Forecasting the Uptake of Low Carbon Technologies (LCTs)

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Outline

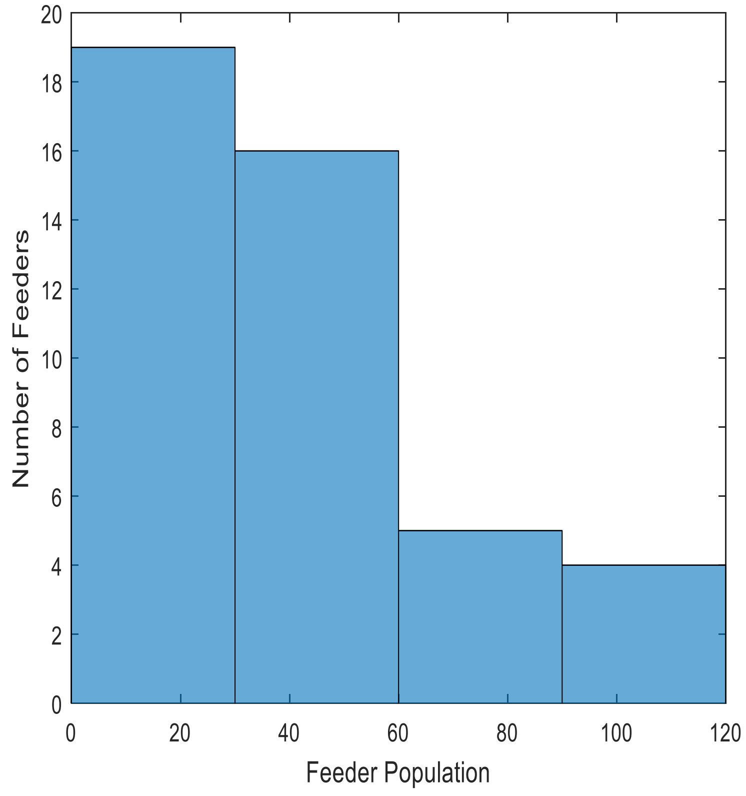
1. Introduction
2. Modelling LCT uptake: The clustering method
3. Uncertainty of the model
4. Introducing additional model features
5. Applications

Introduction

- Low-carbon technologies (LCTs) are expected to be widely adopted in the UK.
- We predict the impact by applying a clustered distribution of these technologies to a sample UK population (Bracknell, UK).
- This clustering method ensures that a household is more likely to acquire a LCT if their neighbour has one.
- We begin with three data sets that correspond to one day in winter, spring and summer. These are energy profiles per household (base loads).
- This sample data comprises of 1848 properties, 7 households with photovoltaics (PVs) , 71 commercial properties and 44 feeders. (This has now been extended to 261 feeders).
- The focus here is the uptake of electric vehicles (EVs), although we have also considered the uptake of PVs and heat pumps.

