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A multi-stakeholder analysis of the economic efficiency of industrial energy efficiency policies: Empirical evidence from ten years of the Italian White Certificate Scheme

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Abstract

There is growing interest worldwide in more effective policies to promote industrial energy efficiency and mitigate climate change. The White Certificates Scheme is a market-based mechanism aimed at stimulating the adoption of Energy Efficiency Measures. The Italian White Certificates scheme - one of the most long-standing and articulated - is a successful example of industrial energy efficiency policies, considered an interesting and remarkable case by other countries, especially due to its robustness in terms of the volume of certificates traded. Despite the considerable interest in White Certificates, an in-depth analysis of the economic efficiency of the mechanism from the perspective of different stakeholders is still lacking. To address this gap, this study develops a cost-benefit evaluation framework and a multi-stakeholder economic efficiency analysis of the Italian White Certificates scheme focusing on the Italian State, utilities, players in the energy efficiency value chain, and energy users. Our findings (also corroborated with sensitivity analyses) show that the White Certificates Scheme has led to several positive impacts for almost all stakeholders involved, with the exception of energy utilities that have suffered a major economic loss mainly due to a reduction of energy sold to end users. Such loss is likely to promote a deep change in the role of utilities in the energy market in terms of the services they offer and their business models. Our findings, in addition to providing useful directions for future research, offer interesting insights and implications for policymakers who may take inspiration from the pros and cons of the Italian White Certificates scheme when promoting energy efficiency through incentive mechanisms.

Keywords White Certificates Scheme; Energy efficiency obligations; Economic efficiency; Multi-stakeholder perspective.

List of acronyms

DSO: Distribution System Operator
EEM: Energy Efficiency Measure
EEO: Energy Efficiency Obligation
EEVC: Energy Efficiency Value Chain
ESCO: Energy Service Company
NEB: Non-Energy Benefit
TOE: Tons of Oil Equivalent
WCS: White Certificates Scheme

1. Introduction

While attention is growing worldwide on designing more effective policies to promote energy efficiency and mitigate climate change [1], more robust data and analyses on the cost-effectiveness of energy efficiency policy instruments are needed [2]. The White Certificate Scheme (WCS) falls within the category of Energy Efficiency (also known as Energy Saving) Obligation (EEO) schemes. These constitute valuable energy efficiency policy instruments [3, 4] with more than 50 EEO schemes currently operating worldwide [5] through which countries strive to achieve their goals to decrease reliance on fossil fuels and increase energy efficiency. WCSs experienced an initial diffusion in the US, followed by a strong momentum in the EU [4] in the wake of the European Energy Efficiency Directive in 2012 [6]. Although several countries are evaluating the introduction of a national EEO scheme [7], further studies on the mechanisms underlying WCSs and their implications and effects are needed (see, e.g. Aldrich & Koerner [8]) to deepen research in this area and provide valuable insights to industrial energy efficiency policymakers in light of near-term mitigation pathways, also through sharing national good practices.

EEO schemes set specific targets for obligated parties on energy savings to be achieved. Such savings can be obtained through the implementation of Energy Efficiency Measures (EEMs), or when permitted, purchasing certificates stating that an energy saving has been achieved by another actor involved in the scheme. The possibility of trading White Certificates among parties is a design option [9] currently implemented in countries such as Italy and France [3]. This option positions the WCS in the category of market-based instruments [10]. These instruments have received much attention in the environmental policy debate [11] and have been analysed in-depth (e.g. [12–16]). Despite the idiosyncrasies of each national scheme, EEO schemes have largely contributed to substantial improvements in energy efficiency [4].

Several studies have attempted to estimate the total cost of a WCS, its cost effectiveness, and economic efficiency. According to Di Santo, Biele and Forno [17], in 2014, the total cost of the Italian WCS - calculated as the product of cancelled certificates and the tariff reimbursement component (see Section 2.1 for an overview of the main characteristics of the Italian WCS) - was around 600 million euro, expected to reach 700 million euro in 2015, in addition to around 10 million euro in annual costs for the Gestore dei Servizi Energetici (GSE - Energy Services Operator) in relation to providing information, evaluation, and control. According to ENEA [18], the Italian WCS is much more cost effective (seven times lower in terms of the ratio of the scheme's annual cost and the energy savings achieved) than tax deductions, the other main Italian energy efficiency incentive scheme. The WCS, beyond providing the largest contribution in terms of energy savings achieved, is also the most cost effective [17], and has become one the main pillars of the national energy strategy [19].

To assess the cost effectiveness of WCSs, existing studies compare the total costs associated with the scheme and the energy saving achieved, i.e. the so-called negawatt-hour cost [20–22]. WCSs are typically characterized by a high level of cost effectiveness [23] compared to the price of energy [10, 24]). In addition to cost effectiveness, a complementary view focuses on the economic efficiency of

WCSs, assessed through the schemes' cost/benefit ratio. Such evaluations show that WCSs have a high level of economic efficiency [23]. In Great Britain, for instance, they have produced 7.41 euro in benefits for each euro spent, excluding CO_2 savings [10].

