DATA SERVER ENERGY CONSUMPTION DTASET

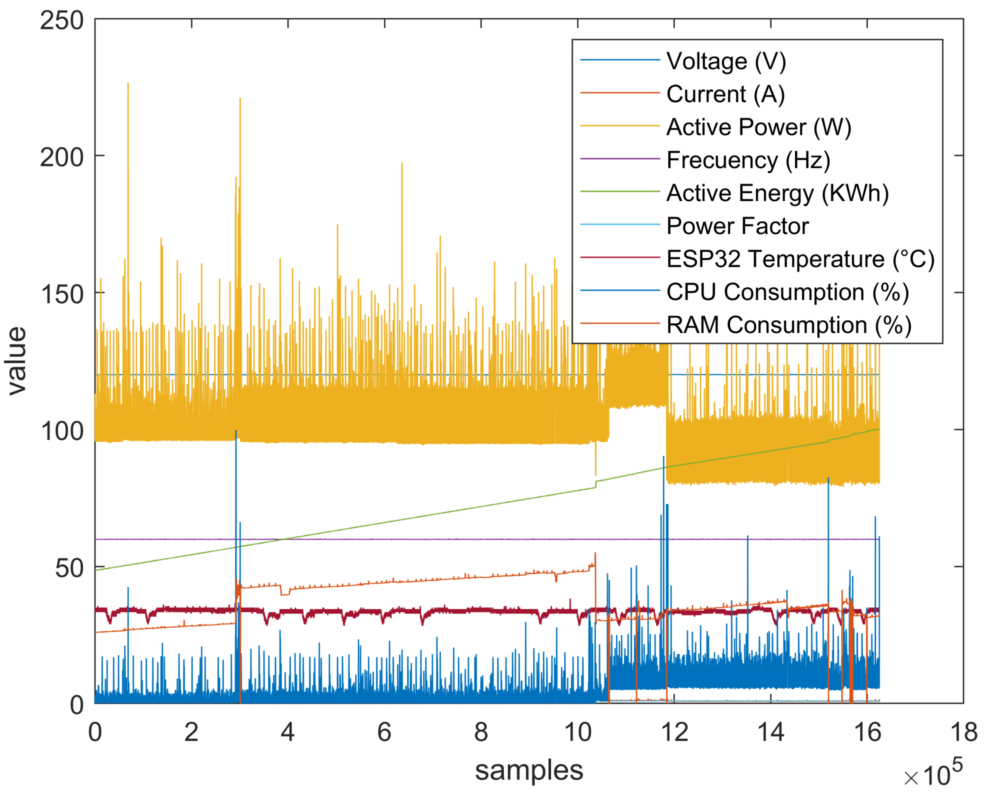
Víctor Asanza, Rebeca Estrada, Adrian Bazurto, Danny Torres

- Main Code: https://github.com/vasanza/Matlab_Code/tree/EnergyConsumptionPredictionDatacenter
- `DataPort:` https://dx.doi.org/10.21227/x6jw-m015
- `More Matlab Examples:` https://github.com/vasanza/Matlab_Code
- Load Data, Sampling Rate=1sample/1seg
- Date = '2021-05-27 00:00:00' AND '2021-06-17 22:04:21'

```
clear;clc;%clear all
%Prepare the raw dataset
addpath(genpath('./src'))%functions folders
%load('./data/dataset.mat');%Load table data
path = fullfile('./data/dataset.mat');
data=load(path);data=data.data;
dataNew=table2array(data(:,4:12));% Array Double
%csvwrite('data.csv',dataNew);%Save as .csv file
```

Plot Raw Data (Dataset)

```
figure
plot(dataNew);xlabel('samples');ylabel('value');
legend('Voltage (V)','Current (A)','Active Power (W)','Frecuency (Hz)','Active Energy (KWh)','P
```



