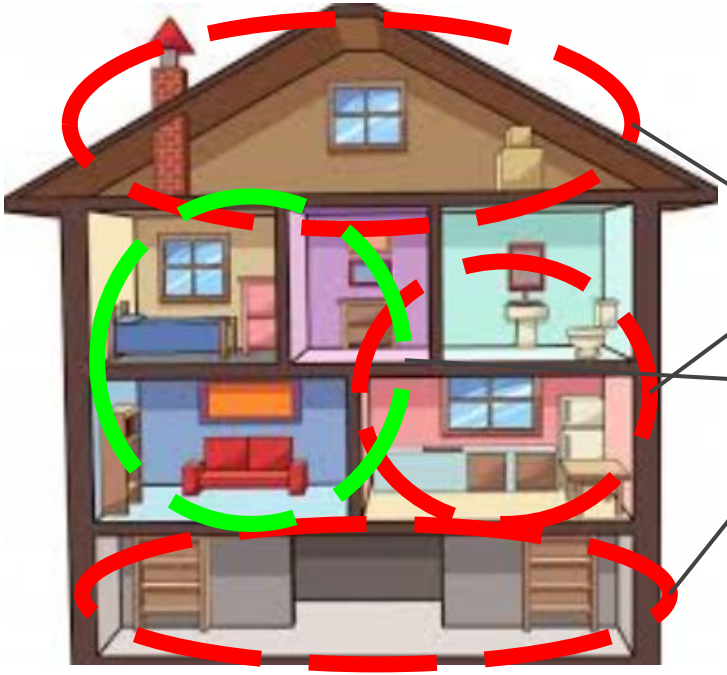
Identifying appliance consumption and user behavior through K-means algorithm in smart meter data

Our data comes from 3 smart meters that collect energy usage by the minute:



3 Submeters

S1: Dishwasher, oven, microwave

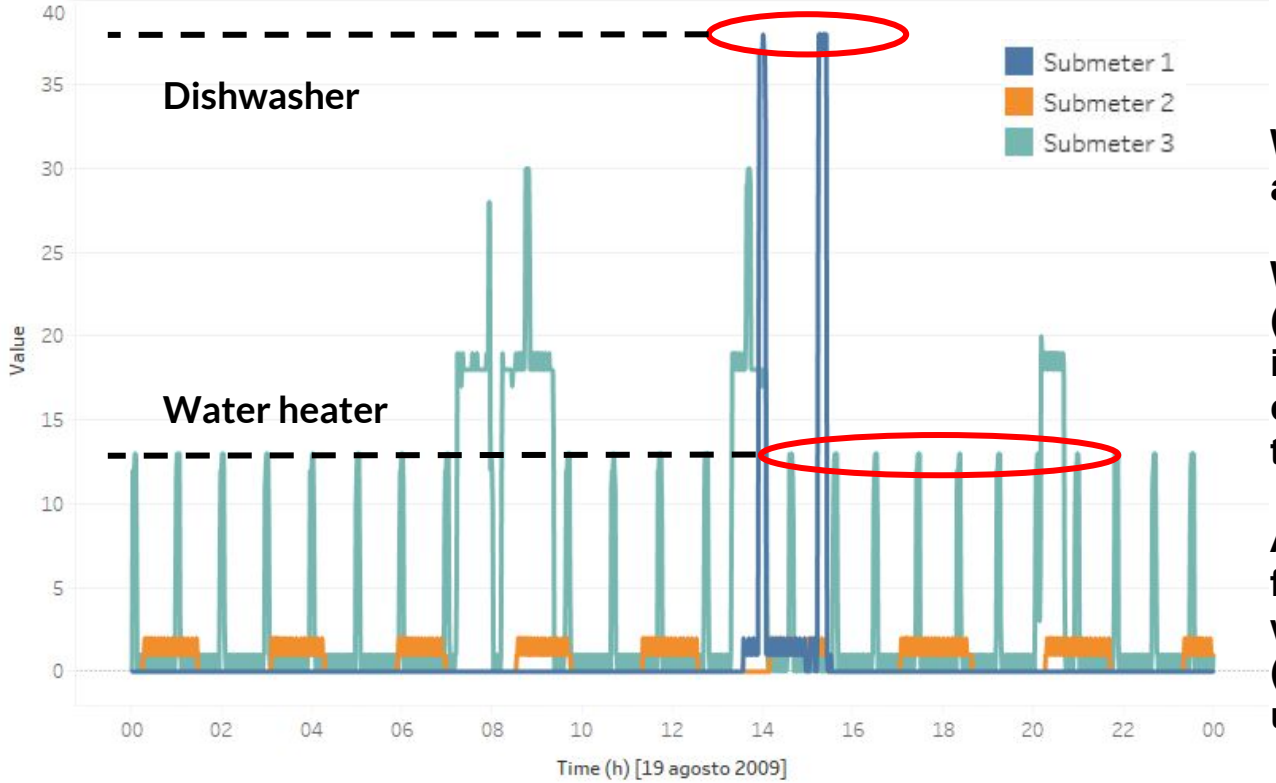
S2: Washing-machine, tumble-drier, refrigerator, light

