OPTIMIZING A COMPANY FLEET OF ELECTRIC VEHICLES UNDER TECHNICAL AND SOCIETAL UNCERTAINTIES

Lukas Gnam[1], Markus Schindler[2], Christian Pfeiffer[2], Markus Puchegger[2]

[1]University of Applied Sciences Burgenland, Steinamangerstraße 21, 7423 Pinkafeld, Austria

[2]Forschung Burgenland GmbH, Campus 1, 7000 Eisenstadt

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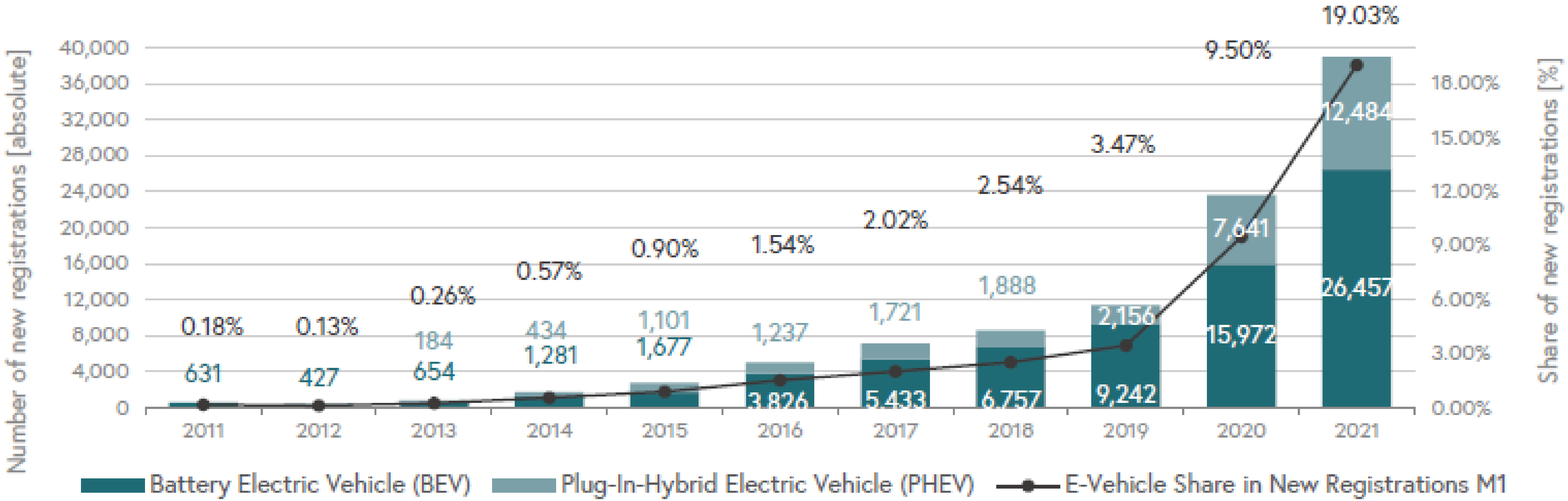
Das Leitprojekt Car2Flex (880780) wird im Rahmen der 3. Ausschreibung im Programm Vorzeigeregion Energie des Klima- und Energiefonds gefördert.

Increasing Shares of EVs in Austria



Source: Statistics Austria; Data status: 31.12. of the corresponding year respectively 31.10.2021; Hydrogen vehicles are not included in this illustration for illustrative purpose; Illustration: AustriaTech

Introduction

- Transforming the mobilitiy sector is essential for achieving a successful energy transition
- Companies can substitute their fossil-fueled cars with Evs
- Increases utilization of (new or existing) photovoltaic systems
- Integration into Renewable Energy Community possible
    - Reduces grid fees

Optimization Model – Work in Progress

- Mixed-integer optimization model
- Objective function aims at minimizing total net costs
- Battery storage and PV system as potential investment choices
- Data available in 15-Minute resolution
- Optimizations conducted for a whole year (2019)

Optimization Model – Work in Progress

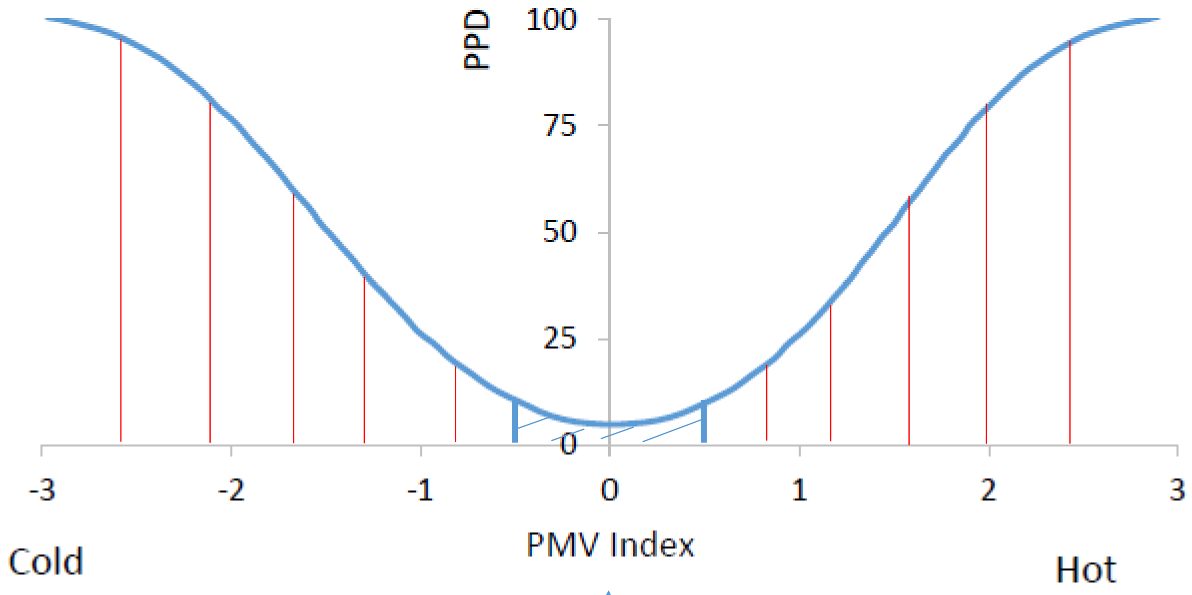
- Single charging point with four connections
- Bidirectional charging possible
- Investment costs for charging station part of objective function
- Model different types of EVs

Including Societal and Comfort Constraints

- Most optimization models limited to techno-economical constraints
- Extension to societal and comfort constraints reflects user behavior and preferences
- Goal is to increase the employees acceptance of EVs
- Travel distances, number of business trips, etc… usually known in advance
- Company can use Vehicle-to-Grid functionality to increase share of renewables (e.g., from own PV system)

Assessing Thermal User Comfort I

- Predicted Mean Vote (PMV) by Fanger (1970)
- Predicted percentage dissatisfied (PPD)
- Inputs:
  - Air temperature
  - Mean radiant temperature
  - Relative air velocity
  - Relative humidity
  - Personal activity level
  - Clothing

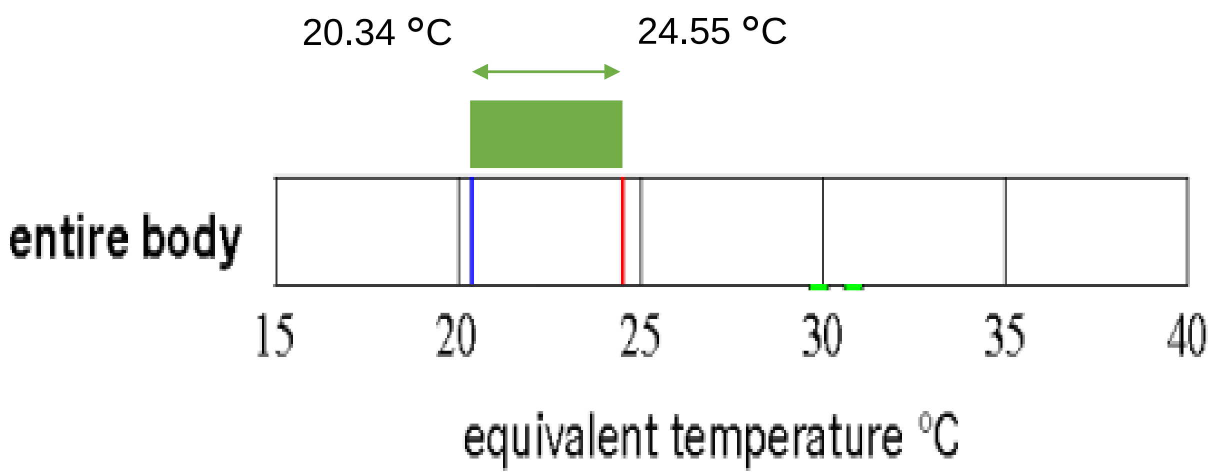


- According to ASHRAE[a] standard, PMV ∈ [-0.5; +0.5] → PPD < 10%

[a] American Society of Heating, Refrigerating and Air-Conditioning Engineers

Assessing Thermal User Comfort II

- Set air temperature boundaries according to Currle & Maué (2000)
  → mean PMV = 0.398
  → PPD ≤10% within [20.34; 24.55] °C



Use Case – Small Company

- Total energy consumption about 8.000 kWh/year
- Optimization decisions with respect to investment into PV system and battery storage system
- Four company cars (Nissan Leaf with 22 kW)
- Two different scenarios
  - EVs only chargeable at charging station
  - Bidirectional charging using connected Evs

Use Case – Small Company

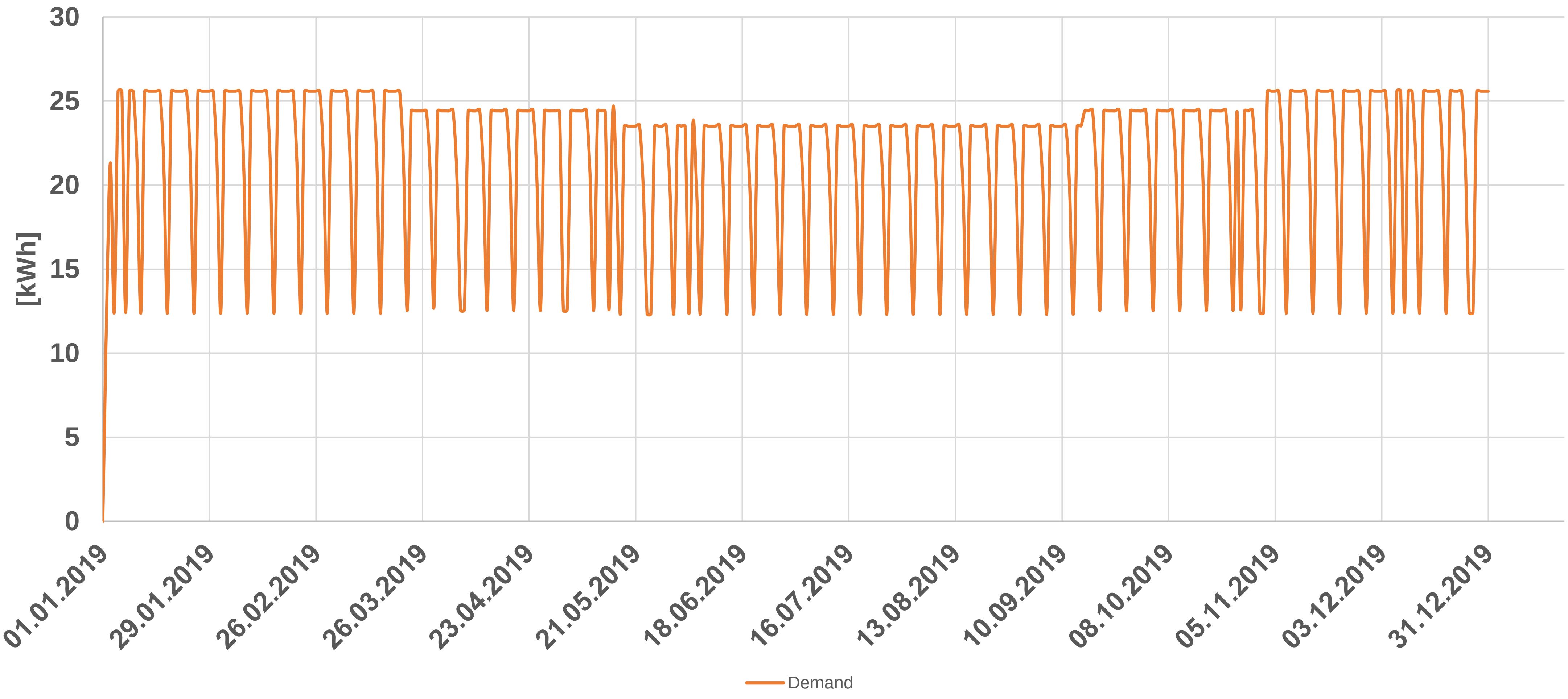
- Mobility data generated with emobpy[1]
- Electricity demand based on standard load profiles[2]
- Electricity prices are Day Ahead prices from Energy Exchange Austria[3]

