An Electricity Supply and Demand Model for Turkey

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There is extensive literature on energy models both globally and in particularly investigating Turkey's energy demand. However there are very few models that can have any use for policy analysis. These models are either very complicated or require extensive data to work with. In Turkey's case, the required data for detailed models are hard to find. But there is a need for modeling particular policy effects such as carbon prices, subsidies, supply security and efficiency targets. In this paper, two separate simple models, one for the supply side and the other one for demand side, for Turkish electricity system will be introduced.

Introduction

A model is an abstract, simplified version of real life systems. Whether it is climate change or energy demand, modeling is a tool to understand the nuts and bolts of the very complex patterns. Turkey's energy demand and supply has been no exception. For years, the discussions were about whether Ministry of Energy and Natural Resources was accurate with its predictions. The remnants of a central decision making have left its place to "market system". Contrary to what is believed, market system relies more on models. This is not because markets require a central planning but every market participant finds it more helpful to make its investment decision based on its forecast on markets. There are more models for Turkey's electricity demand and prices now then it was before. Some models are purely black box type. Some models require extensive data sets. The ends are shaped according to needs.

The aim of this modeling study was to understand how much each consumer type is affecting Turkey's electricity demand and how electricity supply system reacts to it through prices.

On the demand side:

1. Industry
2. Commercial consumers
3. Households
4. Lighting

consumer types were investigated.

On the supply side:

1. Drought
2. Wind
3. Carbon prices

were studied. The model by itself reveals some interesting aspects of Turkish electricity system that may be helpful for policy makers deciding on emerging issues such as smart grids, solar investments and climate change policies.

Demand Side

The main question in this part of the study is to divide a daily load curve in to its relevant parts according to consumer types. There is not enough data on the load profile for the whole country and data sources are limited. To sort out this deficiency problem, the model is designed from a very abstract point of view and improved according to real life data. For example the initial model was based on the third Monday of each month. Later this has been repeated for a whole week.

The data sources of the demand side model are

- 2009, TEDAŞ (Turkish Electricity Distribution Company)'s annual statistics
- 2010, hourly electricity loads
- 2011, demand profiles for meters, approved by EPDK (Energy Market Regulatory Authority)

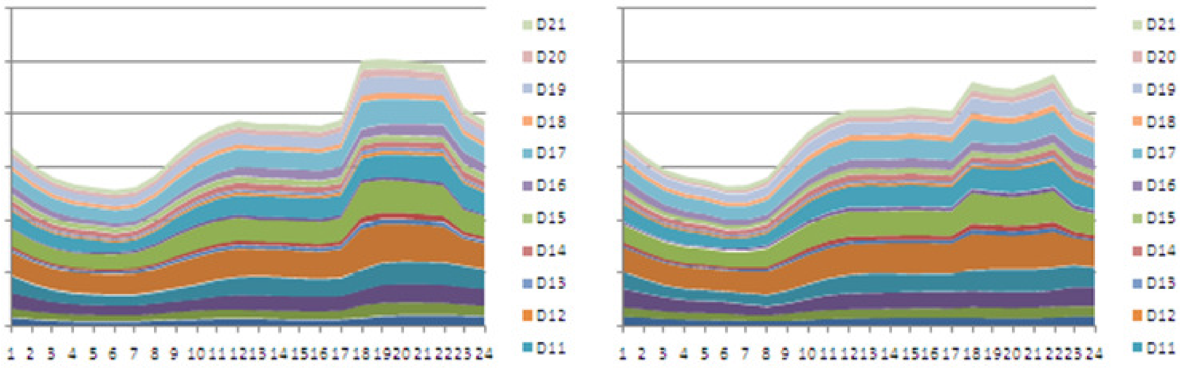
At the time of this study, 2010 distribution statistics were not complete, so 2009 data were increased with the same amount to find the sub consumer type yearly demands for the year 2010. TEİAS provides an hourly total demand data for the whole year.

