MOBILIZING ENERGY EFFICIENCY: ENERGY PRICES VERSUS NON-PRICE INSTRUMENTS

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SYNOPSIS

This paper compares the relative economic efficiency of energy taxes and non-price policies in mobilizing cost-effective energy efficiency resources and reducing carbon emissions.

ABSTRACT

To many economists, the economically efficient way of mobilizing energy-efficient technologies is to increase the price of energy through an energy or carbon tax. However, at levels that bring about significant energy efficiency improvements or carbon reductions, such taxes have significant unwanted distributional side-effects on industries and consumers. Though various schemes can be used to minimize them, they diminish the effectiveness of the tax.

To many practitioners in the energy efficiency field, non-price instruments such as mandated standards, utility incentives, and other market transformation programs are the economically most efficient and most effective mobilization strategy. Yet, such policies have to be applied end-use by end-use and involve new regulations and administrative costs.

This paper outlines a solution for this dilemma: the integration of a low energy tax with a trust fund for financing energy efficiency improvements, complemented by efficiency standards, DSM programs, market transformation programs, and feebates. The theoretical and empirical issues surrounding this approach are outlined, and a comparison is made with the more encompassing concept of ecological tax reform.

INTRODUCTION

Background

Few topics in the current international energy policy debate are more shrouded in controversy than the relative merit of energy taxes versus non-fiscal or non-price policies in achieving economic and environmental goals. The question has attained additional significance for current energy policy because energy efficiency improvements are a key option for reducing carbon emissions.

Energy policy analyses based on macroeconomic models (e.g., Manne and Richels 1990, US CBO 1990) posit that, whatever goals might prompt society to influence the "business-as-usual" path of growing energy demand, an energy tax is the economically most efficient and effective policy approach. Studies based on this approach are also known as top-down studies.

Another group of energy policy studies (ASE 1991, Krause et al. 1995) place only secondary importance on such energy price signals. They are based on engineering- and micro-economic analyses of energy efficiency technologies and end-use markets. These so-called bottom-up studies suggest that the most economically efficient and effective policy instruments are a range of non-fiscal measures.

The non-price instruments of bottom-up studies influence the technology offerings and transactional patterns in end-use markets. They are collectively called market transformation policies in this paper. They include a variety of financial incentives for energy-saving investments, legislated minimum efficiency standards for energy-using equipment, structural reforms in the energy service markets and in utility sector regulation, and improved R&D programs. Though they may influence the prices of energy-efficient equipment, they do not impose changes in energy prices. For this reason, they are also called non-price instruments.

The top-down/bottom-up debate over optimal policy instruments is intricately linked to alternative views on the economic efficiency of current energy supply and end-use markets. These alternative views on market efficiency, in turn, are reflected in different economic modeling approaches and in divergent assessments of the costs and benefits of energy policies.

A more comprehensive theoretical and empirical review of the divergent modeling methods, economic findings, and policy implications is undertaken in Krause et al. (1993) and Krause et al. (1994) for the specific context of mitigating carbon emissions. These reports develop an integrated policy approach for achieving carbon reductions at least economic cost. The present paper captures an element of this broader analysis, i.e., the question of optimal policy instruments for promoting energy efficiency:

- Is an energy or carbon tax the economically most efficient approach for optimizing levels of energy use or for reducing carbon emissions?

- Which other policy instruments, if any, could optimize energy use and reduce emissions and other impacts of energy use in an economically more advantageous manner?

- Would such non-fisal or non-price instruments help avoid the problematic distributional and competitiveness impacts of energy or carbon taxes? What limitations of their own do they bring with them?

- If both types of policy instruments could be advantageously combined, how should this "mixed bag" approach be structured?

METHODOLOGY

A fundamental difficulty in comparing the effectiveness of taxes and non-price policies is that energy taxes stimulate both technological responses and behavioral adjustments. By contrast, non-price instruments aim to stimulate the adoption of more energy-efficient technologies alone.

A second limitation is that the full range of economic impacts of alternative policies cannot be captured at the microeconomic level of engineering economic analysis or end-use market studies. Distributional and competitiveness impacts, feedback effects of reduced energy demand on fuel prices, and other interactions require analysis at the macroeconomic level.

The following analysis first examines the differences between price and non-price policies at the microeconomic level. The technique here is to translate the observed consumer responses to energy prices that underlie macroeconomic modeling formulations into a mathematical form that allows direct comparison with the life-cycle cost analysis of engineering-economic studies. This mathematical form is the implicit discount rate, i.e., the discount rate that appears to be implicit in consumer behavior when viewed from the perspective of minimum life cycle costs. As discussed below, this implicit discount rate is a direct reflection of transaction costs encountered in individual markets.

The second step is to examine whether the discount rates implicit in consumer price responses under status quo conditions are compatible with economically rational behavior in well-functioning markets. If so, energy taxes are the only economically efficient way for increasing energy efficiency investments. If not, non-price measures might be able to improve the transactional arrangements of current end-use markets and offer an economically more efficient instrument. In this case, an optimal strategy might consist of the application of both price and non-price instruments. As an empirical test, data from end-use market studies and from evaluation studies for efficiency programs are used. These data reveal whether and at what cost market transformation programs can reduce the implicit discount rates applied in energy efficiency investments.