[1]Gaete-Morales, C., Kramer, H., Schill, WP. et al. An open tool for creating battery-electric vehicle time series from empirical data, emobpy. Sci Data 8, 152 (2021). https://doi.org/10.1038/s41597-021-00932-9

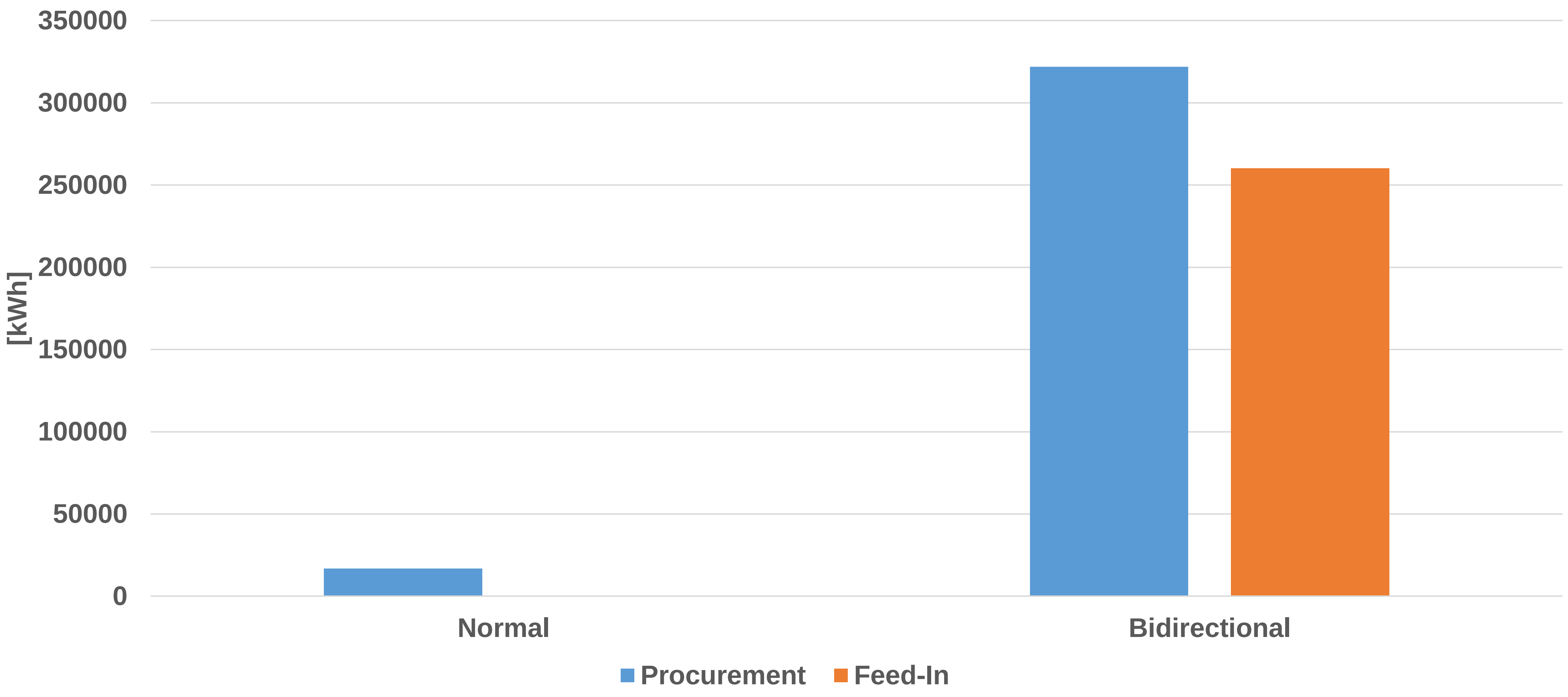
[2]Austrian Power Clearing and Settlement AG, https://www.apcs.at/de/clearing/technisches-clearing/lastprofile

