Multi-Agent Simulation of Intelligent Resource Regulation in Integrated Energy and Mobility

Human-like agents learning E-Car-Sharing

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Why? Climate Change!

Energy transition requires producing and using CO_2-free energy.

Storing and buffering of electric energy is one key issue.

Mobility transition is ~ one quarter of energy transition in volume.
E-Car-sharing is a small but nicely encapsulated and easier to research part of that.

Electric Vehicles (EVs) are an intersection of Energy storage and mobility -
   V2G technology

MASIRI Project

(**M**ulti-**A**gent **S**imulation of **I**ntelligent **R**esource Regulation in Integrated Energy and Mob**i**lity)

Simulate the learning process of human E-Car-Sharing users

- EVs charging process is slower than refueling.
    - might require planned breaks between bookings
- anxiety regarding new technology and new processes
    - charging differs between different charging stations
    - processes and technology are sometimes still buggy
- charging infrastructure not everywhere

Human behaviour at scale can make or break **load shifting.**
Humans don't (always) behave rationally.

core modules

other modules

users

learn & improve
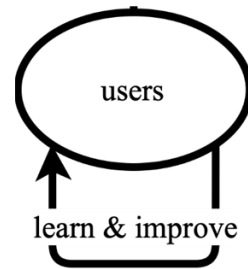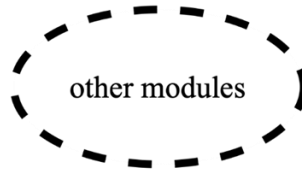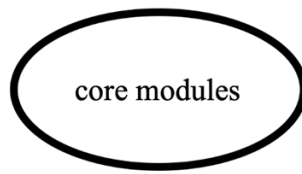
Good Booking or Bad Booking? Quality Metrics

relevant Goals for E-Car-Sharing

zero-CO$_2$ - as little fossil fuel in the energy mix as possible

stability - shift charging away from peak load and discharge battery when needed

price - charge, when energy is cheapest

availability - users get to use the car when they want

Goals can conflict with each other: *availability* vs *price* and *stability*

Quality Metrics: Measuring Success

"operationalization" [ˌɒpəˌɹeɪʃənəlaɪˈzeɪʃən]: the process of transforming abstract concepts or variables into specific measurable indicators or actions that can be observed and quantified in empirical research or practical application.

# Quantifying success of reaching the availability goal

Historic data is our baseline that shows actual mobility needs.

Each missed booking could indicate a partial failure.

But this case is more complex

- individual missed bookings need to be investigated
- requires psychologically valid agents that can have an *emotional state of dissatisfaction*.

