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How should transport emissions be reduced?

Potential for emission trading systems

Charles RAUX
LET - Transport Economics Laboratory
(CNRS, University of Lyon, ENTPE), France

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1. INTRODUCTION

In developed countries, transport generates approximately 25 to 30 per cent of emissions of CO2, the main greenhouse gas (GHG) and these emissions are increasing sharply. There are two explanations for the increase in emissions from transport: the first is dependency on the internal combustion engine for transport with no wide-scale economically viable alternative available in the medium term; the second is the sharp increase in vehicle-kilometres travelled, which seems to be an inherent feature of economic development.

One might well ask, given announcements that oil reserves will run out rapidly, whether we should not simply wait until reserves dry up to obtain a reduction in transport-related emissions. This said, rising oil prices are gradually making it more viable to exploit unconventional reserves, leaving aside innovations in technology which are reportedly opening up prospects for new fossil fuels (including fuels derived from coal, which is in plentiful supply world-wide). Hence, there is every reason to believe that the use of fossil fuels could continue on a large scale in the future.

Foresight studies show that if our aim is to achieve ambitious GHG emission control targets for transport within the next few decades, the policies we implement will have to be more determined: among other things, they should aim at reducing total consumption that is to say vehicle kilometres travelled, not just unitary vehicle consumption (cf. ENERDATA and LEPII, 2005 for France, for instance).

Among the measures identified, carbon taxes and vehicle taxes are the most cost-effective (OECD, 2007; Parry et al., 2007). However, the “fuel tax protests” of September 2000 in several European countries show that public opinion is very resistant to fuel tax increases (Lyons and Chatterjee, 2002). This resistance can also be explained by concerns about fairness, since many households depend on the car for day-to-day living and for getting to work. As well as this, fuel tax increases would require the international harmonization of fuel taxation in different countries, which seeing what has happened in the European Union appears to be extremely difficult.

In the light of these difficulties, another instrument which combines economic incentives and regulation by quantity, namely marketable or Tradable Permits (TPs), might be of interest. This category of instruments is part of a wider one, namely transferable permits. According to a general definition given by O. Godard (OECD, 2001), transferable permits cover a variety of instruments that range from the introduction of flexibility into traditional regulation to the organization of competitive markets for permits. These instruments have in common: the setting of quantified physical constraints in the form of obligations, permits, credits or rights allocated to target groups of agents consuming scarce resources; and the permission granted to the agents to transfer these quotas between activities, products or places (offsetting), periods of time (banking) or to other agents (trading, hence “tradable permits”).

These tradable emissions permits (or quotas1) are frequently referred to as “pollution rights”, implying that those who can afford to are allowed to purchase the right to harm the environment. However, the allocation of emission quotas does not involve the creation of “pollution rights”, but the restriction of these rights when previously they were unlimited. Making these quotas “tradable” therefore amounts to introducing flexibility and minimizing the total cost to the community of reducing emissions.

[1] The terms “quota”, “permit” or “right” will be used interchangeably in what follows.

It is generally considered that tradable permits schemes with a large number of mobile sources involve huge implementation costs. We will argue that allocation methods and emission caps can be defined with no excessive complexity and that administrative running costs can be significantly lowered with a smart design. Adding the advantages of better acceptability and more effective influence on behaviour given by the possibility of free allocation, TPs schemes in transportation deserve a thorough exploration.

This report recaps firstly the theory about tradable permits (TPs) when compared with taxation, and secondly the relevance of TPs in transportation: the current proposal by the European Commission for including aircraft operators in the Emission Trading Scheme is briefly presented. Then a series of proposals elaborated from the author's works are presented: gasoline consumption by drivers of private vehicles, freight transportation, and tradable driving rights in urban areas. Finally potential pitfalls and implementation issues are discussed.

2. THEORY

The economic theory behind pollution permit markets can be traced back to the work of Coase (1960) on external costs, followed by that of Dales (1968) on regulating water use, and the formalization of pollution permit markets by Montgomery (1972).

A system of tradable permits equalizes the marginal costs of reduction between all emission sources. Under some assumptions this is a sufficient condition for minimizing the total cost of achieving a given emissions reduction objective (Baumol and Oates 1988). This result is obtained independently of the initial allocation of rights: it should be stressed that this makes it possible to separate the issues of efficiency and equity.

However, Stavins (1995) has shown that when transaction costs are involved – the search for trading partners, negotiation, decision-making, follow-up and compliance with the rules – the initial allocation of rights affects the final balance and the total cost of reducing emissions. The authorities may therefore attempt to reduce these transaction costs, for example by avoiding finicky regulations or by facilitating the activity of intermediaries between vendors and purchasers (Hahn and Hester 1989; Foster and Hahn 1995).

The use of transferable permits is not new. They have been used in the fisheries, and in the fields of construction rights and water pollution. The US "Acid Rain" scheme has been developed as a large-scale system of tradable sulphur dioxide emission permits (Godard 2000). An appraisal of these experiments has made it possible to identify the principal criteria of success for such systems and the associated legal and institutional pitfalls (see below).

With regard to the quantitative reduction objective, the essential difference between taxes and permits lies in the fact that in practice the public authorities do not possess full information on the reduction costs for the different agents. With a permit-based approach, achieving the quantitative emissions reduction objective is guaranteed, but there is no guarantee with regard to the level of the actual marginal costs of reduction. On the contrary, in the case of the tax, the marginal cost of reduction for each agent is fixed by the tax level, but there is no guarantee with regard to the amount of emissions reduction.

This uncertainty makes it difficult for the regulator to make a choice as errors regarding reduction costs for agents, particularly with regard to the distribution of efforts over time and between agents, may be very costly to the community. Nevertheless, a number of criteria may be of use when making this choice (Baumol and Oates 1988).

