

Vienna young Scientists Symposium 2019

Vienna, 14.06.2019

**Charging infrastructure for electric vehicles: demand, cost and impact
on the energy supply in Austria by 2030**

*Ladeinfrastruktur für Elektrofahrzeuge: Bedarf, Kosten und Auswirkungen
auf die Energieversorgung in Österreich bis 2030*



Institut für Fahrzeugantriebe
& Automobiltechnik



ESEA
Institut für Energiesysteme
und Elektrische Antriebe



DI Thomas Bruckmüller

DI Dr. Werner Tober

DI Dominik Fasthuber

Prof. Dr. Bernhard Geringer

Institut für Fahrzeugantriebe & Automobiltechnik

Content

- Motivation and aim
- Methodology
- Input data and assumptions
- Results
- Summary and outlook

Motivation

- The improvement of **air quality** and **climate protection** is the motivation for **legal regulations** to reduce pollutant (**Euro classes**) and greenhouse gas emissions (**CO₂ fleet consumption**).
- **E-mobility** is understood as **one of the solutions** and **requires appropriate market penetration**.
- However, this also requires a **sufficient charging infrastructure**.

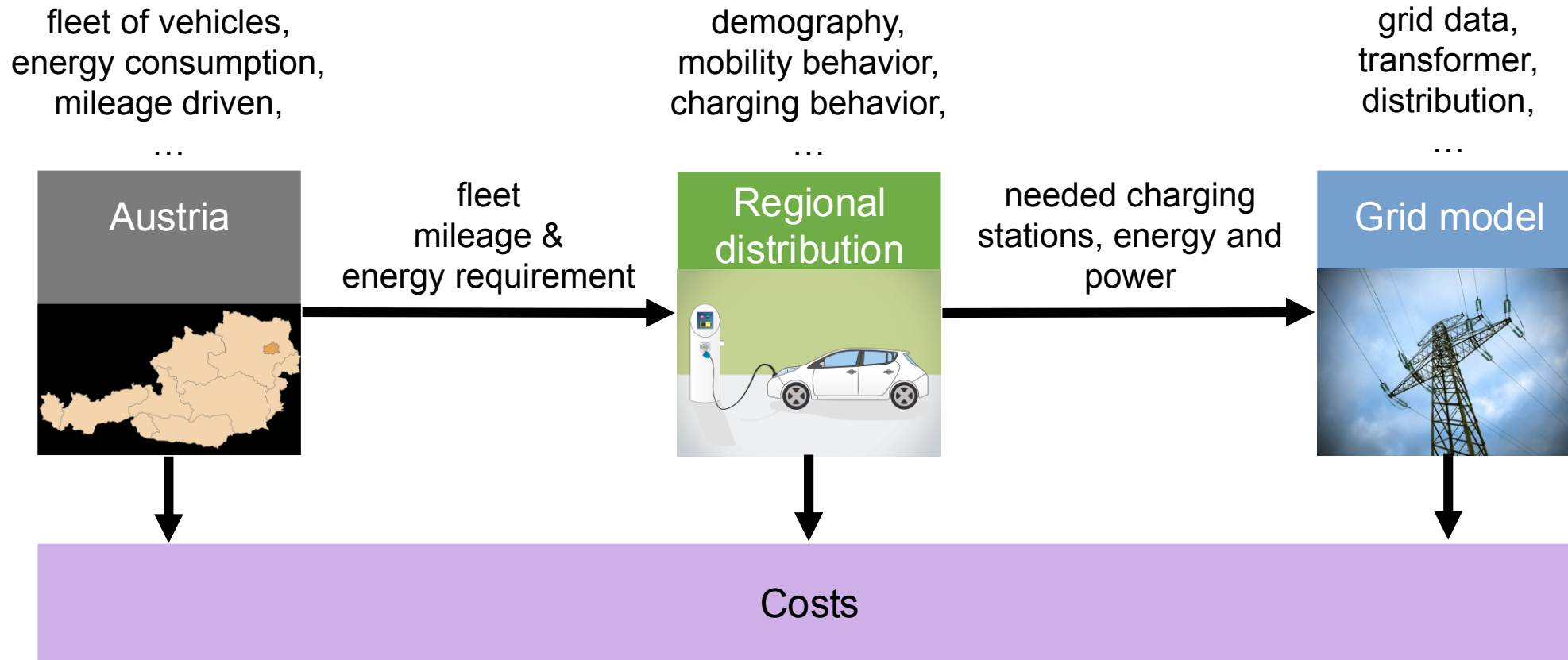


Ref.: www.huk.de, www.walther-werke.de, Austria with States - Multicolor by FreeVectorMaps.com

