ECOLOGICAL ECONOMICS XX (2006) XXX–XXX

available at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/ecolecon

ANALYSIS

The social efficiency of instruments of promotion of renewable energies: A transaction-cost perspective

Dominique Finon[a,b,*], *Yannick Perez*[c]

[a]*Centre International de Recherche pour l'Environnement et le Développement, 32 avenue de la Belle Gabrielle, 94736 Nogent sur Marne, France*
[b]*Ecole des Hautes Etudes en Sciences Sociales et Centre National de la Recherche Scientifique, France*
[c]*Groupe Réseaux Jean Monnet (GRJM)–Institut d'Analyse des Dynamiques Industrielles et Sociales (ADIS). Université Paris Sud 11, Faculté Jean Monnet, 54, Bd Desgranges, 92331 SCEAUX Cedex, France*

ARTICLE INFO

Article history:
Received 28 January 2005
Received in revised form 26 May 2006
Accepted 26 May 2006

Keywords:
Environment
Renewable energy
Innovation
Instruments
Public economics
Transaction cost economics

ABSTRACT

This paper compares the social efficiency of the regulatory instruments used to promote renewable energy sources in electricity generation, taking into consideration their role in promoting the preservation of collective goods. They are based on a purchase obligation and act either by price (feed-in tariffs) or by quantity (bidding for new RES-E capacities; RES-E quotas). From the Public Economics perspective, the two instruments are distinct in terms of cost-efficacy and market incentives in a world of imperfect information. Exchangeable quotas of green certificates are preferred because this instrument allows better control over consumer costs and whilst retaining market incentives. Transaction cost economics (TCE) contributes to the assessment of these instruments, by introducing RES-E investment safeguard as a major determinant of social efficiency, and the instruments' conformity to its institutional environment as a determinant of its viability. In light of this additional consideration, the arrangements between RES-E producers and obligated buyers inherent in each instrument are in fact quite similar—either long-term contracting or vertical integration. We compare and assess RES-E price- and quantity-instruments on several dimensions from both the public economics and TCE perspectives: control of the cost for consumers, safeguards of RES-E investments, adaptability of the instrument in order to preserve its stability in the long run, market incentive intensity, and conformity with the new market regime of electricity industry. It shows neither instruments offer an optimal solution in each of these dimensions. The government will thus select an instrument in accordance with the relative importance of its objectives.

Since the 1990s, multiple objectives have driven governments to develop renewable energy policies: preserving a set of collective goods; climate stability; local environment; and energy security. Ambitious targets have been set at both national and European Union (EU) levels. If the voluntary objectives adopted by EU Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources are met, the share of "new" renewables in the electricity production are projected to increase from 1% to 8% of the total electricity production in average in the EU by 2010 (European Commission, 2001).

Government support is necessary for Renewable Energy Sources in Electricity (RES-E) because, although desirable from a social welfare perspective, their private costs are not competitive in power generation systems dominated by large

* *Corresponding author*. Ecole des Hautes Etudes en Sciences sociales et Centre National de la Recherche Scientifique, France. Tel.: +33 1 4394 7384; fax: +33 1 4394 7370.
E-mail addresses: finon@centre-cired.fr (D. Finon), yannick.perez@jm.u-psud.fr (Y. Perez).

0921-8009/$ - see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.ecolecon.2006.05.011

electricity generation plants. Three reasons account for the bias against RES-E in the electricity market: (i) environmental costs are not adequately internalized for conventional electricity generation technologies; (ii) the absence of scale effects on costs, due to the small size of the plants,[1] and (iii) the random nature of their intermittent production of some major sources of RES (wind power, minihydraulic) which creates negative externalities.

Following failed attempts using systems of voluntary purchases of green electricity by consumers, as well as direct investment subsidies, demand-side strategic deployment policies have emerged as the preferred instrument in most countries. By imposing obligations to purchase RES electricity or to meet a RES-E quota on a clearly specified type of agents, these policies are designed to allow demand-side forces to determine the allocation of RES-E production subsidies to pre-commercial and commercial RES-E technologies. There are three instruments with such common character: feed-in tariffs (FIT), bidding instruments (BI) for the assignment of long-term purchase contracts and exchangeable quotas (EQ).[2]

FIT obliges electricity distributors (or the incumbent suppliers in a spatial area) to purchase electricity from any new RES-E plant in their service area and pay a minimum guaranteed tariff per kilowatt-hour that is fixed over a long period of time. BI selects by auctions RES-E projects and obliges local electricity distributors (or the incumbent supplier in the market regime) to buy electricity from the successful plants by a long-term contract on the basis of bid price in the reference design (or the marginal price in some countries). EQ introduces future obligatory targets for electricity suppliers to buy either green electricity directly from the RES-E producers or green certificates issues to RES-E producers, targets being defined in terms of a percentage of their electricity deliveries. A complementary trait is a compensation mechanism for the opportunity cost for obligated purchasers, which is different in the monopoly regime and in the market regime.

This paper analyses the intrinsic properties of these instruments in their reference design from the perspective of transaction cost economics (TCE). By doing so, we make useful contribution to the findings from the public economics literature which compares the efficiency of policy instruments on different issues:[3] the choice between price-instrument and quantity-instrument in a world of uncertainty, the issue of long-term efficiency by differentiating the support of RES-E technologies and the possibilities of control of the collective cost and the windfall rent for the producers. Using the TCE approach introduces three valuable aspects.

Firstly, instruments are analyzed as "governance structures" that legally bind agents by contractual frames offering safeguard on RES-E investments to agents. Secondly, TCE approach takes into consideration the performances of RES-E instruments both in terms of efficiency and in terms of transaction cost supported by contractors. Finally, TCE also considers issues of feasibility which is strengthened with greater conformity with the new market electricity regime, and issues of credibility, i.e., the strength of its guarantee that the regulatory instrument will not deviate from its course or be abandoned (Levy and Spiller, 1994). Both issues are rooted in institutional environment of transactions firstly analysed by Nobel Prize laureate D.C. North (1990).

To date, few studies have been carried out with specific focus on TCE to assess and compare public policy instruments designed to promote the preservation of environmental goods. Delmas and Marcus (2004) explore the role of transaction costs in determining relative desirability of alternative instruments (command and control, market instruments, voluntary agreements) from the perspective of the firm, by tracing out the parameters of the preferential choice. Langniss and Wiser (2003) and Langniss (2004), on the other hand, compare transaction costs of RES-E instruments from the perspective of the developers–investors. Here we adopt a double perspective: the point of view of government who aims to maximize social welfare by providing sufficient incentives for RES-E investments using the least-cost method, and also the point of view of investors and producers whose objective is to maximize private returns.

We note two methodological difficulties. First, the comparison of the three instruments is made on the basis of the intrinsic qualities of their reference design. This method has its own limitations because each instrument has many variants, each with varying levels of efficiency performance and ability to adapt to address inefficiencies. Second, references to empirical observations is misguiding because we cannot isolate the influence of instruments from other factors that contribute to the development of RES-E.[4] Some factors create obstacles, such as the planning permission procedures and the relation to the grid operators for the recovery of connection costs (these are generally not among the activists of the RES-E promotion). Conversely, each instrument frequently benefits from other support measures such as investment subsidies, low-interest loans, tax credits, or exemption of ecological tax. We therefore do not refer to results of effective RES-E policies based on instruments as proof of intrinsic performances.

The paper is structured as follow. First, we present a survey of the main findings from comparison of RES-E instruments in the public economics perspective in order to throw light on issues let aside. Second, we introduce our theoretical framework for assessing RES-E regulation as a governance structure

[1] This character could be discussed for certain RES-E technologies, as the biomass electricity which could benefit from the scale economies in the supply of the biomass up to a certain size.

[2] Let us note that some instruments are well known under other generic names such as the Renewable Portfolio Standards in the USA and Canada. But in fact, it is not a category of instruments. On the twenty RPS existing in 2004 in the USA, half are in the categories of the bidding, and only seven develop quota with exchange of certificates. RPS based on voluntary commitment of the electricity public utilities also exists, as it is the case of the British Columbia RPS (Berry and Jaccard, 2001).

[3] We focus on their intrinsic characteristics and do not consider the application of these instruments in conjunction with other measures such as direct subsidy, tax credit to investment.

[4] There is an abundant literature discussing causal links between the diffusion of RES-E and variation in design and strength of the governmental policy. Some examples are Reiche (2002, 2005), Morthorst and Jorgensen (2005), Van Dijk et al. (2003), Sijm (2002), European Commission (2004), Haas et al. (2001).

in its institutional environment. Third, we characterize the governance structure implied by the implementation of each instrument. We illuminate the convergence of the three instruments in terms of their role in long-term contracting between RES-E producers and obligated buyers and providing investment safeguards. Fourth, we compare the instruments' relative ability to strengthen market incentives, from both static and dynamic perspectives.

1. The social efficiency of RES-E instruments in the public economics perspective: a survey

In this section, we stress the main findings of the public economics perspective according to the efficiency of RES-E instruments. In this perspective, the rationale behind RES-E promotion policy is the supply of a collective good—by limiting the incremental greenhouse gas effect, it contributes to climate stability. Welfare economics suggest that an environmental tax reflecting the value of the marginal damage will provide incentives to achieve optimal levels of technology substitution and development of clean power generation equipment. However, adopting such tax is difficult for three main reasons. First, no firm consensus has yet been reached regarding the marginal damage of greenhouse gas emissions. Second, a high level of tax is likely to be problematic in terms of public/political acceptability. Third, as any new technology, RES-E technologies meet classical entry barriers, yet eco-taxation is not sufficient to overcome these barriers (Jaffe et al., 2002). From the public economics perspective, policy instruments designed to promote RES-E development can therefore be justified because the market under-supplies "RES-electricity" relative to the socially optimal one, due to the existence of such barriers.

