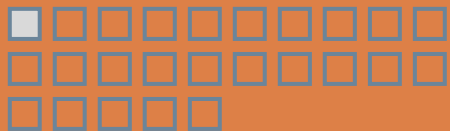


Forecasting prices in electricity markets

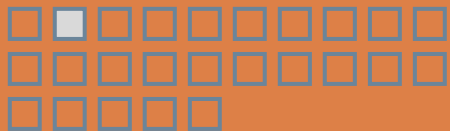
V Modelling Week
Complutense University of Madrid
Tuesday, 21 July 2011



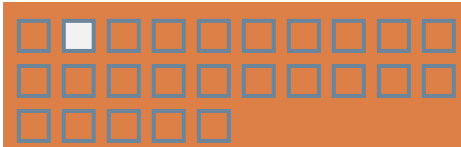
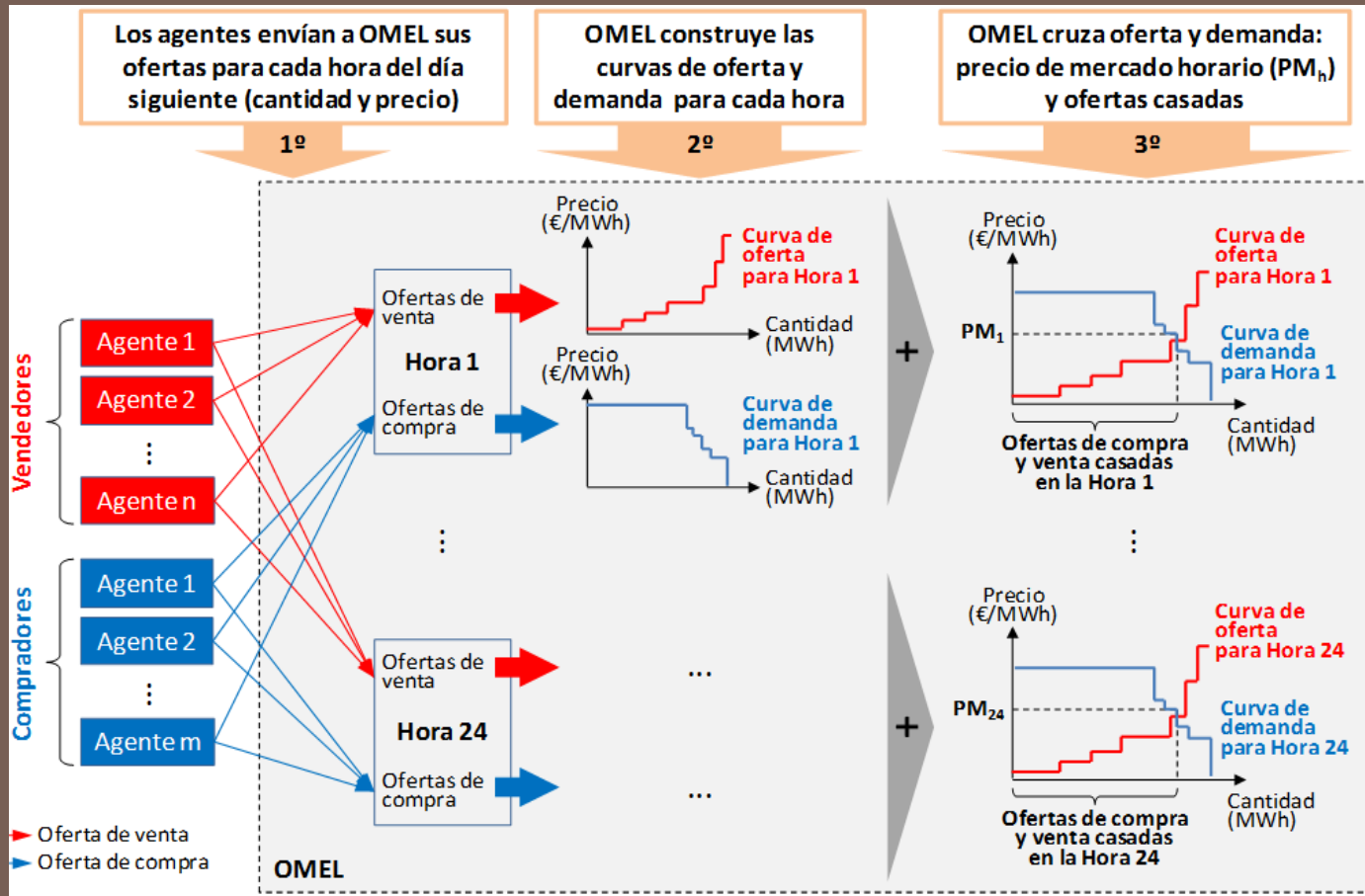
V Modelling Week
Forecasting prices in electricity markets

Contents

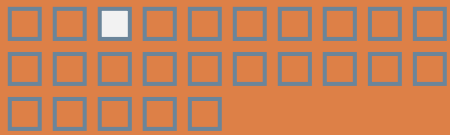
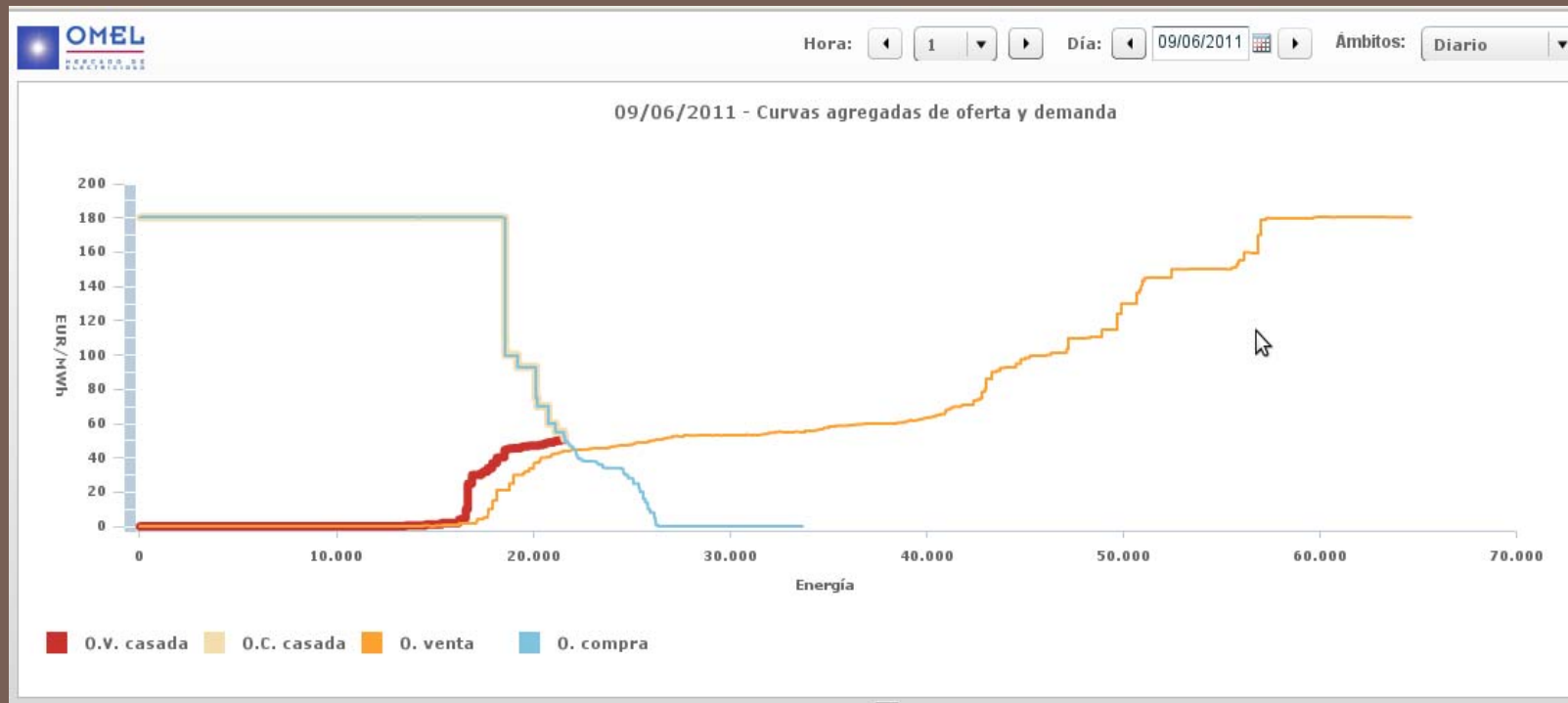
- Introduction to the problem
- Exploratory Analysis
- Arima Model
- Refinements
- KNN Model
- Conclusions



Introduction to the problem



Introduction to the problem

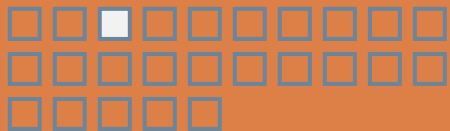
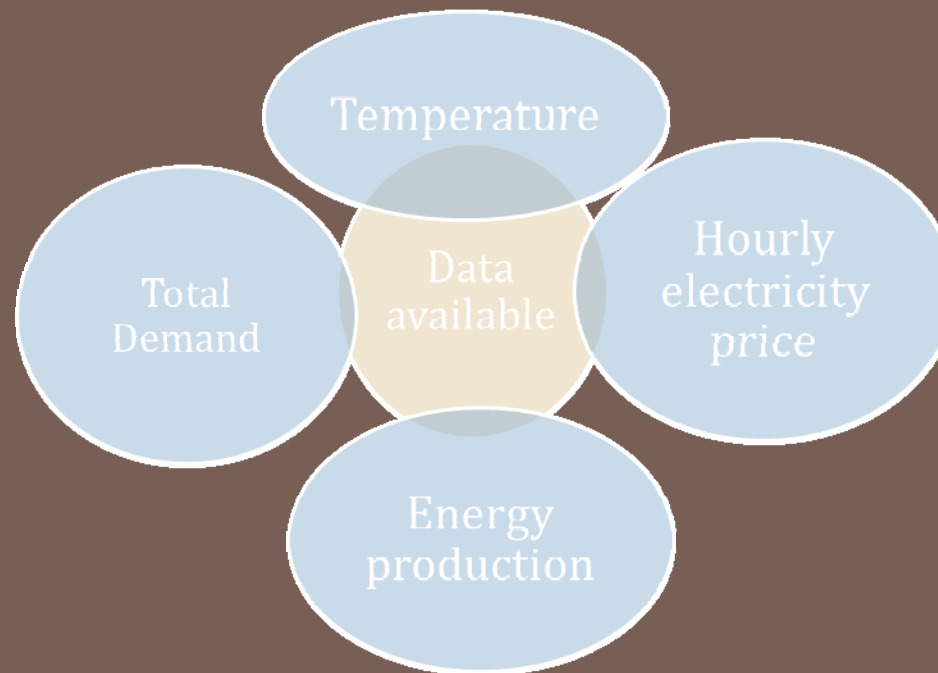