A first criterion for the appropriateness of a quantity-based approach (i.e. emission quotas) is whether the damage to the environment is in danger of increasing very rapidly or becoming irreversible when certain emission thresholds are reached or exceeded. In this case, tradable permits provide a relative advantage over price-based (i.e. tax) approach: in a context of inherent uncertainty quotas control reduces the cost of errors of anticipation of abatement benefits and costs (Weitzman, 1974). The problem of greenhouse gas emissions is a particularly good example of this situation with a steep damage function while the abatement costs are considered as limited (Stern, 2006)[2]. Another, in the field of transportation, is the case in which congestion may in the short term result in hyper-congestion which generates large-scale waste for the community.

A second criterion is whether agents are more sensitive to quantitative signals than price signals, particularly if the price-elasticity of demand is low in the short or medium term as is the case in transportation. Here again a permit system is more appropriate.

For example, emissions from travel may be reduced by various means: changing driving style, reducing vehicle-kilometres of travel (by increasing the number of passengers in vehicles, reorganising trips or changing the locations of activities); by changing one's vehicle or changing mode in favour of one which consumes less energy. Some of these actions may be implemented in the short term, while others such as changing one's vehicle, changing one's place of work or residence, may take much longer. The result of this is elasticities which are generally low in the short term and considerably higher in the long term. For example, for fuel consumption, the price-elasticity values are between –0.3 in the short term[3] and –0.7 in the long term (Goodwin 1988).

Furthermore, a third criterion that is an important factor for the effectiveness of TPs is the heterogeneity of the agents involved in the system. This means that the marginal costs of abatement must be sufficiently different between agents in order to allow benefits from trading permits thereby making the market function effectively.

For instance if we consider the use of private car, the marginal abatement cost curves are highly varied and, in particular, rise as one moves from urban to suburban and then to rural settings. On two essential points, namely changes in the locations of activities and changes in transport mode, the possibilities for action differ very greatly in both nature and degree on the basis of the residential locations of the individuals in question (urban, suburban, rural). Changes in the locations of activities in order to reduce the distances between different activities are much easier to make in urban areas than in suburban or rural locations, as a result of the density of available activities: changes are possible in the short term for activities where the location imposes little constraints, such as shopping or leisure; reducing distances between home and work is easier in a conurbation which provides a high density of job and housing opportunities. Likewise, public transport which provides an alternative to the private car is more frequently available in urban areas.

Finally, last but not least, in political terms, systems where permits are allocated free of charge may be seen as a means of avoiding an additional tax, and this can enhance the acceptability of the new

[2] However some other economists argue the opposite (see for instance Nordhaus, 2006).

[3] i.e. a 10% increase in price would lead to a 3% reduction in fuel demand.

instrument. With this free allocation, economic agents have a supplementary incentive to save whether emissions, trips or distance travelled, beyond their initial allocation of permits because they can sell unused permits and then get tangible reward for their "virtuous" behaviour.

Nevertheless, the choice between taxation and permits requires a case-by-case analysis. A general solution to this problem of uncertainty with regard to the costs of emissions reductions has been proposed by Baumol and Oates (1988, pages 74-76), on the basis of an idea developed by Roberts and Spence.

If the regulator does not put enough permits on the market (for a given year or a given sector), the free play of the permit market will result in an excessive price. The regulator can then introduce a payment in full discharge t (i.e. a "safety valve"): in lieu of buying permits at a price p which could rise to a too high level, the emitter could be discharged of his/her obligation to render permits by paying the charge t for each unit of emission exceeding the rights he/she holds. In this case, as soon as the price of permits exceeds the level t, it is in the interest of polluters to pay the payment in full discharge.[4] The upper bound of the permit price will therefore be equal to t. This is the hybrid solution which combines the allocation of permits and a payment in full discharge. It is to be applied when the regulator must make decisions either with regard to the temporal distribution of efforts (for example annual objectives) or with regard to the distribution of this effort between the different actors or sectors. Of course this implies that the overall quantitative objective of emissions might be exceeded for one specific time period or sector: the corrections which afterwards would be needed, for instance the level of t for the next period, are the responsibility of the regulator.

The main arguments against the use of permits in the transport system are the cost of administration and monitoring over a large number of mobile sources and the transactions costs of quotas transfer. However this issue happened to be similar in the case of road pricing and is now better addressed and effectively implemented thanks to electronic technology which is affordable today. As we will see this technology improvement can be of some help to minimise the operation costs of TPs.

Experiences in implementation of tradable permits markets (OECD 1997, 1998) make it possible to identify some general criteria of success.

First of all it is necessary to share a broad agreement on the need for doing something, on the system effectiveness to improve the environment, and on its lower cost compared to other systems or solutions. Taking account of equity (in particular in the methods of allocation), and more generally of social and political acceptability, is of paramount importance.

The first major criterion is that of the simplicity and the clearness of the system. The target must be clearly identified and the exchange unit must be defined, easily measurable and verifiable. The rules of allocation and exchange of quotas must be simple, so as to limit the transaction costs. The institutional and geographical borders of the market, as well as the participants must be clearly identified.

A second criterion, not less major for the efficiency of the system, is the possibility of market effective operation. It is necessary to have a sufficient number of agents likely to take part in the market and that they can pay the foreseeable price of the permits indeed. Moreover, it is essential that the expected marginal abatement costs are sufficiently different so that benefits can be achieved thanks to the exchanges.

[4] This does not apply to the current European Trading Scheme as the penalty is not a payment in full discharge.

Lastly, the system efficiency also depends on the credibility of emissions monitoring, the checking and the rigour of the sanctions. Moreover, in order to allow the economic agents to optimise their long-term behaviour, certainty as for the validity of the permits in the future is necessary.

3. RELEVANCE IN TRANSPORT

The relevance of TPs in transportation can be assessed firstly by identifying the appropriate nuisances, secondly the potential targets of TPs and then matching the nuisances with these targets. Finally policy aspects regarding a CO2 tax when compared with TPs and the point where TPs should be implemented, upstream or downstream, are analysed.

