VencoPy Beta Release Workshop

Vehicle Energy Consumption in Python

DLR-VE-ESY-EnSYM, Stuttgart

2021-11-16

Dr. Benjamin Fuchs, Fabia Miorelli, Niklas Wulff

DLR

openmod open energy modelling initiative

Agenda

Software engineering and models at DLR-VE

Introduction to VencoPy

VencoPy tutorials 1 and 5

Feedback

VencoPy Beta Release Workshop – Software Engineering and Open Source Models at DLR-VE

DLR-VE-ESY-EnSym, Stuttgart
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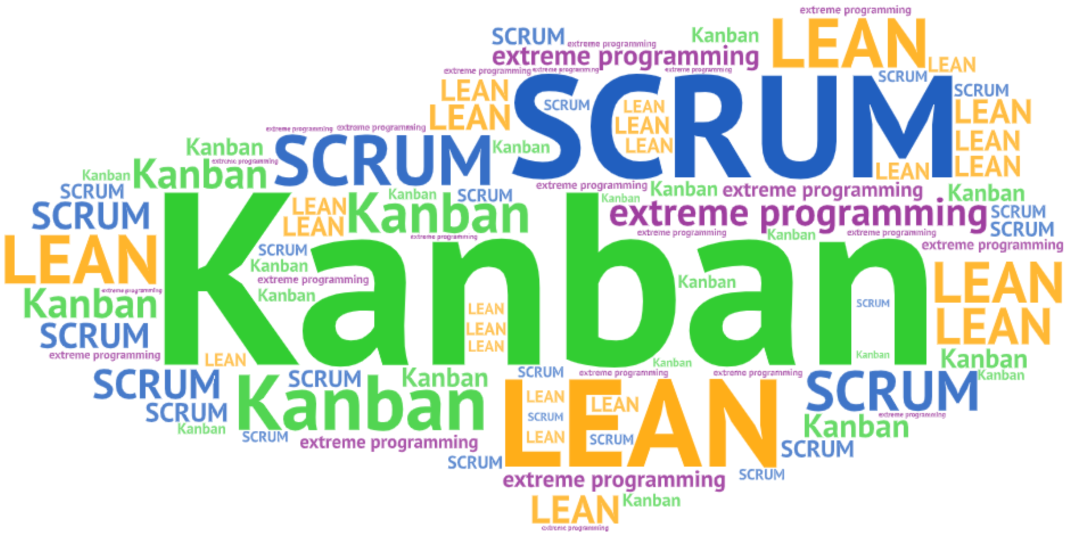
Dr. Benjamin Fuchs

Agile and Modelling



Lessons to learn from SCRUM:

- Defined and clear roles
- Structured communication
- Transparent tasks and prioritization
- Focused undisrupted work

Agile methods focus on:

communication, **processes**, **roles** and **responsibilities**

Aim to…

minimize thoughts/discussions on how to do things

optimize com and coordination to avoid wasted time

maximize the time doing what needs to be done

SE / open source compared to research software development

Shared challenges:

- **High turnover rate** of participants in software projects
- **Broad and varied expectations** of users and developers
- **Warring and changing requirements** from differing perspectives
- **Frequent adaption** of source code

Typical issues that result:

- **Inefficient knowledge transfers** during onboarding new team members
- **Loss of know how** when people leave the team
- **Prioritizing tasks** under warring requirements from differing perspectives

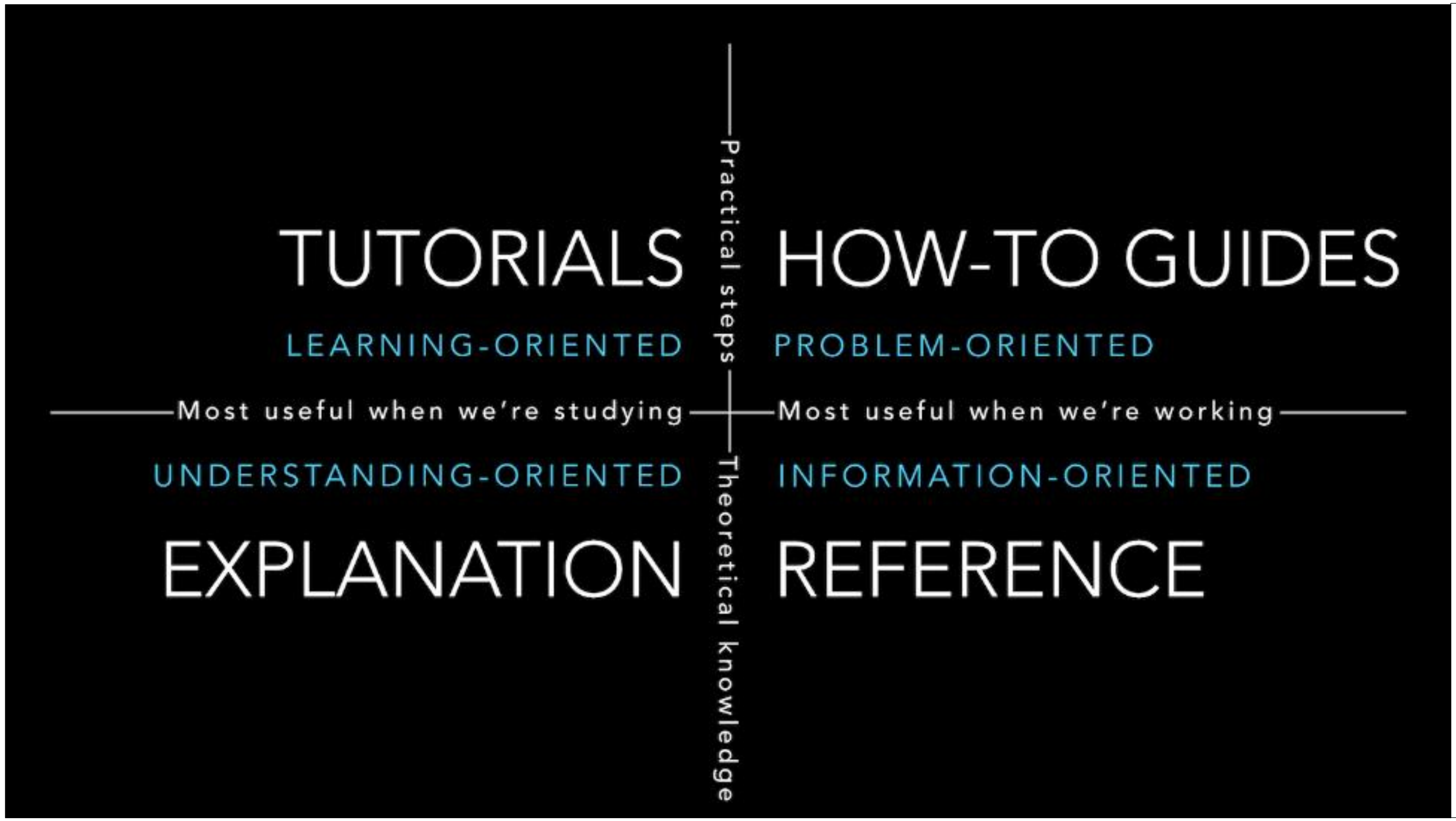
Big difference:

- **software is (usually) not the sole focus** in research software engineering

SE / Open Source and research software development compared

SE & OS methods need tailoring and tuning towards research environment

Example: Documentation

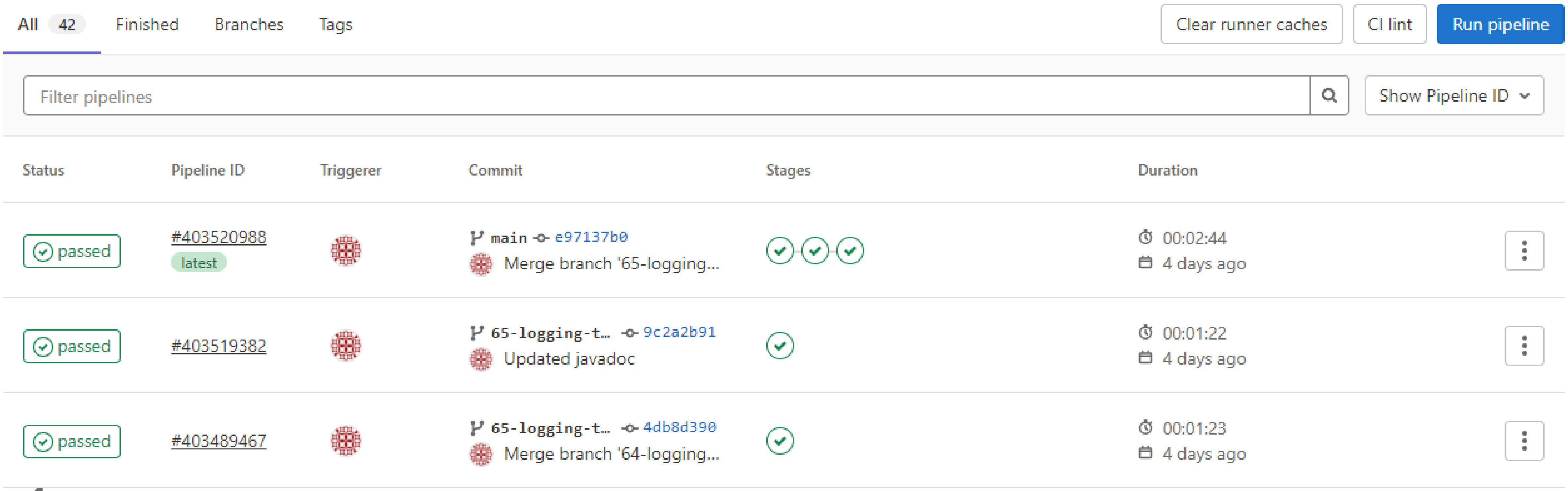


src: https://documentation.divio.com/

SE / Open Source and research software development compared

SE & OS methods need tailoring and tuning towards research environment

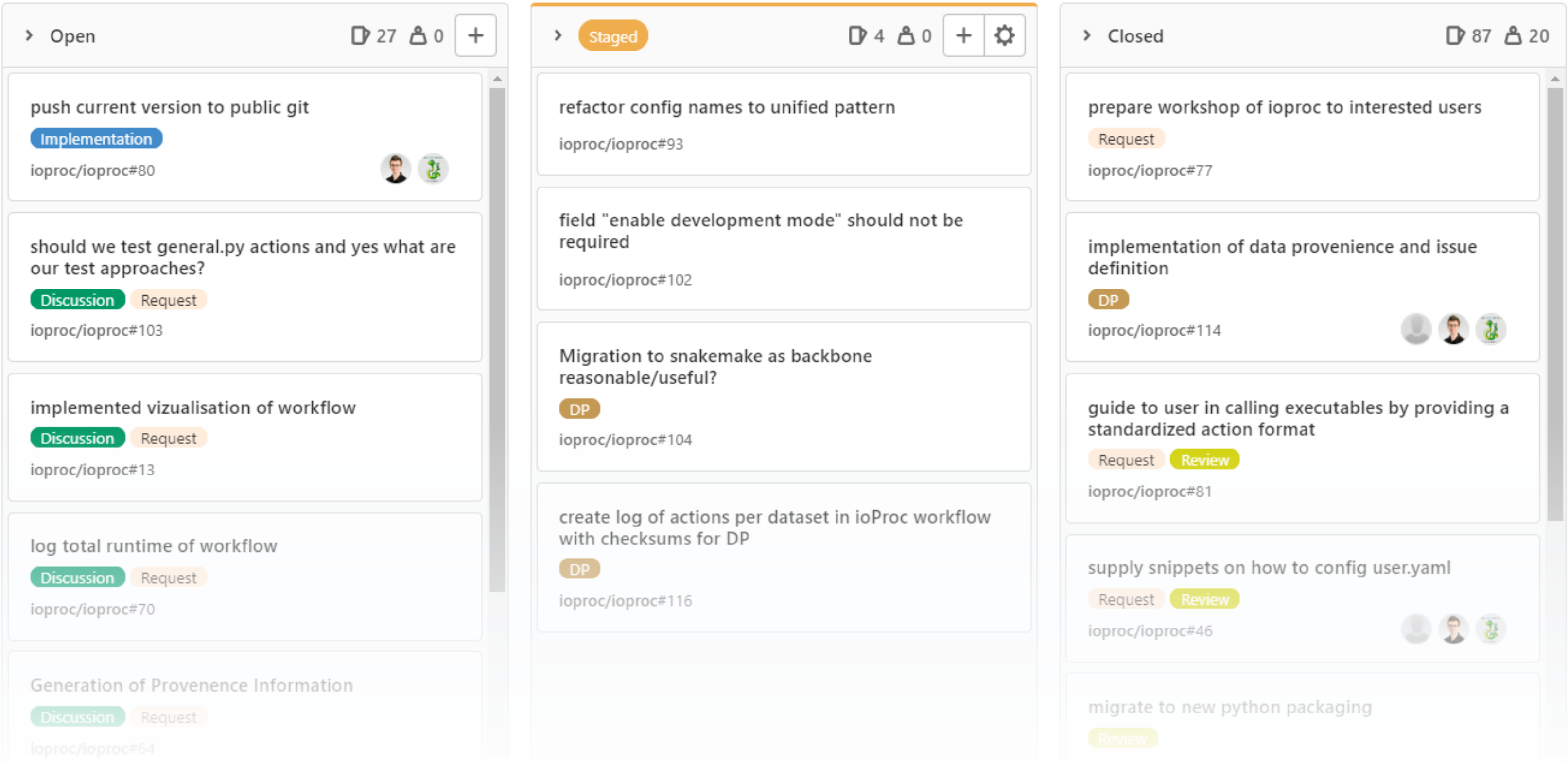
Example: CI & testing



SE / Open Source and research software development compared

SE & OS methods need tailoring and tuning towards research environment

Example: integrated and transparent workflows



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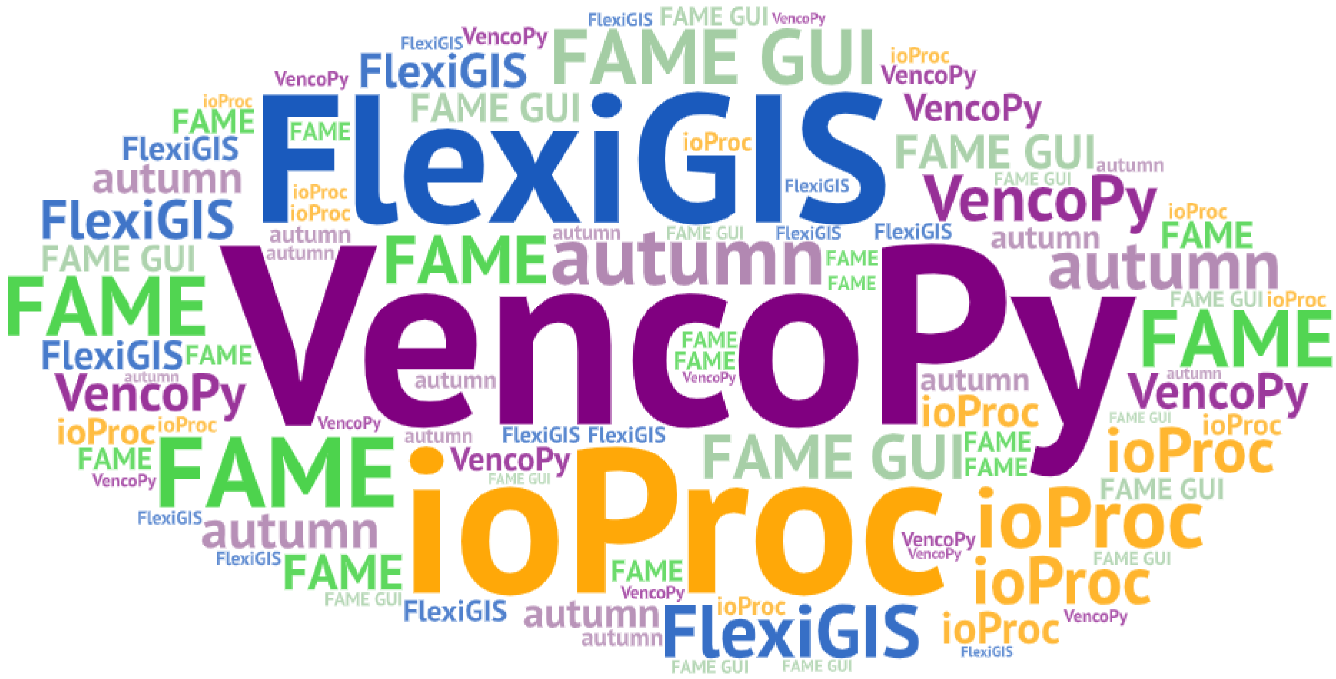
Things we do at ESY

Quality guidelines in ESY centred around **maintainability**, **accessibility** and **transparency**

- **Issue Boards** :: documentation, tracking of tasks
- **Git** :: branches, tags, features, releases
- **Code reviews** :: part of os process, on demand
- **Software companion document** :: internal processes, roles, responsibilities
- **Architecture document** :: purpose, decisions, quality values, requirements

Open Source Models in VE ESY-ST



FAME	Framework for agent based modelling
FAME GUI	Addon to enhance usability
ioProc	maintainable + reproducible workflows
FlexiGIS	Urban areas flex options esy model
Autumn	CO_2 cost potential curves
VencoPy	todays topic!

