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Research Article

Analysis of the Power Cloud Framework Benefits and the Role of the City Energy Provider in the New Italian Electricity Tariff Scenario

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The need to consume less and better energy pushes more and more to find efficient solutions at the individual end-user and community levels. The concept of an energy community is becoming increasingly popular, and recently, many studies try to demonstrate how an aggregation of end-users, which produces energy according to a distributed generation concept, is a mechanism able to overcome the increasingly tight constraints imposed by the electricity market, both for the end-user and for the network and market operators. In this context, the paper is aimed at verifying the convenience for both end-user and aggregator sides to operate in an aggregate form considering the new tariff scenario imposed in some European countries like Italy.

1. Introduction

It is well known that new technologies have obvious benefits on electricity consumption and savings achieved by the end-users. In particular, it has been analysed in [1] how the end-users with enabling technologies such as a nanogrid for home application (nGfHA) have the possibility to interconnect domestic loads, renewable energy source (RES) plant, and storage systems obtaining a double benefit. On the one hand, the savings achievable in the annual electricity bill result from decreased consumption; on the other hand, the social advantage results from participation in a possible energy community managed by an entity who covers the role of an aggregator defined as a *community energy provider* (CEP) [2].

The recent reforms undertaken by the Italian Authority (AEEGSI), such as the reform of the electrical dispatching (RDE) which started with the deliberation 393/2012/R/eel, put as its central topic the full integration of renewable sources in the energy service market, the changes to the electrical dispatching [3], the regulation of energy imbalances [4], and the new tariff (DT) for end-users, as reported in [5, 6]. It has undoubtedly influenced the electricity market, the operators, and the actual technologies and also the introduction of new operators as the *aggregators*.

This redefinition of the electricity market has influenced both the possible activities performed by these new operators and the economic convenience for the end-users to install technologies able to reduce the energy consumption. For this reason, in the paper, an aggregation representing an energy community managed by a CEP, defined by the authors as Power Cloud [1], is considered. Several studies have been performed which led to the definition of an optimization model to evaluate the economic convenience of the Power Cloud framework in the view of new regulation changes' introduced in the electricity market. In particular, it has tried to define (if possible) the aggregation size so that there is a convenience for the CEP and for each single end-user who decides to aggregate, comparing the Italian tariff scenario of 2016 with the one of 2017.

The paper is structured as follows.

In the first part, the optimization model proposed for the valuation of the Power Cloud optimal size is illustrated. The second part shows the most significant case studies demonstrating that an economic convenience of adopting the Power Cloud model is still possible even in the new tariff scenario that would not seem to incentivise the self-consumption and so the PV plant installation.

2. The CEP Optimization Model

Different types of users such as the consumer, prosumers, and producers can coexist in an aggregation. In the paper, the aim is to incentivise the increase of renewable energy sources (RES) and enable technologies to improve a better power management of energy resources. It is assumed that all end-users, participating in the Power Cloud, will be equipped with RES plants and enable technology configuring all the aggregated end-users as prosumers [7]. The community energy provider (CEP) manages the aggregation. In addition, it will refer to the Italian electricity market context.

The goal of the CEP optimization model is to evaluate the optimal Power Cloud size that maximizes the economic benefit of all involved actors, CEP and the end-user considered as a customer (a residential domestic user with an installed power equal to 3 kW). In detail, the CEP will achieve an economic profit ($\mathrm{CEP_{Profit}}$) as the maximum difference between its revenues and operating costs. At the same time, the end-user achieves the maximum profit ($\mathrm{User_{Profit}}$) as the maximum difference between the amount previously paid for the annual electricity bill (before joining the Power Cloud) and the amount that it will pay in case it is joined in the Power Cloud. The CEP optimization model is so formulated as follows:

$$\mathrm{Max}(\text{Aggregation Economic Benefit}), \tag{1}$$

where $\text{Aggregation Economic Benefit} = \mathrm{CEP_{Profit}} + \mathrm{User_{Profit}}$ is the Power Cloud benefit for both, CEP and the end-users; $\mathrm{CEP_{Profit}} = \mathrm{Revenues_{CEP}} - \mathrm{Costs_{CEP}}$ is the CEP profit, and $\mathrm{User_{Profit}} = \text{Annual electricity bill (not aggregated end-user)} - \text{Annual electricity bill}_{\mathrm{CEP}}\text{(Aggregated end-user)}$ is the benefit achieved by the end-user.

In the following, each single quantity will be defined and analysed.

2.1. CEP Profit. Let us start with the analysis of the CEP profit. It is defined as the difference between the management costs ($\mathrm{Costs_{CEP}}$) and revenues ($\mathrm{Revenues_{CEP}}$).

$\mathrm{Costs_{CEP}}$ represents all costs incurred by the CEP for the Power Cloud operating management. These costs are due to the Energy Market Operator (in Italy, GME (Within the Italian electricity market, the GME (Gestore dei Mercati Energetici) is the Energy Market Operator who organizes and manages the wholesale electricity market since the liberalization of the energy sector. On the electricity market managed by GME (also known as Italian Power Exchange (IPEX)), producers and buyers sell and buy electricity wholesale.)) for using the energy exchange platform (PCE) (Exchange energy platform in the Italian electricity market refers to the PCE (Piattaforma Conti Energia) managed by the Energy Market Operator (GME). PCE is used for recording transactions concluded "over the counter." On this platform, parties that have concluded contracts outside IPEX record their commercial obligations and the related electricity input and withdrawal energy programs which they undertake to carry out in compliance with these contracts.), the costs and guarantees owed to the national Transmission System Operator (TSO; in Italy, *Terna* (Terna S.p.A. represents the Transmission System Operator, and it is the owner of the Italian National Transmission Grid. It operates under a natural monopoly regime (so it is the only operator in Italy for the management of the transmission grid) and carries out a public service mission for the transmission and dispatching of electricity across the country. 90% of its activity takes place in the regulated market. The role is essential for the functioning of the entire system and to ensure electricity for citizens and businesses.)), costs for guarantees due to the Distributor System Operator (DSO) and excise duties on electricity due to the Customs Agency Authority [8], and finally operating expenses related to the management service performed by the CEP.

$\mathrm{Costs_{CEP}}$ is so defined as

$$\mathrm{Costs_{CEP}} = C_{\mathrm{PowExcOp}} + C_{\mathrm{TSO}} + C_{\mathrm{DSO}} + C_{\mathrm{Taxes}} + C_{\mathrm{ServCEP}}, \tag{2}$$

where C_{PowExcOp} represents the cost to register energy injection and draw of schedule on PCE. C_{PowExcOp} is so defined as

$$C_{\mathrm{PowExcOp}} = C_{\mathrm{Plat}} + \mathrm{Fee_{Plat}} + \mathrm{CCT}, \tag{3}$$

where C_{Plat} is a fixed cost charged "una tantum"; $\mathrm{Fee_{Plat}}$ are the variable fees, which need to be paid according to the electricity schedule registered on PCE; and CCT represents the difference between the single national price defined as PUN, which is a reference for the energy purchase in the Italian electricity market and zonal price (P_z) that is a reference of sale price for the energy sold in the area where a production plant is located. In particular, it has been assumed that

(i) $C_{\mathrm{Plat}} = 1000.00€^{*}$

(ii) $\mathrm{Fee_{Plat}} = 0.008^{**}\mathrm{ExEn_{Inj}} + 0.008 * \mathrm{ExEn_{Drw}}$

(iii) $\mathrm{CCT} = (\mathrm{PUN} - P_z) * \mathrm{ExEn_{Inj}}$

*The access fee in PCE (*una tantum*) is equal to 1000.00€.
**Fee per MWh exchanged and registered amounts to 0.008 €/MWh—http://www.mercatoelettrico.org/It/Mercati/PCE/CorrispettiviPCE.aspx.

where

$$\mathrm{ExEn_{Inj}} \tag{4}$$

is the quantity of the energy produced and injected which is registered and exchanged in the electricity market, while

$$\mathrm{ExEn_{Drw}} \tag{5}$$

is the quantity of energy absorbed that is registered and exchanged in the electricity market.

