

Communication Intelligence in Smart Grids

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Agenda

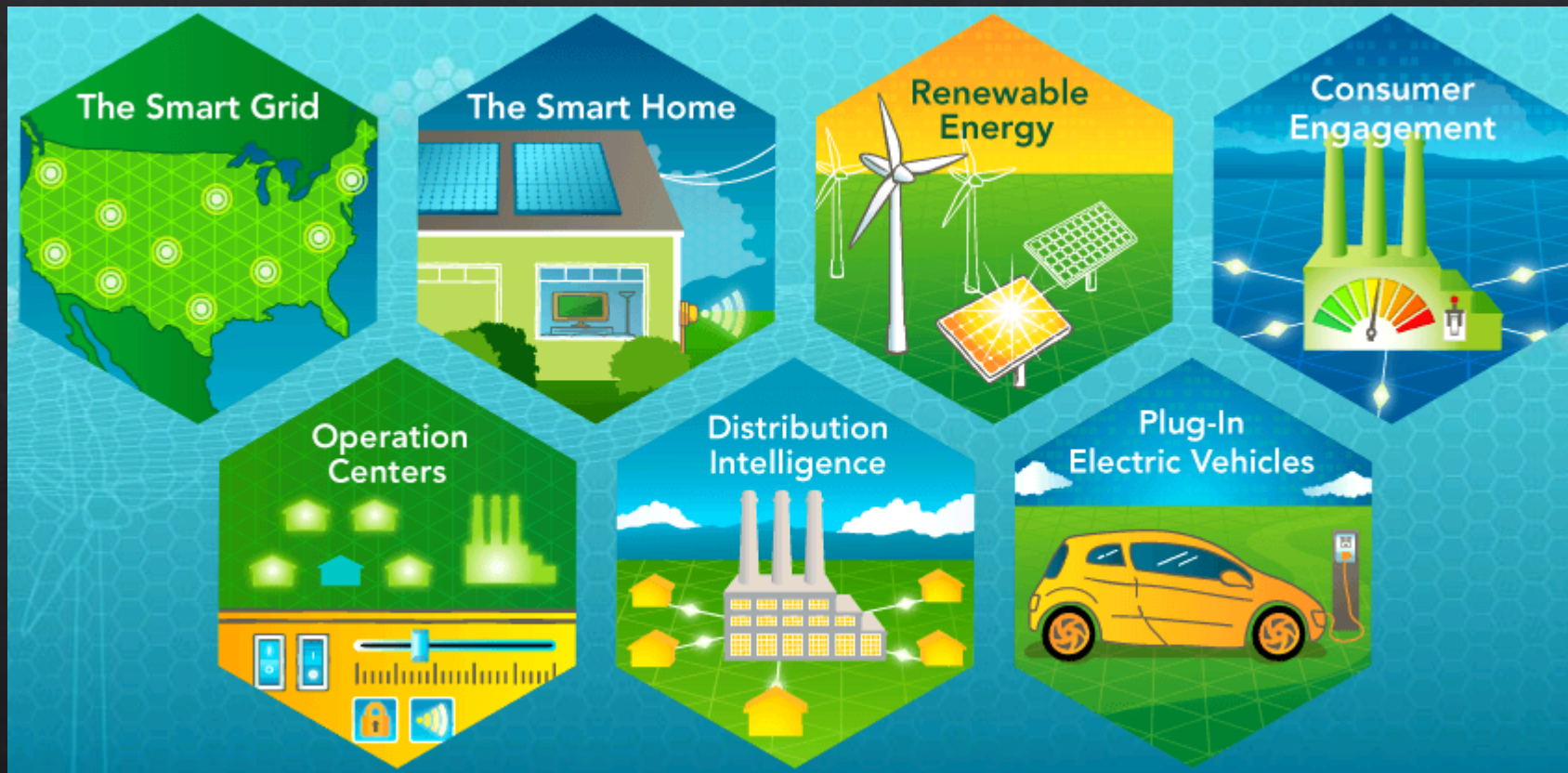
- ◆ Objective
- ◆ Smart Grid
- ◆ Design Model
- ◆ Design Methodology
- ◆ Machine Learning Models
- ◆ Data Analysis
- ◆ Output Expectations
- ◆ Future work

Objective

- ◆ The primary goal of the team project is to develop a methodology, how to correlate the production of solar and biogas power with the demand of the consumer resulting in a simulation software application. The application also simulates introduction of plug-in vehicles (eCars) and how the batteries could buffer the difference between production and consumption.
- ◆ The team will study how the immense potential for optimization and forecast presented by artificial intelligence can be best harnessed to enhance the efficiency and environmental compatibility of the power supply and to ensure the supply security.

