Grid M&V Analytics

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LBNL-SMUD Research
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Research Questions

- What are EE savings at different locations in the distribution grid? How much do those savings impact the energy used at those locations?
- What is the hourly EE savings shape at different locations in the distribution grid? How does this shape vary with season?
- What is the impact of the EE programs on peak demand?

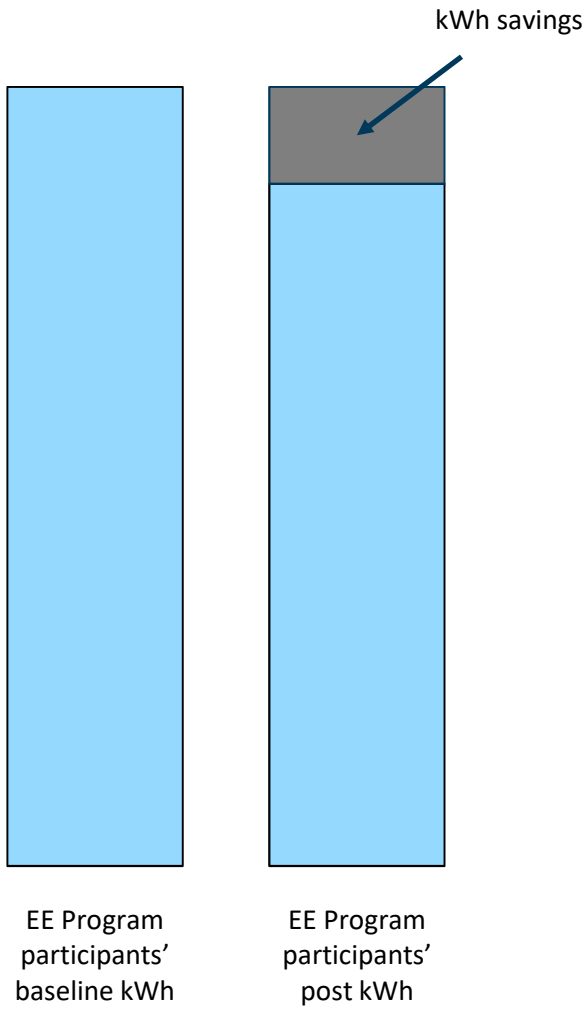
Outline

- Definitions and methodology
- Data pre-processing
- What are EE savings at different locations in the distribution grid? How much do those savings impact the energy used at those locations? (Total*, Substation and Feeder)
- What is the hourly EE savings shape at different locations in the distribution grid? How does this shape vary with season? (Total*, Substation and Feeder)
- What is the impact of the EE programs on peak demand?
- Summary

Total*= Aggregation of all the substations, considered as a proxy for entire territory for this analysis

DEFINITIONS AND METHODOLOGY

Definitions and Methodology



- Fractional savings (FS), as defined by ASHRAE 14 guideline, is defined as

$$FS_i = (Savingsi)/\widehat{Ei}_{post}$$

- The Gradient Boosting Machine (GBM) Model[1] savings numbers are reported.
- Criteria for trustworthy savings: R^2>0.7, CVRMSE <25%, NMBE -0.5% to +0.5%

1 https://buildings.lbl.gov/publications/gradient-boosting-machine-modeling

$\widehat{Ei}$: predicted

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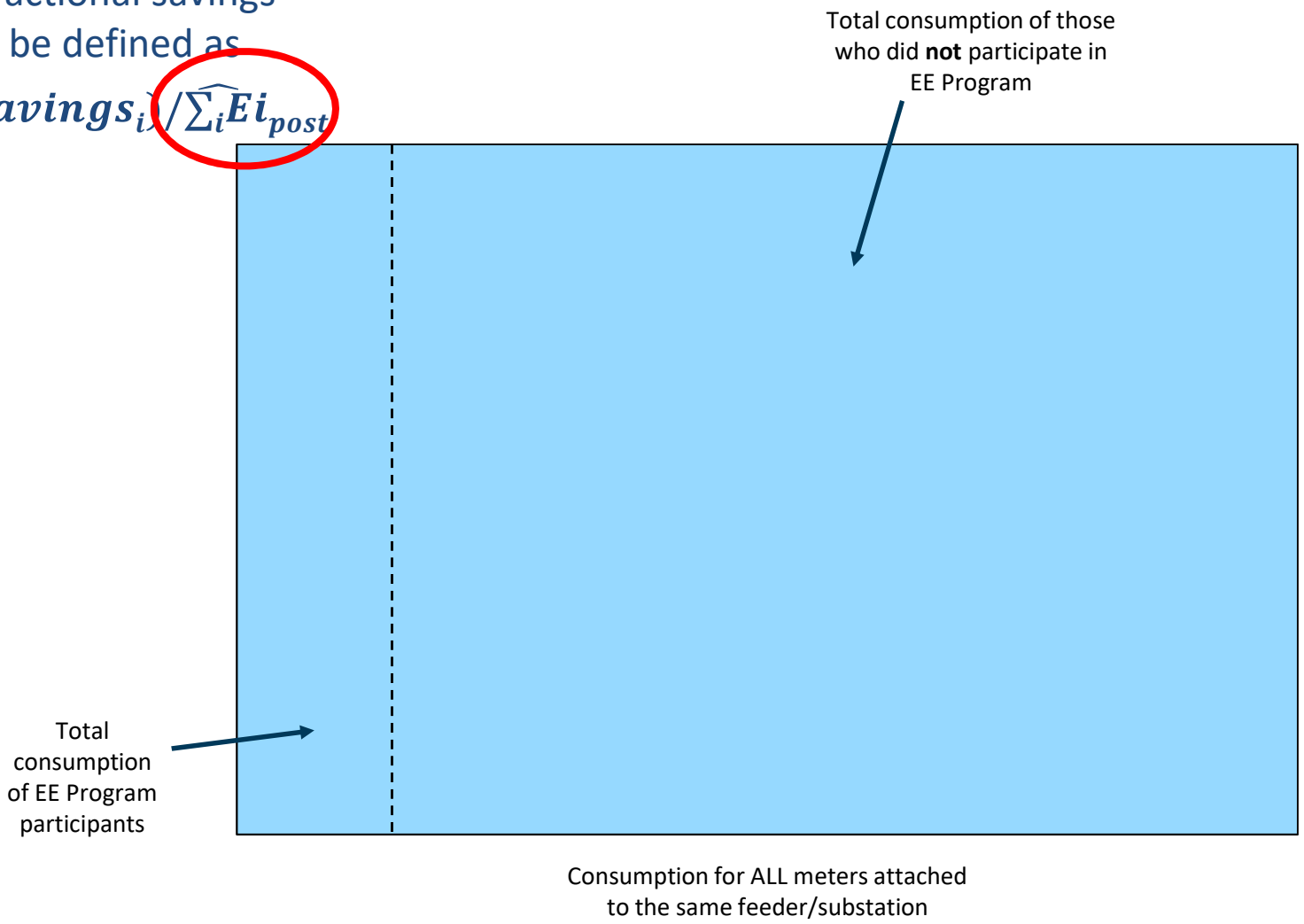
Definitions and Methodology

