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By **Louis-Gaëtan Giraudet,** ENPC/CIRED
Dominique Finon, CNRS/CIRED

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Keywords: White Certificates Schemes, Static Efficiency, Dynamic Efficiency, Vertical Organisation, Policy Coordination

JEL Classification: Q4

Address for correspondence:

Louis-Gaëtan Giraudet
CIRED
45 bis avenue de la Belle Gabrielle
F-94736 Nogent sur Marne Cedex
France
E-mail : giraudet@centre-cired.fr

On the road to a unified market for energy efficiency: the contribution of white certificates schemes

Louis-Gaëtan Giraudet* (ENPC/CIRED) and Dominique Finon (CNRS/CIRED)

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We show that (i) white certificates schemes are depicted in theoretical works as mandatory subsidies on energy efficiency goods recovered by an end-use energy tax, whereby white certificates exchanges are not a central feature; (ii) at current stages, existing schemes are cost-effective and economically efficient, with large discrepancies though; (iii) the hybrid subsidy-tax mechanism seems valid but conditional to cost pass through permissions; otherwise, obliged energy companies merely promote information on the "downstream" side (i.e. at the consumer level); (iv) although white certificates exchange between different types of actors involved can be important as in Italy, trade *among obliged companies* is negligible; instead, flexibility sustains vertical relationships between obliged parties and "upstream" partners (i.e. installers, energy service companies).

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* Corresponding author: CIRED, 45 bis avenue de la Belle Gabrielle, F-94736 Nogent sur Marne Cedex. Tel : +331.4394.7362. E-mail : giraudet@centre-cired.fr

1. Introduction

Energy savings obligations and credits, better known as "white certificates schemes"[1], are a new instrument enhancing the portfolio of policies for energy efficiency and conservation[2], next to taxes, subsidies and regulations. Their recent deployment in Europe (in Great-Britain since 2002, in Italy since 2005 and in France since 2006) is fostered by a renewed interest for energy conservation, generally justified by its ability to correct for two market imperfections. First, reducing energy consumption has positive externalities like cutting CO_2 emissions and improving national energy security. Second and more specifically, energy efficiency policies help overcome "barriers to energy efficiency", a notion gathering market barriers, market failures and behavioral failures responsible for the observed underinvestment in energy efficient technologies, despite their social optimality and private profitability under perfect information conditions (Gillingham *et al.*, 2009; Sorrell *et al.*, 2004).

The specific rationale[3] of white certificates schemes has to be found in demand-side management (DSM) programs implemented in the United Stated in the mid of the 1980s (Waide and Bucher, 2008; Eyre *et al.*, 2009). As part of integrated resource planning aimed at optimizing the electric supply and demand systems, DSM programs obliged utilities to promote measures like information, direct funding or any other kind of measures lowering energy consumption on the demand side, besides measures targeting peak load reduction (Gillingham *et al.*, 2006). White certificates schemes share with DSM programs the underlying motivation that energy utilities have holds over final consumption through commercial relationships, and hence are the best suited agent to tap the scattered potentials for energy conservation, particularly present in the residential sector. Yet an obligation imposed to public monopolies has to be adapted to the European context of liberalized electricity markets, where a disincentive arises from selling energy on the one hand while promoting energy efficiency on the other hand. Flexibility options are thus associated to energy savings obligation in order to help energy companies meet their quantitative targets at the lowest cost, as well as to support the evolution of traditional energy business models towards a broader energy service business model (Eyre *et al.*, 2009; Langniss and Praetorius, 2006). Among flexibility options, the possibility to trade certified energy savings ties in white certificates schemes with the family of market-based instruments, which receive much emphasis in the field of environmental policy (Labanca and Peerels, 2008).

[1] "Energy savings certificates", "Energy efficiency credits" or "White tags" can also be found in the literature. We generally use the most common "white certificates scheme" terminology but "energy saving obligations and credits" would be the most appropriate term.

[2] Theoretically, white certificates schemes aim at energy conservation, i.e. both energy efficiency improvements and changes in energy consumption patterns (Gillingham *et al.*, 2009). In practice, most of the white certificates measures target energy efficiency and we use indifferently the terms "efficiency" and "conservation" in this paper.

[3] In addition to the common objectives presented herein, national schemes can have particular focus. Notably, the British scheme is designed to address fuel poverty. Nevertheless, to keep consistency in the comparison, we will not detail outcomes related to country-specific objectives.

Albeit growing as schemes scale up, the literature on white certificates has felt short to capture the whole complexity of the instrument to date. White certificates schemes guarantee energy savings quantities and promote performance rather than means. As such, they do not target a single technology but rather a still to be created "market for energy efficiency", involving different technologies, skills, and potentially a widespread constellation of actors, e.g. product manufacturers, retailers and installers and energy services companies. Moreover, the flexibility provided potentially implies as many possible compliance strategies as there are obliged parties. The interpretation of white certificates schemes is thus challenging and a substantial amount of theoretical works, have attempted to exhibit a straightforward representation of them by adopting different views, namely mainstream microeconomics, transaction cost approaches and bottom-up modelling. Moreover, from an empirical point of view, due to its youth in existence, national evaluations (Bodineau and Bodiguel, 2009; Lees, 2005, 2008; Pavan, 2008) and comparative ones (Bertoldi and Rezessy, 2008; Eyre *et al.*, 2009; Mundaca and Neij, 2009) are available but generally conclude that schemes performances are context-specific and generalisations thus inappropriate. Lastly, insights from both theoretical and empirical works are basically static, that is to say holding for given stages of the scheme, whereas the architecture is evolutionary and permanently adapting to a new context. Dynamic processes are at stake as long as successive technological potentials are tapped, each transition requiring technology learning and market transformation.

Our goal is to extricate the core nature of white certificates schemes from the complexity of their practical implementation and assess their performances under a unified framework. More precisely, we seek answers to the following questions: ***In spite of different contexts and designs, can we draw common insights from European experiences with white certificates schemes? Are they consistent with the available stylized facts? How to represent the dynamic performance of white certificates schemes?*** For that purpose, we compare as systematically as possible the achieved results of European experiences with white certificates schemes in Great Britain, Italy and France[4]. We update the comparative analysis quoted above and supplement them occasionally with insights from past and present energy efficiency policy in the United States, where DSM programs have been expanded in the form of energy efficiency resource standards (EERS) (Vine and Hamrin, 2008; Loper *et al.*, 2010). We stand from both private and collective point of view and base our comparative analysis on the following assessment criteria[5], inter-dependent but not necessarily convergent:

- *Static efficiency* – Analysed primarily through *cost-effectiveness*, a twofold assessment whereby the amount of induced energy savings are quantified and subsequently put in regard to the measures cost. This is the most common criterion for comparing outcomes of energy efficiency policies (Gillingham *et al.*, 2006; Goulder and Parry, 2008). It is complemented by a *social efficiency* assessment by factoring social benefits accruing from reduced fuel bill and CO_2 emissions. This analysis is of partial equilibrium nature, since we make no case for macroeconomic retroactions on the cost-benefit balance.

[4] Similar schemes exist in the Flemish region of Belgium, in the New South Wales state of Australia and in Denmark (Bertoldi and Rezessy, 2008). We do not handle these schemes herein.

[5] For the justification of using multiple evaluation criteria and their selection, see Mundaca and Neij (2009).

- *Dynamic efficiency* – The previous criteria assume the equilibrium to be the actual location of the economy, whereas it can be seen as where the economy is tending in an evolutionary perspective (Nelson and Winter, 2002). This allows for analyzing the dynamic process of technological change along the successive phases of invention, innovation and diffusion (Milliman and Prince, 1989; Stoneman and Diederen, 1994). Many authors have acknowledged that the relevant failures in the field of energy efficiency are related to the diffusion phase, i.e. the gradual adoption of technologies that are already mature (Sanstad and Howarth, 1994; Newell *et al.*, 1999). Therefore, we use the criterion of dynamic efficiency to assess how flexibility provisions under white certificates schemes influence industrial organisations, learning processes and investments in efficient technologies in the long term (Finon and Menanteau, 2005).

This paper is organised as follows. Section 2 defines basic concepts and reviews theoretical results on white certificates schemes to identify a stylized representation. Section 3 compares the effectiveness of the existing schemes and exhibits national drivers. Section 4 focuses on cost estimation to complete the static efficiency analysis and assess the relevance of the stylized representation. Section 5 departs from this static statement to assess organisational dynamics, closely related to the way obliged parties cope with flexibility options. As a result of the previous static and dynamic analysis, Section 6 proposes a prospective framework for the functioning of white certificates schemes. Section 7 concludes.

2. White Certificates: concepts and practical design

In this section we sum up findings from the literature[6] on white certificates schemes, dealing especially with cost-effectiveness and social efficiency.

2.1 Definition

Bertoldi and Rezessy (2008) provide an extensive definition of white certificates schemes. We consider that the three following principles, common to all existing schemes, are sufficient to broadly define a white certificates scheme in the context of liberalized energy markets:

(i) *Obligation* – White certificates schemes are basically an obligation placed on energy market operators (energy suppliers in the general case, but possibly energy distributors) to promote energy conservation. Individual targets, generally labelled in units of energy to be saved, are set and apportioned among obliged parties according to their market share in the household energy retail market[7]. Obliged parties must comply with their individual target under a given period of time. This constraint is binding, provided that any shortfall in compliance is

[6] We examine primarily per-reviewed articles. Most of them draw upon results from international research projects, notably EuroWhiteCert and the IEA DSM task XIV (See <http://www.ewc.polimi.it> and <http://www.ieadsm.org/ViewTask.aspx?ID=17&Task=14>, websites visited April 2010). For the detail of research projects on white certificates schemes, see Bertoldi and Rezessy, 2008, p.329.

[7] This is the general case so far. Note that Giraudet and Quirion (2008) test different apportionment rules.

financially penalized[8]. In the context of liberalized and competitive energy markets, the promotion of energy conservation might come at a cost (additional to the opportunity cost of energy sales losses) and nothing theoretically precludes passing through this cost on the energy tariff.

(ii) *Flexibility options* – Obliged parties have different means to meet their obligation. They can either produce energy savings by themselves or contract with third parties (equipment manufacturer, retailer or installer, energy service companies). Ultimately, if they fall short of their target, they can buy certified amounts of energy savings on a market supplied by companies exceeding their target, or some non-obliged parties if allowed.

(iii) *Deemed savings* – To keep measurement and verification costs low on the one hand and assign property rights for trading on the other hand, some standardized measures are defined[9]. The associated amounts of energy savings are calculated *ex ante* under conventional assumptions about unitary gains compared to a technological baseline, product lifetime, etc. In this respect, the so-called "white certificate" is both the energy savings measurement unit (labelled in kWh, ton oil equivalent or avoided CO_2 emissions) and the commodity traded. More detailed calculations remain allowed for specific measures, but deemed measures are designed to cover the targeted potential and to be used intensively.

This reduced set of features provides consistency in the functioning of white certificates, and the higher the deviations from them, the higher the probability of regulatory pitfalls. With respect to this characterization, white certificates belong to the family of quantity and performance-based instruments in the field of environmental policy, providing certainty of outcomes when complemented by a penalty. Close to air pollution allowances (SO_2 and NO_X), carbon emission allowances and "green" certificates for the promotion of renewable energy, white certificates can be regarded as a baseline and credit scheme, with *ex ante* rather than *ex post* control. Although much enthusiasm has been showed for the market component, it is not a central feature of the instrument. Rather, the real novelty lies in both obliging energy suppliers to promote energy savings and institutionalizing property rights on energy savings thanks to deemed calculation. Certificate trading is only one flexibility option among others, which altogether concur to minimize the costs of compliance.

