Discussion Papers No. 549, June 2008
Statistics Norway, Research Department

Torstein Bye and Annegrete Bruvoll

Multiple instruments to change energy behaviour:
The emperor's new clothes?

Abstract:
Over the last few decades, several instruments have evolved to deal with similar energy and environmental challenges. For instance, the economic literature prescribes separate tax or cap-and-trade systems to internalize negative environmental externalities and subsidies to internalize positive externalities such as R&D. However, policy is not straightforward because of the influence on cost and competition and concerns for regional employment, economic activity within certain industries, and any distributional effects. Tax discrimination, subsidies and regulations then undermine the efficiency of energy instruments. To balance any environmental concerns, other instruments, including green and white certificates, have been created. While innovative, these work as simple combinations of taxes and subsidies. While the extant literature thoroughly analyzes the partial effects of these instruments, there has been little focus on their basics and the effects of aggregate taxes and subsidies. This complexity calls for research on the efficiency of each instrument, including the administration and transaction costs associated with holding a large set of instruments. We should consider the coordination and simplification of policy tools before complicating the system further by introducing new, primarily equivalent, instruments.

Keywords: energy instruments, taxes, subsidies, green certificates, white certificates, carbon taxes

Acknowledgement: The paper is based on a project partly funded by the Norwegian Research Council

Address: Statistics Norway, Research Department. E-mail: tab@ssb.no, agb@ssb.no

Discussion Papers	comprise research papers intended for international journals or books. A preprint of a Discussion Paper may be longer and more elaborate than a standard journal article, as it may include intermediate calculations and background material etc.

Abstracts with downloadable Discussion Papers
in PDF are available on the Internet:
http://www.ssb.no
http://ideas.repec.org/s/ssb/dispap.html

For printed Discussion Papers contact:

Statistics Norway
Sales- and subscription service
NO-2225 Kongsvinger

Telephone: +47 62 88 55 00
Telefax: +47 62 88 55 95
E-mail: Salg-abonnement@ssb.no

Introduction and background

Several articles in this special issue focus on the functioning of 'white certificate' instruments. Before introducing these instruments, several important questions should be clarified; what is the purpose of adding white certificates to the existing portfolio of instruments, does a white certificate system differ from other instruments, and in what respect, and how does this instrument work in the market, partially and in combination with the other instruments? This article focuses on the differences and similarities between energy market instruments. We then pose the following questions. Do we need all of these instruments, or does one instrument per goal suffice? In addition, how do white certificates compare with other instruments?

Generally, the prices on energy goods in competitive markets reflect operating costs, shadow costs on capacity constraints, and the costs of capacity expansion. Most energy production and use brings about negative externalities. These can include emissions of greenhouse gases (fossil fuels), emissions of sulphur and particulate matter (fossil and bio fuels), aesthetics and noise (wind power), destruction of nature (hydropower), and radiation (nuclear power). Producers and consumers do not normally consider such costs. Correction of negative externalities is then an important argument for taxing energy extraction/production and consumption (Pigou 1920, Weitzman 1974, Sandmo 1975)[1]. Substituting taxes on factor inputs (labour, capital) by taxes on externalities may also increase overall efficiency (the double dividend, Sandmo 1975, Goulder 1995b). In the economics literature, first-best cost efficient instruments in the presence of negative externalities have been extensively discussed (Diamond and Mirrles 1971, Sandmo 1975, Ballard and Fullerton 1992).

In a cost efficient approach, the environmental costs are exposed to all sources according to the stress they cause. Energy-related emissions will then fall through substitution between primary energy sources, the development and utilization of improved technologies in the conversion from primary to secondary energy, substitution between energy carriers, and more efficient technologies in energy consumption. However, direct taxation of externalities may be complex, cf. the additivity problem of capturing complex negative externalities by taxation in Sandmo (1975). A system of tradable emission permitted under a cap is a cost efficient alternative to externality taxes, given that the permit price equals the tax under the same externality cap.[2]

---

[1] See also Wilson (1980), Parry et al. (1999), Weale (1992), Ballard and Fullerton (1992), Ballard and Medena (1993), Bovenberg and de Mooij (1994), Bovenberg and Goulder (2002), Felder and Schleiniger (2002), Goodstein (2003) and Aidt and Dutta (2004).

[2] Some of the literature highlights the differences between these instruments. See, for example, Bovenberg and de Mooij (1994). We do not go into these details here. Rather, we start out with the equality presumption as our focus is on other aspects of the implementation of these instruments.

Since taxes imply increasing costs, technology adjustments and structural changes (Ulph and Ulph 1994, Goulder 1995a)[3], competition, local employment, and income distribution may be affected (Bye and Hope 2006, Hoel 1995). To circumvent these effects, policymakers introduce exceptions from and countermeasures to the first-best instruments (Bruvoll and Bye 2003. Tax exemptions for specific groups and energy end users, free allowances of emission permits and discrimination with respect to both taxation and responsibility under a cap-and-trade system, reduced carbon tax rates and subsidized electricity contracts are all examples of divergence from the first-best solutions. A range of additional instruments are also introduced. These include renewable share requirements in energy production—so-called *green certificates* (Amundsen and Mortensen 2001, Bye 2003, Menanteau et al. 2003), requirements for demand side energy saving—referred to as *white certificates* (Bertoldi et al. 2006, Quiron 2006), cap-and-trade for greenhouse gas emissions—known as *brown certificates* (Hoel 1998, Hoel and Karp 2001)[4], and subsidies for renewable energy.

In the literature, the partial effects of the introduction of different instruments are intensively discussed—see Ballard and Fullerton (1992), Jaffe et al. (2002) and Bovenberg and de Mooij (1994)[5]. The literature concludes that the partial effects of each instrument depend upon the elasticities of both demand and supply and the strength of the instrument. Some studies include the combination of taxes and subsidies (Goulder et al. 1999) while others discuss which instrument is best (Quiron 2006). Fischer and Newell (2008) assess different policies for reducing carbon dioxide emissions in the electricity sector and conclude that a portfolio mix of instruments may be optimal because of knowledge spillover. In this article, we show that *all of these instruments work as combinations of taxes and subsidies* through market effects. In addition, since the effects of the instruments depend on the demand and supply side elasticities, any instrument changes the technological composition. This implies that the instruments' effects depend on the sequence of introduction; they are path dependent.

