PBL Netherlands Environmental Assessment Agency

ENVIRONMENTAL TAXES AND GREEN GROWTH EXPLORING POSSIBILITIES WITHIN ENERGY AND CLIMATE POLICY

POLICY STUDIES

Environmental taxes and Green Growth

Exploring possibilities within energy and climate policy

Environmental taxes and Green Growth. Exploring possibilities within energy and climate policy
This report is a translation of the Dutch publication 'Milieubelastingen en Groene Groei. Verkenning van de mogelijkheden in het kader van het energie- en klimaatbeleid'

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Executive Summary

Green growth is currently a topic of global interest. It aims to foster economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies (OECD, 2011a). The concept of green growth fits in with a long tradition focused on economic growth that takes account of issues such as environmental pollution and quality of life. Although in the Netherlands the political interest in green growth is somewhat lagging behind (PBL, 2012b), it is widely understood and accepted that unbridled economic expansion may pose a serious risk to society in the long term. Offering the right financial incentives through 'environmental pricing' is a key element of policy aimed at sustainable economic growth. Providing these incentives is clearly the government's domain, particularly in relation to fiscal policy. The choices made in this area form an inextricable part of the institutional frameworks within which citizens, organisations and businesses make decisions that bring about sustainable economic change (Hajer, 2011).

The importance of taxation in this context is not new. In the Netherlands, green fiscal reform already has been on the agenda for a very long time. In fact, the relative share of green taxes in the Dutch tax system is one of the largest in the world. At present, there are various (and sometimes incompatible) ideas on environmental tax reform. Some claim to put an end to the leading status of the Netherlands, whereas others advocate a further increase in environmental taxation. There are also those who argue that current environmental taxes are counterproductive and slow down the transition to a 'low-carbon economy' (a commonly held objective of green growth).

To be able to weigh these different and sometimes incompatible views and to make the right choices, this study provides an analytical framework, similar to the *Mirrlees Review* in the United Kingdom. The present paper provides a stepwise analysis of the issues related to the use of tax instruments as part of the policy on sustainable economic growth. The report promotes an evaluation of options using not only standard criteria, such as allocative effectiveness, static efficiency, distributive justice, and feasibility, but also criteria such as dynamic efficiency. The discussion focuses on the two main areas of environmental taxation in the Netherlands, i.e. taxes on energy consumption and transport.

The key lessons for policymakers from this study are as follows:
- environmental regulation through taxes (Pigou) is sometimes at odds with tax revenue generation (Ramsey);
- raising revenue through environmental taxes is not an aim in itself; efforts are better spent on the careful design of environmental taxes aimed at achieving carefully thought out, long-term environmental objectives;

- environmental pricing stimulates citizens and businesses to take environmental responsibility;
- the best approach to environmental pricing is an intelligent combination of 'sticks' (taxes) and 'carrots' (subsidies, exemptions);
- the main challenge is to find the right combinations of carefully designed environmental taxes that are relatively easy to implement;
- short-term cost-efficient solutions can be at odds with solutions aimed at dynamic (long-term) efficiency;
- the objective of simplifying the tax structure can be at odds with the effective use of taxes as environmental policy instrument;
- in a small open economy such as the Netherlands, the possibilities for national policy interventions are limited if international coordination is not feasible.

The design of environmental tax instruments must take explicit account of the context in which these taxes are used (the 'implementation context'). This requires a coherent view of policy objectives and the use of tax instruments. The analysis in this paper shows that environmental pricing is an essential instrument in the government's toolbox. However, to prevent unnecessary welfare losses it should be carefully and properly integrated with the other instruments used. Achieving this ambition requires a thorough analysis of the options for actual implementation of environmental tax instruments. This is illustrated for taxes on energy use and associated atmospheric emissions.

The practical consequences of this theoretical framework for tax reform in the Netherlands will be elaborated in a follow-up paper. The present study merely provides a general introduction to the systematic evaluation of options for environmental tax reform, such as a generic energy tax increase to compensate for inflation , a surcharge on non-renewable energy to fund subsidies for CHP, clean energy production by businesses (the *SDE+* scheme) and households, and the potential improvement of the overall tax structure (tax base and rates) to achieve CO_2 reduction targets and other energy related objectives.

Evaluation of such reform options should take account of the pitfalls and issues discussed in this paper, including the presence of multiple externalities (e.g. climate change *and* air pollution), the interaction between instruments, the various sources and forms of energy use, the different relations between energy use and specific production processes, the arrival of new technologies (e.g. heat pumps, microCHP), the path dependency of innovation, and international tax competition.

ONE

Environmental taxes and green growth: an introduction

'The key to achieving the potential gains from environmental taxes does not lie in the indiscriminate introduction of taxes with a vaguely defined environmental justification. Rather, it lies in the effective targeting of incentives to the pollution or other environmental problems that policy seeks to influence.'

D. Fullerton, A. Leicester and S. Smith (2010), *Environmental Taxes*, IFS, Report of a Commission on Reforming the Tax System for the 21st Century.

Green growth is currently a topic of global interest. It aims to foster economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies (OECD, 2011a). The concept of green growth fits in with a long tradition focused on economic growth that takes account of issues such as environmental pollution and quality of life. Although in the Netherlands the political interest in green growth is somewhat lagging behind (PBL, 2012b), it is widely understood and accepted that unbridled economic expansion may pose a serious risk to society in the long term. Offering the right financial incentives through 'environmental pricing' is a key element of policy aimed at sustainable economic growth. Providing these incentives is clearly the government's domain, particularly in relation to fiscal policy. The choices made in this area form an inextricable part of the institutional frameworks within which citizens, organisations and businesses make decisions that bring about sustainable economic change (Hajer, 2011).

Taxation, however, is not a goal in itself. Taxes are an inseparable part of the modern state, and in fact played a crucial role in its development (Grapperhaus, 1989). In tax design, as well as tax reform, it is important to take account of the actual decision processes by producers and consumers and how environmental pricing changes the conditions that guide these processes. In fact, many economists agree that environmental pricing is essential for a properly working market economy aimed at sustainable long-term economic growth (De Mooij et al., 2012). In contrast, fiscal specialists are traditionally wary of using tax instruments for purposes other than raising revenue for the treasury. They believe that interventions such as environmental pricing are due to make the tax system too complex and incomprehensible to taxpayers, and that the environmental benefits of these interventions are often overestimated.

This paper explores the relevant questions related to the use of tax instruments as part of policy aimed at sustainable economic growth. Linked to the more general discussions on tax reform, this paper thoroughly examines the options for environmental tax reform, using standard evaluation criteria such as (allocative) effectiveness and efficiency, distributive justice and feasibility, as well as less standard criteria such as dynamic efficiency. It focuses on two major areas of environmental taxation in the Netherlands: energy use and transport. It is explicitly outside the scope of this study to explore or evaluate the ambition for green growth itself (see OECD, 2010). Furthermore, this study only briefly discusses the environmental considerations related to other taxes (e.g. value-added tax, income tax) and to tax expenditures.

Chapter 2 of the present paper briefly examines the background of the discussion on 'environmental pricing'. It outlines the relevant choices and criteria related to the various taxation objectives and the possible use of other instruments. Chapter 3 more thoroughly examines how environmental taxes work and what their position is within the general tax scheme. Next, Chapter 4 discusses the effect of environmental taxes on innovation and (the direction of) economic growth. The main focus here is on tax design in relation to long-term environmental policy objectives, and other potential instruments to meet these objectives. Chapter 5 addresses specific design issues related to taxes on energy use and emissions. Chapter 6 concludes this paper with a short discussion of the general options for improving and broadening the use of environmental taxes.

TWO

Greening the tax system

This chapter starts by outlining the background of current ideas for a further greening of the tax system. Section 2.2 provides an overview of the difficult choices to be made, using standard criteria such as allocative effectiveness and efficiency, distributive justice and feasibility. These are discussed in more detail in the following chapters.

2.1 Background

The present economic crisis draws heavily on European government finances. The Netherlands is no exception, on the contrary. To tackle the soaring deficits caused by low or even negative economic growth, tax increases are widely considered to be inevitable. At the same time there is an increasing focus on (fiscal) measures that could strengthen the economy. One of the key strategies in this context is 'green growth'. Green growth means fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies (OESO, 2011a; PBL, 2012b). The G20 embraced the concept of green growth several years ago. The OECD subsequently called for proposals to work out the details, and in the ensuing plans environmental taxes play a prominent role (OECD, 2011b).

The Netherlands has always made a distinction between environmental *taxes* and (earmarked) environmental *charges* or *levies* (Vollebergh, 2007). Environmental taxes are imposed to raise revenue for the treasury without reference to specific benefits received, i.e. the receipts are not earmarked for particular expenditures. Excise duties on fossil fuels and taxes on the purchase, ownership and use of motor vehicles are commonly considered environmental taxes. Furthermore, the Netherlands also imposes various taxes with an environmental tax base (e.g. the energy tax), but again the receipts are not earmarked. In contrast, environmental *charges* are earmarked taxes (also known as environmental levies) which aim to raise revenue dedicated to specific (environmental) expenditures. For example, revenue from the environmental charge levied as part of the Dutch Surface Water Pollution Act (WVO) is spent on mitigating surface water pollution. This paper focuses explicitly on environmental taxes, in particular those related to energy use, CO_2 emissions and air pollutants. Other environmental taxes (including those related to waste disposal and water consumption) and environmental charges will be only briefly discussed here. Their specific characteristics justify a separate study.

The use of taxes as an environmental policy instrument steadily increased in the Netherlands during the past decades. Since 1987 environmental tax receipts have quadrupled, roughly from 5 billion euros per year to 20 billion euros per year in the last few years. This amounts to approximately 10% of total yearly tax revenues; a percentage that has remained more or less constant since the early 2000s. As a result, in terms of environmental taxation, the Netherlands has been one of the leading OECD countries for quite some time now (OECD Revenue

Statistics). During these years new tax bases have been added, and in some cases tax rates have been raised, considerably. Furthermore, the instrument of tax differentiation has been introduced and related to vehicle emissions. This expansion of new tax bases has only recently come to a halt. Based on arguments of tax simplification various environmental taxes have lately been criticised, including the packaging tax, waste tax, groundwater tax, and drinking water tax. Eliminating these taxes would save businesses a lot of paperwork, and would significantly reduce the pressure on the Dutch Tax Administration (National Tax Plan 2012). This criticism fits in with the traditional wariness among fiscal specialists towards taxation for purposes other than revenue generation.[1]

Different views appear to exist on how to proceed with environmental taxation in the Netherlands. Some people explicitly advocate further expansion of environmental taxation based on the argument of green growth, while others consider the leading position of the Netherlands a good reason to lower the relative share of environmental taxes in the overall tax system. A third group emphasises the need for better incentives to support green growth, and is not at all concerned about the consequences for tax revenues. These differences of opinion clearly illustrate the controversies surrounding environmental pricing and green tax reform. This paper aims to provide insight into the underlying considerations, and to outline a framework that allows adequate discussion of environmental tax reform. It is argued that raising revenue from environmental taxes is not an aim in itself, and that efforts are better spent on clever design aimed at achieving carefully thought-out, long-term environmental objectives.

2.2 Difficult choices

Tax instruments are often evaluated based on the following criteria:
- allocative effectiveness and (dynamic) efficiency;
- distributive justice;
- feasibility.

Among these criteria, allocative effectiveness and (dynamic) efficiency address the question whether a given tax instrument actually contributes to the objective for which it was designed, and whether it helps to achieve this objective as efficiently as possible. An important objective of taxation is to generate stable revenues without interfering too much with the economic choices of businesses and citizens. This interference, or *distorting effect*, depends on where a particular tax is implemented and is mainly reflected by the price sensitivity of decisions related to consumption, investment and labour supply. Indeed, a tax is considered efficient if its distorting effect is limited. The second criterion, distributive justice, applies to the effect of taxes on the redistribution of wealth. Many people subscribe to the redistributive 'ability-to-pay' principle, but opinions vary considerably on how this principle should be applied. Finally, the criterion of feasibility relates to the problems associated with tax implementation and compliance. A more complex tax system offers more possibilities for tax avoidance and tax evasion The following paragraphs briefly discuss how each of these three evaluation criteria relates to environmental pricing; a more detailed analysis is presented in the next chapters.

First, *allocative effectiveness and efficiency* also take into account the correction of market failure and externalities. Therefore, taxes could play an important role in environmental regulation, particularly within the context of green growth. Market failure (imperfect, weak or absent markets) is the main cause of environmental decline, as prices often do not adequately account for the costs of environmental resource use.[2] The absence of markets is a well-known phenomenon. For example, there is a demand for public order and flood protection, but these 'public goods' are not automatically provided or paid for by the market. The same applies to environmental quality. To correct this kind of market failure requires adequate government intervention, and environmental taxes are a useful instrument in this context.[3] Such market corrections need not be harmful to long-term economic growth, provided they are carefully designed and timed (Acemoglu et al., 2012; CPB, 2010).

Thus, the pursuit of green growth often translates into a search for taxes that put an adequate price on negative externalities such as environmental pollution (e.g. CO_2 emissions) and traffic congestion (Fullerton et al., 2010). This pricing applies to externalities caused by both producers and consumers. The fact is that taxes always have a regulating effect, even if they are not intended to regulate.[4] Therefore the notion held by some fiscal specialists that revenue will suffer if a tax is primarily designed to regulate is erroneous. But neither is it true that the environment will always suffer if revenue generation is the primary goal. Nonetheless, the choices to be made are difficult, and it requires considerable insight into both aspects (revenue generation and regulation) to make the right decisions to increase social welfare.

A closely related issue is the choice to focus either on 'cost efficiency' or 'dynamic efficiency' with regard to the effect of environmental taxes on achieving environmental policy objectives. Cost efficiency focuses on incentives that achieve the best (short-term) result for a given budget: for example, biomass fuel as a relatively cheap method to reduce CO_2 emissions. This focus can be at odds with dynamic efficiency, which is aimed at achieving more far-reaching, long-term objectives (Acemoglu et al., 2012). If the primary goal of green growth is to promote an economic system that causes less environmental damage in the intermediate and long term, then dynamic efficiency is more important. Key factors here are innovation, change, and a context that encourages citizens and businesses to take environmental responsibility. This calls for environmental pricing in the form of intelligent combinations of 'sticks' (taxes as economic incentives to reduce CO_2 emissions, waste production and water consumption) and 'carrots' (subsidies for green innovations that would not reach the market without this support). Such a system would clearly have no place for environmentally harmful subsidies, i.e. government measures that directly or indirectly keep consumer prices of environmentally harmful products below market level, or producer prices of such products above market level.

