EV Charging and Grid Integration Tool

Workshop for E-mobility Support and Investment Platform for Asia and the Pacific,
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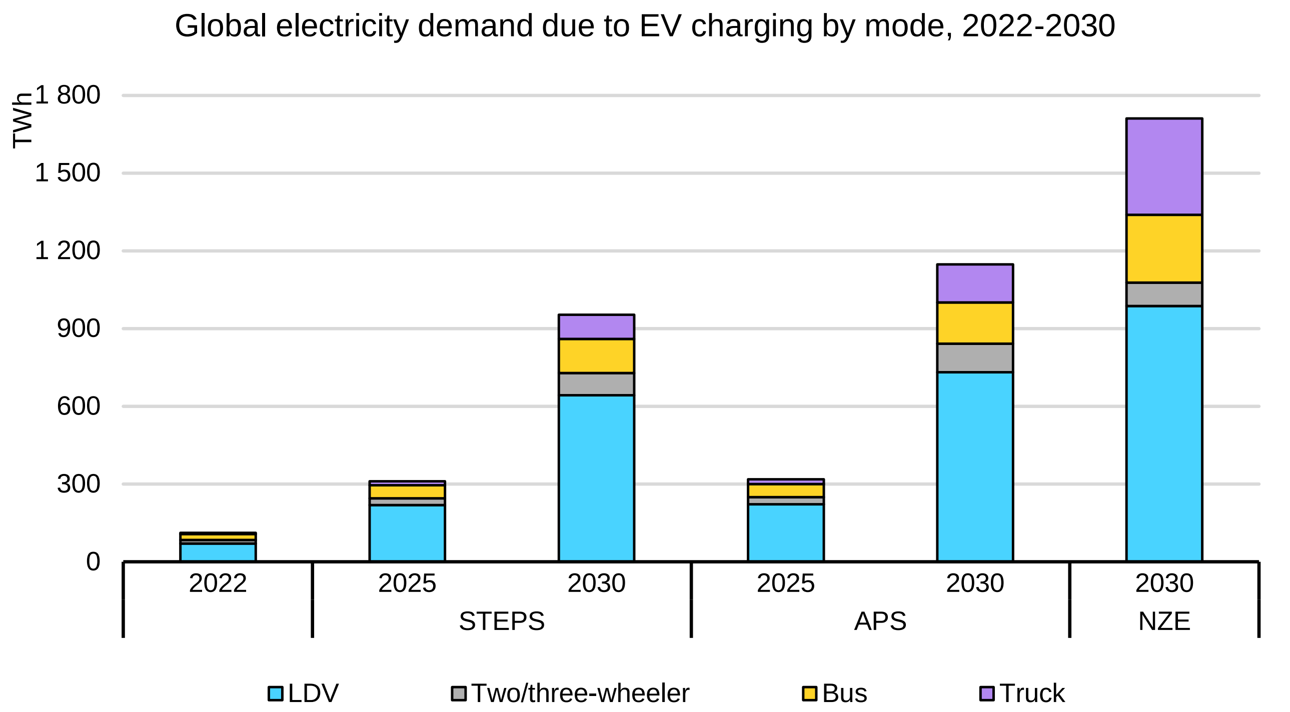
International Energy Agency

Outline

- Grid integration of EVs
- EV Charging and Grid Integration Tool
- Q&A

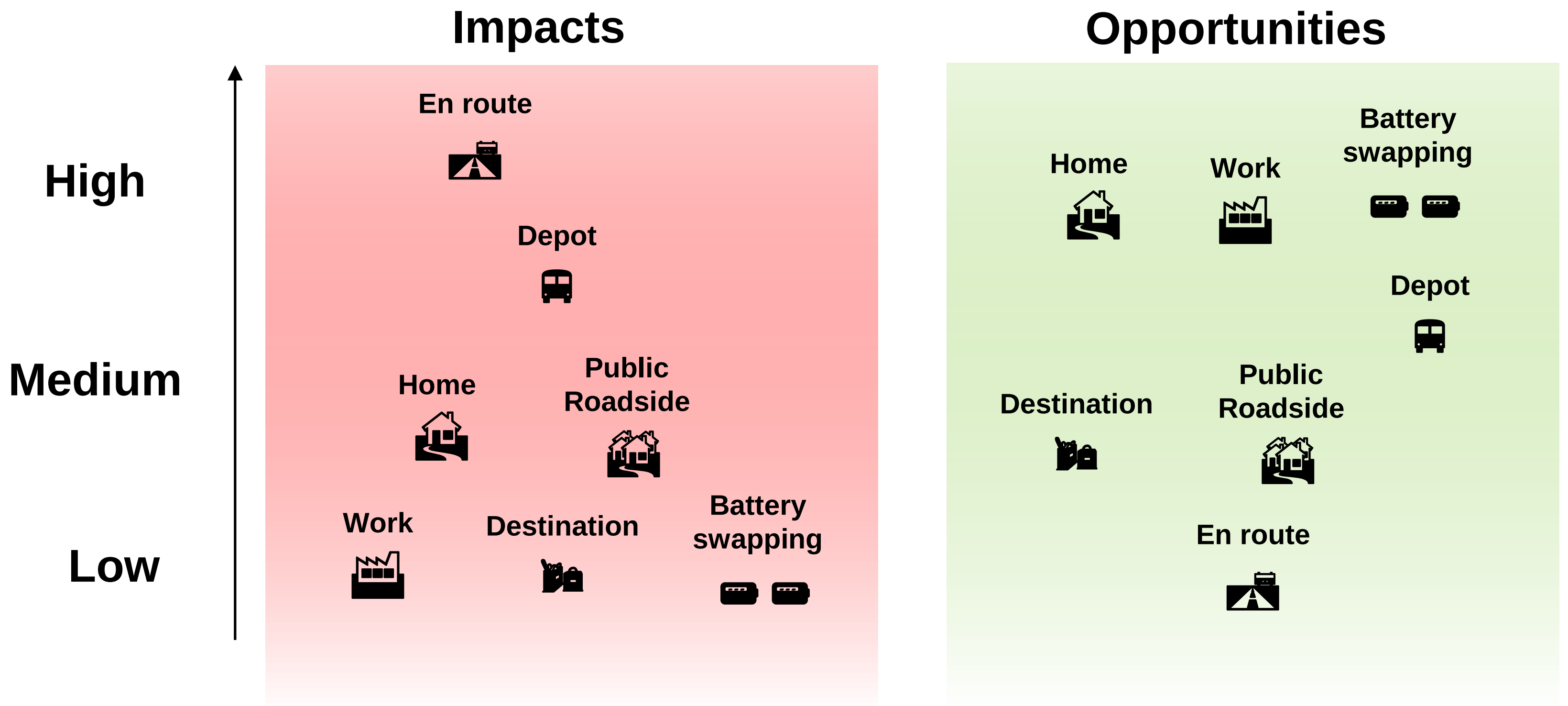
EV charging demand and faster charging will grow substantially



Source: IEA (2023), Global Electric Vehicle Outlook 2023

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.

