QUANTIFYING FLEXIBILITY IN EV CHARGING AS DR POTENTIAL: ANALYSIS OF TWO REAL-WORLD DATASETS

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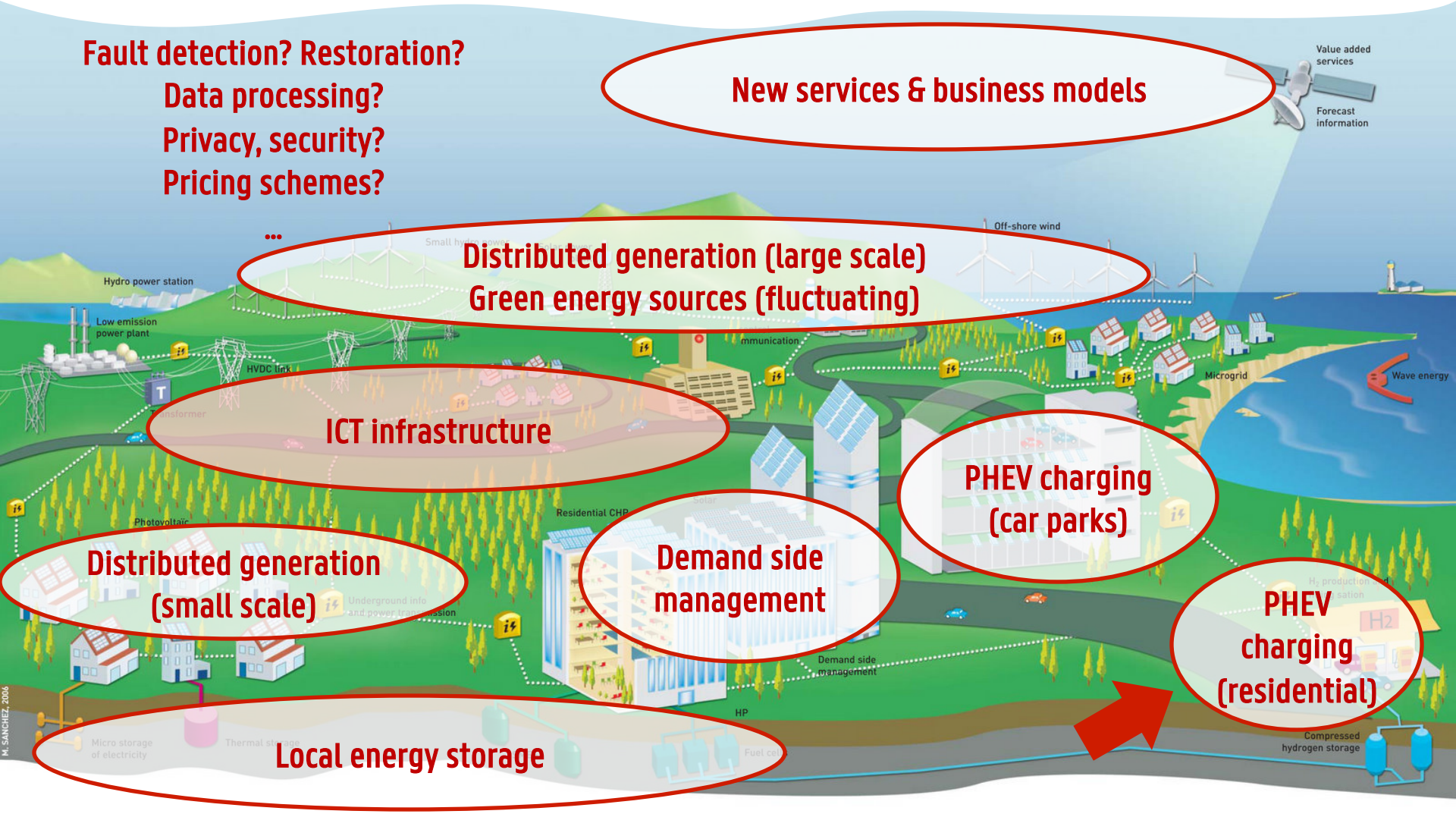
SMART GRIDS



