Grid integration of electric vehicles: A manual for policy makers

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4 key steps for policy makers to successfully integrate EVs

① Prepare institutions for the electric mobility transition

② Assess the power system impacts

③ Deploy measures for grid integration

④ Improve planning practices
1. Prepare institutions for the electric mobility transition
4.1, 4.2 Engage stakeholders and break silos of planning and policy

<table>
<thead>
<tr>
<th>Transport and infrastructure stakeholders</th>
<th>Energy and power sector stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overarching policies</strong></td>
<td></td>
</tr>
<tr>
<td>Transport targets: EV uptake,</td>
<td>Power system targets: VRE shares,</td>
</tr>
<tr>
<td>transport emissions, energy efficiency</td>
<td>electrification, energy efficiency</td>
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<tr>
<td><strong>Countrywide infrastructure</strong></td>
<td>Overarching policies</td>
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<tr>
<td>Charging infrastructure roll-out, roaming</td>
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<tr>
<td>and long-haul travel</td>
<td></td>
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<tr>
<td><strong>Mobility, land use and urban planning</strong></td>
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<tr>
<td>Charging depots, local mobility plans</td>
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<tr>
<td><strong>End users</strong></td>
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<tr>
<td>Fuel tax</td>
<td>Electricity tax</td>
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<td></td>
<td>Smart energy offerings</td>
</tr>
</tbody>
</table>

Plenty of potential synergies between transport and energy stakeholders – breaking planning and policymaking silos is key

### Key recommendations

| Designate contact persons in charge of cross-sectoral co-ordination |
| Create multidisciplinary working groups |
| Establish co-operation at the policy-making level |

- **Designate contact persons in charge of cross-sectoral co-ordination**

- **Create multidisciplinary working groups**
  - [California VGI Working Group](#)

- **Establish co-operation at the policy-making level**
  - [US Joint office of Energy and Transportation](#)
2. Assess power system impacts
Determine vehicle electrification priorities

Different vehicle types and segments imply different charging solutions. Policy makers must identify electrification priorities to determine their grid impacts.

Source: Analysis of IEA Mobility Model
Different charging solutions based on vehicles electrified

Grid impacts of charging solutions can vary based on local contexts. Modelling them should consider mobility scenarios to ensure a robust planning.
Key recommendations

Mobility scenarios
- By transmission operator (France)
- By national lab (United States)

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

Digital Technologies
- GPS in LDVs and in Trucks (United States, Europe)

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

Source: RTE (2019) Integration of electric vehicles into the power system of France
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)
3.4 Co-ordinate EV charging with renewables

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

Hour of 48-hour period

- **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

<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>
</tr>
<tr>
<td>Co-ordinate charging station deployment in areas beneficial to the grid</td>
<td>Passive measures: time-of-use tariffs, vehicle-based charging time delays</td>
<td>Deploy active measures: unidirectional V1G</td>
<td>Deploy active measures, bidirectional charging: V2G</td>
</tr>
<tr>
<td>Norway</td>
<td>France, Netherlands, United States</td>
<td>Island power systems, certain vehicle segments</td>
<td></td>
</tr>
</tbody>
</table>

Norway, France, Netherlands, United States, Island power systems, certain vehicle segments
# A framework for grid integration of electric vehicles

## PHASE 1: No noticeable impact

- Co-ordinate charging station deployment in areas beneficial to the grid
- EV-EVSE interface standardisation and interoperability measures
- Database for EV registrations and charging points
- Data collection of travel and charging patterns
- Frameworks to incentivise demand response

## PHASE 2: EV load noticeable with low flexibility demand

- Passive measures: time-of-use tariffs, vehicle-based charging time delays
- Hourly metering or sub-hourly metering
- Separate metering for EVs or onboard charging measurement devices
- Enable data exchange platforms for grid operators, EMSPs, OEMs, CPOs and EV users
- EV-EVSE-grid standardisation of communication protocols
- Time-of-use or critical peak tariffs
- Self-consumption policies

## PHASE 3: Flexible EV load is significant with high flexibility demand

- Deploy active measures: unidirectional V1G
- Real-time advanced metering and communications infrastructure
- Forecasting of EV availability, electricity prices, VRE generation and grid constraints
- Grid code definition for V1G
- Real-time tariffs
- Contracts and markets for flexibility
- Market access for aggregators

## PHASE 4: Flexible EV load is highly available with high flexibility demand

- Deploy active measures, bidirectional charging: V2G
- Battery state-of-health measurements
- Enable platforms for decentralised power trading
- Battery state-of-health considerations for V2G cycling
- Bidirectional protocols: ISO-15118-20:2022, CHAdeMO
- Reducing or eliminating two-way taxation for storage
- Grid code definition for V2G
4. Improve planning practices
4.1 Pro active grid planning

Streamline interconnection
• Mandating publication of hosting capacity maps
• Minimum connection time windows (Netherlands)

Targets and regulatory incentives
• Clear deployment targets (Mobility Orientation Law in France)

Source: PSE&G. EV Hosting Capacity Map (accessed 3 August 2022).
4.2 Reflect full value of EV charging

Grid expansion criteria

- Non-wire alternatives such as energy efficiency, and demand response programmes (New York)
- Distribution Deferral Opportunity Report (California)

System planning criteria

- From deterministic
  
  ![Graph showing peak load with installed generation capacity](image)

  - Installed generation capacity
  - 20% to 30%
  - Peak load
  - Year

- To holistic and probabilistic

  ![Graph showing shifted load from EVs](image)

  - Shifted load from EVs (78.5% of required capacity during peak periods, Netherlands)
  - Installed generation capacity
  - Year
4 key steps for policy makers to successfully integrate EVs

1. **Prepare institutions for the electric mobility transition**
   - Engage electric mobility stakeholders
   - Break silos in planning and policy making

2. **Assess the power system impacts**
   - Define an electric mobility strategy
   - Gather data and develop insights
   - Assess the grid impacts under mobility scenarios

3. **Deploy measures for grid integration**
   - Accommodate all charging solutions but encourage managed charging
   - Facilitate aggregation by enforcing standards and interoperability
   - Value the flexibility of EVs
   - Co-ordinate EV charging with renewables
   - Incentivise smart-readiness

4. **Improve planning practices**
   - Conduct proactive grid planning
   - Reflect the full value of EV charging
Full Report
Grid Integration of Electric Vehicles: A Manual for Policy Makers
https://www.iea.org/reports/grid-integration-of-electric-vehicles