With regard to *distributive justice*, 'the polluter pays' is often the guiding principle of environmental pricing. In this case the focus is on the contribution to pollution by individual citizens and businesses, not on their ability to pay. A complicating factor here is that polluters often have *de facto* property rights over their environmental resource use, and therefore the right to pollute. Environmental tax reform implies a redistribution of *de facto* pollution rights to the government, and this will undoubtedly be met with resistance (Fullerton and Metcalf, 2001). In term of cost-benefit distribution, environmental tax reform need not necessarily lead to an overall increase in tax burden, although it will generally change the *distribution* of the tax burden. For example, revenue from environmental taxes may be returned to citizens and businesses in the form of lower income taxes and corporate taxes.

In terms of *feasibility*, there is an obvious tension between the objective of tax simplification and the effective use of environmental taxes as an environmental policy instrument. A complex tax structure is difficult to understand for taxpayers and expensive to implement. Clearly, a host of fiscal measures aimed at an endless array of environmental objectives would not help to simplify the tax structure. Advocates of (more) environmental taxes are therefore rightly advised to carefully consider alternative policy instruments for environmental pricing, such as subsidies and emission standards (Vollebergh and Van der Werf, 2013). In this context, the distribution of costs and benefits over various market participants is also an important factor to consider, as win-win situations will be rare. As argued later on in this paper, much depends on the exact options for meaningful regulation through environmental taxes. Good design and critical insight into the implementation context is essential here. A particularly relevant aspect of this context is international policy coordination and tax competition (see Section 3.4).

As indicated in the introduction, the present paper explores the general choices regarding the use of environmental taxes, particularly energy and emission taxes. Well designed environmental taxes ensure that environmental damage is properly priced. A lively discussion is presently taking place in the international literature on environmental tax reform (Fullerton et al., 2010; De Mooij et al., 2012). One of the subjects of discussion is to what extent this evaluation should take account of distortions caused by other taxes (Jacobs and De Mooij, 2012). This brings back the question whether a greater use of environmental taxes could help to improve the overall tax structure, e.g. by using environmental tax revenue to cut distorting labour taxes, which would positively affect the labour market (the 'double dividend' effect). The literature also shows a growing interest in the choice of tax bases and rates, particularly in relation to energy and climate targets and their interaction with other policy objectives (e.g. air quality, security of supply) and instruments (e.g. tradable permits, innovation incentives). This topic recently emerged regarding the transport sector (Newbery, 2005b; Parry and Small, 2005; Sallee, 2012), and the energy and electricity sector (Newbery, 2005a; De Mooij et al., 2012). The present study shows that there are no easy solutions, and that some welfare losses will be inevitable.

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Notes

1 For an interesting exception see De Jager (2007).

2 In this context, environmental resource use is defined as the use of natural resources in the broadest sense.

3 However, environmental taxes and subsidies are certainly not the only options here. Regulation through emission standards or non-tradable quotas, as well as tradable emission permits also put a ‘price’ on environmental pollution.

4 The exception is lump sum tax, but this type of tax is hardly ever used because of its adverse distributional effects. See also Chapter 3.

THREE

Environmental taxes in the tax system

This chapter analyses traditional and new arguments for the design of tax systems that take account of the specific position of environmental taxes. Section 3.1 briefly outlines the theory of environmental pricing. Section 3.2 discusses the choice and design of environmental taxes in general, and shows that the ideal, optimal environmental tax is often not feasible in practice. Section 3.3 focuses on specific issues of (environmental) tax reform, such as distributional effects and tax competition. This chapter shows that fiscal policy and environmental policy are closely linked, and that the key question is whether environmental pricing provides the right incentives. However, the tax objective of environmental regulation can be at odds with the tax objective of stable revenue generation.

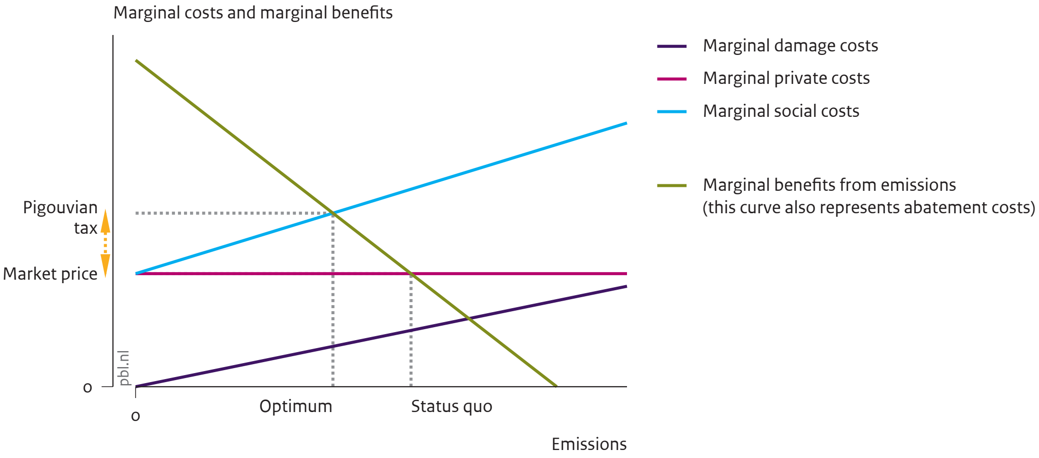
3.1 The theory of environmental pricing

The idea of using taxes as an environmental pricing instrument is far from new, and is in fact part of the broader ambition to optimise the tax structure. As indicated in the preceding chapter, common criteria for evaluating the overall tax structure are effectiveness and (dynamic) efficiency, distributive justice, and feasibility. An effective and efficient tax scheme should have the smallest possible distorting effect on decisions that have an impact on tax payments by citizens and businesses. This distorting effect depends on the number of agents affected by the tax, the (marginal) tax rate, and sensitivity to the financial incentive provided (elasticity). In theory, the distorting effect of taxes is minimised if the marginal tax burden is highest on goods with lowest price elasticity.[1] However, such efficient solutions often disagree with other objectives, particularly the fairness of the tax system. For example, the costs of basic necessities are relatively inelastic, but they constitute a relatively high percentage of the total expenses of low income groups.

In the discussion on income and consumption taxes, effectiveness and efficiency are often equated with 'neutrality' (Studiecommissie Belastingstelsel 2010, p. 15). Neutrality aims to reduce distortions in the choices of businesses and consumers. From the perspective of neutrality, changes in tax rates or tax bases should not lead to different choices with regard to labour participation, labour hours, or consumption patterns. However, it is beyond the scope of this paper to discuss the optimal tax structure in this regard, including the question whether it is desirable to introduce a flat rate for the income tax.

Rather than focussing only on neutrality, the evaluation of effectiveness and efficiency of the overall tax system should also consider the regulating effects of environmental pricing. Interest in environmental taxes and their contribution to strengthening the economic structure has increased considerably – and rightly so. It is widely agreed that environmental aspects are an integral

Figure 3.1
Optimum production and emissions



Source: PBL

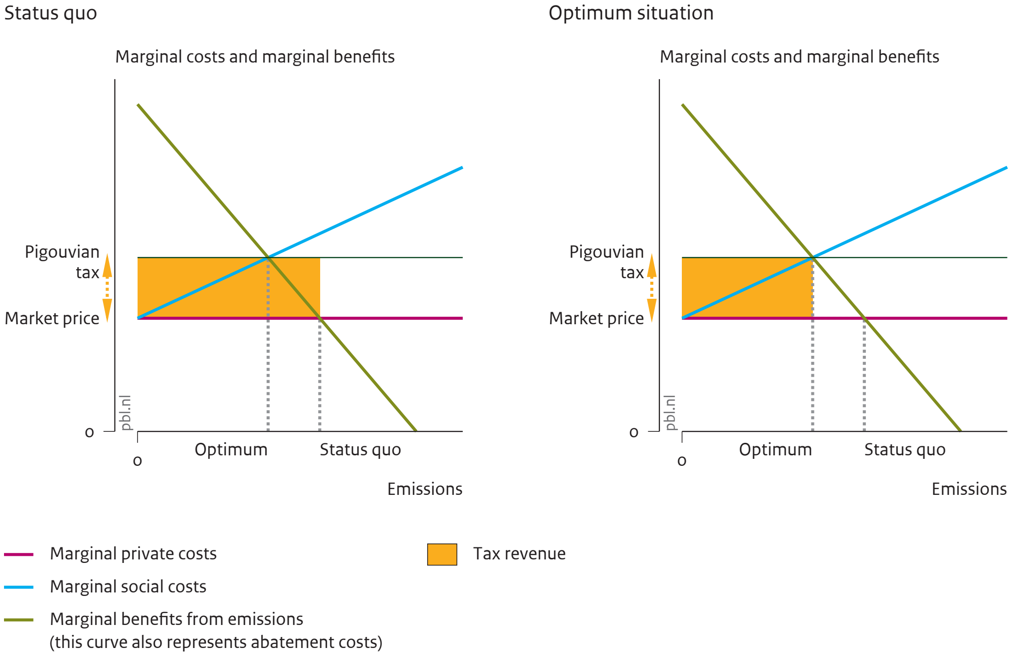
part of this economic structure. In this view, the key point is that environmental taxes help to correct market failure. Whereas all other taxes (except lump sum taxes) lead to *distortions* of market behaviour, environmental taxes aim to *improve* this market behaviour.

From the welfare theory point of view, environmental taxes are an effective and efficient instrument to correct negative external effects on the environment (Vollebergh, 2007; Fullerton et al., 2010; De Mooij et al., 2012). The marginal environmental damage (to the victims of pollution) should be discounted in the tax base and rate of these environmental taxes. This implies a tax base per unit externality and a rate equal to the monetary value of the marginal social damage caused by this externality in the social optimum (see for example Bovenberg and Goulder, 2003). For example, if the consumption or production of a given energy product results in emissions and associated environmental damage, this damage should be discounted in its market price, for instance through an environmental tax per unit emission. This environmental tax will drive a wedge between the price that producers receive and the price that consumers pay (market price including taxation). As a result of the higher market price fewer of these polluting products will be sold, which is exactly the objective of the environmental tax. This mechanism is illustrated in Figure 3.1.

Suppose that producers (or consumers) cause environmental damage through emissions for every unit of production (or consumption) as shown by the increasing marginal damage costs of emissions (i.e. the linear curve for damage costs). At the same time, the marginal benefits of emissions (or consumption) decrease because intra-marginal benefits decrease with the amount of product consumed. In a market such as this, the price is usually established at a level where the marginal benefits equal the marginal private production costs – environmental costs do not play a role. As long as producers (or consumers) maximise their profits (or benefits) without taking account of environmental damage, they will choose a production (or consumption) level that provides the greatest benefit to themselves (*status quo* in Figure 3.1). However, from a social perspective this is not the optimal outcome, because of the high marginal damage costs. These damage costs should be discounted to achieve the social optimum. This optimum is found exactly in the point where the benefit of further damage reduction no longer offsets the further loss of (net) private benefits. Here the emission level is 'optimal'. Relative to the initial situation social welfare increases, because polluters can no longer get away with their emissions without taking into account the damage that these cause.

Incentives are needed to induce polluters (whether they are producers or consumers) to adjust their behaviour for the benefit of society. This behavioural change can be induced through imposing a tax or charge on every unit of pollution caused. The social optimum is then achieved because rational actors (producers or consumers) strive to minimise their payment of pollution taxes (the orange area in Figure 3.2). They can achieve this e.g. through waste reduction or cutting their emissions using the cheapest available abatement technologies or behavioural options.[2]

Figure 3.2
Revenue from Pigouvian tax



Source: PBL

This is exactly the reason why in the social optimum the Pigouvian tax rate should be equal to the *marginal* value of pollution. In this equilibrium there is both regulation (because production and associated emissions are reduced from the initial level to the lower optimal level) and tax revenue generation (the orange area in Figure 3.2). It is an interesting paradox that these tax revenues will be greater when it is more difficult and thus more expensive to reduce environmental pollution (i.e. when the marginal private benefit curve is steeper), and will be smaller when the environmental problem is bigger (i.e. when the marginal damage cost curve is steeper). This instantly shows the tension between the government's objective to maximise tax revenue for a given tax base, and their objective to maximise the reduction in emissions. This is a paradox because, from the social optimum point of view, there is no problem at all: the only thing that counts is that the externality is internalised in – from an allocative perspective – the market price.

Economists traditionally recommend the Pigouvian tax as a *cost efficient* instrument for correcting negative externalities. A uniform emission tax stimulates each and every business (producer) and household (consumer) to weigh the costs of emission reduction against the tax costs for emissions. Assuming that each economic agent makes a rational cost-benefit analysis and chooses the cheaper over the more expensive options, the achieved emission reduction is socially cost efficient. Agents who can reduce their emissions against low marginal costs will choose to reduce their emissions, whereas those for whom this is too expensive will prefer to pay emission taxes. In other words, the polluters who can minimise their tax bill against the lowest costs will change their emitting behaviour. The polluter pays.

Incidentally, the 'optimal' emission level can also be achieved through subsidies on emission abatement, non-tradable quotas, or tradable emission permits (Fullerton, 2001). In the case of non-tradable quotas the government imposes pollution (emission) standards that producers are not allowed to exceed. This way, producers are granted *de facto* pollution rights, which impose a 'ceiling' on the market as a whole. In theory the government can set this ceiling at the social optimum level, provided they know the exact damage and abatement costs. A system of tradable emission permits imposes a similar ceiling, through limiting the total number of permits on the market. In this case the market itself determines the marginal costs (price) of pollution rights. Similar to the case of environmental taxes, businesses that can reduce their emissions against low marginal costs will choose to do so because they can earn money with selling their surplus credits (permits). This will continue as long as the price of emission permits is higher than the marginal costs of emission reduction.[3] In theory, the final market price of emission permits should reach the same level as the Pigouvian tax, and in both cases the targeted emission reduction will be achieved through taking the cheapest available measures.[4]

Obviously, government measures that (unintentionally) *encourage* polluting activities are at odds with environmental pricing (OECD, 2011b). Such measures – tax exemptions, reduced tax rates, tax expenditures or direct subsidies that have unintended negative effects on the environment – are collectively known as environmentally harmful subsidies (OECD, 1999).[5] Government failure to implement adequate environmental pricing measures could also be considered an implicit environmentally harmful subsidy. This will be further discussed in Section 3.3.

