How to ascertain a reasonable obligation level in an energy efficiency obligation scheme: between too little and too much

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Abstract

Since its implementation in 2005, the French EEO scheme has gone through 4 levels of obligation and is preparing for a fifth in 2022. At each period, the consultation showed disagreements between stakeholders to specify the level of obligation for the next period. In 2019–2020 adjustments have been necessary to enable the achievement of the obligation. Different approaches could be implemented to determine the obligation:

- To set the obligation level to fulfil the requirement of the article 7 of the Energy Efficiency Directive.
- To assess the necessary obligation level in order to achieve an energy policy target (e.g. carbon neutrality in 2050 and building mass-retrofit).
- To simply extend the trend thanks to sufficient historical hindsight today without questioning the context.
- To assess the technical energy-savings potentials and accessibility.
- To propose an economic analysis by taking into account market volumes and the level of financial incentive paid by all households for the investments to be triggered.

Some drawback of these methods will be discussed (energy vs. carbon target, contribution of an EEO scheme to a climate policy, lack of economic assessment or understanding of the main driver of an EEO scheme …) and comparative advantages will be presented.

The purpose of this paper is to question the different approaches to open the debate and underlines the necessity to include economic analyses to define an adequate level of obligation. A certainty is that changes in the operating conditions during the EEO period for the purpose of achieving the obligation level lead to uncertainty, and do not secure nor energy savings achievement and nor carbon savings in the long term. Moreover, a self-fulfilling obligation scenario based on price as an adjustment variable is not enough reliable to sustain the scheme. This means that a low EEO price leads to a lack of incentives for customers and a high EEO price leads to a too high cost on the energy bill.

Introduction

Energy efficiency (EE) is one of the pillars of the climate and energy policy thanks to its multiple potential advantages (energy and bill savings, GHG (Green House Gas) reduction, Non Energy Benefits[1] …) and is supported by the European "energy efficiency first" strategy (European Commission 2019).

Within this framework, the Energy Efficiency Obligation schemes (EEOs), a.k.a. Tradable White Certificate or Energy Savings Certificate (Bertoldi et al. 2008), are one of the main policy tools and constitute the policy scheme quoted in the article 7 of the Energy Efficiency Directive (EED) (EED 2012).

The EEO schemes have been part of widespread market mechanisms in many countries (Rosenow et al. 2017) for a very long

1. Like green value, increase of comfort, reducing of heath trouble.

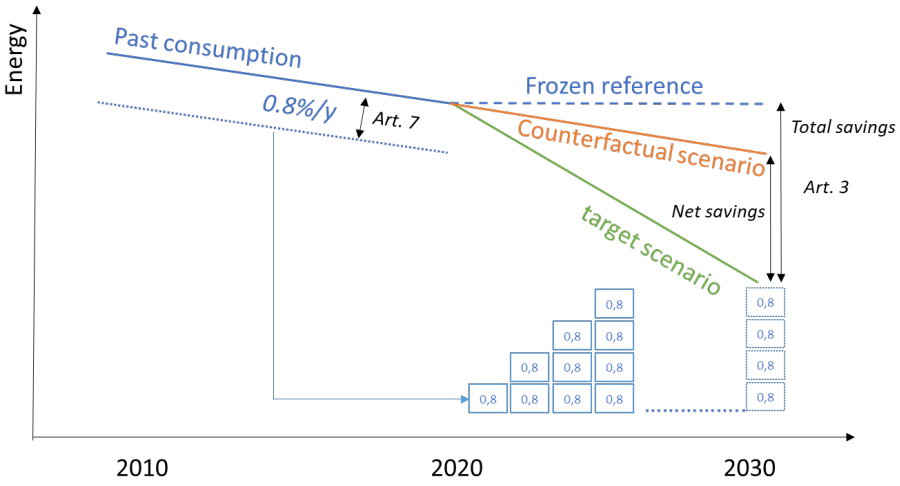


Figure 1. Schematic depiction of the calculation of energy savings in the EED according to article 3 and article 7 (see EMEEES 2008 for details).

time (Bertoldi et al. 2010). To date, 15 European EEO schemes are identified and 54 worldwide (IEA 2017). It should be noted that some European countries (Belgium, Denmark, France, Italy and the UK) implemented an EEO scheme before the EED came into force in 2012.