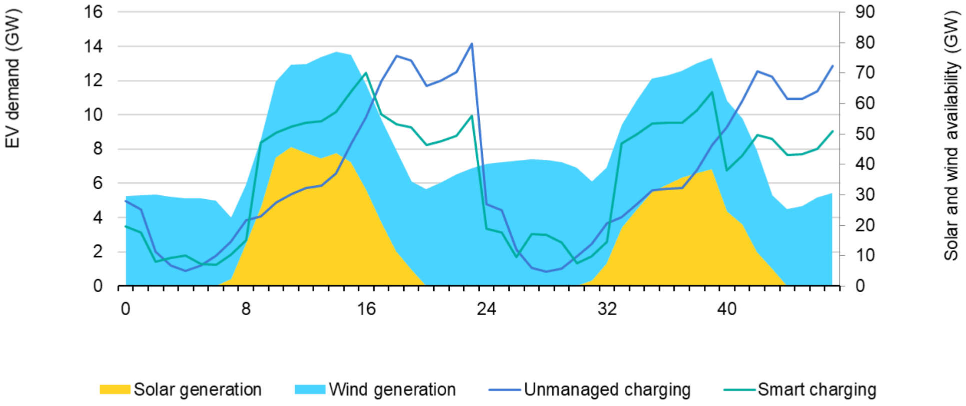
Road transport electrification: from challenges to opportunities



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

Electric vehicle load profiles for unmanaged and smart charging relative to solar and wind availability in Korea 2035 APS



System cost savings for the EV fleet when charging is optimised

	Peak costs	Operating costs	Emissions
$/MWh avoided	18	21	/
% Reduction	30%	21%	21%

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

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

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

Focus for today

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

Focus for today

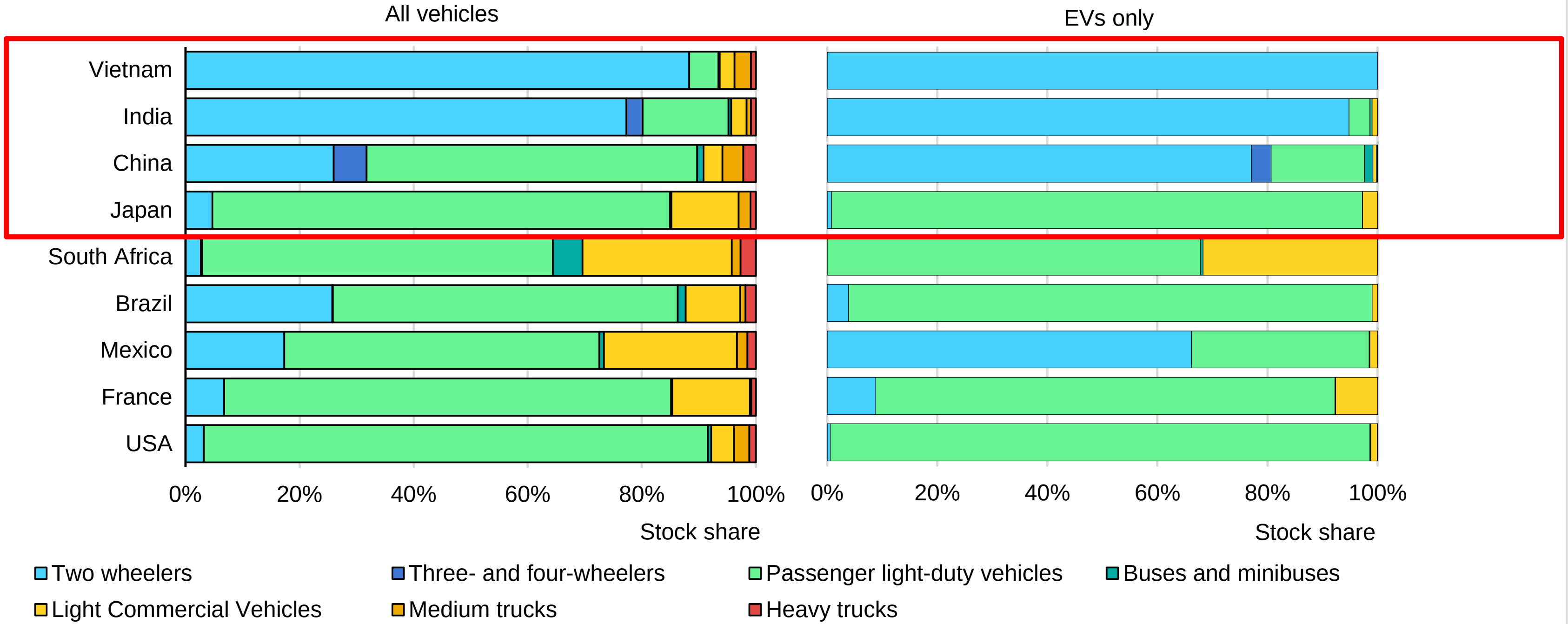
④ Improve planning practices

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

② Assess the power system impacts

Deploying a more diverse EV stock will need adequate planning

Estimated stock share of all vehicles (left) and EVs (right) by vehicle type in selected countries, 2021



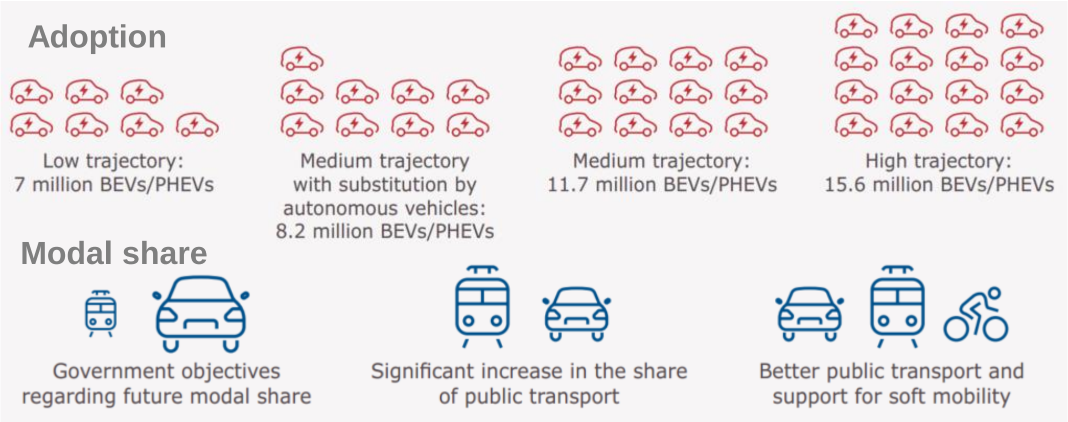
Source: IEA (2022), Grid Integration of Electric Vehicles

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

Recommendations for assessing the power system impacts

Develop mobility scenarios

- By transmission system operator (France)
- By national laboratory (United States)



Source: RTE (2019) *Integration of electric vehicles into the power system of France*

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)

③ Deploy measures for grid integration

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

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 (December 2022)

Grid Integration of Electric Vehicles: A Manual for Policy Makers

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EV Charging and Grid Integration Tool

