Are “environmental” tax incentives efficient?

Jacques BAVEYE and Christian VALENDUC (*)
Conseillers généraux des Finances

ABSTRACT

In Belgium, there are in fact two types of so-called environmental tax incentives in the field of energy. Some aim at energy efficiency, others at innovation. We examine to what extent these two types of incentives are justifiable on efficiency grounds. The theoretical concepts of market failure and externality are central to the discussion.

There are various market failures and externalities in the field of environment that are relevant to energy-efficiency policy. But we show that incentives are generally not the best instrument to address them. Market failures and externalities also apply to the field of green innovation. While energy taxation provides greater incentives for innovation, it does not remove these obstacles. This justifies the use of other instruments, which are subsequently examined.

All these issues come up clearly in the Belgian photovoltaics policy, which is presented as a case study. Although it can be judged positively in terms of innovation, two criticisms are levelled at that policy.

As a conclusion, the case for incentives in favour of innovation is strong, notwithstanding the fact that their design can be improved. As for energy-efficiency incentives, the case is much less convincing. Tax psychology might explain why they are in place.

Keywords: Externalities, Environmental Taxes and Subsidies, Household Behaviour, Global Warming, Environmental Policy

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> “Socialism failed because it couldn’t tell the economic truth; capitalism may fail because it couldn’t tell the ecological truth.”
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> Lester Brown, *Fortune Brainstorm Conference, 2006*

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1 Introduction

In Belgium, over the last few years, a number of fiscal incentives have targeted environmental issues. This has been most notably the case with incentives favouring cleaner, or electric, cars and those in favour of household investments in energy efficiency and renewable energy. These tax incentives have been systematically presented and touted as “environmental” measures. The few critical appraisals of these measures have been accordingly based solely on environmental considerations.

That those incentives might legitimately have another justification is seldom envisaged explicitly. When it is, the idea is readily dismissed as unacceptable, on the ground that such a justification would lead to confusion and be detrimental to the credibility of environmental tax incentives (1). And yet the high cost of avoided CO_2, implied by some incentives (2), suggests that another rationale is probably at work. Upon closer examination, it indeed seems obvious that there are actually two types of incentives. Some aim at energy efficiency (thermal insulation, etc.), others at innovation (photovoltaics, “clean” and electric cars). Of course, to the extent that innovations, in particular, may lead to practical solutions to environmental problems in the future, it is legitimate to look at incentives for innovations as “environmental” measures. However, that is not the only possible perspective.

In this context, the purpose of the present article is to examine, with the help of concepts taken from the economists’ toolkit, to what extent those two types of incentives are justifiable on efficiency grounds. In other words, are they cost effective, i.e., are they such as to allow the achievement of policy objectives at minimum cost? In this respect, the theoretical concepts of market failure and externality are central to the discussion. After a brief reminder of what they mean, we show how these concepts apply to energy efficiency and innovation. In both cases, the most efficient tax incentives are presented, and actual Belgian practice is gauged accordingly. In particular, the support policy for photovoltaics is examined in some detail. The analysis ends up in a set of conclusions, in which we venture briefly into the uncharted territory of tax psychology.

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[1] Conseil supérieur des Finances (2009), p. 168.

[2] *Ibid.*, pp. 129 and 159.

2 Market failures and externalities

Market failure is a technical term that roughly refers to conditions under which the free market does not produce optimal welfare, in the sense that the price mechanism does not provide an efficient resource allocation. It is thus a "failure" compared with the abstract model economists make of a perfect market economy. Market failure is an important reason for public intervention, at least in cases where the costs of correcting for the market failure do not exceed the welfare gains to be obtained.

There are different forms of market failure. Externalities are an important one. These are typically "*an unintended and uncompensated side effect of one person's or firm's activities on another*" (3). Good examples of negative externalities are the health effects of smoke emissions from vehicles, factories and cigarettes. In the presence of externalities, market prices do not reflect full social costs (or benefits, in the case of positive externalities), and regulatory taxes (or subsidies) are called for to restore the efficient workings of the market mechanism.

These concepts apply in various ways to the environment and to innovation.

3 Application to energy-efficiency incentives

There are various market failures and externalities in the environmental arena that are relevant to energy-efficiency policy.

3.1 The environmental externality

The most obvious application concerns an environmental externality proper, namely the contribution of greenhouse gas emissions to global climate change. It is basically a consequence of the public-good nature of climate: it is impossible for individuals or countries to appropriate the benefits of their own actions to protect the climate, giving rise to free-riding incentives. The result is an oversupply of pollution, compared with what would be socially optimal.

The tax system can be used in two different ways to address pollution. Tax-based measures can either set a price for the environmentally harmful goods and activities (the "stick"), or try to foster environmentally beneficial actions by reducing their cost (the "carrot"). Taxes on pollution (or on proxies to pollu-

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3 Sterner (2003), p. 23.

tion, like excise duties) are generally considered the best instrument available to policy makers, as a first line of attack. Taxes provide the greatest range of abatement options to polluters. They create static efficiency – that is, the lowest individual cost abatement measures are undertaken first –, and dynamic efficiency – the incentive to abate is present even after significant abatement may have already occurred.

Tax incentives (“carrots”) have specific drawbacks. First, they can induce additional consumption of environmentally harmful goods and services by lowering costs (rebound effect) (4). Second, they are difficult to design to only target new actions. By not leaving outside their scope actions that would have been undertaken anyway, they give rise to windfall gains. Finally, tax incentives imply making a decision as to what to subsidize. As there are a large number of actions that lead to the internalisation of environmental externalities, any choices among them can be difficult (and inefficient) (5).

