The EU Tradable Emission Permit System: some policy issues identified with the POLES-ASPEN model

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Abstract
This paper provides some insight on the issues raised by the *Tradable Emission Permit System (TEPS)* proposed in a Green Paper of the EU in 2000. It is based on the results of the POLES model for the simulation of the *Marginal Abatement Cost* curves of the EU countries and on the ASPEN software for the assessment of the corresponding structure of permit market. The first section identifies the issue of the national sectoral entitlements, in the context of the European burden sharing agreement, and then derives a simple scheme for the CO2 entitlement of energy intensive industries and electricity sector; this system is based on the hypothesis of entitlements allowing for the equalisation of the *marginal abatement costs* (MACs) across the different sectors of each country. The second section presents and discusses the key outcomes of the simulation of the energy intensive industries and electricity sector TEPS in 2010. The third section discusses the consequences for industries of different environmental regulation schemes, while comparing the grandfathered and auctioned permit system with the tax or technical standard *(Policies and Measures)*. It also identifies some key issues that will have to be further analysed and discussed in the process of designing the EU emission permit market.

Introduction
In 2000 the European Union prepared a *Green Paper* on the creation of a *European Tradable Emission Permit System* to be implemented from 2005 on, in a perspective of early action for the compliance to the Kyoto Protocol. This proposal was issued in order to allow for reactions of industry, stakeholders and academic researchers, before further elaboration by the EU services. The exercise performed with the POLES model and the ASPEN software shows that such a TEPS for large energy consumers in Europe would bring large economic benefits, compared with the no-trade situation. It also shows however that this type of tradable permit system supposes first that the thorny issue of sectoral entitlements is solved in a satisfactory way both inside each country and across member countries.

The EU Green Paper on emission trading
In 2000, the EU published a Green Paper presenting the main lines of a future European emission trading system for the electricity sector and the energy intensive industries, i.e. the industries identified the Directive on Large Combustion Plants. The proposed scheme would start in 2005 and thus be incorporated in an *early actio*n scheme for the compliance to the Kyoto Protocol. But it is also proposed that the market may be progressively extended to other industries and economic actors and thus constitute the core of a future EU-wide tradable emission permit system. It is thus important, in view of these possible developments, to identify the key issues raised by the definition and implementation of such a scheme. The key issues of course relate basically to questions of economic effectiveness on one hand, and equity and competitiveness on the other hand.

The POLES model for the simulation of MAC curves
The POLES model is a partial equilibrium, energy sector model for the world up to 2030. Its geographical and sectoral disaggregation (30 countries or regions in the version used for this exercise, about 12 sectors of activity and 24 power generation and renewable technologies) is however sufficient to provide insights on the potential impacts of energy and environment policies at a country or regional level and, in the case of this study, for Europe.

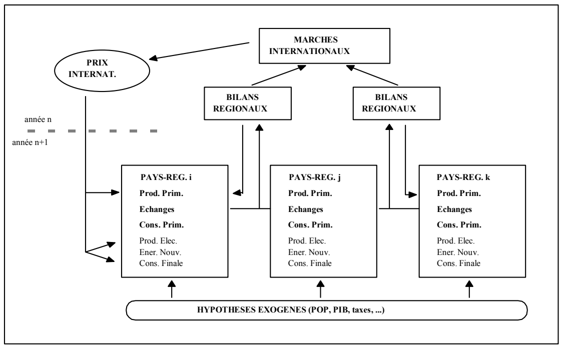

Fig. 1. The POLES model dynamic simulation process

Basically the POLES model simulates energy and environment policies through the introduction of a shadow tax for the considered emissions. In the case of CO2 emission reduction policies, the *shadow carbon tax* is introduced in every module where fossil fuels are burnt, proportionally to the carbon content of the fuel. This shadow carbon tax can indeed represent either a carbon tax, the price of an emission permit or also the dual cost of a technical standard or *Policy and Measure*. We thus denominate it with a generic term: the *Carbon Value*, which represents the value given by society to the reduction of 1 tC of emissions.

By performing a series of simulations of the model with stepwise increases in the Carbon Value, it is possible to simulate the corresponding reductions in emissions and to associate a price/cost with a quantitative reduction target: this allows to build the Marginal Abatement Cost curves for CO2, which can be identified at the sectoral or national model.