The evaluation of the cost effectiveness and economic efficiency of a WCS can be undertaken from three distinct perspectives [26]. The first (*technical perspective*) focuses on estimating the costs associated with the adoption of EEMs and the related benefits linked to reduced energy consumption [27–29], assuming the perspective of parties involved in carrying the cost of such measures. The second (*program administrator perspective*) enables policymakers to make decisions focusing on the impact of an energy efficiency program from their own standpoint, e.g. evaluating the program cost per unit of energy saved or the financial incentives per unit of energy saved [30–32]. However, these two perspectives provide only a partial view, since they do not consider the impact for other stakeholders such as ratepayers, utilities, and society as a whole. A comprehensive evaluation of an energy efficiency program requires a (third) *multi-stakeholder perspective* [33, 34], implying the introduction of further appropriate metrics.

Although this multi-stakeholder perspective is very promising, to the best of our knowledge, few studies adopt this viewpoint, particularly with a focus on the Italian WCS. Extant research mainly conducts cost-benefit analyses at the societal level, in some cases providing a complementary perspective at the customers level (e.g. Mundaca & Neij [23]), or at the utility level (e.g. Rosenow & Bayer [2]). Those studies focusing on the Italian WCS (e.g. Stede [35]; Di Santo et al. [36]) offer broad evidence on the overall success of the scheme, without considering the perspective of each stakeholder involved. Instead, fully understanding whether all stakeholders equally sustain the economic efficiency of the scheme is crucial, since discrepancies could lead to changes in their behaviour (and even opposition) with a negative impact on the overall effectiveness and efficiency of the WCS. In addition, prior studies mainly focus on a limited number of benefits, such as the reduction of energy bills for energy users or avoided CO_2 emissions, thus overlooking other relevant Non-Energy Benefits (NEBs) [23, 38–40].

Starting from these premises, the contribution of our study is twofold. On the one hand, we develop a comprehensive multi-stakeholder cost-benefit evaluation framework that considers the entire set of stakeholders involved and a broad set of cost-benefit items. The framework developed includes eight items that may represent a cost or a benefit for the stakeholders involved in the scheme, i.e. the Italian State, utilities, EEVC players, and energy users. On the other hand, we discuss the results deriving from applying the evaluation framework to the Italian WCS. The choice to apply the evaluation framework to the Italian WCS stems from its peculiarities, as further detailed in Section 2. Among the others: it is one of the first EEO schemes in place (since 2005), sets ambitious energy saving targets, covers all sectors and energy efficiency solutions and includes several flexibility options (such as the participation of voluntary – i.e. non-obliged – parties, in order to promote the Energy Service Company market) [36]. The evaluation builds on a large dataset covering more than 10 years of operation of the Italian WCS, enriched by multiple workshops we conducted with major stakeholders operating in the energy efficiency value chain (EEVC) (25 players), among which utilities, covering more than 20% of White Certificates issued in the year 2016.

The application to the Italian WCS shows that since its introduction in 2005, the scheme has produced a significant net benefit at the country-level (around €2 billion). However, the economic efficiency of the Italian WCS for the different stakeholders is somewhat heterogeneous. In particular, the EEVC players and energy users have benefited most from the application of the scheme, while the State and, mostly, utilities have experienced a negative cost/benefit effect associated with the WCS.

We believe that our analysis may be a valuable source of insights for countries currently evaluating the introduction of an EEO scheme, as well as for those seeking to strengthen the effectiveness and efficiency of an existing scheme. Interestingly, despite the high level of flexibility of EEOs and their adaptability to the national context [4], their impact on different stakeholders remains under-researched. This is even more critical considering the continuous need to adapt and revise such schemes to deliver savings at the lowest possible cost. Finally, the evaluation framework proposed might be useful for a cost-benefit assessment of other energy policy instruments adopted in countries such as Australia [41], China [42], Denmark [43], France [4], the UK [44], and US [8].

The remainder of the paper is structured as follows. Section 2 introduces the main characteristics of the Italian WCS and provides an overview of the main stakeholders involved. Section 3 illustrates our multi-stakeholder evaluation framework, along with the methodological aspects and their limitations. Section 4 presents the results of the application of the evaluation framework in the Italian context. Finally, Section 5 provides concluding remarks with a focus on the change of the role of energy utilities in the energy market driven by the WCS, together with limitations and avenues for future research.

2. The Italian White Certificates Scheme

Table 1 provides a summary of the main design choices underlying the Italian WCS, following the structure that ENSPOL [4] proposed. For a comparison with other WCSs operating at the European level, see Table A.1 in the Appendix.

<< Table 1>>

The Italian WCS is an EEO scheme setting specific annual energy saving targets, measured as primary energy savings to be achieved by the obligated parties either directly, i.e. through the implementation of EEMs at the energy user’s premises, or indirectly, by purchasing energy saving certificates obtained by other players involved in the scheme through an ad hoc market operated by the GME (Gestore Mercati Energetici; Energy Markets Operator) or bilateral contracts. The costs the obligated parties incur are partially reimbursed through a tariff (electricity and natural gas) reimbursement component defined each year by ARERA (Autorità di Regolazione per l’Energia, Reti ed Ambiente; the Italian Regulatory Authority for Energy, Networks, and the Environment) [4]. The energy saving obligation and a market permitting the trade of White Certificates renders the Italian WCS an EEO and an incentive mechanism [17].