3.1. Appropriate nuisances.

Two main criteria can be used to judge the appropriateness of transferable permit systems – the ability to impose a constraint, or a right, defined in a quantitative terms within a specified space and time, and the ability of agents to transfer these quantitative obligations (Godard in OECD, 2001). These criteria can be assessed against the main nuisances associated with transport activity, i.e. regional pollution, greenhouse gas emissions, noise and congestion.
In many instances it is possible to set precise and measurable targets for aggregate emissions. This is the case for greenhouse gas emissions where threshold effects may require a quantity-based approach and where global trading is possible.

Since several local or national health regulations prescribe limits for air pollutant concentrations[5], a quantity-based approach may also be relevant for this kind of emissions. Space-time equivalents may be established for air pollution for which permits could be traded within a geographical area.

In all the previous cases, it is the sum of the individual outputs of agents that produces the overall output. In contrast, this does not apply to noise whose level does not increase linearly with the number of individual emitters.

Congestion is another area where limits may be made explicit. If the local policy is not to increase road capacity, a quantity constraint could be imposed on road traffic. Strictly speaking, space-time equivalents of congestion cannot be defined very broadly since an hour lost at a given time in a given location is not equivalent to an hour lost in another area or time. An efficient scheme would thus restrict trading of driving rights to the users of say a corridor during a limited time span. However, congestion generates network interaction effects: congestion on one section of road makes drivers choose another route in order to save time. Congestion also generates rescheduling interaction effects: congestion at one period makes some drivers decide to drive earlier or later. Because of these two kinds of interaction the trading of driving rights could be extended between different locations within a same urban network and between different times and even days. The equivalence between driving rights could be fine-tuned by weighting them differently according to the level of congestion (see below).

[5] Primary gases in the case of air pollutants such as CO, SO_2, NOx and VOC. Secondary chemical reactions, such as ozone formation, may also be considered.

Another scarce resource indirectly related to transport activity is public parking space. Here again if the local policy is to not increase the amount of public parking space, a quantity constraint could be imposed on its use. However, it is clear that for parking there is no broad interaction as in the case of congestion. The market would be restricted to small scale areas (because generally two parking places are only equivalent when they are within walking range).

3.2. Potential targets for TP implementation.

Environmental impacts of transportation stems from

- the technical characteristics of vehicles (energy source, vehicle unit consumption and pollutant emissions),
- the supply of transport infrastructure and services (price and quality of service for different modes of transport)
- the intensity of travel as a function of economic and social trends, and hence,
- land use through location of activities and its impact on distances travelled.

There is potential for controlling nuisances arising from transport in several but not all of these areas.

3.2.1. Vehicle unit emissions.

The sheer number of automobiles constitutes a basic obstacle to decentralizing emission permit systems in transportation. This is why most proposals to decentralize permits have stopped at the level of automobile makers, and have been targeted at vehicle unit emissions (Wang, 1994; Albrecht, 2000). This is where we find the most advanced use of permits (see for instance a review of the ZEV scheme in California in Raux, 2004). However this approach yields several pitfalls. There is a measurement issue for instance with the (non) inclusion of mobile air conditioning systems. Moreover this criterion cannot control for actual car use, through the type of driving and even more the actual number of kilometres driven. This is why regarding CO2 emissions, end-user fuel consumption appears as a more relevant target.

Regarding atmospheric pollutants, they are produced by the inefficient burning of fuel in vehicle engines and ineffective filtering of exhaust gases. This category includes nitrogen oxides (NOx), hydrocarbons (HC) and particulate matters. For example, in Europe, vehicle unit emissions are regulated by the Euro standards which apply to new vehicles put on the market. Table 1 gives the Euro values for private cars (class M1). It shows that between the Euro IV standard and Euro I standard the permitted levels for HCs and NOx, vary in a ratio of 1 to 10 for petrol vehicles and 1 to 3 for diesel vehicles. Particulate emissions standards have so far only been imposed on diesel vehicles (a ratio of 1 to 6 between Euro IV and Euro I) but the Euro V standard, which was still under discussion at the end of 2007, will introduce limits for petrol vehicles too.

Table 1. **European road vehicle emissions standards**

M1 petrol vehicles	Date of application for new vehicles	HC (in CH4 equivalent)	NOx (in NO2 equivalent)	Particulate matters
		g/km	g/km	g/km
Euro I	1993	0.97 (HC+NOx)	0.97 (HC+NOx)	
Euro II	1997	0.5 (HC+NOx)	0.5 (HC+NOx)	
Euro III	2001	0.20	0.15	
Euro IV	2006	0.10	0.08	
M1 diesel vehicles				
Euro I	1993	0.97 (HC+NOx)	0.97 (HC+NOx)	0.14
Euro II	1997	0.7 - 0.9 (HC+NOx)	0.7 - 0.9 (HC+NOx)	0.08 - 0.1
Euro III	2001	0.56 (HC+NOx)	0.56 (HC+NOx)	0.05
Euro IV	2006	0.30 (HC+NOx)	0.30 (HC+NOx)	0.025

Source : Hugrel and Joumard 2006.

Standards of this type can thus provide a basis for regulating the intensity of vehicle use with reference to their pollutants emissions class. In practical terms, the number of rights required to use a vehicle could, all other things being equal, be varied according to the vehicle's emissions category. This type of modulation was used in the Ecopoints system applied to lorries crossing Austria until the end of 2006 (for a survey of this experiment, see Raux, 2002).

