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Regulatory Response to Self-production of Energy: A Risk for the Development of Renewable Sources and Combined Heat and Power

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ABSTRACT

The high price for electrical energy increasingly leads companies to engage in self-production, so as to reduce costs, increase their own energy efficiency, and achieve market competitiveness. In general such self-production solutions have positive environmental impacts, since they involve exploitation of renewable sources and high-yield cogeneration plants, as well as avoiding inefficiencies due to network losses. However, the resulting reduction in the network exchange of electrical energy does not lead to proportional reductions in the network costs, and finding adequate coverage for these remains a necessity. Given this context, the role of the regulator becomes fundamental. The regulator must implement strategies for purposes of meeting national needs in regards to costs, but without excessively penalizing the companies and their international competitiveness, and without holding back development of environmentally favourable and sustainable solutions. The current article analyzes the possible regulatory interventions, their technical and organizational difficulties, and the impacts of these strategies in the national context.

Keywords: Energy Self-production, Renewable Sources, Combined Heat and Power, Network Costs; General System Fees; Regulatory Interventions
JEL Classifications: L5, Q2, Q4

1. INTRODUCTION

One of the global challenges in the current rapidly growing economy is to find solutions that can satisfy energy needs, diversify energy supplies and optimize energy consumption (Parajuli, 2012). Costs concerning energy supply are a key factor in company competitiveness, particularly in sectors that depend on price and efficiency in the use of electrical energy (Moreno et al., 2014).

Differences in energy prices are important in international competition, and are heavily influenced by the energy policies and regulatory structures of the different countries.

In this regard, particularly in countries where the costs of electrical energy are structurally high, companies have increasingly resorted to energy self-production, which as well as gaining notable reductions in costs, has made the companies ever more independent of the national energy system.

From an environmental point of view, this solution has a very positive impact because the most commonly self-production systems used are combined heat and power (CHP) and renewable sources that allow re-use of heat produced, reduce transmission losses and reduces carbon emissions (Altay and Turkoglu, 2015).

On the other hand this type of approach determines a decrease in the quantities of energy exchanged on the electrical network, and consequently a reduction of the billing basis over which to share the costs for the national electrical system.

In this context the role of the regulator becomes fundamental, in establishing effective policies that can support company competitiveness and adoption of environmental aims, by combining environmental and economic interests (Clemens, et al., 2008; De Marchi et al., 2013; Helminen, 2000; Lucas, 2010; Prakash and Kollman, 2004), and which at the same time are able to support the costs of the national electrical system and so the health of the overall economic system (Coccia, 2010; Eichhammer and Mannsbart, 1997; Worrell et al., 2003). Given this, the regulator has two potential options for achieving total coverage of national system costs: i) By increasing taxes, fees and rates; ii) by seeking continued contributions from users who draw on the network on reduced and/or occasional basis, at the same time as self-producing energy in considerable quantities.

The objective of this article is to analyse the potential regulatory interventions, the relative technical and organisational difficulties, and the impacts that the interventions could generate on the overall economic scenario and on the deployment of CHP and renewable sources. The study begins with an analysis of events in the Italian electrical system, where in recent years the regulator introduced a minimal fee for the share of self-produced electrical energy from renewable sources and high-yield CHP generation, which is then no longer exchanged on the network. The regulation covers "Efficient Use Systems" (Sistemi Efficienti di Utenza, SEU), meaning electrical-energy consumption and production plants using renewable sources or CHP, connected to the national network. The plants subject to the regulation are defined in terms of dates of construction and start-up dates, owner-operators conditions, technical features, and property titles. For the plants affected, the regulator imposed a payment set at 5% of the total system fee rates, to be paid on self-produced and consumed electricity. The revenues collected are directed towards general electrical system activities and contribute to coverage of the network costs.

The study focuses on analysis of the current regulatory policies of the Italian national system, and their potential co-interference. The following section lays out the general context of electrical energy prices. Sections 3 and 4 describe general system costs and incentivisation mechanisms for the Italian case, and the particular intervention introducing Efficient Use Systems. In Section 5 we carry out an analysis of the SEU regulatory model, indicating the strong and weak points from the points of view of both the companies and the regulator. The last section provides the conclusions from the work.

2. PRICE OF ELECTRICAL ENERGY

The dynamics and volatility of electrical energy prices depend on characteristics that have been amply studied in the literature (Arciniegas and Rueda, 2008; Bourbonnais and Meritet, 2006; Byström, 2005; Chan et al., 2008; Clewlow and Strickland, 2000; Guthrie and Videbeck, 2007; Hellström et al., 2012; Huisman and Mahieu, 2003; Lucia and Schwartz, 2002; Mohammadi, 2009; Pilipovic, 2007). In addition, trends in electrical energy prices can differ depending on the user, meaning whether the consumer is "domestic" or "industrial" (Doostizadeh and Ghasemi, 2012; Streimikiene et al., 2013). The present work considers the segment of Italian industrial users.