The scope of the WCS is broad, both in terms of eligible EEMs and the sectors in which such measures may be adopted to produce White Certificates. For each energy efficiency project, White Certificates are issued for a certain number of years (typically 7 or 10). Each certificate corresponds to one TOE of primary energy saved. In particular, only additional savings are considered in issuing White Certificates, i.e. those over a market and regulatory baseline [37]. First, the identification of the market baseline for a given EEM is carried out through a market analysis to assess the average efficiency of the given EEM in the sector. Then, the baseline is compared with the existing regulation, since the presence of improvements required by law might increase the baseline level of the given EEM. Recent amendments to the regulation have reduced the evaluation methods to assess energy savings to be issued to two alternatives: i) "Simplified monitoring projects", and ii) "Monitoring plans projects" [45].

Different types of stakeholders are directly involved in the WCS:

- Electricity and natural gas distributors with more than 50,000 customers as obligated parties.
- Electricity and natural gas distributors with fewer than 50,000 customers, companies linked to or controlled by distributors, Energy Service Companies, companies with an appointed Energy Manager and companies without an Energy Manager but with an Energy Management System in place (in compliance with ISO 50001) as voluntary parties. These players have the opportunity to be involved in the scheme, but are not obligated.
- GSE, GME, and ARERA as main institutional players involved in the administration of scheme.
- Energy users are involved because they are subject to the cost-recovery mechanism for obligated parties financed through ad hoc electricity and natural gas tariffs.

Table 2 synthesizes the role of players involved in the EEVC and their corresponding role in the WCS. Several players, mainly technology manufacturers and distributors, do not play a direct role, even though they benefit from the adoption of EEMs stimulated by the scheme. For this reason, we believe they should be included in a comprehensive multi-stakeholder analysis of a WCS. Finally, energy users (residential, tertiary, or industrial) adopting an EEM at their premises are another important stakeholder.

<< Table 2>>

Our evaluation framework, which considers all direct and indirect effects produced by the Italian WCS, encompasses the following complementary perspectives:

- Energy users, distinguishing between industrial and non-industrial (the latter includes users in the residential and tertiary sectors).
- Utilities, including companies operating in energy distribution and sale.

- Players in the EEVC, i.e. Pure Manufacturers, Wholesalers, Energy Efficiency Providers and Energy Efficiency Manufacturers.
- The State, including institutional players and society at large.

3. The multi-stakeholder evaluation framework

3.1 Items included in the evaluation framework

As a preliminary step in the development of our multi-stakeholder evaluation framework, we identified the items, i.e. the costs and benefits, associated with the WCS, conducting a thorough and comprehensive literature review on the cost-benefit analyses of WCSs [46, 10, 2].

Regarding the costs, Giraudet, Bodineau and Finon [25] argue that total costs (encompassing all capital and installation costs) should reflect the cost of EEMs compared with a reference situation, i.e. the absence of EEMs or the installation of a comparable low-efficient solution. Such costs impact numerous stakeholders, mainly customers and obligated parties, who also bear other indirect costs to inform customers on energy efficiency programs and activities such as project development, marketing, and reporting [47]. Programme costs encompass the sum of the direct and indirect costs for the obligated parties, while societal costs account for the sum of the costs of the scheme and the cost sustained by customers [48, 2]. Finally, administrative costs should also be considered, including the initial costs of setting up the EEO scheme and to define new procedures and guidelines [2].

Regarding the benefits, these differ in nature and involve different stakeholders. First, the reduction of energy bills for energy users should be considered (largely investigated in the literature, see, e.g. Rosenow and Bayer [2]). Second, the avoided CO_2 emissions[1] represent an environmental benefit from a social standpoint.

As a limitation of our study, we identify, but do not evaluate, the following social or private benefits, due to their intangible nature and/or very complex assessment:

- At the utility level, avoided or deferred investments in generation, transmission, and distribution assets and reduced reserve requirements [49].
- At the societal level, improvements in health, comfort, and asset value of buildings and facilities, increasing the rate of employment in the energy efficiency market and the alleviation of fuel poverty [2].

To conclude, our WCS evaluation framework includes the following items (with further details in Table A.2) that in our multi-stakeholder perspective allows considering that each item may represent a cost for one (or even more than one) stakeholder and a benefit for another stakeholder (as detailed in Section 3.2):

[1] Their quantification depends on national mixes in electricity generation and the repartition of the scheme results by fuel type. In addition, the monetary valuation of carbon dioxide savings reflects national assumptions on the social value of carbon.

i. Direct costs of EEMs, including the costs of EEMs implemented.
ii. Tariff contribution related to the scheme: the cost-recovery mechanism for utilities that are obligated parties.
iii. Energy bill reduction: the reduction of energy operating expenditure for energy users that adopt EEMs.
iv. Tax reduction related to energy bill reduction: the reduction of the amount of taxes (VAT, corporate tax, and energy tax) paid by utilities as a consequence of energy bill reduction due to implementing EEMs.
v. Administrative cost related to the scheme: the costs borne by institutional players and paid by energy users for administering the scheme.
vi. Tax increase related to EEMs: the increase in the amount of taxes (VAT, corporate tax, and income tax) paid by EEVC players and energy users as a result of implementing EEMs.
vii. Energy import reduction: the reduction of energy marketed by utilities to energy users imported from other countries.
viii. CO_2 emission reduction: the reduction of CO_2 emissions achieved thanks to the reduction of energy consumption by energy users adopting EEMs.