Statital Information Raw Data (Dataset)

```
xds_v = datastats(dataNew(:,1))%Voltage (V)
```

```
xds_v = struct with fields:
       num: 1625175
       max: 120.2000
       min: 119.4000
      mean: 120.0236
    median: 120
     range: 0.8000
       std: 0.0648
```

```
xds_C = datastats(dataNew(:,2))%Current (A)
```

```
xds_C = struct with fields:
       num: 1625175
       max: 1.9800
       min: 0.7000
      mean: 0.9240
    median: 0.9300
     range: 1.2800
       std: 0.0934
```

```
xds_AP = datastats(dataNew(:,3))%Active Power (W)
```

```
xds_AP = struct with fields:
       num: 1625175
       max: 226.6000
       min: 79.1000
      mean: 98.9189
    median: 96.6000
     range: 147.5000
       std: 9.3631
```

```
xds_F = datastats(dataNew(:,4))%Frecuency (Hz)
```

```
xds_F = struct with fields:
       num: 1625175
       max: 60.1000
       min: 59.7000
      mean: 59.9668
    median: 60
     range: 0.4000
       std: 0.0488
```

```
xds_AE = datastats(dataNew(:,5))%Active Energy (KWh)
```

```
xds_AE = struct with fields:
       num: 1625175
       max: 100.1200
       min: 48.5600
      mean: 73.3169
    median: 72.2300
     range: 51.5600
       std: 14.9472
```

```
xds_PF = datastats(dataNew(:,6))%Power Factor
```

```
xds_PF = struct with fields:
```

```
         num: 1625175
         max: 1
         min: 0.7300
        mean: 0.8946
      median: 0.8600
       range: 0.2700
         std: 0.0443
```

```
xds_T = datastats(dataNew(:,7))%ESP32 Temperature (°C)
```

```
xds_T = struct with fields:
         num: 1625175
         max: 38.3300
         min: 28.3300
        mean: 33.2923
      median: 33.8900
       range: 10
         std: 1.0580
```

```
xds_CPU = datastats(dataNew(:,8))%CPU Consumption (%)
```

```
xds_CPU = struct with fields:
         num: 1625175
         max: 99.8000
         min: 0
        mean: 3.8781
      median: 1.3000
       range: 99.8000
         std: 4.5249
```

```
xds_RAM = datastats(dataNew(:,9))%RAM Consumption (%)
```

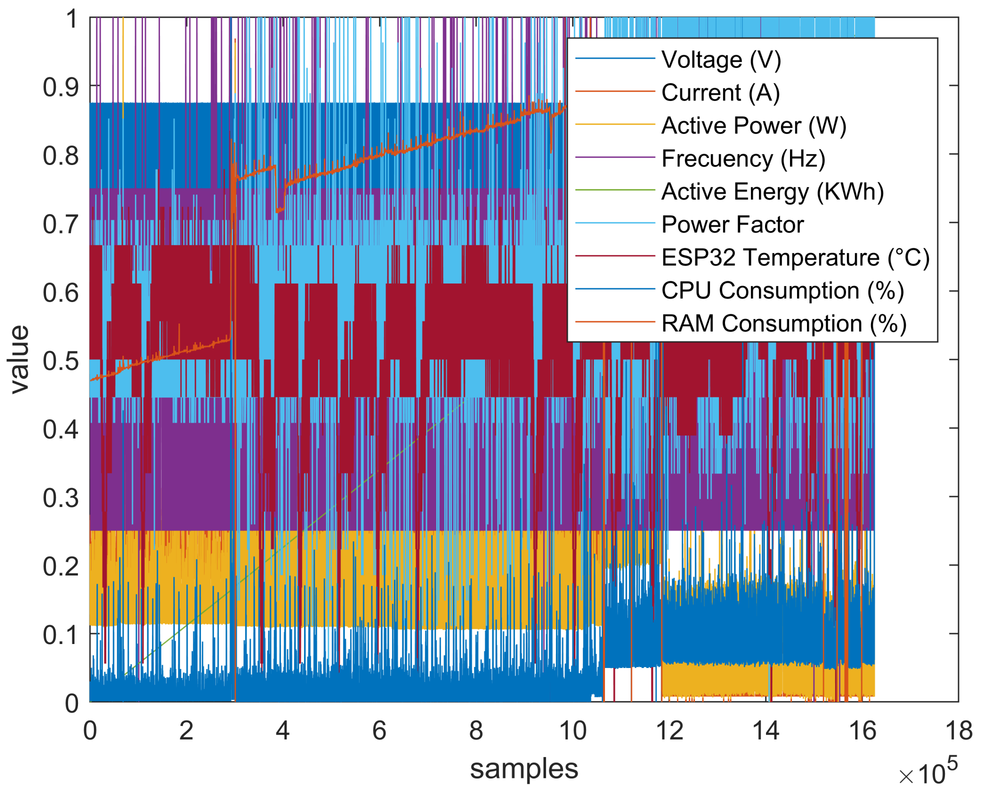
```
xds_RAM = struct with fields:
         num: 1625175
         max: 55.2000
         min: 0
        mean: 37.6688
      median: 36.3500
       range: 55.2000
         std: 7.0824
```

1 - Preprocessing (Normalization)

```
DataNorm=[];
DataNorm=fNormalization(dataNew);
```