In Belgium, taxes on energy and transport do not take fully into account the environmental externalities. This situation has been rightly criticised and propositions have been made to remedy this situation (6). In the meantime, one could justify having some tax incentives, even though they are bound to be more generous (and bring more distortions) than would be the case with adequate internalisation.

3.2 Imperfect information

Another important market failure pertains to environmental goods: imperfect information. The neo-classical approach, which is widely used by economists and backs many policy recommendations, typically assumes that information is freely available to everyone. When information is not fully available and the cost of acquiring it is high, as is often the case for households or small businesses, the market no longer operates perfectly.

As imperfect information leads to uncertainty regarding the outcome of action, it could conceivably be put forward as justifying the existence of certain incentives, even when they reward actions that would have a positive rate of return without incentive. For example, the incentives for energy efficiency could be viewed as necessary to counterbalance the fact that many households are ill-informed on the subject. But it seems on the contrary that the existence of an

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4 The rebound effect comes from the fact that energy-saving technologies trigger a behavioural response by the economic agents, which may prevent the benefits from energy conservation to be entirely tapped. For example, the purchase of a more energy-efficient car can induce more driving.

5 For additional comments on tax incentives, see Conseil supérieur des Finances (2009), pp. 37-38.

6 See Conseil supérieur des Finances (2009).

incentive does not convey much information other than the fact that government encourages the adoption of a precise action. It provides information neither on the financial return nor on technical matters.

Consequently, it has been rightly argued that information campaigns are a better (and less costly) instrument for that purpose (7). Information campaigns can take the form of public-service type messages encouraging citizens to undertake "green" actions or provide greater information on making environmental choices relative to consumption, such as detailing information on energy utilisation and expected lifetime costs of certain appliances. This information, which is typically difficult to collect and compare across different options, can help overcome barriers and reinforce environmentally related taxation on energy. In the particular case of household investments for energy efficiency, the technical information is best provided by making energy audits compulsory (8).

3.3 "Irrational" behaviour

Empirical studies show that consumers can have very high discount rates, preferring sometimes to purchase lower-cost goods (with higher operating costs) rather than higher-price goods (with lower operating costs). The reason we mention this here is that this behaviour has been related to market failures; a lack of information could cause uncertainties over future returns and justify resorting to incentives.

However, these high discount rates may simply reflect the fact that consumers very much prefer consumption in the present period compared to future periods. Generally, experiments have shown that spontaneous preferences by human (and nonhuman) subjects follow a hyperbolic curve rather than the conventional "exponential" curve that would produce consistent choice over time. According to Gowdy et al. (2005, p. 214), "*a growing body of evidence suggests that a straight-line discount rate does not accurately reflect how individual humans actually view the future. Studies by economists and psychologists have shown that people exhibit hyperbolic discounting, where higher value is placed on benefits delivered in the near term, followed by a sharp drop and flattening in the medium term, so that the value of something stays fairly constant out in the distant future*" (Laibson, 1997) (9).

Besides, one can question whether the rational consumer model of mainstream economics, with its key assumptions of rationality, individuality and self-interest, is a good predictor of human behaviour. This is one of the major

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7 Conseil supérieur des Finances (2009), p. 167.

8 As advised by Conseil supérieur des Finances (2009), p. 167.

9 For instance, when offered the choice between € 50 now and € 100 a year from now, many people will choose the immediate € 50. However, given the choice between € 50 in five years or € 100 in six years almost everyone will choose € 100 in six years, even though that is the same choice seen at five years' greater distance.

conceptual issues of ecological economics, a heterodox school of economics. According to this stream of literature, more and more empirical evidence reveals the existence of some degree of altruism in allocation decisions. The social framework is also an important factor in economic decision-making, and people make different decisions as members of a social group than they do as isolated individuals.

The existence of *Homo Oeconomicus* is also deemed highly disputable by evolutionary economics, another heterodox school. Following Herbert Simon's "bounded rationality", agents are viewed as adopting decision "routines" to simplify their decision process and ensure satisfactory (but not necessarily optimal) results. According to Maréchal et al. (forthcoming), "*the concept of habits is essential in analysing the determinants of domestic energy consumption, as it sheds an insightful light on the puzzling question of why it keeps rising even though there is an evident increase in awareness and concern about energy-related environmental issues such as climate change.[…] The next step is thus to assess the role of habits in energy consumption behaviours. To start with, it seems obvious that behaviours such as switching off the lights or turning off appliances meet the three conditions identified by Jackson for the balance of the decision-making process to swing away from cognitive effort and towards automaticity: low degree of involvement, low perceived complexity, and high degree of constraint [arising from the feelings of time pressure* (10) *and information overload that characterise today's society]. One other important element that characterises domestic energy consumption is that it is not visible. This implies that people do not consider the remote environmental impacts of their actions when performing energy-related behaviours. This obviously facilitates the retention of unsustainable habits in this area*" (references omitted).

Furthermore, not only do existing habits get more entrenched as people get older, but so does the general disposition to rely on habits.

These habits could provide an explanation for the "anomalies" that can be found in the field of energy consumption. Many bottom-up studies have shown the existence of a "no-regret" emission reduction potential. An emission reduction potential is said to be "no-regret" when the costs of implementing a measure are more than offset by the direct or indirect benefits (not including climate-related benefits) it generates based on traditional financial criteria. In other words, these investments are not implemented spontaneously, even though their private return is high.

The most obvious example of such "no-regret" measures is the use of appliances that are more energy efficient. Another example is the insulation of residential building shells, which, incidentally, benefits from public financial support in Belgium in spite of a positive private return (Conseil supérieur des Finances (2009), p. 166; and McKinsey&Company (2009), p. 18).

