SUBSTATION MAINTENANCE SCHEDULING

MATLAB KHIVA LIBRARY

info@shapelets.io

WHAT PROBLEM ARE WE TRYING TO SOLVE?

- It is difficult and error prone to determine a suitable maintenance time slot without inspecting the consumption data.
- Even though inspecting the data graphically, a human decision observing a graph could compromise the offered service.
- The maintenance time slots would vary between substations, given the different consumption profiles of the sites being supplied in the different locations.

- What we are trying to achieve here is a model that would determine when to operate/repair a given substation without causing service disruption. The model would be computed based on historical data of the given substation.

DATA OVERVIEW

Exploring the data showing how difficult could be to determine a suitable maintenance spot

WHAT DATA ARE WE GOING TO DEAL WITH?

- Data corresponding to electrical consumption during 2012 of 100 sites.
- Data being collected each 5 minutes. **12 points per hour**.
- **10,531,288 Data points in total**.
- Re-dimension of the time series of each local using the Visvalingam algorithm. The data is reduced to 10,000 points per site.
- **1,000,000 data points in total**.
- The data does not contain substation information, so it is assumed a total of 5 substations. The location of these substations are determined based on the proximity in latitude and longitude of the sites under study.

INDUSTRY METADATA

- Commercial Real Estate – Commercial Property
- Shopping Center/Shopping Mall – Commercial Property
- Business Services – Commercial Property
- Bank/Financial Services – Commercial Property
- Food Processing – Light Industrial
- Manufacturing – Light Industrial
- Other Light Industrial – Light Industrial
- Grocer/Market – Food Sales & Storage
- Primary/Secondary School – Education

	SITE_ID	INDUSTRY	SUB_INDUSTRY
0	6	Commercial Property	Shopping Center/Shopping Mall
1	8	Commercial Property	Shopping Center/Shopping Mall
2	9	Commercial Property	Corporate Office
3	10	Commercial Property	Shopping Center/Shopping Mall
4	12	Commercial Property	Business Services
5	13	Commercial Property	Commercial Real Estate
6	14	Commercial Property	Business Services
7	21	Commercial Property	Shopping Center/Shopping Mall
8	22	Commercial Property	Bank/Financial Services
9	25	Commercial Property	Shopping Center/Shopping Mall
10	29	Commercial Property	Shopping Center/Shopping Mall
11	30	Commercial Property	Bank/Financial Services
12	31	Commercial Property	Commercial Real Estate
13	32	Commercial Property	Shopping Center/Shopping Mall
14	36	Commercial Property	Business Services
15	41	Commercial Property	Corporate Office
16	42	Commercial Property	Shopping Center/Shopping Mall
17	44	Commercial Property	Shopping Center/Shopping Mall

Figure 1: Metadata

WHERE ARE THE SITES UNDER STUDY?