- Relative fractional savings (RFS), can be defined as

$$RFS_i = (Savings_i)/\sum_i \widehat{Ei}_{post}$$



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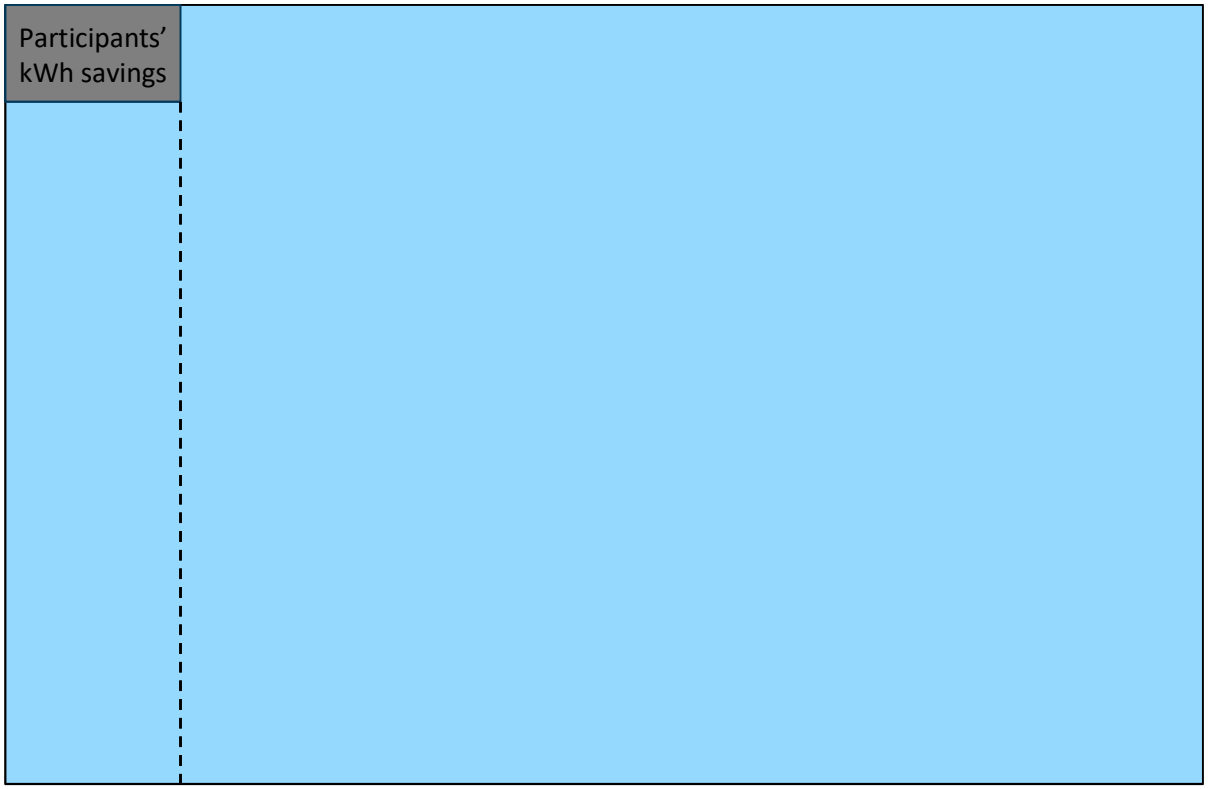

Consumption for ALL meters attached to the same feeder/substation

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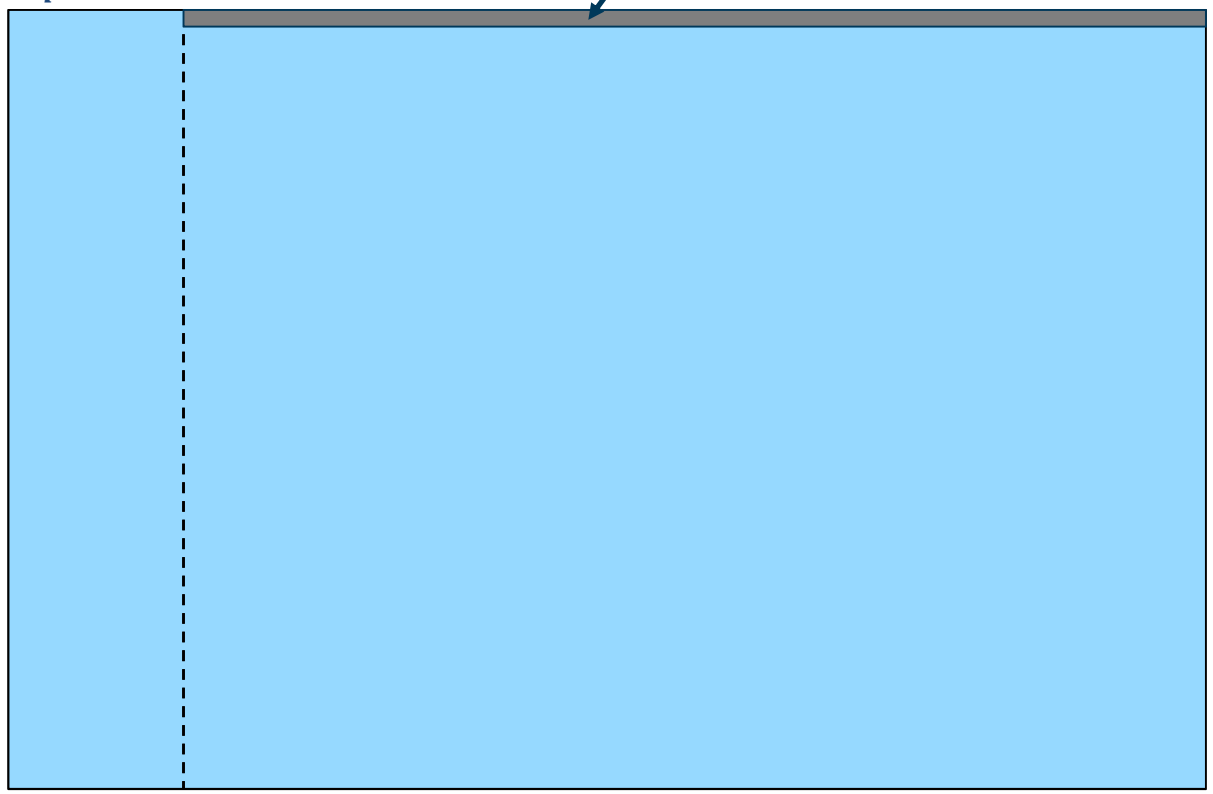

Why season as a variable is important for hourly load shape analysis?