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MODELING EV CHARGING

Literature:

- Model EV usage from regular vehicle usage
- Aggregated EV load estimation
- Pre-defined EV user types (e.g., residents, taxis, commuters…)
- Flexibility as fraction of time spent charging
- …

Gap: data-driven EV modeling & real-world flexibility assessment

1. Typical behaviors in terms of time of arrival and departure?
2. Statistical models of sojourn vs time spent charging?
3. What amount of power can we shift over how much time?

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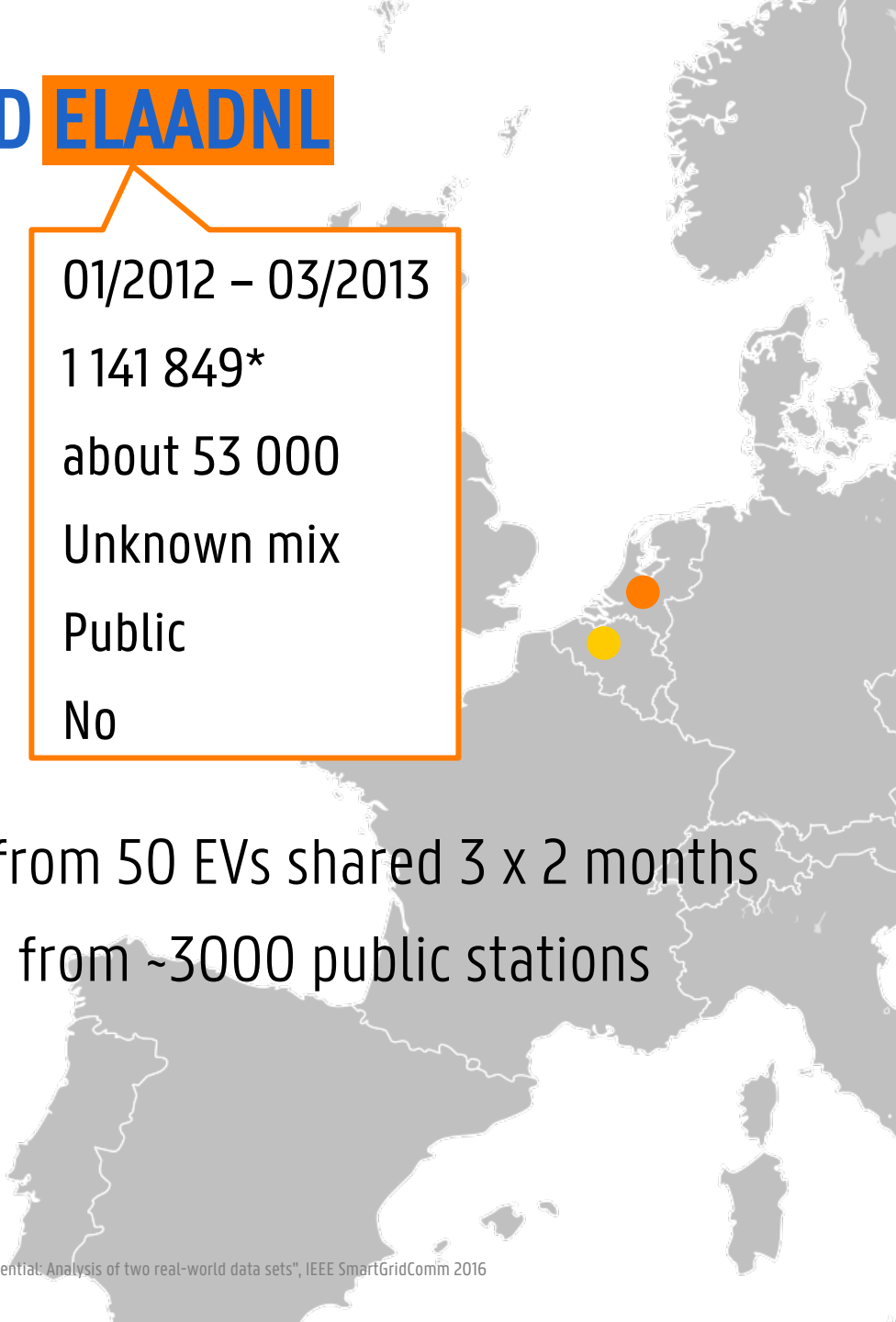
DATASETS: IMOVE (BE) AND ELAADNL