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[10] The obvious advantage of these "habits" in decision-making is to free up resources that can be devoted to solving non routine-like problems and, as such, it can be said to be a highly rational way of allocating our limited cognitive abilities (Maréchal (2009), p. 75).

This "efficiency gap" has been imputed by traditional economists to the existence of hidden costs (mostly transaction costs). However, while such costs do indeed exist, bottom-up studies have shown that they do not quite offset the benefits from identified profitable energy-efficient investments (Maréchal (2007), p. 5183).

The existence of habits in domestic energy consumption would most likely limit the effectiveness of incentives, as these measures do not specifically address the influences that shape and maintain those habits. Policies promoting sustainable energy consumption would need, among other things, to deconstruct habits (as increased environmental awareness is not sufficient in the presence of strong habits). In this perspective, an important point is the dependence of habits on environmental cues (physical and social surroundings, temporal perspective, etc.). "*As far as household energy consumption is concerned, physical location is obviously an important environmental cue. Accordingly, economic incentives aimed at improving energy efficiency would probably be more effective if supporting information was specifically targeted toward new residents (whose previously determined habits have been perturbed with the change of physical location) than they would be among the population of incumbent residents*" (Maréchal (2009), p. 81). However, restricting the benefit of such incentives to people moving into a new house would seriously limit the potential impact of these incentives.

3.4 Capital market failure

A lack of access to capital can prevent some people, in particular low-income households and the elderly, from making energy-efficiency investments, profitable though they may be. In principle, two factors can possibly explain this situation: the way financial institutions work and income distribution. While the first factor can be considered, with due respect for the credit sector, as a market failure, it is hardly the case for the latter factor; according to conventional theory, income distribution cannot be a source of inefficiency.

Financial support (in the form of subsidies and tax incentives) can limit the borrowed amount and thus allow economic agents to overcome a possible lack of access to capital. Is this verified in practice? In the case of the Belgian tax incentive for energy-efficiency investments in households, which may represent up to 40 % of the related expenses, the distribution of the advantage among households has been shown to be less unequal than for most other tax expenditures (Conseil supérieur des Finances (2009), p. 151). Still, households of the bottom two deciles do not benefit from the measure and the size of the tax benefit increases with the income level (Ibid., p. 153).

As for public interventions in the credit cost, resulting in "green" or zero-rate loans, their incidence on the ability of low-income households to secure loans must be negligible, unless they are designed to target specifically those categories. The green-loan system initiated by the Belgian federal government, for instance, seems to have been used mostly by well-off households to finance the installation of solar panels (11).

In principle, third party services offer a better solution. But they will not be treated here, because they do not imply a public intervention.

3.5 Conclusion

From a theoretical point of view, various externalities and market failures justify the principle of tax incentives in the context of energy-efficiency policy. In practice, though, things are a bit different.

As far as the environmental externality is concerned, to make prices right should be far preferable than any tax incentive, for the numerous reasons mentioned above. But as long as a full internalisation is not in place, as in Belgium presently, the granting of tax advantages might be justifiable.

Market failures should only be addressed with tax expenditures if no better instrument is available and to the extent that the social benefit given by the tax expenditure is larger than the cost of correcting the market failure. To remedy imperfect information, campaigns are obviously a better instrument than tax incentives. As for irrational behaviour, the claim made by some heterodox schools of economics that people's choices are driven by habits more than by optimisation appears to be well-founded, as the existence of a "no-regret" emission reduction potential seems to indicate. It follows that economic incentives aimed at improving energy efficiency have a limited effectiveness, as these measures do not specifically address the influences that shape and maintain those habits. They would probably be more effective if supporting information was specifically targeted toward new residents (whose previously determined habits have been perturbed with the change of physical location). Of course, such a design would restrict considerably the number of households targeted. Finally, tax incentives may limit the effect of the capital market failure on low-income households, but the evidence is not overwhelming.

To sum up briefly, energy-efficiency incentives are generally not the best instrument to address market failures. However, it should be added that some of these market failures can hardly be addressed with any other instrument.

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[11] "Les prêts verts: un large coup dans l'eau!", L'Echo (12 June 2010).

4 Application to innovation incentives

Let us now turn to the market failures and externalities that apply to green innovation activities.

4.1 The environmental externality

Unless an appropriate price is put on the environmental externality, there will not only be an oversupply of pollution, as we saw above, but also an undersupply of innovation, compared with what would be socially optimal. And similarly, taxes on pollution should be considered as the prime instrument to encourage innovation. Taxation changes the rate of return to the investor. With a higher expected return, the initial investment and therefore the resulting level of innovation should be higher.

By increasing the cost of pollution, taxes provide incentives to develop innovations as well as incentives to adopt them. Taxes on pollution, and to a slightly lesser extent taxes on proxies to pollution, have also been shown to encourage a wider range of actions (and therefore provide greater incentives for innovation) than other tax instruments, namely accelerated depreciation allowances, R&D tax credits, or reductions in VAT rate (12).

The following market failures and externalities are more specific and have been summed up under the term “innovation externality”.

4.2 Knowledge externalities

Because innovation has to do with ideas, innovating firms may not always be able to recover all the benefits of innovation. This reflects the public-good nature of ideas (13). In particular, an inventor cannot perfectly stop others from benefiting, either directly or indirectly, from the invention. The private rate of return is lowered due to these knowledge spillovers. “This can be thought of, therefore, as the social rate of return remaining the same, in that the economy as a whole derives value from the innovation, but the private rate of return becomes lower, as some of the benefits cannot be internalised by the firm. As firms decide what projects to undertake, these lower rates of private return suggest that fewer projects are undertaken than would be given the social rate of return. This causes

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(12) OECD (2010), pp. 122-125.

