P3014

Assessing the impact of virtual qualified units on the Italian ancillary services market

Marco Stabile
(1) CESI Centro Elettrotecnico Sperimentale Italiano
Via Rubattino, 54 - 20134 Milano (Italy)
Tel: +390221255806
marco.stabile@cesi.it

Abstract

Recent changes in the Italian regulation of the National Transmission Grid (NTG) demonstrate that the Italian Ancillary Services Market (ASM) is opening up to new subjects different from traditional producers, defined by the Italian grid code as “significant units” within a total power not less than 10 MVA. These new players are called Virtual Qualified Units (VQU, in Italian UVA “Unità Virtuali Abilitate”) consisting in non-significant producers, storage systems and loads. To cope with these changes to the regulation framework, the Italian TSO TERNA has launched few pilot projects to foster the participation in the Italian ASM of aggregators and demand response for providing balancing (up-ward and down-ward regulation) and reserves to the NTG.

In this context CESI has developed on behalf of TERNA an innovative simulation tool called MODIS that allows to quantitatively evaluate the impact on the ASM arising from a new transmission infrastructure, storage or a new VQU, in a planning perspective. Starting from the outcomes of the day-ahead market (DAM), this tool simulates the redispatching process of the ASM, minimizing market disbursement hour by hour over a whole year, necessary to ensure the fulfilment of the operational constraints.

This paper presents the methodology and a quantitative analysis to assess the economic benefit, that can be achieved by the VQU deployment in the NTG by 2025 and 2030. The economic benefit is quantified in terms of cost saving for providing regulating services and reserves in the Italian ASM. The methodology relies on scenario simulations and what-if analysis through the comparison of different simulations obtained using the MODIS model.

Introduction

In the transition to a low carbon economy Italy is facing a dramatic increase in Renewable Energy Sources (RES) penetration, which has been fostered by a strong support in terms of subsidies and incentives. Nowadays current policies are pushing the new RES generation to compete on equal basis with the conventional generation through appropriate schemes, mostly based on auctions.

The priority for the European Regulators and TSO's is nowadays to enhance harmonization of the rules for balancing and for exchanging ancillary services in order to implement an effective pan-European competition in the ASM markets and increase efficiency. To this aim, ACER, the European Association of Energy Regulators, has published Framework Guidelines on Electricity Balancing [1] that served as a basis for ENTSO-e to develop the Network Code on Electricity Balancing submitted for approval to the European Commission(EC). In November 2017 the EC has finally published the European Balancing Guideline [2].

Following the new changes at European level also the Italian regulatory authority for energy, networks and the environment (Autorità di Regolazione per Energia Reti e Ambiente, ARERA) has legislated in order to foster the integration of new actors (different from traditional power producers) in the Italian ASM [3]. Consequently, the Italian TSO has established different pilot projects to start a testing phase able to experiment the participation of these new actors in the ancillary services market, in particular renewable, consumer and storage.

These changes in the regulation at national level demonstrate that the Italian ASM is opening up to new subjects different from traditional producers, defined by the Italian grid code as “significant units” within a total power not less than 10 MVA. These new players are called Virtual Qualified Units (VQUs, in Italian UVA “Unità Virtuali Abilitate”) consisting in non-significant producers, storage systems and loads. To cope with these changes to the regulation framework, the Italian TSO TERNA has launched few pilot projects to foster the participation in the Italian ASM of aggregators and demand response for providing balancing (up-ward and down-ward regulation) and reserves to the NTG.

Annex 8 of the “2nd ENTSO-e Guideline for Cost Benefit Analysis(CBA) of Grid Development Projects” [4] mentions the assessment of ancillary services cost reduction as a potential benefit to be considered in the CBA for transmission investments. In this context CESI has developed on behalf of TERNA an innovative simulation tool called MODIS that allows to quantitatively evaluate the impact on the ASM arising from a new transmission infrastructure, storage or a new VQU, in a planning perspective. Starting from the outcomes of the day-ahead market (DAM), this tool, simulates the redispatching process of the ASM, minimizing market disbursement hour by hour over a whole year, necessary to ensure the fulfilment of the operational constraints.

The Italian Ancillary Market

This session describes few basic concepts about the Italian ASM functioning and its recent developments, to clarify which services are procured through the market and it introduces the main steps undertaken by the Italian Authority (ARERA) and the Italian TSO (TERNA) to increase market competitiveness opening up to new subjects, different from traditional power plant. Finally, a short overview about recent trend of the Italian ASM is given.

Italian ASM, brief description

The Italian ASM is an “Energy-Only” market, where all the services requested by the TSO to manage the NTG are procured at zonal level: all the submitted bids accepted in the ASM are valued at the offered price through pay-as-bid clearing mechanism.

