Demand Response in the Italian regulation and first results

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Abstract **— In the overall framework of energy transition, new Demand Response (DR) mechanisms for passive customers have been recently introduced in the Italian electricity system to increase the offer of ancillary services and adequacy in the electricity market. In the paper, at first the concept of DR is recalled, with a taxonomy of the different ways to implement it. Then, regulation and remuneration mechanisms are analyzed for the enabled mixed virtual units (UVAM), introduced by the Italian regulator in 2017 with regulatory sandbox pilot project, and for consumption units to participate in the capacity market (UCMC) introduced in 2019. Eventually, the key points of the two mechanisms are compared in terms of actual service provided to the system, remuneration structure, performance assessment and penalties. Similarities and differences between the two mechanisms are highlighted, which can be useful to the Regulator and to technical and market actors for the possible evolution of DR in Italy and for the role that UVAM and UCMC could play in the next years.**

Index Terms **— Demand Response, Capacity Market, Flexibility, Energy transition, Italian regulation**

I. Introduction and Taxonomy

The electricity system is going through profound changes [1]. The extensive exploitation of renewable energy sources, especially non-programmable ones such as wind and photovoltaics, with the increasing penetration of distributed generation, and the expected rise of demand for electricity, mainly due to the increasing electrification of heating and transport, are leading to a complete revision of the system management paradigm, which inevitably impacts on the operation of the electricity markets and the provision of network services [2].

In Italy, the national Transmission System Operator (TSO), Terna SpA, procures the means to resolve intrazonal congestions, balance the system, guarantee appropriate reserve margins, thus in general ensuring system security, in the ancillary services market Mercato dei Servizi di Dispacciamento (MSD). The MSD has been established when the generation consisted mainly of conventional production plants (thermoelectric and programmable hydroelectric), upon which Terna relied for the provision of services. Even today, the grid code provides for the provision of ancillary services almost exclusively by some units defined as “enabled” [2].[1]

The electricity industry faces increasing difficulties in finding ancillary service providers, due to the diminishing energy production by traditional plants. To reduce the cost of the ancillary services, new innovative solutions begin to be tested, capable of extending the involvement in the provision of ancillary services to resources such as consumption units, at all voltage levels.

The European regulation also is supporting this change of approach: consumers will be qualified as “active”, and they will contribute to the reliability of the power system by introducing flexibility in energy demand [3], either through direct participation or by the intervention of a third-party aggregator pooling different resources. Indeed, the European Directive on the Internal Electricity Market [4] explicitly mentions consumer participation and demand response as general goals underlying the organization of the electricity system.

The evolution towards the participation, in a market perspective, of the demand side in the operation of the electricity system is implemented in Italy through different regulated mechanisms regarding the demand units in the capacity market (Unità di Consumo per il Mercato della Capacità - UCMC) within the overall regulation of the capacity market [5], the pilot project for the enabled mixed virtual units (Unità Virtuali Abilitate Miste - UVAM) [6], and the upcoming pilot projects on ancillary services for the distribution system operator [7]. These mechanisms fall within the scope of the Demand Response (DR), whose main characteristics are described below.

DR is defined as the changes in the use of electricity by end-users compared to the usual profile [8] in a way that increases system efficiency and security of supply. In general, DR may result either in increases or decreases in electricity usage.

This paper represents the views of the authors. It is not intended to represent the position or opinions of any company of the Enel group.

[1] Thermo and programmable hydro generating units with a power of at least 10 MVA and connected to the TSO grid.

Table 1 – Main features of explicit demand response

Procurement	Remuneration	Obligations	System benefits
Spot market	payment for delivered energy (€/MWh)	1) Correct supply of accepted energy [No obligation of availability. Free offer in terms of quantity/price in MSD]	Modulation of withdrawals and injections to improve the short-term management (security, economic efficiency, integration of renewables). Increase of MSD-enabled resources.
Forward capacity market	payment for capacity availability (€/MW)	1) Obligation to bid on the MSD for the capacity awarded, in periods and at price conditions defined ex-ante 2) Correct supply of accepted energy	Availability of energy at predetermined costs to contribute to medium-long term system planning (grid development and generation capacity, maintenance planning, service procurement). Coverage of availability costs for the operator. Increased flexibility offers in the spot market.

Typically, from the point of view of the power system operators, DR is considered effective as a reduction of the withdrawal of electricity during critical periods.

Participation in the DR can be exercised at different voltage levels (LV, MV and HV), individually or as aggregates according to the particularities and needs to be met. It can involve consumption, production, and storage units in the availability of a final consumer, and their combinations as well.

The change of electricity usage can be an implicit DR or an explicit one [9], taking place the first in response to the price of the electricity and the second to a direct remuneration.

The implicit DR takes place as a response to time-variable electricity prices and/or tariffs; for this reason, it is also named price-based DR. Implicit DR can either be self-directed or directed by an energy management service provider [10]. In implicit DR, the user, also through the Balance Responsible Party (BRP) (a market participant or its chosen representative responsible for its imbalances [11]), using both behind the meter production and passive loads arranges to reduce or shift net withdrawals during peak hours in response to the price signal. Based on the retail contracts, price variability over time can be predetermined and fixed ex-ante with the Time-of-Use (ToU) fixed prices, or dynamically (so called market-based prices) depending on the outcomes of the spot market. Tariff and charges set ex-ante by the regulators to cover transport or dispatching costs can contribute to the setting of ToUs by differentiating their value for different sets of hours.

The EU Directive [4] foresees the right of the customer equipped with a smart meter to conclude a dynamic price retail contract which reflects electricity price variations in the spot markets. This provision sets accordingly an obligation for large scale suppliers (at least 200,000 consumers served) to include such an offer in their portfolio.

Explicit DR stands for the change of electric demand remunerated as such; this DR is also named incentive driven. The remuneration can derive from an accepted offer to sell demand modulation (reductions or increases) in an organized market, directly or through aggregation. Explicit DR participation is organized in the spot markets, and, in some case, it is enforced through forward procurement of capacity. Table 1 summarizes the main features of explicit DR with regards to marketplaces involved, remuneration, obligations and benefits delivered to the system.

Implicit and explicit DR, which are not mutually exclusive [9], contribute to reducing system costs, increasing safety and reliability, and increasing the integration of renewable energy resources. Table 2 proposes a taxonomy of the DR mechanism based on the two relevant features of type and timeframe.

To complete this overview, we distinguish two service families that DR can deliver to the system:

- adequacy: contribution to the system capability to supply current and projected demand for electricity. It can be delivered implicitly (by reducing the consumption) or explicitly (by offering the availability to modify the consumption schedule);
- reserve: availability to modify the consumption schedule. This service can be offered only explicitly and requires the fulfilment of specific requirements set by the grid code for each ancillary service.

Implicit and explicit DR mechanisms are applied in some sectors of the Italian electricity market. In this paper, we focus on the two market mechanisms, both explicit, recently introduced with the aim of integrating DR in the active management of the electrical systems by the TSO: UVAM auctions [12] and UCMC auctions [13]. Interruptible loads are not considered in this paper; they have been in place since many years in Italy to deliver emergency services and are activated by the TSO out of the market results as last resort resources in case of severe grid conditions.

II. UNITÀ VIRTUALI ABILITATE MISTE – UVAM

UVAM is a pilot project launched in 2017 by the Italian Regulator with the aim of investigating technical and economic feasibility of the provision of ancillary services for Terna by units not already enabled [14]. The pilot provides for the

Table 2 – Taxonomy of Demand Response mechanism

Type	Timeframe	
	Spot	Forward
Implicit	Dynamic market-based retail prices	Fixed retail prices ToU tariff and charges
Explicit	Energy and Ancillary services spot market	Forward capacity market

voluntary participation in the MSD, in aggregate form, of small-scale power plants, loads, large production units in the availability of a final consumer not subject to mandatory participation, stationary energy storage systems and electric vehicles.

Through the qualification of UVAM by an aggregator, which plays the role of a Balancing Service Provider (BSP), a market participant with reserve-providing units or reserve-providing groups able to provide balancing services to TSO [11], a virtual unit is defined as consisting of one or more Points of Delivery (PODs) enclosed within an aggregation perimeter defined by the TSO; Italy has been divided by Terna in eighteen aggregation perimeters composed of sets of provinces [15], as the result of a simplified approach regarding congestions [16].

A UVAM is characterized by a capacity of at least 1 MW and can participate in the provision of the following ancillary services in the MSD, in upward and/or downward mode: congestion management, tertiary spinning reserve, tertiary replacement reserve, balancing, automatic frequency restoration reserve. To be qualified for the provision of the services, a UVAM must be able to provide at least a single service with the possibility of asymmetric mode, which is the ability of providing only an increase (or a decrease) of its power injection (or withdrawal).

A UVAM does not participate in the energy markets, nor in the settlement of imbalances, but only in the MSD. The schedule of the injections and withdrawals of the units included in the UVAM remains the responsibility of the Balance Responsible Party (BRP) responsible for these PODs, which negotiates the relative quantities on the energy markets and regulates the imbalances with Terna. Appropriate mechanisms (see below) are put in place to coordinate MSD participation by the BSP and energy settlement by the BRP.

UVAM project is an explicit DR mechanism. Participation is possible either through an offer of services in the MSD, paid for the activated energy, or with a forward contract, paid for the capacity, through auctions conducted by the TSO to secure upward services at a price below a strike level fixed by the Regulator. According to the taxonomy of Table 2, UVAM project is an explicit spot and forward DR mechanism.

