資料４

International Energy Agency

Grid Integration of Electric Vehicles:

Supporting grid development for growing EV charging demand

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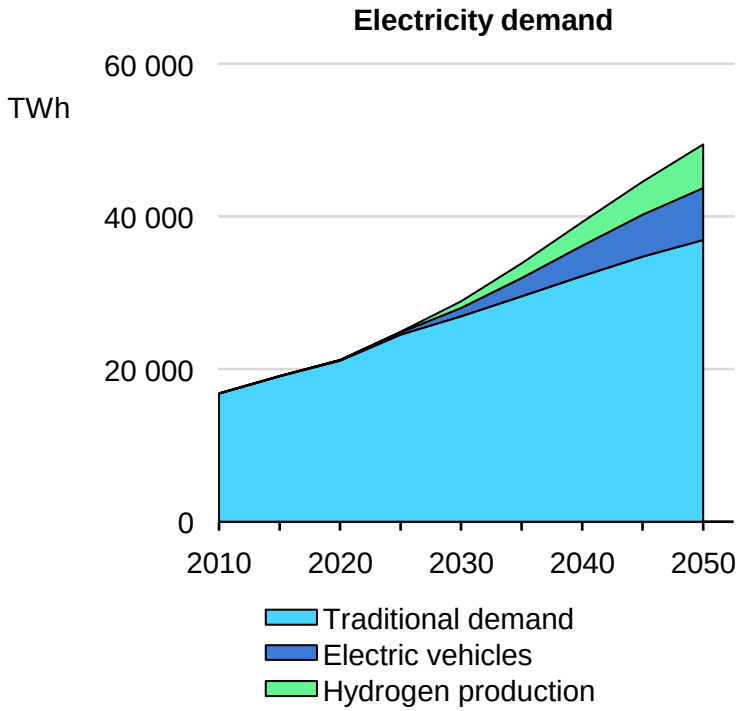
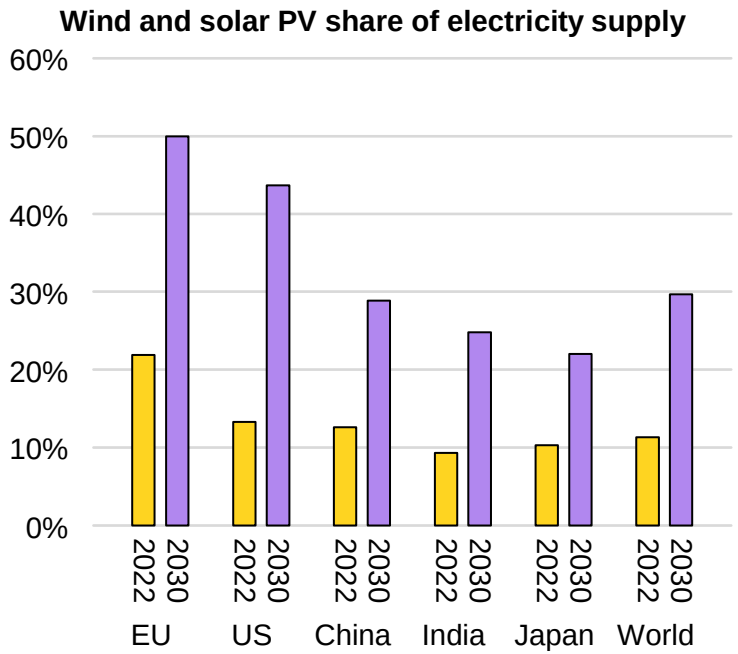
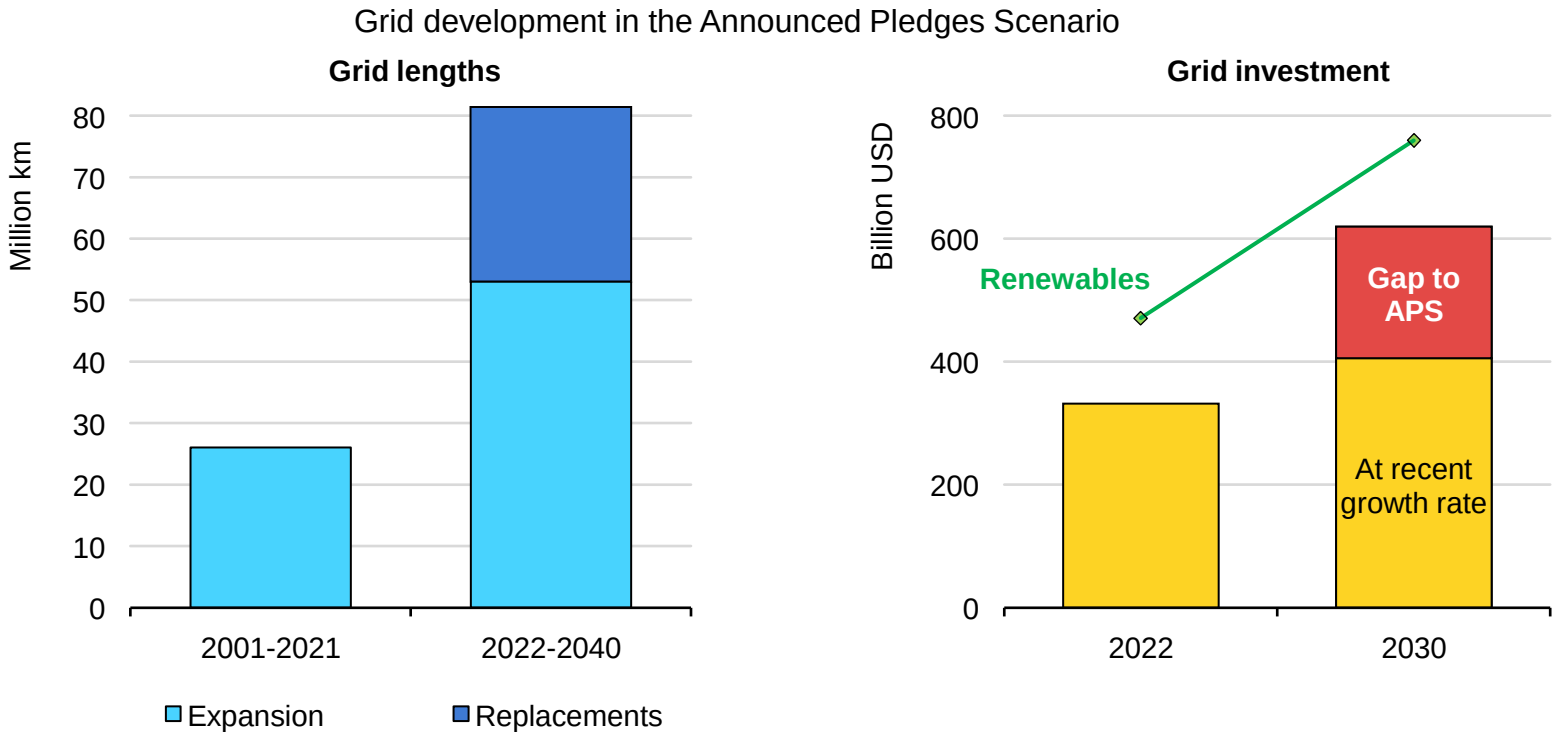
The nature of electricity systems is changing