The Italian TSO procures through the ASM the resources needed to:

- relieving intra-zonal congestions;
- procuring tertiary and secondary reserve;
- balancing the system in real-time.

The resources necessary to maintain the balance between injection and withdrawal are activated at different time starting from the day before real time (D-1) until the real-time, with two main stages:

- MSD Ex-Ante (hereafter named MSD) - in this phase the TSO relieves congestions and creates the secondary and tertiary reserve margin.
- Balancing Market (hereafter named MB) – during the real-time operation the TSO clears the balancing offers (price and quantity) in order to restore the secondary and tertiary reserve margin and balancing the grid.

These two sessions are chronologically procured in sequential order after the day-ahead market (hereafter DAM). Each market participants qualified to participate into the ASM must provide all the residual margins after the DAM by means of specific bids/offers[1], and the offered volume should be consistent with the available margin of the power unit.

Procuring services from Virtual Qualified Units

Starting from 2017 the Italian electrical market opened toward new subjects different from traditional power producers, according to the following road-map:

- 5th May 2017 – ARERA approved the resolution (*Delibera* 300/2017 [3]) in which the Italian ASM should admit in the market new subjects such as demand and renewable and storage system.
- 30th May 2017 – TERNA published specific new rules (Regolamento UVAC MSD [5]) regulating the access to the ASM of consumption units;
- 25th September 2017 - TERNA published specific new rules (Regolamento UVAP MSD [6]) regulating the access to the ASM of non-significant producer unit;
- 19th June 2018 – TERNA published a new regulatory framework for the M-VQU (Regolamento UVAM MSD [7]) regulating the access of heterogeneous units (that could provide upward and downward regulation, including storage facilities).

The new regulatory framework has provided the foundation for aggregating different type of subjects into Virtual Qualified Units (VQU), classifying these new market actors according to the following categories:

- **C-VQU** – consumption virtual qualified unit, able to reduce consumption, with a minimum aggregation threshold between 10 MW to 1 MW.
- **P-VQU** – production virtual qualified unit, able to reduce or increase its injection toward the grid (reducing and increasing its production) with a minimum aggregation threshold between 5 MW to 1 MW.
- **M-VQU** – mixed virtual qualified unit, including P-VQU C-VQU and storage system. This virtual unit can modulate in both direction (upward and downward) their power level (injection or consumption). In this case the minimum aggregation threshold is 1 MW.

Italian ASM trends

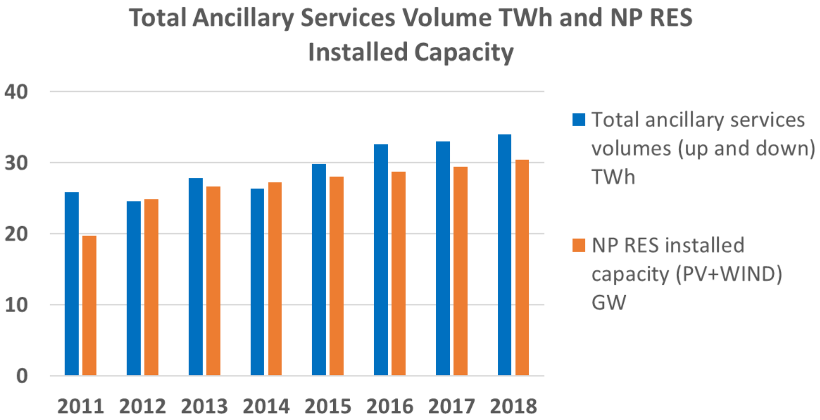
As mentioned above, Italy is witnessing the deployment of a massive share of non-programmable, or variable, RES (hereafter NP-RES, mainly onshore wind and photovoltaic generation) which increased in the last decade from few GW to almost 30 GW. This non-negligible share of NP-RES has two main implications:

[1] Each bid/offer consists in a couple of value representing the quantity (in terms of energy) and the price.

- It increases the amount of unbalance to be offset during real-time operation;
- It increases the amount of tertiary reserve (TR) needed to guarantee an adequate level of security to the NTG.

These two aspects call for a higher volume of services requested in the ASM, and consequently the costs related to the ASM disbursement increase. These costs are transferred to the consumer as highlighted in Figure 1-3;

Figure 1-3 – Italian ASM up/down volume and NP RES installed capacity.



Applied Methodology and Scenario Description

This section explains the numerical approach used to assess the potential impact of VQUs into the Italian ASM and the model used to carry out simulations and the results that have been obtained.

Introducing the simulation tools

Whereas for the DAM, a powerful and accurate simulator (PROMEDGRID) was developed and already applied in the previous national development plans considering the detailed model of the pan-European market [8], the yearly simulation of the impact of a new transmission project on the ASM was so far estimated in an approximated way, owing to the complexity of this market based on a pay-as-bid mechanism.

