Climate Information and Electricity Demand: our experience with the Italian power grid

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Abstract

The activities of electricity transmission system operators (TSO) may be affected by weather conditions and for this reason the availability of accurate information about past and future states can be useful for operations management. ENEA is supporting TERNA (Italian TSO) since 2012 providing them weather and climate information related to electricity demand and renewable energies management.

The first task has been an assessment on the use of weather and climate information to predict electricity demand at short (1-5 days) and long (1-3 months) time scales. Using seasonal climate forecasts to predict electricity demand was a challenging task: using ECMWF System 4 forecasts we were able to predict the electricity demand during summer (June-July).

Operational climate forecasts of temperature have been used both with one and two months of lead-time. A PCA-based approach has been used in order to use the information provided by climate patterns on Europe to forecast electricity demand in seven Italian regions.

The outcome of this collaboration has been two-fold: i) we had the occasion to evaluate the "quality" of weather/climate information considering power grid operational aspects and ii) more challenging questions, not considered at the beginning, have been raised, providing further interesting research goals. Moreover, seasonal climate forecasts have been applied for the first time to predict electricity demand bringing up some interesting aspects about their potentialities.

Analysing the past

This study utilizes data provided by TERNA, which is the transmission grid manager in Italy. Our analysis uses the aggregated data for Italy as a whole and also considers the eight regions in Italy for which daily load data and related weather information are available.

Electricity demand can influenced by several factors: national economic growth (e.g. recession), calendar effects (e.g. holidays) and weather conditions (mainly temperature).

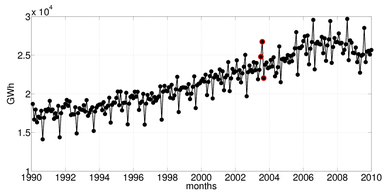

Figure 1: Italian monthly electrical usage. The red dots highlight the summer of 2003.

Furthermore, the relationship between temperature and demand has changed during the last decades due to the diffusion of residential and industrial HVAC (Heating, Ventilation and Air Conditioning).

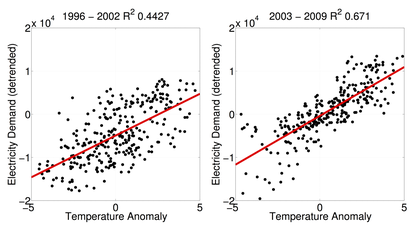

Figure 2: Daily load deviation in South Italy as a function of daily temperature anomaly

In support of this statement, we show some statistics provided by ANIMA/COAER about the installed residential air conditioning equipment from 1991 to 2004.

Figure 3: Number of room conditioning units sold in Italy by year

Introducing Seasonal Forecasts

Here we use retrospective forecasts produced by the ECMWF System 4 forecast system, which has been adopted as operational system since November 2011.

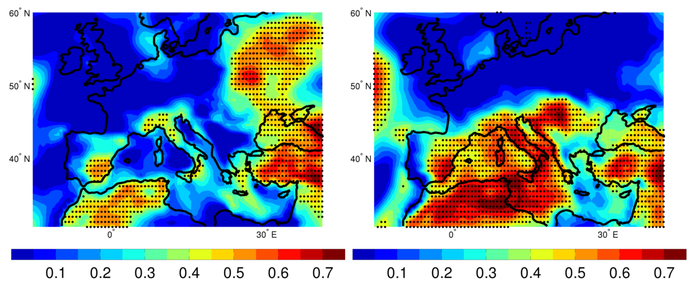

Figure 4: Correlation coefficient between June-July temperature anomaly derived by ERA-INTERIM dataset on years 1990-2007 and climate forecast (left: 2-months of lead-time; right: 1 month). Dots represents points with a 5% of significance calculated by bootstrapping.

With one month of lead time we obtain a Brier Skill Score in predicting electricity demand "above normal" events higher than 0.3 for the Center-South of Italy. Skill related to "below normal" event is generally slightly lower. As expected, with two months of lead time the skill drastically decreases, except for the South of Italy where the skill remains positive.

In the following table we show the probabilistic forecast of electricity demand for Center and South Italy related to the electricity demand above the normal. The percentage value represents how many members inside the ensemble predict the event occurrence. The event occurrence has been highlighted by shaded grey.

	C			S		
Year	Event	May	April	Event	May	April
1990	yes	37.3%	33.3%	no	31.4%	33.3%
1991	no	23.5%	20%	no	25.5%	26.7%
1992	no	43.1%	46.7%	yes	60.8%	46.7%
1993	no	13.7%	46.7%	no	35.3%	46.7%
1994	yes	86.3%	33.3%	no	49%	33.3%
1995	no	29.4%	53.3%	yes	15.7%	40%
1996	no	29.4%	40%	no	25.5%	46.7%
1997	no	39.2%	26.7%	yes	60.8%	33.3%
1998	no	31.4%	33.3%	yes	52.9%	46.7%
1999	no	5.9%	6.7%	no	0%	6.7%
2000	no	29.4%	6.7%	no	2%	0%
2001	no	23.5%	20%	no	2%	0%
2002	yes	52.9%	26.7%	yes	41.2%	20%
2003	yes	68.6%	46.7%	yes	94.1%	46.7%
2004	no	15.7%	53.3%	no	47.1%	46.7%
2005	yes	33.3%	26.7%	no	49%	46.7%
2006	yes	41.2%	73.3%	no	7.8%	53.3%
2007	no	13.7%	26.7%	no	27.5%	46.7%

Power Grids (Work in Progress)

Italy is a big importer of electricity (as we can see in the following graphs).

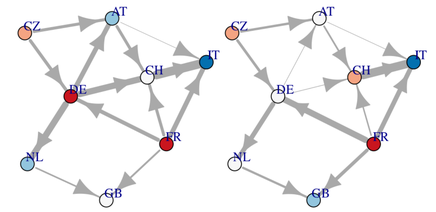

Figure 5: European electricity flows for Jan-Feb (left) and June-July (right) - red nodes are the main exporters and blue the main importers - Data from ENTSO-E (2003-2014)

Given that the consumption of electricity is normally affected by temperature, the same is for its import/export. This means that for a big importer of electricity (like Italy) it would be useful to know in advance the availability (and consequently the price) of electricity on the power market during critical months.

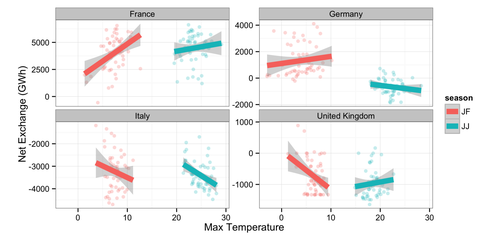

Figure 6: Net Exchange (export minus import)

Linked Papers

1. M. De Felice, A. Alessandri, and P. M. Ruti, "Electricity Demand Forecasting over Italy: Potential Benefits using Numerical Weather Prediction models" Electric Power Systems Research, vol. 104, pp. 71-79, 2013. DOWNLOAD HERE http://bit.ly/DeFelice-EPSR-2013

2. De Felice M., Alessandri A., and F. Catalano, "Seasonal climate forecasts for medium-term electricity demand forecasting" Applied Energy, vol. 137, pp. 435-444, 2015. DOWNLOAD HERE http://bit.ly/DeFelice-APEN-2015