EV Charging and Grid Integration Tool

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Outline

• Grid integration of EVs
• EV Charging and Grid Integration Tool
• Q&A
EV charging demand and faster charging will grow substantially

Global EV charging demand will grow from 110 TWh today to 950-1700 TWh in 2030. Larger vehicle sizes (which require faster charging) could account for over a third of global EV charging demand.

Source: IEA (2023), Global Electric Vehicle Outlook 2023
Managed (flexible) charging unlocks demand flexibility, reduces peak demand and grid congestion, and accelerates electricity decarbonisation.
Charging flexibility is needed to lower system costs and emissions.

Smart charging enables larger contributions of EVs in reducing emissions, operational costs and peak capacity needs for the system.

Source: IEA (2021), Reforming Korea’s Electricity Market for Net Zero
Effective and coordinated action is needed to integrate EVs successfully at scale
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

Focus for today
② Assess the power system impacts
Deploying a more diverse EV stock will need adequate planning. Different vehicle types and segments imply different charging solutions. Policy makers must identify electrification priorities to determine their grid impacts.

Source: IEA (2022), Grid Integration of Electric Vehicles
Recommendations for assessing the power system impacts

**Develop mobility scenarios**
- By transmission system operator (France)
- By national laboratory (United States)

**Develop travel surveys**
- Travel surveys (Chile, Thailand)
- EV charging patterns (France)

**Deploy digital Technologies**
- GPS in LDVs and in Trucks (United States, Europe)

**Record charging sessions + open access**
- Obligation in public tender (Germany)

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Source: RTE (2019) *Integration of electric vehicles into the power system of France*
③ Deploy measures for grid integration
### A framework for grid integration of electric vehicles

<table>
<thead>
<tr>
<th>PHASE 1: No noticeable impact</th>
<th>PHASE 2: EV load noticeable with low flexibility demand</th>
<th>PHASE 3: Flexible EV load is significant with high flexibility demand</th>
<th>PHASE 4: Flexible EV load is highly available with high flexibility demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>No significant impact yet. Encourage higher EV uptake through incentives and public EVSE deployment.</td>
<td>Distinct variability observed caused by EV charging but demand for flexibility is low enough that simple flexibility measures would suffice.</td>
<td>Demand for flexibility is high, matching the availability of flexible EV load and paving the way for aggregated smart charging.</td>
<td>High flexibility demand along with highly available flexible EV load can provide energy back to the system in periods of deficit.</td>
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</tbody>
</table>

**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
Interactive web tool:
EV Charging and Grid Integration tool

Report (December 2022)
Grid Integration of Electric Vehicles: A Manual for Policy Makers
https://www.iea.org/reports/grid-integration-of-electric-vehicles
EV Charging and Grid Integration Tool
EV Charging and grid integration tool

Motivation #1
Assessing the impact of EV charging on the power system

Motivation #2
Assessing effect of measures for mitigating EV charging impacts

Motivation #3
Estimating the CO₂ emissions related to EV charging

Module 1
Simulation of EV charging behaviour
Output: weekly EV charging demand profile

Module 2
Simulation of EV charging behaviour with managed charging
Output: weekly EV charging demand profile with managed charging

Module 3
Simplified representation of the electricity mix
Output: calculation of yearly CO₂ emissions
IEA’s EV Charging and Grid Integration Tool

The tool’s main output is a weekly EV charging demand profile, enabling understanding of the impacts of charging schemes, driving behaviour and infrastructure availability on power demand and emissions.
Motivation #1 (Module 1)

Assessing the impact of EV charging on the power system
EVs can be charged at several types of locations

Source: IEA’s Policy Brief on Public Charging Infrastructure
Ex: 100 buses – base example
Ex: 1000 cars
Ex: 1000 cars – lower access to home/depot charging
Ex: 1000 cars overlapped with 100 buses
Motivation #2 (Module 2)
Implementing managed (more flexible) charging
Applying managed charging measures

Is managed charging possible?

Checking flexibility
- Energy required to charge EV
- Energy available for charging (during connection time)

Flexibility

Participation rate
- Is the infrastructure adapted? AND
- Is the driver willing to participate?

Apply a managed charging measure

Balanced charging

Maximum charging power

Charging power

Arrival time
Departure time

Time-of-Use (ToU) tariffs and smart charging

Shift of energy depending on the hourly tariff schedule

Reference electricity demand curve

Reference profile
Ex: 1000 cars – applying balanced charging
Ex: 1000 cars – applying Time-of-Use tariffs
Ex: 1000 cars – applying V1G
Motivation #3 (Module 3)

Estimating the CO2 emissions related to EV charging
EV charging emissions depend on power mix at time of charging

**Estimate of emissions**

- **Net load without and with EV charging**
- **Running power plants**
- **EV charging related emissions by comparison**

**Simplified dispatch simulation**

- **Net load without and with EV charging**
- **Running power plants**
- **EV charging related emissions by comparison**

- \(\text{Power plants} - \text{Cumulated power sum in MW}\)
- \(\text{Time steps} - \text{Electricity demand (with EV) minus renewable generation}\)
- \(\$ - \text{Energy price in $ per MWh}\)

- = Cumulated power sum in MW
- = Energy price in $ per MWh
- = Electricity demand (with EV) minus renewable generation
Ex: 1000 cars – CO2 emissions estimates

Weekly marginal EV emissions: 29t CO2
Annual marginal EV emissions: 1337t CO2
EV share of total emissions: 0.066%

Show non-EV emissions
Final remarks

• Electrification of road transport is ongoing and will accelerate as it contributes to decarbonisation and helps reducing dependency to fossil fuels

• Electrification will contribute to the increase in electricity demand but is an opportunity for the electricity system as the new electricity end-uses have some embedded flexibility

• The power sector can accommodate a wide range of charging solutions but encouraging managed charging can bring gains in avoided generation costs and emissions, and support faster growth of renewables

• Flexibility of new electricity-end uses needs to be incentivised from early stages

• Our EV Charging and Grid Integration Tool can be a useful resource for a wide range of stakeholders – ranging from pilot project developers, policymakers, and system operators, to utilities and academics
Interactive web tool:
**EV Charging and Grid Integration tool**

Report (December 2022)
**Grid Integration of Electric Vehicles: A Manual for Policy Makers**
https://www.iea.org/reports/grid-integration-of-electric-vehicles
Thank you for your attention.

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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)
Co-ordinate EV charging with renewables

Variable renewable energy patterns and the load-shifting potential of EVs in Korea, 2035

- **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.