Thus, CESI in cooperation with TERNA has developed an ASM simulator, named MODIS, a multi-area market simulator, specifically tailored to the Italian ASM. MODIS reproduces all the balancing actions to ensure the security reserve margins[2], for a whole year with hourly discretization. Recently MODIS has been further strengthened by introducing a dedicated library for a detailed modeling of BESS (Battery Energy Storage System) technology [9], able to optimize e BESS operation[3] when operated to provide services into the ASM. Recently, the simulator was further improved and by adding a specific modelling procedure to replicate the VQUs behavior in the ASM.

MODIS emulates the real ASM behavior starting from the DAM final schedule and tries to ensure the offset between demand and supply, assuring the right reserve margin. For this reason, the deterministic model implemented in MODIS belongs to the class of "*security constrained differential unit commitment problems*", where upward and downward regulation

[2] It simulates the ASM procurement of different services such as balancing, secondary and tertiary reserve.

[3] Maximize usage of BESS and minimize the life-cycle cost of the electrochemical storage.

of the controllable variables are made starting from an initial status inherited from the DAM solution.

Simulation Approach

The results of the various market sessions are obtained by means of sequential simulations, coherently with the sequential order of the real Italian Power Market session.

Figure 2-1 – Sequential simulation process

Simulations are carried out to highlight the main benefit given by the new market players, i.e. the VQUs, competing in the market with the traditional power units, considering two different time horizons addressing the medium and long term (2025 and 2030).

Main benefits envisaged in this paper are:

- The ASM disbursement cost reduction: by tracking the cost of re-dispatching market process in each considered scenario, it is possible to assess the economic impact of VQUs.
- RES integration, quantified in terms of the avoided NP-RES curtailment thanks to VQUs participation into the ASM.

VQUs Modelling

In order to exemplify the heterogeneous characteristics of the VQUs, three main categories have been defined in the model as shown in Table 2-1.

Table 2-1 – VQUs modelled categories

Modelled Cluster	Cluster Description	Services
DSR, RES, DG (hereafter abbreviated in D-R-DG)	• **Demand Side Response**, intended as demand that can reduce consumption: this activation gives to the market upward regulation (balancing and if possible reserve). • **Renewable Generation,** that could provide downward regulation. • **Distributed Generation**, that could be moved upward or downward.	The mix of generation and controllable demand can participate into the market through upward and downward regulation.
Storage	Stationary storage system, mainly refers to electrochemical storage system. The option of future development of new pumping facilities is disregarded by this case studies	It participates into the market through upward and downward regulation
Electrical Vehicles (EV)	The transition from a century of mass-market dominance by the internal combustion to the EVs appears to be imminent. For this reason, this study also considers the impact of millions of EVs connected to the grid able support the ASM with regulating capacity.	It participates into the market through upward and downward regulation

As mentioned before, the VQUs can compete with traditional generator on the basis of their bids, which are exogenous variables. For the purpose of this quantitative analysis the optimization of bid strategies is disregarded and VQUs are considered as most valuable resources than traditional power plant, and consequently their bids are less competitive than traditional units.

Case Studies

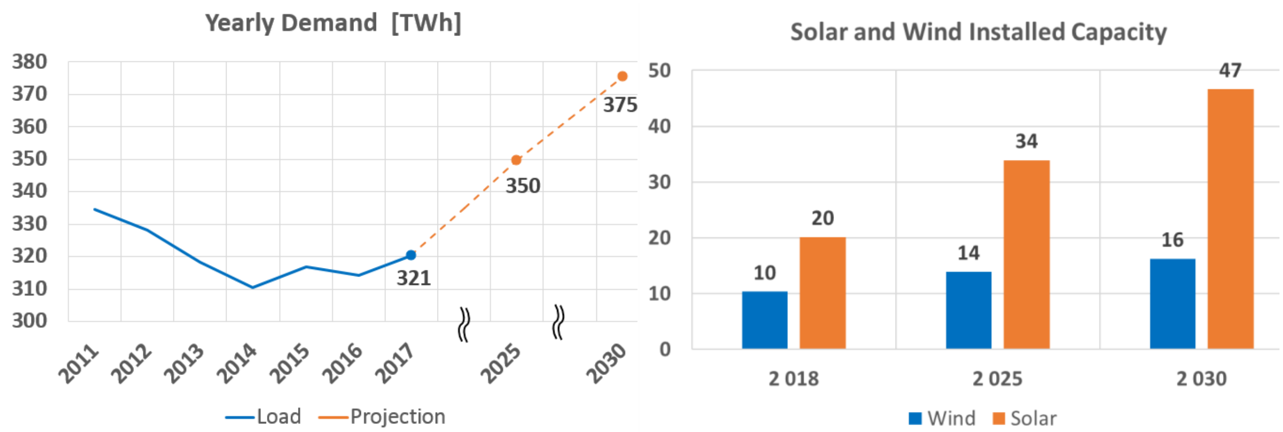
The application of the proposed methodology, implemented using MODIS, is exemplified with some case studies used to point out the benefits arising from considering VQUs participating into the Italian ASM. For the analysis a “what-if” approach (i.e. with and without VSUs participating into the market) has been adopted, to highlight possible beneficial effects given by those virtual units. All the adopted scenarios are based on a realistic description of the Italian ASM with the following problem size, 10 market areas,10 equivalent interconnections between areas, 244 thermal and hydro units.