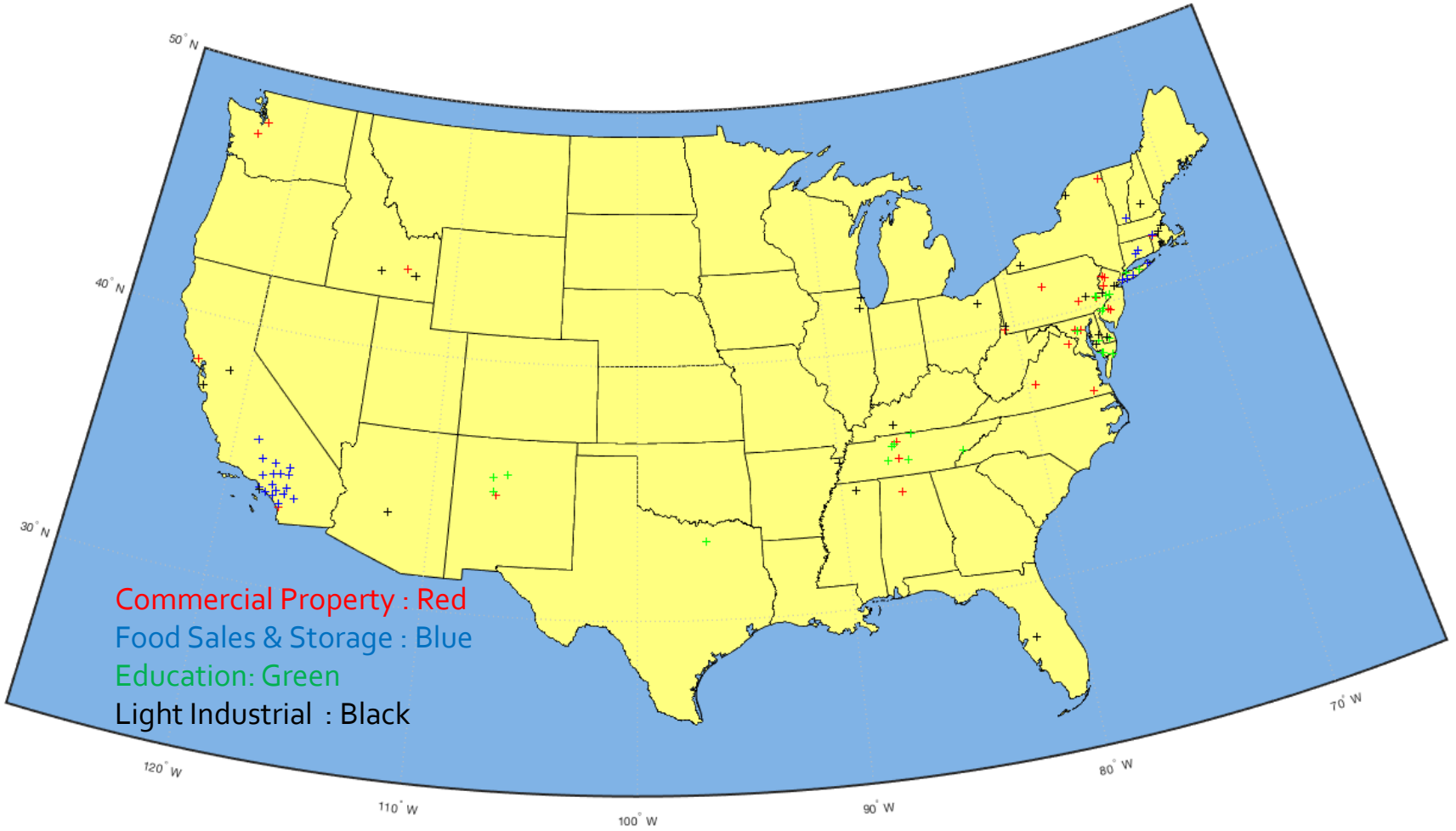

Figure 2: Site locations categorised by Industry

CONSUMPTION PER INDUSTRY

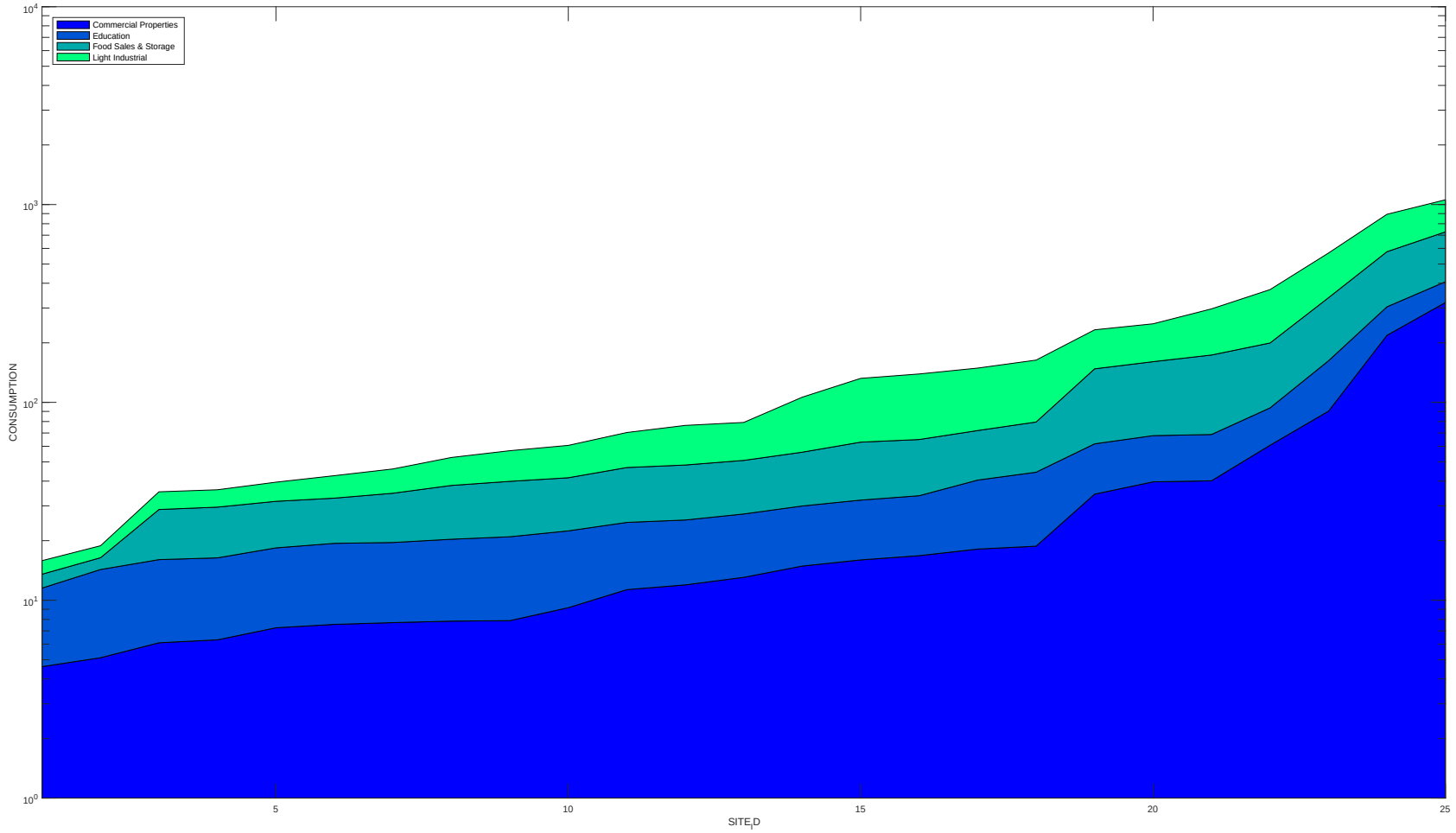

Figure 3: Consumption per industry, sorted by consumption. X-axis reflects the 25 different sites of an industry and the Y-axis the aggregated consumption of the site for the complete year.