The comparative of price and non-price instruments at the macroeconomic level centers around the fact that distributional and competitiveness impacts are greatest when high energy taxes are employed. To reduce these impacts, a "bottom-up approach to energy taxes" is examined in which energy taxes flow into a trust fund for energy efficiency investments. The trust fund concept is then developed as a means for integrating non-price measures and energy taxes in a manner that yields high levels of efficiency improvements at low tax levels and with a net gain in economic efficiency.

RESULTS

THE EFFICIENCY GAP

Expected market patterns

All energy use arises out of the demand by consumers and firms for energy services, such as heated floor area, vehicle-kilometer, tons of steel, etc. These energy services are obtained by investing in engines and vehicles, heating and lighting systems and building shells, motor-driven machinery and industrial processes, and by purchasing energy to operate these end-use technologies.

Commercially available end-use devices and building systems often show a wide range of technological designs, energy efficiencies, first costs, and life cycle costs. Further efficiency resources emerge over time, as technical innovation allows the design of better end-use devices that are more energy-efficient and cheaper to operate.

If energy purchases and efficiency investments were traded off in well-functioning markets with good, low-cost availability of information, one would expect those end-use technologies with the lowest life cycle costs to have a dominant market share.

Similarly, if technology diffusion is free from barriers to economically efficient innovations, one would expect energy-efficient innovations that lower life cycle costs to quickly show up in new commercial products and penetrate into the capital-stock at a speed not too different from the rate of replacement plus expansion of that stock.

Empirical data

Reality presents a different picture. According to a large number of end-use market studies,1 the process of diffusion of energy-efficient technologies does not follow this pattern. The observed evolution of market shares for these energy efficient products indicates two major problems:

- Most off-the-shelf, commercially available energy-efficient products with distinct life-cycle cost advantages command only small and often stagnating market shares. Frequently, they are relegated to high-end niche markets with larger mark-ups.
- Known energy-efficient technical design options show up in new commercial products only with great delay, and sometimes not at all. When they do, they tend to remain the cinderellas of marketing campaigns.

These patterns can be described as representing an efficiency gap, i.e., a gap between cost-minimizing levels of energy efficiency and actual levels of energy efficiency.

Payback requirements and implicit discount rates

The economic significance of these observed market patterns is most easily understood if they are described in terms of the payback requirements consumers and firms apply to energy efficiency investments, or in terms of the discount rates implied. Table 1 shows the relationship between payback requirements and implied discount rates as a function of the life of the investment.

The payback gap

End-use market research[2] shows that consumers and firms are generally not motivated to pay for the extra first cost of energy-efficient devices unless the payback time is very short — less than two to three years, sometimes as little as a month.

This behavior, which significantly increases energy demand, is not limited to residential and small commercial customers, but also describes most energy efficiency decision-making by large industrial and commercial firms. And

though significant variations in payback requirements occur by customer type, end-use and technology, these differences are swamped when compared to payback criteria for energy supply investments.
By contrast, utilities and energy producers satisfy high levels of energy demand by undertaking supply-side investments in power plants, pipelines, refineries, and the like. These long-run investments, which often last 30 years and are undertaken on the basis of a 3-10 percent real discount rate, pay back only over ten to twenty years, not in a matter of months or two to three years (see Table 1).

Implicit discount rates

In financial terms, stringent payback requirements are equivalent to using very high discount rates for the invested capital (Krause and Eto 1988). The discount rates implied in payback requirements of 1-4 years are about 30 to 160 percent. By contrast, utility investments are undertaken on the basis of real rates of return in the neighborhood of 5-7 percent (or 2-4 percent on debt-financed investments).

This means that consumers and firms implicitly or explicitly apply discount rates for their efficiency investments that are one to two orders of magnitude greater than those used by energy suppliers. Moreover, consumer discount rates are far higher than the average real rates of return they can hope to earn from financial investments (Hausmann 1979, Train 1985).

The general picture that emerges is thus one of a great asymmetry between economic investment criteria on the demand side and the supply side. These data again suggest that there is a gap between life-cycle-cost minimizing levels of energy efficiency and actual levels of energy efficiency.

Table 1. Implicit Real Discount Rates, Lifetimes, and Simple Payback Times

SPT (Yrs)	Investment Lifetime (Years)							
	3	5	7	10	15	20	25	30
1	146.5	159.8	161.5	161.8	161.8	161.8	161.8	161.8
1.5	68.4	87.3	91.2	92.3	92.5	92.5	92.5	92.5
2	33.5	55.5	61.3	63.5	64.0	64.0	64.0	64.0
2.5	13.3	37.2	44.4	47.6	48.6	48.8	48.8	48.8
3	0.0	25.1	33.4	37.5	39.0	39.3	39.3	39.3
4		9.7	19.4	24.9	27.5	28.1	28.3	28.3
5		0.0	10.7	17.2	20.7	21.6	21.9	22.0
6			4.6	11.9	16.0	17.3	17.8	18.0
7			0.0	7.9	12.6	14.2	14.8	15.1
8				4.8	9.9	11.8	12.6	12.9
9				2.2	7.8	9.9	10.8	11.2
10				0.0	6.0	8.3	9.3	9.9
12					3.1	5.8	7.1	7.7
15					0.0	3.1	4.6	5.5
20						0.0	1.9	3.0

Source: Krause and Eto (1988).