Optimal taxation of externalities

A direct instrument to internalize the costs relating to energy production and use is a tax equal to the marginal external cost. The tax sets a price on emissions, increases the costs of the production and consumption of fossil fuels, increases the relative profitability of non-polluting technologies, and changes the relative consumption between energy and other goods. The market minimizes the total abatement costs, and R&D in other technologies then becomes more profitable.

---

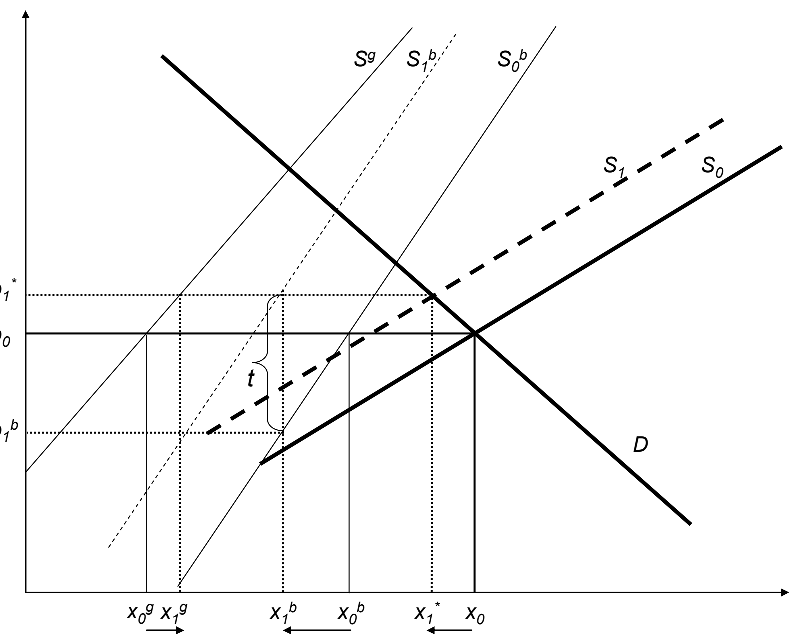
[3] See also Goulder and Schneider (1999), Goulder and Mathai (2000), Jaffe et al. (2002), and Golombek and Hoel (2005).

[4] See also Jensen and Rasmussen (2000), Bertoldi et al. (2006), Böhringer and Lange (2005a, 2005b), and Hasselknippe (2006).

[5] See Goulder (1995a, 1995b), on taxes and subsidies; Amundsen and Mortensen (2001), Bye (2003), and Menanteau (2003) on green certificates; Bertoldi et al. (2006)and Quiron (2006) on white certificates; and Böhringer and Lange (2005a, 2005b), Hoel (1998), Hoel and Karp (2001), and Jensen and Rasmussen (2000) on brown certificates.

In Figure 1 we stylize the direct market effect of an externality tax on the production of a polluting (so-called *black*) technology; for instance, fossil fuel-based energy production. Total supply faces increasing marginal costs comprising the black technology, S^b, and the non-polluting (so-called *green*) technology, S^g. The willingness-to-pay is downward sloping, i.e., volumes increase with decreasing prices. In equilibrium, demand meets supply. The first-best solution to an external problem is to obtain the right prices, i.e., by levying a tax on the black technology equal to the marginal external production cost. The tax shifts both the supply of the black technology and total supply inward to S_1^b and S_1, respectively. In the new equilibrium, the purchaser price increases (from p_0 to p_1^*) and total demand is reduced (from x_0 *to* x_1^*). The black technology output price decreases from p_0 to p_1^b and this equals the purchaser price, p_1^*, minus the tax, *t*. The volume reduces from x_0^b to x_1^b. Since the green technology is not taxed, it receives the total purchaser price, p_1^*, i.e., the price for the technology increases as does output (from x_0^g to x_1^g). Hence, taxing the black technology implies a support to the green technology as profitability increases. The optimal solution internalizing total costs is at p_1^*, x_1^*.

Figure 1. An externality tax on the production technology with a negative externality



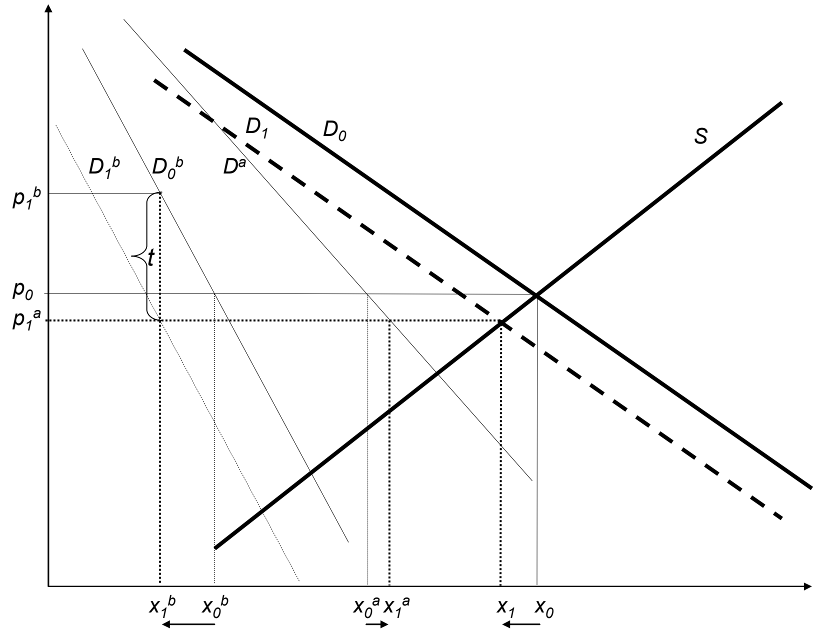
Discriminatory taxation

In practice, however, all energy carriers, including renewable technologies, involve some negative external costs (see Brekke and Bye 2003). For example, the development of hydropower and wind power parks has proven to be controversial as production negatively affects the aesthetic value of the landscape, involves physical intervention in pristine areas, and threatens wildlife. The taxation of the negative externalities (e.g., emissions from fossil fuels, for example, technology *b* in Figure 1) then implies an indirect subsidy of other negative externalities (intervention in the landscape, cf. technology *a* in Figure 1). In fact, *any discrimination implies indirect subsidies to less restricted technologies*. Nevertheless, current European policy discriminates among environmental aspects. This eventually brings about excess consumption of favoured energy sources and excess environmental degradation.