$+C_{TSO}$ represents the costs due to the TSO that includes both the part concerning the energy injection into the grid ($C_{TSO-Inj}$) and the energy drawn from the grid ($C_{TSO-Drw}$), it is so defined as

$$C_{TSO} = C_{TSO-Inj} + C_{TSO-Drw}. \quad (6)$$

$C_{TSO-Inj}$ is composed of the guarantee that needs to be provided towards the TSO for the generation plants in the aggregation and added in the dispatching contract related to the energy injection (C_{WarInj}) (The guarantee to be provided to Terna is a function of the installed power of the production plant added in the dispatching contract for energy injection—Annex A.61: Regulation of the system of guarantees in art. 49 Annex A to resolution 111/06 AEEG-SI—https://www.terna.it/it-it/sistemaelettrico/codicedirete.aspx.), the monthly costs incurred for the actual energy imbalances ($C_{InjEffInba}$) (Analysis performed on some plants assumed that the actual imbalance, i.e., the programming error generated for a photovoltaic plant with a nominal power of 1 MWp, is approximately 1200.00€/year which matches with the total contribution of management to be paid to the GSE in the case of the RID service—http://www.espwr.it/download/espwr_281_SbilanciamentoFV.pdf. This value compared to the equivalent hours of production considered (1400 h/year) has the same cost of 0.85 c€/MWh.), and an adjustment component (defined as *perequativa*) based on the energy imbalance rules adopted ($C_{PerComInj}$) (From analysis performed on some PV plants in the South Italy area, cost due to the adjustment component has been identified that on average in the year 2016 has been equal to 0.215€/MWh registered.). $C_{TSO-Inj}$ is so defined as

$$C_{TSO-Inj} = C_{WarInj} + C_{InjEffInba} + C_{PerComInj}, \quad (7)$$

where

(i) $C_{WarInj} = f(\text{Installed Power})$

(ii) $C_{InjEffInba} = 0.85€/\text{MWh}$

(iii) $C_{PerComInj} = 0.215€/\text{MWh}$

$C_{TSO-Drw}$ is composed of the guarantee (C_{WarDrw}) (The guarantee to be provided to Terna according to the average annual power of the dispatching contract for energy absorbed from the grid—Annex A.61: Regulation of the system of guarantees in art. 49 Annex A to resolution 111/06 AEEG—https://www.terna.it/it-it/sistemaelettrico/codicedirete.aspx. From analysis performed on users, managed for the energy absorption in a dispatching contract, a guarantee requested by Terna of €46.6 per customer with an annual average power of 3.34 kW has been identified, which corresponds to the PMA of household users.) to be provided to the TSO based on the number of point of delivery (POD) managed and on the annual average power absorbed from the grid; the monthly costs incurred for real imbalances on the energy drawn from the grid ($C_{DrwEffInba}$) (From analysis performed on some customers managed by a Supplier in the South Italy area has been identified a cost due to the actual energy imbalance equal to 0.005€/kWh); and nonarbitrage fees (C_{DrwArb}) (From analysis performed on some customers managed by a Supplier in the South Italy area has been identified a cost for non-arbitrage equal to 0.005€/MWh and so 0.0005€/kWh.) which represent a similar cost to the CCT expected in the dispatching contract of energy injection. $C_{TSO-Drw}$ is so defined as

$$C_{TSO-Drw} = C_{WarDrw} + C_{DrwEffInba}, \quad (8)$$

where

(i) $C_{WarDrw} = f(\text{Annual Average Power})$

(ii) $C_{DrwEffInba} = 0.005€/\text{kWh}$

(iii) $C_{DrwArb} = 0.0005€/\text{kWh}$

To complete the charges due to the national TSO, there are other fees in the case of the drawn energy from the grid. Such costs, however, are defined passer-by charges (Fee to cover the costs for the remuneration of the load interruption service (Art. 24.6 Del 107/09 (TIS)), fee to cover the costs for the remuneration of available production capacity (art. 24.5 Del 107/09 (TIS)), fee to cover the costs for Terna's operation (Art. 24.3 Del 107/09 (TIS)), fee to cover the modulation of wind production costs (Art. 24.7 Del 107/09 (TIS)), fee to cover costs of essential units for the system safety (Art. 24.2 Del 107/09 (TIS)), and fee for the resource supply in the MSD (art. of the 24.1 107/09 (TIS)).) and are not included in the CEP profit since they are at the same time a cost and a revenue for the CEP. These charges are costs incurred by the CEP but fully charged to end-users in the electricity bill.

$+C_{DSO}$ represents the guarantee to be provided to the DSO which is equal to three months of the yearly charges ($C_{GridServ}$ discussed in the following) incurred by the end-user and calculated as

$$C_{DSO} = \frac{\text{Annual energy transport charges}}{4}. \quad (9)$$

$+C_{Taxes}$ is the guarantee to be provided to the Customs Agency Authority (in Italy, *Agenzia delle Dogane*), and it is equal to three months of the yearly excises incurred by the end-user and calculated as

$$C_{Taxes} = \frac{\text{Annual Excise duty}}{4}. \quad (10)$$

$+C_{ServCEP}$ are the costs incurred by the CEP corresponding to the sum of depreciation of used facilities (C_{Dpr}), general expenses (C_{GenExp}), Customer Relation Management system (CRM) necessary for the billing process towards the end-users ($C_{BillSist}$), and personnel costs (C_{Empl}) for the staff that manages the end-users and registers the schedule

transactions on PCE. C_{ServCEP} is so defined as

$$C_{\mathrm{ServCEP}} = C_{\mathrm{Dpr}} + C_{\mathrm{GenExp}} + C_{\mathrm{BillSist}} + C_{\mathrm{Empl}}. \quad (11)$$

In the following, the operating revenues of the CEP ($\mathrm{Revenues}_{\mathrm{CEP}}$) are valuated. These revenues can be assessed examining the component related to the marketing and sales operations (PCV). It represents the remuneration to cover all the incurred fixed costs necessary for the commercial management of end-users. Moreover, there is a quota that contributes to the CEP revenues due to the energy supplied to the end-users, evaluated at the price $\mathrm{PE}_{\mathrm{CEP}}$. $\mathrm{Revenues}_{\mathrm{CEP}}$ is so defined as

$$\mathrm{Revenues}_{\mathrm{CEP}} = \mathrm{n.users} * \left(\mathrm{PCV} + \left(\mathrm{PE}_{\mathrm{CEP}} * \overline{\mathrm{WDR}}_{\mathrm{SingUserProsumer}}\right)\right) - \mathrm{CE}_{\mathrm{Market}} * \mathrm{AnExEn}_{\mathrm{Market}}, \quad (12)$$

where

$$\overline{\mathrm{WDR}}_{\mathrm{SingUserProsumer}} \quad (13)$$

represents the average annual energy drawn by the end-user from the grid and is considered as energy net of self-consumption (SelfCons);

$$\mathrm{AnExEn}_{\mathrm{Market}} \quad (14)$$

is the amount of energy that the CEP purchases on the market to satisfy the demand related to the end-user consumption which is not satisfied with the energy produced inside the Power Cloud, and $\mathrm{CE}_{\mathrm{Market}}$ is the related cost on the market.