V Modelling Week
Forecasting prices in electricity markets

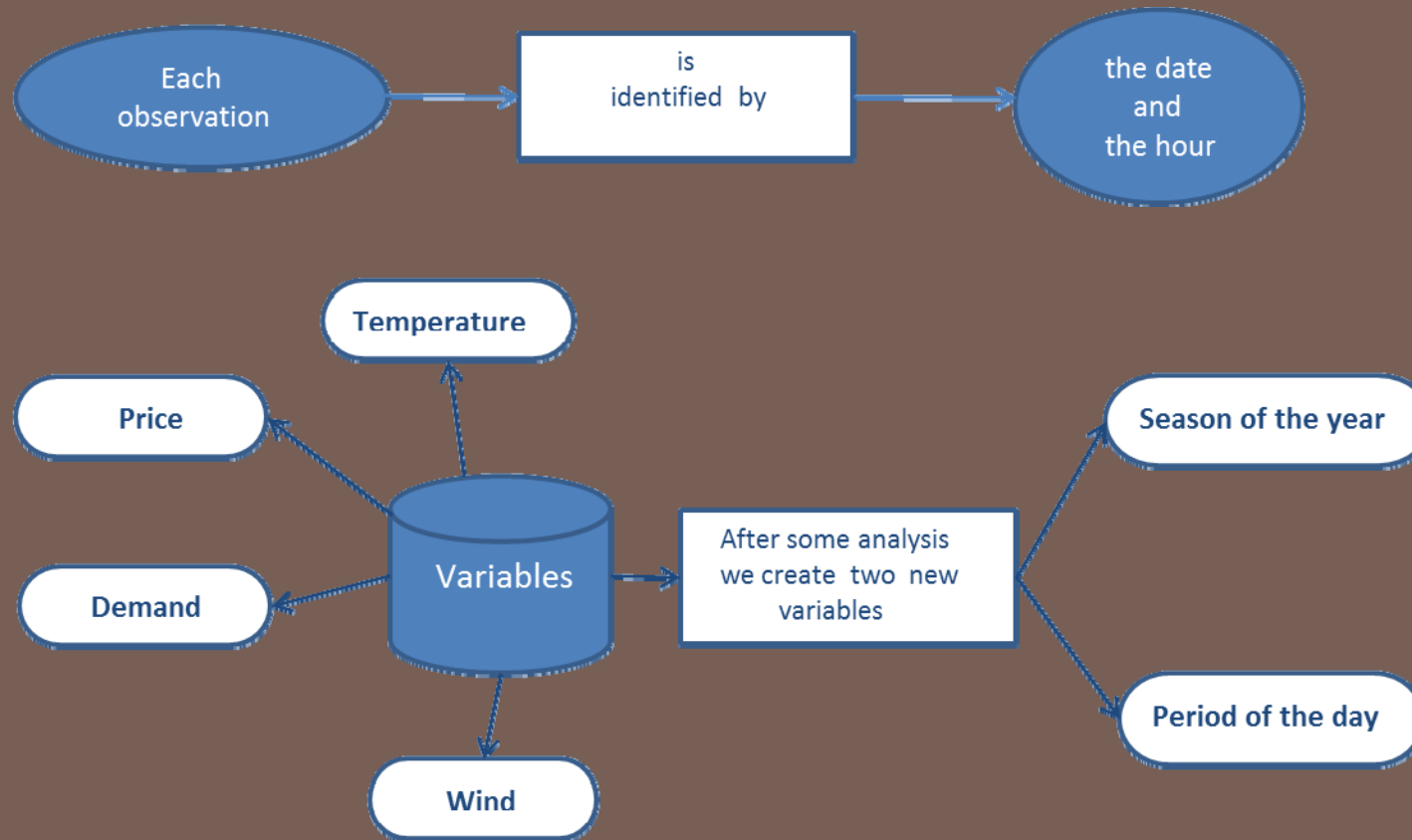


Introduction to the problem

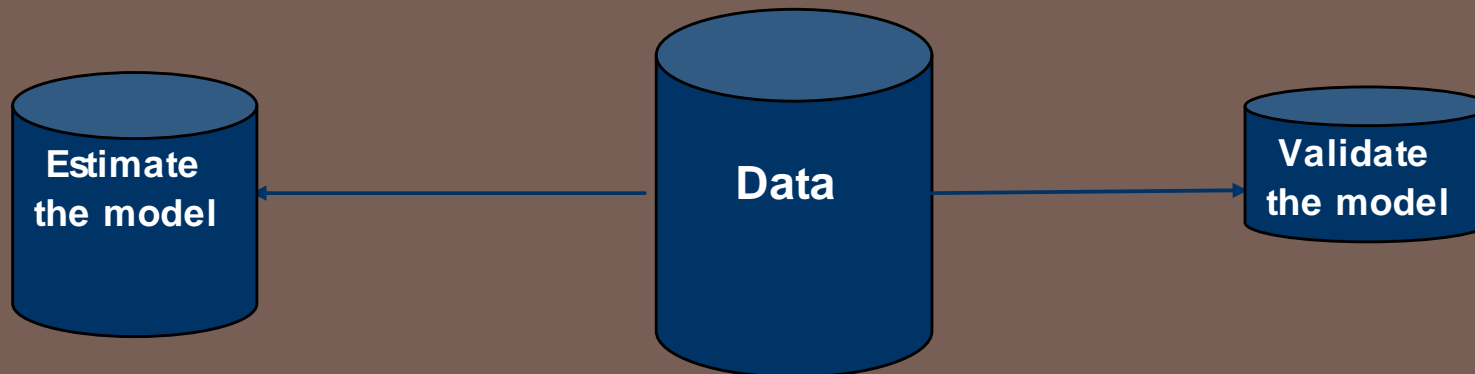
Aim  Hourly electricity price prediction model



Exploratory analysis. Data and variables

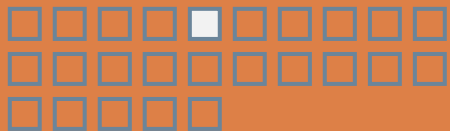


Exploratory analysis. Data and variables



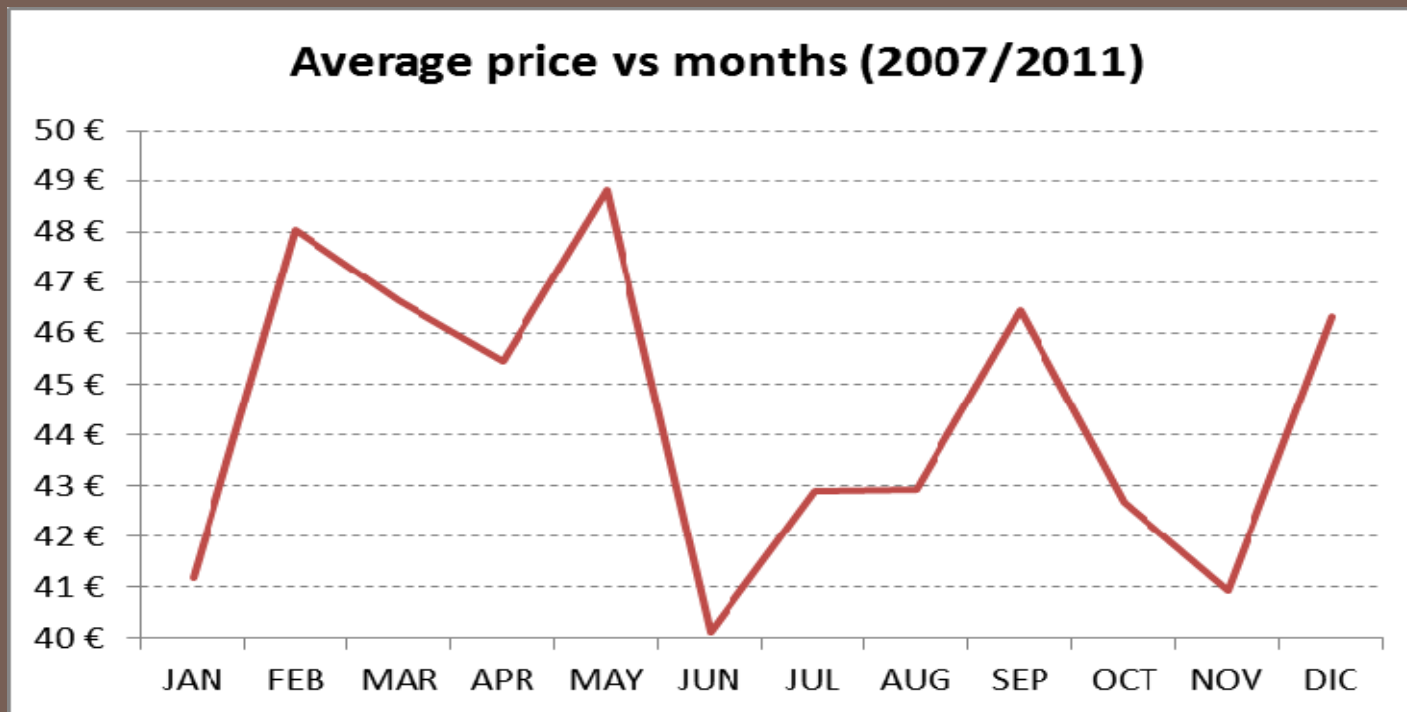
Data to estimate the model: June 2010 – May 2011