In the following, the way UVAMs participate in the spot market is first illustrated, with reference to the offer and remuneration of the service. The forward mechanism of UVAM capacity is then described. The section ends with a description of the overall profit function of the users participating in the forward product.

A. Participation in the ancillary services market (MSD)

The quantity accepted in the MSD in the i-th quarter-hour, $Q_{MSD}(i)$, is the result of the negotiations in the MSD:

$$Q_{MSD}(i) = \sum q_{MSD}^{sell}(i) - \sum q_{MSD}^{buy}(i)\,, \qquad (1)$$

where the summation extends to all the MSD market sessions for the i-th period and all the different offers by the BSP.

To participate in the MSD, the BSP must communicate to Terna the daily withdrawal or injection quarter-hour schedule of the PODs in the UVAM (baseline), net of withdrawals of the loads providing the instantaneous interruptibility services (if any). The choice to set the baseline declaration as a BSP's responsibility (and not BRP's) reflects the need to allow participation of third parties in the ancillary services offer (the BSP) while limiting the changes to the current scheduling regulation (that is a responsibility of the BRP). In detail, the BRP current scheduling area includes all the consumption units belonging to a bidding zone, whilst the UVAM includes typically one or few units, possibly aggregating units of different BRPs. The choice to entrust to BSP the baseline definition allows to avoid the introduction of further and deep change in the regulatory framework as the reshaping of the scheduling perimeters (i.e., setting the UVAM as the scheduling unit) with impact on current BRPs scheduling units. These changes are expected to be introduced at the end of the pilot project [16]. A similar rationale determines the simplified separation of roles between participation in energy markets and imbalance settlement (BRP's responsibility) and participation in MSD and accepted quantity settlement (BSP's role).

The communicated baseline can be corrected by Terna to get the corrected baseline, $E_o(i)$:

$$E_O(i) = \frac{Baseline(i)\cdot 1h}{4} + \Delta Baseline(i), \qquad (2)$$

where $\Delta Baseline(i)$ represents the corrective term (in MWh), calculated as follows:
if $Q_{MSD} > 0$:

$$\Delta Baseline(i) = \max\left\{0; \sum_{j=1}^{n} \frac{Ene_{mis}(j) - \frac{Baseline(j)}{4}}{n}\right\}, \qquad (3)$$

if $Q_{MSD} < 0$:

$$\Delta Baseline(i) = \min\left\{0; \sum_{j=1}^{n} \frac{Ene_{mis}(j) - \frac{Baseline(j)}{4}}{n}\right\}; \qquad (4)$$

in (3)-(4) n is the number of quarter-hours before the i-th one, and the correction is kept constant for the whole period following the i-th quarter-hour in which the ancillary service is provided.

The term $\left[Ene_{mis}(j) - \frac{Baseline(j)}{4}\right]$ represents the difference between the energy withdrawn / injected by the PODs within the UVAM and the energy scheduled for withdrawal / injection by the BSP, as communicated to Terna [12]. The parameter "n" represents the number of quarter-hours preceding the one with respect to which the baseline correction has been made; "n" is always not greater than eight [12].

The quantity Q_{MSD} is remunerated on a pay-as-bid basis, like all the quantities accepted in the MSD.

The assessment of the quantities supplied is carried out by comparing, in the i-th quarter-hour, the $Q_{MSD}(i)$ and the difference between the energy exchanged by the UVAM, $Ene_{mis}(i)$, and $E_o(i)$.

Although there is no explicit penalty in this mechanism for a baseline programming error, the penalty is implicitly introduced in the calculation of the executed quantities, since the baseline programming error affects the quantification of the volumes realized.

Explicit penalties are applied in case of underperformance (i.e., energy supplied less than the accepted quantity), while no penalties are applied in the case of overperformance.

Hereafter we illustrate the rationale of the settlement of non-correctly supplied quantities with regards to the case of upward accepted offer (i.e., reduction of the withdrawal or increase of the injection).

Underperformance – The quantities not correctly supplied, $Sbil_{UVAM}$, are valued through fees for non-compliance. For significant imbalances (higher than 5% of Q_{MSD}), penalties are applied. In addition to not receiving any remuneration the BSP pays the extra system cost on the quantities not executed, quantified in the difference between the MSD maximum accepted price and the price for which the quantities have been accepted on the MSD (p_{MSD}), according to a dual price logic. For minor imbalances (less than or equal to 5% of Q_{MSD}) a refund fee is in place, for which the BSP fully returns the accepted MSD price, resulting in no remuneration or penalty for non-compliance with the order.