In preparation: AMIRIS, agent based model for modelling energy markets

We also work on several other models, that we want to release in the future as open source

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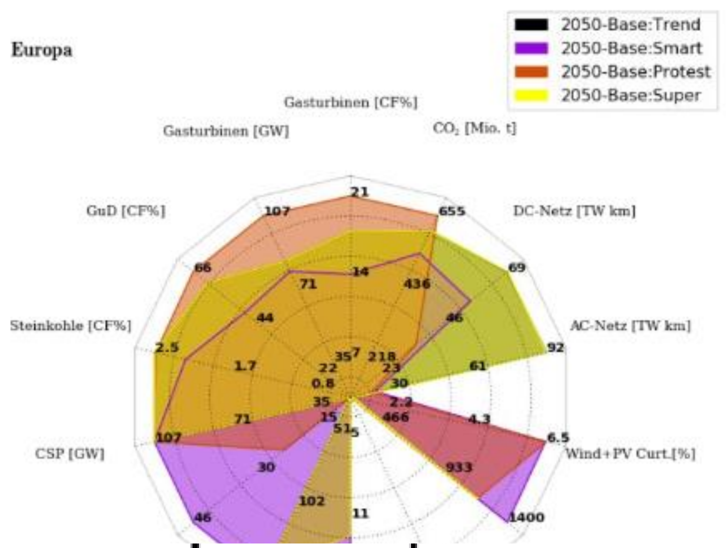
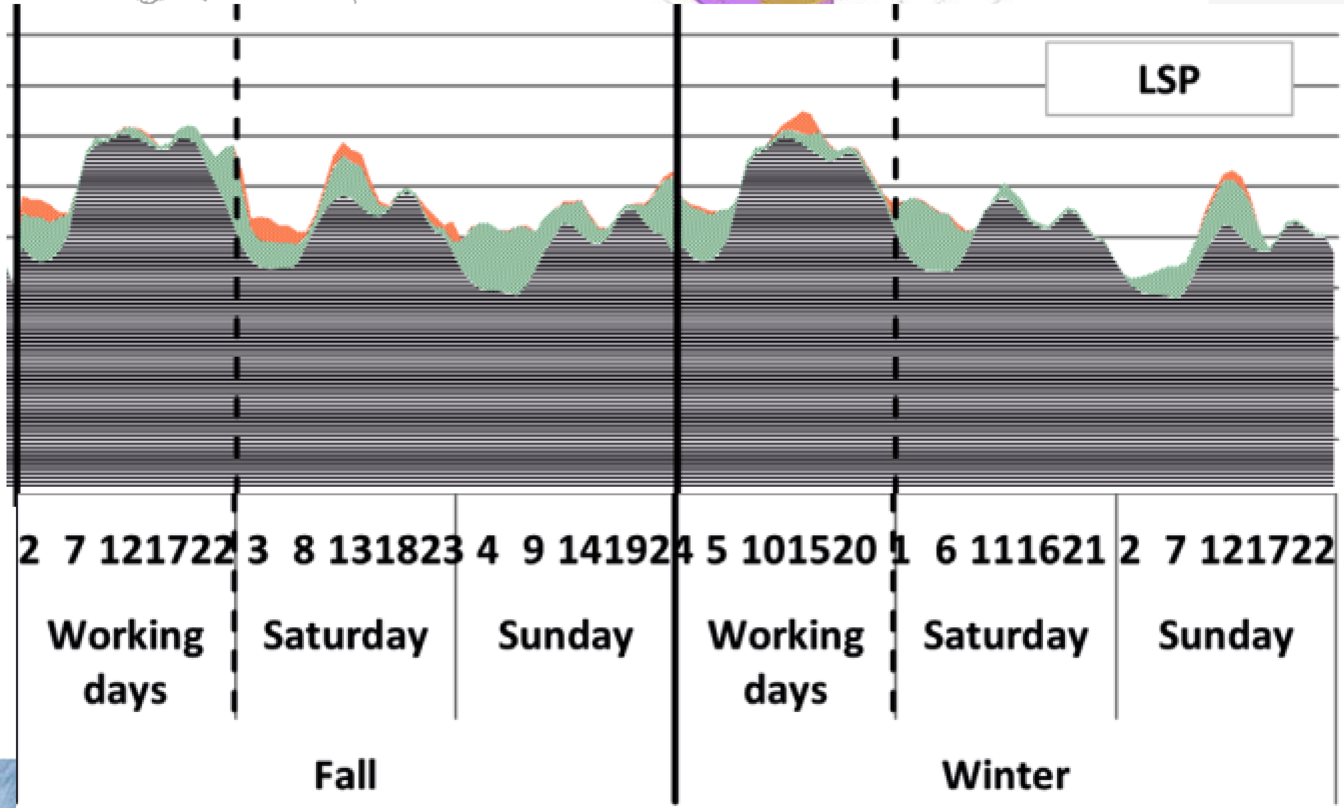
Energy system modelling at DLR-VE-ESY

The goal of energy system modeling is to show the **feasibility of energy scenarios with high shares of renewable energies**, to find **optimal system designs** and to **show trade-offs**

We focus on the **German and European** energy systems

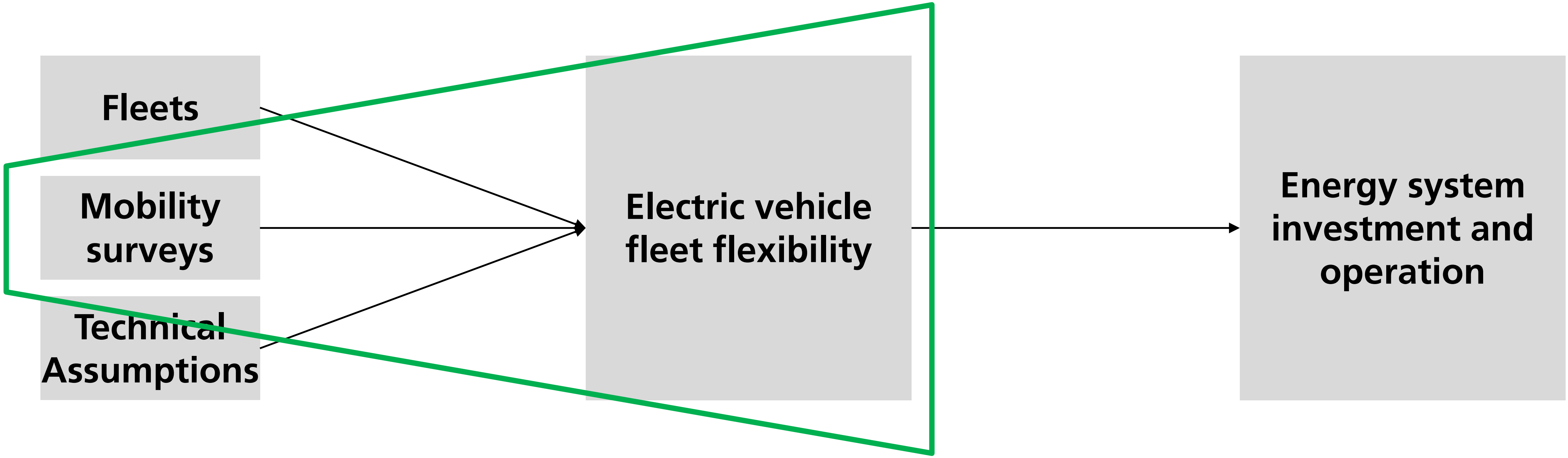
In **highly sector-coupled** energy system designs, different **flexibility options compete** against each other. One of them are future electric vehicle fleets.





Gils et al. (2020)
Cao et al. (2019)
Babrowski et al. (2016)