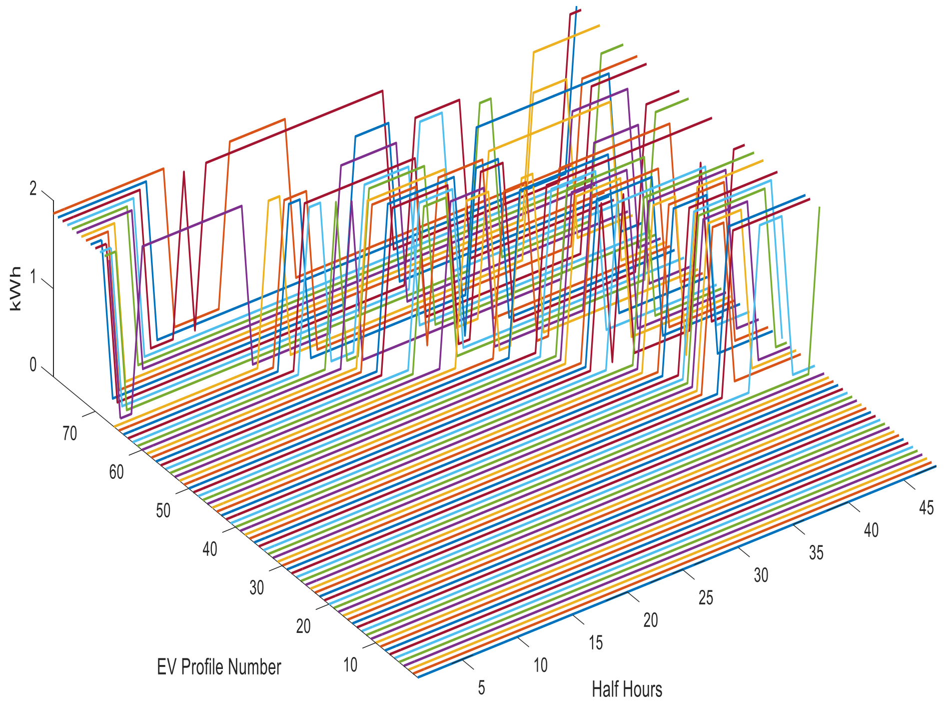
Feeder Populations

- 80% of feeders have a population of 60 households or less.
- Minimum feeder population is 4.
- Maximum feeder population is 114.
- 44 feeders in total.
- For our model, a feeder represents one neighbourhood.



EV profiles

- The EV charging profiles used are from the My Electric Avenue trial (duration of 55 weeks).
- We use 79 EV daily profiles that are representative of winter, spring and summer.
- These are from three separate days of the trial and correspond to the dates of the base loads.
- For the other technologies, we use profiles representative of household usage.



SUMMER

Modelling the uptake of LCTs: EV allocation method

1. Firstly, we establish the percentage of households in the sample that will adopt EVs and the number of years it will take (linear increase assumed).
2. Next, a random distribution of EV seeds is performed to simulate the first year of EV uptake.
3. Then, during the remaining years, EVs are distributed such that households are more likely to receive one if their neighbour has an EV or PV (**a neighbourhood corresponds to a feeder**). As a result, clusters form around the seeds.
4. The number of EV households increases until limit obtained.
5. Then the corresponding EV profile is added to the household's base load profile.

The Thames Valley Vision Project

- Scottish and Southern Electricity Networks use these LCT models as input to their network modelling software.
- Assess voltage and thermal issues.
- As a result, they generate network maps, where certain regions of the network are highlighted due to the impact of LCTs.

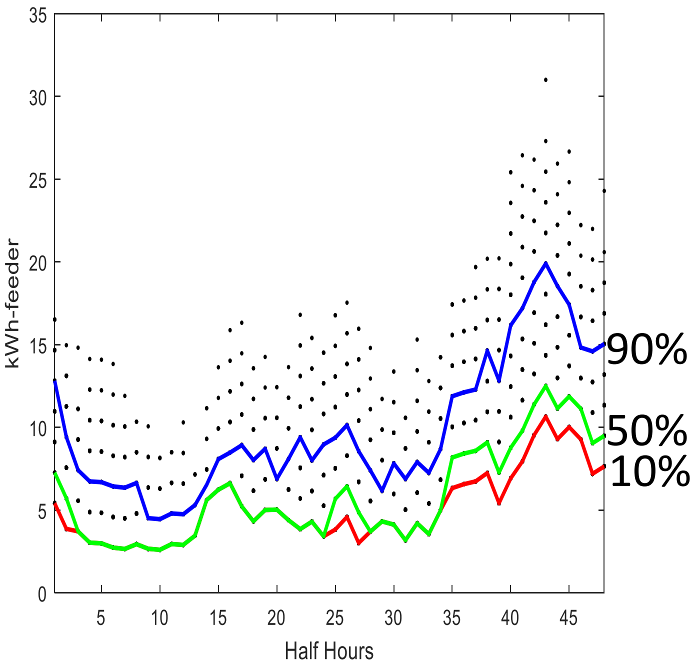
Calculate Uncertainty

- For some fixed uptake percentage, there are many feasible model outcomes.
- We determine an upper and lower bounds for the model response (calculated at the feeders)- **confidence bounds**.
- Highlight problem feeders.
- Computing the confidence bounds:
  - Specify the model parameters i.e. 30% EV uptake.
  - Complete 500 simulations of the EV clustering method.
  - After each simulation, record the aggregate result at the feeder (44 feeders in total).
  - This aggregate data is then used to calculate 10%/50%/90% quantiles at the feeder.
  - The feeder lower and upper bounds correspond to the 10% and 90% quantiles.