[3]Energy Exchange Austria, https://www.exaa.at/

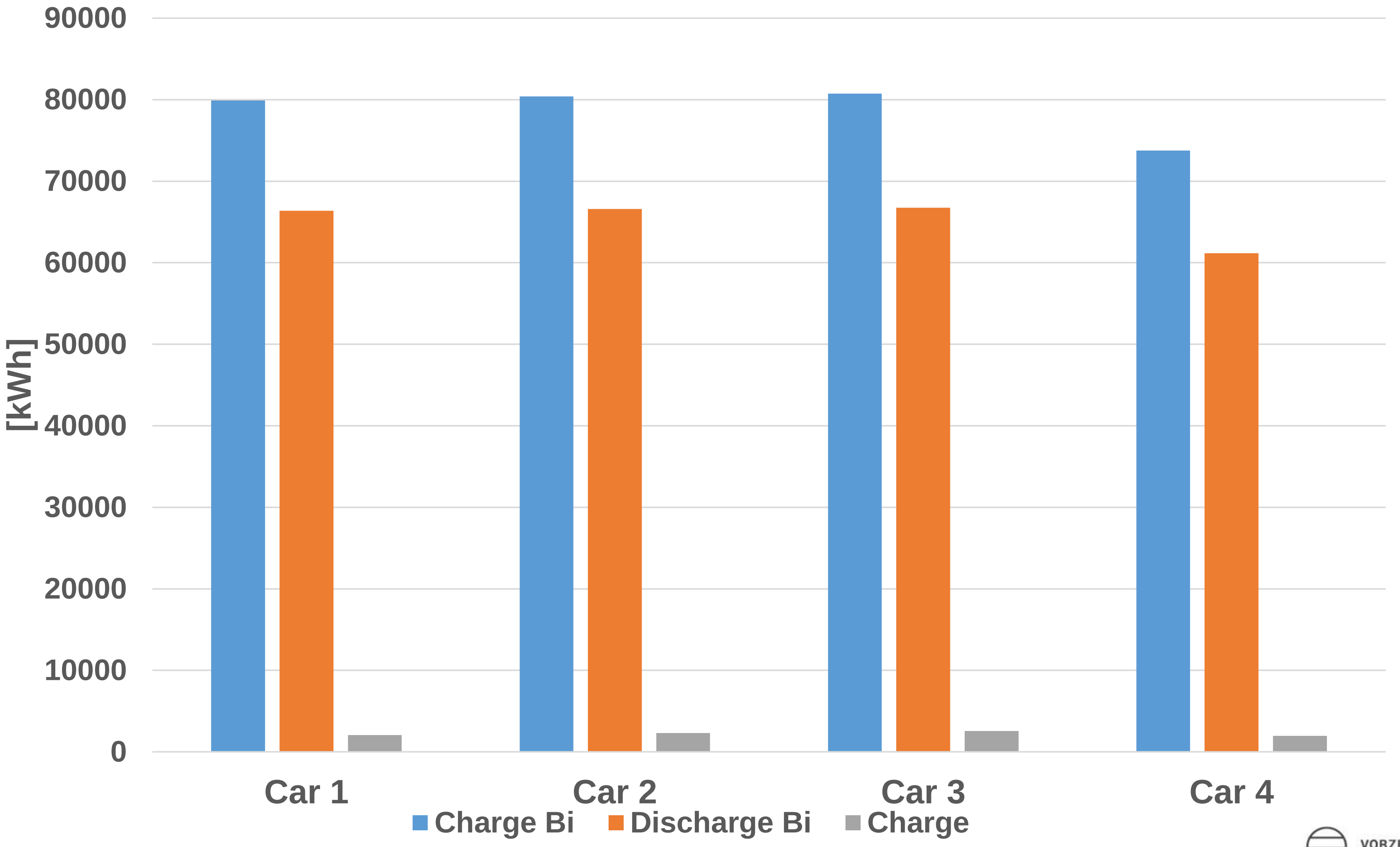
Use Case – Company Load Profile