Similar reasoning applies to *positive* externalities. Positive externalities occur when an economic activity (of producers or consumers) provides unintended benefits to third parties. The classic example is the bee-keeper whose bees pollinate the crops of neighbouring farmers. The farmers receive this crucial benefit without paying for it, and therefore the bee-keeper will tend to keep fewer bees than would be desirable for society as a whole. This way, positive externalities could lead to underproduction, which should be 'corrected' through subsidies (or tax compensation) equal to the marginal value of these externalities in the social optimum. This will be further discussed in Chapter 4.

3.2 Choice and design of environmental taxes

The design of Pigouvian taxes may be clear-cut in theory (Section 3.1), but is far from straightforward in practice. The choice of tax base and tax rate in particular depends on the specific context in which the tax will be used. From the perspective of environmental policy aimed at emission reduction, the optimal Pigouvian tax will be an emission tax, but other tax bases are also possible. An emission tax is a specific excise tax, with a rate *per unit*, not per value. The optimal choice of tax base (unit) and rate (per unit) can be derived from the theoretical framework outlined in the previous section (Baumol and Oates, 1988).

First of all, an obvious choice for the tax base is the externality that causes environmental damage, and taxing this externality where it is produced. For example, CO_2 emissions contribute to climate change, and should be taxed at their source. Thus, if the overall objective of an environmental tax is to reduce environmental damage caused by a particular emission level, then the tax should target this emission level directly.[6] This principle does not change materially if several types of emissions contribute to the environmental problem. For example, in the case of climate change, the optimal design would include all greenhouse gases in the tax base, e.g. through using CO_2 equivalents. The choice to tax environmentally harmful activities rather than compensate the victims of environmental damage mainly follows from the prevailing Pigouvian policy recommendation.

Secondly, a *per unit* or specific tax, which charges a fixed amount per unit of quantity (e.g. a package of cigarettes, a tonne of CO_2 emission) is preferable to an *ad valorem* tax. The ad valorem tax rate is a percentage of the *price*, not quantity, of a good. For example, it would be possible to impose an ad valorem tax on emission-intensive goods. In that case, however, the tax would also apply to activities that are not directly related to emissions, such as distribution and marketing costs (Keen 1998). In contrast, a per unit tax only applies to activities that directly contribute to emissions. Moreover, it does not favour relatively cheap activities (which are often the most polluting).

Thirdly and finally, there is the question of choosing the tax *rate*. This rate is usually based on the expected (discounted) marginal damage. However, marginal damage may differ considerably from average damage if the relation between the polluting activity and environmental damage is non-linear.[7] Moreover, marginal damage often – but not always – depends on the location of the pollution source and the medium (air, soil, water). For example, the location of greenhouse gas emissions is irrelevant for their effect on global climate change, but the effect of air pollutants strongly depends on where and when they are emitted. Furthermore, damage cost assessment is often fraught with uncertainties. Because of these complicating factors, in practice the rate is often based on pollution reduction targets. The greater the targeted reduction, the higher will be the rate (ceteris paribus). In the case of emission tax the rate is based on the (exogenous) objective to reduce emissions to a given target level. This rate is optimal only if the target level is exactly equal to the emission level in the social optimum (see Figure 3.1).

Even though an emission tax appears to be the most practical application of a Pigouvian tax, in reality its implementation is often difficult. For example, the collection costs (including administration and audits) of emission taxes tend to be high, particularly in the case of a completely new tax. Compliance costs tend to be high as well, due to tax evasion, (waste) dumping, and fraudulent invoices and emissions accounts. If other

Text box 1. Classification of environmental taxes

Environmental taxes (including environmental charges and excise taxes) can be classified according to tax base and revenue allocation. This classification is shown in Table 3.1, where $\tau_i > 0$ indicates a positive tax rate and $\tau_i < 0$ a negative tax rate (i.e. a subsidy). In this table, revenue earmarked for specific expenditure (as is the case with hypothecated tax) is also considered a form of subsidy.

The classic *Pigouvian tax* is in fact nothing more than a penalty for emissions (τ_E>0). In Table 3.1 it is assumed that the revenues of this tax are being returned on a lump sum basis, but in practice these revenues are often used to increase overall tax revenue, to reduce other taxes, or as earmarked funds for specific expenditure. The latter is also the case with *hypothecated or earmarked taxes*, an example of which is the environmental charge levied as part of the Dutch Surface Water Pollution Act (*WVO*). This charge is directly based on emissions (into water) and the revenue is earmarked for pollution abatement – which makes it an implicit subsidy (τ_A<0). In fact, this type of charge is a combination of 'stick' (tax on activities that produce emissions) and 'carrot' (subsidy on activities that reduce emissions). In the early 1990s the discussion arose as to whether environmental tax revenue could be used to cut taxes on labour (τ_L↓). This would provide a 'double dividend': environmental gain through reducing pollution levels, *and* a more efficient tax system through reducing distorting taxes on labour (see also Section 3.3).

Table 3.1
Classification of environmental taxes

	Output (Q)	Input (I)	Emission (E)	Emission Abatement (A)	Revenue allocation	Second best solution
Pigouvian tax	0	0	$\tau_E > 0$	0	Lump-sum return	No
Earmarked tax 1	0	0	$\tau_E > 0$	$\tau_A < 0$	0	?
Earmarked tax 2			$\tau_E > 0$	0	Compensation of victims	
Tax with 'DoubleDividend'	0	0	$\tau_E > 0$	0	Reduction in labour taxes (τ_L↓)	Yes
Indirect tax 1	$\tau_Q > 0$	0	0	$\tau_A < 0$	0	Yes
Indirect tax 2	Dirty products: $\tau_{Qd} > 0$ Clean products: $\tau_{Qc} < 0$	0	0	0	0	Yes
Indirect tax 3	0	$\tau_I > 0$	0	$\tau_A < 0$	0	Yes

Due to the implementation problems of (direct) emission taxes, there is a growing focus on *indirect* taxes to achieve 'second-best' emission levels. Particularly Fullerton has shown in various publications that a tax on emission-intensive, 'dirty' products (τ_Q > 0) *in combination with* a subsidy on emission abatement measures (τ_A < 0) could provide an optimal alternative for an emission tax (Fullerton and Kinnaman, 1995; Fullerton et al., 2010). This resembles the idea of a 'deposit', that is, pay for the use of scarce environmental resources (with emissions as implicit – and polluting – input), and receive a refund for maintaining the quality of these resources through emission abatement. This deposit idea can be applied more broadly, for example through taxation of 'dirty' products (τ_{Qd} > 0) combined with subsidising 'clean' substitutes (τ_{Qc} < 0), as has been done with leaded versus unleaded petrol. Finally, instead of taxing outputs it is of course also possible to impose a tax on *inputs* that are related to emissions. An evident example of input tax is a tax on energy consumption. This will be elaborately discussed in the next chapter.

instruments can (indirectly) achieve the same result at lower costs, then an emission tax with high implementation costs is in fact a sub-optimal solution (Fullerton and Wolverton, 1999; Smulders and Vollebergh, 2001; Cremer and Gahvari, 2002; Fullerton et al., 2010, p. 13 *ff*). A suitable alternative, for example, would be to impose an indirect tax (excise tax, value-added tax) on 'complementary' goods that are directly related to the pollution in question (see also Kosonen and Nicodème, 2009). This way, environment-friendly goods can be taxed at lower rates than their environmentally harmful substitutes. The differentiated tax rates for unleaded versus leaded petrol are a case in point.

Depending on their design, environmental taxes engage different substitution mechanisms for emission reduction. Principally, there are three mechanisms through which emissions can be reduced (Smulders and Vollebergh, 2001):

- *Emission abatement*: making use of 'add-on' emission abatement technologies and carbon offsetting;
- *Input substitution*: replacing polluting or emission-intensive inputs with less-polluting or low-emission substitutes; e.g. switching from high-sulphur coal to low-sulphur coal, from fossil fuel to renewable fuel – and from energy inputs to labour and capital inputs;
- *Output substitution*: replacing polluting or emission-intensive products with less-polluting, low-emission products.

The more indirect the environmental tax, the weaker is the relation between tax base and emissions and the greater is the (theoretical) welfare loss. An emission tax uses all of the three mechanisms mentioned above, and is therefore the most efficient. In contrast, output taxes only engage the mechanism of output substitution, and input taxes only make use of input substitution (the latter are more effective when the inputs are more directly related to pollution). Furthermore, an *ad valorem* energy tax on fuel may lead to input substitution between energy and labour, but not between various energy sources – unless the tax rate is differentiated according to emission characteristics, e.g. with reduced rates for fuels with lower sulphur and carbon content.

The preceding discussion makes clear that the design of environmental taxes determines which substitution mechanism(s) are engaged. Generally, the more direct the tax (i.e. the more of the above-mentioned mechanisms are engaged), the more efficient it is at reducing emissions. Therefore, in choosing between direct and indirect taxes, the higher implementation costs of direct taxes should be weighed against the higher welfare losses associated with indirect taxes. The various types of direct and indirect taxes are discussed in Text box 1. Their specific applications are further discussed in the next chapter.

The fact that direct taxation of emissions is ideal in theory but often costly to implement in practice clearly illustrates the tension between the effective use of environmental taxes as environmental policy instrument on the one hand, and tax simplification and implementation feasibility on the other hand. Fortunately, as the above discussion shows, there are alternative options in the form of artful combinations of indirect taxes and subsidies that are much easier to implement. For example, an energy tax provides a good alternative for an emission tax. Such indirect environmental taxes can make a valuable contribution to environmental pricing. Nonetheless, for any (environmental) policy objective the pertinent question will always be whether this objective cannot be better achieved by applying other instruments. This question will be elaborately discussed in the next chapter.

3.3 Tax reform, implementation costs and distributional effects

Environmental taxes not only internalise environmental externalities, but also raise revenue for the treasury. In the latter sense the use of environmental taxes does not differ materially from levying excise or ad valorem taxes on specific consumption goods, such as tobacco or alcohol. As is the case with these consumption taxes, the amount of revenue from environmental taxes initially depends on the specific characteristics of the market in which the tax is used. When polluting goods or activities have a high price elasticity, tax revenues will be relatively limited, while the reverse is true for polluting goods or activities with low price elasticity. As discussed earlier, the paradox here is that polluting products with inelastic demand (and therefore low price elasticity) will generate relatively high revenue – which in fact agrees with optimal tax theory of indirect taxation. This suggests that the optimal strategy would be to tax products with low price elasticity (rather than products with high price elasticity), as this will minimise the distorting effect or 'deadweight loss' (the Ramsey rule).[8] The downside of this strategy, however, is that the regulating effect is limited.

For a long time the economic literature did not take into account the indirect (distorting) effects of environmental taxes (Baumol and Oates, 1988). It was always implicitly assumed that environmental tax revenues would be returned to the taxpayers on a lump-sum basis, without additional costs or welfare gains (see also Text box 1). However, environmental tax revenues can also be used to reduce other – distorting – taxes in the status quo. After all, economic systems in which only non-distorting taxes are imposed do not exist. Green tax reform implicitly means that – for a given revenue level – the overall tax base switches from capital and labour income to consumption of polluting goods and activities. This way, Pigouvian environmental taxes could generate two benefits ('double dividend'): a cleaner environment and revenues that can be used to reduce distortionary taxes such as those on wages (Fullerton et al., 2010, p. 15; Kosonen and Nicodème, 2009). However, environmental taxation has its own distorting effect on labour supply because a tax on consumption is an implicit tax on labour: the increased price of consumption goods due to environmental taxes reduces the real net wage, and this affects labour supply. Evidently there are two opposing, indirect effects at play here. The size of the second dividend will therefore depend on the labour supply response to price changes, and on the level of distortion before the tax reform.

Taking into account this indirect effect of environmental taxes on labour supply implies that the Pigouvian tax rate should be adjusted. The optimal environmental tax rate in this broader context should reflect both direct effects (on pollution reduction) and indirect effects (on labour supply). For this to occur, the tax must be equal to the marginal environmental damage divided by the marginal cost of raising extra tax revenue for public funds (i.e. the marginal cost of public funds, MCF) (Bovenberg and De Mooij, 1994). If the MCF in the initial tax system is greater than one, the optimal environmental tax rate is lower than the Pigouvian rate. The MCF can also be smaller than one – for example when a polluting good such as petrol is complementary to leisure (e.g. West and Williams, 2004)[9] – and in that case the environmental tax rate must be higher than the Pigouvian rate. Partly due to this reason, Fullerton et al. (2010, p. 17) conclude that much depends on the initial design of the tax system: if the initial situation is a system designed to minimise excess burden with little or no concern for environmental damage, then the introduction of, or a greater reliance on, environmental taxes could indeed improve welfare. However, this only holds up to a certain point: as the environmental tax rate increases, its distorting effect on labour supply increases as well.

Jacobs and De Mooij (2011), however, argue that the Pigouvian tax rate need not be corrected for indirect effects at all, if the tax objective of redistribution is explicitly taken into account. Environmental taxes create distortions in the basket of consumer goods (a desirable effect from the environmental point of view), which lead to a *stronger* reduction in real wages than an increase in income tax with identical revenue would cause. From this perspective it would be better to impose direct taxes on income, also because – provided their rates are progressive – income taxes correct the negative distributional effects of environmental taxes. Hence the idea that environmental taxes should be used only for environmental regulation, and income taxes for revenue generation to fund public expenditure. In this view there is no reason whatsoever to correct environmental tax rates for their possible distorting effects on the economic system. In other words, the marginal cost of public funds is always equal to one, provided the tax rates in the initial situation are optimal.

A closely related issue concerns the *distributional effects* of Pigouvian environmental tax or equivalent intervention through auctioned tradable emission permits. An important point to note here is that the *de facto* pollution rights in the status quo (i.e. the situation before the intervention, see Figure 3.1) are owned by the market. In this situation polluters do not pay for their use of environmental resources: businesses as well as their customers use the environment 'for free'. This instantly shows why government failure to implement adequate environmental pricing measures can be considered an implicit environmentally harmful subsidy, where the government in fact fails to create the conditions that would lead to higher social welfare.

