The Electrification of Transportation and its Impact on the Austrian Electricity Demand Curve with a Special Emphasis on European Resource Adequacy Studies

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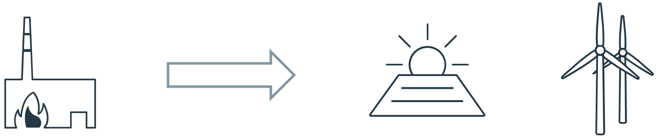
Introduction

- **Goal:** climate neutrality until 2050.
  European Commission suggests reduction of greenhouse gas emissions by 2030 to at least 55% compared to 1990 level.
  ⇨ The European power system is currently facing its largest transformation since it came into existence.

- **On the generation side:** power plants relying on fossil fuels (e.g. coal, lignite, oil) are gradually replaced by renewable generation assets, such as wind farms and PV plants.



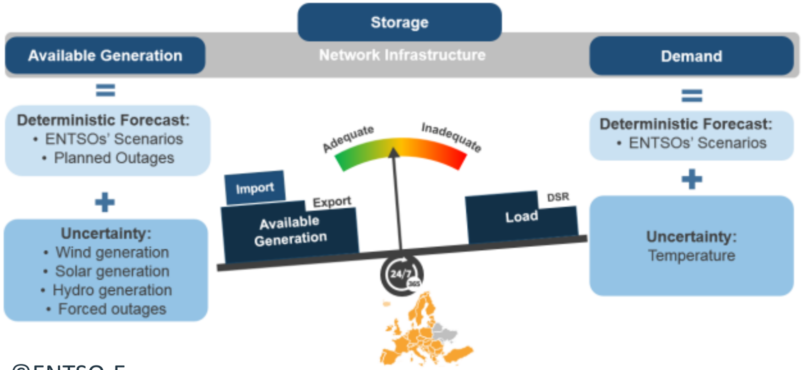
- **On the demand side:** new demand components (e.g. heat pumps, electric vehicles, battery home storages) become more and more important and reshape the overall demand curve.

⇨ focus on the evolution of electric vehicles (EVs), their contribution to the Austrian electricity demand curve and the impact on security of supply.

Methodology – ERAA

- Successor of the **Mid-term Adequacy Forecast (MAF);** tailored towards meeting the needs of the **Clean Energy for all Europeans Package (CEP).**

- Pan-European study with focus on **power system resource adequacy**, aims to model the European power system in order to identify supply/demand mismatch risks.



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- Consideration of **different scenarios** (e.g. Economic Viability Assessment for a scenario with and without capacity mechanisms).

- **Geographical scope:** 56 bidding zones in 37 countries.

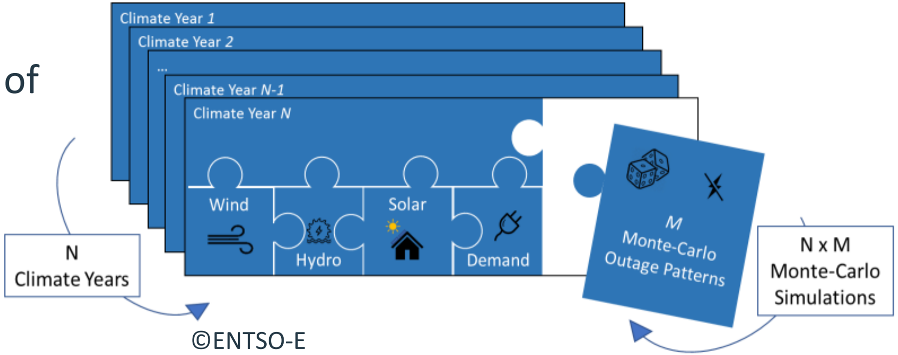
- **Time horizon and resolution:** up to a ten years horizon on an annual granularity (target methodology); in ERAA 2021: 2025 and 2030.

Methodology - ERAA

a) **To reflect uncertainty related to climate conditions:** 35 historic climate years (1982 to 2016) serve as input for building time series for renewable generation and demand.

b) **Uncertainty on outages** taken into account by different scenarios of unplanned outages for generating units or interconnectors.