Plot Normalization Data (Dataset)

```
figure
plot(DataNorm);xlabel('samples');ylabel('value');
legend('Voltage (V)','Current (A)','Active Power (W)','Frecuency (Hz)','Active Energy (KWh)','P
```



2 - Feature Extraction (rms by temporary window)

```
% Select only one TimeStep
% not enough data... TimeStep =2592000;% one month in second
%TimeStep =604800;% one week in second (only 2 weeks)
TimeStep =86400;% one day in second (ok)
%TimeStep =3600;% one hour in second (ok)
%TimeStep =60;% one minute in second (ok)
%TimeStep =1;% one second

DataFeatures = frms_features(DataNorm,TimeStep);

% Feature 1: rms(Active Power (W))
xds_F1 = datastats(DataFeatures(:,1))
```

```
xds_F1 = struct with fields:
       num: 18
       max: 0.8171
       min: 0.7001
      mean: 0.7822
    median: 0.7912
     range: 0.1170
       std: 0.0318
```

```
% Feature 2: rms(Active Energy (KWh))
xds_F2 = datastats(DataFeatures(:,2))
```

```
xds_F2 = struct with fields:
```

```
         num: 18
         max: 0.2795
         min: 0.0942
        mean: 0.1852
      median: 0.1979
       range: 0.1853
         std: 0.0546
```

```
% Feature 3: rms(CPU Consumption (%))
xds_F3 = datastats(DataFeatures(:,3))
```

```
xds_F3 = struct with fields:
         num: 18
         max: 0.2436
         min: 0.1065
        mean: 0.1452
      median: 0.1397
       range: 0.1371
         std: 0.0386
```

```
% Feature 4: rms(RAM Consumption (%))
xds_F4 = datastats(DataFeatures(:,4))
```

```
xds_F4 = struct with fields:
         num: 18
         max: 0.6819
         min: 0.6712
        mean: 0.6777
      median: 0.6777
       range: 0.0107
         std: 0.0027
```

3 - Feature Selection

```
%corrplot(DataNorm)
R = corrcoef(DataFeatures)
```

```
R = 9×9
    1.0000   -0.7763   -0.9700   -0.2775   -0.1205    0.0960    0.2632   -0.1399 ···
   -0.7763    1.0000    0.8457    0.4532   -0.4492   -0.6743   -0.0440   -0.4727
   -0.9700    0.8457    1.0000    0.2958    0.0336   -0.1788   -0.0996    0.0686
   -0.2775    0.4532    0.2958    1.0000   -0.4554   -0.4249   -0.1705   -0.3625
   -0.1205   -0.4492    0.0336   -0.4554    1.0000    0.8613   -0.1227    0.8803
    0.0960   -0.6743   -0.1788   -0.4249    0.8613    1.0000   -0.0350    0.9627
    0.2632   -0.0440   -0.0996   -0.1705   -0.1227   -0.0350    1.0000   -0.0433
   -0.1399   -0.4727    0.0686   -0.3625    0.8803    0.9627   -0.0433    1.0000
    0.0913    0.0697   -0.0833   -0.1255    0.0962   -0.2855   -0.3004   -0.2757
```

```
%'Voltage (V)','Current (A)','Active Power (W)','Frecuency (Hz)','Active Energy (KWh)','Power F
%Heat map
% Experimento: ESP32 Temperature
DataFeatures(:,7)=[];
% Based on corrcoef To delete:
% PowerFactor -> alta correlacion con Active Energy (85%), entonces nos
% quedamos con Active Energy
% Voltage, current -> Alta correlacion con Active Power (91% y 86%),
% entonces nos quedfamos Active Power
DataFeatures(:,6)=[];DataFeatures(:,2)=[];DataFeatures(:,1)=[];
% Parametros electricos: Frecuency
```

```
DataFeatures(:,2)=[];
%Nos quedamos con estas variables: 'Active Power (W)','Active Energy (KWh)','CPU Consumption (%
```