The ASPEN software for the analysis of tradable permit systems and emission reduction policies
The ASPEN software then uses the MAC curves produced by POLES as inputs for the simulation – on simple but robust micro-economic grounds – of Tradable Emission Permit Systems. The principle used is one of cost-minimisation through trading: if a set of economic actors – be it world regions, countries or sectors, each characterised by its own MAC curve and emission constraint – participates in an emission permit market, then the price of the permit will equalise, through the process of exchanges, the Marginal Abatement Costs for each participant.

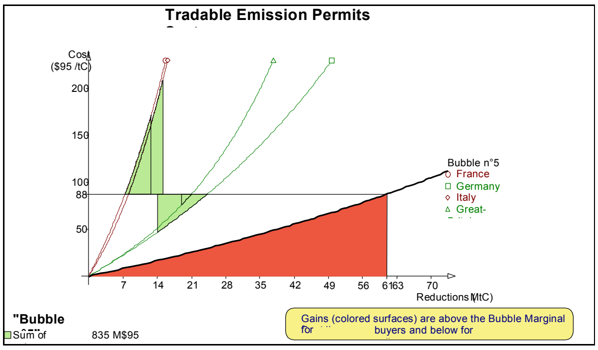

Fig. 2. Example of a permit market simulation with the ASPEN software

The ASPEN software allows to calculate the marginal and total abatement costs with and without permit system and also to evaluate the *gains from trade* for different extensions and structure of the market. This process can be applied either for the assessment of international emission reduction agreements or for the analysis of national policies involving different sectors with different MAC curves.

A starting point: national emission reduction policies and sectoral CO2 entitlements

The design of CO2 emission reduction policies can be based on different policy instruments such as Carbon taxes, Policies and Measures or tradable emission permit systems. Very probably the implementation of actual policies will rely on a mix of these different instruments, according to the characteristics of the different sectors considered (number of economic agents, respective sensitivity of these agents to price signals …).

One key issue in the definition of national policies is the "inter-sectoral equity vs overall economic effectiveness" trade-off. Each type of instrument – P&M, tax or tradable permit – will allow for emission reductions, be it with or without an explicit quantitative target, but it will also involve additional sectoral costs. Thus the policy mix considered in a national policy also corresponds to an explicit or implicit carbon entitlement and to a burden-sharing of the national target among the different sectors.

This question is rarely addressed as such and it raises difficult policy issues, similar to those of the identification of acceptable quantitative emission reduction objectives in an international agreement. Two extreme approaches can be adopted in the design of a national emission reduction policy and in the identification of the corresponding sectoral targets:

- In the case of the adoption of a *general carbon tax* (GCT) system, the emission control is obtained by a price signal. In principle, the same tax introduced in every sector will induce the implementation of all abatement options that present a cost inferior or equal to the tax level. As a consequence, marginal abatement costs are equalised across the sectors while the global target is met, if the level of the GCT has been conveniently determined. This solution thus allows in theory for a full economic-effectiveness. The sectoral targets, total sectoral costs and share of the burden are not identified ex-ante but can only be studied ex-post, after the MAC equalisation process. To some extent, the sectoral equity or fairness of the policy do not even have to be considered in the first stage of the policy process.

- But a different approach may also be adopted through a *uniform reduction objective* system. This is done by considering a uniform limitation or reduction rate relatively to the base year that is equal to the national objective; i.e. if a country has to reduce its emissions of x% relatively to 1990, then this objective is applied in each and every sector. Of course the corresponding sectoral targets allow to meet the national goal and the advantage of this system is that it *apparently* provides a fair burden-sharing among sectors. This may however not be the case if, as maybe expected, the trends in emissions in the no-climate policy scenario and the MAC curves are very different across sectors.

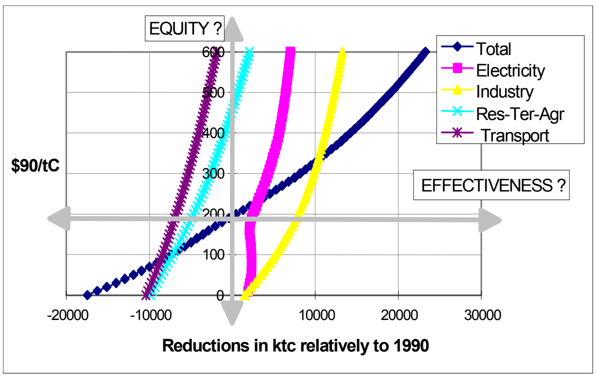

Fig. 3: Sectoral targets for France, equalisation of MACs with a carbon tax vs. uniform reduction objective (0% increase between 1990 and 2010)

The potential consequences of such a *uniform reduction objective* can be analysed and compared with a general carbon tax system while considering, as a simple example, the set of sectoral MACs produced for France with the POLES model and illustrated in Fig. 3.

This case clearly shows the differences in marginal and total costs, incurred by the sectors in the *general carbon tax* versus the *uniform reduction objective* policy: in the former case the MACs are equalised, but some sectors (industry) reduce their emissions more than others (transport), in absolute and in relative terms. In the latter case, all sector stabilise their emissions, but the MAC is null in industry as this sector already reduces its emissions in the No-Policy Case, while it would be rocketing in the transport sector, which presents both a high Reference and a low price-elasticity to the Carbon Value. The case of other European countries may be less easily illustrative, but this only for technical reasons (reduction targets should be differentiated in Figure 3.), while the essence of the problem would remain unchanged.

A third type of policy may reconcile the two approaches by entitling the different sectors according to the uniform reduction objective and then install a nation-wide trading scheme, allowing for the equalisation of sectoral MACs. The distributive consequences of such a scheme would of course be very important, with some sectors being sellers and the other buyers of permits. As mentioned above, actual policies will probably use a mix of instruments and thus follow a hybrid sectoral entitlement scheme.

As no explicit and general rule has up to now be identified either at a country or EU level, one difficulty for economic modelling exercises is to build reasonable hypotheses on sectoral entitlements. In most cases the hypothesis is one of entitlements according to the equalisation of sectoral MACs: it indeed allows to suppose that the cost-effectiveness criteria is respected in the design of national policies and this is its main advantage. But, as underlined above, this hypothesis is not the only one possible and, to some extent, it may even be considered as a "modelling artefact".

A EU trading scheme for industry, under the "equal MAC entitlement" hypothesis

For exploratory purposes, the EU trading scheme for energy intensive industries and the electricity sector has been explored with POLES and ASPEN under the hypotheses of European burden sharing agreement and "equal MAC national entitlement" in each EU country or region. Furthermore, it has to be underlined that this hypothesis corresponds to a certain degree of *grand-fathering* as the entitled emissions are given for free.

The no-trade and EU-wide trading cases as benchmarks for analysis

The Kyoto compliance hypothesis is first studied for the EU in 6 regions (Germany, France, Great-Britain, Italy, Rest of EU-North, Rest of EU-South). The results in Table 1. show that under the European burden sharing agreement with no-trade hypothesis, the national MACs measured by the POLES model lie in a very wide range, from 16 E99/tCO2 (52 $90/tC in Germany) to 118 E99/tCO2 (in Rest of EU-North). The total cost for the EU is of 17 bE99, i.e. approximately 0.17% of EU's 2010 GDP. The theoretical hypothesis of a full perfect market at EU level changes the scene quite drastically, with a permit price of 42 E99/tCO2 and a total cost of 11 bE99. This case is however highly hypothetical, as it supposes the possibility of a market to be established among very different sectors, some of them made of a multiplicity of economic agents.

Table 1. The Kyoto Protocol in the EU, costs in the EU-wide Trade and No-Trade cases

KYOTO 2010	Emissions (MtC)			Trade : Permit Price 134,5 $/tC					No Trade		
	2010 Ref (Mt)	2010 Kyoto (Mt)	2010 Trade (Mt)	Trade (Mt)	Trade Value (M$)	Dom Cost (M$)	Total Cost (M$)	% of GDP	MAC ($/tC)	Cost No Tr (M$)	% of GDP
FRA	121	104	108	-3.5	468	796	1 265	0.08	*185*	*1 350*	*0.09*
RFA	236	210	182	28.0	-3 760	3 167	-593	-0.03	*52*	*643*	*0.03*
ITA	123	103	111	-8.6	1 151	715	1 866	0.13	*279*	*2 454*	*0.18*
GBR	168	141	137	4.4	-585	1 800	1 215	0.09	*108*	*1 274*	*0.09*
REUn	206	146	174	-28.5	3 828	1 835	5 664	0.40	*381*	*8 763*	*0.62*
REUs	131	112	104	8.2	-1 102	1 563	462	0.04	*83*	*680*	*0.07*
Total Bubble	983	816	816	(40,5)	(5447)	9 877	9 877	0.11	-	*15 164*	*0.17*

The energy intensive and electricity sector market

The EU Green Paper on emission trading introduces some realism in the scenarios for emission permit trading in Europe and this is already a major achievement. It is indeed supposed that the market may be progressively introduced, first in sectors built from large energy consuming entities, i.e. the energy intensive industries (EII in Table 2.) and the electricity sector (ELEC).

