

Grid Applications

Frequently Asked Questions on V2G

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Outline

- Will the EV users driving requirements still be met?
- What is the extra battery use from V2G?
- How does V2G impact the local grid?



- Will the EV users driving requirements still be met?

YES✓

- by proper analysis of the customer behavior

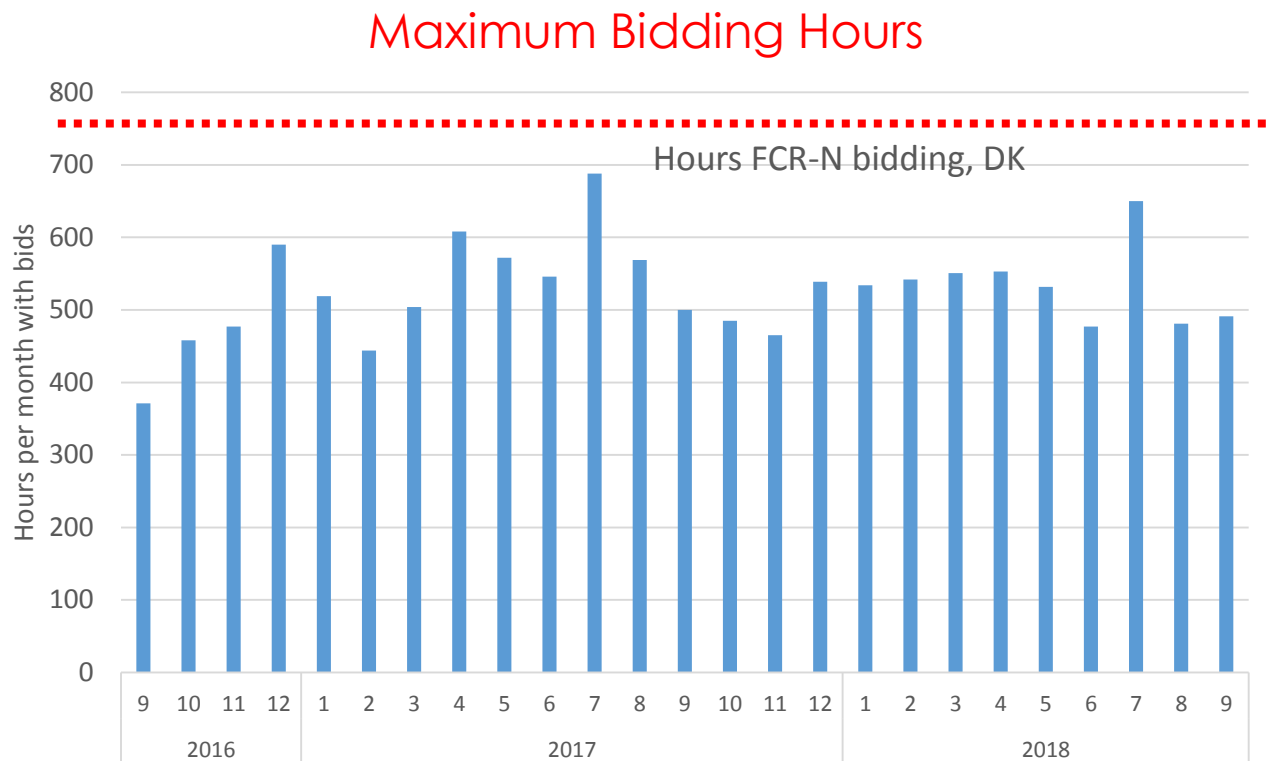




A Real-world and successful Example

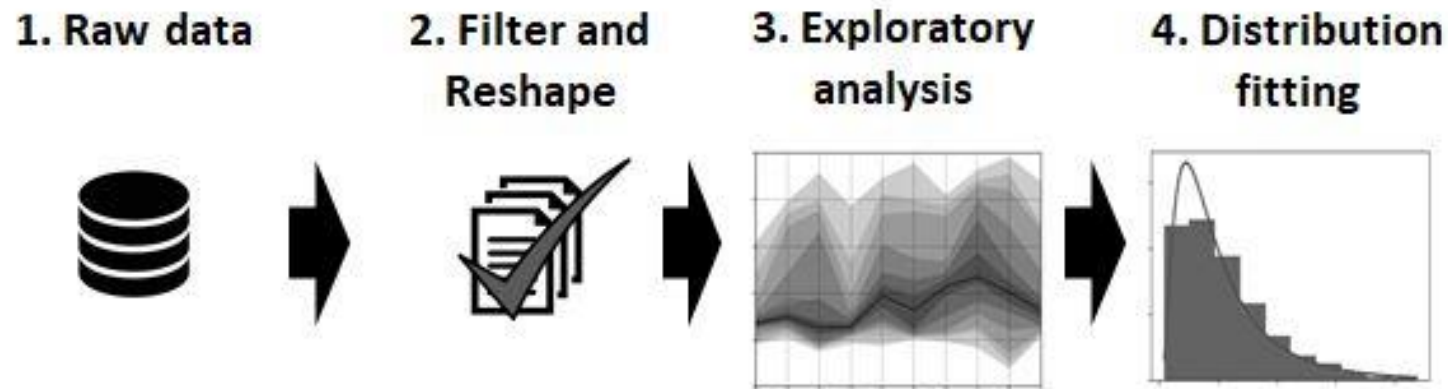
Frederiksberg Forsyning (FF) Fleet

- **Primary service:**
maintenance and service tasks.
- **Expected driving usage hours:**
work days 07:00 – 16:00
- **Power system service:**
Frequency regulation
- **Frequency Regulation:** 16:00 – 06:00
weekdays, 24 hours weekends
- EVs will be fully charged in the morning.



