Forecast Model for Electromobile Loads at Stuttgart Airport and Fair

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Mobility Concepts and Infrastructure

STUTTGART AIRPORT

Messe Stuttgart

Universität Stuttgart
Institut für Arbeitswissenschaft und Technologiemanagement IAT

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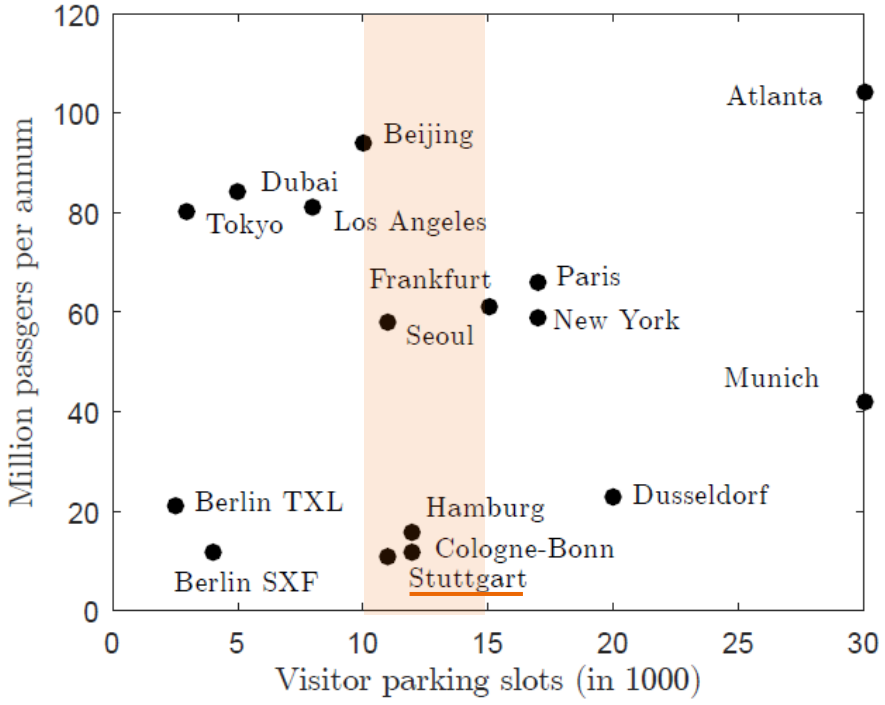
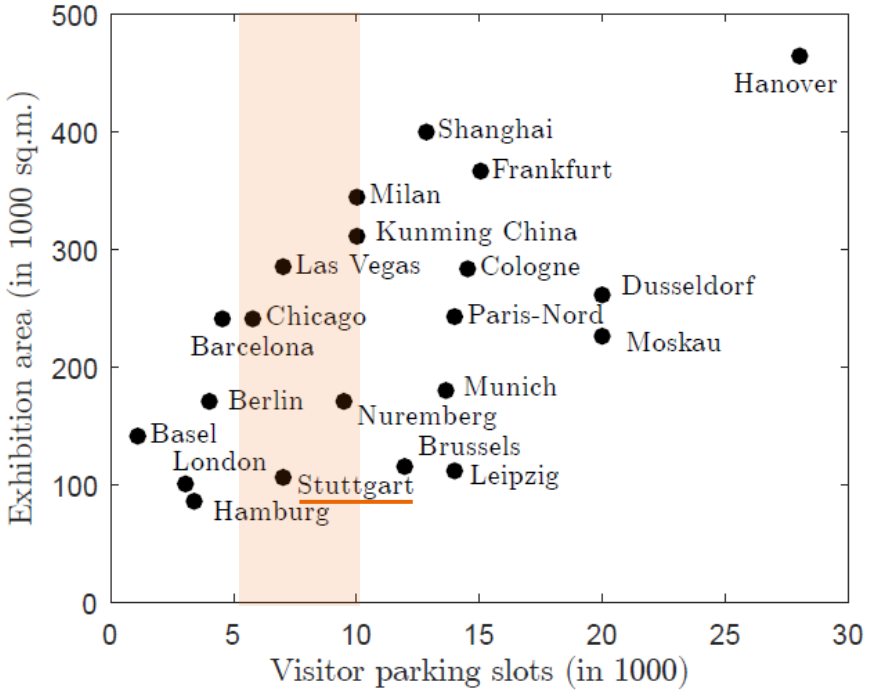
1. Motivation I
Airports and Fairs as electromobile hotspots

- world's largest parking facilities
- particularly affected by EV-mass-deployment

A) International Airports



B) International Fairgrounds



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1. Motivation II

Scientific questions for Stuttgart Airport and Fair

(1) Which **maximum loads in kW** arise from passengers, employees, exhibitors and visitors from 2017-2027?