Data to validate the model: 1 – 12 of June 2011



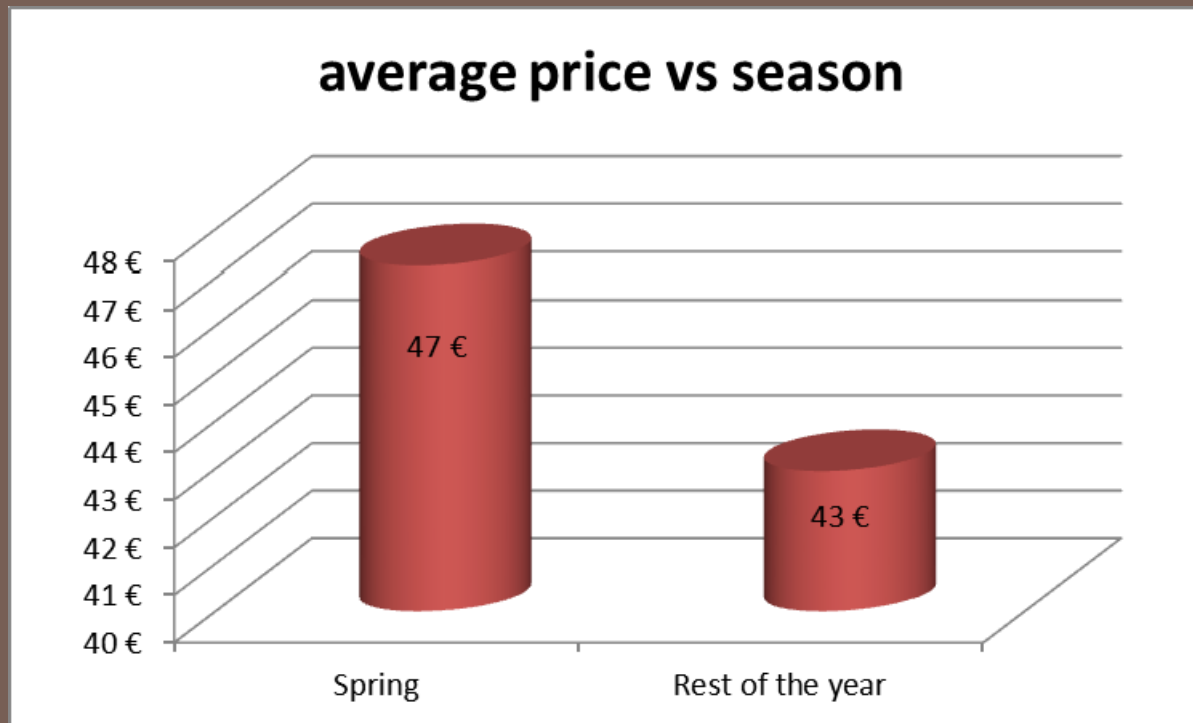
Exploratory analysis. Data and variables.

In this plot we can observe the distribution per months of the electricity prices between January 2007 and May 2011



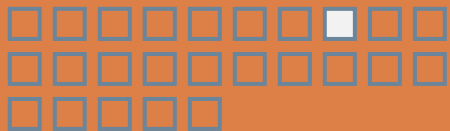
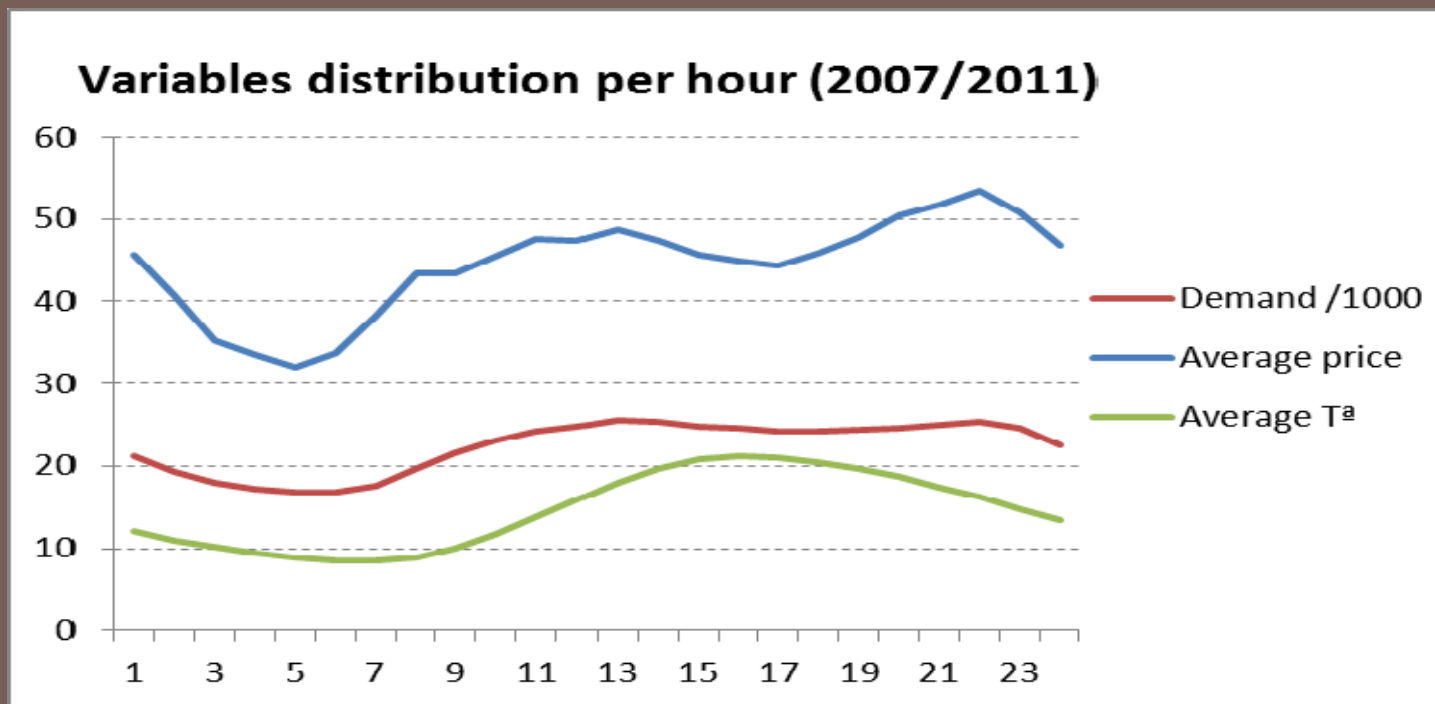
Exploratory analysis. Data and variables

Taking into account the last plot we create a new variable call “Season” that classifies the data in two categories, “Spring” and “Rest of the year”



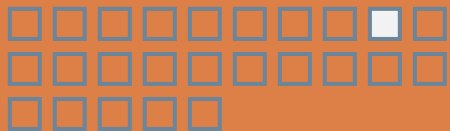
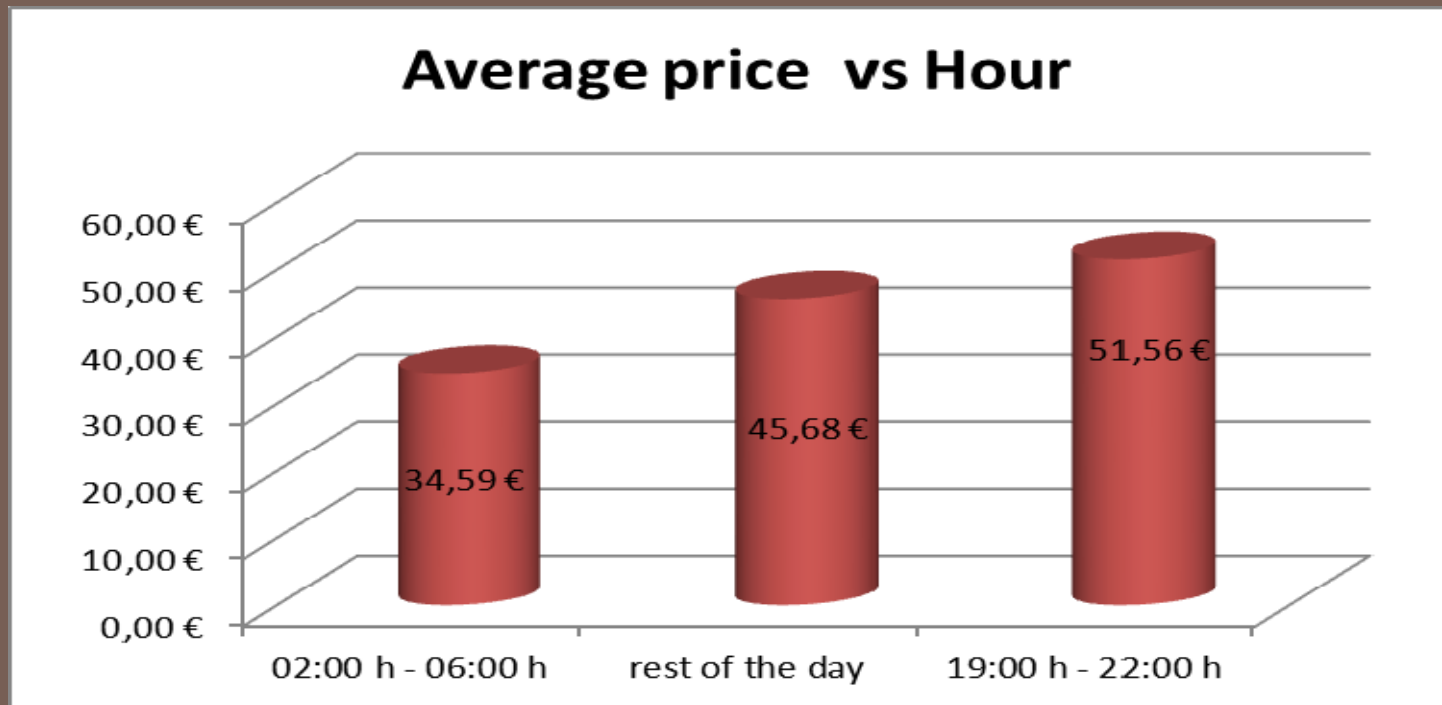
Exploratory analysis. Data and variables

In this plot we can observe the distribution of the electricity demand, Prices and temperature for the different hours of a day.