The price of electrical energy consists of three parts: (i) Energy and sale price (raw material cost, marketing and sales), (ii) network service prices (transport, distribution, metering, general system costs), (iii) fees and taxes.

Table 1, presents the 2015 prices of energy to industrial consumers, gross and net of fees (divided by consumption level). We can see that the Italian price is in the higher range of the nations of the European Union. This effect is primarily due to taxes and fees, which are much higher than most other countries. More specifically, according to Eurostat data, the 2015 energy price for Italian industrial consumers was higher than euro-area price for all classes of consumption (Autorità per l'energia elettrica il gas e il sistema idrico [AEEGSI], 2016).

Figure 1 shows the trend in electricity prices for the largest European countries and overall euro area, by class of consumption, for years 2014 and 2015. We can see that with the exception of the lowest consumption class (<20 MWh), the Italian prices experienced a decreasing trend over the period, relative to the trends of euro-area average price and for most of the other countries examined.

In spite of the improvement, Italian prices remained higher than euro-area levels, and in the second-lowest class the prices were the highest of all nations considered.

Figure 2 provides a graphic representation of incidence of the three components of energy price for the 500–2000 MWh/a class - the one best representing the Italian industrial sector (AEEGSI, 2016).

The figure enables analysis of the incidence of the three components (energy and sales; network costs; taxes and fees) at the European level. Concerning amounts of taxes and fees, it can be seen that Italy is second only to Germany. For the energy and sales component, Italian prices are exceeded only by those of the UK and Spain, while for network costs, Italy has among the lowest prices.

In general, we can observe that the composition of European electricity prices varies significantly due to the remarkable variability of each component. In particular, the variability in network component costs derives from the absence of a universal regulatory approach for investments in transmission, access and price (Olmos and Perez-Arriaga, 2009). The result is that the regulated rates for the network components costs vary significantly from country to country. The lack of a uniform regulatory framework in turn derives from the background theory of reference: The large part of the approaches to fee planning reported in the technical literature fail to address the entire range of implementation problems, which a complete method should consider (Bialek, 1996; Bjorndal et al., 2005; Galiana et al., 2003; Green, 1997; Kirschen et al., 1997; Pan et al., 2000; Rubio and Perez-Arriaga, 2000; Stamtsis and Erlich, 2004; Strbac et al.,1998; Zolezzi and Rudnick, 2002).

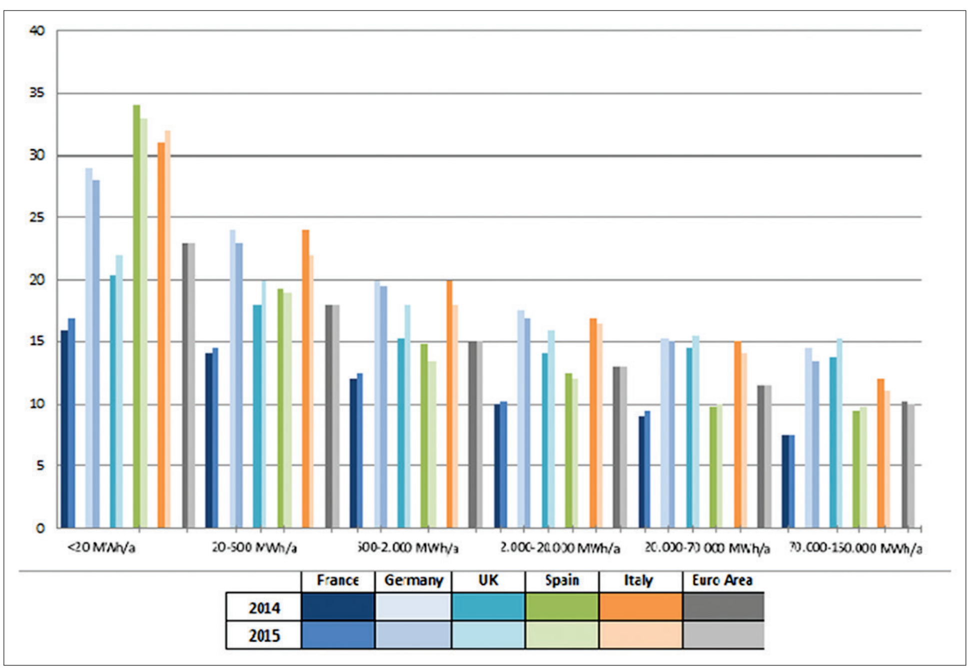
In the Italian case, the component of network fees is regulated by the Electrical Energy, Gas and Water System Authority

Table 1: 2015 electrical energy prices (c€/kWh), gross and net of taxes and fees: Industrial consumers