Besides traditional justification of energy efficiency policies, white certificates are specifically aimed at both tapping the scattered potential of residential energy consumption and supporting the liberalization of energy markets. The definition provided above shows that these policy goals are

[8] Note that the stringency of the penalty is not only a regulatory feature but also an economic signal. In particular, a pre-set penalty as implemented in France acts as a "buy-out" price. The way the penalty is set in other countries is detailed in Bertoldi and Rezessy (2008).

[9] Consistently with footnote 2, most of the standardized measures are considered as "hard measures" and target energy efficiency, i.e. investment in energy efficient technologies (efficient lighting, efficient heating system, insulation measures...). A smaller set of "soft measures" targeting behaviour change also apply, e.g. energy efficiency training for building workers in France. They are generally calculated with short lifetime assumptions.

consistently translated in regulatory terms. The apportionment by market share avoids distortion in the competition between retailers on energy markets. As well, flexibility options allow overcoming the disincentive of encouraging conservation while selling energy. To some extent, new commercial advantages can even be drawn from energy efficiency differentiation (Vine *et al.*, 2003). The use of deemed savings provides information for tapping the scattered potential, hard to reach by definition. White certificates can thus be seen as a *coherent* instrument. Lastly, they are supposed to avoid public expenditures, which advocates for their implementation.

2.2 Theoretical properties

Three main approaches have been investigated to address white certificates to date: microeconomics, bottom-up modelling and transaction cost approaches. The former has been prevailing and has carried out the most robust results.

Findings from microeconomic models

A set of works converge towards a stylized representation of white certificates schemes (Bye and Bruvoll, 2008; Giraudet and Quirion, 2008; Oikonomou *et al.*, 2007, 2008, 2009; Peerels, 2008; Sorrell *et al.*, 2008). Based on similar partial equilibrium models operating under perfect rationality, perfect information and perfect competition assumptions, those papers generally depict the markets for two goods: energy E and energy efficiency EE. The latter is an abstract representation of fragmented markets for energy efficient goods and services (e.g. efficient light bulbs, condensing boilers, insulation panels, training to efficient car driving, etc.)[10]. Three agents are involved: two representative producers of E and EE and one representative consumer. From the consumer point of view, the two goods are partial substitutes to provide an aggregate energy service, e.g. a certain indoor temperature can be reached either by using an efficient boiler (high level of EE and low level of E) or an inefficient one (low level of EE and high level of E). The consumer hence chooses the right combination of E and EE to reach a given level of energy service while minimizing his expenditures (or alternatively to minimise his energy service consumption subject to a budget constraint) and producers maximise their profits (or alternatively minimize their costs) while producing under decreasing returns.

Within this framework, white certificates schemes are an obligation placed on energy producers[11] to fund energy efficiency measures by granting subsidies to energy savings companies, ultimately rebated to consumers. In turn, this burden is recovered through increased energy prices. As such, white certificates schemes are treated as a hybrid instrument combining a mandatory subsidy with an end-use energy tax, as depicted on Figure 1. Note that the representative agent portray prevents

[10] The energy efficiency good can be considered as the difference between a conventional and an efficient equipment, whose cost is the differential between them. In Oikonomou *et al.* (2007), a conventional energy consuming durable is explicitly in trade-off with an efficient one. But this does not change significantly the representation nor the results.

[11] Energy producers are by default retail suppliers. One notable exception is Oikonomou *et al.* (2008) who represent both energy distributors and retail suppliers and relationships among them. Moreover, most of the works, except Giraudet and Quirion (2008), focus on electricity producers.

from representing exchanges among multiple obliged companies. Some authors (Peerels, 2008; Oikonomou *et al.*, 2008) consider white certificate exchange in a simple way, with representative agents selling or buying certificates as price takers.

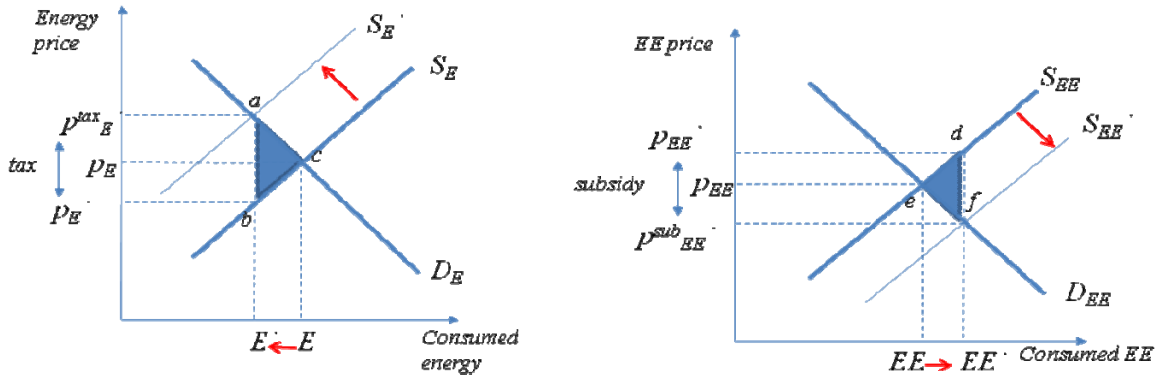

Figure 1: White certificates mechanism: (a) tax in the energy market and (b) subsidy in the energy efficiency market. In the case of a full cost recovery, triangles (*abc)* and (*def)* cover the same area.

Following this representation, all works conclude that white certificates schemes raise energy efficiency investments and lower energy demand. Given upwards slopping supply curves, this physical effect decreases ex-tax energy price and increases ex-subsidy energy efficiency price. But final prices depend on rates applied to ex-tax prices, which in turn depend on a bunch of factors, like the energy market structure (Oikonomou *et al.*, 2009) and the asymmetry between beneficiaries and non-beneficiaries of the scheme on the consumer side. Indeed, Sorrell *et al.* (2008) and Peerels (2008) emphasize that only a few consumers benefit from the subsidy while all of them bear an even energy price increase. As a result, the effect of white certificates on consumer prices is more ambiguous than on quantities but generally increasing for energy and decreasing for the energy efficient good. For example, Giraudet and Quirion (2008) show +1.8% and -4% respective price evolution for a 2% decrease in energy consumption (for a model calibrated on the French economy, under conventional behavioural assumptions). Overall, the results seem mainly affected by the energy demand and supply price-elasticites and the stringency of the instrument (Bye and Bruvoll, 2008). More specific insights can be drawn. Giraudet and Quirion (2008) feature an endogenous level of energy service, allowing for comparing the rebound effects of white certificates to other policies for energy efficiency. Within a cost-effectiveness ranking dominated by energy taxes and whereby subsidies to energy efficient goods stand at the bottom, white certificates entail a limited rebound effect and are thus a good compromise between cost-effectiveness and a moderate price evolution.

Closely related to this approach are engineering bottom-up modelling works. They are generally large-scale numerical application of the partial equilibrium models to national economies like Italy (Farinelli *et al.*, 2005), the Netherlands (Oikonomou *et al.*, 2007), Finland (Peerels, 2008) and even to the EU-25 (Mundaca, 2008). They do not draw additional stylized facts but rather provide case-specific outcomes, very dependent from numerical assumptions for parameters like discount rates (Mundaca and Neij, 2009) as well as from parameters reflecting national economies.

Findings from transaction cost approaches

The concept of transaction costs has been used early in the analysis of white certificates schemes. The pioneer work of Langniss and Praetorius (2006) clearly referred to Transaction Cost Economics, focusing on the explanation of specific arrangements between firms with respect to the type of transactions. A substantial number of works refer to transaction costs with a different theoretical purpose and we recorded three different definitions applied to specific fields of the literature:

- One related to the microeconomics of cap and trade systems, as studied by Stavins (1995) and Montero (1997). Transaction costs are simply defined herein as the costs of trading (which is therefore a pre-requisite) and unambiguously reduce cost-effectiveness of market-based instruments. This is for example put forward in the field of white certificates by Peerels (2008).

- One related to the broader literature of energy services contracts (Sorrell, 2007; Sanstad and Howarth, 1994).Transaction costs are defined as the cost of *ex ante* arrangement and *ex post* control of a contract (more or less related to an investment). They are not necessarily intricate with trading and might arise at any step of the scheme. Overall, this usage has the same theoretical purpose as the previous one, i.e. to assess cost-effectiveness losses along the functioning of the scheme. Such a definition is applied to white certificates schemes by Mundaca (2007), who describes and quantifies transaction costs originating from following steps: planning, implementation, measurement and verification, trading, issuance and redemption of white certificates.

- One more specifically related to Transaction Cost Economics, as defined by New Institutional Economics. Transaction costs are used here with markedly different theoretical purposes, in that they help identify the appropriate governance structure to cope with a more or less "specific" investment related to the "energy efficiency transaction". In particular, the "make or buy" decision results from the minimization of the sum of transaction costs plus production costs. This is the way it is used by Langniss and Praetorius (2006) in the field of white certificates.

Such piecemeal approaches seem confusing and the transaction cost analysis of white certificates schemes is still unachieved. However, it can be helpful in two ways. First, they show how schemes can generate additional costs that hamper their cost-effectiveness performance. For example, Mundaca (2007) shows that the cost-effectiveness of the first period of the British scheme has been effectively but slightly mitigated by costs related to information, consumer persuasion and negotiation with third parties. Second, they highlight organisational arrangements under a flexible scheme, involving many different agents. With this respect, they yield valuable results. For example, Langniss and Praetorius (2006) foresee very little trade among obliged parties and rather long-term contracts.

To summarize their theoretical properties, white certificates schemes have been portrayed as a hybrid instrument combining a subsidy for energy efficient goods with an end-use energy tax

allowing for cost recovery. This representation emphasizes transactions between obliged parties and related energy efficiency business, rather than trade among obliged parties.

2.3 Practical implementation in varying national contexts

The previous attempt to provide a common analytical approach for white certificates schemes turns obsolete as soon as one considers their practical implementation[12]. Because of the variety of agents involved and the range of flexibility provisions, white certificates schemes happen to be more sensitive to their regulatory environment than other instruments. Therefore, their implementation in differing national contexts (in terms of electricity and gas industrial structure, energy policy portfolio and regulatory traditions) led to different designs, and ultimately to different performances. Differences among schemes have been extensively described by Bertoldi and Rezessy (2008), Eyre *et al.* (2009), Mundaca *et al.* (2008), Oikonomou *et al.* (2007) and Vine and Hamrin (2008). We precise in Table 1 some determinant features and comment them hereby.

	Great Britain 2005-08	**Italy 2005-08**	**France 2006-09**
Complementary policies in the household sector **Source : Odysse, 2008**	Building codes "Warmfront", a government scheme aimed at alleviating fuel poverty	Building codes Tax deductions for energy efficiency actions	Building codes Tax credits for energy efficiency actions
Obliged companies	6 electricity and gas *suppliers*	30 electricity and gas *distributors*	2560 energy *suppliers* (all fuel except gasoline)
Target in end-use energy **(Own estimation detailed in annex)**	64 TWh/year (128 TWh/year for 2008-11)	31 TWh/year (100 TWh/year for 2005-12 with recent target increase)	18 TWh/year (100 TWh/year for 2009-12 with projected target increase)
Sectors covered	Households (50% to low income), 37 standardized actions	All sectors, 22 standardized actions	All sectors except ETS installations 170 standardized actions
White certificates exchange	Limited by administrative requirements (preliminary target achievement, agreement of the regulator)	Spot and over the counter markets, participation of non obliged actors allowed	Over the counter market, participation of non obliged actors allowed

Table 1: Determinant features of existing schemes

Energy policy environments

White certificates schemes are inserted in policy-rich environments whereby many interactions occur (Child *et al.*, 2008). First, all white certificates schemes interact on *energy markets* with other market-based instruments, like the European Union Greenhouse Gas Emission Trading System (EU ETS) and national incentives for renewable energy (feed-in tariffs in France and "green" certificates in Great-Britain and in Italy). Those policies are justified by policy goals that are markedly different but

[12] Depending on the period considered, the British scheme is referred to as EEC1 (Energy Efficiency Commitment, 2002-2005), EEC2 (Energy Efficiency Commitment, 2005-2008) and CERT (Carbon Emissions Reduction Target, 2008-2011), the Italian scheme is referred to as TEE (Titoli di Eficienza Energetica, 2005-2012) and the French scheme is referred to as CEE (Certificats d'économies d'énergie, 2006-2009).

physically overlapping: lowering the carbon content of energy *versus* lowering the absolute energy consumption. Nevertheless, the overlaps are limited by the different technological and sectoral coverage of each instrument. Second, and more importantly, white certificates schemes coexist on *energy efficiency markets* with policies designed with the same energy efficiency goal, namely energy taxes, direct and fiscal subsidies, regulations, information disclosure and market transformation programs (IEA, 2008). While much attention has been paid to the former interaction on theoretical basis (Bye and Bruvoll, 2008; Farinelli *et al.*, 2005; Oikonomou *et al.*, 2008; Sorrell *et al.*, 2008), little has been devoted to the latter (Monjon, 2006). In the light of the framework provided by Bennear and Stavins (2007), we will focus hereafter on those interactions, summarized in Table 1.

In a second-best world encompassing market failures, a policy portfolio can outperform any stand-alone policy to address one single environmental problem, hence justifying the use of multiple instruments. In the case of energy conservation, the under-provision of energy efficiency investments is one primary market failure calling for policy intervention. It is generally associated with two market failures that can be regarded both as *jointly ameliorating*, in the sense that the correction of one ameliorates welfare losses from the primary market failure (Bennear and Stavins, 2007; OECD, 2007). First of all, it is generally assumed that consumers face *imperfect information* about energy efficiency investment options (Gillingham *et al.*, 2009; Sorrell *et al.*, 2004) and that providing information can support energy efficiency instruments. This has been acknowledged in the field of white certificates schemes by many authors (Farinelli *et al.*, 2005; Oikonomou *et al.*, 2007; Peerels, 2008) and as a matter of fact, information campaigns and labels for efficient lighting and appliances are present in every country.

Moreover, it is well-known that *technological change* provides knowledge spillovers as positive externalities, backing the joint use of environmental and technology policies (Fischer and Newell, 2007). This seems particularly relevant in the field of energy efficiency, where the diffusion of energy efficient products is not optimal (Sanstad and Howarth, 1994; Newell *et al.*, 1999), and we see in Table 1 that white certificates schemes are complemented systematically by building regulations and frequently by tax credits. Although stand-alone policies are not evenly well suited to promote technology diffusion *ceteris paribus*[13], such combinations can be optimal if they are accompanied by the appropriate *policy coordination* (Bennear and Stavins, 2007). Indeed, white certificates schemes[14] seem to be adequately coordinated with building regulations, the latter providing the former with a dynamic baseline (Sorrell *et al.*, 2008). That is, deemed savings are calculated so as to be additional to the evolutionary market standard set up by building codes for insulation and heating systems. Furthermore, it seems that the joint use of white certificates schemes and fiscal subsidies as in Italy and France can speed-up the diffusion of efficient technologies with small market shares (Monjon,

[13] In particular, Jaffe *et al.* (2004) consider that technology-based standards may inhibit the diffusion of *new* technologies, whereas market-based instruments create incentives for increased diffusion of *existing* technologies.

[14] Note that we consider here white certificates schemes as a "genuine" instrument and abstract from our previous statement that it is *per se* a hybrid instrument, whose own properties regarding technological change have not been clearly established.

2006). In that case, the adequate policy coordination is to condition policy combination to the initial market share of the technology that is promoted.

These *ex ante* considerations require a careful *ex post* assessment, to evaluate to which extent the interactions in place deliver their full benefits, as we will see later.

Energy market structures

At the end of the 1990s, the European Union has engaged major reforms to liberalize electricity and gas markets[15], which changed the motivations for energy efficiency policies compared to DSM programs. On the one hand, the unbundling of vertically integrated utilities discourages the promotion of energy efficiency along the whole value chain: transmission and distribution businesses have no holds over end-use consumers to implement programs, while generation and retail businesses are not keen to reduce their sales as a consequence of energy efficiency programs. On the other hand, the introduction of competition on retail services creates an incentive for suppliers to provide energy service for commercial differentiation (Vine *et al.*, 2003).

		Market shares of the three largest retail companies	Number of companies with more than 5% market shares	Nature of the market
Great Britain	Electricity	58%	6	Unbundled, full competition
	Gas	72%	6	Unbundled, full competition
Italy	Electricity	91%	3	Unbundled, limited competition
	Gas	47%	2	Unbundled, limited competition
France	Electricity	96%	1	Unbundled, limited competition
	Gas	100%	3	Unbundled, limited competition

Table 2: Structure of the electricity and gas markets in 2007 (Source: European Commission, 2008)

The liberalization process has been achieved in Great-Britain in 1998, in Italy in 2004 and in France in 2007. Although electricity and gas markets are similarly unbundled in those countries, the degree of competition on retail markets shows large discrepancies (cf. Table 2), which has important consequences for the functioning of white certificates schemes. The electricity and gas markets are fully competitive in Great-Britain and the market shares of the six obliged energy suppliers range from 11% to 32% (Lees, 2008, p.21). Conversely in France, both electricity and gas markets are concentrated and dominated by EDF and GDF SUEZ, respectively. One can expect from that situation a higher propensity of energy suppliers to use energy efficiency as a marketing tool in Great-Britain

[15] According to the European Commission directives of 1996 regarding the internal electricity market (Directive 96/92/EC) and 1998 regarding the internal gas market (Directive 98/30/EC).

compared to France, in response to the white certificates obligation. Note that in Italy, the obligation is placed on energy distributors, which are actually natural regional monopolies. The rationale for that regulatory choice is not straightforward, such agents not being the best suited ones to influence end-use energy consumption. It seems that it has been made to sustain the development of energy service companies.

Size and scope of the schemes

As shown in the third row of Table 1, the schemes differ primarily in their size and sector coverage. The long-standing British scheme has now the highest target. As can be seen in the fourth row, they also show different scopes. The British scheme encompasses a small number of obliged suppliers (only six) and covers solely the household sector. Conversely, scopes are seemingly wider in Italy and France, given the numerous obliged parties and broader coverage (extended to all end-use sectors, except the EU ETS installations in France). But the large number of obliged parties should not hide that the number of major players is reduced in those concentrated energy markets. Moreover, as we will see later, results focus on the residential sector, in spite of a wider coverage. Therefore, differences in scope with the British scheme should be tempered.

Regarding the array of measures, national portfolios differ in terms of eligible technologies and certificates issuance. There are 37 standardized actions in GB, 22 in Italy and 170 in France. Basic technologies are identical and cover the most relevant potentials for energy efficiency (e.g. efficient lighting, efficient appliances, efficient heating systems and insulation). It is worth mentioning some country specific dispositions like “soft measures” for building professionals training in France or uplift factors granted for innovative equipments and energy services in Great Britain. But the main difference between national portfolios lies rather in the certificates issuance, in particular in the assumptions made for energy savings calculation on conventional unitary consumption, conventional lifetimes and discount rates. Savings are formulated similarly in France and Great-Britain in kWh of end-used energy saved[16], cumulated over average lifetimes of 20-30 years and discounted at close rates of 3.5 and 4%, respectively. Differently in Italy, savings are calculated in ton oil equivalent of primary energy, with fixed lifetime of five years (eight years for insulation measures). We will see that lifetime assumptions have a strong influence on the incentives to implement each measure.

All in all, the combination of a high target and a narrow scope in Great-Britain makes this scheme – older in existence – more ambitious than the others. Nevertheless, the wider scope of the Italian and French scheme provides more flexibility, supposed to lower the cost of energy savings. It is thus expected that the British scheme provides a high level of *effectiveness* and that Italian and French schemes provide a high level of *cost-effectiveness*. This is subject to the proviso acknowledged by some authors that a wide coverage is also likely to bear additional costs from administrative tasks that might hamper cost-effectiveness (Bertoldi and Rezessy, 2008; Langniss and Praetorius, 2006; Mundaca *et al.*, 2008).

[16] This was the case under EEC1 and EEC2. Under CERT, savings are calculated in tons of CO_2 saved and not discounted, since CO_2 is assumed to be removed definitively from the atmosphere once saved. Nevertheless, the calculation method is the same.

Flexibility provisions within schemes

In terms of flexibility[17], two architectures seem to be opposed from the second and fifth rows of Table 1. On the one hand, the "GB-like" architecture fosters obliged parties self-driven measures: the obligation is borne by energy suppliers, whose relationship with final consumers is close and favours direct actions, and white certificates exchanges are legally allowed but hurdled in practice by administrative constraints, like the preliminary agreement of the regulator to engage in any transaction. On the other hand, the "Italy-like" architecture emphasizes white certificates exchange as a central element: the obligation is borne by distributors operating on local and regional networks, who have no commercial interest to support consumers that are not their customers, and exchanges are eased by organised markets (spot and over the counter). Some non-obliged parties are allowed to promote energy savings by themselves and sell them to obliged parties, creating thus an additional supply of white certificates. In-between lies the French scheme: as in Great-Britain, the obligation is borne by energy suppliers, but the flexibility provisions are broad as in Italy (however to a smaller extent, since there is no administered spot market). Given these overall incentive structures, one might expect a different market activity in each country.

Next to flexibility provisions, the way the obligation burden can be recovered depends upon the ability of obliged parties to pass through their costs on energy retail prices. Where the obligation is borne by energy suppliers, as in Great-Britain and France, the market is supposed to be liberalized and such process allowed. While this holds for Great-Britain, the persistence of regulated retail tariffs disconnected from wholesale market prices in France renders this process up to the regulator, who decided not to allow it so far. In Italy, energy distributors are regulated monopolies and the price of the distribution service includes the expenditures generated by the obligation, as a standard contribution of 100€ per ton oil equivalent (toe) saved (Pavan, 2008).

To sum up implementation outcomes, we have highlighted how national contexts condition national designs. Each scheme can be characterized as the most ambitious in Great-Britain, the most market-oriented in Italy, and the most flexible in France. We will analyse hereby the effective functioning of national schemes to figure out how their respective designs condition their performances.

3. Effectiveness of the savings

As a performance-based instrument, the effectiveness of white certificates schemes is assumed to be measured against the mere target compliance. Albeit a matter of concern by itself (Mundaca and Neij, 2009), we will not discuss here the intrinsic ambition of the target but readily examine its

[17] A number of features of white certificates schemes are considered as "flexibilities" by some authors (Bertoldi and Rezessy, 2008; Langniss and Praetorius, 2006). According to Mundaca *et al.* (2008), such flexibilities cover: the range of eligible measures; the number of eligible end-use sectors; the banking provision for surplus of white certificates; the market engagement of non-obliged parties; the trading option to equalise marginal compliance costs. Unlike those authors, we do not consider design features as "flexibilities" *per se*, but rather as drivers of the overall flexibility. We keep the very open definition of flexibility as the different means provided to comply with individual targets, and seek how this notion is bounded and influenced by design features.

fulfilment, at both the aggregate level of national objectives (as labelled in the third row of Table 1) and the disaggregate level of the underlying measures or technologies. Neither do we discuss the accuracy of deemed measures calculation nor the potential realisation defects[18]. To keep consistency in comparison among countries, we focus on energy effectiveness, measured in the same units of energy savings (although savings are now reported in CO_2 emissions savings in the ongoing CERT scheme in Great-Britain).

Note that a comprehensive assessment of effectiveness should take account for effects potentially undermining schemes performances. First, free-riding might occur, due in particular to potential overlaps with pre-existing energy efficiency policies. Second, some rebound effects are likely to follow deemed measures implementation, however to a moderate magnitude (Giraudet and Quirion, 2008). These points will not be addressed here but in section 4.

3.1 Compliance with the target

A meaningful evidence of target fulfilment is the overachievements that occurred in every country[19]. In Great-Britain, the three-year objectives of EEC1 and ECC2 where overachieved by 30% and 44%, respectively (Lees, 2005, 2008). In France, the first three-year period was overachieved by 20% (65 TWh against 54TWh required, according to DGEC, 2009). In all cases, the overachieved energy savings were carried over to the next compliance period. In Italy, where objectives are supposed to be fulfilled annually (but fully assessed in 2012), the first two years led to an overachievement of more than 90% (Pavan, 2008). Yet overachievements have been decreasing as annual targets have been scaled up. The potential for low cost measures is being exhausted, so that obliged distributors are likely to fall short of their targets in the next periods.

Whereas overachievements raise effectiveness, the accounting for "early actions" against target compliance might undermine it. It is noteworthy that in Italy, energy savings promoted between the launch of the scheme in 2002 and its effective implementation in 2005 can be used to meet the annual targets, and have actually represented 27% of the savings generated during the first two years (Pavan, 2008). In Great-Britain, savings generated under the predecessor Energy Efficiency Standard of Performance (EESoP) program[20] were also eligible (with a 10% of the target boundary though) and represented less than 5% of EEC1 target (Lees, 2005). Contentious savings from early actions are thus quantitatively limited and those schemes yielded net overachievements. Lastly, the absence of penalty enforcement could be another piece of evidence for target fulfilment.

[18] As pointed out by Lees (2008), Defra showed that insulation measures did not achieve their full saving potential during EEC2, due for example to incomplete cavity wall fulfilment.

[19] As stated by Mundaca *et al.* (2008), overachievements against the national objective do not necessarily imply a fulfilment of all individual targets. Indeed, two obliged parties went out of business during the EEC1 scheme and thus felt short of their target. But according to the authors, the overall performance can be interpreted as effective.

[20] The EESoP was an obligation placed on energy suppliers to invest in energy efficiency. It was implemented in 1993 and replaced in 2002 by the white certificates schemes, mandating performance rather than means.

With this respect, the mere compliance with national objectives led to savings representing 0.6%, 0.3% and 0.14% of the sectors under coverage in Great Britain, Italy and France respectively, according to the convergent estimates of Eyre *et al.* (2009) and Mundaca and Neij (2009).

3.2 Nature of the savings

A full assessment of the effectiveness of the schemes requires a close look at the technological nature of the savings. To keep consistency in the comparison, we will focus on measures undertaken in the residential sector, which encompasses the bulk of white certificates energy savings even in countries with a broader coverage (86% in Italy, according to AEEG, 2008; 87% in France, according to DGEC, 2009). Industrial measures generally cover small shares of white certificates energy savings, due to a long-standing rational use of energy in this sector.

National measures mix

National breakdowns depicted in Figure 1a show large discrepancies among countries: insulation dominates in Great Britain, compact fluorescent light bulbs (CFLs) dominate in Italy and heating device replacement dominates in France. Such a contrasted picture is striking, since flexibility is supposed to first steer obliged parties towards lowest cost measures and then to operate alongside an upward slopping marginal cost curve. Evidence for convex curves where unitary saving costs increase with increasing energy savings have been recently exhibited from DSM programs (Arimura *et al.*, 2009, Figure 5). For illustration purpose, we use a very stylized step curve (Figure 1b) along which the ranking of energy savings potentials is derived from McKinsey's curve[21] (McKinsey&Company, 2009). Following this representation, one would expect to see quite similar patterns for all countries. The opposite observation raises two questions: (i) *Can we build a single cost curve for all three countries?* (ii) *Is it a relevant picture of the white certificates operating mode?*

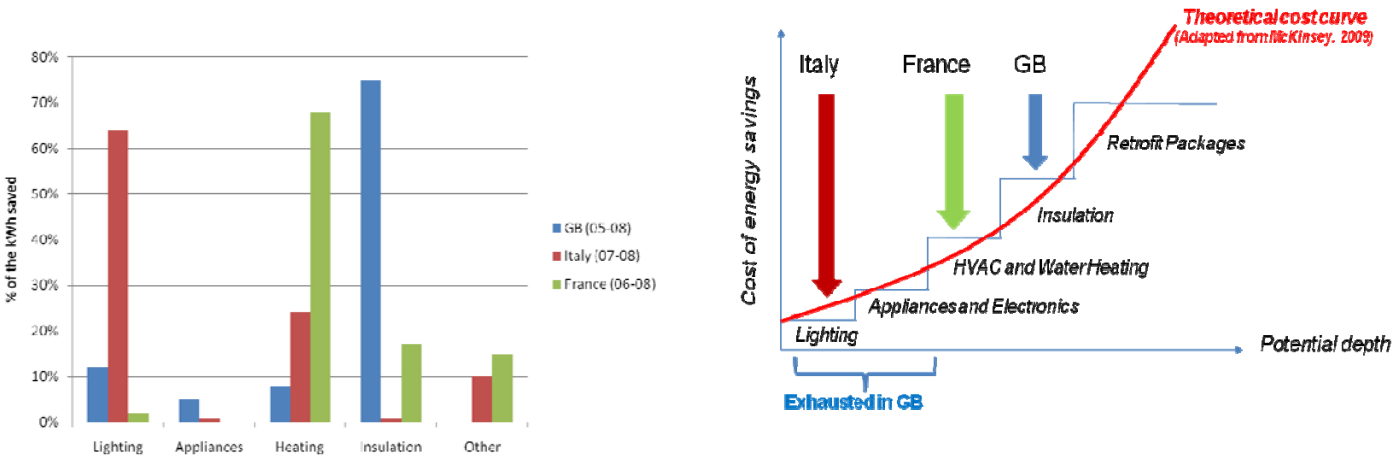

Figure 2: (a) National measures mix (source: AEEG 2009, DGEC 2009, Lees 2008); (b) Stylized marginal cost curve

[21] Unlike this study, we do not consider net present values but solely investment costs. The potentials are thus ranked with positive costs, but the merit order is unchanged.

The answer to the first question is very likely to be negative. Although numerous technologies are similar from one country to another, the associated potentials for energy savings might differ. For example, the market share of condensing boilers in 2004 was approximately 2% in France and 8% in Great-Britain (IEA, 2008, Figure 40). The market has taken off rapidly in Great-Britain and average condensing boiler prices are now 2,200€ in Great-Britain (Lees, 2008, with 1.4€/£) and 8,600€ in France (OPEN, 2009). Moreover, discrepancies between countries might arise for potentials that are intrinsically different in technological terms. A relevant example is the difference between cavity wall insulation (CWI) and solid wall insulation (SWI) measures. The former consists in injecting insulating material in a cavity between indoor and outdoor brick walls and the latter in hanging panels on indoor walls. CWI incurs lower technological costs than SWI because of lower costs of gross material and the possibility to deploy neighbourhood-scale actions (and therefore generate economies of scale). Moreover, there might be substantially higher labour costs in the SWI case. Lastly, hidden costs due to a higher annoyance of indoor works must be added to the cost of SWI. As a result, the average cost per dwelling is 500€ for CWI and 6,000€ for SWI (Lees, 2008, with 1.4 €/£). Unlike depicted on Figure 2, CWI is likely to stand at the beginning of the energy savings curve and SWI at a higher marginal cost step. In France, there is no potential for CWI, which makes the overall potential for insulation costlier than in Great-Britain.

Regarding the second question, the French scheme shows a straight mismatch between the unitary cost of measures and their respective share in the compliance mix (cf. Table 2). Interviewed energy suppliers confirm that proceeding by increasing marginal cost measures is none of their strategy, because they do not owe such information. While focusing on their core business with traditional partners (e.g. installers of heating devices), they experiment at the same time a wide range of measures to identify profitable potentials and then reveal an implicit curve. In addition, obliged parties may keep the exploitation of inexpensive potentials for later use, by strategically anticipating further difficulties under what can be considered as a three-year repeated game. This effect is limited however by the use of dynamic baselines that remove low cost potentials as far as they become the market standard.

Country-specific determinants

Therefore, a stylized theoretical cost curve turns irrelevant to interpret current measures mix, rather driven by national determinants. In Great Britain, energy suppliers concentrate on insulation, whose share in terms of kWh saved has increased from 56% in EEC1 to 75% in EEC2 (Lees, 2008). As just stated, they benefit from the attractive potential of CWI. It is worth reminding that the implementation of the EESoP program in 1993 allowed obliged parties to explore different potentials and early identify the most cost-effective, a process still at stake in other countries. The potential for CWI is far from being exhausted according to observers and energy suppliers would further concentrate on this measure in the future (Eyre *et al.*, 2009). Next to insulation, other potentials have been tapped actively. Under EEC1, the markets for “white goods” like A-rated wet and cold appliances have been dramatically transformed. Likewise, the market for condensing boilers has reached full maturity under EEC2 and some markets like integrated digital televisions and stand-by savers have been rapidly transformed owing to uplift factors (Lees, 2005, 2008).

In Italy, CFLs and hot water economizers dominated until recently in the residential sector (Pavan, 2008). The promotion of these “low hanging fruits” has been boosted by the eligibility of merely

distributing reduction coupons, not even guaranteed by the effective purchase of those equipments. What can be considered as a regulatory pitfall has been corrected in 2008. Furthermore, the 5 years lifespan used to calculate deemed savings does not provide the adequate incentive for long-term savings measures. In the case of insulation, notably absent from the Italian scheme, the theoretical lifetime has been set to eight years, which remains far below the values used in Great-Britain and France (40 and 35 years, respectively). Nevertheless, the current difficulties showed by obliged distributors to reach their recently increased target (Pavan, 2008) after overachievement in the previous years indicates that the least cost potentials are being exhausted. More costly and organisational demanding measures become necessary and a growing number of information campaigns and training programs are observed. In France, around two thirds of the savings have targeted space-heating systems (condensing boilers, heat pumps). Although insulation is the biggest potential[22], it represents less than 10% of the savings. We will see that the overlapping tax credit scheme is the main driver of this breakdown.

	Share of total delivered savings	***Tax credit rate, if any***	***Unitary cost (c€/kWh)***
Individual condensing boiler	22.5%	25-40%	6.4
Individual low-temperature boiler	12.8%	15%	10.9
Collective condensing boiler	7.1%	25-40%	1.0
Air-to-air heat pump	6.9%	50%	10.9
Roof and attic insulation	5.8%	25-40%	1.9
Efficient glazing	4.6%	25%	18.2
Air-to-water heat pump	4.0%	50%	10.0
Collective low-temperature boiler	2.7%	15%	1.6
Independant wood furnace	2.6%	50%	7.0
Wall insulation	2.3%	25-40%	4.8

Table 3: Representative measures in the French residential sector (Source: DGEC, 2009)

To conclude with the nature of the savings, national contexts and evaluation metrics prevail over technological considerations, as stated by Eyre *et al.* (2009). Even though compliance is not necessarily undertaken at the lowest cost according to narrow technological considerations, dominant measures happen to be the most rewarding for obliged parties given the schemes incentive structures and deemed calculations. Every country stands at the very beginning of energy savings potentials, given that obliged parties and their subcontractors promote the diffusion of technologies already mature and commercially available rather than innovation (Mundaca and Neij, 2009). At subsequent stages, one can expect a convergence of the dominant measures in each country towards thermal measures (insulation, air conditioning) and even more costly whole house retrofit packages.