Aim

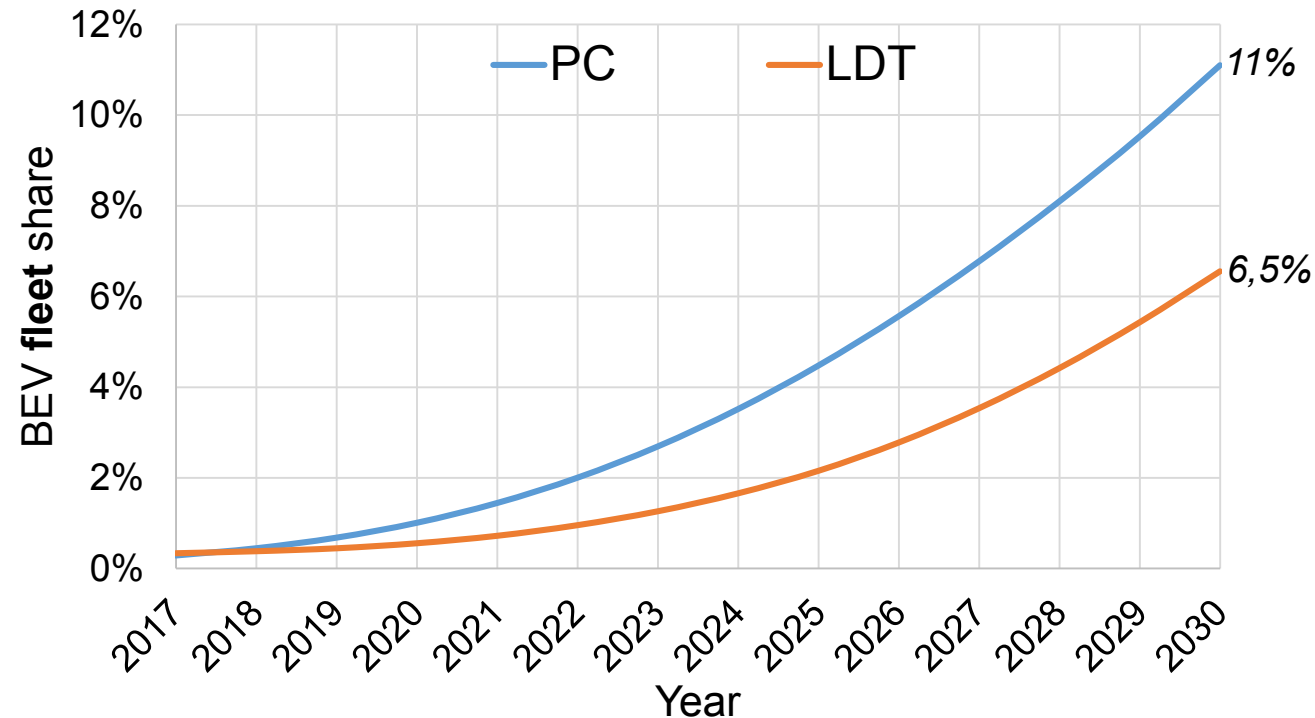
- **Tool-based identification of the required charging infrastructure and its impact on energy supply by 2030 in Austria.**
- Key questions:
 - **How many** charging points are needed?
 - **When** are these required?
 - **Where** are they needed?
 - **Which** charging power should be installed?
 - **What** costs can be expected for the construction of the infrastructure?
 - **What** effects are there on the grid?
- This results in the main topics:
 - Forecast of **new registrations and fleet** of pure battery electric vehicles
 - Analysis of **mobility behavior**
 - Derivation of the **number of charging points per charging power** and their **distribution** (city/country-side)
 - Determination of the **additional electrical power and energy requirements** through electromobility
 - **Costs** for the construction of charging infrastructure
 - **Impact on local grids**

Methodology



New registrations and fleet development

- Based on an expert assessment regarding the development of new registrations of pure electric vehicles up to 2030, **26 % new passenger cars (PC) and 16 % new light duty truck (LDT) registrations** are expected in **2030 in Austria**.
- This leads to a **stock of 11 % passenger cars (PC) and 6,5 % light duty truck (LDT)** of pure electric vehicles in **2030**.