Countries	Industrial consumers, by annual consumption (kWh)									
	<1000		1000–2500		2000–5000		5000–15,000		>15,000	
	NET	GROSS	NET	GROSS	NET	GROSS	NET	GROSS	NET	GROSS
Austria	20.53	35.39	14.53	24.06	12.50	19.96	11.21	17.67	9.65	15.05
Belgium	23.73	28.62	19.65	23.89	18.30	22.39	16.30	20.16	13.47	16.95
Bulgaria	8.10	9.73	7.98	9.58	7.92	9.50	7.91	9.49	7.86	9.44
Czech republic	23.35	28.41	16.27	19.83	10.49	12.83	9.02	11.03	7.85	9.64
Cyprus	17.33	22.04	15.05	18.85	15.19	18.98	14.98	18.72	14.23	17.78
Croatia	16.35	21.01	10.92	14.22	10.06	13.15	9.62	12.59	9.29	12.19
Denmark	11.87	33.32	11.87	33.32	9.66	30.55	8.02	22.40	8.02	22.40
Estonia	9.80	13.35	9.85	13.34	9.51	12.97	8.94	12.34	8.27	11.59
Finland	22.16	30.28	13.97	20.12	10.18	15.41	8.60	13.46	7.05	11.53
France	21.71	28.05	12.69	18.43	10.87	16.50	9.76	15.29	9.44	14.99
Germany	26.10	43.62	16.45	32.10	14.29	29.49	13.04	27.99	12.57	26.78
Greece	18.39	24.41	12.74	18.08	12.19	17.69	11.88	18.88	11.31	19.17
Ireland	42.03	58.90	23.80	30.82	19.81	24.40	17.41	20.77	15.34	17.73
Italy	20.39	29.41	13.85	21.07	14.93	24.39	18.34	30.44	20.64	33.47
Latvia	10.34	15.74	10.94	16.49	10.90	16.43	10.83	16.34	10.64	16.11
Lithuania	8.95	12.81	8.86	12.71	8.69	12.50	8.33	12.07	7.71	11.32
Luxemburg	19.15	23.97	14.77	19.24	13.31	17.67	12.04	16.29	11.04	15.21
Malta	32.61	34.25	13.42	14.09	12.02	12.62	14.40	15.12	35.73	37.51
Norway	29.40	38.69	17.41	23.70	10.64	15.24	6.94	10.61	5.82	9.22
Netherlands	24.13	nd	14.91	11.18	12.45	18.95	11.16	22.81	9.72	19.48
Poland	14.26	18.13	11.86	15.18	11.15	14.31	10.69	13.74	10.55	13.57
Portugal	18.45	39.23	12.32	24.76	11.52	22.82	11.07	21.68	10.90	20.82
United Kingdom	24.92	26.19	22.74	23.89	20.52	21.54	18.71	19.65	17.15	18.01
Romania	9.76	13.64	9.53	13.37	9.33	13.11	9.20	12.95	8.96	12.63
Slovakia	20.36	24.82	14.23	17.45	12.28	15.12	10.66	13.17	9.38	11.64
Slovenia	11.65	22.08	12.72	19.29	11.25	16.10	10.31	14.12	9.68	12.80
Spain	40.76	51.83	21.89	27.84	18.40	23.40	16.04	20.39	15.11	19.21
Sweden	24.44	34.26	13.65	20.78	11.93	18.63	9.33	15.37	7.74	13.39
Hungary	10.12	12.85	9.27	11.77	8.95	11.36	8.74	11.10	9.12	11.57
European Union	23.73	32.50	15.93	22.66	14.11	20.94	13.10	20.01	12.52	19.21
Euro area	25.10	35.95	15.48	23.55	13.67	22.00	12.87	21.50	12.50	20.87

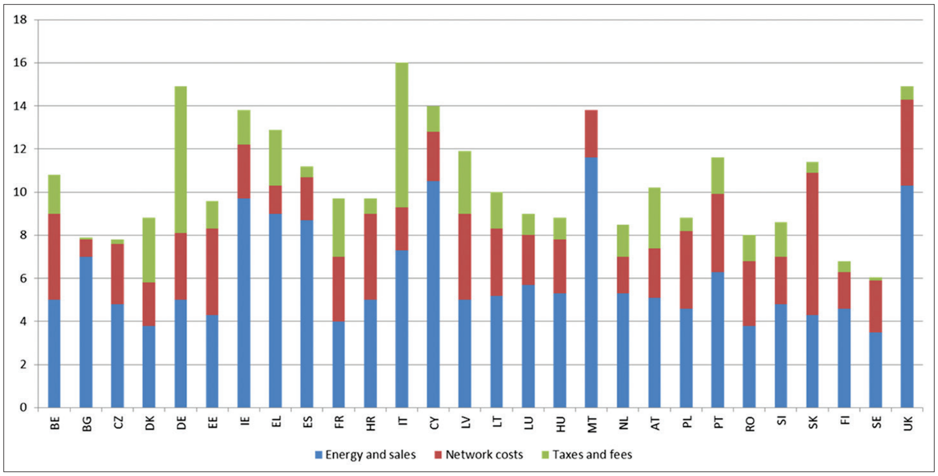
nd: None declared

Figure 1: Electrical energy prices for European industrial consumers (c€/kWh, gross of taxes and fees)



AEEGSI, which has established an incentive system intended to reduce the fee costs. The choice to implement incentivising policies on this particular component derives from the limits to the Authority's regulatory powers, given that it cannot determine the tax component, which is established pursuant to government economic legislation, or the "energy and sales" component.