Overperformance – In the case of overperformance, no penalties are applied, but the overperformance quantity (more energy injected) is accounted for the quantification of the BRP imbalance and is remunerated to the BRP at an imbalance price based on single price rationale [6].

The separation of roles between BSP, responsible for participation in MSD, and BRP, responsible for scheduling and imbalance settlements, which are possibly separate entities, has required the definition of appropriate coordination mechanisms; they aim at avoiding that the action on the MSD of the units included in a UVAM, modifying their operation compared to the schedule, generates unexpected imbalances and improper allocation of costs and rewards between the parties involved. Therefore, the Italian regulation provides for an imbalance adjustment process and a financial compensation between the BSP responsible for UVAM and BRPs affected by UVAM activation in MSD.

Imbalance adjustment consists in adapting the position of the BRPs to which the UVAM PODs belong in a way to prevent involuntary imbalances to BRPs. The program correction is set equal to the minimum between the accepted quantity and the delivered quantity and is added to the schedule of the units participating in the UVAM. In case of perfect execution of the quantity accepted in MSD, the schedule correction coincides with the Q_{MSD}.

Financial compensation is aimed at correctly settle the energy between BSP and BRP. In case of positive quantity accepted in MSD, the BSP restores through Terna the previously purchased energy to the BRP, with a payment of the same energy (formally resold) at the day ahead market (Mercato del Giorno Prima - MGP) hourly price, assumed as a standard representative value of the energy. In case of $Q_{MSD} < 0$, the BRP refund to the BSP the incremental value of energy delivered to the consumption units.

In both cases the BRP is not affected by the exchanges of energy in the MSD. However, there is an impact on the net income of the BSP, which makes a revenue on the Q_{MSD} at the pay-as-bid value, while pays a rebate for the BRP equal to Q_{MSD} multiplied by the MGP system wide consumption energy price (Prezzo Unico Nazionale – PUN), or the MGP zonal price.

This term constitutes the variable revenue of UVAM, R_{UVAM}, which is the following (for consumption units):
in upward services:

$$R_{UVAM_{MSD\uparrow}} = \Sigma\,(Q_i * (pMSD_i - PUN_i) - SbilUVAM_i) \quad (5)$$

in downward services:

$$R_{UVAM_{MSD\downarrow}} = \Sigma\,(Q_i * (PUN_i - pMSD_i) - SbilUVAM_i) \quad (6)$$

B. *Forward Product*

The UVAM pilot project provides for the possibility of forward contracts. The purpose of this product for the TSO is to acquire the upward reserve availability, i.e., the guarantee to get an offer from the UVAM in the MSD in specific time periods. The BSP is awarded a prize for the availability of modulation, divided into the products shown in Table 3.

With the award of the fixed premium, Pr_f, the UVAM undertakes to offer upward energy in the MSD at a price below the strike price. If the BSP does not present compliant offers for at least two consecutive hours of the product availability range, or the offers presented were not executable as assessed in the ex-post verification of the actual reserve margins, penalties Pen_f, can be imposed that imply the reduction or even the withdrawal of the premium.

Considering the contract obligations described above, UVAM project is clearly aimed at delivering reserve services, not adequacy services (for the definitions see Section I).

To summarize, the remuneration of a UVAM participating in the forward product market, R_f, consists of two distinct revenue factors: the remuneration of the capacity and the possible remuneration of the energy activated on the MSD (capped at a strike price):

Table 3 – Features of upward forward products

Product	Availability (Mon - Fri)	Offer commitment [h]	Strike price [€/MWh]	Reservation premium [k€/MW/year]
Afternoon	3 pm – 5:59 pm	3	200	22.5
Evening 1	6 pm – 9:59 pm	4	400	30.0
Evening 2	6 pm – 9:59 pm	4	200	30.0

$$R_f = Pr_f - Pen_f + R_{UVAM_{MSD\uparrow}} \,. \quad (7)$$

C. *Some results and considerations*

Results

The Figure 1 reports the number of qualified UVAMs as per August 2021 [19]. The 272 total UVAMs are mainly made of just one POD and almost 80% is made of no more than two PODs; out of 272 UVAMs, 173 benefit from forward contracts.

In the period September 2020 – July 2021 Terna sent 598 upward dispatching orders for over 6.85 GWh (involving 184 UVAMs and 27 BSPs). 249 of these were issued just for test, while the remaining 349 had the following performances [19]:

- 66% perfectly executed;
- 16% partial execution of at least 70%;
- 28% execution below 70%.

In the same period, the total energy activated by Terna for the MSD has been 15.2 TWh (elaboration from [20]).

Considerations

The strike price fixed limit (Table 3), if not appropriately set against the MGP results (PUN or zonal price), may determine a low or even negative revenue for the upward service [see (5)]. Consequently, in time of high energy prices the variable reward term $R_{UVAM_{MSD\uparrow}}$ in equation (5) could be too low or even negative, inappropriately forcing the dispatching of UVAM resources (accepted at prices below their short run marginal costs). This criticality of fixed strike price could significantly discourage participation in the forward UVAM mechanism in case of high energy prices.