[22] ADEME estimates the theoretical saving potential in the household sector to be 6,750 TWh (lifetime cumulated and 4% discounted), in which insulation measures account for 60%.

3.3 Policy interaction and additionnality of the savings

As stated in Section 2.3, some policy combination can be justified on *ex ante* considerations about the existence of multiple market failures. But whether policies are sub-additive or over-additive in terms of energy savings effectiveness within the portfolio requires a careful *ex post* assessment. We saw that white certificates schemes are accurately defined so as to provide energy savings that are additional to building regulations, which makes this interaction fully effective. Another notable policy overlap occurred in Great Britain between the ECC1 scheme and the "Warm Front" program (Mundaca *et al.*, 2008). Indeed, small amounts of energy savings from this public fund targeted to alleviate fuel poverty have been purchased by some obliged parties to meet their obligation, which did not change crucially the effectiveness of the scheme.

The outcomes are more ambiguous regarding the interaction with fiscal subsidies for energy efficient technologies. In France, the ten most granted measures all benefited at the same time from tax credits ranging from 15 to 50% (cf. Table 3). We estimate that the tax credit scheme has sustained nearly all the measures supported by obliged suppliers in the household sector under the white certificates scheme. In turn, 20% of the tax credit amounts (2.7 billion Euros in 2009 granted to 1.3 million people, according to MEEDDM, 2010) have granted white certificates. If the tax credit scheme has clearly driven the white certificates scheme, some observers consider that it would not have had such a success without being advertised by energy suppliers in their customer persuasion task, acting indirectly as information tool (Bodineau and Bodiguel, 2009). The additionnality of this interaction depends upon the initial penetration of the technologies jointly promoted (Monjon, 2006). Although we lack of distance to fully assess market transformations, it seems that the policy overlap has stimulated the penetration of heat pumps but has been ineffective to foster low-temperature boilers that had already significant market shares. Likewise, the tax credit scheme did not cover installation costs, which prevail in the insulation cost share as opposed to heating devices, and the joint policies have not supported appropriately insulation measures.

4. Costs and benefits of the schemes

4.1 The cost estimation challenge

Next to the assessment of effectiveness, a fully-fledged cost-effectiveness evaluation calls for a cost estimation. Such information is also useful to handle organisational outcomes. Yet under white certificates schemes, this task collides with data availability. Since performance matters rather than means, obliged parties expenditures are not a matter of control. Moreover, on European liberalized energy markets, cost is a sensitive piece of information that energy suppliers are reluctant to furnish. Therefore, costs of white certificates schemes do not have to be reported, as opposed to public utilities DSM programs in the United States, where extensive evaluation can be made (Laughran and Kulick, 2004; Gillingham *et al.*, 2006; Aufhammer *et al.*, 2008; see Arimura *et al.*, 2009, for recent estimates and a review of previous ones).

Any cost assessment thus requires a specific evaluation. Although one would expect the exchange price of white certificates to be helpful data for that task, it turns out to be inappropriate in most of the cases. First, according to economic theory, it equals the marginal cost of compliance, whereas the average cost would be the most appropriate estimate of the total cost of the scheme. Second, its

significance as a marginal cost indicator depends upon the amount of white certificates traded, which is high in Italy but very low in France and Great-Britain. Lastly, the cost share of the underlying energy saving measure attributable to the scheme is uneasy to separate from the one attributable to overlapping energy efficiency instruments. Much empirical data is therefore needed on the cost of realised measures and the type of agent bearing costs (obliged and eligible parties, consumers and public budget). In this prospect, we compare hereafter the costs of the three schemes estimated by a methodology designed by Lees (2005, 2008) for the British scheme.

In a social efficiency perspective, the evaluation of the costs incurred by all agents involved in the scheme implies a basic distinction between costs directly related to investments in energy efficiency on the one hand, and all other costs on the other hand. The "direct costs" represent volume-related rebates granted to consumers and borne by obliged parties, but also by actors specifically involved like social housing providers in Great-Britain and the Government in France (funding the tax credit scheme). The residual part of investment costs is borne by energy saving measures beneficiaries, so that the sum of direct costs equals investment costs[23]. Next to direct costs, "indirect costs" represent the other costs borne by obliged parties while managing their obligation. They may or may not be volume-related. Since the costs of administering the scheme ought to be negligible compared to companies costs from previous experiences[24], we consider solely indirect costs incurred for tasks like project development, marketing, reporting, etc.

4.2 Static efficiency assessment

Cost-effectiveness assessment

The total costs of the British scheme are comparable to the costs of the French one, for a much higher target. In terms of cost-effectiveness, i.e. costs related to the same amount of energy savings, the difference ratio is around four (0.91 against 3.69c€/kWh). The main explanation is probably that thanks to a longer learning process, energy suppliers in Great-Britain have been able to concentrate on highly cost-effective insulation programs[25], whereas they have focused in France on historical but costlier measures on heating systems (heat pump measures being particularly expensive). Nevertheless, overall costs are lower than expected (e.g. 20% less than Defra's expectations in Great-Britain) and in every country, the costs of conserved energy are at least four times lower than energy retail prices. They are of the same order of magnitude as the last available evaluation of United States DSM programs, whereby 1.1% of the residential electricity consumption has been saved at an average cost to utilities of about 6 cents per kWh saved (Arimura *et al.*, 2009).

[23] More precisely, the full investment cost for measures like insulation but the cost differential with the standard technology for boilers and appliances.

[24] Lees (2008) estimates that costs incurred by the administrator (OFGEM) do not exceed 1% of total costs while costs incurred by the regulator (Defra) are negligible.

[25] It is noteworthy that the related cost decrease is apparently countervailed by the progressive shift towards costlier potentials. Indeed, cost-effectiveness estimates of the savings were 1.3p/kWh for electricity and 0.5p/kWh for gas during EEC1 and 2.1p/kWh for electricity and 0.6p/kWh for gas during EEC2 (Lees, 2005, 2008). Early evidence from the CERT scheme shows much higher cost-effectiveness estimates.

	Great-Britain 2005-08	France 2006-09	Italy 2005-08
Program costs			
Obliged party direct cost (M€)	1 085	66	1 080
Obliged party indirect cost (M€)	195	119	
Customer cost (M€)	325	814	-
Other party cost (M€)	153	991	-
TOTAL COSTS (M€)	**1 758**	**1 990**	**-**
Program benefits			
End-use energy savings (TWh)	192	54	128
Monetary value of energy savings (M€)	13 020	4 320	11 181
CO_2 savings ($MtCO_2$)	72.6	17.7	42.7
Central monetary value of CO_2 savings (M€)	6 302	815	853
TOTAL BENEFITS (M€)	**19 322**	**5 135**	**12 035**
Net social benefits, excluding CO_2 savings (M€)	11 262	2 330	-
Net social benefits, including CO_2 savings (M€)	**17 564**	**3 145**	**-**
Cost-efficiency, excluding CO_2 savings (€ gained per € spent)	7.41	2.17	-
Cost-efficiency, including CO_2 savings (€ gained per € spent)	**10.99**	**2.58**	**-**
Cost-effectiveness (c€ spent per kWh saved)	**0.91**	**3.69**	**-**
Unitary cost for obliged parties (c€ spent per kWh saved)	**0.67**	**0.34**	**0.84**

Table 4: Static efficiency analysis (consolidated results, see annex for calculation details)

Social efficiency assessment

Benefits should be balanced against costs to assess the socio-economic efficiency of the schemes. Benefits come primarily from the monetary valuation of reduced energy operating expenditures and avoided CO_2 emissions ensuing energy savings from the consumer standpoint, although social benefits accruing from the British scheme should be intangibly magnified by fuel poverty alleviation. Private benefits might also accrue to obliged parties from energy price increase or market share gains. We consider them as transfers between consumers and energy companies or among energy companies, and thus do not count them. Table 4 shows that the French and British schemes (and very likely the Italian scheme) have undoubtedly gathered net social benefits. They pay for themselves, whether environmental benefits from carbon savings are taken into account or not. Large discrepancies between cost-efficiency estimates (excluding CO_2 savings) arise, due to the much higher target in Great-Britain, related to comparable costs. These discrepancies are magnified by a

very contrasted valuation of CO_2 savings, according to industrial differences in electricity generation in both countries (see Annex for details).

4.3 Cost distribution among involved agents

A closer look at the distribution of costs among agents is helpful for explicating obliged parties strategies. Table 5 shows that the bulk of obliged parties costs are direct costs in Great-Britain (85%) as opposed to France, where the share of direct costs is generally much lower (36%) but contrasted among obliged parties. In particular, direct cost shares are low for the two main obliged parties but comparable to British shares for fuel oil retailers. Apart from that distinction, the last row of Table 6 exhibits a very low cost heterogeneity within countries, cost differences never exceeding 5% among obliged parties, for a given measure. According to Lees (2008) and Mundaca (2007), half of the indirect costs in Great-Britain are volume-related, mainly for tasks like marketing, providing information to consumers and negotiating with third parties. In France, the development of energy efficiency allegations in commercial offers has borne sizeable indirect costs, by 77% variable. For instance, EDF has launched a new brand "Bleu Ciel" on the mass market, enriching the former brand "Vivrelec" with information and advice services. Without changing the mark, GDF SUEZ has developed a quite similar strategy while including a financial support for energy efficiency measures in its brand "Dolce Vita"[26].

	Great-Britain 2005-08	France 2006-09
Share of total costs incurred by obliged parties	73%	9%
Share of direct costs within obliged parties cost	85%	36%
Total cost variation among obliged parties	5%	4%

Table 5: Cost distribution among involved agents (Source: Lees (2008) and Mundaca and Neij (2009) for Great-Britain; own estimation for France)

This breakdown can be interpreted as follows. In all segments in Great-Britain and on the fuel oil segment in France, high direct costs correspond to large subsidies granted by obliged parties to consumers for investments in energy efficient equipments. Conversely, on the other French energy markets, obliged parties develop services less appealing from the consumer perspective, like information, energy diagnosis, etc (Bodineau and Bodiguel, 2009). Unlike the early assertion of Bertoldi and Rezessy (2008), the reference *modus operandi* of subsidies granted by obliged parties is therefore not systematic. As a result, albeit four times less cost-effective for the society, the French scheme is approximately twice less expensive for obliged parties than the British one (see Table 5, last row). In particular, the current obliged parties cost is far below the penalty and the 1c€/kWh reference cost generally used in *ex ante* evaluations.

When extending the analysis to all agents involved, it turns out that the total costs of the scheme are mostly covered by obliged parties in Great-Britain, whereas consumers investing in energy efficiency are large contributors in France. In addition, the tax credit scheme is actively used by obliged agents

[26] See <www.edf-bleuciel.fr> and <www.dolcevita.gazdefrance.fr> (website visited April 2010)

to persuade customers, which makes the public budget the most significant funder of energy efficiency measures realised by white certificates schemes. With the assumption of a variable public deficit, this outcome is not consistent with the rationale of the scheme to avoid public costs. Moreover, even though performance matters rather than means, this raises property rights concerns, since certificates are owed by parties that sometimes barely funded them (Bertoldi and Rezessy, 2008).

4.4 Cost recovery practices and "downstream" strategies

"Downstream" strategies, i.e. obliged parties strategies towards final consumers, appear to be determined by cost recovery practices, deeply influenced by liberties given to obliged parties in energy price setting. This can be established from the comparison of three different regulatory situations, differing by whether the obligation is placed on energy suppliers subject to unregulated energy prices (as in Great-Britain and partly in France), on energy suppliers subject to regulated prices (as in dominant cases in France) or on energy distributors, whose business (and output price) is regulated (as in Italy).