If the externality relates to the use of energy rather than production, the tax could be levied instead on consumption. When it comes to externalities related to renewable energy, they are typically linked to production. For fossil fuels, pollution is emitted in both the production and consumption process, and the externality that has been most emphasized—the emission of greenhouse gases—is independent of the location of the emission source. Hence, unless external costs vary, taxes should be equal over all consumers of fossil fuels. In practical energy policy, externality taxes are discriminatory out of concern for fair international competition among industries (cf. Krugman 1996 for the relevance of this argument).

Figure 2 illustrates the effect of a discriminatory tax on a consumer with demand D^b while another consumer with demand D^a is exempt. Demand for consumer *b* shifts from D_0^b to D_1^b, and total demand from D to D_1. This implies a decrease in the market price from p_0 to p_1^a, which the remaining market, represented by consumer *a,* faces. Consumer *b* faces a higher price, p_1^b, equalling p_1^a plus the tax, t. The same argument applies for the supply side: the tax implies an indirect market subsidy for consumer *b*, i.e., a subsidy on the externality from this emitting source. That is, *the non-taxed polluting consumer is indirectly subsidized.* Her consumption then increases despite any externality associated with energy use. This counteracts the tax impact on the stated goal of reducing externalities.

Figure 2. A (discriminating) externality tax on consumption



For the purpose of practical policy, the discrimination usually favours the most price elastic producer/consumer, i.e., the industry is exempt or faces reduced carbon and energy taxes, while households face the highest tax rates.[6] The less elastic the demand, the lower the effect on pollution. This increases the need for the introduction of additional instruments to combat emissions. After the tax, the total market demand elasticity is higher (the portion of less elastic consumption is reduced) and the effect of additional instruments has increased.[7]

Brown certificates—tradable permits

We can regulate externalities with either price (as with the exogenously set taxes described above) or volume. Optimal taxes should equal the (estimated) external marginal costs. The level of emissions will then be endogenously determined. However, it is typically easier to relate regulation to society's perception of the optimal emission level. An alternative to carbon taxes is then a cap-and-trade system, so-called *brown* certificates. In principle, if all emitting sources were included, a cap-and-trade system could directly regulate total emissions as committed to in international agreements and the permit

[6] Note that for the ease of illustration, the figures imply constant derivatives, i.e., elasticities vary along the curves. When we discuss differences in elasticities among consumers or producers and the total market, constant elasticities are more realistic.

[7] The demand elasticity ε measures by how many per cent demand changes when the price increases by one per cent; $\varepsilon = (\delta x/x)/(\delta p/p)$. The more elastic demand is, the higher the elasticity. The total market elasticity is a weighed average of the individual elasticities. Hence, if the market share of an individual with relatively low elasticity decreases due to taxation, the average market elasticity increases.

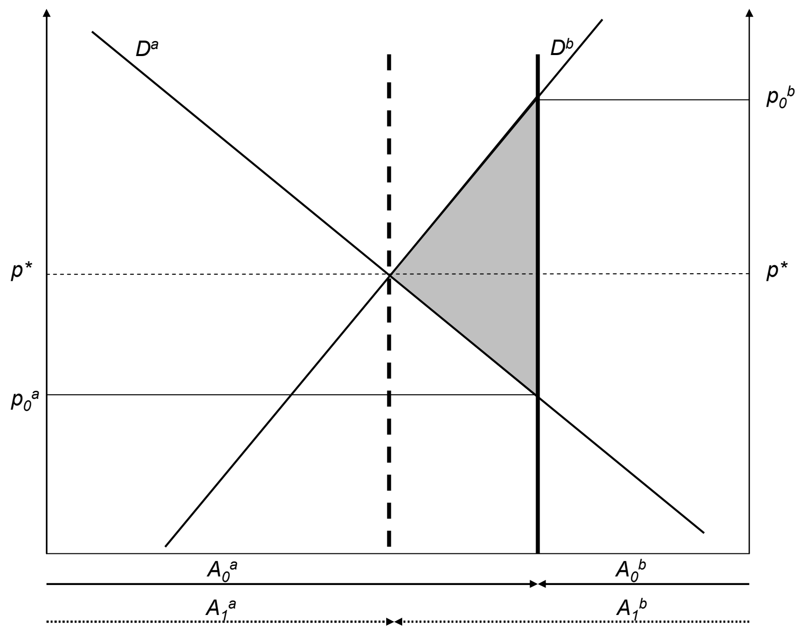
price would equal the necessary tax to reduce emissions. According to the literature, this is in many senses equally efficient to a tax system.[8]

Figure 3 illustrates the equilibrium in a market with two consumers, *a* and *b*, given a fixed number of allowances equal to the initial allocation $A_0^a+A_0^b$. The willingness-to-pay at the initial allocation is higher for consumer *b* than *a* ($p_0^b>p_0^a$). If trade is restricted, consumer *a* cannot sell any share of her initial allowances A_0^a, despite the greater willingness of consumer *b* to pay. Consequently, an efficiency loss (illustrated by the shaded triangle) arises.

In a free market, the two consumers trade allowances along their demand functions, D^a and D^b, until the willingness-to-pay, i.e., the marginal abatement cost, equalizes at price p^*. The outcome (A_1^a and A_1^b) is efficient and independent of the initial distribution of permits (A_0^a and A_0^b). As long as trade in the permits is unrestricted, total welfare is maximized.

A tighter bathtub, i.e., lower total emissions and less permit allocations, increases the price and marginal abatement costs. Given a free market, trade secures cost efficiency in reducing emissions to the restricted level. This implies an implicit tax (shadow price) on emissions; therefore, the tighter the market, the higher the implicit tax.

Figure 3. A permit market with and without free trade



---

[8] See Footnote 2.

The initial distribution of permits among producers/consumers determines the distribution of the total value of the permits that occurs in a market with free trade. Both the assignments of free allowances (i.e., income transfers resulting from competitive concerns) as well as the auction of permits based on fundamental polluter-pays principles produce the efficient final allocation of permits, *as long as* there is no restriction with respect to trade. In practice, this policy proves hard to achieve. Given the preceding allocation of value through unregulated emissions, optimal trade and permit prices cause cost increases, reduced activity, and the closing down of firms, all of which appear as politically controversial. Free allowances are then not only used as an income transfer alone, rather *as a subsidy* for existing activities to keep them running.

Several markets have implemented cap-and-trade systems for greenhouse gases, e.g., the EU emission trading system (ETS) (see, for instance, Bertoldi et al. 2006). In the pre-Kyoto period, i.e., from 2003–2007, this system faced three kinds of problems. First, the total allocation of permits did not imply any real restriction on emissions. Second, the use of percentage-free allowances produced both production and investment inefficiency. Since some emitters[9] received a percentage increase in the emission allowances if they increased production, allocation had an impact on behaviour. Third, a dynamic allocation rule, which may be employed, produce investment inefficiencies as the allocation for the next period increased with any increase in pre-period emissions. Another problem undermining the cost efficiency across sectors is that this market covers less than half of the total greenhouse gases within the EU.