From a theoretical economic viewpoint an EEO scheme may seem simple in as much as it relies on a combination of a tax on energy suppliers and a financial incentive for EE actors (Bye & Bruvoll 2008) with a "low hanging fruit" strategy.

However, the life of an EEO scheme is not without obstacles. For example in the case of the UK scheme (DBE&IS 2018), the customers targeted change over time, by ending the carbon-focused Carbon Emissions Reduction Obligation and by increasing the part of the scheme focused on low income and vulnerable households, the scheme becoming fully focused on these last groups in the ECO3 period (2018–2022).

Concerning the Danish scheme (Petersen 2018), criticism has been heard about fraud, cross-subsidising, transfer pricing and lack of incentive to reduce the cost. These findings led to the termination of the scheme at the end of 2020 and the proposal of a new scheme (tender model targeting only the industry sector).

THE ENERGY EFFICIENCY DIRECTIVE

Concerning the future of energy consumption at the EU level, the main document is the EED and especially the article 3 and article 7 detailing the obligation of energy savings for the period 2021–2030 to be applied for each Member States. Subsequently, it is possible to use these objectives as a basis for defining levels of obligation to achieve them, depending partly on how much a public body wishes to contribute to an EEO scheme.

As a minimum, the level of obligation must achieve the annual savings required under the article 7 of the Energy Efficiency Directive. The amended directive in 2018 states that EU countries will have to achieve new energy savings of 0.8 % each year of final energy consumption for the 2021–2030 period (European Commission 2021a) (Figure 1). This article 7 highlights the obligation for Member state to put in place an EEO scheme even if alternative policy measures are possible (Carbon tax, support fund …) (EED 2012).

ENERGY EFFICIENCY OBLIGATION: A SCHEME WIDELY USED TODAY

An EEO scheme is generally defined by primary principles:

- An obligation level (e.g. the target to achieve) and a division of this obligation among obligated parties according to an allocation key. This target could be expressed in different units: carbon emission in $MtCO_2$ like in UK (Abraham 2013), energy savings in kWh like in France (Osso et al. 23019) and Ireland (SEAI 2014); or tonne of oil equivalent (toe) like in Italy (Di Santo & De Chicchis 2019) and Poland (Deloitte 2021) These annual units could be cumulated over lifetime (or over a reduced period of time) and discounted at a low rate.
- The obligated parties: usually utilities (energy retailer or wholesaler or distributor) on which the fulfilment of the obligation is based upon.
- A portfolio of EE actions eligible to implementation in different chosen sectors (residential, tertiary, transportation, industry, agriculture …) and/or customer types (e.g. fuel poor).
- A certification and control procedure managed by a public body (a.k.a. regulator) to validate obligation fulfilment and in some scheme deliver certificates.
- A penalty in case of non-compliance with the obligation and a buy-out price for paying the fund when completing a part of the obligation.
- A cost recovery mechanism (pass-through of EEO costs to utilities' customers).

There are also some optional principles:

- A marketplace and/or bilateral agreement to exchange EEO certificate potentially limited to obligated parties or open until to trading companies.
- Authorized companies (aka eligible or delegate parties) to deliver EEO certificate without any obligation like energy consulting companies, ESCOs, public authorities, social housing organization, company with energy management …

Table 1. EEO national obligation level and certificates delivered since the beginning of the scheme (as of 1st April 2021) (MTE 2021a).

Period	EEOs obligation (TWhc)		EEOs delivered (TWhc)	
	Standard	Low-income	Standard	Low-income
2006–2009	54	none	65	–
2010	none	none	164	–
2011–2014	465	none	634	–
2015–2017	700	150	1,249	175
2018–2021	1,600	533	2,043	789
2022–2025	1,770	730	–	–

Note: this table do not take into account the stock of certificate filed in the national registry but not yet issued (287 TWhc).

- A sub-obligation dedicated to fuel poverty (or low-income households).

The objective of this paper is to present the methods for defining a level of obligation in the context of an EEO scheme. To do this, we will use the French case as a case study. In the first section we will present a short description of the French EEO scheme that will serve as an example for our study. In the second section, the way of assessing an obligation level based on policy objectives (top-down) will be presented. In the following third section, the different methodologies used to assess an obligation level on the basis of bottom-up analysis will be reviewed.