Four main issues arise when evaluating the social efficiency of RES-E policy instruments (Langniss, 2004; Menanteau et al., 2003). First is the debate on the choice between price-instrument and quantity-instrument in a world of uncertainty. In terms of RES-E, FIT could be considered a price-instrument, while bidding and exchangeable quotas are similar to quantity instrument.[5] Second, we discuss the issue of long-term efficiency by differentiating the support of RES-E technologies in relation to their level of maturity. Third, we consider the possibilities of control of the collective cost and the windfall rent for the producers and then the possibilities of correction of inefficiency by adaptation of the instruments.

1.1. *Price instruments versus quantity instruments in a context of uncertainty*

As with environmental policies, under the dual hypothesis of perfect information on the RES-E long run marginal cost curve and zero transaction costs, price-based and quantity-based schemes produce very similar results. It is therefore equivalent to introduce a feed-in tariff resulting in an overall quantity of production, or to fix a capacity target in the bidding instrument or a quota corresponding to the same quantity. The marginal price in the case of bidding processes and the equilibrium price in the green certificates market are established at the level of the feed-in tariff. The administrative authority can define the "price" in the case of the feed-in tariffs, or the "quantity" in the case of competitive bidding or exchangeable quotas, so as to reach the same green electricity production target. However, as for environmental policies, price-based and quantity-based approaches are not equivalent in situations in which information is incomplete and there is uncertainty on the shape of the cost curve (and damage curve) (Cropper and Oates, 1992). The picture changes in the same way as for the environmental instruments (Weitzman, 1974).

Let us consider briefly what it means for the choice of RES-E instrument in a context of uncertainty on the level and slope of the supply curve around the equilibrium, and with a flat marginal social benefit curve also set at an uncertain level[6] (Menanteau et al., 2003). Given that the RES cost curves are relatively flat on a large range of cumulative installed capacity, it can be seen that a slight variation in the proposed feed-in price will have major repercussions in terms of quantities produced. As the whole cost of achieving an objective q is given by the product $p \times q$, an overestimated fixed feed-in price which reflects an overestimated environmental benefit will produce a significant increase in RES-E capacities and a large subsidy total which dramatically necessitates an increase of electricity rates.

Under the same assumptions, the quantity-based approach will help to limit this risk. The total volume of subsidies and, hence, the quantity of emissions abatement can be controlled by fixing a quota or organizing successive competitive bids with quantitative targets. The other side of the coin is the risk to overestimate the cost of the different RES-E or to underestimate the social value of the environmental goods. This may result in targets being set too low for the bidding instrument or quotas. However, Weitzman's findings suggest that the consequence of the error on the social surplus with a quantity approach is less important than in the case of FIT.

1.2. *Long-term efficiency: the issue of differentiation of the RES-E technologies*

To meet the social welfare maximisation criteria, development of RES-E occurs to the point where marginal cost of RES-E and the marginal social utility are equalised, i.e., the point of static efficiency. This level of RES-E is developed at least costs by utilising the best available RES-E technologies at the best

[5] Competitive bidding is not exactly a pure quantity-driven mechanism. The reason is that no quantitative objectives of renewable electricity production are set to electricity suppliers. The objective here is defined on a national basis, a given capacity of RES to be reached in the long term. We consider anyway that it belongs to the quantity-driven approach as it allows control of quantities produced.

[6] In the Weitzman's results (1994), when the benefit function is near to be flat or/and when the cost function is steeply rising, the price instrument is the best one to minimise the regulator's regret. Conversely, when the cost function near the equilibrium is rather flat, the quantity-instrument is the best. Let us notice that the shape of the cost curves is not precisely known, but in Europe, some studies suggest that in the countries they may be rather flat, below the objectives set by the EU Directive 2001.

sites. However, if we consider dynamic efficiency, there is an advantage in differentiating support between technologies. In the long run, if we use a unique price for all technologies in the FIT, a unique auction in the BI or a unique RES-E quota in the EQ, the immature and non-competitive technologies will not have progressed when resource potentials of the most mature RES-Es are exploited and immature technologies have to take over the previous ones; consequently, marginal costs will increase sharply. With the FIT system, governments differentiate rates between technologies. With the bidding system differentiation is allowed by separation of auctions in different "technology bands". However, the EQ instrument covers all the eligible technologies undistinctly; an eventual differentiation of EQ by technologies would reduce the scope of certificate exchanges.

To allow technology differentiation in an economically efficient way requires the public authority to know the supply curves of each renewable energy sources with certainty. Yet with the FIT system, it is possible to overestimate the marginal cost curves for some of the technologies and underestimate others. In the bid system organised by "technology band" the regulator may fail by discouraging one technology in terms of target.

1.3. *Control of the collective cost by market incentives*

In the public economics perspective, control of the collective cost is possible if the support instrument captures market efficiency by including elements of competition. In this respect, market incentives are weakest with price support by the FIT system, in contrast to auctioning of contracts with the bidding system or the quotas system where market incentives remain intact. The bidding system that makes producers compete with one another through competitive bids forces them to adopt the most efficient available technologies in order to be awarded contracts. Competition works as an incentive for the reduction of every static cost. With the green quotas (Voogt et al., 2000), the opportunity to profit from selling unused green certificates encourage the obligated suppliers to reduce the cost of reaching their RES obligations and developing projects beyond their quotas. Developers who seek to have long-term contracts or to sell on the certificates market are also incentives to search the least-cost technologies and best geographical sites. We shall go back to this discussion later, given the trade-off with risks created by such market mechanisms and the need for new safeguards.

The government has also to control the cost for consumers, i.e., the redistributive effects arising from the RES-E developers' surplus resulting from regulation, which constitutes a windfall gain. This rent is either differential (site advantage) or a matter of technological advantage. It is paid indirectly by the consumers through higher electricity prices, as electricity suppliers pass on the costs to meet regulatory obligations. Some part of windfall gain could be reallocated in a socially efficient way, for example by further investment in R&D by developers and for payment of risks associated with RES-E projects, yet there is no guarantee that this will strictly happen. There is even less incentive for controlling costs if the rent is large. A legitimate concern for the public authority therefore is to ensure that the burden on consumers is minimised.

In this respect the feed-in tariffs system is the least propitious instrument. In the simplest case of a uniform feed-in tariff for a given technology band, producers whose marginal cost is lower than the fixed feed-in tariff (i.e., those who have an easier access to innovating technology) benefit from the same tariff *p*. The bidding instrument established under the rule of pay-as-bid price allows a strict control of the producers' rents. This is not the case for the rule of marginal price (strike price), which would allow similar collection of rent to RES-E producers as the FIT system. Proposals within a technology band are classified in increasing order of price until the total capacity to be contracted is reached. Competition in auctions is expected to yield bid prices that reflect the marginal production costs on the general supply curve. With the exchangeable quotas system, there are few opportunities to collect differential and technological rents. The RES-E investors–producers are in competition to offer their production to the obligated buyers via contracts or spot sales of certificates. Competition between them draws down their price offers. Differential rents result only from the advantage that some (ones who sell part of their RES-E production by sales of certificates, rather than by contracts at fixed price) could draw from favourable local situations and low cost production capacity.

1.4. *Correction of inefficiency by adaptation of the instruments*

In fact, observation of the RES-E policies shows that, in order to correct the deficiencies of each instrument and improve the control of the collective cost, governments opt to implement simultaneously a combination of instruments.

With the feed-in tariffs systems, the levels of tariffs for new projects can be redefined after reaching a certain amount of capacity (or in some cases after a time period). In the case of bidding systems, governments choose to jointly control quantity and price by fixing a maximum expenditure cap and sharing it between the technologies bands, from which maximum price by RES technology band is derived.[7] In the EQ system, the quantity-based instrument becomes a hybrid instrument including price-based measures. It is supposed to present the same advantage as hybrid instrument in environmental policies which is supposed to improve the social efficiency in a world of uncertainty on costs and environmental benefits (Roberts and Spence, 1976). On the one hand, a penalty has to be paid by operators who are unable to respect their quotas of RES certificates by certificate purchases, self-production, or contractual purchases. The penalty de facto constitutes a price cap on the certificates market which in fact has a dual function: to enforce the quota, yet at the same time, to safeguard obligated agents by offering a way to partly escape to the quota if the marginal cost is too high.

However, some important issues are let aside in this public economics perspective that a transaction cost approach could deal with. Welfare economics does not consider difficulties arising with the combination of capital intensiveness of the projects and the various associated risks with each RES-E instrument. Beside the issue of the level of the support and the

[7] See Mitchell's analysis of the British bidding system in place up to 2000 (Mitchell, 2000).

windfall, such analysis does not address the necessity to control risks from the investors' perspective. Importantly, the long-term stability of the instrument and the exposure of RES-E investors to the regulatory and political risks are not taken into account. RES-E support instruments have to evolve under learning effects, budgetary considerations and changing goals, but not in a discretionary way. TCE perspective sheds light on such dimensions of the RES-E policy, previously ignored in conventional policy assessment.

2. The governance structure of an RES-E policy in its institutional environment

From the transaction cost economics perspective, RES-E instruments can be interpreted as a governance structure shaping transactions between the public authority (government or a regulator), the RES-E producers and the obligated buyers. The main aim of this contractual scheme is to provide guarantee on the long-term support to attract investors. The TCE also shed light on the government and the RES-E producer relational contracting, given the evolving costs of new equipment on the one hand, and the political risk of discretionary changes on the other.

2.1. *The theoretical framework of transaction cost economics*

The choice of an appropriate governance structure to shape transactions between different parties is in the central focus of TCE. Bounded rationality and opportunism[8] are the behavioural hypotheses which explain the need of protection in order to invest in specific equipment. Specific investments are made as they create more value than the alternative solutions of generic equipment which sell their production in spot transaction on a market. Specific investments generate surplus of economic value in comparison to their next profitable utilization, a surplus named "quasi-rent" by Williamson (1985). Rationale inherent in TCE is that performance depends on the fitness of governance structure to the real features of the transactions studied. The choice of a governance structure responds to an efficiency criterion, i.e., attaining the minimum costs for transaction and production. That means that a point of compromise must be found between investment safeguard and the incentive intensity which drive production cost minimization and innovation.