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

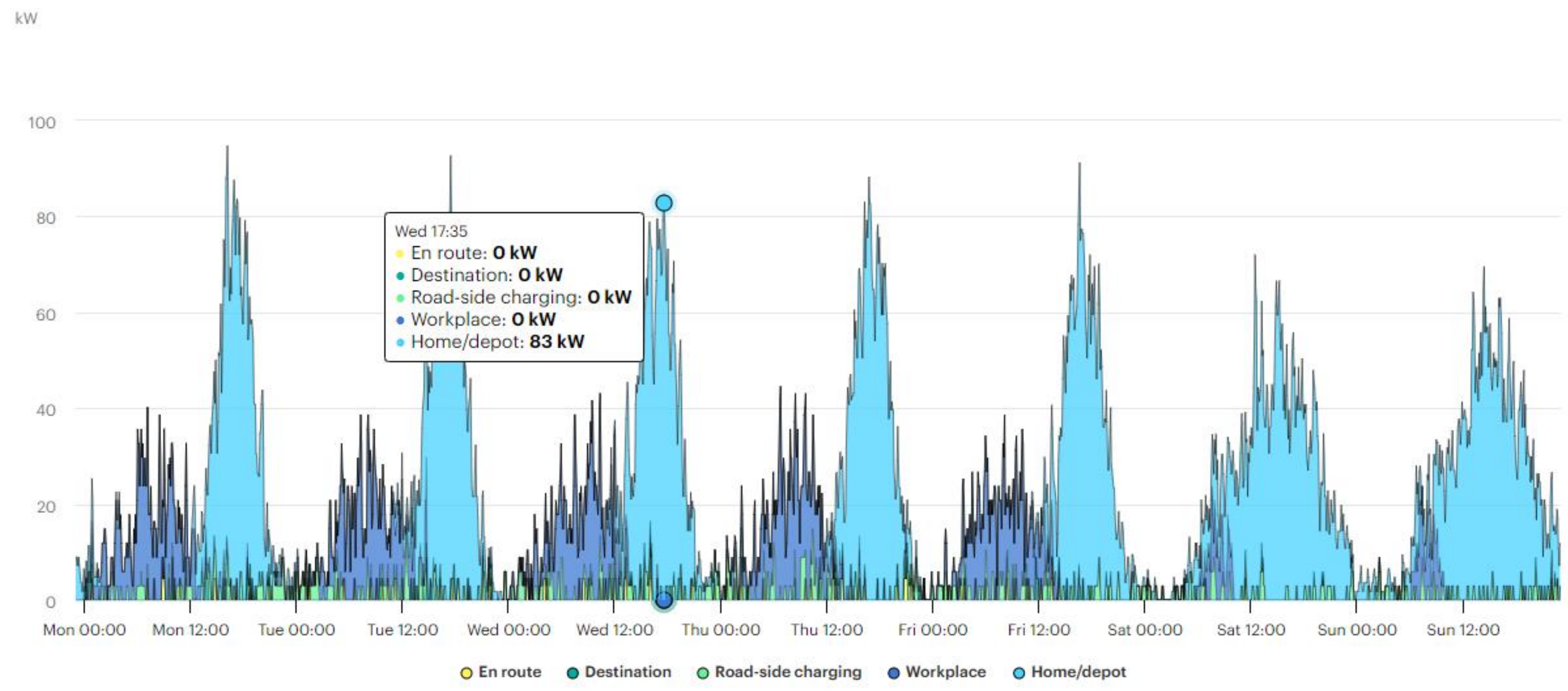
Estimating the CO_2 emissions related to EV charging

Module 3

Simplified representation of the electricity mix

Output: calculation of yearly CO_2 emissions

IEA's EV Charging and Grid Integration Tool

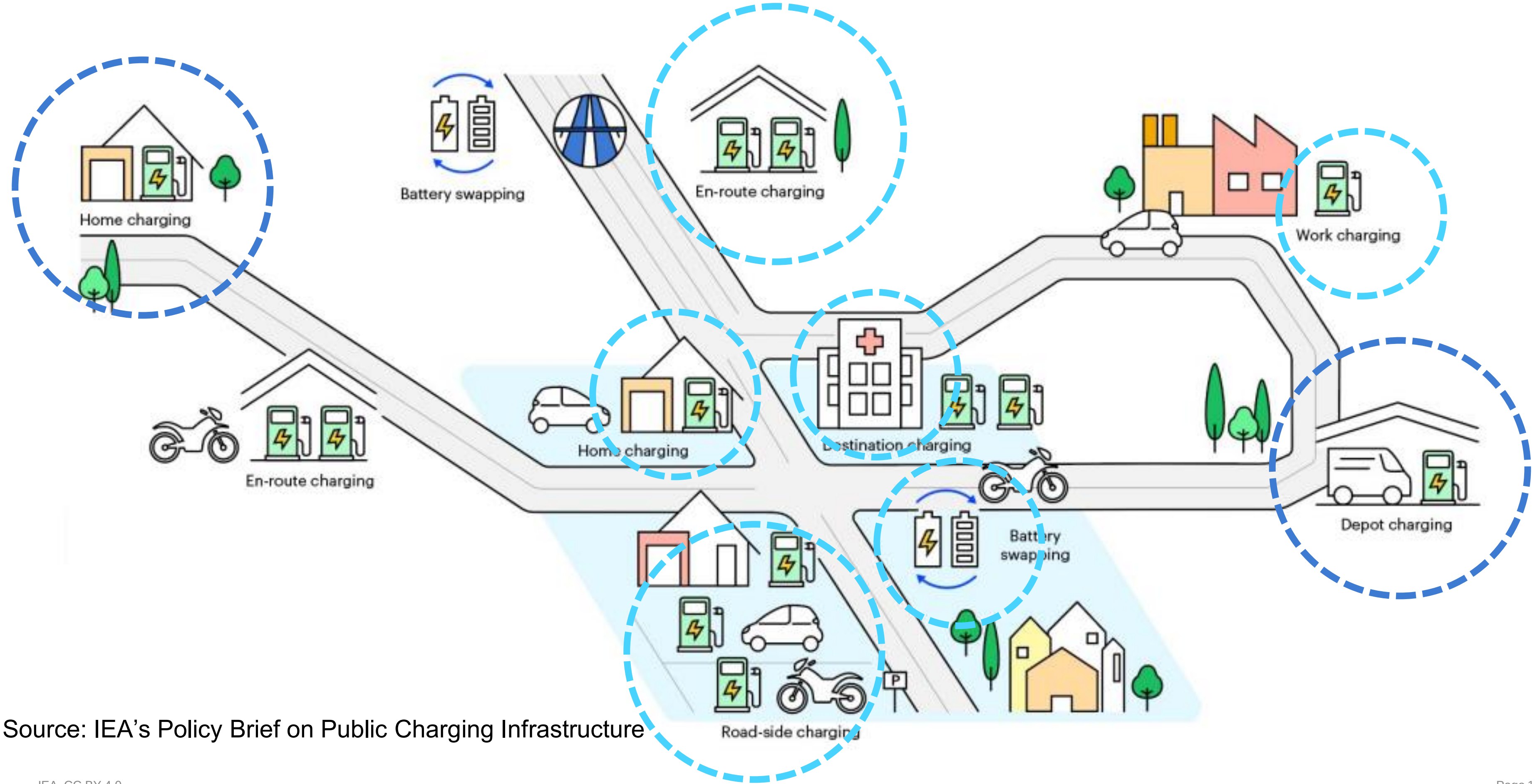


The tool's main output is a weekly EV charging demand profile, enabling understanding of the impacts of charging schemes, driving behaviour and infrastructure availability on power demand and emissions.