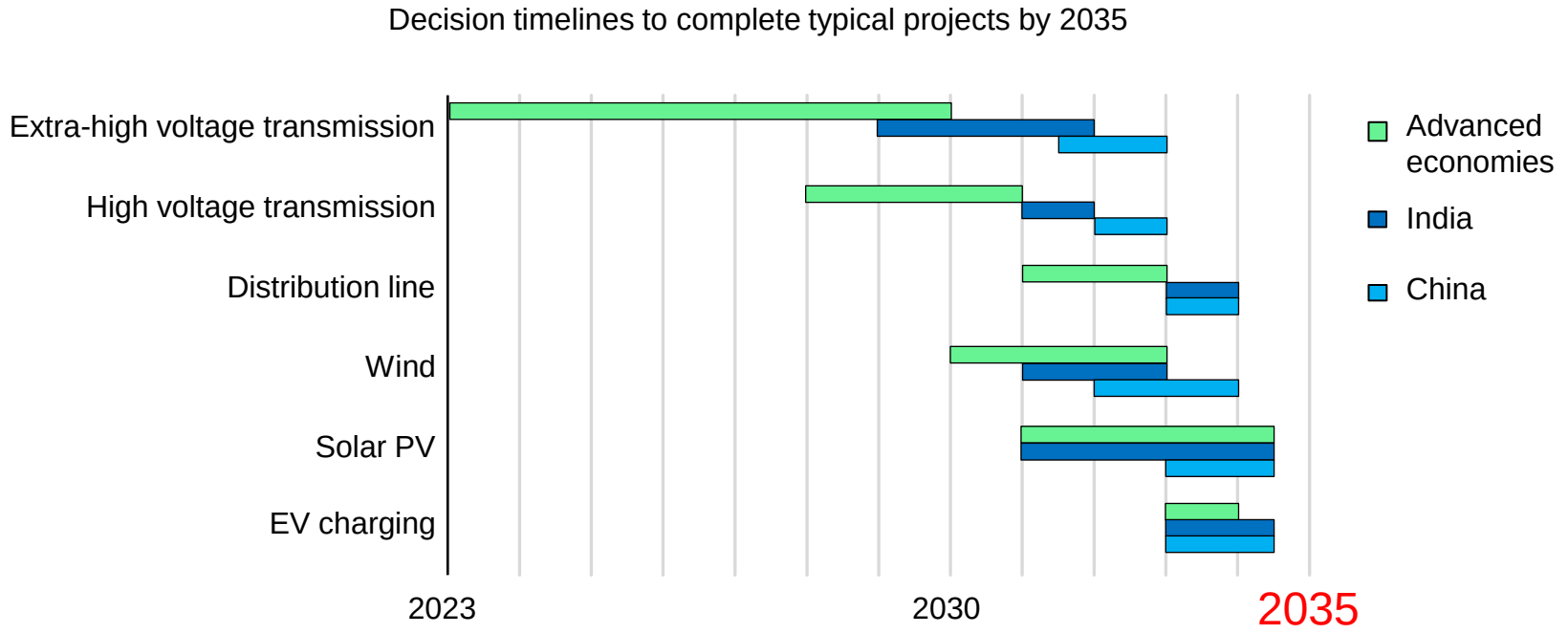
Electricity is the beating heart of modern economies and demand is set to grow fast, with new demand types growing, while wind and solar PV are re-shaping electricity supply and are set to be 80% of new capacity additions

