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ELECTRICITY STORAGE IN ITALY: A LONG TERM COST-BENEFIT ANALYSIS CONDUCTED WITH A MARKAL-TIMES MODEL OF THE ITALIAN ELECTRICAL SYSTEM

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OVERVIEW

The load curve of the Italian electrical system uses to present a high peak/base ratio: a typical "M-shape", with two peaks a day, and a strong load difference between night&day/seasons. The electricity market price (IPEX, Italian Power Exchange) presents a similar profile, with a peak price almost double within respect to the baseload price.
The Demand Side Management measures were not strong enough to modify the load profile: the supply-side electricity storage – hydro pumped-storage power plants - has been the only solution to optimize the electrical system. But the physical potential of hydro power in Italy has been already reached, it is not possible to develop new plants, except of mini-hydro.
Furthermore, the wind farms are facing a very strong growth, stimulated by the Green Certificates mechanism under the renewable energy EU target, and by the high electricity price, set by natural gas CCGT power plants. But wind power in Italy presents a strong production uncertainty on a hourly/dalily base. The growth of wind energy penetration into the electrical system requires a strong (and expensive) system back-up, which has an important impact both on the fossil fuel power plants and the transmission/distribution grids.
Those three main factors – M-shaped load/price curve, hydro pumped-storage potential saturation and wind energy penetration – make the Italian electrical system a very favourable environment for the development of electricity storage. It is calculated that the turnover of a load-profiling electricity storage plant in Italy would be one the highest in the world, *ceteris paribus*.
In this study, the AIEE research group analyzes the cost-benefit of the electricity storage technologies (available or near to maturity) penetration into the Italian electricity market:

- CAES – Compressed Air Energy Storage (both underground and surface storage)
- Flywheels
- Super-Capacitors (ECC)
- Superconducting Magnetic Energy Storage (SMES)
- Sodium Sulphur (NAS) Battery, Polysulfide-Bromine (PSB) Battery, Vanadium Redox Battery (VRB),
- H_2/FuelCell

METHODS

In order to assess the cost-benefit of several electricity storage technologies penetration into the Italian electrical system, a mid/long-term scenario analysis with a Markal-Times model of the Italian electrical system has been conducted.
The model has been developed in three years (2002-2004) by three joint research groups: AIEE (Italian Association of Energy Economist), Turin Polytechnic and CESI (Italian Electro-technical Experimental Centre), funded by an Italian public research program, already tested and used for several scenario analysis between 2004 and 2010 committed by utilities,

private operators and public Institutions. The well known Markal-Times methodology – developed by the IEA-ETSAP Implementing Agreement – consists in a bottom-up technique, based on complex operational research algorithms, to perform scenario analysis of energy systems, mainly focused on technology. Using such model, several electricity storage technologies has been modelled with a "black-box" approach (energy commodity input/output, average efficiency, investment/O&M costs, etc.) within a time-horizon of 20 years. Running the model, the penetration of the technologies is simulated in several alternative scenarios and the economic impact on the Italian electrical system is calculated, together with the GHG emissions from the sector.

RESULTS

Leaving the Markal-Times model of the Italian electrical system free to install the electricity storage technologies mentioned in Overview – under certain constraints – it select the CAES technology as the most competitive and decides to install about 5 GW of new CAES plants in 2050, starting with about 350 MW in 2020 (the plants construction begins three years before), not reaching the user-defined potential. It means that such choice represents the optimum for the Italian electrical system, i.e. the least-cost solution.

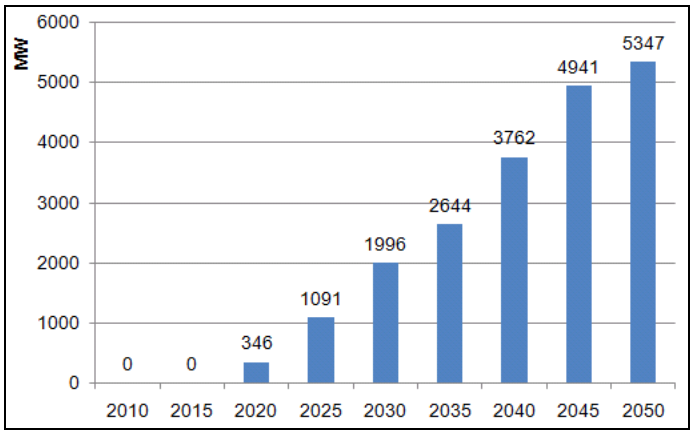

Fig. 1. CAES Total Installed Capacity into the Italian electrical system – CAES Scenario

If the model is free to integrate surface storage CAES plants to the new wind farms, the optimum electricity storage total capacity grows to about 9 GW in 2050, 7 GW in 2030. In this scenario, the total electricity production from wind-farm in Italy can reach 30 TWh in 2050, 5 TWh more than in the b.a.u. scenario.

CONCLUSIONS

The new electricity storage technologies entering into the world energy market can find a room in the Italian electrical system, which needs at least 5 to 10 GW within 2050 in order to optimize its structure. The CAES technology integrated into wind farms seems to be the most competitive electricity storage technology, it depends on the assumption about the future development of the NAS batteries. The related investments can rise from about 300 million euros in 2015/2020 to over 5 billion euros in 2050; further investments should be made for technology development and demonstration.