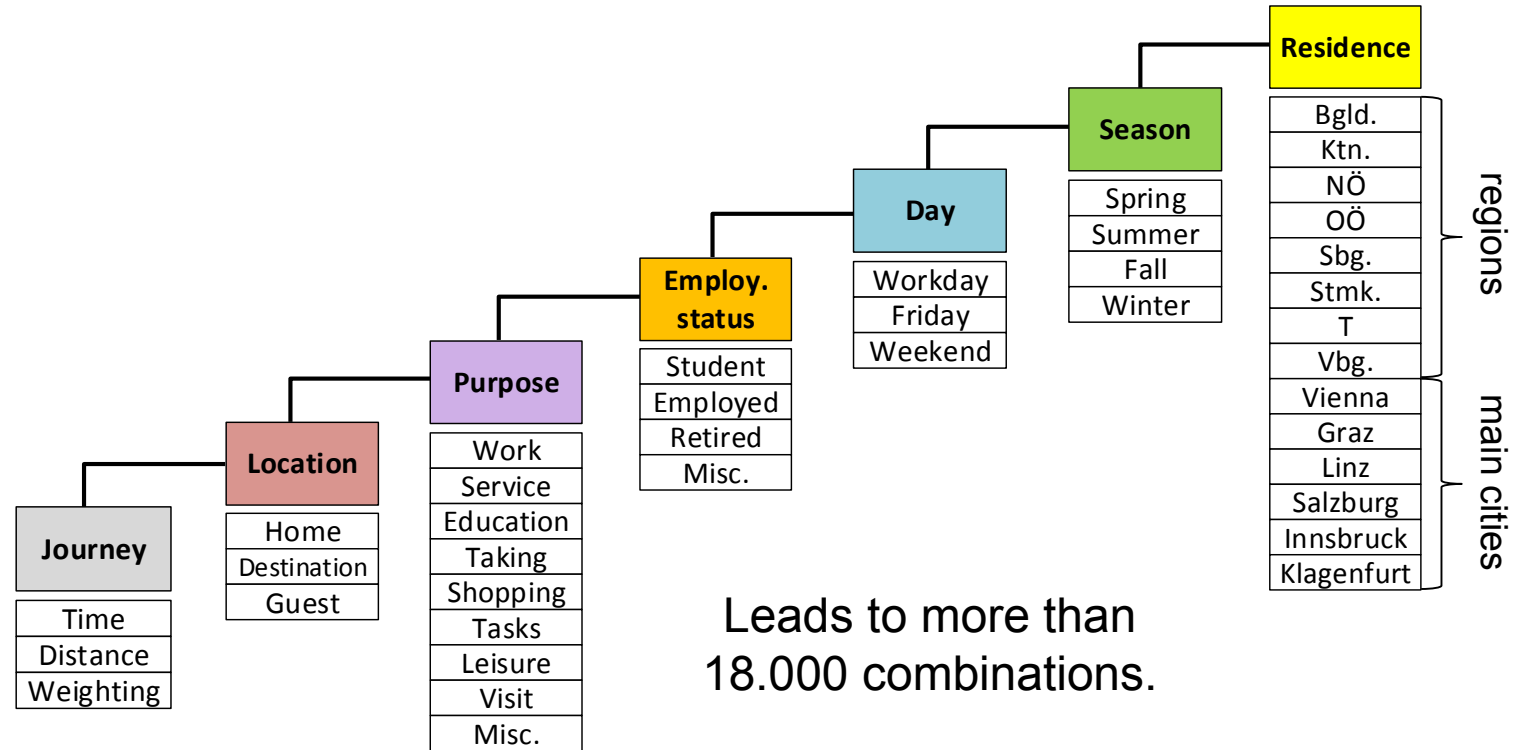


Ref.: Geringer, B., Eichseder, H.: ÖAMTC Expertenbericht Mobilität und Klimaschutz 2030, Wien: ÖAMTC, 2018 (for PC)

Mobility behavior

to define the charging behavior by time and duration

- A highly detailed austrian-wide **survey on individual mobility behavior** was used.
- Main data of a single trip
 - arrival time
 - trip length
 - weighting factor
- Differentiated according →

