Lessons from the Polder: Is Dutch CO_2-Taxation Optimal?

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Summary

This paper evaluates energy tax reform in the Netherlands between 1988 and 2002 from a climate change perspective. A tax on fuels and the so-called regulatory energy tax since 1996 are examples of indirect and non-uniform taxation of emissions. The overall tax base and rate structure corroborates recent theoretical findings that heterogeneity in production processes and transaction costs may justify optimal departures from the Pigovian corrective tax rule. Surprisingly, the Dutch revenue-raising tax matches the (modified) Pigovian policy prescription rather well, whereas the regulatory energy tax mainly follows the revenue raising Ramsey logic. Further improvements of the energy tax structure are also discussed, such as targeting the energy tax base and linking the tax rate more precisely to fuel characteristics

Keywords: Climate change, Energy taxes, Optimal indirect taxation, Specific and ad valorem taxation

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1. INTRODUCTION

Conventional wisdom has it that environmental taxes are – at best – of limited importance in pollution policy. Recent evidence, however, suggests that green tax reforms have changed this picture in many OECD countries (Ekins and Speck, 1999; Stavins, 2002; Barde and Braathen, 2003). One particular area for reform has been the use of the tax system to provide proper incentives to reduce climate change emissions. Indeed, the burning of fossil-fuel-based energy products contributes significantly to climate-change-related emissions, and current green tax reforms are usually motivated by this externality. Several countries, such as the Scandinavian countries, Austria and the Netherlands, have introduced new energy taxes or modified existing tax systems. These initiatives reflect the extensive policy discussion in the European Union (EU) and even in the US at the beginning of the 1990s, although neither the EU nor the US decided to introduce climate change taxes.

This paper focuses on one country in particular, the Netherlands. In the last decade, several tax policy initiatives caused a major shift in the way in which energy products are treated. The tax burden as well as the tax base of the existing fuel tax changed considerably between 1988 and 1992, and even an explicit hybrid carbon/energy tax was introduced in 1996. Furthermore, this tax is combined with specific incentives to stimulate investments in non-fossil-fuel-based energy technologies, such as biomass, solar and wind power, and its revenue is used to lower other taxes.

At face value, the Dutch reform appears suboptimal from the traditional regulatory perspective. According to the Pigovian view, efficient taxes on so-called 'large number' externalities should be direct and uniform, i.e. a uniform rate on the emission itself (Baumol and Oates, 1988). Energy taxes, however, are examples of the *indirect* taxation of emissions. Moreover, as will be explained in further detail later, these taxes are *not uniform* in the Dutch case. This raises the important question of how to judge this green tax reform. Does the reform provide the right incentives to curb climate change emissions? Or is it a relatively distorting way to raise revenue, given that at least part of the tax revenue is raised on intermediate goods?

The benchmark for the traditional view is a government that chooses efficient taxes to internalize externalities (for homogeneous agents) in economies with full information. However, recent theoretical developments suggest that indirect and even non-uniform taxes, such as energy taxes with exemptions, can be efficient instruments in a second-best environment (see: Bovenberg and Goulder, 2001; Fullerton, Hong and Metcalf, 2001; Cremer and Gahvari, 2001; Smulders and Vollebergh, 2001). With a revenue-raising government or (endogenous) transaction costs included, the choice of an optimal energy tax structure has to reflect appropriate (indirect) incentives for emission reduction and weigh also the role of these taxes as a revenue-raising instrument. In fact, the choice of the optimal regulatory tax *base* is an essential ingredient of the policy of the government. The main lesson from this literature is that environmental tax policy evaluation should not only look for explicit taxes on emissions or their statutory rates, but also evaluate the *effective* emission tax burden across products and its uses, sectors and agents from both a regulatory and a revenue-raising perspective. To provide such an evaluation is the main purpose of this paper.

My major concern is the choice of the energy tax base and rate structure to lower the levels of climate change emissions, in particular CO_2 emissions, due to the use of energy products (oil, gas, coal, electricity) as an (intermediate) input. Therefore the focus of this evaluation is the use of energy for heating purposes (including power generation), and not for combustion in transport (see Fullerton and West, 2002). Careful examination of the optimal energy tax structure in this case reveals the importance of heterogeneity in production processes using energy as a heating fuel (Smulders and Vollebergh, 2001). Sectors differ not only in their energy elasticities but also in their input–emission linkage. For instance, if sectors use residual gases, input taxation is likely to exacerbate emissions. Furthermore, energy is an intermediate input produced by upstream sectors, which introduces the choice as to where it is optimal to levy the indirect tax. Finally, sectors may also differ as to how costly it is to implement (additional) tax. Consequently, non-uniform input taxes including exemptions can be efficient from the regulatory perspective. Also higher energy taxes on households may add to Ramsey considerations in raising energy tax revenue with lowest distortions.

Interestingly, much of the current rationale of the Dutch energy tax structure follows from a sometimes even accidental recognition of this heterogeneity. For instance, the current Fuel Tax (FT) does exempt residual gases. This exemption is optimal from the regulatory perspective, as will be explained later in detail, but its existence is only due to a ruling of the Dutch Supreme Court on completely different grounds. Similarly, the newly introduced regulatory energy tax (RET) signals green tax reform because of its high amount of revenue raised on a 'green' tax base, i.e. energy use by households and small firms. However, although the RET is (relatively) efficient from a Ramsey perspective, a simple increase in the tax rates of the existing tax on fuels would probably have been better from a regulatory perspective. Thus the revenue-raising tax on energy accommodates important exemptions from the regulatory perspective, whereas the regulatory tax mainly taxes relatively inelastic uses of (fossil-fuel) energy. This just illustrates that higher tax revenues from energy tax bases may not always signal Pareto improvements, even if one restricts the evaluation to the environmental dividend alone.

The structure of this paper is as follows. The next section shows why the changes in the energy tax structure in the Netherlands are a clear example of green tax reform. Next, section 3 discusses the energy tax structure in more detail. Section 4 presents criteria for evaluation based on recent theoretical work in optimal corrective tax theory. Section 5 evaluates and section 6 concludes.

Finally, some limitations of this evaluation should be mentioned. First, I simply take the policy objective of the Dutch government for granted, i.e. the Netherlands aims to reduce climate change emissions by means of energy taxes. Therefore, interaction with other policy goals, such as other environmental problems or congestion, is not discussed.[1] The same applies to the interaction with other environmental policy instruments. Finally, the reader interested in the effectiveness of the energy tax structure reform should consult other sources.[2]

2. TAXING ENERGY PRODUCTS IN THE NETHERLANDS

This section presents the energy tax structure in the Netherlands in detail. It shows that the change in the tax treatment of different energy products meets the two major conditions for green tax reform. First, the taxation of ‘polluting’ energy products raises more revenue on all measures than ever before. Second, major shifts can be observed in its incentive structure: not only is the consumption of more energy products subject to tax, but also the tax rates are now more closely linked to differences in pollution characteristics across these products.

Revenue aspects

Taxation as a means of creating direct incentives to reduce the climate change impacts of energy products has a long history, albeit its revenue-raising impact has always been modest. Although the origin of the FT dates back to charges introduced in the early 1970s, when the

[1] Climate change emissions are, of course, only a subset of externalities related to the burning of fossil fuels. Ideally, green tax reform should take account of the cost of the whole vector of emissions and their shadow prices including the ‘green’ energy product substitutes, such as biomass, wind and solar power. Viscusi et al. (1994), for instance, estimate the social cost of different energy products related to smog, damage to the ozone layer and acid rain. See Newbery (2003) for a discussion on the interaction of corrective taxes with multiple externalities, in particular congestion.

revenues were used to finance government outlays for combating pollution, reducing climate change impacts as a reason to tax energy products dates back to the end of the 1980s. As in most European countries, energy taxes predominantly piggybacked on existing excises on mineral oils (mainly motor fuels), and only a few very small taxes on coal and uranium were added. In 1988, excises on mineral oils and the FT together were responsible for 4% of total tax revenue in the Netherlands (see Table 1). [INSERT TABLE 1] The FT and an inventory tax on oil products contributed rather little to these revenues.

Since 1988, the relative importance of energy taxes has increased considerably. First, the FT became more important as a revenue-raising instrument. This tax has grown out of a set of small charges with a rather complicated tax base for financing purposes (including air pollution and noise).[3] After these charges were transformed into a transparent tax on fuels in 1988, their rates were raised substantially at the beginning of the 1990s. Second, the Dutch government introduced a completely new tax in 1996 to regulate energy consumption and reduce CO_2 emissions. This tax, the RET, has been introduced despite the failure of the European Commission to introduce an EU-wide carbon tax.

As a result, the role of the mineral oil excise (MOE) has declined from almost 100% of overall energy tax revenue in 1988 to only 66% in 2002. Together, all energy taxes accounted for 8.8% of total tax revenue in 2002. Even though the total tax burden (excluding social security contributions) of the entire Dutch economy fell from 26.3% in 1990 to 23.6% in 2001, tax revenue from energy products has almost doubled as a share of GDP. Not surprisingly, it is now more important both as a share of overall tax receipts and as a share of the indirect tax burden (including value added tax or VAT). The major tax reform in 2001 reinforces this trend. Aside from a revision in the income tax, the government has raised the tax rates of the RET and the VAT further (from 17.5% to 19%).

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[2] For instance, Linderhof (2002) finds clear evidence from household microdata that residential use of gas and electricity is affected by the energy tax reform.

Tax bases and rates

The shift in the tax treatment of energy products underlying the rise in revenue excluding VAT is illustrated in detail in Table 2. [INSERT TABLE 2] The table not only reveals large differences in the current treatment of energy products by the different energy taxes, but also shows how the newly introduced taxes, in particular the FT and the RET, broaden the tax base. These taxes are responsible for the inclusion of energy products such as coal, natural gas and (small-scale consumption of) electricity as well as mineral oils used for heating purposes. In particular, the RET is responsible for from over 50% to 100% of the excise burden of some products. Note also that large differences exist between tax rates on energy products used as motor fuels, heating fuel, feedstock or for other applications. In general, MOE tax rates are highest for gasoline and lowest for mineral oils used for heating purposes. All excises are specific per unit of energy volume. The FT has had a hybrid tax base since 1990. Initially, a fixed CO_2 component was added to the initial tax base by energy content. Since 1992, the different fuels have been (more or less) taxed according to their relative energy and carbon content, each counting for 50% in the overall tax base.

Initially, the RET taxed energy products used for heating purposes (mainly gas in the Netherlands) or power generation (electricity) by small-scale consumers, like households and small firms. However, the tax base has been broadened since the RET's introduction in 1996 and now also includes consumption by intermediate firms. Tax rates are degressive with the level of consumption for each connection to the grid, and very large electricity consumption levels face a zero rate. All products are also taxed according to the normal VAT rate.

Together, these taxes create the incentive structure on *energy products* used for heating or power generation. Note, first of all, that *mineral oils* not used as motor fuels are

[3] Later, other tax bases were introduced, such as a tax on groundwater extraction, water and landfills.

subject to all the taxes. The much lower MOE on mineral oils used as heating fuel is compensated partly by the RET. Crude oil is only taxed indirectly, i.e. downstream *after* the refinery process, by the taxation of refined mineral oils (gasoline, etc.). Accordingly, the energy consumed (and emissions caused) by refining is excluded from the tax base, as are particular refinery products, such as petrocokes and liquid and gaseous residuals, which are often recycled in the same plant.

The Netherlands is one of the few countries that taxes and not subsidizes *coal*, although still at a low rate (coal mines were closed at the end of the 1960s). Interestingly, (large) consumers may opt for different calculations of the tax base for the FT, either a fixed amount per tonne or a fixed amount per GJ and per unit carbon. The latter option is profitable for consumers using coal categories with quality characteristics different from the category on which the fixed amount per tonne is based. Note also that special provisions exist for typical energy products produced and recycled in production processes based on coal, such as steel production. For instance, there are exemptions for blast-furnace and coke-oven gas, if recycled within a particular (large) plant. Only if these products are traded does the tax apply.

Consumption of *natural gas* (NG) is taxed through the FT, although the tax rate for large-scale consumption is very low. The degressive tax rates of the RET, however, are much stronger, with even no tax applying to large-scale NG consumption. Also, an exemption existed for consumption up to $800m^3$ between 1996 and 2001, but this has recently been changed into a tax credit with equal value in terms of income loss (Euro 142). Finally, reduced tax rates apply to gas consumed for horticulture.

The consumption of *electricity* is, like the consumption of NG, taxed through the RET, including also a degressive rate structure and an exemption for very large consumers. Note that NG input for *electricity production* is exempted from the RET, and all inputs have been exempted from the FT since 2001. Electricity producers originally also had to pay FT for the use of fuels, such as coal and NG, and a uranium tax was due for nuclear power generation between 1997 and 2001. In 2001, this regime was changed in favor of what is called an ‘output’ tax. Now, all fuels used for electricity generation are exempted, including the fuels used in combined heat and power (CHP) plants (with electric efficiency over 30%). Simultaneously, the tax rates on electricity were raised under the RET regime.

Specific *provisions* existed for flue gas desulfurization in the FT between 1988 and 1995. In particular, Euro 1 per tonne of heavy fuel oil or coal could be refunded if these fuels were used in combustion plants from which the fuel gases did not contain more than 400mg SO_2/m^3 and if at least 85% flue gas desulfurization was applied. Finally, several energy products were originally exempted from these energy taxes, like consumption and production of electricity from *biomass, wind and solar power*. Since January 2003 these products are taxed at a reduced rate. Methane is still subject to zero-rate MOE.

The *revenue* raised by these taxes is also treated differently by source. Both the MOE and the FT are traditional revenue-raising instruments. However, specific provisions exist for the RET because this tax was introduced as part of a (balanced-budget) green tax reform. Both industry and households have been compensated by lower income and corporate tax rates as well as employers’ social security contributions. Part of the revenue raised by the RET is spent on subsidies that aim to improve energy efficiency and reduce CO_2 emissions. In particular, (decentralized) subsidies exist for the generation of electricity using biomass, wind, solar power and CHP by producers, as well as for insulation and energy-efficient products bought by households.

Summarizing, the Netherlands clearly experiments with green tax reform: by all measures, direct taxation of energy products has become more important over the last decade. Overall, energy taxes are responsible for 59% of the revenue raised by environmentally related taxes.[4] Furthermore, energy tax reforms in the Netherlands over the last decade reflect an interesting broadening and reform of the energy tax base (and rates), even though several exemptions have been introduced.

3. ENERGY TAX STRUCTURE AND CLIMATE CHANGE

The current energy tax structure in the Netherlands reveals that different energy taxes affect different energy products differently. Some products are subject to all three energy taxes, while others are taxed only through one tax. Also, the tax bases of the different taxes vary with price and energy product characteristics, such as energy or carbon content. Finally, the different energy taxes are often not uniform, i.e. taxation of the products also depends on which agent consumes the product.

Table 3 specifies how two energy products, light fuel oil and natural gas, are affected by the various energy taxes and including also VAT. According to Dutch tax law, the overall tax on *light fuel oil* (LFO) comprises three elements:

- a specific excise at a rate of Euro 47 per 1,000 liter according to the MOE Act;
- a specific FT and the RET at rates of Euro 14 and Euro 132 per 1000 liter, but levied according to the fuel's energy and carbon content on a 50/50 basis relative to crude oil for the FT and relative to natural gas for the RET;
- VAT at an ad valorem rate of 19% on the net retail price plus all specific taxes.

The tax structure of *natural gas* (NG) consumed by households is as follows:

- a specific excise, based on both the FT and the RET, at an overall rate of Euro 135 per $1000m^3$, and levied according to the fuel's energy and carbon content on a 50/50 basis;
- VAT at an ad valorem rate of 19% on the net retail price plus all specific taxes.

[4] In 2000, total environmentally related tax revenue (including a tax on groundwater extraction, water use and landfills and taxes on the purchase, possession and use of cars) amounted to Euro 13.8 bln.

The problem with this (common) representation of the energy tax structure is its poor informative content with respect to its (regulatory) incentives. Volume of the fuels is a poor indicator of the relative performance of energy products for heating purposes. Although an increase in the tax rate per unit of volume always induces agents to look for cheaper alternatives, the impact of a similar rise in tax differs across products due to differences in, for instance, heating potential. To account for such differences across goods characteristics, Table 3 presents a standardized decomposition of energy taxes per GJ. [INSERT TABLE 3] The table illustrates the importance of standardization of the tax base for the evaluation of the tax impact. One immediate observation, for instance, is that the apparently higher total excise tax on LFO than on NG is much smaller after normalization. The relative difference declines from 1.47 (198/135 in Table 2) to 1.28 (5.49/4.27 in Table 3).

Furthermore, the linkage between emissions and input use varies across products, even for a standardized representation of inputs in GJ. For instance, LFO is more pollution-intensive per unit of (standardized) fuel than is NG. The relevance of such quality differences across products are well known and usually call for a well-targeted choice of the tax base. Indeed, the choice of quality *between energy products* is an important dimension of the regulatory incentive provided by the choice of the tax base. This is typically translated, in the climate change context, into taxes that should differ across energy products according to the carbon content of these products.

Finally, even for *one and the same product* the choice of the tax base and rate is a delicate issue. An energy product can be mutable or it might be produced under conditions of imperfect competition. If so, the choice between ad valorem and specific rates for one and the *same* energy product matters.[5] Energy markets are typically not known for their competitive

[5] See Keen (1998) for a discussion of why the equivalence theorem of *ad valorem* and *specific* taxes no longer holds under mutability and imperfect competition.

character (although this might change in the next decade). More interestingly for our purpose, the quality of one and the same product is a choice variable as well. Even though (the production of) energy products face(s) typical technical limitations due to materials balance constraints, even goods characteristics of an energy product are mutable. Examples include gasoline such as Pura from Shell, but also variants of coal with much lower sulfur content. Indeed, the linkage between specific product characteristics and their associated emissions is particularly important for the choice between different regulatory tax types.

To account for differences in goods characteristics and net-of-tax prices across energy products, it is useful to introduce some tax ratios using the previous example:

- First, the *total (effective) tax burden* T is equal to the ratio of the sum of all taxes to the gross retail price, or $T = [t_s + t_a(p_n+t_s)]/p$. For LFO, this ratio reads Euro 8.22 (the sum of all taxes) to Euro 17.09 (the gross retail price), which is 0.48 or 48%; for NG, it is 0.47 or 47%. Thus the difference in retail price between LFO and NG is only slightly enlarged by differences in the tax system.
- Second, the *overall share* S is the share of specific excises in total tax, or $S = t_s/[t_s + t_a(p_n+t_s)]$, which is 67% for LFO and 66% for NG. Apparently the share is almost identical for the two products even though their net retail prices differ considerably and only LFO is subject to the MOE. Thus the higher absolute amount of specific excise for LFO does not change the relative price differential excluding taxes. Note, however, that specific excises have a different impact, even if no retail price differences exist, due to differences in characteristics of the energy products (such as energy or carbon content). Because not all characteristics of the products are taxed, selective taxation induces a shift towards untaxed elements, causing a so-called *upgrading effect* (Keen, 1998, p. 6). Firms may choose to alter the characteristic composition, or the market equilibrium between different variants of the same product (with 'fixed quality') is affected.

- Third, the *linkage share* L is the share of specific excises with a particular emissions-related tax base in the total amount of specific excise, which is 39% for LFO and 46% for NG for the carbon tax base.[6] One would have expected a higher share for LFO because LFO contains more carbon per unit of (useful) fuel than NG. The reason for this anomaly is an allowance provided by the Dutch government for LFO since the rise in the RET tax rate in 1999 (see below).[7] Finally, note that the linkage share reflects one specific aspect of the upgrading effect – how much of the specific excises is directly linked to environmental characteristics (one in this case). The measure is particularly useful for products used as inputs in production or final consumption, such as energy products. The higher this share, the more targeted is the environmental incentive.
- Fourth, the *multiplier* M is the ratio of the gross retail price to this retail price excluding ad valorem taxes, or $M = 1/(1–t_a)$. Both LFO and NG are only taxed through the standard VAT rate of 19% of the net retail price plus specific excises. Accordingly, M is entirely similar for LFO and NG.[8]

The overall picture is that the absolute tax burden is considerable, with specific excises being responsible for almost half of the gross retail price. Interestingly, the higher (standardized) absolute tax burden for LFO than for NG is modest though significant in terms of *relative* prices. The net relative retail price differential between LFO and NG per GJ is 1.19, whereas the overall tax differential raises the gross price differential to 1.23. This rise is only due to differences in specific taxes, in particular LFO being subject to the MOE whereas

[6] Calculations reflect the CO2 component in the specific tax base based on emission factors of fuels used by the Dutch Ministry of Finance in 1997 (see Vermeend and Van der Vaart, 1997). Available on request.

[7] The calculation above is based on the assumption that the allowance is distributed equally over both underlying tax bases. If the hybrid tax base applied across the board, L would typically be 46% for LFO. Also for the FT and RET alone, i.e. excluding the role of the MOE, the linkage share rises only to 47% for LFO.

[8] The multiplier reveals that firms must increase the price charged to the consumer by more than Euro 1, i.e. Euro $1/(1–t_a)$, in order to increase their net price by Euro 1. Part of any increase in the consumer price goes to the government as tax revenue, and this creates a disincentive for costly improvements in product quality (see Keen, 1998, p. 5). Because no *ad valorem* taxes other than VAT are applied to energy products, M is typically similar for all products. Note also that VAT does not have a direct impact on firms' input decisions in a competitive market because they are able to shift their tax burden fully forward to the next stage of production.

NG is not. Furthermore, the recent overall allowance in the RET tax rate for LFO indeed compensates for the difference in treatment by the MOE, but also reduces the linkage effect. Apart from the modest incentives for substitution *between* the two energy products, we can also observe that the upgrading effect tends to dominate the multiplier effect as far as costly improvements in product quality are concerned. This effect, however, is not yet fully exploited from the climate change perspective, as the linkage share is well below 50% and does not even reflect these environmental impacts properly.

Table 4 characterizes the current overall energy tax structure in the Netherlands using the tax ratios introduced above. [INSERT TABLE 4] First, there is great variation in the total tax burden T across energy products. In particular, mineral oils used as motor fuels face a very high tax burden, e.g. 78% in the case of regular gasoline, whereas the (marginal) burden for a large industrial consumer of NG or electricity is only 20% or 16% respectively. Second, the role of specific excises more or less correlates with this overall picture. Interestingly, this share is lower for energy products consumed by firms. The only exception is coal, where the FT is the dominant factor in raising its tax-inclusive price relative to its substitutes. This excise alone raises the net retail price of coal by 26%, while this effect is only 17% for heavy fuel oil and not even 5% for large consumers of NG. Thus the much higher specific excise burden on coal strongly compensates for its lower net retail price.

One important reason for these differences is the use of product characteristics in defining the tax base of both the FT and the RET. The tax structure reveals remarkable differences in its linkage share L. The recognition of carbon characteristics in defining the overall excise burden for energy products used for heating purposes is significant, at generally 50%. Linkage is particularly limited for oil-based fuels, while 61% of the specific tax burden of coal is directly linked to carbon.

Summarizing, the particular energy tax structure in the Netherlands reflects a modest, though certainly not insignificant, effect of the introduction of green tax reform. In particular, the introduction of the RET has broadened the energy tax base being mainly responsible for higher rates on small-scale NG consumption and the taxation of electricity. Furthermore, despite its low tax rates, the effect of the FT should not be underestimated, given its wide applicability, in particular to (very) large consumers of coal and NG. As a result, the tax burden on (downstream) consumption of fossil fuels for heating purposes, such as mineral oils, small-scale NG consumption and electricity, is now significant in the Netherlands.

4. TRADING OFF REGULATORY AND REVENUE-RAISING OBJECTIVES

This section explains the relevance of recent developments in the theory of optimal corrective taxation for the assessment of the Dutch energy tax structure. First, I discuss how constraints on the set of instruments change the optimal corrective tax rules. Next, the consequences of these adaptations for energy taxation in particular are explained.

Optimal tax rules

Economists usually consider taxes as appropriate instruments for regulating environmental problems. Environmental economists especially stress their admirable role as a cost-efficient incentive mechanism to internalize environmental externalities. This view reflects the traditional Pigovian approach, which follows a rather narrow *regulatory perspective* on the role of environmental taxation (Baumol and Oates, 1988). According to this view, a uniform tax on effluents that reflects marginal damage of externalities in the optimum would be sufficient to reproduce the first best. So a tax on carbon emissions equal to the associated marginal damage in the social optimum would guarantee a welfare improvement due to the environmental dividend gained by the internalization or regulation of the externality.