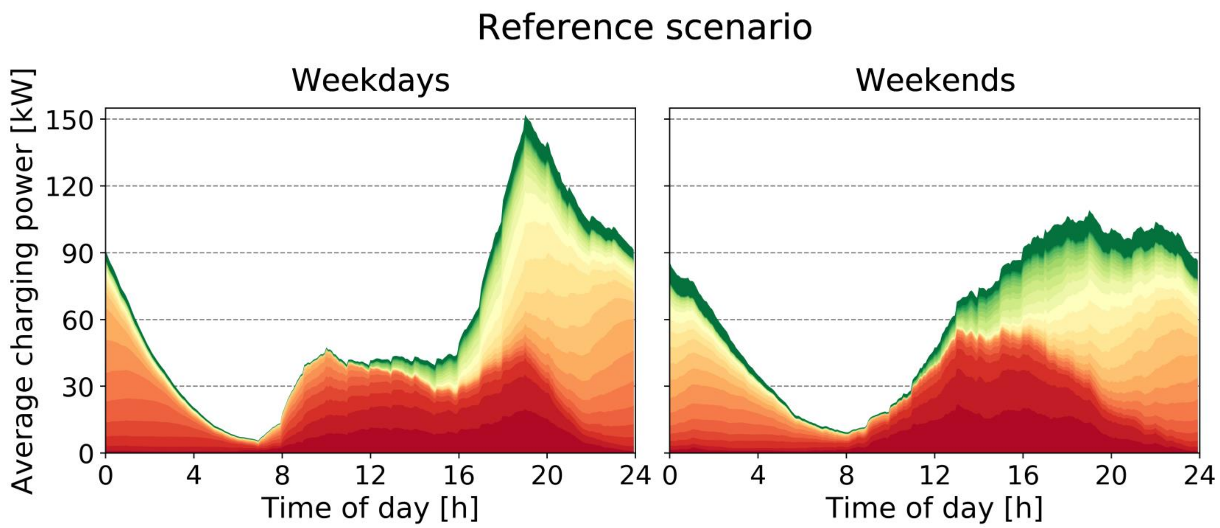
The application context of VencoPy

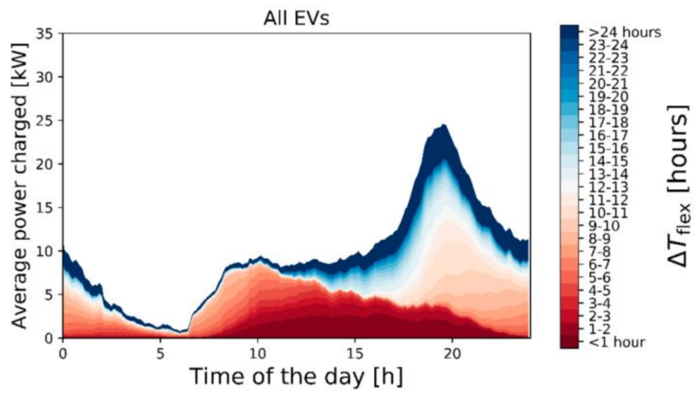


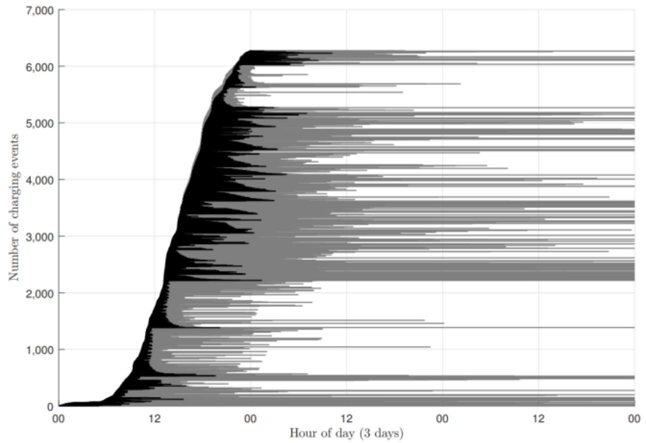
Two options of modelling EV load profiles and flexibility

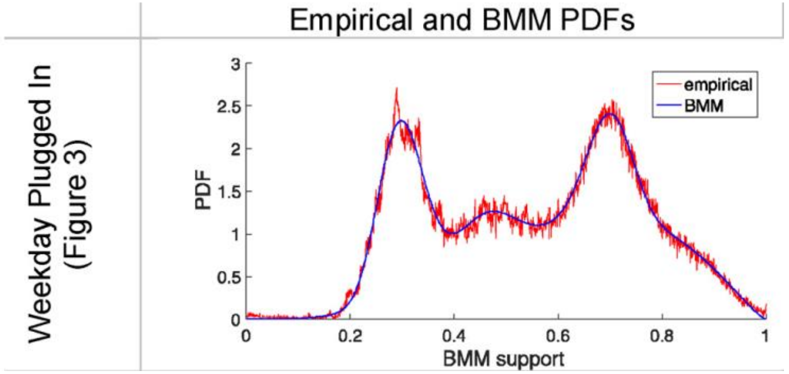
Data driven

- Measured EV data is scaled to represent respective fleets of the model scope
- Either measured vehicle SOC data or charging station data is used
- Publications
    - Schäuble et al. (2017)
    - Flammini et al. (2019)
    - Gerritsma et al. (2019) / Brinkel et al. (2020)









Two options of modelling EV load profiles and flexibility

Data driven

- Measured EV data is scaled to represent respective fleets of the model scope

elink SOLUTIONS synPRO

FORECAST FORecasting Energy Consumption Analysis and Simulation Tool | eLOAD energy LOad curve ADjustment tool

FFE - eFlame

KIT-IIP – MobiFlex

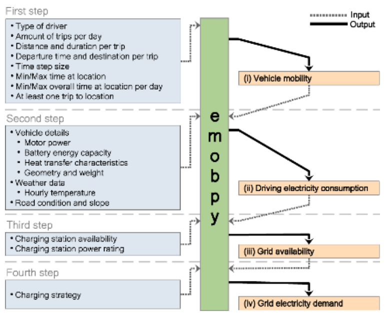
Fraunhofer IEE – Michael v. Bonin

DLR-VF – CURRENT

Bottom-up simulation

- Today's mobility patterns as input (for us: Mobilität in Deutschland, the German travel survey)
- Vehicle stock scenarios (possibly model output from stock models)
- Assumption on charging controllability
    - Resulting fleet electric load profiles
    - Flexibility of charging

Example tools

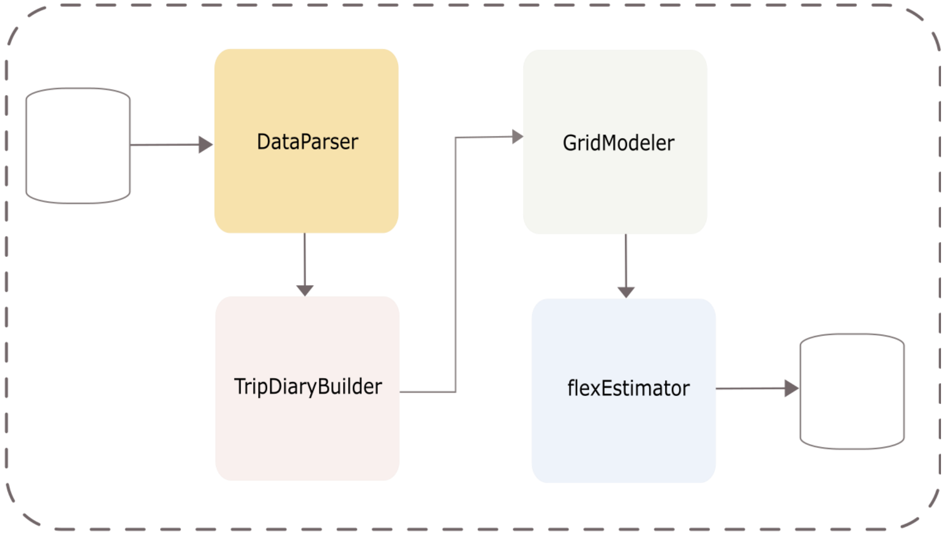


RAMP MOBILITY
Stochastic electric vehicle load profiles

https://www.elink.tools/elink-tools/synpro/Logo_synPRO.png/view
https://www.forecast-model.eu/forecast-en/index.php
https://github.com/RAMP-project/RAMP-mobility
https://emobpy.readthedocs.io/en/latest/

VencoPy introspection – MiD input

VencoPy Framework



MiD 2017 (B2 regional dataset)

