Flexible power generation and interconnection capacity needs of the Italian power system using PLEXOS® LT plan.

Leading the field in Energy Market Modelling

Executive Summary

One of the main developments of the last few years on the Italian power market has been the significant increase of renewable capacity in the form of wind and solar power plants. Using a PLEXOS® dataset based on data available from Terna and various utilities, we have modelled the Italian power market through the six geographical zones and considered the medium term expected scenarios. The Southern zones (namely South, Sicily and Sardinia), already characterised by a significant amount of renewable capacity, are expected to experience the largest concentration of renewable development. In addition, these regions are characterised by a relative lower level of interconnection with neighbouring countries compared to the Northern zones. Given the variability introduced on the system by the increasing renewable capacity and the relative isolation of the Southern zones, the deployment of flexible power plants and the expansion of interconnection capacity are assessed using the PLEXOS® Long Term (LT) Plan feature. This feature, designed for long term optimal investment analysis, provides useful insights about potential bottlenecks, system flexibility and power prices, and is a critical tool for analysts, researchers, regulatory and utility decision makers to evaluate network adequacy and expansion, security of supply, investment options and energy policy development.

Introduction and Model Description

The power market simulation and analysis software PLEXOS® Integrated Energy Model has been used to represent the Italian power market in 2012 and its development in the medium term, considered up to the year 2017.

We built a dataset including all the relevant plants within each geographical market zone in 2012, with the poles of limited production aggregated to the surrounding geographical zones as: BRNN, FOGN and ROS to the SUD zone, and PRGP to the SICI zone.

Fig.1 - Geographical zones of the Italian power market.

Installed capacities of conventional plants and aggregated figures of renewable generators are obtained from Terna reports, utilities websites and ENTSO's Scenario Outlook & Adequacy Forecasts reports. Such capacities cover the year 2012 and extend up to 2018. In addition, for each technology we have taken a representative set of operational characteristics (heat rates, ramp rates, start costs etc.) and applied it to each of the plants of that particular technology.

Renewable generation profiles are obtained from the in-built PLEXOS® feature to create stochastic samples from a given profile, taken as the real 2012 data in this instance.

The long term country demand profiles, and zonal profiles for Italy, were built using the 2012 hourly values and the PLEXOS® in-built load forecasting feature that uses a given base profile, annual peak and energy demand forecasts; such a procedure was applied to each of the countries included in the model (Italy, France, Switzerland, Austria, Slovenia, Albania, Montenegro and Greece).

The aim of this study was to assess the need for additional interconnector capacity or the development of flexible power plants, and for that reason we employed PLEXOS® Long Term (LT) Plan feature.

Long Term Capacity Expansion Planning with PLEXOS®

Assessing the risk and return of new investments both in new power plants and in the reinforcement of the transmission grid requires highly specialized tools. PLEXOS® Integrated Energy Model feature of Capacity Expansion refers to the problem of finding the optimal combination of generation new builds (and retirements) and transmission upgrades (and retirements) that minimizes the net present value (NPV) of the total costs of the system over a long-term planning horizon. That is, to simultaneously solve a generation and transmission capacity expansion problem and a dispatch problem from a central planning, long-term perspective.

The optimization problem takes into account in the objective function two types of costs; capital costs (costs of new generator builds and transmission expansion costs) and production costs (costs of operating the system with any given set of existing and new builds and transmission network as well as the notional cost of unserved energy).

The PLEXOS® LT Plan phase by default spans the whole simulation planning horizon in a single optimization 'step', while it gives the user the option to control the type of chronology used, and choose between preserving the full chronology (Fitted chronology) or using the partial chronology (Load duration curves, LDC).

Results and Discussion

In this case study we define generator and transmission expansion candidates which PLEXOS® will assess in order to give the optimal solution. Therefore, in the inputs we define the optional investments to be either the expansion of the existing interconnectors (with France, Switzerland, Slovenia and Greece) or the building of new ones (with Croatia, Montenegro and Albania), as per Terna development plans. In addition, we give PLEXOS® the option to select to build new CCGT, GT or ST power plants in all of the 6 Italian zones.

The optimal solution as calculated by the PLEXOS® LT Plan shows that between 2015 and 2017 all the existing interconnectors used to import electricity into the country are congested most of the time

(see Fig.2); the list includes those with France, Switzerland, Austria and Slovenia and excludes only the one with Greece, which is operating mainly for export.