Total

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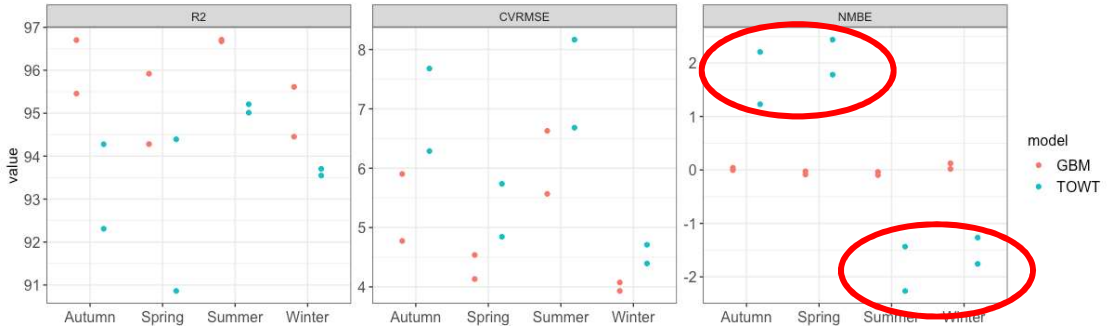
Total



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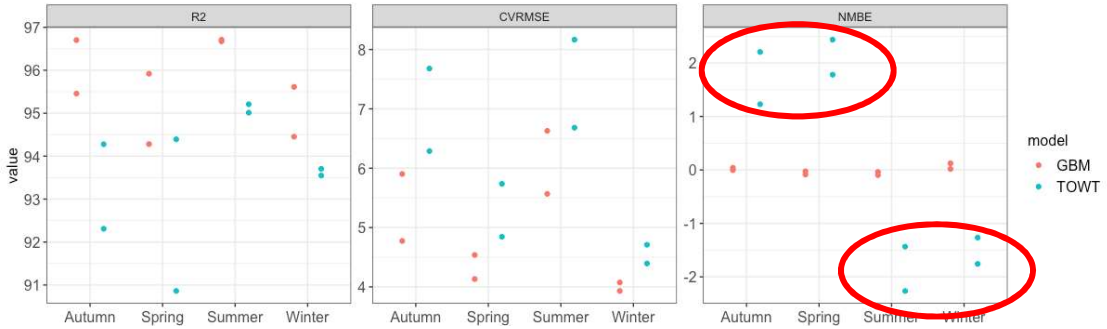
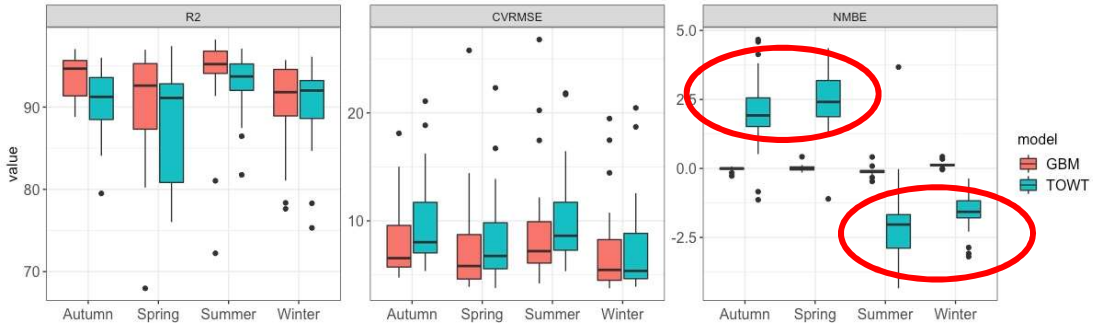
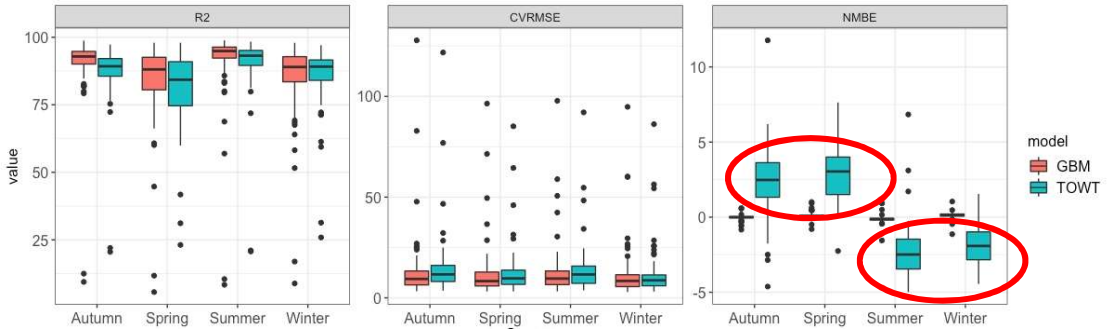


Substation



Feeder



Data pre-processing

- 2015 considered baseline year
- 2018 considered reporting period year
- Kept only “no-move” customers data
- Excluded EV, PV customers
- Excluded customers with incomplete data
- Consumption aggregated for “EE” and “NonEE” customers

What are EE savings at different locations in the distribution grid?

How much do those savings impact the energy used at those locations?(Total*, Substation and Feeder)

Total*= Aggregation of all the substations, considered as a proxy for entire territory for this analysis