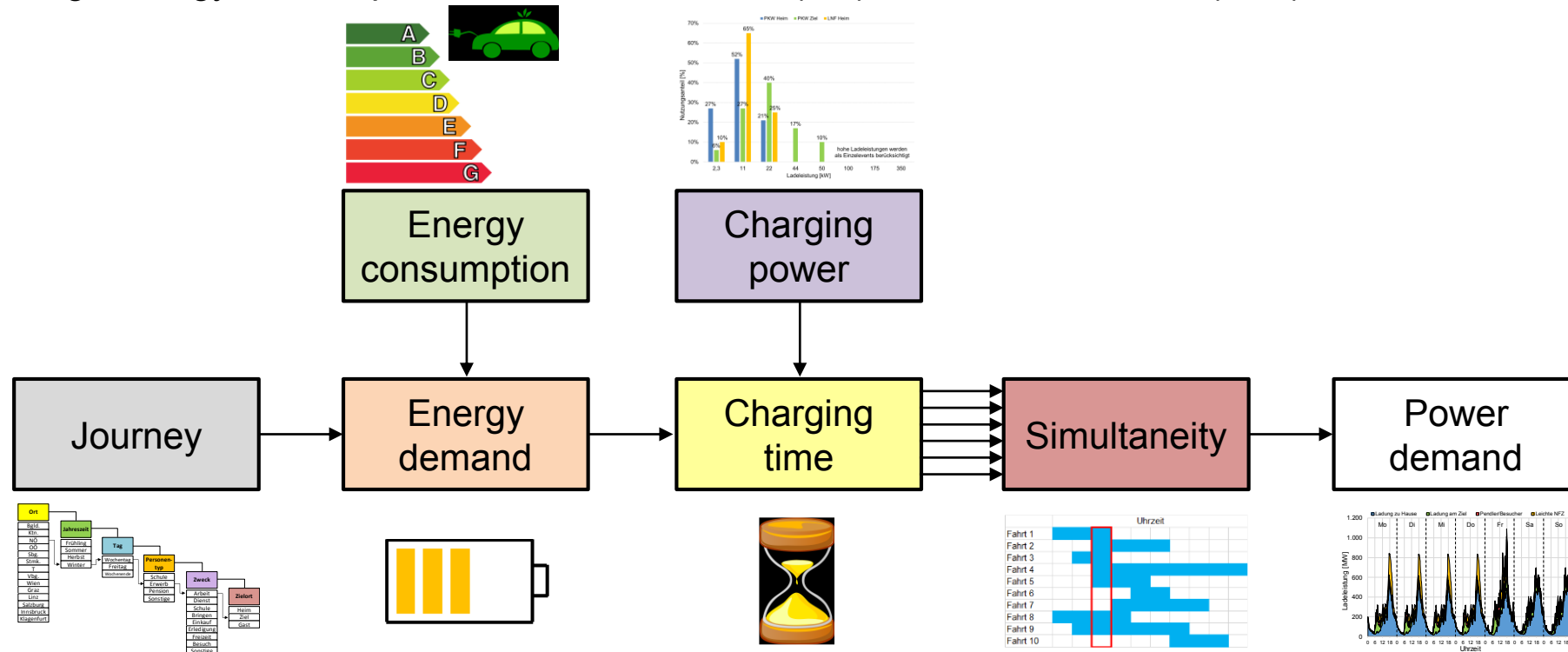


Ref.: Tomschy, R., Herry, M. et al: Ergebnisbericht zur österreichweiten Mobilitätsenerhebung "Österreich unterwegs 2013/2014",
Wien: Bundesministerium für Verkehr, Innovation und Technologie (Hrsg.), Juni 2016