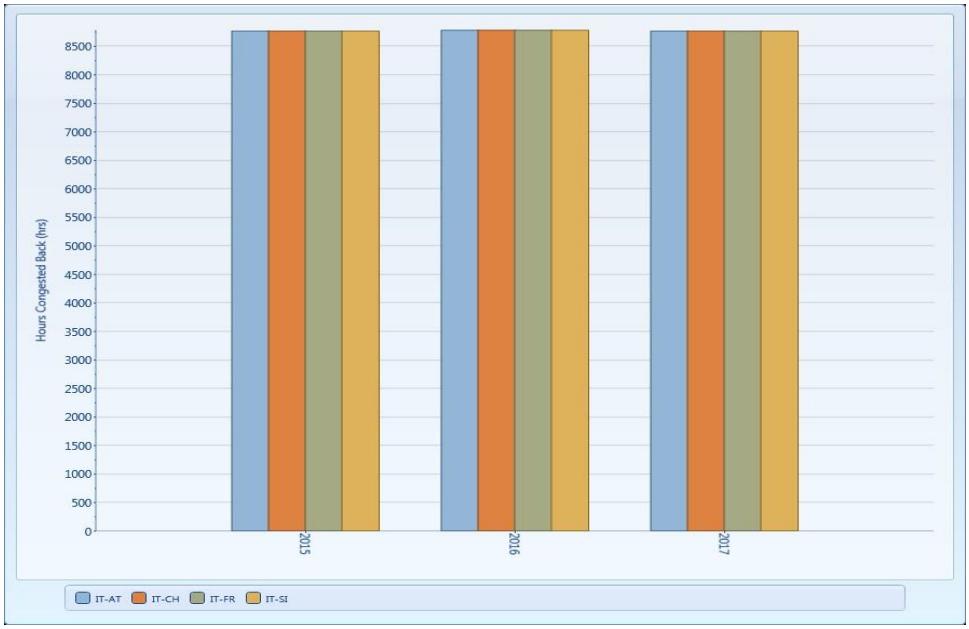

Fig.2 - Congestion of interconnectors with Northern neighbour countries

Given the need for more interconnector capacity, the PLEXOS® solution is to build an interconnector linking the South zone with Albania. This interconnector is indeed in the Terna plans and the PLEXOS® result is well suited, given that most of the renewable capacity and therefore the greatest need for balance of intermittent generation is located in the South. Together with the security of supply constraint, which is met by this new build, the other critical parameter largely impacted by the availability of interconnection capacity is the price in the country. Given the limited horizon in the PLEXOS® model compared to the typical economic lifetime of an interconnector project, further builds are prevented, as the cash-flow from the lower-cost imported electricity savings does not justify the investment.

The net result is a higher power price compared to the neighbour countries, an outcome strongly dependent on the chosen planning horizon and that can be extended as part of Energy Exemplar services to clients' specific needs.

In addition to the interconnector with Albania, the PLEXOS® optimization includes also the building of new CCGT plants in Sicily. This result is justified by the limited spare capacity of conventional plants on the island and represents a measure to prevent the prices to be too sensitive to the generation from renewables, as shown in Fig.3. Nevertheless, the price in Sicily is higher than in the rest of Italy, as shown in Fig.4, with significant peaks in the summer. The congestion of the interconnector with the mainland for most of the year suggests that an increased capacity might limit the price spread, but the cash-flow argument used for the interconnectors with neighbour countries applies also to the one between Sicily and the mainland.

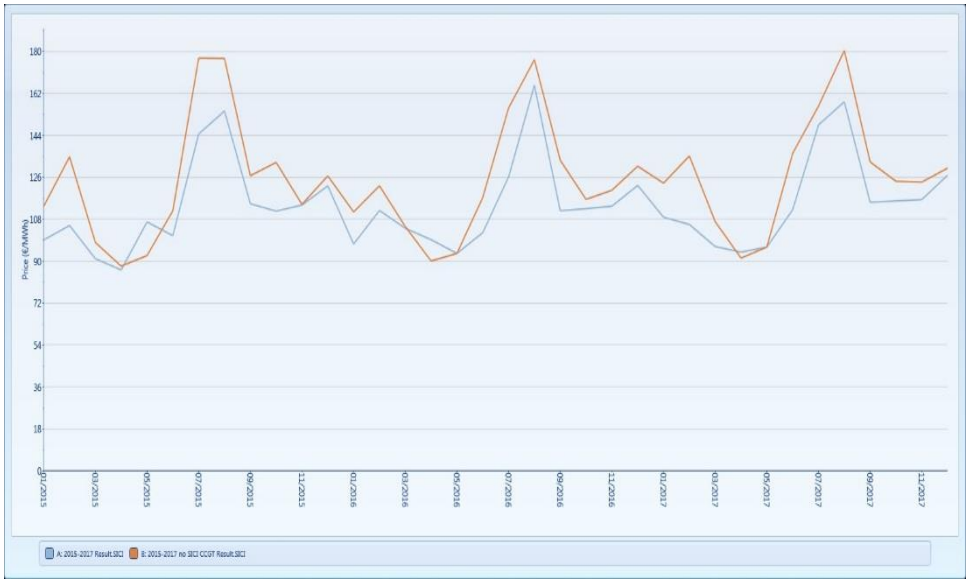

Fig.3 - Effect of new-built CCGT plants on Sicilian power prices

Fig.4 - Comparison of power prices among the 6 Italian zones

Another insight also obtained from the PLEXOS® LT Plan results is the level of congestion of all of the interconnectors exporting electricity from the South zone, as shown in Fig.5.