Figure 2: Components of energy price for European industrial consumers (500–2000 MWh/a class, c€/kWh)



The companies, on their part, have attempted to reduce the incidence of energy costs and increase their international competitiveness, by increasingly resorting to self-production of electrical energy: A phenomenon typically encountered in countries with particularly high energy costs.

Therefore, to support the competitiveness of the sectors most exposed to competition, and of the companies operating in turbulent markets, which could be placed at risk by high energy costs, it is important that the regulator adopt incentivizing systems aimed at improving energy efficiency (Sorrell, 2009).

3. SYSTEM FEES AND INCENTIVISATION MECHANISMS

In this section we describe the incentivisation system designed to reduce user payments towards the system costs component of the overall electrical energy price.

First, we define system fees as the set of fee components directed to covering the general activities of the electrical system. These consist of a series of items: A2 - dismantling decommissioned nuclear-powered plants, closing the nuclear-fuel cycle and related activities; A3 - provision of incentivisation for renewable and assimilated sources; UC7 - promotion of energy efficiency; A4 - costs deriving from special rates to the state railway corporation; UC4 - compensation for small electrical companies; A5 - coverage of costs for research and development for the electrical system; As - coverage of price protection for electrical-energy clients in conditions of social disadvantage, "social bonus;" MCT - compensation for regions with nuclear-power sites; Ae - relief for energy-intensive companies.

Most of the components determining general fees for the Italian system are not present in other EU countries, with the exception of A3 (fees covering incentivisation of renewable sources), which are observed in Germany, France, England and Denmark, among others.

Table 2 reports the incidence of overall system fee components in Italy, averaged over the years 2010-2015:

From the data reported, it can be noted that component A3, for incentives of renewable and assimilated sources, represents around 90% of Italian general system costs.

In Italy incentivisation systems have been introduced to reduce or eliminate these fees for energy-intensive businesses.In this regard, Article 17 of Directive 2003/96/EC (Council of the European Union, 2003) identifies an "energy-intensive business" on the basis of requirements and parameters concerning minimum consumption levels and incidence of energy costs on the value of company activity, specifically as "a business where either the purchase of energy products and electricity amount to at least 3.0 % of the production value or the national energy tax payable amounts to at least 0.5 % of the added value". Under this definition the Member States can apply more restrictive concepts, including terms concerning company revenues or definitions of sectoral production processes.

In the Italian regulatory context the definition of energy-intensive businesses was established by a decree of the Minister of Economy and Finance (Ministero dell'Economia e delle Finanze, 2013), in understanding with the Ministry of Economic Development. The decree establishes energy-intensive companies as those meeting both of the following conditions over the year in question:
(a) That they used at least 2.4 GWh of electrical and/or other energy for their own activities;
(b) That the ratio of effective costs the above use of electrical energy to total revenues was not <2%.

The restructuring of general fees for the Italian electrical system is developed pursuant to criteria of decrease in function of energy consumption levels and of the ratio between effective energy costs for company activities to company revenues. Consideration can also given to the type of business activity ("ATECO" class, assigned by national statistics institute) and the voltage levels, in keeping with a Decree of the Minister of Economic Development (Governo italiano, 2012).

In April 2013, the Ministry of Economic Development (MISE) issued AEEGSI a first directive which limited fee relief to companies surpassing high thresholds of energy consumption. In particular, the directive set the "A" components of overall energy

Table 2: Average annual revenues from fees towards general system costs (2010–2015)

Component	2010 (M€)	2011 (M€)	2012 (M€)	2013 (M€)	2014 (M€)	2015 (M€)	Weight %
A2	410	255	151	167	323	622	2.8
A3	4400	6542	10,281	12,643	12,903	13,804	88.7
A4	376	345	295	448	435	248	3.1
A5	62	61	41	43	51	52	0.5
As	157	54	18	17	17	17	0.4
Ae	-	-	-	-	799	689	2.2
UC4	69	70	69	66	64	66	0.6
MCT	48	35	33	62	47	48	0.4
UC7	8	110	236	191	114	250	1.3
Total	5530	7472	11,124	13,637	14,753	15,796	

fees at zero, for companies with monthly consumption over 8 GWh at medium voltage or consumption over 12 GWh at high and extra-high voltage. This directive also amended the relief from system fees on the basis of an indicator of the cost of electricity used relative to revenues subject to VAT, in particular:

- 15% relief for energy-intensive companies with electrical-energy costs at 2–6% of revenues subject to VAT;
- 30% relief for companies with costs at 6–10% of revenues subject to VAT;
- 45% relief for companies with costs at 10–15% of subject revenues;
- 60% relief for companies with costs over 15% of subject revenues;

Finally, in July 2013, MISE issued AEEGSI a second directive which further increases the selectivity regarding fee relief:

- Permitting access to relief for energy-intensive companies only under condition that their primary ATECO class is in manufacturing;
- Excluding energy-intensive companies drawing low-voltage supply;
- Establishing specific regulations for companies "in crisis conditions" (pursuant to Article 6.1 of Decree 5 April 2013).