Two different time horizons have been taken into account in this analysis, considering **2020** as **short-term scenario,** to represent the near future, and 2030 as **long-term scenario**.

The proposed scenarios have been voluntarily created with the purposes of emphasizing the effect of those new actors (distributed generation, DSR, small scale generation, storage facilities and EV) in scenarios with high penetration of NP-RES.

Load projections (in terms of yearly energy demand) and NP-RES installed capacity[4] considered in each scenario (2025 and 2030) are reported in the following Figure 2-2.

Figure 2-2 – Load projection to 2025 and 2030



In the proposed scenario VQUs are modelled according to the categories already described in Table 2-1, whereas the installed capacity is shown in the following figure (see Figure 2-3), where D-R-DG installed capacity is given by linear progression of observed amount of VQU participating into the ASM in the last months, whereas storage installed capacity is given by a policy target[5]. The draft document “the integrated plan for energy and climate (PNIEC)” [10] issued by the “Italian Minister of Infrastructures and Transport” marks out the new national energy strategy where storage is at the centre of the agenda to increase the

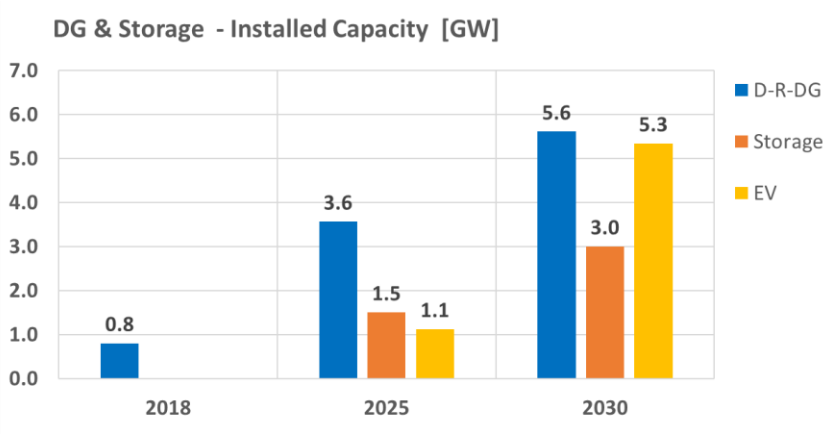
[4] Load and NP-RES installed capacity are the main variables upon which depend the volume of tertiary reserve requested by the system and the amount of unbalance generated during real-time operation.

[5] Should be noted that electrochemical storage facilities, dedicated to grid regulating services, have been developed till today only through the form of pilot projects by the Italian TSO.

flexibility necessary to expand the share of renewable energy in final energy consumption to 28% by 2030. According to this national energy plan the amount of storage expected at 2030 should be 6000 MW, allocated between stationary (pumping PP) and electrochemical. In this analysis we wanted go conservative taking half capacity by 2030, represented by the 3000 MW in Figure 2-3.

EVs installed capacity in participating in the Italian ASM is estimated taking into account the target of 6 million circulating EVs at 2030. The values shown in Figure 2-3 represent the average consumption value (1.1 GW at 2025 and 5.3 GW at 2030) which exemplifies the variable consumption given by the EV chargers during the simulation timeframe (one year, 8760 hours).

Figure 2-3 – VQUs installed capacity



What-if analysis

The basic methodological approach underlying the what-if analysis presented in current paper consist in comparing a scenario without having the VQUs participating into the ASM (Baseline scenario, BS), with a scenario where the VQUs actively bid into the market.

Another variable that at this point of the process to open the Italian ASM to VQUs, have an uncertain impact on the volume traded into the market is the contribution of the VQUs to the tertiary reserve requested into the ASM. Theoretically also VQUs could provide TR under some technical restrictions; in accordance with this assumption this analysis shows a comparison between the scenario where VQUs provide only upward and downward regulation with the scenario where VQUs provide also TR.

