Revisiting Selection of Residential Consumers for Demand Response Programs

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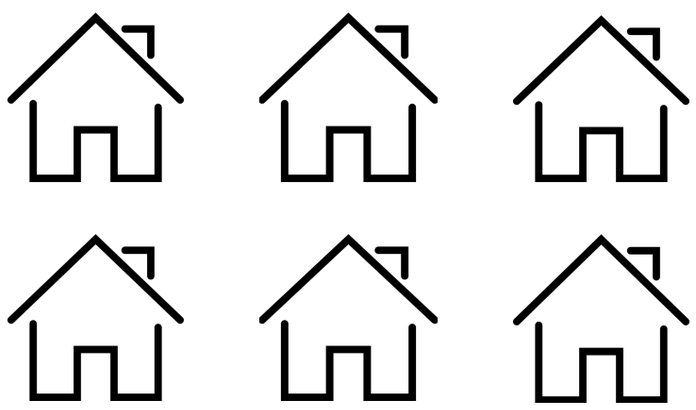
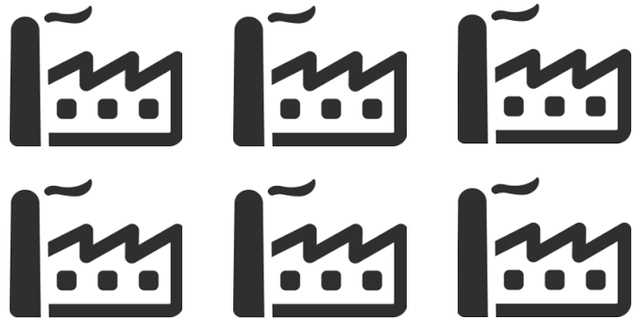
Run Demand Response (DR) Program

Demand Response program is run between an electric utility and electricity consumers

Electric Utility



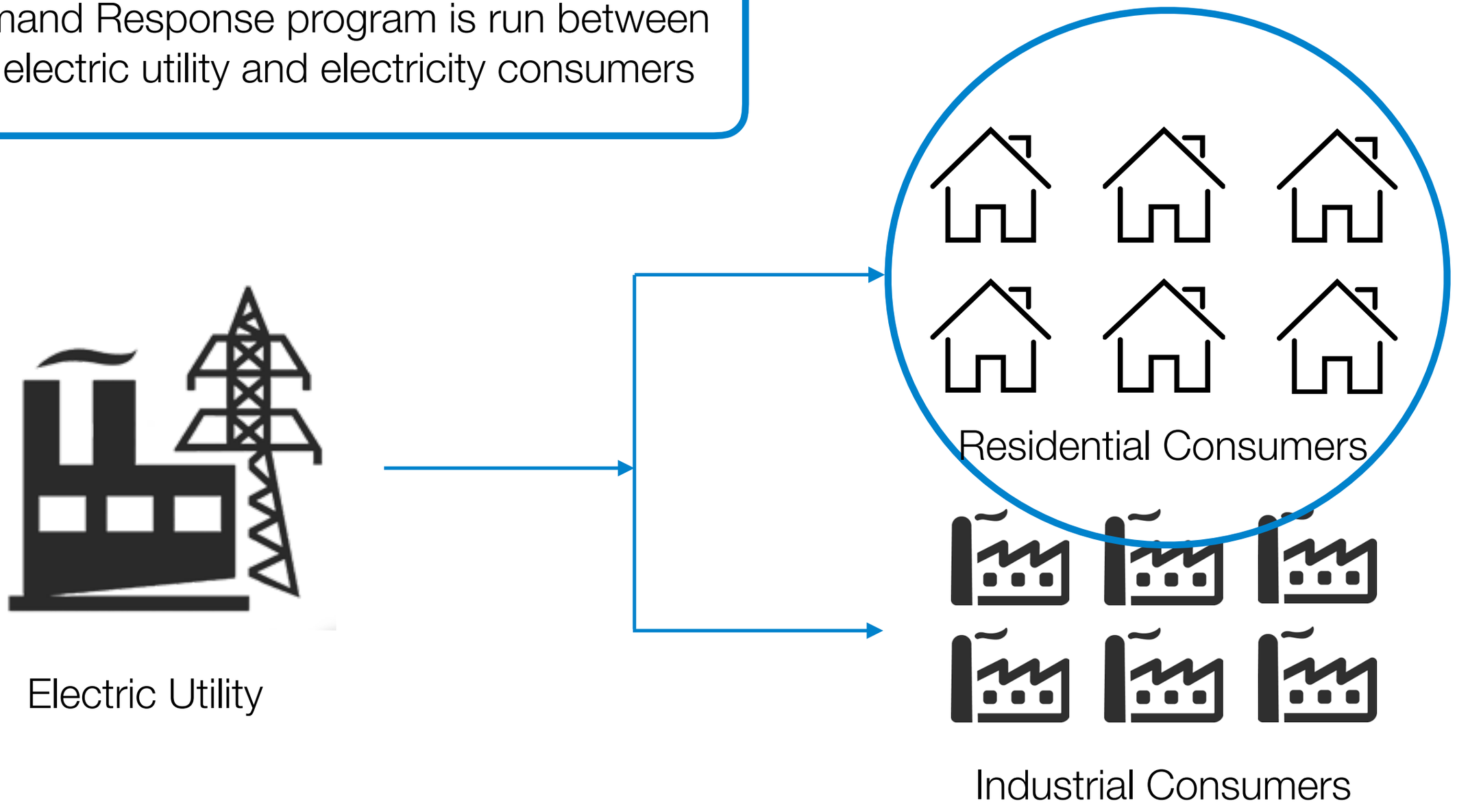
Residential Consumers



Industrial Consumers

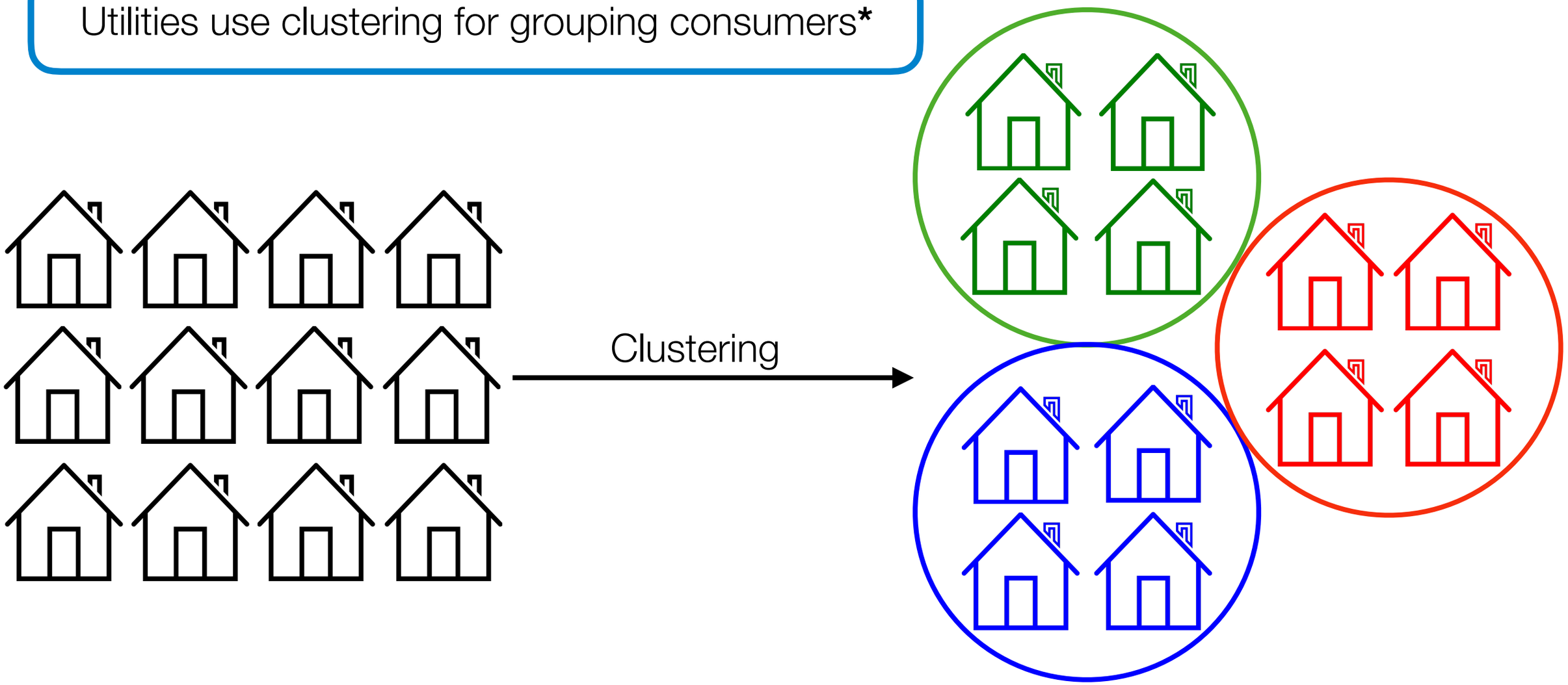
Run Demand Response (DR) Program

Demand Response program is run between an electric utility and electricity consumers



How does Utilities Select Consumers for DR?