The critical part in the demand side is the profiles. The profiles were downloaded from EPDK web site, since they are attached to relevant commission decision on profiles. They are normalized hourly data for each consumer types for each month. The profiles themselves are not perfect, but they give some idea.

The share of each consumer type for a year is normalized according to end of year data from TEDAS statistics. This is the first pitfall of the model. For example agricultural irrigation is not normally distributed across the year, nor does the households. So a seasonal pattern from TEİAS's yearly forecasts have been applied uniformly for each consumer type. At this point, it is assumed that all consumers are showing the same pattern. This monthly averages are then converted to daily averages using hourly load data.

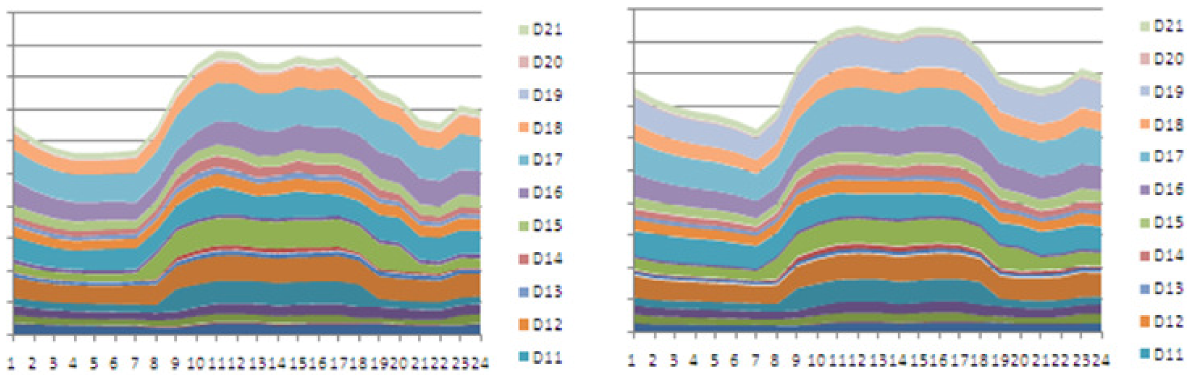
Demand Side Results

Households have two different patterns. One is for a winter day in December, the other is for a summer day. The biggest increase in household demand starts around 17:00 and relaxes after 22:00. The peak at 17:00 is much higher in winter than summer. The households look like as if they are not responding to prices. This is an important point, since this demand pattern stirs up controversy whether time-of-use tariff will benefit the consumer.



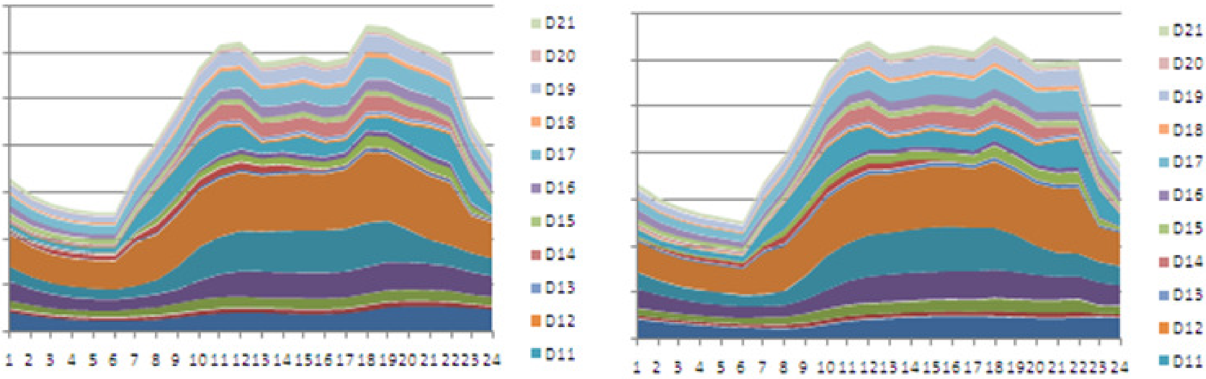
Graph 1- Household demand, December (right), July(Left)

Industry's demand pattern does not vary greatly across different seasons. It ramps up in the morning slows down by 10:00-11:00. The biggest drop in the demand is the start of the peak hours. According to model, this consumer group is the most responsive of all to the price signals.



