LONG-TERM FORECAST OF INDUSTRIAL ELECTRICITY DEMAND. A DSO VISION: SCALE REALLY MATTERS !

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Overview

Electricity grid operators, especially the distribution network, are facing new challenges with the energy transition towards an increased development of distributed generation and further electrification of mobility and heating. In order to focus investments in efficient network assets and to communicate with local stakeholders, the Distribution System Operator (DSO) has to anticipate changes in electricity demand at a small geographical scale. The French DSO Enedis has previously built a forecasting tool based on publicly available data and expert consultations [1].

However, long-term forecasting with small scale precision is challenging for the manufacturing sector, for which electricity demand relies strongly on both local and international conditions. Economic situation as well as how electricity is consumed are specific to each type of industrial goods, e.g. iron casting sector may have dissimilar economic and energy outlooks than other smelters. As one industrial plant may represent a significant part of electricity consumption in a local network circuit, it is therefore necessary to work with a detailed level of sectoral nomenclature.

Most of electricity forecasts at the industry level are either focused on one or a few specific sectors with details, or on the whole manufacturing sector but using large aggregates. This paper addresses the issue of the local scale forecasting for the manufacturing sector with a new methodology highlighting drivers of changes in electricity demand for 90 distinct sub-sectors in France. This approach allows a local relevance of forecasting while using a standardised estimation.

Methods

Electricity demand forecasting towards 2035 for 90 different manufacturing sub-sectors in France is based on the decomposition of the main underlying factors of electricity demand:

- Population
- Average Demand per Habitant
- International Competitiveness
- Energy Efficiency
- Process and System Electrification

The following decomposition is then used for each sector (***i***):

$$\text{Electricity consumption}_i = \text{Population} * \left(\frac{\text{Demand}_i}{\text{Population}}\right) * \left(\frac{\text{Production}_i}{\text{Demand}_i}\right) * \left(\frac{\text{Energy consumption}_i}{\text{Production}_i}\right) * \left(\frac{\text{Electricity cons.}_i}{\text{Energy cons.}_i}\right)$$

Historical data on production volumes, exports and imports have been gathered between 1994 and 2013, in nominal value, for every sub-sector in the manufacturing sector from publicly available datasets. However, data on energy consumption are available only since 2007 on an annual basis, with a similar sectoral nomenclature.

In order to differentiate long-term trends for these explaining factors from changes related to the economic situation, time-series regressions have been performed for each sector. Asymmetric impacts of GDP fluctuations are considered as well as time-lagged effects related to stock delays. In particular, historical energy efficiency improvements may also be related to GDP short-term changes in some segments of the manufacturing sector, as plants may not be operated at their optimal utilisation rate.

Finally, forecasting at the local level is performed by linking forecast outcomes, according different economic growth scenarios, to current electricity demand data at a small geographical scale.

Results

The methodology proposed in this paper is used to forecast electricity demand in the French manufacturing sector up to 2035. Outcomes highlight a great sensitivity of forecasting results in relation to the level of sectoral nomenclature for local electricity demand.

- First, at the national level, forecasting results with or without a detailed sectoral disaggregation display very different outcomes for electrical demand. As shown below, forecasting of electricity demand for the aggregated French food and beverage sector up to 2035 (+1.3%) mask strongly contrasted estimations for sub-sectors (from -20% to +45 %).

