EV Charging and Grid Integration Tool

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Outline

• Background

• Presentation of the tool features

• Live demo

• Q&A
### Thematic Working Groups
- Knowledge materials and tools
- Network for advocacy, technology and policy advice

### Regional Platforms
- Capacity building
- Establish communities of practice
- Replication and upscaling

#### Country Projects
- Onsite demonstration

#### GEF Global Programme to Support Countries with the Shift to Electric Mobility

**Thematic Working Groups**

- **2 & 3 wheelers**
  - **2 & 3 wheelers**
  - **Heavy-Duty Vehicles**
  - **Light-Duty Vehicles**

**Regional Platforms**

- **ADB**
  - Asia & Pacific
- **European Bank for Reconstruction and Development**
  - Europe, Middle East, West Asia
- **UN Environment**
  - Latin America & Caribbean
- **UN Environment**
  - Africa

**Country Projects**

- 30+ country projects

[https://www.thegef.org/project/global-programme-support-countries-shift-electric-mobility](https://www.thegef.org/project/global-programme-support-countries-shift-electric-mobility)
Emissions from Electric Vehicles (EV) charging

As the power sector decarbonises, net reduction of GHG emissions from shift to EV accelerates.
Meeting climate pledges will require electricity demand for EV to grow 20 times by 2030 compared to 2021.
A wide range of road transport electrification priorities

Assessing grid impacts is a necessary step for planning the uptake of EV.
EV Charging and grid integration tool

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

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

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

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

Motivation #3
Estimating the CO$_2$ emissions related to EV charging

Module 3 (API)
Simplified representation of the electricity mix
Output: calculation of yearly CO$_2$ emissions
Motivation #1 (Module 1)

Assessing the impact of EV charging on the power system
Many factors influence the profile of electricity demand by EV

Grid impacts of EV charging vary based on EV fleet and electricity system characteristics.

![Graph showing total charging demand in kW]

Grid impacts of charging solutions vary based on EV fleet and electricity system characteristics.
Example: 1000 private cars – fleet size and driving pattern

How can tool users enter a fleet?

- **Label**: Private LDVs
- **Vehicle type**: LDV
- **Stock**: 1000
- **Average battery capacity**: 46.0 kWh
- **Energy consumption**: 0.18 kWh/km
- **Average weekday driving**: 30 km per day ± 5 km
- **Average weekend driving**: 20 km per day ± 5 km
- **Behaviour profile**: Private driving
Modelling charging behaviour to calculate power demand profile

User inputs

Charging needs

Charging opportunities

Charging location types
- home
- destination
- enroute
- work
- road-side
- opportunity charging

Weekly based model

Weekday

Weekend

Fleet based model

Input

Modelling

Output
Modelling charging behaviour to calculate power demand profile

User inputs

Charging needs

Charging opportunities

Charging preferences

Preferences define with which opportunities the needs are supplied

Weekly based model

Weekday

Weekend

Fleet based model

Input

Modelling

Output
Example: 1 000 private cars – charging behaviour

How can tool users define the charging preference and opportunities?

### Availability

<table>
<thead>
<tr>
<th>Home/Depot</th>
<th>Workplace</th>
<th>Road-side charging</th>
<th>En route</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charger power</td>
<td>Charger power</td>
<td>Charger power</td>
<td>Charger power</td>
<td>Charger power</td>
</tr>
<tr>
<td>3.5 kW</td>
<td>3.5 kW</td>
<td>11 kW</td>
<td>50 kW</td>
<td>11 kW</td>
</tr>
<tr>
<td>Weekday availability</td>
<td>Weekday availability</td>
<td>Weekday availability</td>
<td>Weekday availability</td>
<td>Weekday availability</td>
</tr>
<tr>
<td>90%</td>
<td>60%</td>
<td>0%</td>
<td>0%</td>
<td>50%</td>
</tr>
<tr>
<td>Weekend availability</td>
<td>Weekend availability</td>
<td>Weekend availability</td>
<td>Weekend availability</td>
<td>Weekend availability</td>
</tr>
<tr>
<td>90%</td>
<td>5%</td>
<td>0%</td>
<td>0%</td>
<td>50%</td>
</tr>
</tbody>
</table>
Example: 1,000 private cars – charging behaviour

How can tool users define the charging preference and opportunities?

- **Charger power**
  - **Home/Depot**: 3.5 kW
  - **Workplace**: 3.5 kW
  - **Destination**: 11 kW

- **Availability**
  - **Weekday availability**
    - Home/Depot: 90%
    - Workplace: 60%
    - Destination: 50%
  - **Weekend availability**
    - Home/Depot: 90%
    - Workplace: 5%
    - Destination: 50%
Example: 1,000 private cars – charging behaviour

How can tool users define the charging preference and opportunities?
Example: 1,000 private cars – charging behaviour

How can tool users define the charging preference and opportunities?