3.2 Players and items

We analysed the aforementioned items based on their impact for all the stakeholders identified, as summarised in Table 3, and showing for each item in the evaluation framework whether its impact is positive or negative for a specific stakeholder, i.e. a benefit or a cost.

<< Table 3 >>

Regarding the EEM costs (item #1), we have assumed that all the direct EEM costs are sustained by energy users. Despite that other players (e.g. those in the EEVC) may sustain such costs, even within the same energy efficiency project, their role in financing EEMs in the Italian energy efficiency market is rather limited [49]. This item represents a benefit for players in the Italian EEVC offering EEMs. Tariff contribution related to the scheme (item #2) is set by ARERA and paid by electricity and natural gas users through ad hoc electricity and natural gas tariffs. This item represents a benefit for utilities, given that it is a cost-recovery mechanism established for such players. Energy bill reduction (item #3) is a benefit for energy users adopting EEMs, and in turn, a cost for utilities, due to the reduction in their turnover following a decrease in the amount of energy sold to energy users. Tax reductions related to energy bill reduction (item #4) represent a benefit for utilities following a reduction in their turnover (due to a decrease in the amount of energy sold), and a cost for the State, which collects such taxes. Administrative costs related to the scheme (item #5) are paid by energy users (as taxpayers) to support hiring new employees (by national authorities in charge of the WCS administration) involved in managing the scheme itself, without a negative impact for the other stakeholders in the WCS[2]. Tax increases related to EEMs (item #6) are a cost for the EEVC players and energy users as a consequence of implementing EEMs. One of the three taxes analysed, i.e. income tax, is indirectly linked to the implementation of EEMs, as it refers to the increase in employment due to implementing EEMs, and represents a benefit for the State, which collects this tax. Energy import reduction (item #7) and CO_2 emission reduction (item #8) may be considered a benefit for utilities and society, without a negative impact for other stakeholders of the WCS.

3.3 Values of items for different stakeholders: Assumptions

Following the identification of the items to be included in the evaluation framework and their impact on all stakeholders, we set an ad hoc metric for their estimation. Multiple information sources were used to collect data (e.g. official documents issued by institutional stakeholders, i.e. GSE, GME, and ARERA). Furthermore, regarding the other variables considered in our framework, we formulated several conservative and robust assumptions.

3.3.1 Direct costs of EEMs

To estimate the direct costs of EEMs (item #1), we measured the total costs of EEMs (due to data availability) instead of their incremental costs [26] from 2006 to 2016 in Italy (i.e. only estimating the impact within the country's boundaries).

We first identified those EEMs whose installation was driven by the presence of the WCS. In particular, the analysis (Table 4) focuses on EEMs yielding the highest energy savings [23] (in particular, more than 60% of White Certificates issued). Due to data availability, the changes in the scheme's operating principles, and the annual reports issued by institutional players, we divided the entire period into two sub-periods, respectively, 2006–2012 and 2013–2016.

<< Table 4 >>

For all the technological families identified, we have assumed that the total number of White Certificates issued in the 2006–2012 period and in the 2013–2016 period refer to one specific technology (EEM), i.e. the reference technology reported in Table 4. Given the unavailability of official statistics for the entire period under investigation, we identified the reference technologies through a series of workshops involving 25 of the most relevant players and utilities in the Italian EEVC. In addition, the workshops enabled estimating the average unitary cost of each EEM. Given that the collected values have very limited variance (in the +/– 10% range compared to the average value), we

[2] Despite that this item may determine an increase in the country's GDP and an indirect positive effect for the State due to a tax increase (e.g. due to income tax on new employees' wages and VAT due to these employees increasing consumption), we do not consider this impact in our analysis due to its marginal effect.

used the average unitary cost value of each EEM to calculate the costs of EEMs (Section 4) and to further conduct a sensitivity analysis (Section 4.1).

We calculated the costs of EEMs by multiplying the number of EEMs implemented in the two sub-periods and their unitary costs. Finally, given that the EEMs analysed cover 66% of White Certificates issued in the 2006-2016 period, we estimated the costs of EEMs referring to 100% of White Certificates issued according to the relative weight of EEMs. Moreover, we distinguished between the costs of EEMs implemented by industrial users and non-industrial users (belonging to the residential and tertiary sectors) based on the typical application field of each EEM. In addition, we further distinguished between the portion of EEM costs increasing the turnover of Italian players from those of foreign players.