Results for 30% EV:
Initial seed distribution is random

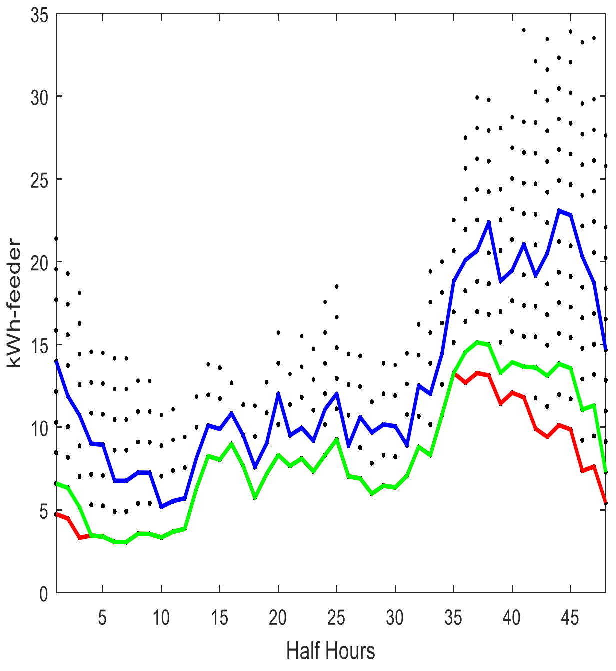
FEEDER 16: 27 HOUSEHOLDS, 0 PV, 0 COMMERCIAL

SUMMER



FEEDER 16: 27 HOUSEHOLDS, 0 PV, 0 COMMERCIAL

WINTER



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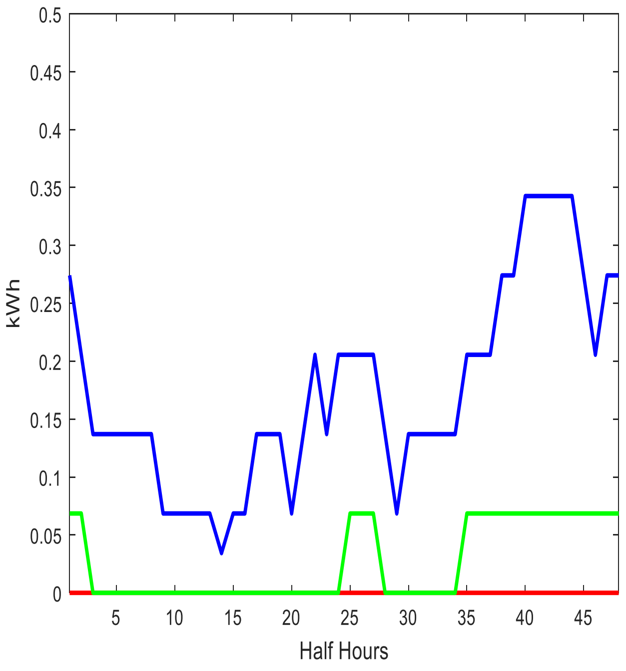
SUMMER

Quantile minus base load, divided by number of households (EV load)



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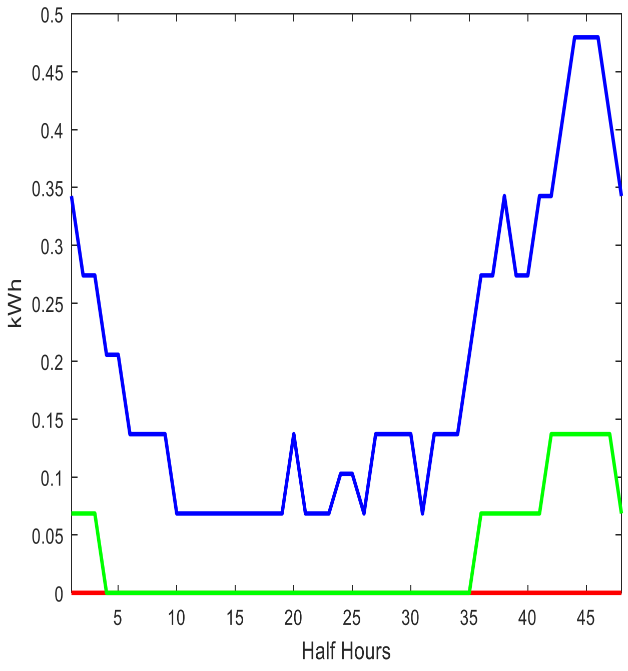