2.2. End-User Profit. Focusing on the end-user side, it is possible to say that the main profit is given by the difference between the amount paid for the annual electricity bill in the case he is *not aggregated* (so, as a single end-user which is in the regulated services defined in the Italian Market "*Maggior Tutela*" and thus not equipped with the enabling technology) and the annual electricity bill that the end-user equipped with the enabling technology would pay if he is aggregated. For this purpose, in the following, the cost of the annual electricity bill for a not aggregated end-user will be analysed and evaluated, considering him as a simple consumer and the case of the end-user aggregated and operating as a prosumer.

2.2.1. Not Aggregated End-User. Taking into account the case of a residential domestic user with a 3 kWp installed power, the cost of the electricity bill consists of four main components [9]: *energy supply*, *energy transport and meter management* (*grid services*), *system charges*, and *taxes* (*excises* and *vat*) [10]. It is remarkable to consider that the year 2016 represented a transition period in Italy by a tariff structure, which persisted from 1970 to a greater flexible tariff structure starting from 2017. This new tariff scenario, with a continuous change until 2025, will encourage the energy consumption from the grid and will eliminate the differences between residential and nonresidential end-users in order to define a single and unique tariff, called *Domestic Tariff* (DT). The occurred changes [5] regard the displacement/changes of fixed components and/or changes of variable quota and some threshold values. Obviously, these components between the previous and new tariff scenario have different values, but the CEP optimization model previously illustrated is still valid. For these reasons, it is possible to evaluate the end-user electricity bill cost as

$$B_{\mathrm{DoUser}} = C_{\mathrm{EnMat}} + C_{\mathrm{GridServ}} + C_{\mathrm{SysCh}} + C_{\mathrm{UsTax}}. \quad (15)$$

$+C_{\mathrm{EnMat}}$ represents the cost of the energy supply that includes the *variable costs* (CV_{EnMat}) of the energy, the *fixed quota* ($\mathrm{FixComp}_{\mathrm{EnMat}}$) and a *power quota* ($\mathrm{PwrComp}_{\mathrm{EnMat}}$), all as defined by the Italian tariff scenario [11]. It includes the amounts related to the various activities carried out by the seller to supply the energy to the end-users.

The total price applied in the bill for CV_{EnMat} is given by the sum of the prices for the following components: energy price (PE), dispatching (PD), adjustment (PPE), and dispatching component (DispBT). The tariff scenario defines the value of all those components. The price of $\mathrm{FixComp}_{\mathrm{EnMat}}$ is given by the price for marketing and sales operations named PCV and by the fixed quota of the dispatching component (DispBT). $\mathrm{PwrComp}_{\mathrm{EnMat}}$ related to the energy supply is currently equal to 0, thus $\mathrm{C}_{\mathrm{EnMat}}$ is defined as

$$C_{\mathrm{EnMat}} = \left(CV_{\mathrm{EnMat}} * \overline{\mathrm{WDR}}_{\mathrm{SingUser}}\right) + \mathrm{FixComp}_{\mathrm{EnMat}} + \left(\mathrm{PwrComp}_{\mathrm{EnMat}} * \mathrm{InstPower}\right), \quad (16)$$

where

$$\overline{\mathrm{WDR}}_{\mathrm{SingUser}} \quad (17)$$

represents the average annual energy absorbed by the end-user (*the same quantity considered in the following for the prosumer net of self-consumption*) and

$$\mathrm{InstPower} \quad (18)$$

represents the installed power (equal to 3 kW).

$+C_{\mathrm{GridServ}}$ is the cost for the energy transport and the meter management. It is also named *grid services* [12] which include the transmission, distribution, and metering components, respectively, $\tau 1$, $\tau 2$, and $\tau 3$, the components necessary to cover the imbalances of the equalization systems' costs for the energy transport (UC3) and cover a part of the costs incurred by the system to encourage and subsidize the companies that manage the transport and distribution networks for actions that lead an improvement of the service quality (UC6). The total price applied in the bill for the variable quota C_{GridServ} is given by the sum of the prices of the three components $\tau 3$, UC3, and UC6 (variable quota). The price of the fixed component $\mathrm{FixComp}_{\mathrm{GridServ}}$ is exactly the value of component $\tau 1$.

The power component $\mathrm{PwrComp}_{\mathrm{GridServ}}$ is given by the sum between the power quota of $\tau 2$ and the power quota of UC6; thus, C_{GridServ} is defined as

$$C_{\mathrm{GridServ}} = \left(CV_{\mathrm{GridServ}} * \overline{\mathrm{WDR}}_{\mathrm{SingUser}}\right) + \mathrm{FixComp}_{\mathrm{GridServ}} + \left(\mathrm{PwrComp}_{\mathrm{GridServ}} * \mathrm{InstPower}\right). \tag{19}$$

$+C_{\mathrm{SysCh}}$ represents the cost for the end-user due to the general system charges which include amounts billed to cover the costs related to activities of general interest for the whole electricity system [13], paid by all end-users which use the electricity service. The total price includes the components A2 (*nuclear charges*), A3 (*incentives for renewable sources*), A4 (*subsidies for the railway sector*), A5 (*system research*), Ae (*advantages for energy-intensive industries*), As (*costs for the electricity bonus*), UC4 (*smaller electricity companies*), UC7 (*promotion of energy efficiency*), and MCT (*entity that host nuclear plants*). The total price CV_{SysCh} charged into the bill is given by the sum of the variable part of all listed components.

Currently, for the analysed end-user (residential domestic user with an installed power equal to 3 kW), both fixed quota $\mathrm{FixComp}_{\mathrm{SysCh}}$ and variable component $\mathrm{PwrComp}_{\mathrm{SysCh}}$ are equal to 0. C_{SysCh} is so defined as

$$C_{\mathrm{SysCh}} = \left(CV_{\mathrm{SysCh}} * \overline{\mathrm{WDR}}_{\mathrm{SingUser}}\right) + \mathrm{FixComp}_{\mathrm{SysCh}} + \left(\mathrm{PwrComp}_{\mathrm{SysCh}} * \mathrm{InstPower}\right). \tag{20}$$

$+C_{\mathrm{UsTax}}$ represents the excise duties paid by the end-user in the electricity bill that maintains a banded structure and where the reform started in 2017 was not affected because the definition of the excise duties does not concern the Authority AEEGSI [14], and it is calculated according to the relation below:

$$C_{\mathrm{UsTax}} = \left(\overline{\mathrm{WDR}}_{\mathrm{SingUser}} - 4440\right) * 0.0227 + 1800 * 0.0454 + 840 * 0.0227, \tag{21}$$

considering the following thresholds:

(1) 0-1800 kWh/year = 0***

(2) 1800-2640 kWh/year, excises equal to 2.27c€/kWh

(3) 2640-4440 kWh/year, excises equal to 4.54c€/kWh

(4) >4440 kWh/year, excises equal to 2.27c€/kWh

***In case of energy supply with installed power over 1.5 kW and up to 3 kW: if the consumption is up to 220 kWh/month, the excises are not applied to the first 150 kWh; otherwise, the kWh exempted from excise is gradually reduced.