THE FRENCH EEO SCHEME

As there is a lot of already recent papers concerning the French EEO scheme[2] (Giraudet et al. 2015, Osso et al. 2019) we will limit our general description to the following elements:

- The obligated parties are the energy retailers and there are delegate parties involved in the scheme.
- The unit of EEOs in expressed in kWhc (annual energy savings cumulated over lifetime and discounted at 4 %).
- The obligation amount is announced for a three- or four-year period by the MTE (Ministry of Ecological Transition). Since 2016, an additional fuel poverty obligation of +33.33 % is added to the standard obligation (low-income EEOs) (+41.24 % after 2022 (DGEC 2021)).
- The national register of EEOs allows exchange[3] of certificates and there is also a private marketplace[4].
- The cost of the EEO scheme is paid mainly by households on their energy bills.

Since its inception in France, the French EEO scheme, which drives notably building retrofit, undergone to a growing obligation[5] in each new period from an annual obligation of 18 TWhc/y in 2006 to 533 TWhc/y in 2021 (Table 1). The scheme has experienced different historical phases with low or more recently high prices (from €1.41/MWhc to €8.35/MWhc) that show different contexts reflecting in a first approximation the ease or otherwise of fulfilling the obligation (Osso et al. 2020). To date (i.e. 1st February without taking account the EEOs not yet processed[6]), 129 % of the low-income obligation is met compared to 77 % for the standard EEO obligation.

It should be noted that in each period of obligation, the modality and content of the EEO scheme show evolutions and several revisions that can impact the achievement of the obligation. For example, energy savings per EE action are regularly reviewed (often downwards), some EE actions are stopped (MTE 2021f). At the opposite, additional bonuses per action are put in place to help certain EE actions and new EEO eligible EE actions and accompanying programs are created.

Thus, the level of obligation to fulfil is of great importance and impacts for all stakeholders (obligated parties, delegate parties, customers, public body). Recently, the criticism of setting an obligation level disconnected from economically accessible energy savings potentials was noted in an inter-ministerial evaluation report (Assemblée Nationale 2021).

The different strategies to assess the obligation level

Concerning the obligation level, in France it is defined by a public body (e.g. ministry of energy) after a concertation phase between stakeholders. How this obligation level is set is not so well documented and, based on the French experience, we will present the various methodologies that could be applied.

From a general viewpoint, the *ex-ante* methodologies used to estimate an obligation level for an EEO scheme could be based on one hand, on a policy target in a top-down approach, and on the other hand, on energy savings potential in a bottom-up approach.

In this paper, we suggest ways to estimate an obligation level through an economic analysis based on the ratio of subsidy to up-front cost (i.e. coverage rate) in order to improve the analysis of EEO potential in a bottom-up approach.

ARTICLE 7 OF THE ENERGY EFFICIENCY DIRECTIVE

Relying on an EEO scheme is the way that France choose to fulfil his article 7 obligation as explained in the last French NECP (National Energy and Climate Plans): "the cumulative volume of energy savings expected from the EEO scheme for the period 2021–2030 will be at least equal to that of the energy savings obligation […] for the period 2021–2030 under Article 7 of Directive 2012/27/EU. France does not envisage, at this stage, resorting to alternative public policy …" (NECP 2020).

2. Named in French: "Certificat d'Economie d'Energie".

3. Powernext, https://www.emmy.fr/public/accueil.

4. C2E maket, https://www.c2emarket.com.

5. The French certificates are expressed in kWh of energy savings cumulated over lifetime and discounted (4 %) (i.e. kWhc).

6. And, with the stock of unprocessed EEOs, obligation fulfilled to 178 % for the low-income and to 100 % for the standard EEOs (MTE 2021a).