Seminal authors have noted two attributes of transactions—the transaction-specificity of assets and its differentiated nature (physical specificity, site specificity, dedicated specificity, temporal specificity) as the decisive factors in the choice of governance structures (Williamson, 1996; Milgrom and Roberts, 1992). Transaction-specificity is associated with the mutual dependency between parties. It opens the door for opportunistic behaviour of parties least committed in the transaction. Transactions requiring a specific investment must be made through contracts in order to protect investors against opportunistic behaviour by other parties. In a context of uncertainty, contracts are necessarily incomplete and, hence, opened to the risk of opportunism. If the investing party faces in a lock-in situation whereby there is a weak possibility to redeploy the equipment for other uses, they are subjected to the risk of "hold-up". Henisz and Zelner (2001, p. 127) define the hold-up problem as "the absence of credible commitment by the political actors at the helm of the state not to expropriate capital assets or the returns generated, [which in its turn] increases the risk associated with investment in assets that are largely sunk—i.e., that cannot be redeployed without significant loss of value and therefore have large quasi-rents." Without a mechanism for safeguard, the risk to be expropriated from the quasi-rent deters investment.

Therefore, the choice has to be made between a number of governance structures between hierarchy and markets, including different types of contracts. It will rely on arbitration between the advantages to create safeguards for specific investments and high-power incentives which are provided by markets to reduce costs and bring about innovation.[9] In brief, the more complex the nature of transaction and contracting process, and the higher the uncertainties over required performance, the more likely governance structures lead to hierarchical forms.

2.2. *The preference of a regulation to private transactions in the RES-E policies*

Analysis of the choice of regulatory instruments designed to promote the RES-E development for the supply of collective goods relies on the same concepts as the analysis carried out in TCE terms by Goldberg (1976) on regulations for the control of natural monopolies in public utility industries.[10] He introduces the concept of "regulatory contract" in order to explain that the contractual delegation of responsibilities to public utility monopolies with an operational supervision by a regulator is more feasible and efficient than to operate a franchise bidding solution for the monopoly. Franchise bidding is the market solution proposed by Demsetz (1968) in order to suppress the ex post control on the franchised monopoly by a regulator and the classical regulatory capture problem. Demsetz demonstrates that the selection of franchise contracts by bidding under the criteria of price and quality of service proposed to consumers would be sufficient, as consumers can thereafter negotiate with the successful utilities individually.

If we transpose the Goldberg's approach to the case of RES-E promotion, it appears that the governments prefer regulation rather than market, i.e., they prefer indirect control over the RES-E development, for example, thoroughly imposing

[8] Opportunism is defined by Williamson (1985) as self-interested behaviour unconstrained by morality and mutual confidence.

[9] Empirical studies also demonstrate that other attributes of transactions–uncertainty in the relations between parties because of opportunism, uncertainty in the environment, complexity, frequency, and measurability of the performances within the transaction–influence the choice of governance structures (Milgrom and Roberts, 1992; Masten and Sausssier, 2002).

[10] From the TCE perspective, the government's choices of governance structures for different types of policy transactions (regulatory, procurement, redistribution, sovereign, judiciary and infrastructure transactions) could be analyzed in relation to the attributes of the transactions (Williamson, 1999).

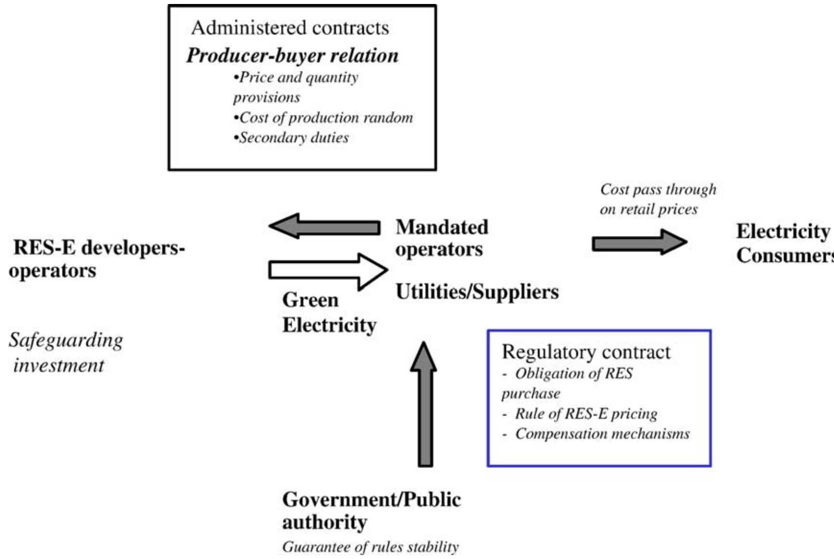

Fig. 1 – General governance structure for promotion of RES-E.

RES-electricity purchase obligations, rather than a situation of *laissez faire* with direct trade transactions between consumers and RES-E producers in which governmental role only consists of certifying green electricity. Studies have shown that there is no strong direct link between the willingness to pay expressed in census studies (around 20–25% of electricity consumers) and the revealed preferences as demonstrated in payment behaviour in actual market situations (around 2–4% of the consumers) (Bird et al., 2002; Morthorst and Jorgensen, 2005).

In terms of designing an RES-E regulation for establishing indirect subsidisation of production via the setting of purchase obligations, the government has a choice between three instruments. Each corresponds to a specific regulatory contract between public authority, obligated purchasers and developers (Fig. 1).[11] The regulatory contract gives an obligation to a set of agents (the electricity suppliers in most of the cases[12]) for purchasing RES-electricity from new RES-E plants. The regulatory contract function is to create safeguards to the RES producers and obligated buyers in order to help the realisation of RES-E investment by the former and to organise de jure or de facto for the latter, the recovery or the compensation of the extra-cost in the tariffs or prices paid by all the electricity consumers. The payment of the extra-costs of new RES-E productions is shared by the whole of the electricity consumers. If electricity price increases are kept to an acceptable degree (between 0.1 and 0.3 c€/kW h in the European countries to compare to an average final price of 7–10 c€/kW h), this allows an amplification of the support to new RES-E projects.

2.3. *General characters of an RES-E regulation*

The function of the regulatory contract creates favourable conditions that allow realisation of investments in RES-E. The regulatory contract between the public authority and the obligated purchasers specifies partly the contractual relation between RES-E producers and purchasers. They are aimed to reduce the freedom of parties to define their contractual arrangement in volume and price in order to create safeguards to the investing party and help the realization of RES-E plants. Moreover, the regulatory contract also defines pricing conditions of grid connections for the plants to be built in remote areas. In liberalised electricity systems, it also defines the economic responsibility of balancing costs supported by the electricity system operator for the real-time electricity balancing to weakly programmable production by intermittent renewable sources, wind power and mini-hydraulic (see below for more details).

RES-E project risks for the investor–producer are significant and various. They must be shared between parties in the contractual arrangement between RES-E producers and buyers, which is administered by the regulatory contract. They concern first preparation cost, investment cost and operational performances of the plants. For some RES-E technologies (mini-hydraulic, windpower), it concerns annual resource availability. Preparation costs are high and increased by the lengthy and risky procedure of planning permission, while there are no guarantees for the recovery of preparation costs in the case of failures of the permission process. Another risk concerns the regulator's opportunism and the discretionary changes in the instrument which are major issues for private actors.

[11] In order to simplify the analysis, we ignore regulation based on voluntary agreements of purchase green electricity by electricity distributors, large consumers or households. This instrument has high transaction costs (negotiation, ex post renegotiation) because of the weakness of the property rights, which are not compensated by significant economic benefits in development of RES-E plants for the developers, if it is applied without other significant supports as tax credit.

[12] The obligation is defined in relation to the distribution grid operators. In the monopoly regime they are the local, regional or national monopoly suppliers. In the market regime they are the incumbent suppliers which keep the ownership of the distribution networks. The obligation of purchase could be placed on the electricity consumers (as in the Netherlands for instance), but in fact, it is only symbolically, given that as consumers they must delegate their obligation to their supplier or distributor in order to simplify the transactions, with the exception of some very few large consumers.

In order to characterise the trilateral relation of a RES-E regulation, we must distinguish investors–purchasers transactions and regulatory transactions.

2.3.1. *The investor–purchaser relations*

Here, transaction costs are borne mainly by the developer–operator of the project: search costs of projects, preparation and negotiation costs, permission costs, and monitoring costs (i.e., the cost of observation of the arrangement). They also include costs of establishing the financing contract with lenders, which are much lower if the project is bankable with long-term contracts and if the investment safeguards are perceived as credible. It is noteworthy that for a given instrument, private transaction costs also depend upon the electricity regime. Therefore, it is the costs associated with transactional complexity inherent to the physical transactions associated with any electricity sales in liberalised industries. For the intermittent RES-E production by wind power or mini-hydraulic plants, transaction costs are amplified because this production generates a problem of instantaneous adjustment of physical supply to the quantities that must be contractually provided to the purchasers. This is not a marginal effect: the external cost associated to wind power which generates at a cost of around 60 €/MWh is estimated at around 3 €/MWh (Holtinen, 2005).[13]

2.3.2. *The regulatory contract*[14]

At the level of the regulatory contract between public authority, producers–investors and obligated buyers, the TCE perspective casts light on the "credibility" of new regulation in its institutional environment. That is, the guarantee that these regulations will not deviate from their course or prove abortive, in the line of Levy and Spiller's comparative work on reforms in public service industries in different countries (Levy and Spiller, 1994). With the RES-E instruments, RES-E generation investments are strongly specific to the regulatory contract which gives concrete expression of the policy of promotion of green electricity production. Consequently, the realisation of RES-E installations depends heavily on the credibility of the public authority's long-term commitment, regardless of which among the three regulatory instruments is selected. The public authority is not committed in the regulatory contract as much as the developers–operators who invest money in RES-E projects; this opens the door to discretionary changes in the contract. The possible government's opportunism, exerted in unforeseeable amendments of the design of the instrument or by willing to change the instrument, creates a risk of expropriation of quasi-rents on existing RES-E plants or current RES-E investments, and this risk can be a strong deterrent against investing in RES-E.

