Whitepaper

# The Art of Accurate Load Forecasting Services

Energy Load Forecasting is fundamental for the energy planning sector since a time-ahead power market requires demand-scheduling for power generation, transmission, distribution etc. Forecasting can be performed with different methods; the selection of each method relies on several factors including the quality and the relevance of the available historical data. Also, the method used is strictly correlated with the forecast horizon and the level of accuracy of the historical data. The time horizon is chosen based on the specific application in power system planning; i.e. the time horizon is specified according to each participant's needs. Distribution and transmission planning need a short-term horizon while financial or power supply planning require a more long-term horizon. Energy market participants, depending on the market structure they participate in, might require a very short time horizon and lastly, end consumers require a mid-term time-horizon. Based on the time-horizon and the level of data aggregation the adequate method is used.

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## Definition

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## Supply – demand equilibrium

Power markets work by balancing supply and demand, i.e. system operators are required to feed the network with the amount of energy demanded by the consumers at all times. This synchronisation requires great accuracy because otherwise supply and demand will not be equal. Should supply be higher than demand, energy is wasted and usually penalties are imposed to market participants. Should demand be higher than supply, then the grid cannot serve all consumers and might even face "blackout" cases.

In a competitive market, each energy producer proposes an individual supply curve to the system operator. Operator is responsible for collecting these bids and arranging them in an order of merit, based on their price per MWh. In other words, all generation units are "stacked up": in ascending order of marginal cost (See Figure 1). Commonly, renewable sources are deployed first, followed by hydro and nuclear plants, then coal plants and

lastly natural gas and oil plants. The system operator is responsible to decide which generators and when will be turned on. This decision is taken, by intersecting the supply with the demand curve. The intersection of these curves is the point, up to which generators will be turned on. I.e. all the generators that lie on the left of the intersection will be used, whereas these that lie on the right will be discarded. However, in order to locate the exact intersection point future load consumption prediction is required.

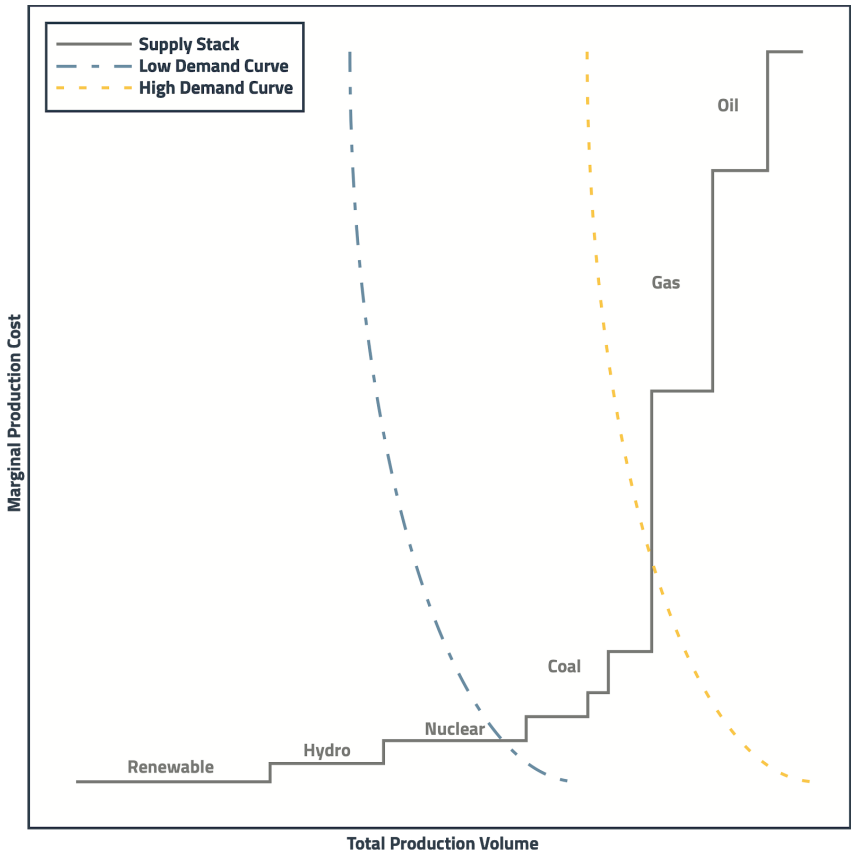


**Figure 1 - Supply and Demand Curves**

Reliable, secure and cost-optimal grid operation is already more complicated because of extensive renewable sources' penetration to the modern grid. The shift to renewables made it much harder for utilities to predict how much energy they need to cover demand at any given time, as increases in supply from renewable sources fail to line up with