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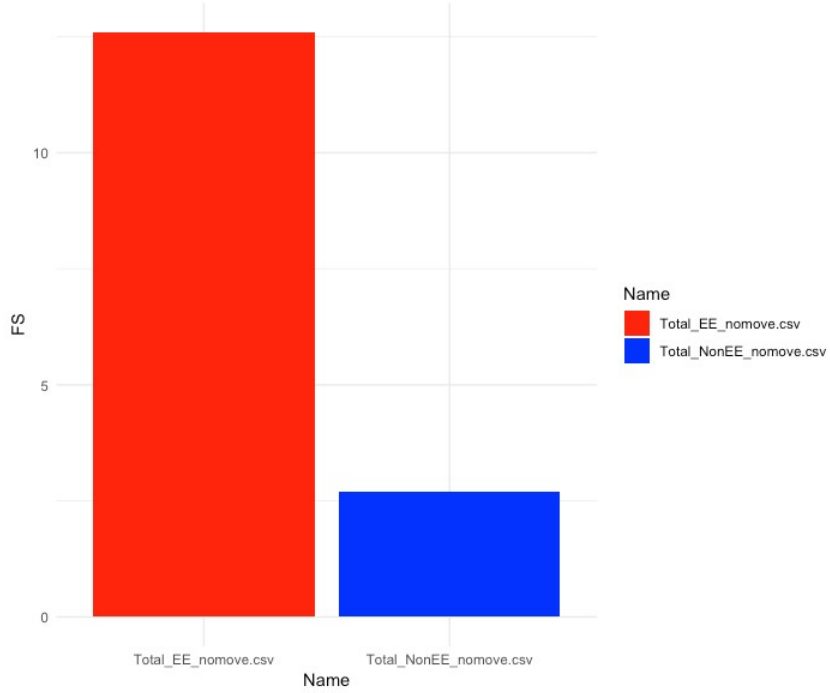
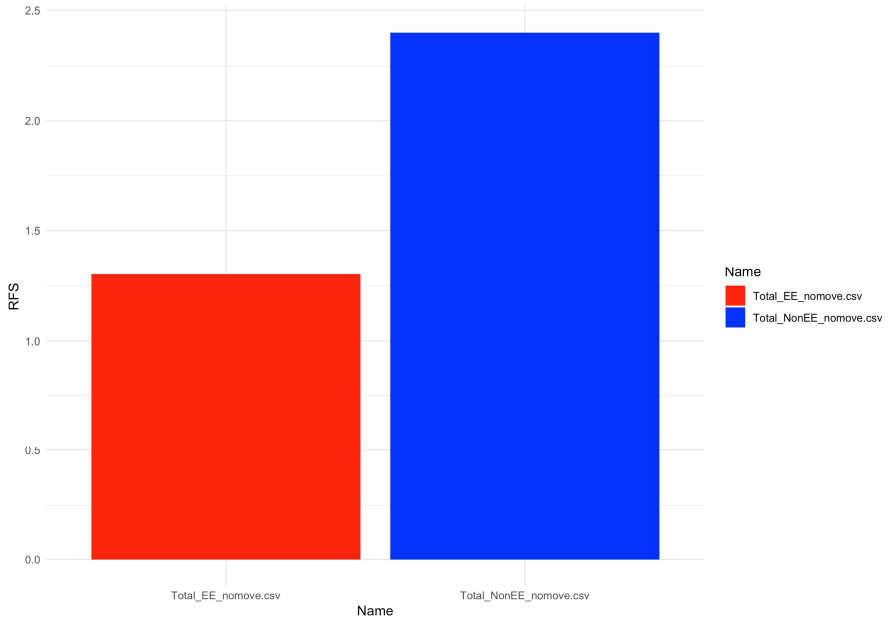
What are EE savings at different locations in the distribution grid? : Total

	R^2	CVRMSE	NMBE
Total EE	96.8	4.8	0.01
Total Non-EE	96.72	5.47	-0.01



Fractional Savings (FS)
Total EE : 12.6%
Total NonEE: 2.7%



Relative Fractional Savings (RFS)
Total EE : 1.3%
Total NonEE: 2.4%

- EE customers have trustworthy savings over the 2018 period (FS 12.6%)
- When viewed at the grid level, these savings have a lower impact (RFS 1.3%) due to the limited number of EE customers

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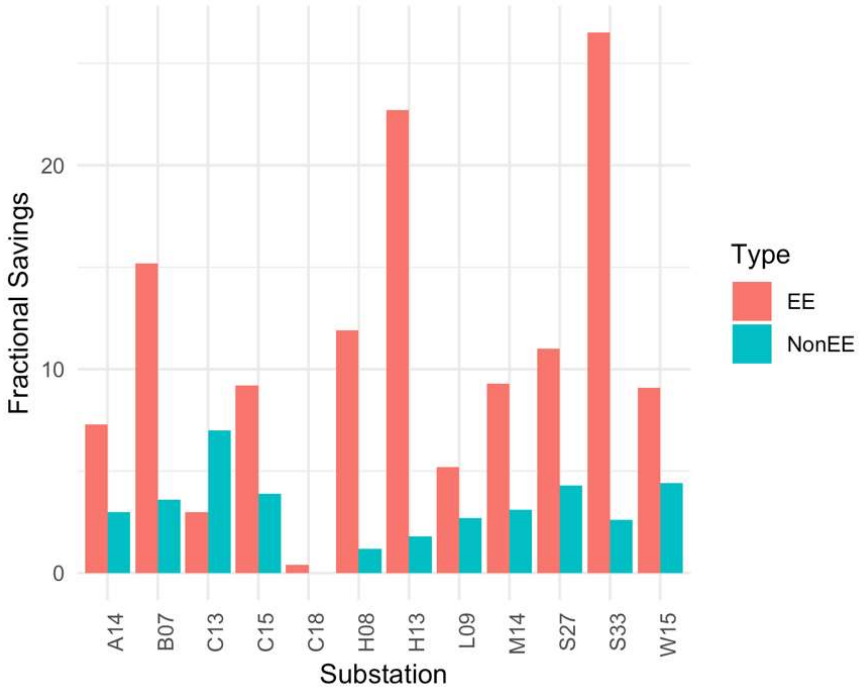
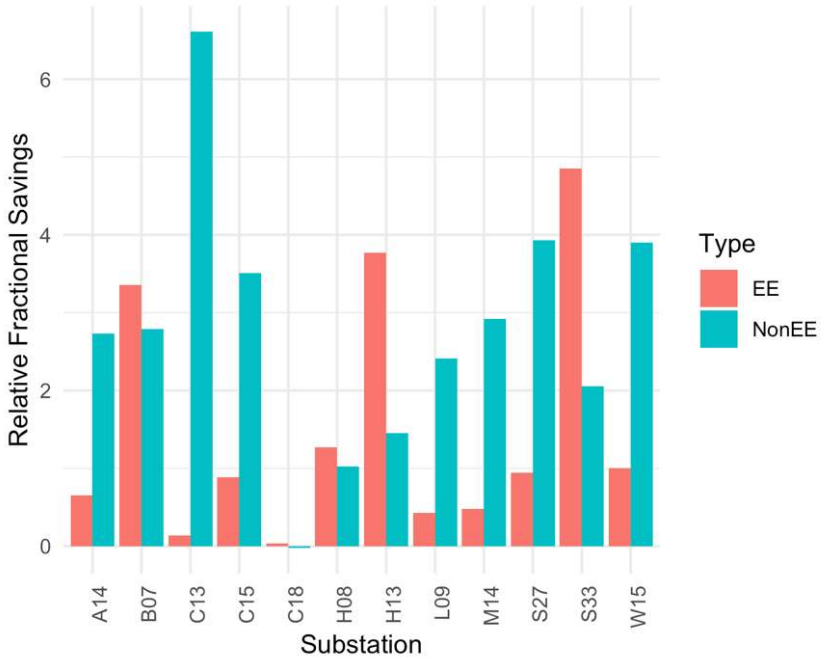
What are EE savings at different locations in the distribution grid? : Substations





- Range of FS for EE [0.4%, 26.5%]
- For 11 out of 12 substations, EE participants have higher FS than Non-EE

- Range of RFS for EE [0.03%, 5%]
- For 42% substations, EE participants have higher RFS than Non-EE
- Due to small number of EE participants, impact less visible (Number of EE participants at each substation range between 1.3% to 8%, with an average of 5%)

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What are EE savings at different locations in the distribution grid? : Feeder

- Range for FS EE [-4.7%, 42%]
- Range for RFS EE [-2, 12%]

- FS EE>FS NonEE at 76% feeders
- RFS EE> RFS NonEE at 22% feeders (N=11)

- EE impact at total grid level is 1.3%.
- Vs EE impact substation level : 0.03% to 5%, avg was 1.42%.
- Vs EE impact feeder level : -2% to 12%, avg was 1%

What are EE savings at different locations in the distribution grid? --Summary--

- Total (Impact was 1.3%)
  - The EE participants have a significantly higher reduction in energy consumption than Non-EE customers
  - Due to a relatively limited number of EE participants at the grid level the impact of the EE programs is less visible, which can be seen by the smaller RFS metric of EE participants in comparison to the Non-EE customers.
- Substation (avg impact was 1.42%)
  - For 11 out of 12 substations, EE participants have higher reduction in energy consumption than Non-EE customers
  - The savings of the EE participants at the grid level is higher than the decrease in energy consumption of Non-EE participants at 5 substations
- Feeder (avg impact was 1%)
  - For 39 out of 51 feeders the EE participants have higher reduction in energy consumption than Non-EE customers
  - The savings of the EE participants at the grid level is higher than the decrease in energy consumption of Non-EE participants at 11 feeders

What is the hourly EE savings shape at different locations in the distribution grid?