What does the efficiency gap mean?

Interpretations of the efficiency gap must take into account that consumer decisions are shaped not just by tangible (life cycle) costs reflected in prices, but also by intangible costs such as consumer surplus and transaction costs. The latter consist of costs for obtaining reliable information on products, evaluating their applicability to consumers' particular circumstances, verifying manufacturer claims, finding vendors and trustworthy installers, etc. In addition, decision criteria other than minimization of economic cost may influence consumer behavior.

More specifically, the efficiency gap could be explained by the following underlying factors (Krause et al. 1993):

a) Losses in consumer surplus. Reduced consumer surplus could result from (1) loss of convenience, comfort, reliability, appearance, product selection, precision of functioning, or any other form of amenity in the provision of energy services such as warmth, ventilation, lighting, cooling, transportation, etc.; and (2) other indirect costs that are borne by the purchaser of the equipment, such as work disruptions or costs related to the assembly or installation of energy-efficient technologies in individual premises.

b) Market failures. Established markets for energy efficient technologies exhibit pervasive transaction costs, information costs, and costs related to risk and uncertainty, i.e., imperfect market conditions prevent economically rational consumers from achieving optimal results.

c) Diffusion barriers. The process of diffusing new energy-efficient technology into commercial products and of establishing markets for them is broadly suboptimal due to various information and transaction cost barriers that arise in the technology innovation process.

d) Bounded economic rationality. Consumer behavior is not adequately described by economic theory, i.e., economic rationality is partially or wholly replaced by alternative decision-making rules and social and psychological factors.

Of these four intangible costs, the last three — inefficient technology diffusion, market failures, and bounded economic rationality — are associated with the manner in which consumers, vendors, installers, financing institutions, manufacturers, renters, and owners behave and interact in the market, and how the market is configured in terms of institutional and regulatory frameworks.

If these transactional patterns and market configurations can be changed so as to reduce intangible costs, and at a societal cost less than that of preserving the status quo, then well-designed policy action could increase the economic efficiency of the energy system. Market patterns as presently observed would then have to be described as an inefficient allocation of capital in the energy sector.

Classical economic interpretation

Some top-down modelers argue that the low market shares and diffusion problems of energy-efficient technologies are not caused by market failures, as bottom-up analysts claim, but are in fact "normal" features of well-functioning markets. The claim is that the efficiency gap merely represents instances where consumers find efficiency investments unattractive on the basis of high information and transaction costs, investment risks, and budgetary constraints. It is further surmised that in some cases, they also may reject energy efficiency technologies on the basis of reduced consumer surplus, such as loss of amenity, functionality, aesthetics, etc.

In either case, so the interpretation, these intangible costs exceed the benefit of lower life cycle costs. Thus, the apparently inefficient rejection of energy-efficient devices by most consumers is seen as, in fact, economically rational. It is further argued that

- information, transaction, and uncertainty costs do not represent market failures in the standard economic sense and are really generic to all investment decisions in the economy, and that

- government policy measures cannot cost-effectively alter these "normal" conditions.

It should be noted that this view, which is fundamental to all econometric calculations of costs and energy demand, is based not on empirical research, but on theoretical arguments (Sanstad and Howarth 1994). They appeal to the standard neoclassical theory of welfare economics and its "rebuttable presumption." According to that theory, which was formulated for a highly stylized model of an economy in equilibrium, the decentralized decisions of market participants in a system of complete and perfect markets automatically lead to a welfare-maximizing allocation of resources. This classical model ignores emerging market theories, notably those based on information economics, which focus on the fact that transaction costs are highly variable and depend on the manner in which market interactions are institutionally configured (Sanstad et al. 1993).

Empirical findings from end-use market research and program evaluations

The key issue for the efficiency of current markets — whether transaction costs can be significantly reduced at favorable costs through policy intervention — can be resolved on an empirical basis by examining the costs of policy interventions to induce energy consumers to buy end-use equipment with optimal life cycle costs. If the cost of these interventions is expressed per kWh of energy saved, it can be added to the cost of conserved energy obtained from engineering-economic analyses. So long as the combined cost is less than the avoided cost of marginal energy supplies, the market transformation policy increases economic efficiency.

A large and growing body of practical, in-field experience and evaluation research is available for predicting the approximate cost of policy interventions in end-use markets. Tested instruments include energy efficiency standards; information, energy audit, and labeling programs; utility demand-side management programs, procurement programs, and others. Experience shows that administrative costs and other secondary economic impacts depend strongly on the type of policy and the design of the program. The two key market transformation instruments are mandatory energy efficiency standards, and voluntary incentive programs for energy efficiency investments.

Energy efficiency standards

A major portion of the unrealized cost-effective potential for energy efficiency improvements can be realized through regulatory norms or standards for energy efficiency in buildings, vehicles, appliances, etc. In applying this policy tool, care must be taken to avoid creating excessive transition costs for manufacturers or hidden costs for consumers. Well-designed efficiency standards preserve or enhance consumer choice and amenity, emphasize flexible performance standards over prescriptive standards, allow sufficient adjustment times during phase-in, and establish a participatory process and clear timetable for periodic updates.