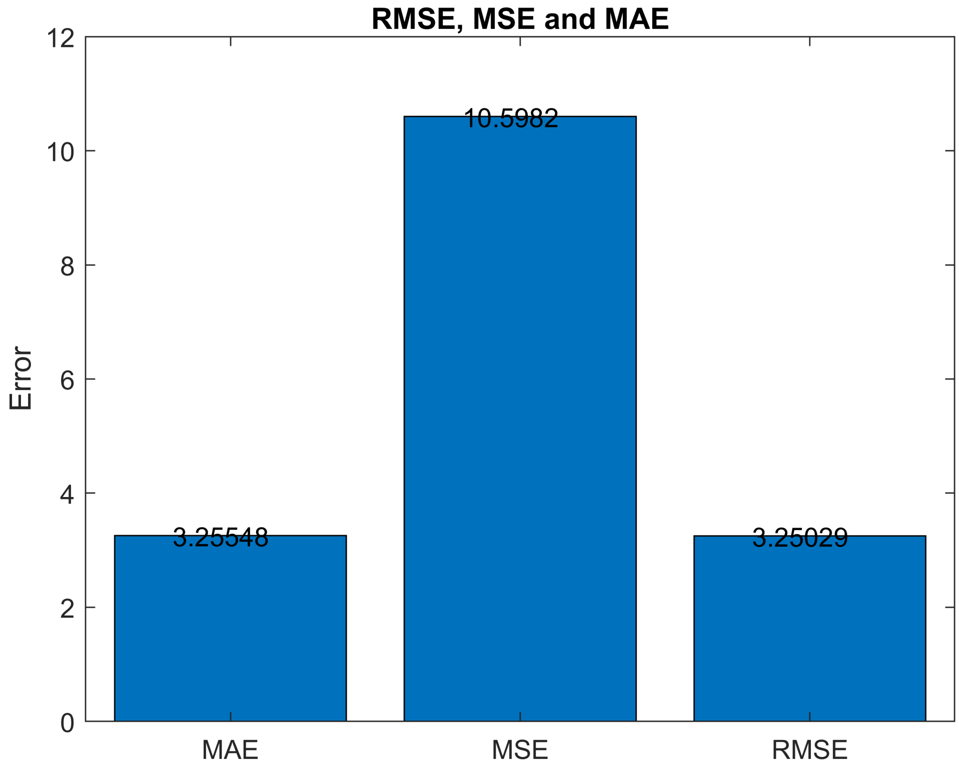
4 - Regression Learner (Input output Data)

```
training=0.85; %70 Training, 15% Validation, 15% Testing
testing=0.15;

input=[];output=[];
% inputs: Active Power (W),Active Energy (KWh),CPU Consumption (%),RAM Consumption (%)
input=DataFeatures(1:round(length(DataFeatures)*training)-1,:);
% output: Energía in the following time step
output=DataFeatures(1+1:round(length(DataFeatures)*training),2);
Samples=length(DataFeatures)*0.85-1
```