2.2.2. Aggregated End-User. Considering now the same type of end-user (a residential domestic user with an installed power 3 kW) but equipped with a RES plant and enabling technologies, he will be subjected in the electricity bill to the same cost components [9]. However, in this case, the energy cost component related to the energy ($\mathrm{PE}_{\mathrm{CEP}}$) is due to a customized price fixed by the CEP and therefore different from the price PE (PE corresponds to the expected cost for the purchase of energy, which is sold to end customers, and it includes network losses, i.e., the cost of energy that does not reach in a useful way the delivery point.) defined by the Authority, as previously shown. The electricity bill cost, in this case, is so defined as

$$B_{\mathrm{DoUserCEP}} = C_{\mathrm{EnMatCEP}} + C_{\mathrm{GridServ}} + C_{\mathrm{SysCh}} + C_{\mathrm{UsTax}} + \mathrm{TechPaym} - \left(\mathrm{PremPrice}_{\mathrm{CEP}} * \overline{\mathrm{INJ}}_{\mathrm{SingUserProsumer}}\right). \tag{22}$$

$+C_{\mathrm{EnMatCEP}}$ represents the cost of the energy supply in the aggregation which includes the *variable costs* of the energy (CV_{EnMatCEP}), the *fixed quota* ($\mathrm{FixComp}_{\mathrm{EnMat}}$) and a *power quota* ($\mathrm{PwrComp}_{\mathrm{EnMat}}$), as defined and illustrated in Section 2.2.1. Contrary to the not aggregated end-user case, in this one, the variable energy component has a different value because of the energy price customization ($\mathrm{PE}_{\mathrm{CEP}}$) defined by the CEP and the amount of energy absorbed by the end-user and considering that the self-consumption quota is different. Then, C_{EnMatCEP} is defined as

$$C_{\mathrm{EnMatCEP}} = \left(CV_{\mathrm{EnMatCEP}} * \overline{\mathrm{WDR}}_{\mathrm{SingUserProsumer}}\right) + \mathrm{FixComp}_{\mathrm{EnMat}} + \mathrm{PwrComp}_{\mathrm{EnMat}} * \mathrm{InstPower}. \tag{23}$$

All other components, burdens owed to the grid operators, remain equal as previously shown in Section 2.2.1. The energy consumption from the grid by the single end-user, in this case,

$$\overline{\mathrm{WDR}}_{\mathrm{SingUserProsumer}} \tag{24}$$

is referred to as a prosumer, and therefore, it represents the average annual energy drawn from the grid by the end-user considering the self-consumption quota. The other cost components that define $B_{\mathrm{DoUserCEP}}$ have the same structure of the case in Section 2.2.1 (*see cost items which compose the user's electricity bill in the case in* Section 2.2.1) but consider now $\overline{\mathrm{WDR}}_{\mathrm{SingUserProsumer}}$:

$$\begin{aligned} C_{\mathrm{GridServ}} &= \left(CV_{\mathrm{GridServ}} * \overline{\mathrm{WDR}}_{\mathrm{SingUserProsumer}}\right) + \mathrm{FixComp}_{\mathrm{GridServ}} + \left(\mathrm{PwrComp}_{\mathrm{GridServ}} * \mathrm{InstPower}\right), \\ C_{\mathrm{SysCh}} &= \left(CV_{\mathrm{SysCh}} * \overline{\mathrm{WDR}}_{\mathrm{SingUserProsumer}}\right) + \mathrm{FixComp}_{\mathrm{SysCh}} + \left(\mathrm{PwrComp}_{\mathrm{SysCh}} * \mathrm{InstPower}\right), \\ C_{\mathrm{UsTax}} &= \left(\overline{\mathrm{WDR}}_{\mathrm{SingUserProsumer}} - 4440\right) * 0.0227 + 1\,800 * 0.0454 + 840 * 0.0227. \end{aligned} \tag{25}$$

+TechPaym represents the instalment cost incurred by the end-user in order to install the RES plant and the enabling technologies (nGfHA *including storage system*) to make him a prosumer. The instalment cost is supposed to be calculated using an amortization plan with a flat rate for t time with an interest rate i:

$$\overline{\mathrm{INJ}}_{\mathrm{SingUserProsumer}} \tag{26}$$

represents the average annual energy injected into the grid by the end-user net of the self-consumption and the energy needs to charge the storage system. It will be sold to other end-users of the Power Cloud. Such energy will be remunerated to the end-user according to a tariff $\mathrm{PremPrice}_{\mathrm{CEP}}$ defined by the CEP according his economic convenience limits.

2.3. Energy Balance Constraints. It is possible to define, in the purpose of the CEP, an equation on the annual energy balance. The fundamental constraint has to be considered for the operating of an energy aggregation and so of the Power Cloud. The annual energy balance is

$$\left(\mathrm{AnExEn}_{\mathrm{Drw}} - \mathrm{AnExEn}_{\mathrm{Inj}}\right) - \mathrm{AnExEn}_{\mathrm{Market}} = 0, \tag{27}$$

where

$$\mathrm{AnExEn}_{\mathrm{Inj}} \tag{28}$$

is the average annual energy injected into the grid by all end-user net of the self-consumption, which is the number of end-users multiplied by the average annual energy $\overline{\mathrm{INJ}}_{\mathrm{SingUser}}$ previously defined:

$$\mathrm{AnExEn}_{\mathrm{Inj}} = \mathrm{n.users} * \overline{\mathrm{INJ}}_{\mathrm{SingUser}}, \tag{29}$$

where

$$\mathrm{AnExEn}_{\mathrm{Drw}} \tag{30}$$

is the average annual energy absorbed by all end-users, which is the number of end-users (n.users) multiplied by the average annual energy absorbed from the grid $\overline{\mathrm{WDR}}_{\mathrm{SingUser}}$ for the single end-user (in the case where the end-user is a prosumer, the energy absorbed $\overline{\mathrm{WDR}}_{\mathrm{SingUserProsumer}}$ is considered as energy net of the self-consumption):

$$\mathrm{AnExEn}_{\mathrm{Drw}} = \left(\mathrm{n.users} * \overline{\mathrm{WDR}}_{\mathrm{SingUser}} \text{ or } \mathrm{n.users} * \overline{\mathrm{WDR}}_{\mathrm{SingUserProsumer}}\right). \tag{31}$$

$\mathrm{AnExEn}_{\mathrm{Market}}$ is previously defined in Section 2.1.

2.4. Discount Thresholds on Absorbed Energy. The enhancement of the energy component ($\mathrm{PE}_{\mathrm{CEP}}$) with respect to the case of not aggregated end-user can be defined by the CEP according to some economic convenience limits, which correspond to a percentage of discount applied to the energy price defined by the regulated service *Maggior Tutela* (PE) (For the analysis, the PE is considered flat. PE flat is an option of the regulated service Maggior Tutela where the price is always the same at any time.). In detail, the CEP may establish discount thresholds based on the number of end-users of Power Cloud, so

$$\mathrm{PE}_{\mathrm{CEP}} = \mathrm{PE} - x\%, \tag{32}$$

where x depends on n.users.

2.5. Premium Price Thresholds for Produced Energy. The energy produced and injected into the grid because it is not consumed by the end-user can be virtually utilized by the CEP in order to satisfy the energy needs of other end-users. It must be underlined that at this scope, the use of the enabling technology such as the nGfHA is fundamental because by using such system, the CEP, at the aggregation level, can demonstrate that "the energy absorbed from an end-user is exactly the surplus production injected into the grid by another end-user which has sold this energy to the CEP."