3.3.2 Tariff contribution related to the scheme

We calculated the tariff contribution related to the scheme (item #2) in each year by multiplying the number of White Certificates annually presented to ARERA to verify the obligated parties' target accomplishment [51–55] and the unitary electricity and natural gas tariffs set by ARERA [56–67]). Moreover, we distinguished between the tariff contribution paid by industrial users and non-industrial users based on the whole amount of electricity and natural gas consumed by industrial and non-industrial users at the national level (given that the unitary tariff contribution is the same for all Italian energy users and is paid on each unit of energy consumed).

3.3.3 Energy bill reduction

We estimated energy bill reduction (item #3) by multiplying the amount of annual energy savings generated by implementing EEMs and the average annual energy price. We calculated energy savings as the additional savings generated by implementing EEMs, differently from previous studies (e.g. Yushchenko & Patel [26] who calculate energy savings as the difference between energy consumption before and after implementing EEMs). In particular, we converted the number of White Certificates issued in each year for each energy carrier (i.e. electricity, natural gas, and other fuels) into kWh by applying the relative conversion factors set by national authorities. Further, we divided the value of White Certificates issued since 2011 by a multiplier (the so-called "tau", τ, introduced in 2011), which adds discounted future savings for technologies with a lifespan of more than 5 years to the annual savings (given that White Certificates were usually issued for a 5-year lifetime). Fossil fuel savings are considered as equivalent to natural gas, both in terms of energy savings and economic value [23]. Although fossil fuel savings are related to EEMs to reduce solid, liquid, and other gaseous fuel consumption (apart from natural gas), the official statistics associated with each fuel are not available. In addition, given that energy savings in recent years mainly occurred in the industrial sector (e.g. in the 2013–2016 period, around 65% of electricity savings and around 70% of natural gas and other fuel savings), we distinguished between the two types of energy users.

Regarding energy price, we considered the annual average electricity and natural gas prices in each analysed year, distinguishing between industrial and non-industrial users (source: EUROSTAT).

Regarding the latter, we exclusively considered annual average electricity and natural gas prices for residential users, as most energy savings achieved by non-industrial users could refer to residential users, also analysing the type of EEMs implemented. We included VAT on electricity and natural gas prices.

The energy bill reduction corresponds to a loss in utilities' turnover. Consistently with the literature [2], we assumed that the reduction of energy consumption for energy users after the implementation of EEMs leads to a reduction of the same amount in energy bills, despite that utilities might increase the unitary energy price to counterbalance the loss of turnover (due to energy efficiency), and energy bills include both fixed and variable costs, although this could possibly generate slight misalignments. Moreover, we assumed that the reduction of energy sold by utilities does not have a significant (negative) impact in terms of employment, as the reduction is less than 2% of the total annual turnover of the sector (see Section 4 for further details).

3.3.4 Tax reductions related to energy bill reduction

We calculated tax reduction related to energy bill reduction (item #4) using different approaches. We measured VAT reduction (item #4.1) considering the reduction of energy bills driven by the implementation of EEMs multiplied by the average VAT rate in each year (10%) (source: Italian Revenue Agency).

We calculated corporate tax (IRES – in Italy) reduction (item #4.2) considering the reduction in energy bills driven by the implementation of EEMs, which corresponds to a loss in utilities' turnover. Then, we measured average the Earnings Before Taxes (EBT)-turnover ratio for electricity and gas/other fuels (AIDA – Bureau Van Dijk) to assess the reduction of EBT due to the reduction of energy bills. Finally, we calculated corporate tax reduction by multiplying the reduction of EBT by the average corporate tax rate in each year (source: Italian Economic Development Ministry).

We measured energy tax reduction (item #4.3) as the reduction of energy bills driven by the implementation of EEMs multiplied by the average tax rate in each year, distinguishing between residential and non-residential energy users (source: Italian Customs and Monopolies Agency).

3.3.5 Administrative cost related to the scheme

We estimated the administrative costs related to the scheme (item #5) by analysing the financial reports issued by institutional players involved in the WCS (GSE and ARERA). In particular, from the profit and loss accounts, we calculated the variation of administrative costs (i.e. personnel and service costs) between the year in which the WCS was managed for the first time by the different institutional players and the year before its introduction (i.e. 2006 vs 2005 for ARERA, and 2013 vs 2012 for GSE), assuming that such difference is due to the introduction of the WCS. For the other years, we assessed the administrative costs proportionally to the number of White Certificates issued. As per item #2, we distinguished between administrative costs related to the scheme paid by industrial users and non-industrial users based on the separation of the whole amount of electricity and natural gas consumed by industrial and non-industrial users at the national level (even though such costs are paid by taxpayers, regardless of their energy consumption).

3.3.6 Tax increases related to EEMs

We calculated tax increases related to the implementation of EEMs (item #6) according to different approaches. We measured the VAT increase (item #6.1) starting from the costs of EEMs (only referring to the turnover generated by the EEVC player falling within the system boundaries, i.e. Italy), multiplied by the average VAT rate in the two sub-periods (source: Italian Revenue Agency).

We assessed the corporate tax (IRES – in Italy) increase (item #6.2) starting from the costs of EEMs, which corresponds to an increase in turnover for EEVC players. Then, we calculated the average EBT-turnover ratio for EEVC players (source: AIDA – Bureau Van Dijk) to assess the increase in EBT due to the costs of EEMs. Finally, we measured the corporate tax increase by multiplying the reduction of EBT by the average corporate tax rate in each year (source: Italian Economic Development Ministry).