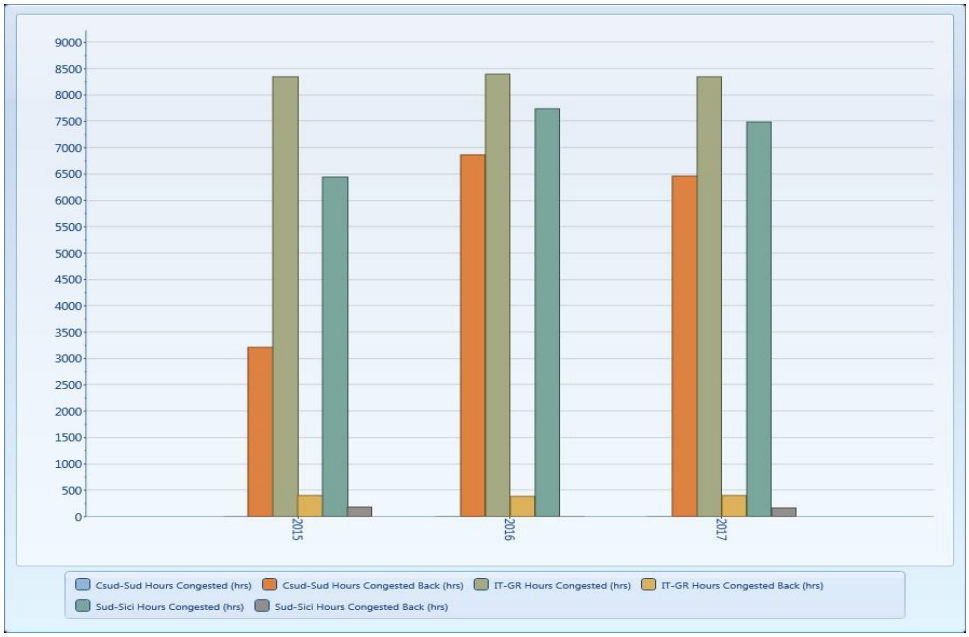

Fig.5 - Congestion of interconnectors connected to the South zone

Conclusions

The Terna plans to increase these export capacities and the new interconnector with Albania described above, is a way to address the large imbalance between demand and supply, as shown in Fig.6. Such expansion would also avoid the significant cycling costs and low capacity factors of the conventional power plants in the region, thus mitigating their effect on the energy prices in the area with likely positive effects for all the country.

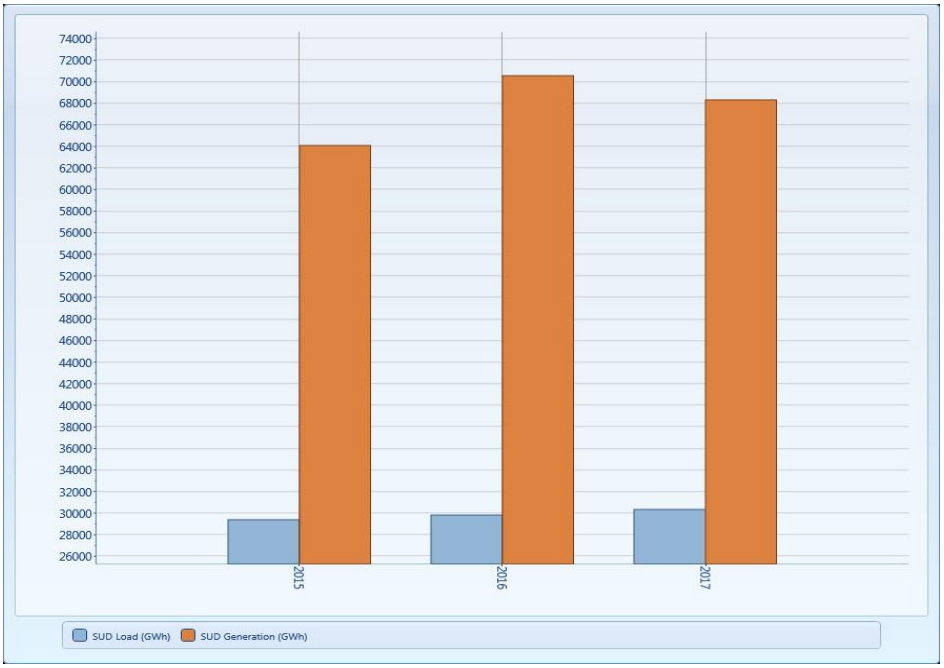

Fig. 6 – Demand and supply in the South zone