Motivation #1 (Module 1)

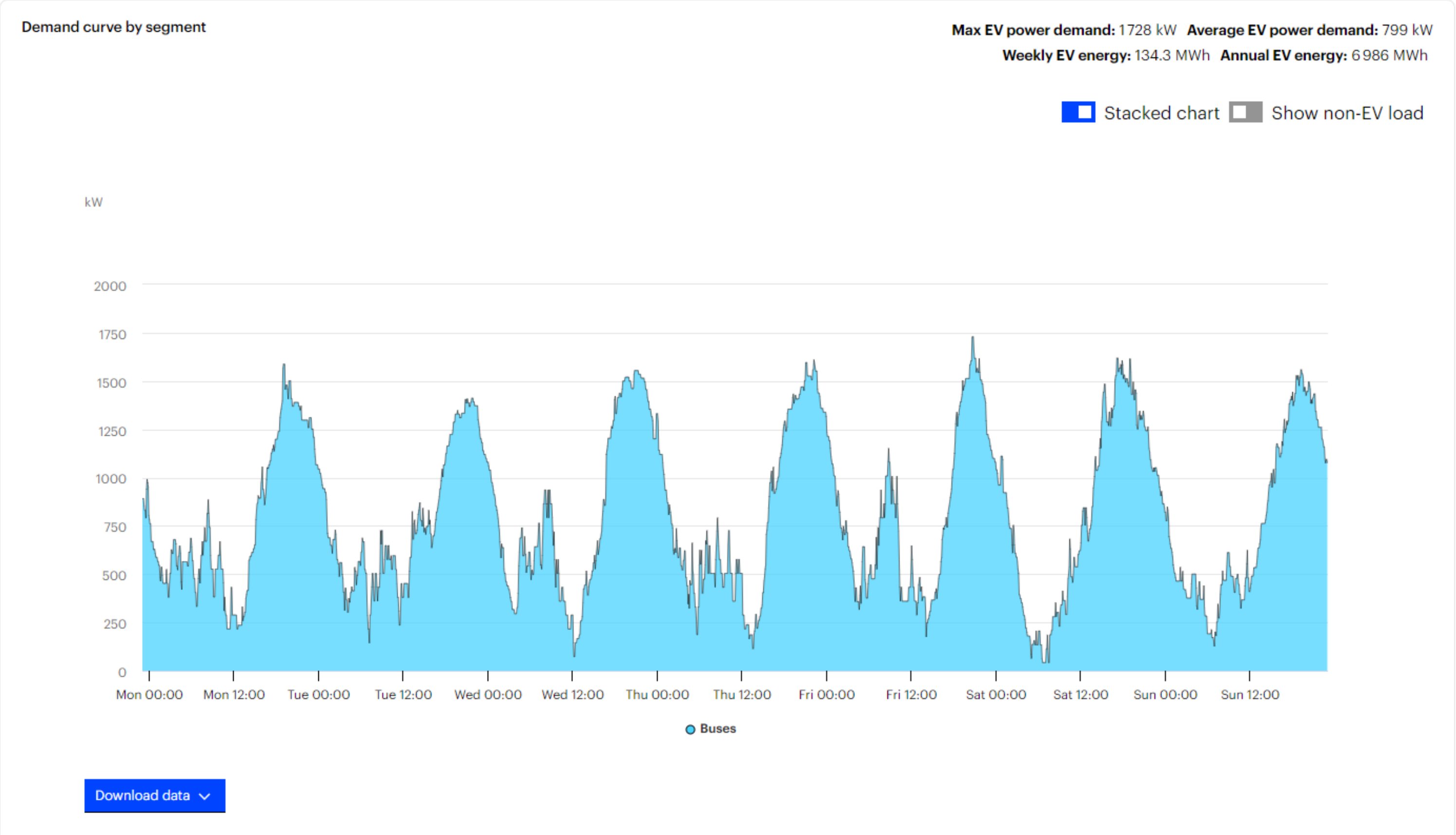
Assessing the impact of EV charging on the power system