In Great Britain, where energy prices are set freely in liberalized and effectively competitive energy markets, subsidies for energy efficiency measures are a basic strategy for energy suppliers. We are not able to decompose their margin, so there is no way to ascertain whether energy suppliers fully pass through the compliance cost[27] on energy prices. Nevertheless, it is assumed as such by the British Government and Lees (2008) estimates that the expenditures by the energy suppliers represent on the average 6.9£ (or 9.7€) per customer per year, equivalent to 1-2% of the average annual fuel bill. This conforms well to the hybrid subsidy-tax mechanism depicted in microeconomic models and as outlined in Section 2.3, the high level of competition on energy markets exacerbates the incentive provided to energy suppliers to have aggressive "downstream" strategies. The correlation between subsidisation and flexibility in energy price setting seems all the more robust that it holds also for the fuel oil segment in France, where prices are not regulated and obliged suppliers vastly use rebates. One could expect that the pre-existing incentive of the tax credit scheme would reduce rebate levels, but fuel oil retailers need to keep incentives high to countervail the marked decline of their business with growing environmental concerns[28].

In France, the target was set to generate limited energy price increase of +0.5%. On the dominant electricity and natural gas mass market segments in France, the persistence of regulated tariffs dramatically restricts cost recovery permissions and obliged suppliers are not keen to provide financial incentives to consumers. Instead, they tend to offer relatively inexpensive services like information and diagnosis which bear indirect rather than direct costs. They concentrate on lowering costs, in particular indirect costs by working on structuring the upstream business. This is a way to

[27] The compliance cost is supposed to equal the cost of the subsidy, if any, plus the opportunity cost of energy sales losses.

[28] Interestingly, although not obliged at the beginning of the consultation process, fuel oil retailers saw an opportunity to make their business evolve and asked for participating to the scheme. As stated previously, their participation was also an opportunity for the regulator to enhance the number of players and therefore enhance trade provisions.

safeguard paybacks by commercial advantages, rather than playing on the output price. Note that the situation is slightly different on other markets like local communities, for which more specific measures have to be promoted and where consumers are more aware of potential benefits from the scheme[29].

In Italy, a peculiar situation occurs, whereby obliged distributors are granted 100€ for every toe of certified savings, paid ultimately by energy consumers through a flat tariff contribution (Pavan, 2008). While energy service companies are acting towards consumers, distributors provide few incentives for energy efficiency measures and rather buy certificates at an average spot market price[30] of 60€/toe. This situation yields large private benefits for distributors at the expense of consumers and moves away from the rationale of the instrument, supposed to avoid public fundraising. That forced the regulator to intervene on white certificates markets by increasing the number of obliged parties and unifying the electricity and gas '*titoli*' to reduce the concentration of market players. The market reacted in increasing the average exchange price, thus lowering the benefits accruing to distributors and keeping the incentives for energy service companies to invest in costlier measures high. Recently, the contribution tariff has been decreased.

To conclude this section, white certificates schemes conform to stylized facts if they are inserted in the appropriate unregulated energy price context, as in Great-Britain and on the fuel oil segment in France. Where output tariffs are regulated, in Italy and on electricity and gas markets in France, obliged actors must develop strategies more remote from the consumer level.

5. Flexibility provisions and "upstream" strategies

From Radov *et al.* (2006), we consider flexibility options as two basic forms of trade[31]:

- *Vertical trade* – Outsourcing relationships between *different* parties facing uneven transaction costs[32], namely obliged energy companies and third parties, aimed at minimizing transaction costs, thus lowering the *cost of delivering energy efficiency measures*.

[29] It should be underlined that the scheme has been designed for these actors, leaning on the fact that they would produce white certificates and sell them. Such investments being not ensured by the actual low exchange price, they have showed a preference towards long-term contracts to date.

[30] As stated earlier, marginal costs of compliance should equal the spot market price. Nevertheless, it is likely that spot exchanges are risky and thus bear additional costs. Taking the spot market price as a proxy for costs is thus conservative and underestimates potential private benefits.

[31] The authors consider the banking of energy savings as a third, "intertemporal" form of trade, essentially aimed at reducing temporal risk. Albeit significant in all countries (see Section 3.1), we do not consider it as a relevant element to tackle with organisational issues and therefore leave it aside from our analysis.

[32] Broadly defined as costs other than production costs.

- *Horizontal trade* – White certificate exchange between *similar* parties facing heterogeneous production costs, aimed at equalizing marginal costs, thus lowering the *overall cost of the scheme*.

Such a distinction based on the type of parties engaged in transactions allows for disconnecting the broad concept of trade from the narrow concept of white certificates exchange. While generally perceived as horizontal trade, we argue that white certificates exchange might also be seen as vertical trade if it involves two different types of parties. It is noteworthy that by linking target compliance to transfers from energy producers to energy saving goods producers, microeconomic models have stressed vertical rather than horizontal trade.

The "flexibility" component has been advertised by policy-makers alongside the implementation process to convince obliged suppliers of the potential benefits they could draw, thereby overshadowing the elementary "obligation" component. In particular, the prospect of capturing new rents thanks to market mechanisms has been appealing for obliged agents, up to the point that it certainly drove the large scope of the Italian and French schemes. But the experience indicates that white certificates exchange has not been a panacea to date. By comparing updated results of the three European experiences, we seek answers to the following questions: to which extent does the market for white certificates bring flexibility in the functioning of white certificates, as compared to other options? Altogether, what is the influence of flexibility options on "upstream" organisation, i.e. obliged parties strategies towards their related energy businesses?

5.1 Overall activity of the markets for white certificates

One straightforward outcome of white certificates schemes is the opposite market activity in France and Great-Britain, as compared to Italy. Whereas white certificates exchanges were negligible in Great-Britain and cover only 4% of certified energy savings in France (Bodineau and Bodiguel, 2009), they represent 75% of white certificates issuance in Italy so far (Eyre *et al.*, 2009). From the contrasted designs exposed in section 2.3, we expected a high market activity in Italy, a low market activity in Great-Britain and ambiguous outcomes in France. The fact that French results match the British ones suggests that from the two determinant design features, namely the type of obliged agents (common to France and Great-Britain) and the easiness of exchanges (common to France and Italy), the former prevails for explaining the market activity. Italian specific outcomes can thus be interpreted as follows. Energy distributors have no direct holds over final consumption nor commercial advantages to draw from end-use consumers because they are not their customers. Moreover, the high level of normalized cost recovery provides an incentive to maximise the margin and buy at low cost or to outsource energy efficiency measures. As a result, energy distributors are not keen to promote actively energy conservation and prefer to purchase white certificates. White certificates exchanges are mostly realised over the counter (78%) rather than on organised spot markets, intrinsically riskier. While the demand for white certificates comes exclusively from obliged parties, the supply might be a number of different actors and 72% of certificates were traded between an obliged party and a third party (Pavan, 2008). In other words, small energy service companies have been the main suppliers of white certificates. In most of the cases, those are subsidiaries of obliged distributors within an integrated industrial group. The predominance of bilateral exchanges between energy distributors and related energy service companies suggests that

long-term outsourcing contracts dominate (Eyre *et al.*, 2009; Langniss and Praetorius, 2006). That is to say, vertical trade dominates.

Whenever the type of obliged parties provides sufficient grounds for explaining the level of market activity, other factors are at play to explain the absence of white certificates exchanges in France and especially in Great-Britain[33]. First and foremost, costs borne by obliged parties must be heterogeneous to allow for horizontal trade. Applying the framework provided by Newell and Stavins (2003) to white certificates schemes, cost heterogeneity might arise from (i) the heterogeneity in individual targets and (ii) the heterogeneity in firms cost functions. Regarding the first criterion, individual targets are distributed according to market shares in the household sector and it is clear that they are very contrasted in Italy and France but rather homogeneous in Great-Britain. Regarding the second criterion, we showed that obliged suppliers face very similar costs in France and Great-Britain, regardless of their size (cf. Table 5). In the perspective of supporting the diffusion of goods that they do not product, energy suppliers' cost function depends directly on their access to other energy efficiency businesses, and it seems that those actors propose very similar prices. Outcomes regarding these two criteria are likely to be magnified by some sensitive policy parameters like the scope of the obligation and especially the stringency of the overall target. Peerels (2008) provides numerical simulations showing that market exchanges could become significant in Finland for a coverage of at least 28% of the saving potential; below that threshold, measures are inexpensive and trade is useless. In the real world, targets do not exceed 0.6% of the energy consumption under coverage. Second, reluctance to trade can be invoked to explain the low market activity. As obliged suppliers compete on energy retail markets, some commercial benefits might arise from non-trading, like market share preservation and cost increase for competitors. Through a game simulation involving real energy suppliers, Mundaca *et al.* (2008) show that potential losses associated with trading can exceed additional costs of non-trading in Great-Britain. As a result, obliged suppliers show preference towards autarkic strategies[34].

This issue can be narrowed to past and present experiences with market-based instruments for environmental policy in the United States. In the 1990s, the air pollution cap and trade programs have witnessed very low market activity, due mainly to a preference towards autarky (Burtraw, 1996). More recently, in the four states where EERS have been implemented with market provisions, namely Massachusetts, Pennsylvania, Vermont and Connecticut, only in the latter does the market show a significant activity (Loper *et al.*, 2010). This reminds us that under quantity instruments, the market is just a way among others to comply with the elementary "command and control" component.

[33] In their extensive analysis of the market activity, Mundaca *et al.* (2008) review a large set of explanations, including: commercial benefits of non-trading; excess supply; limited number of parties and market power; perceived high transaction costs; banking options.

[34] Nevertheless, this does not prevent optimization behaviour at the margin. One major supplier in France claims having purchased a small amount of white certificates to have a benchmark of marginal cost. Albeit volatile, the average exchange price on the French market for white certificates (0.32 c€/kWh) equals obliged parties cost estimates of 0.34 c€/kWh acknowledged in Section 4.3.

5.2 Vertical trade and "upstream" transactions

Altogether, results from the three European experiences show that energy suppliers take advantage of flexibility options mainly through vertical trade. We have seen that the high market activity observed in Italy should not be interpreted as horizontal trade between obliged parties, but rather as vertical exchanges between energy distributors and related energy service businesses. As well, there is no horizontal trade in France and Great-Britain, owing to the near absence of organized white certificates markets between obliged parties. Instead, obliged suppliers tend to develop contracts with upstream businesses under a win-win relationship: obliged parties need installers to diffuse information[35] and ultimately undertake measures, while small installers benefit from the large customer portfolio of energy suppliers. Let us consider the upstream relationships emerging in different countries.

According to different authors (Eyre *et al.*, 2009; Lees, 2008; Mundaca *et al.*, 2008), British energy suppliers develop close relationships with insulation contractors, managing agents, housing promoters, retailers and manufacturers, and develop partnerships with social housing programs and charity organisations. The market for insulation contractors is dominated by a few actors and 100% of insulation measures have relied on subcontracting. This implies a very competitive bidding process that equated compliance costs among obliged suppliers. As well, some energy suppliers deal directly with manufacturers to promote innovative equipments like integrated digital televisions (Lees, 2008). In Italy, the scheme was supposed to serve the development of energy service companies, which fill the gap between distributors and final consumers[36]. As said above, many of them are subsidiaries of obliged distributors and deal with them through "intra-obliged party" trade. It must be emphasized though that they are generally very small units, sometimes solely created to distribute reduction coupons on CFLs to consumers. So far, the scheme has only partly succeeded in supporting the development of formal energy service companies, independent from obliged parties. In France, major energy suppliers acknowledged that all of their energy efficiency actions are co-operated with installers or formally subcontracted. While they have few rooms to recover the burden through increased energy prices, they work with installers to develop attractive commercial offers, rather than directly grant their customers with large rebates (as stated in Section 4.4). As opposed to Great-Britain, the market for insulation counts thousands of small actors, for which insulation is not a specialisation but rather one skill among others dedicated to housing works. Obliged suppliers strengthen networks around them to structure this market by training professionals[37] , labelling them and rewarding their energy efficiency actions towards consumers. This task is all the more innovative

[35] Mahapatra and Gustavsson (2009) showed for example that installers of heating systems are the most important communication channel for providing information to final energy consumers.