It is, however, important to distinguish the stake of stability of the instruments for the existing RES-E plants and the projects currently in development, on the one hand, and the stake of foreseeability for the next RES-E projects, on the other. Credibility of the regulation to encourage investment is at stake when changes in the design of the instrument or the adoption of a new one would alter earnings for the production of the RES-E plants developed within the first instrument. Yet in the long run, there is a necessity to amend the design of instrument and its pricing rule for the next projects. For the government, it is a way to uphold the instrument when the learning effects have made to decrease the cost and increase the profit of the future producers or when the cost for the consumers is increasing if the instrument becomes successful.

2.3.3. *Incompleteness of the regulatory contract*

TCE suggests a general need for stability in any long-term contracts, through making them incomplete with clauses of price flexibility and provisions for renegotiation, such that contracts can resist to changes in the contractual environment (Williamson, 1985). Incompleteness of a RES-E regulatory contract results from both the complexity of the environment in which it is formulated, and uncertainties over the future course including that of the learning effects. It results also from the endogenous evolution of the technologies by the help of the learning stimulated by the support.

However, incompleteness creates risks of opportunistic behaviour. Definition of ex ante flexibility rules can limit such risks. Flexibility of the regulatory contract is, however, an important issue to allow durability of the instrument and maintain an environment favourable to investment in new RES-E installations. Public authority could be attracted by the adoption of a new instrument by considering its theoretical properties. Ex post negotiation cost of the existing regulatory contract must be put in balance with ex ante transaction cost during the period of designing the new instrument and the negative effects of uncertainties on the RES-E investment during the preparation and learning periods. These ex ante costs could more than compensate the gain in incentives with the new instrument in the long term. Improvement could be better gained by amending the design and the rules of existing instruments.

From a dynamic perspective, each RES-E instrument may in fact be viewed as an incomplete contract which has to evolve in relation to changing costs, learning and changes to electricity markets. Moreover, empirical observations of different RES-E instruments confirm that each encounter problems when applied (Reiche, 2005; Sawin, 2004). The design of each instrument is necessarily imperfect because it is a result of influences from imperfect anterior policies and political compromises. Therefore, the design of a RES-E instrument ex ante must include provisions for adaptation and

[13] In the liberalised electricity regime, the market logic leads to real-time individualisation of responsibility of actors involved in bilateral or multilateral transactions. They therefore bear responsibility for the instantaneous balance between injection of their random production into the electricity grid and off-takes by their purchasers. Under the regime of regulated monopoly, this problem was solved by the purchase obligation, which imposed the responsibility of real-time balancing due to intermittence to the monopolies.

[14] From the perspective of the government, the choice of a governance structure of a regulation could be considered as driven by the transaction cost minimisation as does Williamson (1999). However, here we make the hypothesis that transaction efficiency in the regulatory transaction is not the main determinant of the choice of the instruments, given the fact that the selection is generally a matter of "polity" (Moe, 1990). But it is important to stress that transaction costs could, however, be an element of the choice between keeping an existing instrument by improving it and adopting a new one.

renegotiation dates. It can be altered on these dates within limits to improve performances in certain dimensions (e.g., cost for consumer, installed capacity, technologies variety). The comparison must therefore include the character of adaptability of each instrument and the associated costs of renegotiation.

2.3.4. *Conformity with the electricity regime*

Levy and Spiller (1994) highlight the need for compatibility of regulatory regimes with their institutional environment of the market concerned. In the RES-E regulation case, there is strict necessity for RES-E instruments to conform to the existing regulatory regime in the electricity industry. The introduction of competition has fundamentally disturbed the public obligations imposed to regulated monopolies, within the scope of which RES-E obligations lie. Indeed, before the competition reforms took place, the spatial monopoly of regional or national distributors allowed to mandate the RES-E purchase obligation on them and to pass the extracost in the tariffs. Liberalisation reforms have, however, limited most of the spatial monopoly regime of retail supply. So the design of each instrument must address this by ensuring competition between the obligated actors and the other players in the electricity markets is not disturbed by the burden of the obligation.

3. Convergence of the governance structures of RES-E regulation

We consider now the features of the three RES-E instruments, i.e., the regulatory contract with its internal contracts between producers and buyers, and their conformity with the market regime. We will study successively FIT (Section 3.1), BI (Section 3.2) and EQ mechanism (Section 3.3) in a two-step process: examining the combination of the regulatory contract and the administered contract which shape the development of RES-E equipment. Because of the transactions costs between RES-E producers and buyers, we show after that the governance structures of the three instruments tend to converge towards similar internal arrangements based on long-term contracts with a fixed price (Section 3.4). Moreover, even if the exchangeable quotas system is generally considered as being the sole instrument that suitably conforms to the electricity market regime, depending on their designs, the two other instruments also has potential to conform to the market environment (Section 3.5).

3.1. *The feed-in tariffs*

In a FIT system, the regulatory contract and the administered contracts between producers and obligated buyers are relatively simple. The main elements in price and quantity are completely defined by the regulatory contract, contrary to the two other instruments (Langniss, 2001, 2004).

3.1.1. *The regulatory contract in FIT*

In the FIT system, the regulatory contract compels the regional distributors or the incumbent suppliers to buy the electricity of new RES-E plants developed in their area at an administered price much higher than the wholesale price of the so-called “grey” electricity. The feed-in tariffs are defined for different technologies and different project size (wind power plants by size level, by location on shore/offshore, mini-hydraulic, sewage gas, landfill gas, etc) and guaranteed for a long period of 15–20 years. The tariff levels are adapted to each technology according to their respective degree of competitiveness.

There is a variety of rules for tariff definition from which government can choose, depending on its will of public authority to support RES-E development[15] and to limit distributional effects in favour of the new RES-E producers. The definition of FIT tariffs refers to the average retail price of the electricity corrected by abatement coefficients associated with each technology. An alternative way is to refer to the actual cost of the new RES-E plants and to include a risk premium in the feed-in tariffs. The FIT system could be also conceived as a combination of a tax credit to production and a quite modest tariff.[16] This latter design indicates government’s commitment to guarantee the tax credit for the new equipment on a long-term period of 10 years at least.

Incompleteness of the regulatory contract in the FIT system can be organised in order to limit the future producers’ technological rent by renegotiation of tariffs; for that purpose, a deadline or a target of installed RES-E capacity can be defined, beyond which the tariffs will be recalculated. However, price provisions can be ex ante designed with this flexibility in order to limit the renegotiation costs. The pricing can be conceived with an ex post adaptation rule in relation to the learning factor and technical progress effect.

With regards to the rule of extra-cost recovery, it depends on the electricity regime. In the monopoly regime, the extra-cost of RES-E purchases is recovered by passing it to the retail tariffs; this ensures the indirect subsidisation by all electricity consumers. In the market regime, if the incumbent suppliers who bear the obligation are in competition, there are two options. Cost recovery is made through a special fund financed by a tax on every kilowatt-hour transported and thus passed mechanically to all consumers on an equal basis as in France and Spain. An alternative solution is a mechanism of cost compensation between obligated regional companies, generally the incumbent suppliers, who do not bear the same burden because of spatial differences in the installations of RES-E capacities in their respective geographic area as in Germany.

3.1.2. *The administered contracts in FIT*

In terms of governance structure, the obligated agent acts as an agent of the public authority assigned to purchase the green electricity produced by new RES-E plants in its area. The solution that governs transactions between producers and purchasers offer the maximum clarity and simplicity whereby the regulatory contract defines much of each arrangement (Langniss, 2001). This allows reduction of all transaction costs for the setting up and following up of the

[15] Historically, at the origin, the FIT was defined in relation to the avoided marginal cost of the utilities, which was not an effective rule to pay the capital cost of the RES-E plants.

[16] It is the case in the Netherlands, Denmark and in some states in the USA.

producer–buyer transaction. There is no need for coordination on prices and quantities between producer and purchaser, to the extent that, in the most archetypical form of the FIT instrument, there is no need of explicit contract, except for the secondary duties on the physical and financial conditions of connection and method of settlement. Each producer–buyer contract is defined ex ante in price for any produced quantity. With regard to volumes, the purchase obligation implies the obligated companies do not know a priori the quantities that they should take in future. It implies also that in real time, they must assume the balancing costs related to the random nature of the production of the RES-E plants in wind power and mini-hydraulic plants.

3.2. *The bidding instrument*

With Bidding Instrument, the regulatory contract assures the investor to sign a contract with an obligated buyer and defines the main provisions of it, but at a lesser extent than in the FIT system.

3.2.1. *The regulatory contract in BI*

It has three main features. The first is the spatial purchase obligation, which is quite similar to the FIT mechanism. The second is long-term arrangements between developers–producers and obligated purchasers which are supported through the regulatory contract. The third is the procedure of auctions to select RES-E projects under some criteria of selection, the bidding price for the purchase contract being the main one.[17] The successful projects will benefit from a long-term sales contract signed with obligated buyers. Hence, the regulatory contract binds the public authority, obligated buyers and developers by the definition of contractual rules: obligation to buy all electricity produced by new RES-E installations in the supply area, long contracting period (15 years), pricing rule (either the strike price, i.e., the bid price of the marginal project, or more commonly the bid price of the project).[18] The period of contracting has a direct influence on the level of bid prices, given the necessity of investment recovery during the contractual period (Mitchell, 1995).[19]

When the government is very keen to limit the cost to the consumers, the regulatory contract can include a cost-cap rule in supplement to the control of expenses allowed by the definition of the quantity target. The annually allowed expenses for paying the extra-cost of regulation cannot exceed a given limit. The regulator shares the subsidies envelop between the different “technology bands”. This means that, in each technology band, there is an implicit price cap for the selection of bid contracts, yet it is not explicit at the moment of the bid.[20] For the bidders, this requires them to not overcharge in their tenders. For the obligated purchaser, the extra-cost of the purchase obligation is recovered either by passing the cost to the tariffs when the industry is in monopoly regime or by recovery through a special fund financed by a tax on each kilowatt-hour transported in market regime.