Concerning, the French case study, the calculation could be based on the past 2017–2019 consumptions (i.e. a reference volume of 141 Mtoe per annum) (MTE 2021b). Thus, the calculation of energy savings to fulfil the article 7 in the French EEO framework is:

$$EEO = EED_{art.7} * C_{reference} * 11.628 * DF^{4\%} \quad (1)$$

with:

EEO	volume of certificate to be issued (in TWhc/y)
$EED_{art.7}$	level of energy savings (i.e. 0.8 %)
$C_{reference}$	average past reference consumption 2017–2019 (in Mtoe)
$DF^{4\%}$	discount factor to consider the savings cumulated over the lifetime[7]

It should be noted that the French EEOs are expressed as cumulative energy savings over the lifetime of the implemented action and discounted (4 %) to account for the lower value of future energy savings. This equation leads to an annual EEO obligation level of 210 TWhc/y, or about 40 % of the current obligation (i.e.[8] 533 TWhc/y in 2018–2021). Over the 2021–2030 timeframe, the cumulated energy savings have to be 62 Mtoe (Figure 1). As the average lifetime of the implemented actions under the EEO umbrella is around 25 years, we could consider in a first approach that the energy savings initiated in 2021 and after are still effective in 2030 to fulfil the requirement of the article 7.

These lower energy savings required by the EED than the current EEO scheme's obligation level show that the French scheme has other national targets. We must keep in mind that a share of the EEO issued today are not pure energy savings but are also subject of bonus (31 % in 2018–2020) to target dedicated customers and accompanying programmes (e.g. information, training …) without direct savings (9 % in 2018–2020) (MTE 2021e).

ARTICLE 3 OF THE ENERGY EFFICIENCY DIRECTIVE

The European target of -32.5 % of energy consumption in 2030 at the EU level set in the article 3 of the EED, must be translated at a national level and this contribution is usually presented in the NECP of each country.

According to France's latest NECP published in March 2020, France has set itself the dual target of reducing its energy consumption to 120.9 Mtoe of final energy and 202.2 Mtoe of primary energy in 2030 (NECP 2020).

If we compare the target of 120.9 Mtoe of final energy in 2030 with the reference consumption (141 Mtoe), the energy to be saved is 20 Mtoe (total savings). It should be noted that in the absence of a counterfactual scenario, to our knowledge, we are unable to calculate net savings. However, as the national consumption is relatively stable in the last years (MTE 2020a), the difference between the counterfactual scenario and the "frozen reference" remains low.

This volume to be achieved over the period 2021–2030 leads to an annual saving of 2 Mtoe/y. Translated into EEO according to Equation 1, this 371 TWhc/y is corresponding to 69 % of the current EEO annual obligation[9]. We must keep in mind that this consumption reduction will be obtained by a policy mix with various measures[10] (regulation, taxation, EEO …). But such approach leads to make a single scheme responsible for the whole energy policy.

OBLIGATION IN ORDER TO ACHIEVE AN ENVIRONMENTAL POLICY

The level of obligation level could be assessed to contribute to the climate change policy targets like the carbon neutrality in 2050 which is the long-term strategy of the EU (European Commission 2021b). But it must be translated into final energy savings compatible with the requirement of the article 7 of the EED assuming that the EEO scheme remains the tool to fulfil the article 7 obligation. Indeed, EE is one of the measures to reduce GHG emissions but not the unique one. Climatic objectives intend to reduce drastically the final energy consumptions but also to expand low-carbon energy solutions (MTE 2020b).

This means that EEO eligible actions need to be assessed in terms of carbon reduction (Green House Gas savings) and not only in terms of final energy. Consequently, two terms of the Equation 2 must be considered: energy savings and potential additional carbon savings in case of energy switch:

$$GHG_{savings} = \left(C_{initial} - C_{final}\right) * EF_{final} + C_{initial} * \left(EF_{initial} - EF_{final}\right) \quad (2)$$

with:

$GHG_{savings}$	Green House Gas savings (in gCO_2).
EF	Emission Factor of energy (in gCO_2/kWh).
C	energy consumption before ($C_{initial}$) or after (C_{final}) EE action (in kWh).

Thus, we estimated the value of 47 $MtCO_2$ of GHG avoided of an energy saving of just over 200 TWhc in the residential sector based on Equation 2 for the most implemented EE actions. Moreover, the GHG assessment could help to subsidize EE actions not enough valuated by the final energy but with great impact on carbon emissions (e.g. fuel switching). In the residential sector, the EE action concerned is the installation of an air-to-water heat pump instead of a boiler.

Thus, some French policy objectives, such as fossil fuel reduction, cannot be directly translated into the current EEO obligation, but need to be addressed at a lower level by promoting specific measures under the EEO scheme through specific programmes[11]. For this purpose, the programmes provide energy savings overvalued by bonuses[12]. But this leads to a double accounting imposed by the need to separate the energy savings eligible for EED from the bonus for fossil fuel mitigation (MTE 2021). In order to go one step further in the integration of carbon consideration, it would be necessary to review thoroughly the

7. For the period 2018–2019, the weighted average discount factor is equal to 16 (equivalent to a lifetime of around 25 years).