(2) Which daily **energy turnovers in kWh/d** can be expected within this time period?

(3) Are there any essential **peak-times** over the day?

(4) How does land-sided electromobility influence the site's **overall energy consumption**?

2. Scientific Approach I

Within the MATLAB environment in two steps:

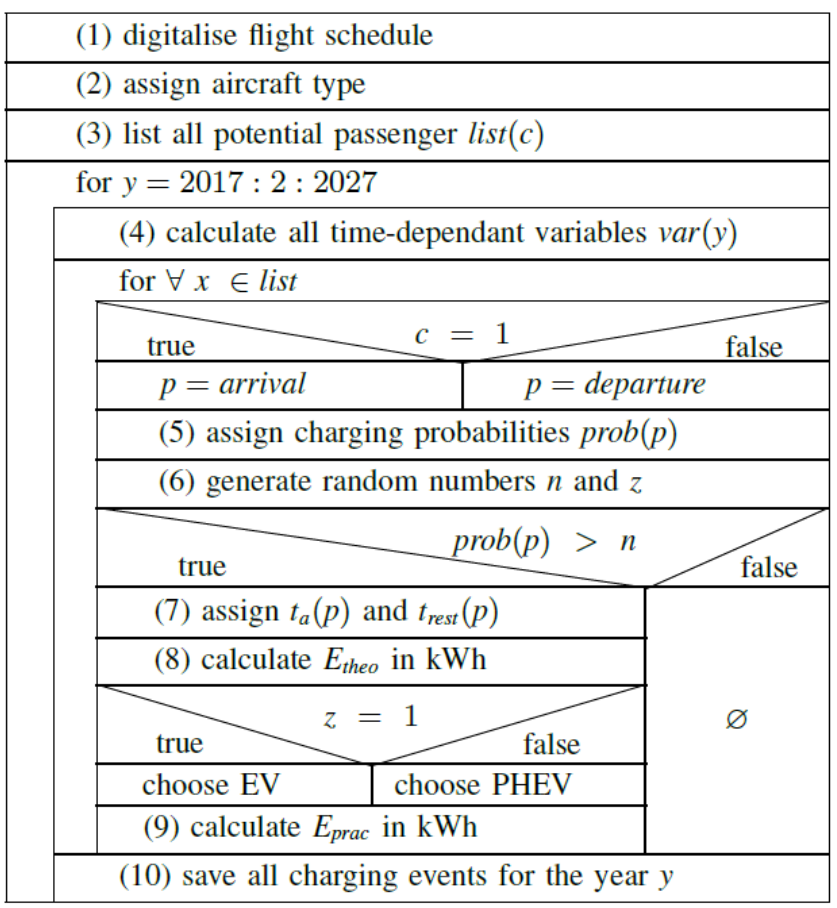
I. The **mobility behaviour** of each user group is reconstructed for half an year by means of site-specific data.

a) Airport user groups: passengers & employees
b) Fair user groups: employees, visitors & exhibitors

II. By means of probability factors, all **trips are omitted** which statistically do not result in a charging event.

What are those probability factors?

Simplified modelling procedure for passengers:



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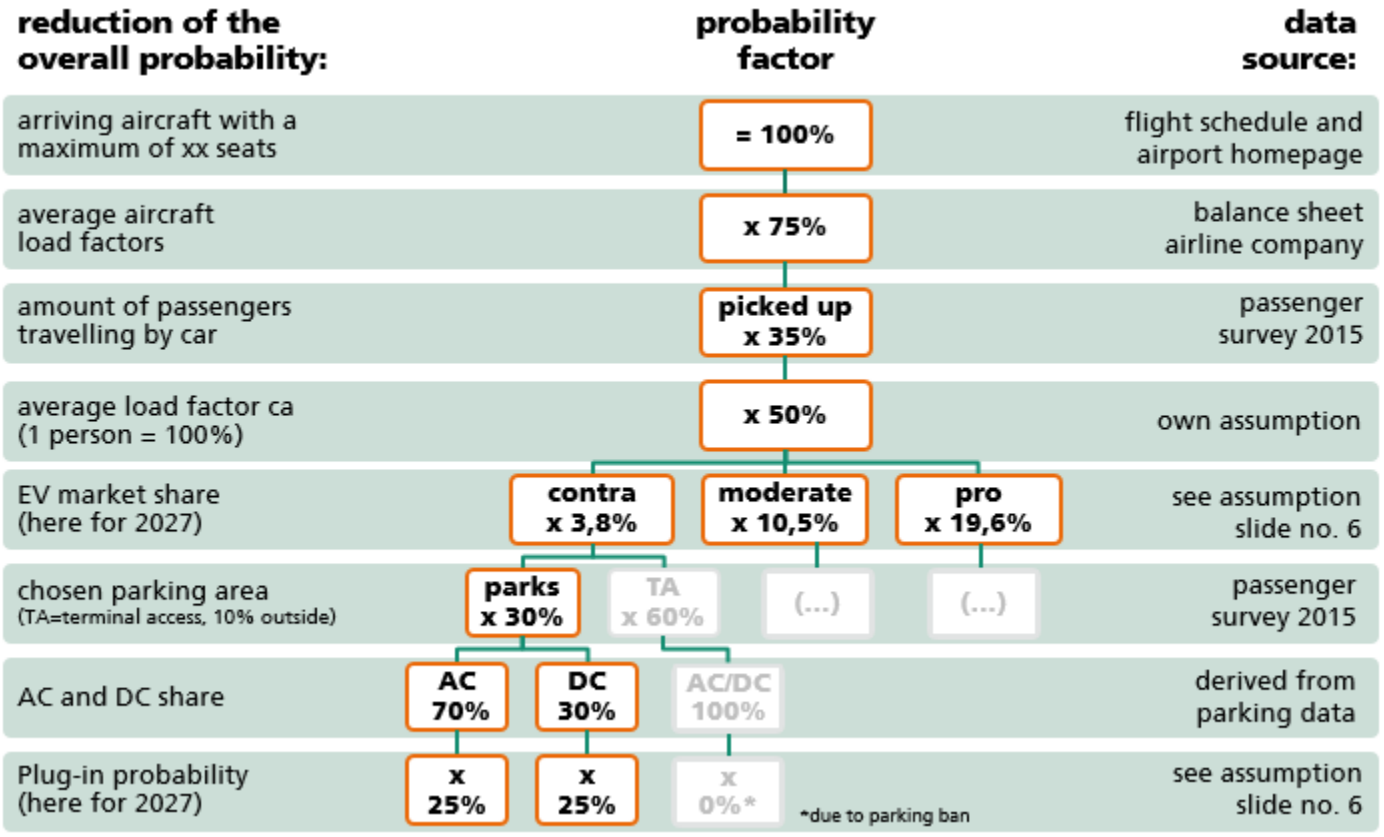
2. Scientific Approach II

How many charging events result from an arriving plane?