As in the tax system, a discriminating cap-and-trade regime implies an *indirect tax on the restricted producer/consumer and an indirect subsidy on the non-restricted producer/consumer* in normal, elastic markets. The subsidy element counteracts the impact on the stated goal—that is, to reduce emissions. Moreover, since the discrimination normally in practice favours the most elastic producer/consumer (industry versus households), the effect on pollution is low. The shadow price on the discriminated consumer increases when the cap constrains. As for discriminating taxes, discrimination in cap-and-trade regimes also serves as an argument for the introduction of additional instruments.

Subsidies

As described earlier, in the presence of negative externalities, the optimal policy may be direct regulation (for instance some local problems) or taxation (global problems) of the externality. In practice, a subsidy for less polluting, green energy sources appears more politically acceptable. While the underlying motive is to reduce the negative externalities from competing energy sources, this does

[9] New and expanding enterprises

not yield efficient solutions to the externality problem. In the presence of positive externalities, however, subsidies serve optimal solutions. Typically, this applies to research on new technologies through learning-by-doing—see, for instance, Spence (1984), Hall and Howell (1985), Joskow and Rose (1985), Romer (1986), and Schrattenholzer (2002).

We can frame a subsidy as a direct support to desired activities, i.e., direct lump sum transfers or feed-in tariffs. It may also be framed as indirect support, such as differences in domestic and world market prices (resulting from trade restrictions), foregone resource rents in public projects (low discount rates), or prices lower than marginal costs (publicly owned enterprises/lack of pricing negative externalities). In the following discussion, we focus on direct subsidies. In principle, all other subsidy frames contain elements of the same impacts.

The design of an environmental policy based on subsidies involves a set of challenges. These are: i) what technologies should be subsidized, ii) what is the extent of the total subsidies, iii) how does the technology objective interplay with other instruments addressing the same target, iv) what should be the relative effort on the supply and demand side, v) what is the market effect of the subsidies, and vi) funding the subsidies may introduce tax inefficiencies elsewhere in the economy and raises the question about the marginal cost of funds (Vennemo 1991, Håkonsen and Mathiesen 1997, Madsen and Sørensen 2002).

Figure 4 depicts the same market as in Figure 1 with two production technologies (black S^b and green S^g). Rather than taxing the negative externality in the black technology, as in Figure 1, the government subsidizes the green technology, and the supply curve then shift outwards (S_1^g). Total supply also increases (from S_0 to S_1). The market equilibrium price decreases (from p_0 to p_1^b). This lower market price works as an *indirect tax on the black technology*. Consumers benefit from lower prices, while black producers lose. The profitability of the green technology also increases. Further, the cheapest producers harvest a ground rent, i.e., a flat feed-in tariff is generally too high to just launch these investments.

As the production of green increases and black decreases, this seems to be a favourable regime. However, contrary to the tax alternative, overall energy consumption increases. While the optimal quantity in the presence of externalities is reduced from x_0 to x_1^* in Figure 1, the realized quantity with subsidies increases to x_1 in Figure 4. Decreased purchaser prices also implies lower willingness to pay for new, potentially green but high cost energy technologies in the upper part of the marginal cost curve.

In the presence of positive external effects, e.g., from research and development, prices should be corrected by subsidies. If such an externality is associated with technology *g*, the subsidy should equal the value of the externality *s*. Figure 4 then illustrates the optimal outcome.

Figure 4. A subsidy on the supply side

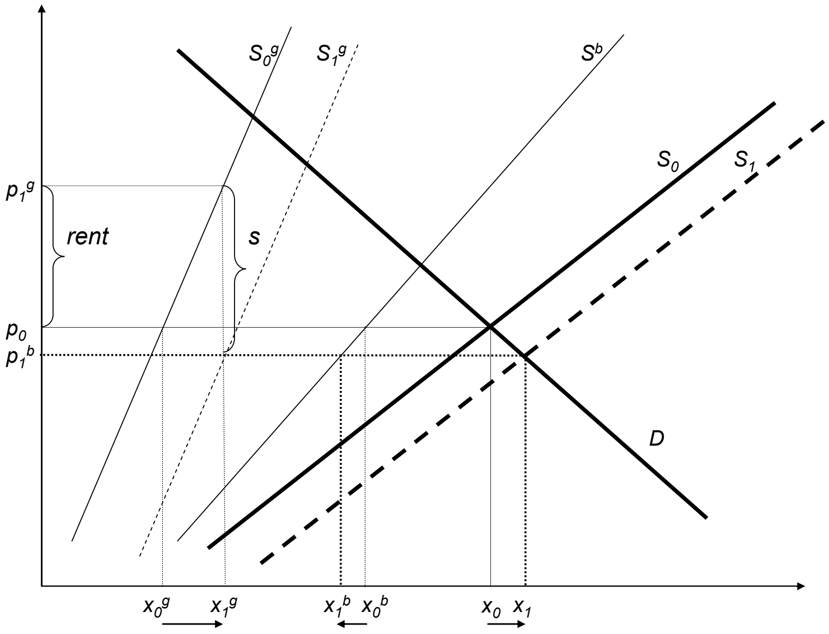
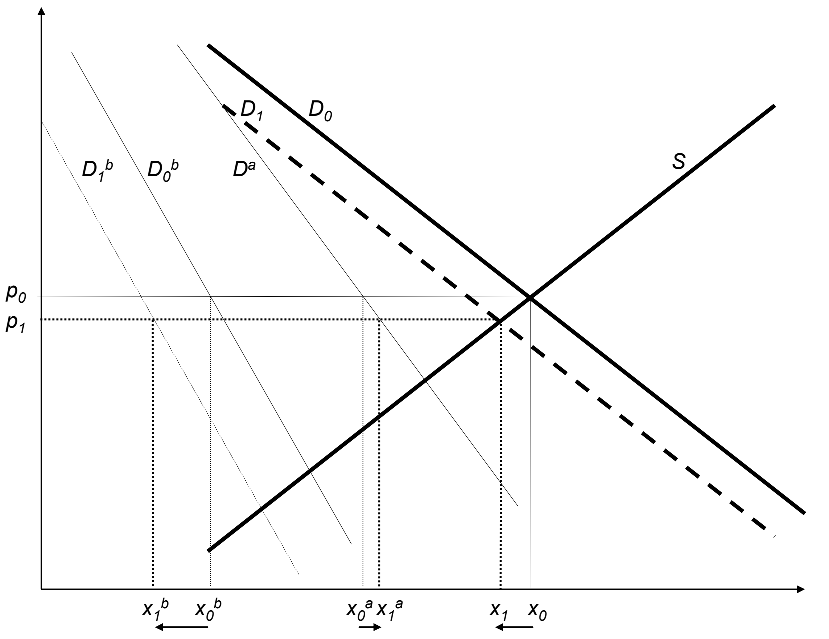