Grid development needs to accelerate to keep up with transitions



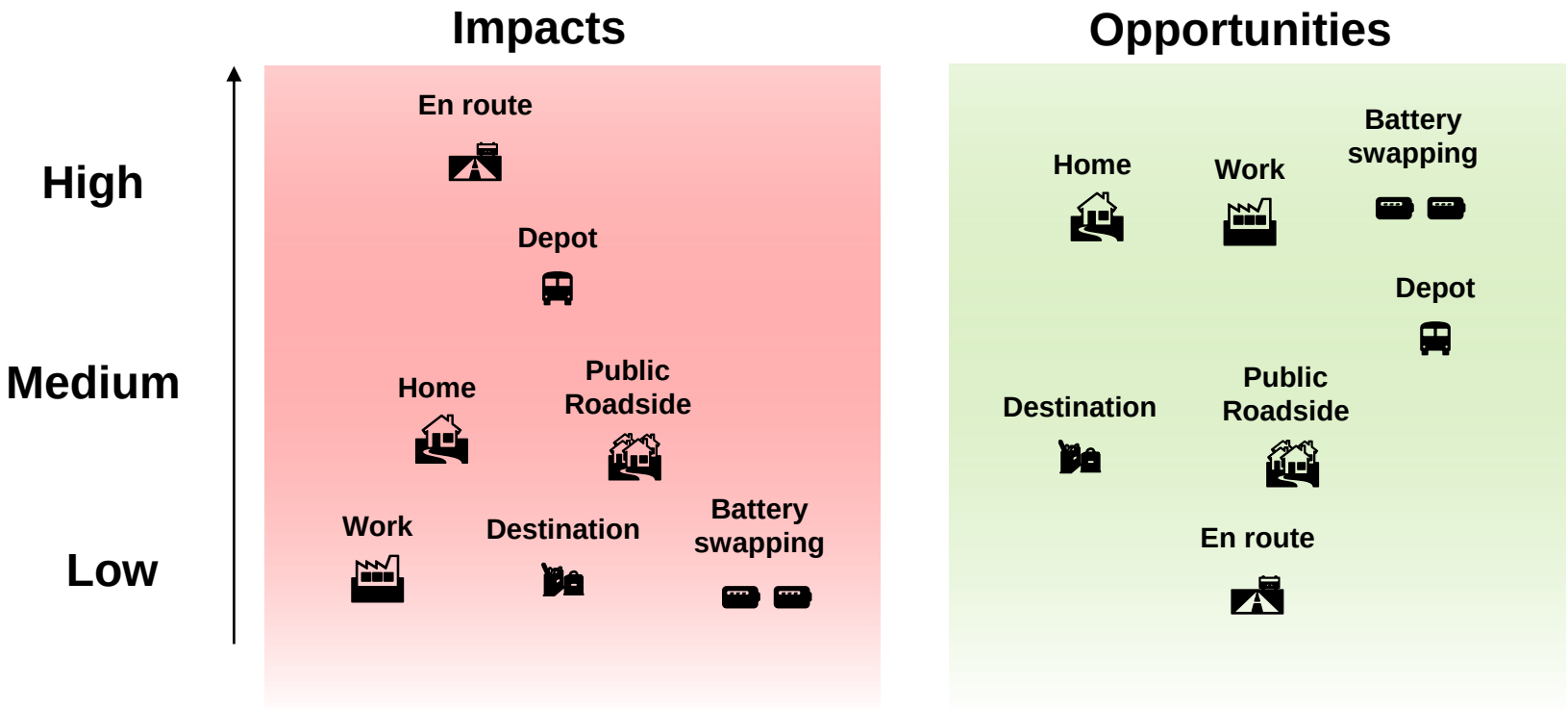
Over the next two decades, 80 million km need to be added or replaced, as much as the global grid length today, calling for grid investment to double by 2030, in step with renewables, raising material needs.