The optimality of this classic Pigovian tax follows from (at least) two essential conditions:[9] (i) the government has no revenue-raising objective; and (ii) the set of available instruments for regulation is unconstrained. The first condition has been challenged in the literature on (potential) double dividends of green tax reforms in the 1990s. The (traditional) benchmark here is the optimal targeting principle reflecting both the Pigovian and optimal tax considerations (Sandmo, 1975). That is, if taxes face the dual task of correcting for externalities and generating revenues to finance public spending, the optimal tax rules typically suggest correcting externalities through externality taxes and using 'other' tax instruments for other public policy objectives.

For instance, in a typical second-best model with polluting consumption and a distortionary labor tax, both the optimal tax rate on consumption and the optimal labor tax reflect the Ramsey rule for raising revenues with the lowest costs to private incomes. At the same time, the tax on dirty consumption also faces a Pigovian component that corrects for the environmental externality (Bovenberg and Goulder, 2002). Thus the typical second-best aspect is the correction of this Pigovian component for the marginal cost of public funds (MCPF) – that is, the ratio of the shadow cost of raising government revenue to the shadow value of an incremental increase in private income. That environmental tax reforms, i.e. switching from (distorting) labor taxes to (distortion-reducing) energy taxes, do not necessarily reap a double dividend typically follows from this modification. If the MCPF is high, i.e. raising public revenues is already expensive, then the (social) benefits from pollution abatement should be relatively higher to justify a given environmental tax. Only if the tax reform moves the tax system closer to its non-environmental optimum would an

[9] Another condition is that a uniform tax on effluents is *optimal* only if (consumption) externalities depend on aggregate demand (Diamond, 1973, p. 527).

improvement of both the labor market and environmental quality be possible (Bovenberg, 1999).

The policy implication for the optimal tax structure of the targeting principle is that tax rates on the externality-generating commodity should reflect a balance between both tax principles. The presence of an externality only alters the tax formula for the externality-generating commodity, and this is independent of, for instance, energy being an intermediate input or a final consumption good (Bovenberg and Goulder, 2002).[10] Even with the targeting principle, trade-offs between regulation and revenue-raising goals are inevitable for a given tax structure. If, in the status quo, the MCPF is large, the regulatory tax should be (relatively) low. Thus, if elastic goods are taxed at (relatively) high rates, a large additional regulatory tax on these goods would further exacerbate the tax distortion because the MCPF is large. Not only will it be optimal to have a lower environmental tax, but the government might improve overall welfare by finding other, less distorting ways to 'internalize' the externality.

The benchmark for this traditional second-best view is a government that has access to efficient taxes to internalize externalities. In other words, the previously mentioned second condition of an unconstrained set of instruments holds. This condition, however, has been challenged in a set of recent papers that apply second-best analysis to the choice of the *type of tax* (Fullerton, Hong and Metcalfe, 2001; Smulders and Vollebergh, 2001; Cremer and Gahvari, 2003). If, for some reason, it is very costly to implement an agent-specific emission tax, other taxes, such as uniform taxes or taxes on inputs or outputs, might provide efficient alternatives. In such a second-best environment, the choice of the optimal regulatory tax *base* is an essential ingredient of the policy of the government.

In a series of papers, Cremer et al. (1998, 2001 and 2003) have finally shown that the targeting principle might fail in economies characterized by emissions that are not publicly

[10] Note, however, that the Ramsey component is still equal to zero for the intermediate good.

observable. In a model that analyzes the choice between emission and output taxes in an economy with imperfect observability of emissions, Cremer et al. (2003) show that the production efficiency rule is violated. The reason is that in their model, the effect of a marginal increase in emissions on the unit production cost varies across industries (due to differences in concealment costs). This has the important implication that (emission) tax rates have to differ across industries. As a consequence, output taxes have a Pigovian role to play in their model, because the concealment problem prevents the emission taxes being set equal to the full marginal social damage of emissions.

Comparable findings are reported by Smulders and Vollebergh (2001) in a setting with sector-specific abatement but without a revenue-raising goal of the government. In their model, second-best considerations arise due to the assumption of administrative costs associated with different types of taxes, such as emission or input taxes. In choosing between environmental taxes, the targeting principle asks for taxes that are closely 'targeted' to the problem at stake. That is, the better targeted the instrument is to emissions, the smaller is the opportunity cost of losing incentives. Indirect taxes also regulate the emission intensity of an economy, but potentially at a cost of not exploiting all substitution mechanisms available for emission reduction.[11] If sectors differ in terms of their gross abatement potential, the optimal tax rule should balance this potential with sector-specific administrative costs for each type of tax. In this model, (sector-specific) input taxes have a Pigovian role if administrative cost are high (across sectors) relative to the gross abatement potential (of this sector).

[11] Note that, in general, four substitution channels can be exploited by a tax system that aims to internalize externalities. First, output substitution accounts for the substitution between dirty and clean products. Second, input substitution is the replacement of dirty by clean inputs, such as labor. Third, linkage substitution replaces emission-intensive inputs for emission-extensive energy inputs, such as high-sulfur for low-sulfur coal. Fourth, abatement might separate emissions from input use.

Energy taxation

What are the implications of these optimal tax rules for the taxation of energy products, i.e. choice of tax base and rate structure, given the climate change issue? Indeed, by taxing energy use energy consumption will be reduced, and thus the (set of) associated emissions. Smulders and Vollebergh (2001) explore in detail the conditions for specific energy taxes to be efficient substitutes for emission taxes. With close linkage between energy use and emissions, and if abatement of emissions (as an alternative means to reduce the pollution intensity of production besides changing the input mix) is relatively costly, taxes on polluting inputs such as energy may supplement emission taxes that fall short of marginal damage to internalize pollution externalities more fully. If linkage is close and abatement expensive, and if administrative costs associated with energy taxation are also sufficiently low relative to administrative costs associated with emission taxation, taxes on energy inputs should even fully replace emission taxes.

This 'modified' Pigovian rule implies, for the climate change tax *base*, that all polluting inputs could be taxed according to their environmental goods characteristic responsible for the regulated emission ('linkage') unless sufficient options for abatement exist. Thus, instead of taxing carbon emissions from combustion, additional tax may be levied on heating fuel inputs, on the assumption that environmental damage is proportional to the amount of input used. Also, a broad tax on fossil-fuel-based energy products is efficient if a potential gain in savings on administrative costs outweighs the cost of not exploiting direct abatement opportunities.

Two further complications arise, however. First, energy is not a homogeneous product and is typically produced as an intermediate input for firms and households upstream within the energy production sector. Second, energy use differs fundamentally across production sectors. In some sectors energy use is restricted to input use in a typical combustion technology, but in other sectors it is part of a very different joint production technology, like in steel making and oil refining. Optimal regulatory tax policy rules should therefore acknowledge heterogeneity in (emission) technology across sectors. Indeed, sector-specific exemptions or non-linear taxes may be justified if input-emission linkage fails or (additional) administrative costs are prohibitive for sectors.[12] The consequences of such heterogeneity for the choice of the energy tax base and rate are explored in detail in the next paragraphs.

First of all, it is typically assumed that an energy-based carbon tax should apply to fossil-fuel energy composite – that is, to *all fossil-fuel energy products*. Any consumption of these fuels causes emissions, and therefore each energy product should be taxed where it is actually burned. However, this presumption is rather strong. An important choice exists between what Pearson and Smith (1992) have called a 'primary' carbon tax and a 'final' carbon tax. A 'primary' carbon tax would be one that was levied early in the chain of production and processing, or 'upstream', i.e. on raw energy sources at the point where they are mined or extracted (coal mines, oil wells, etc.). A 'final' carbon tax, on the other hand, would not be levied until much later in the chain of energy production and processing, or 'downstream', i.e. at the point where energy sources had been converted into final fuel products sold to business and domestic energy consumers. Thus the main difference between the two approaches concerns production processes in which primary ('raw') energy is processed into energy products suitable for use at later stages of the production and consumption chain.[13]

Obviously, the primary carbon tax establishes the best linkage to (potential) emissions, because it implicitly accounts for emissions in the production stage of the final fuel products by taxing the carbon content of the raw materials. The linkage with carbon emissions in the energy production and consumption chain is much weaker if the tax is based on the carbon content of

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[12] For instance, if a particular tax already exists in the status quo, environmental tax reform could take advantage of the sunk administrative cost associated with this tax.
[13] See Pearson and Smith (1992) for a discussion of the pros and cons of both types of carbon taxes.

the final fuel products. If an assessment of the whole chain of fuel production and processing from the primary stage until the point at which the tax is levied can be made, an appropriate linkage could be established. This, however, calls for an estimate of the level of such emissions to be included in the amount of tax that should be paid on each final fuel product. Such an estimate would need to be based on assumptions about the processing of fuels, and these will inevitably be imprecise. Since they will have to be based on average practice, no incentive for greater carbon efficiency during processing is provided.

Another example of the type of problems that may arise is that *electricity* consumption may run the risk of 'double taxation', i.e. a tax on both (fossil-fuel) inputs and output. Although electricity as such is not polluting, a downstream tax on electricity consumption has the advantage of discouraging this relatively inefficient use of fossil-fuel energy. Conversion losses in the electricity sector are, on average, much higher than in the direct use of these fuels. Furthermore, if the tax were levied on the distributors of electricity, the government could combine it with incentives to stimulate these substitutes, including CHP facilities. Without a tax on upstream fossil-fuel inputs in electricity production, however, the upstream emissions are only implicitly taxed if the fossil-fuel inputs are not exempted from a broad-based energy tax. Thus a trade-off exists between more efficient use of energy in particular applications, such as the generation of heat, and the comprehensiveness of the (indirect) input tax base.

A second issue is that energy use in *some complex joint production processes*, such as steel making, oil refining and other related chemical processes, deserves special treatment.[14] For instance, steel-making companies that use coke-oven gas (a by-product of coke manufacturing) as a fuel in their coke ovens, boilers and reheat furnaces in fact recycle or 'abate' carbon emissions (Ayres and Ayres, 1998). The same holds for other by-products in

[14] Also Poterba and Rotemberg (1995) acknowledge the importance of joint production of energy sectors. They focus, however, on the implication of unilateral carbon taxes for border tax adjustments.

steel making and oil refining, such as blast-furnace gas, coal gas, petrocokes and other liquid and gaseous residuals. Energy inputs and carbon emissions could easily become substitutes if these gases were taxed, and environmental externalities would be exacerbated instead of reduced. In other words, the use of these residuals should be optimally exempted from a regulatory energy tax. [15]

Other issues of heterogeneity relate to *specific carbon abatement opportunities* that are not distributed randomly across agents. Usually, carbon abatement options are taken into account which are entirely separable from existing production processes, such as 'offsetting' techniques like carbon sequestration. Recently attention has grown for another set of opportunities, such as large-scale storage using monoethanol and decarbonisation in integrated power plants or in other gasification processes (Anderson and Newell, 2003). These options, however, are mainly related to large existing fossil fuel based production processes, in particular to electricity production and the joint production processes of oil refining and steel making.

An energy tax design based on fossil fuel input use would not provide any incentives for such abatement options. Therefore, in order to provide proper incentives from a regulatory perspective the tax should allow for agent-specific tax rebates. Accordingly, one mimics a 'net' carbon emission tax base by allowing agents to subtract taxes due from their overall energy tax bill. This also accounts for a natural limit to this subsidization because the rebates would never exceed the original amount of tax due.

A final consideration in (optimal) energy tax design is how to avoid unintended distortions on other margins of choice. As Keen (1998, p.20) has shown, regulatory energy taxes should be related to the underlying externality-causing goods characteristic (Keen, 1998, p. 20). Thus a *specific* tax on the carbon content of a fuel is the best-targeted indirect

[15] Note that taxation for revenue raising purposes is not effective in these cases as the energy tax could easily evaded by burning off residual gases.

instrument in the case of climate change, whereas an *ad valorem* tax would also penalize characteristics that are not responsible for climate change, such as the heating potential of energy products. But specific taxes also have important caveats. For instance, climate change is not the only environmental externality that an energy tax should address. Other environmental problems, such as acid rain and smog, are well known. The heterogeneity of production processes in terms of their emission profile across different environmental dimensions can be considerable. If specific taxes tend to stimulate different adaptations in production processes, they might even generate important trade-offs. Whether carbon, energy content or any other characteristic provides the best incentives is an issue of optimal targeting in itself.[16] In this paper, I simply assume that carbon is such an appropriate indicator, given other policy efforts to internalize other environmental externalities.

Conclusion

To conclude, first of all, uniform corrective taxation is not always the best solution to 'repair' an externality. Specific sectors might be optimally exempted from indirect environmental taxes. Emissions and inputs can be substitutes in some sectors, and administrative cost might be prohibitive (relative to the abatement potential). Second, the complicated interplay between regulatory and revenue-raising objectives can no longer be solved by the targeting principle in all circumstances. Although the fundamental idea that more direct instruments are beneficial to society still remains valid, these benefits should be weighed against efficiency losses due to other second-best elements, such as heterogeneity in administrative or abatement costs. Third, higher tax revenues from an environmental tax base need not signal optimal tax reform. Higher tax revenues on some energy inputs, or equivalently, lack of appropriate abatement

[16] Note that the solution here is not a simple aggregation across externalities by translating them into one common measure (money value) and then adding the (marginal) values in order to find the optimal tax *level*. The problem is that emissions can become substitutes if taxes are well targeted in different environmental policy dimensions, which is related to the choice of the tax *base*.

incentives, may even exacerbate emissions, whereas alternative tax bases (e.g. consumption) may raise revenue at lower (distortionary) cost.

5. DUTCH ENERGY TAX POLICY LESSONS

What can we learn from the energy tax structure developments in the Netherlands? At face value, regulatory considerations seem to be dominant. Whereas the FT (and the MOE) has been designed for revenue-raising reasons, the newly introduced RET raises much more tax revenue but also claims to focus on the regulation of fossil-fuel energy use and its associated (climate change) emissions. As a reference for the subsequent discussion of the choice of the overall tax base and rates of the energy composite as well as potential improvements, Table 5 summarizes the main characteristics of the FT and the RET. [INSERT TABLE 5]

Choice of energy composite tax base

A first observation is that the FT, not the RET, is mainly responsible for the remarkable comprehensiveness of the Dutch energy excise structure from a climate change perspective (see also Table 2). The FT taxes coal and NG upstream (if used as fuel or if distributed to others for domestic use) and oil through a tax on refined oil products. In contrast, the RET mainly focuses on the downstream consumption of the major energy products consumed at the household and small-firm level in the Netherlands, i.e. NG and electricity. Only the direct taxation of electricity has been added to the energy tax base, while NG is now also taxed at the household level.

The choice of these energy tax bases reveals intriguing paradoxes. First of all, the upstream taxation of energy products is considered particularly distortive from the revenue perspective, whereas the downstream taxation of energy products implicitly exempts upstream emissions. Thus the choice of tax base is precisely opposite to the main purpose of both taxes. One wonders why a *specific* excise, like the FT, has been introduced for revenue reasons because energy consumption is already taxed through the VAT. The explanation for this ‘anomaly’ is that the FT replaces a system of small environmental charges. Therefore its tax base had to be linked to ‘the environment’ (even though its revenue no longer has to be used for environmental expenditures). The RET has always been regarded as a unilateral environmental tax, which should exempt exposed energy consumption, i.e. upstream energy use by energy-intensive industries and electricity producers.

Second, the choice to tax climate change emissions indirectly through energy (input) use is particularly viable if such indirect taxes already exist in the status quo and the welfare loss due to less emission-specific incentives is small. Indeed, carbon emissions are closely linked to energy use and the FT provided an excellent opportunity to reduce additional administrative costs for a targeted *regulatory* input tax. This tax applied to most energy products, except electricity and crude oil, and all (upstream) consumers, although lower rates apply to large energy-intensive firms (see below). Adding a small CO_2 excise component to the original excise rates based on energy content in 1990 made perfect sense, just like the reform into a hybrid energy tax based on CO_2 and energy content in 1992. After the failure of the European hybrid tax on energy, further increases in the tax rates of the FT would have been logical, given the relatively cheap options for carbon abatement in the energy-intensive industries. This option has not been pursued, though, due to fear of tax-based relocation of the (large) energy-intensive industries in the Netherlands. The choice of the Dutch government to introduce another tax, the RET, primarily aimed at the sheltered sectors with their rather inelastic consumption of NG and electricity, however, makes more sense from a revenue-raising perspective. It is rather unlikely that the much higher cost of carbon abatement by the non-exposed sector, together with the higher administrative cost, outweighed the cost of a rise in the tax rate of the FT.[17]

[17] Therefore the only administrative economies of scale are the concurrence of the excises taxed under the FT with the oil tax base of the MOE, and in the taxes due from households because the excise on electricity and NG under the RET are due from the energy distribution firms. Additional administrative costs for small-scale consumption of NG and electricity, however, were also rather limited because the network for delivery is almost

Another set of paradoxes is apparent from the current energy excise structure, which is mainly of the 'final' carbon tax type (see section 4). Only the FT on coal and NG applies to upstream fuel use, but CO_2 emissions associated with the production of several energy products of the final type are exempted either implicitly, as in the case of crude oil, or explicitly, as in the case of electricity production.

Note, first of all, that none of the excises (including the MOE) taxes fuels that are used in *refinery processes*. In the case of mineral oils, the FT is (like the MOE) a typical 'output' tax, leaving the main fossil-fuel input, crude oil, untaxed. Consequently, carbon emissions in the refinery are exempt. Attempts by the Dutch tax authority to bring own consumption of the residuals of refinery processes, such as refinery gases and petrocokes, under the jurisdiction of the FT failed. The decision settled by the Dutch Supreme Court in 1999 was based on the presumption that other excises on mineral oils could not be applied outside the realm of the MOE. European harmonization of excises on mineral oils would not leave room for other (revenue-raising) excises to be applied to refineries.[18] Paradoxically, this decision improves the (implicit) regulatory incentives of the FT, as the taxation of residuals clearly favors substitution towards untaxed elements in the refinery process, or even towards flaring. The taxation of fuels for revenue-raising purposes would clearly result in *more*, instead of less, CO_2 emission. This exemption on fuel use clearly benefits the environment. Note, however, that a carbon tax of the 'primary' type would avoid such problems altogether.[19]

A similar observation holds for the taxation of other *residual gases* from energy-intensive industries, such as steel making. Own consumption of residual gases, such as blast-furnace and coke-oven gases, is currently exempted from the FT, but delivery to other firms is subject to tax (see Table 2). The current exemption is rational from a regulatory perspective

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entirely controlled by energy distribution firms in the Netherlands, and they already exploit economies of scale in the control and monitoring of household energy consumption.

[18] This decision basically follows a decision of the European Court on the applicability of Directive 92/81 on other excises on mineral oils.

because reuse of residuals *always* reduces CO_2 emissions. Therefore it should be made permanent. The same holds for delivery to other parties. The current taxation of the carbon-based input, i.e. coal, already accounts for the (implicit) taxation of carbon emissions, including those associated with the use of residual gases. Bringing these gases under the FT implies double taxation of the carbon contained in this input.

The recent tax reform with respect to *electricity* is another example of the paradox that the revenue-raising FT serves regulatory incentives better than its explicit regulatory alternative. Electricity is only taxed directly under the 'output-based' RET regime, which exempts carbon emissions during electricity production. Until recently the FT also applied to the main inputs for electricity production in the Netherlands, NG and coal. Since 2001, the energy products used for electricity production, including CHP installations, have been exempted from the FT in favor of higher rates of the output-based RET. Accordingly, input substitution by electricity producers to reduce CO_2 emissions is now no longer directly addressed by the energy excise structure.

The main reason behind this remarkable tax shift is a compensation for CO_2 abatement measures as promised by electricity producers according to the so-called 'coal covenant'. Moreover, the measure sustains the promotion of (NG-based) CHP generation in the Netherlands. After the termination of a generous subsidy to any (potential) producer of CHP several years ago, the booming CHP business came to a sudden standstill and even existing installations were threatened.[20] Broadening the NG tax base to include firms of medium size under the RET would impose a further disincentive to CHP. Shifting the tax burden from the FT to a tax on 'output', i.e. the RET on electricity, would lower the tax burden on the generation of electricity. Because the different modes of power generation are treated similarly under this

[19] Use of crude oil as a feedstock in the chemical sector could easily be exempted.
[20] CHP was subsidized in the Netherlands through a fixed price per kWh delivered to the national grid. This price was considerably above the market price for electricity and therefore stimulated a fast expansion of CHP in the Netherlands. Note that CHP is still subsidized by a reduction of the RET on electricity produced from these plants (not larger than 200GWh).

reform, large-scale power plants no longer face input and abatement incentives to reduce climate change emissions.

Consistent with the purpose of the tax is the lack of incentives for *carbon abatement* in the FT. Apart from stimulating CHP generation, the FT has no provisions for ‘carbon’ rebates. Although carbon abatement investments by large energy-intensive firms subject to the FT are profitable even at (very) low rates, they are at odds with the revenue-raising purpose of the tax. And even proposals to favor carbon sequestration through afforestation by providing offsets in the RET have never been put into practice. Firms distributing NG and electricity would have got tax rebates for certified afforestation (under the Carbon Offset Verification System), but not for other carbon abatement investments.

Interestingly, the RET and its associated policy package include typical elements of a two-part instrument for subsidizing energy-efficient technologies and non-fossil-fuel-based energy production (Fullerton and Wolverton, 1997). First of all, electricity produced from renewable resources (green electricity and gas) was originally exempted (zero rate), and it has had a lower rate since 2003. Second, the energy distribution firms might qualify for tax rebates (at given prices) for CHP plants, for the production of electricity from renewable resources and even for subsidies on energy-saving technologies. Also, sustainable production of heat in 100% biomass installations (electricity, heat or both) is stimulated through this subsidy.

Summarizing, taken together the Dutch energy taxes provide comprehensive taxation of energy products. All upstream and downstream fossil-fuel products, except crude oil, are subject to tax. Furthermore, the exclusion of own consumption of residual gases is a clear case of *optimal non-uniform corrective* energy taxation. The extension of this exemption to residual gases delivered to others should even be considered. Finally, the so-called regulatory energy tax shows that green tax reform does not always generate optimal regulatory taxes. Its design clearly reflects several unexploited regulatory incentives that can only be explained by the necessity to guarantee stable revenues. Therefore, one might wonder whether this tax on energy consumption is not a relatively distorting way to raise revenue.

Choice of energy composite tax rates

As far as tax rates are concerned, both taxes are specific with a hybrid structure, while FT rates are much lower than RET rates (see Table 5). With its upstream orientation, the FT also taxes energy-intensive consumers but only at low rates, while the RET taxes the consumption by small firms and households of NG and electricity, the main energy products consumed by these agents, at high rates. Even though all agents are due to pay RET over their inframarginal consumption of energy, energy-intensive industries face no tax at all at the margin.

Again, tax rates on the different *energy products* also hardly follow the logic as implied by the purpose of both taxes. The much lower tax burden for energy products consumed by industry (see ratio T in Table 4) reflects the Ramsey perspective. In general, (energy-intensive) industry is more sensitive to the energy tax base, and distortions are more likely for intermediate inputs, such as heavy fuel oil (HFO), coal and (large-scale consumption of) gas and electricity. Moreover, the VAT is the most important element of the total tax burden for these products and therefore has less of an (upstream) impact because it is shifted downstream to consumers. Thus to tax energy substitutes for households and small firms at a much higher level through the RET primarily makes sense from a revenue perspective.

Furthermore, the two specific taxes raise the overall tax burden in remarkably different ways (see column S). Apart from the VAT, the (normalized) tax burden for the energy substitutes for (energy-intensive) industries is dominated by the FT, and for households and small firms by the RET. As a result, the Pigovian element is exactly opposite to what one would expect. The FT clearly favors NG over oil and coal for the relevant substitutes at the industry level. Coal faces a total tax burden almost twice as high as the tax burden on NG which closely follows the Pigovian logic of indirect taxation according to the (relative) pollution intensity of these products. In contrast, the relative (normalized) total tax burden of heating products for households and small firms, such as NG, LFO and electricity, is similar. Clearly, this burden, which is mainly caused by the RET, appears not to follow the Pigovian logic.

However, closer inspection of the overall *upgrading effect* of both specific taxes, and of carbon linkage in particular, (see also share L in Table 4) reveals that both taxes still stimulate upgrading towards less carbon-intensive fuels. To evaluate these upgrading incentives in the current tax structure in more detail, Table 6 compares this structure with the externalities related to the energy products, in particular CO_2 emissions. [INSERT TABLE 6] Emission factors for CO_2 reflect the linkage between product characteristics of fuels and particular emissions associated with their consumption. They are particularly useful for externalities that are not process-specific or that vary with time and space, such as CO_2 emissions. Moreover, the shadow price for each emission is similar, irrespective of its source. In this case, the shadow price only affects the tax level, not the (energy) tax structure.

The first column of Table 6 shows relative CO_2 emissions per GJ, excluding upstream emissions. The picture is well known: gas is relatively clean, followed by the different oil-based products, and coal is the most polluting product in terms of (potential) CO_2 emissions. The lower 'direct' CO_2 impact of electricity from the national grid is somewhat misleading because conversion and transport losses are not included. Comparing these emission factors with (normalized) ratios of FT and RET (column 2) suggests that the excise structure does not reflect these emission factors at all. Even though linkage is around 50% for most energy products used for heating purposes, coal appears to be subject to much lower excise rates than NG and oil-based products. However, appearances are again somewhat deceptive here. With the MOE included, the relative tax burden is more similar to the carbon emission factors (see column 3). Moreover, the differences are less dramatic for particular energy substitutes. For instance, the

FT (and RET) on HFO, coal and NG consumption for large consumers reflects the underlying carbon characteristics rather well. The same holds for energy substitutes at the household level, such as LFO, NG and electricity.[21]

Our findings sketch a much more refined picture than the view that exemptions and reliefs would usually run counter to the economic logic of using environmental taxes (Ekins and Speck, 1999). Note, first of all, that these sometimes loosely called ‘exemptions’ for large energy-intensive industries only apply to the decreasing rates for NG and electricity and the (implicit) exemptions of coal and HFO from the RET tax base in the Netherlands. Apart from the tax base exemptions for residual energy products under the FT, only electricity consumption over 10 million kWh is not subject to taxation. Second, exemptions for energy-intensive sectors can be observed in other countries applying carbon or energy taxes as well, and they were even a cornerstone of the older proposal for a hybrid EU carbon tax to prevent carbon leakage from (large) energy-intensive industries.[22] Unilateral action of a small open economy might decrease local welfare, not even necessarily at the gain of a global reduction in climate change emissions (Hoel, 1992). Third, one has to evaluate the entire energy tax burden across energy products to account for important differences in elasticities within the overall energy composite, rather than to look at only one tax at a time. Moreover, even with low tax rates, careful design of specific excises may still provide useful incentives for upgrading.

To conclude, the non-uniform overall tax *rates* on the fossil-fuel energy composite in the Netherlands seem to reflect the Sandmo (1975) rule, although coincidentally. The tax rate structure combines a more or less upstream indirect corrective tax at low rates by the FT with the generation of relatively non-distortive downstream tax revenue at high rates by the RET.

[21] The use of coal for heating purposes at the household level is strongly restricted by other (environmental and health) regulations.
[22] Also, the difference between unleaded gasoline and diesel is a result of tax policy competition on the (international) transport market.

More detailed analysis of the unit of taxation of both specific excises, however, shows that both taxes feature similar Pigovian elements as far as the upgrading or linkage effect is concerned.

Energy tax reform

A final, though interesting, issue is whether (Pareto-improving) tax reforms might be available. If we focus on corrective tax base aspects, the combination of inframarginal exemptions, tax rebates and income tax compensation leaves considerable room for improving the regulatory incentives of the energy taxes in general (Vollebergh, Koutstaal and de Vries, 1997; Bovenberg and Goulder, 2001).[23] In the Dutch case, some of these options are already exploited, but some remain. One option, for instance, is to change the FT into an 'upstream' tax across the board while allowing for carbon tax rebates and exemptions for (downstream) feedstocks, CHP or even carbon capture and storage. This implies the (implicit) inclusion of emissions by refineries in the tax base and a reintroduction of an electricity input tax. Consequently, tax rates would be lower for a given amount of emission reduction because the elastic demand for energy of large energy intensive industries is exploited.

The main objection against raising the tax burden on energy-intensive industries is, as mentioned before, its unilateral nature. Whether tax rate differences between exposed and non-exposed agents make sense very much depends on the issue of whether the current structure is optimal. Moreover, evidence on the relocation of industries due to environmental regulation is scarce and the literature is hardly conclusive on its significance (Jaffe et al., 1995; Smarzynska and Wei, 2001). One important (recent) finding is that governments tend to find other ways to compensate industries for increasing the (environmental) regulatory burden (Eliste and Fredriksson, 2002). Burden distribution and compensation through corporation and income taxes have also dominated the policy debate on the introduction and adaptations of both the FT

[23] Interestingly, the RET used to apply such inframarginal exemptions, but only for households. This exemption for 800m^3 and 800kWh has been changed recently into a tax credit with similar value (Euro 142).

and, in particular, the RET in the Netherlands. However, energy-intensive industries now also pay tax on their NG and electricity consumption, but only on its inelastic part.

Apart from the energy tax structure across agents, the design of the tax rate itself is also important. The use of specific excises instead of ad valorem rates certainly makes sense from the regulatory perspective. Accordingly, the energy tax induces quality improvements. Firms and households are more likely to produce or choose fuels of higher quality, in particular if the tax rate structure is linked to characteristics that are also the focus of the regulator. However, the current design is not transparent and the implied linkage leaves room for improvements.

Both the FT and the RET are now defined in relation to a standardized hybrid tax base in terms of GJ and carbon. That is, the administrator selects a particular set of energy product characteristics and normalizes the tax rates relative to both characteristics of one fuel. Next, the taxes due on the different products are recalculated into a tax per volume. A nice feature of the current FT on coal is, as explained in section 2, that agents can vary their taxes due by selecting different qualities of coal. Firms may choose a selective excise per GJ and per carbon instead of per volume. The advantage of this system is that it implicitly penalizes grades of 'ore', in this case coal, of low quality in terms of energy content or energy content per unit of carbon if the goods characteristics are based on 'average' performance. For instance, if a firm uses grades of lower quality, it has to pay more tax for a given amount of energy performance of fuels.

However, these incentives for upgrading, i.e. reducing CO_2 emissions per GJ, are not fully exploited now. To provide further and more transparent incentives for quality improvements, the system for coal could be applied more generally, i.e. to NG, oil, oil products and even electricity. This would encourage firms to select those fuels as well as variants of these fuels with the lowest tax per GJ and per carbon. Environmental goods characteristics, including grade and quality of the 'ore' (coal, NG and crude oil), are usually well known and well documented. The same holds for derived fuels (gasoline, LFO and HFO) and the use of the fuels as feedstock in steel-making processes and chemical processes – that is, emission factors are public information for all fuels. Accordingly, the excise rate would become more closely linked to the actual underlying emission factors. Administration costs for the government are limited because the burden of proof for using different qualities of coal falls on the firm.

6. CONCLUSION

Broadly speaking, the two Dutch energy taxes taken together nicely fit general findings from economic theory. These findings suggest taxing carbon emissions through an upstream input tax in order to regulate these emissions at lowest cost, and taxing downstream energy products in order to minimize distortions from (indirect) taxation. Remarkably, the general purposes of both taxes are precisely at odds with these findings. In general, the FT, with its broad, mainly upstream tax base, serves regulatory objectives best, whereas the RET, with its small, downstream tax base, makes sense from a revenue-raising perspective. Additional regulatory incentives remain rather limited, although the RET employs some emission-saving mechanisms, such as subsidies for CHP and the use of non-fossil-fuel inputs and electricity production.

One important lesson is that improving regulatory incentives of existing (upstream) taxes is particularly efficient in the case of climate change. Introducing emission taxes is relatively expensive if existing (indirect) taxes provide an efficient substitute. With their strong linkage, the limited (cheap) options for direct emission abatement and their low transaction costs, upstream taxes based on the carbon content of fossil-fuel inputs are still preferable. Even low tax rates would trigger large energy-intensive firms to invest in carbon abatement options, in particular if the tax allowed for (self-enforcing) tax rebates.

Another lesson is that tax exemptions might very well improve welfare, in particular if one restricts the analysis to the environmental dividend alone. Exempting (carbon-based) recycling gases (e.g. refinery gas, blast-furnace coal) from any energy tax base is useful in restraining some producers from emitting more instead of less. However, other exemptions, such as energy inputs to power plants and refineries, are less reasonable. Higher ‘output’ tax rates on refined oil and electricity never compensate for the loss of abatement potential from these plants, in particular because they are usually large and energy-intensive. Other ways to improve the effectiveness of the existing taxes would be to allow for tax rebates for abatement and to relate the tax rates even more explicitly to product characteristics.