Indeed, for consumption units a correct economic assessment of this form of participation in the MSD should also consider the marginal cost or revenue of delivering the service.

For upward services, it is related to the cost of renouncing or postponing the scheduled consumption. For downward services (consumption increase or anticipation via MSD buy offer), the marginal revenues is the increase in the net value of energy consumption for the customer (value minus costs), calculated by comparing the final usage resulting from accepted bid execution and the optimal operation scheduled before dispatching order. In fact, the participation in the MSD by a consumption unit with upward offers requires a change in its organization to respond to the requests; it represents a cost (*Call Cost*). The existence of the Call Cost exacerbates the criticality

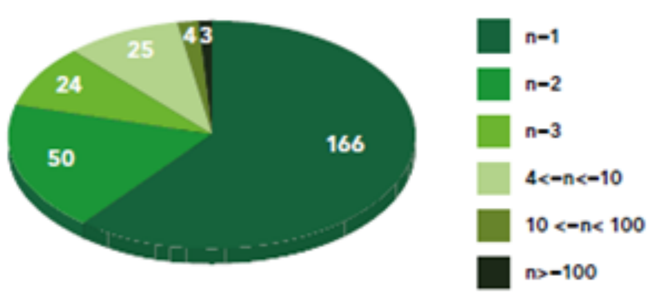

Figure 1. Number of UVAMs qualified for the number of underlying PODs in August 2021 [19].

of the fixed ex-ante strike price setting, since $R_{UVAM_{MSD\uparrow}}$ should allow for recovery of this short-term cost.

For downward services, the energy purchased by the UVAM upon the provision of the service has a value (*Energy Value*) which depends on its energy processes.

The overall profit for the participation in the UVAM mechanism, π, should then be expressed as:

upward services:

$$\pi_{UVAM\uparrow} = R_f - Call\ Cost \,; \quad (8)$$

downward services:

$$\pi_{UVAM\downarrow} = R_{UVAM_{MSD\downarrow}} + Energy\ Value \,. \quad (9)$$

III. UNITÀ DI CONSUMO PER IL MERCATO DELLA CAPACITÀ – UCMC

With the introduction of the Capacity Market (CM) discipline in the Italian regulation [5], all consumption users must pay a fee to contribute to the market net cost incurred by the TSO.

The tariff is a ToU one: 70% of the mechanism cost is recovered in 500 peak hours (hours with expected major adequacy constraints set ex-ante by the TSO), the rest in the remaining hours. As of 2022, the peak tariff is 39.7 €/MWh whilst the off-peak is around 1.3 €/MWh (average value based on the tariff set in the first two quarters of 2022).

In the CM, final customers can reduce the fee either by reducing withdrawals during peak hours (implicit DR) or by offering their availability to reduce consumption in the CM by establishing a UCMC (explicit DR).

The UCMCs are defined within the Italian CM Regulation [5] as aggregates of withdrawal consumption only points; customers with behind the meter generation cannot participate in the UCMC mechanism. This requirement introduces a serious limit to the participation of DR in the CM since many flexible customers, ideal candidates to this mechanism, manage some generation facilities.

A UCMC is characterized by an aggregate load modulation capacity (*Pmax*), the maximum acceptable load modulation in the MSD. The maximum capacity that can be offered in the market, or Derated Capacity (CDP) of a UCMC, is calculated by Terna based on average historical withdrawals registered in peak hours and cannot exceed the maximum load modulation capacity in MSD. According to the taxonomy of Table 2, it is a forward explicit DR mechanism.

The CM is based on a reliability option model: the capacity provider receives an availability remuneration in exchange of the obligation to contribute to system adequacy. DR participation in this mechanism, which is mutually exclusive with the UVAM one, requires to qualify for MSD to offer an upward service, with:

- obligation to offer the capacity awarded in the MSD (see subsection B) in pre-defined six hours a day for each week (see Figure 2); the offered price is left with the UCMC, not bounded to any strike price;

- obligation to be available for remote disconnection, with a quarter-hour advance notice [13].

The revenue from the participation in the CM by a UCMC consists of three factors:

- remuneration of availability through a discount of the CM fee (Fee Exemption, *FE*);
- remuneration of energy activated upward in the MSD ($R_{UCMC_{MSD\uparrow}}$);
- remuneration for possible remote disconnection orders (UCMC Interruption, I_{UCMC}):

$$R_{UCMC_{\uparrow}} = FE + R_{UCMC_{MSD\uparrow}} + I_{UCMC} \; . \tag{10}$$

The rationale behind the availability remuneration scheme is to distinguish the customers actively engaged in the CM from the ones not participating in the market. The UCMC are committed to provide adequacy themselves by the obligation to offer their availability to reduce consumption and in turn are entitled for an exemption by CM fees (see detail in subsection A). The other customers are supplied with adequacy by the TSO through the CM and as such they are obliged to contribute based on their consumption (their only way to avoid the CM fee is reducing the actual consumption).