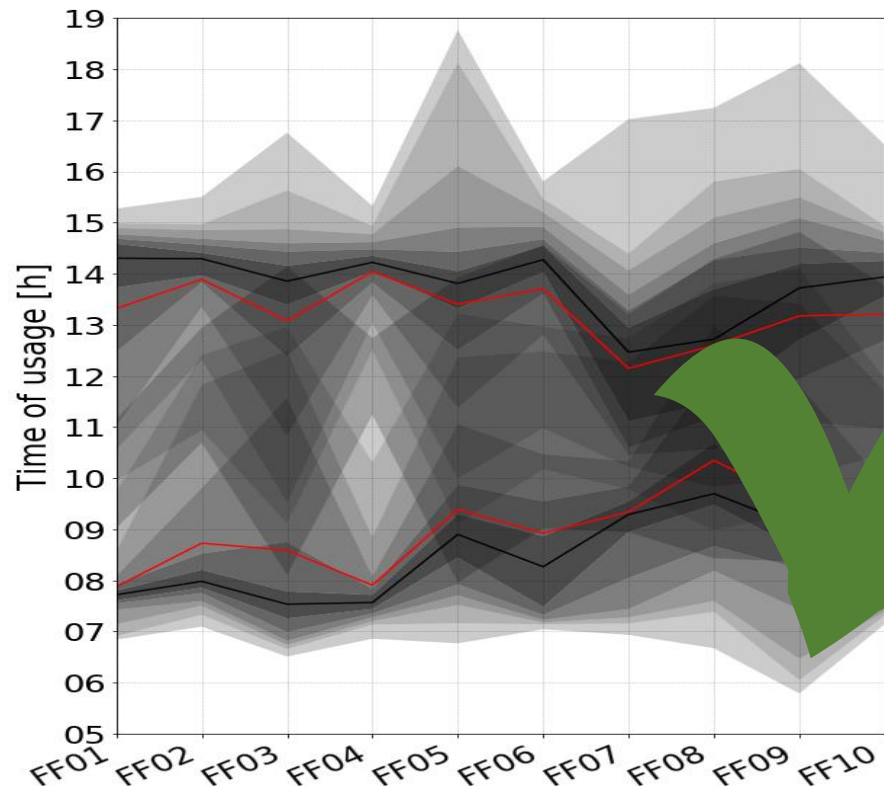
Frederiksberg Forsyning (FF): Big Data Analysis

- The data is collected during more than 450 days.
- Each charger is used by a specific driver as part of the utilities service.

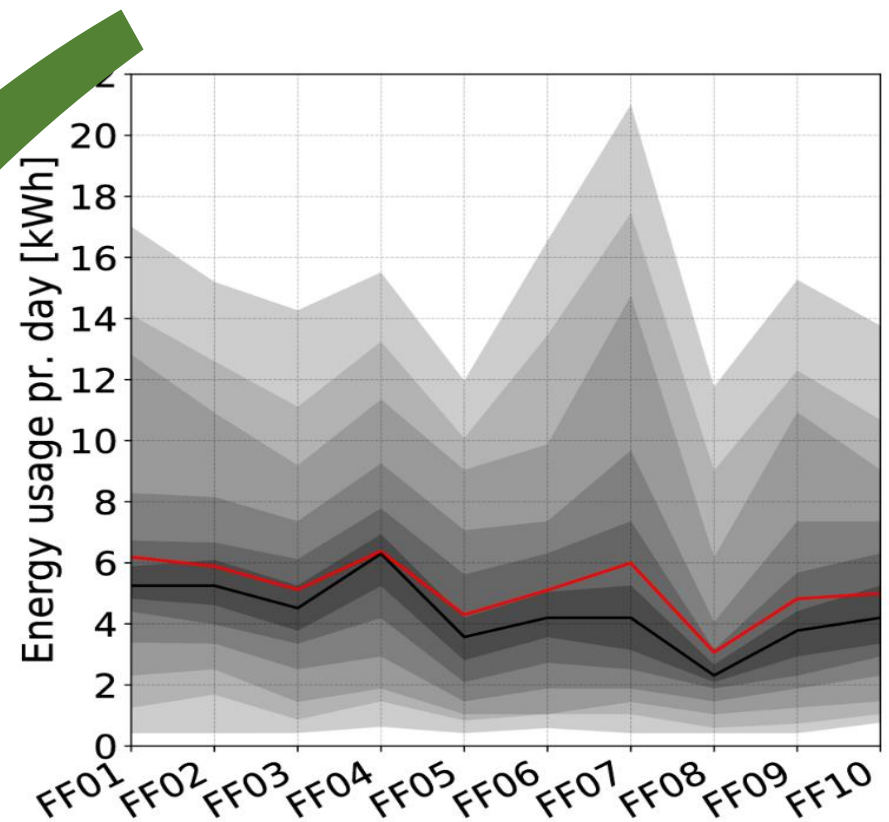




Frederiksberg Forsyning (FF): Part of Results



Leave Time: around 8
Average Return Time: around 14



Energy Usage per Day:
around 8 kWh



Conclusions and References

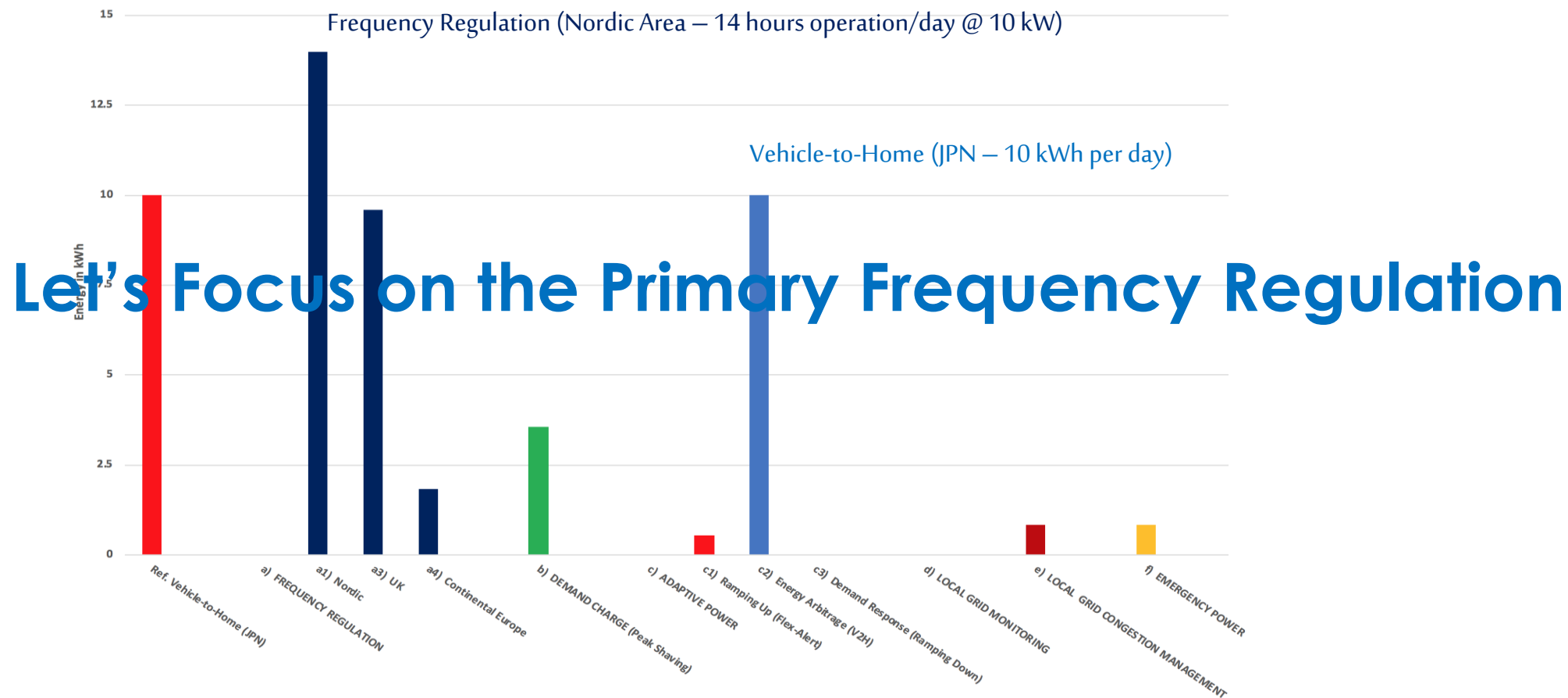
- Data analysis may be used to identify a per-user profile with an energy target, leave time and return time.
- By a proper user behavior analysis, a higher benefit is reachable.
- Customer comfort level should be considered.
- **More Information:**
 - **Conference paper:** Added Value Of Individual Flexibility Profiles Of Electric Vehicle Users For Ancillary Services, 2018.
 - **Master Thesis:** Flexibility User Profiles for Electric Vehicles , Frederiksberg Forsyning fleet data, 2018.
 - **Journal Paper:** Assessment of Economic Benefits for EV Owners Participating in the Primary Frequency Regulation Markets, under review.



- **What is the extra battery use from V2G?**

It depends on the type of service...