Results and main findings

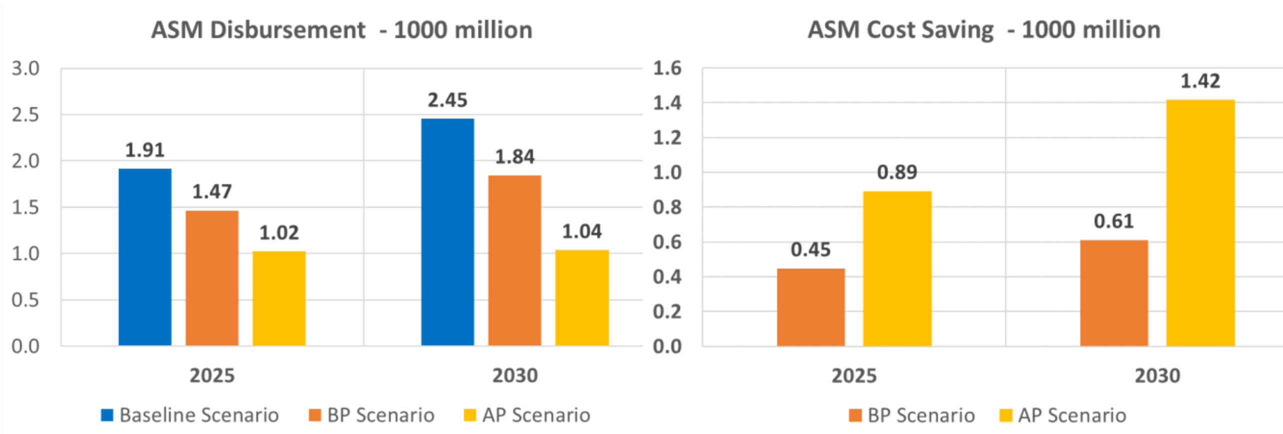
In the following session are presented the main findings of the analysis: all the results are collected starting from the hourly output given by the simulation tool. To summarize the main results, which are calculated with hourly detail, all the data have been collected and presented at country level, disregarding the zonal detail.

ASM cost assessment

In the following figure (see Figure 3-1) is reported the cost of the Italian ASM as result of the simulation (chart on the left) and the cost saving due VQUs which participate into the ASM[6]. Here below a brief explanation of the reported chart:

- Blue bar represents the cost for the Baseline Scenario (BS), where VQUs do not provide any ancillary services: these two scenarios represent the future snapshots under the assumptions VQUs are not participating into the ASM.
- The orange bar represents the Basic Procuring Scenario (BP), where VQUs are activated only for balancing purposes.
- The yellow bar represents the Advance Procuring Scenario (AP), where VQUs are activated for providing balancing and reserve[7].

Figure 3-1 – ASM disbursement and cost saving due VUs



In the BP scenario the cost saving due VQUs participating into the market and providing upward/downward regulation is about 450 million in 2025 (-23% respect to the BS cost) and 610 million in 2030 (-25% respect to the BS cost). For the AP scenario the high value of cost saving (-57% respect to the BS cost) is partially imputable to the advent of the VQUs, and partially related to the Italian ASM mechanism characteristics[8].

Figure 3-2 helps in understanding the way the model works: both figures represent upward and downward yearly activation in GWh, for 2025 and 2030 scenario, comparing the

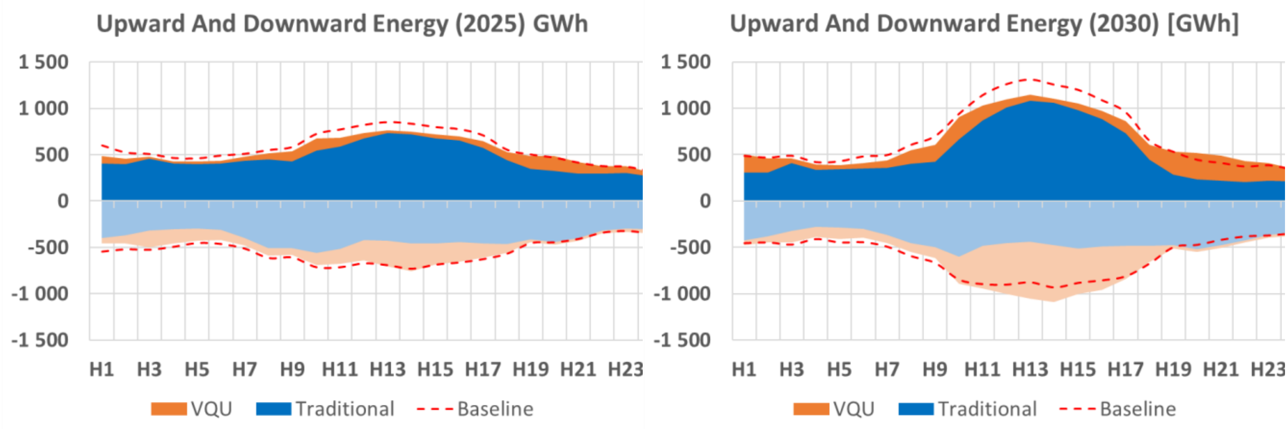
[6] this value is obtained as difference respect to the baseline ASM disbursement.