periods of high demand (See Figure 2). As a result, money and resources are wasted on generating and purchasing power that is not needed.

The timing is perfect though for utilities and retail energy providers to update their load forecasting practices to reflect today's rapidly changing energy landscape. Access to smart meter data (AMR or even more granular) while utilizing AI and machine learning can be the game changer in generating forecasts that save money while ensuring that customers get the electricity they need for their homes, businesses and electric vehicles (EVs) [Ref].

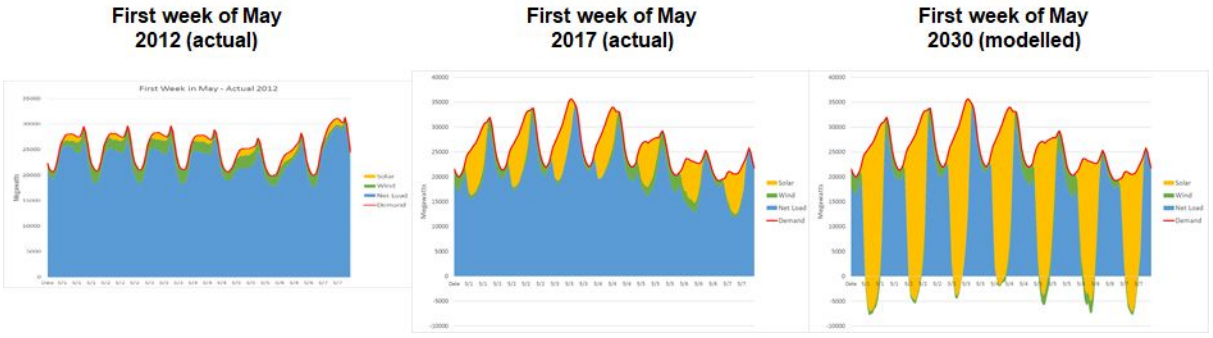


**Figure 2 - Evolving structure of power supply (source: CAISO OASIS)**

Apart from system operators, day-ahead aggregated load forecasting is crucial for the TSOs and DSOs that want to plan energy distribution. TSOs and DSOs may benefit from future load forecasting by ameliorating their planning regarding requirements for new distribution lines in places where congestion exists. Lastly, load forecasting is crucial for market participants because advance knowledge of future energy consumption may lead to high gains and avoid unexpected losses.

## Different Load Forecasting Services

At NET2GRID we are able to provide, on an aggregated basis, varying load forecasting services depending on the needs of different stakeholders. What makes our solution unique is that we are able to address divergent load forecasting spectra, i.e. the

**long-term** for next weeks, months or years and the **day-ahead**, while maintaining very high accuracy standards.

As inputs we make use of past load data, most of the time in the form of AMR data (15-30 min resolution), weather & meteo data, time windows of energy consumption and type-of-day data. Other kinds of data, e.g. profile information metadata can be useful as well but not a must-have for our solutions to run in a very accurate way.

On top of that, we can also deliver **intra-day** load forecasting services, assuming that a hardware-enabled real-time energy data acquisition process is in place. NET2GRID is strategically positioned to offer that solution since we have developed cost-efficient and easy-to-install hardware options for almost all smart meter interfaces globally. So, imagine an implementation that would allow an energy market participant to "correct" his position within the day or optimize his performance because of having access to data that competition will have the next day (at the earliest).