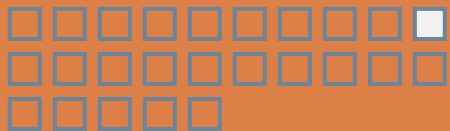
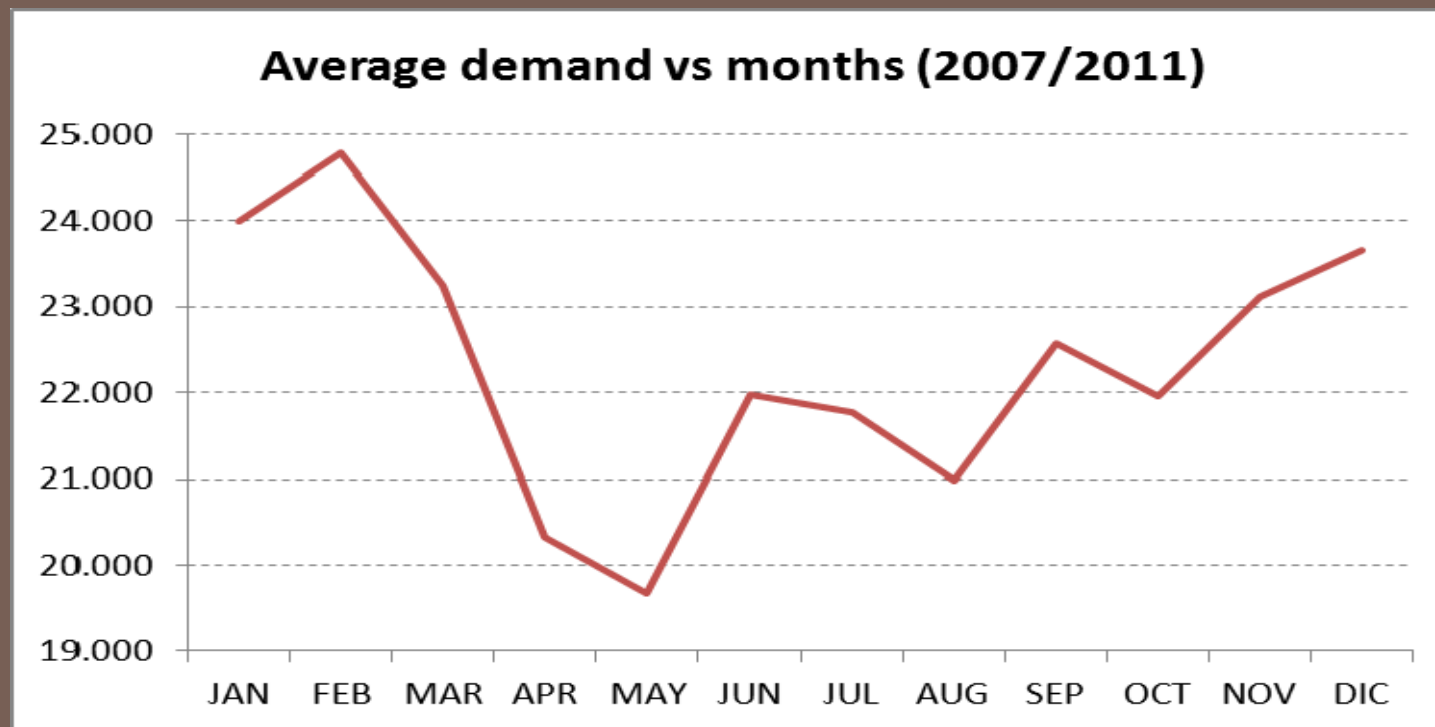
Exploratory analysis. Data and variables

Looking to the last plot we can create a new variable called “period of a day “ that classifies the 24 hours in three periods



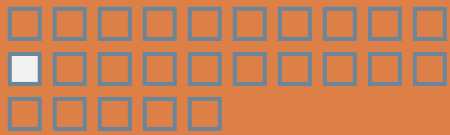
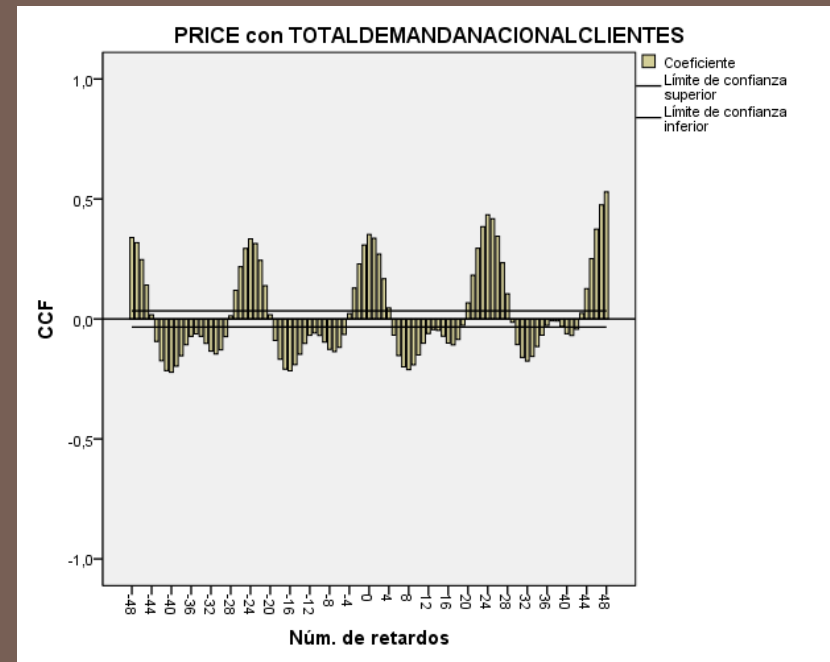
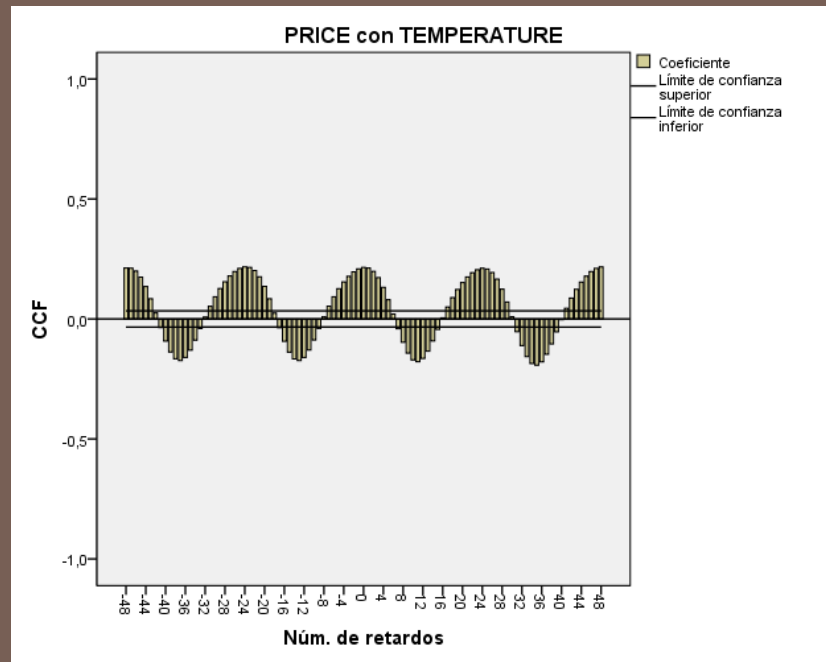
Exploratory analysis. Data and variables

