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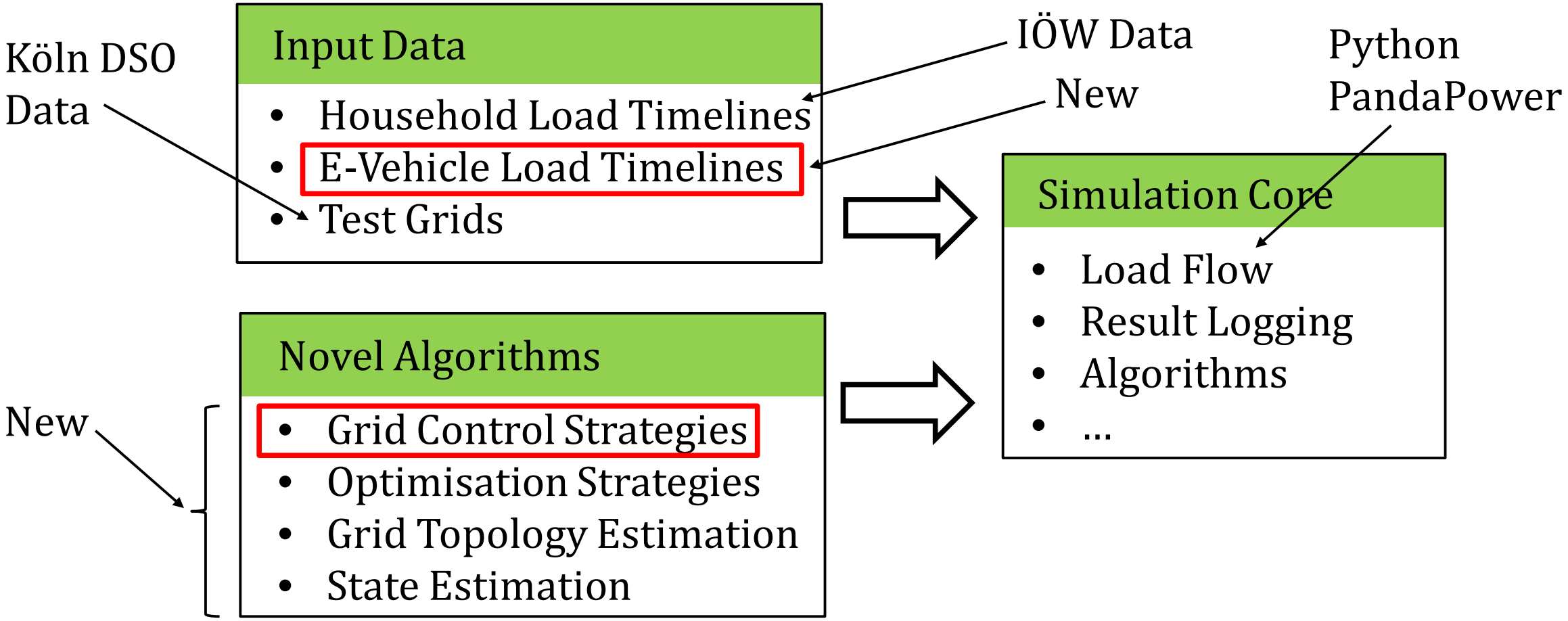
E-VEHICLE LOAD PROFILE GENERATOR

09.11.22

Content

- Simulation Environment
- Sociological and Market Research
- CCCV-charging
- Compiling the components
- Use Case

Simulation Environment – Low voltage grid and e-vehicles



The Idea

We want our e-vehicle load timeline generator to be

- **sociologically accurate**
- **technically accurate**

It will be based on

- a household activity study
- a mobility report
- CCCV charging technology
- technical specifications on state-of-the-art e-vehicles

Household Activity Study

Work by Pflugradt

An existing work by Pflugradt yields household activity data

Input parameters:

- number and demographics of people in hosehold
- number of electrical cars in household
- income structure, region type
- etc.