[36] It is worth mentioning that there are exceptions to that outsourcing process. Actually, energy distributors operate by themselves where they have operating licence with municipalities like on public lighting and district heating system, which represented respectively 7% and 5% of the white certificates issued in 2005-2007.

[37] Up to now, 10,400 people out of 356,000 small companies have received training courses funded by 95% by energy suppliers (CAPEB, 2009).

and competitive that some companies try to investigate the same business segment as eligible parties, without bearing the opportunity costs of energy sales losses (e.g. 'Certinergy' company[38]).

It comes out that the obligation to promote energy conservation in liberalized energy markets prompts energy companies to turn their traditional business model into an energy service provider business model, through integrated up- and downstream strategies. On the downstream side, commercial offers are all the more changing in countries where the constraint cannot be recovered. Competitors can differentiate by providing information and advice (Hinnels, 2008), as it is argued in France by EDF commercial director (Poiroux, 2009). In Great-Britain, commercial offers are more stable and energy suppliers keep energy efficiency operations separate from their core business (Eyre *et al.*, 2009), while providing large rebates though. The former strategy bears lower but essentially indirect costs, whereas the former bears higher direct costs that can be recovered by energy tariffs. In parallel, powerful change occur similarly in every country on the upstream side through vertical arrangements with energy efficiency businesses.

6. An evolutionary perspective of white certificates functioning

In what precedes, we basically drew country-specific conclusions, holding at the current steps of the schemes. They reflect the complexity of the instrument and underline the effects of design details on the performance and strategies of involved parties. The performance of white certificates schemes to deliver long-term and cost-effective benefits requires consistency between three elements: (i) a proper definition of deemed savings, favouring actions with long lifetimes and ensuring that the white certificates issuance is clearly additional to the business as usual; (ii) an adequate cost recovery permission, allowing for subsidizing end-use customers, which is seemingly the most powerful way to reach costly saving potentials; (iii) an appropriate policy coordination with overlapping instruments.

Taking this "consistency principle" for granted, we argue that by aiming energy performance without mandating any specific technology, white certificates schemes have the ability to bring closer fragmented and isolated markets for energy efficient technologies, leading ultimately to a fully-fledged market for energy efficiency. This would combine various technologies and energy services (e.g. whole retrofit packages[39]) and involve many market players to help obliged parties handle very ambitious energy efficiency policy. Vertical arrangements like long-term contracts or joint ventures sustain that process as long as actors progress towards higher marginal costs savings. When a new potential is tapped, technological and organisational learning is triggered and lowers technology costs. Likewise, besides diffusion, growing emphasis is placed on the innovation process. National

[38] <www.certinergy.com> (webpage visited April 2010)

[39] There is early evidence of such commercial products, for example the "Optireno" offer promoted jointly by Banque Populaire (bank), Isover (insulation products) and GDZ SUEZ as main partners. See <www.optireno.fr> (website visited April 2010).

institutions, white certificates schemes designs and policy portfolios must be adapted to accompany this evolution, in order to preserve the “consistency principle”.

It is therefore fundamental to have a dynamic view of white certificates schemes and we propose hereafter the prospect of a four step deployment of white certificates schemes, alongside the implicit marginal cost curve of energy efficiency potentials (as roughly depicted on Figure 2). Transitions to subsequent potentials are conditional to changes in regulation, like energy savings target settlement and cost recovery permissions. Although schemes have drawn country-specific outcomes in their early stages, we foresee an ideal but slow convergence towards a unified market for energy efficiency.

Step 1: Technology and flexibility experimentation

At the implementation step, obliged parties focus on their core business with traditional partners (equipment producers, retailers and installers). They do not compete head-on because they operate on separate markets (e.g. efficient electric heaters for an electricity supplier *versus* condensing boilers for a gas supplier) and concentrate on their captive customers, so that there is no real competition among them on the downstream side. However, they also tap low cost potentials (e.g. lighting) and might experiment a wide range of technological fields to reveal their costs and develop new skills. They initiate vertical relationships with related businesses. Under this first stage, energy savings come at low cost and strategic intertemporal banking can be important to anticipate further difficulties in tapping costlier potentials.

Step 2: Low hanging fruit picking

Obliged parties harvest the low cost potentials that they have identified previously. They subcontract or partner with related business to reinforce vertical arrangements aimed at minimizing overall compliance cost. On the consumer side, they enhance their commercial offers with services like information, diagnosis, etc. In countries where costs can be recovered, they start granting important subsidies. Where costs cannot be recovered, major suppliers focus on information services and upstream business structurizing. This is made possible by the presence of complementary instruments (e.g. tax credit) that support consumer investments. Low cost potential being still abundant, banking remains important.

Step 3: Activity upscale

As low hanging fruit potentials start being exhausted, more labour and organisational demanding measures become necessary. Vertical arrangements linking obliged parties and related businesses become fully operational to extend skills, to investigate markets more remote from the core business (like insulation) and to capture new market shares. Cost heterogeneity might arise among vertical arrangements but to such a low extent that they are still reluctant to trade. Energy savings provisions that were carried over start being used for compliance and the banking of new savings declines. On the consumer side, information is not sufficient anymore to incentivise customers. To reach this maturity step, cost recovery must be allowed consistently to ease the systematic use of financial rebates.

Step 4: Energy efficiency unified market

In that ultimate step, a unified and competitive market for energy efficiency emerges, supplied by a few integrated vertical clusters. They are able to provide whole retrofit packages merging different skills and technologies, like insulation, lighting, heating system, etc. Consumers benefit from large subsidies for retrofits but pay a higher energy price because as long as targets have scaled up, obliged parties have been allowed to recover the burden through energy tariff. The process of vertical organization is now fully mature. Cost heterogeneity among clusters competing on one single market arises and horizontal trade between clusters allows for equalizing marginal costs. Promoting innovation is another way to differentiate. Intertemporal banking is over.

The rate of that evolutionary process will be primarily influenced by the increase of the energy savings target (Peerels, 2008). The eligibility of non-obliged actors might also attract new players and increase the competition to acquire property rights on energy savings, thus speeding-up that overall dynamics. The penalty for non-compliance might be another driver of that process, since the higher the pre-set penalty, the more profitable it is to investigate high cost potentials for target fulfilment. In this prospect, we guess that France and Italy stand currently in step 2 and the longest running British scheme (in its current CERT version) stands at step 3. In Great-Britain, the Government has announced maintaining the energy suppliers obligation until 2020 at least and market provisions are being enhanced to serve that purpose (Defra, 2007). In Italy, targets have been prolonged and increased from 4.4 Mtoe over the 2008-09 period to 21 Mtoe over the 2008-2012 period (Pavan, 2008). In France, the scheme is about to be extended to gasoline retailers, with an overall target scaled up to 100 TWh/year[40] (against 18 TWh/year from 2006 to 2009). The dynamic framework proposed above helps assess some of the evolutions foreseen for white certificates schemes. Regarding the extension of the obligation to gasoline retailers, an issue addressed by Rezessy *et al.* (2009), we expect transfers from the transport sector to the building sector. Actually, the potential for savings is less profound than in the residential building sector, and relationships with final customers are much more remote, so that gasoline retailers will have fewer direct means to comply with their target. As a result, they will either pay the penalty or purchase cheaper certificates produced in the residential sector, which will undoubtedly raise acceptability concerns. Regarding the creation of a EU-wide system, an issue addressed from the early implementation of white certificates schemes onwards (Farinelli *et al.*, 2005; Mundaca, 2008), it has been underlined by many observers that country-specific issues are currently overwhelming and preclude any design convergence. We consider that any country intending to participate should at least have reached step 4 to join any international scheme. Moreover, national energy security objectives can be contradictory among countries (Pointvogl, 2009) and concur to limit the advantages of an EU-wide scheme.

[40] Ministry of Sustainable Development, press communiqué, 26 may 2009

7. Conclusion

On the methodological point of view, we provided and partially validated a stylized representation of white certificates schemes. From a review of theoretical works, we depicted white certificates schemes as a constrained subsidy on energy efficient goods coupled with a compensatory end-use energy tax, whereby transfers between obliged parties and related business prevail. The confrontation of these findings to practical outcomes required two preliminary tasks. Firstly, to make explicit the influence of the national regulatory context on the design of the instrument on the one hand, the influence of the design on the performance on the other hand. Secondly, to perform a comprehensive analysis of costs which are only partially disclosed. This resulted in a twofold representation of white certificates schemes. On the upstream side, they induce powerful vertical process to create a whole market for energy efficiency embodying costly potentials. On the consumer side, they act as a subsidy for energy efficient goods where the burden can be recovered, and more simply as an information tool otherwise. With this respect, the hybrid subsidy- tax mechanism is valid but conditional to energy price setting rules and following cost recovery liberties. As well, the pre-eminence of vertical transfers is valid but holding for current steps only. A fruitful area for future research could be to better represent the trade-off between vertical and horizontal organisation.

By supplementing this static analysis by a dynamic efficiency evaluation, we back the view that white certificates, or broadly defined energy savings obligations and credits, can draw positive social outcomes by accurately tapping scattered potentials for energy conservation in the context of European liberalized energy markets. The use of multiple evaluation criteria, as performed differently by Mundaca and Neij (2009) is crucial to fairly judge schemes outcomes. For instance, the British experience shows the highest level of static efficiency but a lower level of dynamic efficiency than the French one. But altogether, white certificates experiences appear to be cost-effective and carry out net social benefits wherever they are implemented. Marked discrepancies among countries arise in early steps but should probably be narrowed as schemes scale up. More importantly, white certificates schemes show good “dynamic” properties. In particular, they prompt obliged parties to transform the markets for energy equipments and services and to federate related energy service businesses around them through vertical arrangements. In frequent situations where the burden cannot be immediately passed through on energy price, capturing new market shares and investigating new technological fields is the only way for obliged companies to take advantage of the scheme. This is part of the explanation for the absence of horizontal trade, i.e. white certificates exchange among obliged parties. Albeit a commodity, the “white certificate” is not homogeneous but split among numerous markets, involving different technologies and skills. Deemed savings are a physical abstraction that guarantees energy performance and provides fungibility among separate markets. But it is not sufficient to create a homogeneous good providing a fully-fledged “energy efficiency” service, merging different technologies. The main process at stake in white certificates scheme is therefore to build vertical relationships aimed at supplying such a unified market. That impetus is triggered by the “obligation” component rather than the “market” component. At subsequent steps, when appropriate vertical clusters will be consolidated, we could expect market provisions to become important and enhance the efficiency of the scheme. Lastly, it is worth mentioning that white certificates schemes serve that purpose within a policy mix including

information programs, building codes and even tax credits. Owing to their performance rather than technology focus, white certificates are likely to be the main driver of the mix though.

Lastly, distributive effects and policy interaction deserve more attention for both theoretical and empirical works in the future. Whereas only a few people might benefit from the scheme, the cost can be passed through to all consumers. As schemes scale up, the question of beneficiaries is raising crucial equity concerns. Fischer (2005) underlines that this issue is linked to the structure of the markets for energy efficiency technologies. Similarly, we saw briefly that policy interaction is a crucial issue in terms of efficiency and beforehand, in terms of justification.