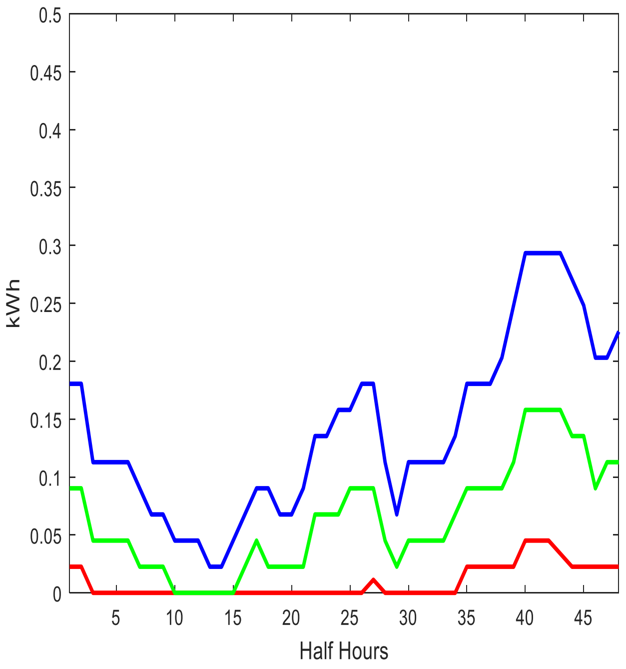
- Increased activity summer day
- Larger peak winter night
- Feeder missed EV allocation- feeder size

Results for 30% EV:
Initial seed distribution is random

FEEDER 4: 82 HOUSEHOLDS, 0 PV, 1 COMMERCIAL

SUMMER

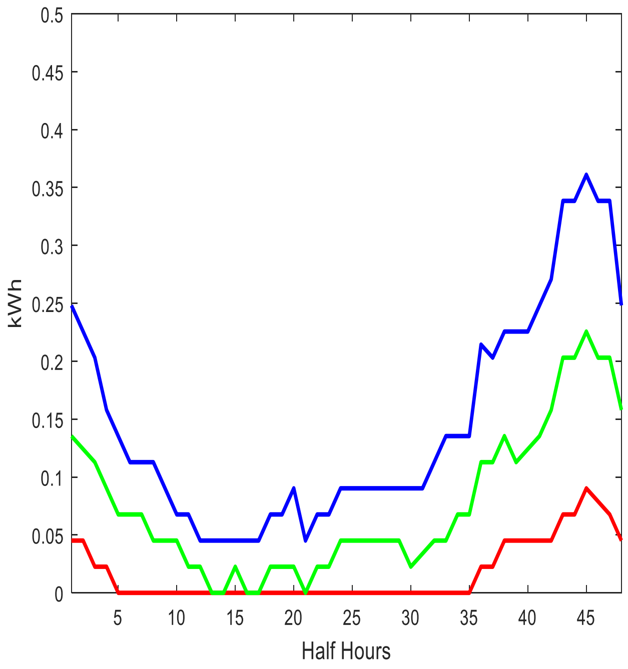
Quantile minus base load, divided by number of households