The enhancement of this energy injected into the grid for an end-user is a way of participating to the local market as if it was a small producer who sells energy on the market at a price defined with the CEP. Such modality is similar to what is done by the bigger producers that sell energy through "over-the-counter" contracts (bilateral contracts) agreed with the energy wholesalers or the RID (in Italy, *Ritiro dedicato*) of the GSE [15]. An additional example for small users can be the energy exchange named in Italy *Scambio Sul Posto* (SSP), which provides the enhancement of the energy injected into the grid. Being the RID, the enhancement of the energy at the average hourly zonal price (P_z) (The zonal price (P_z) is defined as a reference of the valuation price of the sales offers accepted on the day-ahead market in the relevant period, in the area where the production unit is located.), the *premium price*, is defined as the additional percentage on the RID:

$$\mathrm{PremPrice}_{\mathrm{CEP}} = \mathrm{RID} + y\%, \tag{33}$$

where y is defined by the CEP according to the economic convenience of the aggregation and based on n.users.

2.6. End-User Billing System. The billing system to end-users is the core of the end-user management service for the CEP. The unit management cost per end-user of a CRM system that is able to provide data aggregation, data transmission, and billing for energy consumption has been examined for the analysis. Such a system involves start-up costs related to the installation which includes a small number of end-users that can be managed. After that, for a group of 500 PODs (*point of delivery*), the cost is €6 per user/year. Based on these considerations, it has been possible to define cost thresholds for groups of end-users as shown in the following:

$$C_{\mathrm{BillSist}} = C_{\mathrm{BillUser}} * \mathrm{n.users}, \tag{34}$$

where

$$C_{\mathrm{BillUser}} \tag{35}$$

depends on n.users according to the following scheme:

$$\begin{cases} 1-3000, & \text{end-users} \rightarrow 12.5€/\text{year}, \\ 3001-4000, & \text{end-users} \rightarrow 11€/\text{year}, \\ 4001-5000, & \text{end-users} \rightarrow 10€/\text{year}, \\ 5001-6000, & \text{end-users} \rightarrow 9€/\text{year}, \\ >6000, & \text{end-users} \rightarrow 8€/\text{year}, \end{cases} \tag{36}$$

3. Simulations and Case Study

Once the CEP optimization model was defined, the numerical results will be reported considering the most significant cases of study after making specific hypothesis on both the end-user side (i.e., consumption, RES plant size) and CEP side.

3.1. Hypothesis on the End-User Side

(i) The single end-user, so the prosumer, has an annual total consumption of 5620 kWh

(ii) The PV plant has a peak power equal to 3 kWp

(iii) The estimated annual production of the PV plant supposing to be located in South Italy is set equal to 1430 kWh/kWp

(iv) The PV plant production per year is approximately 4288 kWh/year

(v) Each nGfHA is equipped with a storage system having a capacity equal to 3 kWh

(vi) For each end-user, *demand response* (DR) software in coordination with the storage management system is installed. It allows to achieve a higher level of self-consumption (referring to the produced energy) equal to approximately 70% and so 3037 kWh/year

(vii) The additional annual energy required by the end-user according to the management model of the Power Cloud will be satisfied through the energy surplus produced by other end-users or the energy that the CEP buys from the electricity market

3.2. Hypothesis on the CEP Side

(i) The kWp cost of the PV plants is considered equal to 1200.00€/kWp. Consequently, the overall PV plant cost is equal to €3600.00

(ii) The cost of nGfHA equipped with storage system is considered equal to €3500.00. So, the overall cost for the end-user enabling technology is equal to €7100.00

(iii) The useful life of technological equipment is assumed to be 25 years

(iv) The guarantee to be provided to Terna is a function of installed PV power added in the dispatching contract. From empirical analysis and data processing, for the year 2016, a guarantee amount of €4803.00 per MWp has been considered

(v) For 2017, it has resulted that because of new Terna's *Annex A.61* for a new end-user that applies to a new dispatching contract, the calculus of the first guarantee on a 1 MWp PV plant is approximately about €138000.00. It can be reduced by a correction factor (CF) equal to 20 times lower, only if it results in a balanced energy program after six months with minimum energy imbalance. For the analysis, being this value so excessive, it has been considered the already reduced value and equal to 6932.00€/MWp. It corresponds to an increase of about 44% compared to 2016 scenario for which the value is considered 4803.00€/MWp

3.3. Simulations. The main changes between 2016 tariff scenario and the amendments starting from 2017 mainly consist of three items as shown in Table 1:

(i) The estimated change in the CCT value, based on the price changes (*average PUN and average*P_z)

(ii) The effect of the new imbalance regulation scenario, due to the application of the new dual mechanism on the small production plants [4] which will result in a higher cost ($C_{\mathrm{InjEffInba}}$)

(iii) The amendment of Terna's Annex A.61 related to the 111/06 deliberation on dispatching which results in a higher guarantee amount (C_{WarInj})

In the following, the numerical results of the main case studies are shown in order to evaluate the aggregation size in terms of n.users that guarantees the balance between costs and revenues for the CEP and maximizes the end-user profit.

3.4. Case Study. First of all, in this case study, any discount percentage or incentive to production is considered to understand how, in the two tariff scenarios (2016 *vs.* 2017), the above-mentioned changes have impacted in the two different years from the CEP point of view. Moreover, the purpose is to find the minimum number of end-users so that there is a balance between costs and revenues for the CEP.

It is worth to underline that, between the prices and profit margins, it is possible to see a greater value of PCV component and a higher profit margin due to the difference between the PUN and PE of 2017 scenario compared to those of 2016 (*this difference represents the profit margin between purchasing electricity in the day-ahead market, MGP in Italy, and the sale to the end-user*). In Table 2, some of the price data used in the analysis are reported.

Table 1: Main changes 2016 vs. 2017.

Hypothesis	2016	2017	Considerations
CCT* (€/MWh)	5	6	Increase of +1€ for the difference PUN and P_z SUD.
$C_{\mathrm{InjEffInba}}$ (€/MWh)	0.85	2.55	The new energy imbalance rules ("dual price") that affect the cost in +300%.
C_{WarInj} (€/MWp)	4 803	6 932	Increase the first guarantee for the dispatching contract of 44%.

∗ refers to an estimate based on the analysis performed.

Table 2: Market prices 2016 vs. 2017.

Hypothesis	2016	2017	Considerations
Average PUN (€/MWh)	42.74	47.44	It has been considered the average PUN of the last four quarters of 2016
Average P_z SUD (€/MWh)	40.34	44.17	It has been considered the average PUN of the last 4 quarters, thus three quarters of 2016 and the first quarter of 2017 to assess the price changes
PE (€/MWh)	47.08	53.16	Value related to the PE component established by the Authority for the quarter under analysis (IV 2016 vs. I 2017)
RID (€/MWh)	39.00	39.00	It has been considered the minimum remuneration of the GSE for the production plants ("*Ritiro dedicato*," (RID))
PCV (€/year)	28.38	34.04	Value related to the market and sales component established for the energy suppliers necessary to cover its costs. The PCV is yearly paid by the user

Table 3: Numerical results for 2016 tariff scenario.