Field experience with standards in a number of countries shows that energy efficiency standards are much more effective in eliminating market problems than information programs. Information programs remain important for end-uses where standards are difficult to apply. As a rule, well-designed standards have very favorable administrative costs, adding less than one percent to the levelized cost of saved energy (Krause et al. 1994). Standards also have the effect of reducing the mark-up on energy-efficient products, which may push their prices far below those assumed in engineering-economic calculations based on current market prices (Levine et al. 1994). On both counts, experience with standards squarely contradicts the hypotheses built into top-down models.

Voluntary incentive-based programs

Voluntary incentive-based programs are best exemplified by the so-called demand-side management (DSM) programs conducted by many utilities in the U.S. and increasingly elsewhere. These programs, and similar programs outside the utility sector, offer a synergistic supplement to energy efficiency standards and can be used to implement a significant portion of the total potential of cost-effective efficiency improvements. Again, these types of programs are far more effective than information programs alone in reducing or eliminating market problems. Problems of program-induced hidden costs are avoided on account of the voluntary basis of consumer participation.

In conventional rebate programs, administrative costs including possible free rider effects typically add at least 10 percent to the costs of saved energy. Actual corrections for administrative costs show a significant range, depending on program design, customer group, and consumption sector. In some cases, e.g., when serving low-income residential customers, the total program costs after including administrative costs and free rider effects may exceed the benefits of the program.

However, claims in one widely publicized study (Joskow and Marron 1993) that such costs could add as much as 100 percent to the cost of saved energy have been shown to be unfounded. More recent research that used a far more comprehensive data set and a more sophisticated methodology (Eto et al. 1994) showed that based on U.S. experience, administrative and free-rider costs add about 15 percent to the cost of saved energy. As a rule, these programs achieve a 2:1 benefit-cost ratio even after program administrative costs and free rider effects are taken into account. Here again, empirical data squarely contradict the hypotheses built into top-down models.

Furthermore, a new generation of procurement-based market transformation programs aimed at manufacturers rather than consumers offers substantially reduced administrative costs that are closer to those of standards than to those of traditional DSM programs.

By juxtaposing these empirical data with the standard theoretical model of the economy, Krause et al. (1994) arrive at three alternative "rebuttable presumptions:"

1) The energy efficiency gap cannot be explained by the hidden-cost hypothesis. With few exceptions, energy efficient products are amenity-neutral or increase consumer surplus.

2) The energy efficiency gap is mainly an economic efficiency gap. It is caused by transaction costs, information problems, and other features of end-use markets that represent market failures in the standard economic sense. "Normal" energy service markets do not produce welfare-maximizing outcomes.3

3) Regulatory and incentives policies can cost-effectively reduce the problems encountered in end-use markets and in technology diffusion processes, at a significant net benefit of improved economic efficiency.

It should be noted that as far as explaining existing investment patterns under status quo conditions are concerned, end-use market studies largely agree with the classical interpretation of the efficiency gap: High information and transaction costs are the main factors that prevent consumers from investing in energy efficiency on their own. Due to these intangible costs, a unit of saved energy may appear to cost several times as much as a unit of energy supply. From both perspectives, observed consumer behavior is thus largely economically rational. The difference in the assessment of market efficiency arises from the fact that information and transaction costs can be greatly reduced through government action.

THE LIMITS OF PRICE-BASED POLICIES

Impact of market transformation policies

As shown by end-use market studies, the efficiency gap indicates an inefficient allocation of capital in the energy sector of the economy. Market transformation policies that reduce intangible costs and shift consumer decision-making toward life-cycle-cost minimizing choices could thus result in significant economic efficiency benefits. How do such policies compare with price-based policies?

The economic effect of market transformation policies is to lower the payback requirement or implicit discount rate in energy efficiency investments. This effect is schematically illustrated in Figure 1. The graph shows two stylized supply curves of energy efficiency improvements (conservation supply curves or CSCs) that differ only in the discount rate with which efficiency investments are evaluated. In each supply curve, energy efficiency options are shown in levelized form. The levelization of investments in the top curve is based on a roughly four-year payback (discount rate of 30 percent, see Table 1 above), as minimally required by most industrial and commercial firms.