Utilities use clustering for grouping consumers*



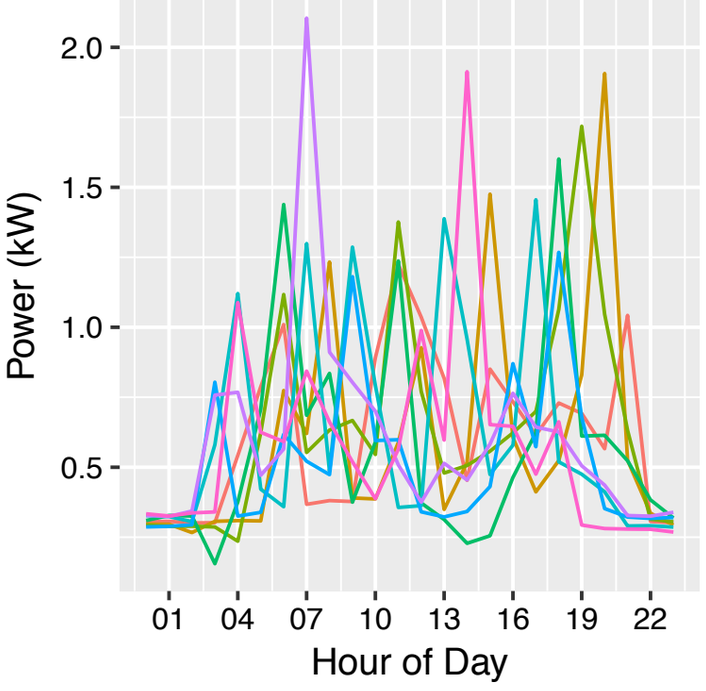
Consumers meter data

Similar consumers group together

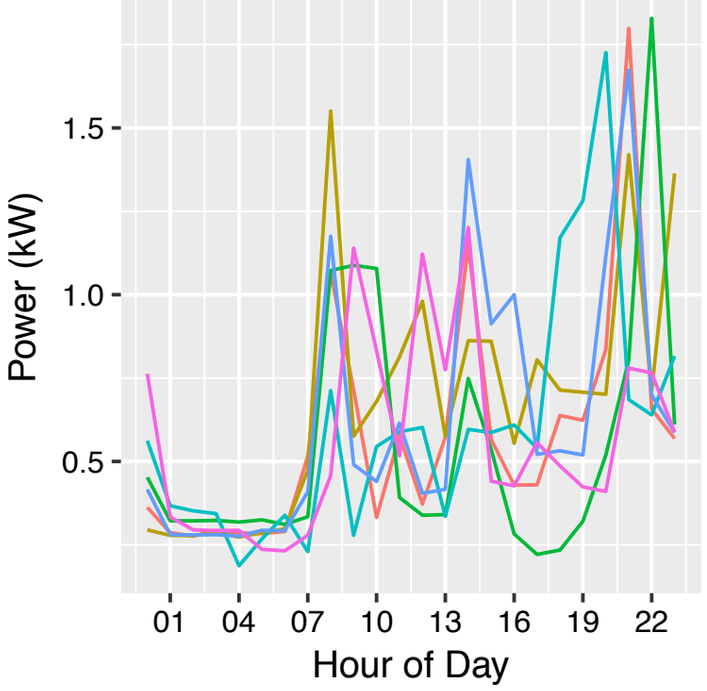
*J. Kwac et al. Household energy consumption segmentation using hourly data, IEEE transactions on Smart Grid, 2014

How does Utilities Find Consumers with a Consistent Pattern?

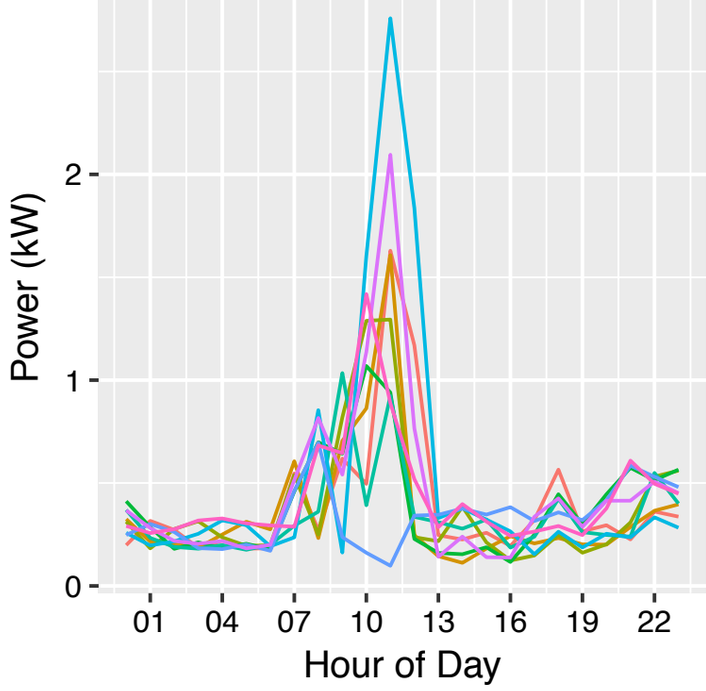
A Consumer is consistent if it follows the same energy consumption pattern over consecutive days.



Apartment 1



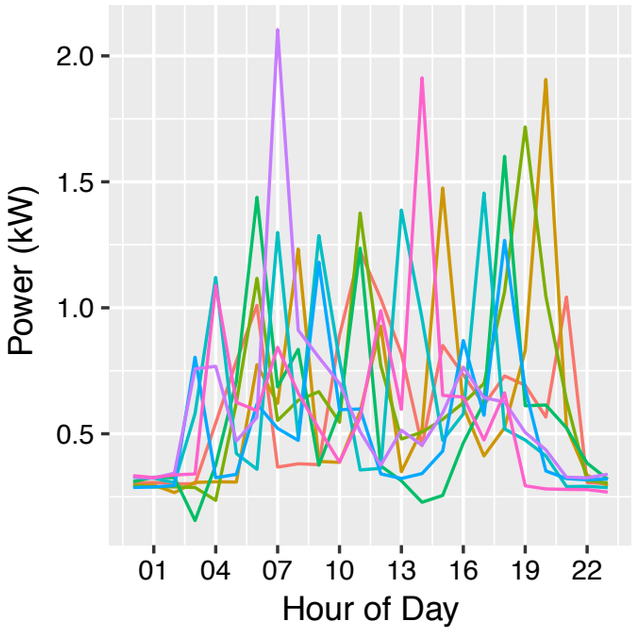
Apartment 2



Apartment 3

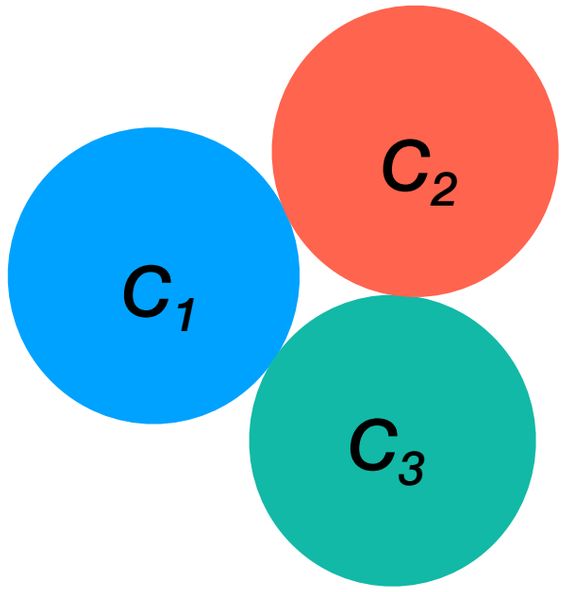
Existing Approach to Measure Consumer's Consistency

Entropy based metric*



Apartment 1

Clustering, $k = 3$

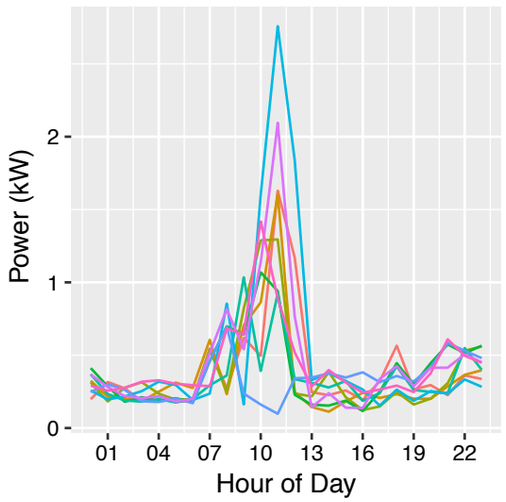


Clusters

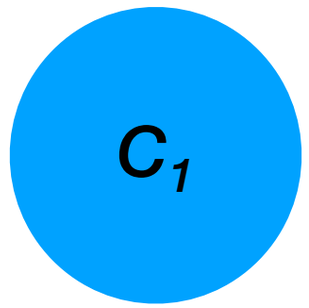
$$Entropy, H = -\sum_{i=1}^{k} p(c_i) * log(p(c_i))$$

*J. Kwac et al. Household energy consumption segmentation using hourly data, IEEE transactions on Smart Grid, 2014

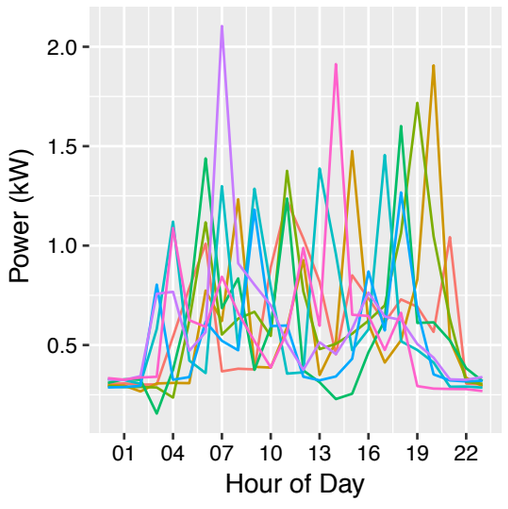
Existing Approach to Measure Consumer's Consistency