Both in the case of emission taxes and auctioned tradable emission permits, pollution rights are transferred *on payment* from the private to the public domain. Whereas the *de facto* pollution rights were available to the market 'for free' before the intervention, the taxing or auctioning of these rights implies a transfer of these 'scarcity rents'. Other forms of environmental regulation, such as non-tradable quotas and 'grandfathered' tradable permits (freely distributed permits based on historical emissions), do put an end to the cost-free exploitation of the environment, but they transfer only part of the pollution rights (i.e. only for the regulated amount of pollution). As a result, the scarcity rents remain in the hands of the private sector (Fullerton and Metcalf, 2001).[10]

Thus, the 'artificial' scarcity created by environmental policy will *always* have distributional effects, which depend on the specific policy design. After all, revenues from environmental taxes and permit auctions can be used to reduce other taxes in the system, thus providing tax benefits to other market parties. This, however, does not alter the fact that environmental taxes and permit auctions at first will reduce the real net wage and thus have an additional negative effect on labour supply. This additional distortion necessitates a lump-sum return of revenues to compensate taxpayers.[11] Nevertheless, various analyses have shown that the free distribution of emission permits may lead to considerable welfare losses, whereas auctioned permits and emission taxes may actually provide welfare gains (Parry, 2003).

The issue of scarcity rents makes clear that environmental taxes will never create a 'win-win' situation for all taxpayers (whether businesses or citizens). Environmental tax reform will thus lead to both welfare gains (particularly for pollution victims) and welfare losses (particularly for polluters). This redistribution effect is further enhanced by lump sum returns of revenues to compensate taxpayers. As *exact* compensation is not possible, this will inevitably affect the distribution of costs and benefits among groups of citizens and businesses. This distribution will also be affected by the economic changes resulting from behavioural responses to environmental taxes. Often, therefore, governments will seek specific solutions to 'ease the pain' – for example, through tax provisions for special interest groups. These provisions often take the form of specific exemptions or non-linear rates.

The above discussion makes clear that there is no quick and easy answer to the question how to best deal with the indirect effects of environmental taxes. Much depends on the level of distortion in the initial situation, where it is often unclear what the turning points and elasticities are and how these may change over time. According to Jacobs and De Mooij (2011) it is not necessary to take account of the additional distortionary effects of lump sum returns of environmental tax revenue on other parts of the tax system.[12] This would imply that the Pigouvian approach outlined in Section 3.1 is sufficient after all. However, as this approach aims solely at environmental dividend (i.e. welfare gains due to internalisation of negative externalities), it leaves no room for speculation about double dividend.

3.4 Tax competition

The discussion so far has been based on the implicit assumption of a closed economy, i.e. a system without international trade. Obviously, this assumption does not hold for the Netherlands. An open economy presents specific challenges, particularly if it is a small country that wants to establish unilateral environmental policy. This leads to additional distortions. A case in point is the reduction in greenhouse gas emissions. Starting out from an unregulated system in which emissions are *de facto* for free, the introduction of a carbon emission tax (or auctioned emission permits) would damage the Dutch business environment for companies involved in international trade, if this policy is implemented only in the Netherlands. Such unilateral policy would lead to market inefficiencies, particularly in economic sectors that face strong international competition, and would encourage international firms to move to countries where emissions are not restricted. This could even lead to an *increase* in global carbon emissions, because in many other countries production methods are less efficient (Hoel, 1991). These additional emissions, caused by moving economic activities out of the Netherlands and Europe, are known as 'carbon leakage'. Obviously, specific compensation measures for economic sectors exposed to international competition are required to offset the impacts of unfair tax competition (Bollen et al., 2011).

The room for national (environmental) tax policy is also affected by tax competition in a different form: the direct and deliberate competition for tax revenues between countries. This competition not only applies to revenue from direct taxes on income and capital gains, but also to indirect taxes such as excises, including environmental taxes. Particularly with regard to cross-border trade and transport, countries may try to increase their revenues through imposing lower excise taxes than their neighbours (Kanbur and Keen, 1993; Brueckner, 2003). A case in point are excise taxes on diesel and petrol. Some countries (e.g. Luxembourg) deliberately keep diesel tax rates low to encourage international transport companies to refuel in their country. This way they broaden their tax base at the expense of other countries' tax revenues. This form of tax competition certainly discourages unilateral increases of excise taxes on internationally tradable goods, and requires specific compensation measures (Evers et al., 2004).

The limitations posed by tax competition on implementing unilateral policy in open economies thus could seriously frustrate national policy ambitions. In the Netherlands, this problem particularly applies to the ambition to improve local environmental quality through raising various environmental taxes, which would negatively affect economic sectors dependent on export and import (e.g. agribusiness, energy-intensive sectors) and companies involved in international transport. For example, an increase in energy tax or transport-related tax (e.g. excises on petrol or diesel) would inevitably lead to cross-border effects and tax competition problems. However, although the open economy of the Netherlands clearly poses some unavoidable limitations, this certainly does not mean that environmental tax reform is altogether impossible.

This chapter has shown that, from the perspective of allocative effectiveness and efficiency, there is every reason to make room for environmental taxes in fiscal policy. Environmental damage is not automatically accounted for in a market economy, and thus requires adequate correction, for example through environmental pricing. The key question here is whether environmental pricing provides the right incentives. The objective of environmental regulation can be at odds with the objective of stable revenue generation, but this is certainly not always the case. Although environmental taxes do have distributional effects, these can be partly avoided if environmental taxes are adequately integrated in the overall tax system. This would also facilitate the planning and design of compensation measures, should this be required to meet redistribution objectives. In terms of feasibility, the use of *direct* environmental taxes is faced with various problems due to potentially high implementation costs. Fortunately, there are various possibilities for environmental pricing through *indirect* tax measures.

Notes

1 This well known simplification of the Ramsey rule does not apply to lump sum taxes. By definition, lump sum taxes cannot be avoided and therefore have no distorting effect (no 'deadweight loss'). An example of a lump sum tax is a fixed amount paid by all members of the population (regardless of their income or ability to pay).

2 The marginal benefit curve also represents the marginal abatement costs in the *status quo* (according to the principle of duality). The marginal abatement cost curve is usually a bottom-up curve, which ranks the costs of the available abatement options. Figure 3.1 implicitly assumes that emissions abatement coincides with a reduction in output (or demand). See Section 3.2 for further details.

3 The exact costs of emissions reduction are often not known *ex ante*. As a result the ceiling is often set too high (i.e. too many permits are issued). This issue is also relevant for the EU Emissions Trading System (ETS). Therefore various economists have argued in favour of building *ex post* flexibility into tradable permit systems (Burtraw et al., 2010).

4 Note, however, that in the case of tradable permits the price of emissions is the result of market activity – within the limits ('ceiling') set by the government through the number of permits issued – whereas in the case of *taxes* the price of emissions is determined directly by the government.

5 Note that the OECD definition of environmentally harmful subsidies is broader, and includes all government measures that directly or indirectly keep consumer prices below market level, or keep producer prices above market level, or in other ways reduce costs for consumers and producers, and at the same time have an unintended negative effect on the environment and natural resources (OECD, 1999). The PBL report on environmentally harmful subsidies (PBL, 2011a) reviews the recent debate on this topic, and provides concrete examples for the Netherlands.

6 An *indirect* tax on emissions – for example on complementary goods – is a 'second-best' solution resulting in welfare losses, as will be explained later on.

7 For example, in the case of noise pollution the marginal costs are lower than the average costs (Newbery, 2005b, p. 207), as long as the noise level is lower than the threshold for physical damage.

8 Distortionary taxes are taxes that change the choice behaviour of economic agents such as businesses (producers) or individual consumers. These taxes raise the price of taxed goods, and therefore *reduce* the *relative* prices of substitute goods. The resulting substitution effect indicates the level of distortion. The size of this effect depends on the price elasticity of the taxed good, the marginal tax rate, and the relative share of the taxed good in the basket of consumer goods before the tax was introduced. The combination of these factors ultimately determines the distorting effect of the tax in question (see for example Crawford et al., 2008).

THREE

9 This argument goes back to a publication by Corlett and Hague (1953). They showed that the efficiency of the tax system can be increased by taxing goods that are complementary to leisure, because such goods tend to have low price elasticity. This argument justifies the use of differentiated tax rates for diesel versus petrol – provided that the consumption of diesel is mainly related to work, not leisure.

10 The value of these scarcity rents is exactly equal to the revenue that would be generated by an emissions tax, paid by polluters over their remaining ('optimal') emissions (see Figure 3.2). Note, however, that this does not apply in the case of partial exemptions (e.g. the exemption for natural gas consumption up to 800m^3, which was part of the former 'Regulating Energy Tax' in the Netherlands). See also Vollebergh et al. (1997).

11 Compensation played an important role in the discussion surrounding the introduction of the Dutch 'Regulating Energy Tax' in 1995. In the end, firms were compensated through a reduction in Corporate Income Tax. A similar discussion recently arose with regard to Phase III (2013-2020) of the EU Emissions Trading System. In this new phase, free allowances will be largely replaced by auctioned permits (see Bovenberg and Vollenbergh, 2008).

12 The argument of Jacobs and De Mooij (2011) is based on the assumption that the marginal cost of public funds is equal to one – but this is only the case in an optimal tax system. The relevance of their argument therefore crucially depends on the status quo of the tax system. If, in this status quo, externalities have not been adequately internalised, then the distortionary costs and distributive gains should still be taken into account. Assessment of the value of externalities in the status quo will be discussed in a follow-up report.

FOUR

Environmental taxes, innovation and environmental policy

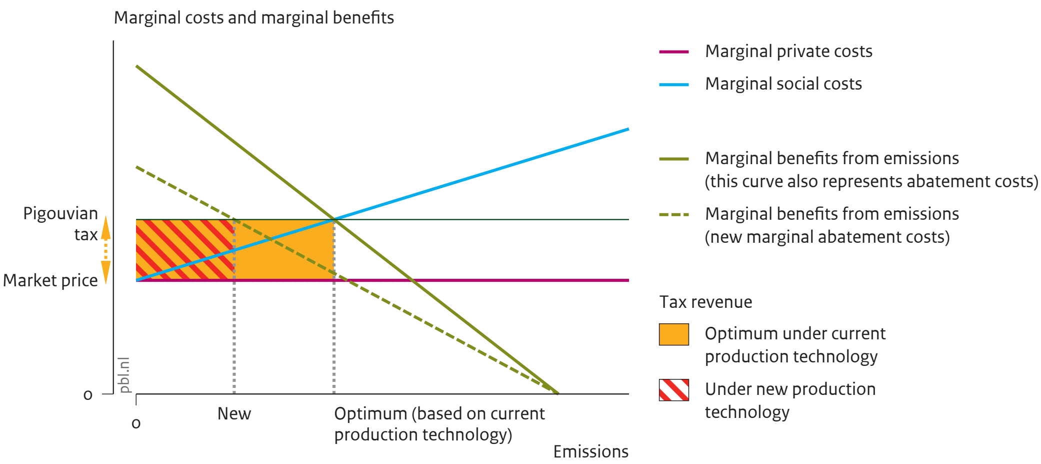
The first chapter of this paper pointed out the importance of environmental taxes for green growth. According to various authors, an important advantage of tax instruments is that they provide an ongoing incentive to reduce environmental pollution, also in the long-term (Fullerton et al., 2010; OECD, 2010; OECD, 2011b). This view underlines the *dynamic* efficiency of environmental taxes, i.e. their contribution to technological change and (long-term) economic growth. In this context it makes good sense to carefully coordinate the design of environmental taxes (in terms of tax base, rate, and timing) with innovation policy. The strategic direction and coherence of environmental policy is also important, particularly with regard to its policy targets and instrument choice. In this chapter, Section 4.1 discusses the relation between environmental taxes and dynamic efficiency. Section 4.2 discusses the importance of environmental policy design and, finally, Section 4.3 highlights the interactions between environmental taxes and other policy instruments as an important design issue.

4.1 Environmental taxes and innovation

Environmental taxes can promote technological change because, once imposed, they provide an ongoing incentive for (environmental) innovation. As illustrated in Figure 4.1, the introduction of an environmental tax results in the social optimum where production and consumption are reduced, but the environmental tax burden on polluters is still considerable (the orange area in the graph). To further reduce their tax burden, firms may invest in research and development (R&D) towards new production technologies with lower emissions (see also Text box 2). If these R&D activities are successful, the same level of production (output) can be realised with lower emissions. As a result, the slope of the (implicit) abatement cost curve decreases, implying a decrease in marginal benefit of emissions.[1] The new production technology results in substantial tax savings, equal to the non-hatched orange area in Figure 4.1. It is profitable to invest in R&D as long as the expected average costs of additional investments are lower than the average tax savings.[2]

Compared to environmental taxes, other policy instruments provide much weaker incentives for invention and innovation. Grandfathered quotas, for example, do force companies to limit their emissions to the optimal level but provide no incentive to invest in improvements beyond this level. This is due to the fact that emissions *within* the quota are free; in other words companies do not pay for the use of environmental resources as long as they do not exceed the (optimal) pollution level defined by the quota. If companies are able to comply with these quotas using existing technology that has already been developed ('sunk costs'), further investment in R&D is simply not profitable. Only if compliance involves substantial maintenance or operational costs, or if producers expect

Figure 4.1
Change in tax revenue under new production technology



Source: PBL

stricter quotas in the near future, the incentive to invest remains (see also Section 4.3). Furthermore, there is an interesting difference between the incentive effects of a tax versus a tradable permit system. As long as the tax rate is not adjusted *ex post*, the incentive to invest at the margin remains strong even after the new technology has been developed and adopted. However, in the case of a tradable permit system the new technology would reduce the market price of emission permits to a level below the optimal tax rate; as a result the incentive for innovation will be weaker over the next trading period. In the case of an emission *tax*, it would obviously be possible to adjust the tax rate *ex post* (i.e. after arrival of new technology), but this would require a statutory change.[3]

Environmental taxes not only directly address environmental damage, but they also indirectly influence the direction of technological development, in the literature labelled as 'directed technological change' (Popp, 2002; Acemoglu et al., 2012). This effect should be taken into account when assessing the importance of taxes for green growth, because technology development is also subject to market failures .