Belief Desire Intention (BDI) Model
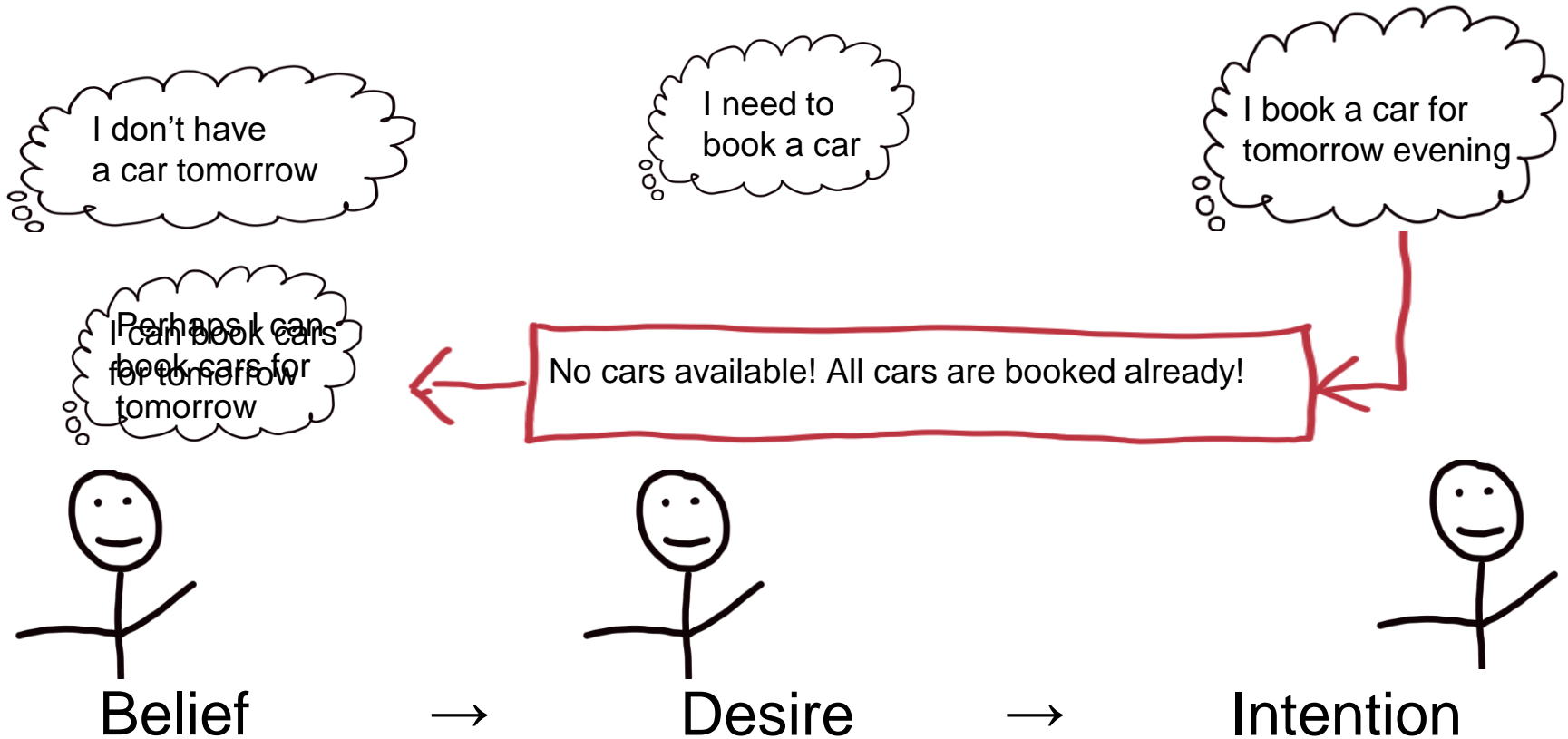
Based on your experience, how would you model this?

How to compare desires and beliefs, and how would you operationalize them?

How would do you update desires or beliefs?
e.g. "I can book a car for tomorrow with a probability of 63%," and adjust the numerical value?

How to form new beliefs or desires? e.g. "I will take my bike instead of a car."

How would you limit the range of beliefs and desires to sensible options? How do you determine the scope of your beliefs and desires?