probability factor @2027 & contra EV

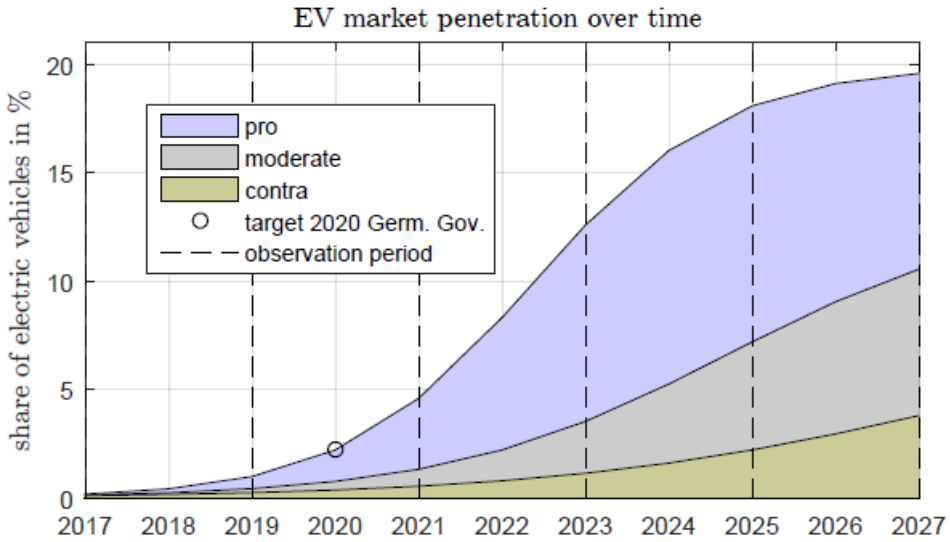
~1 out of 10,000 arriving passengers

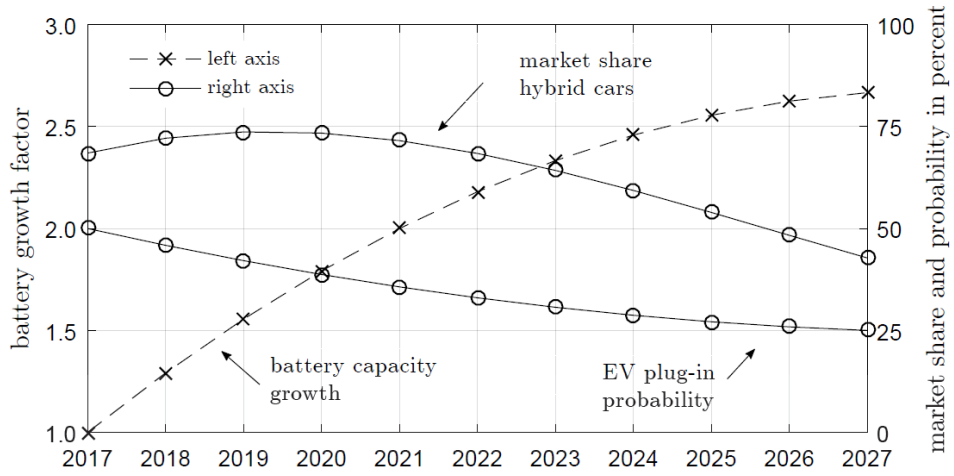
~3 out of 10,000 arriving passengers

3. General Assumptions

Which parameters change with time?

1. Market share of electric vehicles
2. Battery capacity
3. plug-in probability of electric vehicles (EV)
4. Proportion of PHEV and full EV





Other assumptions:

- Consideration of 36 full EV and 33 PHEV according to [1)]
- EV consumption 20kWh/100km
- Constant mobility behaviour
- Static charging performances of 22kW$_{AC}$ and 50KW$_{DC}$