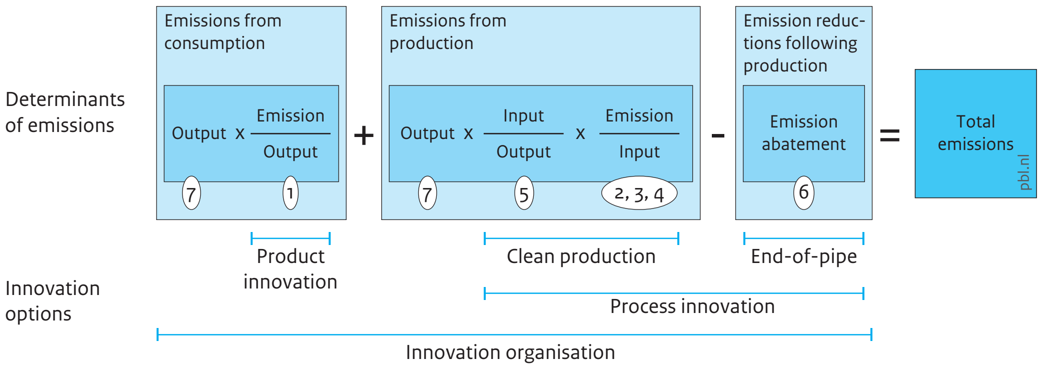
The interactive effect here is that market failure is not only due to the fact that individual firms ignore their negative environmental impact, but also to the fact that these firms want to avoid knowledge leakage risks associated with R&D investments. Because of these risks, individual firms do not invest enough in R&D. This also applies to R&D investments in environmental innovation or technology diffusion (De Groot et al., 2004), where, likewise, it is 'safer' for individual firms to profit from investments made by other firms than to invest in their own R&D. This market failure also calls for government intervention, for instance through promoting diffusion of existing clean technologies or providing incentives for development of entirely new technologies. Promoting diffusion should expand existing knowledge about efficient production methods, whereas R&D subsidies (which ideally cover the difference between social and private benefits of R&D) should lead to higher R&D investments and thus enable the development of new knowledge.

It is beyond the scope of this paper to discuss in greater detail the interaction between negative externalities related to environmental pollution and positive externalities of technological innovation (but see Jaffe et al., 2005; CPB, 2011; Acemoglu et al., 2012). Recent empirical insights into this subject clearly demonstrate the importance of the process of knowledge generation (Popp, 2002; Popp et al., 2009; Dekker et al., 2012). Technology development is not only affected by the difference between private and social benefits of R&D, but its *direction* is also affected by the existing knowledge base. In other words, the knowledge that has been generated over time in a specific area (primarily) contributes to knowledge development *in the same direction*. This effect is also known as 'lock-in'. Thus, R&D in fossil fuel technology will primarily lead to more knowledge in this area, whereas research on clean energy technology lags behind because the knowledge base for this particular area is relatively small.

Text box 2. Determinants of emissions in relation to opportunities for innovation

The various ways in which taxes may influence innovation and diffusion have been elaborately analysed by the OECD (2010). This influence varies with the type of environmental tax and its combination with other policy instruments. Furthermore, different tax instruments provide different innovation incentives, depending on where in the production-consumption chain they are applied (Figure 4.2). Assuming that both the production *and* consumption of output (product) lead to emissions, total emissions can be broken down in three components, or 'determinants':

Figure 4.2
Determinants of emissions and innovation options



Source: OECD (2010)

As Figure 4.2 shows, the three determinants of direct and indirect emissions are the emissions from consumption, the emissions from production, and the emission abatement or carbon offsetting measures taken by the producer (see also Section 3.2). Below the equation in Figure 4.2, the numbers 1-7 refer to the various innovation opportunities for reducing emissions:

1. Develop new products with lower emissions from consumption, e.g. energy-efficient products.
2. Replace emission-intensive inputs with less polluting inputs of the same category: e.g. use low-sulphur coal rather than high-sulphur coal for energy production.
3. Replace emission-intensive inputs with less polluting inputs of another category, e.g. use natural gas instead of coal. This requires a change of the production process and associated capital goods.
4. Reduce the emission intensity per unit input (without changing the inputs). An example is the use of electronic diagnostic systems in vehicles to reduce emissions per unit of fuel.
5. Reduce the inputs per unit of output; for example, improve the efficiency of the production process through minimising heat losses (note that this does not reduce emissions per unit of output).
6. Take 'end-of-pipe' measures to reduce emissions, e.g. through carbon capture technology; and or use carbon offsetting to compensate emissions.
7. Reduce the production and or consumption of outputs.

Acemoglu et al. (2012) show that governments – apart from correcting negative externalities – should no longer aim to correct both types of knowledge spillovers, but focus on the one *with the highest social gains*. The intuition here is that knowledge spillovers, in fact, compete with each other because the technologies are substitutes. Acemoglu et al. (2012) further show that the market tends to *wait too long* with switching to clean innovation – even if (CO_2) emissions are optimally priced. This is due to the fact that the ratio between private benefits of clean innovation versus dirty innovation is partly determined by the size of the market for clean technology relative to the size of the market for dirty technology, as well as by patent terms. Similar findings were reported by Fischer and Newell (2008). Based on a model for the US electricity market, these authors showed that putting a price on emissions in combination with subsidising the extra costs of clean electricity results in lower total costs than a no-subsidy policy (see also CPB, 2011).

The fact that environmental taxes contribute to diffusion of existing knowledge and technology *and* provide an incentive for developing new knowledge and technology, is particularly relevant to the question whether to focus on cost efficiency or dynamic efficiency in achieving environmental objectives. This question arises when the chosen tax base encourages firms to invest in R&D that is undesirable from a long-term perspective (e.g. R&D in dirty technology). Therefore the design of environmental taxes (tax base, rate and timing) should be carefully coordinated with innovation and diffusion policy. Clearly, a strong emphasis on cheap, *short-term* solutions could easily conflict with *long-term* policy goals (PBL, 2011b).

However, hardly any research has been done on the question how the choice of tax base affects innovation, particularly in the case of environmental taxes. For example, an energy tax based on *energy* content is likely to lead to a different innovation response than a tax based on CO_2 emissions (OECD 2010). This probably also applies to the differentiated purchase tax for new passenger cars, which was introduced in the Netherlands a few years ago. This problem is compounded by interference from indirect tax instruments, such as levies on dirty products, or subsidies on clean products based on the argument of positive knowledge externalities (see Text box 1). This interference may also be due to indirect instruments in a broader sense, such as the Dutch Energy Investment Allowance (EIA) for energy-saving innovative technologies, as part of the energy tax regulation. A careful coordination between environmental taxes (for correcting negative environmental externalities) and subsidy schemes (for promoting positive knowledge externalities) is therefore essential (Jaffe et al., 2005). However, matters are further complicated by the multi-dimensional nature of many environmental problems. This will be discussed in the next section.

4.2 Environmental taxes and environmental policy design

So far, the discussion in this paper has been based on the implicit assumption that environmental pollution consists of separate problems that require separate solutions. This is an obvious simplification of (non-linear) reality. To be sure, some environmental problems are completely unrelated to each other, even when they occur side by side within the same medium (soil, air, water), but usually they are strongly interrelated – as are their solutions. The problem of climate change alone is related to a range of greenhouse gas emissions that, moreover, are linked to various key sectors of the economic system (electricity production, heating, traffic and transport). These emissions furthermore interact with air-polluting emissions, which also generate their own environmental effects.

Nevertheless, the dominant view is that environmental problems should be addressed separately, through individual policy instruments. Therefore, if climate change is a problem and CO_2 is the most important cause, then regulation of these emissions should be the main focus in the design of a CO_2-related environment tax (De Mooij et al., 2012). A similar reasoning is applied to other emissions, including those that affect air quality. This way, each pollution problem calls for an individual solution, in the form of a separate policy objective and corresponding policy instrument. In this application of Tinbergen's rule, each problem (externality) is paired with a separate policy instrument.

This approach leads to widespread concern about overlapping objectives and instruments (Hepburn 2006, p. 231; Fullerton et al., 2010, p. 25). Indeed, welfare losses do occur as a result of the 'patchwork' of (in some cases counteracting) policy instruments. Furthermore, this approach also confirms the fear held by fiscal specialists that the multitude of environmental problems and related emissions will lead to a multitude of environmental taxes. This directly conflicts with the objective of tax simplification, and in their view would soon result in a completely unworkable system.[4] Thus, there are valid arguments against the blind application of Tinbergen's rule. It is certainly true that there are other options for correcting market failure besides environmental taxes. Instruments such as tradable permits, non-tradable quotas and subsidies also put a price on environmental resource use because they increase the (implicit) costs of environmental pollution (Fullerton et al., 2010, p. 7-12).

The question of how to optimise environmental policy objectives in relation to instrument choice is particularly relevant for policy aimed at green growth. Green growth policy is usually based on the argument of climate change, and to a lesser extent biodiversity loss. A case in point is the EU policy aimed at a 20% reduction in greenhouse gas emissions by 2020 compared to the 1990 benchmark, and the ambition to achieve a low-carbon economy by 2050. Additional EU targets for 2020 are a 20% increase in the share of renewable energy sources in total energy consumption, and a 20% reduction in primary energy use compared to the 1990 level. This package not only aims to contribute to the 'two degrees target' that should keep climate change under control, but also aims to contribute to energy security and improving air quality.[5] Apart from climate targets, the EU has also committed to improve local air quality through enforcing the maximum allowable emission levels ('emission ceilings') defined within the framework of the Gothenburg protocol. These ceilings have been set for various air-polluting emissions, including SO_2, NO_x, CO, NH_3 and particulate matter (fine dust).

The objectives of this EU policy strategy are in some cases overlapping and, moreover, sometimes conflicting. For example, CO_2 reduction objectives do not necessarily go hand in hand with incentives for renewable energy production and energy saving measures. This inevitably leads to welfare losses. A case in point is the counterproductive 'water bed effect', where effects achieved by one policy measure are cancelled out by effects of other measures (Van der Werf et al., 2010; PBL, 2011b; Anthoff and Hahn, 2012). Therefore some people have argued to limit energy and climate targets to reduction in CO_2 emissions. According to this view the EU should maximise the use of the emission trading instrument, as this would remove the need for environmental taxes. The only other instrument required would be a subsidy scheme for fundamental research, because of the positive external effects of new technologies. In this line of thinking there is no room for costly implementation of sustainable (long-term) solutions where cheaper options may become available in the future.

On the surface there is an appealing logic to simplifying environmental policy to climate policy and focussing on an effective and proven policy instrument such as emission trading. Moreover, it is perfectly conceivable that such an approach would solve various contradictions in current climate policy (Helm 2010). However, some caution is in order. After all, environmental policy and climate policy are not the same thing: numerous other environmental problems besides climate change are waiting to be solved. Neither are climate policy and energy saving policy the same thing. Energy production based on renewable sources should help to cut CO_2 emissions and may even reduce air pollution, but does not help to lower energy consumption; besides, renewable energy production does involve externalities as well. Hence, it would be just as valid to simplify environmental policy to the reduction in overall energy consumption, as this would also address a wide array of environmental problems at once. In other words, the complementarity of CO_2 policy, energy saving policy and air quality policy is still an open question (Van der Werf et al. 2010, p. 145 *ff*).

The above discussion mainly illustrates the actual relevance of the question of how to optimise the design of long-term energy and climate policy and instrument choice. The challenge is to design policy objectives *and* instruments in such a way that the social costs of any inefficiencies are minimised, and a fair distribution of the burden is ensured. Hence, a systematic analysis of the relevant policy framework is essential for the successful design and implementation of environmental taxes. This analysis should definitely include the interactions between environmental taxes and other environmental policy instruments, as will be shown in the next section.

4.3 Environmental taxes in relation to other instruments

The discussion so far has focused mostly on using environmental taxes in a 'single instrument approach', in which no other instruments are used to address the same environmental problem. However, the latter is quite common. In this context it is important to distinguish between hybrid and multiple instruments (Hepburn, 2006, p. 230). Hybrid instruments are tailored combinations of instruments, for example taxes and tradable permits. Multiple instruments are a 'package' of policy measures to address a single problem, but these are often poorly coordinated.

The design of hybrid instruments calls for a careful analysis of the policy objective and potential instruments for achieving this objective. Less obvious choices of instruments should also be considered, such as penalties for non-compliance, or liability and risk insurance.[6] An example of a hybrid instrument is a non-linear environmental tax with reduced rates for specific sectors based on considerations of competitiveness. Another example is an emission trading scheme with a price ceiling and/or price floor. The government can guarantee these prices by committing to sell permits if the price ceiling is reached, and to buy permits if the floor price is reached. It is also possible to combine a tax with tradable permits, if the former applies to different sectors than the latter (Vollebergh et al., 1997; Hepburn et al., 2006).

Frequently, a single problem is being addressed by multiple instruments. This is often the case in an *ad hoc* policy process, in which ever more elements are being added to the set of instruments already in place. If, at some point, the results of a price instrument (e.g. environmental tax) are disappointing, policymakers may become tempted to add a quantity instrument (quotas, or even tradable permits). In that case both price and quantity can be controlled, but this creates considerable additional complexity and hence regulatory costs. Meanwhile the same result could very well have been achieved through some minor adjustments to the price instrument (e.g. higher rate, fewer exemptions). Obviously, a combination of instruments can be very useful if their effects are complementary. For example, in combining environmental taxes with an information campaign the former ensures that environmental gains are achieved, while the latter can help businesses and households to keep their tax bills down.[7]

In this light, uncertainty and flexibility are key issues to consider in the choice to use environmental taxes as a policy instrument. These issues are particularly relevant for policy aimed at *long-term* change, as is the case with green growth. Uncertainty is inevitable and plays an important role in policy processes, particularly in the case of long-term strategies. These policies will need to be adjusted over time in response to unexpected economic developments, new scientific insights, and the arrival of new technologies. Thus, there must be some room for discretion to make policy adjustments.[8]

However, as Hepburn (2006, p. 233) rightly points out, discretionary policy also has some drawbacks. First of all, the regulated firms may try to influence future regulation. By showing that it is impossible to comply with current regulatory requirements, they send the message that compliance is too costly – hoping that this will lead to more lenient regulation. Secondly, discretionary policy can also result in credibility problems. If the profits from irreversible investments strongly depend on future policy choices, and the government could indeed change its priorities in the future (*ex post*), the firms will not invest ('hold-up'). Thirdly and finally, there is the problem of inappropriate risk allocation. The uncertainty about future policy adjustments presents a risk to investors, for which they will charge an additional risk premium. This makes investments with a long time horizon more expensive.