Conclusion

- Multi-Agent-Simulation of humans involved in the energy transition, who share resources (energy, cars) makes sense.
- Help our society stop catastrophic climate change.
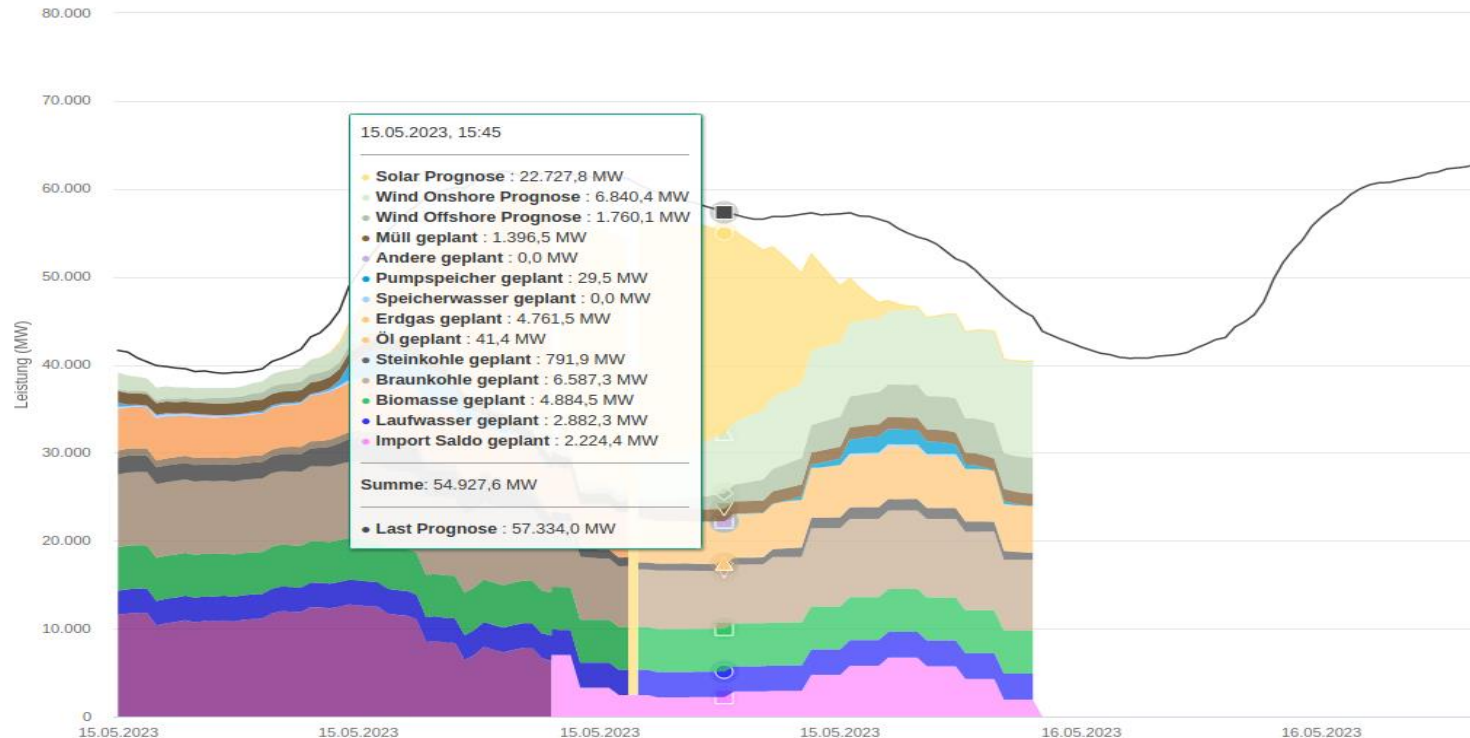- Results can inform policymakers.
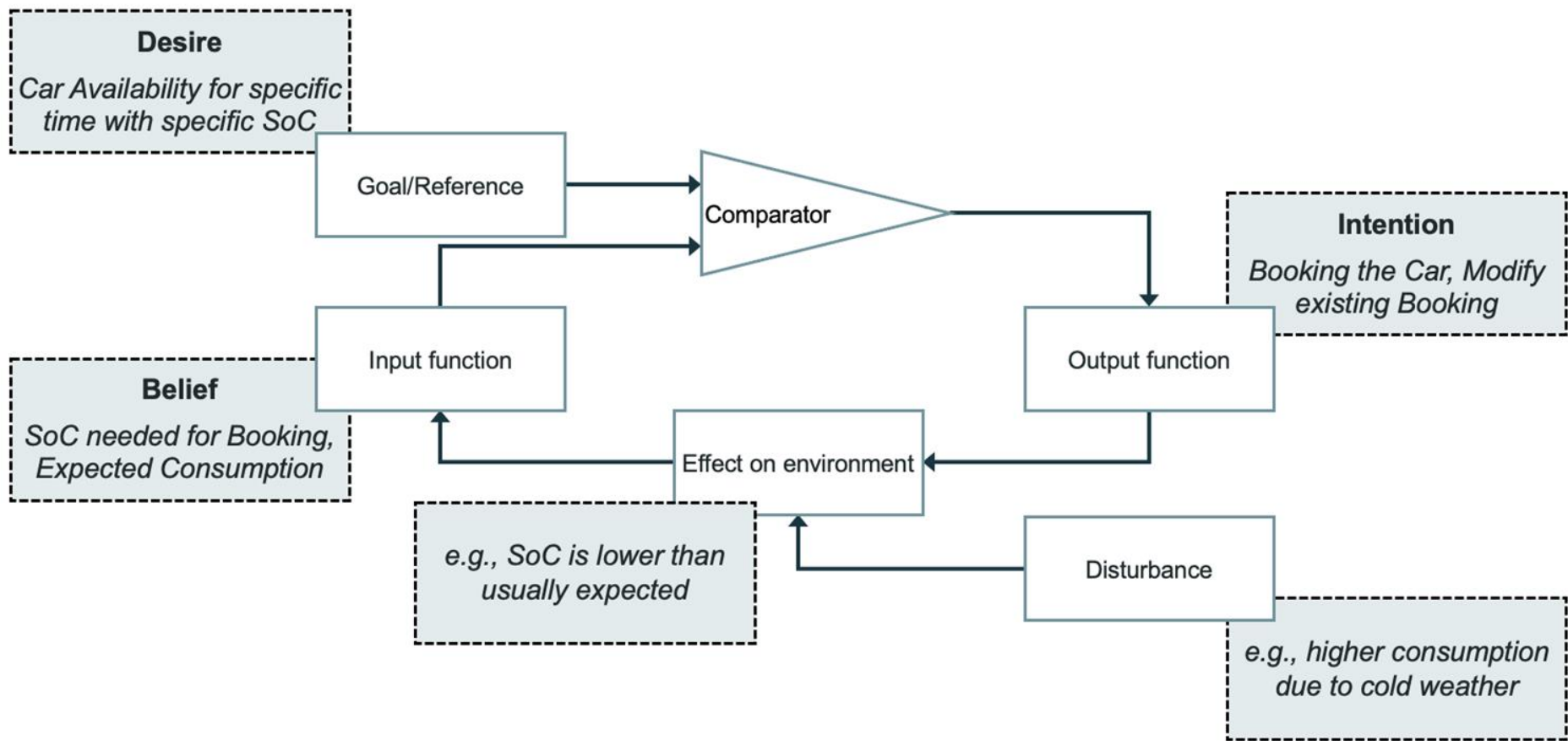