3.2.2. *The administered contracts in BI*

In comparison to the FIT instrument, the regulatory contract does not define the price in the producer–buyer contract, but it specifies the rule for defining the contractual price. The regulatory contract specifies the contractual time span (from 15 to 20 years generally), as well as the rule for defining the kilowatt-hour price generally the bid price is preferred to the strike price, i.e., the price of the marginal project, which creates too much windfall rent for the other successful projects for the entire contractual period. After the commissioning of the installations, ex post transaction costs are reduced. This requires neither surveillance, nor renegotiation, nor flexibility of contractual provisions. Concerning the intermittence of the RES-E production, the purchase obligation transfers the effects of the complexity of the physical transactions on the obligated buyer, as it is the case in the FIT mechanism.

3.3. *The instrument of exchangeable quotas*

This governance structure of RES-E regulation presents two specific features. First, the instrument dissociates electricity and property rights on environmental goods associated to green electricity: the obligation is in fact defined in terms of quotas of green certificates and these certificates are traded in a distinct way.[21] Second, the regulatory contract lets the obligated buyers and the developer–investors choose between spot market transactions, long-term contracts and vertical integration.

3.3.1. *The regulatory contract in EQ*

The particularity of this instrument is indeed the absence of administered contracts. The regulatory contract is weakly coercive and leaves considerable scope of choice to obligated purchasers and producers. One type of agent, generally the electricity suppliers, is required to have a specific proportion of green certificates in relation to their annual sales.[22] This quota is defined on an equal basis to a percentage of their respective sales. The suppliers may buy certificates from any RES-E generator, whatever their location. The logic of this design is twofold: competitive equity between market players who have to support identical obligations, and pressure of competition to encourage them to limit their expenses to respect the quotas. With regard to the extra-cost recovery for obligated purchasers, this instrument differs significantly from the former instruments. As long as the quota of renewable electricity is

[17] The other criteria are the technical quality of the project, its socio-economic impact and its environmental effects.

[18] The pricing rule of pay-as-bid allows limitation of the producers' profits and is considered to be socially more equitable because it is less costly for consumers.

[19] In the successive British NFFO rounds, a decrease of the average price from 11 p/kWh to 4.43 p/kWh for wind power projects is observed when there has been an extension of the contract terms from 7 years in the first rounds to 15 years in the third round of 1994.

[20] The definition of the cost limit by technology refers generally to an envelope of subsidy to be paid by the consumers and shared between technologies.

[21] A variant of the instrument is the possibility to exchange part of the obligation between those who have a RES certificates surplus and those who are in a deficit.

[22] A variant of the obligation is to impose the RES-E quotas on the producers and importers, as it is the case of the design of the Italian EQ (Lorenzoni, 2003).

equivalent for all the competing suppliers, there is no rule of cost recovery; the players pass the extra cost of their RES-E purchases to their retail prices in relation to the respective price elasticity of each market segment. Provided that there is no externalized financing of RES-E costs for compensating theses parties, the acceptation of the RES-E policy by the regulator and the large purchasers of electricity is facilitated.

Two other institutional rules complete the regulatory contract.

- A penalty system is established to encourage purchasers subject to quotas to respect them. However, the penalty may be used by the regulator in a symmetric way to control the collective cost of the policy because the penalty payment acts as a cap on the cost of the marginal RES-E project and limit the purchasers' spending up to it. Payment of the penalty is full discharge, so that the marginal costs in respect to the quota do not exceed the penalty.[23]
- Secondly, given that a market is organised for certificates trading, the regulator can decide to govern the market prices of the certificates market with a ceiling and a floor price.[24] Logically, the ceiling price is established at the level of the penalty. The price floor guarantees a minimum of earnings for them. With the ceiling and floor prices, the actors can refer to an interval of reference prices in order to be able to invest or to commit themselves in long-term purchase deals in green electricity.

The tuning of the parameters of the instrument is quite delicate. On one side, in order to create a long-term economic incentive to invest, the investors need a long-term prospect of the value of the certificates. Hence, there is a necessity for a long-term targeting quota with regular increases in order to allow the anticipation of significant and quite stable certificate prices as allowed by the expression of a certificate demand (indeed, obligated suppliers are incited to have long-term contractual arrangements at fixed price with developers–producers to control the cost of the obligation for them, as seen below, and the demand on the certificate market would tend to be reduced when the quota becomes stable). On the other side, the definition of the penalty level is crucial for the incentive placed on the obligated buyers to respect the quota and reaching the target of the policy. If the penalty level is low, it offers a large opportunity to escape the obligation of renewable energy certificates.

3.4. *Convergence towards similar long-term arrangements*

If we characterise the three instruments from the perspective of the RES-E developers, the differences between the three underlying governance structures are not as important as first observations suggest. The need for investment safeguards leads to a convergence of internal arrangements towards long-term contracts between producers and obligated buyers, and bring the three instruments closer, in particular the EQ with the FIT and the BI.

Despite the difference of characters of the FIT and BI instruments, there is a de facto similarity of producers–buyers arrangements. The risk between purchasers and developer–operators is totally alleviated in the cases of feed-in tariffs and bidding. This is due to the administered contract being defined comprehensively with sufficient safeguards from the regulatory contract issued from the political transaction. One should note, however, that in the bidding system, the preparation and realisation of the projects are another story. Ex ante transaction costs are much higher for the developer–operators than in the FIT system, because of the cost of preparation of the bid in the tendering process. They are included in the price proposed in the developer's bid, but will only be recoverable if the tender is successful and thereafter if it succeeds in installing its equipment despite possible administrative and political obstacles. Moreover, the cost cap puts a limit on the risk premium sought by the developers. However, after the successful selection of a bid, the future long-term contract governance will not imply significant transaction costs.

In the quotas system, in which the regulated contract is alleviated and gives choice between different arrangements to RES-E producers and obligated purchasers, the strong bilateral dependence between developers and obligated purchasers leads to long-term contracts and to vertical integration. Recourse to spot transactions of green certificates is only marginal in allowing adjustments by the agents subject to the quotas to comply to them. Some authors (for instance, Lemming, 2003) argue that on the RES-E investors' side, with regard to their financial risks, the quota system may give incentives to RES-E generators to avoid contract with forward fixed price because the certificate exchange will give higher prospects for return on spot trading of certificates.

However, four elements play against this optimistic view. First, volatility and price risk are high because the size of the certificates market is small a priori. Second, RES-E producers have to sell green electricity as two products (electricity sale on one hand and green certificates on the other), and the risk on the green certificates price is added to the risk on the wholesale electricity price. Certificates banking which is supposed to help the obligated suppliers to respect their quotas can increase the lack of liquidity in a period of tight supply of certificates. Third, transactional complexity which results from intermittence of the RES-E generation also influences the choice of long-term contract. The absence of a purchase obligation on physical electricity (it is only a quota of certificates) reinforces the producer's incentive to conclude a long-term contract in order to simplify transactions. (Long-term contracts define the party which assumes the balancing costs: generally the obligated suppliers assume them.) Fourth, the price of the certificate is affected by a number of risks, in particular the regulatory risk arising from an eventual alteration in the RES-E portfolio of eligible technologies (adding a technique will lower the prices because it increases the quantity of available certificates) and the risk of market

[22] A variant of the obligation is to impose the RES-E quotas on the producers and importers, as it is the case of the design of the Italian EQ.

[23] However, in order to avoid social losses through payment of the penalty, the public authority can create an additional incentive to invest in RES-E projects by allocating income from collected penalties to agents who respect their quotas on the basis of their certificates. So it is in the UK case of the Renewable Obligation adopted in 2001. This provision can be very efficient because it allows those competitors who respect the quota to be subsidised by those who do not.

power exercise. So the RES-E producers have good reason for negotiating contracts with buyers who are subject to quotas: they need long-term contracts with fixed forward prices because of the additional safeguards offered by a private contract.

The producers' interest meet the obligated buyers' interest which prefer either to purchase by mid-term or long-term contracts, or, in a more "hierarchical" arrangement, by installing themselves the RES-E equipment that they need to respect quotas, because they are in competition and strongly encouraged to respect their RES-E quota by limiting costs and risks. The current experience shows it in Texas and the UK (Langniss and Wiser, 2003; Mitchell and Connors, 2004; Dinica, 2006).[25] However, this convergence of interests is relative, in particular for low-sized suppliers: they search to limit the time span of their contractual arrangements, because they bet that the prices of the RES certificate will decrease in the future, in particular when the quota ceases to increase and subsequently the demand for certificates decreases.[26] However, big-sized suppliers can prefer vertical integration as an arrangement which improves the safeguards to obligated suppliers by fully integrating the ownership and the plant operation in their business with respect to their quota by the cheapest and least risky way. The incentive to select vertical integration is reinforced by its financing cost advantage. Indeed, if one considers the financing conditions of RES-E investment, long-term contracting is always associated with a classic project-financing contract guaranteed on the future cash flow of the project in order to making them bankable. However, large obligated suppliers can get arrangements of corporate financing and obtain much cheaper direct loans guaranteed on their assets if they develop their own RES-E projects. These loans are much cheaper than the arrangements in project financing which present higher interest rates and transaction costs.