8. By counting only the standard EEOs and without the low-income EEOs (corresponding to an additional obligation of +33 %).

9. The obligation for the next period (2022–2025) should be of the same order (i.e. 612 TWhc/y).

10. According to the reference scenario of the PPE-SNBC: "taking into account all the measures resulting from the PPE and others not yet arbitrated to come" (NECP 2021).

11. For example, this is one of the objectives of the "Helping hand energy saving bonus" programme which provides a premium for EE actions (see Osso et al. 2020 for details).

12. Different targets in these programmes: reduce GHG (especially fuel oil), enhance issuing of EEO certificate, lower the market price.

functioning of the EEO scheme. These GHG objectives could be also in line with the EU-ETS revision that could include buildings and transportation (Taylor 2021, Stenning et al. 2020).

EXTRAPOLATING AN HISTORICAL TREND

In case of a lack of detailed data[13], a rough methodology consists in extrapolating the historical rate of EEO issuance (observed over a past period) according to different scenarios (e.g. low, median and high). To construct each of these scenarios without any modelling details, some mathematical function could be used: a bottom-up approach for each energy efficiency action or a top-down approach at the overall EEO level.

The drawback of this methodology is that it needs historical data of an existing energy policy scheme. Moreover, this is a "black box" approach without any added value (in terms of knowledge of the EEO drivers which require regular updating in accordance to changes in the EEO scheme).

Such a methodology is used to assess the future potential of French EEO in the tertiary sector (Suaud et al. 2020) but appears to be the last resort in case of a weak knowledge. This may explain why the energy savings potential for the tertiary sector has varied greatly over time in French studies (Table 2).

THE ENERGY SAVINGS POTENTIALS

The concept of energy savings potential could be a good framework to assess an attainable level of EEO obligation. However, the notion of energy savings potential is very broad and it is necessary to define what type of potential is being used:

- The technical potential: based on the possible energy savings using the Best Available Technology (BAT) without any other consideration.
- The techno-economic potential: the share of the technical potential with an acceptable economic return according to an economic actor.
- The accessible potential: the techno-economic potential which may be subject of an EEO certificate. In the assessment of the techno-economic potential accessible to the EEO scheme, we include the detailed price or economic dynamic linked to the EEO scheme. This methodology is still in its infancy and tends to be more innovative.

The technical potential

The assessment of the technical potential is of little use in estimating a level of obligation although there seems to be a possible consensus on its evaluation (Lefebvre 2012). The technical potential relies on a fine description of the buildings stock and current characteristics or equipment consuming energy, their consumption and their energy efficiency. To replace inefficient solutions with effective ones (BATs) and the assessment of energy savings is fairly straightforward but does not explain how much and how quickly this potential is being accessed.

For example, the technical potential of energy savings was assessed at 7,100 TWhc with a techno-economic potential of 300 TWhc/y (Lefebvre 2012), i.e. 24 years to exhaust the potential in a linear evolution. But this approach gives us any information about the rate of exhausting[14].

This methodology is used to assess the technical potential in the transportation sector (Suaud et al. 2020). The assessment of the amount of certificate that can be achieved through the EEO scheme is subject to separate scenarios based on past EEO certificate issuance and the evaluator's expertise on the possible use of BAT in the vehicle fleet.

The techno-economic potential

The assessment of the techno-economic potential (ADEME 2016, Suaud et al 2020) is generally based on the knowledge of the market of the concerned EE action and the level of efficiency implemented:

$$EEO_{techno-economic} = Q * G_r * EEO_{unitary} * EE_l * M_c \quad (3)$$

with:

$EEO_{techno-economic}$	techno-economic potential (in TWhc/y)
Q	quantity of unit sold in the market (in unit/y)
G_r	growth rate of the market (in %)
EE_l	level of EE to be eligible to subsidy (in %)
M_c	market capture of the EEO scheme (in %)
$EEO_{unitary}$	amount of certificate for an EE action implemented (in kWhc/unit)

Such methodology is used by ADEME[15] to assess the potential of EEO in order to prepare the level of obligation (Suaud et al. 2020). The ADEME study refines the analysis by taking into account different sub-potentials:

- Baseline: the current situation considering the current EE market and the EE actions eligible to an EEO subsidy (trend situation).
- Performance improvement: transformation of the EE actions with a too low efficiency to a higher level eligible to an EEO certificate (market transformation).
- Professionalization: transformation of EE action achieved by households (Do It Yourself[16]) to the professional market (market enlargement).