1) https://www.greengear.de, last accessed 26.08.2017

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4. Simulation Results I

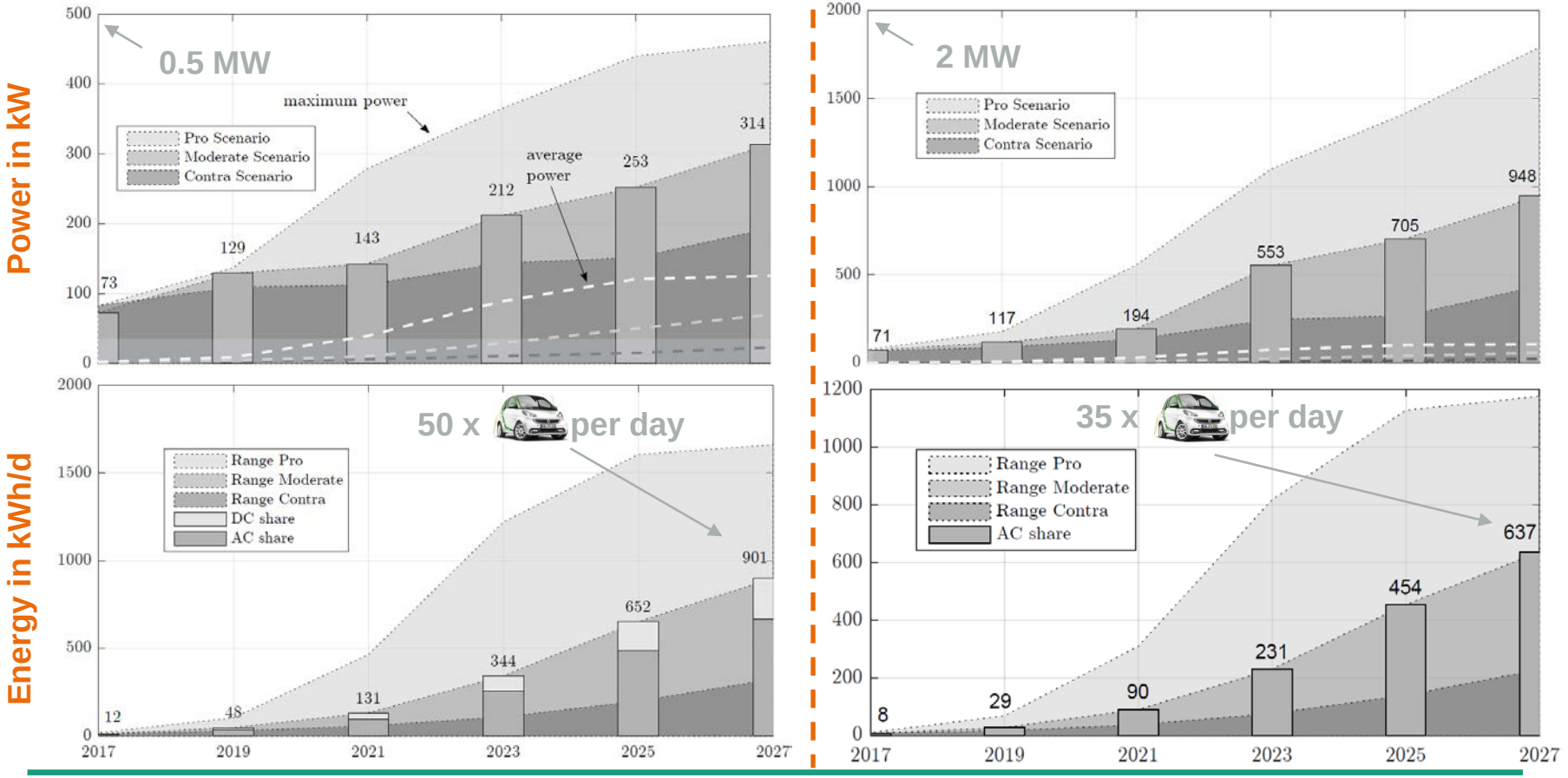
Maximum loads and daily energy turnover

Stuttgart Airport

"much energy at moderate power rates"

Stuttgart Fair

"little energy at high power rates"



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4. Simulation Results II

Essential peak times and load shift potentials

A) Stuttgart Airport
~0,5MW @2027, pro EV

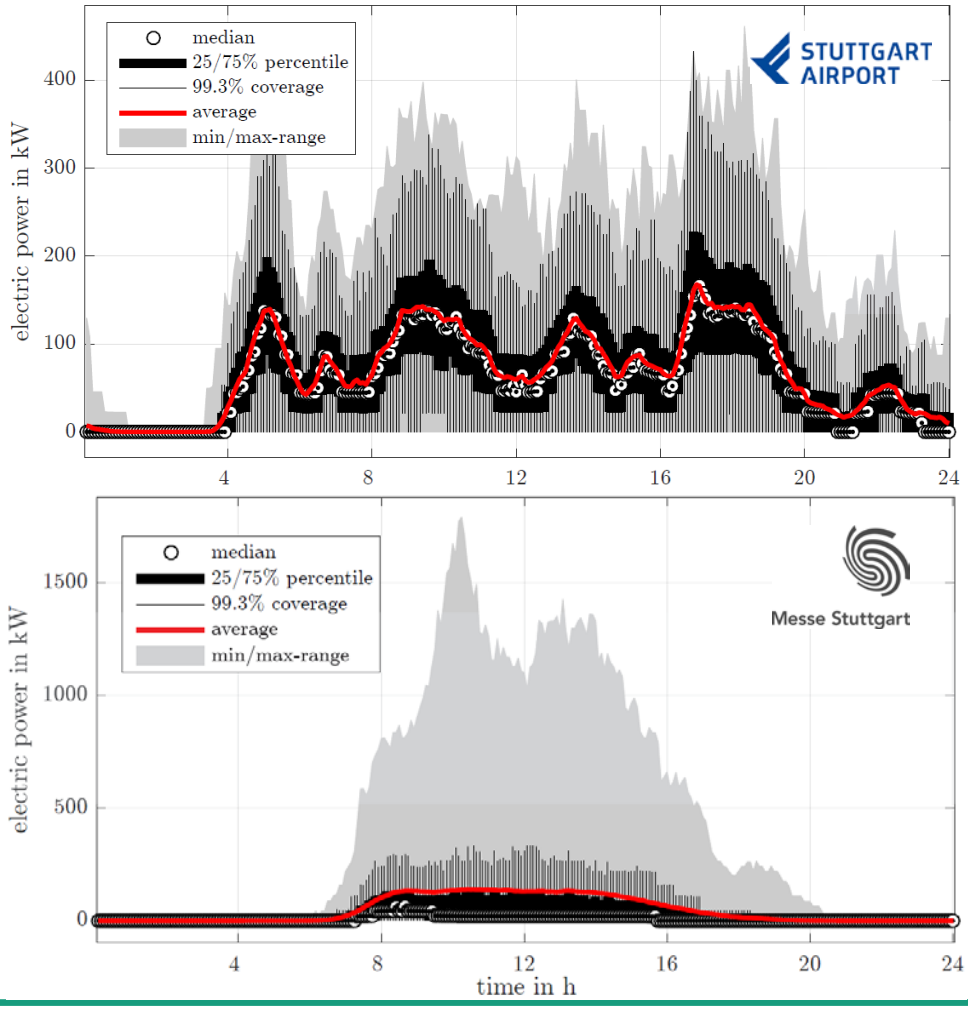
- continuous operation
- good load shift potentials:

  passenger : employee
  1 : 1

B) Stuttgart Fair
~2MW @2027, pro EV

- harsh peak time
- event-driven occupation
- limited load shift potentials:

  visitor : employee/exhibitor
  6 : 1



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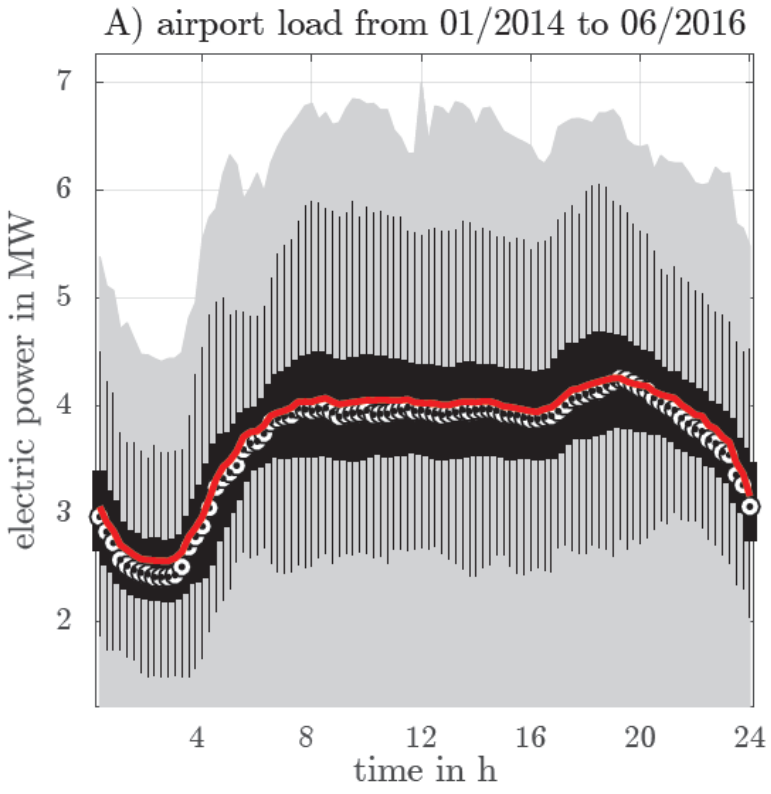
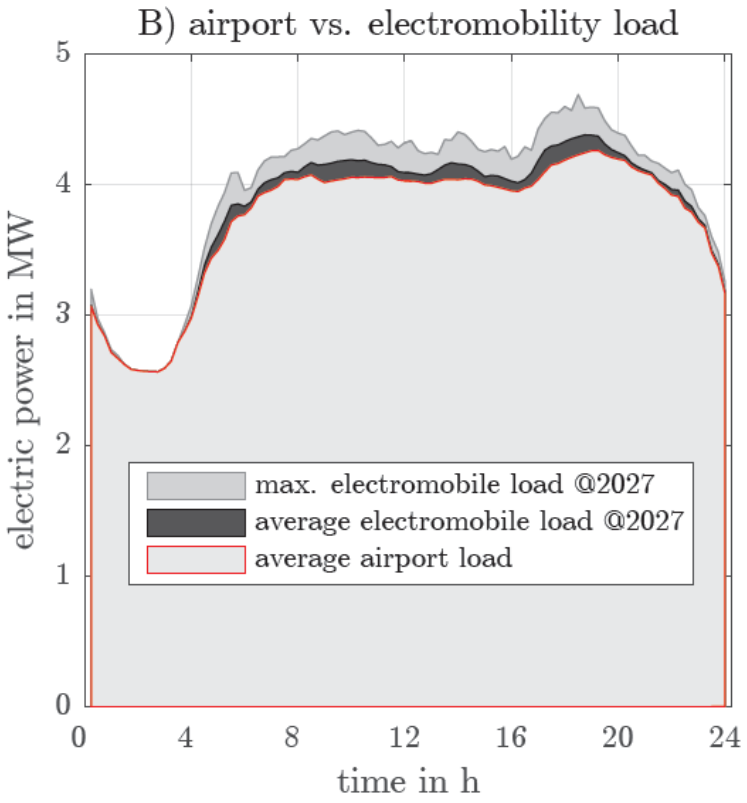
4. Simulation Results III