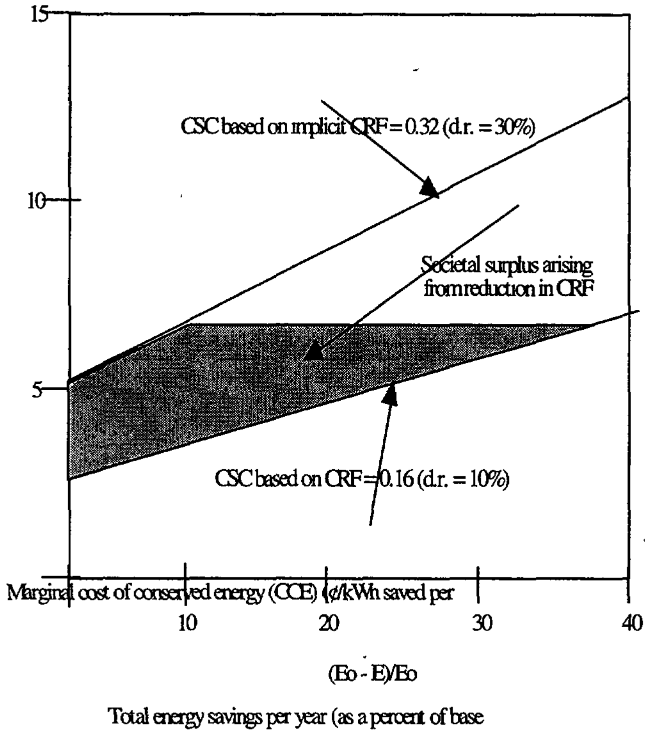
The price of energy in the reference case (levelized over the life of the efficiency investment) is shown as a horizontal line. For this price, economically worthwhile energy efficiency improvements are defined by the point at which the supply curve intersects with the horizontal energy price line. Worthwhile energy savings from efficiency improvements amount to ten percent in this example.

This supply curve is based on conservative parameters. Many efficiency investments are based on shorter than four-year payback times, implying higher discount rates than 30 percent. At discount rates of more than about 40 percent — applied or implied by most consumers — all efficiency investments in our example become more expensive than energy supplies. The marginal cost curve for energy-efficiency would then look no different than in top-down models.

The second supply curve covers the same energy efficiency investments, but is based on a 10 percent discount rate. This discount rate is a conservative proxy for the economic criteria used in designing market transformation policies. It is closer to (though still higher than) the average rate of return on capital in energy supply investments. It allows for some irreducible uncertainties that may be associated with the market transformation policy itself.

Based on this discount rate, savings of about 38 percent are economically worthwhile at the given price — an increase of roughly 28 percentage points, or almost a fourfold increase of the cost-effective resource potential under business-as-usual conditions. The net economic benefit of moving from status-quo market conditions (high implicit discount rates) to improved transactional arrangements (low implicit discount rates) is illustrated by the shaded area in the graph.

Figure 1: Dependence of cost-effective energy efficiency potentials on the implicit discount rate



Note: CCE calculated assuming project life = 10 years
CSC= conservation supply curve
CRF= capital recovery factor

Impact of energy taxes

The application of an energy tax is equivalent to raising the horizontal price line in the graph. This moves the point of intersection with the efficiency supply curve to the right, i.e., toward higher savings.

The graph shows that in the presence of significant market failures, price-based policies are considerably less effective than non-price policies. Suppose the 38 percent savings from market transformation policies under reference prices were to be matched by energy pricing policies. For this to occur, the levelized price of energy in Figure 1 would have to be about twice as high. It is worth noting the real rate of price increase if this doubling of the levelized price were to be phased in over an investment life of 10 years. Assuming a 10 percent discount rate, the price of energy would have to increase by 14 percent per year in real terms, or by a cumulative factor of 3.7 over 10 years — a draconian price policy by any measure.4

Even then, price policies would not necessarily catch up with non-price options. At these higher prices, the market transformation policies represented by the lower supply curve would themselves unlock greater savings . In fact, for one and the same price change, market transformation policies may lead to a much larger increase in cost-effective savings: the slope of the energy efficiency supply curve is more shallow at lower discount rates. Only once technical options are exhausted do prices become more effective in limiting energy demand. However, at this point, it is the consumption of energy services itself that will be rationed.

Advantage of combining price and non-price policies

The above exercise illustrates that if intangible costs are reduced through market transformation programs, increased energy prices are not necessary to realize large improvements in economic and energy efficiency. Moreover, market transformation policies deliver large economic efficiency gains that inherently cannot be obtained through price-based policies.

Nevertheless, the most effective policy approach would be to raise both prices (e.g., to account for externalities and to remove subsidies) and improve transactional arrangements in end-use markets. It is obvious from Figure 1 that the combination of both would result in larger cost-effective energy savings than either approach can deliver on its own.

Such a combined approach is also desirable for several practical reasons. Market transformation policies are administratively more cumbersome than taxes. Because these policies are tailored to individual sectors and end-uses, the necessary programs and suitable technical-administrative institutions need to be built up in a number of areas before all dormant efficiency potentials in the economy can be mobilized. This means that the implementation of energy efficiency potentials will take time and may be uneven across the various end-use markets and sectors.

By contrast, a cross-cutting energy tax on calorific or carbon content (a "Pigouvian" tax) affects all energy-related decisions at the same time and on the same basis. They thus provide at least a partial compensation during the transition period in which market transformation programs are fully developed. Higher energy prices also underline the usefulness of these new programs, providing them with needed public support.

A BOTTOM-UP APPROACH TO ENERGY TAXES

Competitiveness impacts of tax policies

As shown in the preceeding section, low tax levels do not achieve significant energy efficiency improvements when used alone. This feature is also borne out by the many macroeconomic studies of energy and carbon tax policies that have been performed in recent years. According to studies for both Europe and the U.S., the aggregate impacts of tax policies depend on the manner in which revenues are recycled and can be kept rather small in terms of lost economic output.5 They could even be neutral or slightly positive when energy or carbon taxes are combined with tax shifts that reduce payroll and investment taxes (Shakleton et al. 1992, CEC 1992).