Calculation scheme

to determine the simultaneity and load profile

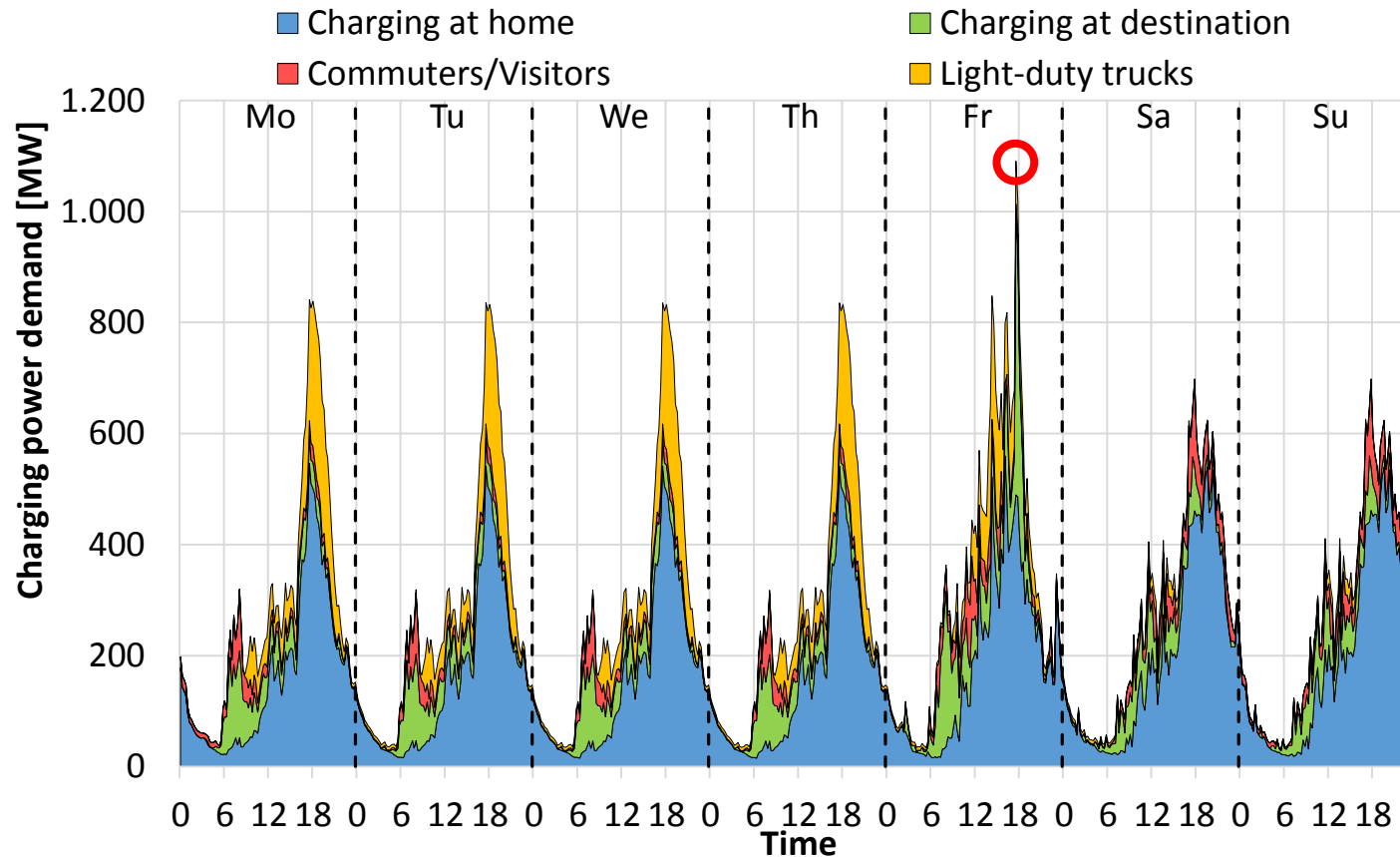
- Based on the input data and assumptions shown above, the simultaneity and load profile were calculated, respecting
 - 93.000 different single trips; statistically recorded
 - an average yearly mileage of 12.900 km (PC) and 18.600 km (LDT)
 - an average energy consumption of 25,6 kWh/100km (PC) and 55 kWh/100km (LDT)