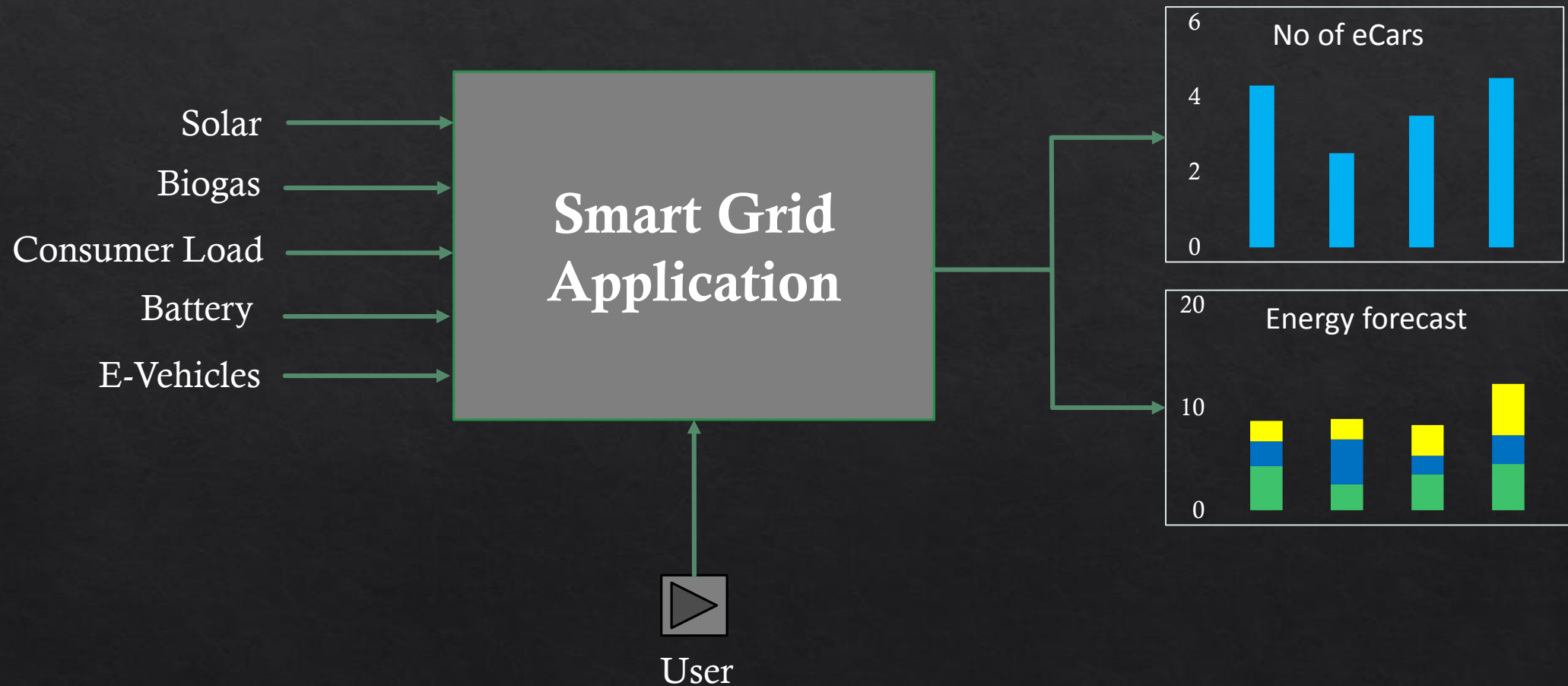
Smart Grid

The digital technology that allows for two-way communication between the utility and its customers, and the sensing along the transmission lines makes the grid smart