Figure 5. A subsidy on the demand side



Subsidies are also used to support particular parts of the demand side. These sorts of subsidies are generally not theoretically well founded. The arguments are rather that the subsidies reduce negative externalities in other parts of the market, but subsidies granted to insulation and low-energy light bulbs and appliances to increase energy efficiency in residential heating do, as for supply side subsidies, not secure cost efficient solutions to the negative externalities.

These subsidies are depicted as subsidies for energy saving in demand D^b in Figure 5. Only one part of consumption (directly related to heating and insulation) is subsidized. As energy efficiency increases, part of the demand decreases, and the end-use demand curve shifts inwards (from D_0^b to D_1^b) as does the total demand curve (from D_0 to D_1). A lower total demand needs less expansion of supply (from x_0 to x_1) at a lower marginal cost, i.e., prices decrease in the market (from p_0 to p_1). This original subsidy for energy saving then serves as an indirect subsidy for other end users and their consumption increases from x_0^a to x_1^a. This implies that the initial saving effect on energy from the subsidy is counteracted by the implicit subsidy element on the energy end users. If the subsidy is directed towards relative elastic demand, e.g., heating, the total elasticity of the energy market is reduced. This implies that the subsidy reduces the effect of other instruments applied to reduce energy production and consumption.

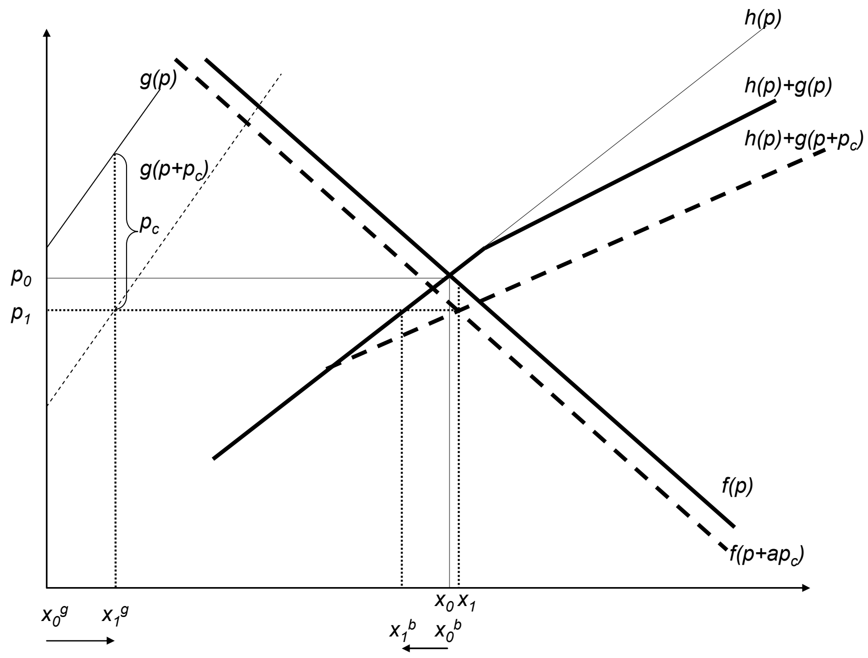
Green certificates

A green certificate is proof of an environmentally favourable origin of an amount of energy produced.[10] This instrument particularly focuses on the supply side of the energy market. The government issues a green certificate to the producer for each unit of secondary energy produced by a green energy carrier. Consumers are required to purchase a number of certificates proportional to the total amount of their energy consumption. This creates a market for the green certificates. The producers of green energy harvest a certificate price in the certificate market additional to the energy price in the energy market. This increases the profitability of producing energy from green technologies. An advantage over a simple lump sum subsidy is the incentive for cost efficient investment for capacity expansion that this instrument creates. The system is then comparable to an auction-based subsidy system.

Figure 6 illustrates a combined energy and green certificate market (for a more precise elaboration of the model, see Bye 2003). Assume a continuous supply curve producing a homogenous energy commodity based on two heterogeneous technologies with respect to the production of externalities, a green technology, $g(p)$ and a black technology, $h(p)$. This adds up to an increasing marginal cost curve, $h(p) + g(p)$ (the supply).

[10] Different kinds of renewable energy sources are classified as green; see COM (2000), Voogt et al. (2000), Voogt et al. (2006), Amundsen et al. (2001), and Jensen and Skytte (2002). Brekke and Bye (2003) discuss whether we can characterize any energy source as green. In European countries that have introduced a green certificate system, the definition and scope of the technologies differ tremendously.

Figure 6. The green certificate system



The increasing marginal cost of expanding capacity equates demand (*f(p)*) and results in an equilibrium price p_0 and volume x_0. The marginal costs of the green technologies (*g(p)*) are too costly to allow them to penetrate the market, $x_0^g = 0, x_0 = x_0^b$. We then offer with these technologies a green tradable certificate with a potential market price p_c. The certificate price now serves as a subsidy to the supplier of green energy and the supply of the technologies changes to $g(p + p_c)$. The total supply of energy changes accordingly to $h(p) + g(p + p_c)$. On the demand side, consumers are obliged to pay a part a of the certificate price for each unit of energy; this shifts demand inwards ($f(p + ap_c)$). The obligation to purchase certificates is then equivalent to a tax on consumption (the tax equals ap_c). The new equilibrium is (x_1, p_1).

As the supply of green technologies faces increasing marginal expansion costs, the certificate price obviously increases by the obligated share of the green technologies. In addition, the energy price must decrease as the green technologies substitute for black energy. The lower share of black energy then competes at a lower marginal cost.