The Authority identified 1 July 2013 (AEEGSI, 2013) as the start date of fee relief for energy-intensive companies.

4. REGULATORY INTERVENTION: INTRODUCTION OF EFFICIENT USE SYSTEMS

With the increasing resort to self-production of electricity and the resulting reduction of quantities exchanged on the network, as described above, a decision was made in the Italian case to revise the billing pool over which to distribute the fees for the national system. To balance the distribution of effects from "lost" fees, one of the possibilities is to require a minimum contribution based on the shares of self-produced and consumed energy, and therefore not exchanged on the network. Development of suitable regulations on such matters requires analysis of the following: (i) Characteristics of the customers that will be subject to regulation; (ii) census of the subjects to be regulated; (iii) identification of methods for calculating the share of fees to be applied in support of general system costs; (iv) identification of potential interactions with the existing incentivisation schemes.

The Italian government addressed the matter with Legislative decree 115/08, which introduced the concept of simple systems for production and consumption (SSPC), including "efficient use systems" (SEU) (Governo Italiano, 2008), with the aim of obtaining contributions from self-producers of electrical energy.

In December 2013, following three rounds of public consultation (DCO 33/11, DCO 183/2013/E/eel, DCO 209/2013/R/eel), the AEEGSI (2013) issued Provision 578/2013/R/EEL, "Consolidated ruling on regulation of simple systems for production and consumption (TISSPC)". The regulatory provision covers matters of connection, measurement, transmission, distribution, dispatch and sales of self-produced electrical energy.

The analysis of the AEEGSI regulatory intervention required examination addressing the points introduced above, specifically: (i) The definition of characteristics necessary for a self-producing company to be considered "SEU-SEESEU; " (ii) census of all the companies that meet the said characteristics; (iii) means of calculating the share of fees, relative to the general fee rate; (iv) identification of potential interactions with the pre-existing incentivisation schemes.

i. Systems recognised as "efficient use" (SEU) or "equivalent to efficient use" (SEESEU) must have the following features:
    - One or more electrical energy production plants fed by renewable sources, or operating on high-yield co-generation basis, directly managed by the owning entity (physical or legal person, or set of legal persons belonging to the same corporate group);
    - Consumption by a single final user (physical or legal person, or set of legal persons belonging to the same corporate group);
    - Private connection to the energy production plant(s), without inter-connection of third parties between the plant(s) and final consumer;
    - One or more connection points to the national electrical network.

To be considered "SEU/SEESEU" the system must be constructed within a property area owned by or fully available to the final consumer, without requiring use of the road, rail, inland-waters or marine transport networks. Further, the system must also meet:

- Time-schedule requirements (dates of request and issue of permits, date of system start-up);
- Owner-operator requirements (concerning permit holder, network connection points, corporate and commercial

structures between the production and consumer units, presence of production or consumption units not included in the system);
- Property title requirements (contiguity and unity of properties, correct title registration);
- Technical requirements (suitability of metering systems, products and services achieved by the system, features of production plants).

ii. Concerning the census of companies meeting the SEU-SEESEU definition, the entry in force of Legislative decree 91/2014 (Governo Italiano, 2014) required all companies meeting the stated characteristics to register on the Energy Services Manager portal (Gestore dei Servizi Energetici, GSE) and upload all necessary documentation concerning the characteristics of their systems. At the moment of registering on the portal, the GSE simultaneously receives the necessary documentation and then carries out the documentary, administrative and physical checks to ensure owner-operator, technical and documentary compliance. In case of inadequacies or incompleteness, the GSE informs the company, which is then obligated to resolve these.

iii. Formula 1 shows the calculation of the fee for SEU/SEESEUs, based on the fee rate for general system costs:

GSF=Power rating*h*α*fixed fee rate (1)

Where:
- General system fee (GSF) is the GSF for the SEE/SEESEU;
- Power rating is the power rating of the electrical energy production plant;
- h is a variable representing hours of plant production;
- α is a variable representing incidence of self-consumed energy out of total self-produced energy;
- Fixed fee rate is defined annually in €/MWh (e.g the 2015 fee was set at 2.73 €/MWh).

  With AEEGSI Ruling 302/2015/R/COM of 25 June 2015 (AEEGSI, 2015) the variables of hours h and α were differentiated on the basis of plant type, as reported in Table 3.
- The regulations concerning SEU-SEESEU systems also govern the case of companies that qualify as both SEU-SEESEU and energy-intensive businesses. In this case the fee benefit again consists of paying only 5% of the GSF on self-produced and consumed energy, but the identification of the quantities consumed and produced is instead based on a specific calculation using data from the company financial statements, rather than data established for the flat-rate calculation.