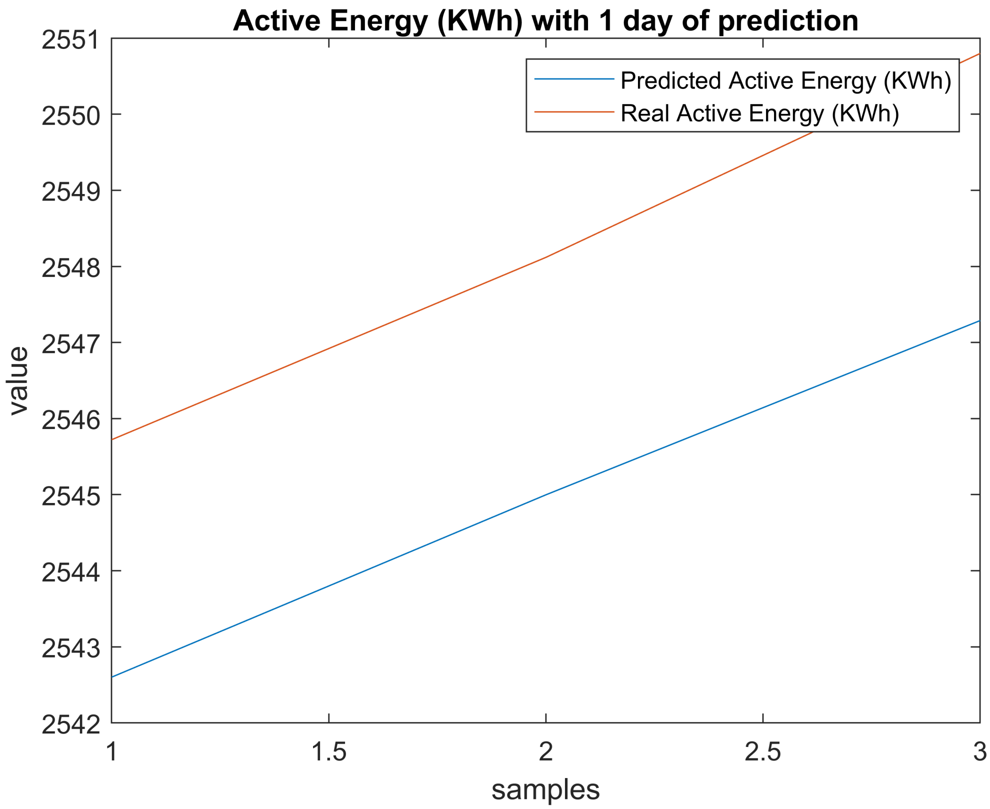
```
Samples = 14.3000
```

RMSE (Testing): 1 day

```
% inputs: Active Power (W),Active Energy (KWh),CPU Consumption (%),RAM Consumption (%)
TimeStep =86400;% one day in second (ok)
DataFeatures = frms_features(DataNorm,TimeStep);
DataFeatures(:,7)=[];DataFeatures(:,6)=[];DataFeatures(:,2)=[];DataFeatures(:,1)=[];DataFeature

input_testing=DataFeatures(round(length(DataFeatures)*training):length(DataFeatures)-1,:);
% output: Energía in the following time step
output_testing=DataFeatures(round(length(DataFeatures)*training)+1:length(DataFeatures),2);

% To make predictions on a new predictor column matrix, X, use:
% yfit = c.predictFcn(X)
% replacing 'c' with the name of the variable that is this struct, e.g. 'trainedModel'.
% X must contain exactly 4 columns because this model was trained using 4 predictors.
% X must contain only predictor columns in exactly the same order and format as your training
% Do not include the response column or any columns you did not import into the app.

trainedModel_1day=load('trainedModel_1day.mat');%Load Best Prediction Model by 1day
predictValue_1day=trainedModel_1day.trainedModel_1day.predictFcn(input_testing);
% Denormilize Data
DpredictValue_1day=fDenormalize(predictValue_1day,xds_AE.max,xds_AE.min);
Doutput_testing=fDenormalize(output_testing,xds_AE.max,xds_AE.min);
[rmse_1day,mse_1day,mae_1day]=fBar_RmseMseMae(DpredictValue_1day,Doutput_testing);
```

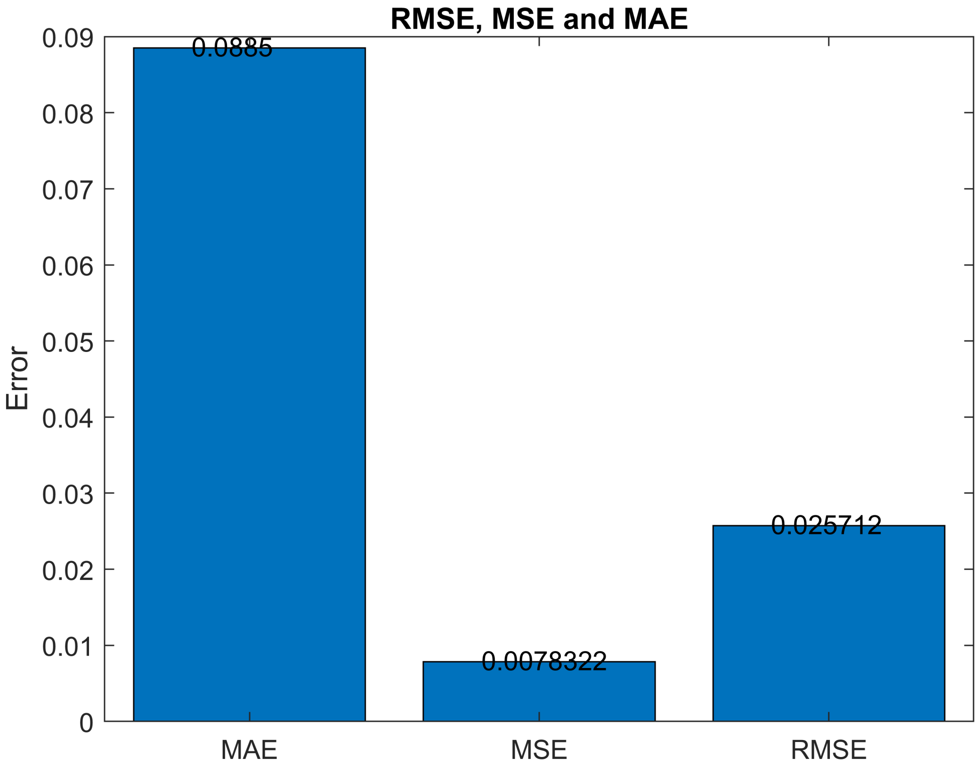


```
figure
plot([DpredictValue_1day,Doutput_testing]);xlabel('samples');ylabel('value');
legend('Predicted Active Energy (KWh)','Real Active Energy (KWh)');
title('Active Energy (KWh) with 1 day of prediction');
```