EVs can be charged at several types of locations

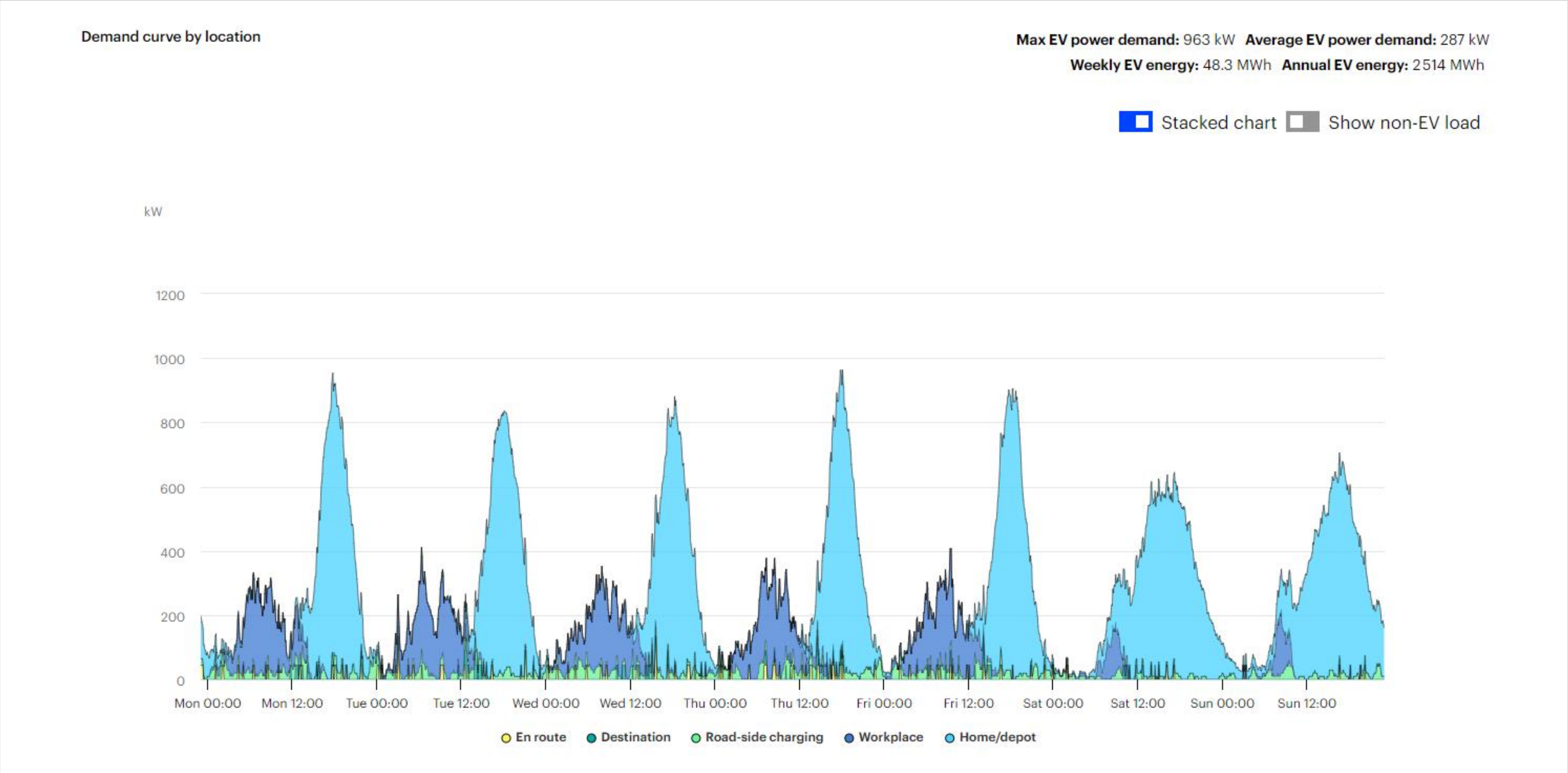


Source: IEA's Policy Brief on Public Charging Infrastructure

Ex: 100 buses – base example

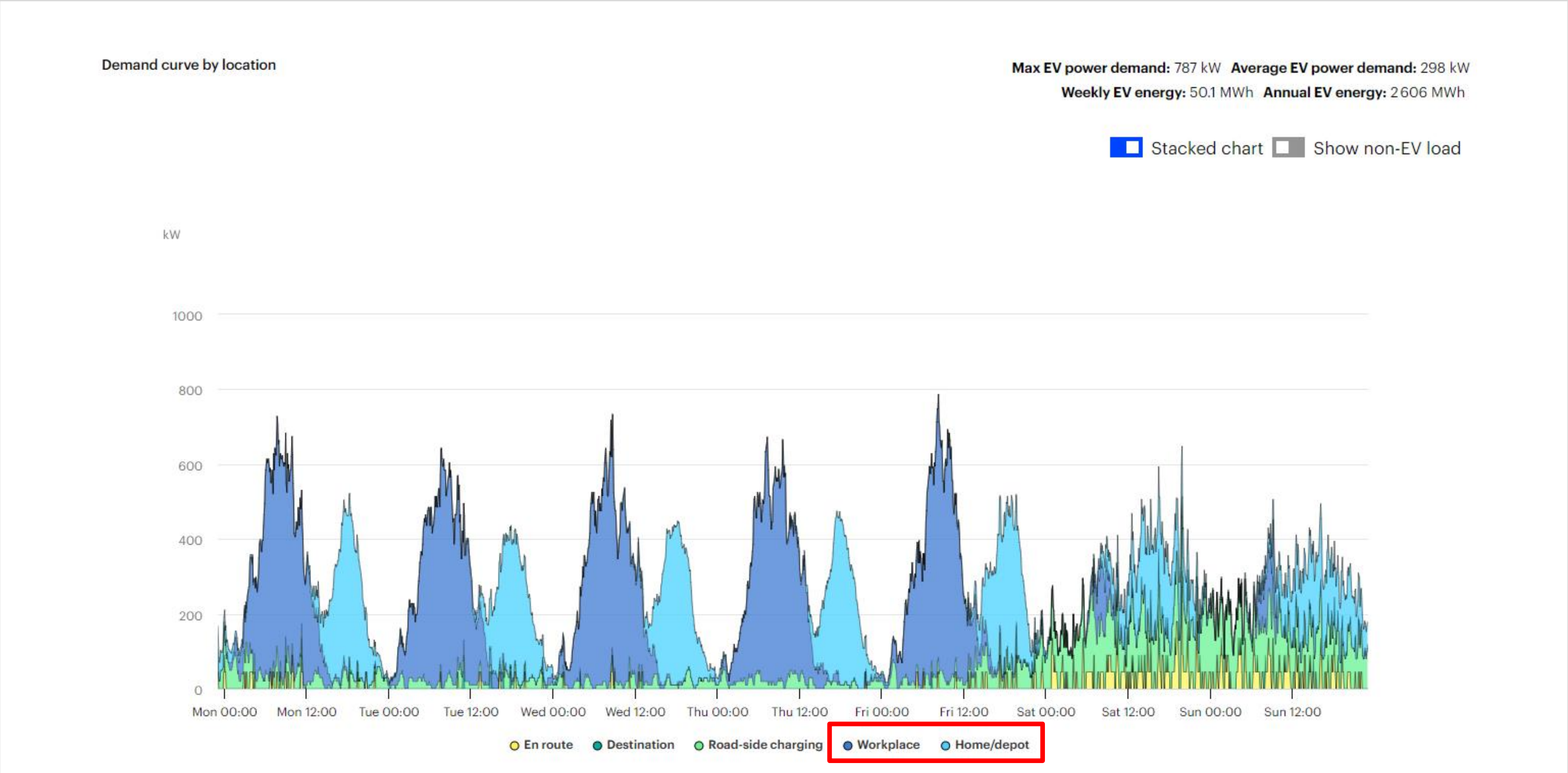


Ex: 1000 cars

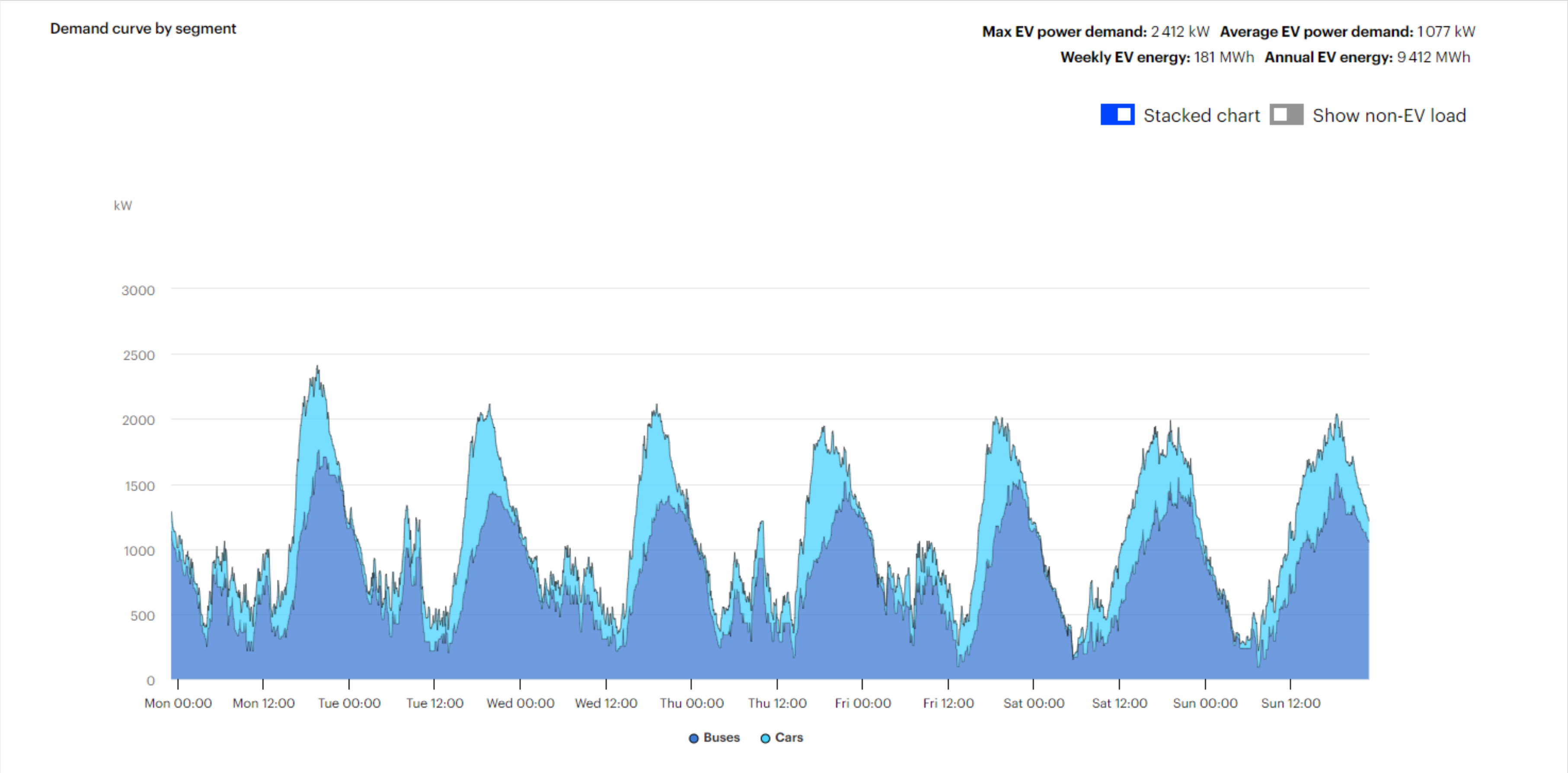


Demand curve by location
Max EV power demand: 963 kW Average EV power demand: 287 kW
Weekly EV energy: 48.3 MWh Annual EV energy: 2 514 MWh
Stacked chart
Show non-EV load
kW
1200
1000
800
600
400
200
0
Mon 00:00
Mon 12:00
Tue 00:00
Tue 12:00
Wed 00:00
Wed 12:00
Thu 00:00
Thu 12:00
Fri 00:00
Fri 12:00
Sat 00:00
Sat 12:00
Sun 00:00
Sun 12:00
En route
Destination
Road-side charging
Workplace
Home/depot

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

Flexibility

Energy available for charging (during connection time)

↓

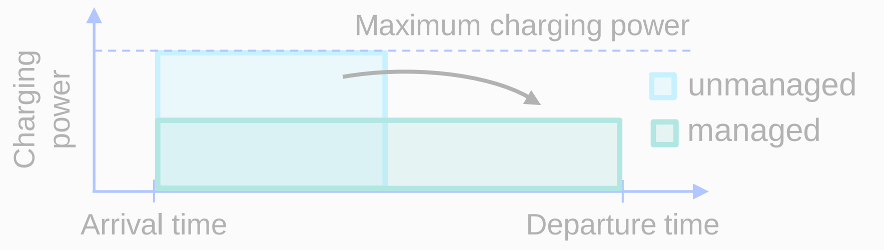
Participation rate

Is the infrastructure adapted? AND
Is the driver willing to participate?