Table 3: Values of h and α for calculation of flat-rate GSF, differentiated by plant type

Plant type	H	α
Photovoltaic	1 200	0.35
Hydroelectric	4 000	0.25
Wind-powered	1 200	0.10
Other	5 000	0.60

GSF: General system fee

Formula (2), below, is the "specific calculation" method for the GSF applied to an SEU/SEESEU belonging to an energy-intensive company:

SF=Self-consumed EE *5%*fixed fee rate (2)

Where:
- Self-consumed EE is the difference between Total EE produced and Total EE dispatched to the network;
- Fixed fee rate (€/MWh) is calculated quarterly, based on plant voltage and monthly consumption.

5. ANALYSIS OF REGULATORY IMPACT

In this section we analyse the impact of the incentivisation model for SEU-SEESEU systems, dealing with the sequence of matters as in points i to iv, above.

i. The complexity in developing a regulatory intervention of this type lies in identifying the full potential range of varied and completely different configurations, however the AEEGSI classification does succeed in identification and managing most of those currently operating. On the other hand, the companies are confronted with significant cost, both in terms of understanding the regulation and in relation to the technical interventions necessary to bring the plants into line with the specific requirements for certification. These difficulties inevitably cause delays in achieving registration.

ii. As of 31 May 2016, around 22000 companies had registered on the GSE portal and uploaded the documentation for receipt of SEU-SEESEU certification. On the same date, the GSE issued certifications for around 4000 companies. The regulation provides sanctions for companies eligible for SEU-SEESEU that fail to register on the GSE portal, however there are few instruments available for detecting such avoidance. The only means available would be to carry out cross-checks on the plants registered in the Consolidated Registry for Management of Production Plants and Users (GAUDI), which would be a very complex and laborious task. Another critical issue would be the mass of documents requiring GSE checks before the award of certification.

iii. The calculation of the SEU-SEESEU fee share relative to the SF is calculated at flat-rate, using parameters pre-determined on the basis of plant type. This facilitates the calculations remarkably, but can lead to disparities between companies, which are described and analysed in point iv, below.

iv. Analysis of methods for calculating the SEU-SEESEU GSF reveals a limit in the model concerning in the case that a company, in addition to being recognised as SEU-SEESEU, could also be categorised as energy-intensive. In the "SEU-SEESEU only" case, the fee is calculated at a flat rate, applying formula (1), while for the second case the calculation is "specific," meaning based on data from the company financial statement, applying formula (2).

  Our analyses show that the joint SEE-SEESEU/energy-intensive companies pay higher fees towards the general system than what they would if they declared themselves as only energy-intensive - a result contrary to the regulator's intention of reducing costs to energy-intensive businesses. We arrived at this conclusion by carrying out simulations on the model variables, as part of our test of validity of the two calculation methods and evaluation of regulatory policy effectiveness. Although the simulations were conducted on a small sample the results clearly have broad validity, given the outcomes of sensitivity tests conducted on all the variables.

To better illustrate the disparities described in points iii and iv, we conduct an analysis based on the real data from three companies qualified as both SEU-SEESEU and energy-intensive, named here "A, B, and C." Table 4 shows the calculations of the SEU-SEESEU fee applying both the flat-rate and the specific calculations using balance-sheet data.

The examples show that the GSF calculated specific to company financial data is always higher than the fee calculated at flat rate. This means that having declared themselves to be energy-intensive, the companies in question paid a greater share of general system costs than what they would have paid by not declaring it.

For purposes of generalising our results we carry out a comparison between the two calculation methods, variable by variable, concentrating attention first on variable α, representing incidence of self-consumed energy out of total self-produced energy. We then calculated the value of α_{REAL}, obtained from the ratio of self-consumed electrical energy to total energy produced, to determine whether the value of $\alpha_{FLAT\text{-}RATE}$ differs from the real one. Table 5 and Figure 3 present the results.

Figure 3 shows the trend of $\alpha_{FLAT\text{-}RATE}$ and α_{REAL} calculated for our three examples. We observe that the value of α_{REAL} is always greater than the $\alpha_{FLAT\text{-}RATE}$ value, and that for plant C, the % variation in α is much higher than for plant B, in spite of these both being co-generation plants with rated power of around 5000 kW. The difference derives from the intrinsic self-production capacity of the two plants.

In the view of the regulator, the choice in fixing relative low levels of $\alpha_{FLAT\text{-}RATE}$ values may signify an intention to avoid penalising lower performing companies, while from the point of view of an efficient self-producing energy-intensive company, this would be seen as a disadvantage, given that the calculation based on the effective self-consumed electrical energy results as less advantageous.

Next we focus on the variable of the "Fixed fee rate", analyzing the effect of the different values applied under the two calculation methods: Specific and flat-rate.