3.2.2. Fuel standards

Some of the atmospheric pollutants result from the composition of fuels and therefore may be tackled by applying TPs to fuel standards. The use of lead as an additive in petrol is being phased out in developing countries and has also been the subject of a successful application of TPs in the USA. The lead rights trading program between refineries between 1982 to 1988 accelerated the phase-down of lead in gasoline until a complete ban came into effect in 1996 (for a survey of the literature on this case see Raux, 2002). Sulphur dioxide (SO_2) emissions from vehicles are also covered by standards on the basis of the sulphur content of fuels.

3.2.3. Car ownership

In Singapore a scheme of car-ownership rationing involving auctions of a limited number of certificates of entitlement to purchase a new car was initiated in 1990. The number of certificates is determined each year on the basis of traffic conditions and road capacity and the certificates are issued each month (Koh and Lee, 1994). Chin and Smith (1997) showed quantity control of ownership to be a useful instrument since automobile demand is inelastic and the social cost function is steep. Compared with price controls, quantity control reduces the welfare loss arising from any misperception of optimal equilibrium by the authority.

3.2.4. Car use

Some proposals involve setting quotas for vehicle-kilometres traveled (VKT) or trips within a given urban area for motorists that could be transferred among them, as an alternative to pure congestion pricing given the issue of acceptability (Verhoef et al, 1997; Marlot, 1998).

A credit-based congestion pricing mechanism has been proposed by Kockelman and Kalmanje (2005) by which motorists would receive a monthly allocation in the form of credits (in principle monetary), which could be used to travel on a road network or within a zone with congestion charging. The motorists would therefore have nothing to pay if they did not use up their allocation: beyond this allocation, they would be subjected to the congestion charging regime. Those who failed to use up their allocation completely would be able to use their credits later or exchange them for cash.

3.2.5. Parking use

Parking rights may also be considered as an indirect way of managing congestion. However most of road externalities are created by vehicles that move while parking policy basically addresses vehicles that are stationary. For instance an excessively restrictive parking policy in residential areas would generate additional vehicle traffic as a result of vehicles moving elsewhere to escape the policy. In areas that are similar to a CBD in which jobs rather than residences are concentrated, the implementation of parking rights would interfere with or even duplicate driving rights with the same objective. These drawbacks mean that parking right markets do not merit further analysis (for a more detailed analysis see Verhoef and al 1997).

3.2.6. Land-use

In scattered settings, public transport is not viable so trips are usually made by car and distances travelled are longer. Land use is generally managed through regulation; however, there have been proposals for applying tradable permits to real estate developers on the basis of the travel volumes that their projects will generate (Ottensmann, 1998).
In order to do this, it would be necessary to identify traffic generators (for example, shopping centres, industrial or small business zones) and it poses many market organization problems, in particular with regard to minimizing transaction costs and making trading possible, not only within a conurbation but also between different conurbations.

3.2.7. End user fuel consumption

Regarding GHG emissions the environmental effectiveness pleads for targeting as close as possible to tailpipe GHG emissions themselves. Moreover, as seen above, the economic efficiency criterion implies to equalise the marginal cost of reduction of the CO2 emissions, therefore of reduction of the fuel consumption: targeting intermediate behaviours with specific quantitative objectives (i.e. type of vehicle, vehicle-kilometres, and for freight, ton-kilometres, load rate or empty journeys) would be at the same time expensive in terms of information needed for the regulator and source of efficiency loss.

Taking into account the quasi complete transformation of the carbon contained in the fossil fuels into CO2 during combustion[6], the more efficient solution consists in directly targeting consumption of these fuels.

The tradable quotas would be thus quotas of CO2 calculated from the carbon contained in the fuel consumed by the end-user. For any quantity of fossil fuel bought (thus intended to be burned) by the motorist or the carrier, obligation would be made to her/him to return to the regulating authority the corresponding quotas, which would then be cancelled.

[6] For instance in France, the combustion of one litre of gasoline emits on average 2.401 kg of CO_2 while this figure is 2.622 kg of CO_2 for one litre of diesel oil (source ADEME).

3.3. Matching nuisances reductions to targets

The amount of distances traveled is one of the main drivers of nuisance levels, given the current transport technologies, whether considering greenhouse gases, air pollutant emissions or congestion. Controlling land use is in principle an attractive way of reducing these distances, but its effects are controversial: it has still not been proven that it is possible to reverse the tendency to travel longer distances by compacting locations again. However one must recognise that the spatial concentration of activities yields more opportunities for cost-efficient transport alternatives such as mass transit, which is less energy consuming per passenger-km.

Car ownership is another indirect way of controlling car travel but the linkage with actual fuel consumption is very crude.

Other targets may have various relevance according to the three types of nuisance: GHG emissions, regional pollution and congestion (cf. Table 2).

For GHG emissions, targeting the fossil fuel consumption of end users with tradable permits is the most decentralized incentive for reducing such emissions: end-users as the final decision-makers can modify, albeit with more or less constraints, their travel choices, activity locations, or choice of vehicle or transport mode.

However, political resistance to travel rationing may suggest more indirect incentives. Among them are vehicle unit emissions (criterion of gram of CO2 per kilometre) and fuel standards such as lowering of carbon content with agrofuels. These targets are only one component of total GHG emissions. The other component is VKT which could also be controlled by TPs but this has the same drawback of rationing travel as TPs on fossil fuel consumption, while being less optimally linked to this consumption and hence to GHG emissions.

For regional pollutant emissions, the appropriateness of different targets is similar to the situation for GHG emissions. However, targeting fuel standards is particularly appropriate – they are, along less polluting engine combustion technologies, another way of reducing harmful tailpipe exhaust emissions per kilometre driven. On the opposite targeting only VKT or trips has the drawback of rationing travel, while being less optimally linked to pollutant emissions, since there is no incentive to shift to cleaner vehicles. This is why targeting VKT with an adjustment according to emission category may be a superior policy for local and regional pollutant emissions.

Table 2. **Appropriateness of TP targets for different nuisances**

Nuisances / Targets	GHG emissions	Regional pollution	Congestion
Land use	x	x	x
Car ownership	x	x	x
Unit emissions or vehicle technology	xx	xx	-
Fuel standards	xx	xx	-
End user VKT or trips	x	x	xxx
End user VKT adjusted to emission category	x	xxx	x
End user fuel consumption	xxx	xx	-

From x = low to xxx = high level of appropriateness

Regarding congestion, the most efficient and decentralised incentive is on end-user VKT (or even trips on specific corridors or through an area). End-users as the final decision-makers can modify their travel choices, activity locations, or transport mode. However this has the same basic drawback of rationing travel (as mentioned above).

3.4. CO2 tax, upstream or downstream permits?

The instrument of taxation is widely used in the transport sector, essentially because of its tax yield. Excise duties levied in the European Union in 2002 varied widely in Member States, from €0.296 to €0.742 per litre for premium grade petrol and from €0.242 to €0.742 per litre for diesel oil (CEC, 2002). In France, fuel excise duties provided the central government with bn€27 in 2002 for a GDP of bn€1,522. Although the current level of taxation might be considered high, it is not high enough to further reduce road fuel consumption.

The "tax rebellion" that took place in several European countries in September 2000 shows how sensitive public opinion is to fuel taxation (Lyons and Chatterjee, 2002). Central government is a focus for opposition as it benefits from the tax, although it has little control over oil prices. Proposing a "CO2 tax" in view of GHG emissions reduction is likely to start again the debates on the use of the fiscal revenues from the excises, which currently in the majority of the European countries are not earmarked and play an essential part in the balance of public finances.

Although for the economists the resulting effects of tax or permits on fuel demand are equivalent, the political perception of the instrument can have some importance. There would be thus some interest to elaborate mechanisms which explicitly separate the objective of fiscal revenues from the objective of reduction of CO2 emissions.

In order to reduce the administrative costs, it seems relevant to set up the system of permits at the very upstream, on a level where the actors are very few: it could be the fuel refiners or distributors, which already transmit the current excise duty to the ultimate consumer and return the product of the excises to the central government. By imposing to the producers and importers of oil, natural gas and coal to return the quotas, the system would cover the whole CO2 emissions resulting from the combustion of the hydrocarbon fuels by the end-users (Winkelman et al, 2000).

However, this advantage of complete coverage by an upstream permit system has lost its strength today in Europe, with the operation since 2005 of the Emission Trading Scheme (ETS) between energy intensive fixed industrial facilities (see Box 1). An upstream permit system should now be modulated as a complement to the ETS.

Moreover an upstream system is prone to two disadvantages.

First relates to the risk of dilution of the incentive effect of permits on the final emitter, so that they implement the complete panoply of behavioural adaptations which are available to them. Indeed, whether the permits are acquired by auction or distributed free to the fuel suppliers, these suppliers would pass opportunity costs[7] relating to these permits to their customers as a simple additional fee. In this case, the advantage vis-à-vis the current system of fuel taxation is null.

The second disadvantage appears in the event of free allocation of quotas to the fuel suppliers. If the permits are allocated free what would be the use of revenue generated by this initial distribution? The fuel suppliers could transmit the opportunity costs relating to these permits which they would have received free: that would not call into question the economic efficiency of the system but certainly its acceptability, since those supporting the effort of reduction would not benefit from the revenue created by the free allocation. An upstream permits system thus seems, for reasons of political acceptability, incompatible with a free allocation[8].

[7] As the permits will have a value on the market, the opportunity cost for a fuel supplier would consist in not selling on the market the permits received for free, or not recovering their value in the form of extra costs to their consumers.

[8] Except taxing this revenue, from which arises a new complexity.

Box 1. **The European Trading Scheme**

We know that most developed countries agreed to quantitative, legally binding targets for reducing emissions of the six main greenhouse gases[9] in the 1997 Kyoto Protocol. The European Union committed to reducing its emissions by 8 per cent on 1990 levels over the period 2008-2012 (the first commitment period)[10], sharing the burden among its Member States under the "EU bubble".

Keen to set an example for other countries, particularly industrialised countries, the European Union took the lead in establishing a European emissions trading scheme (European Trading Scheme or ETS) at enterprise level in Europe. At present, this system, which has been operating since 1 January 2005, applies only to CO_2 emissions from stationary combustion plants with a heater power of over 20 MW, in other words, to around 12 000 installations in the European Union. In practice, it applies mostly, but not exclusively, to the power generation industry an industries that are heavy energy consumers (i.e. mainly the ferrous metals, cement, glass, ceramics and paper industries). For the moment, it applies only to CO_2. Pursuant to the Directive and to the subsidiarity principle, the responsibility for allocating quotas to the companies concerned lies with Member States: each state is required to submit its National Allocation Plan (NAP) to the European Commission[11].

An analysis of the implementation of the Directive in France (Godard, 2005) demonstrated that quota/allowance allocation had been particularly lax – in what was a classic example of the capture of public policy by big business -- ostensibly so as not to undermine the competitive position of the companies concerned. The latter were subsidised by generous, free allocations including some which had been intended for expanding the activities of new entrants, which meant virtually zero constraints for the companies concerned. In practice, the micro-economic incentive to trade, which makes a system efficient, was missing.

Despite this laxity, which was also the practice in other Member States, the pressure on the price of the allowance in the first months of operation took observers by surprise: the spot price for a tonne of CO_2 soared from EUR 8.5 to as high as EUR 30 in July 2005, fluctuating between EUR 20 and EUR 25 thereafter. Most buying was by electricity generators, owing to cyclical factors – the cold winter of 2005, increased use of coal, which emits more CO_2, in response to the rise in oil and gas prices. There was also some precautionary buying in view of uncertainties as to future economic growth and what would actually come of the carbon cap (Alberola, 2006). For the year 2005, transactions totalled an estimated 12 per cent of the 2.2 billion allowances allocated at European level.