## How it works

After having collected the required data, a pre-processing procedure of time-series analysis takes place that ensures the integrity of the data as well as the treatment of the erroneous and/or missing data. Then data is fed-in neural-networks based in-house implementations and using an adequate algorithm the optimal solution is found and a forecasting model is created. This model can replicate future load consumption. An example of the load forecasting model is represented in figure 3 on the next page.

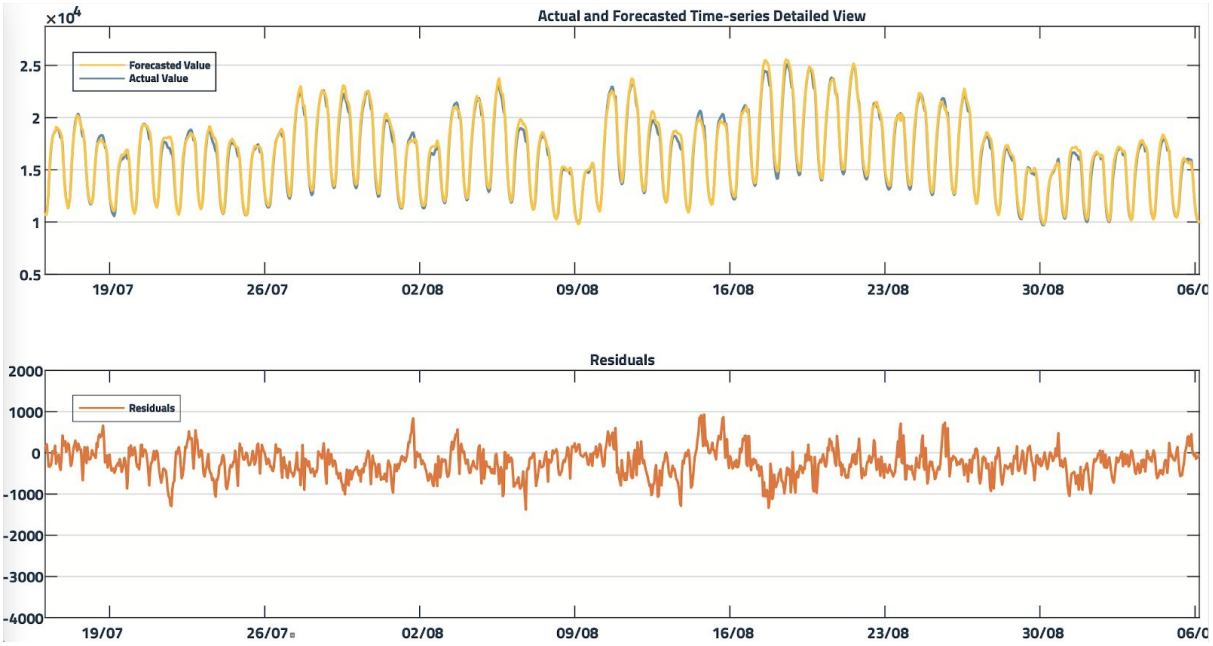


**Figure 3 - Load Forecasting & Residuals Plot**

The accuracy of the forecasting procedure based on the Mean Absolute Percentage Error (MAPE) metric can be as good as 1.9% based on the integrity and the availability of past data. More detailed information and results on a monthly, daily and hourly basis can be found in the following sub-figures of Figure 4.