COMMERCIAL PROPERTIES CONSUMPTION IN A RANDOM WEEK

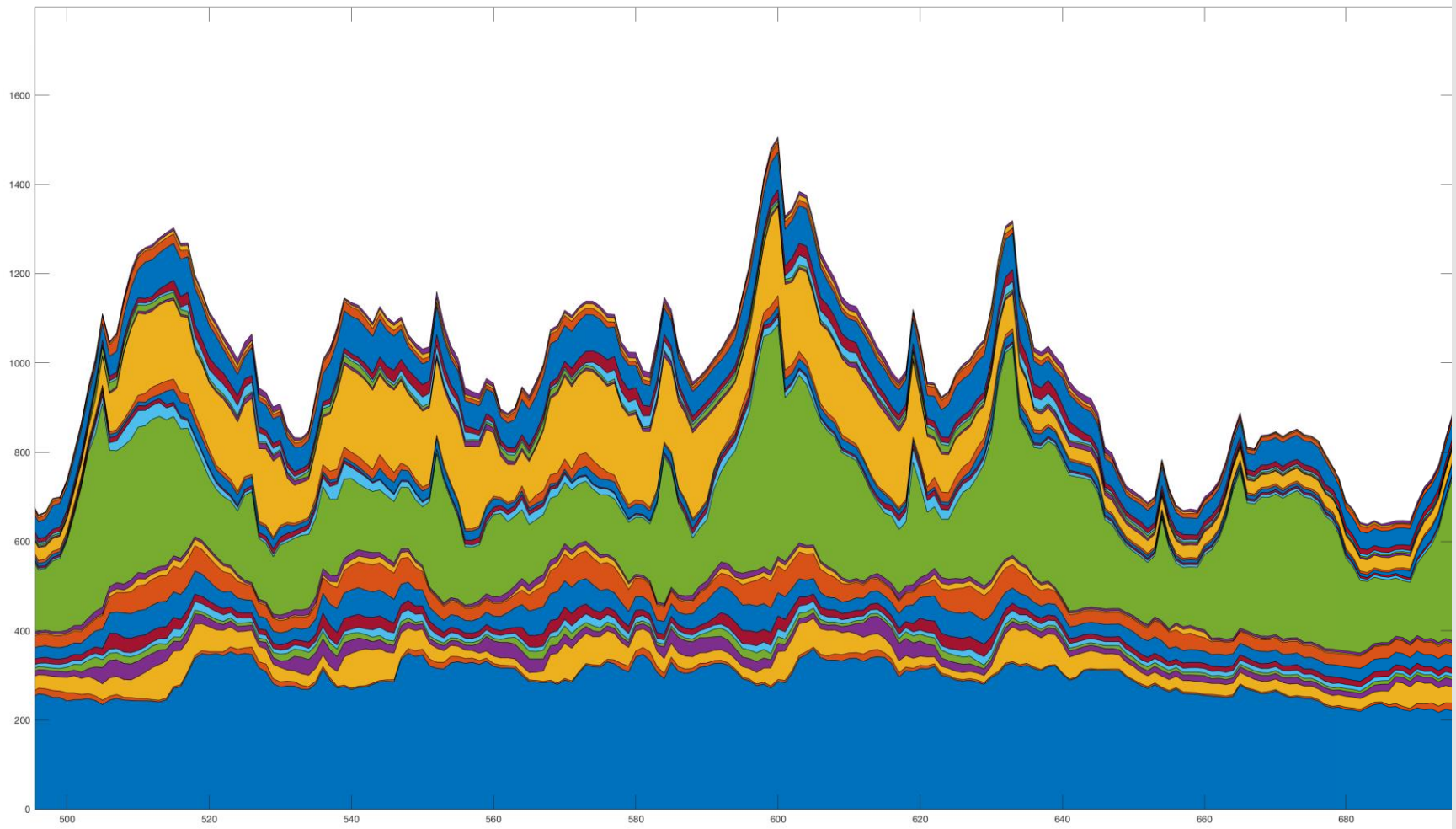

Figure 4: Consumption of a random week for the 25 commercial property sites. Each colour represents a different site. X-axis is time and Y-axis the consumption.

EDUCATION SITES CONSUMPTION IN A RANDOM WEEK

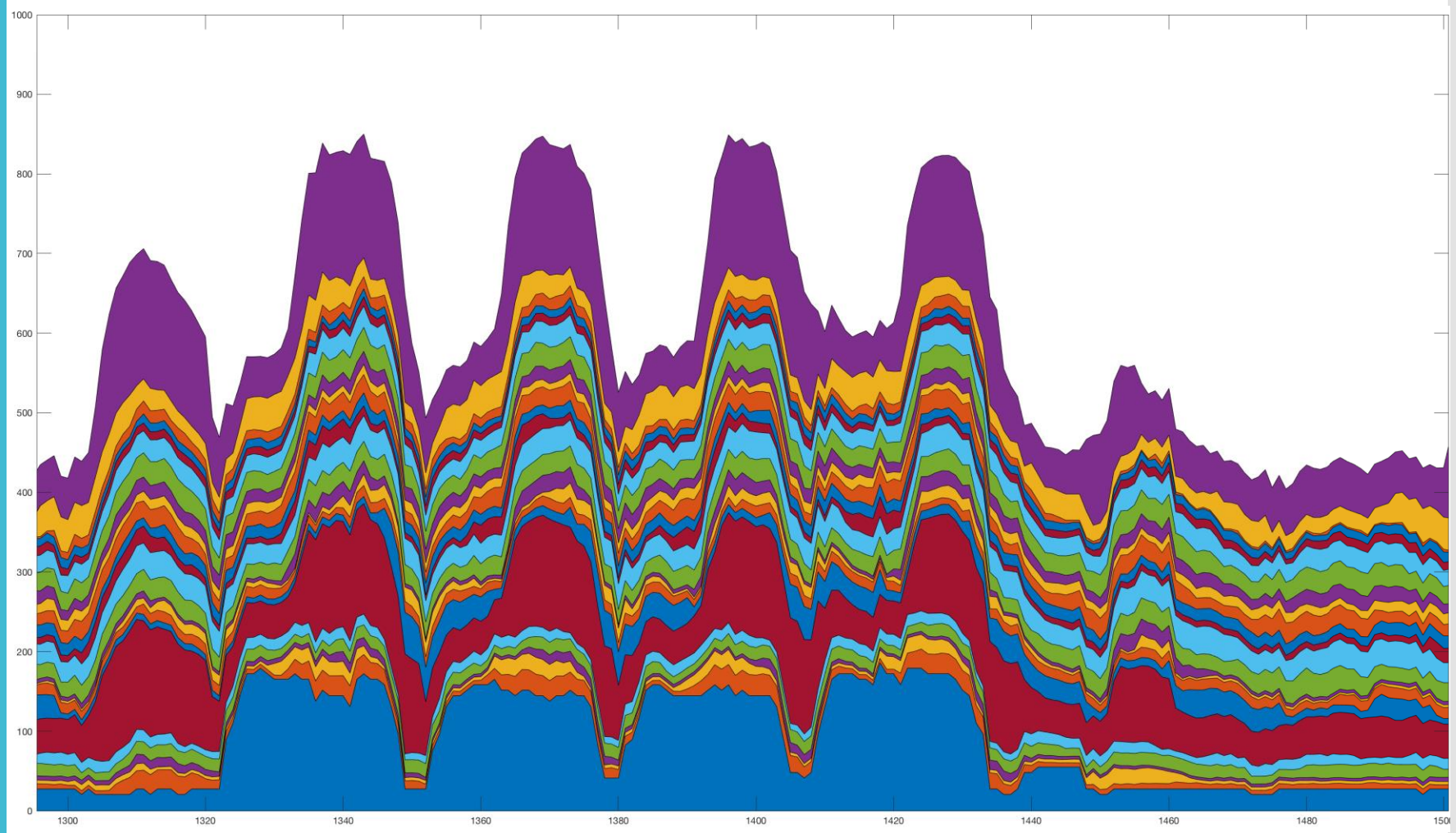

Figure 5: Consumption of a random week for the 25 education sites. Each colour represents a different site. X-axis is time and Y-axis the consumption.