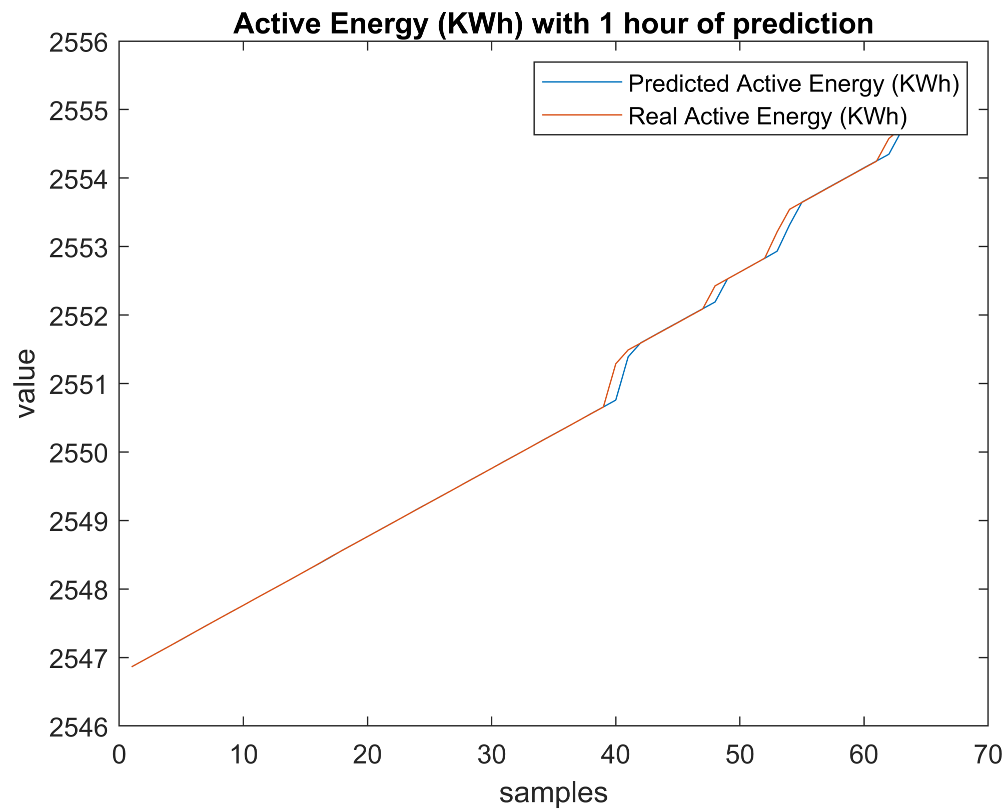


RMSE (Testing): 1 hour

```
TimeStep =3600;% one hour in second (ok)
DataFeatures = frms_features(DataNorm,TimeStep);
DataFeatures(:,7)=[];DataFeatures(:,6)=[];DataFeatures(:,2)=[];DataFeatures(:,1)=[];DataFeature

input_testing=DataFeatures(round(length(DataFeatures)*training):length(DataFeatures)-1,:);
% output: Energía in the following time step
output_testing=DataFeatures(round(length(DataFeatures)*training)+1:length(DataFeatures),2);

trainedModel_1hour=load('trainedModel_1hour.mat');%Load Best Prediction Model by 1hour
predictValue_1hour=trainedModel_1hour.trainedModel_1hour.predictFcn(input_testing);
% Denormilize Data
DpredictValue_1hour=fDenormalize(predictValue_1hour,xds_AE.max,xds_AE.min);
Doutput_testing=fDenormalize(output_testing,xds_AE.max,xds_AE.min);
[rmse_1hour,mse_1hour,mae_1hour]=fBar_RmseMseMae(DpredictValue_1hour,Doutput_testing);
```