Break-even point		n.users	% SelfCons	% energy discount	% premium price
$\mathrm{Costs}_{\mathrm{CEP}}$	-€764027	18069	71% of production (3037 kWh)	0%	0%
$\mathrm{Revenues}_{\mathrm{CEP}}$	€764027				
n.users	$\overline{\mathrm{WDR}}_{\mathrm{SingUser}}$ (kWh)	$\overline{\mathrm{WDR}}_{\mathrm{SingUser}}$ (kWh) Prosumer	SelfCons (kWh)	$\overline{\mathrm{INJ}}_{\mathrm{SingUser}}$ (kWh)	$\mathrm{AnExEn}_{\mathrm{Drw}}$ (kWh)
18069	5620 (100%)	2583 (46%)	3037 (54%)	1061	46643438
$\mathrm{Revenues}_{\mathrm{CEP}}$ (e. supply)	Total energy cost	$\mathrm{Revenues}_{\mathrm{CEP}}$ (e. supply per user)*	$\mathrm{Revenues}_{\mathrm{CEP}}$ (PCV per user)	Total profit (e. supply + PCV)	
€2195973	€1583982	€33.87	€28.38	€1124861	
$\mathrm{AnExEn}_{\mathrm{Inj}}$ (e. sold in the market)				€386697	
$\mathrm{PremPrice}_{\mathrm{CEP}}$ (premium price for producers)				-€747532	
Total				€764027	

*Such revenue depends on the reused energy, provided by the prosumer injection into the grid, used to cover a part of the total energy needed. Otherwise, the energy profit would be lower as shown in Table 4.

In the following, the numerical results for each tariff scenario are illustrated.

3.4.1. Case 1: Analysis with 2016 Tariff Scenario. Despite a series of costs charged on the CEP, which have been lower if compared to 2017 (see Table 1), a lower profit margin between the market prices has been found (PE, Average PUN, and Average P_z, see Table 2). This leads to the results reported in Table 3. The minimum number of end-users that guarantees the financial balance between CEP costs and revenues is 18069 users.

The margins occurring in the energy sales are shown in Table 4.

It is possible to see that the consumption of the 2583 kWh from the grid of the single end-user returns a 4.34€/MWh CEP profit (0.434c€/kWh) for a total amount of about €11.20 per year to which is added a yearly fixed component, received by the energy supplier, the PCV of €28.38 per year. In addition, a minimum margin is obtained on the surplus energy that the end-user yields to the CEP (*that provides to resell to other end-users or in the energy market at the price*P_z); it returns a profit margin of about €41 per user per year.

In Table 5, it is reported how the Power Cloud cost change depend on the number of users and the related balancing point (*break-even point* (BEP)).

Graphic representation of Table 5 is illustrated in Figure 1.

3.4.2. Case 2: Analysis with Tariff Scenario 2017. In the following, a simulation with the same hypothesis of Case 1 is shown, considering the 2017 tariff scenario.

Table 4: Yearly CEP profit for single end-user (2016).

Absorption (kWh)	PE-PUN (€/MWh)	Energy quota (€/year)	PCV (€/year)	Total (€/year)
2583	4.34	11.20	28.38	39.58
e. injection (kWh)	P_z-RID (€/MWh)	Profit for e. injection (€/year)	—	—
1061	1.34	1.43	—	1.43
Profit (€/year per user)				41.00

Table 5: CEP costs and revenues per users—2016.

n.users	1000	5000	10000	15000	20000
Costs	€176202	€320510	€484020	€657530	€831040
Revenues	€42284	€211420	€422840	€634261	€845681

Although CEP costs are greater if comparing the 2017 tariff scenario with that of 2016 (see Table 1), the solution of the CEP optimization model leads to a balance situation in the Power Cloud with a lower number of users of approximately 50% as shown in Table 6. This is due to an increase of the possible profit margins in the market prices applicable on the market due to the increased gap between prices (see Table 7).

In this second case, the consumption of 2583 kWh from the grid of the single end-user determines return of 5.71 €/MWh CEP profit (0.571c€/kWh) for a total amount of about €14.75 per year to which is added a yearly fixed component (net PCV) received by the energy supplier increasing to €34.04 per year (*significant increase with respect to 2016*). In addition, taking into account the profit margin on the excess energy that the end-user yields to the CEP (*which have a greater value with respect to 2016*), it returns a profit margin of about €54 per user per year. This significant increase in the CEP profit margins determines a recovery of the CEP costs with a smaller number of users equal to 7868 (*see* Table 6). On the contrary, it was expected that the tariff scenario 2017 (*which implies an increase in the management costs*) would make an increase of the users' number for the balance condition between CEP costs and revenues. This would be true if the profit margin conditions had remained the same; however, changes in the nature of expenses are necessary to take into account the changes of the possible revenues. In this case, it is shown how the CEP costs change depending on the number of users involved, as reported in Table 8.

Graphic representation of Table 8 is illustrated in Figure 2.

It must be said in fact that for an increase in the costs has been observed a more than proportional increase in profit margins that can be generated from the energy supply (see Tables 4 and 7) and as a consequence a reduction in the user number needed for the economic balance.

In such a situation, the main problem remains the economic advantage of the end-user compared with the standard situation that he would have if he did not participate in an energy community. The situation shown above is certainly useful and makes advantages for the CEP who manages the Power Cloud but shows a drawback from the end-user side.

As it is possible to see below, the break-even situation shown with the current market margins leads to an economic balance for the CEP but not for the end-user that if it is compared to the previous tariff scenario 2016, he pays for the electricity an annual amount slightly higher due to the instalment costs of the enabling technologies (see Table 9).

At this point, it has been decided to evaluate the end-user profit, applying firstly the maximum possible discount on the energy component (PE_{CEP}) by the CEP and secondly applying the maximum premium price on the energy injected into the grid by the end-user. The constraint is placed that the end-users could not exceed the number of end-users expected for 2016 tariff scenario (that is, 18069). Finally, in the same conditions, a third case has been evaluated, applying the maximum discount value and premium price simultaneously so that the end-user would get the maximum savings.

Observing the results in Table 10, it is relevant that, in any case, the annual electricity bill paid by the end-user is less convenient comparing with the case of the absorption from the grid (end-user not aggregated, see Table 9). Therefore, a better solution is needed to improve the situation and get a real convenience for the end-user.

4. Observations

The numerical results demonstrate that by *also trying to facilitate the end-user in a better way according to the CEP economic constraints*, *the end-user with high electricity consumption has a reduced convenience to participate in the Power Cloud with the tariff scenario of 2017*. Such a situation is due to the decrease in average cost per kWh when the electricity consumption increases. This situation is well clear in Figures 3 and 4 considering the annual electricity bill for an end-user not aggregated in terms of his annual electricity consumption.

In the 2016 tariff scenario, for greater electricity consumption, the introduction of a RES plant is more convenient because it cuts the highest cost due to the cost progressivity in dependence of consumption. With the 2017 tariff scenario, the higher consumption is not so penalized (*being the new tariff a nonprogressive tariff*) having an average kWh cost lower than that of 2016 [5]. For a better understanding, it is possible to see Table 11 where the annual electricity bill (*with a flat* PE) of an end-user is calculated comparing the 2016 tariff scenario with that of 2017 and considering several annual electricity consumption cases.

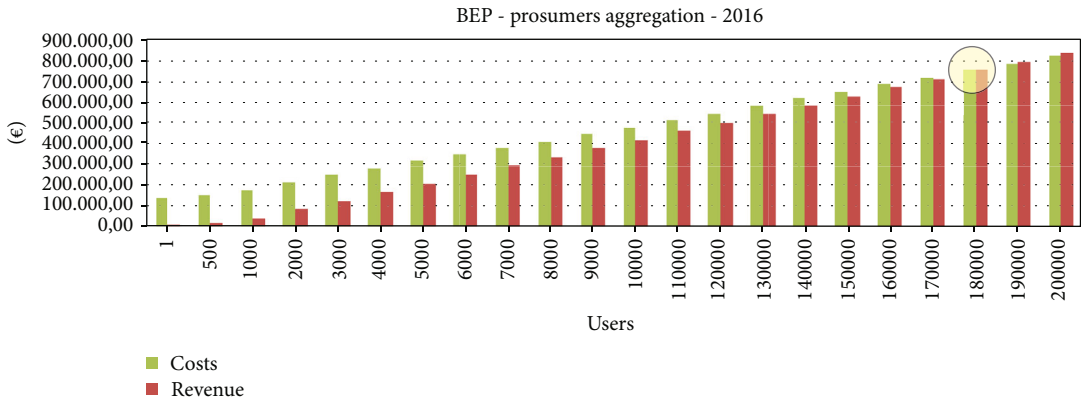

Figure 1: CEP costs, revenues, and break-even point 2016.