FOOD & SALES SITES CONSUMPTION IN A RANDOM WEEK

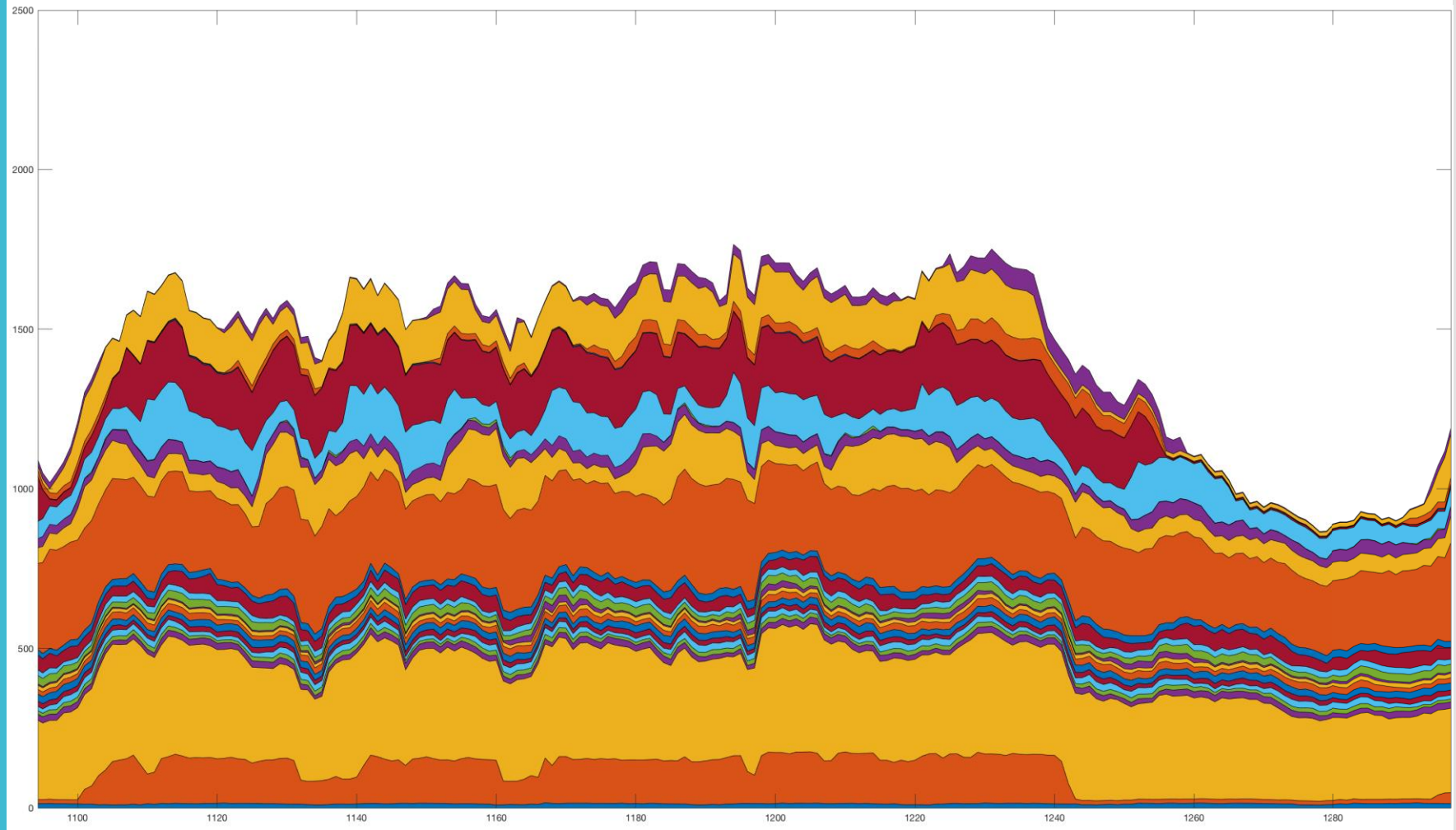

Figure 6: Consumption of a random week for the 25 food & sales sites. Each colour represents a different site. X-axis is time and Y-axis the consumption.

INDUSTRIAL SITES CONSUMPTION IN A RANDOM WEEK

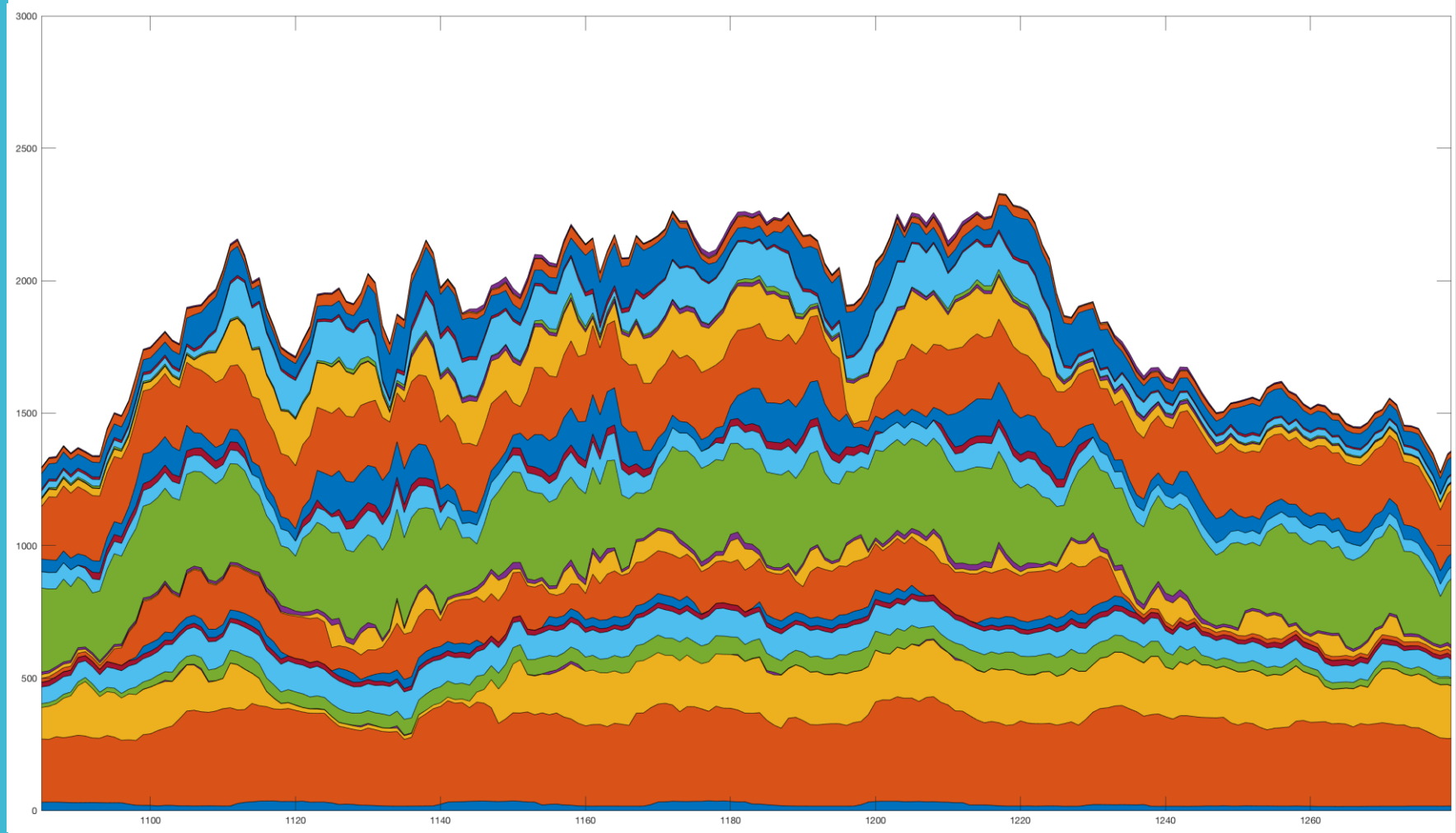

Figure 7: Consumption of a random week for the 25 industrial sites. Each colour represents a different site. X-axis is time and Y-axis the consumption.

