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# Intermittent non-dispatchable renewable generation and reserve requirements: historical analysis and preliminary evaluations on the Italian electric grid

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**Abstract**

Intermittent renewable generators, mostly solar photovoltaic (PV) and wind power plants (W), have been growing across the Italian electric grid at an unprecedented rate over the last years. At the beginning of 2013, GSE (state-owned company supporting renewable energy sources) surveyed 16,4 GW of installed PV systems and 8,1 GW of wind farms, covering a significant share of Italian electric demand, which has been ranging between 21 GW and 54 GW over the same year.
Such a relevant amount of installed intermittent power generators, fostered by priority dispatch, has already had relevant effects on the electricity market, in both its two components: the energy market (MGP) since the end of 2013 has been steadily lowering its single national purchase price (PUN), even recording zero purchase prices; at the same time, the amount of resources needed to establish reserve margin on the dispatching services market (MDS) has increased, due to a growing amount of intermittent generators penetrating on the grid, at a yearly rate of 5%, as shown from our historical analysis.
A preliminary evaluation method of reserve requirements was developed taking into account forecast variability in electric load and intermittent renewable generation. The model was used to evaluate the growth of reserve requirements with an expected larger share of renewable generators. The magnitude of this relevant parameter was assessed, thus estimating the addressable penetration of energy storage systems and virtual power plant needed to overcome renewable intermittency.


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Keywords: Reserve; requirement; forecast; renewable; integration; standard deviation.

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## 1. Introduction

The large amount of variable renewable energy sources (vRES) installed capacity, mostly photovoltaic and wind, has deeply changed the shape of net load (or residual demand), which represents the demand that must be met by

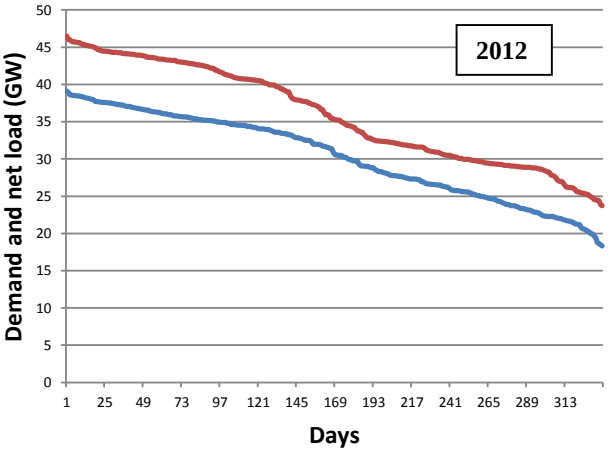


Figure 1: Net load duration curve (2012). Red lines stand for overall electric demand, while blue lines represent net load.

non intermittent dispatchable generators along the merit order to determine the energy price, considering a competitive market.
Two of the main effects comes mostly from PV installations:

- a deep residual demand reduction during the central hours of the day
- a related growth in residual demand slope at night time

vRES installed capacity has already shown a deep impact on residual demand duration curve (as we can see from Fig.1) as well as on day ahead energy market. In fact energy prices at evening hours have been raising due to solar PV lack of production during these hours and, at the same time, a shift in conventional power plants merit order was introduced, changing after several years the typical market paradigm and thus resulting in the exit of several conventional power plants from this bidding market.

At the same time, vRES have impacted on the dispatching services market requiring an additional amount of operating reserve (needed to balance on real time electric grids, making second by second the amount of demanded power exactly equal to the amount of available power). This is due to the stochastic behavior of vRES production, which assumes different features for wind and photovoltaic resources.

The importance of vRES impact should be assessed considering how it is intensified by the exit of several power plants from the day ahead bidding market, which reduces spinning reserves and forces conventional power plants to an increased number of startings, often to provide only dispatching services.

The Italian code for transmission, dispatching, developing and security of the grid (Grid Code), provided by Terna, defines how the grid could be operated on real time using reserves differentiated by rapidity with which they can respond: primary, secondary and tertiary from the most to the less responsive, varying from a few minutes to one hour. Primary reserve is a mandatory and automatic requirement for all producing power plants, meanwhile secondary and tertiary come from dispatching services market (MSD). MSD structure contains a three steps day ahead programming market (MSD ex-ante) and 5 steps operating during the day (MB).

Day ahead reserve requirements in terms of tertiary reserve, which contains secondary reserves, are sized by the grid operator to face combination of three main phenomena: