Emission trade and the electricity markets

Juha Honkatukia
Government Institute for Economic Research

Abstract:
European countries are introducing an emission trading scheme that, overall, may result in cost savings in CO2-abatement. Emission trading may have unintended consequences, however, in integrated electricity markets. In integrated markets, the price of electricity is determined by the marginal costs of the marginal producers, while all intra-marginal producers earn profits. Emission trade raises the costs of all producers who use fossil fuels. In the integrated Nordic electricity markets, the marginal producers are also the largest emitters of greenhouse gases, usually utilising coal-fired condensation plants, which in the short run are unlikely to be entirely be replaced by less carbon-intensive plants. As it is likely that much of the cost increase can be passed to prices, emission trade is likely to raise the market price of electricity in the integrated Nordic electricity markets. As a side effect, the profits of non-marginal producers are increased. This has been seen as a problem for several reasons. In the Nordic electricity market much of the emission-free capacity is based on fixed natural resources, particularly hydropower, which cannot be substantially increased. The price rises also raise the energy bill of all electricity users and may shift the burden excessively to consumers. Finally, the European emission trade scheme bases on grandfathering, which compensates even part of the cost increase of marginal producers. A number of remedies have been suggested to the excess profit problem. The current paper evaluates some alternative proposals to lower the costs of emission trading by taxing the profits of intra-marginal producers, by developing energy taxes in general, and by introducing an investment incentive mechanism financed by the revenues from profit taxes. The results indicate that an introduction of a pure CO2-tax would lower the costs of emission reductions at the macroeconomic level, and, provided the price of emission permits is high, an investment subsidy to emission-free technologies financed with the profit tax might also lower the overall costs of reductions.

Key words: Emission trade, CO2-tax, investment subsidies

1. Introduction

The European Union has entered a new phase in climate policies by introducing mandatory trade in CO2 emission rights from 1 January, 2005. Emission trade has been widely regarded as a cost-effective way to cut greenhouse gas emissions. The idea behind emission trade is to introduce a carbon penalty that encourages all users of fossil fuels to reduce their emissions by switching to cleaner fuels and technologies or by cutting down their consumption. Trade in emission rights then ensures that emissions are cut in a cost-effective way. However, emission trade has also produced a few surprises. In the Nordic countries, where electricity markets are fully integrated and liberalised, emission trading has been raising the price of electricity and creating windfall profits to a large share of electricity producers.

Nordic electricity generation is characterised by a wide variety of different production methods. Hydropower accounts for most of electricity production in Norway and to an extent also in Sweden, where nuclear plants also play a role. Finland relies on a mixture of hydro, nuclear and fossil fuels and along with Denmark is also distinguished by a large share of CHP. Denmark, then, relies largely on coal, but also increasingly on wind.

The four Nordic countries make up the NordPool electricity market, where electricity is freely traded within the whole Nordic generation and transmission system. The NordPool market prices are common to the market area – transmission capacity permitting – and are determined by the marginal costs of the marginal generator. The market price is set hourly on the basis of a bidding process, where the lower bound for the supply prices is given by the marginal costs of the generators. Generators will typically make an offer to deliver power to the grid whenever the market price exceeds their marginal cost. Thus, on a given winter's day, the market price would typically be given by the marginal costs of a coal-fired condensation plant in Finland or Denmark. A key feature of the pricing process is that generators that have lower costs than the marginal one earn profits, the margin being determined by the difference of the market price and their marginal cost.

Introducing emission trade does not change the way the market functions, but it does affect the marginal costs of those generators that use fossil fuels. The rise in costs is largest for the coal-fired electricity generators. Thus, on that same winter's day, the price of electricity will be determined by the marginal cost of coal-fired plants inclusive the cost of emission rights. Again, all other units earn profits, but the introduction of emission trade widens their profit margins. This may be beneficial to investment in cleaner technologies.

Table 1 gives an overview of the effect of the obligation to acquire emission quotas on the costs of various types of plant.

Table 1. Increase in marginal production costs caused by emission quotas, euro/MWh

Generation type	**Price of emission quotas euro/tCO_2**		
	conversion efficiency %	**10**	**20**
Coal condensation	38	8,8	18
Peat condensation	38	10	20
Oil condensation	40	6,9	14
Natural gas condensation	51	3,9	7,9
Coal CHP	90	3,7	7,4
Peat CHP	88	4,2	8,5
Natural gas CHP	92	2,2	4,4

It is clear form the table that the marginal costs of the most expensive generation types are raised quite markedly, which in the Nordic market is reflected as a higher market price for electricity. The price rise has been estimated to be more than ten per cent even for low permit prices. It is also evident that non-fossil generators – hydro, nuclear or biofuel – are not the only ones experiencing widening margins as a consequence of emission trade. This has the implication that emission trading is not only creating incentives for investment on cleaner non-fossil technologies, but also on fossil fuel –based technologies. Furthermore, since the European emission trading scheme is based on grandfathered emission quotas, in practice, fossil-based plants may benefit from the rise in the market price for electricity more than biofuel-based plants. In effect, emission trading is creating windfalls for quite a few producers.