S3: Electric water heater, air-conditioner

Rest of the house (Remaining)

CAN WE, THROUGH ML TECHNIQUES, IDENTIFY SINGLE APPLIANCES?

This is what our data looks like for a single day.



We know which appliances are in each submeter.

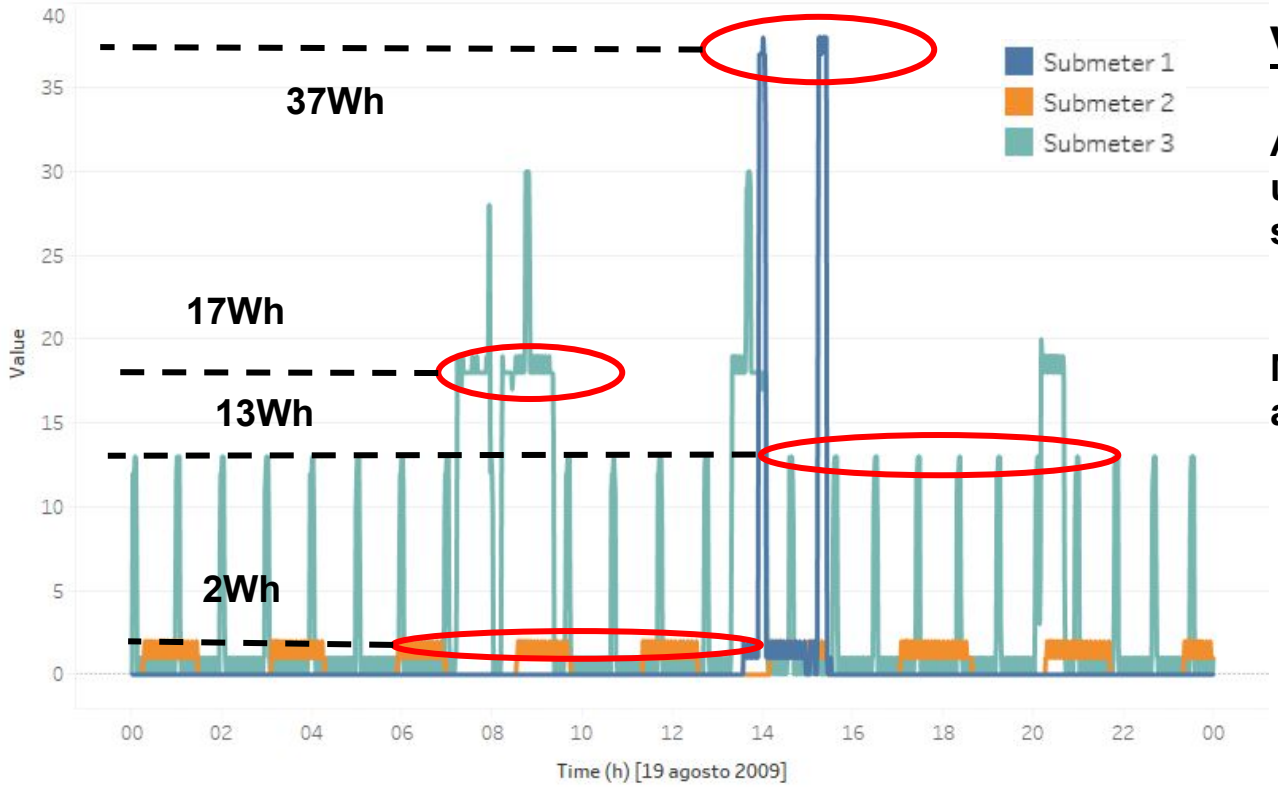
We have another lecture (Remaining) which provides information on the energy consumption of the rest of the house.