Stromproduktion und Börsenstrompreise in Deutschland im Mai 2023
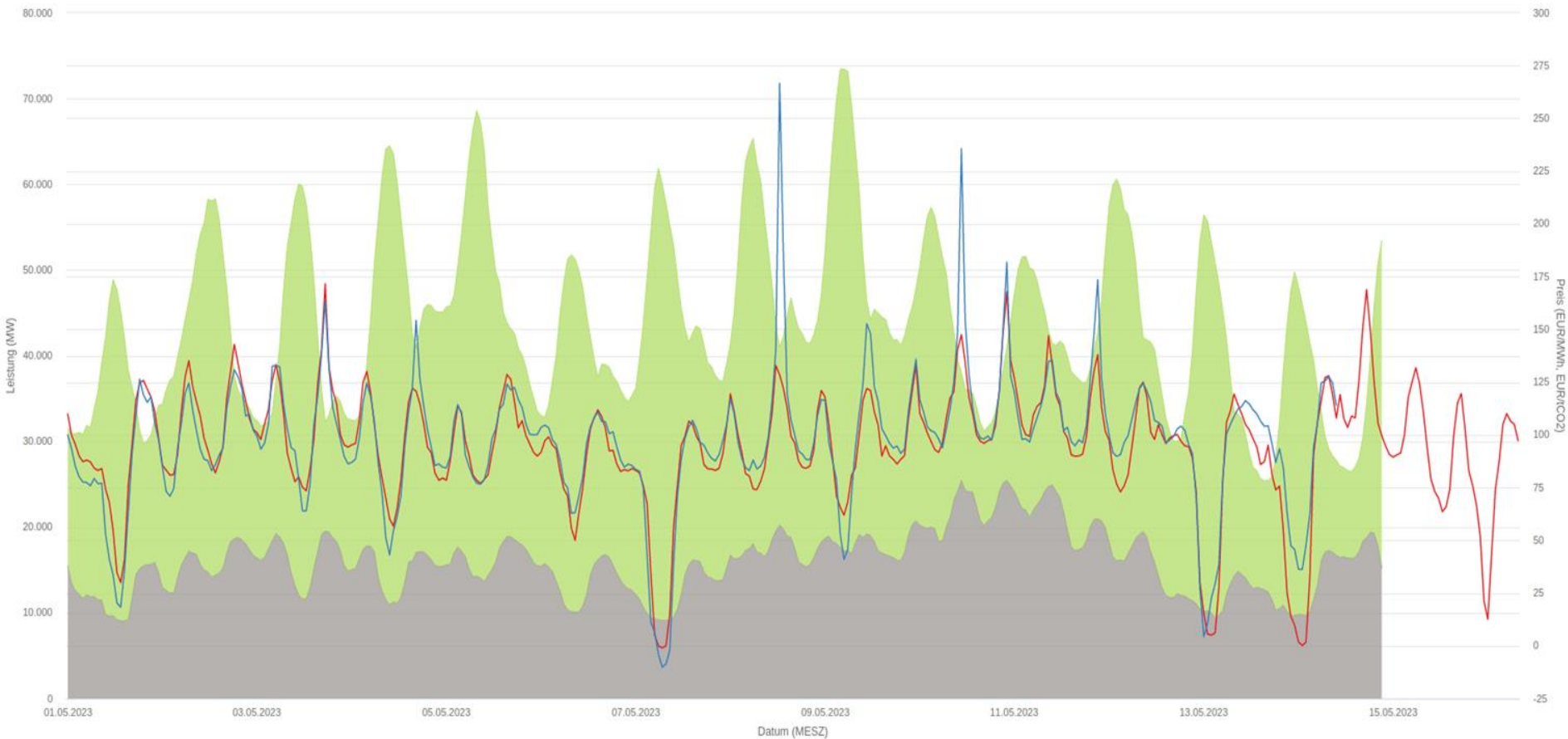
Germany's national grid, its energy mix and its stability

