load forecasting - Opportunities for distributed PV + storage

Blonsky, Michael, Nagarajan, Adarsh, Ghosh, Shibani, McKenna, Killian K, Veda, Santosh, and Kroposki, Benjamin D. Potential Impacts of Transportation and Building Electrification on the Grid: A Review of Electrification Projections and their Effects on Grid Infrastructure, Operation, and Planning. United States: N. p., 2019. Web. doi:10.1007/s40518-019-00140-5.

Electrification – effect to the grid

EVs can help smooth out load profiles and provide grid flexibility

Example of a base load (without EVs) and total load (with EVs) profile for a spring day.



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THANK YOU
FOR YOUR ATTENTION!

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