However, a standard finding of most top-down studies is that comparatively high carbon taxes are required to stabilize or cut carbon emissions. A mere stabilization of emissions at 1990 levels by 2000-2005 is found to require taxes in the neighborhood of $100/T of carbon. Achieving significant reductions below 1990 levels (e.g., cuts of 20 percent over the next 15 to 30 years) is found to require taxes in the range of hundreds of dollars per ton of carbon.

Even a level of 100 $/tonne C — at best enough to achieve emission stabilization for a limited time — could be problematic for the competitiveness of some industries. A tax of 100 $/tonne C would be enough to approximately double industrial energy prices. The basic materials industry (steel, chemicals, cement, aluminum, etc.) would be hardest hit.

Table 2 illustrates the change in energy bills that would have resulted from a hypothetical 100 $/tonne C tax if it had been instantaneously imposed in 1985, based on data from Pezzey (1991). The change in energy expenditures is expressed as a percentage of total value added (VA) produced in each sector in 1985.

Cost impacts on industry overall are small, of the order of 1-2 percent of VA. This reflects the fact that in industries outside the basic materials sectors, energy costs represent less than three percent of production costs. However, for individual energy-intensive sectors, impacts can be as high as 13 percent. Various tax shifts and offsets could dampen these impacts, but short of an outright exemption, a differential effect on energy-intensive industries always remains.

Even when a uniform energy or carbon tax is applied in all OECD countries, competitiveness impacts for individual industries can vary strongly from country to country, due to the different degree of linkage to the world market. A similar problem arises with tradeable permits under an OECD cap for carbon emissions.

Table 2: Impact cost of a $100/tC Carbon Tax, in % of 1985 industrial value added

	Cost of tax on sector as a percentage of 1985 VA production in that sector										
	Total industry	Iron & steel	Chemicals	Non-ferr. metals	Non-met. minerals	Transport equipment	Machinery	Food, etc	Paper, etc.	Wood, etc.	Textiles
US	2.3	13.1	7	7.3	7.8	0.5	0.4	1.2	2.6	1.2	1.5
Japan	1.3	8.2	3.3	1.8	3	0.2	0.1	0.3	1	0	0.8
Germany	2.1	8.9	5.9	5.5	5.7	0.6	0.3	0.8	2.2	0.7	0.9
France	1.2	5.9	3.2	3.1	3.7	0.2	0.2	0.4	0.6	0.2	0.4
UK	1.6	4	3.8	4.5	4.4	0.8	0.6	0.7	0.8	0.1	0.8
Italy	1.5	4.6	3.4	1.8	5.7	0.2	0.5	0.5	1	0.4	0.5
Spain	1.5	5.7	3.4	3.9	4	0.4	0.3	0.4	1.3	0.4	0.6

Source: Pezzey 1991

Political economy implications

Predictably, these projected impacts have prompted various manufacturing industry associations to close ranks with the energy supply industries in opposing energy or carbon taxes. The result is a paralysis at the political level. This paralysis must be considered an inherent side effect of all energy strategies that mainly or solely rely on price instruments:

— Either governments seek serious emission reductions — which means, within the paradigm of conventional top-down analyses, high energy taxes — and thus get into conflict with powerful status quo stakeholders;

— Or, governments limit themselves to that which is politically "doable" — i.e., very low energy taxes that are more or less symbolic — and give up the goal of serious emission reductions.

WHY HIGH TAX RATES APPEAR TO BE NEEDED

The need for comparatively high carbon taxes in macroeconomic modeling calculations arises for two reasons. First, any substitution investments in response to the tax are assumed to be undertaken under prevailing conditions of pervasive end-use market failures. These failures increase the effective or perceived cost of demand-side efficiency measures relative to substitutions on the supply side. As a result, investments are shifted toward more costly measures than would be the case if end-use markets had first been transformed.

Second, the tax needs to be high enough to at least match the marginal abatement cost for the targeted emission reduction. This marginal cost is defined by the last incremental measure in the supply curve of substitution options that is needed to achieve any specified emission reduction goal. This last technology or measure is generally significantly more expensive than the sum of all needed measures is on average.

This means that the money spent on substitution investments by consumers and firms is only a fraction of the tax revenues collected. For every dollar that does get invested, several dollars in taxes have to be raised to create the necessary price signal. The energy or carbon tax thus represents a huge diversion of funds from taxpayers to the treasury and back to taxpayers, and all this only to bring about a much smaller volume of substitution investments. This explains why energy tax proposals have become increasingly associated with proposals for comprehensive tax reform.

OPTIONS FOR INCREASING THE EFFECTIVENESS OF LOW TAX LEVELS

To make an energy tax more effective at lower tax rates, it is necessary to improve the efficiency of end-use markets and to ensure that most revenues end up being used directly for energy efficiency improvements and carbon substitutions. Trade and competitiveness impacts can be further reduced by achieving as large an impact as possible through market transformation programs that do not require tax financing in the first place.