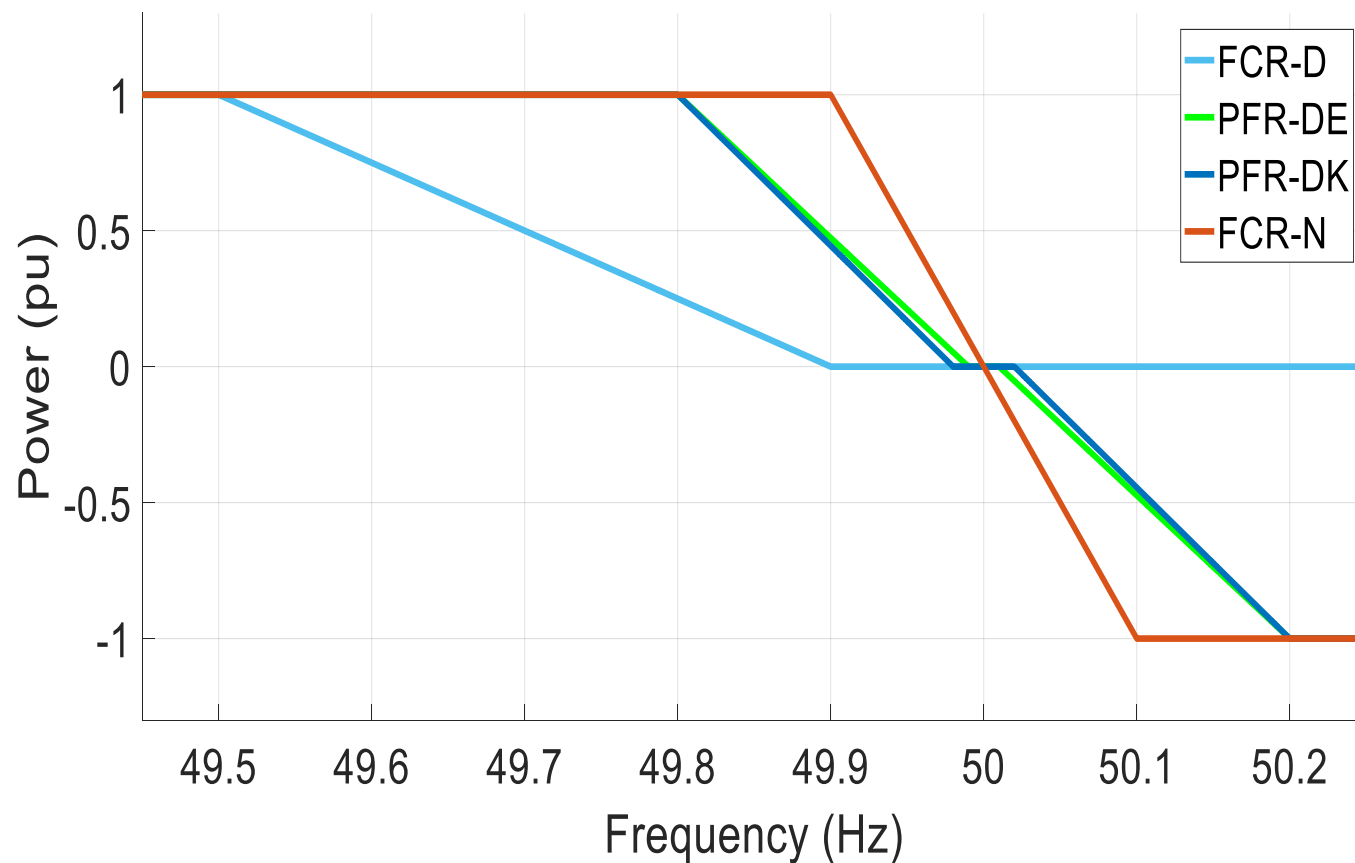




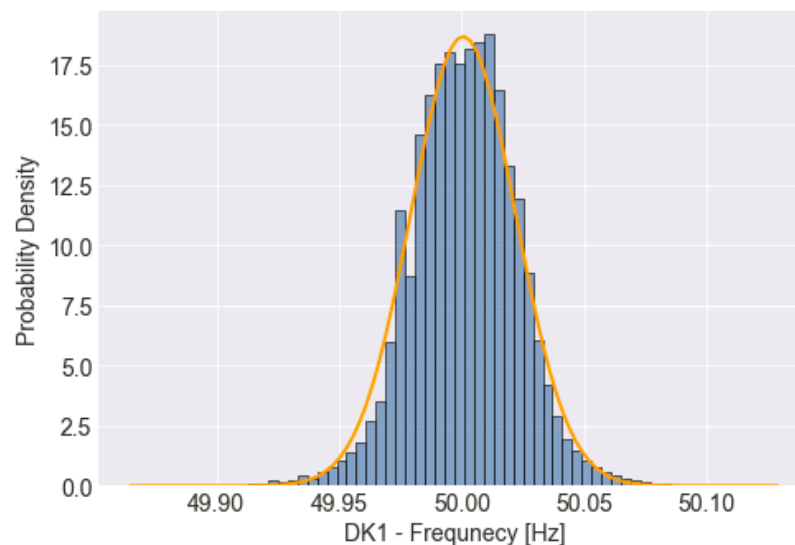
- Emergency power and congestion management have low energy contents.



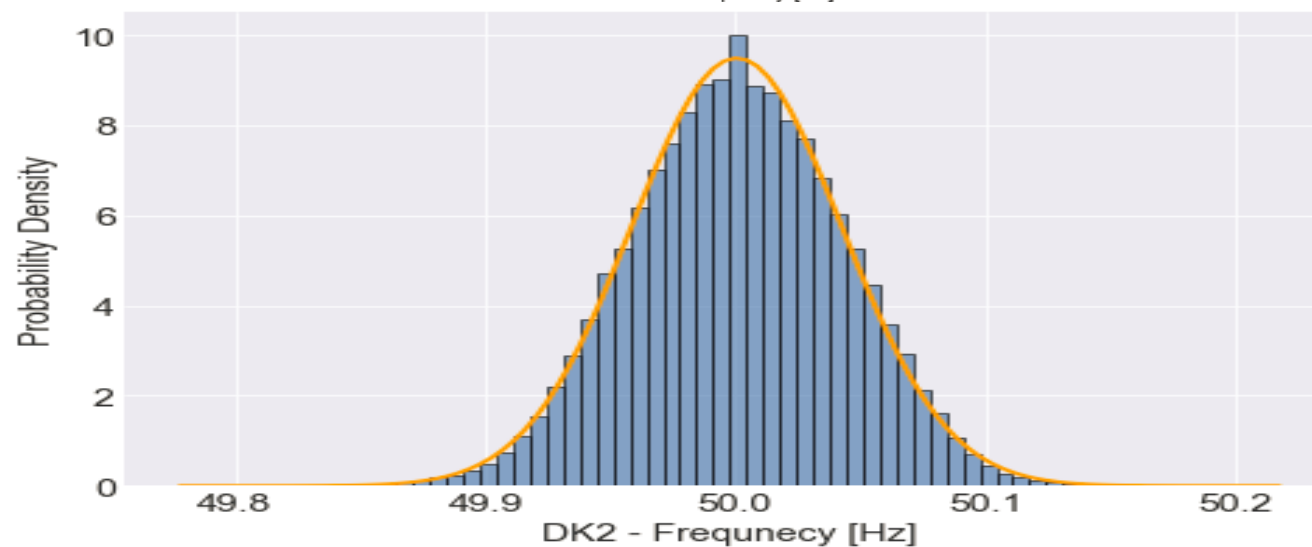
Frequency Regulation: Impact of Regulation