We calculated the income tax (IRPEF) increase (item #6.3) starting from the costs of EEMs corresponding to an increasing turnover for EEVC players, distinguishing between the costs of EEMs implemented by industrial users and non-industrial users. In terms of the increase in employment, we used a straightforward estimation, i.e. we multiplied the costs of EEMs (i.e. the amount of money invested in EEMs, which is equal to the turnover related to the adoption of EEMs) by the number of jobs created per million euro invested in EEMs (employees-turnover ratio), as Rosenow and Bayer [2] suggested. In particular, we assessed the average employee-turnover ratio of EEVC players (source: AIDA – Bureau Van Dijk) to measure the increase in employment due to the increased turnover. Finally, we calculated the income tax increase through multiplying the number of new employees by the average annual wage in the EEVC and the average income tax rate in each year (27%) (source: Italian Economic Development Ministry).

3.3.7 Energy import reduction

We measured energy import reduction (item #7) starting from the amount of annual energy savings generated by the implementation of EEMs. Then, we used the yearly import quota for electricity and natural gas (source: Italian National Energy Balance) to calculate the amount of electricity and natural gas import reduction. Finally, we multiplied it by the average wholesale price of electricity and natural gas (sources: Terna, Italian Economic Development Ministry).

3.3.8 CO_2 emission reduction

We measured CO_2 emission reduction (item #8) starting from the amount of annual energy savings generated by the implementation of EEMs. Then, we used the average emission factors for electricity and natural gas consumption [68] to calculate the amount of CO_2 emission reduction. Regarding the monetary value of CO_2 emissions, due to the absence of an official carbon value set by Italian public authorities, we have assumed that carbon savings can be traded on the EU-ETS (as Giraudet, Bodineau and Finon [25] suggest) at a price ranging from 4.4 €/tCO_2 to 22 €/tCO_2 (source: SENDECO2).

4. Results and Discussion

We applied the multi-stakeholder evaluation framework introduced and discussed in Section 3 to the Italian WCS. Table 5 shows the results for the 2006–2016 period.

<< Table 5>>

According to the aforementioned assumptions, and taking a country-level perspective, the introduction of the WCS in Italy has generated a net benefit of around €2 billion since it came into force. On average, this means an annual average positive net benefit of around €180 million. Therefore, it can be concluded that, assuming a country-level perspective, the introduction of the WCS has produced remarkable positive results.

However, the impact for each analysed stakeholder is somewhat heterogeneous. First, the State has experienced a negative cost/benefit balance, equal to –967 million €, due to tax reduction related to energy bill reduction, which is only partially offset by the tax increase related to EEMs and other benefits, such as carbon savings. In this scenario, the State triggered the development of the economic system, enabling the achievement of positive effects for several stakeholders, specifically EEVC players and energy users.

The EEVC players have obtained the greatest portion of benefits from the mechanism, achieving a net benefit of €4.9 billion, mainly due to the direct costs of EEMs implemented. The introduction of the WCS has led to a significant expansion of the Italian EEVC. For example, the number of ESCOs certified in compliance with UNI CEI 11352:2010 and further modifications increased from a few dozen in 2011 (i.e. one year after the introduction of the certification) to 272 in 2016. To also be highlighted is that 45 ESCOs out of 272 (16.5%) were founded after 2012 [69]. The achievement of UNI CEI 11352 certification may be considered a proxy of a player' ability to provide an integrated energy efficiency service, offer a contractual guarantee of energy efficiency improvements, and link the remuneration to energy savings achieved[3]. In light of the above, this growth can be seen both in terms of the numbers and the competences and skills of such ESCOs, as is also clear from analysing the evolution of the

[3] To be noted is that the WCS has been a stimulus for EEVC players to achieve UNI CEI 11352 certification, given that it has been a mandatory requirement for such players to act as voluntary parties since 18 July 2016.

technological portfolio ESCOs offered, with an increasing impact of more complex and customized EEMs (e.g. technologies for heat recovery in industrial processes) [50].

A similar impact is detected for energy users who experienced a net benefit of € 3.2 billion due to a very significant reduction in their energy bills (€ 16,713 million), offsetting all the costs they incurred (i.e. direct costs of EEMs and tariff contributions related to the WCS). Such net benefit is shared among industrial and non-industrial users, both achieving positive results. Around two-thirds of the net benefits are captured by non-industrial energy users (€ 2.185 billion), while the remainder are associated with industrial users. This is consistent with the amount of energy savings achieved by energy users through the WCS. In particular, about 32% of electricity savings and 56% of natural gas as well as other fuel savings in the analysed period refer to the industrial sector (the remainder to non-industrial users).

Nevertheless, to be highlighted is that the benefits achieved by energy users in terms of energy bill reduction are even higher, mainly for three reasons. First, as reported in Section 3.3.3, we calculated energy savings in the evaluation framework as additional savings generated by the implementation of EEMs, thus not as the mere difference between energy consumption before and after the implementation of EEMs (the former item is by definition equal to or lower than the latter). Second, EEMs typically have a useful life that is longer than the time horizon covered by the present study, thus enabling the achievement of further energy savings. Third, the evaluation framework does not account for several NEBs associated with the implementation of EEMs (e.g. noise reduction, labour and time savings, improved process control), as Worrell, Laitner, Ruth and Finman [70] highlight. Even though their measurement can be difficult, they have a significant role in influencing the investment decisions of energy users [39, 40].

