CHANGES IN FORECASTING OF HV/MV-TRANSFORMER LOADING DUE TO DISTRIBUTED GENERATION

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ABSTRACT

This paper describes how Enexis, one of the largest distribution network operators in the Netherlands, has adapted its load forecasting method for HV/MV-transformers to incorporate the influence of distributed generation. This new method involves the making of separate forecasts for demand and generation and determining the resulting transformer loading, based on the known correlation between demand and generation.

INTRODUCTION

The past few years distributed generation (DG) in the Netherlands has increased and it now has a significant influence on design and operation of distributon networks [1,2]. This paper focuses on how the presence of DG in the medium voltage (MV) grid influences the powerflow from the high voltage (HV) grid to the MV-grid. The loading of the HV/MV-transformer is now no longer merely determined by electricity demand but also depends on the possible infeed of distributed generators. This additional and uncertain factor complicates network planning: forecasting of the transformer load is less accurate and therefore it is uncertain whether and when transformer reinforcements are necessary.

This paper describes how Enexis has adapted its load forecasting method for HV/MV-transformers to take into account the influence of DG.

PROBLEM DESCRIPTION

In the past, no DG being present, historical values of the maximum transformer loading were the basis for load forecasting. The observed annual demand growth could simply be extrapolated, as a first estimate of future demand development, as shown in figure 1.

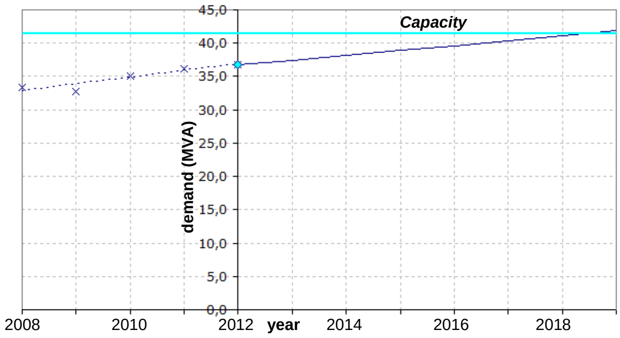


Figure 1: Linear extrapolation of annual demand growth

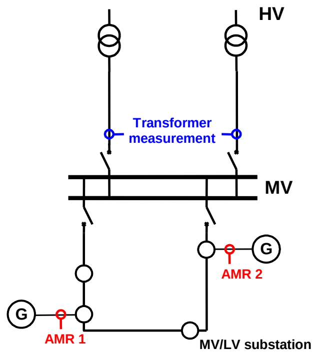
Nowadays, the transformer is loaded with the resulting powerflow of simultaneous demand and generation. From a certain penetration level of DG, the measured values of transformer loading are no longer suitable for demand forecasting. As the measurement of the powerflow at the transformer is the 'net' result of total demand and total generation that occur in the network simultaneously, it cannot be used for determining annual growth of total demand. This lack of information on the development of demand in the network complicates network planning.

Moreover the dispatch of distributed generators is driven by external factors (market, weather, etc.). The infeed of DG, that reduces transformer loading, is therefore uncertain and it would be risky to rely on it and assume it will continue to reduce transformer loading in the future in the same extent as it does today.

OUTLINE OF THE NEW METHOD

It is clear from the above that more information on actual demand and generation is necessary for better load forecasting. Therefore Enexis has adapted its forecasting method to include more available measurement data.

Customers that are connected to the MV-grid in the Netherlands mostly are equipped with automatic meter reading (AMR). The measurement data of all customers that produce electricity in a certain MV-grid, can be used to get insight in total DG infeed in this grid. As the powerflow through the transformer is also known, total demand in this grid can now be derived. To illustrate this, figure 2 shows the available measurements in a simplified MV-grid and how total generation and total demand can be calculated.



Total generation = AMR 1 + AMR 2
Total demand = Transformer measurement + Total generation

Figure 2: Available measurements and calculation

The measurement data of the power flow at the transformer and the AMR measurement data are both available at 15 minutes interval, so total demand and total generation in the network can be calculated for each 15 minutes throughout the year. The annual peak demand and peak generation can now be determined as the maximum of all these 15 minutes values.

These peak values are starting points for separate forecasts for demand and generation. Next, to obtain an estimate of future transformer loading, the separate forecasts of demand and generation are merged again into a single forecast.