It is certainly no foregone conclusion that environmental taxes would send a more credible signal to companies to commit to long-term investments, than other forms of (flexible) environmental policy. The same can be said of tradable permits. Both these policy instruments allow flexibility in the complementary domain; environment tax with respect to the physical outcome (i.e. the amount of emission reduction), and tradable permits in that of market price. An important question for further research would be whether or not combined instruments, such as imposing a tax as minimum price related to the emission trading scheme (Hepburn et al., 2006), or entirely different instruments, such as emission standards, could provide a better alternative.[9] The present discussion about the benefits and trade-offs of flexibility once again demonstrates the importance of setting appropriate time horizons for (environmental) policy objectives and carefully coordinating this with instrument choice. Undoubtedly, other instruments are suitable in relation to short-term investments with relatively low operational risk, than in relation to long-term investments where irreversibility plays an important role (Van Soest, 2004).

This chapter has shown that allocative effectiveness and efficiency involves more than the use of environmental taxes to achieve environmental objectives at the lowest possible cost. Particularly important are the effects of environmental taxes on innovation and diffusion, and interactions between environmental taxes and instruments used as part of innovation and diffusion policy. The latter often include fiscal measures, such as income and corporate tax deductions for R&D or specific investments. In this context the use of hybrid instruments – in the form of tax refunds, non-linear rates and tax exemptions – is also justifiable, if no other instruments are available that can be implemented at lower social cost. The key is to design policy objectives *and* instruments in such a way that the social cost of possible inefficiencies are minimised, and a fair distribution of the burden is ensured. The use of environmental taxes in relation to energy consumption and air emissions provides a good case study to demonstrate the importance of a thorough analysis of the implementation context. A first outline of this case study is presented in the next chapter.

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Notes

1 However, this does *not* lead to a decrease in the marginal benefit of consumption. This is because the assumption that every unit of production leads to one unit of emissions is no longer valid after the introduction of the new technology.

2 Note that Figure 4.1 does not reflect the dynamic aspects of investment decisions, nor the potential benefits from selling the new technology to other firms (see also Van Soest, 2004).

3 This discussion illustrates the important role of market *expectations* in R&D investment decisions. The incentive effect of environmental regulation (whether through taxes, quotas, or tradable permits) largely depends on *expected* future regulation changes (e.g. higher tax rates, stricter quotas, fewer permits).

4 It is true that economists often do not take account of the implementation costs and indirect effects of the instruments they propose. Nevertheless, the concept of indirect emissions taxes such as discussed in Section 2.3 did arise from their recognition of implementation problems and costs.

5 The 'two-degrees target' of the European Union aims at global action to keep average global warming within two degrees Celsius (with reasonable probability).

6 Risk insurance in fact creates 'contingent markets', which also internalise various externalities. See, for example, Faure and Skogh (2003).

7 The analysis, so far, has assumed that producers and consumers make rational choices. Obviously this is a simplification. Insights from behavioural economics show that this assumption may indeed be too heroic, and that additional policy is needed to take account of 'less than rational' behaviour. That is not to say that underlying behavioural dynamics do not follow rationality, albeit sometimes less rigidly than economists may assume (Levitt and List, 2007).

8 See, for example, the argument of Kelly and Vollebergh (2012) in relation to the inflexibility of current EU air quality policy.

9 For example, Gerrard and Lave (2005) conclude that emissions standards have played a significant role in the development of catalytic converters to reduce HC and CO emissions. See Vollebergh and Van der Werf (2012) for an elaborate review of the contribution of standards to technology development.

FIVE

Taxation in relation to energy use and air emissions

The conclusion that environmental taxes are potentially useful instruments from the perspective of allocative effectiveness and efficiency (with regard to correcting negative externalities) and distributive justice (the polluter pays), does not mean that it is immediately clear how to best apply them in concrete cases. Much depends on the specific implementation context. Discussions about the particular design of environmental taxes often mainly reflect the complexity or even the contradictory aspect of policy objectives that, in essence, would all be worth pursuing. Moreover, markets may also differ fundamentally, and externalities simply come in all shapes and sizes. Moreover, environmental taxes are often used in tandem with other instruments addressing the same policy objective.

These observations show that good design of environmental taxes partly depends on recognising and understanding the context in which these taxes are applied. The present chapter illustrates this argument by examining the specific case of taxes on energy consumption and related air emissions (greenhouse gases, air pollutants). Section 5.1 describes the various forms of energy use and emission production in the economic process. Next, Section 5.2 analyses the choice of tax base for taxes on energy consumption and emissions related to heat and power generation. Section 5.3 does the same for taxes on engine fuels for traffic and transport. The chapter concludes with discussing the effect of these two types of taxes on innovation and long-term change, and their combined use (and interactions) with various other instruments.

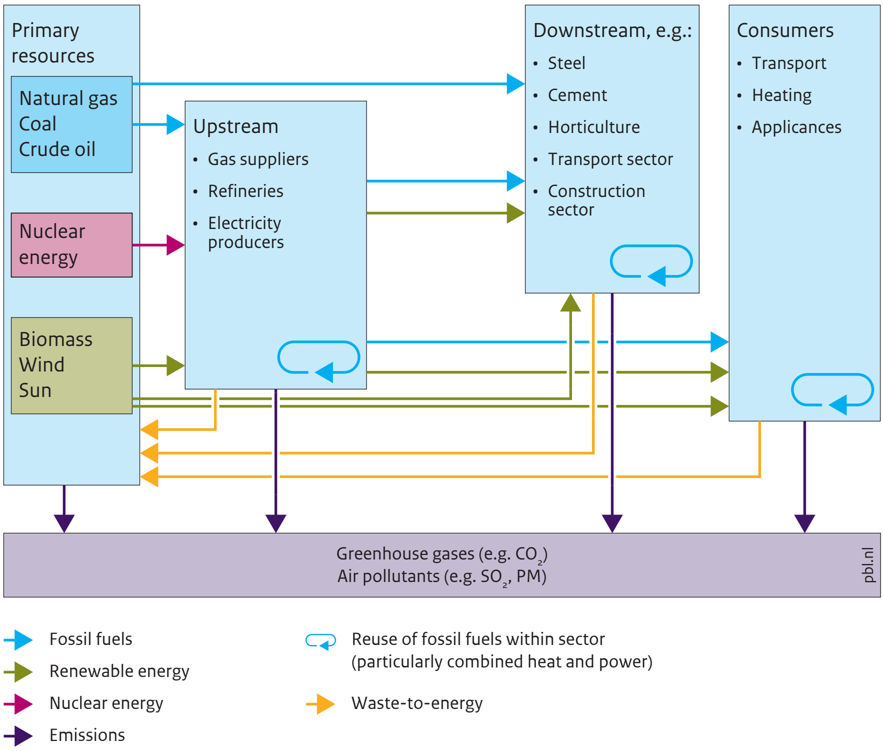
5.1 Emissions and energy use in the economic process

For a proper use of environmental taxes in the energy domain it is important to recognise and understand the various forms and roles of energy in different parts of the economic system. The consumption of energy, in particular of fossil fuels, comes in many different forms; in other words, energy is not a homogeneous good. In the context of environmental and energy policy the most important energy consumption categories are:

- fuel used for heat or power generation in industrial processes (heavy fuel oil, natural gas, coal, electricity) and for household heating;
- motor fuels (petrol, diesel, LPG) used for traffic and transport;
- feedstock for the production of steel or chemical products;
- electricity.

The first three categories are hereafter referred to as heating fuels, transport fuels and feedstock, respectively. It also must be noted that energy is released again when waste from production and consumption chains is reused (e.g. in incinerators).

Figure 5.1
Energy and emissions in the economic process



Source: PBL

Before energy can be used by industries and households (e.g. in the form of electricity, petrol) it first has to pass through various stages of the energy supply chain (Figure 5.1). In the case of fossil fuels, this chain begins with the extraction and production of raw fuel (crude oil, coal, natural gas), which may be followed by processing (e.g. refining), and ends with the distribution of energy products to businesses and households. The energy production sector for fossil fuels thus includes refineries, and gas and electricity companies. This sector converts primary fossil fuels into secondary fossil fuels and electricity, and is therefore located 'upstream' in the system.[1] Heat and power generation through CHP installations (circular arrows in the diagram) is also part of this sector. The derivative products, as well as electricity and heat, are subsequently consumed by 'downstream' sectors (e.g. greenhouse horticulture, paper production, transport, construction) and households, which may also make use of CHP (the circular arrows in the diagram).

In addition to fossil fuel-based energy, alternative energy production methods also play a role in this system, such as large-scale electricity production based on wind, solar, hydro and nuclear power. Noteworthy here is that some of these methods are increasingly used in decentralised, small-scale electricity production (wind turbines on farms, solar panels on household rooftops). Furthermore, organic waste from households and industries, as well as biomass from agricultural crops, also serve as fuel source in energy production.[2]

Figure 5.1 also illustrates the difference between 'dirty' and 'clean' energy sources from the perspective of climate and air quality policy. The consumption of fossil energy sources such as coal, oil and natural gas leads to emissions, not only of carbon dioxide (CO_2) – one of the principal greenhouse gases related to climate change – but also of air pollutants such as SO_2, NO_x and particulate matter (fine dust). It should be noted here that the amount of CO_2 released by combustion is usually directly related to the carbon content of the fuel source; emission abatement technologies that improve combustion processes with regard to CO_2 are scarcely available as yet (Anderson and Newell, 2003). In contrast, emissions of air pollutants often partly depend on specific combustion processes, and in this case various abatement options are available for individual pollutants. A case in point is sulphur dioxide abatement technology. Clean energy production such as wind and solar energy do not involve direct emissions of CO_2 or air pollutants, and neither does nuclear energy.

Matters are less straightforward for energy production based on biomass. On the one hand, biomass could be waste, which has already passed through an entire life-cycle and contains CO_2 fixed in solid form (Ayres and Ayres, 1998). On the other hand, however, it also concerns agricultural products which may or may not be grown for the explicit purpose of electricity production. The net carbon balance of this second source of biomass strongly depends on indirect land-use effects, that is, whether biomass production takes place on existing farmland or requires conversion of natural land (PBL, 2012a).

Figure 5.1, in fact, defines the context for the use of environmental taxes in relation to emissions and energy consumption. It implicitly demonstrates that the use of taxes in this domain (also in relation to other policy instruments) requires a thorough analysis of the various forms of energy and associated emission characteristics. As discussed earlier, tax base and rate are important determinants of the regulating effect of environmental taxes (see Section 3.2 in particular). In this context, it is therefore important to carefully choose the tax base and rates of *indirect* environmental taxes, such as those on heating and motor fuels. The principle of 'uniformly taxing emissions at the margin' is complicated due to the various interrelationships within the energy supply chain. For example, if emission taxes are already being levied on crude fossil fuels, it is difficult to justify additional emission taxes on secondary fuels. Furthermore, due to possible interactions between environmental taxes and other instruments such as tradable emission permits, careful coordination is required to prevent double (or incomplete) taxation. These and other relevant design questions are addressed in detail in the following sections.

5.2 The environmental tax base: emissions or energy?

Environmental taxes on greenhouse gases and air pollutants are not common: only very few countries levy direct taxes on CO_2, SO_2 or NO_x emissions (OECD, 2010). Most countries tax emissions indirectly, through levying taxes on energy consumption (e.g. fossil fuel excises). This is also the case in the Netherlands, which has progressively broadened the tax base and increased the tax rate in relation to energy products during the last 20 years. As a result, more energy products are taxed now than ever before – through energy taxes on heating fuels and electricity as well as excise taxes on fossil fuels used for transport – and the rates of these taxes have also been raised several times.[3] This increased tax burden should encourage households and industries to lower their energy consumption, and hence reduce their emissions.

Various allocation considerations play a role in energy taxation. This refers to:

- taxation to correct negative externalities such as pollution of air, water and soil;
- taxation to account for resource ownership ('royalty rents'), resource depletion and energy security;
- (negative) taxation to promote positive externalities such as knowledge spillovers from new technologies;
- general taxation of (consumption) goods, including Value-Added Tax (VAT);
- additional taxes or subsidies justified on other grounds.

This paper emphasises the first category, but within the context of considerations underlying the other categories. The second category, therefore, requires a separate analysis because the roles of exploration and exploitation of certain energy sources, such as natural gas and petroleum, carry specific characteristics. With regard to the third category, the use of environmental tax instruments for promoting positive externalities – e.g. tax credits for energy-saving and environmental investments – is only briefly discussed in this paper (for an elaborate discussion, see Vollebergh (2012)). The fourth category is only of indirect importance, because VAT increases the price for consumers but not for producers.[4] The relevance of the fifth and last category depends partly on the presence of interaction effects within the tax system (see Section 3.3.)

From the perspective of allocative effectiveness and efficiency, the question is whether a tax on energy is a suitable environmental policy instrument. In Section 3.2 it was argued that, compared to an emission tax, *indirect* environmental taxes such as an energy tax lead to welfare losses. An emission tax not only encourages consumers and producers to reduce their emissions, but also provides an ongoing incentive for technological innovation to further reduce emissions; thus, reducing *energy consumption* would be just one of various possible actions in response to an emission tax. In contrast, an energy tax only indirectly addresses emission reduction, and its effect strongly depends on the relation between energy consumption and relevant emissions. This leads to welfare losses, particularly because an energy tax lacks the substitution effects of a direct emission tax. It is therefore a valid question whether an energy tax is a suitable regulatory instrument to reduce emissions of CO_2

Table 5.1
Characteristics of primary fossil fuels

Fuel	Standard unit	GJ/unit	CO_2/unit	CO_2/GJ
Primary fossil fuels				
Coal	1,000 kg	28.3	2,677.18	94.6
Crude oil	1,000 l	42.3	3,117.51	73.7
Natural gas	1,000 m^3	34.27	1,922.55	56.1
Secondary fossil fuels				
Petrol	1,000 l	31.5	2,182.95	69.3
Diesel	1,000 l	36.55	2,708.36	74.1
LPG	1,000 kg	47.3	2,984.63	63.1
Light fuel oil	1,000 l	40.65	2,930.87	72.1
Heavy fuel oil	1,000 kg	40.4	3,126.96	77.4

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories

and/or other air pollutants such as NO_x and particulate matter, and if so whether this should be a uniform tax.