Table 6: Cost, revenues, and users' distribution—2017 (a).

Break-even point		n.users	% SelfCons	% energy discount	% premium price
$Costs_{CEP}$	-€440760	7868	71% of production	0%	0%
$Revenues_{CEP}$	€440760				
n.users	$\overline{WDR}_{SingUser}$ (kWh)	$\overline{WDR}_{SingUser\ Prosumer}$ (kWh)	SelfCons (kWh)	$\overline{INJ}_{SingUser}$ (kWh)	$AnExEn_{Drw}$ (kWh)
7868	5620 (100%)	2583 (46%)	3037 (54%)	1061	20310397
$Revenues_{CEP}$ (e. supply)	Total energy cost	$Revenues_{CEP}$ (e. supply per user)	$Revenues_{CEP}$ (PCV per user)	Total profit (e. supply + PCV)	
€1079700	€765634	€39.92	€34.04	€581909	
$AnExEn_{Inj}$ (e. sold in the market)				€184356	
$PremPrice_{CEP}$ (premium price for producers)				-€325505	
Total				€440760	

Table 7: Yearly CEP profit for single end-user (2017).

Absorption (kWh)	PE-PUN (€/MWh)	Energy quota (€/year)	PCV (€/year)	Total (€/year)
2583	5.71	14.75	34.04	48.79
e. injection (kWh)	P_z-RID (€/MWh)	Profit for e. injection (€/year)	—	—
1061	5.17	5.49	—	5.49
Profit (€/year per user)				54.28

Table 8: CEP costs and revenues per user number—2017.

n.users	1000	5000	10000	15000
Costs	€180107	€340037	€523075	€716113
Revenues	€56020	€280100	€560200	€840300

Considering EU's 2050 goal (to increase the production from renewable sources [16] to 80%-90% and improve the load management [17]), in the analysis, a 100% of self-consumption of the production capacity of RES plant (*thanks to new home automation technologies, storage systems, and demand response software*) (corresponding to a 76% of the total annual electricity consumption) can be assumed for an end-user with enabling technology (*prosumer*) and aggregated. In this case, the end-user will not have an annual electricity bill more expensive than the one that it would pay in the 2017 tariff scenario if it was not equipped with enabling technology (see Table 12) and not aggregated.

In Table 12, the annual electricity bill is reported, comparing the case of the simple consumer, a prosumer with a consumption of 70% with respect to the production capacity of RES plant, and a prosumer with 100%.

From the results of Table 12, it is evident that the main effort of the enabling technologies must be addressed to maximization of the electricity self-consumption percentage.

In the 2017 tariff scenario, only under the hypothesis of a 100% electricity self-consumption, the end-user achieves convenience in the installation of a RES plant and enabling

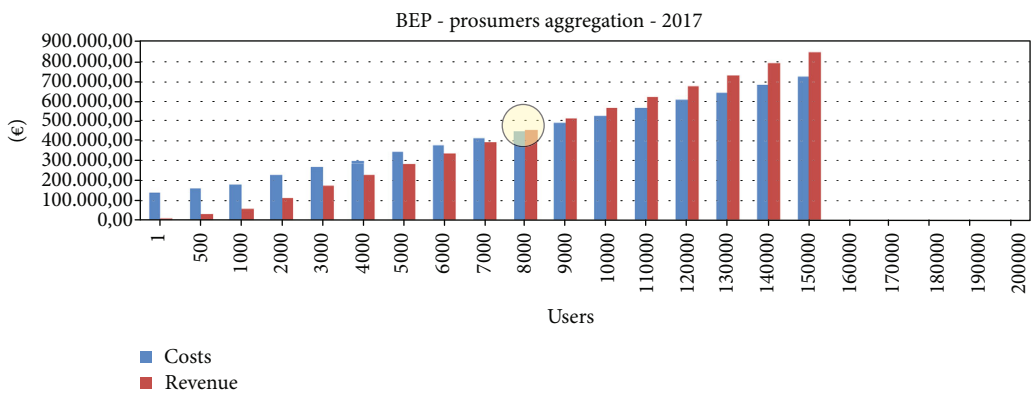

Figure 2: CEP costs and revenues 2017.

Table 9: Yearly electricity bill 2016 vs. 2017 for the end-user not aggregated and aggregated.

Year	$\overline{WDR}_{SingUser}$	Annual e. bill for end-user not aggregated	Annual e. bill for end-user aggregated	Savings	Savings with premium price
2016	5620 kWh	€1381.45	€1255.62	€125.82 (9%)	€167.20 (12%)
2017	5620 kWh	€1073.78	€1268.25	-€194.47 (-18%)	-€153.10 (-14%)

Table 10: Annual electricity bill 2017 with advantages.

	%	Annual e. bill for end-user not aggregated	Annual e. bill (CEP)	Savings with premium price
(1) max discount	7.16		€1216.06	-€142.28 (-13%)
(2) max premium	23.7	€1073.78	€1217.04	-€143.26 (-13%)
(3) max discount & premium	5.5 + 5.5		€1216.29	-€142.51 (-13%)

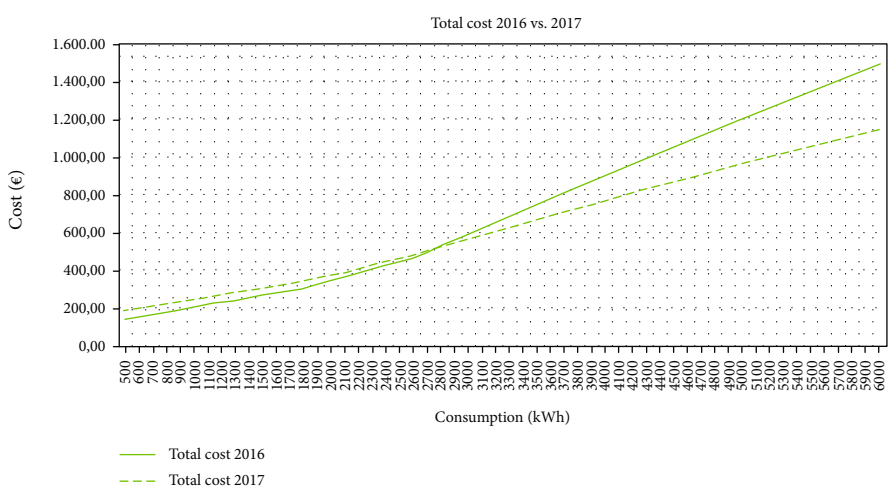

Figure 3: Annual electricity bill cost 2016-2017.

technologies, and at the same time, the CEP reaches an economic balance between costs and revenues. From the CEP view point, this situation implies that there will not be a dispatching management being the energy produced by each end-user entirely self-consumed.

Naturally, under that hypothesis, the number of end-users that guarantees the balance between the CEP costs and revenues changes as reported in Table 13.