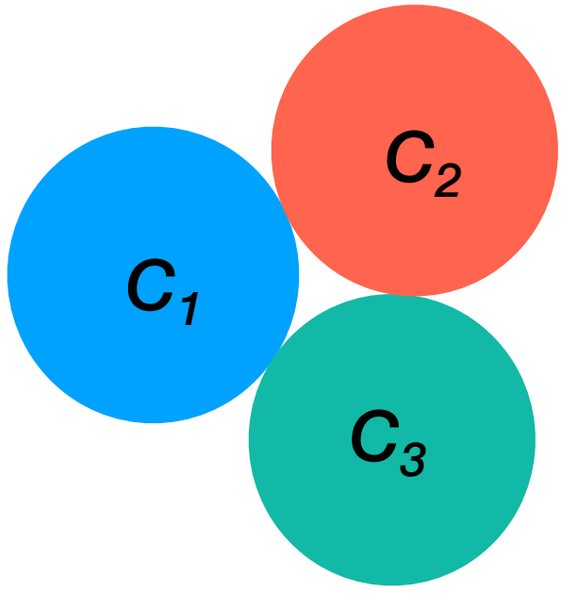
Clustering, $k = 1$



$H = 0$



Clustering, $k = 3$

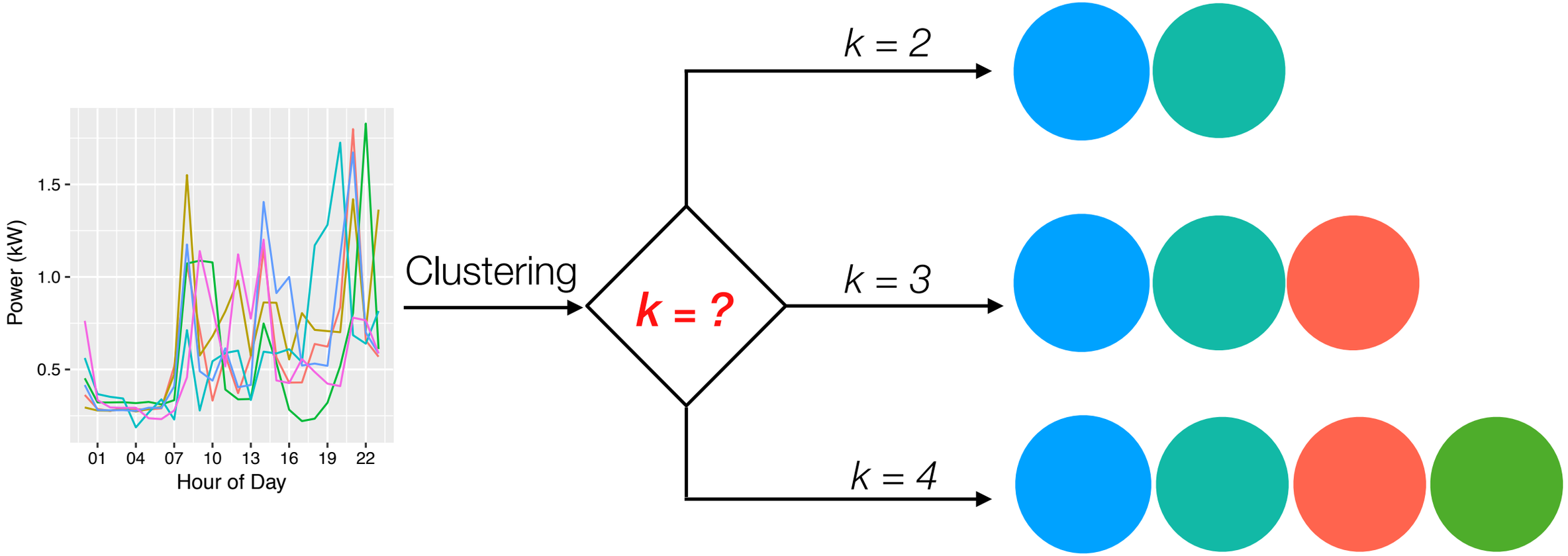


$H > 0$

Consumers having zero entropy are most consistent

Issue with the Existing Approach

- Entropy measure depends on the value of *K,* number of clusters
- Knowing correct *K* value for every consumer is hard



Outline

- Demand Response (DR) program
- Clustering to select consumers for DR
- Entropy metric to measure consumer's consistency
- Proposed consistency metric
- Experimental results
- Conclusion

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Our Approach to Find Consumer's Consistency

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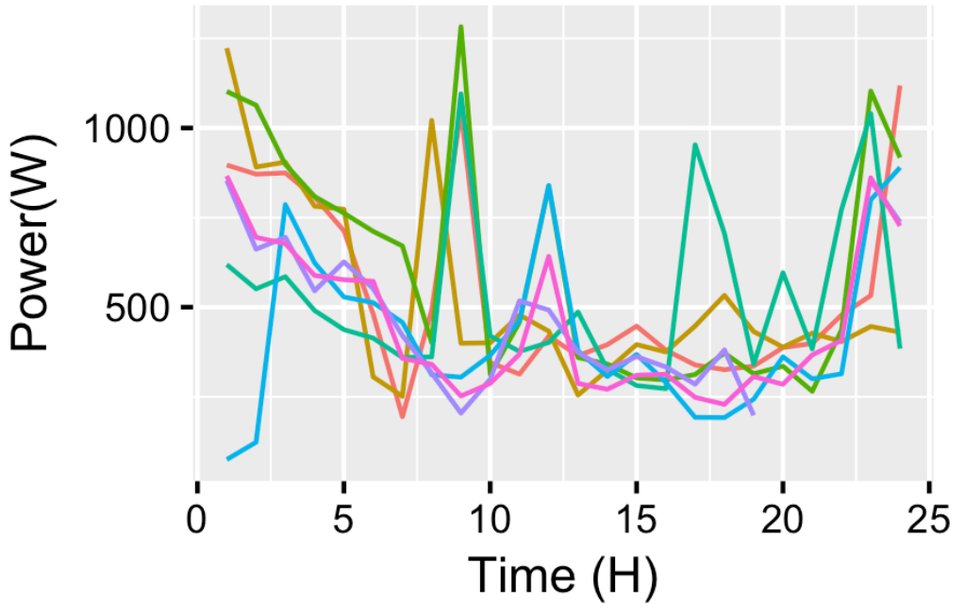

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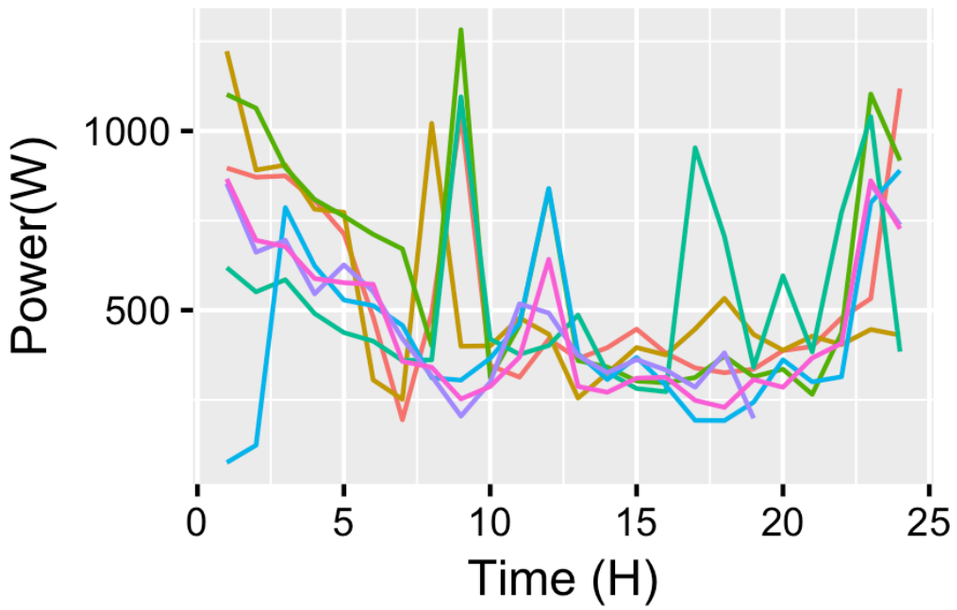

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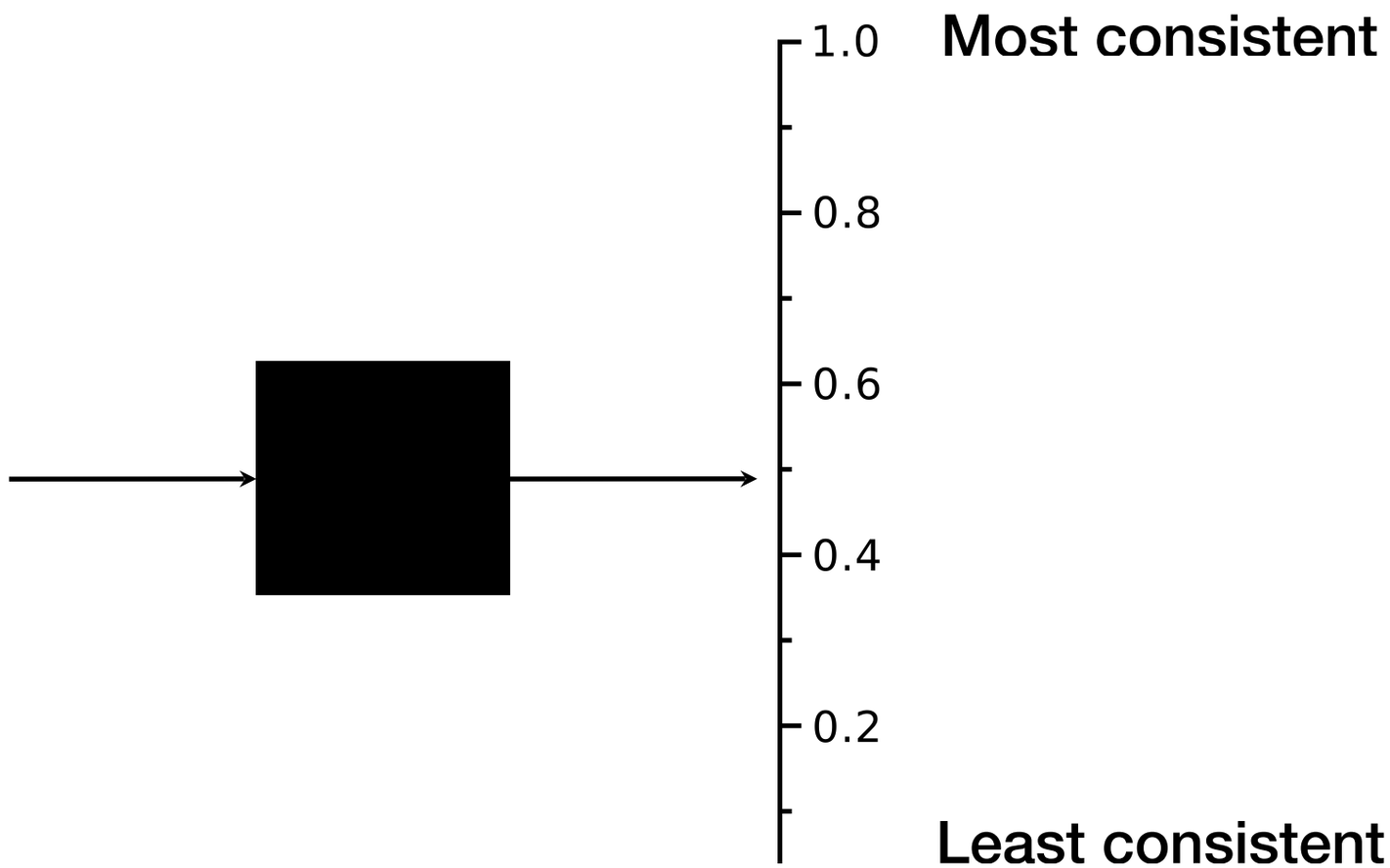
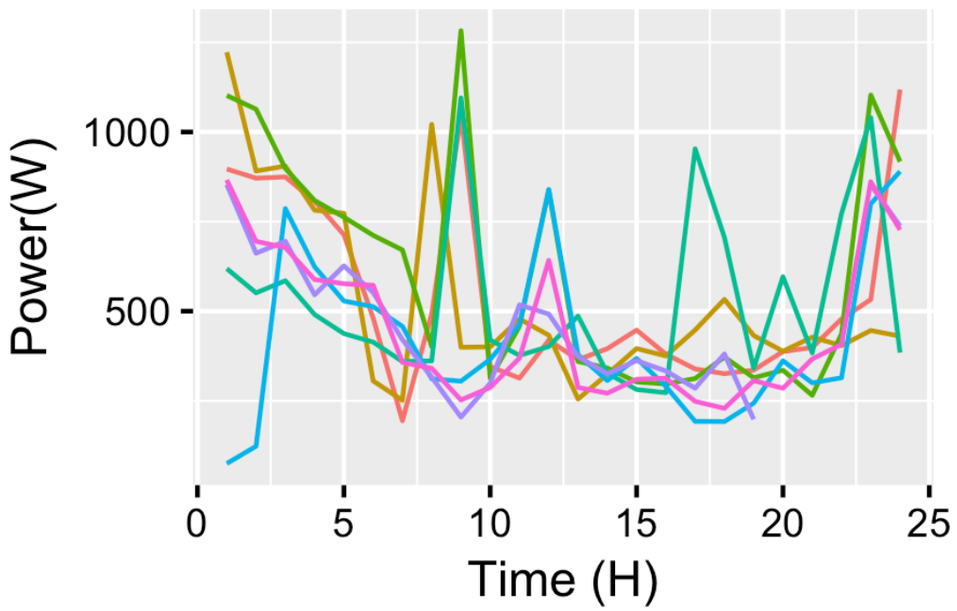