The simulation of such a market with POLES and ASPEN, supposing that each sector's entitlement correspond to the equalisation of the MACs *at the national level* shows that this initial market would indeed capture quite a large part of the gains that would be obtained in the much less realistic case of a full EU-wide trading scheme.

Table 2. The EU industry and electricity sector market, costs in the Trade and No-Trade cases

EU Buble 2010	Emissions (MtC)			Permit Price 123 $/tC				No Trade	
	2010 Ref (Mt)	2010 Kyoto (Mt)	2010 Trade (Mt)	Trade (Mt)	Trade Value (M$)	Dom. Cost (M$)	Total Cost (M$)	MAC ($/tC)	Cost No Tr (M$)
FRA-ELEC	9	8	8	0.3	-39	28	-12	*(37)*	*11*
FRA-EII	9	8	9	-0.4	53	47	100	*185*	*113*
RFA-ELEC	63	50	38	12.0	-1 479	1 345	-134	*52*	*325*
RFA-EII	14	13	13	0.9	-108	94	-14	*52*	*17*
ITA-ELEC	31	23	27	-3.4	422	235	657	*279*	*911*
ITA-EII	9	7	8	-1.2	142	58	200	*279*	*287*
GBR-ELEC	46	31	30	1.2	-143	801	658	*108*	*666*
GBR-EII	10	9	8	0.1	-18	81	63	*108*	*64*
REUn-ELEC	46	24	34	-10.1	1 247	642	1 888	*380*	*2 987*
REUn-EII	18	12	16	-3.7	459	127	586	*380*	*1 031*
REUs-ELEC	39	28	25	3.9	-474	795	322	*83*	*401*
REUs-EII	9	8	7	0.5	-61	113	52	*83*	*63*
Total Bubble	304	221	221	(18,9)	(2322)	4 364	4 364	-	*6 877*

The key results in Table 2. Indeed show the following:

- The intensive industries and electricity producers market covers approximately 30 % of the Union's emissions (given the POLES model sectoral disaggregation).
- The gains that may be expected from the trade among these sectors amount to 2.85 bE99, i.e. about one half of the total gains from trade (in the full EU-wide vs. no-trade cases).
- The price of the permit is of 38 E99/tCO2, slightly inferior to the hypothetical EU-wide Carbon Value.

With the national entitlement system considered here (equal sectoral MAC in each country) the trade flows in the European energy intensive industries and electricity sector market principally consist in:

- Purchases from the electricity sector and energy intensive industries in EU-North (respectively 10 and 4 MtC) and in Italy (3 and 1 MtC).
- Sales from the electricity sectors in Germany (12MtC), Great Britain (1MtC), EU-South (4MtC).

All participating units benefit from the emission permit market. In the four importing units identified above, the gains come from a permit price that is inferior to the national carbon value. For the three exporting units the permit price is higher than the national carbon value, but further reductions are more than compensated by the permit sales revenues.

A particular situation occurs in France, where the electricity sector presents a backward bending MAC curve for intermediate carbon values. This is explained in the model's results by the following phenomenon: when the carbon value is low, the electricity sector's emissions are reduced; when it increases further, electricity – which presents in France a very low carbon intensity because of the nuclear share in power generation – replaces more carbon intensive fuels in final consumption, but as a consequence, the emissions of the power sector increase; then for high carbon values the effect is again a net reduction in the electricity sector. This type of situation should clearly deserve more analysis in terms of the complex indirect effects of a carbon value on the fuel mix and sectoral emissions.

The total cost for industry and the issue of the entitled vs. auctioned permits

It has been supposed in the above analysis that the permits have been initially entitled to the different sectors according to the MAC equalisation rules. In that case the total cost for the sector is the one indicated in Table 2. It corresponds solely to the cost of the abatement inside the sector plus or minus respectively the buying or sale of permits for the difference between the entitlement and the effective emission.