DETERMINE DEMAND AND GENERATION

The measurement data of the transformer load during a year in a certain HV/MV-substation is presented in figure 3. The maximum load can be established at 59 MW and the transformer capacity is 62 MW (the ampacity of the transformer has been converted into MW, using the local power factor), so transformer loading is about 95%.

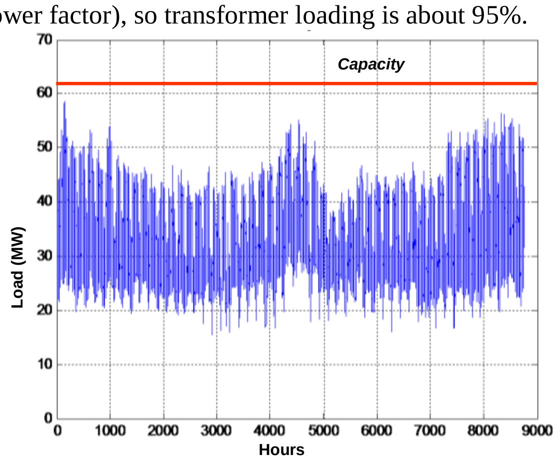


Figure 3: Transformer load during a year

Because of the presence of DG, the actual demand in this MV-grid will be higher than the load measured at the transformer. Using the AMR measurement data of the DG customers, total generation and total demand can be determined. The result is shown in figure 4.

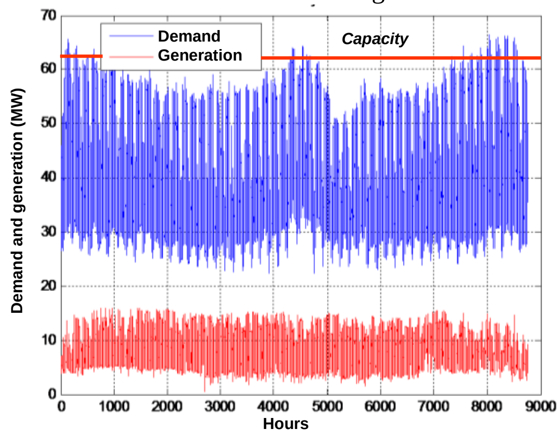


Figure 4: Demand and generation during a year

It can be seen that maximum generation is 16 MW and maximum demand is 67 MW. So without the reducing influence of DG, the transformer would be (over)loaded at 108%. The question now is whether we can rely on the DG to produce the same infeed in the future, or we need to reinforce transformer capacity, although no actual overloading occurs.

CORRELATION DEMAND AND DG

The dispatch of DG is uncertain as it can depend on various factors, like weather conditions (windturbines), heat consumption (combined heat and power, CHP) and electricity prices. For distribution network operators it is important to know which minimum amount of infeed is always present, especially during periods of high demand, since the actual infeed during peak demand determines the loading of the transformer.

To get more insight in this, the simultaneous values of demand and generation can be plotted in a graph. Figure 5 shows such a plot, based on the same data as figure 4.

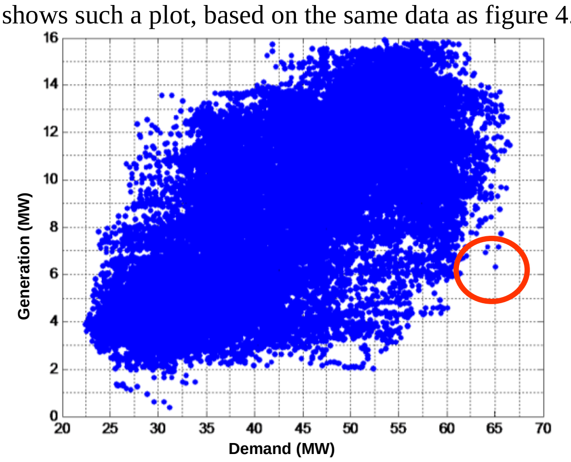


Figure 5: Generation (CHP) as a function of demand during a year

It can be seen that a certain positive correlation exists between generation and demand: at higher demand values, also generation is higher. We can now estimate the minimum infeed during maximum demand to be about 6 MW (in the red circle). In this case the DG in this grid consists of 20 CHP units with a total installed generation capacity of 17 MW. This means that during peak demand the typical minimum infeed is **35%** of installed capacity. Apparently this is a typical value for the dispatch of the CHP's in this grid. Similar values of the minimum infeed of CHP's have been found at other HV/MV-substations.