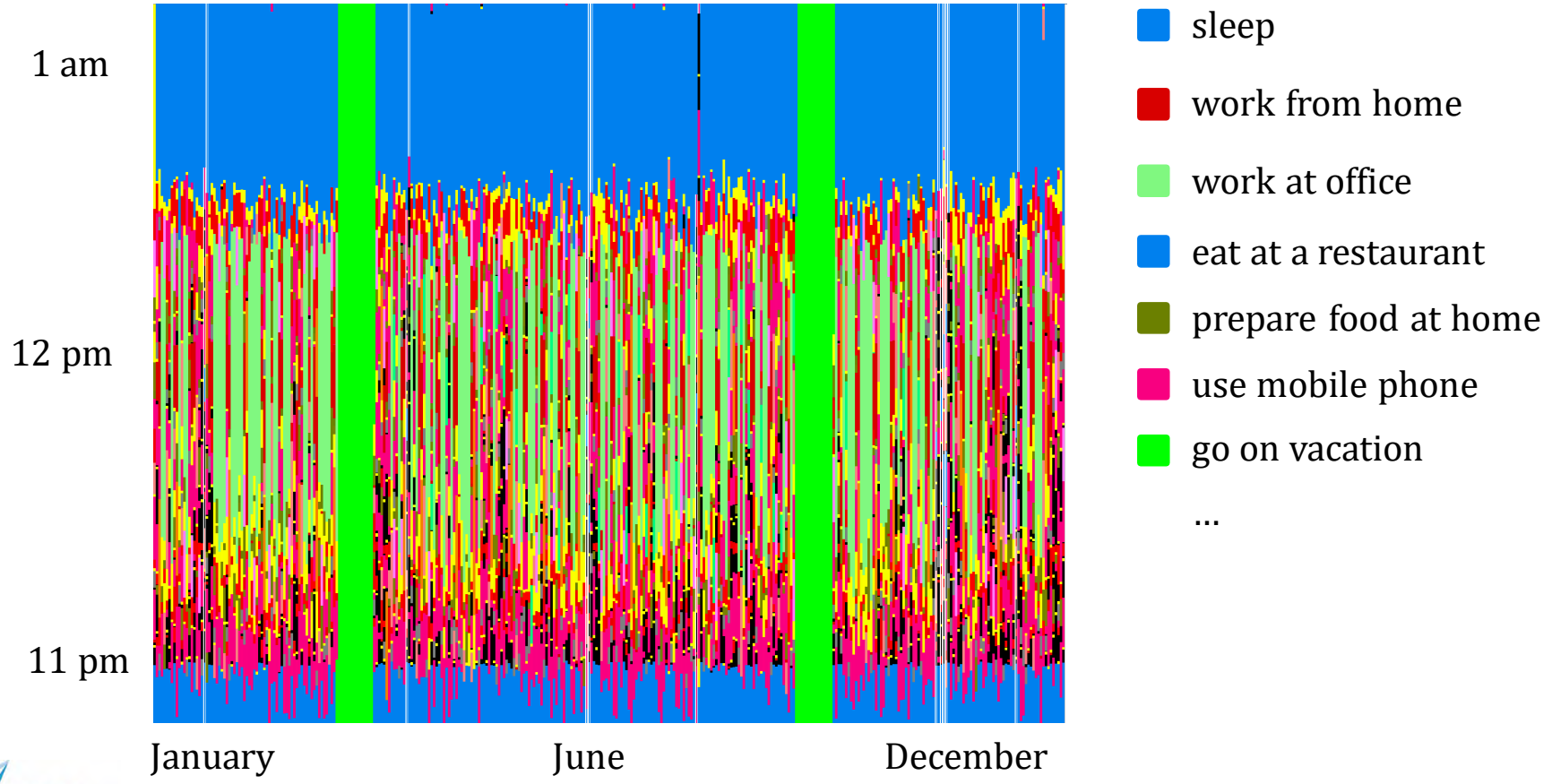
Output:

- activity timelines (e.g. school, cooking, laundry, TV etc.)
- think of it as the videogame “The Sims”
- “**outdoor activities**” include sports, shopping, travels etc.
- “outdoor activities” are basis for further analysis

Household Activity Study

Work by Pflugradt

Example: this is how Ruby (25, F) they spent his year:



German Mobility Report

An extensive report on mobility in Germany yields further input for our generator

A few examples of what we found:

Table 1 : Shares of household types per region

Household type / Region type	Metropol. area	Large City	Urbanised Area	Suburb	Town Center	Rural Area	Decentral Area
Young households age < 35 years	11 %	11 %	6 %	4 %	6 %	4 %	4 %
Household only adults	36 %	34 %	32 %	31 %	32 %	33 %	36 %
Households in age > 65 years	34 %	37 %	40 %	41 %	45 %	42 %	38 %
Family household, at least one child	18 %	17 %	21 %	23 %	16 %	19 %	22 %

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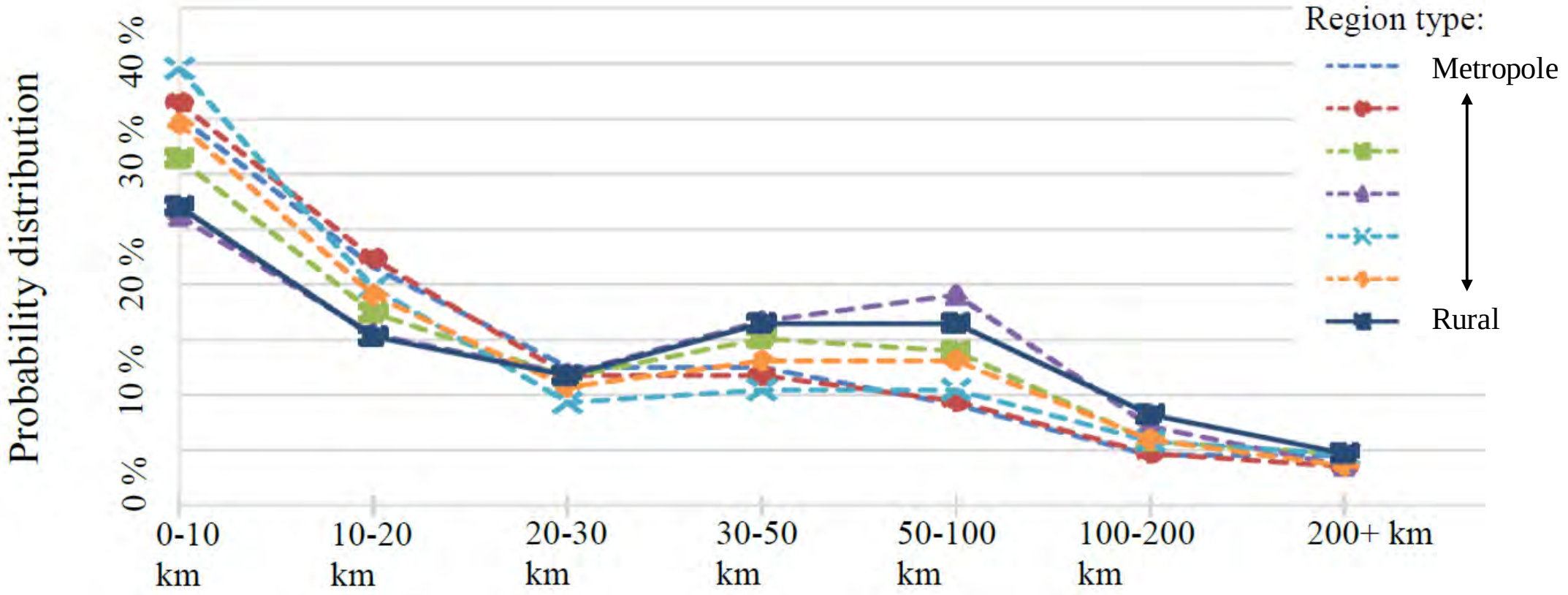
A few examples of what we found:



German Mobility Report

An extensive report on mobility in Germany yields further input for our generator

A few examples of what we found:

Table 2 : Numbers of cars for different household types

	Cars per household				
Region type	**none**	**1**	**2**	**3 or more**	**average**
1.1	42 %	48 %	9 %	1 %	0.96
1.2	31 %	53 %	15 %	1 %	0.86
1.3	15 %	56 %	25 %	4 %	1.18
1.4	11 %	52 %	31 %	6 %	1.32
2.1	24 %	57 %	17 %	2 %	0.97
2.2	15 %	56 %	24 %	5 %	1.19
2.3	10 %	53 %	30 %	6 %	1.31

Table 3 : Shares of means of transportation

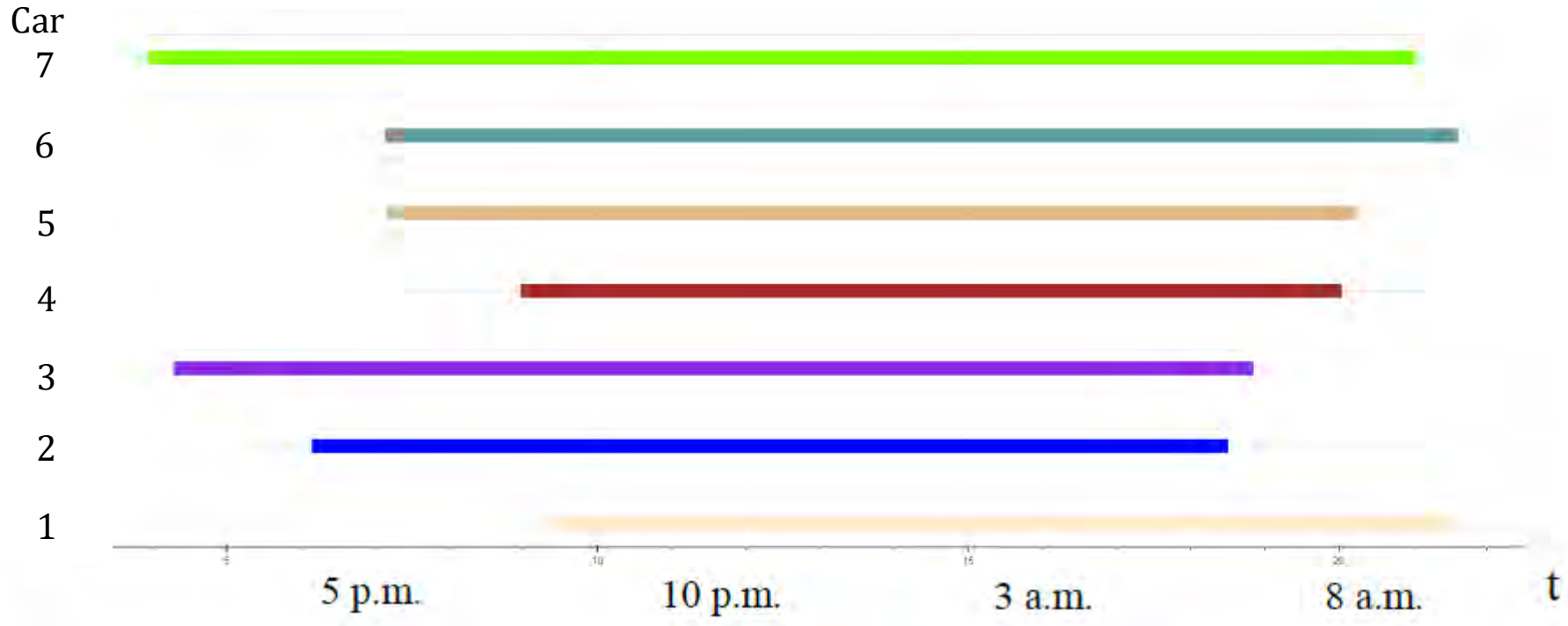
Means of transportation	**Share**
Car (as driver)	55 %
Car (as passenger)	20 %
Public transport	19 %
Bicycle	3 %
Walking	3 %