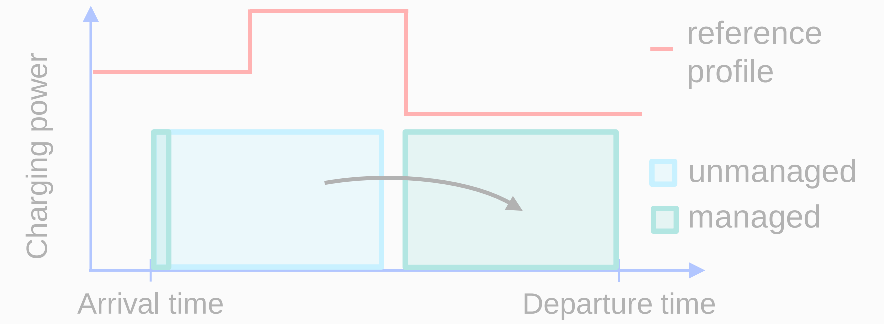
↓

Apply a managed charging measure

Balanced charging

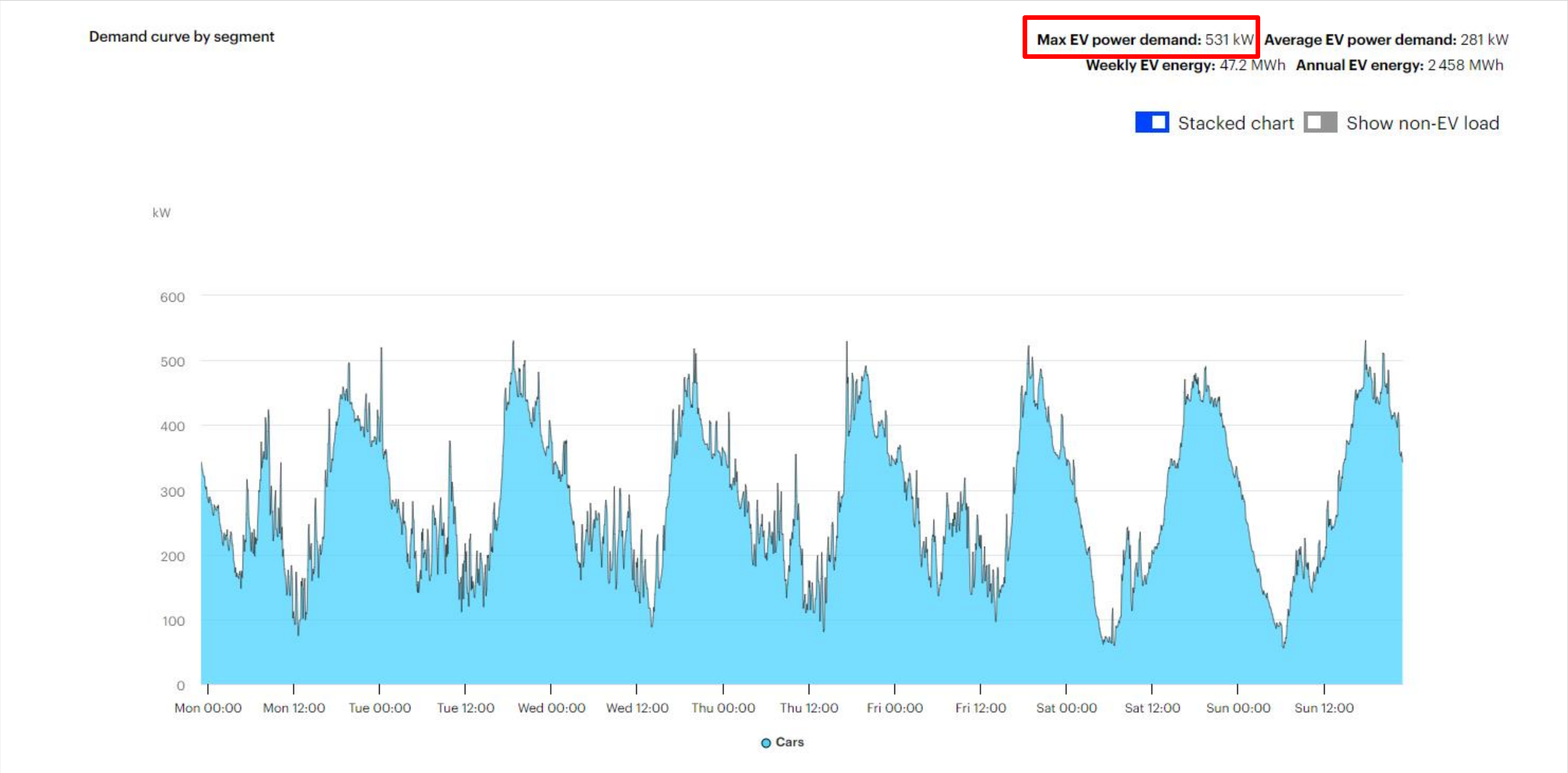


Time-of-Use (ToU) tariffs and smart charging

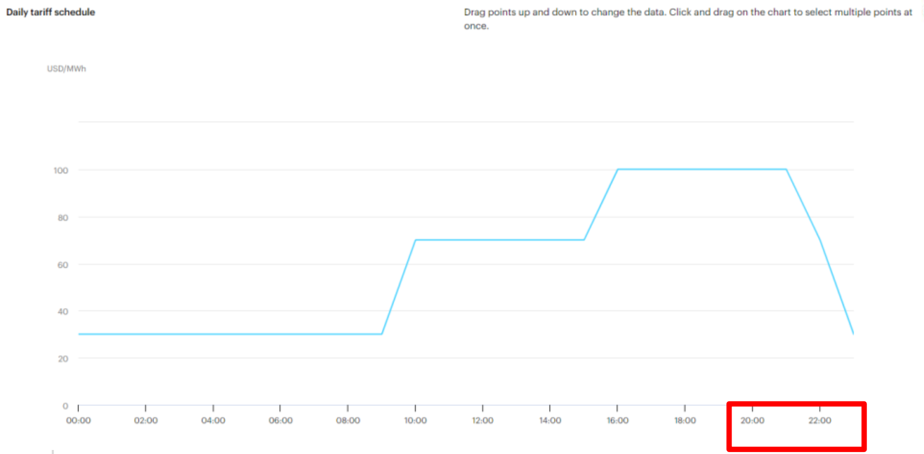


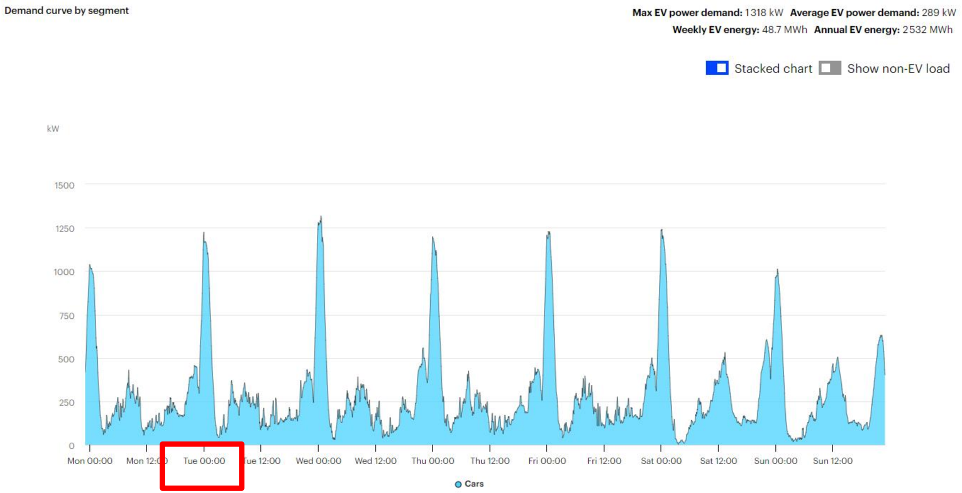
- Shift of energy depending on the **hourly tariff schedule reference electricity demand curve**