At the beginning of May 2006, following the first declarations by Member States of actual emissions for 2005, the spot market price of an allowance plummeted to EUR 8.5, later picking up to around EUR 15 (during the summer of 2006). Since then, the market has collapsed again with prices crashing to less than EUR 1.

Lastly, the European Commission has said that it wished to include transport in the ETS gradually, starting with air transport (cf. Box 2).

9 These six greenhouse gases are: carbon dioxide (CO2), methane (CH4), nitrous oxide, hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulphur hexafluoride (SF6).

10 The aim of the Protocol is an average reduction of 5.2 per cent for industrialised countries as a whole, while the Rio convention aspired to a reduction of 50 per cent.

11 In contrast, the Directive set a standard penalty in the event of a firm exceeding its allocation; payment of the penalty tax of EUR 40 per tonne of CO_2 does not release the offending firm from its obligations.

Box 2. **EU plans to include air transport in the ETS**

Air transport is showing very rapid growth in traffic: in Europe, for instance, the annual growth in the number of flights has increased from 2.5 per cent, to more than 4 per cent per year in the past 10 years. Emissions of CO_2 from air traffic, which rose by 73 per cent over the period 1990 to 2003, could cancel out the equivalent of more than one-quarter of the reduction that the European Union must achieve under the Kyoto Protocol (Wit *et al.,* 2005). According to a 1999 report by the IPCC, aviation accounted for only a small fraction (3.5 per cent) of anthropogenic radiative forcing en 1992, but given the speed at which air traffic is growing, this percentage is set to increase rapidly. Furthermore, the report estimates that the full impact of aviation is two to four times higher than just that of CO_2 emissions, since the nitrogen oxides it generates lead to the formation of ozone and condensation trails, the effects of which are suspect but, as yet, little-known[12].

Although domestic air transport emissions are the responsibility of the States party to the Kyoto Protocol, the latter referred the issue of international air transport emissions to the International Civil Aviation Organization (ICAO). While the ICAO remains firmly opposed to any fuel tax on an international scale, it has agreed to the principle of an emission permit trading system for civil aviation on the condition that the system is open to other economic sectors with no distortion of market access or allowance allocations.

Given the slow progress with negotiations at the ICAO, The European Commission issued a communication in September 2005 proposing to bring aircraft operators into the EU Emissions Trading System (ETS) for all flights departing from the European Union, whether or not the destination country was an EU Member State. Based on the study it had commissioned (Wit *et al.*, 2005), the Commission considered this to be a better approach than other options such as ticket or departure taxes and emission charges. It would only have a limited impact on the price of airline tickets costs (EUR 0 to EUR 9 per return flight within the EU).

Following a review of the practical implementation of the proposal and a resolution by the European Parliament in July 2006, the European Commission proposed a Directive to include aviation activities airlines in the ETS in December 2006 (CEC, 2006). The Commission proposes to implement the programme for all flights departing from or arriving at EU airports as of 2012, beginning in 2011 with only flights (both domestic and international) between European airports. In contrast to the current ETS scheme, the method of allocating allowances will be harmonised across the EU, especially the benchmark for calculating allowance allocations, i.e. the ratio of total quantity allowances to the tonnes-kilometres achieved by the operators. The total quantity of allowances for allocation would be calculated on the basis of average CO_2 emissions for the aviation sector over the period 2004-2006. A set percentage of this total would be allocated free of cost (100 per cent for 2011-2012) and the remainder would be auctioned. Each aircraft operator could then apply for a free allowance based on historical activity (tonne-kilometres). In addition, operators would be able to buy allowances from other sectors covered by the ETS.

This two-stage approach has come in for criticism from several stakeholders and from members of the European Parliament, mainly because they say it would create distortions in competition between airlines. As well as this, major disagreements persist on the total amount of allowances that should be allocated and the level of free allowances for airline companies. Lastly, the United States is vehemently opposed to the inclusion of non-European airlines in the programme.

12 For a detailed review of the physics and chemistry of air transport emissions and a discussion of possible ways of measuring them, cf. Wit *et al.*, 2005.

In a study on the design of a GHG emissions trading system for the United States, Nordhaus and Danish (2003) ruled out a downstream system from the outset, judging that it would be too difficult to administer millions of sources. Like Winkelman *et al.* (2000), they argue the case for a hybrid approach which would combine an upstream procedure for fuel producers with a downstream procedure for automobile manufacturers. However, as German (2006) points out, an analysis of the detailed implementation of a hybrid scheme such as this shows that there are a number of difficulties: one of the main problems is the risk of double counting both in terms of credits to automobile manufacturers for fuel efficiency improvements and in terms of allowances for fuel producers. This risk of double counting arises mainly from the timing of calculations of allocations and credits: allocations for vehicle manufacturers are based on the entire lifetime of the vehicle, while those for fuel producers are for emissions in the current year. Generally, the incorporation of vehicle manufacturers in an upstream permit scheme would mean subtracting manufacturer efficiency allocations from annual allocations to fuel producers each year, which would require accurate monitoring of vehicle kilometres actually travelled, driving conditions that influence actual consumption and vehicle scrapping. Furthermore, this type of programme does not cover the existing vehicle fleet, which is known to have a lifespan of around 25 years on average. In short, such a programme would be highly complex.
This is why it is of some interest to explore the possibilities of a fully downstream decentralisation of permit markets within the transportation sector.

4. TRADABLE FUEL RIGHTS FOR PRIVATE VEHICLES

Here is described a proposal of "tradable fuel consumption rights" for motorists (based with some alterations on Raux and Marlot, 2005). In the case of France, private cars account for approximately three-fifth of automotive fuel sales (gasoline and diesel oil), the rest being consumed by light and heavy goods vehicles. We shall then evaluate this system both quantitatively and qualitatively.