How does this shape vary with season?

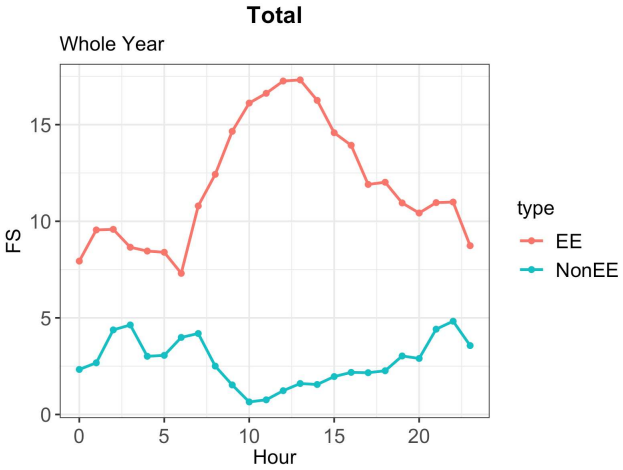
Total-Substation-Feeder

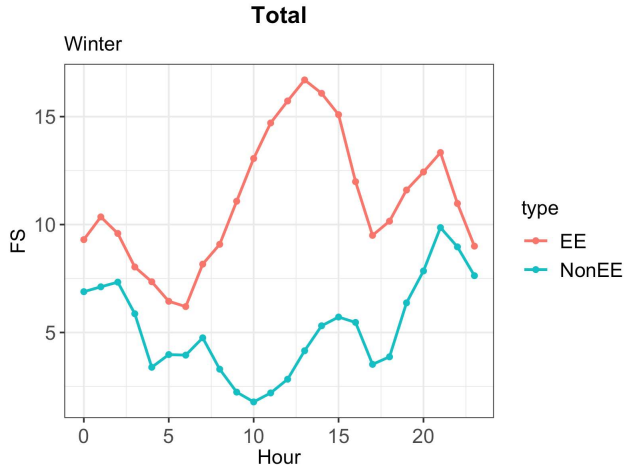
What is the hourly EE savings shape at different locations in the distribution grid?

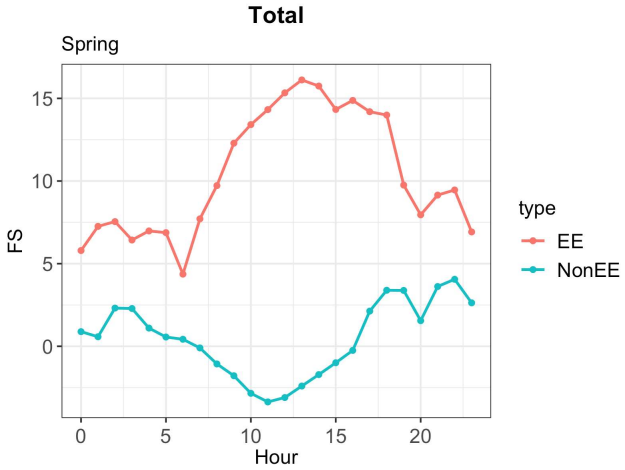
- For annual and each season, an average hourly savings is estimated for weekdays for EE and NonEE customers
- To evaluate the trustworthiness of hourly savings, the gap in the fractional savings between EE and NonEE customers is assessed
  - We quantify the average number of hours for which FS of EE participants is higher than NonEE customers over 24 hours

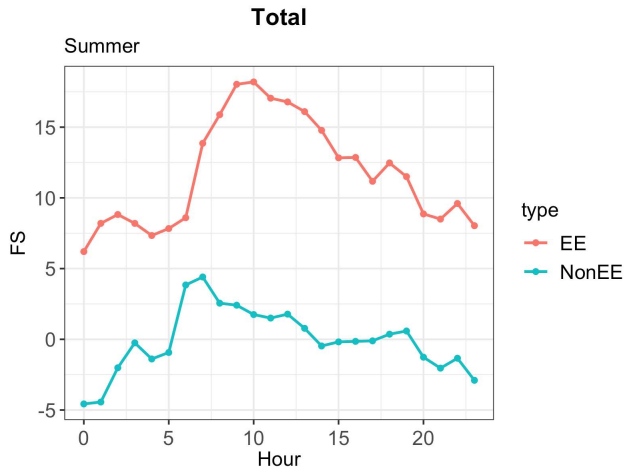
What is the hourly EE savings shape at different locations in the distribution grid?