The sign of the change in the purchaser price (energy price plus a share of the certificate price) is ambiguous and depends on the elasticities and actual obligated share. In this figure, the subsidy element is stronger than the tax element, so the purchaser price decreases and total energy demand and supply increase. Bye (2003) illustrates the point in a simulated numerical version of the model under increasing impositions of the green technology market share. Providing an increasing marginal cost of expansion for both traditional and green technologies hold (elasticities vary), the purchaser price effect is negative, and the volume effect is positive when increasing the imposed green share, even if the production cost of green energy is very high. Increasing marginal cost in the traditional energy supply sector and equilibrium effects imply that the producer of traditional energy pays more than the incremental total cost for the green technology and thereby allows consumer surplus to increase. Only for strict environmental conditions, i.e., with a high share of green technologies, are the price effects positive and the volume effects negative. Such levels are less realistic in the near future, as investments take time.

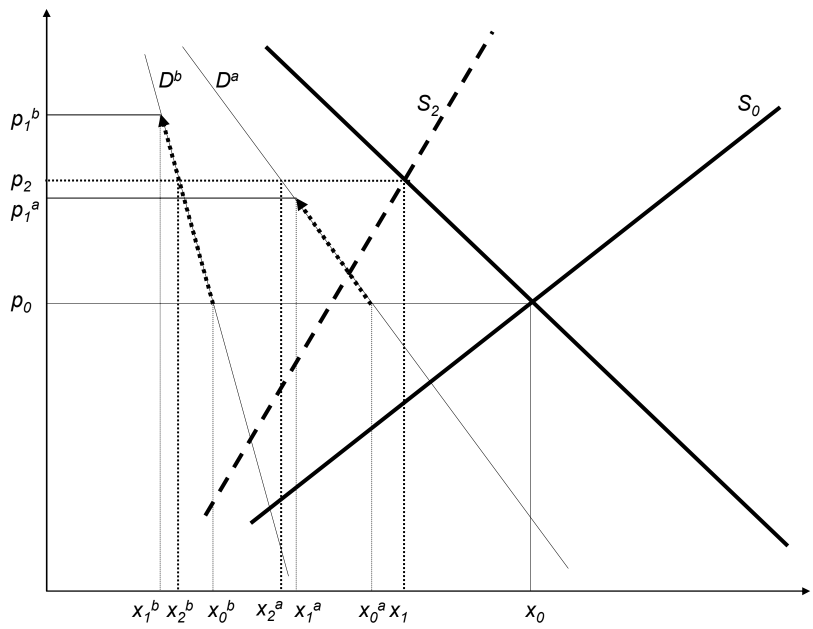
Then, a green certificate system also combines subsidies and taxes. The distribution of the certificate price (the "tax") and the subsidy benefit among producers and consumers is ambiguous.

White certificates

While green certificates deal with the supply side, white certificates concern energy savings on the demand side. A white certificate system may impose a restriction on total allowable energy consumption for separate consumer groups. In practice, the restrictions are imposed on distribution companies or the energy suppliers (e.g., white certificate systems in Italy, France, and the United Kingdom). These invest in energy efficiency measures on behalf of their consumers, and consumers eventually pay through additions to energy tariffs.

Figure 7 illustrates the functioning of a white energy certificate system. The willingness-to-pay for the two consumers (D_0^a and D_0^b) adds up to total demand (D_0). For ease of explanation, we assume that one additive supplier (S_0) represents all suppliers. A perfectly competitive market realises the price p_0 and consumption x_0^a and x_0^b for the two consumers.

Figure 7. The white certificate system



Now we impose an energy-saving obligation. Assume that the consumers have to save an equal share of their reference consumption. Demand then shifts inwards to consumption x_1^a and x_1^b. Since the elasticities of demand around the equilibrium price differ between the two consumers, the shadow price of this restriction also differs (p_1^a and p_1^b) and cost efficiency is not obtained.

This is where white certificates—trades in energy savings—serve a purpose. If consumers could trade energy saving certificates directly, trade would continue until prices are equalized and the costs of energy savings minimized. In practise, the energy supplier takes over the saving obligation. The cost of energy-saving appliances adds to the energy cost, and the supply shifts inwards and twists[11] to S_2. The cost of energy savings among consumers will be minimized. Total consumption of energy equals the new supply of energy and appliances (p_2, x_2^a, x_2^b). Compared to the initial restriction (x_1^a, x_1^b), consumer *a* demands less and consumer *b* demands more. Both consumers have reduced their demand compared to x_0^a and x_0^b, but in different proportions. In this sense, both consumers are imposed an equal 'tax' on their consumption $(p_2 - p_0)$[12]. Suppliers of energy-savings appliances receive a subsidy, measured by the units of energy saved, for the same amount. Suppliers of energy also face a "tax".

[11] Both the supply of energy and the supply of energy-saving appliances face increasing marginal costs. This implies both a shift (adding cost) and a twist (adding a marginal increasing cost) in the supply curve.

[12] An alternative picture could shift total demand parallel inwards so that the new demand equalised supply in x_1

Hence, this is principally a combined system of a *tax on the consumption and production of energy and a subsidy for suppliers of energy-saving appliances*. Again, this instrument combines the two well-known tax and subsidy instruments.

Standards

In a perfectly competitive market, consumers invest in the most cost efficient appliances. This results in comprehensive combinations of technology choices. In some instances, politicians introduce standards for energy consuming appliances to stimulate and increase the relative competitiveness of green to polluting technologies. The introduction of standards, for instance, best available technology (BAT), imposes restrictions on consumption/production technology choices. Since the willingness-to-pay, i.e., costs related to different technology choices, varies, standards imply varying shadow prices. In line with the initial regulation exemplified in relation to white and green certificates in Figures 6 and 7, this implies differentiated taxes and subsidies among consumers/producers.

Other relevant aspects

Some primary energy sources, such as crude oil, gas, and coal, are scarce and exhaustible. Other primary energy sources, such as hydropower, face decreasing returns to scale. Both resources then enjoy scarcity rents and are perfect tax bases (Hotelling 1931, Kemp and Long 1980, Karp and Newberry 1991). However, a tax on scarcity rent does not cause inefficiency (with respect to either operating costs or investment in new capacity) nor does it correct for any externality. Hence, we must not confuse scarcity rent taxation with environmental taxes.

The exercise of market power in energy markets power keeps volumes low and prices high, which are comparable to some of the tax effects. For instance, the market power of OPEC plays an important environmental role, not only in supplying oil, but also in keeping consumption and emissions down. Taxes on the monopoly producer’s product may then, contrary to intuition, play a minor role in combating pollution as the tax may instead compete for the monopoly profit. Taxation may reduce the producer price while the consumer price may change less and, consequently, consumption and emissions may change less. The conclusion is that the effect of a tax is not straightforward in markets where market power is exercised.