Continental Europe



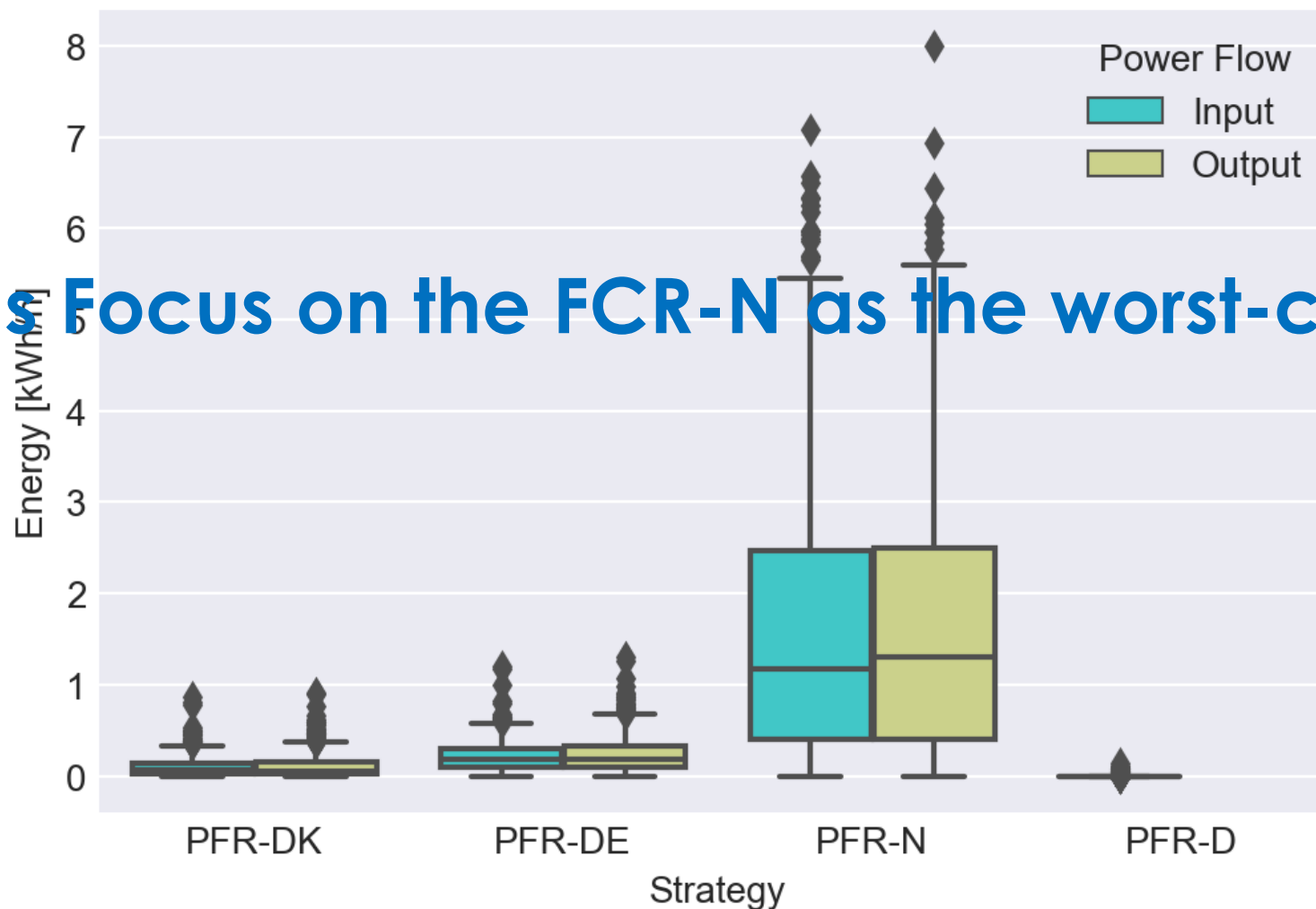
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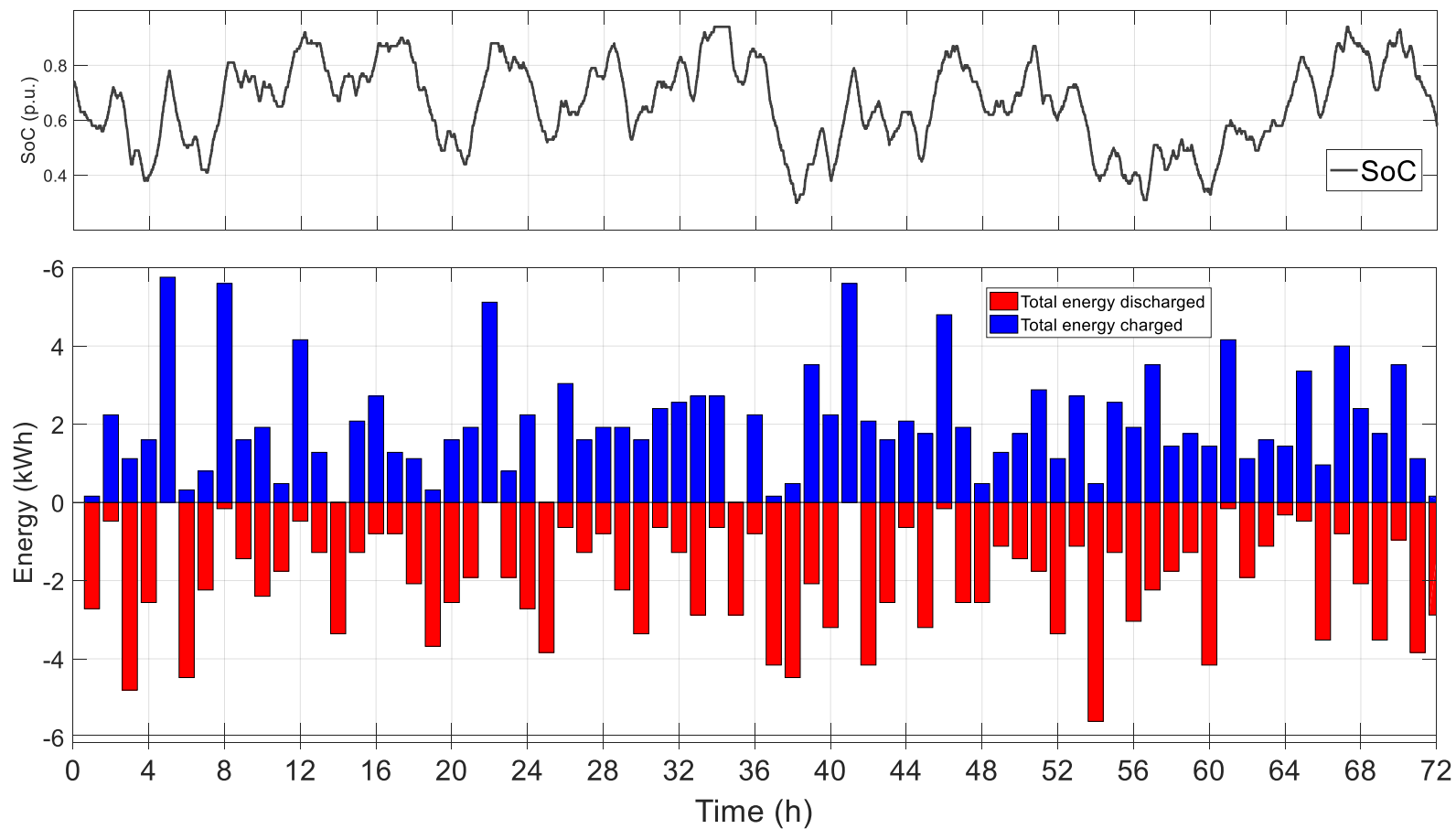
Frequency Regulation: Comparison of Energy Profiles