Öffentliche Nettostromerzeugung in Deutschland in Woche 20 2023

Energetisch korrigierte Werte

15.05.2023, 15:45

- **Solar Prognose** : 22.727,8 MW
- **Wind Onshore Prognose** : 6.840,4 MW
- **Wind Offshore Prognose** : 1.760,1 MW
- **Müll geplant** : 1.396,5 MW
- **Andere geplant** : 0,0 MW
- **Pumpspeicher geplant** : 29,5 MW
- **Speicherwasser geplant** : 0,0 MW
- **Erdgas geplant** : 4.761,5 MW
- **Öl geplant** : 41,4 MW
- **Steinkohle geplant** : 791,9 MW
- **Braunkohle geplant** : 6.587,3 MW
- **Biomasse geplant** : 4.884,5 MW
- **Laufwasser geplant** : 2.882,3 MW
- **Import Saldo geplant** : 2.224,4 MW

Summe: 54.927,6 MW

- **Last Prognose** : 57.334,0 MW

Example from a practical implementation
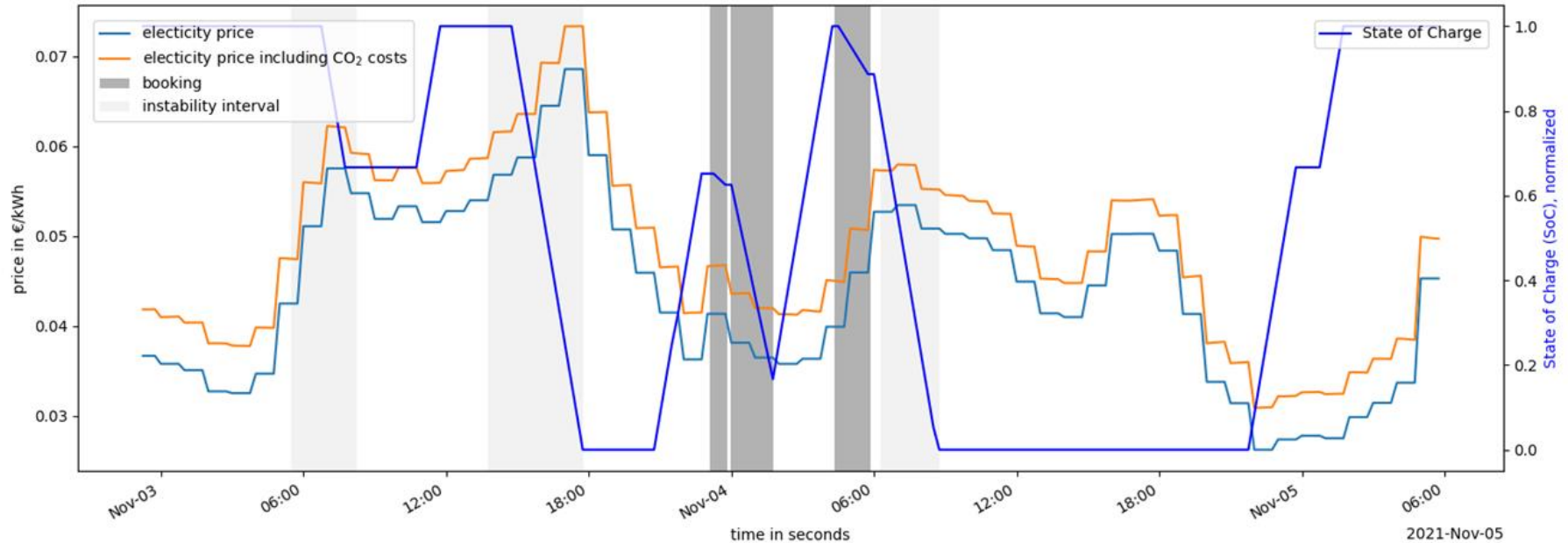
Vorhandene Buchungen
Mo, 30. Juni 2023

Zeit	
08:00	
09:00	
10:00	gebucht
11:00	10:30 - 11:30
12:00	Ihre Buchung
13:00	12:30 - 13:30
14:00	gebucht
15:00	14:15 - 15:30
16:00	
17:00	
18:00	
19:00	
20:00	
21:00	

Zeit mit hoher Stromnachfrage

Kosten Ihrer Buchung

Die Berechnung fand auf Grundlage der von Ihnen gemachten Buchungsanfrage und der aktuellen Buchungsauslastung statt. Ebenso wurde die erwartete Auslastung des Netzes integriert.

12 €

1 €   100 €

Score Ihrer Buchung

Die Berechnung fand auf Grundlage der von Ihnen gemachten Buchungsanfrage und der aktuellen Buchungsauslastung statt. Ebenso wurde die erwartete Auslastung des Netzes integriert.

Score Ihrer Buchung

0,4

0   1

Wichtigste Einflüsse für das Scoring

Grund 1 · Nähe zu anderen Buchungen · hohe Stromnachfrage - 12:00 - 14:00

Grund 2 · Grund 2 · Grund 2 · Grund 2 · Grund 2 · Grund 2

Neu buchen

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Existing bookings
Mon, 30th June 2023

Option 1	12:30 pm - 1:30 pm	
Option 2	2:30 pm - 3:30 pm	
Option 3	3:00 pm - 4:00 pm	
Option 4	4:30 pm - 5:30 pm	
Option 5	6:15 pm - 7:15 pm	

08:00 am

09:00

10:00

booked
10:30 - 11:30

11:00

12:00 pm

Your booking
12:30 - 1:30

1:00

2:00

booked
2:15 - 3:30

3:00

4:00

5:00

6:00

7:00

8:00

9:00

Time with high energy demand

Price of your booking

The calculation took place on the basis of the booking request you made and the current booking load. Likewise, the expected utilization of the network was integrated.

Price of your booking

12 €

1 €   100 €

Score of your booking

The calculation took place on the basis of the booking request you made and the current booking load. Likewise, the expected utilization of the network was integrated.

Score of your booking

0,4

0   1

Most important factors for the score

reason 1	Proximity to other bookings	high energy demand - 12:00 pm - 2:00 pm
reason 2	reason 2	reason 2	reason 2	reason 2	reason 2

Book time slot

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