Household (N=156,420)
49 variables

Trips (N=960,619)
157 variables

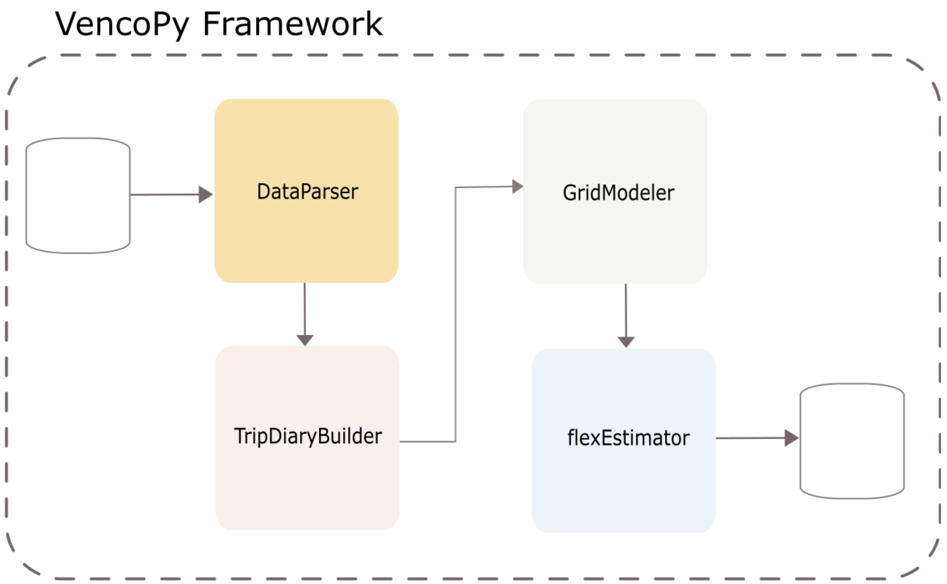
Person (N=316,361)
107 variables

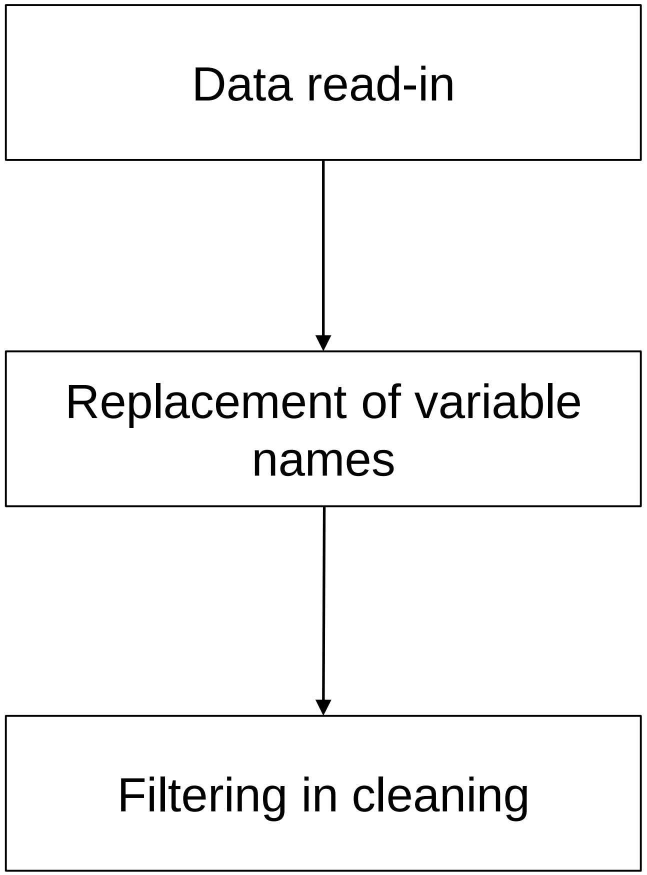
Travels

	W_VM_G	HP_ID_Reg	W_ID	W_SZ	W_AZ	zweck	wegkm	wegmin_imp1	ST_JAHR	ST_MONAT	ST_WOCHE	ST_WOTAG	W_SZS	W_SZM	W_AZS	W_AZM	W_FOLGETAG	weg_intermod
0	703	1410	1	14400	15600	8	70703	20	2017	3	10	1	4	0	4	20	0	703
1	703	1410	2	27000	30600	1	70703	60	2017	3	10	1	7	30	8	30	0	703
2	703	1410	3	43200	45000	8	70703	30	2017	3	10	1	12	0	12	30	0	703
3	1	1410	4	50400	53400	2	9.5	50	2017	3	10	1	14	0	14	50	0	0

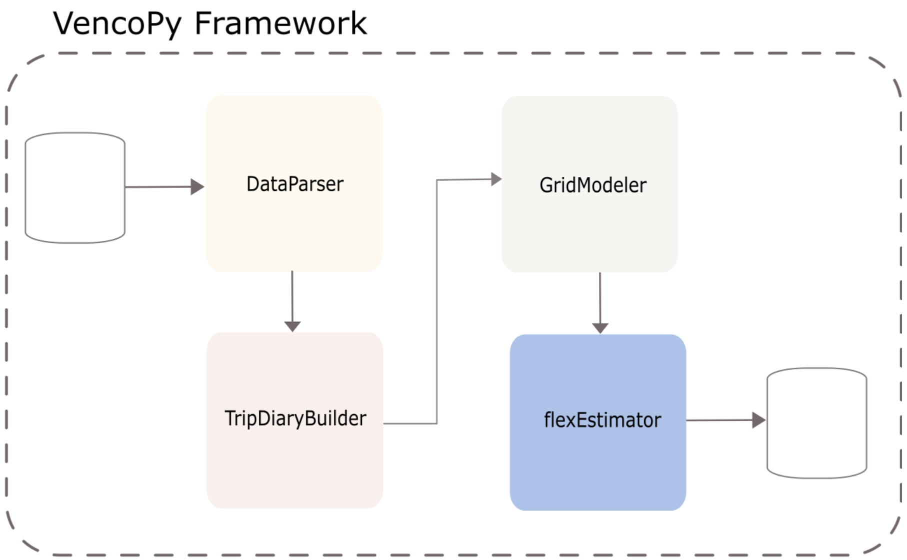
Miorelli, F. & Wulff, N. (2021)

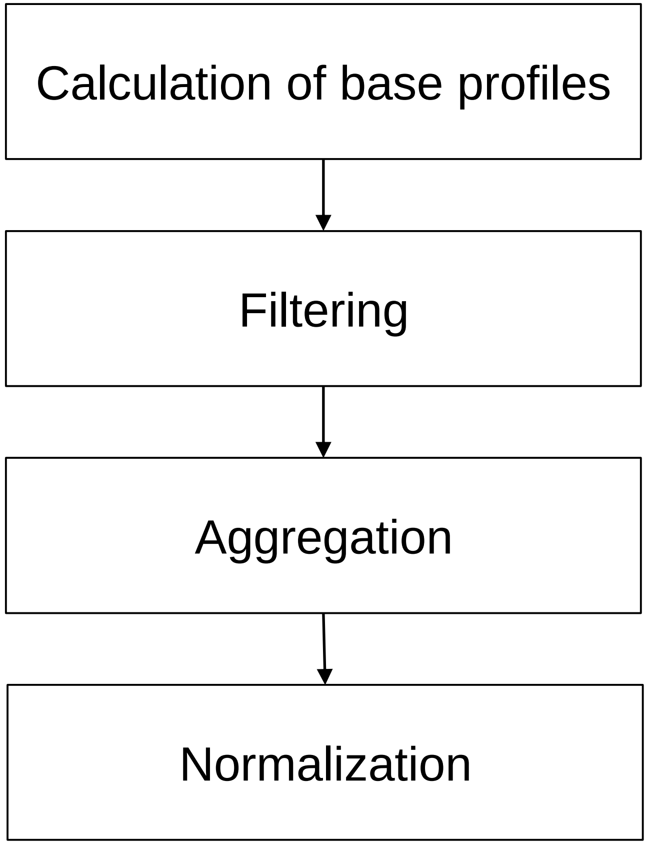
VencoPy introspection – data parsing



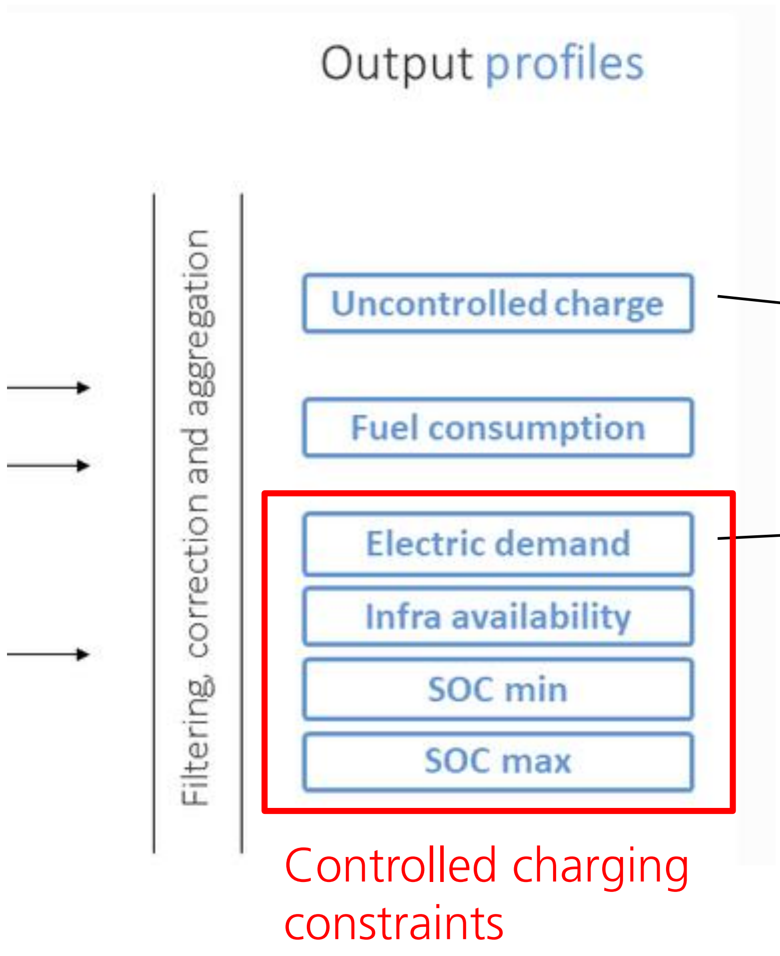


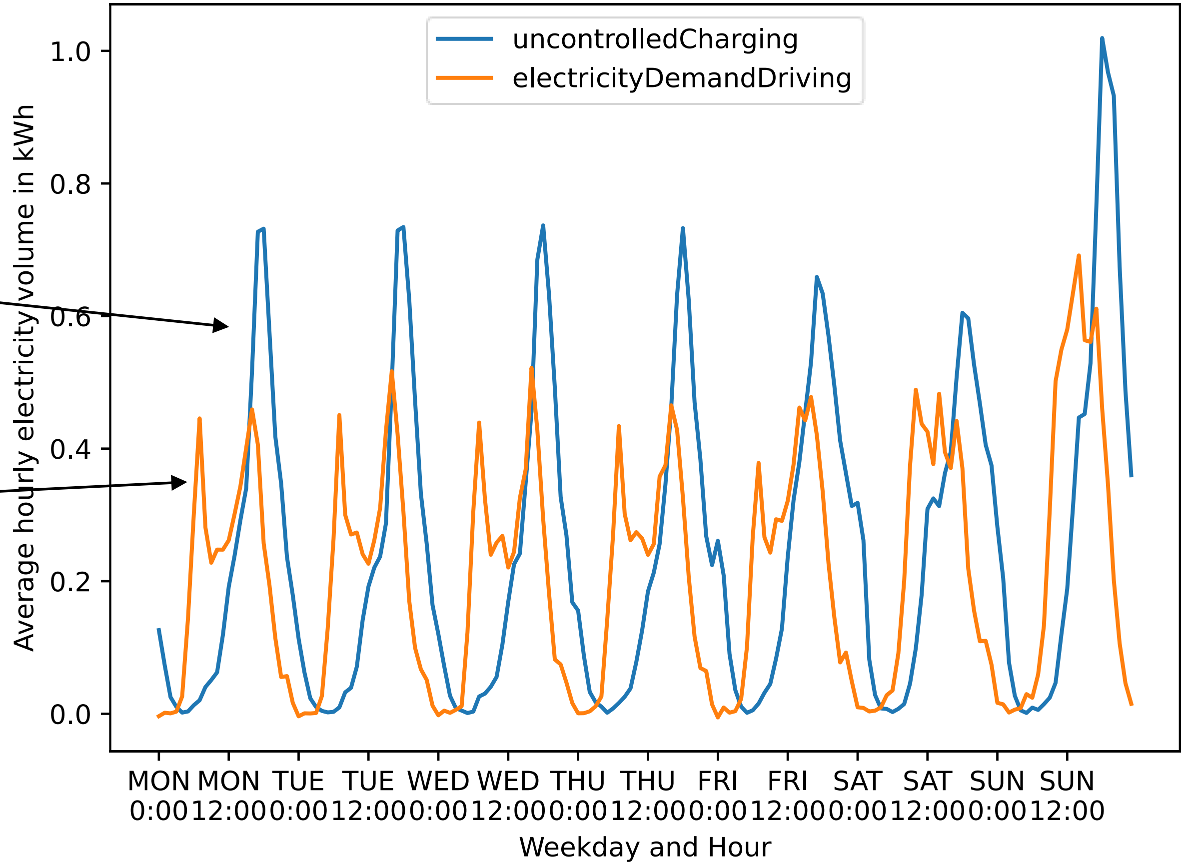
VencoPy introspection – fleet flexibility estimation





