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Project summary

The power grid is the backbone of modern society. Analyzing its components and structure allows to tackle one of the greatest problems our society is confronted with: climate change. This project will investigate the technical challenges of incorporated renewable energy into the energy mix. Renewable energy sources such as solar panels and wind turbines have a fluctuating power output unlike traditional energy sources such as hydroelectric plants, nuclear plants and other thermal plants that have a stable and adjustable outputs. Since wind and solar energy fluctuate with the weather, their overall output has to be stabilised to fit the demand. This is done either by storing energy (for example by pumping up water to dams) or backing up renewable energy with stable fossil fuel to supplement it in periods with no wind and sun.

The research question that is going to be answered in this project is: What is the optimal plan of action to provide energy to europe as an increasing number of fluctuating renewable energy sources are added to the grid ? In other words, what should be the output of each power plant in a given situation, where should the power be sent to and how should the output be controlled given the weather forecast. And finally, given the optimal plan of action, how much renewable power can be included in the system without having a risk of power grid failure.

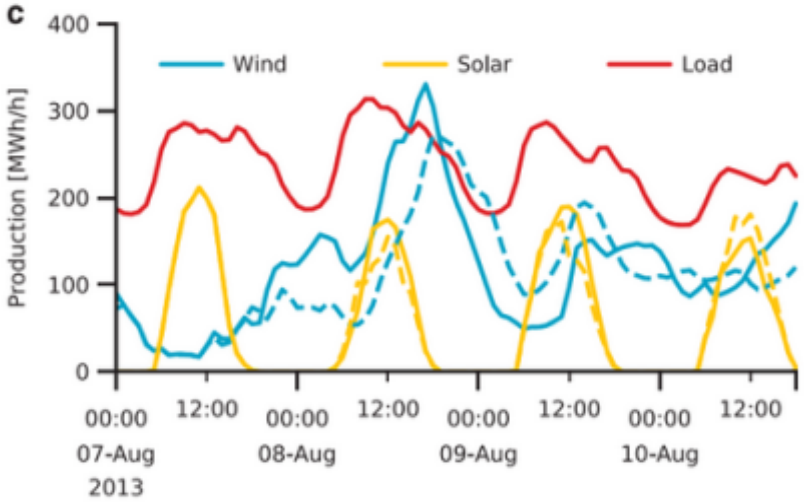
The RE-Europe dataset was chosen to perform the desired network analysis. It includes information about the location, maximal output, and type of power plants all over europe, as well as information about the power lines that form the power grid. Additionally it contains the predicted power output and effective power output (as a function of time) for each solar panel and wind turbine over the course of 3 years, which altogether allows for a spatial and temporal evaluation of the power grid. A representation of the data and an example of the predicted power output can be seen on page 2.

The network will be used to train a neural network that will predict the optimal output of each thermal plant and the distribution of power through the electric lines. This information allows to fully control the power grid since it answers the question: how much power should each plant produce and where should the power be sent.
What “optimal” means is going to be defined (in the form of a loss function) taking into account the cost and the eco friendliness of the energy production and transportation as well as to what extent the obtained grid is failproof. In a second part, the addition of power lines and power sources to the grid is going to be investigated to find the most beneficial building project.
After training the neural network, a new network is going to be built to obtain new edges and new features. This new graph which will differ from the first only by its powerline and by the power output of each of its nodes will be analysed and compared to the original graph. Properties such as connectedness, sparsity, diameter, clusters, degree distribution and spectrum are going to be compared. This will make it possible to qualitatively evaluate the results and improve the cost function. The neural network will then be retrained with the improved cost function. The type of random graph best suited to model the found graph is

going to be determined. This will allow to further discuss the properties of optimal power grids in view of improving them.

The project of building a few new power plants and power lines is going to be presented. Arguments are going to be given as to why this project is beneficial.
The graph will be plotted over a map showing the location of the building projects.

Data Descriptor: RE-Europe,a large-scale dataset for modeling a highly renewable European electricity system. Tue V. Jensen & Pierre Pinson. [Power grid]



Data Descriptor: RE-Europe,a large-scale dataset for modeling a highly renewable European electricity system. Tue V. Jensen & Pierre Pinson. [Power output prediction (dashed line), effective power output (full line) and load]