Concluding remarks

Many arguments vindicate the regulation of energy markets. Correction of market failures, harvesting resource/scarcity and monopoly rents, and pricing the use of transport infrastructure are the more important. International energy policy appears to be driven by concerns for climate gas emissions, local pollution, nature conservation, and energy supply and security. Obvious instruments to be used to internalize these concerns in the energy market are taxes (prices on the negative externality), cap-and-trade systems for emission allowances (if the externality is independent of its source), and subsidies to foster positive externalities through R&D.

However, concerns about regional employment, economic activity, and distributional effects are important political issues that have partly hampered the introduction of cost effective instruments. Competing concerns have brought about extensive exemptions in the taxation of energy use and climate gases, and subsidies to protect partial interests. Discrimination of taxes and subsidies among actors implies that some non-taxed consumers are indirectly subsidized and that some non-subsidized actors face indirect taxation through market effects. Excluding some of the emitting sources from the internalization of costs reduces the effects of the instrument, and the political goals for total emissions are undermined. This is for both national and global instruments. Since energy markets are integrated, the design of instruments in one country interplays with the markets and instruments in other countries. Hence, evaluating the domestic effect of a support policy is difficult without also calculating the effect of the interrelationship between different interlinked countries.

Generally, taxes prove both politically unpopular and undesirable in public. Subsidies appear easier to accept, but must be funded. Politicians are also concerned with alternative costs in terms of necessary reductions in other expenses to balance budgets and the costs of extra funding. Budget concerns then call for additional revenue-neutral instruments. Both green and white certificates satisfy this requirement. In the green certificate system, producers of environmentally friendly energy make a certificate per green energy unit. The certificate's value is determined in the market, as consumers must purchase a certain amount of certificates proportional to their energy use. The certificate market ensures a cost efficient distribution of the total share of green energy. Policy measures are then limited to the definition of 'green' and the issue of certificates. Principally, this instrument is a combination of an indirect subsidy to green producers and a tax on energy consumption and a tax on non-green energy production. However, empirical illustrations show that under reasonable assumptions, the market turns the initial tax on consumption into a subsidy for consumers. Black capacity in the market then pays all of the extra costs incurred by the green objective.

The white certificate system is principally a revenue-neutral system that addresses the consumer side of the market. If consumers are obliged to reduce their original consumption by a certain proportion, the shadow prices will vary among consumers because of different demand elasticities. Proportional reductions in demand do not then secure the optimal distribution of savings. The white certificate system introduces a system for trading energy savings among consumers, and cost efficiency is attained. In addition, this instrument serves as an indirect tax on energy consumers and a subsidy on energy-saving appliances.

All the instruments introduced to reduce energy use, resource extraction or the externalities from energy activities turn out to be combinations of direct taxes, indirect taxes, and subsidies. Even though the direct effect of an instrument may be obvious, the indirect market effects of even one instrument may be difficult to track. Introduction of several instruments that combine subsidies and tax elements may also have obscure and ambiguous effects on political measures. Discrimination in taxes and subsidies adds to this complexity.

Generally, the effect of an instrument depends heavily upon the elasticities of the demand and the supply sides of the market. Instruments to change the level of energy demand/supply most often lead to investments in more efficient technologies and substitution to other energy carriers. Thus, the supply and demand elasticities change. In other words, the sequence of the introduction of the instruments changes the effect of the instrument itself. This increasing complexity calls for theoretical and empirical research on efficiency over several simultaneous instruments. Inefficiency losses and administration and transaction costs by holding a larger set of instruments probably call for instrumental reforms.

References

Aidt, T.S. and J. Dutta (2004): Transitional Politics: Emerging Incentive-based Instruments in Environmetal Regulation. *Journal of Environmental Economics and Management*, **47**, 458-479.

Amundsen, E.S. and J.B. Mortensen (2001): The Danish Green Certificate System. Some Simple Analytical Results. *Energy Economics*, **23**, 489-509.

Ballard, C.L. and D. Fullerton (1992): Distortionary taxes and the provision of Public Goods. *Journal of Economic Perspectives*, **6**, 117-131.

Ballard, C.L. and S.G. Medena (1993): The Marginal Efficiency Effects of taxes and Subsidies in the Presence of Externalities - A CGE Approach. *Journal of Public Economics*, **52**, 199-216.

Bertoldi, P., S. Rezessy, O. Langniss and M. Vogt (2006): White, Green and brown Certificates: How to make the most of them. Paolo Bertoldi, Paper # 7203.

Bovenberg, A.L. and R.A. dé Mooij (1994): Environmental Levies and Distortionary Taxes. *American Economic Review*, **84**, 1085-1089.

Bovenberg, A.L. and L.H. Goulder (2002): "Environmental Taxation and Regulation". In A. Auerbach and M. Feldstein (Eds.): *Handbook of Public Economics*. *Volume 3.* Amsterdam; London and New York: Elsevier Science, 1471-1545.

Brekke, K.A. and T. Bye (2003): Green Certificates - concealed subsidies of externalities. *Economic Forum* 9/2003.

Bruvoll, A. and T. Bye (2003): Triple somersault in regulating energy supply and demand (Trippel salto i reguleringspolitikken). *Økonomisk Forum* **1**, 20-27.

Bye, T. (2003): On the Price and Volume Effects from Green Certificates in the Energy Market. Discussion Papers 351 - Statistics Norway, June 2003.

Bye, T. and E. Hope (2006): "Deregulation of electricity markets. The Norwegian experience". In L. Sørgard (Eds.): *Competition and Welfare.* The Norwegian Competition Authority, Oslo.

Böhringer, C. and A. Lange (2005a): Economic Implications of Alternative Allocation Schemes for Emission Allowances. *Scandinavian Journal of Economics*, **107**, 563-581.

Böhringer, C. and A. Lange (2005b): On the Design of Optimal Grand fathering Schemes for Emission Allowances. *European Economic Review*, **49**, 2041-2055.

COM (2000): European Commission, 2001, Directive of the European Parliament and of the council on the promotion of electricity from renewable energy sources in the internal electricity market. COM (2000)0884 final, Brussels, Belgium.

Diamond, P. and J. Mirrles (1971): Optimal Taxation and Public Production I: Production efficiency. *American Economic Review*, **61**, 8-27.

Felder, S. and R. Schleiniger (2002): Environmental Tax Reform: Efficiency and Political Feasibility. *Ecological Economics*. August 2002; **42**(1-2): 107-16.