Finally, utilities are the stakeholders with the highest negative cost/benefit balance associated with the WCS, equal to –5.1 billion €. This is mainly due to energy bill reduction (corresponding to a loss in utilities' turnover), which is only partially offset by the benefits achieved. Considering the last five years for which statistics are available (i.e. 2011-2015), we estimate that the reduction of energy marketed by utilities is less than 2% of the total annual turnover of these players associated with energy sales, highlighting the primary role the Italian WCS plays in achieving the national energy saving targets.

Worth highlighting is that, also thanks to the WCS, utilities increasingly consider energy efficiency as a growing business opportunity and have started offering related energy efficiency services. A recent analysis involving the main 22 Italian utilities shows that 18 have already established a division or a business unit offering energy efficiency services [68], half of which are pure energy sellers, while the other half operate both as energy sellers and distribution system operators (DSO). Furthermore, the number of companies in the sample without a division or a business unit providing energy efficiency services has halved from 8 in 2012 to 4 in 2016.

4.1. Sensitivity analyses

The average unitary cost of the analysed EEMs affects the estimation of two cost/benefit items included in our evaluation framework, namely, direct costs of EEMs and the related tax increases. As mentioned above, the data on the costs of EEMs collected through interviewing a significant number of utilities and players in the Italian EEVC show a rather small variance, in the +/–10% range compared to the average value. Therefore, in this section, we introduce a sensitivity analysis to evaluate two extreme cases (A and B), where the unitary cost of each reference EEM is respectively 10% lower and 10% higher than the average value, as reported in Table 6.

<<Table 6>>

In case A, assuming a country-level perspective, the lower average unitary cost of the reference EEM determines an increase in the net benefit from € 1.996 billion to € 2.268 billion (+14%). Energy users, given the reduced amount of money to be invested in EEMs, show the most significant improvement in their net benefits among the stakeholders analysed, from € 3.172 billion to € 4.100 billion (+29%), around two-thirds of which captured by non-industrial energy users (€ 2.831 million). On the other hand, EEVC players have suffered a worsening cost/benefit balance, although remaining largely positive. Finally, the State is negatively affected by the reduction in tax related to EEMs, while utilities are not affected by such reduction.

In case B, assuming a country-level perspective, the higher average unitary cost of the reference EEM determines a decrease in the net benefit from € 1.996 billion to € 1.724 billion (–14%). Energy users, given the higher amount of money required to be invested in EEMs, show the most significant reduction in their net benefit among the stakeholders analysed, from € 3.172 billion to € 2.244 billion, around two-thirds captured by non-industrial energy users (€ 1.540 billion), mainly for the benefit of EEVC players.

The results of the sensitivity analysis on the average unitary cost of the reference EEMs point to the high level of robustness of the results in the application of the multi-stakeholder evaluation framework to the Italian WCS. Indeed, from the sensitivity analysis, the variation of the unitary cost of reference EEMs within the evaluated range does not produce a remarkable variation of the overall net benefit and the benefits associated with each stakeholder.

5. Concluding discussion

The development of a multi-stakeholder evaluation framework and subsequent application to the analysis of the economic efficiency of the Italian White Certificates Scheme from the perspective of the main stakeholders shows that the introduction of the White Certificates Scheme in Italy in 2005 has generated a significant net benefit at the country-level. Nevertheless, while at the country-level the White Certificates Scheme has led to remarkable positive results, the economic efficiency for stakeholders is heterogeneous. In particular, our analysis shows that Energy Efficiency Value Chain players and energy users derived the largest share of benefits generated by the scheme.

On the one hand, the Italian Energy Efficiency Value Chain players undoubtedly benefited from the introduction of the White Certificates Scheme. The net benefit of €4.9 billion, mainly due to the implementation of Energy Efficiency Measures by Energy Efficiency Value Chain players, enabled a significant growth in the number and competences of such players [50]. Energy users experienced a similar positive impact, mainly due to a very significant reduction in their energy bills (€ 16,713 million). For such stakeholders, the White Certificates Scheme is a valuable opportunity to increase their competitiveness vis-à-vis local and foreign competitors, especially in the industrial sector. In addition, White Certificates enable overcoming one of the main obstacles of the adoption of Energy Efficiency Measures [71], i.e. the very short pay-back time threshold typically set by industrial firms to evaluate the economic viability of energy efficiency [72].