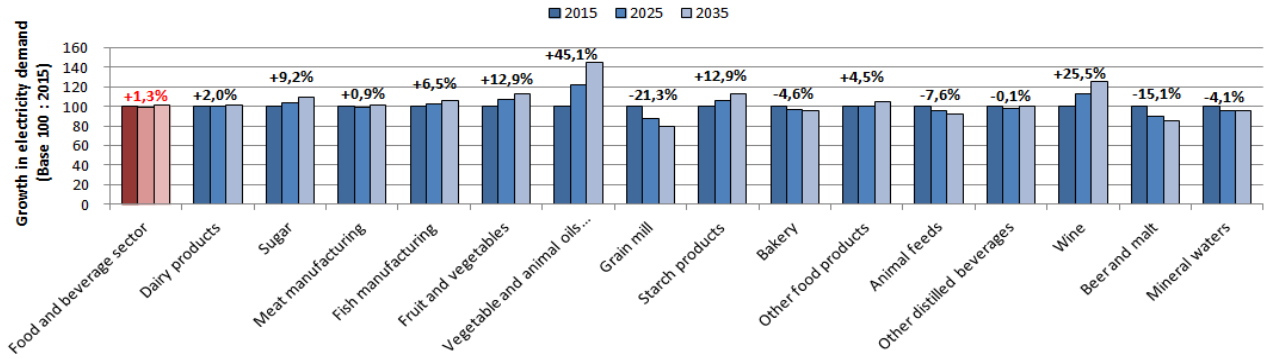

Figure 1 : Electricity consumption forecasting for the French food and beverage sector up to 2035.

- Secondly, using different scenarios for economic growth shows that each manufacturing sub-sector has a specific relationship with GDP changes. Some sectors are very reliant on GDP fluctuations; others depend only on population growth for the most part, e.g. food industry.

- Third, application of forecasting results to local data demonstrate the relevance of sectoral disaggregation for small geographic area, for which one industrial plant may represent a large part of the electricity consumption. In the example below, relative changes in electricity demand in the manufacturing sector by municipality for a French department, between 2015 and 2035, are described according to two level of sectoral disaggregation ; one with 90 sub-sectors, the other case with only 6 large sectors. Between the two simulations, local level results are very divergent.

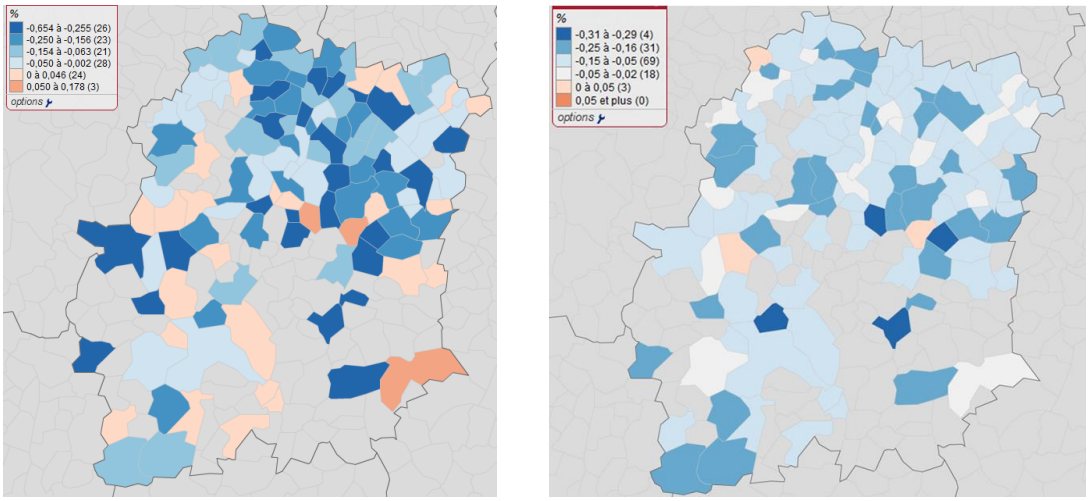

Figure 2 : Electricity demand forecasting at the municipality level, up to 2035 for a French department (Essonne). On the left: With 90 manufacturing sub-sectors | On the right: With only 6 large manufacturing sectors. (Grey area represents municipality without manufacturing sector)

Conclusions

Electricity transport and distribution operators will be key drivers of energy transition in many countries (distributed generation, electric vehicles...). To cope with these new challenges and related uncertainties, it becomes necessary to anticipate the evolution of electricity demand at the local level. This article proposes a methodology to address the specific issue of the manufacturing sector, both reliant on local and global conditions. Results highlight the high sensitivity of forecasting at a small geographical scale to the level of sectoral disaggregation.

References

Chiappini, F., Heggarty, T. (2016): “Forecasting the evolution of electricity demand and distributed generation towards 2035: An innovative bottom-up approach”, IAEE International Conference at Bergen, Norway.