Ex: 1000 cars – applying balanced charging

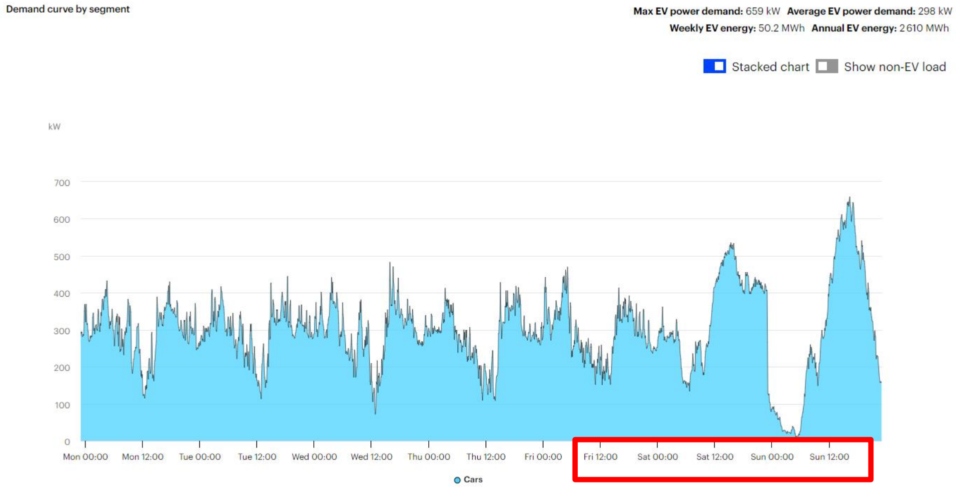


Ex: 1000 cars – applying Time-of-Use tariffs





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

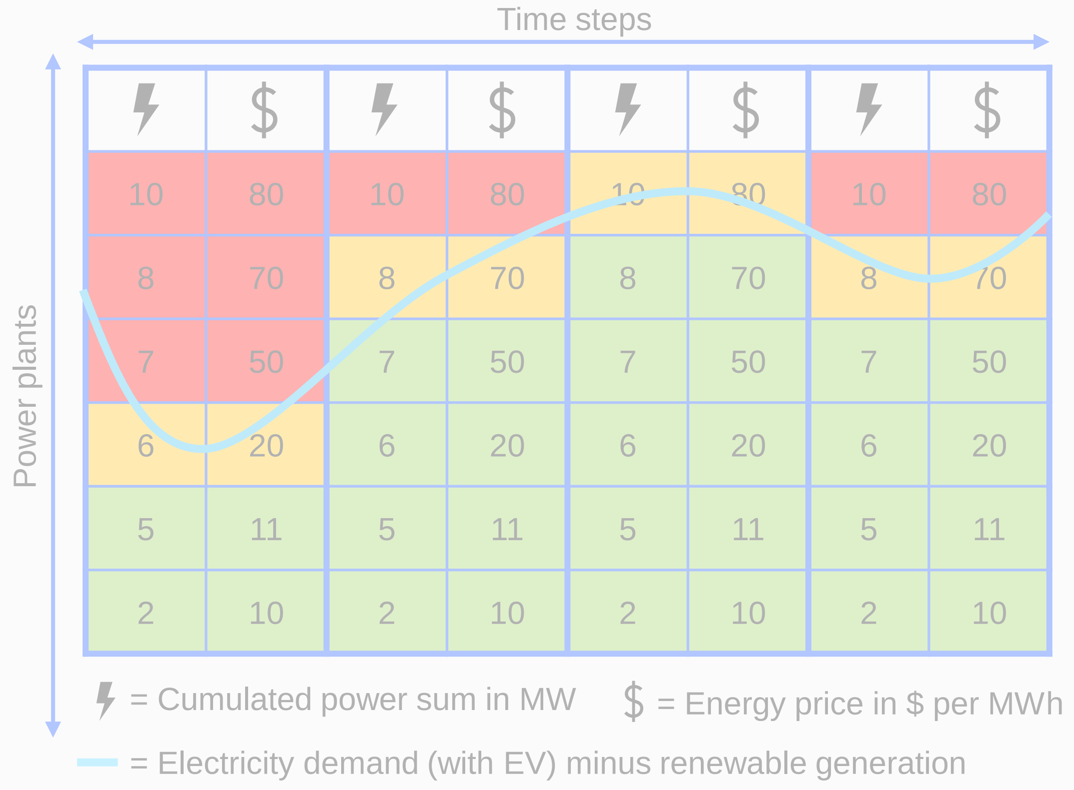
↓

Running power plants

↓

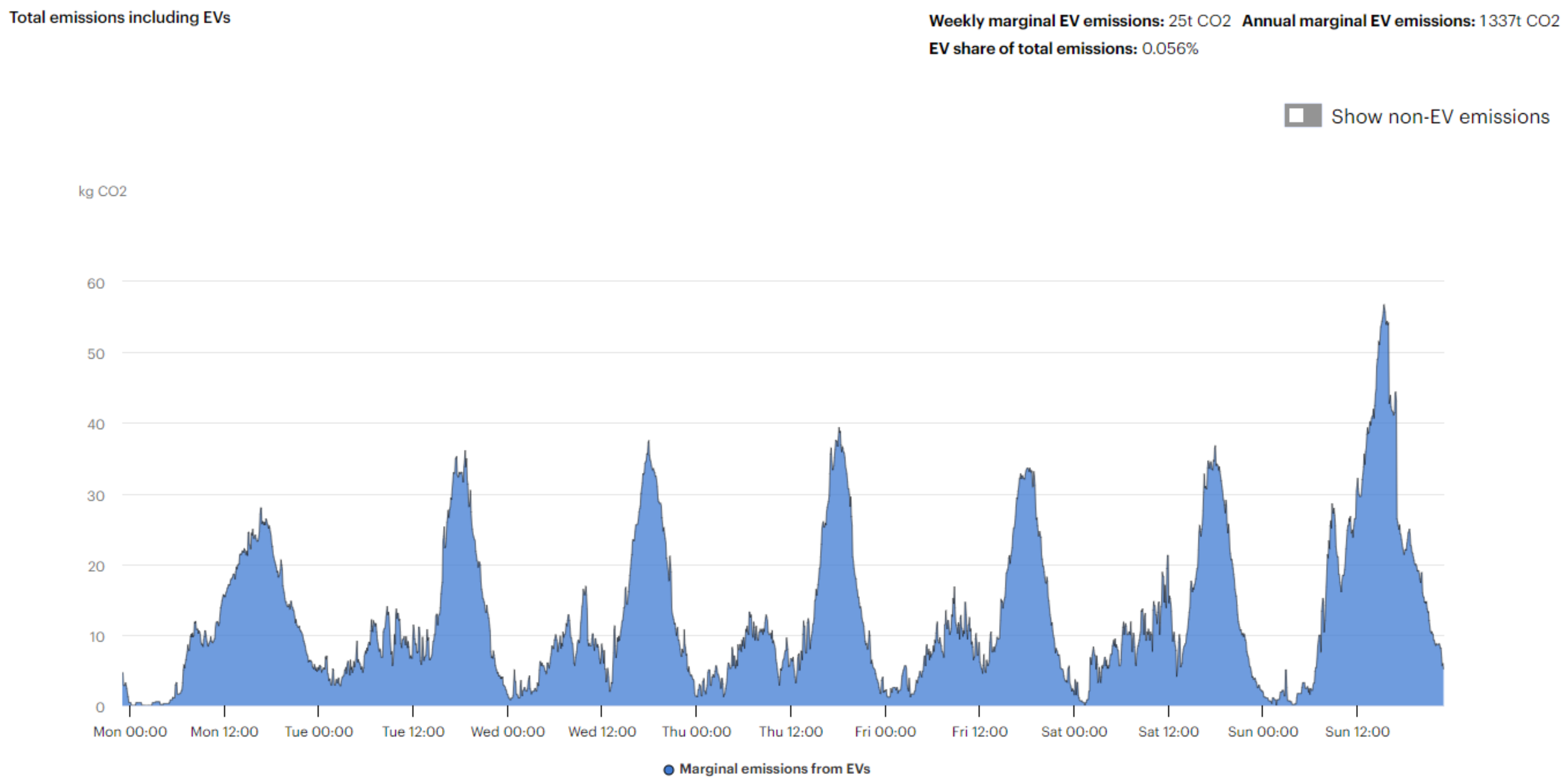
EV charging related emissions by comparison

Simplified dispatch simulation



⚡	$	⚡	$	⚡	$	⚡	$
10	80	10	80	10	80	10	80
8	70	8	70	8	70	8	70
7	50	7	50	7	50	7	50
6	20	6	20	6	20	6	20
5	11	5	11	5	11	5	11
2	10	2	10	2	10	2	10

Ex: 1000 cars – CO_2 emissions estimates



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

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Q&A

Thank you for your attention.

Thank you to all contributors:

- Tool specifications: **Luis Lopez, Jacques Warichet**
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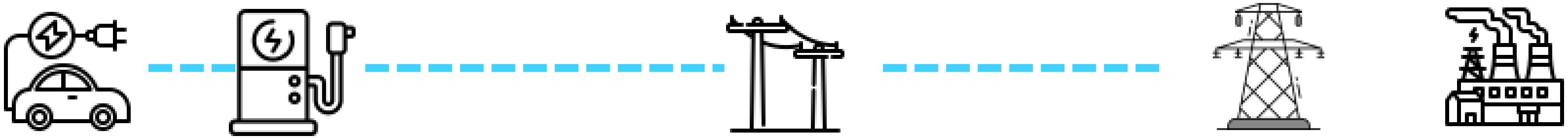
- Support for organising this event: **Jae Sun Lee**

Annex

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)

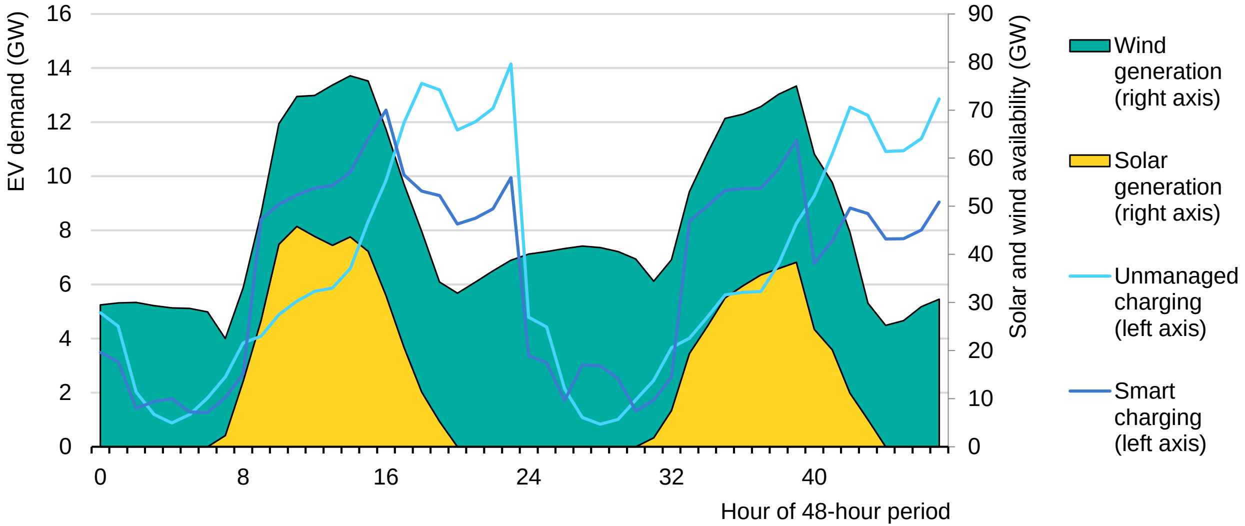
Wholesale + Balancing Markets

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

Photo credits: Power plant icons created by photo3idea_studio; Transmission icons created by Souayang;Transmission tower icons created by Mehwish; Electric car icons created by kmg design; Ev icons created by juicy_fish

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.