➡ Relate a) and b) to construct a variety of different **Monte-Carlo years.**



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c) Each Monte-Carlo scenarios is assigned to a **Unit Commitment and Economic Dispatch (UCED) problem** and solved in an hourly granularity:

"Minimize total system costs subject to technical constraints"

Methodology - ERAA

Key simulation outputs to evaluate system adequacy: **Expected Energy not Served** (EENS) in gigawatt hours and **Loss of Load Expectation** (LOLE) in hours:

$$EENS = \frac{1}{K}\sum_{k=1}^{K} ENS_k \quad \text{and} \quad LOLE = \frac{1}{K}\sum_{k=1}^{K} LLD_k,$$

where

- K denotes the total number of Monte-Carlo Years.
- ENS_k the Energy not Served in Monte-Carlo year $k \in \{1, \dots, K\}$.
- LLD_k the Loss of Load Duration in Monte-Carlo year $k \in \{1, \dots, K\}$.

Methodology – demand time series

- For most of the bidding zones modelled in ERAA: hourly demand forecasts calculated centrally at ENTSO-E, using **TRAPUNTA** (Temperature Regression and loAd Projection with UNcertainty Analysis), developed by Milano Multiphysics.
- The Trapunta methodology can be divided into two separate steps:

Model training and base load prediction
Singular value decomposition (SVD) of the available daily loads. Generic daily load profile can be written as

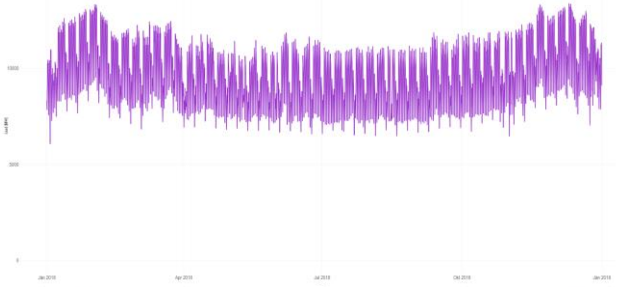
$$P(t; m_1, \dots, m_n) = \sum_{i=1}^{N} C_i(m_1, \dots, m_n)\, \Phi_i(t)\,,$$

where
- N denotes the number of load components,
- Φ_i the i-th load component,
- C_i its associated weight,
- $m_1, \dots, m_n$ the climatic variables.

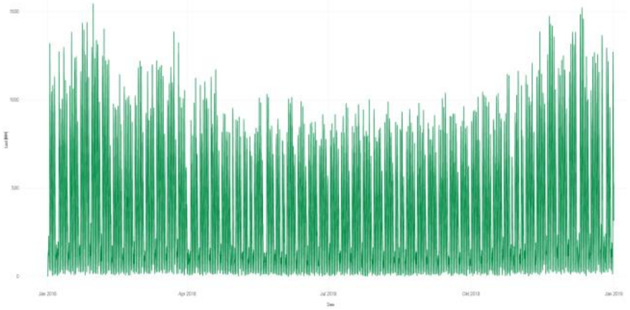
C_i are determined by a polynomial regression on the available data (historical load and corresponding climate data).

Technological development
Technological developments not inherent in the historic load data (development of electric vehicles, heat pumps, batteries, additional base loads and energy demand increase) are added exogenously.

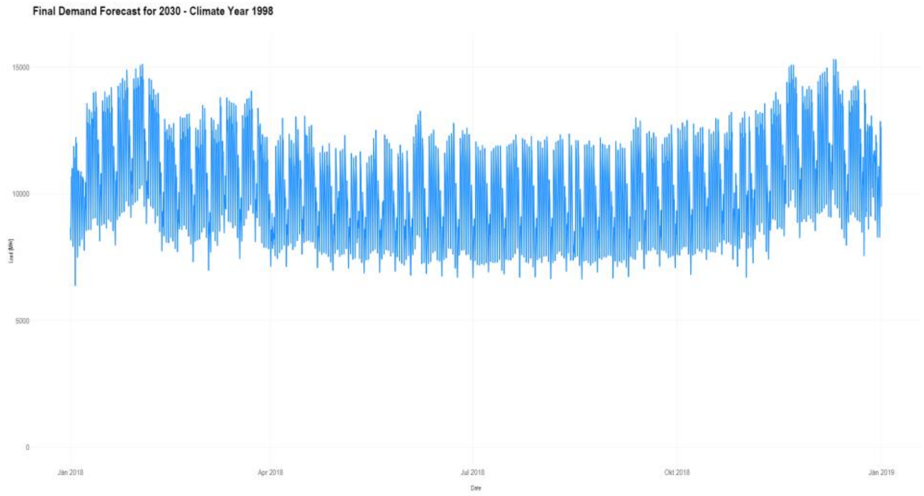
Methodology – demand time series

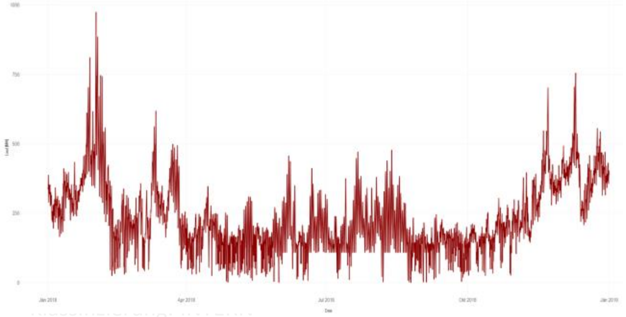


Base Load (calculated with Trapunta)
Postprocessing: Outlier correction.