Let's focus on the FCR-N as the worst-case scenario





FCR-N: Total energy charge and discharge during 72 hours

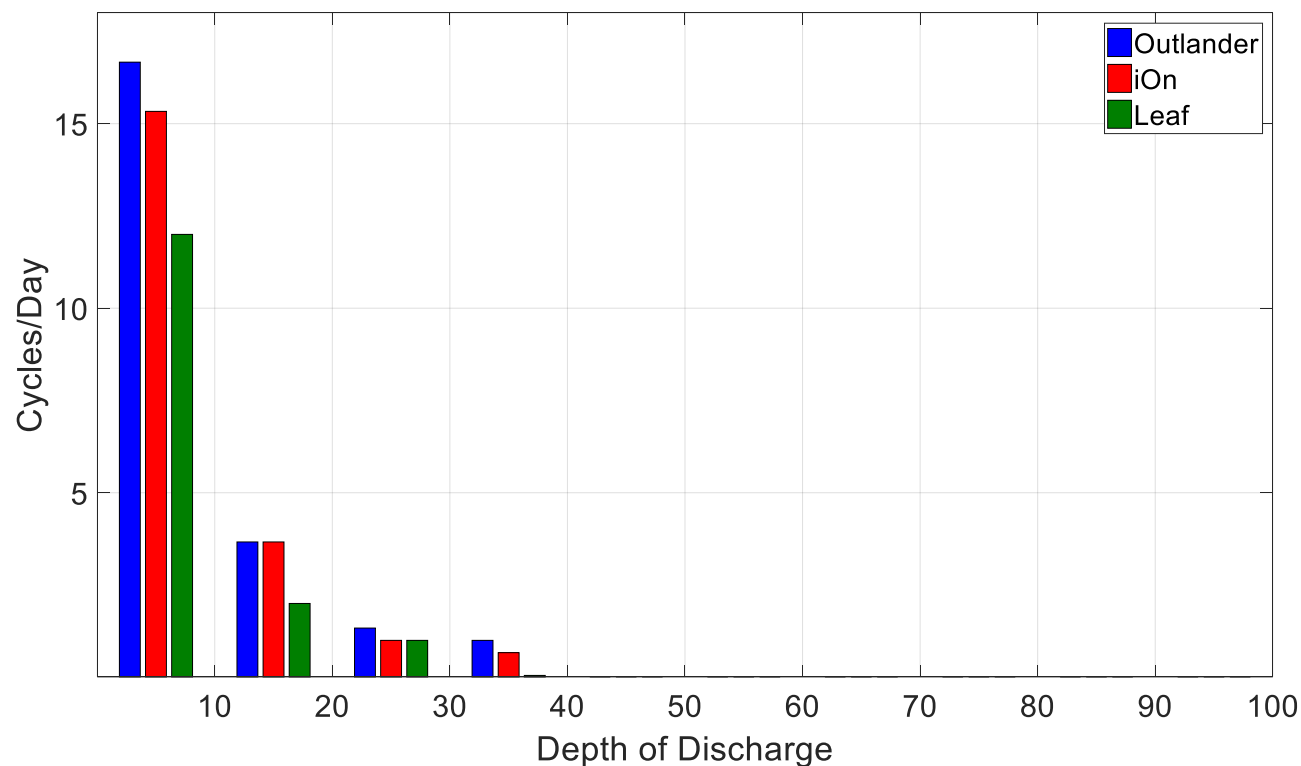




Depth of Battery Cycles, FCR-N

There is not a standardized 'V2G cycle' like we have standardized "driving cycles"

- Smaller EV batteries have more and deeper cycles. Outlander with the smallest battery capacity has the deepest cycles' depth.
- Smaller DoDs usually result in less battery degradation compared to deep cycles; therefore, an EV with smaller battery capacity has potentially higher battery degradation.