FEEDER 4: 82 HOUSEHOLDS, 0 PV, 1 COMMERCIAL

WINTER

Quantile minus base load, divided by number of households



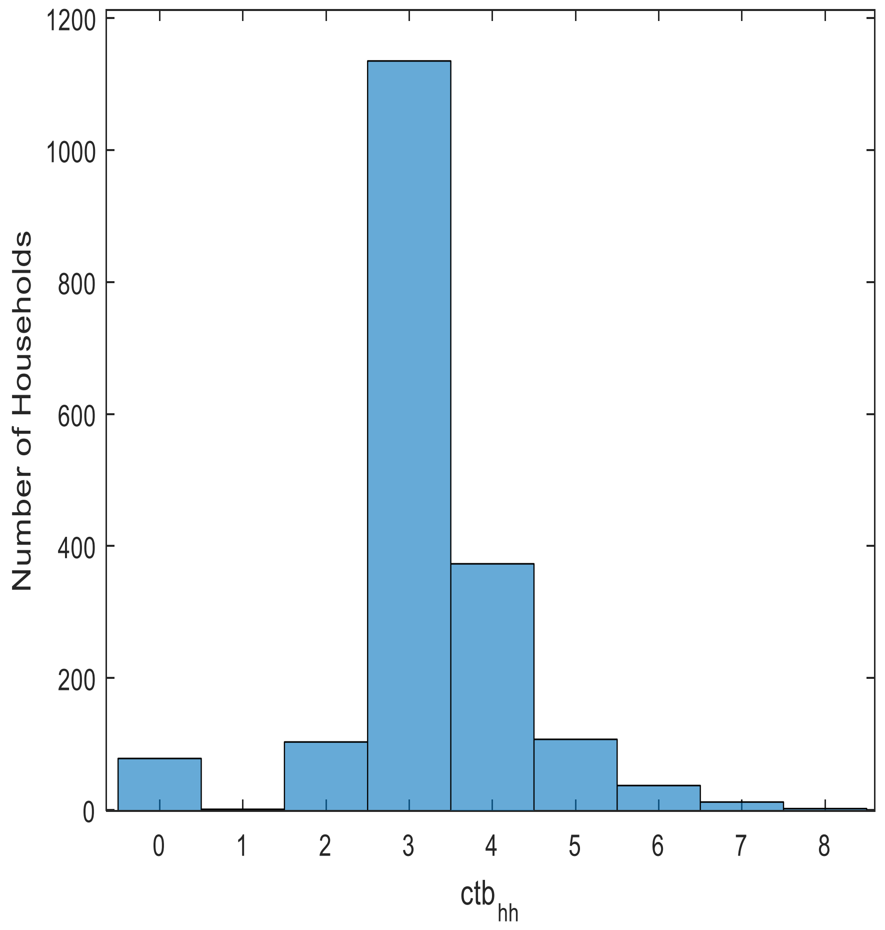
- Feeder generally receives some EVs-feeder size
- Peak smaller due to more households-diverse environment

Additional model features
Council tax bands

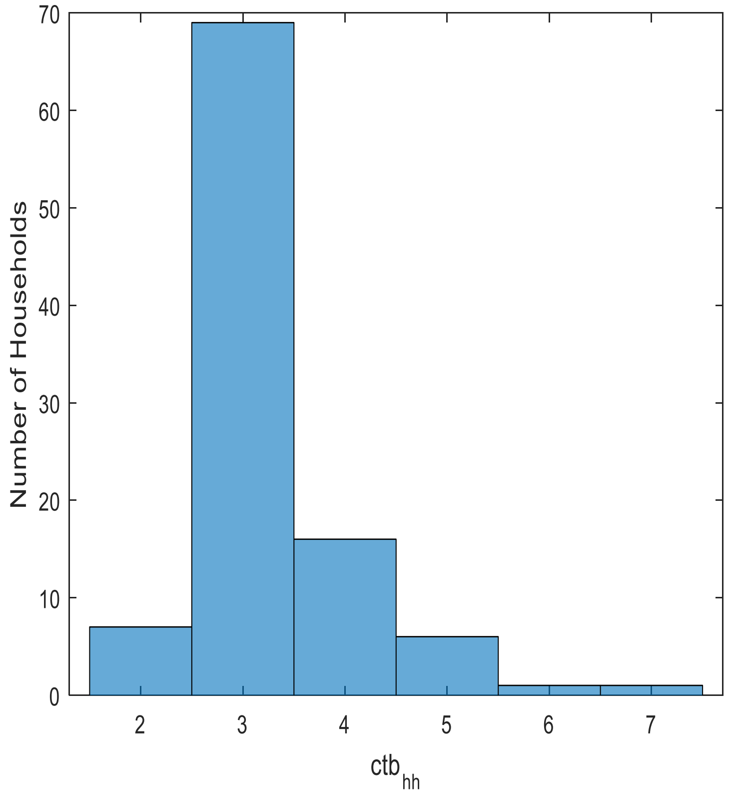
- We introduce household council tax bands to instead inform seed distribution (assume larger households have higher council tax band).
- A previous study suggests current EV owners (US) generally live in larger households that have parking and space to install a charging point.
- Also, present EV owners commonly have a PV installed at their house.
- Therefore, we want the seeds to be guided by CTB and PVs, and then neighbour influence to determine EV growth.
- Confidence bounds can measure the effect of introducing this model assumption.