Tax-lowering effects of a trust fund

Instead of treating energy taxes as general revenues, they could be recycled into the economy through a special budgetary arrangement that functions like a trust fund (Sanghi 1991). The fund would directly finance abatement measures by residential, commercial, institutional, and industrial energy consumers and/or manufacturers of end-use equipment. A recent application of the trust fund concept is the environmental levy established by the electricity distribution companies in the Netherlands, which are to be used specifically to provide incentives for energy efficiency investments.

In the trust fund approach, the energy or carbon tax rate is set at a level that is just sufficient to pay for the total capital requirements of all measures needed to achieve specific reductions, i.e., at the average cost of emission abatement. The ratio between tax revenues collected and investments in energy efficiency or emission-reducing measures is equal to one. Thus, a trust fund tax rate would be only a fraction of the general revenue tax rates calculated in macroeconomic studies. The same result is obtained from a detailed comparison of macroeconomic tax levels with trust fund tax levels for Western Europe (Krause et al. 1995a, 1995b).

Tax-lowering effects of market transformation programs

Desired emission reductions could be achieved at still lower tax levels than indicated by this average-cost approach. First, experience with utility rebate programs and other incentive schemes suggests that financial incentive programs do not need to provide 100 percent of extra first costs in order to motivate consumers and firms to make greater investments in energy efficiency (Krause et al. 1989, Nadel 1992).

Second, a major portion of carbon-reducing efficiency investments could be induced through regulatory means, avoiding the detour of an across-the-board energy tax altogether. Most important in this respect are mandatory efficiency standards that eliminate market failures and direct manufacturers' and consumers' own capital at previously inaccessible money-saving efficiency opportunities.

Finally, the burden of raising funds for market transformation programs could be placed more directly on the beneficiaries of such programs in each sector. This would again lower across-the-board energy tax levels. Two innovative approaches of this kind are least-cost planning reforms in the utility sector, in which incentive programs for demand-side efficiency investments are financed by customer collectives through electricity rates rather than through across-the-board taxes (Krause and Eto 1988), and fee/rebate (feebate) programs in which rebates on purchases of energy-efficient vehicles or other products are paid for by fees on inefficient ones (Davis et al. 1993, DeCicco et al. 1993). Experience with successful utility programs also illustrates that engineering-economic end-use analyses and audits can be used effectively to allocate funds and prioritize investments among a broad range of different end-uses and customer groups.

INTEGRATED TRUST FUND/MARKET TRANSFORMATION APPROACH

Using these elements, an integrated energy tax and market transformation approach could be fashioned as follows (Krause et al. 1993):

1) Programs for reducing market and regulatory failures in energy service markets:
    - Energy efficiency standards for buildings, appliances, lighting systems, vehicles, and other suitable end-uses, with legally defined procedures and schedules for updates.
    - Regulatory reforms to provide profit incentives for utility demand-side management programs.
    - Complementary government-operated incentive programs and information, audit, and extension services to help industries and consumers invest in retrofits and new energy efficient equipment.
    - Financial incentives (golden carrots) for manufacturers of energy-using devices that increase the energy efficiency of their products beyond best commercially available levels.
    - Market creation programs for energy efficiency options through government and utility procurement.

- Accelerated and greatly expanded research, development, and commercialization efforts for energy efficiency and renewables.

2) An energy tax designed to fund those market transformation programs that are not self-financing, using an efficiency fund.

What about ecological tax reform?

The efficiency fund/market transformation approach presented so far is suited to achieve large energy efficiency investments and emission reductions at low tax levels. It also increases economic output and international competitiveness by lowering energy bills. In this way, it helps increase employment. But it does not change payroll costs, and it is unlikely to achieve the full internalization of externalities into energy prices.

The energy tax/efficiency fund/market transformation approach is thus just a minimum core of a comprehensive policy approach. In an optimal approach, it would be integrated with other fiscal policies, by setting tax levels higher than needed for trust fund purposes alone, and/or by realizing tax savings from the removal of subsidies to environmentally harmful energy sources. Such additional energy tax revenues could then be recycled into several other desirable uses: tax shifts to reduce fiscal drag on investments and employment, deficit reductions, and assistance for economic conversion in industries and regions that will lose assets and jobs as a result of reduced energy production (golden parachutes).

Seen this way, an economically efficient energy policy reform as defined in this paper dovetails with ecological tax reform proposals (Von Weizsäcker und Jesinghaus 1992, Repetto et al. 1992). However, these proposals have been based on price corrections alone, and thus have overlooked the large economic efficiency gains that can be mobilized through non-price policies.

The optimized "mixed bag" strategy outlined here thus has the effect of substantially increasing the degrees of freedom in implementing desirable energy policies. In particular, it provides a means for achieving significant reductions in carbon emissions at a profit while avoiding the competitiveness concerns that have contributed to the current stalemate in the area of climate stabilization. To the extent that these competitiveness concerns can be overcome in the discourse over ecological tax reform, the strategy presented in this paper would simply become a component of such broader reform.

CONCLUSIONS

If energy taxes are to be applied as a complement to market transformation programs, policy makers have to guard against competitiveness impacts. These price effects can occur even when the overall economic impact of energy tax policies is neutral or favorable. To minimize these effects, it is desirable to keep energy taxes to low levels.