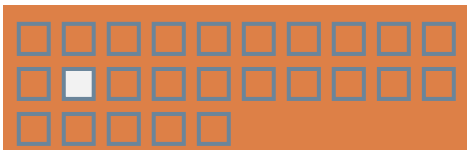
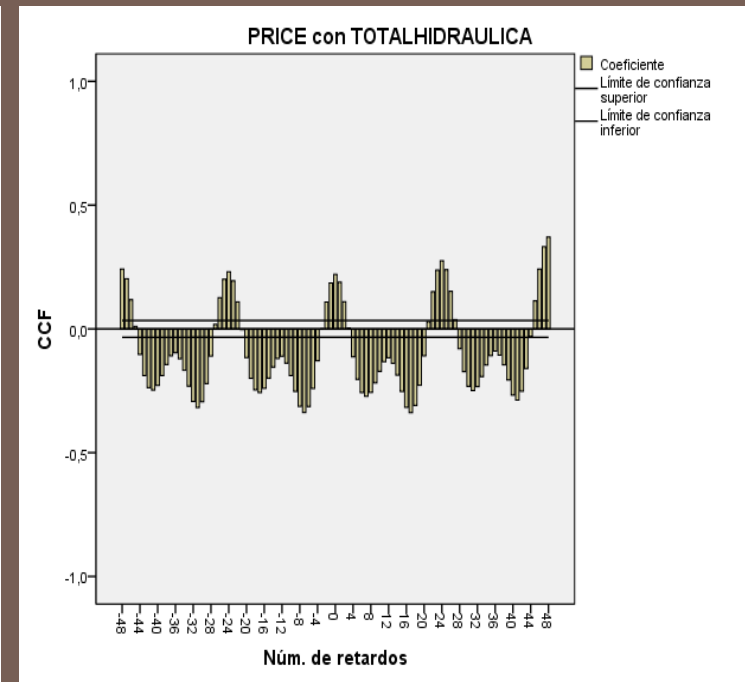
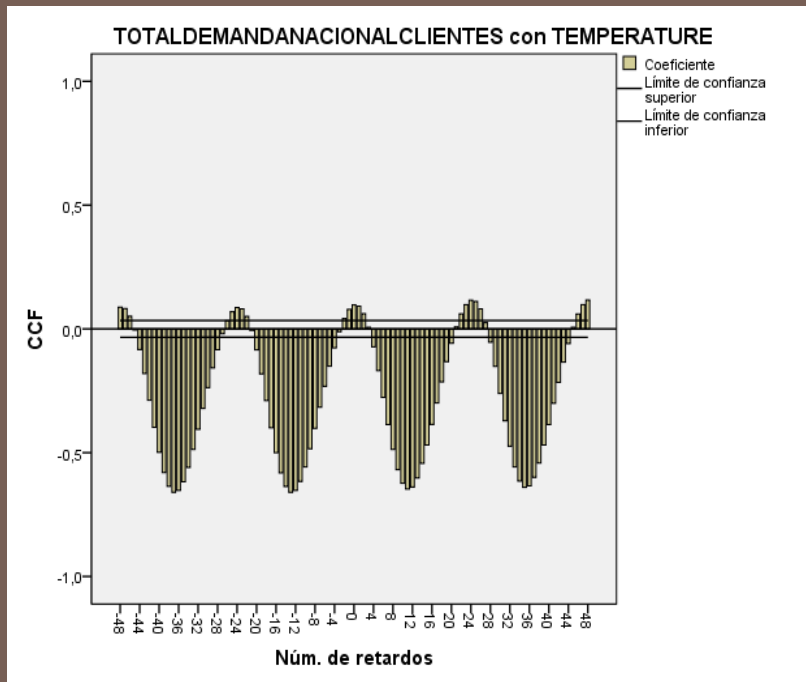
In this plot we can observe the distribution per month of the electricity demand during the last four years.



Exploratory analysis. Correlations.

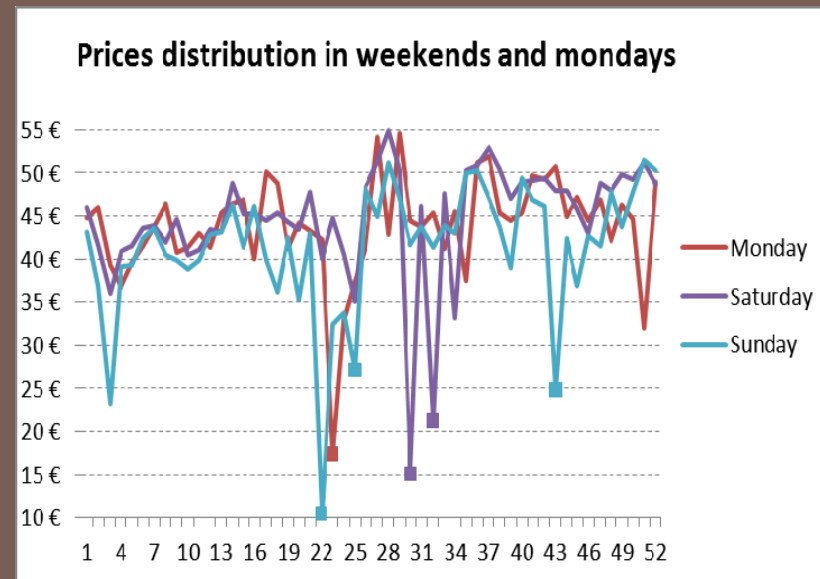
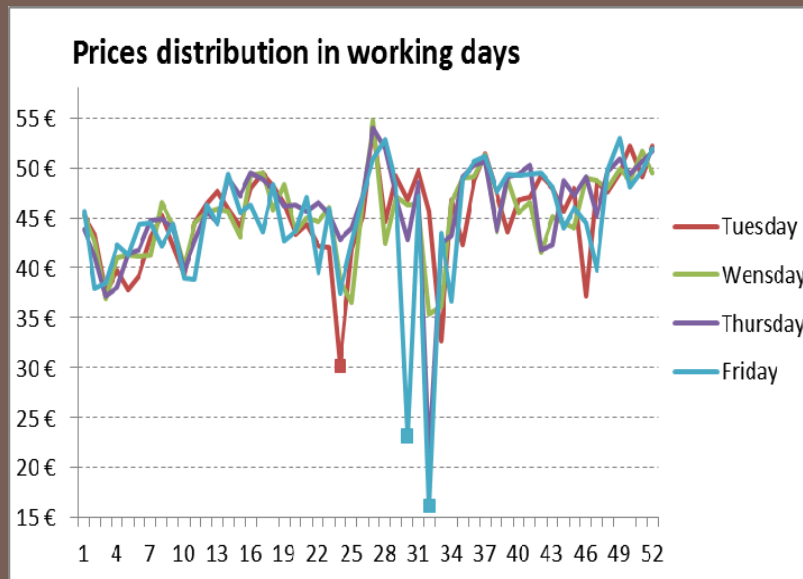
Here we represent the higher correlations between the different variables.



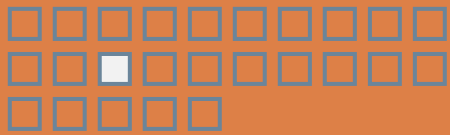


Exploratory analysis. Electricity prices.

In this plot we recognize some points that breaks the tendence of the Series. The horizontal axis represent all the weeks from 2007 to 2011



All these days corresponde to holidays in Spain (Christmas day, easter,...)



Prediction model building

- Methods
 - ARIMA Model
 - K- Nearest Neighbors (KNN)

- Data
 - Training dataset: 1 year
 - Validation dataset: 2 weeks

- Measures of the error
 - Mean Daily Error
 - Mean Weekly Error

$$\text{MDE} = \frac{1}{24} \sum_{h=1}^{24} \frac{|P_h - \hat{P}_h|}{\overline{P_h}}$$

$$\text{MWE} = \frac{1}{168} \sum_{h=1}^{168} \frac{|P_h - \hat{P}_h|}{\overline{P_h}}$$

- Previous works on forecasting electricity prices (Weron, 2008)
MWE 10-15%



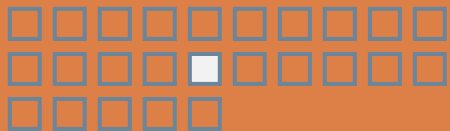
ARIMA Model

- Correlation between weeks = 0.557 \rightarrow Lag 168 = hours of a week
- Seasonality of 24 hours

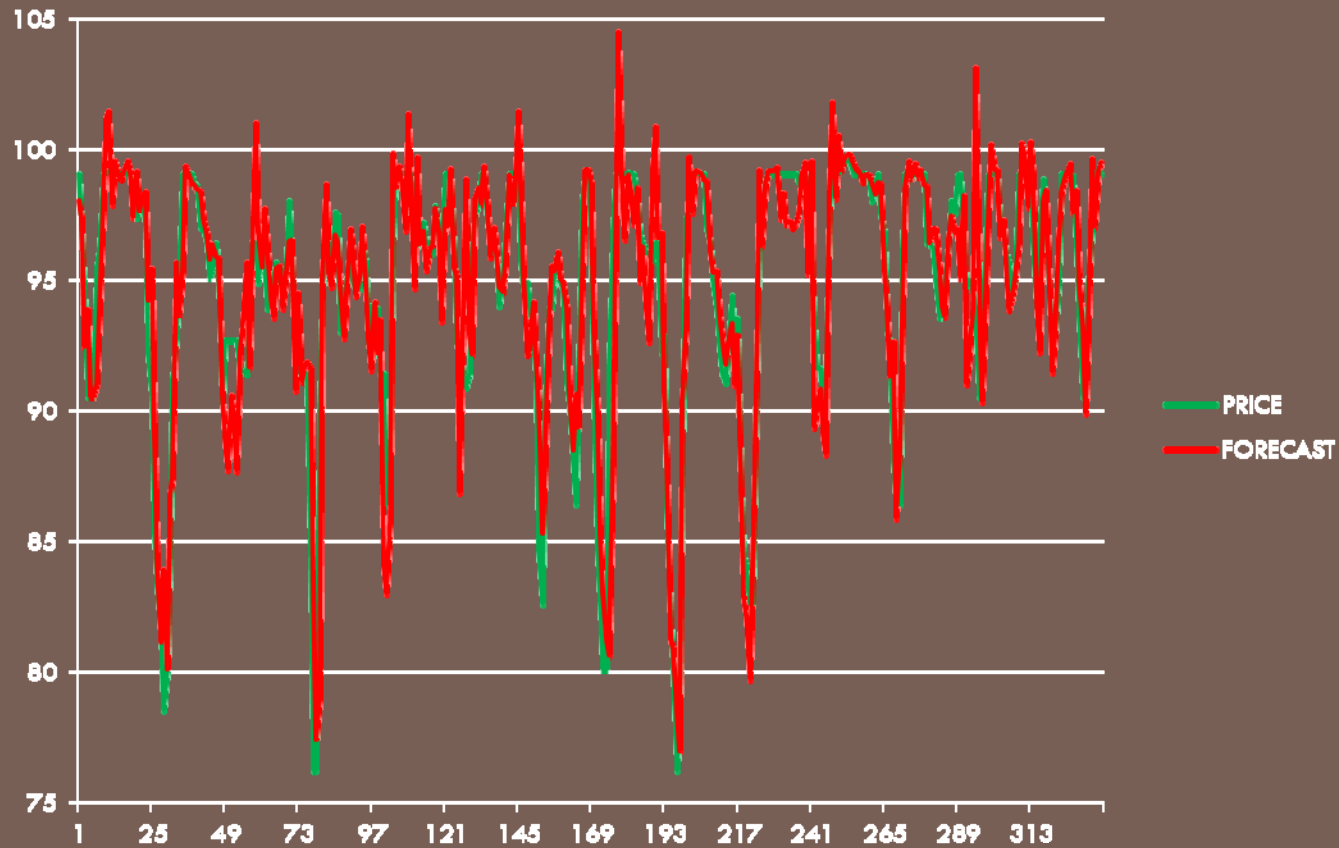
FINAL MODEL FOR FULL SERIE:

- ARIMA (3, 0, 10) \times (1, 1, 1)₂₄ \times (0, 1, 0)₁₆₈

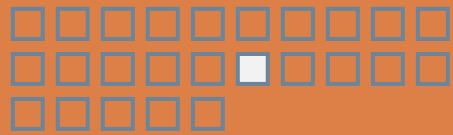
$$, \theta_3 = \theta_4 = \theta_5 = \theta_7 = \theta_8 = \theta_9 = 0.$$



FORECAST FOR PRICE USING THE VARIABLE PRICE AND ARIMA MODEL



Mean Weekly Error: 2.3 % for both weeks

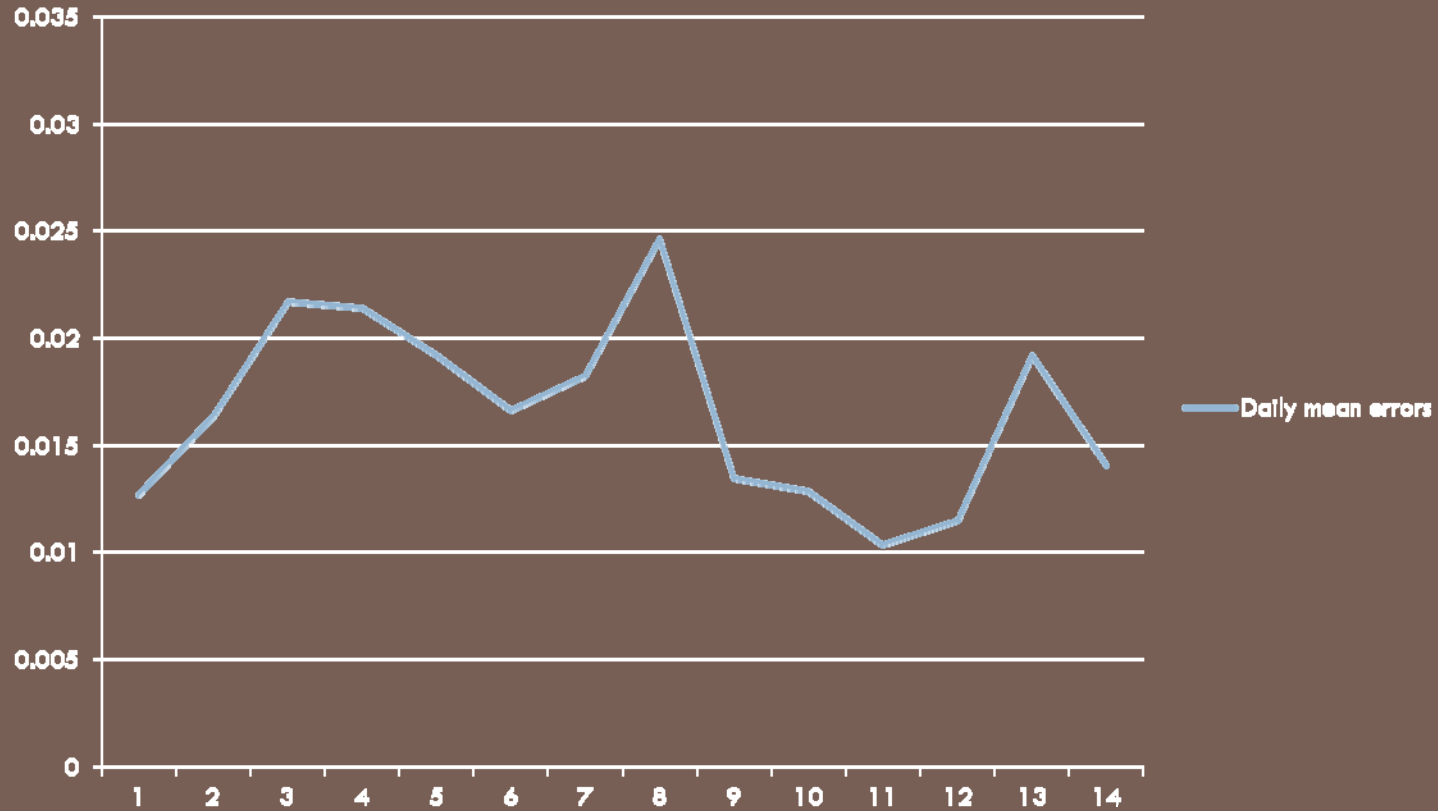


V Modelling Week
Forecasting prices in electricity markets

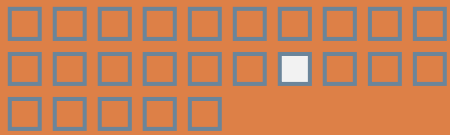


FORECAST FOR PRICE USING THE VARIABLE PRICE AND ARIMA MODEL

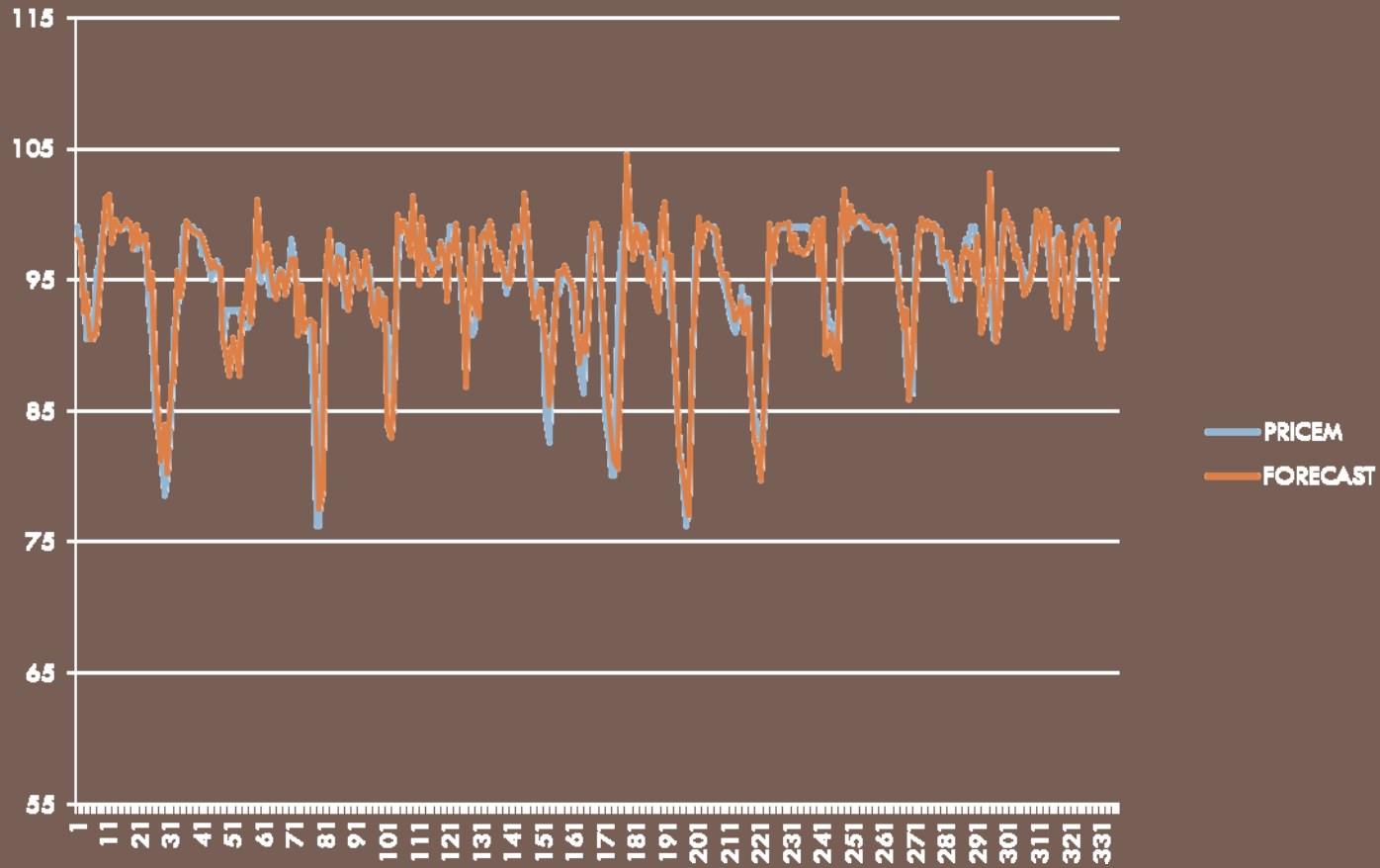
Daily mean errors



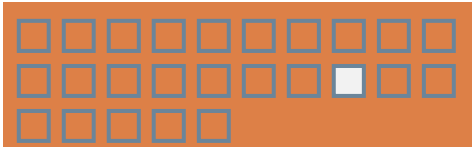
Maximum = 2.46 % in 6 June 2011



FORECAST FOR PRICE USING THE VARIABLE PRICE AND NATIONAL DEMAND



Mean Weekly Error: 2.0 % for both weeks



V Modelling Week
Forecasting prices in electricity markets



ARIMA Model

FINAL MODEL FOR FULL SERIE:

- ARIMA (3, 0, 10) x (1, 1, 1)₂₄ x (0, 1, 0)₁₆₈

$$, \theta_3 = \theta_4 = \theta_5 = \theta_7 = \theta_8 = \theta_9 = 0.$$

No mean term in this model.