In the following, details are given for the two parts of the remuneration: availability and participation in the MSD.

A. Availability remuneration – Forward product

As said, the acceptance of an offer in the CM results in a discount on the tariff (*FE*) component that covers the costs of the CM. This exemption consists in the right to be exempted from the payment of the hourly CM tariffs on the amount of the actual withdrawal that customer is available to reduce by complying to the obligation of the CM contract. *FE* is consequently the difference between the theoretical tariff applied based on the withdrawal and the tariff applied to UCMC only to energy withdrawals exceeding its availability to reduce them. The user has thus an incentive to offer in MSD its availability to reduce the withdrawal, enabling the provision of adequacy service from these units.

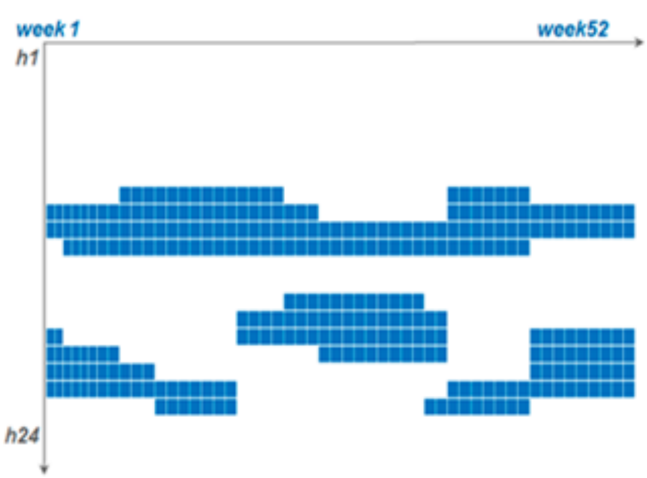

Figure 2. Weekly peak hours in 2022 [18].

In case the obligation to offer in the MSD is not temporarily fulfilled, the discount is reduced. In case of a prolonged non-fulfillment, the participation of the UCMC can be cancelled; this is also the case of non-fulfillment of the remote disconnection order.

B. Participation in the MSD

A UCMC contracted in the CM has the obligation to offer in the MSD a quantity equal to the minimum between the baseline and the CDP (the capacity qualified and awarded in the CM). Indeed, it would make no sense to offer a quantity higher than the baseline, since the service is already satisfied if the UCMC withdraws less than the CDP. This highlights that the participation of the UCMCs in the CM is designed to provide adequacy to the system and not – as for the UVAMs – a (upward) reserve service. Reliability contracts do not require to offer in MSD as the only way to deliver adequacy: the contract can be fulfilled also by self-reducing consumption scheduled in the market. The rationale behind this flexibility approach derives from the adequacy concept itself.

For the UCMC, a baseline is defined to compute the quantity than can be offered in the MSD. While for the UVAMs there is an implicit penalty on the remuneration of the Q_{MSD} related to the error on the baseline, an explicit penalty is provided for the UCMCs depending on the magnitude of the deviation and its duration.

For the UCMC, the balancing orders are considered as fully respected if the measured energy is greater than the minimum between zero and the algebraic sum of the Q_{MSD} and the E_O (1). This mechanism penalizes the underperformance, but not the overperformance; in fact, if the UCMC further reduces its withdrawals, the dispatching order is deemed as executed.

Finally, considering that UCMCs participate only in MSD (they do not participate in energy markets, nor in imbalance settlement), an imbalance adjustment mechanism and a financial compensation are foreseen with the same criteria described for the UVAMs.

Based on above-described mechanism, $R_{UCMC_{MSD\uparrow}}$ has the same structure analyzed for $R_{UVAM_{MSD\uparrow}}$:

$$R_{UCMC_{MSD\uparrow}} = R_{UVAM_{MSD\uparrow}} \; ; \tag{11}$$

the penalties due to non-compliance with the baseline and the fees for non-compliance with the balancing orders provided for this mechanism must be subtracted from this revenue.

In case the remote disconnection is activated, UCMC is rewarded (see I_{UCMC}) at a price equal to 3.0 k€/MWh, which is the conventional imbalance price determined according to the Italian regulation in case of inadequacy event [17]. This mechanism is specific to UCMCs and is not included in the UVAM mechanism.