(13) But because its non-excludability is only partial, R&D itself is not a public good (European Commission, 2009, p. 9).

an undersupply of innovation compared to the social optimum" (OECD (2010), p. 19).

Invention is not the only innovation stage where such externalities occur. Similar externalities are related to use. Many times, the value of an innovative product or process grows as users use it. This learning experience can be a source of information for other users, thereby creating externalities. These externalities are commonly referred to as "learning-by-using" or "learning-by-doing", depending on whether one considers the consumption or the production aspect.

4.3 Incomplete information

As in the case of energy efficiency, incomplete information can hamper innovation to a level below the social optimum. The potential of the innovation may not be clearly foreseen and future policy action may be uncertain. Such unknowns may require a higher private rate of return for innovations to be developed, causing an undersupply of innovation.

4.4 Capital market failure

Together, these market failures may have adverse effects on the functioning of financial markets, limiting access to finance for investment in green technologies.

4.5 Additional barrier: technological "lock-in"

Though not a market failure proper, technology lock-in can be an additional barrier to innovation. Previous innovations, because they were successful, came to dominate the market. To overcome the resulting inertia may require large-scale investments on a number of different fronts, as would happen for example in the case of a transition to a hydrogen economy. Some of those investments may have to be carried out by government.

4.6 Is taxation enough ?

These various market imperfections and other constraints clearly suggest that the realised level of innovation will be below that of the social optimum unless public policies are put in place to stimulate innovation.

As for the instruments to be used, we have noted the prime role taxation should play. Could taxation be effective to the point where no other instrument would be necessary? According to the OECD (2010, p. 74), the work to date on the effectiveness of taxation to induce innovation has not been extensive. The various case studies undertaken by the OECD itself to investigate this void highlight the difficulty of empirically testing the innovation impacts of taxation, because of the interactions with other factors.

Theoretically, optimal environmentally related taxation is supposed to address only one externality: the oversupply of pollution. While taxation should also provide greater incentives for innovation, it does not remove the obstacles to innovation that were mentioned above. This justifies the use of other instruments to specifically address those obstacles. Some simulations confirm this view by showing that the optimal carbon price would have to be higher when using only one instrument (the carbon price) rather than a combination of carbon pricing and subsidies in favour of clean R&D (Aghion et al.(2009), p. 3). This recalls the well-known oral tradition handed down by economists, which says that when there are two problems to deal with, using two instruments gives better results than using only one. "*Particularly, the lock-in process makes it unlikely that traditional cost-efficient measures (such as carbon taxation, or tradable emission rights) aimed at internalising external costs will be sufficient to bring about the required radical changes in the field of energy, because they fail to address structural barriers […]*" (Maréchal (2007), p. 5190).

4.7 What other instruments?

The principle of public intervention in favour of innovation being admitted, what instruments should be advocated? Before answering this question, it is necessary to detail somewhat the different stages of innovation.

4.7.1 The stages of innovation

Core to the concept of innovation is technological change. The process of technological change is typically broken down into the following stages (Ekins (2009), p. 5):

- invention – *i.e.* the first development of a scientifically or technically new product or process; it covers basic and applied R&D;
- demonstration – *i.e.* the application of inventions in demonstration projects;
- commercialisation – *i.e.* the development of niche applications and markets (14);
- diffusion – *i.e.* the adoption of the product or process by firms and individuals.

4.7.2 Intervention at the first stages

The first pre-market phases of the process of technological change, which are described as “technology push”, are influenced by business and government policy drivers. At the early stages, the potential innovations may not have immediate market implications or are of a more fundamental nature. Basic innovation, in particular, is consistently flawed by long time horizons, significant uncertainty and less tangible end results. In other words, the obstacles to innovation we mentioned above apply, justifying government policies and funding.

The tax system can be used to provide incentives for innovation. Two types of measures can be taken that tend to address the obstacles mentioned by reducing the cost of undertaking innovation. These measures are a reduction of the labour costs of innovation activities and the granting of R&D tax credits.

Both measures have been applied in Belgium for some years. First, employers’ tax burden on labour can be reduced through a reduction in withholding tax on researchers’ wages (15). The reduction percentage was initially 25 % or 50 %, depending on various criteria. It was subsequently levelled out to 65 % in 2008 and 75 % in 2009. Second, a tax allowance (“investment deduction”) enables businesses to deduct part of “green” R&D investments from the tax base. For assessment year 2010, the percentage is 15.5 %. Alternatively, companies can opt for a tax credit (16) equal to the tax allowance multiplied by the corporate tax rate (33.99 %) (17).

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14 Niche markets may be viewed as “small, focused and targetable portions of a larger market, comprising a group of actors whose needs for products or services to perform particular functions are not being addressed by mainstream providers” (Ekins (2009), p. 12).

15 The reduction of the withholding tax has no effect on the personal income tax liability of the employee. It just reduces the withholding tax that the employer has paid to the tax administration. It thus acts as a wage subsidy.

16 Tax credits differ from tax allowances in that they provide a deduction from taxes payable, while tax allowances provide a deduction from net income for tax purposes.

17 Additional measures that are in force in Belgium have a much more limited scope. As from assessment year 2008, a tax allowance for patent income allows companies to deduct from the tax base 80 % of income from the granting of licences as well as income from patent use by the company on its own behalf. This measure helps to increase the after-tax return to in-

In spite of their theoretical justification, the use of both measures has some drawbacks. First, the responsiveness of R&D activities to such incentives may be lessened by a limited supply of high-skilled researchers, resulting more in wage increases than in additional R&D. Second, they may provide tax relief to R&D that would have nevertheless been undertaken by the firm (18). The extent of this windfall gain effect is hard to assess. Last but not least, it is worth recalling that these measures alone provide no incentive to adopt or use the resulting innovations, as there is no economic incentive to abate non-priced emissions in the first place. This in turn has a negative effect on the expected return to innovators, reducing the impact of the measure.

There is little empirical literature on the efficacy of R&D tax measures in Belgium. Working on a sample of 126 firms representing 47 % of R&D in 2007 in Flanders, Plasmans et al. (2009) have investigated the use of R&D tax measures by companies and their effect on R&D intensity. The econometric analysis of the intramural (19) R&D intensity explanation demonstrates that, of all the tax measures (including those listed above in footnote 11), only the reduction in withholding tax on researchers' wages and the tax allowance for innovation premiums have a significant positive effect. And on the basis of the results of a qualitative enquiry, the authors conclude that the measure that most stimulates R&D investments by companies in Flanders is the notional interest deduction, followed by the reduction in withholding tax on researchers' wages.

The fact that the notional interest deduction was not introduced to stimulate R&D investments but rather to improve the international competitiveness of firms leads to the following question: for the sake of innovation itself, would it not be preferable to replace some of the R&D tax measures by a lower corporate tax rate across the board? After all, lowering the corporate tax rate would increase the after-tax return to innovation, along with all other activities of a firm. Such a policy is however costly and clearly lacks targeting. Moreover, it creates a windfall gain since the existing stock of capital would benefit from the tax break. Moreover, young innovative companies often make no profit and therefore would not benefit from a lower corporate tax rate. On the whole, R&D tax credits seem preferable, especially if they are refundable.

4.7.3 Intervention at the later stages

The commercialisation and diffusion processes are driven by consumer "demand-pull". The diffusion of innovative products and processes is also hindered by obstacles. Uptake starts at a low speed, then accelerates and slows

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novation. Another provision allows the deduction from the tax base of regional premiums for R&D (as from assessment year 2008). Finally, a tax allowance is also granted on behalf of the employee for innovation premiums paid by the firm (as from assessment year 2006).

18 One way to try to avoid this would be to consider only additional R&D, such as that above a three-year average.

19 *i.e.* carried out inside the company, as opposed to outsourced.

down again when the level of saturation is approached. This is reflected in the logistic or S-curve (20). The acceleration in uptake is due not only to the spread of information among economic actors, but also to improvements and cost reductions occurring in the course of the diffusion process due to economies of scale and learning effects. Cost reductions as a function of the accumulative production (or sales) of a particular technology can be represented by “learning curves”. For example, the learning curve in the production of photovoltaic cells is such that a doubling of production induces a lowering of the total production cost by about 20 % (Poignant (2009), p. 38).

As was shown above, various externalities as well as technological lock-in, justify public intervention at these later stages of technological change. However, such a public intervention raises at least two questions.

Up to this point, we have discussed innovation policy without considering the fact that support measures are implemented at the national level while their impact may take place at the world scale. It is obvious as far as externalities are concerned, for innovation is a semi-public good. It may also be the case regarding the impact on innovation-related production. In a context of free trade, support measures aiming at the diffusion of innovation may result in imports, depending on the existence of competitive national products. In this case, the direct benefits of innovation do not accrue to the national economy, although, generally speaking, imports can have a backlash effect on exports.

The question of the benefits of innovation may seem beyond the scope of this article. It deserves nonetheless to be asked, especially in the case of a small open economy like Belgium. The implementation of a policy implies that a price has to be paid and no government can escape the question of the acceptability of that price in relation to the benefits to be gained.

Actually, the question arises in a similar manner for scientific research, except that the latter is a public good. In this case, the best answer is probably that scientific research is a matter of participating in a joint effort. A country with sufficient resources and ambition will deem necessary to contribute to a common effort that will benefit to all. And by so doing, it will be able to keep its position among its peers. *Mutatis mutandis,* the same can be said of innovation. Likewise, this whole discussion suggests that the benefits of innovation are greater when innovation policy is coordinated at the international level.

Public intervention raises a second question: is the public sector well placed to pick winners (instead of letting markets decide) in terms of the technologies of tomorrow? By granting tax advantages for the purchase of a product incorporating a new technology, the government fosters the development of that technology, to the detriment of other technologies. In fact, the question is

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20 See OECD/IEA (2008, p. 25) for a documented example.

twofold. First, should one technology be favoured over another? In the event of an affirmative reply, the result may indeed be a technology lock-in that ultimately proves inefficient. Second, is it up to the government to make a choice? It can be argued that the choice of technology is best left to the private sector and that governments should act to keep open a range of technological options. On the other hand, "*governments should also promote the type of measures that have been proven successful in overcoming lock-in situations (see the set of necessary conditions in Windrum*" (1999, p. 31). (Maréchal (2007), p. 5190) The International Energy Agency (IEA) stresses, for its part, the need for "*the development and implementation of appropriate incentives guaranteeing a specific level of support to different technologies based on their degree of technology maturity, in order to exploit the significant potential of the large basket of renewable energy technology over time*" (OECD/IEA (2008), p. 23).

4.7.4 Case study: photovoltaics

All these issues come up clearly in the Belgian photovoltaics policy, which is presented here as a case study.