Policy instruments and total cost for industry

Figure 3. illustrates in a generic way the possible elements of the total cost for a sector, in a buyer case (i.e. when the marginal abatement cost in the no-trade situation is higher than the permit price in the trade situation) and for four types of policy instruments:

- In a no-trade + Policy and Measure (or emission standard) the total cost is only the sector abatement cost (A+B1+B2).
- In a no-trade + carbon tax system the total cost is the sum of the sector abatement cost (A+B1+B2) plus the tax paid on remaining emissions (C1+C2).
- In a trading case + entitled or grand-fathered permits, the total cost is limited to the sector abatement cost (A) – which is of course lower than in the no-trade situation as the permit market allows to lower the required MAC – plus the permit purchase (B1).
- In a trading case + auctioned permits, the sector cost is the sum of the abatement cost (A), plus the costs of the permit corresponding to the total emissions (B1+C1).

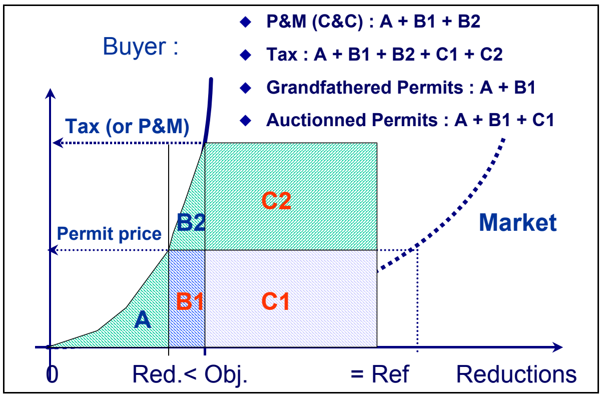

Figure 3. Total cost for a sector of four types of policy instruments (buyer case)

This type of analysis allows to identify the similarities in terms of cost structure between the P&M system and the entitled (or grand-fathered) permit market on the one hand, and the carbon tax and auctioned permit on the other hand. It also provides an insight on the possible preferences of industrialists as regard the choice of the policy instrument. In the case of a buyer, examined here, the carbon tax is systematically the highest cost solution and the entitled permit the lowest one. The comparison between the Policy and Measure and the auctioned permit systems depends in the industry's perspective on the relative surface of B1 and C1, i.e. of the Reference, the permit price and the MAC curve shape.

For concision's sake a similar analysis for the seller-case is not provided here. It would show slightly more complex results in the comparison of instruments, but the entitled permit market would still be lowest cost option.

Distributive impacts, competition and uncertainties

These analyses of the cost consequences for industry, reminds us that the "equal MAC national entitlement" hypothesis used in the quantitative analysis in Section 2. is only but one of the possible cases for an EU industry emission permit system. As illustrated above an auctioned permit system would of course introduce strong distributive consequences, but it would also raise several difficult questions such as:

- What institution would receive the probably large funds resulting from the auction and for what uses?
- What should be the total amount of permits auctioned at EU level for the subset of energy intensive industries and power producers?
- How would the emission profile of each sector participating in the auction permits, be made compatible with the sectoral targets of national policies?

Comparatively, the entitled permit system seems to present in its definition and implementation less uncertainties and consistency problems. Besides the fact that it would probably be preferred by industrialists (as involving less transfers from their part) it would also respect the consistency of national abatement policies.

One key remaining issue is however that it may raise problems of competition between similar industries in the EU. Indeed while every participant would gain from trade, some of them may gain much more than others, as illustrated in Table 2. These may probably claim that the situation results in an unfair competition inside the EU. More important than the particular results obtained in this preliminary simulation is the fact that this type of situation may exist, depending on the national targets, structural conditions and sectoral entitlement policies. This latter issue is probably the one that should deserve more attention in the process of launching of a European permit trading scheme.

Conclusion

This exploratory study aimed at identifying some key issues related to the implementation of a European CO2 emission permit trading system for energy intensive industries and power generators. The quantitative results of the simulation – performed for entitlements with equal sectoral marginal costs at the national level – show that the gains to be expected from this type of system are large. It may indeed capture half of the total gain of a hypothetical full-EU trading system, relatively to a no-trade situation. As it was to be expected, all sectors participating in this market may gain from trade, but the simulation also shows that some sectors in some countries gain much more than others.

The study thus indicates that several key issues should deserve, in the process of designing the EU tradable emission permit system, more in-depth analyses. In the case of an auctioned permit system the key issues relate to the status of the authority in charge of emitting the permits and receiving the corresponding funds, as well as to the necessary consistency between the EU market and the national policies. In the case of national sectoral entitlements, it remains to be studied how entitlement schemes different from the one considered in the study would allow to combine economic effectiveness in the implementation of national emission reduction policies and fair competition conditions among the different European industrial sectors.

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