4.1. A market for fuel rights

4.1.1. Obligation liability

Motorists as consumers of fuel and hence emitters of CO_2 would be liable for the obligation to return the fuel rights to the regulating authority.

A consumer who purchases motor vehicle fuel (which will necessarily be burnt) will have to transfer the corresponding rights to the regulating authority. These rights will then be cancelled. The right corresponds to an authorisation to emit the CO_2 equivalent of a litre of fuel[13]. These rights may be held initially by the agent or transferred from another agent who holds rights or participates in the permit market.

4.1.2. Allocation of rights

[13] Strictly speaking, this value should vary according to the type of fuel: diesel fuel contains more carbon than gasoline, gasoline with ETBE can have different emissions than gasoline without ETBE. A conversion factor would apply for each kind of fuel. For the purpose of simplicity of exposition and evaluation in this paper we have assumed that one right unit corresponds to one litre of any fuel.

Free allocation of fuel rights could be made for car owners. To do this, a starting point can be an average consumption of 1,000 litres per car per year in France[14]. If we impose say a 10% reduction in this consumption, 900 rights should be allocated per car per year (i.e. rights to buy 900 litres at the regular price including current taxes). Since the allocation is on annual basis, new incoming participants (e.g. individuals buying their first car) will get the same allocation as other car owners. The increase or decrease of cars will, ceteris paribus, respectively decrease or increase the individual allocation on the following year in order to comply with the overall objective.

Since this kind of allocation may be debated as unfair for non car owners, another option could be to allocate fuel rights on a per capita basis (see Box 3).

Box 3. **An example of a per capita fuel rights allocation for France**

For example, starting in year 1, the rights allocation would be of the order of 27 billion litres of diesel or petrol used by private cars in France for 2005, or per capita – child or adult living in France– rights amounting to 450 litres per year. Based on an average consumption of 8 litres per 100 km, that would work out at 5 600 km of travel by car per year or 22 400 km for a family of four. Car-pooling would therefore leave families some room for manoeuvre depending on their size. The rate by which rights allocations would be reduced each year would be announced several decades ahead and periodically adjusted by a regulatory authority independent of the government in office.

Short-term travel behaviours are to a large degree determined by more long-term location choices – particularly residential ones. The regulating authority should therefore introduce and publicise a regular reduction in the number of rights that are allocated with a rolling horizon of about a decade.

The rights would remain valid for an unlimited period, which may lead to hoarding and speculation. However, the CO2-equivalent value of quotas held by an agent could be reduced in the following year in accordance with the rate of the reduction in free rights allocations decided by the regulating authority.

4.1.3. Exchange mechanism

In order to consume more fuel than his/her free allocation, a consumer must purchase additional rights on the market. On the other hand, a consumer who does not use all his/her allocated rights could sell them. The possibility of selling unused rights provides an additional incentive for modifying one's behaviour, particularly for persons who can do so at low cost.

However, given the huge number of potential participants, the exchange would not be bilateral, but rather centralised through a stock exchange which would yield the daily value of right. Practically participants would buy and sell rights through intermediates like their usual bank operator or buy them at the petrol pump (see below). This means perfect information of participants about the current price of the fuel right. Since transactions would be free on the market, there is no risk of black market.

The trading of rights could take two possible forms:

14 Based on the mileages and unit consumption figures which are *reported* in panel survey (13,719 km on average, and slightly less than 7.5 l/100 km) average annual consumption is 1,022 litres (Hivert, 1999).

- The more ambitious option would consist of a full market, those rights which are not allocated freely being auctioned. Financial intermediaries could be involved in trading and then propose rights to their clients. These auctions would produce an equilibrium price at which private individuals holding unused rights could sell them.
- A less ambitious option would try not to leave the management of fuel rights entirely to the market for acceptability reasons: rights would be sold at a price fixed by the authority and at which the authority would buy back unused rights. This implies that the authority would adjust this price on a yearly basis while the level of CO2 tax t would be fixed on a multiyear basis.

4.1.4. *Monitoring, verification and penalties*

The sale and purchase of rights would be supervised at national level by a regulatory authority. In order to reduce administrative costs and enforce a reliable monitoring, fuel rights transactions will have to be validated as close as possible to the time of fuel purchase, that is to say when the motorist buys fuel at the pump. The rights which are awarded annually would be held on a chipcard which records rights debit and credit operations. This could be either a smart card compatible with the automatic teller machines (ATM) that are already installed at petrol stations or a modification of credit smartcards currently used. Rights could therefore be debited (or purchased at the current rate) when buying fuel. It would also be possible to purchase or resell permits in banks, using ATM bank distributors or over the Internet.

4.1.5. *A combined taxation and marketable rights system*

It would be socially unacceptable to apply suddenly the fuel rights system to all motorists, so the implementation of the fuel rights market should be progressive and would coexist with the current taxation system. Moreover taking part in the fuel rights system should be voluntary. Lastly since rights transactions would be monitored when buying fuel at the pump it will not be possible to create an impenetrable administrative barrier between the system of taxation and the system of fuel rights.

A possible solution is to set up the "safety valve" t referred to in section 1 above (in fact a "CO2 tax"), which would be paid both by fuel consumers who wish to stay outside the rights market and those who are taking part in it but who have used up their allocation and who are either unable or unwilling to purchase permits on the market. This tax would therefore constitute a price ceiling of permits on the market and would have to be calculated with reference to the country's international commitments.

If the rights are allocated on a per capita basis, people not willing to cope with this system could immediately sell their rights. However in case they buy fuel they would be liable to pay the "CO2 tax".

To sum up, the current fuel taxation system will be supplemented by the coexistence of two systems: the rights market on the one hand, and the extension of taxation with a "CO2 tax" on the other hand. These two systems will be the alternative proposed to motorists: the incentive to adopt the fuel rights system will be effective if the price of fuel right is lower than the CO2 tax.