3.5. *Conformity with electricity market regimes: a limited split between instruments*

The change from a monopoly regime to a market regime in the electricity industry apparently qualifies the EQ instrument in a definitive way (Morthorst, 2003); however, adaptation of the two concurrent instruments is possible for making them compatible with electricity market regimes. A clear advantage of the EQ instrument is its compatibility with the market electricity regimes as highlighted by the following three reasons. First, for the EQ mechanism, no problems are posed by the suppression of the monopoly, since the obligation of the suppliers is not linked to the location of new RES-E installations. However, it is instead linked to the possession of green certificates, which can be bought from any generating RES-E plants, as it could be with emission trading. Second, as long as the quota of renewable electricity is equivalent for all the competing suppliers, it is not necessary to envisage a specific financing mechanism to compensate the obligated parties for the RES-E extra-costs. Third, the value of green electricity is linked up to the electricity market price, given that the certificate price is added to it for paying the RES-E producer.

In contrast, a FIT system and bidding instrument set de facto the RES-E productions outside the electricity market, given the obligation to purchase at fixed price. First, concerning the problem of the assignment of the obligation, it raises a problem in the two cases because there is a clear-cut unbundling between distribution network and supply activities. In this regime, the adaptation is complex and counter-natural. It becomes necessary to entrust an agency with the responsibility for buying RES-E electricity at guaranteed tariffs–or at the contractual fixed price in the bidding instrument–because the incumbent suppliers have no spatial monopoly. This body then auctions or shares out the RES-E that it buys between the suppliers in proportion to their market shares; hence, some market principles are re-introduced. However, the compatibility of FIT and bidding instruments within the market regime is not so problematic in the countries where the activities of local, regional or national incumbent operators have been only moderately 'unbundled' (that is with only accounting unbundling between network and supply activities). The spatial obligation of RES-E purchase can remain simple because incumbents are completely dominant, as in France, Germany or Spain where FIT systems have been in place in 2005. However, it requires that the incumbents which are obligated by the purchase obligation are compensated on a transparent and fair basis from a fund financed by a special tax on every transported kilowatt-hour.

Second, concerning the linkage of the RES-E price to the electricity market price, if the bidding instrument is not adaptable, feed-in tariffs can be adapted in order to be connected with the market prices. A variant of the FIT system (recently adopted in Spain) consists of adding an RES-E premium rate to the wholesale market price. This rate is calculated each year by reference to the price cost of the RES-E technology and the average wholesale price of the "grey" electricity market.[27]

Hence, in summary, the governance structures of the three instruments tend to converge towards similar internal arrangements based on long-term contracts with fixed prices because of the needs of safeguarding RES-E investment in the transactions between obligated buyers and producers–developers. Moreover, even if the exchangeable quotas system is generally considered as being the sole instrument which conforms to the electricity market regime, the two other instruments are also usable in a market environment after adaptation.

[25] In Texas, the Renewable Portfolio Standard system based on quotas which is in place since 1999 shows a massive recourse to long-term contracts and no use of exchange of obligations (Langniss and Wiser, 2003). In the same way, the British experiment started in 2002 shows that the five main suppliers who bear 90% of the quotas have recourse to long-term contracting or develop themselves the new RES-E plants to follow the increase of their quotas (Mitchell and Connors, 2004; Dinica, 2006).

[26] In the TCE terms such behaviour of one party to avoid ex ante a contractual arrangement which would be beneficial to the two parties, in order to impose an arrangement less binding for him is named passive opportunism.

[27] This solution is one of the two options offered to the obligated purchasers with fixed tariffs in Spain. However, the protection needed by investors is lower than the one offered by the feed-in tariff because it introduces an uncertainty on the level of the earnings.

4. Regulatory discretion and RES-E investment safeguards

The instruments present different qualities to protect against the government or the regulator's opportunism. The State which acts as the legislator is the main potential source of instability of the RES-E regulation and of potential hold-up on the quasi-rent of the existing equipment. However, at the same time, in order to limit such a risk, each instrument must be designed as an incomplete contract in order to avoid discretionary withdrawal of instrument or radical changes to it. In this respect, each instrument presents specific properties for safeguarding investors against government's opportunism; hence, it comes down to the propensity to flexibility of a given instrument.

4.1. *Safeguarding RES-E investments from government's opportunism: the role of private contracting*

From the investor perspective, every instrument is subject to the requirement of long-term predictability; however, even if it is designed in this direction, they are exposed to the risk of regulatory change.[28] For the given RES-E regulation, safeguards lie first in the political legitimacy of the instrument. In the regulatory ladder, a parliamentary vote imparts much more instrument stability than would its creation by decree or by governmental decision, in particular when the vote of parliament includes the pricing details (such as the tariffs in the feed-in system as in Germany in the EEG law voted in 2000). However, as Levy and Spiller (1994) point out for institutional reforms of public utility sectors, the main protection against discretionary regulatory changes lies in the institutional environment of the regulation. In the case of RES-E regulations, Langniss and Wiser (2003) underline the deterrent character of appeal to courts, as they show in the case of the Texas EQ instrument and the German FIT system.[29]

In any case, eventual alteration of the RES-E instrument exists, which could affect the existing RES-E plants and the current developers. Private contracting is the first protection of RES-E investors against the government opportunism. The FIT system most directly exposes the RES-E producers to the regulatory risk, given that there is no need for private contracts. This risk lies from eventual discretionary changes of tariffs and purchase obligation for existing facilities and those in development. The initial political commitment to tariff stability for a 15–20-year time span is not a sufficient safeguard by itself. In some countries, private contracts between investor–producers and obligated purchasers add a complementary protection for the investors for a minimum contractual period covering part of the pay-out time of the equipment, as it is the case in Spain (Dinica, 2006). But as shown in the Spanish example, the time span of the contract (5 years) tends to be much shorter than needed for the capital cost recovery.

The variant of the FIT instrument which most allows for government opportunism is the one which relies on a mix of low feed-in tariffs and a tax credit on the production, as those existing in the Netherlands and Denmark, and some states in the USA. These systems are subject to regular checks by parliament and government. As a consequence, they are exposed to the uncertainty of the electoral game and the conflicting pressures of competing interest groups. If the tax credit on the production has been established without guaranteed time-span for new equipment, its withdrawal will affect the support of existing equipment and could provoke the bankruptcy of RES-E producers.[30] More commonly, even if the existing equipment are not affected by tax credit withdrawal, technological and industrial momentum is affected by the effects of stop and go, as shown by the RES-E development in the USA since the mid-1980s up to 2000 (Sawin, 2004; Gielecki and Poling, 2005).

In the bidding and the exchangeable quota systems, the protection against the government's and the regulator's opportunism is offered to the new producers by the private contract which governs their relation with the obligated buyers. In the EQ system, vertical integration is also a way of securing their RES-E investment for the former ones. However, besides this protection, the quotas instrument significantly exposes the parties to the regulatory risk.

Indeed, in the EQ system, the private contracts can be weakened by any alteration of rules—level of quotas, portfolio of eligible technologies, level of the penalty or buy-out price, rules of borrowing and banking on the certificates market. This is because they would change the value of certificates and consequently the value of RES-E assets. Any reduction in the level of the quota, any reduction of the penalty or any addition in the portfolio of RES-E will all result in lower certificate prices and decreases in the RES-E asset value. However, there is a difference in the regulatory risk exposure of each party. The buyers are in fact the least protected because of changing the instrument or ending with it would result in an immediate expropriation of the quasi-rent from contracts they signed and which concern existing plants and plants in construction. The obligated buyers cannot break the contracts without large penalties to be decided by the courts. Hence, they are unable to easily transfer part of the risk of hold-up onto the RES-E producer. In this respect, the contract protects the investor–producer from the regulatory risk. However, it remains exposed to the risk of the eventual ending of the RES-E regulation

[28] The other forms of support which are not considered here would be interesting to analyse in their exposition to the discretionary risk. In this respect, as suggested by Dinica (2006), it appears that governmental guarantee on project loans, project aggregation programs for governmental large project finance loans and third party financing pose low risks.

[29] According to Langniss and Wiser (2003), "the 'protection of legitimate expectations' through the German constitution provides a safeguard against a sudden phase-out of the regulation. German constitution provides a safeguard against a sudden phase-out of the regulation. Case law has enforced protection of legitimate expectations in the past (....)".

[30] The example of the Danish system of tax credit to production is very illustrative. While an early tax credit system has helped to jump-start the wind power development in the eighties and nineties, once the credit and fixed price collapsed in 2002, the industry collapsed and numerous wind energy firms went bankrupt (Lauber, 2004).

which would constitute a force majeure case and allow the buyer to break the contract.[31]

4.2. *Intrinsic adaptability of instruments*

As already highlighted, flexibility of instruments is a necessity given the unforeseen effects of learning and in the case of successful instruments, increasing costs for the consumers. From the point of view of the public authority, transaction costs for the definition and the adaptation of the new instrument are larger than those of adaptation to the design of a RES-E instrument. However, flexibility must not be based on discretionary changes, as we just highlighted. For the investors the credibility of the regulatory contract arises from its foreseeability, based on ex ante rules governing the adaptation of instruments to price and quantity coordination between RES-E producers and obligated buyers.

In this respect, the FIT instrument is the best suited to include ex ante flexible rules. Of course, it can be designed with rigid provisions, no evolutionary pricing rule in time, no differentiation between locations and no timing for the redefinition of the tariffs level, as it was the case during the first experience in the 1990s. This had the advantage of simplicity and transparency for the investors, however, generated increasing rents for the producers. Of course, renegotiation of the FIT could be programmed in the regulatory contracts after a short period in order to improve efficiency and limit increasing rents for the new producers. However, both the administrative demands and the informational needs of FITs could rise rapidly if the system becomes very fine-tuned and complicated in order to meet efficiency and equity conditions (Sijm, 2002, p.15). Moreover, the principles of the instrument allow the design of ex ante flexible pricing rules such as a sharp decrease of the FIT after the pay-out time or a steady decline of the tariffs for next plants by anticipation of the learning effects on their cost.[32] This introduces a real stability of the instrument with foreseeable producer–buyers relations.