Council Tax Bands

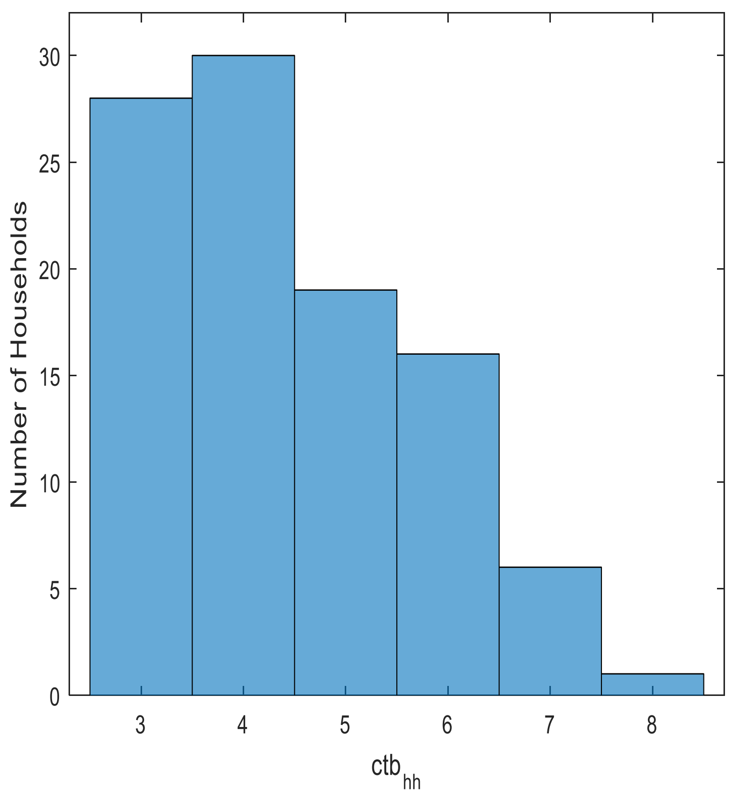
- CTB A=1 (1)
- CTB B=2 (103)
- CTB C=3 (1135)
- CTB D=4 (373)
- CTB E=5 (107)
- CTB F=6 (37)
- CTB G=7 (12)
- CTB H=8 (2)
- Non-residential=0 (78)



Compare the distribution of seeds



Result of 100 seeds distributed **randomly**



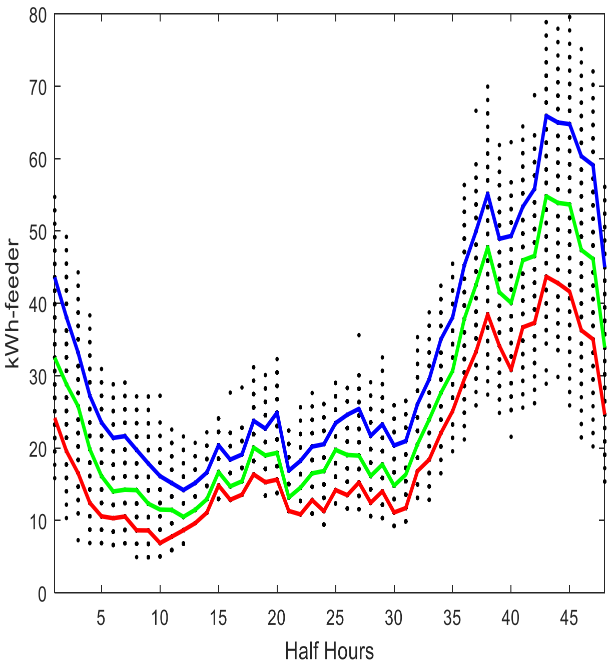
Result of 100 seeds distributed informed by CTB