Airport Load vs. Electromobile Load @2027



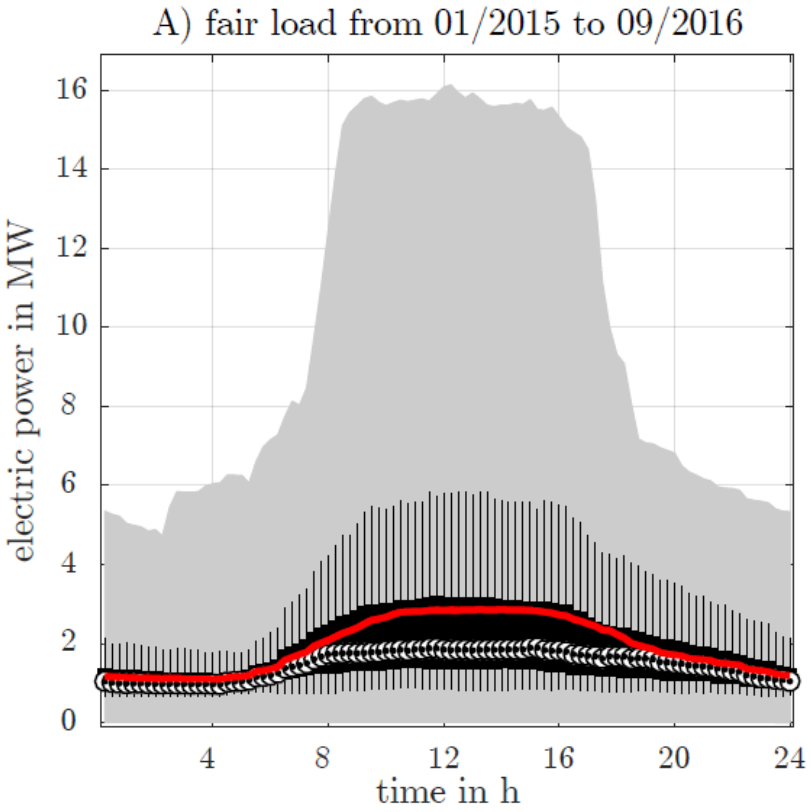


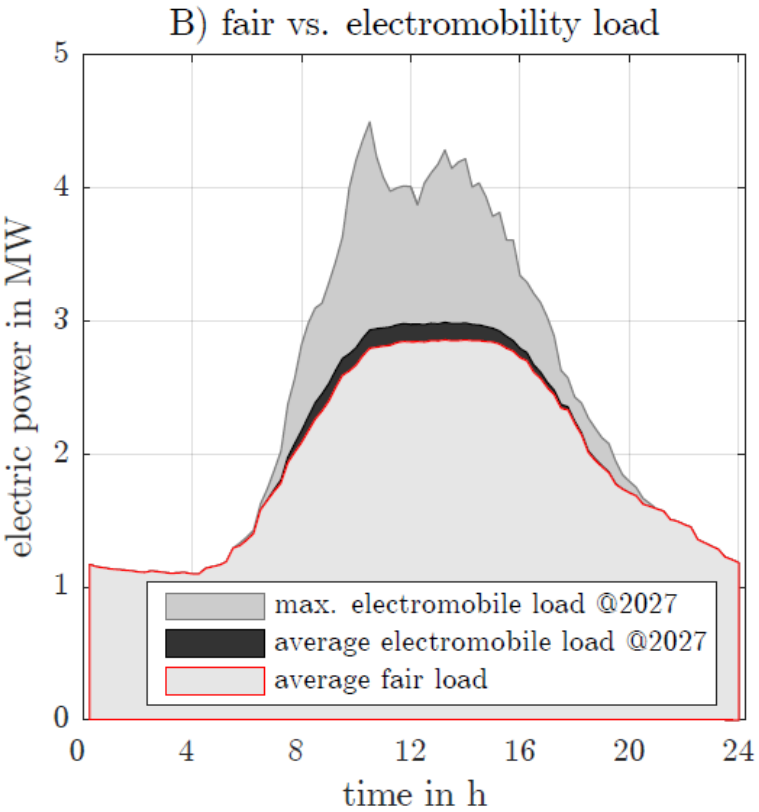
- Even in long-term, electromobile loads from passengers and employees will have **no significant influence** on the Airport's overall energy consumption and generation.