In the two other instruments BI and EQ, ex ante definition of evolutionary rules seem much less feasible than in the feed-in tariffs system. In the bidding system, the social efficiency which is sought by the public authority implies that the bidding rules in the "regulatory contract" should be regularly adapted in order to benefit the returns of experience from the preceding tenders and to target technical progress on some technological bands (Mitchell, 2000; Sawin, 2004). However, intrinsic adaptation cannot be anticipated. In fact, the public authority should give clear information to the applicants in various directions, in order to limit ex ante transaction costs, to encourage the potential applicants to prepare projects and auction selection and to incite the successful ones to commission their plants. Indeed, because the government is not committed to respect a schedule of call for tenders in the bidding system, it is easy to not issue a tender. The same issue relates to the evolution of criteria, the definition of technology bands and the price cap by technology band. The developers' strategies are heavily restricted to investing in the preparation of new projects by anticipation when the tender conditions are not yet known, as observed in the UK NFFO system in place between 1990 and 2000 (Mitchell, 2000). Hence, because the adaptability of the BI cannot be defined ex ante, it makes it difficult for the policy based on this instrument to gather momentum.

Concerning the EQ system, it lies on an ex ante rule of increasing quotas of RES-E; however, all the other alterations which will be introduced for improving the instrument are not ex ante definable. Moreover, anticipation of the effects of any alteration on certificates prices is uncertain. Let us take the case of an eventual change in the quotas trajectory. Picking the optimal quotas trajectory is critical: if they are set too low with a slow timetable, they will not produce the economies of scale and the learning effects needed to reduce cost; if they are set too high, they can push certificates prices up dramatically. Besides, even if the regulatory contract could anticipate the direction of any change in the portfolio of eligible technologies, penalty for compliance, the rule of tradability (life span of certificates, floor and ceiling prices), it is uncertain to what extent the value of RES-E assets and the level of the "quasi-rent" will change, since it is a complex market with so many determinants to clear the equilibrium price of certificates.

5. Market incentives to static and dynamic efficiency

The TCE perspectives and welfare economics shed light in the same way on the market incentives in the realisation of public policies; however, the TCE introduces the trade-off with the needs of investment safeguards. Indeed, the TCE approach considers that transactions should be governed by markets as much as possible to achieve benefits of incentive intensity for market governance, if the arrangement provides sufficient safeguards (Williamson, 1985). Hence, the more the public authority wishes to control the collective costs, the more the selected instrument will introduce intensive forms of competition inside its governance structure–public auctions in BI; obligated buyers' private calls for tender for long-term contracts and spot exchanges in the EQ system–however, the more it introduces risks. Hence, the efficiency of the market incentives must be put in balance with their disincentives effects on the RES-E investment and the effect of risk management on the cost for consumers. It must also be put in balance with their effects on the technological momentum that the RES-E regulation is supposed to create, given that the aim is to promote the dissemination of technologies by making the development to reach autonomy in normal market conditions.

[31] In Texas, the change of the value of RES-E assets resulting from the alteration of the RPS portfolio could be a case to benefit from the stranded cost recovery procedure which has been used for investments which were undertaken under a regulated framework but which are now stranded due to deregulations.

[32] For instance, the German EEG law (2000) guarantees renewable energy producers premium prices for the power they generate. For example, wind turbines are granted a premium price of 9 € cents/kWh for the first 5 years of operation. Thereafter, site quality is evaluated against predefined performances standard; if the site has performance above 150% of the standard, then the tariffs drops to 6 €c/kWh; and conversely for weaker sites; etc. See: Paul Gipes, "German Electricity Feed Law Policy Overview," available from http://www.windworks .org.

5.1. *Static efficiency of instruments*

The FIT instrument is often considered as the least suited to cost control by market incentives, given that the RES-E price is guaranteed. On one hand, the developer–operators can certainly bring the equipment constructors into competition; however, if they do not succeed in tightening their costs and margins as far as possible, they will not be excluded for the RES-E business, as they would be on a competitive market. However, on the other hand, the plants are purchased on competitive markets in the new RES-E manufacturing industry; so the FIT can act as a minimum standard price, as if the RES-E producer–investor refers to a competitive market price and would be the price-taker. Developers–investors search to increase their profits by looking for the cheapest equipment and minimizing their costs by generating competition between manufacturers.

The bidding instrument leads to the lowest cost projects in each technology band of the call for tenders. Bidding drives down the bid price of projects, making the instrument very cost-effective. Moreover, the cost cap adds an incentive to limit the bid prices in each technological band and this constitutes an incentive for an efficient realization of the equipment in the case of bid success. However, the other side of the coin is that this character could be also an excessive way to limit the quasi-rent allocate to developers, given the project risk. This raises the classical problem of the bidding systems which include a cost cap in the tendering process, so that it can deter potential candidates from applying (Bajari et al., 2004). The bidding system including a low cost cap is a risky instrument for a developer because the cost cap is generally too low and does not allow the recovery of preparation costs in the event of project failure in the licensing process. The developers are dissuaded from making a tender. Another possible action would be to make an opportunistic bid. In fact, they could deliberately underestimate their bid price in order to be selected because they have no threat of penalty sanction if they do not commission a plant in case of a successful bid. They refer to the best case project in terms of innovation and successful installation permission; in addition, they tend to abandon their project when they meet the first difficulty in the licensing process.[33]

Exchangeable quotas system has the potential to encourage ex ante competition between developer–operators to seek contracts with obligated purchasers, dramatically driving down the costs of the projects developed in response to the increasing demand of certificates of the obligated purchasers. These have an actual interest in minimising the cost of their quota compliance and they search for the best contractual opportunity with RES-E developers. However, it does not mean that the cost for the consumers is lower than these costs in the FIT and bidding systems. In fact, the upper risk of investment makes necessary a higher profitability of the investments in less costly RES-E equipment, other things being equal (Butler and Neuhoff, 2006). Empirical observation on the UK case shows that, under the Renewables Obligation, the earnings of commissioned wind power plants are similar to payments that the same projects would have had in the German FIT system, whereas a large part of the quota is not complied with (Mitchell and Connors, 2004; OFGEM, 2004).

5.2. *Dynamic efficiency of instruments*

Despite static optimization criteria which inclines to adopt a unique approach for all the RES-E (see above), FIT and BI are designed by differentiating technologies in order to respond to long-term Energy Policy aiming diversification. In this respect, the EQ system, which does not differentiate technologies in its reference design, presents an important limitation. This limitation could be corrected by establishing a complex set of different quota systems, arranged by technology band, with very narrow exchanges of technology-specific certificates.

The feed-in tariff system is the instrument that most favours technological progress in the two following ways. First, it opens to investors and manufacturers the possibility to invest in R&D. Through their relationship with the equipment industry the developer–operators are not under the same pressure of market incentives to reduce the costs of the new RES-E plants and consequently to share the quasi-rent with the equipment manufacturers. Theoretical analysis of the relations between regulated utilities and input suppliers shows that rent-sharing between them implies that regulated firms are likely to face higher costs than competitive costs on a free market. Indeed as the producer–investors' profit is guaranteed, the profit could be shared with the manufacturers (Baumol and Klevorick, 1970).

Being in a position to benefit from the profit increase that will arise from the incremental innovation to be introduced by the latter, the producer–investor can share part of profits with them in their contracts and allow incorporation of new knowledge through R&D. The two other mechanisms do not greatly favour technological progress because they do not allocate profit to the producers–investors, given the pressure of competition in the bidding system to be selected by the public authority under a restriction of price cap, or in the quota system for award of contract by the obligated purchasers (Finon and Menanteau, 2003).

Second, effectiveness of an instrument in terms of installation has an endogenous effect of speeding-up of the learning process and the cost reductions of different technologies. Hence, it may be cheaper to provide generous support to RES-E plants within a securing framework over a period of, say, 15–20 years to bring technologies rapidly down their learning curves, and thus reduce costs quickly, rather than to introduce RES-E relatively slowly and over a longer period of time with an associated slower reduction in costs. The weakness of the incentives intensity of an instrument in a static perspective could become an advantage in terms of dynamic efficiency, as it is the case with the FIT instrument. We consider it is no coincidence in Germany, Denmark and Spain, who were early to adopt the FIT system in the 1990s, are now the three lead wind-power equipment industries in the world in 2005 and an absence of RES-E equipment industries or national manufacturers in wind equipment or other RES-E technologies, in Great Britain where bidding has been adopted and where developers prefer to buy on the international market (Mitchell, 2000: 299). The development of an RES-E manufacturing industry has been a part of the political rationale of in the choice of the FIT

[33] The incentive could be the threat of penalty in order to encourage successful applicants to bid at a reasonable price and to realise their installation project (Mitchell and Connors, 2004).

Table 1 – Comparison of performances of the governance structures of the three instruments

	Feed-in tariffs		Bidding		Exchangeable quotas	
	Ex ante	Ex post	Ex ante	Ex post	Ex ante	Ex post
Investment safeguards	++	−	−	++	+	±
Ex ante adaptability of the instrument	+		0		0	
Incentives intensity and cost control	+/0		+		++	
Technological progress	++		0 [a]		− [b]	
Conformity with electricity market regime	0		0/+		++	

[a] Best available per technology band in the BI.
[b] The most mature techniques in the EQ system.

system. However, it is also a fact that the relation between an instrument and this industrialisation effect concerns only the first stage of a RES-E life cycle when it is still time for a country to compete in order to be in the leading runners. This objective loses its interest when the technological maturity is reached. Investors in one country can henceforth prefer to benefit from the performance of the best available technology by buying the facilities from the most efficient foreign enterprises.