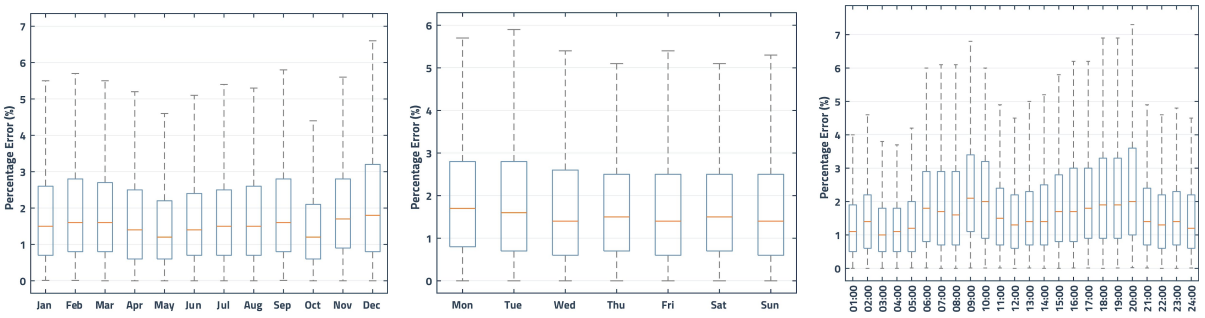


**Figure 4 - Load Forecasting & Percentage Error on Monthly, Daily and Hourly Basis**

## Forecasting of Peaks and "Consumption Spikes"

A particularity that makes load forecasting extremely challenging is that energy consumption is extremely volatile, far more volatile than any other commodity. Another feature of electricity is that the spikes' intensity is non-homogenous in time. I.e. load spikes are mostly observed during specific time windows. Although these spikes usually have a very short duration, the impact on the system is extreme if no measures are taken. Load forecasting on an aggregated basis can help limit and manage these abnormalities.

NET2GRID is able to forecast such unwelcome consumption spikes and the ramp-up and ramp-down effects before and after respectively. For the grid operator to deal with such spikes usually cost inefficient actions are required, so prior knowledge will help for a more effective asset management from his side. For example, as it is also shown on Figure 5, our implementation can very accurately predict the significant jump in the consumption on the 10th of June.