The emergence of windfall profits has been taken to be problematic in at least the Finnish discussion on emission trading. Apart from the possible weakening of the relative incentives for investment on greener technologies, it is obvious that there is an issue of income distribution involved. Basically, grandfathering per se can be seen as a subsidy to firms' profitability, which, in combination with the effects on profits of electricity prices has been seen as unjust to those facing the bill of higher electricity prices. On the other hand, the incentives for investing in green technologies are the raison d'etre for emission trading, which, if affected by the windfall profits, might benefit from enhancing actions. The issue is, however, complicated by the fact that there is not much room for increasing hydro power in the Nordic countries.

The Finnish ministry of trade and industry commissioned a study to evaluate the possibilities for removing the effects of emission trading on electricity prices, for enhancing investment in green technologies, and for taxing the windfall profits. This article consisted a part of the evaluation report. The report considered the use of various tax schemes to, first, tax the windfall profits created by emission trading, and second, to enhance investment in cleaner technologies by ear-marking the revenue from the windfall tax for use in investment subsidies for non-fossil generation technology.

2. Policy evaluation

2.1 Methodology

The study utilises the EV-model to evaluate the policy proposals (Forsström and Honkatukia 2002). The EV-model contains a detailed description of the Finnish economy, combining traditional elements from economic CGE-models to engineering approaches for certain key sectors of the economy. The key modelling target in setting up the model has been to capture the essential process-level features and peculiarities of Finnish energy use. The model thus relies heavily on engineering data about the details on fuel use, the often fuel-specific processes that are used in the production of heat and electricity as well as in process industries. By and large, Finnish industry was for a long time characterised by process industry, such as forest industries utilising the country's one natural resource, wood, and metal industries specialising in the manufacturing machinery and equipment, but also to metal manufacturing. Production in these industries is modelled along bottom-up, or engineering, descriptions of the processes. The model also makes a distinction between different electricity and heat generation technologies. This is essential for the analysis of the Finnish energy sector, which contains a lot of combined heat and power generation, as well as communal district heating.

The EV-model distinguishes between several processes for electricity and heat generation. The basic distinction is made according to the fuel used, which is of significance in that the thermal efficiency of generation processes is to an extent dependent on the fuel choice. More importantly, however, the model defines distinct processes for condensing plants that only generate electricity; district heat processes that only generate heat; and combined heat and power generation processes that generate both heat and electric power. The large-scale use of the latter is a distinguishing feature of the Finnish energy sector and its inclusion is therefore one of the essential elements of the model. The model combines the electricity and heat generated from the various processes either following the technology-bundle described in the introduction or with the full-fledged engineering approach.

The baseline scenario follows closely the Finnish Climate strategy's With Measures baseline. There, industrial production is assumed grow at an average annual rate of 3.5 to 2010, the reference year for the impact evaluations. Emissions are also growing, though at a lesser pace. to reach the Finish emission target (1990 levels), CO_2 emissions from fossil fuels will have to be cut by 13 per cent. The baseline assumes that a fifth nuclear plant becomes operational by 2010, and in the policy scenarios, the possibility of a sixth one is not excluded.

The policy scenarios also make assumptions on certain variables that are determined outside the model. For example, the price of NordPool electricity is exogenous to the EV-model. Since imports of electricity make up a large part of the total finnish electricity supply however, the price of imported electricity is of interest to the evaluation of the effects of emission trade. The model therefore utilises electricity price estimates from the electricity market model of VTT. according to this model, the price of Nordpool electricity would rise by 10%, 20% or 40% depending on the price of emission permits. The EV-model then assumes that the Nordpool price sets a ceiling to domestic electricity prices.

Since the study focuses on effects during the Kyoto commitment period, assumptions need also be made on the allocation of emission quotas during the period, since the (official) National Allocation Plans for the period are not yet complete. Here, the assumption is that process industries are allocated quotas in quantities closely matching their baseline emissions, which can be justified by noting that these industries have scant possibilities for reducing their specific emissions. The implication of such an allocation plan would be that the energy sector needs to cut its emissions relatively more.

Table 2 summarises the assumptions concerning the allocation of the quotas. the table also reports the assumed baseline emissions (as of mid-2004). The assumptions for the allocation imply that the emission trading sector would get 19% less quotas than its emissions on the baseline.

Table 2. Sectoral baseline emissions and allocation of emission quotas, Mt CO2 in 2010.

Table 2 Allocation of emission quotas (Mt CO2)		
	Baseline	**Quota**
Electricity (condensation)	11,1	6,1
Heat (including CHP)	15,3	11,8
Paper and pulp	6,3	6,1
Steel and iron	6,7	6,7
Mineral	2,2	2,1
Oil refining	3,6	3,5
Other industries	1,5	1,3
Total	46,7	37,7

The price of emission permits is exogenous to the model. It is assumed that the price takes values ranging form 5, 10 or 20 euro/tCO2.