Exemplary results





How to contribute

1. Send an email to Niklas or Fabia
2. Fill out the docx and send it to us → **DLR Individual Contributor License Agreement**
3. Check out the repo and follow the set-up instruction
4. Send us pull requests!
5. Join the gitter chat!

Background Literature

Brinkel, N., Alskaif, T. & van Sark, W. (2020). *The Impact of Transitioning to Shared Electric Vehicles on Grid Congestion and Management. Preprint.* Online: https://www.researchgate.net/publication/344155869_The_Impact_of_Transitioning_to_Shared_Electric_Vehicles_on_Grid_Congestion_and_Management

Cao, K.-K. et al. (2019). Analyse von Strukturoptionen zur Integration erneuerbarer Energien in Deutschland und Europaunter Berücksichtigung der Versorgungssicherheit (INTEEVER). Schlussbericht. Online: https://elib.dlr.de/126264/1/Endbericht_INTEEVER%20final.pdf

Flammini, M.G., Prettico, G., Julea, A., Fulli, G., Mazza, A., Chicco, G. (2019). Statistical characterisation of the real transaction data gathered from electric vehicle charging stations. Electric Power Systems Research 166, 136-150. Online: https://doi.org/10.1016/j.epsr.2018.09.022

Gerritsma, M.K., AlSkaif, T.A., Fidder, H.A., van Sark, W.G.J.H.M. (2019). Flexibility of Electric Vehicle Demand: Analysis of Measured Charging Data and Simulation for the Future. World Electric Vehicle Journal 2019, 10, 14. Online: https://doi.org/10.3390/wevj10010014

Gils, H.C. et al. (2020). MULTI-SEKTOR-KOPPLUNG. MODELLBASIERTE ANALYSE DER INTEGRATION ERNEUERBARERSTROMERZEUGUNG DURCH DIE KOPPLUNG DER STROMVERSORGUNG MIT DEM WÄRME,GAS-UND VERKEHRSSEKTOR. Endbericht. Online: https://elib.dlr.de/135971/1/MuSeKo-Endbericht-2020-08-31.pdf [11.10.2021].

Miorelli, F., Wulff, N. & Butte, P. (2021). VencoPy Documentation. Available Online: https://vencopy.readthedocs.io/en/latest/

Pfenninger et al. (2018). Opening the black box of energy modelling: Strategies and lessons learned. Energy Strategy Reviews. Online: https://doi.org/10.1016/j.esr.2017.12.002

Schaeuble, J., Kaschub, T., Ensslen, A., Jochem, P. & Fichtner, W. (2017). Generating electric vehicle load profiles from empirical data of three EV fleets in Southwest Germany. In: *J Clean Prod 150,* 253-266. https://doi.org/10.1016/j.jclepro.2017.02.150

https://www.elink.tools/elink-tools/synpro/Logo_synPRO.png/view

https://www.forecast-model.eu/forecast-en/index.php

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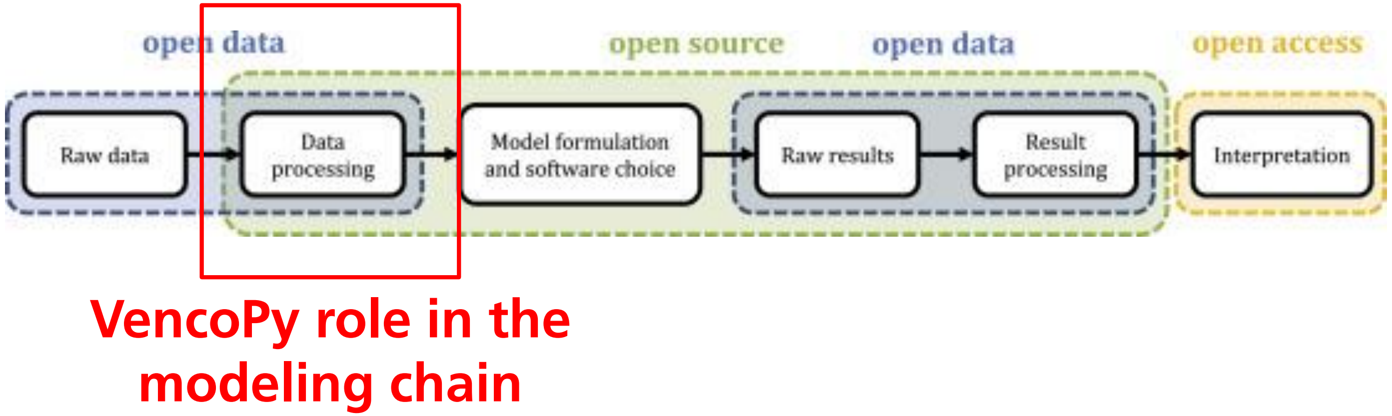
Feedback

- Make the MiD open access
- Seasonal differences in VencoPy output profiles
    - Temperature dependency
- Derive representative profiles in order not to have to do an aggregation to fleet batteries
- Account for multi-day SOC and plugging behavior
    - SimBEV
- Add description of aggregation method and reference Sabrina Rieds paper
- Charging availability and distribution

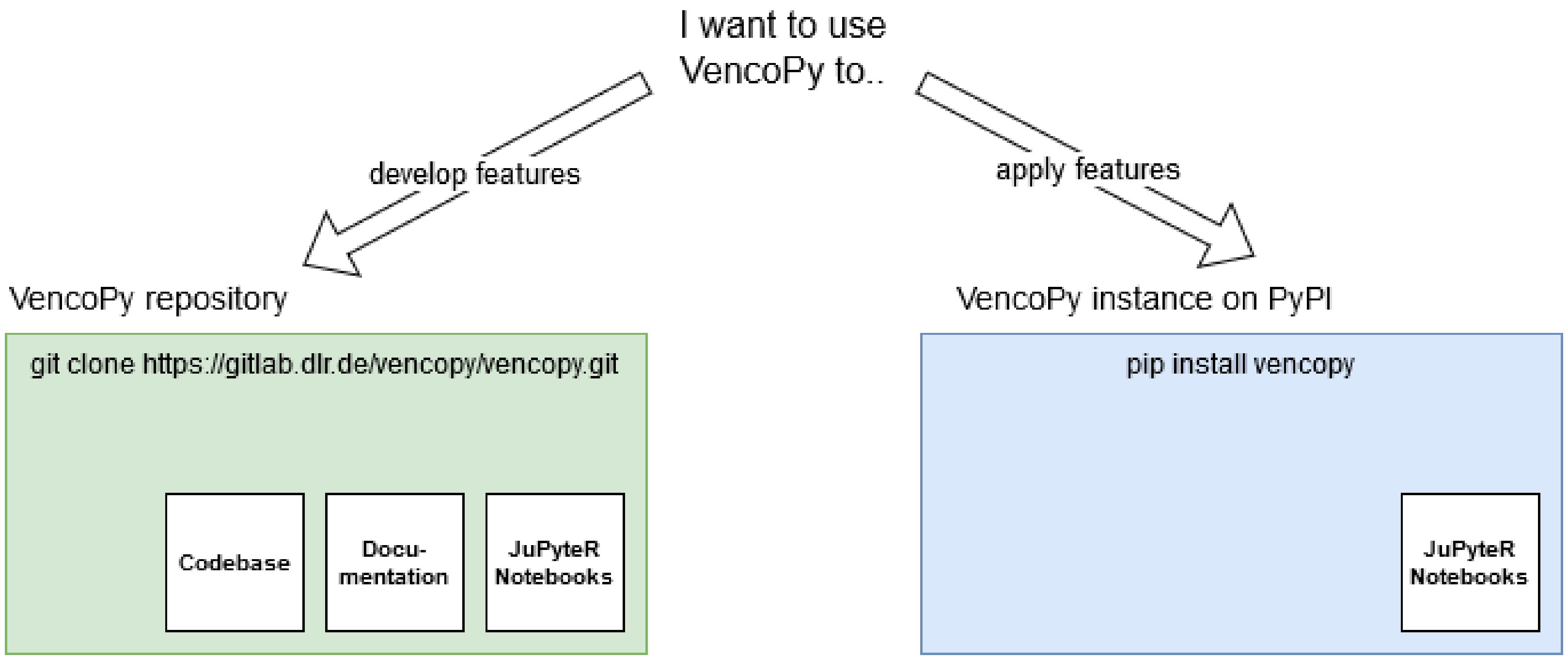
Backup Slides

Reproducibility of energy scenario studies requires transparency across the whole data processing chain