Fischer, C. and R. G. Newell (2008): Environmental and technology policies for climate mitigation. *Journal of Environmental Economics and Management* **55**, 142-62.

Golombek, R. and M. Hoel (2005): Climate Policy under technology Spillovers. *Environmental and Resource Economics* **31**, 201-227.

Goodstein, E. (2003): The Death of the Pigovian Tax? Policy Implications from the Double-Dividend Debate. *Land Economics* **79**(3), 402-14.

Goulder, L.H. (1995a): Effects of Carbon Taxes in an Economy with prior Tax Distortions: an intertemporal general equilibrium analysis. *Journal of Environmental Economics and Management.*

Goulder, L.H. (1995b): Environmental Taxation and the Double Dividend: A Readers guide. *International Tax and Public Finance*, **2** (2), 157-183.

Goulder, L.H., I.W.H. Parry, R.C. Williams and D. Burtraw (1999): The Cost-Effectiveness of Alternative Instruments for Environmental Protection in A Second best Setting. *Journal of Public Economics*, **72**, 329-360.

Goulder, L. and S.L. Schneider (1999): Induced Technological Change and the Attractiveness of CO_2 Emissions Abatement Policies. *Resource and Energy Economics* **21**, 211-253.

Goulder, L. and K. Mathai (2000): Optimal CO_2 Abatement in the Presence of Induced Technological Change. *Journal of Environmental Economics and Management*, **39**, 1-38.

Hall, G. and S. Howell (1985): The experience curve from the economist's perspective. *Strategic Management Journal*, **6**, 197-212.

Hasselknippe, H. (2006): The Role of the Carbon Market in Future Climate Policy, Intereconomics. *Review of European Economic Policy*, **41**(2), 74-77.

Hoel, M. (1995): Should a Carbon Tax be Differentiated Across Sectors? *Journal of Public Economics*, **59**, 17-32.

Hoel, M. (1998): Emission Taxes Versus Other Environmental Policies. *Scandinavian Journal of Economics*, **100**, 79-104.

Hoel, M. and L. Karp (2001): Taxes and Quotas for a Stock Pollutant with Multiplicative Uncertainty. *Journal of Public Economics*, **83**, 91-114.

Hotelling, H. (1931): The Economics of Exhaustible Resources. *Journal of Political Economy*, **39**, 137-75.

Håkonson, L. and L. Mathiesen (1997): On the measurement of economic costs related to public resource use (Om måling av samfunnsøkonomiske kostnader ved offentlig ressursbruk). *Norsk økonomisk tidsskrift* **111**(2), 185-206.

Jaffe, A.B., R.G. Newell and R. Stavins (2002): Environmental Policy and Technological Change. *Environmental and Resource Economics*, **22**, 41-69.

Jensen, J. and T.R. Rasmussen (2000): Allocation of CO_2 Emission Allowances: A Generela Equilibrium Analysis of Policy Instruments. *Journal of Environmental Economics and Management*, **40**, 111-136.

Jensen, S.G. and K. Skytte (2002): Interactions between the Power and Green Certificate Markets. *Energy Policy*, **30**(5), 425-435.

Joskow, P. and N.L. Rose (1985): The effects of technological change, experience, and environmental regulation on the construction cost of coal-burning generating units. *RAND Journal of Economics* **16**(1), 1-17.

Karp, L. and D.W. Newberry (1991): Optimal Tariffs on Exhaustible Resources. *Journal of International Economics*, **30**, 285-299.

Kemp, M.C. and N.V. Long (1980): "Optimal tariffs in Exhaustible Resources". In M.C. Kemp and N.V. Long (Eds.): *Exhaustible Resources, Optimality and Trade.* Amsterdam, North Holland.

Krugman (1996): *Pop Internationalism*, MIT Press, Boston.

Madsen, A.D. and M. Sørensen (2002): Effects of trade and market integration in a small open economy – a dynamic CGE approach, www.dreammodel.dk

Menanteau, P., H.-L. Lamy and D. Finon (2003): Les instruments de marche pour la promotion des energies renouvelables: Interet et limites des echanges de certificats verts, entre efficacite allocative et efficience dynamique. (Promoting Renewables through Green Certificate Markets: A Way to Combine Allocative and Dynamic Efficiency? With English summary. *Economies et Societes*, **37**(2-3), 381-400.

Parry, I.H.W., R.C. Williams III and L.H. Goulder (1999): When can Carbon Abatement Policies increase welfare? The Fundamental Role of Distorted factor Markets. *Journal of Environmental Economics and Management*, **37**, 52-84.

Pigou, A.C. (1920): *The Economics of Welfare.* London, Macmillian.

Quiron, P. (2006): Distributional Impacts of Energy-Efficiency Certificates Vs. Taxes and Standards. CIRED Working paper. Fondazione Enrico Eni Matei. Nota Di Lavoro 18.

Romer, P.M. (1986): Increasing returns and long-run growth. *Journal of Political Economy* **94**(5), 1002-37.

Sandmo, A. (1975): Optimal taxation in the presence of externalities. *Swedish Journal of Economics* **77**, 86-98.

Schrattenholzer, L. (2002): Analyzing the Case Studies from the Point of View of the RandD and Deployment Model. Environmentally Compatible Energy Strategies (ECS) Project. International Institute for Applied Systems, Laxenburg, Austria. http://www.iea.org/workshop/deploy/session2.pdf

Spence, A.M. (1984): The learning curve and competition. *The Bell Journal of Economics* **12**, 49-70.

Ulph, A. and D. Ulph (1994): The Optimal Time Path of a Carbon Tax. *Oxford Economic Papers*, **46**, 857-868.

Vennemo, H. (1991): An applied general equilibrium assessment of marginal cost of public funds in Norway, Discussion Paper 62, Statistics Norway.

Voogt, M.H., Boots, M., Shaeffer, G.J. and J.W. Martens (2000): Renewable electricity in a liberalised market – the concept of green certificates. *Energy and Environment* **11**, 65-79.

Voogt, M., Luttmer, M. and E. de Visser (2006): Review and analysis of national and regional certificates schemes. Task report work package 2. EuroWhiteCert Project.

Weitzman, M.L. (1974): Prices versus Quantities. *Review of Economic Studies*, **41** (4), 477-491.

Weale, A. (1992): *The new politics of pollution*. Manchester: Manchester University Press.

Wilson, J. Q. (1980): *The politics of regulation*. New York: Basic Books, Inc., Publishers.