Improved representation of initial EV uptake

Results for 30% EV: Initial seed guided by CTB

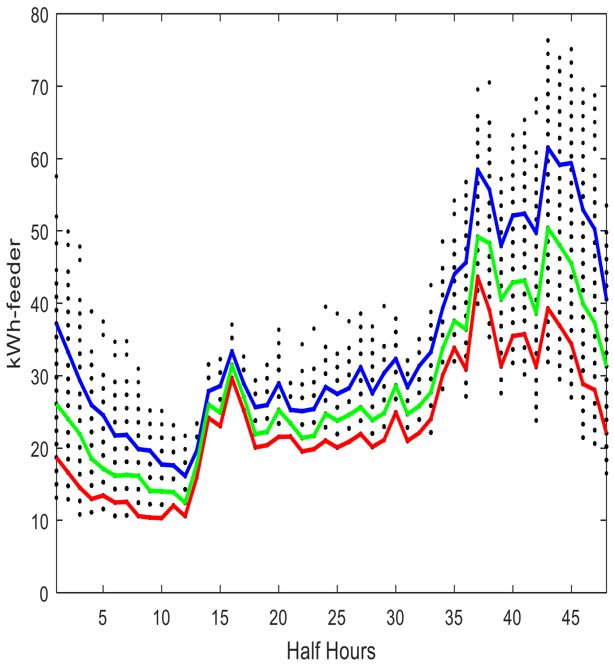
FEEDER 4: 82 HOUSEHOLDS, 0 PV, 1 COMMERCIAL, CTB>4=54%

WINTER



FEEDER 43: 86 HOUSEHOLDS, 1 PV, 2 COMMERCIAL, CTB>4=0%

WINTER



Feeders are same size so expect to have similar EV load

Results for 30% EV:
Initial seed guided by CTB

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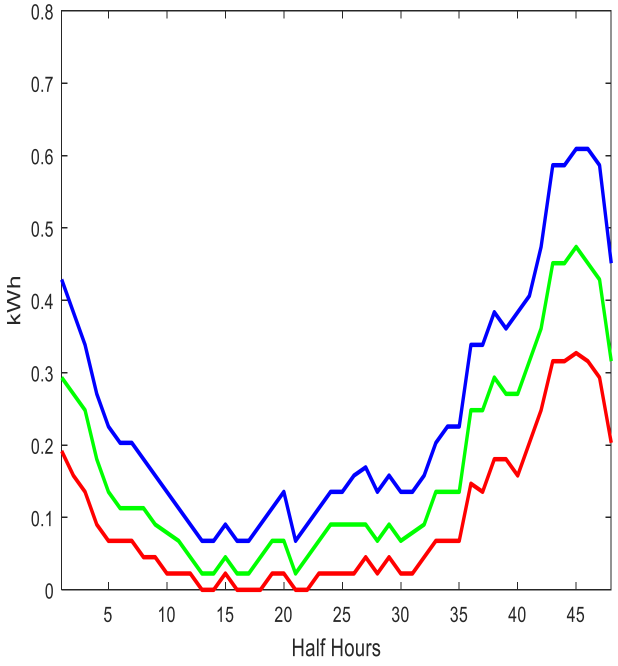
WINTER