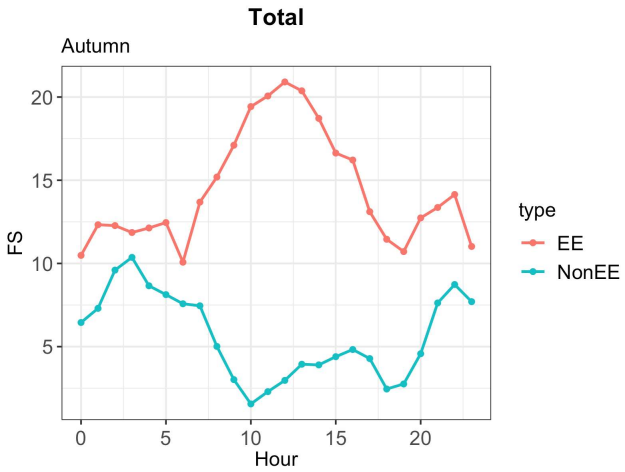
--- Total Level ---











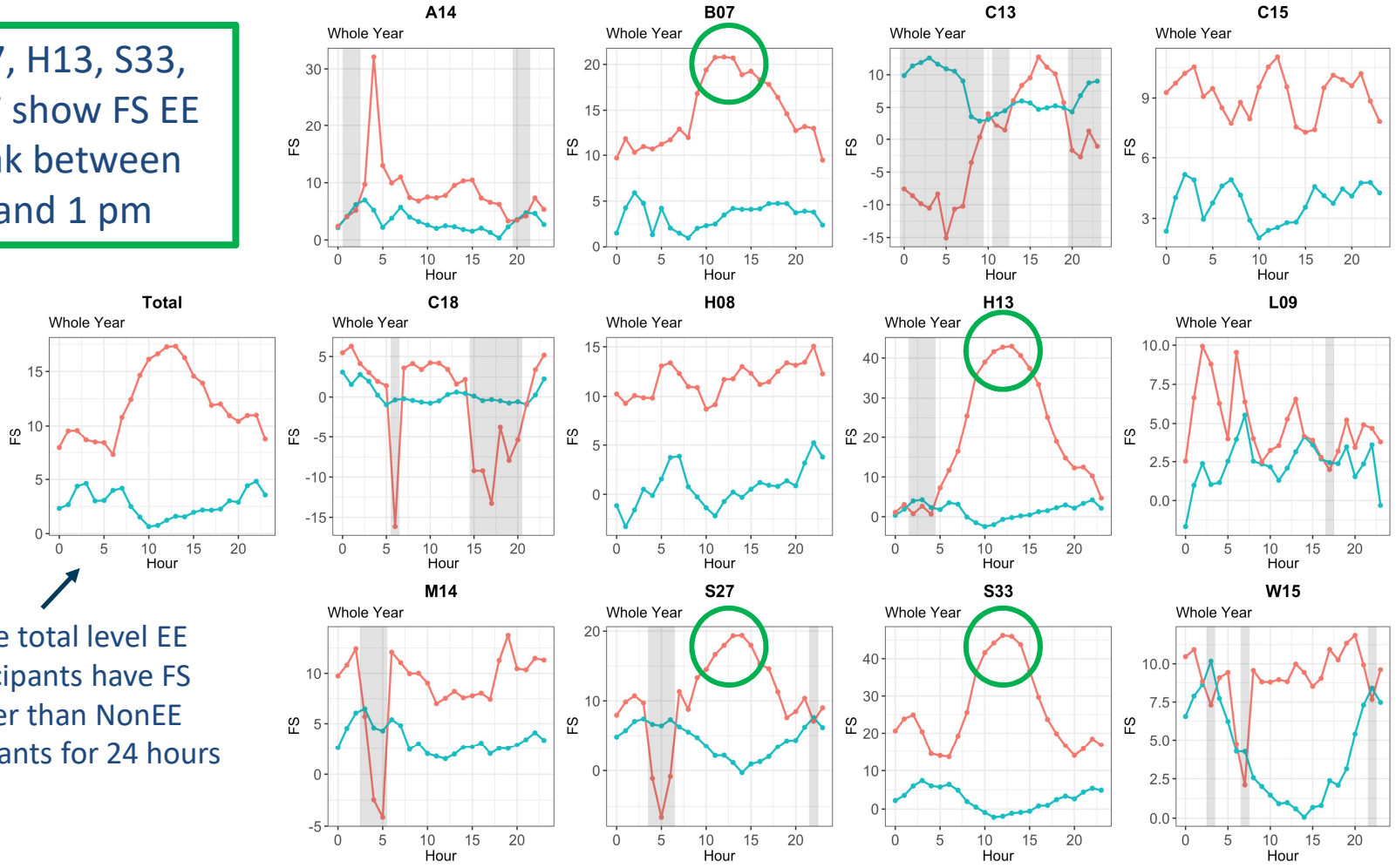
FS EE has clear peak between noon and 1 pm

	Whole year	Winter	Spring	Summer	Autumn
Total	24	24	24	24	24

Number of hours where FS of EE participants is higher than FS of NonEE

What is the average hourly EE Fractional savings shape at total and substation level over the whole analysis period (i.e., whole year) ---Total level and Substation level---

B07, H13, S33, S27 show FS EE peak between 11 and 1 pm

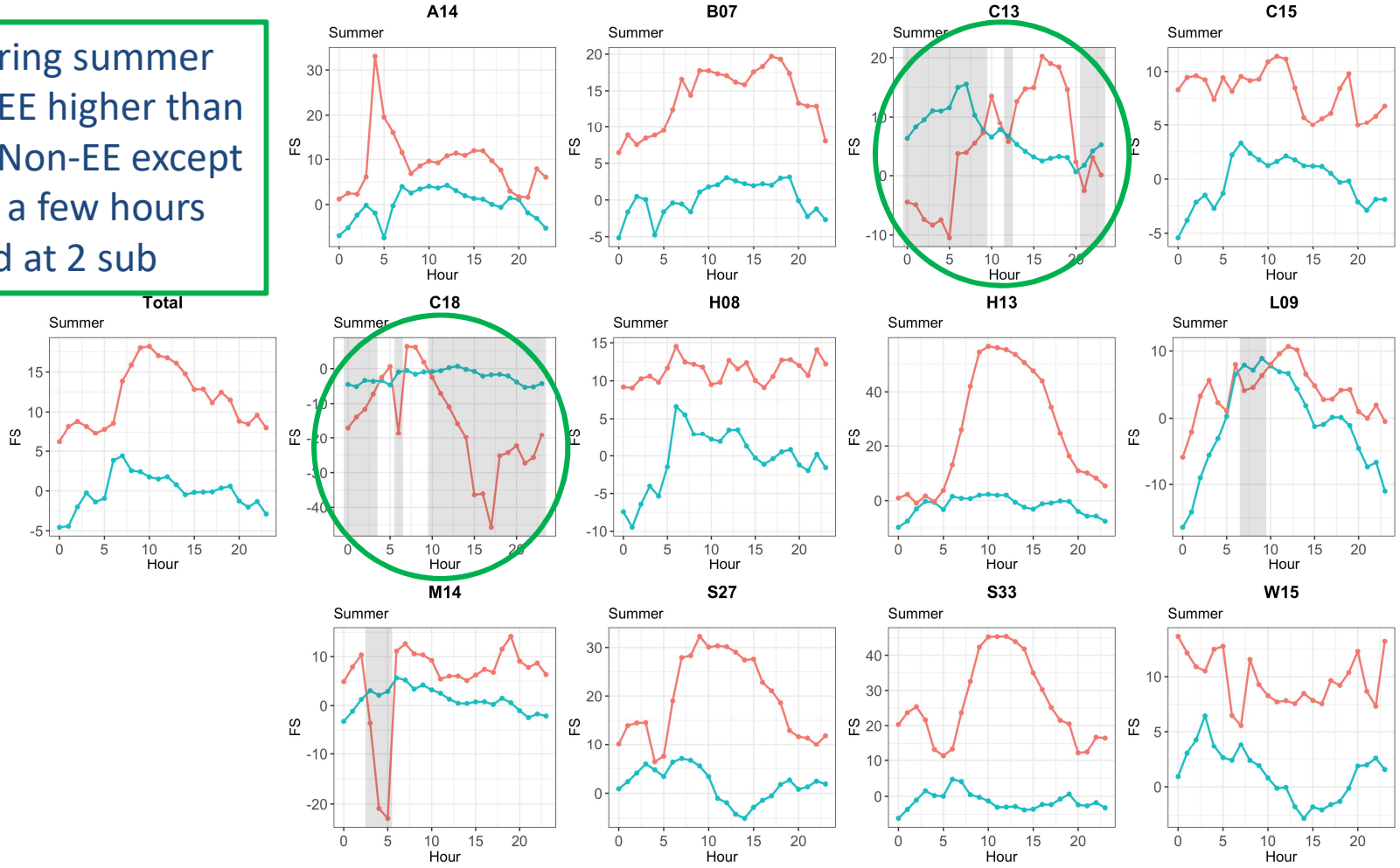


At the total level EE participants have FS higher than NonEE participants for 24 hours

- On an average over all the substations EE participants have FS higher than NonEE participants for ~ 21 hours of the 24 (i.e., ~ 88%).