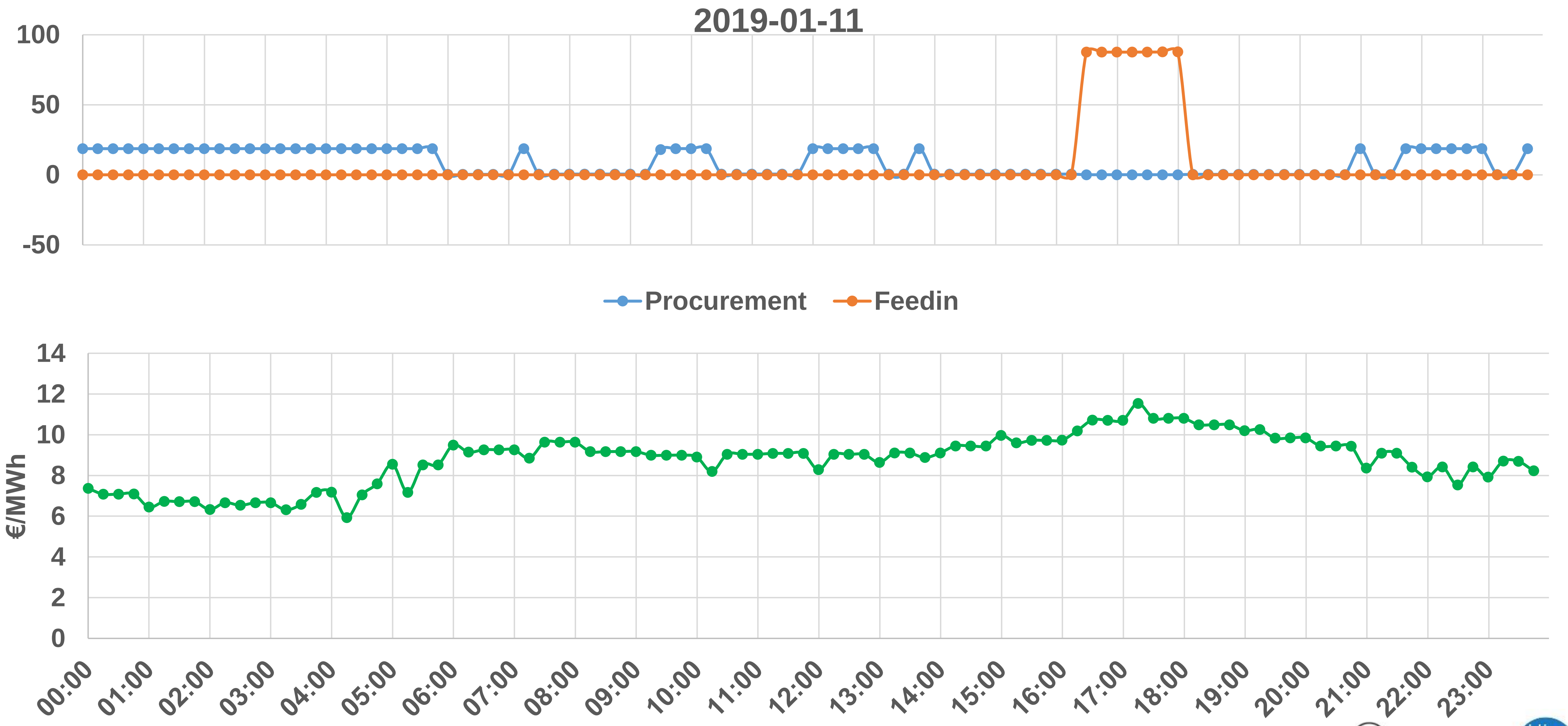
Results – Energy Procurement and Feed-In over a year