[7] It's important to stress that the AP scenario represent a pure academic exercise and it has been carried out only to exploit VQUs capacity in reducing the Italian ASM yearly expenditure. Probably in the coming years some of the VQUs will be able to provide TR, but not all of them, whereas in the proposed scenario all the VQUs are providing TR.

[8] In the Italian ASM TR is indirectly paid through the upward and downward regulation, and there is no reservation and remuneration of capacity. For this reason, in many hours VQUs are capable to provide reserve even without been directly committed by the TSO. In the AP scenario the reserve is taken from those unit for free, reducing the cost of the ASM of 46% in 2025 and 57% in 2030.

Baseline scenario result (red dotted line) with the BP scenario result (blue and orange colored area).

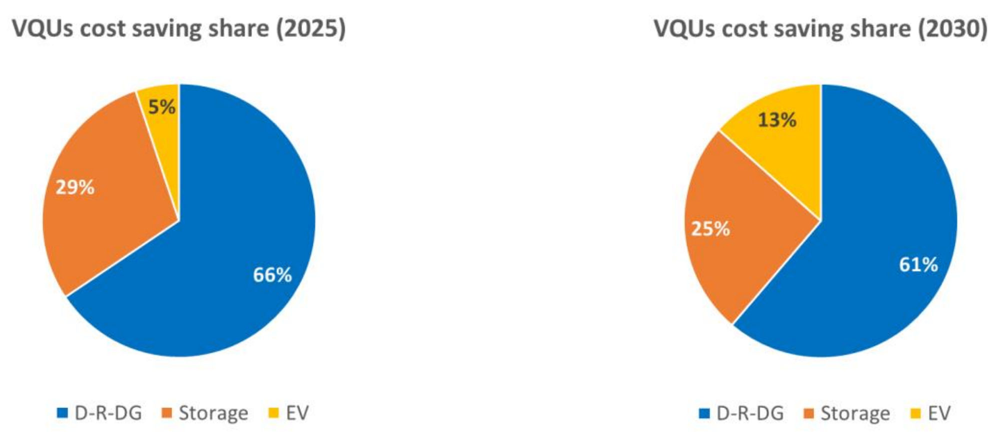
Figure 3-2 – ASM annual upward and downward volume (Baseline vs BP scenario)



The headroom between the red line and colored area in the positive side of the chart of Figure 3-2 indicates the avoided upward activation volume in the case VQUs are participating into the market. On the contrary, looking into the negative part of the chart, downward activation for BP scenario is greater than the quantity observed in the Baseline scenario. This result is consequent the augmented flexibility of the system given by the VQUs, which permits to integrate more NP-RES production (by increasing system capacity of providing downward regulation during solar hours).

Thanks to the MODIS simulation tool is possible to breakdown the cost saving due to a specific category of VQUs (see Figure 3-3). This figure refers to the BP scenario, and as noticeable in both years the greatest contribution in reducing the cost of the ASM is given by controllable demand, controllable renewable production, distributed generation and storage facilities. At 2025 the contribution in reducing the cost of the ASM given by the EVs is marginal (5%), it increases a little in 2030 contributing in reducing the ASM cost with a share of the total cost reduction of 13%[9].

Figure 3-3 – ASM cost saving breakdown by VQUs.



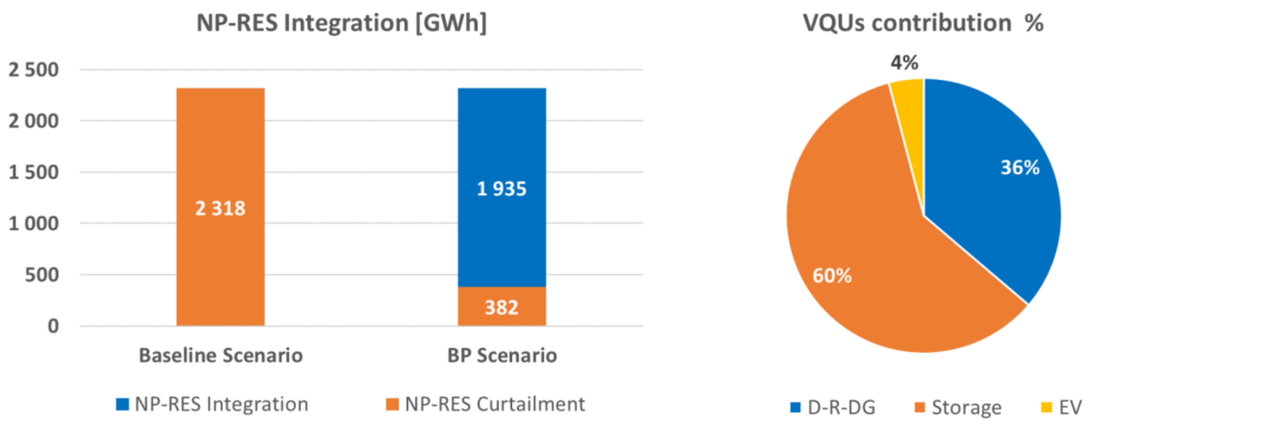
[9] under the assumption of 6 million EV circulating in the country.