MAINTENANCE TIME SLOTS MODELLING

Modelling the suitable maintenance spots

MAINTENANCE TIME SLOTS MODELLING. INTRODUCTION

- In this use case, electrical substation maintenance spots without service disruption are found and classified based on the electric consumption rates of 100 sites of different industries.
- The suitable maintenance spots are determined using the aggregated electric consumption, the peak power consumption and a user specified threshold of the percentage of the substation that needs to be shut down while being repaired.
- A decision tree classification ensemble is applied to explain when to operate the substations without compromising the service. This is done using the maintenance slots of the required time and a decomposition of the date.
- In this use case, the Khiva library has been used in order to reduce the input data, in order to plot the consumption over time of the sites per industry, in order to observe that they behave similarly, even though the magnitude of the series might differ.

MAINTENANCE TIME SLOTS MODELLING. RESULTS

- Using the tree classification ensemble, the results are:
  - Good maintenance time slots for substation 1:
    - Weekends at any time
    - Working days between 6am and 10 am

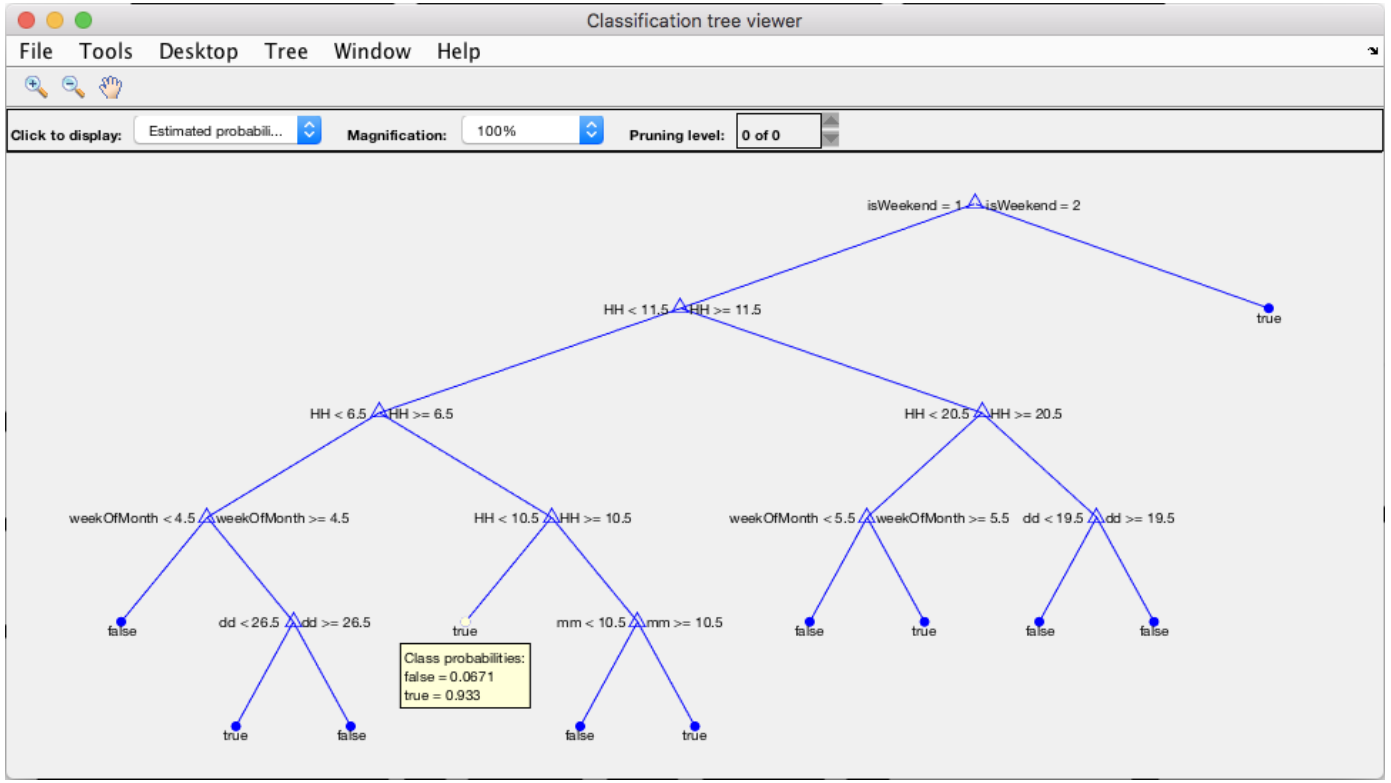

Figure 8: Decision tree for the substation 1. Hour (HH), Day (dd), Month (mm)

MAINTENANCE TIME SLOTS MODELLING. RESULTS

- Let's observe the maintenance slots graph to check if the classifier works or not:

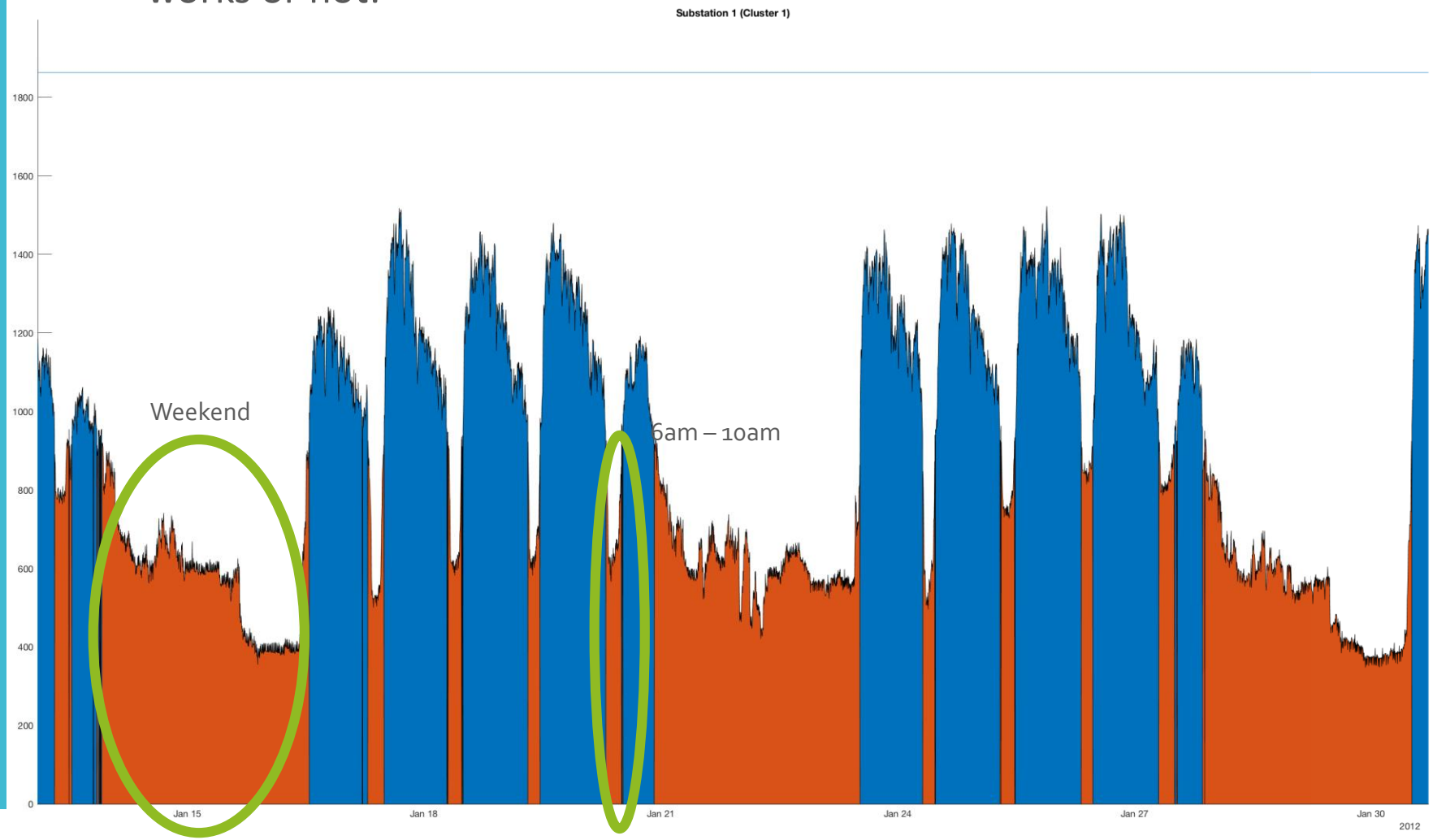

Figure 9: Maintenance slots in orange for the substation 1

MAINTENANCE TIME SLOTS MODELLING. RESULTS

- Let's observe the maintenance slots graph to check if the classifier works or not:

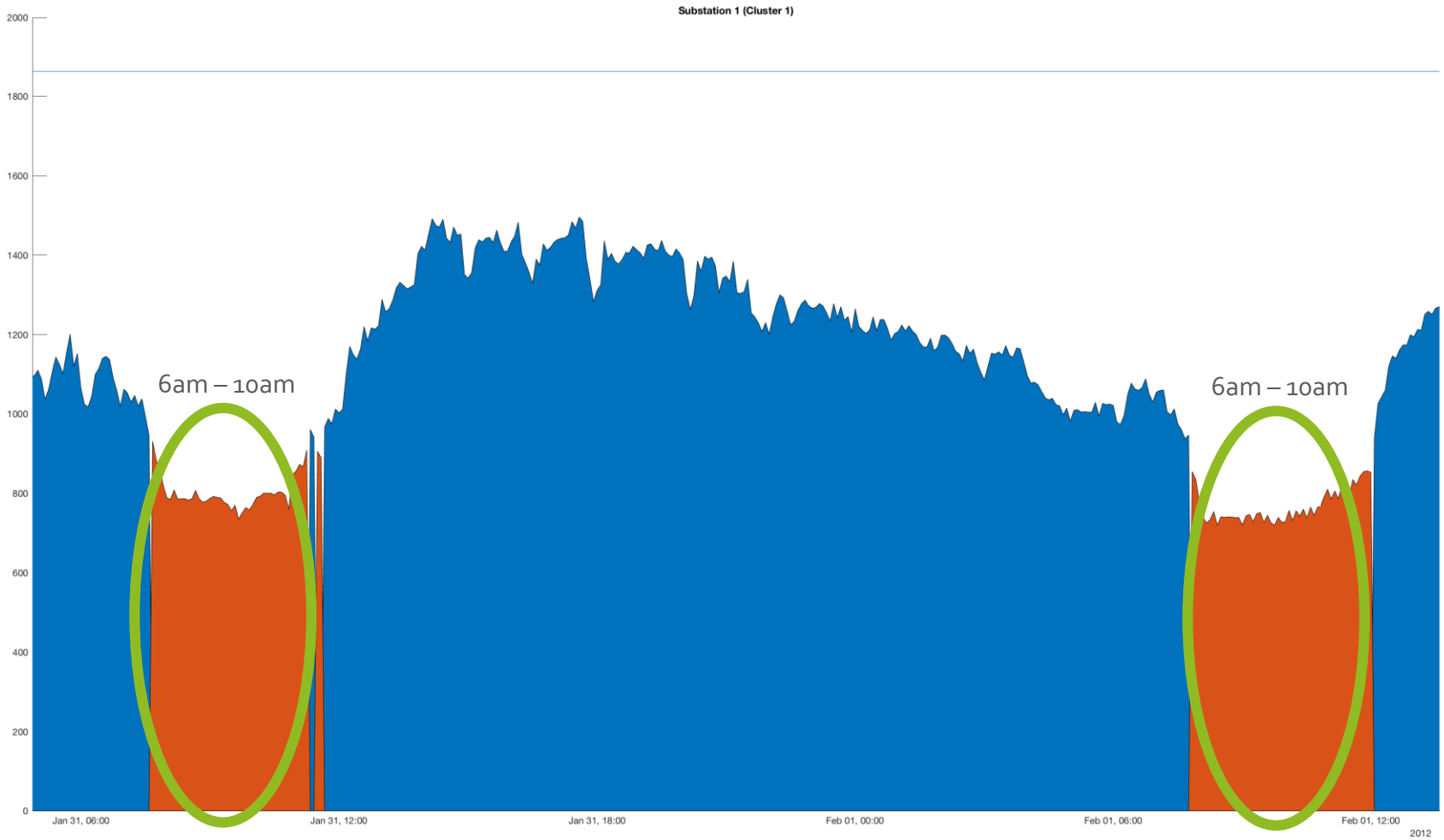

Figure 10: Maintenance slots in orange for the substation 1

MAINTENANCE TIME SLOTS MODELLING. RESULTS

- Using the tree classification ensemble, the results are:
  - Good maintenance time slots for substation 2:
    - Weekends from 1pm.
    - Any day between 1am and 11am.