6. Conclusion

The paper has compared the three RES-E instruments in several dimensions related to the TCE perspective: safeguards of RES-E investments, adaptability of the instrument in order to preserve its stability, market incentive intensity and conformity with the new market regime of electricity industry. The TCE approach focuses on the safeguarding of investment specific to a RES-E policy and its balance with incentive intensity for controlling the collective cost of the policy and the cost of consumers. This approach shows up other qualities of RES-E regulatory mechanisms than those highlighted by Public Economics and recalled in the first part. Public economics approach focuses on collective cost control to determine the clear superiority of exchangeable quotas because of intensiveness of market incentives and limitation of producers' rent. By focusing on the risks of expropriation of RES-E investors and in particular the regulatory risk, the TCE approach underlines importance of safeguards. Such safeguards must be obtained in two ways: through long-term contracting and credibility of regulation. In the first, there is a de facto convergence of the three instruments towards more hierarchical arrangements. It is intrinsic to the FIT governance structure and in a lesser extent to the bidding system; whereas in the EQ system which a priori is set to capture cost efficiency by markets, producers and obligated buyers are forced to seek long-term contracts or vertical integration (Table 1).

In a complementary way, conditions of a successful instrument vis-à-vis the regulatory risk include long-term government's commitment, foreseeability of the instrument and ex ante flexibility to capture decreasing RES-E cost and correct redistributive effects. Social efficiency must be sought by incompleteness of the regulatory contract and ex ante definition of rules of flexibility rather than in the high-powered market incentives which in fact tend to create large risks to invest. In this respect, the FIT instrument is the most suited to adaptability. Moreover, if it is the combination of investment safeguards and the generosity of the support which determine the efficacy in terms of installation of RES-E plants, these two characters are not independent. The generosity of the support must not be abstracted from the incurring risks and transaction cost. Indeed, an instrument must not be the source of excessive transaction costs for preparation of projects, installation and ex post adaptation of the producers–buyers contracts, as shown by the difficulties met through the experience with bidding instruments and EQ systems. If an instrument creates de facto an investment risk and transaction costs, the earnings of the investor–developers should have to be higher than the cost-price of the equipment. In this respect, the bidding system with a tight cost cap and EQ instrument are quite unfavourable to the realisation of plants because of insufficient payments.

Finally, in terms of market conformity with the electricity market regimes for which the EQ instrument is unquestionably the best, the differentiation between instruments is not so clear. Even if the FIT and bidding instruments appear to lack compatibility with the pure market model, adaptations of the instruments are possible in those of the electricity industries in which market reforms are imperfect and preserve territorial dominant positions. It appears to be sufficient to impose the purchase obligation on incumbents, before viewing to transfer the purchase obligation to a public agency.

This paper shows that none of the three instruments offer an optimal solution in all dimensions: safeguards of RES-E investments, market incentive intensity, and conformity with the market regime of electricity industry. As a consequence, a government will have to select an instrument and sustain it in the long run in accordance with the relative importance of its objectives.

REFERENCES

Bajari, R., MacMillan, P., Tadelis, S., 2004. Auctions vs Negotiations in Procurement: An Empirical Analysis, Working Paper. Standford Economic Instititute.
Baumol, W.J., Klevorick, A.J., 1970. Input choices and rate of return regulation: an overview of the discussion. Bell Journal of Economics 1 (2), 162–190 (no. 2, Autumn).
Berry, T., Jaccard, M., 2001. The renewable portfolio standard: design consideration and implementation survey. Energy Policy 29, 263–277.
Bird, L., Wüstenhagen, R., Aabakken, J., 2002. Green Power Marketing Abroad: Recent Experience and Trends, National Renewable Energy Laboratory, NREL, TP-620-32155, May.
Butler, L., Neuhoff, K., 2006. Comparison of Feed in Tariff, Quota and Auction Mechanisms to Support Wind Power Development, Cambridge Working Papers in Economics, CWPE 0503, March.
Cropper, M., Oates, W., 1992. Environmental economics: a survey. Journal of Economic Literature 30, 675–740.
Delmas, M., Marcus, A., 2004. Firm's choice of regulatory instruments to reduce pollution: a transaction cost approach. Business and Politics 6 (3).

Demsetz, V., 1968. Why regulate utility? Journal of Law and Economics 11, 55–65.

Dinica, V., 2006. Support systems for the diffusion of renewable energy technologies—an investor perspective. Energy Policy 4 (4), 461–480.

European Commission, 2001. Directive on the Promotion of Electricity Produced from Renewable Energy Sources in the Internal Energy Market 2001/77/EC-OJ L283/33-27.10.2001.

European Commission, 2004. The Share of Renewable Energy in the EU-Country Profiles. Overview of RES in the Enlarged European Union, COM (2004) 366 Final Commission Staff Working Document SEC (2004) 547, Brussels, 26.5.2004.

Finon, D., Menanteau, P., 2003. The static and dynamic efficiency of promotion of renewables. Energy Studies Review 12 (1), 53–81 (January 2004).

Gielecki, M., Poling J., 2005, Policies to promote non-hydro renewable energy in the United States and selected countries, Washington: EIA-US DOE, February.

Goldberg, V., 1976. Regulation and administered contracts. Bell Journal of Economics 7, 426–448.

Haas, R., Faber, T., Green, J., Gual, M., Huber, C., Resch, G., Ruijgrok, W., Twidell, J., 2001. Promotion strategies for electricity from renewable energy sources in EU countries. Institute of Energy Economics, Wien.

Henisz, W.J., Zelner, B., 2001. The institutional environment for telecommunications investment. Journal of Economics and Management Strategy, vol. 10, 1. Blackwell Publishing, pp. 123–147. 03.

Holtinen, H., 2005. Optimal electricity market for wind power. Energy Policy 33, 2052–2063.

Jaffe, A., Newell, R., Stavins, R., 2002. Environmental policy and technological change. Environmental and Resource Economics 22, 41–69.

Langniss, O., 2001. Transaction cost economics of regulation to foster renewable energy sources in the electricity sector. ENER Bulletin 15.

Langniss, O., Wiser, R., 2003. The Texan renewable portfolio standard, an early assessment. Energy Policy 31, 527–540.

Langniss, O., 2004, Governance Structures for Promoting Renewable Energy, PhD. Dissertation, Stuttgart University.

Lauber, V., 2004. Refit and RPS: options for a harmonised community framework. Energy Policy 32, 141–1405.

Lemming, J., 2003. Financial risks for green electricity investors and producers in a tradable green certificate market. Energy Policy 31 (1), 21–32.

Levy, B., Spiller, P., 1994. The institutional foundations of the regulatory commitment: a comparative analysis. Journal of Law, Economics, and Organisation 10 (2), 201–246.

Lorenzoni, A., 2003. The Italian Green Certificates market between uncertainty and opportunities. Energy Policy 31 (1), 33–42.

Masten, S.E., Sausssier, S., 2002. Econometrics of contracts: an assessment of developments in the empircal literature on contracting. In: Brousseau, E., Glachant, J.M. (Eds.), The Economics of Contract: Theories and Application. In Cambridge University Press, Cambridge, pp. 273–290.

Menanteau, P., Finon, D., Lamy, M.L., 2003. Prices versus quantities: environmental policies for promoting the development of renewable energy. Energy Policy 8, 799–812 (June. 31).

Milgrom, P., Roberts, et, 1992. Economics, Organization, and Management. Prentice Hall, New York.

Mitchell, C., 1995. The renewable NFFO, a review. Energy Policy 23 (12), 1077–1091.

Mitchell, C., 2000. The England and Wales non-fossil fuel obligation: history and lesson. Annual Review of Energy and the Environment 25, 285–312.

Mitchell, C., Connors, P., 2004. Renewable energy policy in the UK 1990–2003. Energy Policy 32, 1935–1947.

Moe, T., 1990. Political institutions: the neglected side of the story. Journal of Law, Economics, and Organization 6 (1990), 213–243.

Morthorst, P.E., 2003. A green certificate market combined with a liberalized power market. Energy Policy 31, 1393–1402.

Morthorst, P.E., Jorgensen, D., 2005. Stable conditions for developing a European-wide framework for expansion of renewable energy technologies, re-Xpansion, Work Package 2, Evaluation of renewable support schemes, Final Report, RISØ National Laboratory, Denmark and EWEA, European Wind Energy Association, April 2005.

North, D., 1990. A transaction cost economics of politics. Journal of Theoretical Politics 2, 355–367.

OFGEM, 2004. The Renewables Obligation, First annual report, February.

Reiche, D. (Ed.), 2002. Handbook of Renewable Energies in the European Union. InPeter Lang GmbH, Berlin.

Reiche, D. (Ed.), 2005. Handbook of Renewable Energy Policies in the European Union—Case Studies of All Member States. InPeter Lang GmbH, Berlin.

Roberts, M.J., Spence, M., 1976. Effluent charges and licenses under uncertainty. Journal of Public Economics 5, 193–208.

Sawin, J.L., 2004. National Policy Instruments. Policy Lessons for the Advancement and Diffusion of Renewables Energy Technologies Around the World. Worldwatch Iinsititute, Washington.

Sijm, J.P.M., 2002. The Performance of Feed-in Tariffs to Promote Renewable Electricity in European Countries, November, ECN-C-02-083.

Van Dijk, A., Beurskens, L., Boots, M., Kaal, M., De Lange, T., Van Sambeek, E., Uyterlinde, M., 2003. Renewable Energy Policies and Market Developments. ECN-Energy Research Centre of the Netherlands, march, ECNC03-029.

Voogt, M., Boots, M., Schaeffer, G.J., Martens, J.W., 2000. Renewable electricity in a liberalised market: the concept of green certificates. Energy and Environment 11 (1).

Weitzman, M., 1974. Price versus quantities. Review of Economic Studies 41 (4), 477–491.

Williamson, O.E., 1985. The Economic Institutions of Capitalism. Free Press, New York.

Williamson, O.E., 1996. The Mechanisms of Governance. Oxford University Press, New York.

Williamson, O.E., 1999. Public and private bureaucracies: a transaction cost economic perspective. Journal of Law, Economics, and Organisation 306–342.