EV Load (calculated by AIT)
Postprocessing: Scaling
(to avoid double counting).





HP Load (calculated with AIT HP load generator)
Postprocessing: Scaling, replacement of conventional heating, accounting for auxiliary energy.

Methodology – research with AIT

i) **Assessment of future level of EV penetration in Austria** for the target years related to the ERAA process (until 2030) and outlook until 2040.

- Basis for the time horizon **until 2030**: IEA Sustainable Development Scenario (SDS) of the **global EV** outlook. **For 2040,** penetration targets of the **ONE100** study are taken into account (goal of a climate neutral energy system in Austria).

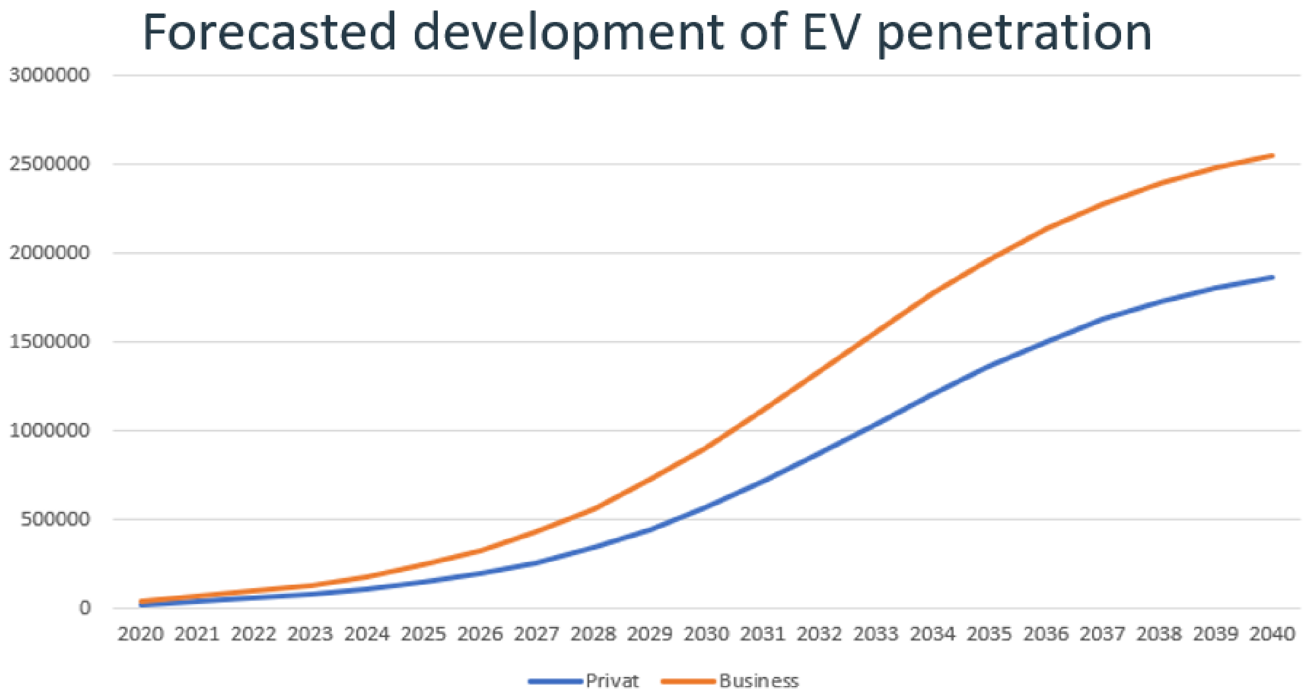
- Two types of electric vehicles are assumed:

  1. private EVs
  2. non-private EVs (“business”)

which are additionally specified according to their charging behavior:

a) pure electrical charging (EVs)
b) mixed plug-in hybrid EVs (PHEV)
c) light commercial vehicles (LCV)

Methodology - research with AIT



Methodology - research with AIT

ii) Forecasting of the overall charging behavior of the Austrian EV fleet on an hourly granularity.