Such studies are difficult to carry out with complete objectivity as some variables are difficult to appraise and could depend on the perception and perspective of the analysts[17]. Besides, economic data are not always well-known and subjected to many market drivers (e.g. evolution of the different incentive schemes …). As an example, the techno-potential of EEOs for the period 2022–2025, is estimated at 500 TWhc by ADEME whereas 287 TWhc according to EDF's study (EDF 2020). In fact, this type of approach depends on the context (EEO current price, will of the public authorities …) and the techno-economic potential could vary over time including within the same entity (Table 2). Obviously, as long as the obligation level

13. Like market analysis, description of the existant energy efficiency state, energy consumption.

14. Concerning energy renovation, more than 20 million homes will be concerned by 2050, and a potential 14 billion euros per year (BATIRAMA 2021).

15. Agency for the Environment and Energy Management.

16. Concerning the Single Family Housing (SFH), around 30 % of the retrofit is done by DIY (Descoeur & Meynier-Millefert 2021).

17. "Prospective studies are most often carried out for a target audience, they illustrate a discourse or reinforce a message. At the very least, the authors have constraints to respect. The signature is therefore important" (Laurent et al. 2011).

Table 2. Evolution of the techno-economic potentials according to the year of realization (triennial evaluation) (Lefebvre 2012, ADEME 2016, Suaud et al. 2020) (in TWhc).

sector	year 2012	year 2016	year 2019
Residential	629	700	1,030
Tertiary	14	270	75
Industry	38	210	247
Transportation	165	50	50
Agriculture	20	10	27
Others	25	35	72
Total	891	1,275	1,501

Table 3. Evolution of the French boiler market (Uniclima 2021), standard EEO issued (BAR-TH-106) (MTE 2021c) and assessed EEO subsidy.

	2015	2016	2017	2018	2019
Total boiler sold (unit)	594	600	631	661	598
Efficient boiler (unit)	396	454	488	544	515
EEO issued (TWhc)	7.38	5.97	2.47	2.54	5.61*
EEO subsidy (€)	210	140	159	250	392
EEO index price (€/MWhc)	2.69	1.82	3.25	5.20	7.13
EEOs/EE action (MWhc)	78	77	49	48	55

** Estimated.*

is supposed to increase, the entire techno-potentials increase, but the sectorial breakdown is very sensitive. The techno-economic potentials fluctuate from one assessment to another for the tertiary and agricultural sectors. Meanwhile, the industrial and residential ones grow steadily.

In addition, the techno-economic potentials may change following consultation with stakeholders. These exchanges can lead to the revision of the calculations, consequently to stakeholders' contestation, and to all evidence the latter could provide to the public authorities (Baïz 2018).

A retrospective analysis of these evaluations made in 2016 to assess the level of obligation for the period 2018–2021 enables to gauge that looking ahead is complex and at least uncertain. At a disaggregated level (i.e. EE action), there are examples of EEO certificates delivered below the assessed techno-potentials, but others issued over the assessment even if they do not compensate value for the EEOs not realised in absolute. Such partial compensation between opposing errors are observed also in energy demand prospective study (Laurent et al. 2011).

The efficient boiler

In order to study retrospectively the correlation between an *ex-ante* techno-economic potential and the EEO issued, the efficient boiler case is a good example because the overall market of boiler is relatively stable. Inside this market, the trend of efficient boiler (i.e. condensation) increases over time (i.e. EE_l in Equation 3) (Uniclima 2021). Thus, we must expect that the issuing of EEO certificate follows the same trends if the market capture (M_c) remains constant.