4.7.4.1 The facts

In Belgium, various measures have been taken at both federal and regional levels with the stated objective of supporting the diffusion of photovoltaics. For households, the tax incentive consists of a tax credit for investments in photovoltaic arrays. It was first set at 15 % of expenses incurred in 2003 (revenue year) and raised to 40 % in 2005. The maximum amount of tax credit was initially € 600; it was brought up to € 1,000 in 2006 and to € 2,600 in 2007 (which translates into € 3,680 after indexation for 2011). As of 2009, interests paid on loans contracted to finance such investments are also eligible for a 40 % tax credit. For enterprises, the investment deduction was extended in 1983 to apply to energy-saving investments, among others in renewable energy. At the regional level, the measures are feed-in tariffs, a quota obligation system with tradable green certificates and regional premiums.

In terms of public expenditures, the cost of the tax credit and premiums for households is extremely high. Spies et al. (2008) give a global amount of € 1,558 per ton of avoided CO_2, compared with € 23 for wall isolation. For the tax credit alone, a simple calculation (Annex 1) shows that the cost is at present € 497 per ton of avoided CO_2. This figure can be compared with the market price of CO_2, which is now around € 15 per ton. In consequence, we cannot but assume that the primary goal of support was other than climate policy, namely innovation policy. To what extent has that goal been attained? This is the question we are going to attempt to answer. Of course, the assessment must be of the entire policy framework, of which the tax incentive is only a part.

In terms of diffusion, the policy has been highly effective. At the end of 2009, the total installed capacity was estimated to be 363 MWp (21), putting Belgium at the fifth place in the European Union in terms of photovoltaic power per inhabitant. In 2009 alone, Belgium installed 292.1 MWp, of which 251 MWp in the Flemish Region, 38 MWp in the Walloon Region and 3.1 MWp in the Brussels Capital Region. "*The reason for the sharp rise in installed capacity in the Flemish region is that this region operates a particularly attractive regional green certificate system, which offers a minimum price of 450 euros (or € 0.45/kWh) for a photovoltaic green certificate (equivalent to a production of 1 MWh) regardless of installation capacity or type. This system has naturally been a boon to high-capacity installations that have gained the most from the drop in the price of modules*." (Eurobserv'er (2010), p. 143) (22) As a result, about 70 % of the installed capacity in Flanders belongs to the middle and large-scale industrial segments (23). By contrast, installed photovoltaic capacity in Wallonia is mainly composed of small residential systems. Another reason for the difference is that the Walloon support scheme was only launched in 2008, two years after the Flemish one (24).

As a consequence of this success, the cost for the public finances has grown dramatically.

The amount of the related tax expenditures is not available but it is possible to give a partial estimate for tax year 2010 on the basis of the capacity installed in revenue year 2009. As far as the tax credit for households is concerned, our estimate reaches € 168 million (details in Annex II) (25). And since the amount of the tax credit exceeding € 3,600 can be carried over to the three following years, additional impacts can be expected to reach globally € 167 million. For the investment deduction, the tax expenditure can be estimated at a maximum of € 65 million (see Annex II). Although the related investments are larger than for the tax credit, the amount is smaller, because the rate of the investment deduction is only 15.5 % and the investment deduction is a tax allowance rather than a tax credit.

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21 Watt-peak (Wp) is a measure of the nominal power of a photovoltaic solar energy device under laboratory illumination conditions. A megawatt-peak is equivalent to one million Wp.

22 An adjustment has set the price of a photovoltaic green certificate at € 350 from January 1, 2010.

23 European PhotoVoltaic Industry Association (EPIA), "Country Focus: Belgium. Interview with Frank Gérard", available at http://www.epia.org/policy/national-policies/belgium/interview-with-frank-gerard-edora-adviser.html

24 European PhotoVoltaic Industry Association (EPIA), "Country Focus: Belgium. Interview with Manoel Rekinger", available at http://www.epia.org/policy/national-policies/belgium/interview-with-manoel-rekinger-photovoltaic-business-facilitator-at-energie-facteur-4.html

25 The Walloon Region and the Brussels Capital Region face a similar surge in premiums granted. The Flemish Region does not have such a system.

As for the impact on CO_2 emissions, it remains limited. We estimate that the total installed photovoltaics capacity by the end of 2009 supplies only 0.3 % of final electricity consumption(26). Of course, the importance of photovoltaics is expected to grow further in the future with the lowering of cost. The physical potential is supposed to be considerable. According to IEA (2002), solar power production from photovoltaic roofs and façades in Western Europe could provide 30 % of electricity consumption.

The impact on innovation, which is our main interest, is more difficult to gauge. Most of the cells, and even most of the arrays, used in installations are imported. Although the Belgian market represents only a fraction of the world market, we may assume that it has contributed to innovation. In Belgium itself, a few firms have been created in the sector, not to speak of the induced effect on their suppliers. By far the most prominent of these firms is Photovoltech.

Set up in December 2001 as a spin-off of IMEC, Photovoltech is based in Tienen. Its main shareholders are Total (50 %) and GDF Suez (through Electrabel (47.5 %) and Soltech (2.5 %)). IMEC (Interuniversity Microelectronics Center), which is based in Leuven, is a research institute specialising in nanoelectronics and nanotechnology, with a staff of more than 1,750 people. Photovoltech started production of multicrystalline silicon solar cells in November 2003. In 2006, Photovoltech was awarded the Flanders Investment and Trade Young Exporter Award. Photovoltech currently has a yearly production capacity of 80 MWp, with a staff of more than 200. In August 2010, the total yearly capacity will be expanded to 150 - 160 MWp. Soltech, which is also located in Tienen, supplies both grid-connected and standalone photovoltaic systems (27).