E-Vehicle Connection Timelines

We now compile household behavior and mobility report to connection timelines

We use household activity profiles and statistical mobility data

Example: We examine seven electrical vehicles in the same street in a rural area



CCCV-Charging

Going from connection timeline to charging power timeline:

Constant Current Constant Voltage

Generally:

$$I_{charge}(t) = \frac{U_{charge}(t) - U_{cell}(t)}{R_i}$$

$$U_{cell} = f(SOC)$$

CC-Phase:

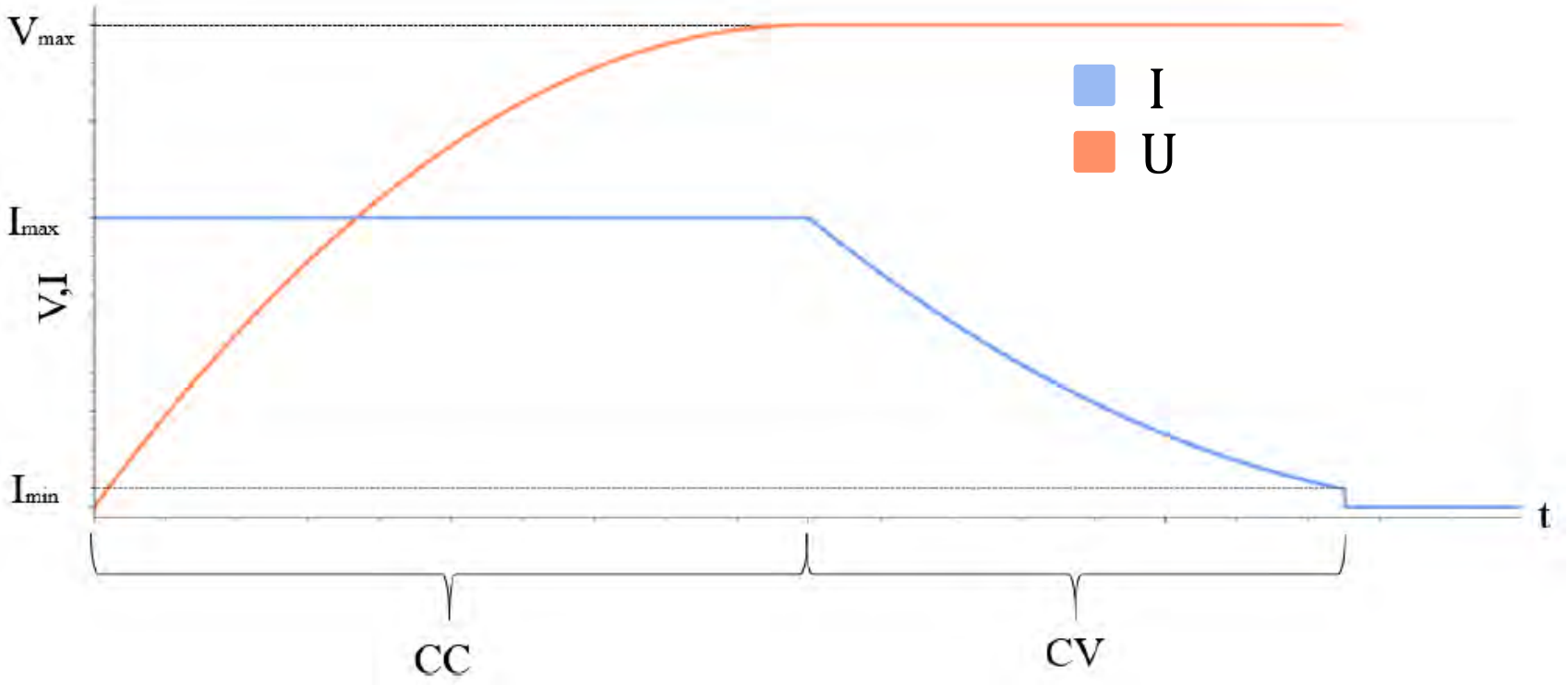
$$I_{charge}(t) = I_{max}$$

$$U_{charge}(t) = \frac{I_{max}}{R_{i,cell}} + U_{cell} < U_{max}$$

$$until\ U_{charge}(t) = U_{max}$$

CV-Phase:

$$I_{charge}(t) = \frac{U_{max}(t) - U_{cell}(t)}{R_i}$$



Typical E-Vehicles

And a little market analysis for charging powers…

Table 4 : Market analysis of electric vehicles, 2022 (excerpt)

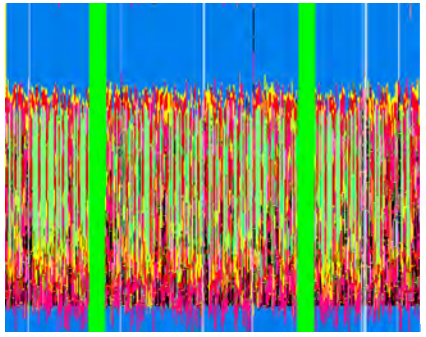
Manufacturer	Car model	Battery capacity	Max charging power	Consumption per 100 km
Audi	A3 Sportback e-tron	8,8 kWh	22kW	11,4 kWh
Chevrolet	Volt	10,3 kWh	4,6 kW	22,4 kWh
CITROËN	Berlingo Electric	22,5 kWh	3,2 kW	17,7 kWh
Hyundai	Kona Elektro	64 kWh	7,2 kW	14,3 kWh
Mercedes-Benz	B-Klasse B 250 e	28 kWh	11 kW	16,6 kWh
Peugeot	iOn	14,5 kWh	3,7 kW	14,5 kWh
Tesla	Model S 70D	70 kWh	16,5 kW	20 kWh
Toyota	Prius Plug-In Hybrid	4,4 kWh	2,8 kW	7,2 kWh
Volkswagen	e-up!	18,7 kWh	3,6 kW	11,7 kWh
Volvo	C30 Electric	24 kWh	22 kW	17,5 kWh

Summary

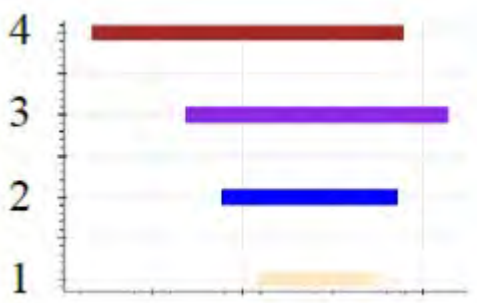
Putting the pieces together we gain the following program:

Set parameters:
- Number of households
- Simulation duration
- Type of region
- Electrification rate
- Neighbourhood type

Create Household Activity profiles



Derive vehicle connection profiles



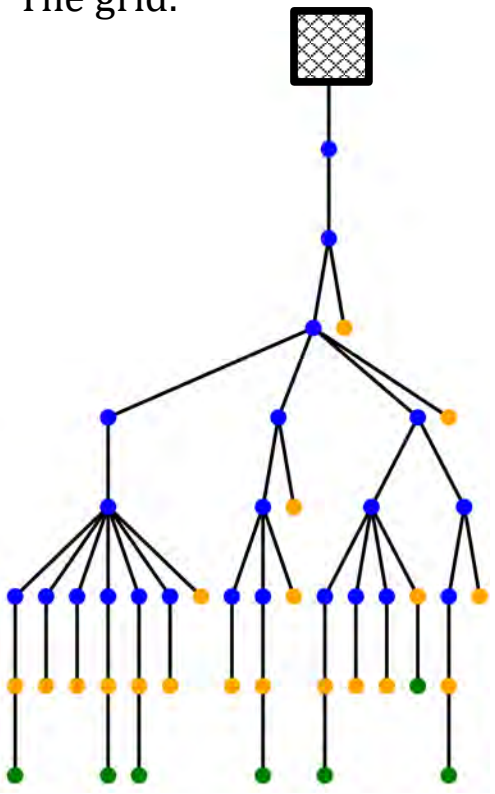
Assign vehicles and chargers

Audi A3
8,8 kWh
22 kW,
...