Charging power demand for pure electric vehicles (PC and LDT) in 2030

Maximum power in calendar week 3

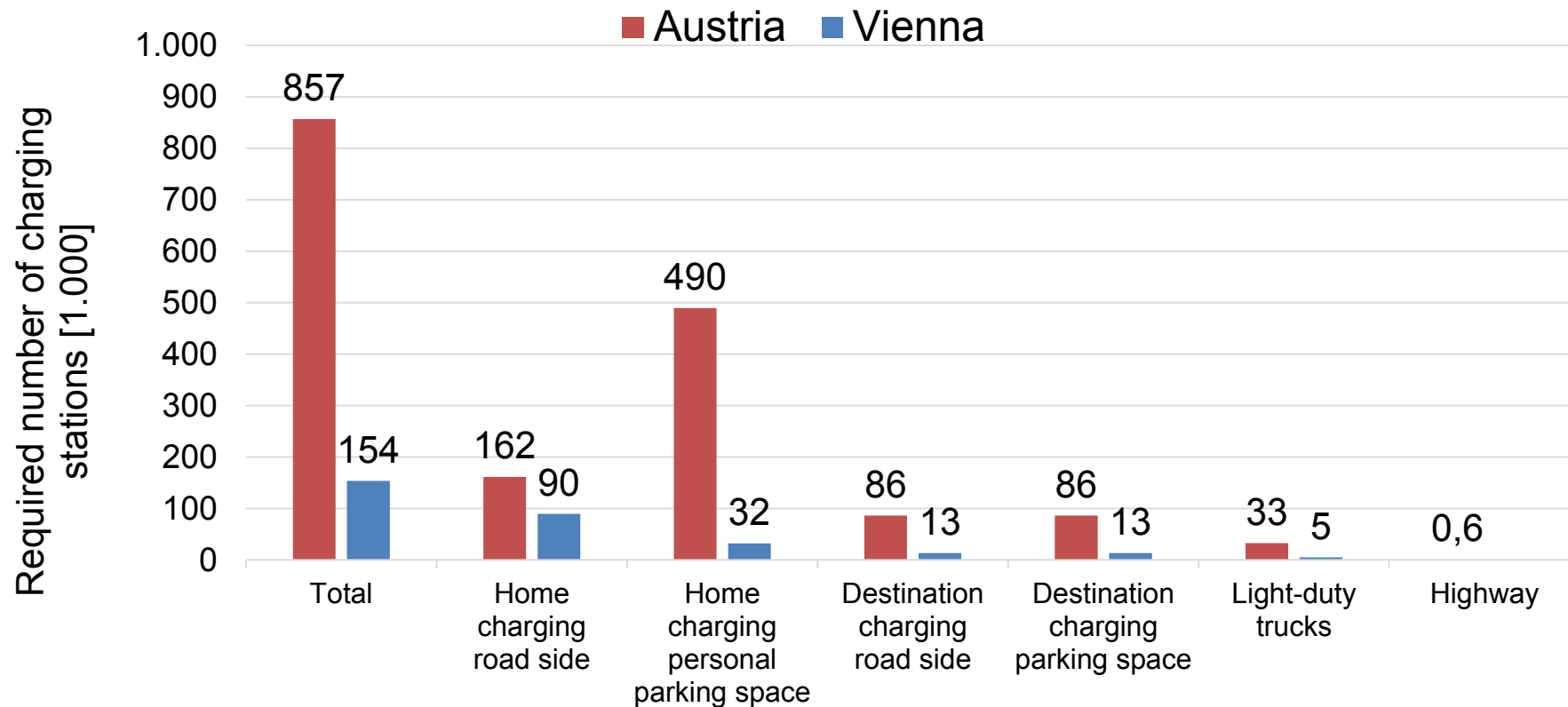
- Energy demand: **2,23 TWh** (equals **3,2 %** of the energy demand in 2018)
- Maximum power demand: **1,1 GW** (equals **10,8 %** of power demand in 2018)



Required number of charging stations until 2030

Distribution according to place of loading

- By **2030**, Austria will require **857.000** charging points for **623.000** PC and LDT.
- This corresponds to **1,38** charging points per vehicle.
- **39 %** of them in **public space**.



Costs for the construction of charging stations until 2030

Distribution according to charging power

Cost estimate of various energy provider and operators.

Consideration of the costs of:

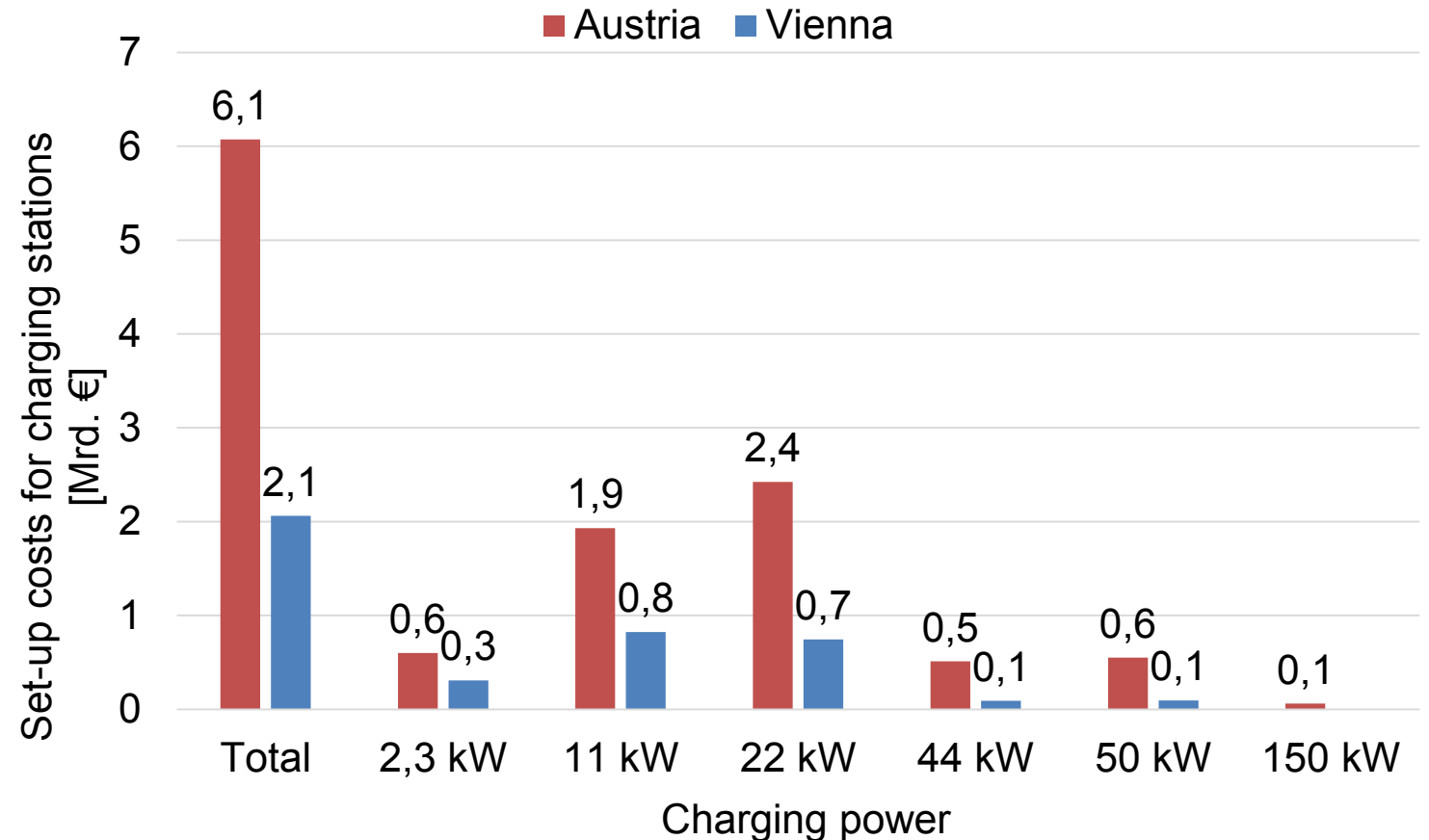
- Hardware
- Grid fees
- Building measures

Distinction according to:

- Charging power (2,3 - 50 kW)
- Loading location (urban / rural)
- Loading type (roadside/parking space)

In total **6,1 Mrd. € until 2030**.