C. Some results and considerations

<u>Results</u>

In the main auctions of December 2019 for the CM for delivery years 2022-2023, 75.5 GW were awarded to generation units, and no MW to UCMCs [21][22]; the main auction of February 2022 for the delivery year 2024 awarded 41.5 GW [23] to generation units, and no MW to UCMCs.

Considerations

The main reasons that have caused the non-participation of UCMCs in these auctions are the following:

- exclusion of PODs mixed with behind-the-meter generation;
- obligation for remote disconnection;
- rigidity in updating the portfolio (repeated qualification tests for the new UCMC configuration, definition of the PODs before the auctions).

As seen before, the UCMC mechanism penalizes the underperformance, but not the overperformance. In case of overperformance, the UCMCs may realize an implicit DR due to the reduction of the tariff component related to the power capacity, in addition to the explicit mechanism.

Just like for the UVAMs, also for the UCMCs the total profit should consider the *Call Cost*, i.e. how much the reduction in withdrawals impacts on the customer's core business; not considering any penalty, the gain should be:

$$\pi_{UCMC\uparrow} = R_{UCMC\uparrow} - Call\ Cost\ . \quad (12)$$

IV. CONCLUSIONS

The UVAM and UCMC mechanisms represent alternative ways of implementing the DR in the Italian regulation relevant to the TSO. UVAM allows aggregation among heterogeneous resources (load, generation, storage, mixed), whereas UCMC allows participation of consumption only units.

Both UVAM and UCMC can be made up of aggregates of points not related to the same BRP; the aggregation is carried out by a BSP (for UCMCs the BSP can coincide with the BRP).

UVAMs are still in an experimental phase and should reach full implementation in the next years; UCMCs have been recently regulated and have not yet provided any result.

Both UVAMs and UCMCs can be seen as forward provision of explicit DR resources; although both mechanisms envisage aggregate participation in the MSD, UVAMs are a way to get reserve services, while UCMCs help in obtaining adequacy. This conceptual difference is reflected in the delivery structure of the two mechanisms.

The user's revenue has a similar structure as it consists of a fixed part, which depends on the results of the auction for availability, and a variable part which depends on the actual dispatching calls. The consideration of the *Call Cost* and of the *Energy Value*, i.e., the quantification of the cost of not using energy or paying less for it, would contribute to the assessment of the net gains.

In both UVAMs and UCMCs, the user is required to define a baseline; if it is incorrect, it entails an explicit penalty for UCMCs, while for UVAMs it entails an implicit penalty at the verification of the service realized. Both mechanisms provide for similar asymmetric penalties (only in case of underperformance) if the quantities requested are not correctly realized.

In the current Italian electricity market, the two mechanisms are configured as possible tools to encourage explicit DR. UVAM pilot projects should end with the enlargement of the number of units enabled in the MSD, with a complete implementation of the reform of the Italian regulation [18]. The UCMC mechanism, on the other hand, is conceived as stable, governed by the CM rules; however, since no UCMC capacity has still been awarded in the CM, it can be expected that the mechanism will undergo revisions to allow effective participation of consumers to the CM.

REFERENCES

[1] ENTSO-E, ENTSO-E Position Paper - Assessment of Future Flexibility Needs, October 2021, https://eepublicdownloads.azureedge.net/clean-documents/Publications/Position%20papers%20and%20reports/2021/ENTSO-E%20Position%20Paper%20on%20the%20assessement%20of%20future%20flexibility%20needs%20211019.pdf, available online, accessed 6 July 2022

[2] Rossi S., Benini M., Gallanti M., Partecipazione al mercato dei servizi di dispacciamento: attuali requisiti e possibili evoluzioni, L'energia elettrica, Luglio-Agosto 2016, ISSN 0013-7308

[3] Losi, P. Mancarella, and A. Vicino, editors, Integration of Demand Response into the Electricity Chain – Challenges, Opportunities and Smart Grid Solutions. Wiley-ISTE, 2015, ISBN 9781848218543

[4] European parliament and Council of the European Union, Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU, Official Journal of the European Union, June 2019

[5] Terna, Disciplina del Sistema di remunerazione della disponibilità di capacità produttiva di energia elettrica, Ottobre 2021, available online: https://download.terna.it/terna/Disciplina_Prima_Attuazione_8d9c9f720b99730.pdf, accessed 6 July 2022

[6] ARERA, Documento di Consultazione 300/2017/R/eel - Prima apertura del mercato per il servizio di dispacciamento (MSD) alla domanda elettrica e alle unità di produzione anche da fonti rinnovabili non già abilitate nonché ai sistemi di accumulo. Istituzione di progetti pilota in vista della costituzione del testo integrato dispacciamento elettrico (TIDE) coerente con il balancing code europeo, Maggio 2017, available online: https://www.arera.it/it/docs/17/300-17.htm, accessed 6 July 2022