Score

Our Approach to Find Consumer's Consistency



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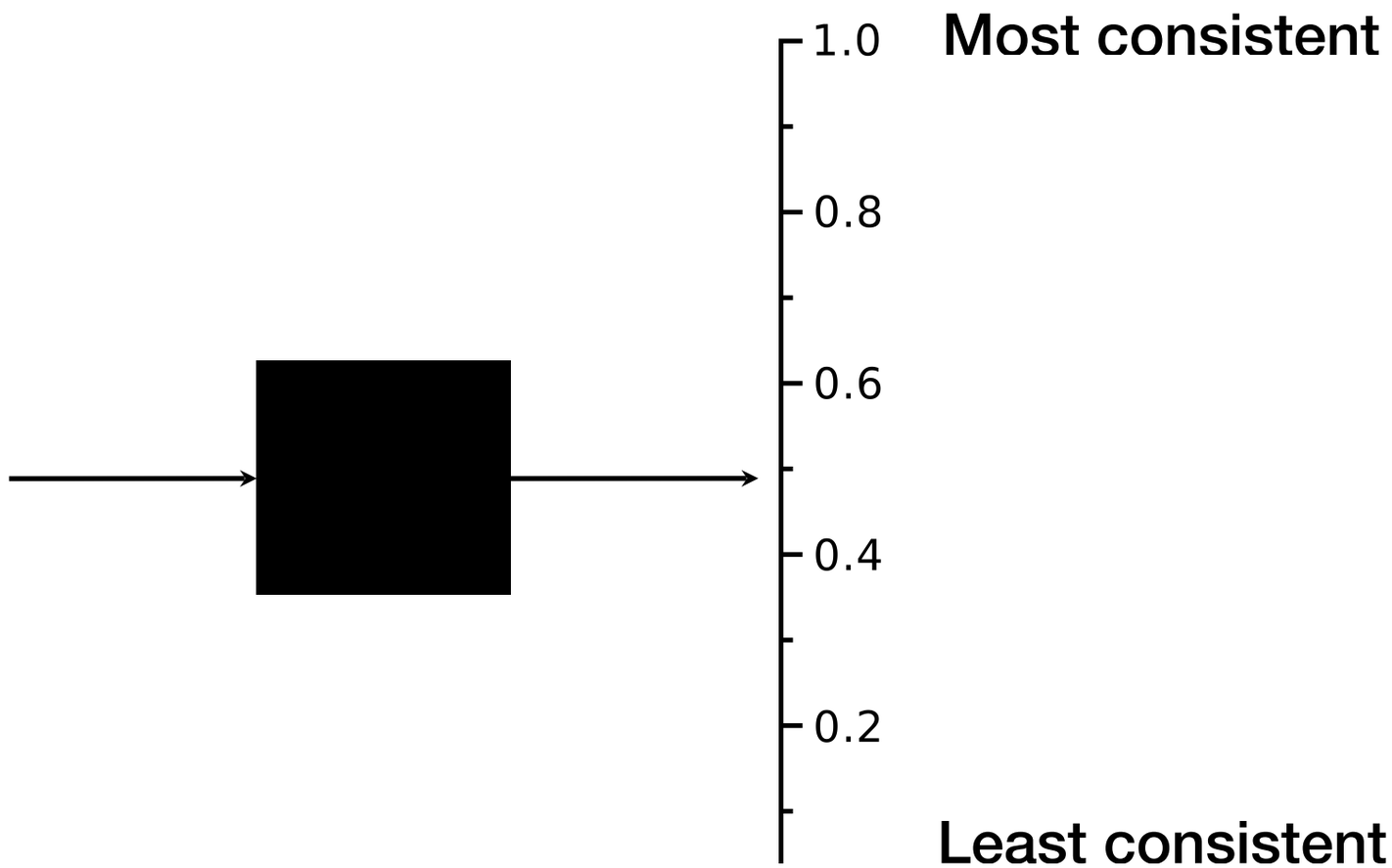
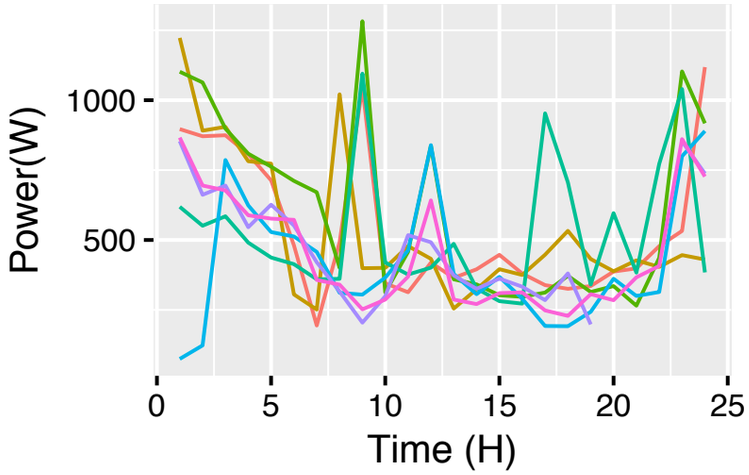


Score

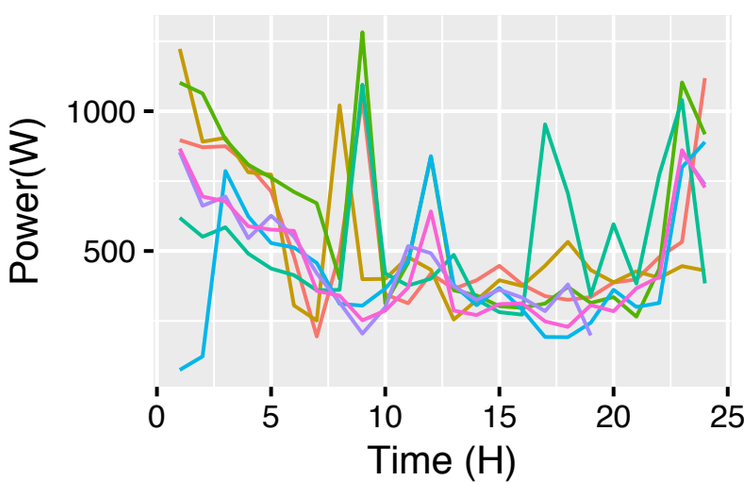
Utmost consistent consumer gets a consistency score of 1 and an inconsistent consumer gets a score of 0

Steps to Find Consumer's Consumption Score



Consumer's Consumption

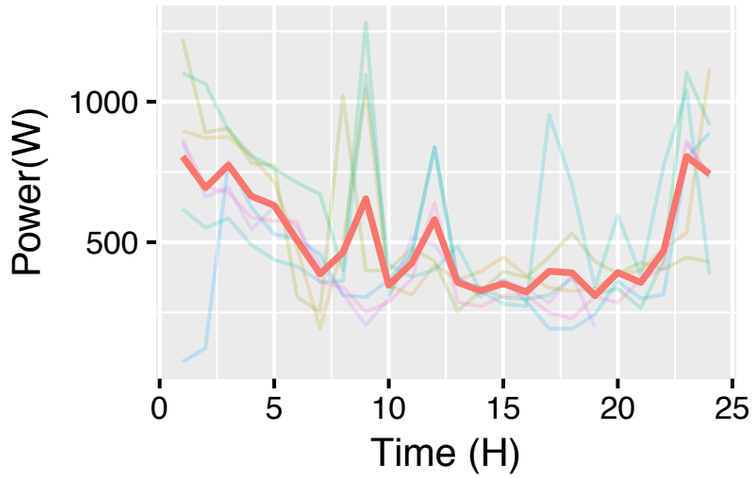
Steps to Find Consumer's Consumption Score



Consumer's Consumption

1

Compute Mean



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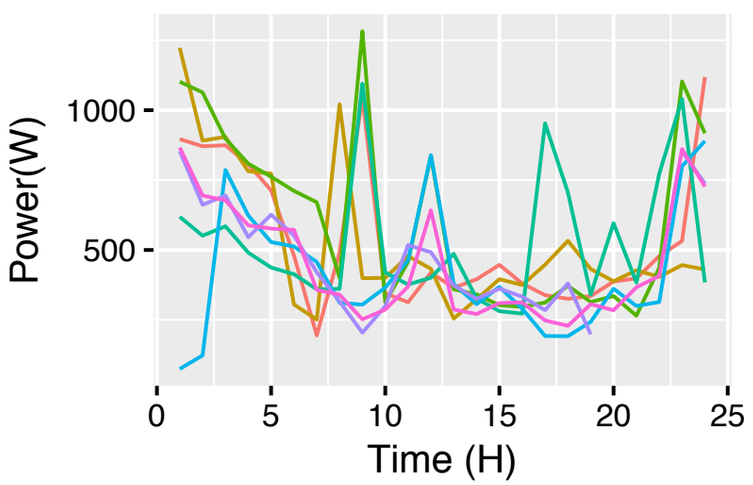