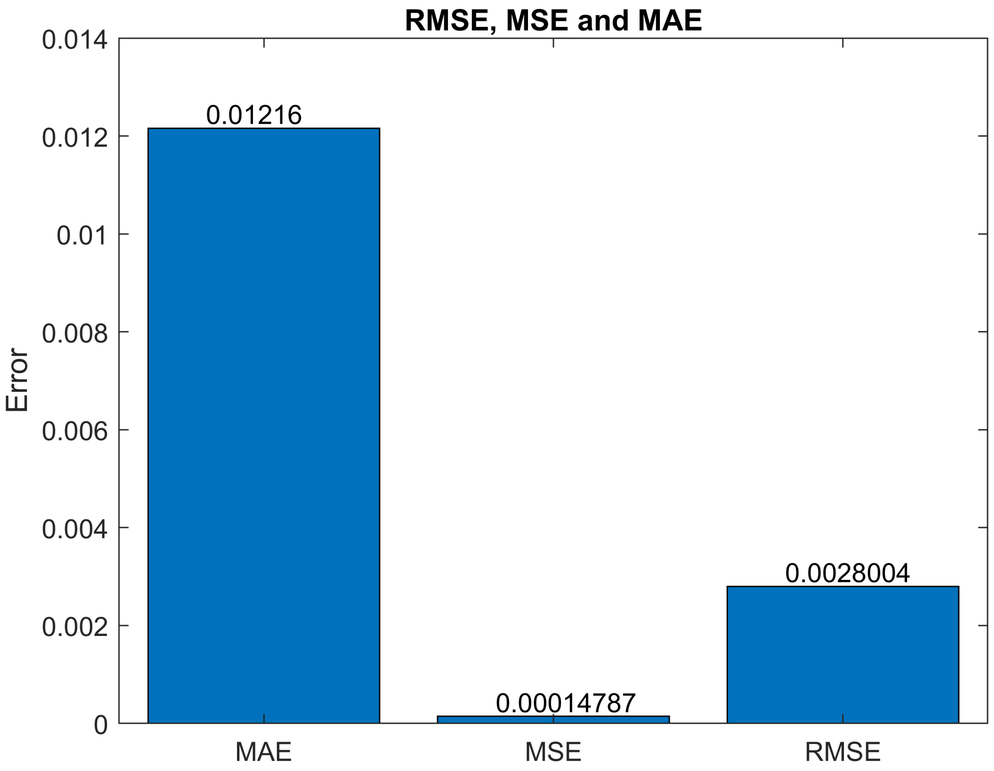


```
figure
plot([DpredictValue_1hour,Doutput_testing]);xlabel('samples');ylabel('value');
legend('Predicted Active Energy (KWh)','Real Active Energy (KWh)');
title('Active Energy (KWh) with 1 hour of prediction');
```