After close analysis, we can find patterns and identify what each value means (which appliances are being used).

What’s our goal?

We use K-means algorithm in order to find clusters in energy consumption. These clusters provide different values which we associate to different appliances. This way, we can find which appliances are being used at each minute.

How? We find appliances that have a constant consumption value.



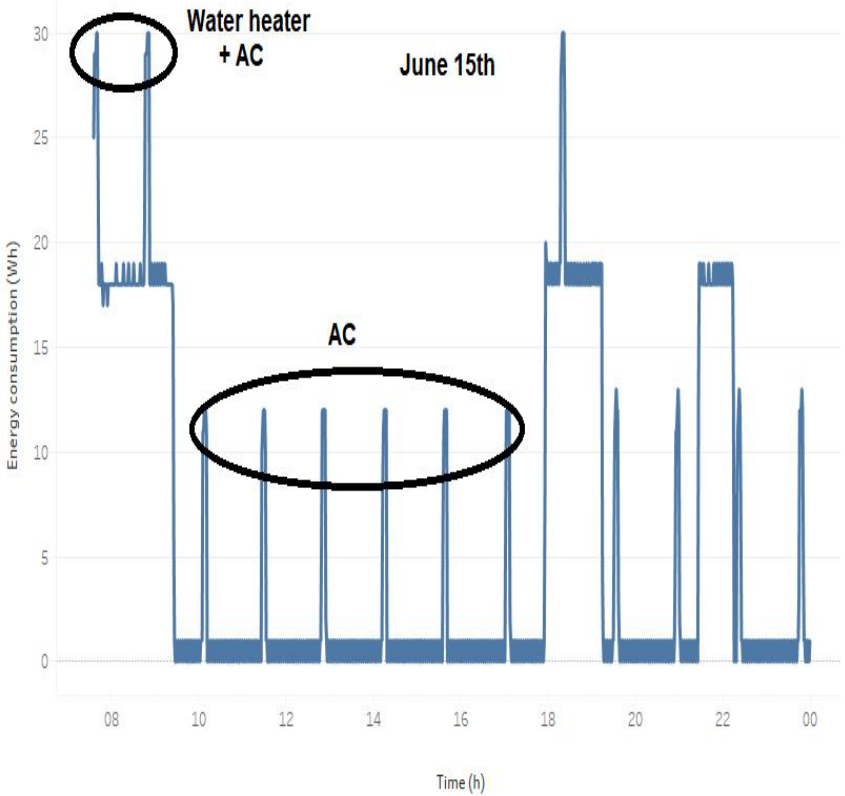
<u>Visible patterns</u>:

A specific value in power usually belongs to a specific appliance.

Match values to single appliances.

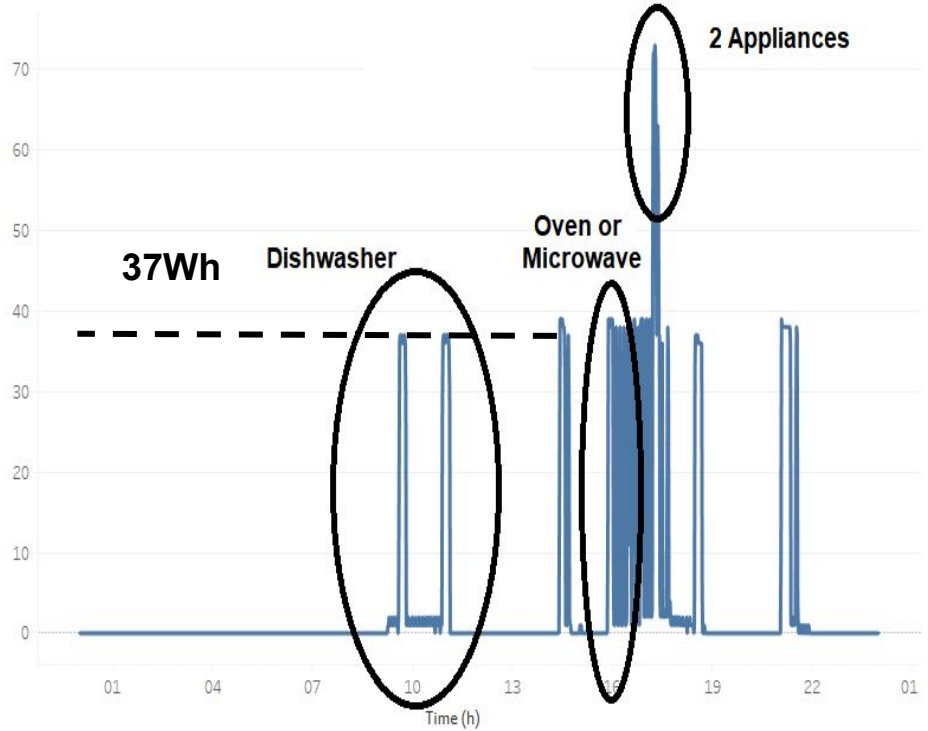
When does this method work well?