[7] ARERA, Risoluzione 352/2021 - Progetti pilota per l'approvvigionamento di servizi ancillari locali, Agosto 2021, available online: https://www.arera.it/it/docs/21/352-21.htm, accessed 6 July 2022

[8] ACER, Framework Guidelines on Electricity Balancing (2012), Ljubljana, September 2012, available online https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Framework_Guidelines/Framework%20Guidelines/Framework%20Guidelines%20on%20Electricity%20Balancing.pdf, accessed 6 July 2022

[9] Smart Energy Demand Coalition, Mapping Demand Response in Europe Today – 2015, 2015, available online: http://www.smarten.eu/wp-content/uploads/2015/09/Mapping-

Demand-Response-in-Europe-Today-2015.pdf, accessed 6 July 2022

[10] ACER, Methodology for the European resource adequacy assessment, October 2020, available online: https://ec.europa.eu/energy/sites/default/files/methodology_for_the_european_resource_adequacy_assessment.pdf, accessed 6 July 2022

[11] European Commission, Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing, November 2017, available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2017.312.01.0006.01.ENG&toc=OJ:L:2017:312:TOC#d1e325-6-1, accessed 6 July 2022

[12] Terna, Regolamento recante le modalità per la creazione, qualificazione e gestione di unità virtuali abilitate miste (UVAM) al mercato dei servizi di dispacciamento, Giugno 2021, available online: https://download.terna.it/terna/Regolamento%20MSD%20UVAM%20del.215-21_8d9276de4d1cbd3.pdf, accessed 6 July 2022

[13] Terna, Regolamento recante le modalità di abilitazione al mercato per il servizio di dispacciamento delle unità di consumo per il mercato della capacità, Settembre 2021, available online: https://download.terna.it/terna/Regolamento_UCMC_8d9ae8a6e5ed977.pdf, accessed 6 July 2022

[14] F. Gulotta, A. Rossi, F. Bovera, D. Falabretti, A. Galliani, M. Merlo, G. Rancilio, Opening of the Italian Ancillary Service Market to Distributed Energy Resources: Preliminary Results of UVAM project, 2020 IEEE 17th International Conference on Smart Communities: Improving Quality of Life Using ICT, IoT and AI (HONET), ISBN 978-0-7381-0527-7

[15] Terna, Allegati Regolamento UVAM del. 215-21 – Allegato 6 "Perimetri di aggregazione di cui all'articolo 3.1 lettera b) del regolamento MSD UVAM", Giugno 2021, available online: https://www.terna.it/it/sistema-elettrico/progetti-pilota-delibera-arera-300-2017-reel/progetto-pilota-uvam, accessed 6 July 2022

[16] ARERA, Documento di consultazione 322/2019/R/eel - Testo Integrato del Dispaccia-mento elettrico (TIDE) - Orientamenti complessivi, Luglio 2019, available online: https://www.arera.it/allegati/docs/19/322-19.pdf, accessed 6 July 2022

[17] ARERA, Risoluzione 111/2006 - Condizioni per l'erogazione del pubblico servizio di dispacciamento dell'energia elettrica sul territorio nazionale e per l'approvvigionamento delle relative risorse su base di merito economico, ai sensi degli articoli 3 e 5 del decreto legislativo 16 marzo 1999, n. 79, Giugno 2022, available online: https://www.arera.it/allegati/docs/06/111-06allnew.pdf, accessed 6 July 2022

[18] Terna, Mercato della capacità – Allegato alle disposizioni tecniche di funzionamento, available online https://download.terna.it/terna/CM_DTF2_allegato2022_8d73227d2ed7fdd.pdf, accessed 6 July 2022

[19] Politecnico di Milano, Electricity Market Report 2021, Novembre 2021, available online https://www.enostra.it/wp-content/uploads/2021/12/EMR21.pdf, accessed 6 July 2022

[20] GME, Market Results, available online https://www.mercatoelettrico.org/it/, accessed 6 July 2022

[21] Terna, Mercato della capacità rendiconto degli esiti – asta madre 2022, Dicembre 2019, available online https://download.terna.it/terna/2019_12_06_Rendiconto%20EsitiAsta%202022_PUBBLICATO_8d7c06cc9f8470b.pdf, accessed 6 July 2022

[22] Terna, Mercato della capacità rendiconto degli esiti – asta madre 2023, Dicembre 2019, available online https://download.terna.it/terna/Rendiconto%20EsitiAsta%202023_8d78adbacbbe508.pdf, accessed 6 July 2022

[23] Terna, Mercato della capacità rendiconto degli esiti – asta madre 2024, Febbraio 2021, available online https://download.terna.it/terna/Mercato_Capacit%C3%A0_Rendiconto_esiti_Asta_madre_2024_8da140f8874afcd.pdf, accessed 6 July 2022