For other types of DG the correlation with demand can of course be different. Take for example a HV/MV-substation with infeed of 4 windturbines (10 MW) and maximum demand of 51 MW. Figure 6 shows a plot of windgeneration versus demand and, as could be expected, no correlation exists between them. At maximum demand the minimum infeed is **0%** of installed windcapacity.

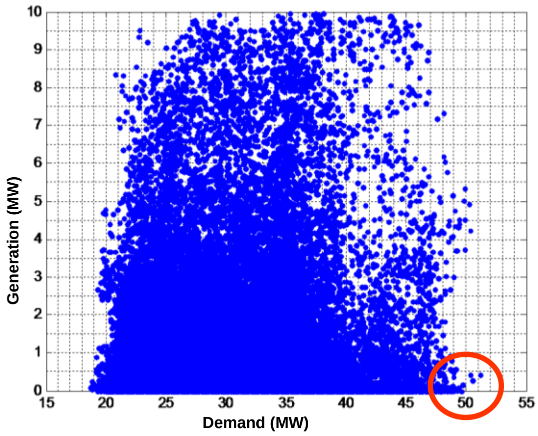


Figure 6: Generation (wind) as a function of demand during a year

In this way for different types of DG at different HV/MV-substations, information can be obtained on the typical dispatch of this DG at this location and how this correlates with demand.

FORECASTING TRANSFORMER LOAD

The peak values of demand and generation that have been obtained using AMR and transformer measurement data, can be used as a starting point for separate forecasts for demand and generation. Moreover, the generation forecast can be split up into separate forecasts for each type of DG.

The information for these forecasts can be derived from historical growth figures, plans of existing and new customers, market information, area development plans, etc. This information could for example lead to the demand and generation forecasts that are shown in figure 7.

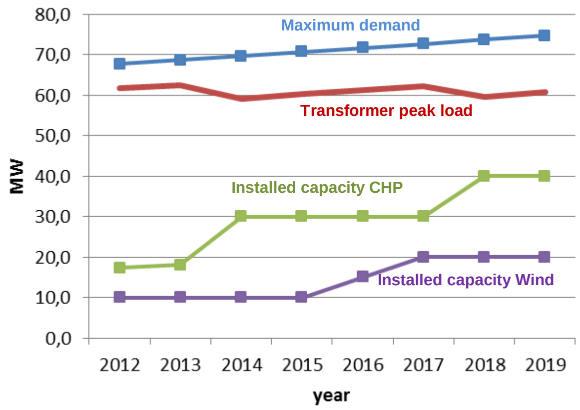


Figure 7: Forecasting of transformer load

The separate forecasts for maximum demand, installed CHP capacity and installed wind capacity will together result in a certain future transformer loading. A single forecast of the peak transformer load can be obtained from these separate forecasts using the information on the typical dispatch of the DG, in particular the minimum infeed during peak demand. The expected transformer peak load can then be calculated by reducing the maximum demand values by the expected minimum infeed for each type of DG:

Transformer load = Demand – 35% CHP – 0% Wind

In this way a single forecast for transformer loading can be established. The resulting forecast is also shown in figure 7. Next, this forecast can be used in the regular network planning process.

OPERATIONAL MEASURES

The implicit assumption that has been made here, is that the dispatch of the different types of DG will stay more or less the same in the future. In this paper the DG infeed has been analysed for only one year. A similar analysis for multiple years will give more certainty about the dispatch of DG in the longer term. The uncertainty on the dispatch may partly be managed by using different scenario's for future DG infeed. However, there is no guarantee that for instance unexpected future market developments will suddenly lead to a significant lower infeed or to a complete shutdown of DG's. To prevent overloading of grid components in such a situation, we would have to take operational measures. In this case the redundant transformer in the HV/MV-substation could be put into service to share the load. When this situation would last for a longer time, more structural measures (network reinforcement) would have to be taken.

CONCLUSIONS

The load forecasting method for HV/MV-transformers has been adapted to incorporate the influence of DG, enabling proper network planning and timing of network reinforcements. The key elements of the new method that have been mentioned in this paper will be summarised here.

- Using AMR measurement data, total generation and total demand in an MV-grid can be determined and separate forecasts can be made for them.
- A certain correlation between demand and generation has been established for different types of DG.
- Based on this correlation a minimum DG infeed can be determined, as a percentage of installed generation capacity.
- Using this information, the demand and generation forecasts can be merged into a single forecast of transformer loading.

REFERENCES

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