In the "specific" calculation the fee rate is established on a quarterly basis, as a function of the voltage of and monthly self-consumption for the plant under consideration. For the flat-rate calculation, the fixed rate is established on annual basis, independent of the plant voltage and consumption. Table 6 shows the 2015 rate values used for specific and flat-rate calculations, while Table 7 shows the system fees due applying the different rate values.

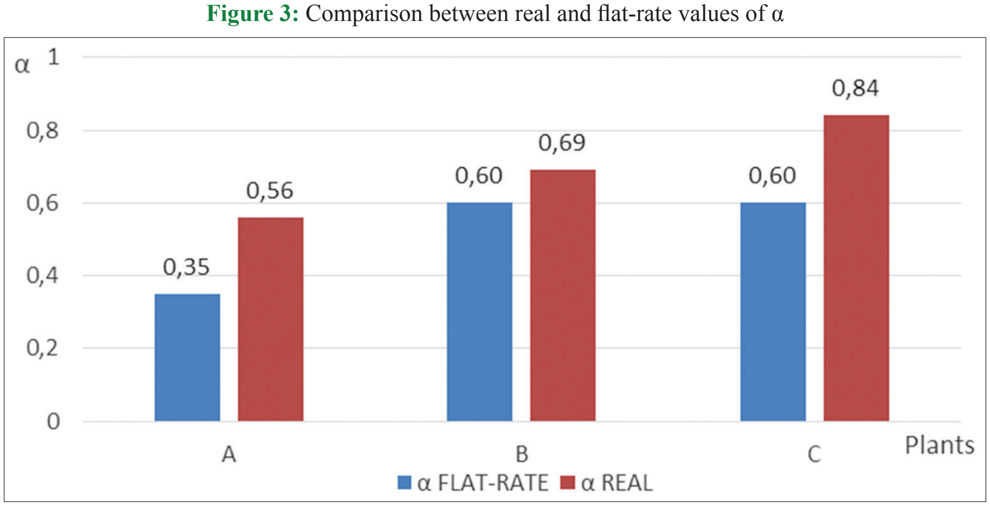
The comparison shows that the fee rate applied in the specific calculation is on average higher than the one used for the flat-rate calculation. As shown in Table 7, the effect is a difference of around +4% in the GSFs.

Table 4: "Flat-rate" and "specific" calculations of GSF

Plants	Qualification	Energy-intensive 2013	Rated power	Hours	α	Fixed fee rate (€cent/kWh)	Flat-rate fee (€)	Specific fee (€)	Delta
A (Photovoltaic)	SEU	Yes	862	1 200	0.35	0.273	988	1 388	400
B (CHP)	SEU	Yes	6 320	5 000	0.60	0.273	51 761	91 338	39 577
C (CHP)	SEESEU A	Yes	4 866	5 000	0.60	0.273	39 853	63 504	23 652

GSF: General system fee

Figure 3: Comparison between real and flat-rate values of α



Next we analyse the variable representing self-produced electrical energy under varied hours of operation, for photovoltaic plants with rated power of 1500 kW. Figure 4 shows an x–y graph with regression line equal to the rated plant power. We observe that for a number of hours <1200 the value of self-produced electricity is less than the corresponding value calculated by flat-rate method. This means that for the company, it results that the specific-method calculation is economically more advantageous in cases where the plant operates for <1200 h; in the case of more than 1200 h operation, the flat-rate calculation is more advantageous.

Generalising, we can therefore attest that a company gains economic advantage in using the specific calculation only in the case where the real hours of plant operation are less than those established for the flat-rate calculation, for all types of plant regardless of their rated power. Once again, the result obtained appears contrary to the intent of supporting energy-intensive companies and self-producing companies.

The final analysis examines the effect of joint variation of α-$_{REAL}$ and hours-$_{REAL}$, considering the case of a photovoltaic plant, where the flat-rate calculation is conducted using an h (hours) value of 1200 and α value of 0.35, as established for that type of plant. The results are illustrated in Figure 5, where the zone under the curve represents the points corresponding to α and h values where the company would achieve greater advantage by specific calculation rather than fixed-rate calculation.

In this context, it is important to differentiate by plant type, because photovoltaic plants have less margin of control over hours of operation, since the technology is bound by seasonality. This is contrary to a cogeneration plant, where the operators can decide the hours of operation and control energy production.

In closing, the analyses conducted have revealed that for energy-intensive businesses with SEU-SEESEU systems, it is not always advantageous to declare themselves as energy-intensive, because this would bring about the "specific" calculation of fees for general system costs, and that the specific calculations could result in higher fees compared to fixed-rate calculations.