Long lead times for grids call for advanced planning



Electricity grid development is complex, involves many stakeholders and can take many years, requiring decisions well in advance to support electrification and renewables that can be deployed more quickly

Electrification of demand is an opportunity for the power system



Grid impacts of EV charging solutions can vary based on local contexts.
EV charging can be shifted in time to reduce peak demand and match renewable generation.

4 key steps for policy makers to successfully integrate EVs

① Prepare institutions for the electric mobility transition

1. Engage electric mobility stakeholders
2. Break silos in planning and policy making

② Assess the power system impacts

1. Define an electric mobility strategy
2. Gather data and develop insights
3. Assess the grid impacts under mobility scenarios

③ Deploy measures for grid integration

1. Accommodate all charging solutions but encourage managed charging
2. Facilitate aggregation by enforcing standards and interoperability
3. Value the flexibility of EVs
4. Co-ordinate EV charging with renewables
5. Incentivise smart-readiness

④ Improve planning practices

1. Conduct proactive grid planning
2. Reflect the full value of EV charging

③ Deploy measures for grid integration

3.1 Accommodate all charging solutions but encourage managed charging

Mitigating the impacts of lowering barriers to e-mobility

Locational signals

- Hosting capacity maps (New Jersey New York and California)
- Variable fees by location, storage requirements