4. Simulation Results III

Fair Load vs. Electromobile Load @2027

Messe Stuttgart





- Building load **correlates strongly** with the electromobile power peaks.
- Existing power network is already **considerably stressed** by major events; EV-deployment further aggravates this situation.

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5. Conclusion
Summary and field of application

- **Proof of Concept:**
  - For an optimistic EV market penetration of 20% by 2027, **uncontrolled EV loads** up to **0.5MW for Stuttgart Airport** respectively **2MW for Stuttgart Fair** can be expected
  - BUT: model did not account for (a) air-sided EV-deployment or (b) e-mobile taxis, buses, business fleets and delivery vehicles
  - Necessity of public transport expansion

!

- **Wide range of applications:**
  - infrastructure dimensioning & evaluation of grid-strengthening
  - development of load management strategies
  - economic and ecological assessments
  - need for additional power generation capacities
  - development of new billing systems

Thank you for your attention!

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Back-up I:
General assumptions Airport loads

TABLE I
ASSUMPTIONS ARRIVAL AND RESTING TIME

		arriving aircraft t_A	departing aircraft t_D
EV arrival time	DC	t_A + 10min	t_D - 120min
	AC	t_A + 10min	t_D - 120min
	∓	30min normally distr.	45min normally distr.
EV resting time	DC	10-60min	10-60min
	AC	30-90min	30-90min , AC_{self}: >8h
	∓	equally distributed	equally distributed

TABLE II
ASSUMPTIONS CATCHMENT AREA PASSENGERS

arrival share	departure share	passenger provenence	distance in km	variance in km
11%	11%	Boeblingen	19	±5
11%	14%	Esslingen	16	±5
2%	3%	Goeppingen	38	±10
–	3%	Heilbronn	74	±15
5%	8%	Ludwigsburg	30	±10
–	3%	Ostalbkreis	94	±20
37%	14%	Stuttgart	13	±7
4%	6%	Tuebingen	33	±5
4%	9%	Rems-Murr-Kreis	52	±10
4%	4%	Reutlingen	30	±5
22%	25%	Other	50	±45

TABLE III
EMPLOYMENT GROUPS AND THEIR ASSUMPTIONS

share %	employment group (perm. stationed at airport)	working model in % C	F	P	24	O
27%	airline staff, flight crew	-	50	50	-	-
20%	domiciled companies airport	90	10	-	-	-
13%	runway monitoring, passenger handling, ground handling services and flight operations	-	85	-	15	-
10%	customs, (federal) police, security service and flight safety	-	95	-	5	-
7%	haulage and cargo handling	40	60	-	-	-
6%	retailers and restaurant business	5	25	-	-	70
5%	energy and water supply, cleansing and waste disposal	5	65	-	30	-
3%	commercial department, internal services, public relation	90	10	-	-	-
3%	facility and IT management	80	-	-	20	-
6%	other (accumulated)	100	-	-	-	-

TABLE IV
ASSUMPTIONS WORK MODELS & SHIFTS

	name of the working model	from - to hh:mm	no. of shifts	shift begin hh^{rst}/hh^{nd}/hh^{rd}
C	core hour	8:00 - 17:00	none	8
F	flight operation	6:00 - 23:30	3	4/10/16
P	flight crew	4:00 - 20:00	none	equally distributed
24	24h operation	0:00 - 0:00	3	5/13/21
O	opening hours	variable	1-2	airport booklet