What is the average hourly EE Fractional savings shape at total and substation level over the summer
---Total level and Substation level---

During summer FS EE higher than FS Non-EE except for a few hours and at 2 sub



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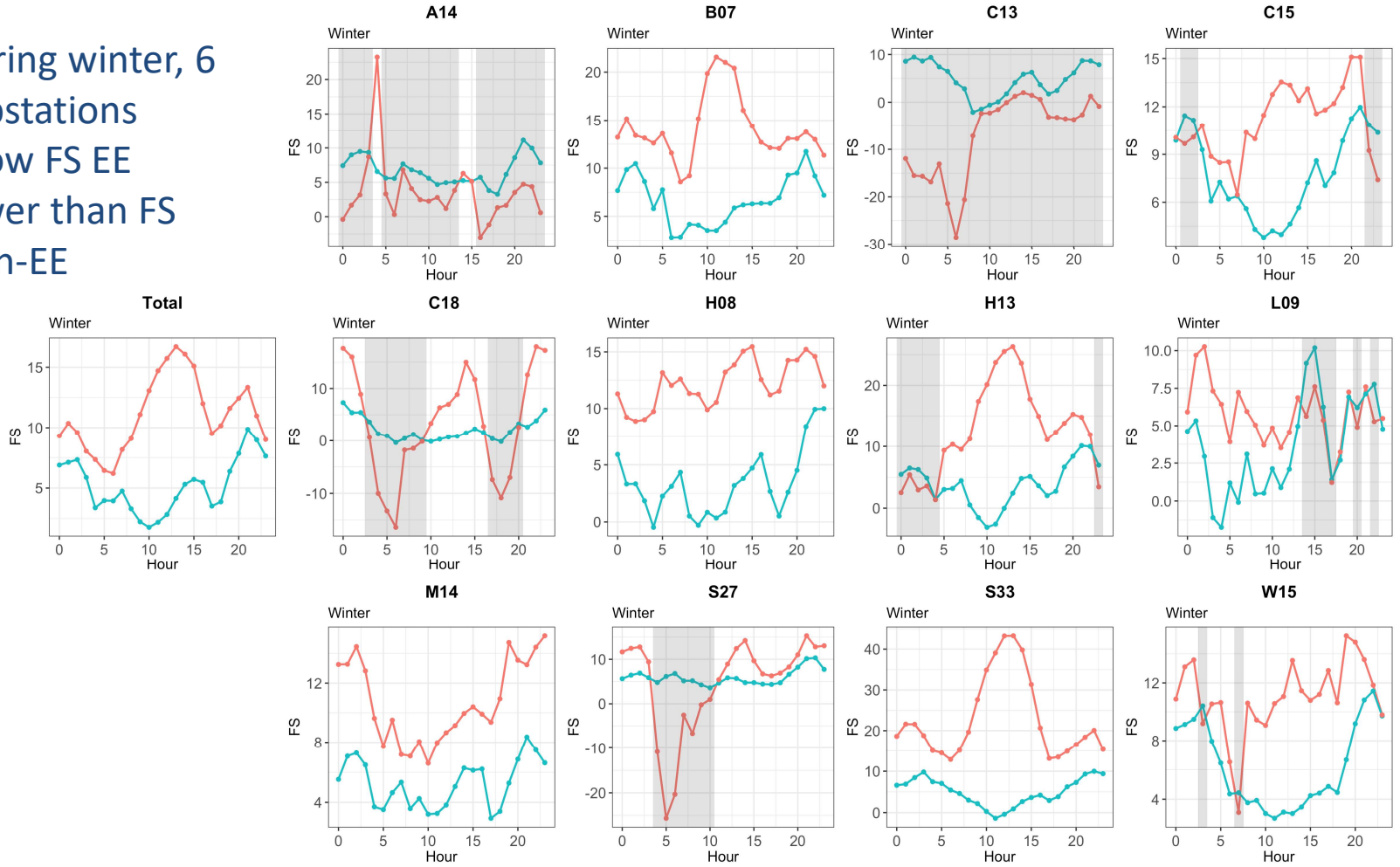
What is the average hourly EE Fractional savings shape at total and substation level over the winter
---Total level and Substation level---

During winter, 6 substations show FS EE lower than FS Non-EE



- At the total level EE participants have FS higher than NonEE participants for 24 hours
- On an average over all the substations EE participants have FS higher than NonEE participants for ~ 17 hours of the 24 (i.e., ~ 72%).

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How does these average savings hourly shapes vary with season?

Over 24 hours (Average by substation and feeder)

	Total	Substation	Feeder
Whole year	24		
Winter	24		
Spring	24		
Summer	24		
Autumn	24		

How does these average savings hourly shapes vary with season?

Over 24 hours (Average by substation and feeder)

	Total	Substation	Feeder
Whole year	24	21	
Winter	24	17	
Spring	24	18	
Summer	24	21	
Autumn	24	20	

How does these average savings hourly shapes vary with season?

Over 24 hours (Average by substation and feeder)

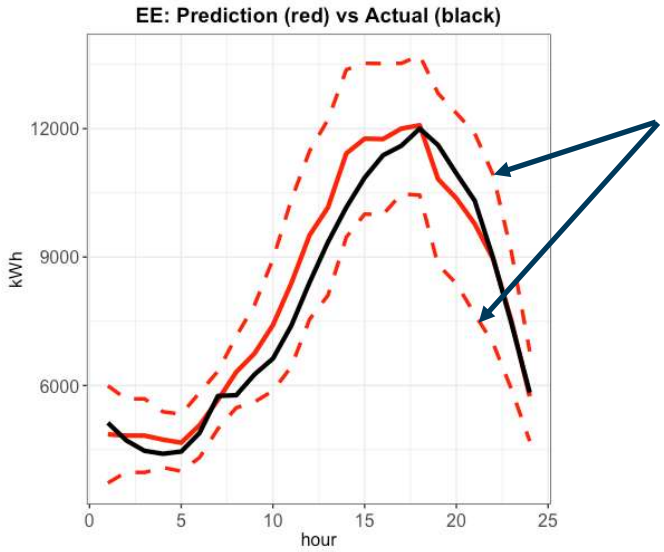
	Total	Substation	Feeder
Whole year	24	21	17
Winter	24	17	17
Spring	24	18	15
Summer	24	21	17
Autumn	24	20	16