Non-firm connection

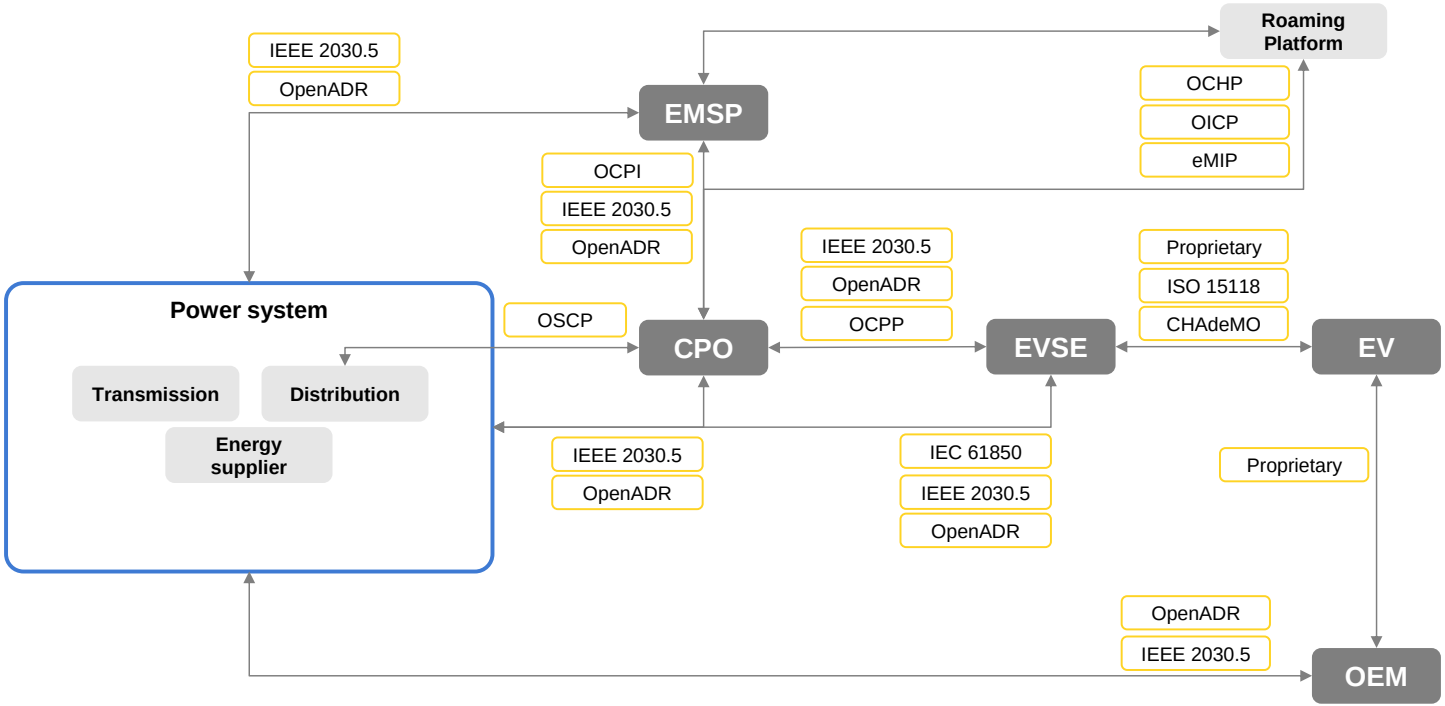
- Lower fees for “flexible connection” (DNO in United Kingdom)

Influencing connection

Variable fees

- Based on maximum power and controllability (proposed, Netherlands)

3.2 Facilitate aggregation by enforcing standards and interoperability



Several charging standards and communication protocols exist between different interfaces. Enforcing interoperability addresses the user's range anxiety, and increases the volume of aggregated vehicles

3.2 Facilitate aggregation by enforcing standards and interoperability

Incentives

- Tax deductions for residential and commercial EVSE (OCPP in Belgium)
- Grant for charging stations (OCPP in Luxembourg)

Regulations

- Public tender guidelines (OCPP and OCPI in the Netherlands)
- Charging regulations (OCPP in the UK and in India)

3.3 Value the flexibility of EVs

Tariff Design

- Time of Use (EV-specific in Korea)
- Real-time pricing
- Critical peak pricing (United States)

Flexibility Contracts and Markets

- Local flex markets (UK, Germany, Italy, Netherlands, Switzerland)