Unfortunately, the amount of EEO certificate issued does not follow the increasing trend of the efficient boiler market. The evolution of the EEO certificate seems more in line with the subsidy: a decrease followed by an increase (the subsidy being the product of the number of EEO certificate per EE action and the EEO index price – see Equation 4). The market capture rate therefore seems to vary according to the subsidies.[18]

The accessible energy savings potential

In the particular framework of an EEO scheme, it is reasonable to ask what are the criteria that make an actor commit to the scheme, beyond his interest in an EE actions. Indeed, an action may be interesting in itself but not very interesting to integrate into an EEO scheme, reducing the techno-economic potential accessible to the scheme to none.

Then we propose an economic analysis of the EEOs by taking into account the indirect costs of an EEO certificate beyond the financial incentive as an EEO scheme is a market-based instrument (e.g. "the low-hanging fruit will be harvested first"). Two different costs must be taken into account: one is the transaction cost for the customers, the other is the administrative cost for the obligated parties.

To our knowledge, the level of incentive ($P * E_s$) compared to the up-front cost (CAPEX), defined as the coverage rate (C_r), is the one that makes customer sense:

$$C_r = \frac{P * E_s}{CAPEX} \quad (4)$$

with:

C_r coverage rate (in %)
$CAPEX$ capital expenditure (up-front cost of the EE action) (in €)
P price of the EEO certificate (in €/kWhc)
E_s cumulated energy savings (in kWhc)

18. Table 3: Evolution of the French boiler market (Uniclima 2021), standard EEO issued (BAR-TH-106) (MTE 2021c) and assessed EEO subsidy. Calculated as: average EEO/EE action * weighted EEO index price.

If the coverage rate in too low, and even if the EE action is cost-effective from the customer perspective, there is no incentive to ask for an EEO subsidy, especially if filling an application file is complex and time consuming (as it is in the French case – see Osso et al. 2019 for details about the constitution of an EEO file). A study indicates on this point that almost one household out of two has not consciously chosen the valuing of its EEO subsidy (Descoeur & Meynier-Millefert 2021).

We must notice that the EEO subsidy depends on two factors: the energy savings of the action (in kWhc) and the EEO market price (in €/kWhc) and is then time dependant according to market fluctuations and update of the EEO energy savings of an EE action.

To solve this thorny issue of coverage rate, the market price of the EE action must be known. And beyond an average cost, the price variations and what constitutes them need to be analysed as we observed large market price distribution and uncertainty (Osso et al. 2018, Vouillamoz et al. 2018).

On the obligated parties' side, the interest in proposing an incentive offer according to the administrative cost (the amount of EEO delivered by each EE action) is crucial. Indeed, *ceteris paribus*, it is strategic for obligated parties to propose EE actions that yield the most EEO and cost the least to administer. However, in the residential sector, many EE actions yield little EEO certificate compared to other sectors.

Finally, it should also be reminded that, in the EEO framework, renovation works must be carried out by a certified installer (RGE label[19]), but only 65,000 construction companies are qualified among the 320,000 existing ones, decreasing the potential of issuing EEOs showing an insufficient number of RGE-labelled companies to produce enough EEO eligible retrofit. We can highlight that many professionals say not to want a label that does not necessarily lead to a new and sustainable market for them. EEO certificate production problems are also linked to weak implementation capacities in the field, which depend on an insufficient number of companies (Descoeur & Meynier-Millefert 2021).

The double glazing windows

An example in the French EEO scheme of a too low coverage rate for customer and a too high administrative cost for obligated parties concerns the double-glazing windows. For a household, the subsidy for a new double-glazing window is around[20] €46 with an average up-front cost of €1,000, i.e. a coverage rate of less than 5% (for a very low-income household[21] the coverage rate is around 9 %).

The amount of EEO per window is between 2.8 MWhc and 8.2 MWhc according to geographical location (north vs. South) and space heating energy (electricity vs. fossil fuel) (MEDDE 2021). The window renovation market is estimated at 6 million units with a growing rate of 1.2 % from 2017 to 2019 (P&P 2020). However, the double glazing windows accounted for 2.3 % of issued EEO certificates in the first semester of 2015 (i.e. 1,634 GWhc, rank #9), but only 0.6 % in the first semester of 2019 (i.e. 679 GWhc, rank #29) despite a higher obligation (MTE 2021c).

To put this in perspective, the average EEO file for window concerns 4 installed units, i.e. at best 32.8 MWhc per renovation site. This should be compared with the roof insulation action[22] that provides at best 132.6 MWhc (MTE 2021d) (without considering the bonus of the programme with the possibility of €1 commercial offer). Moreover, the administrative costs of both EE actions are identical.