	IMOVE (BE)	ELAADNL
PERIOD	03/2012 – 03/2013	01/2012 – 03/2013
# SESSIONS	8 520	1 141 849*
# USERS	134	about 53 000
CAR TYPE	Full EV	Unknown mix
CHARGE POINT	At home	Public
TRIP DETAILS	Yes	No



iMove: Flemish EV field trial; data from 50 EVs shared 3 x 2 months

ELaadNL: EV innovation in NL; data from ~3000 public stations

* : Analysis on data from 1 Jan.–31 Mar. 2015 (N = 90 562)

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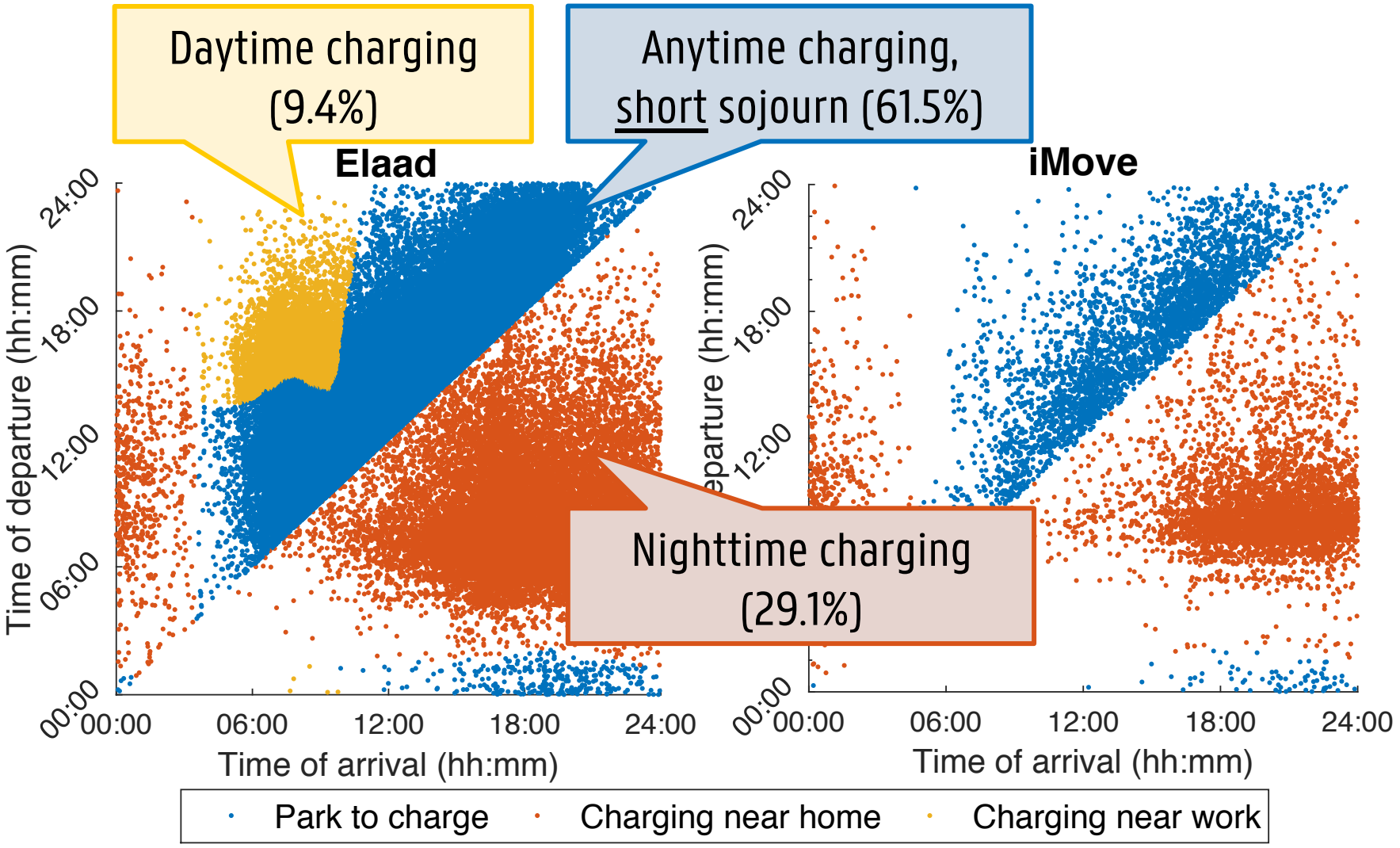
TYPICAL ARRIVAL AND DEPARTURE TIMES (1/2)