Our review of end-use market studies suggests that economic efficiency can be raised substantially, and carbon emissions cut significantly, even if — as currently the case — price signals remain distorted by subsidies and externalities and no energy taxes are applied.

Energy policies could yield a significant economic dividend if based on an integrated approach that emphasizes non-price policies, sets energy taxes at low levels, and recycles revenues directly into investments. Market transformation programs enhance economic growth and employment and make large emission reductions possible at low tax levels.

The combination of energy taxes, tax system restructuring, and market transformation policies proposed in this paper are shown to offer advantages over tax policy proposals that are based only on the top-down framework. The broader and more ambitious social and environmental goals of ecological tax reform can be pursued without delaying action to increase energy efficiency and cut carbon emissions soon.

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ENDNOTES:

1. See, for example, DPA 1989, Enquete-Kommission 1992, Krause et al. 1993/95, Mills et al. 1991, UCS et al. 1991.
2. See, for example, EPRI (1988).
3. See, for example, Howarth and Anderson (1993) and Sanstad and Howarth (1994).
4. There is some evidence that continually and predictably rising energy prices are more effective than one-time rises in refocusing the attention of consumers and firms and reducing problems caused by bounded rationality. This effect is not captured in this calculation. The need for large annual price hikes would nevertheless remain.
5. See, for example, CEC 1992, CBO 1990, Manne and Richels 1990.

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Panel 6 Overview

Transportation, Urban Planning and Land Use

Panel Leaders: Lee Schipper and Laurie Michaelis

Final energy consumption in the transport sector is growing faster than that in any other sector. Energy intensity — energy per unit of passenger travel or of freight movement — is increasing for most transport modes in most countries. At the same time transport activity is continuing to increase with rising economic activity, disposable income and access to motorised transport, and with falling real vehicle and fuel costs. Societies are becoming increasingly dependent on the car for domestic passenger transport, air travel for international travel and the truck for freight transport. Meanwhile, the transport sector imposes burdens on society, including the effects of traffic congestion, accidents, climate change, urban air pollution and noise.

Governments and others agree on the need to do more to address the environmental and social problems caused by transport, and various approaches are advocated:

- changes in vehicle technology, including reductions in vehicle size and performance.
- changes in energy sources.
- changes in transport mode.
- changes in land-use patterns and lifestyles to reduce the amount of travel and freight transport.

No one of these approaches is likely to be adequate to achieve an environmentally and socially sustainable transport system, and most transport analysts now advocate an integrated approach to transport policy that encourages changes in all four areas.

The papers in this session are organised as follows:

Technical approaches to reducing energy use

Schol presents a paper on SAVE-T, a detailed transport sector energy model which can be used to examine the effects of a number of influences, including policy influences, on energy use by freight and passenger transport. Although the model can be used to evaluate the cost-effectiveness of energy-saving technology, Schol emphasises the uncertainty in this type of analysis, which leads transport energy analysts to address a wider range of non-technology options.

Lewald's paper on the results of the Swedish electric vehicle procurement program provides an example of a concrete attempt to change the energy source used for vehicles. The paper emphasises that, whereas the aim of introducing electric vehicles is to reduce emissions and improve energy efficiency, this will only be achieved if the vehicles are used, and displace conventional vehicles from the market.

Another technological approach to addressing transport's environmental impacts is described in Gustavsson's paper on the energy use by personal rapid transport (PRT). This is a guideway-based, electrically powered, automated system of personal vehicles available for public use. The paper demonstrates that the use of such a system in place of buses and cars could offer a considerable energy saving relative to buses and cars.

Spatial organisation and transport operation management

The paper by Boege emphasises for us the problem of freight transport. This is the area of road transport where energy use is rising most rapidly in Europe, and where the challenge to reduce energy intensity seems almost insurmountable. Boege emphasises the role of the spatial organisation of production and distribution as well as the management of freight transport operations.

Regions with rapidly growing transport activity

With the paper by Pacudan and Faudry, we move to the complex and intractable problems posed by precipitate transport growth in the world's megacities, and to the importance of integrated approaches to addressing these problems. In Singapore, the government has implemented, and the citizens have accepted, wide-ranging, consistent and successful policies to manage car ownership and energy use. This situation is contrasted with that of more laissez-faire cities such as Bangkok, Jakarta and Manila.

Zegras and Hook draw our attention to Central Europe, another region where private transport and hence energy use are rising rapidly, and to policies and investment patterns that appear to be supporting that growth. They suggest a shift in transport investment and planning appraisal which might help to develop more energy-efficient, environmentally sustainable and equitable transport systems.

Integrated approaches to transport policy

The next paper provides another perspective on transport policy. Many policy analysts advocate the internalisation of the social and environmental costs of transport in user fees. Crozet and Perez comment that, even if these costs were all internalised, the social and environmental problems caused by transport activities would remain, and would not be much reduced. They point to a fundamental conflict between our individualist culture and the aim of sustainable development.

Finally, Wade, in a paper on personal transport in the European Community, notes the need to move away from concentrating on technological solutions towards the combination of a variety of policy instruments. Wade proposes a methodology for policy assessment based on the need for an integrated approach to address a range of problems and aims.