Autoregressive Factors

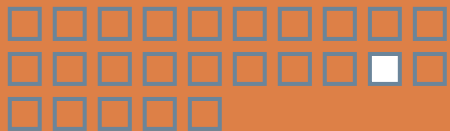
Factor 1: $1 + 0.28912 B^{**}(3)$

Factor 2: $1 - 0.82937 B^{**}(1)$

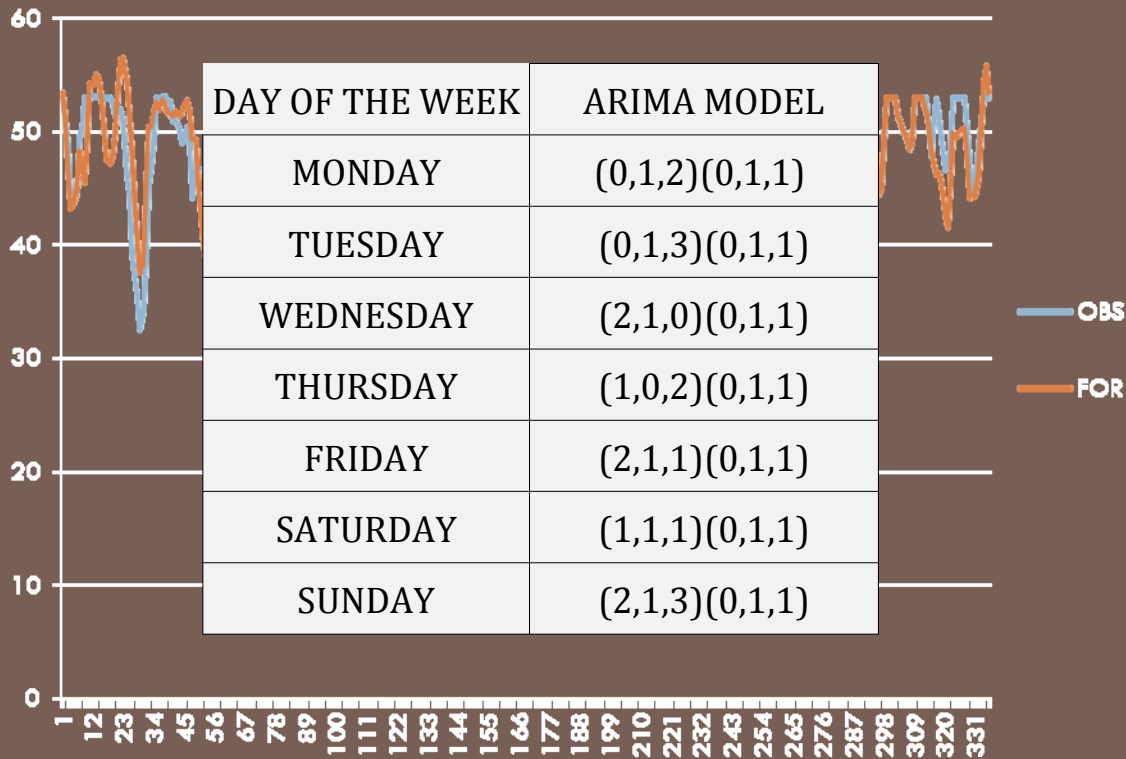
Moving Average Factors

Factor 1: $1 - 0.46842 B^{**}(1) + 0.34295 B^{**}(2) - 0.05455 B^{**}(6) + 0.06695 B^{**}(10)$

Factor 2: $1 + 0.62342 B^{**}(1)$

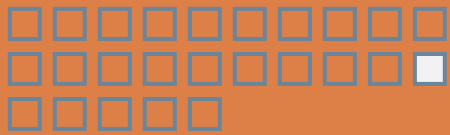


ARIMA by days.



- 7 time series, one for each day
- Problem: no information about the previous day

MWE1	5,32 %
MWE2	6,02 %



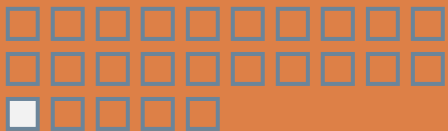
KNN method

We take the data for the price each day to be a vector of 24 entries.

Training set of data, say $\{p_1, p_2, p_3, \dots, p_t\}$.

Rank each day in order of similarity to today, choose k Nearest Neighbours say $\{v_1, v_2, \dots, v_k\}$

Day next to a nearest neighbour of today will be nearest neighbour of tomorrow. $\{v_1, v_2, \dots, v_k\}$

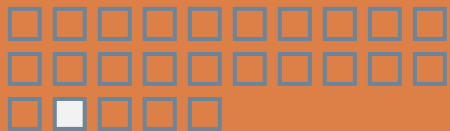


KNN method

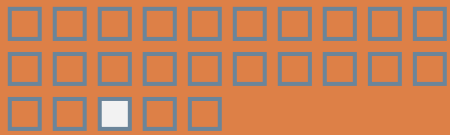
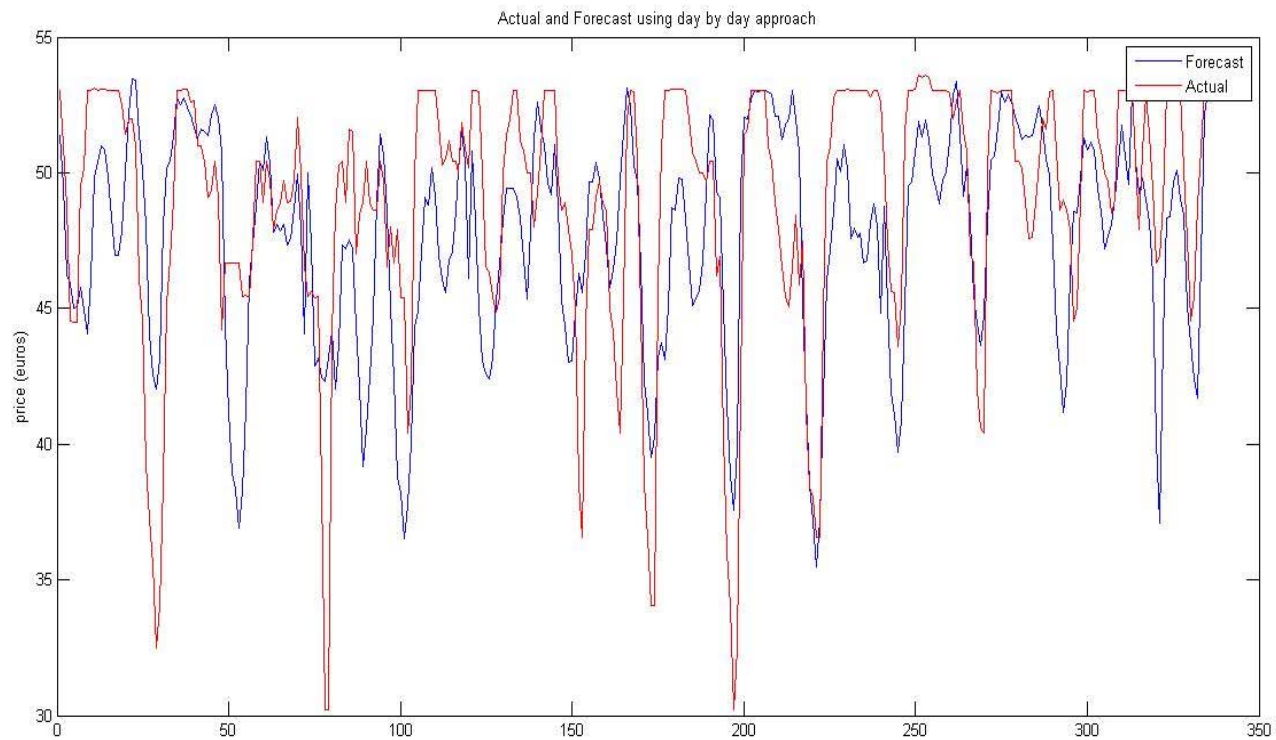
Tomorrow's price is a weighted linear combination of its k nearest neighbours.

$$p_{t+1} = \frac{1}{\alpha_1 + \alpha_2 + \dots + \alpha_k} \sum_{i=1}^{i=k} \alpha_i \bar{v}_i$$

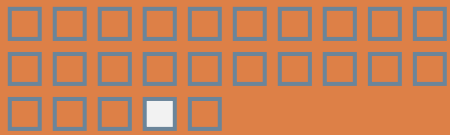
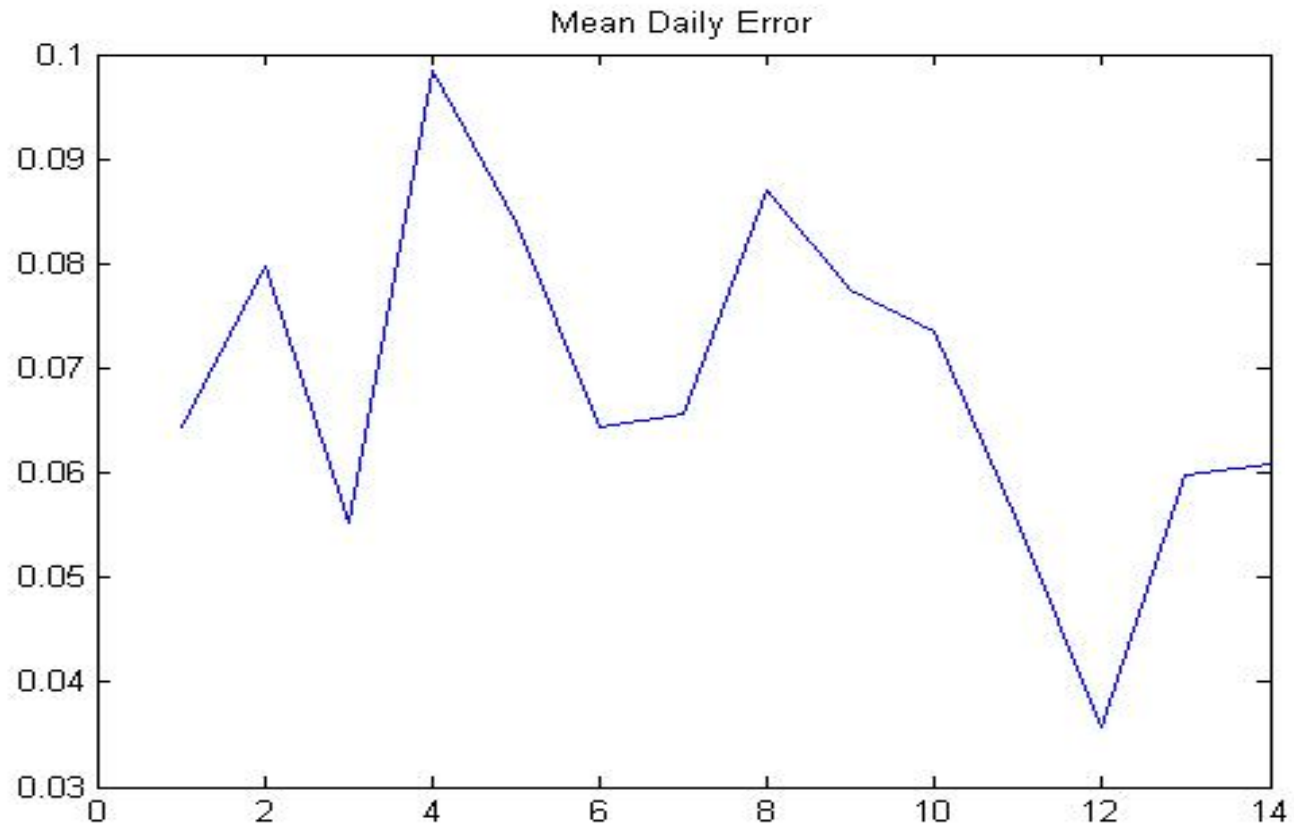
$$\alpha_i = \frac{d(p_k, p + t) - d(p_i, p_t)}{d(p_k, p + t) - d(p_1, p_t)}$$