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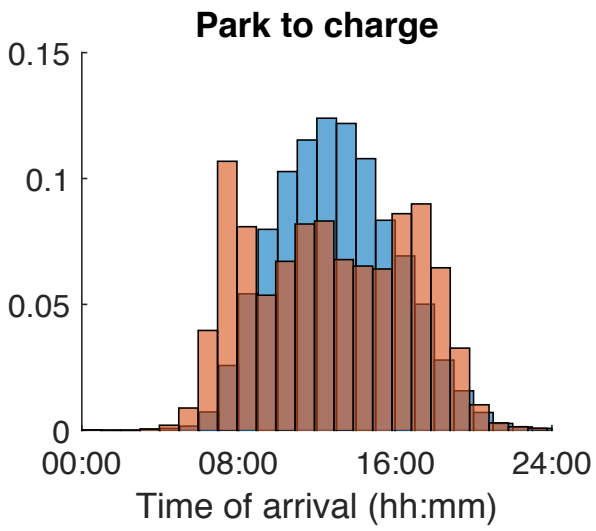
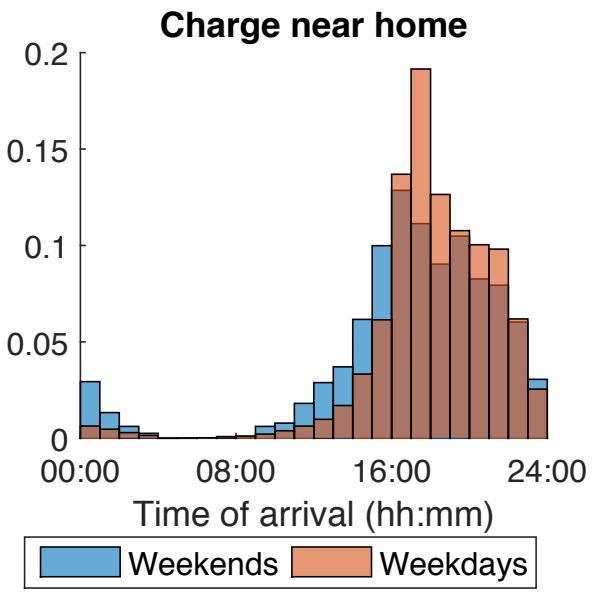
TYPICAL ARRIVAL AND DEPARTURE TIMES (2/2)