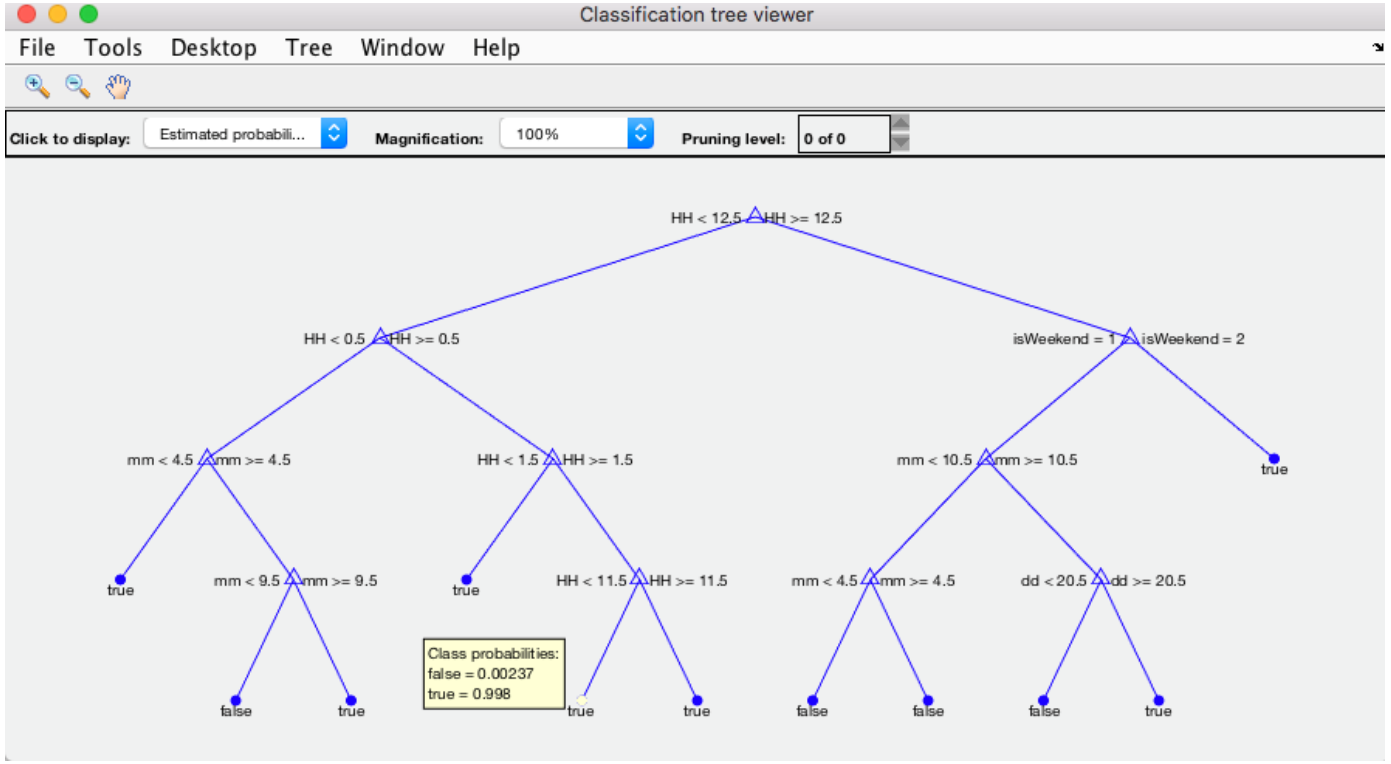

Figure 11: Decision tree for the substation 2. Hour (HH), Day (dd), Month (mm)

MAINTENANCE TIME SLOTS MODELLING

- Let's observe the maintenance slots graph to check if the classifier works or not:

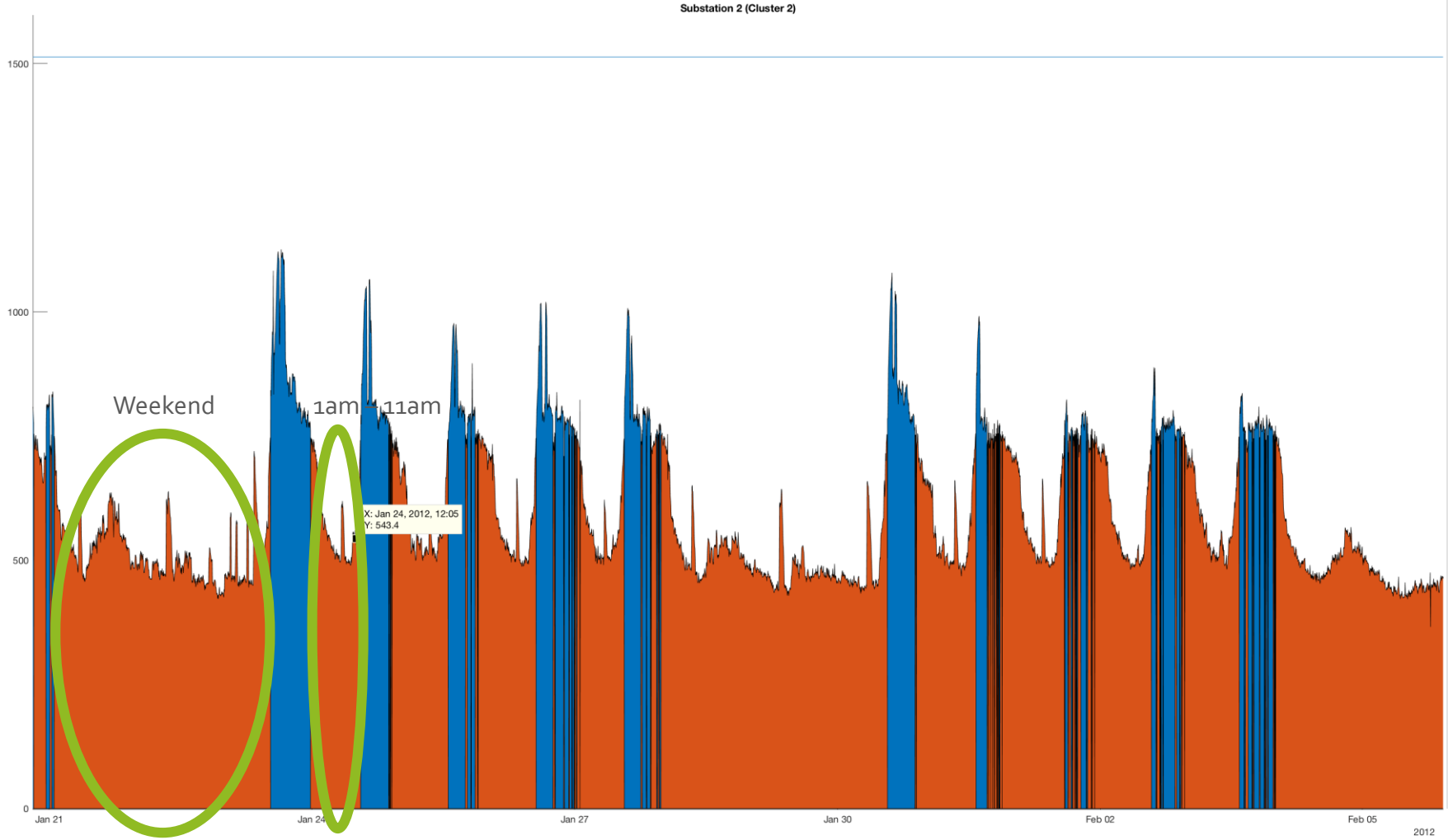

Figure 12: Maintenance slots in orange for the substation 2

MAINTENANCE TIME SLOTS MODELLING

- Let's observe the maintenance slots graph to check if the classifier works or not:

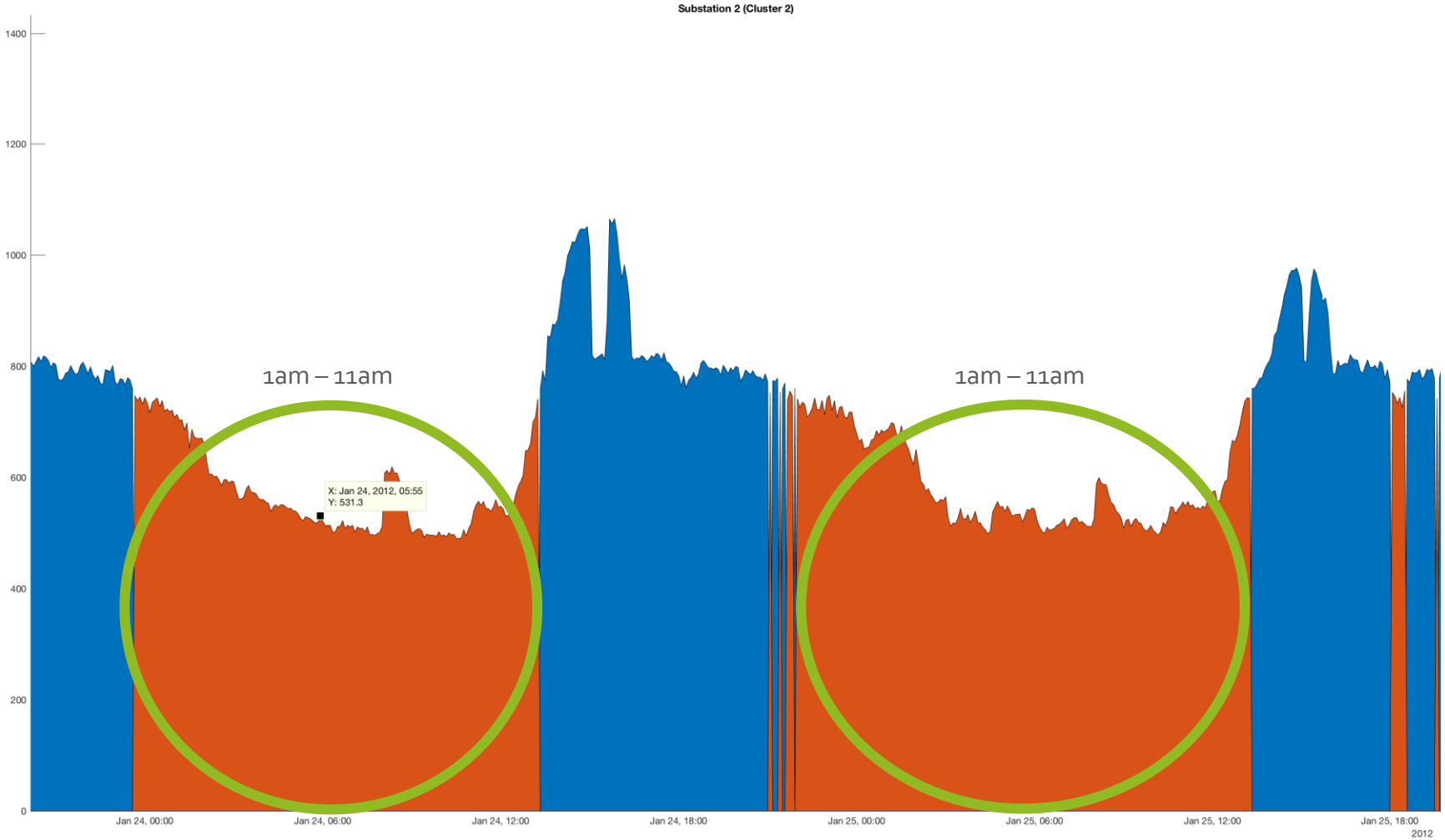

Figure 13: Maintenance slots in orange for the substation 2

CONCLUSIONS

MAINTENANCE TIME SLOTS MODELLING. CONCLUSIONS

- In the data overview section the complexity of determining suitable maintenance time slots was illustrated.
- The method used to determine the suitable slots just requires:
  - Historical data.
  - Percentage of the substation to be shut down.
  - Required time to repair the station.
- The resulting model simplifies the substation maintenance scheduling to operators and decision-making people.
- The resulting model is able to provide a probability measure of a given time period being a suitable maintenance time slot or not.
- In this use case, some assumptions have been made and the reality might have been simplified. But, it yet demonstrates the potential of these methods.