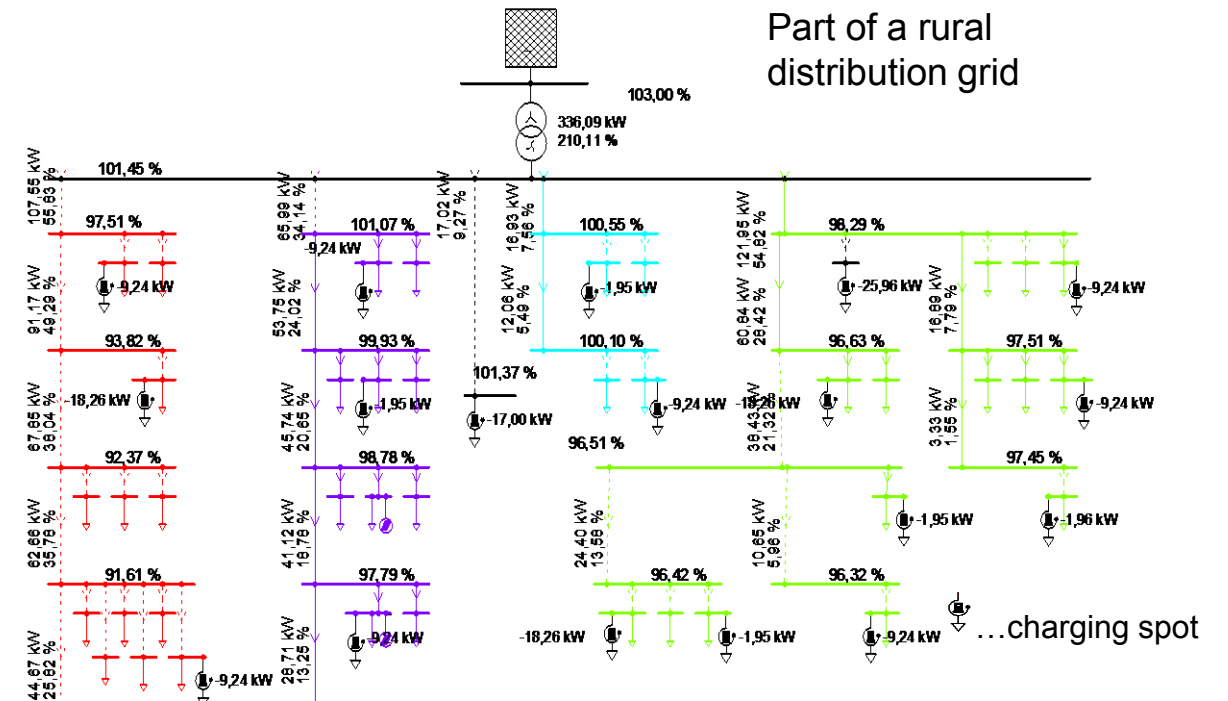
This corresponds to **9.800 €/vehicle** in the scenario described.



Impact on the grid

Consideration of various local grid models

- Considering a model for a
 - Rural grid (59 households)
 - Small town grid (87 households)
 - Metropolitan grid (168 households)
- Random distribution of the required charging points in the grid model
- Using the calculated load profile
- Determining the impact on the local grid
- Derivation of possible corrective measures



Impact on the grid

Results by 2030

- ❑ In the analyzed rural, small town and metropolitan grids, there has been **no inadmissible resource utilization and voltage range deviations occurred.**
- ❑ The grid models considered in the study **reach their limits** at a fleet share of
 - Rural grid: 30 % PC and 18 % LDT pure electric vehicles
 - Small town grid: 56 % PC and 33 % LDT pure electric vehicles
 - Metropolitan grid: 48 % PC and 28 % LDT pure electric vehicles
- ❑ **The limits of the considered grids are achieved by the maximum utilization of the transformers** and not by voltage band violations or line overloads.
- ❑ In unfavorable cases (e.g. old or higher loaded grids) an inadmissible operation can not be excluded even before 2030.
- ❑ **Due to the long planning phases** in grid expansion, the start of **extensions** for higher fleet shares of pure electric vehicles may already be **appropriate before 2030.**
- ❑ To **protect the grid** in a first step, **intelligent charging management** (e.g. smart meter) controls the charging power (e.g. P_{\max} , $P_{(U)}$) and/or the charging time (start, end, duration).

Summary

- With the methodology developed, a **tool** was created to **assess the requirements and consequences of electromobility** with regard to the **charging infrastructure and energy supply** of a country under **free selectable boundary conditions**.

Based on the parameters shown, for Austria in 2030:

- Pure electric vehicle **stock of 11 % passenger cars (PC) and 6,5 % light duty truck (LDT)**.
- For most journeys, **low charging power is sufficient**.
- The **additional annual energy demand** amounts to **3,2 %** of the energy demand in 2018.
- The **additional power requirement** amounts to **10,8 %** of the maximum power level in 2018.
- **857.000 charging points** for 623.000 PC and LDT **needed**.
- The construction of **charging infrastructure** will incur cumulated **costs of 6,1 Mrd. €** or 9.800 €/vehicle
- The analyzed grids show **no problems with inadmissible resource utilization and voltage range deviations**.

Thank you for your attention!



Institut für Fahrzeugantriebe
& Automobiltechnik



ESEA
Institut für Energiesysteme
und Elektrische Antriebe



DI Thomas Bruckmüller
thomas.bruckmueller@ifa.tuwien.ac.at