There is no production of solar cells in the other regions. In Wallonia, Issol (staff: 60, based in Verviers) produces PV arrays. Another producing firm, named Droben and based in Tubize, was apparently overwhelmed by the demand surge following the introduction of premiums by the Walloon Region and went bankrupt in early 2009. Of course, the hundreds of electricians and the like who took up installing PV arrays have seen their businesses prosper, but this can hardly be considered as innovation proper.

To complete the picture, it must be added that R&D in photovoltaics has long since benefited from the financial support of the Flemish government. IMEC was launched in 1984, as a non-profit organisation, within the context of the Third Industrial Revolution Flanders Initiative ("DIRV") of the Flemish government, which helped with subsidies from the start (BELSPO (2010), p. 86). The development of new commercial applications of PV cells is subsidised by the Agency for innovation by Science and Technology (IWT) (28). In contrast, R&D in photovolta-

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26 The installed capacity of 363 MWp can be assumed to produce 290.4 GWh per year, to be compared with an electricity consumption of roughly 95,599 GWh in 2007.

27 http://www.photovoltech.com/

28 http://www.ode.be/zonnestroom

ics has never been a policy priority in the other regions. Somewhat surprisingly, this has not prevented these regions from supporting the diffusion of photovoltaics with generous incentive schemes. In the future, however, R&D in photovoltaics could possibly fit in the new "competitiveness pole" focusing on environmental technologies that will be launched within the framework of the Walloon "Marshall Plan 2. Green".

4.7.4.2 Conclusion

It seems that, taken as a whole, the Belgian incentive policy regarding photovoltaics can be judged positively in terms of innovation, apart from the fact that an adequate price has not been placed on carbon. Yet, the granting of such tax incentives by the federal government does raise some questions.

In federal Belgium, economic policy, and in particular R&D, is a regional competence. Although the federal government is free to introduce tax measures (within some limits), one is allowed to find its intervention rather inappropriate in this case. Even admitting that the support of a particular technology by the federal government is justified, such a support is acceptable only if it conforms to the priorities of all regions. It was obviously not the case with photovoltaics, except for the fact that the tax incentive fitted neatly with the Flemish government's priorities (29).

Another remark can be made in relation to recommendations made by the OECD/IEA (2008, p. 23). According to the IEA, the main objective of an integrated approach is to achieve a smooth transition towards mass-market integration of renewables. Therefore, renewable policy design should involve, among other things, the introduction of transitional incentives, decreasing over time, to foster and monitor technological innovation and move technologies quickly towards market competitiveness. In the Belgian case, not only did the incentive not decrease over time but it increased considerably in 2009, with the introduction of carry-over. As a result, the diffusion process did not run smoothly. The demand exploded, giving rise to various problems at the supply level. Moreover, chances are that such a generous incentive will soon prove unsustainable for the public finances and be repealed, as already happened with the premium in Wallonia. This lack of smoothness is all the more regrettable since "*beyond some minimum threshold level, higher remuneration levels do not necessarily lead to greater levels of policy effectiveness*" (OECD/IEA (2008), p. 17).

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29 A parallel with environmental policy is tempting. But although environmental policy is a regional competence, the use of a federal instrument may be indispensable. Such is the case with excise duties for climate policy. As for the deductions stimulating energy efficiency, their effects on activity are more diffuse and widespread than those of photovoltaics incentives.

As for the above-mentioned picking of winners, it is a fact that no other electricity-producing technology has benefited from a similar tax incentive. But it remains to be seen whether other technologies liable to interest the general public had reached a comparable degree of maturity at the time the photovoltaic support scheme was launched. Wind energy is destined for another market and has consequently been stimulated with a support scheme of its own.

5 Conclusion

This article considers so-called environmental incentives in the field of energy. In actual fact, there are two types of incentives. Some aim at energy efficiency (thermal insulation, etc.), others at innovation (photovoltaics, “clean” and electric cars). We examined to what extent those two types of incentives are justifiable on efficiency grounds. The theoretical concepts of market failure and externality are central to the discussion.

There are various market failures and externalities in the field of environment that are relevant to energy-efficiency policy. But incentives are generally not the best instrument to address them. As far as the environmental externality proper is concerned, to make prices right should be far preferred to any tax incentive. To remedy imperfect information, campaigns are obviously a better instrument than tax incentives. As for consumers’ irrational behaviour, the claim made by some heterodox schools of economics that people’s choices are driven by habits more than by optimisation appears to be well-founded, as the existence of a “no-regret” emission reduction potential seems to indicate. It follows that economic incentives aimed at improving energy efficiency are bound to have a limited effectiveness. Finally, tax incentives may limit the effect of the capital market failure on low-income households, but the evidence is not overwhelming.

Market failures and externalities also apply to the field of green innovation. Firstly, unless an appropriate price is put on the environmental externality, there will be an undersupply of innovation. For various reasons, taxes on energy should be considered as the prime instrument to encourage innovation. Secondly, because innovation has to do with ideas, which are basically a public good, innovating firms may not always be able to recover all the benefits of innovation. This causes an undersupply of innovation compared to the social optimum. Other knowledge externalities, commonly referred to as “learning-by-using” or “learning-by-doing”, are related to use. Thirdly, these market failures, together with incomplete information on the future, may have adverse effects on the functioning of financial markets, limiting access to finance for investment in green technologies. Finally, technology lock-in, *i.e.* market domination by a previously successful technology, can be an additional barrier to innovation.