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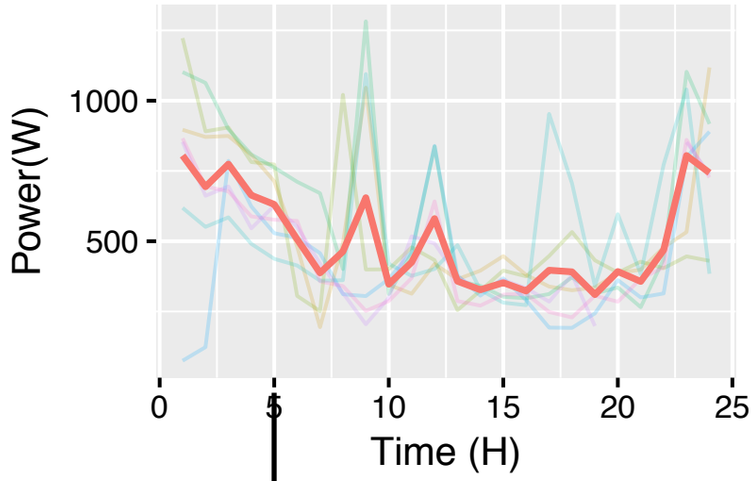
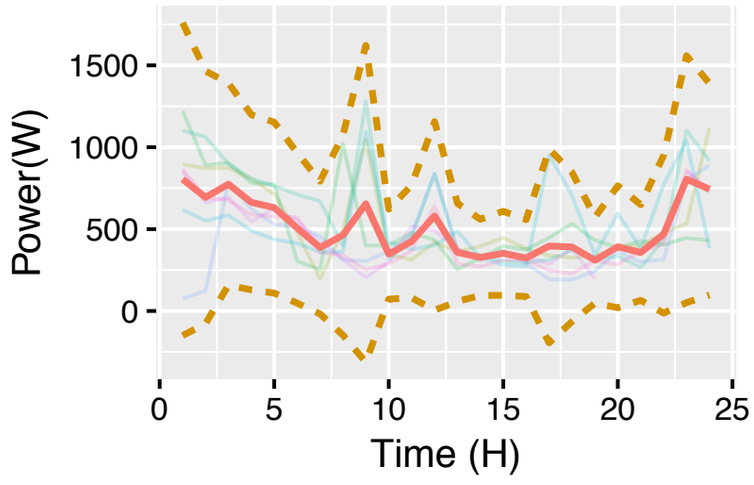


2

Compute Standard deviation



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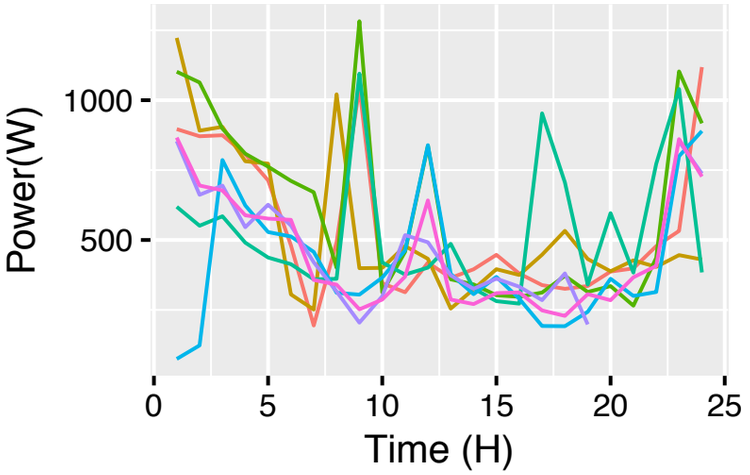
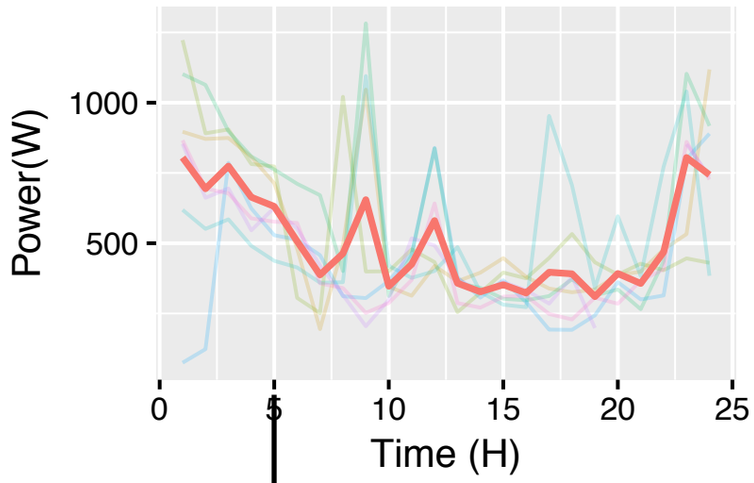


Consumer's Consumption

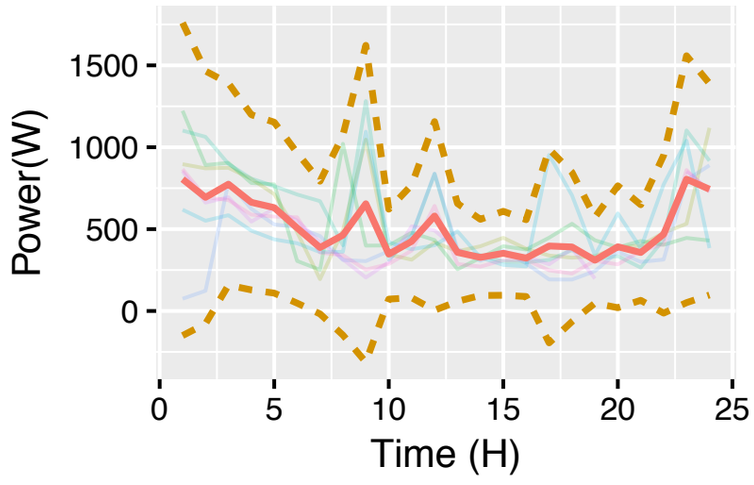
1

Compute Mean



2

Compute Standard deviation

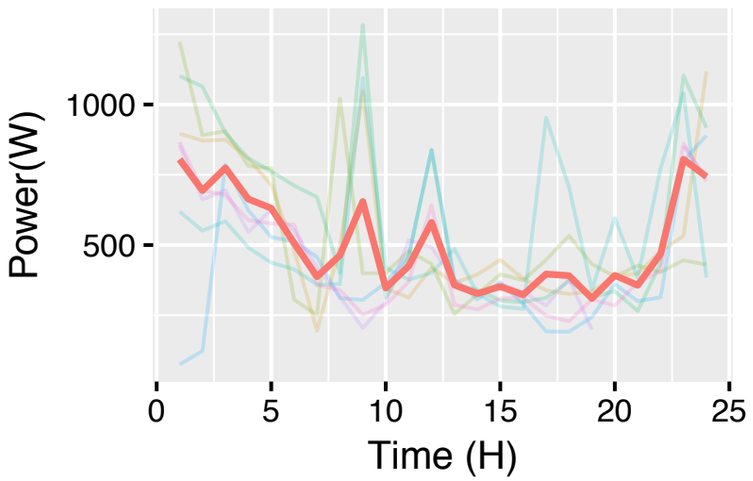


3

Score =

$$\frac{\text{No. of days within standard deviation band}}{\text{Total number of days}}$$

Steps in Finding Peaks and Their Locations



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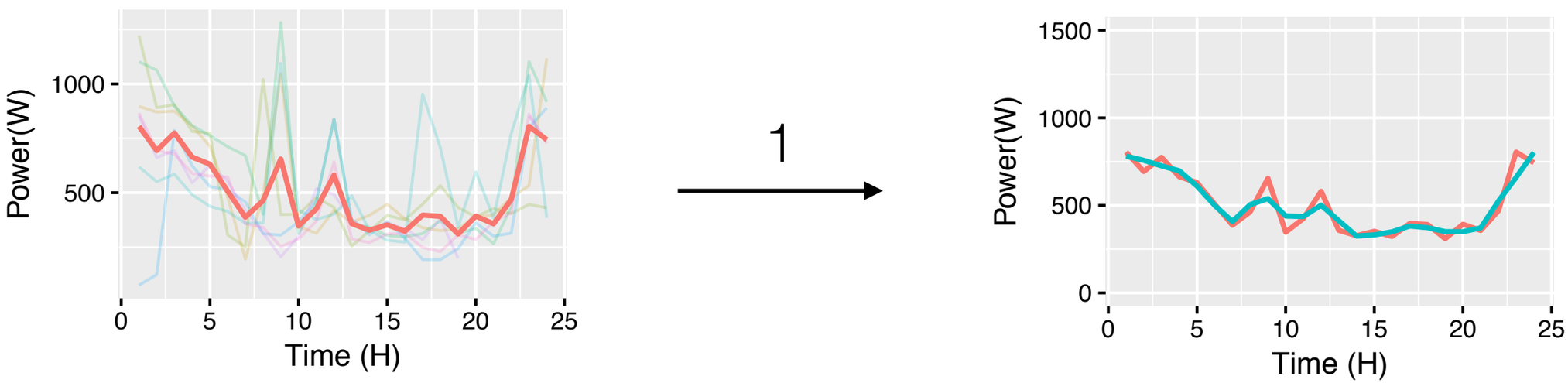

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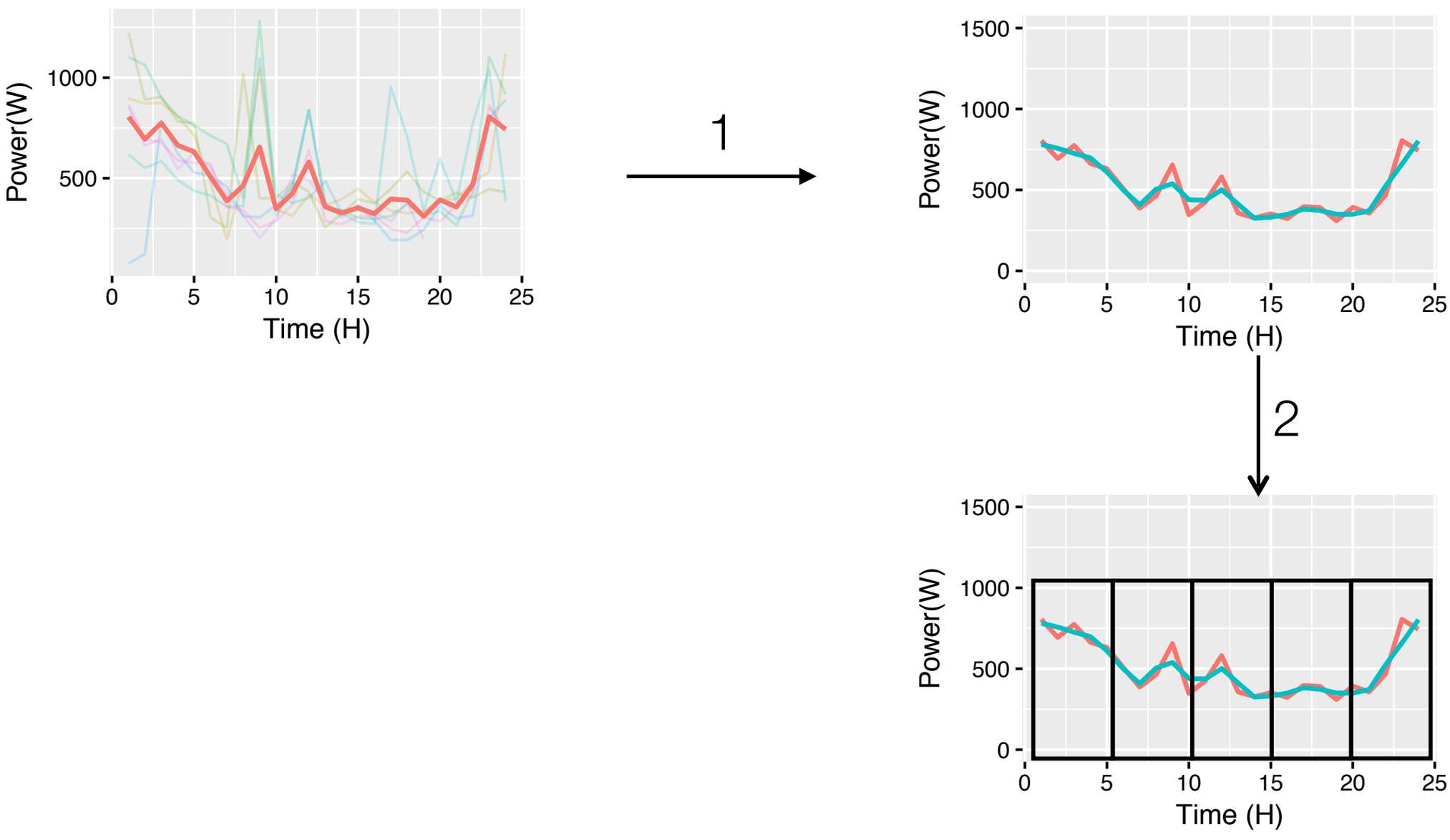

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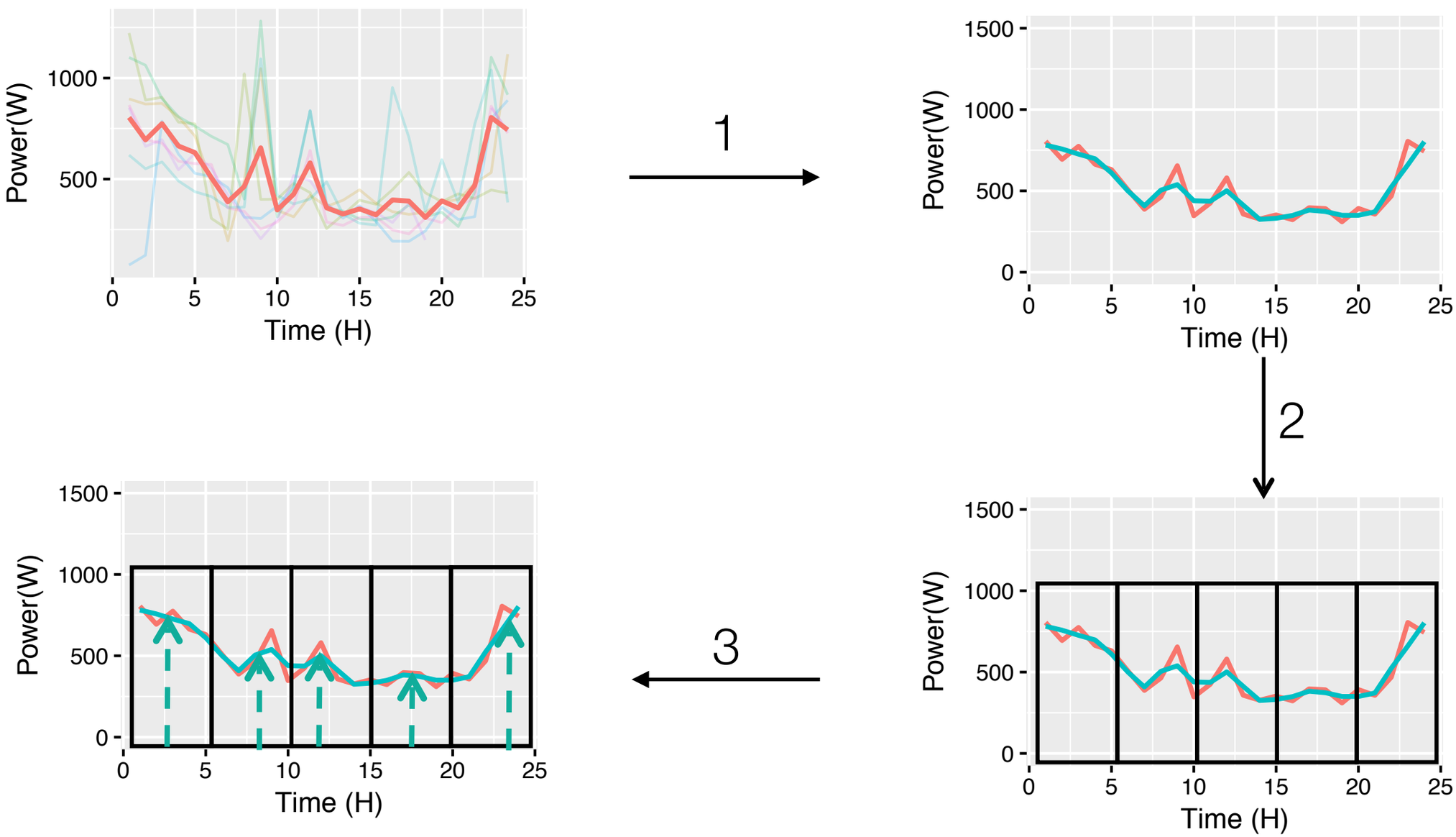

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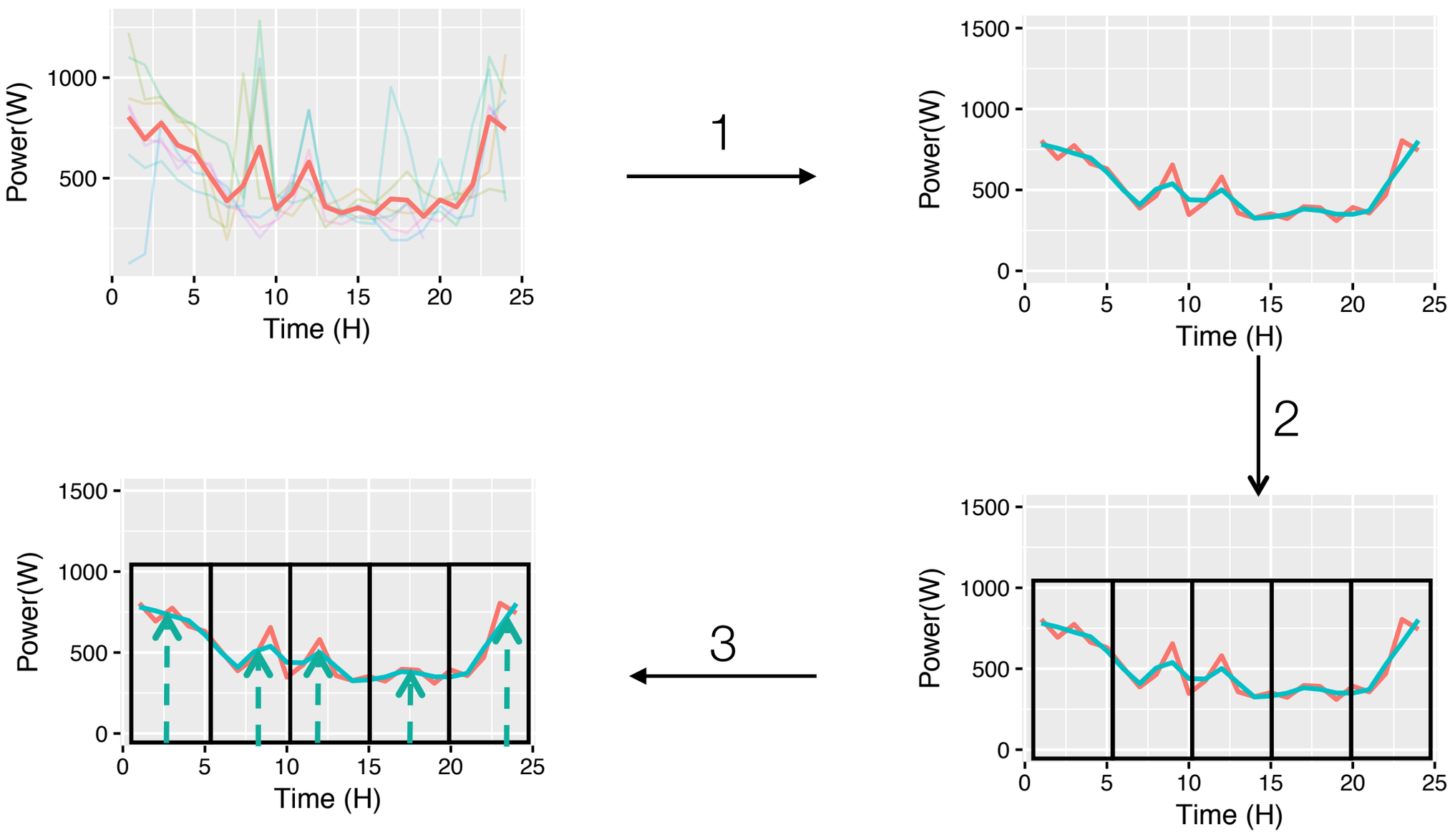
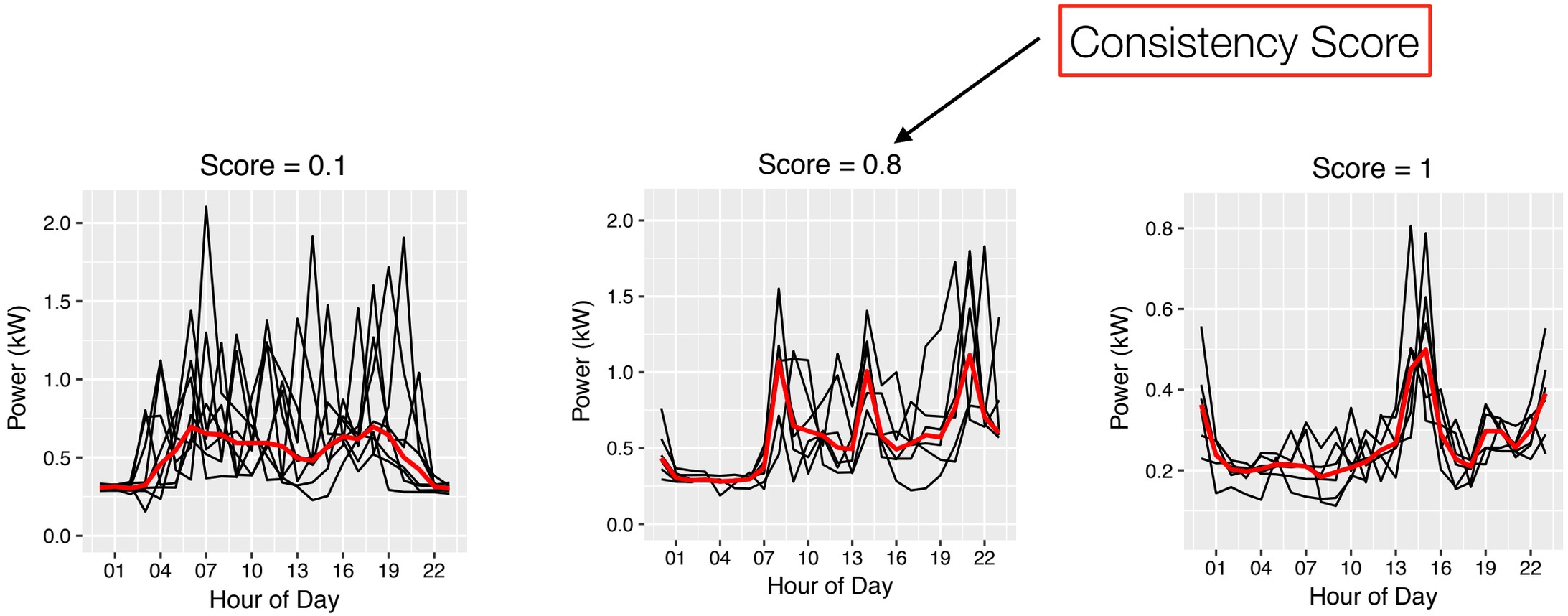