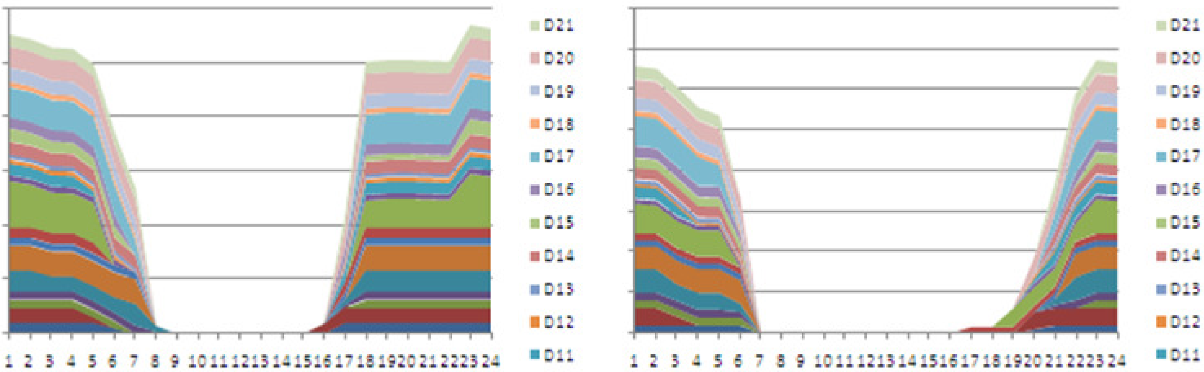
Graph 2- Industry demand, December (right), July(Left)

Commercial consumers are reflecting the climatic effects (heating and cooling) very dramatically. For example in a winter day their load increases with sunset, while in a summer day load is higher during the noon hours.



Graph 3- Commercial demand, December (right), July(Left)

Lighting demand itself is a function of daylight hours and seasonal variations. In December it starts from 16:00 to 07:00 early morning, while in July, from 19:00-20:00 to 06:00 in the morning. The duration is around 15-16 hours in winter while in summer it ranges between 10-11 hours.



Graph 4- Lighting demand, December (right), July(Left)

In total, the summation of demand side results is given below:

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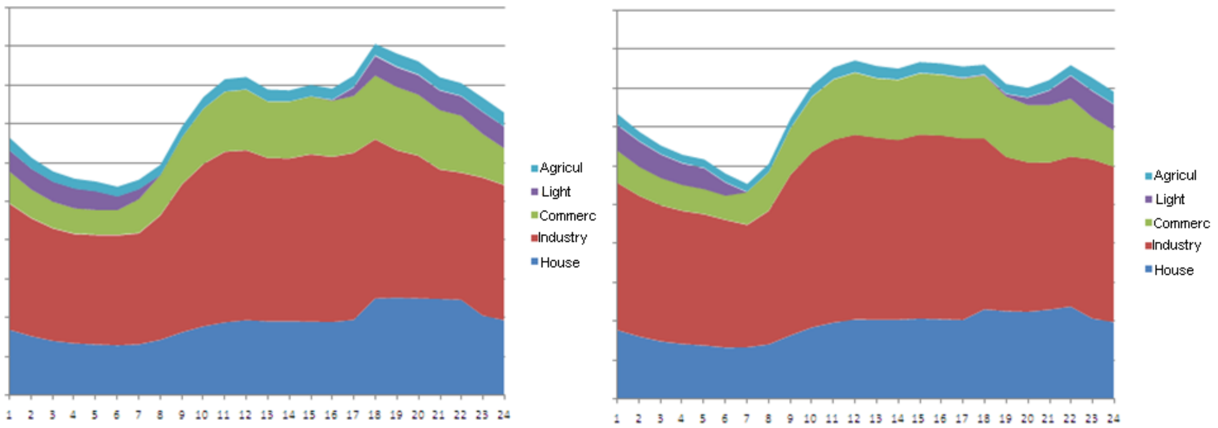
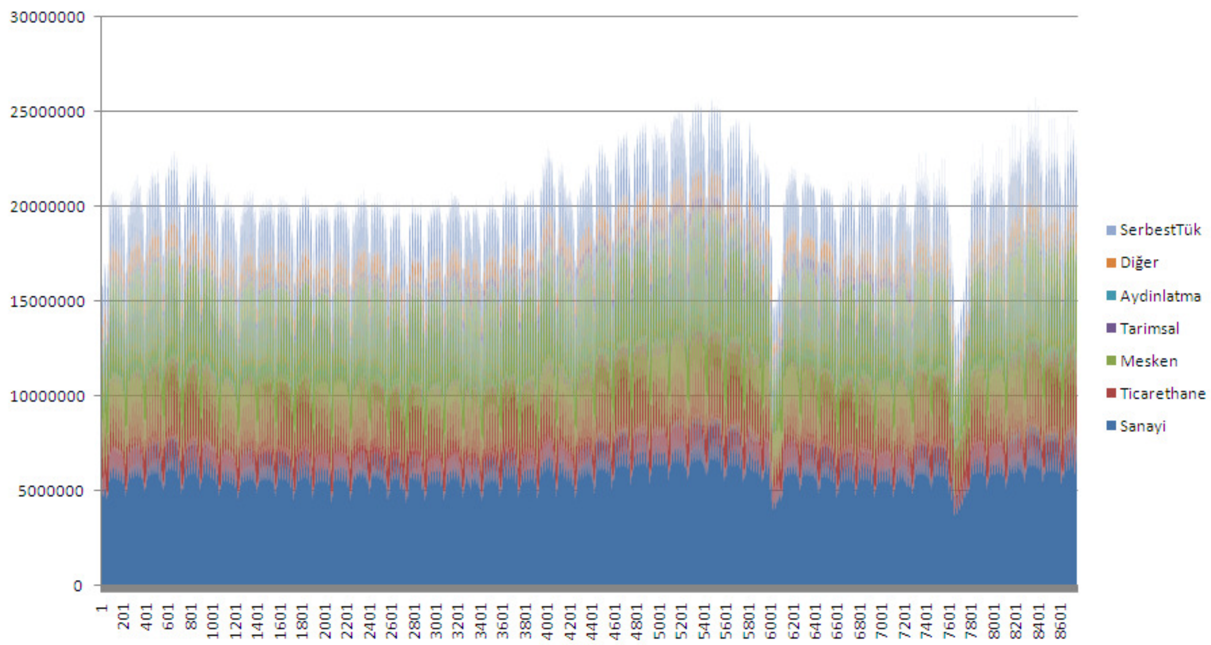


Graph 5- Total demand, December (right), July(Left)

This model is further carried out to reflect a yearly distribution of demand with a VBA (Visual Basic for Applications code). At this point a 8760 hourly load data has been divided in to consumer type demands. The results are not perfect but briefly summarize the dynamics.



Graph 6 – Yearly demand data subdivided in to consumer types

Supply Side

On the supply side, the main question is to calculate a load curve from the statistics gathered from open sources. The first abstraction of the supply side model is assuming aggregation in

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year-on-year installed capacity increases. That is to say, if from 2009 to 2010 if the installed capacity of wind is increased by 800 MW's, it is considered as a one wind project with same financing, operating parameters.