Annex: Normalized energy savings, costs and benefits calculation details

We detail hereafter the calculations made for Table 1 (third row) an Table 4. We strove for expressing each target in the same normalized unit as for the French scheme: TWh of end-use energy, cumulated over the average lifetime of the measures and discounted at 4%. Please note that we solely considered energy savings realised against the target and did not count overachievements for the estimation of costs and benefits.

France

Cost estimates

We have carried out an inductive estimation of the costs of the three main obliged agents, namely EDF, GDF Suez and Ecofioul (professional association representing fuel oil retailers), based on ADEME data. We have conducted a systematic review and quantification of the relevant sources of costs borne by the three companies and other bodies under consideration. As outlined in Table A1, we distinguished fixed and variable parts within indirect costs. Fixed costs are sunk costs paid to develop news activities in response to the white certificates obligation. This covers material investments like information networks and immaterial investments in energy efficiency training. Variable costs are indirect costs related to the volume of energy efficiency measures, like phone centers and marketing. A basic rule of thumb has been used to derive values for the national objective of 54 TWh from the results related to the three main obliged parties, whose obligation covered 48 TWh cumac.

Direct costs	Indirect costs	
	Variable	Fixed
• Advice • Diagnosis • Subsidies • Soft loans • Energy services	• Call centers for delivering energy advice • Technical advice • Professional partnership • Marketing • Administration of the scheme	• Training • Commercial offer development • Information networks

Table A1: Relevant sources of costs borne by obliged parties in France

Costs borne by consumers are the full investment cost for measures like insulation but the cost differential with the standard technology for boilers and appliances, net from tax credits and obliged parties subsidies. It has been calculated using the measures repartition provided by DGEC (2009) and the average measure price from ADEME database. The Government is assumed to be the only "other party" bearing costs, as tax credits granted to consumers and tax deductions granted to fuel oil suppliers who join professional associations. Those amount to 966 and 25 M€ respectively, thus 991M€ altogether. Tax credits to customers represent on the average 26% of the investment cost.

Obliged parties direct costs (M€)	66
Obliged parties indirect costs (M€)	119
Customer costs (M€)	814

Other parties costs (M€)	991
TOTAL COSTS (M€)	**1990**

Table A2: Costs of the main contributors in France

Note that free riding and rebound effects should be considered against costs. Although part of them is supposed to be accounted for in deemed savings calculation, a residual part might hamper cost-effectiveness[41]. Unlike the British evaluator, we were not able to perform an in-depth analysis of these elements for France.

Monetary savings from reduced energy bill

Monetary benefits from reduced energy bill are calculated using a constant average energy price of 0.08 €/kWh (including VAT). Note that as the energy savings are discounted, thus so are the monetary savings. We find that the scheme yielded **4,320 M€** of monetary savings.

Monetary savings from reduced CO_2 emissions

We build the monetary value of carbon savings upon both carbon dioxide savings estimates and the social value of carbon. The amount of CO_2 emissions saved is not straightforward to estimate in France. First, the fuel breakdown of energy savings is not provided by the regulator and from the main measures implemented we deducted fuel shares of 23% for electricity, 56% for gas and 21% for fuel oil. Second, the French electricity generation mix is highly dominated by nuclear power for base load and peak load is mainly supplied by fossil fuels. Therefore, estimates of carbon savings from reduced electricity consumption might differ whether one considers the *average* or *marginal* carbon content of electricity. For the dominant heating measures, the *average* value is 180 gCO_2/kWh (ADEME and EDF, 2005) and the *marginal* value is 550 gCO_2/kWh (ADEME and RTE, 2007). We use these values for low and high estimates, plus a central one set at 365 gCO_2/kWh. Carbon contents of natural gas and fuel oil are assumed to be 206 and 271 gCO_2/kWh, respectively (ADEME, 2008). Note that the CO_2 savings are related to undiscounted energy savings, since CO_2 is assumed to be removed definitively from the atmosphere once saved.

Social benefits accruing from reduced CO_2 emissions are valuated in monetary terms using the social value of carbon proposed for the French economy (Quinet *et al.*, 2008). It is set at 32€/tCO_2 in 2010, 56€/tCO_2 in 2020 and 100€/tCO_2 in 2030. From DGEC data we estimated the average measures lifetime to be 20 years, energy savings thus lasting from 2006 to 2028. We use 46€/tCO_2 as an approximation of the carbon value in the intermediate year 2016.

	Low value	Central value	High value
CO_2 savings from electricity ($MtCO_2$)	3.2	4.6	9.8

[41] According to the stylized representation outlined in Section 2, Giraudet and Quirion (2008) show that the "tax" component is likely to induce "sufficiency" behavior, and thus bound the rebound effect to 10% of energy efficiency losses compared to effective energy savings. In the real world, due to very low price-elasticity of residential energy consumption, this behavioural response might be limited and the rebound effect higher.

CO_2 savings from natural gas ($MtCO_2$)	8.7	8.7	8.7
CO_2 savings from fuel oil ($MtCO_2$)	4.4	4.4	4.4
TOTAL SAVINGS ($MtCO_2$)	**16.3**	**17.7**	**22.9**
Monetary savings (M€)	**751**	**815**	**1054**

Table A3: CO_2 savings in France

Great-Britain

We build primarily on the values provided by Lees (2008) for the evaluation of the EEC2 scheme. We generally use a 1.4 €/£ exchange rate, which is a good guess of the average market exchange rate over the April 2005-March 2008 period, according to monthly records of OANDA (<http://www.oanda.com/>, website visited March 2010).

Normalized energy savings

The quantitative obligation of the EEC2 period was 130 TWh of cumulated energy savings fuel standardized, discounted at 3.5%. When converted in their original fuel units, discounted at 4%, those savings amount to 45.9 TWh for electricity, 134.9TWh for gas and 11.6TWh for other fossil fuels, thus altogether 192 TWh (Lees, personal communication). This means 64 TWh/year for the three years of EEC2.

Although labelled in $MtCO_2$ saved, the CERT target is twice the EEC2 target, therefore 384TWh or 128TWh/year over 2008-2011.

Cost estimates

Direct costs have been calculated by Lees using estimates from the policy regulator (Defra) and the share paid by each agent is derived from information reported to the administrator (Ofgem) by obliged suppliers. Indirect costs are considered as the sum of “administrative costs” and “transaction costs”. The latter have been estimated under EEC1 as shares of investment costs dedicated to tasks like persuading consumers and negotiating with third parties. They have reached 8-12% and 24-32% of total investment cost for lighting and insulation measures, respectively (Mundaca, 2007). Overall, indirect costs are estimated by Lees on a deductive manner as 18% of the obliged parties direct costs under EEC2.

Other notable parties bearing costs are social housing providers and managing agents. Note that the costs borne by customers are the resulting part of the investment cost (full cost for insulation, cost differential with the market standard for heating systems and appliances).

	Lees estimates (M£)	Corrected estimates (M€)
Obliged parties direct costs	775	1085
Obliged parties indirect costs	140	195
Customer costs	232	325

Other parties costs	109	153
TOTAL COSTS	1256	

Table A4: Relevant sources of costs borne by obliged parties in Great-Britain (Source: Lees, 2008)

Monetary savings from reduced energy bill

Interestingly, free-riding and rebound effects are accounted for by the British evaluator thanks to a "deadweight" factor of 20% and a "comfort increase" factor of 15%. Nevertheless, we use the values including both deadweight and the value of comfort (including VAT) to keep the comparison to other schemes consistent (Lees, 2008, Table A5.3).

	M£	M€
Present value to electricity consumers	4,800	6,720
Present value to gas consumers	4,030	5,642
Present value to fuel consumers	470	658
TOTAL	9,300	**13,020**

Table A5: Present value of the energy savings (Source: Lees, 2008; 1£=1.4€)

Monetary savings from reduced CO_2 emissions

We build the monetary value of carbon savings upon both carbon dioxide savings estimates and the social value of carbon. We first use Lees' estimation of lifetime carbon dioxide savings to target of 72.6 $MtCO_2$, including deadweight (Lees, 2008, Table A5.6). Then we use the last available social value of carbon recommended by DECC for the use of carbon values in economic appraisal (DECC, 2010, Table 1). The average measures lifetime has been estimated to be 34 years (Lees, personal communication). Carbon savings are thus supposed to last from 2005 to 2028, so we take the 2023 social value as an average (given a linear increase of the recommended value). For policies affecting non-ETS sectors, DECC provides low, central and high 2016 values of 31, 62 and 93 £/tCO_2, respectively (43, 87 and 130 €/tCO_2). Contrary to France, the uncertainty is thus placed on the carbon price rather than on the carbon savings. As a result, the central estimate of monetary savings arising from reduced CO_2 emissions is **6,302** M€, with low and high values of 2,846 and 8,639 M€, respectively.

Italy

Our estimation of the Italian scheme is much rougher, due to a lack of cost data. Following partial results thus are to be interpreted carefully.

Normalized energy savings

One preliminary task is to convert annual savings of primary energy in toe into lifetime end-use savings in kWh. First, we use the 2/3 ratio used by Eyre et al. (2009) to convert primary savings into end-use savings. Second, since the white certificates are issued over five years, we cumulate the savings over the same period, discounted at 4%. Note that insulation measures must be cumulated

over eight years, but given the low amount of insulation measures realised so far, we apply the five years lifetime to all measures. Lastly, the conventional conversion factor from toe to kWh is 11,630.

	Electricity	Gas	TOTAL
2005 primary energy target (Mtoe)	0.1	0.1	0.2
2006 primary energy target (Mtoe)	0.2	0.2	0.4
2007 primary energy target (Mtoe)	0.4	0.4	0.8
2008 primary energy target (Mtoe)	1.2	1	2.2
2005-2008 primary energy target (Mtoe)	1.9	1.7	3.6
2005-2008 lifetime primary energy target (Mtoe)	8.8	7.9	16.7
2005-2008 lifetime end-use energy target (TWh)	**68**	**60**	**128**

Table A6: Energy savings expressed in normalized units over the 2005-08 period in Italy

Following this methodology, the initial target covering the 2005-2009 period was 156TWh, thus 31TWh/year. The recent regulatory changes increased and prolonged the target, so that it represents 796 TWh, thus 100TWh/year over the 2005-2012 period.

Cost estimates

From Pavan (2008) and AEEG (2008), we estimate the average exchange price of white certificates to be 60€/toe over the 2006-2008 period. Given the predominance of white certificates exchanges in the scheme, we consider this price to be a good proxy for the marginal cost of the scheme for obliged distributors and other market actors (undifferentiated from direct and indirect costs). For the total amount of energy savings, this yields **1,080 M€ of** monetary savings.

Regarding the operating mode that has prevailed up to now in the residential sector, namely the nearly free distribution of CFLs and water economizers, we simply assume the customer cost to be zero. Note that the 100€/toe contribution that customer pay for the cost recovery mechanism is ultimately rebated to obliged distributors. We consider it as a transfer within the scheme and hence do not count it. Other costs should include, among others, the contribution of public authorities to the investment cost on measures realised on their premises, like public lighting. Data are not available to serve that purpose. Therefore, our evaluation of the costs of the Italian scheme is very likely to be an underestimate.

Monetary savings from reduced energy bill

Pavan (2008) figures out that avoided energy costs for consumers are around 600€/toe for electricity and 750€/toe for gas. This yields 5,700 and 6,375 M€ of electricity and gas savings, for a total of amount of **11,181M€**.

Monetary savings from reduced CO_2 emissions

According to Eyre *et al.* (2009), 4.5 TWh of annual end-use savings saves 1.5 $MtCO_2$ in Italy. With a basic rule of thumb be assume the 128 TWh target to save 42.7 $MtCO_2$. Italy has not set any official

social value of carbon. We thus use the conventional 20€/tCO_2 value to estimate monetary savings accruing from carbon dioxide savings. Those amount to **853M€**.

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