Experimental Setup

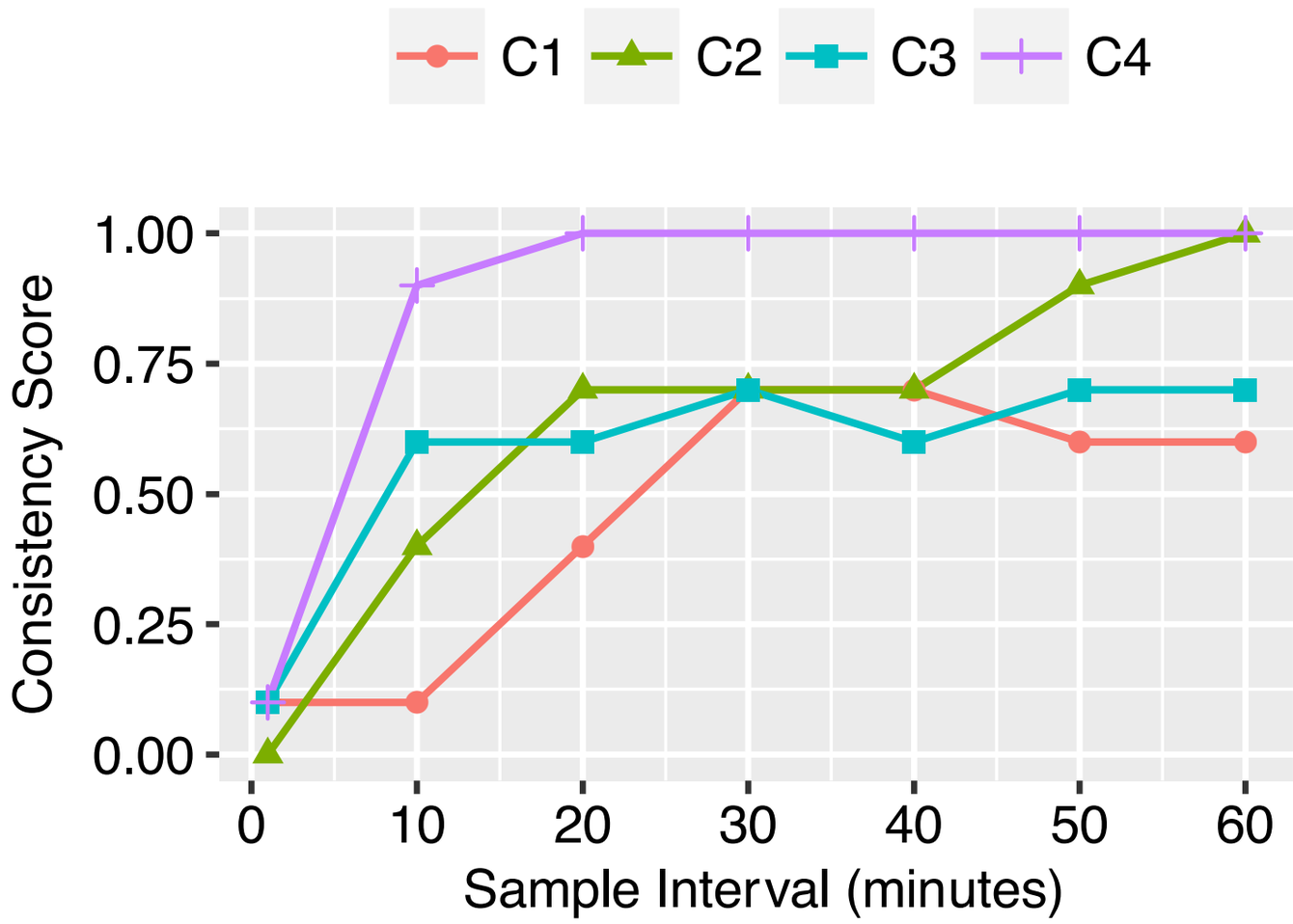
- Dataset
  - IIT Bombay faculty residential building
  - Ten minutes data
- Number of historical days: 7
- Standard deviation: 2

Compare Consistency Score and Consumption Patterns



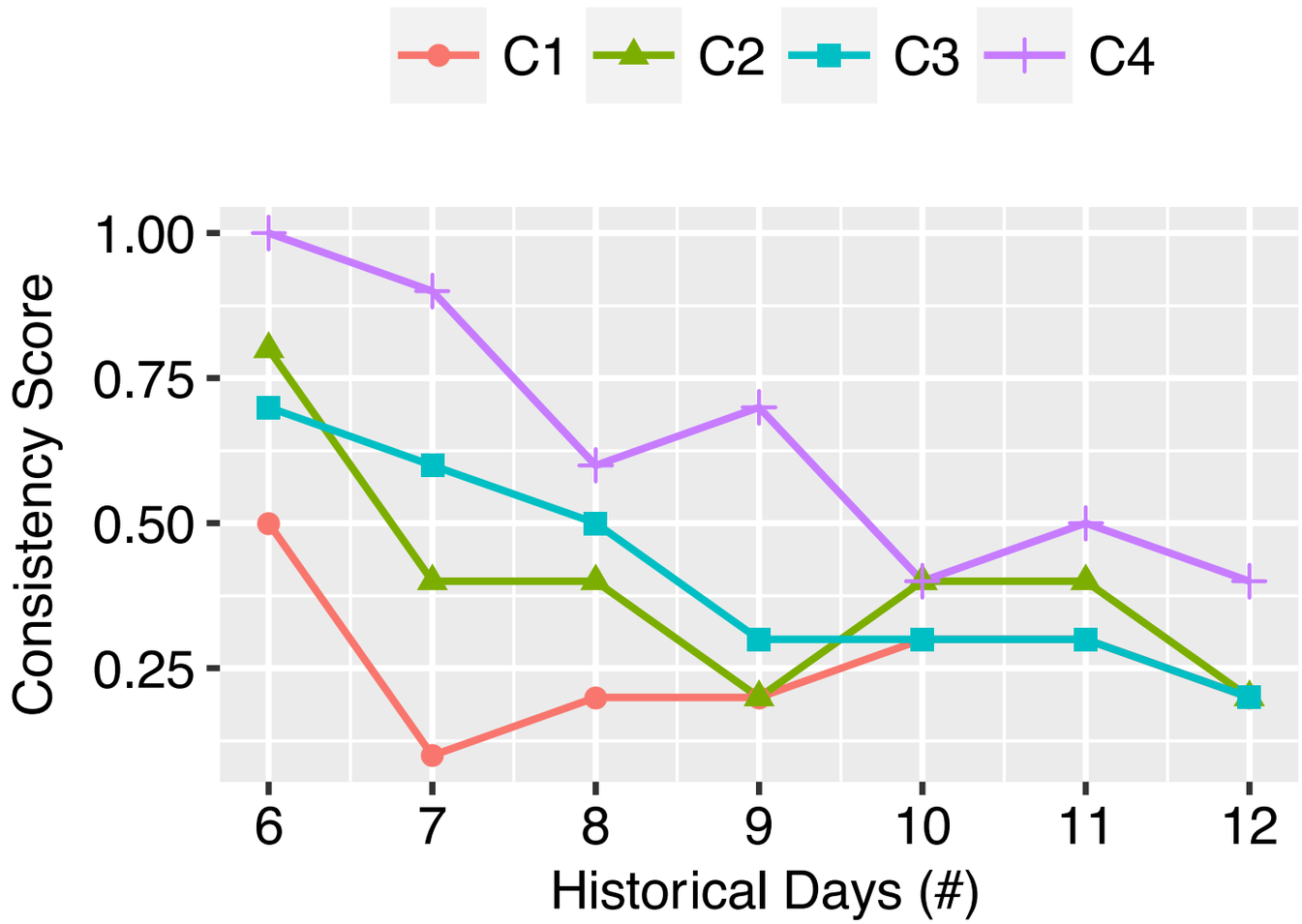
Consistency score reflects the consistency in consumer's consumption pattern accurately