Pfenninger et al. (2018)

Overview over the VencoPy environment (from the documentation)

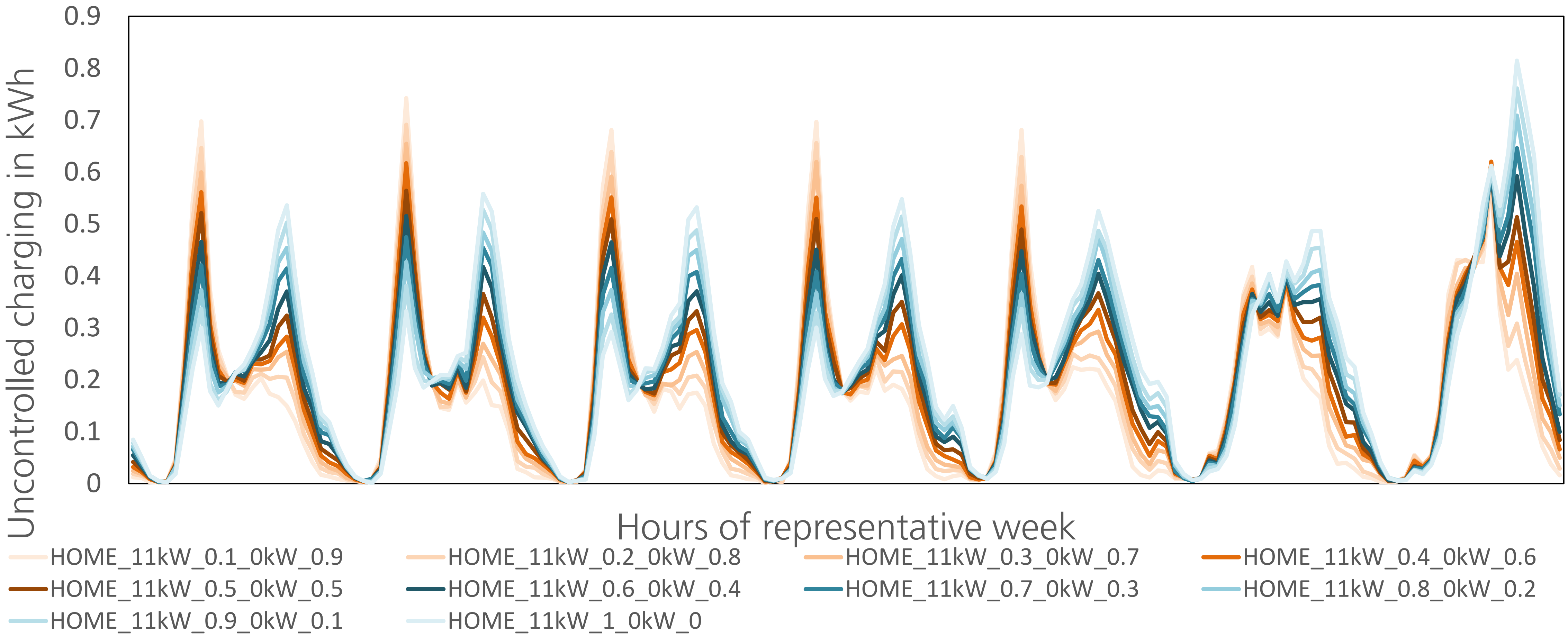


- Parse any mobility or EV data set with my own routines
- Make use of VencoPy class object functionalities
- Contribute to the codebase
- Contribute to the documentation

- Parse MiD data and use it for EV analyses
- Generate hourly EV mobility and parking profiles
- Assume charging column scenarios
- Calculate EV charging profiles with and without charging flexibility

https://vencopy.readthedocs.io/en/latest/index.html

Grid modelling – ongoing work testing the profile sensitivity to home charging availability



Introduction – our research on the background of the granularity gap for the case of electric vehicle fleets

Transportation research
- Routing, car sharing, autonomous vehicles, congestion management etc.

Environmental science
- How much does electric mobility lead to GHG emission reductions (potentially at what Life Cycle stage)?
- What emissions do EV fleets cause (Schuller et al. (2015))

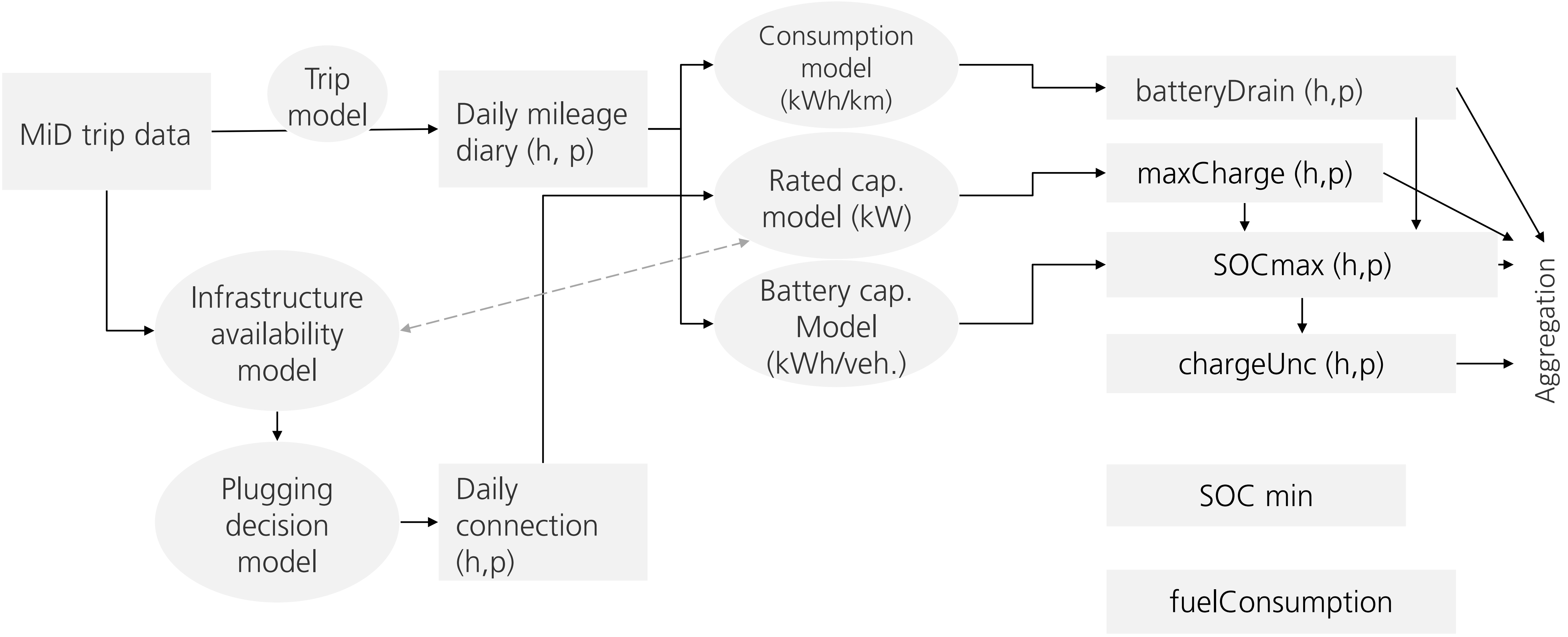
Electrical engineering research
- Does EV electric load pose a risk to grids?
- Grid stability services by EV fleets, …

Energy system analysis
- EV-energy system interface modeling
- Influence of EVs on electricity prices
- Curtailment reduction potential of EVs
- …

Ried et al. (2021) “The crucial difference of EVs compared to the other types of flexible loads […] is that they are **less homogeneous**, **not always available for charging**, and need **certain energy levels for trips at certain moments**.”