It can be observed that the number of end-users is less than the previous case (see Table 6) because the energy to

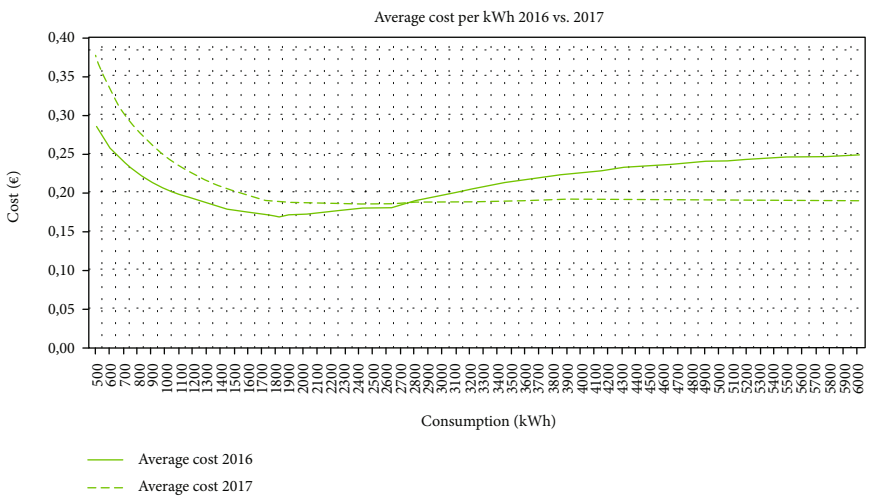

Figure 4: Average cost 2016-2017.

Table 11: Energy bills 2016 vs. 2017 and average costs.

Annual energy consumption (kWh)	2016 annual e. bill (€)	2017 annual e. bill (€)	Delta (€)	2016 average cost	2017 average cost
500	142.66	188.02	-45.35	0.2853	0.3760
900	192.74	234.54	-41.80	0.2142	0.2606
1800	305.40	339.20	-33.80	0.1697	0.1884
2700	498.33	503.14	-4.81	*0.1846*	*0.1863*
3600	779.47	688.05	91.42	0.2165	0.1911
4500	1059.12	871.47	187.65	0.2354	0.1937
5400	1317.78	1033.91	283.87	0.2440	0.1915
5620	1381.45	1073.78	307.67	0.2458	0.1911

be purchased on the market is less due to the higher electricity self-consumption percentage.

Also, for this case, it has been taken into consideration the possibility of applying an additional discount on PE. In Table 14, it is illustrated how the number of end-users changes with increasing of the PE discount quadrupling with a PE discount of 20%.

A significant increase of the number of end-users is necessary to compensate for the discount on PE (*consequent savings in the bill despite the difficulties of the nonprogressive tariff*) and to reach the balance between CEP costs and revenues simultaneously.

5. Conclusions

In the paper, the authors tried to prove that there is still the possibility to create aggregation forms of end-users maintaining a common benefit (CEP *and end-users*) despite the new electricity tariff scenario like the Italian 2017 tariff scenario, which from the analysis reported in [18] does not seem to incentivise the electricity self-consumption. At this scope, a CEP optimization model has been formulated suitable to each type of end-user (*consumer*, *producer*, *and prosumer*).

In the paper, the case of prosumer end-users equipped with enabling technologies has been considered. In this case, it can be observed that

(i) aggregation forms are more advantageous in terms of the number of end-users considering the 2017 tariff scenario with respect to the 2016 one. This is because with the 2017 tariff scenario, despite the increase in the CEP management costs, at the same time, an increase of the profit margin in energy supply has been observed

(ii) the advantage for the aggregated end-user becomes positive only in the case of self-consumption, which is almost equal to the production capacity of RES plant. This can be assumed realistic with the growing of new technologies, efficient storage systems, and smart building systems. As reported in [19], in the short term, the expected and progressive decrease in storage system costs will support the situation that will allow to achieve higher electricity self-consumption percentage and to make more competitive the energy cost of the self-consumption with respect to the cost of energy purchased from the grid [20]

(iii) in such a context, there is a lot of space for other possible configurations of new energy production systems defined in the Italian electricity market, efficient system for users (in Italian, SEU) where the end-user does not pay the RES plant but he pays

Table 12: The annual electricity bill in terms of electricity self-consumption percentage.

	Consumer	Prosumer (70%)	Prosumer (100%)
$\overline{WDR}_{SingUser}$ total per year (kWh)	5620 kWh	5620 kWh	5620 kWh
$\overline{WDR}_{SingUser}$ from grid (kWh)	5620 kWh	2583 kWh	1340 kWh
Annual SelfCons (kWh)	0 kWh	3037 kWh	4280 kWh
Electricity cost (€)	€1073.78	€480.24	€285.77
Technology instalment (€)	0	€788.00	€788.00
Average cost (grid) (€/kWh)	€0.19	€0.19	€0.21
Average cost (self-consumption) (€/kWh)	—	€0.26	€0.185
Annual electricity bill 2017 (€)	€1073.78	€1268.25	€1073.78

Table 13: Cost revenues and users' distribution—2017 (b).

Break-even point		n.users	% SelfCons	% energy discount	% premium price
$Costs_{CEP}$	-€297648	7128	99% of production	0%	0%
$Revenues_{CEP}$	€297648				
n.users	$\overline{WDR}_{SingUser}$ (kWh)	$\overline{WDR}_{SingUser}$ (kWh) Prosumer	SelfCons (kWh)	$\overline{INJ}_{SingUser}$ (kWh)	$AnExEn_{Drw}$ (kWh)
7128	5620 (100%)	1340 (24%)	4280 (76%)	8	9555716
$Revenues_{CEP}$ (e. supply)	Total energy cost	$Revenues_{CEP}$ (e. supply per user)	$Revenues_{CEP}$ (PCV per user)	Total profit (e. supply + PCV)	
€507981	€452030	€7.85	€34.04	€298604	
$AnExEn_{Inj}$ (e. sold in the market)				€1249	
$PremPrice_{CEP}$ (premium price for producers)				-€2205	
Total				€297648	

Table 14: Discount thresholds—2017.

% PE discount	n.users prosumers	Savings	$Costs_{CEP}$	$Revenues_{CEP}$
0%	7128	—	€297648	€297648
5%	8750	€3.92	€334210	€334210
10%	11328	€7.84	€392317	€392317
15%	16061	€11.76	€498971	€498971
20%	27583	€15.68	€758656	€758656
PE = 53.16 (€/MWh)		PUN = 47.44 (€/MWh)	P_z SUD = 44.18 (€/MWh)	

the electricity self-consumption at a price equal or less than the price applied to the energy purchased from the grid. In this case, however, other problems arise, such as the huge initial investments needed to provide the enabling technology to the end-users. It requires a high level of participation by the end-users towards a new energy business model

(iv) last but not the least, a certain stability of the electricity market regulation is required. The 2017 tariff scenario is in an ever-changing situation, as demonstrated by the evolution of the electricity tariff and market regulations that tries to find solutions less expensive to manage the grid despite the significant development of the distributed generation

Data Availability

The energy platform and imbalance costs' data used to support the findings of this study are included within the article as reported in the notes. Others as billing system's costs have been provided from the national service provider based on specific quotation (https://www.terranovasoftware.eu/it/). The national market energy price data used to support the findings of this study were supplied by the national market operator (GME) and freely available at (http://www.mercatoelettrico.org/en/) the section "Result&Statistics." The standard tariff data for the domestic consumer were supplied by the national Authority (AREA) and freely available at (https://www.arera.it/it/prezzi.htm) the section

"Prices&Tariffs." All other data used during the study have been obtained as calculations and analysis.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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