On the other hand, the State and utilities have suffered a negative cost-benefit ratio. Regarding the former, the State introduced the White Certificates Scheme as one of the main tools supporting energy transition in Italy, as highlighted by the recent national energy strategy [19] and in line with the long-term European goals to tackle climate change [73]. Regarding utilities, their negative balance has been mainly caused by the reduction of energy sales due to the improved energy efficiency of end users, which is one of the main objectives of the White Certificates Scheme. In addition, as obligated parties, utilities are unable to implement the mechanisms voluntarily, i.e. following a market logic. However, the White Certificates Scheme has provided a stimulus for utilities to evolve their business model towards the integration of energy efficiency services in their offer portfolio, targeting energy efficiency as an important business opportunity, and *de facto* triggering a transformation of their business model towards those typical of Energy Efficiency Value Chain players. For instance, as emerged from the discussions in the workshops, in 2017, one of the main Italian energy utilities decided to rethink its competitive strategy with the aim of strengthening customer relationships by designing and offering new solutions and energy services enabled by digital technologies (e.g. advanced energy monitoring systems for industrial processes and buildings). In this regard, utilities have recently navigated several disruptive changes in their traditional way of doing business, such as the decreasing cost of distributed generation, increased interest in demand-side management, shifting government policies towards renewable energy incentives and higher electricity prices [74, 75]. As discussed in the literature, to remain competitive, utilities must go beyond their traditional business models based on the supply of an energy commodity and start delivering a broader and more integrated bundle of services to their customers [76–80]. In this context, our analysis suggests that the Italian White Certificates Scheme, as a policy introduced to support energy transition, has created an indirect incentive for utilities to innovate their service offering, therefore facilitating the transformation of their business models in light of the aforementioned disruptive factors [81, 82].

The entry of utilities in the energy efficiency market is a significant competitive threat for incumbent Energy Efficiency Value Chain players. Utilities have the opportunity to exploit their slack financial resources to support the implementation of Energy Efficiency Measures and their existing relationships with energy end users. This may occur despite typically suffering competitive disadvantages linked to the lack of specific Energy Efficiency Measure competencies and skills, especially those less standardized in the industrial sector. To close this gap, some Italian utilities have started a series of mergers and acquisitions deals aimed at acquiring and integrating Energy Efficiency Value Chain players - mainly Energy Service Companies – to accelerate the transformation of their business model [69]. Indirectly, this flow of deals has also been stimulated by the effects of the White Certificates Scheme.

Our findings offer suggestions for policymakers on the pros and cons of White Certificates Schemes that are useful when designing new or modifying existing energy efficiency incentive schemes. In particular, the multi-stakeholder evaluation framework proposed in this study provides a more integrated, comprehensive perspective to evaluate the economic efficiency of White Certificates Schemes worldwide. Recent studies aimed at providing policymakers with guidelines for designing or revising their national White Certificates Schemes have focused mostly on the main design choices, such as type of Energy Efficiency Measures, obligated parties, actors involved, and target setting [83, 84]. However, they have largely overlooked the analysis of the (expected) impact of introducing the schemes on all stakeholders. Our findings suggest that such implications should be carefully considered, given their potential high magnitude and impact on the economy. Furthermore, our results may have implications on how Italian authorities define the additionality criterion, which plays such an important role in the functioning of the White Certificates Scheme. The discussion should encompass considerations based on the whole energy system (see, e.g. Di Santo [84]), which policymaking research should pay greater attention to.

As for industrial policies, our study points to the relevance of possible external drivers, promoted by external stakeholders, for the successful implementation of Energy Efficiency Measures [85, 86]. Furthermore, our analyses seem to reveal the importance of further considering the role of Non-Energy Benefits, following recent research [39, 40], so as to more specifically tune incentives towards the promotion of Energy Efficiency Measures.

Some limitations of our evaluation framework should also be highlighted, which could lead to further improving the model. First, our calculations, although considering a large portion of the issues of the White Certificates Scheme in the period 2006–2016, do not refer to the total amount of White Certificates issued nor to the whole set of possible Energy Efficiency Measures for which White Certificates have been issued. Further specific information on other Energy Efficiency Measures not considered in our study, along with their specific costs and benefits, would enable broadening the scope of our analysis. Second, the inclusion of indirect Energy Efficiency Measures costs (such as for project development) may add a further important improvement to our framework, despite the well-known difficulties in collecting or estimating these types of costs. Third, the inclusion of other Non-Energy Benefits in the White Certificates Scheme evaluation framework, beyond avoided CO_2 emissions, would be interesting, albeit quite complex [2]. Similarly, we do not account for the avoided electricity distribution losses or the avoided costs of electricity grid expansion for transmission and distribution system operators. Finally, more details could be added to calculating the administrative costs, even though our preliminary results seem to suggest that they account for a very minor portion of total costs. For instance, administrative costs could be better assessed by considering the number of full-time equivalent employees working in the different regulatory authorities involved in managing the White Certificates Scheme as well as their salaries, even if very detailed information would be required. These improvements to the evaluation framework would enable policymakers to perform a holistic evaluation of the economic efficiency of a White Certificates Scheme by recognizing other important reasons – beyond energy saving – driving the adoption of Energy Efficiency Measures [87].

The last avenue for future research is the application of our evaluation framework in other countries in which White Certificates Schemes have been adopted. However, given that each national scheme has been adapted to suit the idiosyncrasies of the local context, e.g. in terms of different energy market structures and regulations [88, 23, 46], the results from applying our framework should be compared with caution.

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Appendix

Table A.1

Table A.2