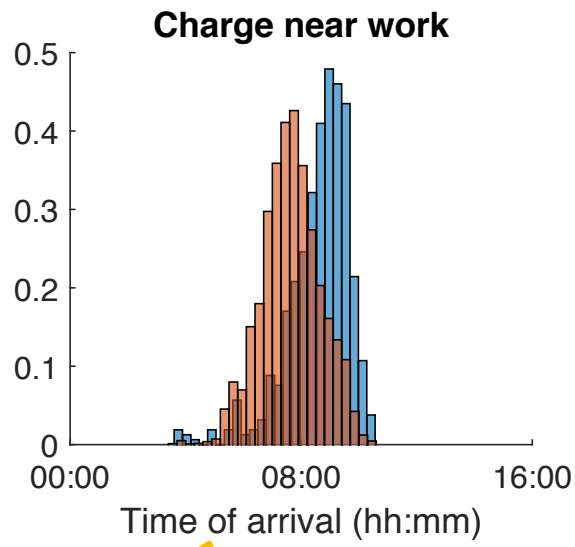
Anytime charging, short sojourn (61.5%)

Nighttime charging (29.1%)

Daytime charging (9.4%)







AM/Noon/PM peaks on weekdays

Shift to later times on weekends

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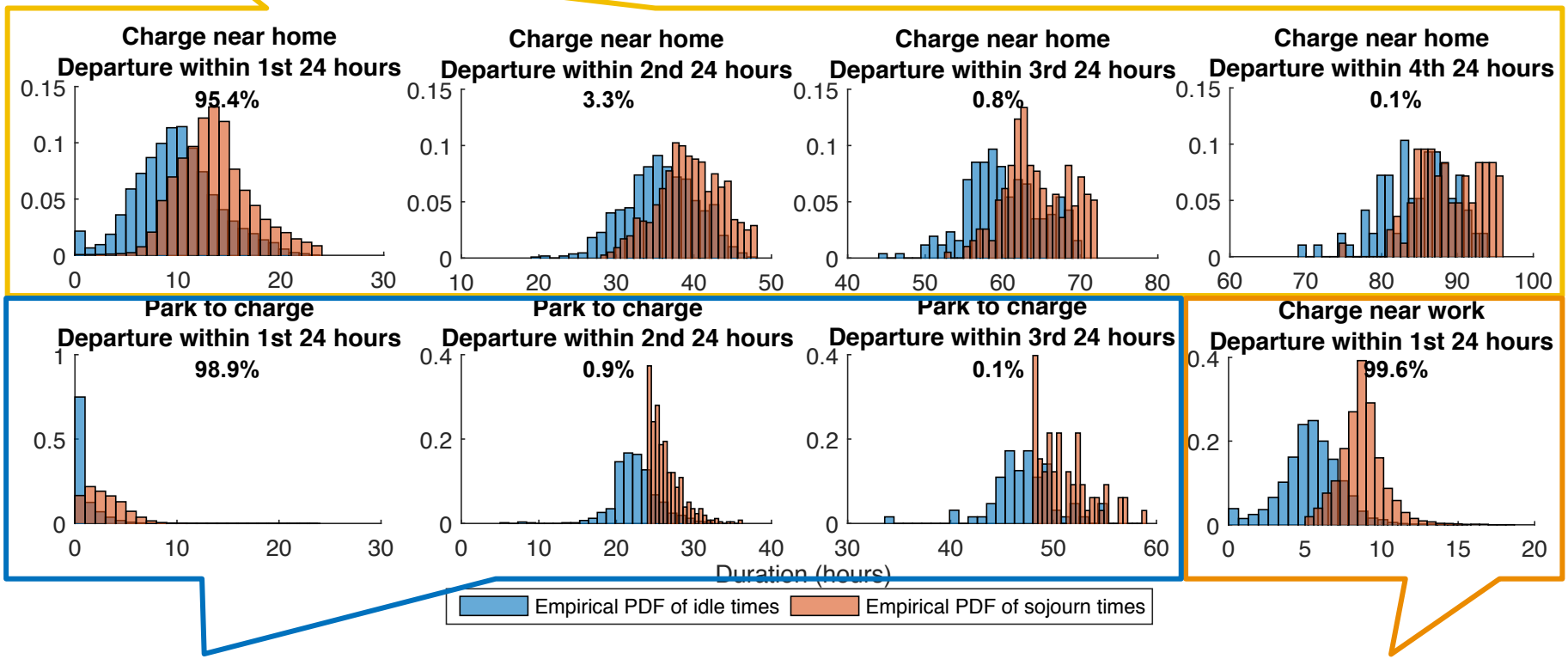
SOJOURN AND IDLE TIMES (1/2)