Figure 4: Function of self-produced energy

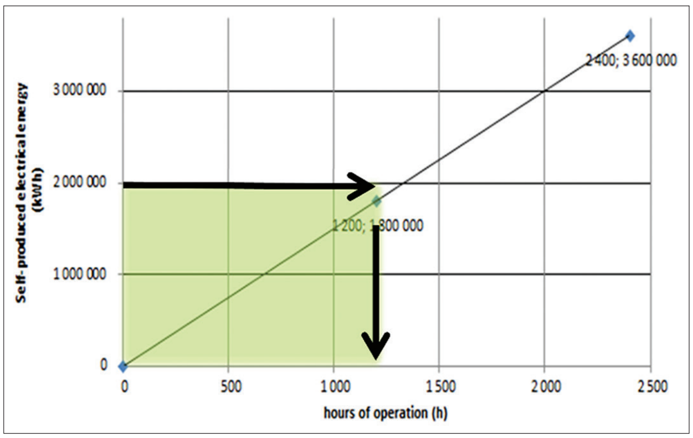


Table 5: Percentage variation of α_{REAL} from $\alpha_{FLAT\text{-}RATE}$

α Values	Plants		
	A	B	C
$\alpha_{FLAT\text{-}RATE}$	0.35	0.6	0.6
α_{REAL}	0.56	0.69	0.84
% increase in α	60	15	40

6. CONCLUSIONS

The objective of this article was to analyse the incentivisation system for "Efficient Use Systems", recently introduced in Italy, bringing out the difficulties of implementation in terms of transposing the reference directives, and in terms of achieving technical conformity of the plants.

The study revealed the difficulty in defining regulations that on the one hand meet national needs for coverage of general system costs, and on the other hand support and favour development of efficient systems with reduced environmental impact. In passing, we should in any case note that the greatest benefits for a self-producing and consuming company derive from the reduction of electricity costs net of incentives, and from the rapid amortisation of production plants, meaning that the resort to self-production is not necessarily done with an eye to great efficiency. Consequently, a solution like the one presented would put at risk the development of low-impact

Table 6: Fee rate applied in "specific" and "flat-rate" SEESEU fee calculation

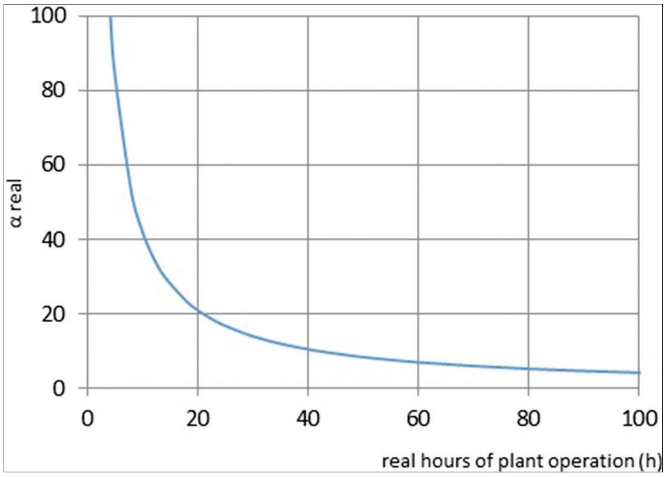
Fee rate	Period	Specific calculation (€/MWh)	Flat-rate calculation (€/MWh)
2015 fee rate for MV plants with monthly consumption<4 GWh)	1st quarter	2.73	2.73
	2nd quarter	2.80	
	3rd quarter	2.88	
	4th quarter	2.97	
Average value		2.85	2.73

Table 7: Percentage variation of GSF s with variation of fee rate

Company	General system fee (€) - specific calculation	GSF (€) - specific calculation applying "flat-rate" fee	Delta	Variation %
A	1 388	1 329	59	4.3
B	91 338	87 746	3 592	3.9
C	63 504	61 236	2 268	3.6

GSF: General system fee

Figure 5: α-real as a function of real hours of plant operation



energy self-production systems as CHP and renewable sources.

In confirmation of our analytical results, the Italian government recently amended the incentive system by an "Adjustment decree law 2016" (Parlamento Italiano, 2017), which establishes that as of 2017, the variable part of system fees will be paid only "on energy drawn from public networks with obligations of connection for third parties". The law also annuls the effects of previous regulation on the matter, including cancellation of all general network fees on self-consumed energy retroactively to 1 January 2015.

A remaining problem is the reduction of the billing base over which to distribute the shared costs of the national electrical system, brought about by the lesser quantity of energy exchanged. The main issue is to decide how to redistribute missing revenues without penalizing virtuous companies and the development of low-impact energy self-production systems. A suitable proposal, subject to prior evaluation, could be: To introduce a regulatory model designed to obtain greater payment of general costs by self-producing companies only when these, for insufficiency of energy produced, find it necessary to draw on the public network.

The introduction of this kind of model would permit both incentivisation of self-production of energy (penalising only occasional consumption from the network), and the resolution of the problem deriving from different methods of calculation (evidenced by the analyses in this work). In fact the fees for general system costs could be calculated specific to each company, using company financial data, rather than by flat-rate calculations applying fixed values of parameters to different plant types.

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