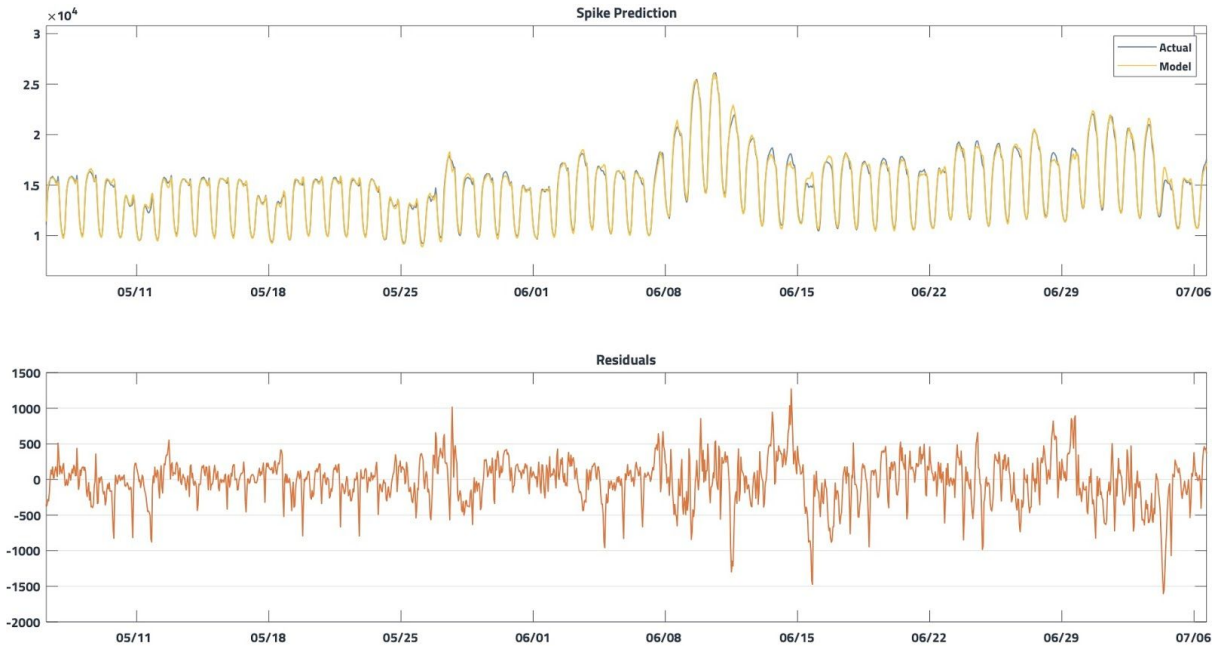


**Figure 5 - Accurate Consumption Spiked Forecasting**

## Moving to the Real-Time world

In parallel, at NET2GRID we are also able to provide real-time EV charging detection based on our in-house state-of-the-art NILM solution and also real-time solar generation metrics. For example, in Figure 6, we can see our Ynni app presenting in real time the respective consumption bubbles. Such information combined with accurate consumption spikes prediction can be a game-changer for the system operator who is trying to achieve cost optimization. Moreover, being able to take decisions that can unlock more effective demand response capabilities and are based on real-time detection of appliances of interest and intra-day demand forecasting is a unique proposition. Imagine for example a use case where the grid operator is notified for a peak predicted in the next few hours for a specific part of the grid. Operators can act proactively and i) throttle the charging rate of EVs and ii) decide to inject more solar generation capacities (instead of that being stored somewhere).

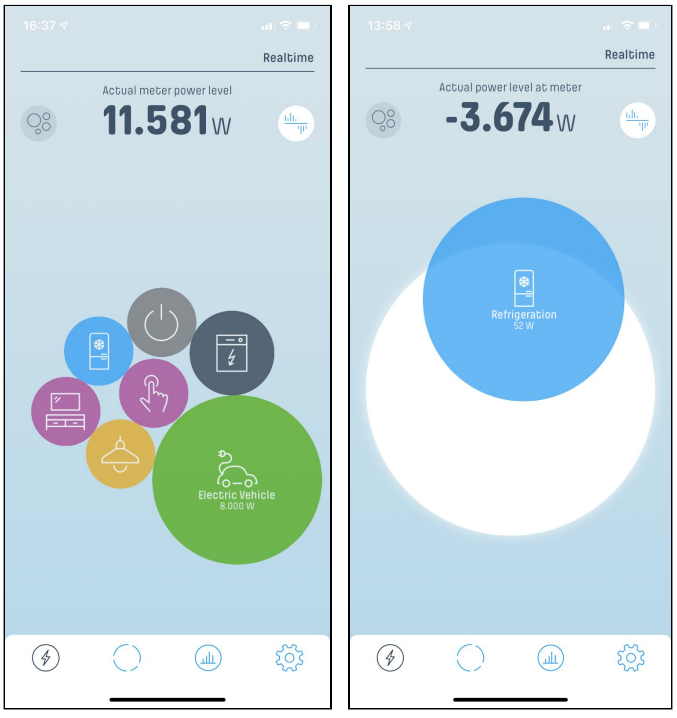


**Figure 6 - NET2GRID Ynni app screens for real-time EV and Solar generation detection**

## Business Cases

Different stakeholders can benefit from accurate load forecasting services:

a. **End-users:** They can be informed about their forecasted load consumption and therefore decide, based on their budget, whether they can augment or reduce their energy consumption habits. Changing energy retailers can now be negotiated and decided upon based on more information. Moreover, end-consumers can benefit from better energy prices since the energy retailer can purchase energy against better conditions and at better trade hedge moments due to better forecasting.
b. **Energy retailers:** In a very competitive landscape, such companies lose old customers and gain new ones continuously. To that end, demand forecasting is a must-have service to build short and long term business models but also to be able to cover consumers' needs in a cost-effective manner.
c. **TSOs, DSOs, grid operators:** They are informed about future load transmission and distribution requirements. By using this information, They are able to predict where grid hotspots will occur due to imbalance, and can plan the need for investments, pinpoint grid reinforcement needs, plan load distribution and finally avoid nodal or zonal congestion. It's of critical importance to obtain information regarding future load consumption and therefore ameliorate day-ahead or intraday planning.
d. **Energy market participants:** Such parties that are willing either to buy or sell energy or derivatives on energy, to speculate or to hedge risks associated with load fluctuations may benefit from load forecasting by ameliorating their transaction strategy. In the context of the new market models introduced in many countries, real-time access to consumption data (which is captured by additional hardware ) can generate additional value on top of participation in the day-ahead market etc.