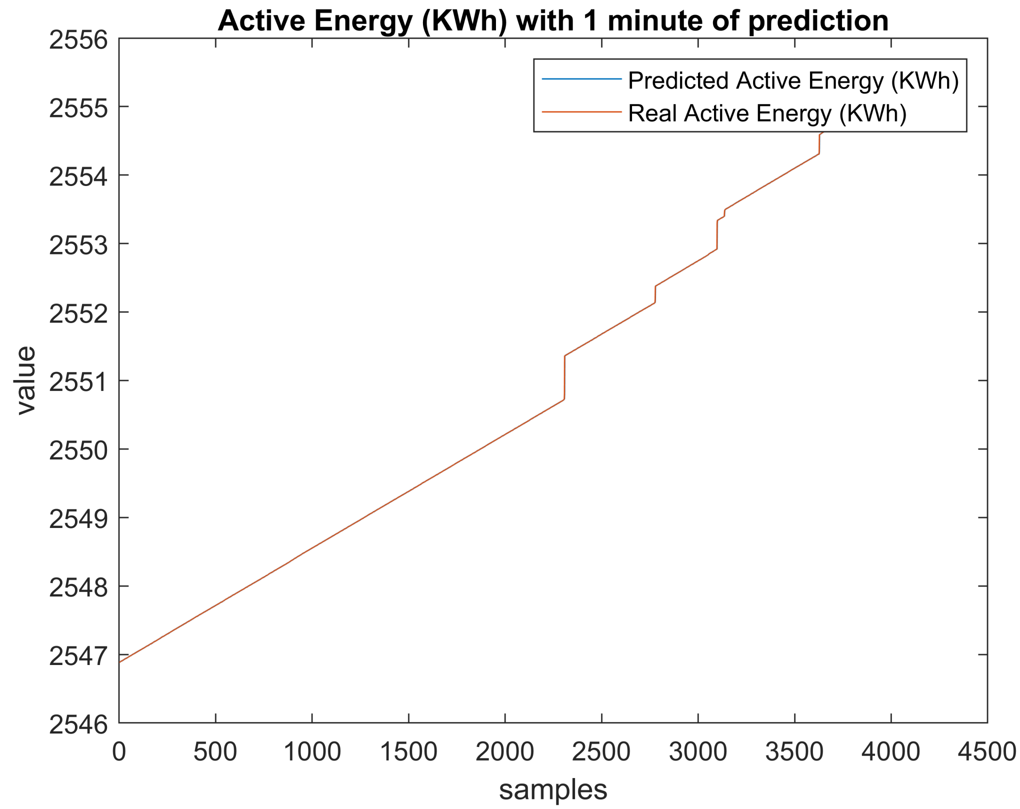


RMSE (Testing): minute

```
TimeStep =60;% one minute in second (ok)
DataFeatures = frms_features(DataNorm,TimeStep);
DataFeatures(:,7)=[];DataFeatures(:,6)=[];DataFeatures(:,2)=[];DataFeatures(:,1)=[];DataFeature

input_testing=DataFeatures(round(length(DataFeatures)*training):length(DataFeatures)-1,:);
% output: Energía in the following time step
output_testing=DataFeatures(round(length(DataFeatures)*training)+1:length(DataFeatures),2);

trainedModel_1min=load('trainedModel_1min.mat');%Load Best Prediction Model by 1min
predictValue_1min=trainedModel_1min.trainedModel_1min.predictFcn(input_testing);
% Denormilize Data
DpredictValue_1min=fDenormalize(predictValue_1min,xds_AE.max,xds_AE.min);
Doutput_testing=fDenormalize(output_testing,xds_AE.max,xds_AE.min);
[rmse_1min,mse_1min,mae_1min]=fBar_RmseMseMae(DpredictValue_1min,Doutput_testing);
```

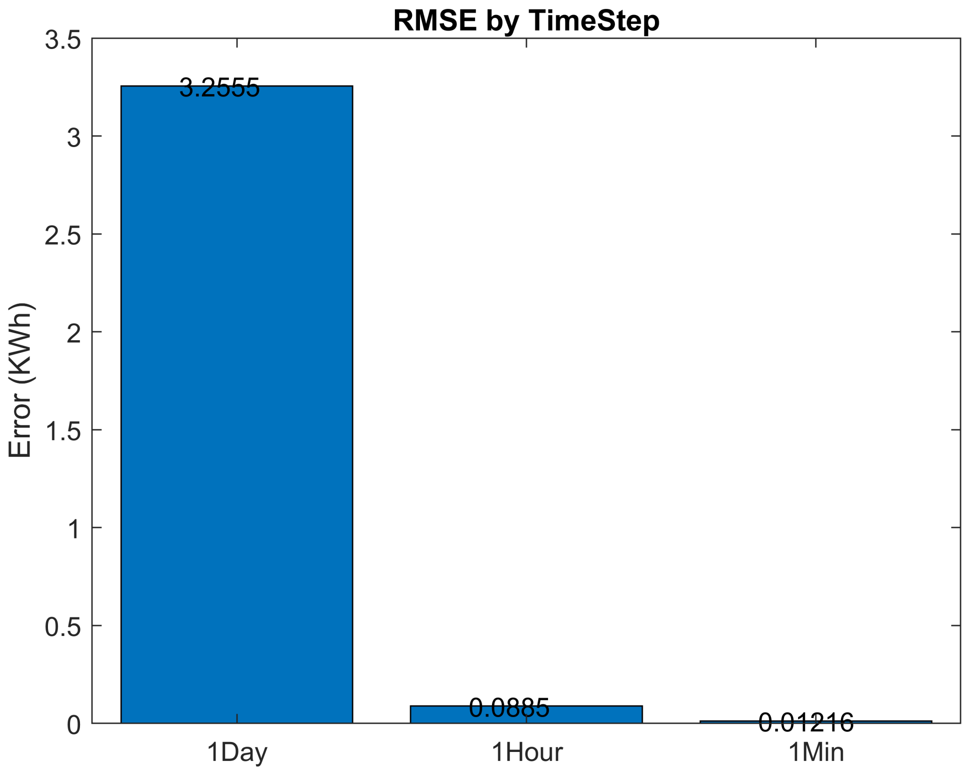


```
figure
plot([DpredictValue_1min,Doutput_testing]);xlabel('samples');ylabel('value');
legend('Predicted Active Energy (KWh)','Real Active Energy (KWh)');
title('Active Energy (KWh) with 1 minute of prediction');
```



Summary RMSE (Testing): day, Hour and Min

```
c = categorical({'1Day','1Hour','1Min'});
values = [rmse_1day rmse_1hour rmse_1min];
figure;
b=bar(c,values);
ylabel('Error (KWh)')
title('RMSE by TimeStep')
xtips1 = b(1).XEndPoints - 0.2;
ytips1 = b(1).YEndPoints + 0.0003;
labels1 = string(b(1).YData);
text(xtips1,ytips1,labels1,'VerticalAlignment','middle')
```



FutureWork

```
%New Testing adicional...
% NOTA: hacer una prueba sin CPU Consumption (%),RAM Consumption (%) y ver
% si ayudan a mejorar la prediccion...
```