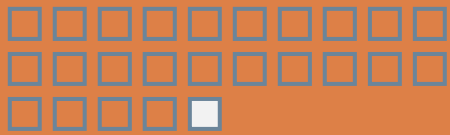
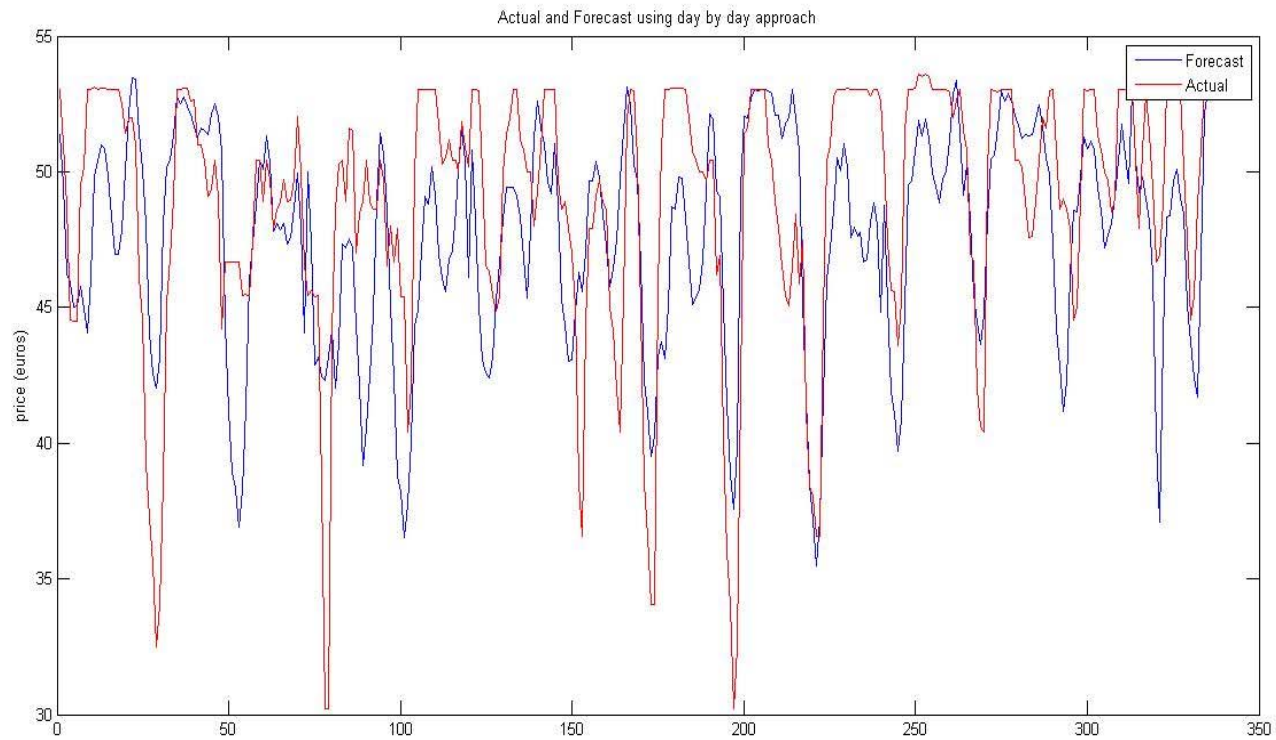
KNN method



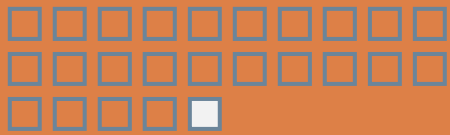
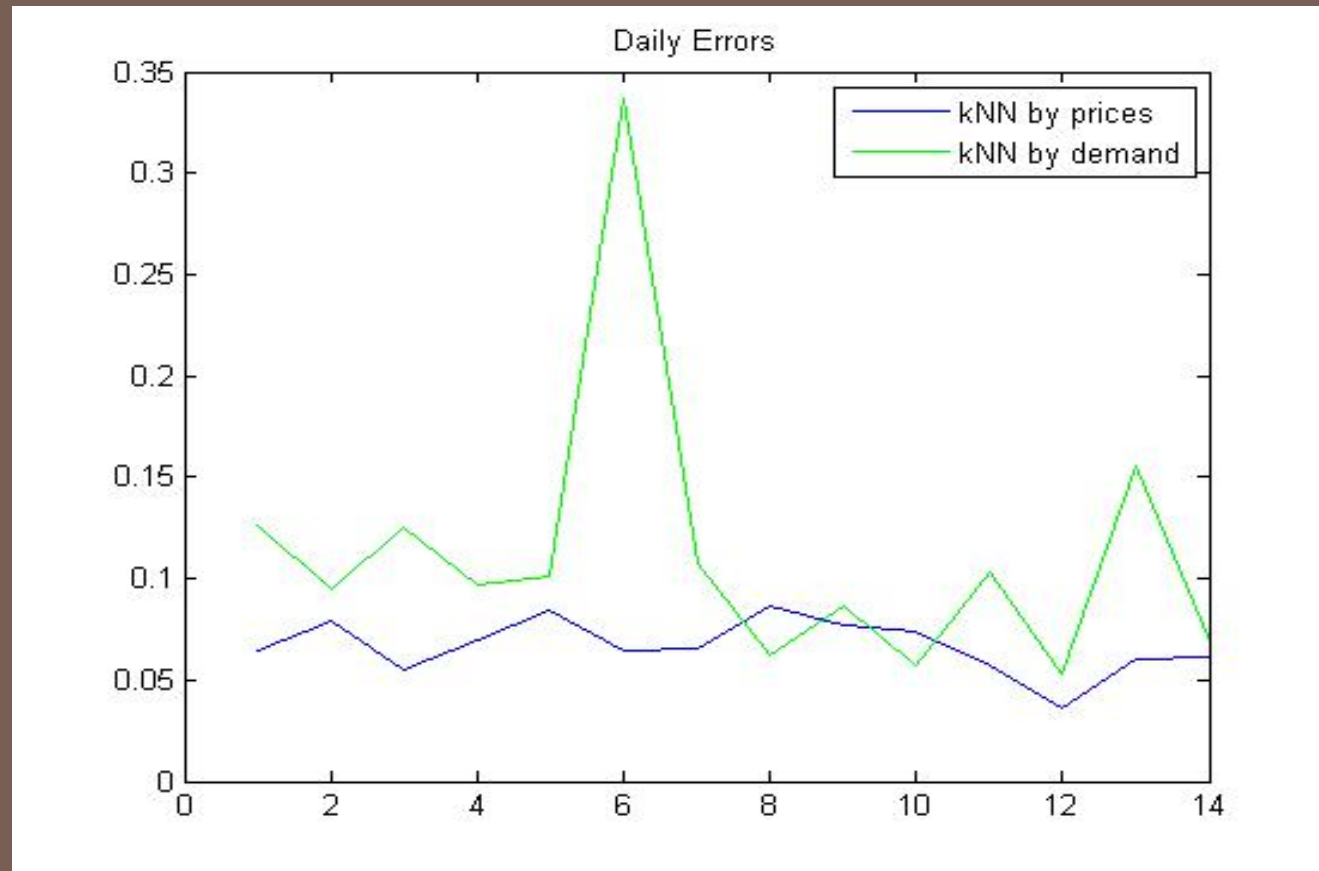
KNN method



KNN method by Demand



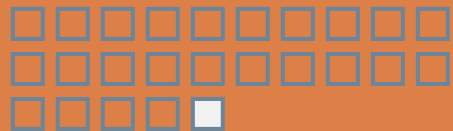
KNN method by Demand



Conclusion

	ARIMA	ARIMA + Demand	ARIMA + Demand , by days	KNN	KNN by demand
MWE 1	2.05%	2.0%	5%	7.3%	14%
MWE 2	2.1%	2.0%	6%	6.4%	8.4%

Lots of future investigation....



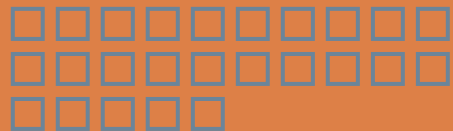
Thank you!

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Charmi Devendra Panchal
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Instructors

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V Modelling Week
Forecasting prices in electricity markets