Could energy taxation be effective to the point where no other instrument would be necessary? While taxation provides greater incentives for innovation, it does not remove the obstacles to innovation that were mentioned above. This justifies the use of other instruments to specifically address these obstacles. A reduction of the labour costs of innovation activities and the granting of R&D tax credits tend to act along these lines by reducing the cost of undertaking innovation. Both measures have been applied in Belgium for some years. At later stages of innovation, the diffusion of innovative products and processes is also hindered by obstacles, which again justify public intervention. The question of the direct benefits of innovation deserves nonetheless to be asked: support measures aiming at the diffusion of innovation may result mainly in imports, especially in the context of a small open economy like Belgium. Public intervention raises a second question: is the public sector well placed to pick winners (instead of letting markets decide) in terms of the technologies of tomorrow?

All these issues come up clearly in the Belgian photovoltaics policy. Taken as a whole, the Belgian incentive policy regarding photovoltaics can be judged positively in terms of innovation, apart from the fact that an adequate price has not been placed on carbon. Yet, two criticisms can be levelled at this policy. In federal Belgium, economic policy, and in particular R&D, is a regional competence. Although the federal government is free to introduce tax measures (within some limits), one is allowed to find its intervention rather inappropriate in this case. Even admitting that the support of a particular technology by the federal government is justified, such a support is acceptable only if it conforms to the priorities of all regions. It was obviously not the case with photovoltaics, except for the fact that the tax incentive fitted neatly with the Flemish government's priorities. The second criticism concerns the level of the incentive. It did not decrease over time and was even raised considerably in 2009 with the introduction of carry-over, resulting in a lack of smoothness of the diffusion process.

As a general conclusion, one can say that the case for incentives in favour of innovation is strong, notwithstanding the fact that there exists a potential for improvement in the design of such incentives. As for energy-efficiency incentives, the case is much less convincing. Why then are they in place? To try to answer this question, one might be tempted to envisage the response of individuals to taxes. This is largely unchartered territory, as tax psychology has yet to be explored at all. Nevertheless, a simple reflection along those lines suggests the following explanation. It seems as if the general public perceives incentives as an opportunity to get back some of the tax money that was grudgingly and reluctantly given to the State. As a consequence, politicians would be keen to have their image associated with tax incentives. Fundamentally, the way incentives are viewed would thus depend on the nature of relations between society and the State, which, by the way, is a dimension of the social (or rather societal) capital.

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7 Annexes

7.1 Annex I: cost of avoided CO_2 with photovoltaic arrays

The production of electricity with photovoltaic arrays allows a reduction of electricity production by other means, which in turn entails a reduction in CO_2 emissions. The purpose of this annex is to calculate the cost, in terms of tax expenditures granted by the federal government, of the avoided CO_2 emissions.

Since PV electricity is an intermittent power source, one has to assume that it replaces peak load (rather than baseload) supply. In practice, we can assume that, in the absence of PV arrays, electricity would be produced by a combined-cycle gas turbine plant, emitting 307 gCO_2/kWh (30).

For photovoltaic arrays, we assume a yearly electricity production of 100 kWh/m^2. Simple arithmetic shows that 1 m^2 of PV arrays allows to avoid the emission of 30,700 gCO_2 per year or 0.768 tCO_2 in 25 years of use.

We also assume an installation cost of € 900/m^2, entitling to a 40 % tax credit. The ceiling of € 3,600 is not considered, since the excess can be carried over to the three following taxation years, provided the first occupation of the dwelling dates back to at least 5 years before the installation of the PV arrays. It is assumed that the installation size is such that the tax credit applies to it all. The tax credit thus amounts to € 360/m^2 (€ 382/m^2 if the credit on a 6 % municipal surcharge is added).

The cost of avoided CO_2 is then equal to 360/0.768 = € 469/tCO_2 or 382/0.768 = € 497/tCO_2 when the municipal surcharge is taken into consideration.

A 40 % tax credit is also granted on the interest paid on green loans incurred for the installation of PV arrays, after deduction of the interest rate subsidy (1.5 %). Alternatively, interest paid can be considered in the context of the deduction for an only owner-occupied house. Capital repayments can also be taken into account. As a consequence, the cost of avoided CO_2 that was calculated above should be taken as a minimum.

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30 International Energy Agency (2009), “CO_2 Emissions from Fuel Combustion”, p. 110.

7.2 Annex II: amount of tax expenditures related to photovoltaics

On the basis of the additional capacity installed in 2009, it is possible to calculate the related cost in terms of tax expenditure.

As was written above, Belgium installed 292.1 MWp in 2009, of which 251 MWp in the Flemish Region, 38 MWp in the Walloon Region and 3.1 MWp in the Brussels Capital Region. About 70 % of the installed capacity in Flanders belongs to the middle and large-scale industrial segments. By contrast, installed photovoltaic capacity in Wallonia is mainly composed of small residential systems. We can translate these data into separate figures for residential and industrial arrays.

A total of 116.4 MWp is thus liable to benefit from the tax credit for households. If we admit that, on average, 1 m^2 = 0.125 kWp, the related surface is 931,200 m^2. With an installation cost of € 900/m^2 and a 40 % tax credit on that amount, the global cost for the federal government reaches € 335 million. This amount will have to be borne in tax year 2010 or in any of the following three tax years. To have a figure for tax year 2010 alone, let us assume that the average surface of an installation is 20 m^2, resulting in 46,560 installations. Recalling that the maximum yearly tax credit is € 3,600, the amount of the tax expenditure is then € 168 million.

As for enterprises, 175.7 MWp of installed capacity represent 1,405,600 m^2. Assuming, somewhat unrealistically, that all enterprises are aware of the tax advantage and have enough tax base from which to deduct the allowance, the whole of the above surface is concerned by the 15.5 % investment deduction and the amount that is deductible from the corporate tax base is € 196 million. At a corporate tax rate of 33 %, the tax expenditure amounts to € 65 million.