Conclusion and policy implication

At the beginning of an EEO scheme, the level of obligation is generally low in order to set up the scheme and learn how to run it (ENSPOL 2015). But after this trial period and an increasing level of obligation, it appears a need to provide robust evidence for the estimation of the obligation. In this context, we presented different methodologies that could be used to assess the obligation in order not to jeopardise the EEO scheme. These methodologies are complementary and it is necessary to further develop them in order to assess the right level of obligation.

For this purpose, 2 types of approaches are possible:

- Top-down methodologies based on energy or climate policy objectives, with the obligation calculated to achieve a given target. This approach can be used to calculate the minimum level of obligation to meet a directive.
- Bottom-up methodologies based on the knowledge of the EE market and the capacity of the EEO scheme to exploit part of it. This This approach can be used to calculate the maximum level of obligation consistent with the market.

In both cases, it is necessary to make assumptions (i.e. scenarios) about the future capacity of the EEO scheme to deliver enough certificates. These assumptions are currently based more on an evaluator's estimate than on economic modelling especially for the bottom-up methodologies.

If the top-down methodology is rather straightforward, the bottom-up methodology is more time and data consuming. But based on the French case, we can show that there is not a direct correlation between the obligation of the EEO scheme and the obligation defined by the EED (lower obligation from EED).

Meanwhile, the more the bottom-up method is based on few data (i.e. technical potential, extrapolation of renovation trend, retrofit market …), the more the estimates fluctuate over time (Table 2). For this reason, we have proposed ways to estimate through an economic analysis based on the ratio of subsidy to up-front cost (i.e. coverage rate) in order to improve the analysis of EEO potential. Indeed, beyond the global economic analysis (market level), it is necessary to carry out a more detailed economic study at the level of the EEO scheme itself.

However, such approach is not shared by all stakeholders. (Suaud et al. 2020) consider that the level of obligation for a given period is one of the major parameters affecting the price and that the "the market" should lead to an equilibrium price

19. In French : "Reconnu Garant de l'Environnement" meaning Recognised as an Environmental Guarantor (https://www.ecologie.gouv.fr/label-reconnu-garant-lenvironnement-rge).

20. https://prime-c2e.com; https://prime-travaux.cdiscount.com; https://www.primesenergie.fr.

21. Annual income <€21,000.

22. With an average of 78 m^2 of insulated area.

corresponding to an optimal incentive for the customer at an "optimal cost" for the obligated party. In their opinion, the price is an endogenous factor, considered through the market capture (*Mc*) and the evolution of the EE markets (*Q* and EE_l). Moreover, in relation to the level of obligation set, the obligated parties will adjust their strategy for acquiring EEO certificates, which will also have an impact on the EEO price.

Even if this is true, we consider that the customer perspective (coverage rate and energy bill) is not enough taken into account as well as the EEO price limit which is the penalty. This may have consequences for the trade-offs between the actions promoted by the EEO scheme and those that are most profitable for both the client (high coverage rate) and the obligated party (low administrative cost), which will then diverge from the market capture estimates.

In these discussions about the link between the EEO price and the EEO obligation we are in the paradoxical situation of "the egg or the hen". Both types of analysis are beneficial. In conclusion, in case of a significant estimation error of the assessment of the obligation level, there are adjustment variables inside an EEO scheme that could possibly help to achieve the target:

- The EEO price (or the cost in the absence of a market) which increases the level of subsidy to customers (within the limit of the penalty). But with a cost recovery mechanism (pass through) the impact on customers' bills increases, which can be a problem in the long run.
- The creation of new EE action eligible for certificates in order to increase the energy savings potential.
- The creation of additional certificates that are not directly equal to energy savings (programmes, bonus …).

But with the feedback from experience, this makes the management of the EEO scheme even more cumbersome and sometimes significantly modifies the balance of the scheme to the detriment of the long-term vision necessary for the sustainability of the EE markets.

Moreover, a self-fulfilling obligation scenario based on EEO price as an adjustment variable is not enough reliable to sustain the scheme. This means that a low EEO price leads to a lack of incentives for customers and a high EEO price leads to excessive cost on the energy bills.

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