RES integration potential

VQUs are effective to prevent RES curtailment, also called overgeneration, which represent the amount of NP-RES production which cannot be integrated by the electrical system due the minimum power constraint of thermal units.

Calculation has shown that the amount of NP-RES curtailment, necessary to match the system reserve requirement, settles down to 973 GWh in 2025 and 2318 GWh in 2030 for the BS scenario. Particularly in the 2030 scenario, when the overgeneration is not negligible, the participation of VQUs into the market gives a huge effort in avoiding NP-RES curtailment (see Figure 3-4, figure on the left shows the amount of NP-RES curtailment in the Baseline scenario and in the BP scenario, whereas figure on the right indicates in which proportion VQUs are contributing to integrate 1935 GWh of overgeneration at 2030).

Figure 3-4 – NP-RES curtailment and NP-RES integration thanks to VQUs (year 2030)



The NP-RES curtailment is particularly evident during solar hours when PV production is at its maximum. This effect reveals just after DAM schedule, becoming relevant during the ASM in the moment it is necessary to start-up more thermoelectric power units in order to satisfy TR and SR constraints. Figure 3-5 show hourly concentration of NP-RES curtailment on yearly basis in the scenario at 2030 (figure on the left). This volume of overgeneration is then reduced thanks to VQUs (BP scenario on the right).

Figure 3-5 – NP-RES curtailment profile (Baseline scenario vs BP scenario, year 2030)

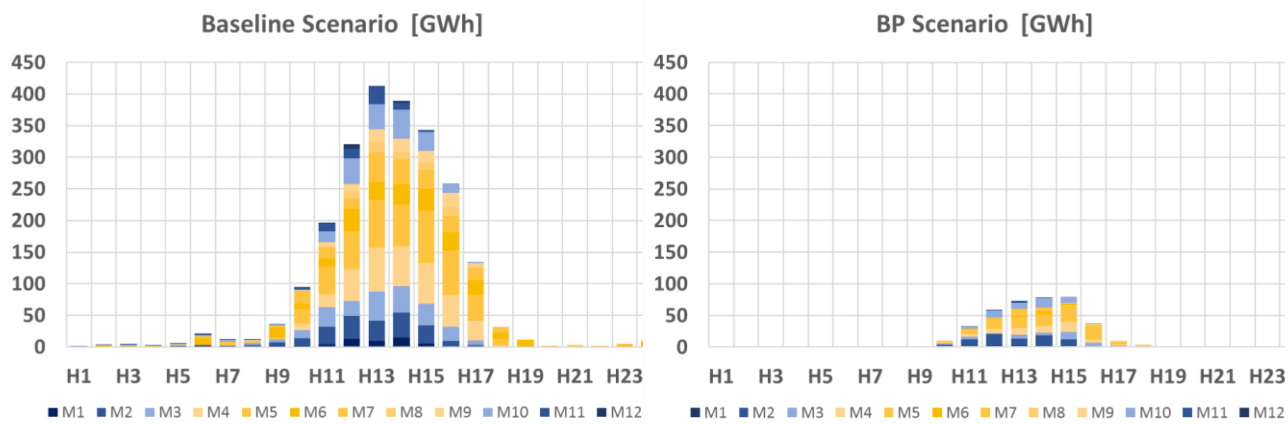
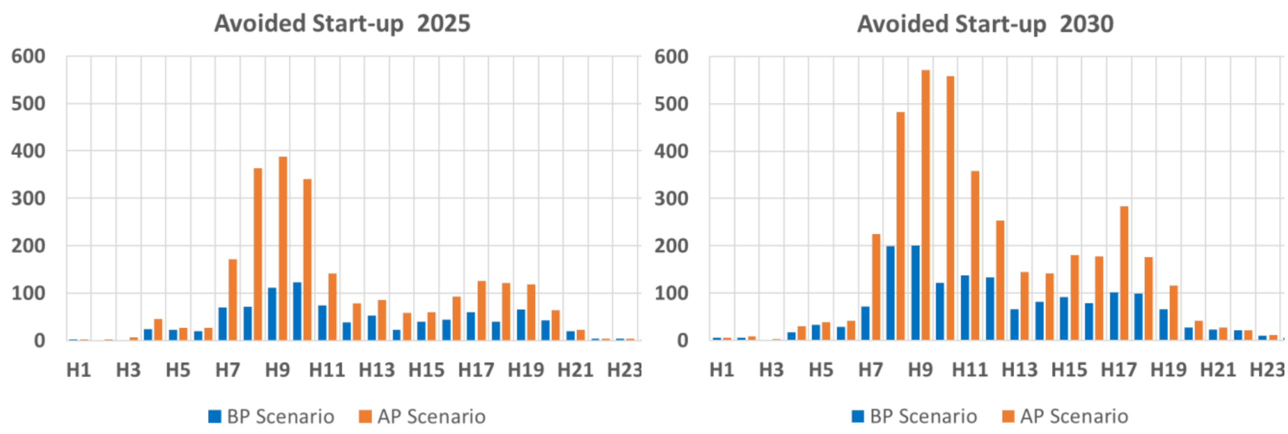