Conclusions and References

- EV Battery usage from V2G depends on the type of service, FCR-N in DK2 has the highest energy content among frequency regulation services.
- A proper ratio between the battery capacity and the bidding power minimizes the battery degradation.
- **More Information:**
 - **Conference paper:** Frequency Regulation Provision Using Cross-Brand Bidirectional V2G-Enabled Electric Vehicles, 2018.
 - **Conference paper:** V2G enabled EVs providing frequency containment reserves: field results, 2018.
 - **Master Thesis:** Electric Vehicle Battery Patterns Based On Frequency Regulation Services, 2018.
 - **Journal Paper:** Validation of primary frequency regulation using grid-integrated vehicles, under review.
 - **Journal Paper:** Assessment of Economic Benefits for EV Owners Participating in the Primary Frequency Regulation Markets, under review.

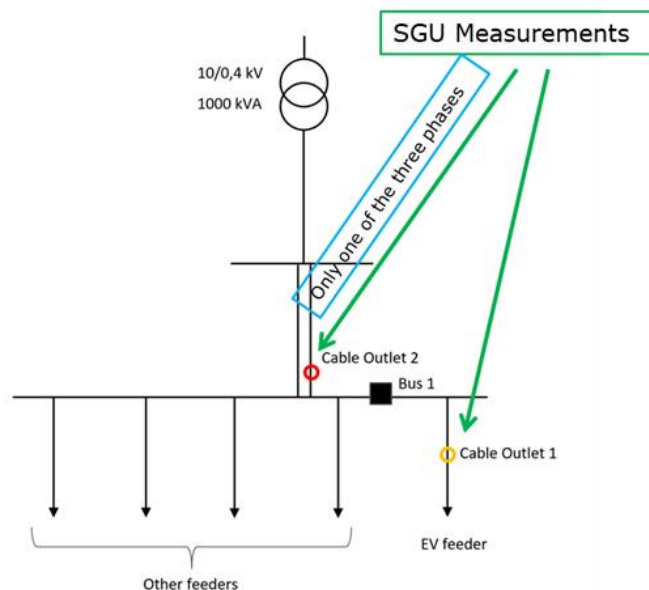


- **How does V2G impact the local grid?**

It depends on the grid strength.

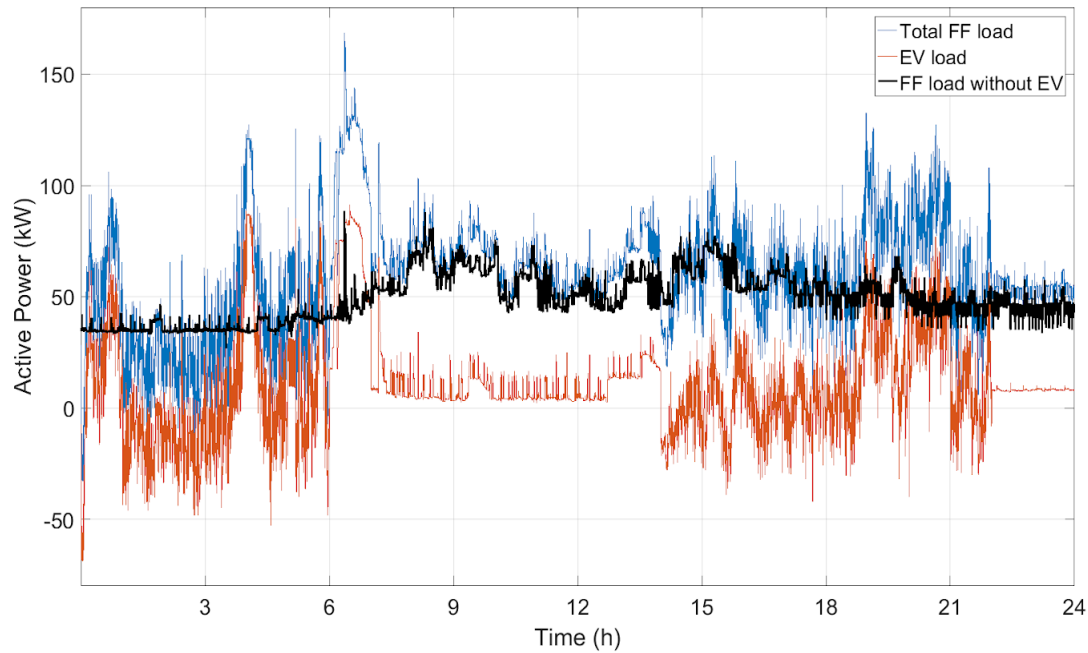


- A smart grid unit (SGU), was installed at the electricity distribution room in 2017.

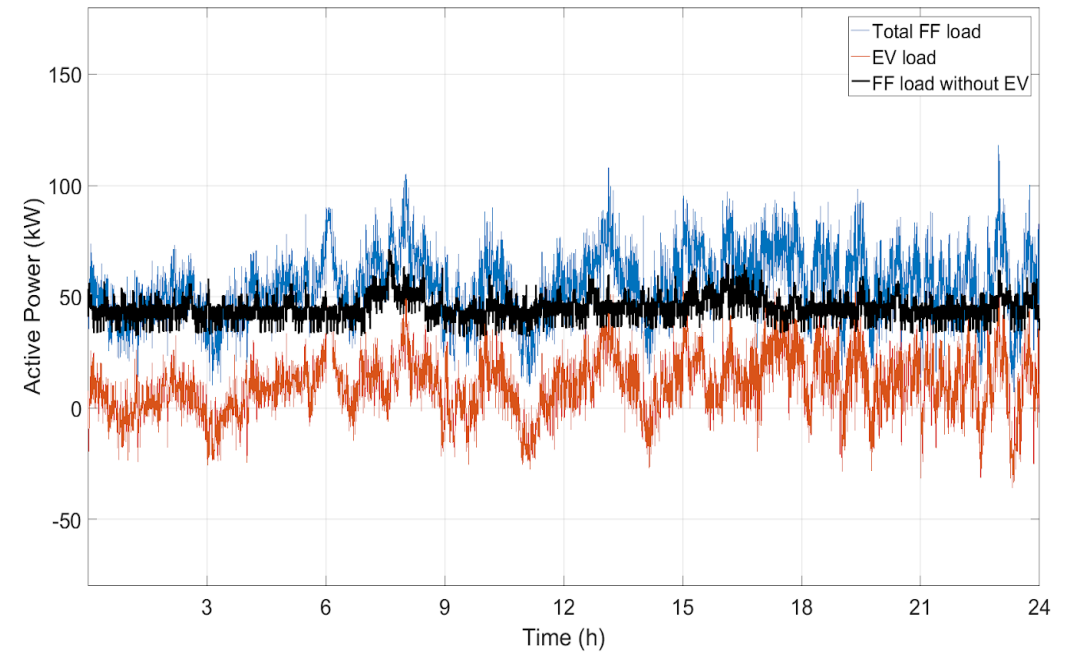


Impact of Frequency Regulation on the Feeder Load

- It may cause power fluctuation and grid congestion in specific hours.



- A Weekday in 2018

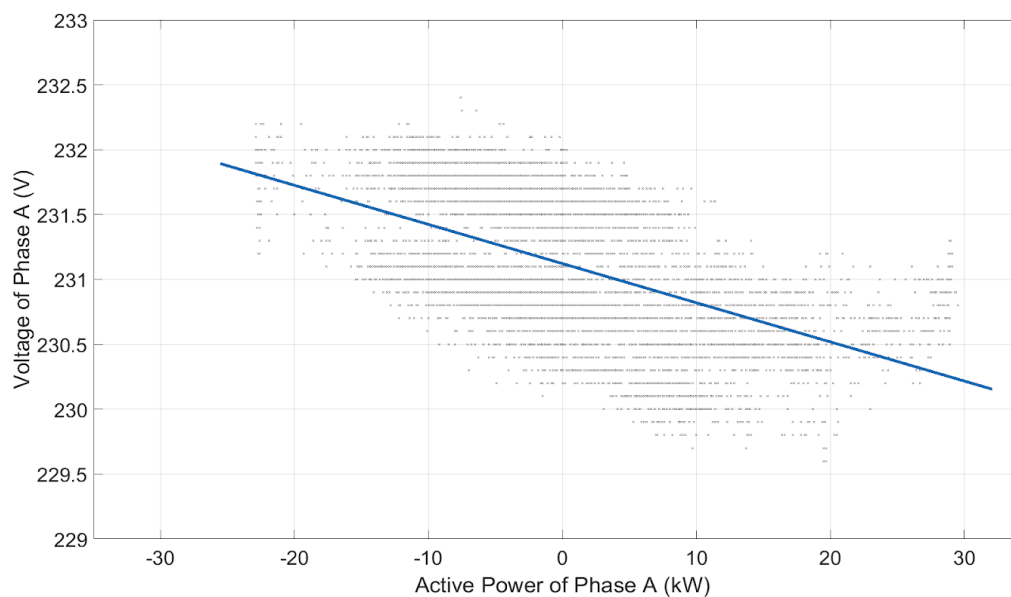
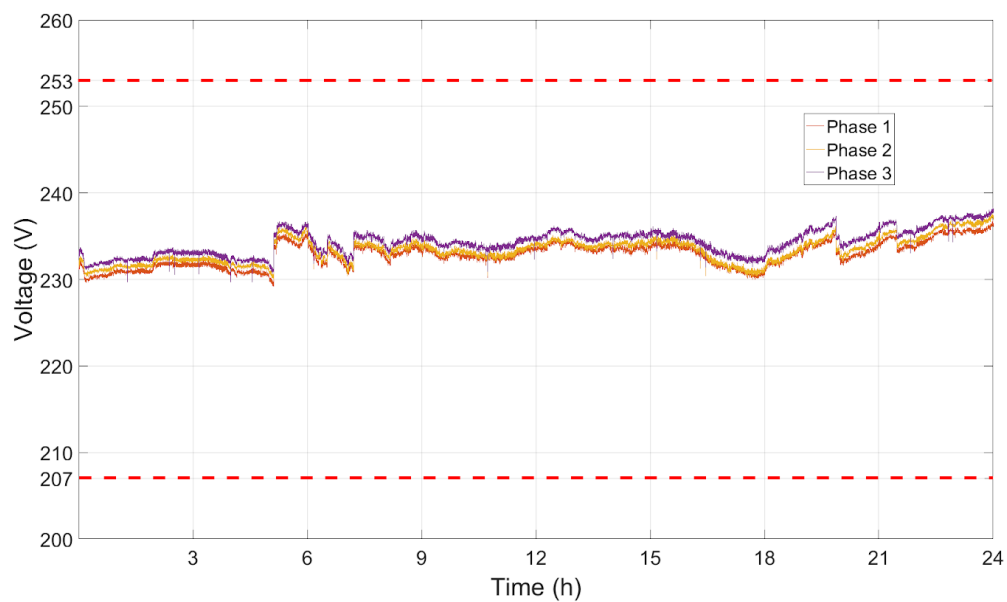


- A Weekend in 2018



Impact of Frequency Regulation on the Voltage

- It depends on the grid strength



- Grid impact from V2G depends on the grid strength.
- A proper control strategy can mitigate the grid congestion.
- Using state-of-the-art charges can potentially mitigate the grid voltage issues, e.g. reactive power provision that will be discussed in the next presentation.
- **More Information:**
 - **Master Thesis:** Grid impact study of frequency regulation with EVs, 2018.
 - **Journal Paper:** Assessment of Economic Benefits for EV Owners Participating in the Primary Frequency Regulation Markets, under review.
 - **Journal Paper:** Raising the Potential of a Local Market for the Reactive Power Provision by Electric Vehicles in a Distribution Grid, under review.





Thanks for your attention

Questions?

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