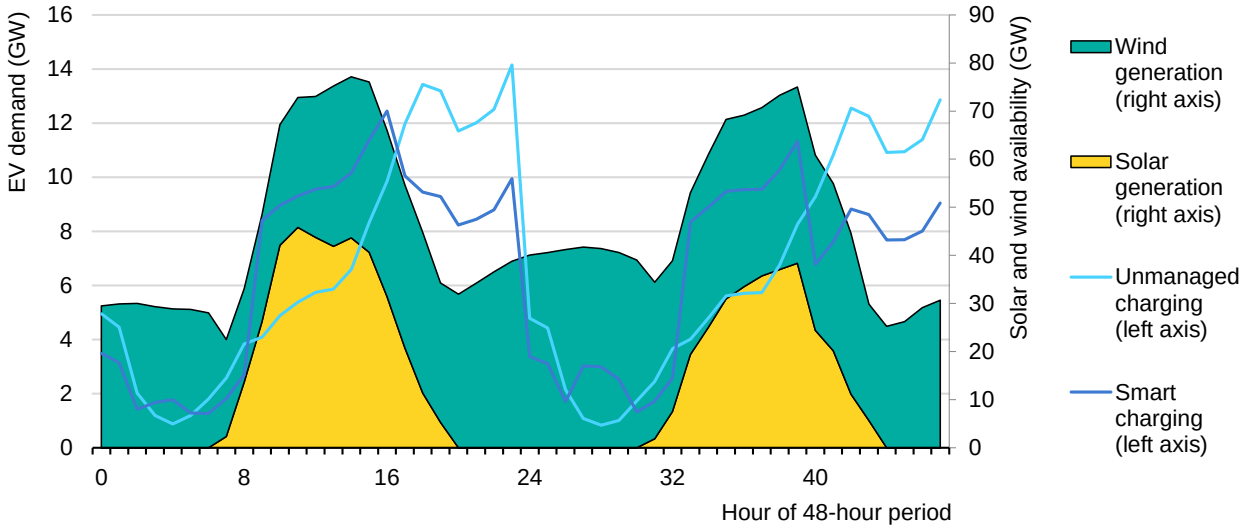
Wholesale + Balancing Markets

- Through aggregators (UK)
- Adjusting product specifications (100 kW minimum in Sweden for primary regulation)

Photo credits: Flat icons

3.4 Co-ordinate EV charging with renewables

Variable renewable energy patterns and the load-shifting potential of EVs in Korea, 2050



Encourage daytime charging

- Work place charger incentives (UK, US)

Incentives

- RE supplier or on-site generation (Belgium)

Options to directly contract RE supply

- Lowering size requirements (1 to 0.1 MW in India)

Source: IEA (2021), Reforming Korea's Electricity Market for Net Zero.

A framework for grid integration of electric vehicles

PHASE 1: No noticeable impact	**PHASE 2:** EV load noticeable with low flexibility demand	**PHASE 3:** Flexible EV load is significant with high flexibility demand	**PHASE 4:** Flexible EV load is highly available with high flexibility demand
No significant impact yet. Encourage higher EV uptake through incentives and public EVSE deployment.	Distinct variability observed caused by EV charging but demand for flexibility is low enough that simple flexibility measures would suffice.	Demand for flexibility is high, matching the availability of flexible EV load and paving the way for aggregated smart charging.	High flexibility demand along with highly available flexible EV load can provide energy back to the system in periods of deficit.
Co-ordinate charging station deployment in areas beneficial to the grid	**Passive measures:** time-of-use tariffs, vehicle-based charging time delays	Deploy active measures: unidirectional V1G	Deploy active measures, bidirectional charging: V2G
Most countries today	**Norway**	**France, Netherlands, United States**	**Island power systems, certain vehicle segments**

Source: IEA (2022), Grid Integration of Electric Vehicles

A framework for grid integration of electric vehicles

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Co-ordinate charging station deployment in areas beneficial to the grid	Passive measures: time-of-use tariffs, vehicle-based charging time delays	Deploy active measures: unidirectional V1G	Deploy active measures, bidirectional charging: V2G
EV-EVSE interface standardisation and interoperability measures	Hourly metering or sub-hourly metering	Real-time advanced metering and communications infrastructure	Battery state-of-health measurements
Database for EV registrations and charging points	Separate metering for EVs or onboard charging measurement devices	Forecasting of EV availability, electricity prices, VRE generation and grid constraints	Enable platforms for decentralised power trading
Data collection of travel and charging patterns	Enable data exchange platforms for grid operators, EMSPs, OEMs, CPOs and EV users	Grid code definition for V1G	Battery state-of-health considerations for V2G cycling
Frameworks to incentivise demand response	EV-EVSE-grid standardisation of communication protocols	Real-time tariffs	Bidirectional protocols: ISO-15118-20:2022, CHAdeMO
	Time-of-use or critical peak tariffs	Contracts and markets for flexibility	Reducing or eliminating two-way taxation for storage
	Self-consumption policies	Market access for aggregators	Grid code definition for V2G

Charging strategy | *Technology requirements* | *System operations* | *Regulation and market design*

Addressing grids scarcity - A call to action

- **Bring planning up to date –** Strategic and integrated planning across sectors
- **Unlock investment –** Improve how grid companies are remunerated
- **Address barriers –** Regulatory overhaul towards proactive grid development
- **Secure supply chains –** Firm & transparent project pipelines to enable resilient supply chains
- **Leverage digitalisation –** Digitalise infrastructure and advance distributed resources
- **Build a skilled workforce –** Create a pool of talent with digital and electricity skills

Interactive web tool:

EV Charging and Grid Integration tool

http://www.iea.org/data-and-statistics/data-tools/ev-charging-and-grid-integration-tool

Report

Grid Integration of Electric Vehicles: A Manual for Policy Makers

https://www.iea.org/reports/grid-integration-of-electric-vehicles