Whether green tax reform is a viable policy strategy depends on the *embedding* of such reforms. In particular, for a tax to be a viable option for such a reform, one has to balance carefully the choice of a particular tax base and rate in relation to issues such as (local and global) environmental benefits, (emission) elasticity, availability of other indirect taxes, transaction costs and the international dimension. But even if the answer would be in favor of such a green tax reform, higher revenues from environmental tax bases, such as energy, do not always guarantee environmental improvements. Actually, they may even exacerbate pollution if not properly designed.

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Table 1 Tax revenue from excises on specific energy products in the Netherlands in 1988, 1994 and 2002 (bn Euro)

	1988	1994	2002[a)]
Type of tax:			
- Mineral oil excise	2.2	4.0	5.8
- Fuel tax	0.1	0.3	0.6
- Regulatory energy tax	0	0	2.4
Total	*2.3*	*4.3*	*8.8*
as a share of indirect taxes (including VAT) (%)	9.2	13.8	15.3
as a share of total tax receipts (%)	4.3	6.7	8.8
as a share of GDP (%)	1.1	1.6	2.0

a) Estimate.

Source: National Budget (Miljoenennota's), several years.

Table 2 Total excise rates on specific energy products in the Netherlands in 2002 (Euro)

Energy product	Unit (thousands)	Mineral oil Excise	Fuel tax	Regulatory energy tax	Total excise tax
Mineral oils: motor fuels					
- leaded gasoline	Liter	685[a]	12		698
- unleaded gasoline	Liter	615[a]	12		627
- diesel/light fuel oil – low S[b]	Liter	332[a]	14		345
- diesel/light fuel oil	Liter	346[a]	14		359
- LPG	Kg	104	16		120
Mineral oils: other use					
- diesel	Liter	53[a]	14	131	197
- light fuel oil	Liter	53[a]	14	132	198
- heavy fuel oil	Kg	16	16		32
- LPG	Kg		16	156	172
Coal					
- coal[c]	Kg		12		12
- blast-furnace, coke-oven, coal and refinery gas[d]	GJ		117		117
- coal gasification gas	GJ		462		462
Natural gas					
- gas (0–5,000)	m^3		11	124	135
- gas (5,000–170,000)	m^3		11	58	69
- gas (170,000–1mn)	m^3		11	11	21
- gas (1mn–10mn)	m^3		11		11
- gas (> 10mn)	m^3		7		7
Electricity					
- electricity (0–10,000)	KWh			60	60
- electricity (10,000–50,000)	KWh			20	20
- electricity (50,000–10mn)	KWh			6	6
- electricity (> 10mn)	KWh				

a) Includes strategic storage tax of Euro 6 per unit.
b) Sulfur content below 50 ppm.
c) Taxpayer may opt for GJ and carbon content as a tax base, with a rate of Euro 0.198 per GJ or Euro 2.4493 per 1,000kg CO_2.
d) If traded; the rate is zero if these gases are produced and used in the same plant.

Source: Statistics Netherlands; Dutch Ministry of Finance.

Table 3 **Decomposition of the retail price of two energy products in 2002 (Euro/GJ)[a)b)]**

		Light fuel oil[c)]			Natural gas[d)]			Difference		
1.	*Gross retail price* (p_n+t), including taxes			17.09			13.95			3.14
2a.	*Specific excise* (t_s)									
	a. Volume (t_{s1})	1.48						1.48		
	b. GJ or C content (t_{s2})	4.02			4.27			−0.25		
	d. Total $(t_{s1}+t_{s2})$		5.49			4.27			1.23	
2b.	*Value added tax* (t_a)									
	Total $(t_a(p_n+ t_s))$		2.73			2.23			0.50	
2.	*Total tax* (t)			8.22			6.49			1.73
3.	*Net retail price* (p_n) excluding taxes			8.87			7.46			1.41

a) Calculations are based on energy prices including excises but excluding VAT; the energy price for natural gas is based on the retail price of a small consumer (2,000m^3).
b) All prices and taxes are normalized per GJ based on data from Dutch Ministry of Finance.
c) Light fuel oil is subject to mineral oil excise, fuel tax and RET (see Table 2).
d) Natural gas (800–5,000m^3) is subject to fuel tax and RET (see Table 2).

Source: Statistics Netherlands; Vermeend and van der Vaart, 1997.

Table 4 Tax ratios for specific energy products in the Netherlands in 2002 (%)[a)]

Energy product	T	S	L
Mineral oils: motor fuels			
- leaded gasoline	78	80	1
- unleaded gasoline	72	78	1
- diesel/light fuel oil	62	74	2
Mineral oils: other use			
- light fuel oil	48	67	39
- heavy fuel oil	28	43	27
Coal			
- coal	32	53	61
Natural gas			
- gas (0–5,000)	46	66	46
- gas (5,000–170,000)	36	56	46
- gas (170,000–1mn)	24	33	46
- gas (1mn–10mn)	21	25	46
- gas (> 10mn)	20	19	46
Electricity			
- electricity (0–10,000)	47	66	n.a.
- electricity (10,000–50,000)	32	49	n.a.
- electricity (50,000–10mn)	21	25	n.a.
- electricity (> 10mn)	16	0	n.a.

Source: Own calculations based on energy prices from Statistics Netherlands and emission factors of fuels used by Dutch Ministry of Finance in 1997 (see Vermeend and van der Vaart, 1997).

a) No energy prices are available for some products, like LPG and coal gasification gas.

Table 5 Comparison of fuel tax and regulatory energy tax

	Fuel tax	Regulatory energy tax
Main purpose	- revenue raising	- regulation (climate change emissions)
Tax base	- all energy products except electricity	- only small-scale consumption of natural gas and electricity
Linkage	- upstream coal and natural gas - downstream oil	- downstream
Exemptions	- residual energy products - fuels used for electricity production	- large energy-intensive industries - horticulture
Abatement incentives	- no	- carbon sequestration - subsidies for non-fossil-fuel products
Tax rate structure	- specific (hybrid)	- specific (hybrid)
Level	- low	- high, but decreasing with higher levels of consumption

Table 6 Pollution coefficients compared with total nominal excise rates and gross retail prices for energy products in the Netherlands in 2002[a)]

	Climate –impact		Standardized nominal	
		FT and RET	Total excise[b)]	Gross retail price[c)]
	CO_2/GJ	Euro/GJ	Euro/GJ	Euro/GJ
Mineral oils: motor fuel				
- unleaded gasoline	100	10	350	191
- diesel	101	9	182	121
Mineral oils: other use				
- light fuel oil	100	100	100	100
- heavy fuel oil	106	10	14	36
- LPG	90	95	69	n.a.
Coal				
- coal	129	11	8	14
Natural gas				
- households (< 5,000m^3)	77	106	78	83
- industry (> 10bn m^3)	77	6	4	33
Electricity				
- households (< 10,000kWh)	52[d)]	415	303	325
- industry (50,000–10bn kWh)	52[d)]	42	31	94

a) Pollution coefficients as well as taxes and prices are standardized relative to LFO
b) Including (if applied) mineral oil excise (MOE), fuel tax (FT), inventory tax and regulatory energy tax (RET), but excluding VAT.
c) Includes VAT.
d) Emission factor for electricity is based on carbon composition of fuel inputs of electricity sector in 1998.

Source: Own calculations using emission factors used by Dutch Ministry of Finance in 1997 (see Vermeend and van der Vaart, 1997).

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(lix) This paper was presented at the ENGIME Workshop on “Mapping Diversity”, Leuven, May 16-17, 2002

(lx) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications”, organised by the Fondazione Eni Enrico Mattei, Milan, September 26-28, 2002

(lxi) This paper was presented at the Eighth Meeting of the Coalition Theory Network organised by the GREQAM, Aix-en-Provence, France, January 24-25, 2003

(lxii) This paper was presented at the ENGIME Workshop on “Communication across Cultures in Multicultural Cities”, The Hague, November 7-8, 2002

(lxiii) This paper was presented at the ENGIME Workshop on “Social dynamics and conflicts in multicultural cities”, Milan, March 20-21, 2003

(lxiv) This paper was presented at the International Conference on “Theoretical Topics in Ecological Economics”, organised by the Abdus Salam International Centre for Theoretical Physics - ICTP, the Beijer International Institute of Ecological Economics, and Fondazione Eni Enrico Mattei – FEEM Trieste, February 10-21, 2003

(lxv) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications” organised by Fondazione Eni Enrico Mattei and sponsored by the EU, Milan, September 25-27, 2003

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