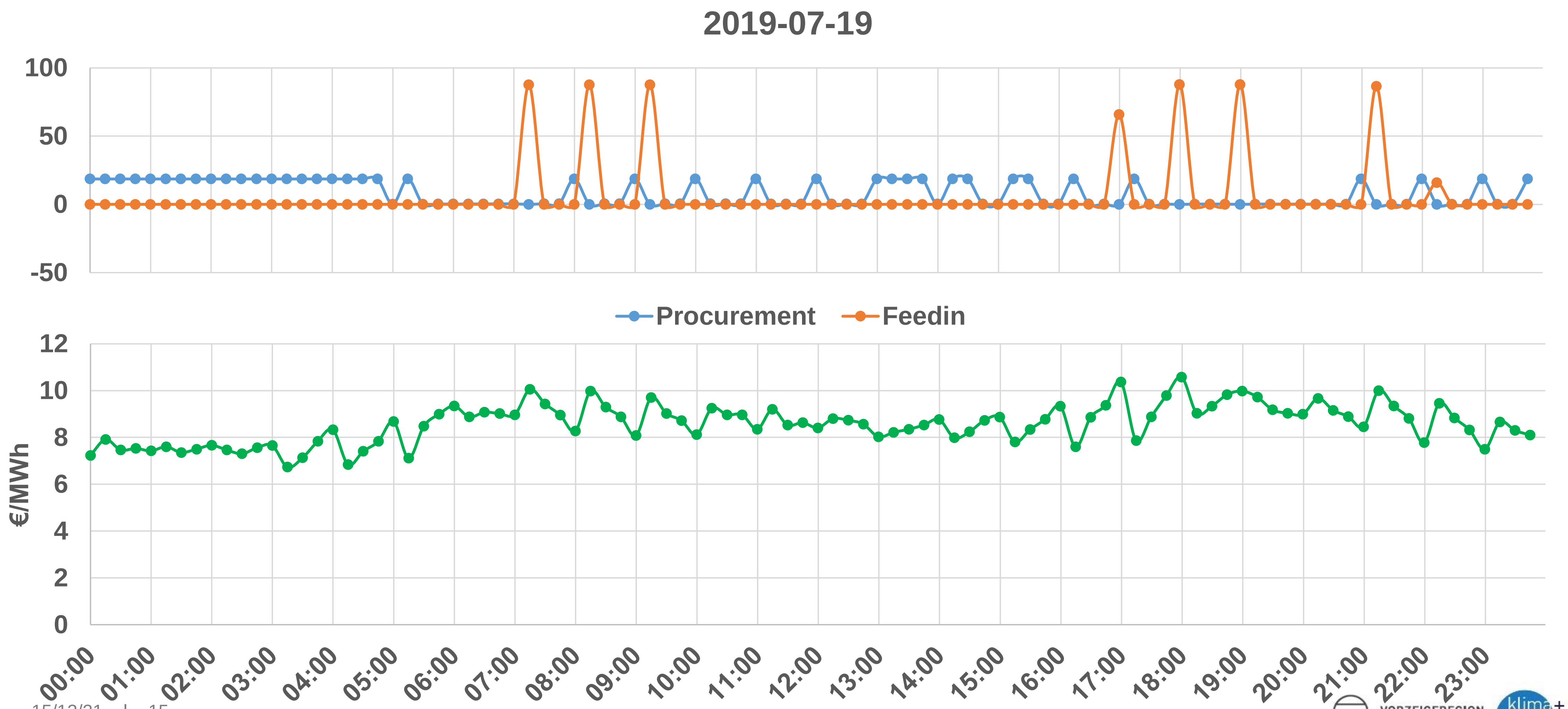
Results – Car charging and discharging over a year



Results – Winter Day Bidirectional Charging



Results – Summer Day Bidirectional Charging



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Conclusions

- Vehicle-to-Grid-Functionality could improve economic feasibility of transforming a company fleet to Evs
- Limitation of charging/discharging cycles per car and day required
- EV battery lifetime crucial
- Investments in PV and Battery storage for this small scale company fleet not feasible

Challenges

- Number of companies with PV systems

- Number of users and EVs

- User behavior
  - Driving distances
  - Acceptance of EVs
  - Charging behavior

- EV demand and PV production forecasts

Future Work

- Extensions of the optimization model
- Implementation in real life use case within the project Car2Flex
- Surveys among company employees to capture correct distribution functions
- Analyzing various charging strategies with increasing number of charging stations and EVs

Thank your for your attention!

Lukas Gnam, University of Applied Sciences Burgenland,
Steinamangerstraße 21, 7423 Pinkafeld, Austria

www.fh-burgenland.at

lukas.gnam@fh-burgenland.at

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