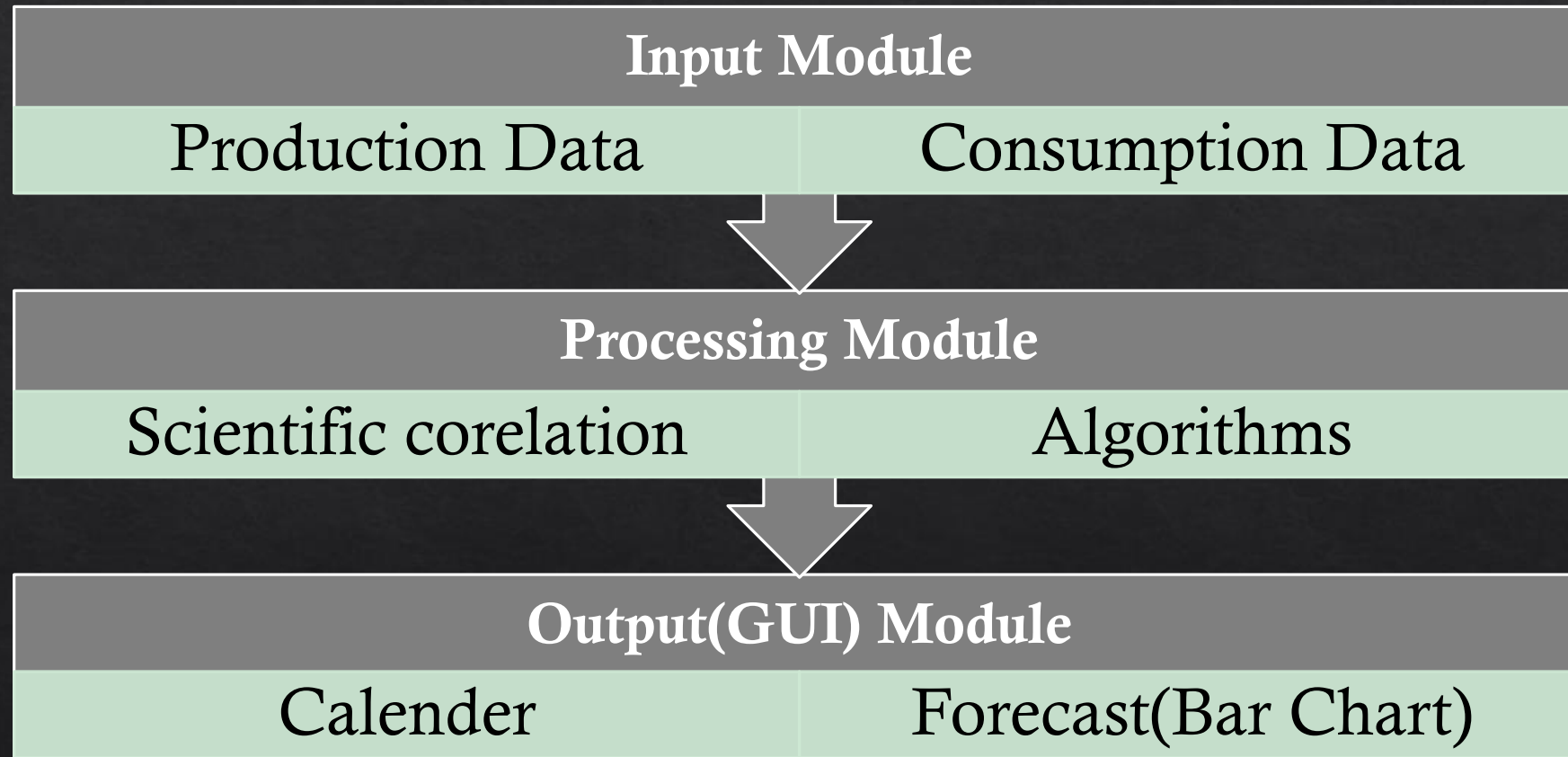
Design Model

◇ Smart-Grid Application:



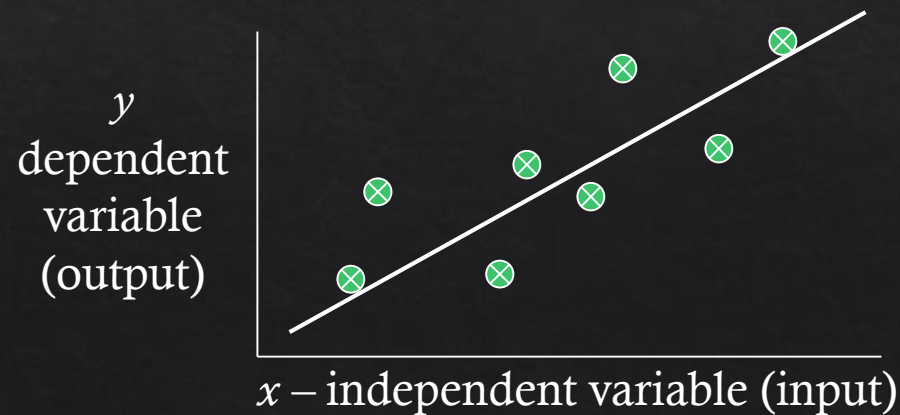
Design Methodology

◇ Modular Approach:



Regression

- ◇ For classification the output(s) is nominal
- ◇ In regression the output is continuous
 - ◇ Function Approximation
- ◇ Many models could be used – Simplest is linear regression
 - ◇ Fit data with the best hyper-plane which "goes through" the points



Simple Linear Regression

- ◇ Simple linear regression is a statistical method that allows us to summarize and study relationships between two continuous (quantitative) variables:

1. predictor, explanatory, or independent variable
2. response, outcome, or dependent variable.

$$Y = b_0 + b_1 X$$

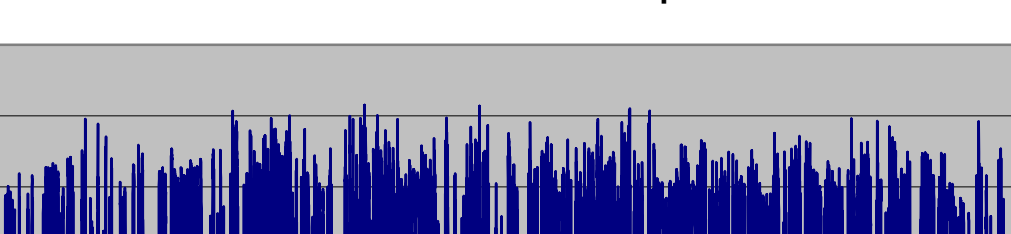
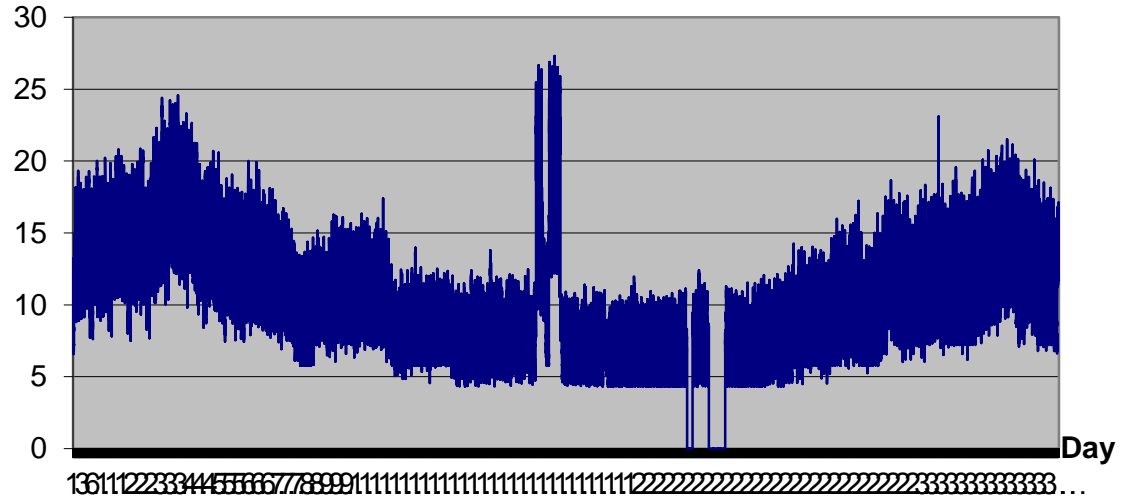
One nice advantage of linear regression models is the potential to look at the coefficients to give insight into which input variables are most important in predicting

- The variables with the largest magnitude have the highest correlation with the output
 - ◇ A large positive coefficient
 - ◇ A large negative coefficient
 - ◇ A small or 0 coefficient suggests - uncorrelated with the output

Linear regression can be used to find best "indicators"

Data Analysis

The graph displays the daily consumer load in Amperes (A) over a 365-day period. The y-axis ranges from 0 to 30 A with major grid lines every 5 units. The x-axis is labeled 'Day' and ranges from 1 to 365. The load starts around 15A, peaks at approximately 24A around day 30, then generally declines with fluctuations to about 10A by day 100. A sharp, high peak occurs around day 150, reaching nearly 28A. Following this, the load drops and remains relatively low (around 5-10A) until day 200, where it begins to rise again, reaching another peak of about 23A around day 250, and then fluctuates between 10A and 20A until the end of the year.

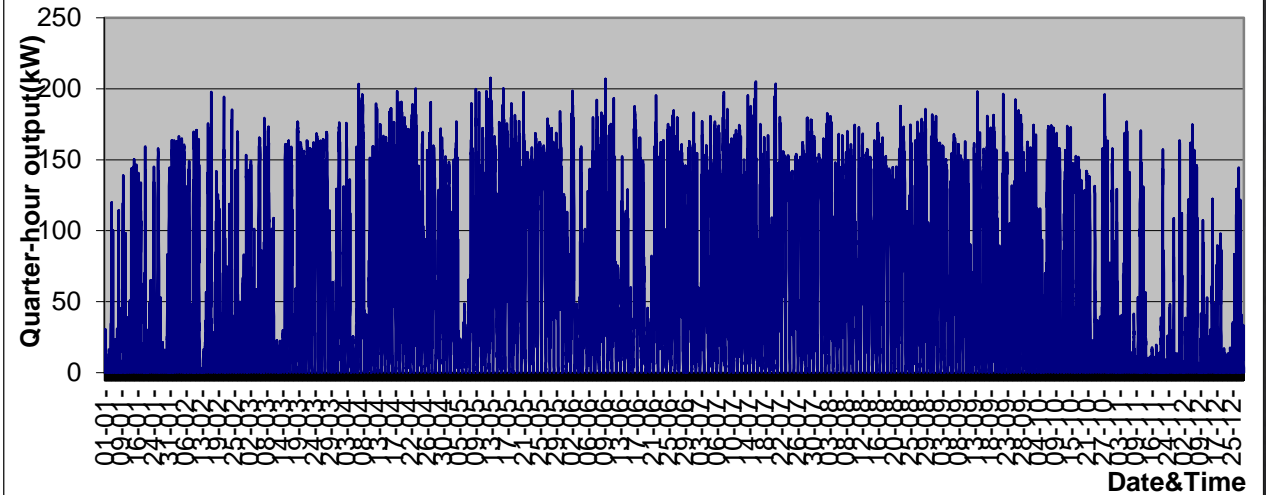


Quarter-hour PV output 2017

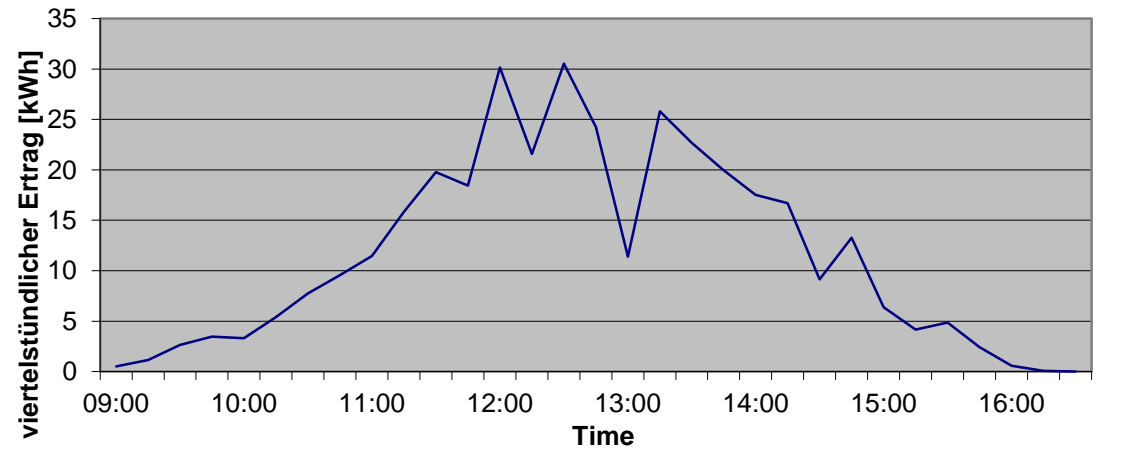
Quarter-hour output(kW)

Date&Time

This figure is a line plot showing the quarter-hour PV output for the year 2017. The y-axis is labeled 'Quarter-hour output(kW)' and ranges from 0 to 250 in increments of 50. The x-axis is labeled 'Date&Time' and shows the progression of the year from January to December. The plot displays a highly variable time series with frequent peaks and troughs, indicating significant fluctuations in PV output throughout the year. The output generally peaks during the day and drops to zero at night. The overall trend shows a seasonal variation, with higher output during the summer months and lower output during the winter months.



Time	viertelstündlicher Ertrag [kWh]
09:00	0.5
09:15	1.0
09:30	2.0
09:45	3.0
10:00	3.5
10:15	3.5
10:30	5.0
10:45	7.0
11:00	10.0
11:15	12.0
11:30	15.0
11:45	18.0
12:00	30.0
12:15	25.0
12:30	22.0
12:45	30.0
13:00	25.0
13:15	12.0
13:30	26.0
13:45	23.0
14:00	20.0
14:15	18.0
14:30	17.0
14:45	9.0
15:00	13.0
15:15	6.0
15:30	4.0
15:45	5.0
16:00	0.0



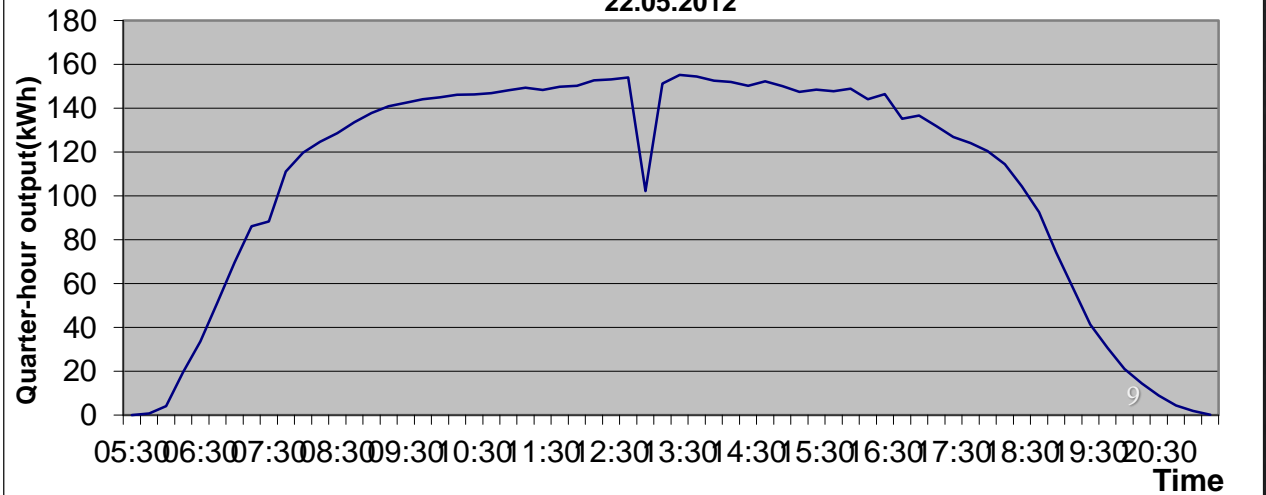
Quarter-hour PV output(kW)

22.05.2012

Quarter-hour output(kWh)

Time

9



Output Expectations

- ◇ Accuracy by trial- and error methods
- ◇ Stacked Bar Plot Visualization:
 - ◇ Predictions of number of eCar's that can be charged
 - ◇ Daily load (Energy Demand) forecasting
 - ◇ Correlation of Consumption of Energy with that of Generation
- ◇ ..

Future Scope

- ◇ Extending operation of the application to monthly/yearly load forecasting
- ◇ Integration of smart meters into the application for consumer engagement
- ◇ Predicting dynamic changes in cost of electrical energy
- ◇ Inclusion of Distributed Generation (small scale power generation)