Diagram showing preference sliders for Home/Depot, Workplace, and Destination.
### Example: 1,000 Private Cars – Charging Behaviour

How can tool users define the charging preference and opportunities?

<table>
<thead>
<tr>
<th>Weekday</th>
<th>Typical charging times</th>
<th>Weekend</th>
<th>Typical charging times</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arrival time 19:00 ± 1 hours</td>
<td>Arrival time 16:00 ± 2 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Typical stay time 12 hours</td>
<td>Typical stay time 12 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arrival time 09:00 ± 1 hours</td>
<td>Arrival time 09:00 ± 1 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Typical stay time 9 hours</td>
<td>Typical stay time 9 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arrival time 12:00 ± 12 hours</td>
<td>Arrival time 12:00 ± 12 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Typical stay time 3 hours</td>
<td>Typical stay time 4 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arrival time 15:00 ± 2 hours</td>
<td>Arrival time 15:00 ± 2 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Typical stay time 15 minutes</td>
<td>Typical stay time 2 hours</td>
<td></td>
</tr>
</tbody>
</table>
Example: 1,000 private cars – charging behaviour

How can tool users define the charging preference and opportunities?

**Weekday**
- Arrival time: 19:00, +/- 1 hour
- Typical stay time: 12 hours

**Typical stay time**
- 12 hours

**Weekend**
- Arrival time: 16:00, +/- 2 hours
- Typical stay time: 12 hours

**Typical stay time**
- 12 hours
Example: 1,000 private cars

If unmanaged, most charging takes place in the early evening, when the non-EV electricity demand peaks. This can overload grids and require expensive thermal units to cover the additional demand.
Example: 1,000 private cars – lower access to home charging

What does happen, if the charging availability change?
Example: 1,000 private cars – lower access to home charging

Tool output 1: Power demand profile from EV charging over one week
Example: 1 000 private cars – lower access to home charging

Tool output 1: Power demand profile from EV charging over one week

High reliance on public charging network could create sharp surges in demand.
Example: 1,000 private cars – increased access to workplace charging

What does happen, if the charging preferences change?
Example: 1,000 private cars – increased access to workplace charging

Tool output 1: Power demand profile from EV charging over one week

Daytime charging reduces amplitude of evening peak and makes better use of solar energy.
Example: 1,000 private cars – increased access to workplace charging

Tool output 1: Power demand profile from EV charging over one week

Daytime charging reduces amplitude of evening peak and makes better use of solar energy.
Ex: 1 000 private cars – drivers less proactive in connecting to grid

What does happen, if 600 (60%) EV-drivers wait for charging until state of charge of battery = 50%?
Ex: 1 000 private cars – drivers less proactive in connecting to charger

Tool output 1: Power demand profile from EV charging over one week
Ex: 1 000 private cars – drivers less proactive in connecting to charger

Tool output 1: Power demand profile from EV charging over one week

Charging events are less intense but longer if drivers tend to charge only when the battery state of charge is low.
Motivation #2 (Module 2)

Assessing effect of measures for mitigating EV charging impacts
Managed charging unlocks demand flexibility, reduces peak demand and grid congestions, and accelerates electricity decarbonisation.

Power demand profile from EV charging of 1000 private cars driving (one week)

Managed charging effects
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

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

Shift of energy depending on the hourly tariff schedule
reference electricity demand curve
Ex: 1 000 private cars – applying balanced charging

How can a managed charging strategy be applied?
Ex: 1 000 private cars – applying balanced charging

Tool output 2: Power demand profile from EV charging over one week with managed charging

Total charging power in kW

- Home
- Destination

M 00:00 M 12:00 Tu 00:00 Tu 12:00 W 00:00 W 12:00 Th 00:00 Th 12:00 F 00:00 F 12:00 Sa 00:00 Sa 12:00 Su 00:00 Su 12:00

Ex: 1 000 private cars – applying balanced charging

Tool output 2: Power demand profile from EV charging over one week with managed charging

Total charging power in kW

- Home
- Destination

M 00:00 M 12:00 Tu 00:00 Tu 12:00 W 00:00 W 12:00 Th 00:00 Th 12:00 F 00:00 F 12:00 Sa 00:00 Sa 12:00 Su 00:00 Su 12:00
Balanced charging has a significant smoothing effect on demand. Peak power is reduced, leading to lower impact on electricity supply capacity.
Key messages
Key messages

- 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.

- Expansion of grids and charging infrastructure supports the update of EVs, but this requires breaking silos between sectors.
Thank you for your attention.

Thank you to all contributors:

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• Algorithm developers: Luis Lopez, Juha Koýkka, Woan Ho Park, Andreas Bong
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Live Demonstration
Interactive web tool: EV Charging and Grid Integration tool