The second abstraction is to divide the cost components of the supply side in to four parts

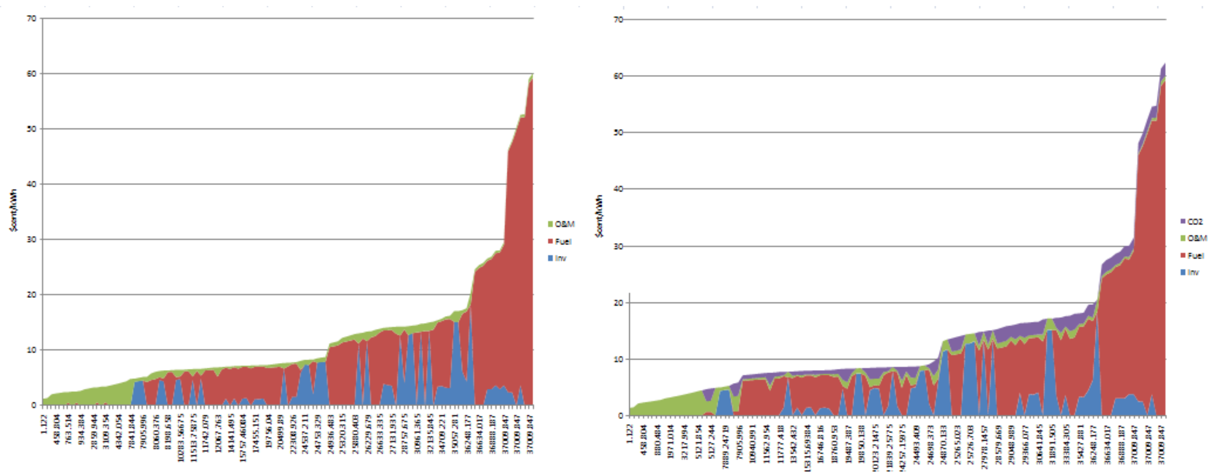
1. Fuel
2. Financing
3. Operating and Maintenance (O&M)
4. Carbon costs (assuming €15 per ton CO_2)

To achieve better results, the inputs are divided into several categories.

1. As explained above, the plants are divided into categories according to their age and fuel source. The year on year negative values(decommissioning) in installed capacity is assumed initially from fuel oil powered plants and then coal plants.
2. Efficiency of fossil power plants are decreased according to their age.
3. Fuel costs are referenced from local sources and division between local lignite and exported coal are made.
4. O&M costs are taken from "Projected costs of generating electricity" publication of IEA
5. Load factors are derived from averages and availabilities are considered exogenous to ease a scenario study.
6. Investments costs are a combination of international sources and domestic data since the equipment is foreign but financing is carried out with respect to local conditions. Financing costs are calculated with interest rates, maturity date and etc.

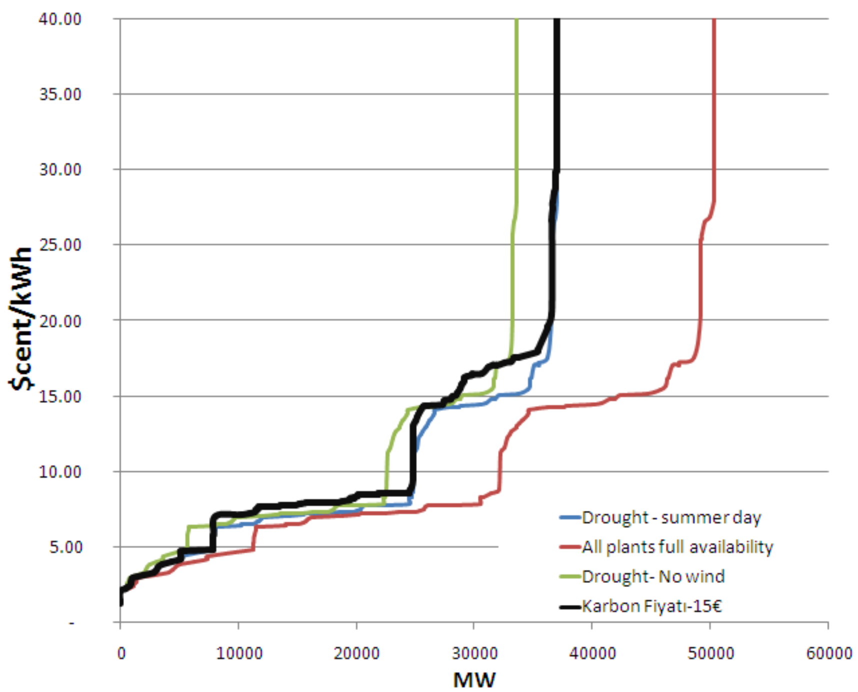
Each of these data is in the form of matrices. Rows represent different fuel sources and columns represent the age of plants. Each cell is the calculated factor for that power plants using the fuel source(row) installed at the year given(column).

The relevant matrices are then transposed, multiplied, summed and total costs are calculated. For a specific given scenario, the supply curves are given below.



Graph 7- Electricity supply curves, without carbon price (left), with carbon price of 15€ (right)

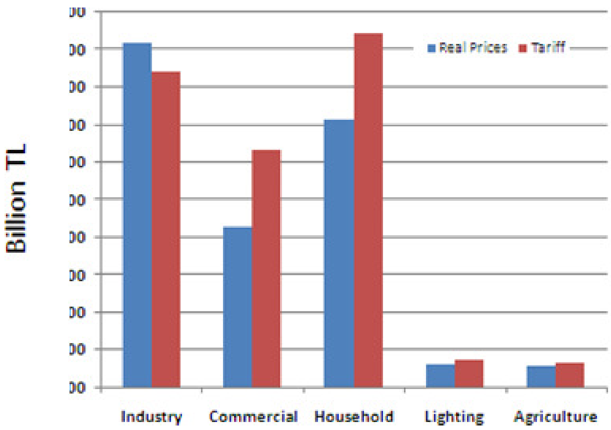
The second stage in the supply model is to calculate the effect of different "availabilities". For example what will happen if drought happens or wind turbines generate electricity at full capacity.

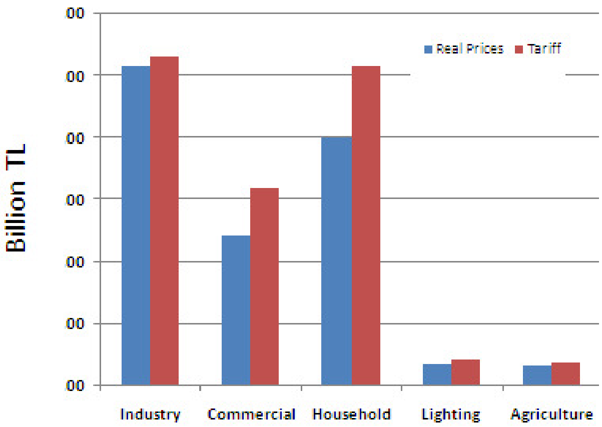


Graph 8 – Supply curves shift and change according to various factors

Conclusion

Demand and supply side models are explained above. The last step is to calculate the difference of costs incurred by the prices from tariff and supply model on different consumer types that is taken from demand model. Initially, before May 2011, the supply curve and demand model suggest an unbalanced relationship among industrial, commercial and household consumers. The result shows that as if commercial and household consumers are subsidizing industrial consumers.





Graph 9- The costs of electricity according to supply model and tariffs on different consumer groups of the demand side model

But considering the tariffs of January 2012, the outlook looks more balanced. Although not perfect, model gives an idea about the policy impact of a tariff decision.

The model is still in the process of development and aiming to reveal the dynamics of supply and demand parameters within the limits of acceptable errors.

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