2.3. Energy tax proposals

The study considers three main alternatives to the current tax system, each aiming at reducing windfall profits. The tax scenarios considered are thus:

ET1: Current tax structure. Current fuel and electricity taxes are retained at present in the trading sectors. In the non-trading sectors, current taxes are raised by the amount necessary for the non-trading sectors to meet their reduction target, which is implied by the national target and the allocation of grandfathered permits to the trading sector.

ET2: CO2 taxes. Uniform CO2 taxation is introduced. In effect, this raises the tax on natural gas, which the current tax system has been favoring in comparison to coal. Otherwise, the raise in the energy taxes of non-tradings sectors would be used in this alternative as well.

ET3: Investment subsidy. A windfall tax on electricity generation is introduced. the tax is implemented as a uniform tax on electricity generation in a way to generate revenue matching the expected prifts o electirity generation. The revenue of the tax is recycled to consumers.

ET4: Windfall profit tax. A windfall tax on electricity generation is introduced. the tax is implemented as a uniform tax on electricity generation in a way to generate revenue matching the expected profits of electricity generation. The revenue of the tax is used to finance subsidies to low-emission generators (including nuclear).

3. Results

This section summarises the effects of cutting emissions while also introducing the tax schemes. Table 3 shows the estimated effects on GDP, consumption, investments and employment when permit price is 10 €/t CO2, and figure 2 for the permit price 20 €/t CO2. The effects on GDP range from a fall of 0.5 – 0.6 per cent from baseline under the 10 euro permit prices to 0.7 – 0.9 under the more expensive permits in 2010. The fall in GDP is mostly due to a fall in consumption, driven by price increases caused by the introduction of emission permits, and also by the negative effects on income stemming from reduced economic activity in the economy. The effect on employment ranges from a fall of 0.2 – 0.4 per cent from baseline under 10-euro permits to 0.4 – 0.6 per cent from baseline under 20-euro permits. The macroeconomic effects clearly indicate that removing the exceptions for natural gas lowers the overall effects of cutting emissions, since it increases the cost-effectiveness of the tax structure (ET2). The investment subsidy scheme does not fare any worse (ET3), but the windfall tax without any earmarking appears to be the least desirable of the proposals (ET4).

Table 3: Macroeconomic effects

	ET1:5€	ET1:10€	ET1:20€	ET 2:5€	ET 2:10€	ET 2:20€	ET3:5€	ET3:10€	ET3:20€	ET4:5€	ET4:10€	ET4:20€
GDP	-0,5	-0,6	-0,9	-0,4	-0,5	-0,7	-0,5	-0,5	-0,6	-0,5	-0,5	-0,7
Consumption	-1,2	-1,5	-2,2	-1,1	-1,2	-1,7	-1,2	-1,3	-1,6	-1,3	-1,3	-1,7
Investment	0,0	0,0	-0,2	0,0	0,0	-0,3	0,0	0,0	0,0	0,0	0,0	-0,1
Employment	-0,3	-0,3	-0,6	-0,2	-0,2	-0,5	-0,3	-0,3	-0,4	-0,4	-0,3	-0,4

The industry level effects are presented in table 4. At the industry level, the present tax-scheme intuitively (ET1) induces larger changes in production in most of the emission trading sectors than the subsidy alternative (ET3). Trading per se also has a large effect on process industries whose process emissions are included in trading, changing their cost structure very markedly. The rise in the price of electricity also affects some of the non-trading sectors.

Table 4: Sectoral effects

	ET1:5€	ET1:10€	ET1:20€	ET 2:5€	ET 2:10€	ET 2:20€	ET3:5€	ET3:10€	ET3:20€	ET4:5€	ET4:10€	ET4:20€
Minerals	-1,0	-1,7	-3,5	-1,0	-1,6	-3,6	-1,2	-1,8	-3,3	-1,5	-1,8	-3,3
Pulp and paper	-1,4	-1,7	-5,7	-1,2	-1,5	-6,8	-2,4	-2,9	-5,4	-3,5	-2,6	-6,1
Oil refining	-4,2	-5,8	-9,6	-3,9	-5,1	-8,5	-4,1	-5,5	-8,2	-4,3	-5,4	-8,4
Metals	-4,1	-7,5	-15,1	-4,0	-7,4	-15,6	-4,6	-7,9	-14,9	-5,2	-7,9	-15,0
Other industries	-0,1	0,0	-0,1	-0,1	0,1	-0,1	-0,2	-0,1	0,0	-0,3	-0,1	0,1
Services	-0,4	-0,5	-0,6	-0,4	-0,3	-0,4	-0,4	-0,4	-0,4	-0,4	-0,4	-0,4
Electricity and heat	-0,2	-0,2	-7,0	0,3	-0,1	-9,3	0,4	0,4	-0,8	0,0	0,5	-3,0

4. Conclusions

The results of this study suggest that the effects of emission trading on GDP, consumption and employment can be reduced by adjusting the energy tax structure. It appears in any case advisable to implement uniform CO2-taxation. Furthermore, if the price of emission rights should be high, an investment subsidy on clean energy technologies may become attractive. At the industry level, the ineffectiveness of the current tax system signals the need to switch to a more harmonious tax structure, but at that level, the tax on windfall profits appears only beneficial when combined with an investment subsidy scheme.

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