Execute simulation

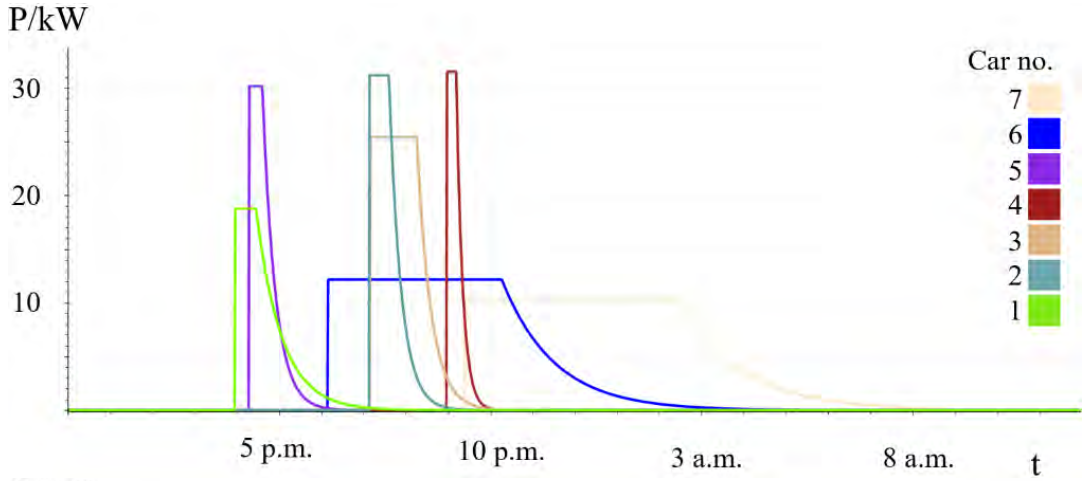
We simulate a day in a grid with electrical vehicles without and with P(U)-control

The grid:

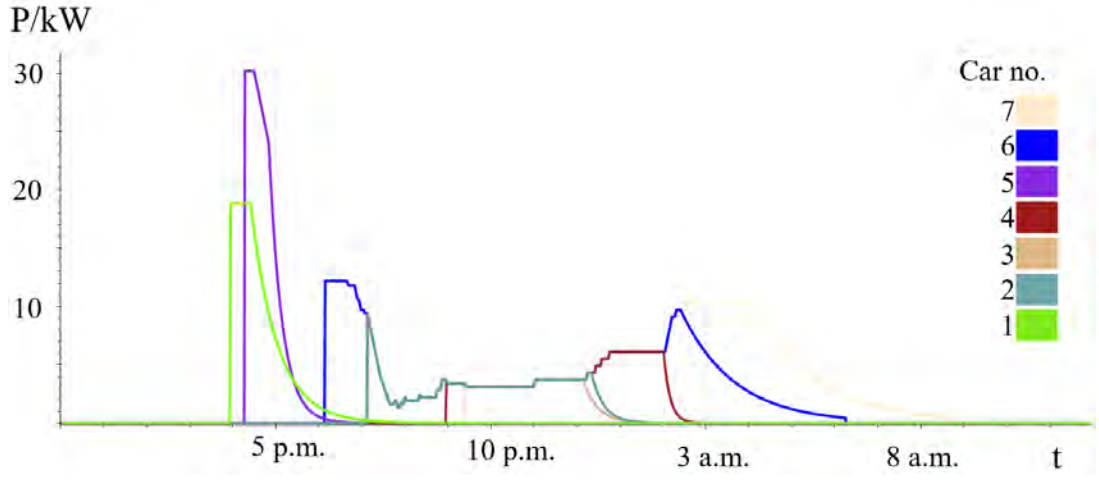


7 cars

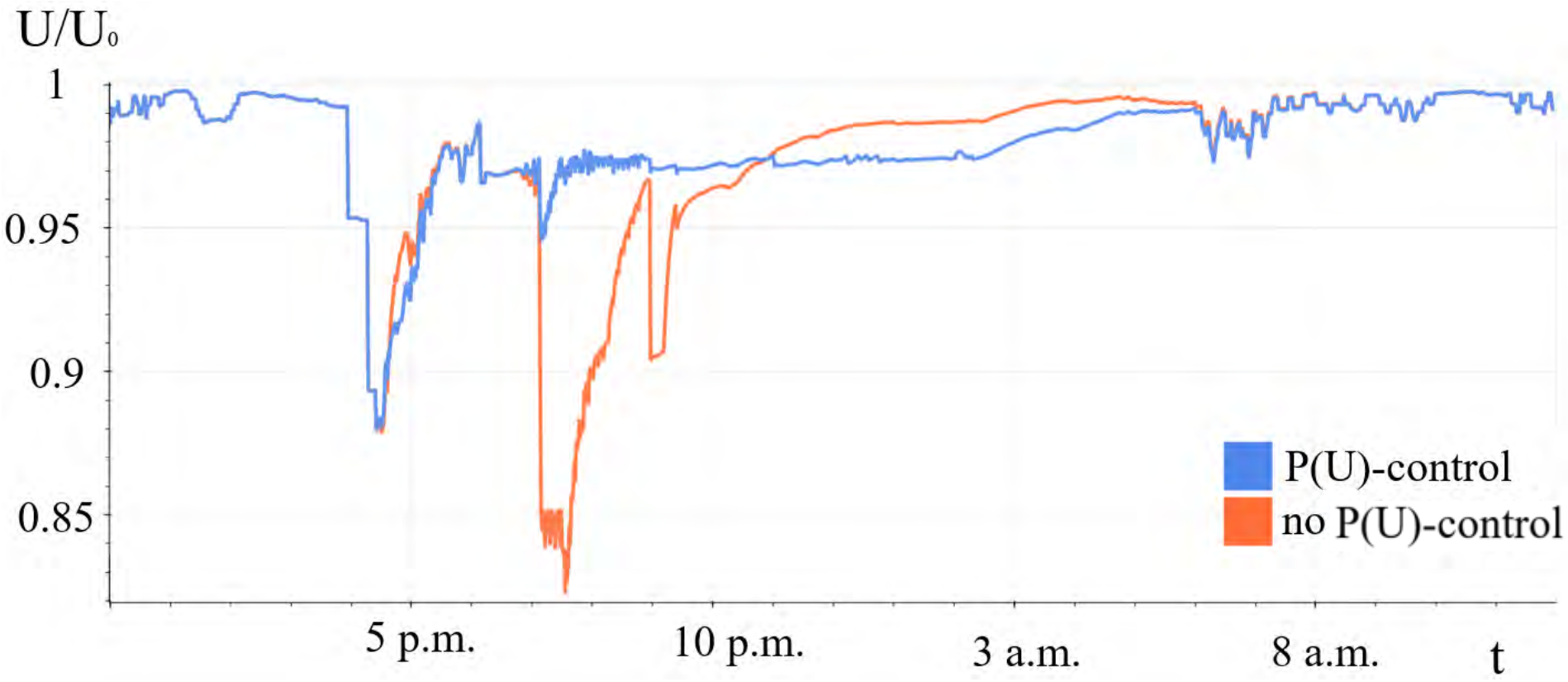
no P(U)-controls:



P(U)-controls, global cap:



Worst voltage drop across the system for both cases:



Conclusion

- The e-vehicle load profile generator works well
- It has a solid foundation of preliminary research data
- Great basis for a comprehensive simulation environment

Thank you!