Submeters that contain appliances with clearly distinct consumption values.



When does this method NOT work well?

Submeters that contain appliances with the same consumption values.



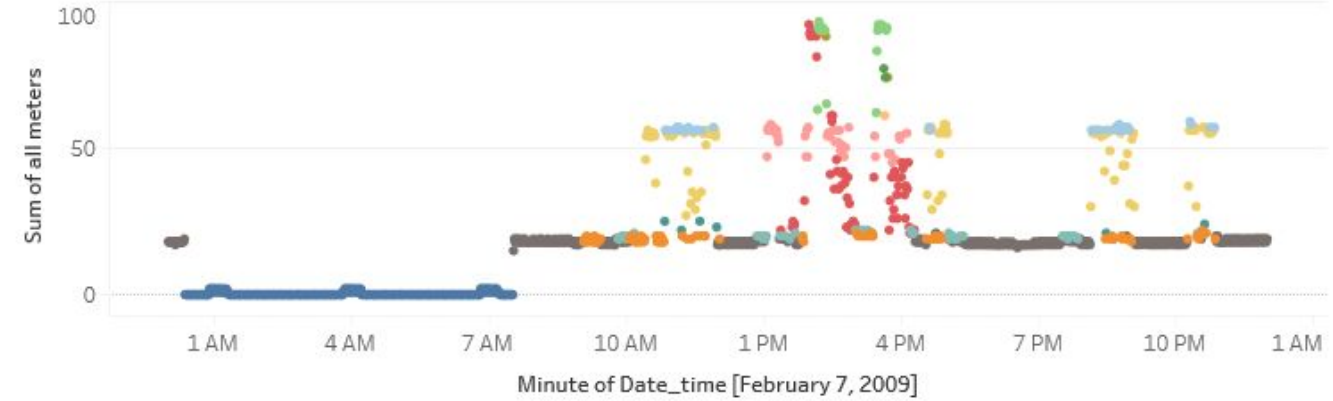
Appliance recognition Interface (Link to the app)
-User can see use and power consumption of single appliances for a specific period of time.

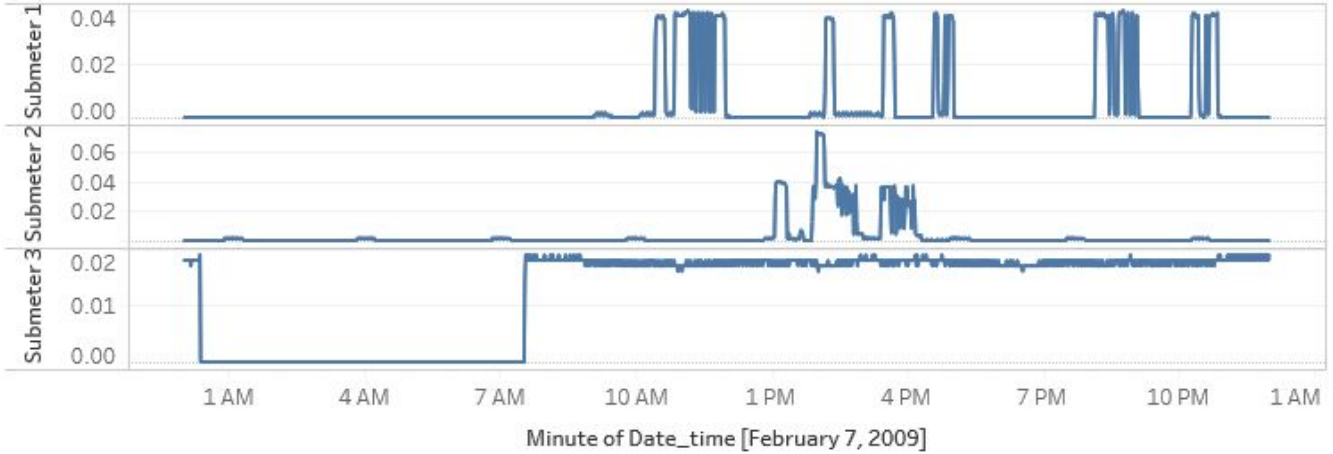
-Each submeter was clustered, as well as all submeters at once, using the **K-means** algorithm:

Submeter 1: 3 clusters.
Submeter 2: 4 clusters.
Submeter 3: 4 clusters.
Remaining: 5 clusters.
All submeters together: 40 clusters.

https://public.tableau.com/profile/max.goldston#!/vizhome/AppllianceClusteringinElectricitySubmetering/Dashboard1?publish=yes

EXAMPLE OF ALL APPLIANCES BEING USED AT ONCE:
K-means on all submeters (40 clusters)





Start Date

2/7/2009 12:00:00 AM

End Date

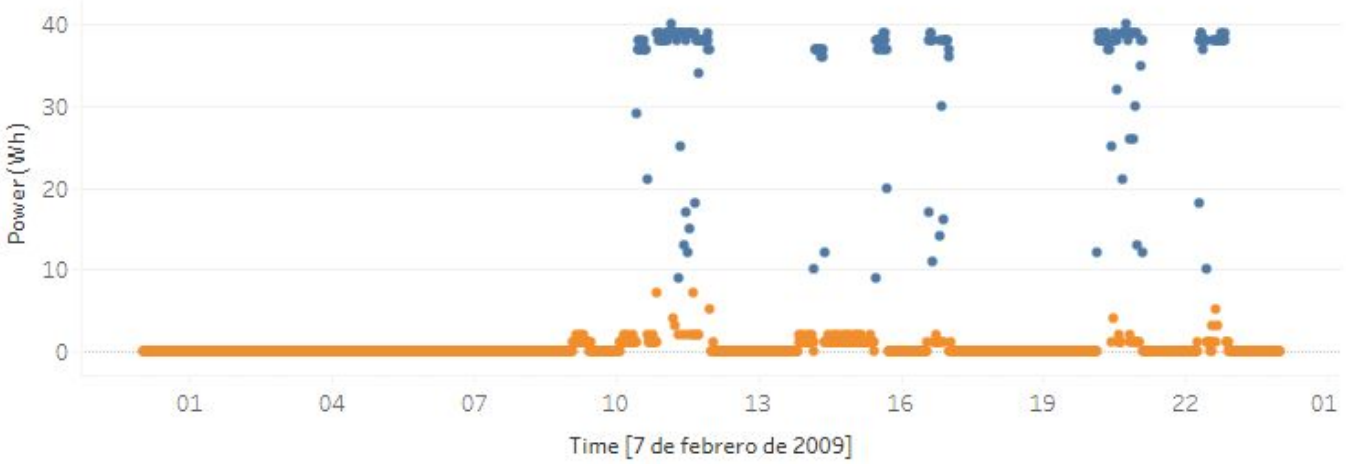
2/7/2009 11:59:00 PM

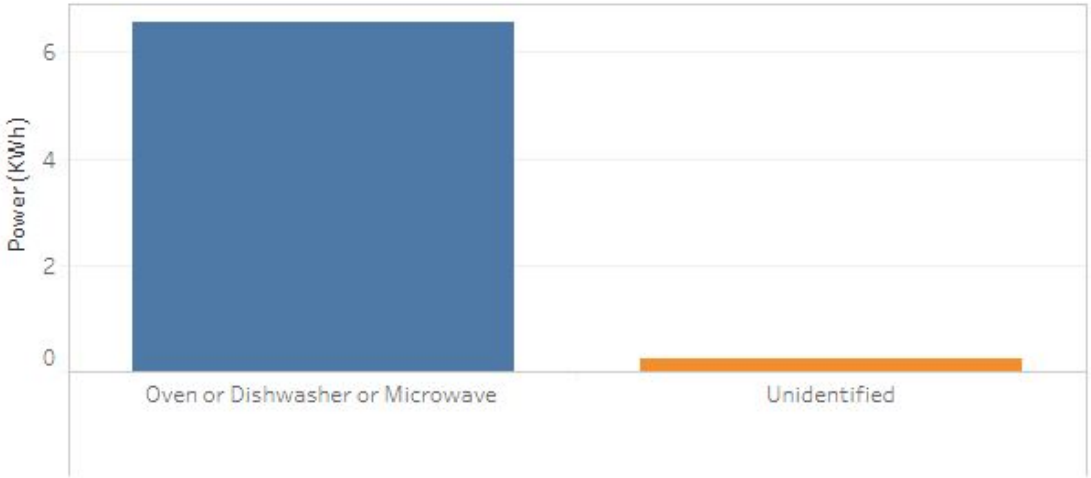
Choosing Submeters

All appliances

Appliances

EXAMPLE OF SUBMETER 1: K-means on Submeter 1 (3 clusters)





Submeter 1

0,25	U.	
6,57	O.	

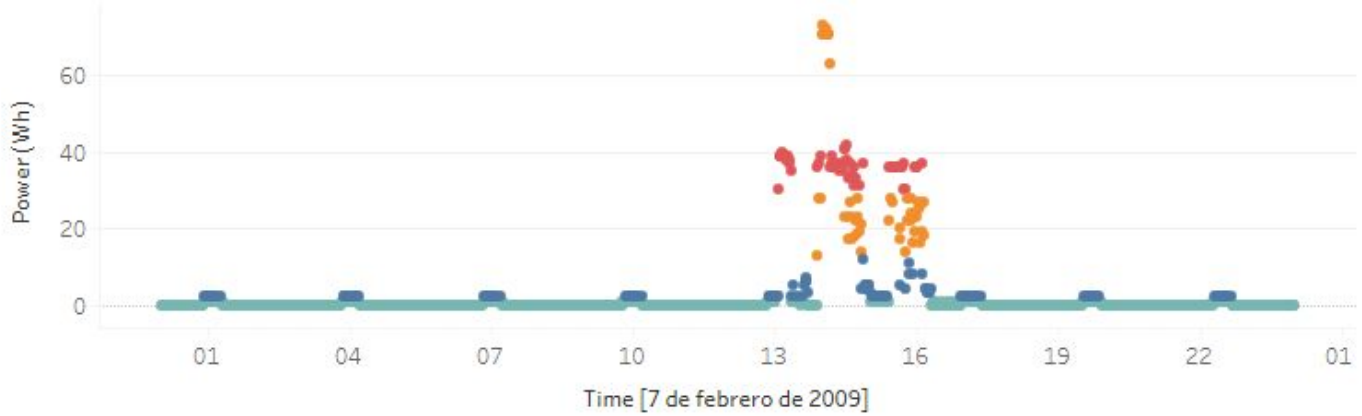
Start Date
7/2/2009 0:00:00 ()

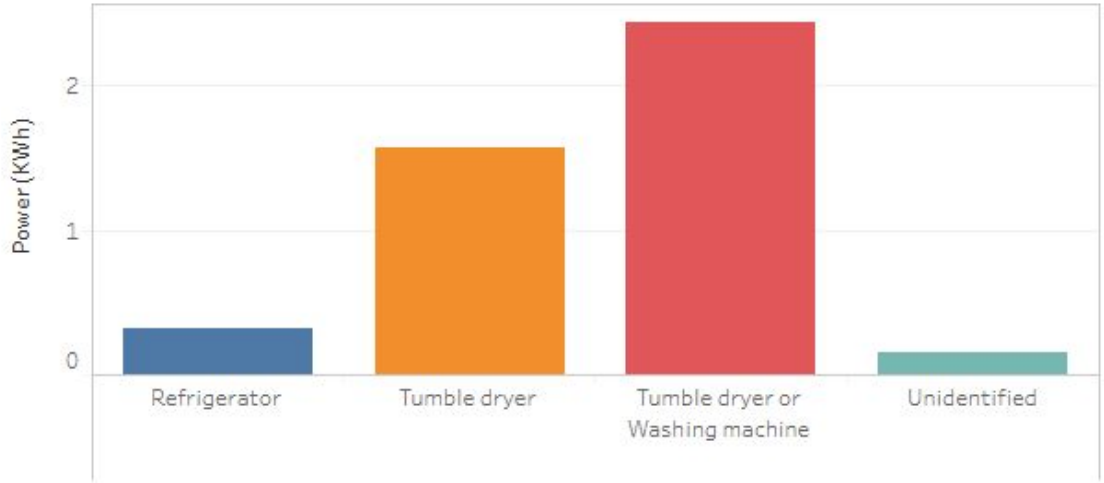
End Date
7/2/2009 23:59:00 ()