Thus, the relevant question is: under what conditions are *indirect* taxes such as an energy tax a good alternative for a (uniform) emission tax? According to Smulders and Vollebergh (2001, p. 11) the following three conditions must be met:

i. the relationship between energy consumption and emissions is sufficiently strong;
ii. the use of separate emission abatement technologies is relatively expensive;
iii. implementation costs are lower than for a direct emission tax.

The first condition bears upon the relation between (energy) inputs and emissions. If this relation can be altered, such as by applying emission abatement technologies, the effects of an energy tax will differ from those of an emission tax. For example, whereas CO_2 emissions are directly related to the carbon (C) content of the fossil fuel used, emissions of NO_x can be reduced by improving the combustion process. Furthermore, this condition implies that if an energy source is *not* related to emissions (e.g. wind, solar), it should be energy tax exempt. Hence, energy taxes are implicit CO_2 emission taxes as long as they apply only to the consumption of *fossil* fuels.

Table 5.1 compares the relevant characteristics of various types of fossil fuels. As this table shows there are considerable differences between the various fuels, and these will ultimately determine the choice between taxing energy or CO_2 emissions. In terms of CO_2 per unit energy (CO_2/GJ, last column of Table 5.1), coal is much dirtier than oil, which in turn is much dirtier than natural gas. The choice of tax base is therefore important: a (uniform) charge per unit energy content (GJ) will have a different effect than a charge per unit carbon content (C). In fact, an energy tax in the form of an excise on carbon content is not different from tax on CO_2 emissions. With regard to emissions of air pollutants there are similar quality differences between fuels, but in this case the relation between input and emission also depends on characteristics of the combustion process.

The second condition refers to the option of mitigating the various types of emissions separately; for example, by using emission abatement technologies. Such options are preferred to other methods of emission reduction as long as they are available at lower cost. However, their availability depends on the type of emission and also varies across the energy chain (Figure 5.1) For example, there are emission abatement technologies for air pollutants such as SO_2 or NO_x, but for CO_2 the case is less straightforward. Although specific CO_2 abatement technology is available (Anderson and Newell, 2003), but – in contrast to catalysts and particle filters – only for very specific processes (steel manufacturing) and large incineration plants. However, there are various other options to at least partly mitigate CO_2 emissions, including co-firing with other fuels (biomass) and compensation measures elsewhere in the ecological system (afforestation).

Thus, opportunities for substitution vary significantly across the energy chain, and therefore the allocative effectiveness of an emission tax or energy tax will partly depend on where in this chain it is applied. For example, an upstream tax levied on crude fuels will also have a regulating effect on downstream energy consumption – because higher input costs will be passed on through higher secondary fuel prices – but the direct value of such a tax as an incentive to regulate *emissions* separately will be limited:[5] it provides no direct incentive to firms to reduce their emissions; at most it is an *indirect* incentive due to increased fuel prices (including excises). The issue of missing incentives should be taken into account when comparing the regulating effects of various indirect instruments.

Finally, the third condition applies to the implementation costs of energy taxes versus emission taxes. Particularly in the case of a new tax, such as on emissions, these costs can be considerable if this tax has to be imposed on many payers. An energy tax usually involves fewer tax payers than a tax on CO_2 emissions, and therefore involves lower costs (Vollebergh et al., 1997) – particularly, when linked to existing taxation.

As Smulders and Vollebergh (2001) pointed out, an energy tax would not necessarily need to satisfy these three conditions for all sectors at once. The relation between energy consumption and emissions is usually sufficiently clear, particularly when consumption is limited to relatively simple combustion processes for heat and electricity generation, but in some cases this relation is more complex. Furthermore, asymmetry between sectors may result from sector-specific differences with regard to emission abatement options and tax implementation costs. This asymmetry implies that an energy tax need not be uniform. In other words, in the presence of intersectoral differences a non-uniform *energy* tax can actually be an optimal solution.

Assessment of whether these three conditions are met – for instance in the case of Dutch energy taxes – is further complicated by the fact that energy is not a homogeneous but a *composite* good, consisting of a range of products that each play a different role depending on the production process in which they are used (Ayres and Ayres 1998). Moreover, in the case of fossil energy these products are all interrelated, because they are part of the same supply chain from raw fuel to final fuel product (as discussed in Section 5.1). After all, every phase of this chain offers options for substitution of various fuels and to varying degrees, and this is also true for the options to abate emissions.

In light of the preceding discussion, questions could be raised about pleas for a CO_2 tax to address climate change (see e.g. De Mooij et al., 2012). In principle, a CO_2 tax is an emission tax aimed at reducing the emission of CO_2. It is usually based on the carbon content of fuel inputs and may include compensation measures for emissions abated during production processes. However, because, often, in the economic process, too little attention is paid to the fuel cycle (Figure 5.1), carbon inputs are likely to be taxed – or exempted – several times during this cycle. This is for example the case when production *and* consumption of fossil fuel derivatives and electricity are taxed. Another problematic tax base is an input tax on fossil energy sources that does not take into account the overall higher emissions involved with the use of CO_2 as feedstock in coal production.

The relationship with existing energy taxation is also problematic, as these all implicitly tax CO_2 emissions. The question for instance is whether such taxation should be implemented on top of existing taxes, and whether or not the existing tax level and structure should be taken into account first. The answer partly depends on possible other arguments for taxing energy, as listed at the beginning of this section (see also Newbery 2005a). Furthermore, many fossil fuel products are not (yet) taxed, and from a CO_2 perspective the present rates are unbalanced (Vollebergh, 2007).

As was discussed in Chapter 3, economists argue for a *uniform* tax on all emissions when the objective is to mitigate environmental damage from these emissions *and* all emissions contribute equally to this damage. For CO_2 this is indeed the case: for global climate change it does not matter whether CO_2 is emitted in the Netherlands or elsewhere in the world, and each unit of emission reduction therefore has the same weight. This is a case of so-called stock pollutants, with CO_2 being the 'stock pollutant' accumulating in the environment over time. As climate change results from a change in the total atmospheric stock of greenhouse gases including CO_2, the benefit of each unit of CO_2 reduction is identical.[6] This satisfies the requirement of 'equal benefit' defined by Baumol and Oates (1988, p. 169), i.e. that there must be a 'direct and additive' relationship between emissions and environmental damage.

Yet, economic valuation of this damage is difficult, and the damage can only be addressed through concerted global intervention (see also De Mooij et al., 2012). Be that as it may, a non-uniform tax on CO_2 emissions would irrevocably lead to discrimination between activities. In contrast, in the case of a uniform tax rate the *total* tax payable on emission-intensive activities will surely be considerable, but the *relative* costs (i.e. per unit CO_2) will be the same as for less-polluting activities. Thus, a uniform (Pigouvian) tax confronts all payers of tax with the same marginal (shadow) price for the pollution they cause – in this case CO_2 emissions leading to climate change.

This Pigouvian tax principle, in essence, does not change when emissions of other gases also contribute to climate change. In that case the optimal solution is to tax all greenhouse gases at a rate that reflects their relative contribution to the environmental problem. In the context of climate policy this can be achieved through the use of CO_2 equivalents. This approach, however, will involve more market participants, and must also take account of the emission of multiple relevant emissions. This applies, for example, to farms that use fossil fuels (causing CO_2 emissions) *and* keep livestock (emissions of CH_4, a potent greenhouse gas).

A further complication is that combustion processes not only lead to emissions of greenhouse gases but also to that of air pollutants, which have their own effects on human health and the environment. As discussed in Section 5.1, emissions of air pollutants are not always linearly related to input (resulting in a difference between marginal and average damage costs); moreover, their effect *does* depend on emission location – in contrast to CO_2. Ideally, an air pollution tax would not be uniform but location- and time-dependent, but this would require continuous monitoring of individual emission sources. Obviously, this is very difficult to implement, not only for mobile sources such as transport, but even for large stationary sources.

All these complicating factors must be taken into account when comparing the regulating effects of different indirect environmental taxes. In other words, assessment of allocative effectiveness and efficiency of tax instruments used for environmental regulation should not only take into account the different forms and roles of energy in the economic process, but also the relations between various forms of energy consumption and relevant emissions of greenhouse gases and air pollutants. Furthermore, it should be realised that these relations may be influenced by other instruments used for the same purpose – including the European Union Greenhouse Gas Emission Trading System (EU ETS). The implications of the heterogeneity of production processes, products and sectors for the specific design of energy and emission taxes (and related policy objectives) has yet to be systemically analysed.[7]

5.3 Environmental taxes in relation to traffic and transport

In addition to taxes on energy use in the form of heating fuels, taxes on traffic and transport are nowadays also considered environmental taxes (OECD, 2010). These include excise taxes on fossil motor fuels (e.g. petrol, diesel) as well as taxes on the purchase, ownership and use of motor vehicles (e.g. passenger cars, lorries). Clearly this involves a number of policy areas. The relation between the tax base structure of traffic and transport taxes and the environmental issues they address is much more complex than in the case of stationary emission sources related to the use of heating fuels. For example, the environmental damage caused by traffic and transport is often non-linear. Furthermore, various non-environmental policy issues also play a role, such as congestion, road construction and maintenance, and traffic victims. Finally, there is the interaction between the described taxes on engine-fuel consumption in traffic and transport and the other taxes mentioned.

There are various options and arguments (from an allocative perspective) for using environmental taxes on traffic and transport (Newbery, 2005b, p. 195):

- taxation to correct negative externalities such as environmental pollution, noise and traffic accidents;
- taxation to account for the use of scarce, valuable space for roads, as well as the costs of congestion and road maintenance;
- general taxes imposed on (consumption) goods, such as value-added tax (VAT);
- additional taxes or subsidies justified on other grounds.

As was the case with energy taxes (Section 5.2), this discussion focuses on the first category. After all, a tax on energy (fuel) consumption related to traffic and transport is an implicit tax on air emissions (where emissions are just one of the negative externalities associated with traffic and transport). The third category only applies to private consumption, as was the case with heating fuels (Section 5.2). The fourth category applies to the interaction between taxes on engine fuels and other traffic- and transport-related taxes, and also to the interaction with general fiscal considerations.

Problems similar to those associated with using indirect energy taxes rather than direct emission taxes (Section 5.2) complicate the design of an optimal environmental tax regime for traffic and transport fuel consumption. Again the pertinent question is how to optimise the design of an indirect tax on energy to adequately internalise external effects. The same three conditions play a role here as in the choice between direct emission tax and indirect energy tax (Section 5.2). The only difference is that the emission sources related to traffic and transport are mobile; the negative externalities associated with motor fuel consumption thus vary over space and time, and this may require some adjustments in the design.

For example, Parry and Small (2005) showed that an indirect environmental tax on motor fuels requires a differentiated rate structure, due to the different externalities associated with car use. According to these authors, the optimal solution would be to levy part of the taxes in proportion to the consumption of the type of fuel, similar to the current tax rate on mineral oils, while another part is related to the number of kilometres travelled. In this combination, the fuel tax addresses the negative externality of climate emissions related to *fuel consumption*. It provides an incentive to improve fuel efficiency (more miles per litre), and stimulates driving diesel cars because of their low fuel use. The tax on vehicle mileage addresses externalities that are mainly related to *travelling distance*, such as local air pollution, congestion and traffic accidents.

As was the case for energy taxes, the design of excise taxes on fossil motor fuels should take account of the fuel life cycle (Figure 5.1). For example, from a CO_2 perspective, a valid alternative for an excise tax on fossil motor fuels could be an upstream tax on crude oil. After all, such an input tax on primary fuel would cover implicit CO_2 emissions downstream along the chain; from the refining process as well as the burning of derivatives. This would remove the need for an environmental excise tax on fossil motor fuels as far as CO_2 emissions are concerned. After all, if CO_2 emissions from traffic and transport can only be reduced through stimulating the development and use of fuel efficient cars, then it does not matter whether this is achieved through *excise taxes* on motor fuels or *higher market prices* for these fuels due to the upstream tax on primary energy. Equally valid is the question whether the CO_2 in these fuels is already being taxed through the EU-ETS. If that is the case, an environmental excise on motor fuels would not be justified, as it is not efficient to pay twice for an externality.

Furthermore, the design of motor fuel excise taxes should explicitly take account of the availability of substitutes and their indirect effect on vehicle purchase decisions, also in relation to existing vehicle purchase *taxes*. As was the case with heating fuels, tax differences between substitutes (petrol versus diesel) not only have marginal effects – i.e. on the total consumption of the taxed good – but also intramarginal effects – i.e. on purchase and investment decisions. For example, a higher excise rate on petrol not only provides an incentive to reduce car travel, but also stimulates the purchase of diesel cars (ceteris paribus). Clearly this requires a balanced package of taxes on vehicle purchase, ownership and use.

Other tax interaction effects also play a role (Newbery, 2005b, p. 220). For example, if a (non-environmental) objective of motor fuel taxation is to put a price on road use and congestion, then the total excise (including the environmental tax) should be higher than the net environmental tax. This is because the environmental tax will lead to lower fuel consumption, and thus reduce the tax base in relation to road use and congestion. The relevance of this point was also shown by Parry and Small (2005). These complicating factors must also be taken into account in road pricing, in addition to the question if, in this case, priority should be given to revenue considerations, because of the limited price elasticity of road use. A further question concerns the possible interactions with other instruments that also address emissions – such as the European vehicle emission standards (Euro Norms), and the European emission trading system (ETS). As is the case with energy and emission taxes, a comprehensive and systematic assessment of relevant factors for the specific design of environmental taxes on motor fuels is lacking so far.

5.4 The use of environmental taxes in relation to long-term ambitions

A relevant aspect of allocative effectiveness and efficiency of environmental taxes is their effect on long-term technological change and economic growth. As discussed in Chapter 4, it is also important to carefully coordinate the design of environmental taxes (tax base, rate and timing) with innovation policy. With regard to energy and emission taxes, this discussion focuses on the question of how to bring about a transition towards a low-carbon society. Particularly important in this transition are *path dependencies*, as technological development in the energy domain tends to build upon existing technologies that are based on fossil fuel. Equally relevant is the growing adoption of new technologies, also in 'dirty' energy sectors (e.g. shale gas and shale oil extraction, but also clean coal plants and CCS technologies). Although these new technologies still involve negative externalities due to combustion of fossil fuels (climate change, air pollution), they also include positive externalities associated with the development and marketing of innovative technologies. In fact, this refers to an additional aspect of the context within which the effectiveness and efficiency of environmental taxes must be regarded. Closely related issues are the open economy of the Netherlands, the role of tax competition, and the coordination of environmental policy. However, this section is limited to a few observations regarding the application of environmental tax instruments. in relation to long-term policy objectives.