Figure 3-6 shows the avoided number of start-up of thermoelectric units over the 24 hours, for the whole year: the avoided start-ups indicates an increase of the flexibility of the system due the presence of VQUs.

Figure 3-6 – Avoided start-up during ASM re-dispatching thanks to VQUs



List abbreviation and Acronyms

Acronym	Meaning
ARERA	Italian Regulatory Authority for Energy, Networks and Environment
ASM	Ancillary Services Market
BESS	Battery Energy Storage Systems
BS	Baseline Scenario, reference scenario used for comparison of sensitivities
C-VQU	Consumption Virtual Qualified Unit
DAM	Day Ahead Market
DG	Distributed Generation
DSR	Demand Side Response
EV	Electrical Vehicle
MSD	Italian acronym for the ancillary services market
M-VQU	Mixed Virtual Qualified Unit
NP-RES	Non-Programmable Renewable Energy Source
NTG	National Transmission Grid
PP	Power Plant
P-VQU	Production Virtual Qualified Unit
RES	Renewable Energy Source
SR	Secondary Reserve
TERNA	Italian Transmission System Operator
TR	Tertiary reserve
TSO	Transmission System Operator
VQU	Virtual Qualified Unit

References

[1] ACER, "*Framework Guidelines on Electricity Balancing*", FG-2012-E-009, September 2012 (available at the following link: http://www.acer.europa.eu/official_documents/acts_of_the_agency/framework_guidelines/framework guidelines/framework guidelines on electricity balancing.pdf)

[2] EC, "*Guideline on Electricity Balancing*", Commission Regulation (EU) 2017/2195, November 2017 (available at the following link: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32017R2195&from=EN)

[3] ARERA (the Italian Regulatory Authority for Energy, Networks and Environment), Delibera 300/2017 "*Prima apertura del mercato per il servizio di dispacciamento (MSD) alla domanda elettrica ed alle unità di produzione anche da fonti rinnovabili non già abilitate nonché ai sistemi di accumulo*", Italy, May 2017 (available at the following link: https://www.arera.it/it/schedetecniche/17/300-17st.htm)

[4] ENTSO-E, "2nd ENTSO-E Guideline for Cost Benefit Analysis of Grid Development Projects"- draft for ACER opinion, Brussels, Dec. 2016 (also available at the following link:http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Opinions/Supporting%20documents%20to%20ACER%20Opinion%20052017/Supporting%20doc_Annex%20IV_ENTSO-E_draft%20CBA%202.0.pdf)

[5] TERNA, "*Regolamento recante le modalità per la creazione, qualificazione e gestione di unità virtuali di consumo abilitate al mercato dei servizi di dispacciamento - regolamento MSD*"- 30th May 2017

[6] TERNA, "*Regolamento recante le modalità per la creazione, qualificazione e gestione di unità virtuali di produzione abilitate al mercato dei servizi di dispacciamento - regolamento MSD*"- 25th September 2017

[7] TERNA, "*Regolamento recante le modalità per la creazione, qualificazione e gestione di unita' virtuali abilitate miste (UVAM) al mercato dei servizi di dispacciamento*"- 19 June 2018

[8] B. Cova, P. Capurso, E. Elia, P. Portoghese, M. Stabile, F. Vedovelli, A. Venturini, "*Market integration in Europe: a market simulator taking into account different market zones and the increasing penetration of RES generation*", CIGRE General Session 2012, Paris, August 2012, paper C5-101

[9] Arianna Rossi, Marco Stabile, Cinzia Puglisi, Davide Falabretti, Marco Merlo, "*Evaluation of the energy storage systems impact on the Italian ancillary market*", Sustainable Energy, Grids and Networks 17, Elsevier March 2019 (also available at the following link: https://www.sciencedirect.com/science/article/pii/S2352467718301449)

[10] Italian Minister of Infrastructures and Transport, "I*taly draft national energy and climate plan*", 31th December 2018 (also available at the following link: https://www.mise.gov.it/images/stories/documenti/Proposta_di_Piano_Nazionale_Integrato_per_Energia_e_il_Clima_Italiano.pdf)