Assumptions and Input:

- Parameters for the ten most common types of EVs in Austria (taken from the “EV-Database”).
- Taking into account **temperature dependency.**
- To reflect on the **mobility behaviour:** probability distribution of the arrival times of different user types extracted from the study “Österreich unterwegs 2013/2014”.
- Information on **driving performance**: Statistik Austria (Mikrozensus über den Energieeinsatz der Haushalte).
- Assumed **travel distances:**

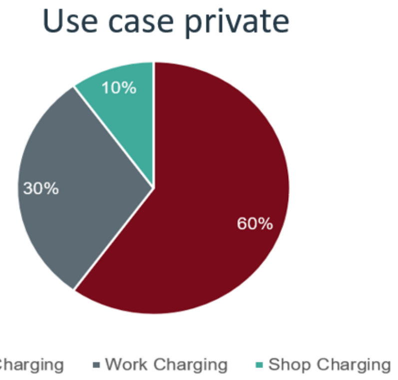
	Business (km / day)	Private (km / day)
Week day	53	36,25
Saturday	42,13	27,94
Sunday / bank holiday	0	25,59

Methodology - research with AIT

- Commuter flows between the 35 NUTS3 regions of Austria, separated according to the targets **“travel”, “shopping”** and **“business”.**

- Assumption: upon arrival, drivers connect their vehicle to the grid to kick off a charging procedure. Charging of EVs entering Austria from external countries not considered.

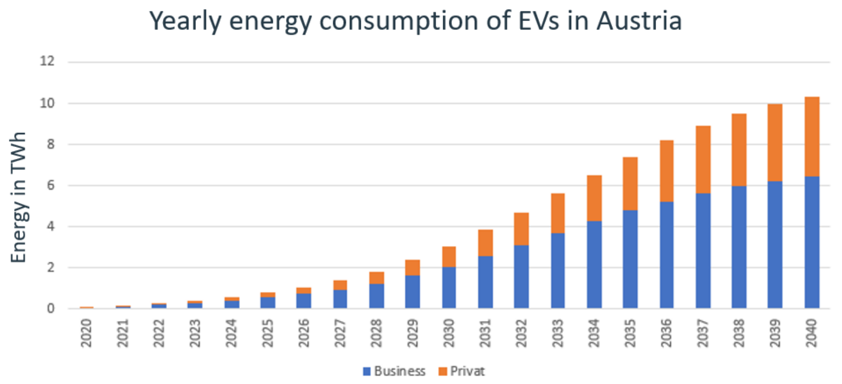
- Applied split between home, work and shop charging:

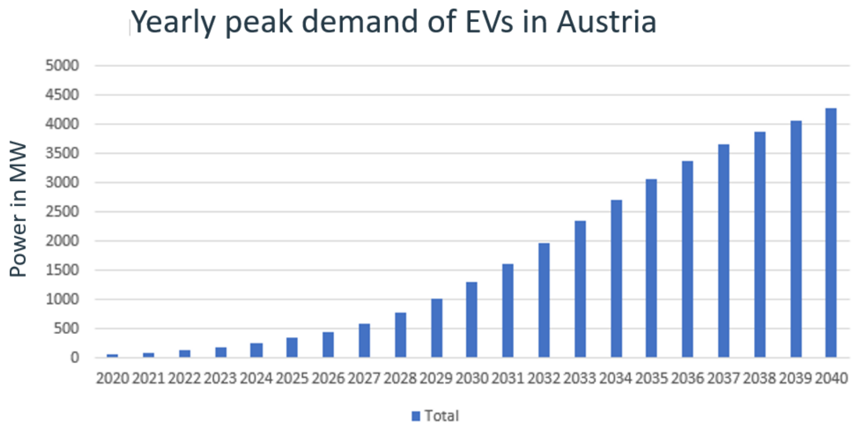


Maximum charging capacities of private and business EVs:

Maximum charging power output	Home charging	Work charging	Shop charging	Business charging
11 kW	95 %	80 %	70 %	45 %
22 kW	5 %	20 %	10 %	40 %
50 kW			20 %	10 %
150 kW				5 %

Methodology - research with AIT





Impact Assessment

- **To provide first estimate of the potential of flexible EV charging in adequacy assessments:** trilateral model containing only Austria and two neighbouring bidding zones has been set up.

  ⇨ Due to reduced geographical scope: particularly suitable for studying sensitivities on input data and modelling assumptions.

- Test model is set up in the large scale Monte-Carlo Simulator **ANTARES**, an open source adequacy simulations software from the French TSO RTE.

- Three different shares of EVs with flexible charging capability implemented: **10%, 20%** and **50%.**

- Additional assumptions: price sensitive EVs can shift its load within a moving **six hours** time frame.

- **Target year:** 2030.

Impact Assessment

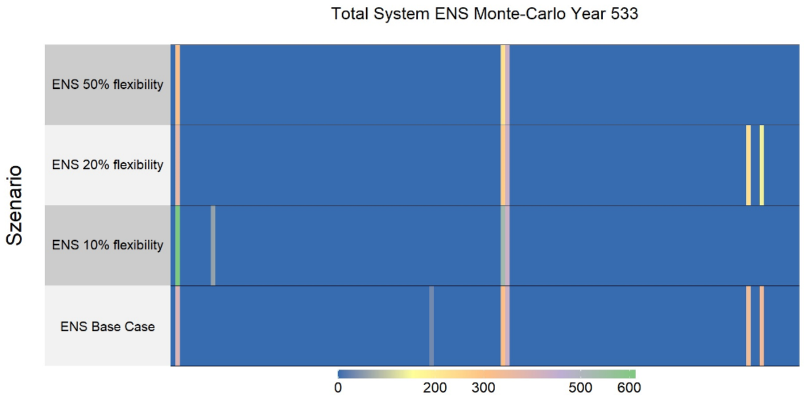
- For the simulation: 35 climate years and 20 different unplanned outage patterns (resulting in 700 Monte-Carlo years) have been chosen.

Results: The ten Monte-Carlo years where additional flexibility showed the highest impact:

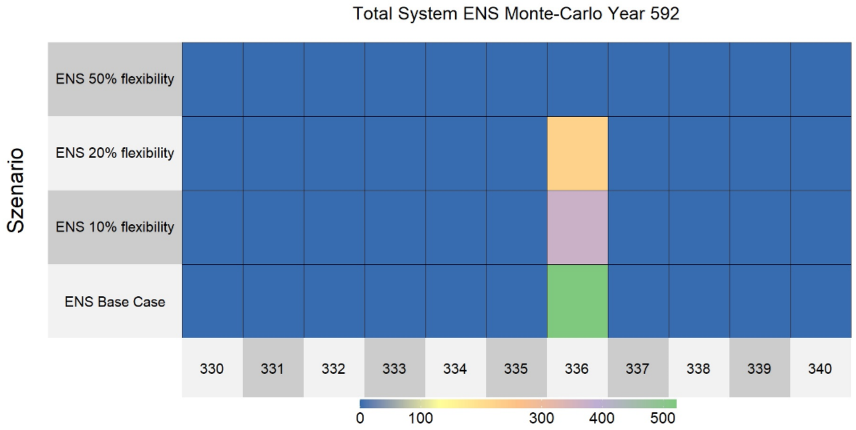
	ENS Base Case	ENS 10% EV flexibility	ENS 20% EV flexibility	ENS 50% EV flexibility	ENS relative change compared to base case: 10% flexibility	ENS relative change compared to base case: 20% flexibility	ENS relative change compared to base case: 50% flexibility
592	522	370	224	0	0.291187700	0.570881200	1.000000000
533	1850	1627	1437	968	0.120540500	0.223243200	0.476756800
692	219	188	158	152	0.141552500	0.278538800	0.305936100
524	3832	3666	3504	3106	0.043319420	0.085594990	0.189457200
440	1124	1089	1055	970	0.031138790	0.061387900	0.137010700
242	11794	11463	11133	10387	0.028065120	0.056045450	0.119297900
555	3579	3481	3384	3191	0.027381950	0.054484490	0.108410200
368	7313	7158	7003	6578	0.021195130	0.042390260	0.100505900
557	14783	14425	14069	13346	0.024217010	0.048298720	0.097206250
695	7883	7721	7557	7179	0.020550550	0.041354810	0.089306100

Impact Assessment

Results suggest that in certain tense situations the occurrence of ENS can be mitigated or even be prevented:



heatmap of ENS occurrence in Monte-Carlo year 533 (displayed are hours 680 to 820 of the target year)



heatmap of ENS occurrence in Monte-Carlo year 592

Conclusions

- By means of a trilateral test model, first insights on the impact of different penetration rates of price reactive EVs on security of supply have been gained.
- Results show that under certain circumstances, additional flexibility can be utilized to mitigate or even prevent events of scarcity.
- Since the overall system within the test model is – by its design – exposed to extended periods of scarcity: real “market behavior” of price reactive EVs could not be assessed adequately.

⟹ further investigations on a full European model need to follow.

Thanks for the attention!