Average charging time ≈ 3h 42min



Average idle time ≈ 23min

Average charging time ≈ 3h 44min

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SOJOURN AND IDLE TIMES (2/2)

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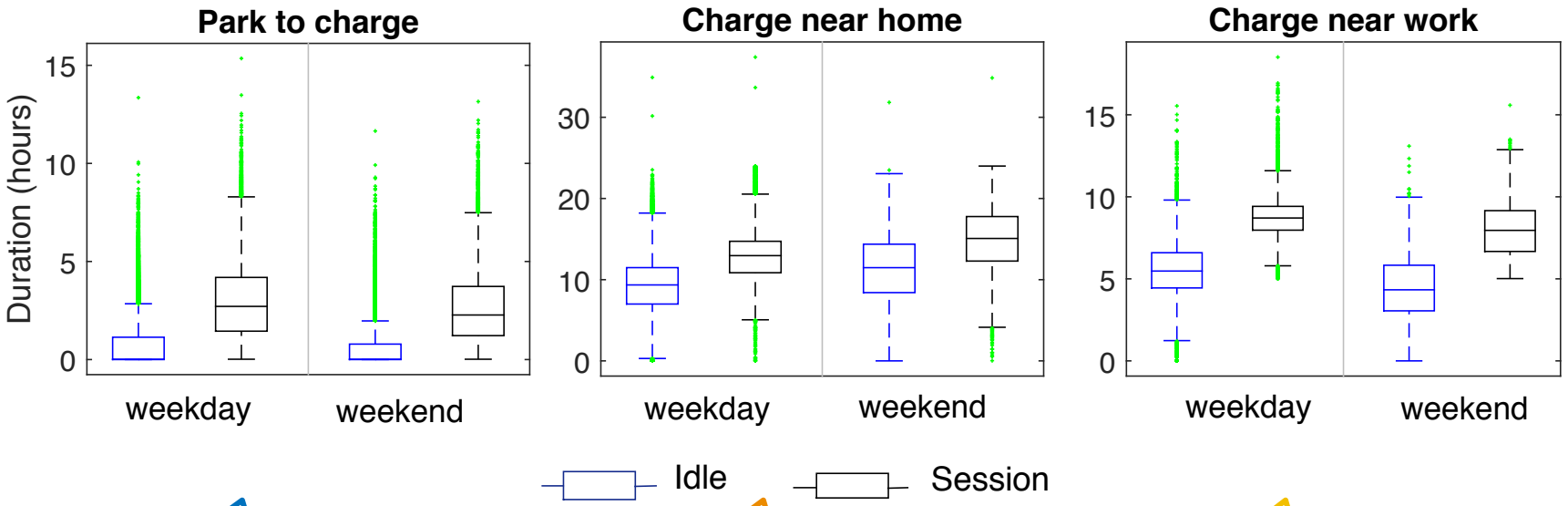

Week ≈ Weekend

Longer in weekend

Shorter in weekend
Lower var. in week

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QUANTIFICATION OF FLEXIBILITY: CALCULATION

Upper bound: we disregard impact of using/suppressing power in [t, t+Δ] on flexibility at other times t'

$P_{FLEX}(t, \Delta)$ = Maximal power that DR could either consume constantly, or not at all, in interval [t, t+Δ]

- Charging session has to include [t, t+Δ]
- Charging duration ≥ Δ [else we could not consume in full interval]
- Flexibility = session duration − Δ ≥ charging duration [we can move it away]