- The number of hours (average for substations and feeders) where FS EE participants is higher than NonEE customers decrease with the aggregation level (from total to feeders)

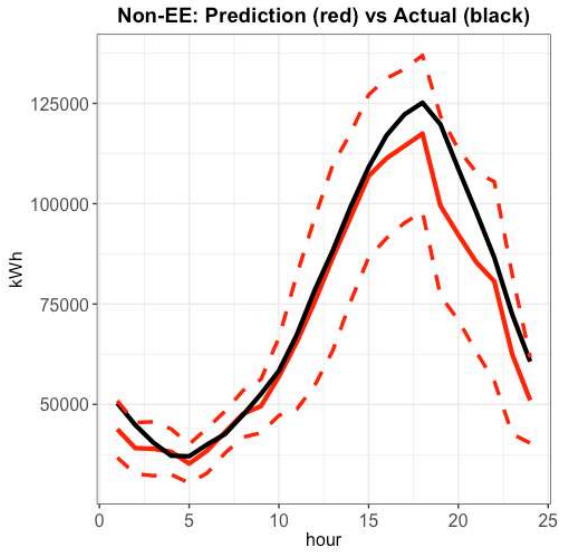
What is the impact of the EE programs on peak demand?

Peak Day: July 25, 2018

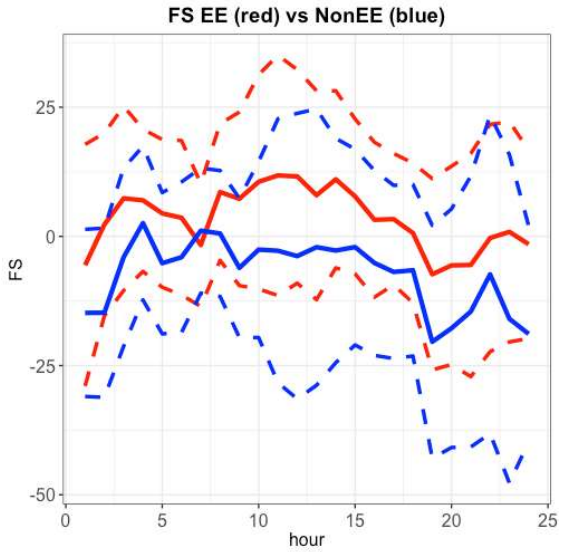
What is the impact of the EE programs on peak demand? : Total Level July 25, 2018



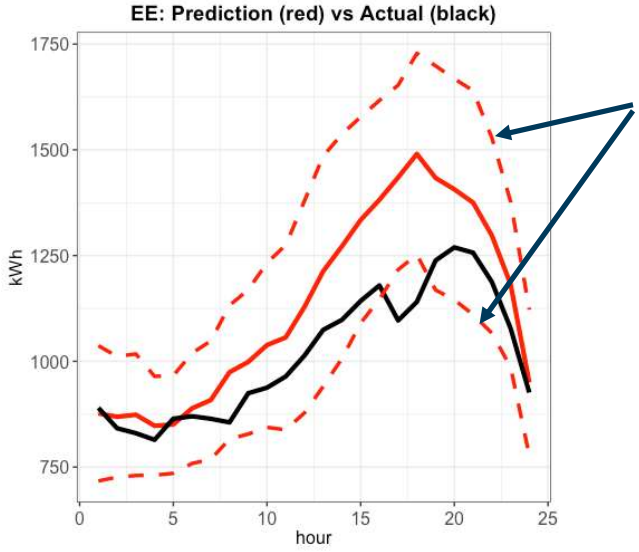
Uncertainty bands (i.e., prediction interval) at 99% of confidence level



- Hourly savings of EE participants are not high enough to be distinguished from the noise using the modelling technique applied in this analysis



What is the impact of the EE programs on peak demand? : B07 Substation July 25, 2018



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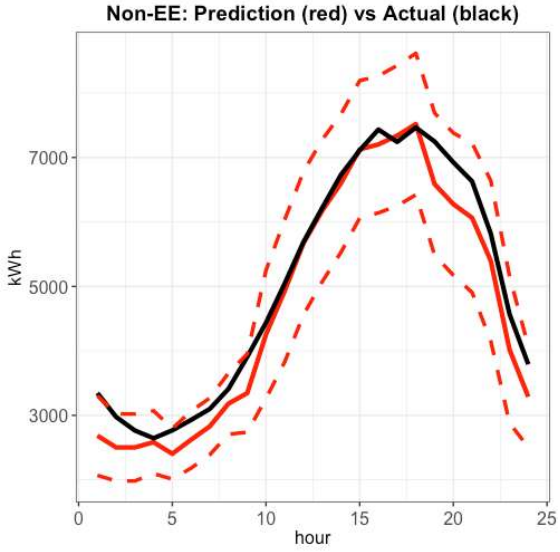
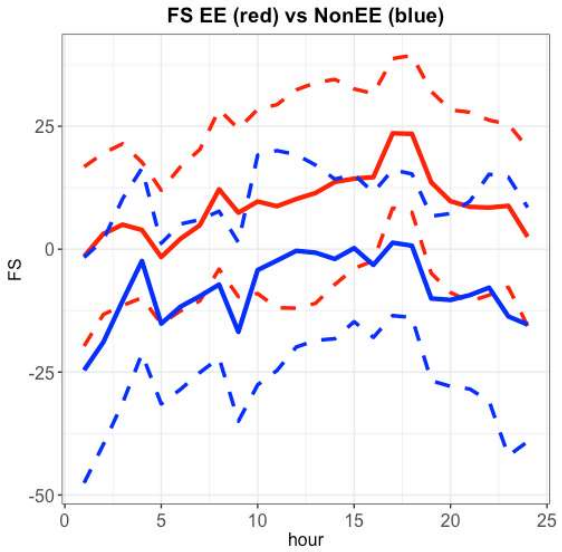


- B07 is the substation that has the highest hourly difference between predictions and actual energy consumption



What is the impact of the EE programs on peak demand? --Summary--

- The modeling approach applied to analyze the peak day showed that the statistical uncertainty surrounding the hourly prediction of the energy consumption is significantly high in comparison to the estimated decrease (or increase) in energy consumption

- There is a need to develop a more adapted modeling technique to provide more accurate (and less uncertain) hourly prediction of high energy consumption periods

Summary

- Overall the study reveals that meter-based analytics can reveal disaggregated savings patterns at the grid level and provide useful insights at specific substations and feeders.
- Method could be integrated into EE impact tracking process to capture temporal and locational benefits
- This can be valuable in quantifying past utility program activities and targeting future DSM efforts, while also providing a useful comparison through analysis of non-participants.
- This methodology could be extended to assess NWA scenarios of intentional targeting
- Future work could include looking at how ratios of residential vs commercial and other customers at each feeder and substation effects overall savings at the distribution level