Choosing Submeters
Submeter 1

Appliances
- Oven or Dishwasher or Microwave
- Unidentified

EXAMPLE OF SUBMETER 2: K-means on Submeter 2 (4 clusters)





Submeter 2	C..
0,15	U.
0,32	R.
1,57	T..
2,44	T..

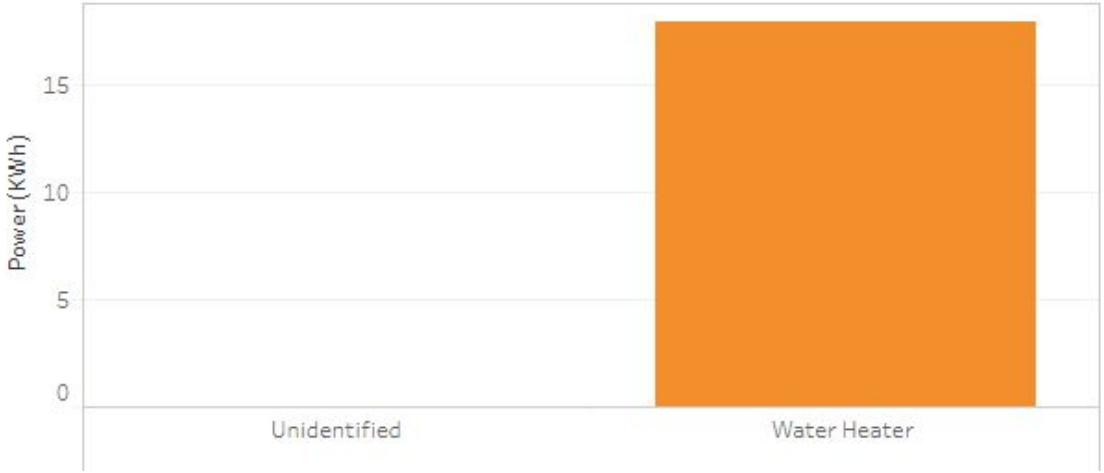
Start Date
7/2/2009 0:00:00 ()

End Date
7/2/2009 23:59:00 ()

Choosing Submeters
Submeter 2

Appliances
Refrigerator
Tumble dryer o...
Tumble dryer
Unidentified

EXAMPLE OF SUBMETER 3: K-means on Submeter 3 (4 clusters)



Submeter 3	C..
0,00	U.
17,87	.

Start Date

7/2/2009 0:00:00 ()

End Date

7/2/2009 23:59:00 ()