Effect of Sampling Interval on Consistency Score



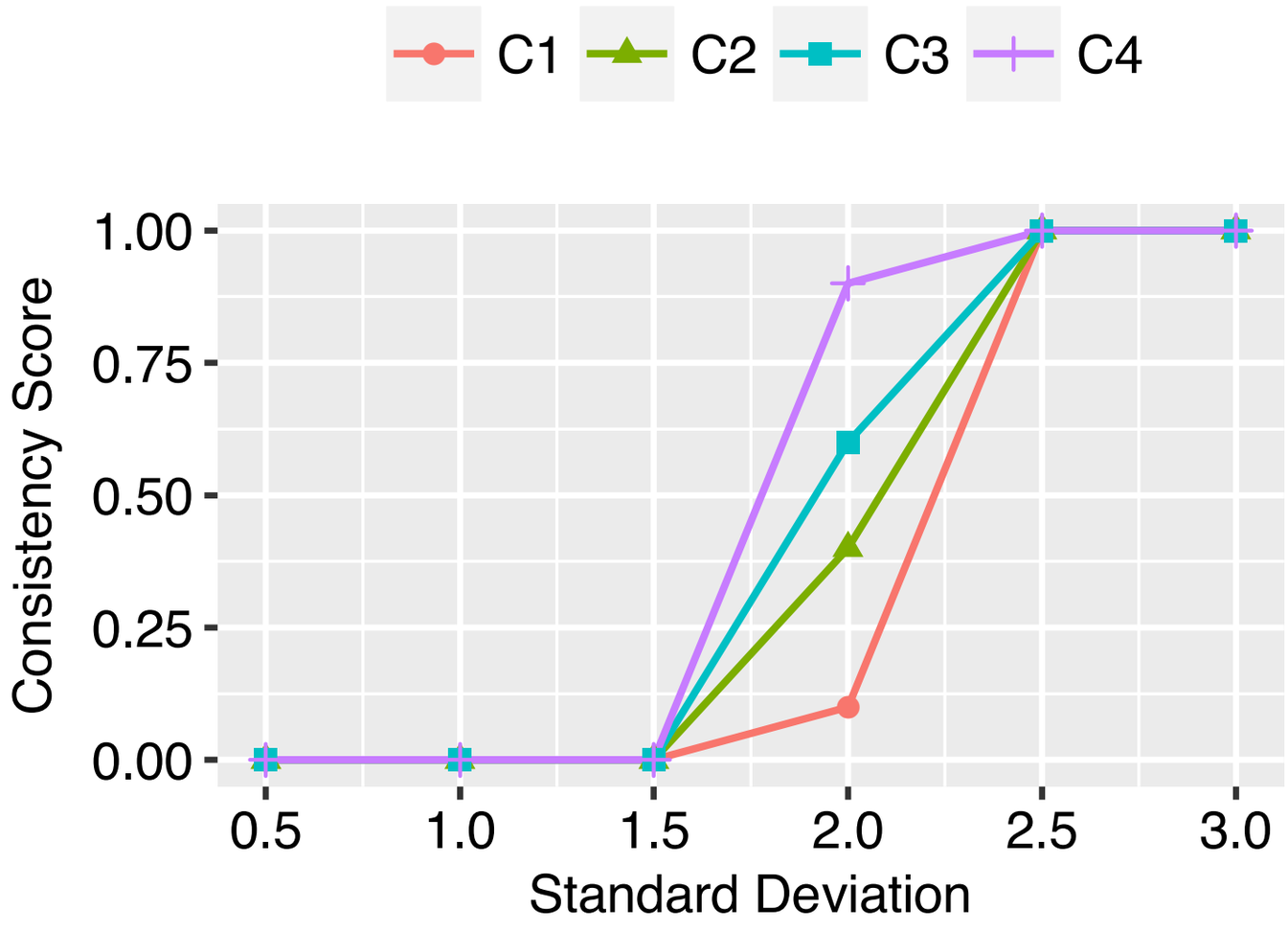
Consistency score increases while decreasing the sampling rate.

Effect of Historical Days on Consistency Score



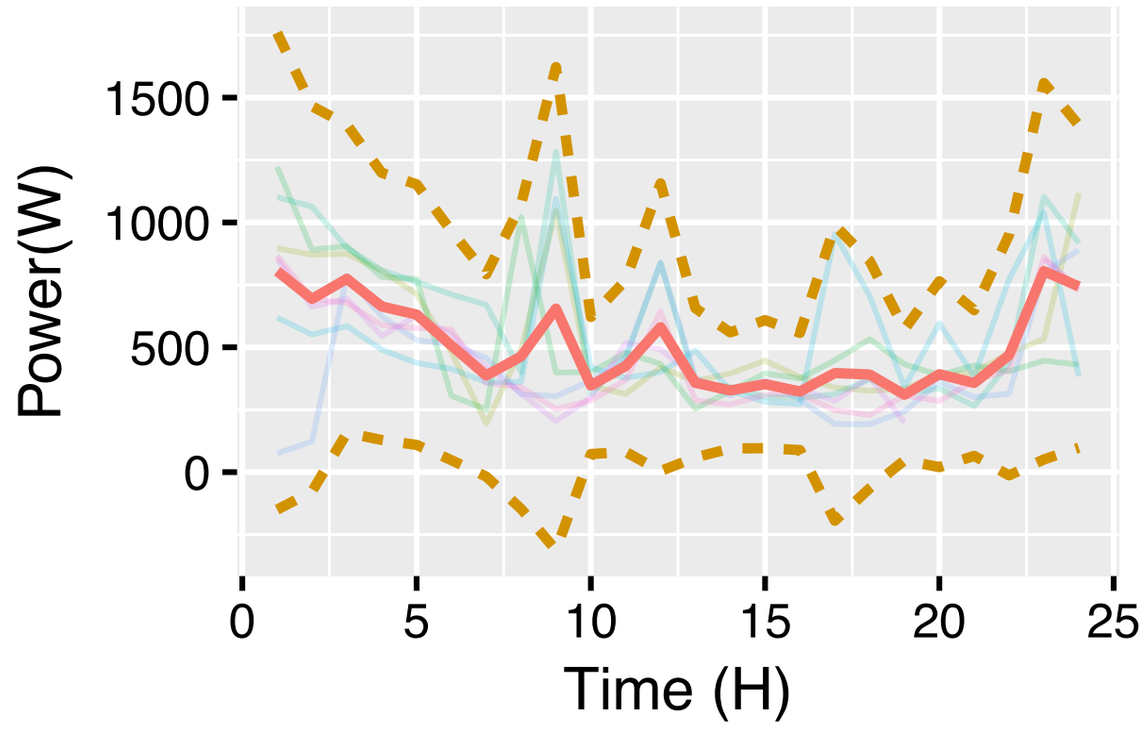
Consistency score decreases with the increase in number of historical days.

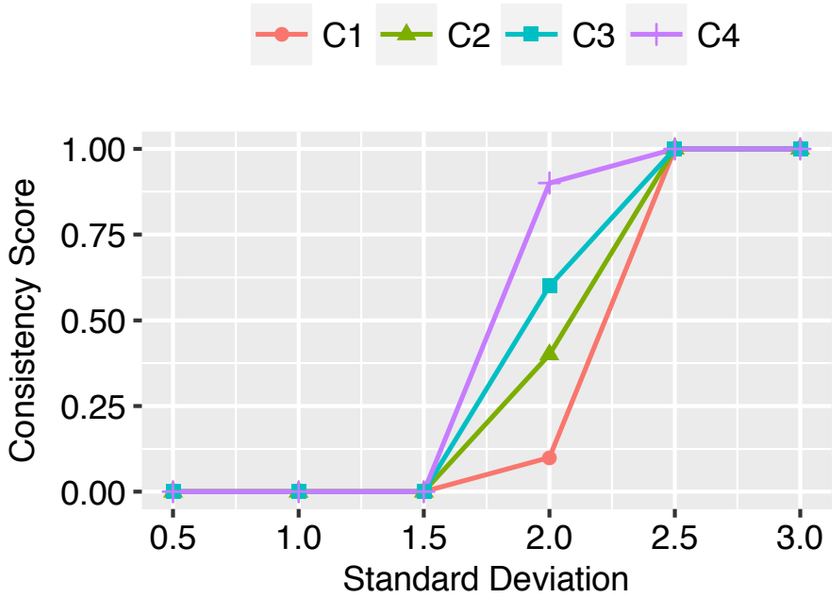
Effect of Standard Deviations on Consistency Score



Consistency score increases with the increase in standard deviations.

Effect of Standard Deviations on Consistency Score

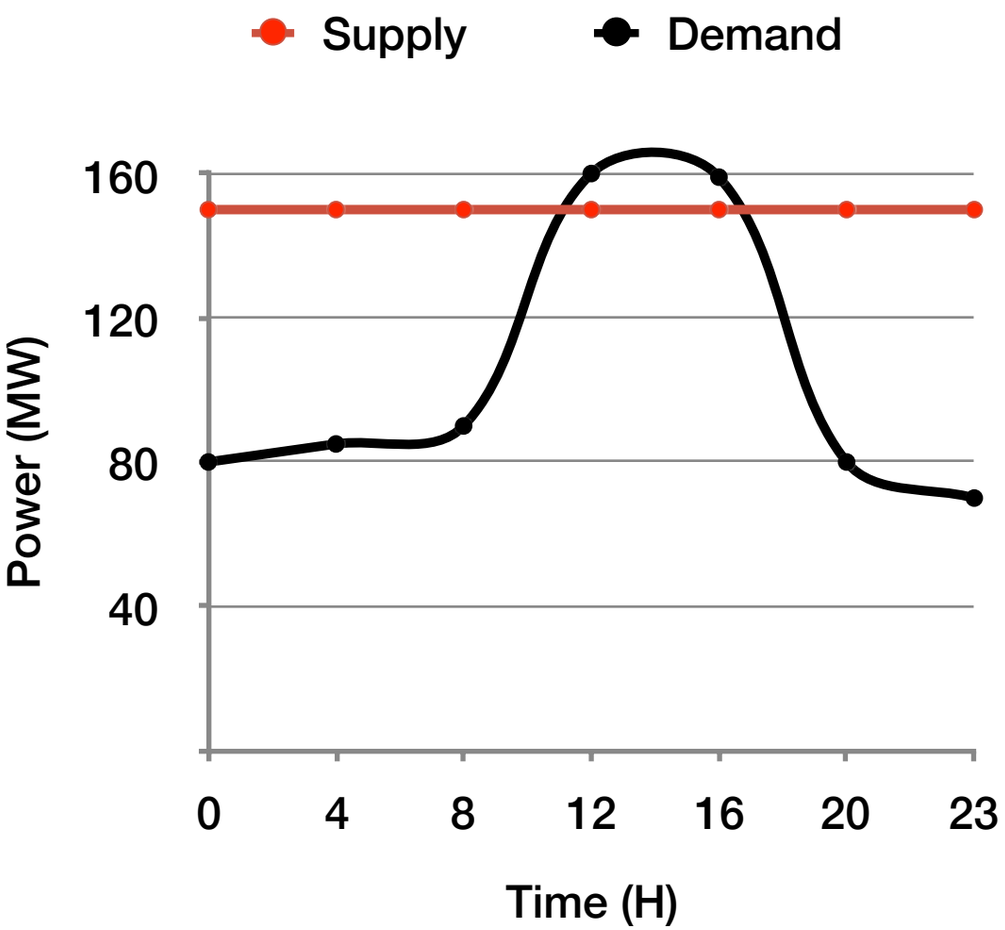




Conclusion

- Utilities select consistent consumers using entropy measure
- Entropy measure depends on *k* value
- Our proposed metric is *k* independent

APPENDIX


Supply
Demand
160
120
80
40
Power (MW)
0
4
8
12
16
20
23
Time (H)

Demand Response