VencoPy data flow diagram

h: Hour
p: Household-person ID



A glimpse in the REMix representation of controlled charging

Grid
Hourly electricity production costs

- $P_{charge,avail}(t)$
- $C_{uncontr}(t)$
- η_{GtV}
- $\Psi_{CC}(t)$

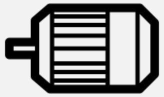
Maximum controlled charging

Fleet battery

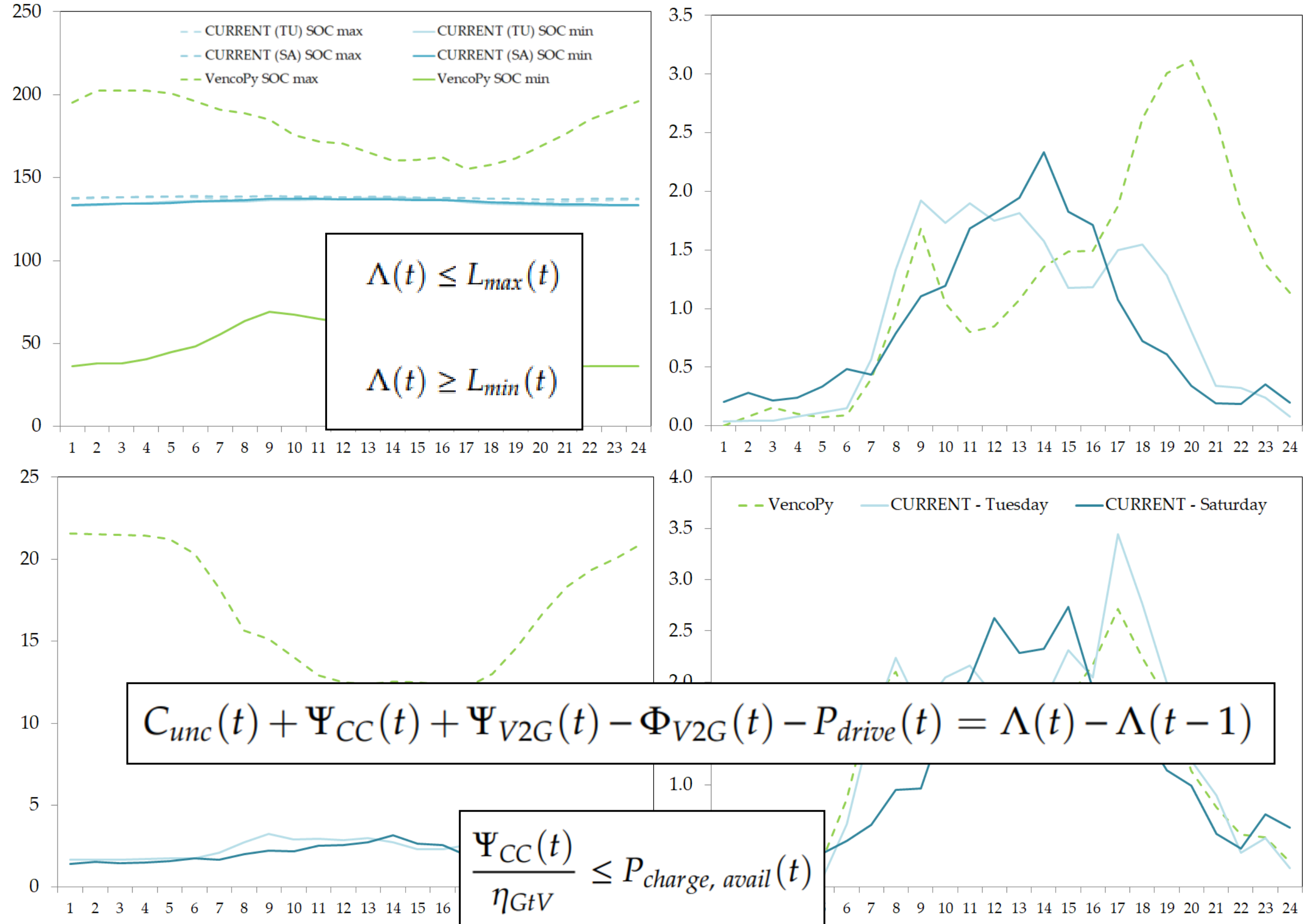
$\Lambda(t)$

$L_{min}(t)$ **Maximum SOC**
$L_{max}(t)$ **Minimum SOC**
$\Lambda(t-1)$ **Battery level balance**

- $P_{drive}(t)$ **Electric drive power**



Final energy demand for driving



$$\Lambda(t) \le L_{max}(t)$$

$$\Lambda(t) \ge L_{min}(t)$$

$$C_{unc}(t) + \Psi_{CC}(t) + \Psi_{V2G}(t) - \Phi_{V2G}(t) - P_{drive}(t) = \Lambda(t) - \Lambda(t-1)$$

$$\frac{\Psi_{CC}(t)}{\eta_{GtV}} \le P_{charge,\,avail}(t)$$

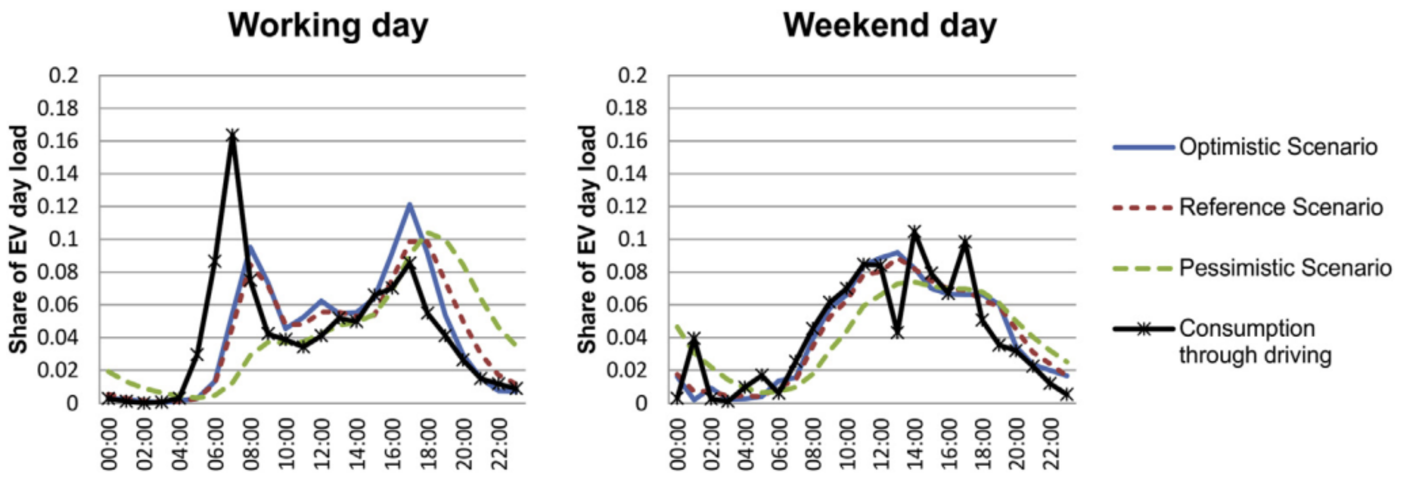
x-Axis: time t

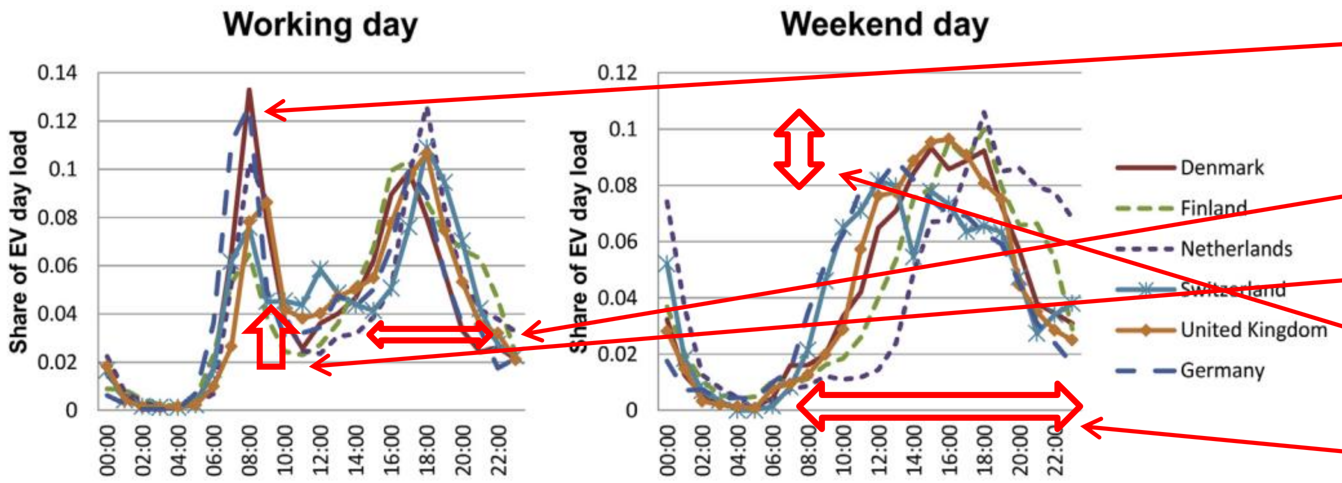
y-Axis: GW

Adapted from Wulff et al. (2020)

Image source
https://static.thenounproject.com/png/116156-200.png

Paper 2: Motivation
Regional differences





Technical assumptions

Battery size: ~30 kWh

Consumption*: 17.7-21.6 kWh / 100 km

Charging availability*: 3.5-60 kW (avrg. 3.5-17.6 kW / charger)

Higher morning peak for Germany & Denmark

Wider evening peak for Finland

Swiss people drive more during midday

Different weekend distance peak amplitudes …

… , times and distributions.