Choosing Submeters

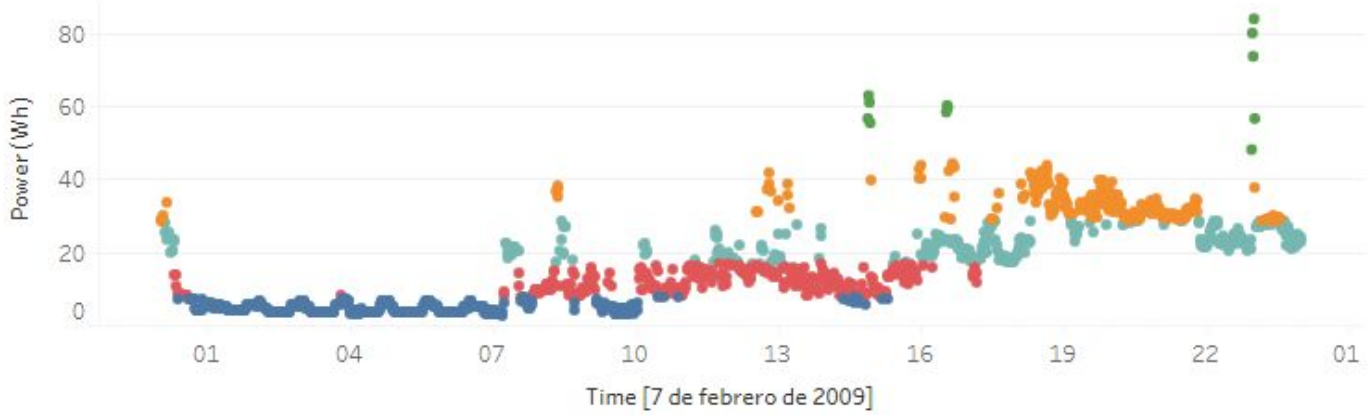
Submeter 3

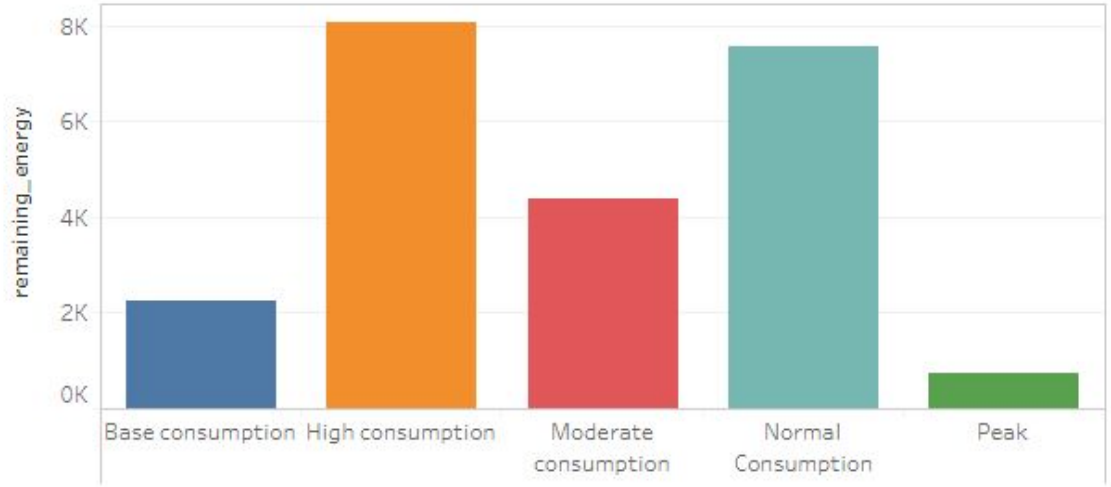
Appliances

Unidentified

Water Heater

EXAMPLE OF REMAINING: K-means on Remaining energy (5 clusters)





Remaining	C..
0,76	P..
2,25	B.
4,37	M.
7,59	N.
8,06	H.

Start Date
7/2/2009 0:00:00 ()

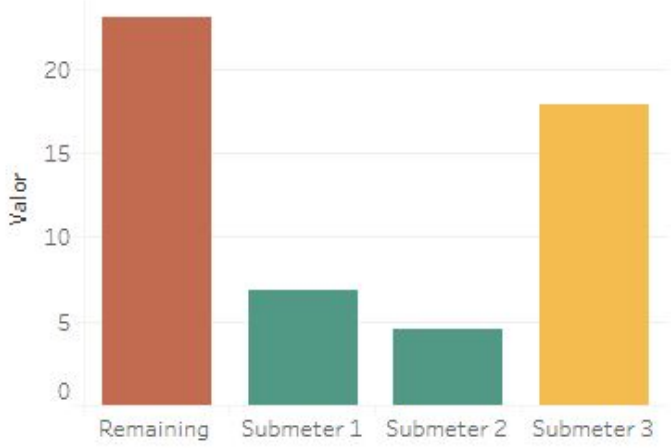
End Date
7/2/2009 23:59:00 ()

Choosing Submeters
Remaining

Appliances

Base consumpt... Moderate cons...
High consumpt... Normal Consu...

EXAMPLE OF TOTAL: Usage of each submeter



Submeter 1	Submeter 2	Submeter 3	Remaining	Total
6,82	4,48	17,87	23,01	52,19

Start Date

7/2/2009 0:00:00 ()

End Date

7/2/2009 23:59:00 ()

Choosing Submeters

Total Energy

Appliances