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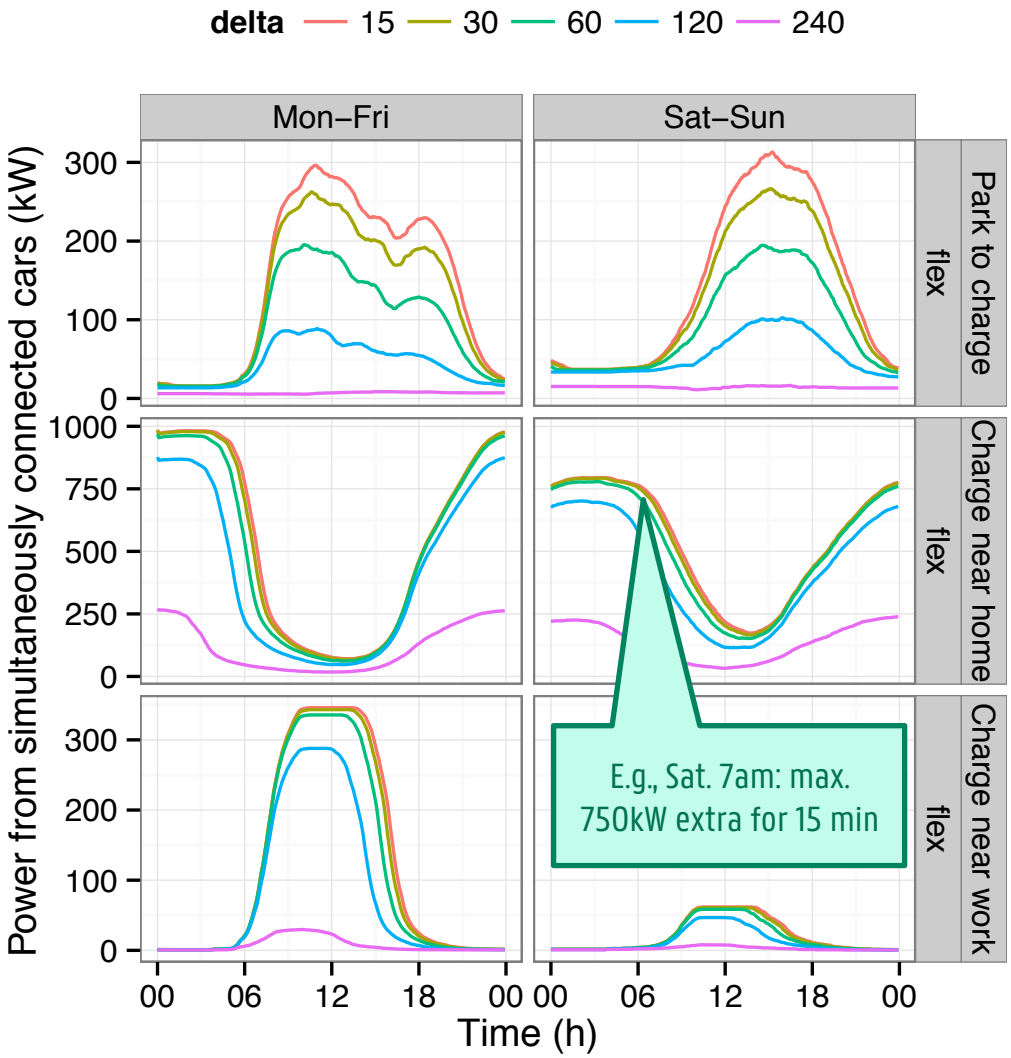
QUANTIFICATION OF FLEXIBILITY: RESULT



- Park to charge:
  - Daytime flexibility
  - Weekend: ≈ volume, but ≠ timing
- Near home:
  - Nighttime flex
  - Weekend: lower & more spread
- Near work:
  - Daytime flex
  - Low in weekend

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CONCLUSION

- Real world data set
- Three major types of charging sessions
- Statistical models of user behavior
- Methodology to quantify flexibility

Application?

E.g., extrapolation of iMove data to 3% of Flemish fleet by 2020:

- ~100k cars out of ~3.2M
- E.g., noon in weekend ⟹ can have ~7MW extra for 2h

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THANK YOU … ANY QUESTIONS?

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