The focus on a low-carbon society mainly originates from the climate change problem and related externalities (see also De Mooij et al., 2012; Acemoglu et al., 2012). The EU, for example, has chosen to integrate its energy and climate policies, guided by the ambition to achieve a low-carbon energy supply by 2050 (Section 4.2; PBL, 2011b). The United States have defined similar ambitions. But while the ambitions are clear, it is far from obvious how they could actually be achieved, and what would be the best environmental tax policy to support this.

First of all, there are significant long-term uncertainties that discourage firms to invest in innovation, development and use of new, low-carbon technologies (CPB, 2010; Van der Werf et al., 2010). These uncertainties are, for example, related to the potential future adoption of new technologies. The Copenhagen negotiations in December 2009 showed that a broad international agreement on CO_2 reduction is not in sight. Moreover, the countries that are prepared to take measures have widely varying emission reduction objectives (Den Elzen et al., 2012). This makes it difficult for investors to gauge the present and future potential of new technologies. Apart from negative trade effects such as relocation of polluting industries and import of relatively cheap, polluting products (Bollen et al., 2011), this also reduces the incentive for innovation due to the risk of losing knowledge spillovers.

Furthermore, there is also uncertainty in relation to the time horizon of policy tools. For example, neither Dutch nor European policies offer guarantees about a long-term price for CO_2 emissions. The importance of policy credibility for innovation investments has already been discussed in a previous section. A case in point is the EU emission trading system (ETS). This system does provide clarity about the actual achievement of emission reduction targets up to 2020 (and moreover improves marginal efficiency; see Section 3.1), but not for the period thereafter. Thus, the time horizon of climate and energy policy is shorter than the time horizon of major investment decisions such as the building of new power plants. These uncertainties affect the estimated cash flow and risk premium of investment projects and may seriously hamper the transition to a low-carbon economy.

A third issue is the use of multiple instruments to address different, but strongly interrelated EU policy objectives (see also Sections 4.2 and 4.2). A case in point is the combination of the EU emission trading system with (European and domestic) energy taxes. Due to its high implementation costs the ETS currently includes only large installations (e.g. factories, power stations), whereas the energy taxes apply to a broader range of firms (which may, or may not, be covered by the ETS) and often also contain exemptions and regressive rates. Although there are no principal objections against the use of multiple instruments, in this case it is unclear whether the instruments are properly coordinated to prevent unnecessary welfare losses. For example, some sectors or firms may be disproportionally hit – or spared – by these measures, but this is not clear. Neither is this clear for the proposed European CO_2 tax on energy products, nor for the various proposed changes in the ETS system to address the problem of the low carbon price.

A fourth issue is that interaction between various environmental policy instruments used for different (but interrelated) objectives may negatively affect the effectiveness and efficiency of individual instruments. In various European countries including the Netherlands, policy to stimulate investment in clean energy technology (solar, wind) often boils down to taxpayers' subsidies to firms that are also regulated by the ETS. These measures are meant to bridge the gap between the cost price of fossil fuel energy and renewable energy, but they also result in a significant 'water bed effect' – such that the subsidised CO_2 reductions achieved by firms that also participate in the ETS will *not* lead to CO_2 reductions at the European level. This is because these firms can sell their unused credits on the ETS market, allowing the buyers of these credits (other European firms) to *increase* their emissions. Due to this water bed effect the total CO_2 emissions of the EU will *not* go down, and on top of this the carbon price will *decrease*. This way, taxpayers indirectly subsidise the polluters.

In addition, this example demonstrates the difficulties surrounding policy instrument design. In theory, there are good reasons to tax 'dirty' sectors by the pricing of CO_2 emissions through the ETS (externalities). The same reasoning applies to the subsidising of 'clean' sectors (consider path dependency). However, this combination, in fact, is a variant of the two-part instrument in Table 3.1, whereby the ETS delivers the pricing of CO_2 emissions by – mostly freely allocated – tradable emission rights. The reason is that – in contrast to an environmental tax, where the price of CO_2 emissions is fixed – the price of emission permits on the ETS market automatically responds to the use of the other policy instrument, i.e. subsidies. Ideally this effect should be factored in *ex ante*, similarly to the tax interaction effect described for motor fuel excises in the preceding section. In the case of an environmental tax the *ex ante* rate should be set higher, and in the case of the ETS the quantity cap on emissions (i.e. the number of permits issued) should be set lower.[8] A valid question, therefore, is whether the water bed effect is such a problem after all. Rather, it appears merely indicative of the inevitable problems of 'second-best' solutions, which arise due to interactions between instruments used to correct externalities. In other words, it is the price to pay for the impossibility to solve each externality separately and without welfare losses. Moreover, in this particular example, the subsidy instrument should compensate for the positive externalities of innovation (knowledge exchange, learning processes; see Section 4.1).

The fifth and final issue concerns the use of existing and new technologies that influence the relation between energy use and emissions. Some of these technologies have been around for a while, such as Combined Heat Power (CHP) installations in industries, as well as heat pumps and microCHP in households. These technologies achieve much higher (fossil) energy efficiency than conventional heating solutions. Moreover, new technologies are also becoming available. These technologies are particularly relevant when they change the total abatement costs (see also Section 5.2). Technological developments also have consequences for the design and use of tax instruments for environmental regulation. If these developments are not sufficiently accounted for in the design, or do not lead to periodic tax adjustments, this could weaken the regulating effect of the tax. This way, an indirect energy tax could eventually lead to distortions in technology choice.

Notes

1 Following Fullerton et al. (2010), the term 'upstream' in the present paper specifically refers to sectors that use *primary* energy sources as inputs; it excludes sectors involved in exploration and extraction.

2 Biomass concerns (1) incineration of organic waste in incinerator installations; (2) use of biomass as a co-fuel in power plants; (3) production of electricity from biogas; and (4) incineration of biomass in installations specifically designed for the incineration of a certain type of biomass (e.g. for waste wood, chicken manure).

3 Past and present developments in environmental taxation in the Netherlands will be discussed in greater detail in the next paper of this series.

4 VAT imposed on producers does not have much of a regulating effect, because, in accordance to the principle of VAT, these costs are directly passed on to consumers. Nevertheless, there are good options for VAT differentiation based on environmental criteria (see Kosonen and Nicodème (2009), in particular).

5 This issue, which is insufficiently recognized in the Mirrlees Review (see Fullerton et al., 2010, p.24), requires a more thorough analysis of the costs of missing incentives (see further down this section, and Section 3.2).

6 In terms of social welfare it can be assumed that governments whose sole objective is to meet emissions reduction targets are neutral about *where* these reductions take place. However, if they also have other welfare objectives, such as distributive justice, then this assumption does not hold.

7 An exception is Vollebergh (2004), who applied this systematic approach to the choice between an energy tax and a CO_2 emissions tax. This study however did not consider the role of other emissions, nor the interactions with other policy instruments such as the EU ETS.

8 The EU claims that, in setting the overall EU emissions cap for the period 2013-2020, they have explicitly taken account of the (potential) effects of EU renewable energy policy on CO_2 emissions in the ETS sector. However, it does not seem likely that they have also reckoned with an economic crisis of the present magnitude.

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Conclusions and follow-up

The analysis in this paper has provided insight into the relevant considerations for the use of tax instruments as part of sustainable economic growth policy. Using standard criteria such as (allocative) effectiveness and efficiency, distributive justice, and feasibility, it has described the close interrelationship between fiscal and environmental policy, particularly in the areas of energy consumption and traffic and transport. Linked to broader discussions on general tax reform, this study has outlined the choices and difficulties related to *environmental* tax reform in particular. The key question here is what the relevant options, arguments and obstacles are for using tax instruments as part of policy aimed at 'green growth'. Using taxes to achieve environmental objectives can be at odds with the objective of stable revenue generation, but this is definitely not always the case.

As the discussion in Chapter 3 has shown, the key is to find the right combinations of cleverly designed environmental taxes that are relatively easy to implement. Often these are indirect environmental taxes combined with subsidies; nevertheless the question should always be asked whether the same objective may be better achieved by other instruments (e.g. tradable permits, non-tradable quotas). Assessing the effectiveness and efficiency of taxes used for environmental regulation does not generally benefit from evaluating a specific instrument in isolation; all too often the complications inherent to the implementation context are ignored.

The effectiveness of an environmental tax not only depends on the choice of who should pay what and when (tax design), but also on the context in which the tax is used (i.e. the implementation context). This context includes the nature of the environmental problem and its relation to other environmental problems (e.g. climate change and air pollution), the technological characteristics of relevant production processes (e.g. the use of CHP), and market conditions (e.g. free market, monopoly). Interactions with other policy instruments – used to address the same objective as the tax in question, or for a different purpose altogether – also play an important role. As indicated before, the challenge is to design policy objectives and their instruments in such a way that the social costs of any inefficiencies are minimised and a fair distribution of the burden is ensured. Thus, a systematic analysis of the policy framework is essential for the successful design and implementation of environmental taxes.

A solid understanding of the implementation context in relation to tax design also helps to temper unrealistic expectations about the effect of environmental taxes on green growth. All too often, ambitious plans are overtaken by reality – not just fiscal implementation problems, but also external circumstances that undermine the regulating effect of the tax. A case in point is the Energy Tax policy adjustment in the Netherlands during 2002–2004. Quite soon after the introduction of the Energy Tax in 1995 – which at that time mainly applied to households and small businesses – it became clear that the tax exemption for renewable energy led to a 'reversed leakage' effect. Instead of stimulating renewable energy production within the Netherlands, the tax resulted in a growing import of wind energy and particularly hydro electricity from other countries. This way, the tax advantage (i.e. implicit subsidy) for renewable energy disappeared to other countries. Therefore the exemption was phased out during 2002-2004, at the expense of its positive effect on the use of renewable energy sources.[1] There are various other examples, including the current policy discussions in the Netherlands about net metering for local renewable energy production, and the regressive electricity and gas rates for large industrial users.

The following key lessons for policymakers can be drawn from this study:

- regulation through taxes (Pigou) is sometimes at odds with tax revenue generation (Ramsey);
- raising revenue through environmental taxes is not an aim in itself; efforts are better spent on a clever design of environmental taxes aimed at achieving carefully thought out, long-term environmental objectives;
- environmental pricing stimulates consumers and producers to take environmental responsibility;
- the best approach to environmental pricing is an intelligent combination of 'sticks' (taxes) and 'carrots' (subsidies, exemptions);
- the main challenge is to find the right combinations of cleverly designed environmental taxes that are relatively easy to implement;
- short-term cost-efficient solutions can be at odds with solutions aimed at dynamic efficiency;
- the objective of tax simplification can be at odds with the effective use of taxes as environmental policy instrument;
- in a small open economy such as the Netherlands, the possibilities for national policy interventions are limited if international coordination is not feasible.

These lessons provide a number of starting points for further research. First of all, a detailed overview of the position of the Netherlands relative to other countries is presently lacking – particularly with regard to the use of environmental taxes within the specific context of energy consumption and associated emissions. Such an overview will allow identification of the bottlenecks for the Netherlands and other issues that should be considered in the evaluation of tax reform proposals. It should provide the relevant background facts and figures on long-term developments in energy consumption and associated emissions in the Netherlands, as well as on the social damage of these emissions and the available emission abatement options, including their costs.

Furthermore it has become clear that, for an efficient design of environmental taxes, the implementation context must be taken into account. This also requires a coherent view of policy objectives and the use of tax instruments. While environmental pricing is an essential instrument in the government's toolbox, it should be carefully and properly integrated with existing instruments in order to prevent unnecessary welfare losses. This ambition requires a thorough analysis of the options for actual implementation of environmental tax instruments. This was illustrated for taxes on energy consumption and associated atmospheric emissions, which are currently the main source of environmental tax revenue in the Netherlands. National policy making is often complicated by environmental tax competition, both within and outside the EU – although for some policy areas (e.g. CO_2 emission regulation) this issue is more relevant than for other areas (e.g. waste regulation). Cross-border effects inevitably limit the room for (increasing) motor fuel excises, and the same is true for energy taxes in energy-intensive sectors.

Finally, there are a number of options for energy tax reform that deserve further analysis:

- a generic increase in energy taxes (without changing the tax structure) to compensate for inflation and environmental damage;
- a surcharge on non-renewable energy to fund subsidies for CHP and clean energy production by businesses (the *SDE+* scheme) and households; improving the overall tax structure (tax base and rates), based on careful consideration of CO_2 reduction targets versus other energy related objectives;[2]
- reforming energy tax rates for small users, to account for local renewable energy production (wind, solar, biogas), particularly in relation to the issue of net metering.

Similar options exist for reforming environmental taxes on motor fuels and other traffic and transport related environmental taxes:

- a generic tax increase (without changing the tax structure) to compensate for inflation and environmental damage;
- improving the overall structure (tax base and rates) of taxes related to vehicle purchase, ownership and use (separately and combined), in the light of CO_2 reduction and air quality targets and dynamic regulation.

The analysis of these tax reform proposals should take account of the various pitfalls and issues discussed in this paper, such as the presence of multiple externalities (e.g. climate change and air pollution), the interaction between instruments, the various sources and forms of energy, the different relations between energy use and specific production processes, the arrival of new technologies (e.g. heat pumps, microCHP), the path dependency of innovation, and international tax competition.

It is certainly not always true that environmental pricing, which is required to account for the social cost of pollution, is best achieved through environmental *taxes*. As indicated more than once in this paper, governments have a whole range of instruments at their disposal – particularly if influencing behaviour is the main objective. For example, conventional regulation through technology mandates and emission standards has proven to be very effective in directing technological change. This form of regulation is particularly useful when the environmental problems are complex, or when international coordination of market-based instruments (taxes, tradable permits) proves too difficult (Vollebergh and Van der Werf 2012). However, the available options should always be carefully considered. In this context it should not be forgotten that the tax instrument is an eminently suitable tool for regulating our vices (Cnossen 2005).

Notes

1 Nowadays, reduced rates are granted only for the use of bio-methane (a renewable gas source known as 'green gas' in the Netherlands). Import and reversed leakage effects play no significant role here.

2 Relevant in this context are recent EU proposals to add a CO_2 component to the EU minimum tax on energy products.

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