Quantile minus base load, divided by number of households



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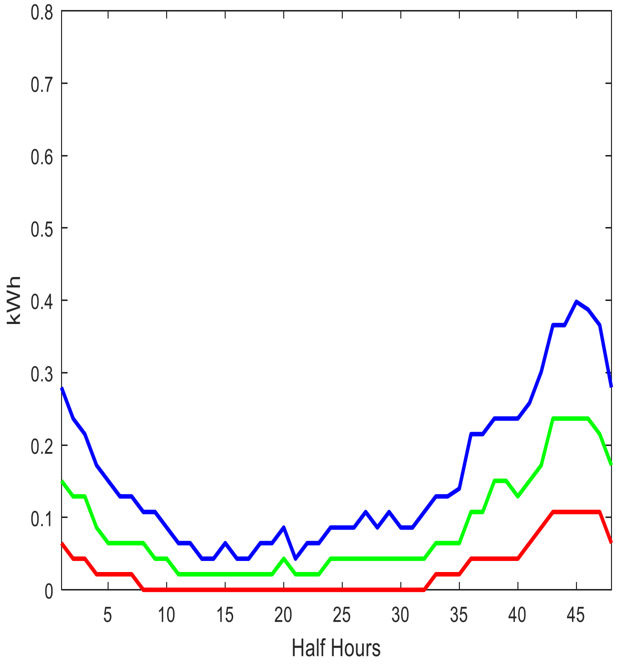
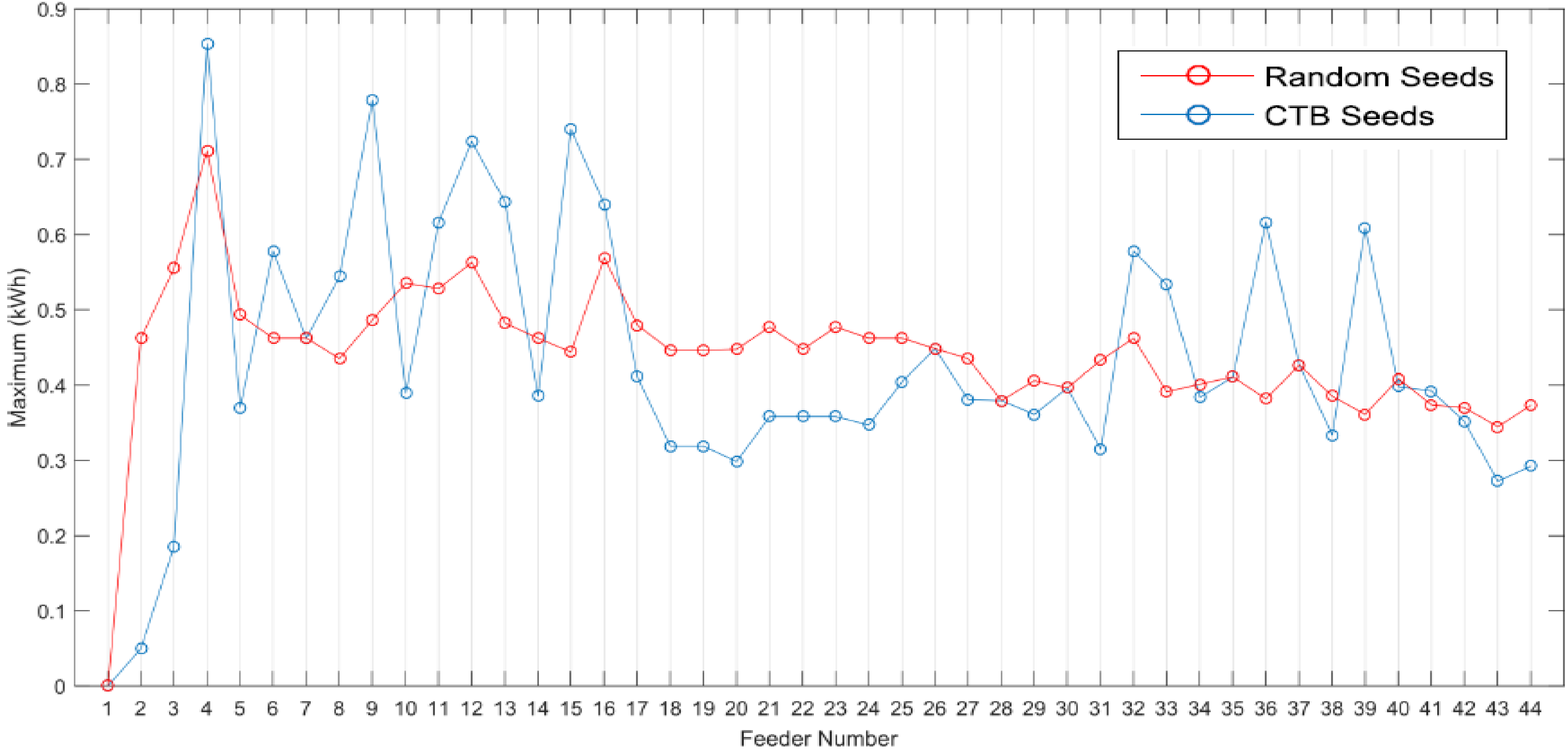


- Feeder 4 has larger EV load
- Quantiles used to measure impact of changing model assumptions

Overview of results at all 44 feeders- Maximum of the EV upper bound/ number of households



Applications

- Assess the inner workings of the model and the effect of changing model assumptions.
- The feeder upper bounds can be used as input to network modelling software to assess voltage and thermal issues.
- Highlight vulnerable sites of the network.

Conclusion

1. The EV allocation method for forecasting uptake
   - Initial random seed- first year.
   - Clusters formed around the seeds- neighbour influence.
2. Uncertainty
   - Upper and lower bounds for the model response at feeders.
   - Highlight problem feeders.
3. Introducing additional model features
   - Initial seeds guided by CTB
   - Use confidence bounds to measure the change in model response due to new assumptions.