4.2. Evaluation for the French case

An assessment of such a system of marketable fuel rights has been performed in the case of France. In this application rights were supposed to be allocated to car owners. The quantitative results are based on empirical data collected in 1997 which was the most recent year for which data on the car fleet and fuel consumption was available at the time of the study.

4.2.1. Surplus distribution

Since we are evaluating two policy options to obtain a given objective of emission reduction, the differences between pure carbon taxation and tradable fuel rights lie in the distributions of surplus between categories of motorists and between motorists and the central government (for details on methodology and results see Raux and Marlot, 2005).

The quantitative exercise is performed with an objective to reduce fuel consumption by 10%. Given the uncertainty of price response function of fuel consumers we can only hypothesise values for the price-elasticity of demand, which as stated above varies between –0.3 (short-term elasticity) and –0.7 (long-term elasticity). With the objective to reduce fuel consumption by 10% the tax would have to be adjusted accordingly.

Consumers must modify their behaviours in order to reduce fuel consumption, in particular by reducing vehicle-kilometres travelled: the difficulty of this adaptation will depend on the closeness of jobs, shops and services, and supply of alternative transport modes to the car. An essential dimension therefore is the type of residential area. Four types of location are distinguished: the city centre, the suburbs, the periurban zone and rural areas (Hivert, 1999; Madre and Massot, 1994).

Because of the hypotheses needed about the different elasticities according to the type of residential location, the quantitative results summarised hereafter should only be considered as providing an order of magnitude for a possible distribution of surpluses. However three main points can be stressed.

First, the comparison between taxation and permits involves the fiscal gain in the case of the tax and the fiscal loss for the central government in the case of fuel rights because of the free allocation. In the case of tax and with an elasticity of –0.3, which is the least favourable adaptation hypothesis, central government gains almost bn €5.1 (see Table 3) but "only" bn €1.2 with an elasticity of –0.7. This gain results from the newly paid tax even if the quantity of fuel consumed decreases. On the opposite with fuel rights the central government loses more than bn€1.7 of tax revenue. This is due to the reduction in the amounts of fuel consumed, which is not compensated for by an additional tax. As a matter of interest, the total tax collected on fuels amounted to approximately bn€30.5 in 1998, of which bn€23.6 came from excise duty. Thus the fiscal revenue loss in case of fuel rights would only represent about 5% of current fiscal revenue due to fuel consumption.

Table 3. **Distribution of surplus in case of tax and fuel rights**

	total surplus motorists (M€)	total surplus central gov. (M€)	average motorist surplus per vehicle (€)
tax			
e=-0.3	-7 198	5 107	-275
e=-0.7	-3 076	1 183	-118
fuel rights			
e=-0.3	-374	-1 718	-14
e=-0.7	-161	-1 732	-6

Source: Raux and Marlot, 2005

Second, in the case of the tax motorists as a group lose between bn€3 (with an elasticity of –0.7, see again Table 3) and almost bn€7.2 (with an elasticity of –0.3). Moreover, whatever their type of residential location all motorists “lose” to the benefit of society (between €118 and €275 on average per vehicle). On the opposite with fuel rights, because of the free allocation, these transfers are very much reduced. For each of the two elasticity values (–0.3 and –0.7) motorists as a group would lose respectively €374M and €161M, the annual loss per vehicle would be on average respectively €14 and €6.

Third, in the case of fuel rights, residential location plays a fundamental role: the main winners (see Table 4) are households living in the city centre or the suburbs who, on average, sell rights (they can more easily save fuel, therefore rights, by reducing their vehicle-kilometres travelled) while the households living in periurban areas are on average the largest purchasers. Between 1 billion and 1.4 billion rights would be exchanged (on the basis of one right for one litre of fuel): this figure is to be compared with annual fuel consumption of 26 billion litres. The orders of magnitude are of a few euros or tens of Euros of net gains or losses on average every year for each vehicle and between each category of residential location. Although these sums might seem small at first sight, it should be remembered that they are average results per category of motorists and may cover extremely varied adjustment behaviours.

Table 4. **Distribution of surplus according to location in case of fuel rights**

	e=-0.3		e=-0.7	
Location	average motorist surplus per vehicle (€)	rights exchanges (millions)	average motorist surplus per vehicle (€)	rights exchanges (millions)
city centre	9	870	1	577
suburbs	3	546	0	453
periurban	-41	-1 367	-16	-1 019
rural	-16	-49	-5	-11
total	-14	0	-6	0

Source: Raux and Marlot, 2005

Finally, the cost of CO2 saved can be roughly estimated. The net surplus loss for a 10% reduction of consumption, which is given in Table 3 (fuel rights case) is between €161 and €374M. The quantity of tons of CO2 saved, i.e. 10% of 26 billion litres with an average of 2.5 kg CO2 emitted per litre, amounts to 6.6 million tons of CO2. The cost of CO2 saved is approximately €24 per ton with the assumption of high elasticity (– 0.7) and €56 with a pessimist assumption of low elasticity (– 0.3). The first figure has the same order of magnitude as the price of CO2 ton in the first months of ETS, in both case not including the administrative costs.

4.2.2. Administrative costs

The costs of setting up and administering the system would include altering the software in the ATM at petrol stations so they can deal with the fuel right system (reading the balance, debiting); manufacturing and distributing chipcards, or installing the microcode software on existing bank chip cards during periodic replacement; the information campaign for this new system of transactions; managing the rights exchange market which could be included in the Stock Exchange. In view of the fact that the transactions and verifications required for the rights exchanges will be highly integrated with the current system of credit card transactions, these costs should be moderate. The maximum cost of implementation is estimated between 3 and 4 euros per card. Furthermore, operation could be covered by a fee charged on each right exchanged, fee which would be very low in view of the high volumes involved.

4.2.3. Acceptability and equity issues

If we consider the development of more stringent objectives of emissions reduction in the future, a fuel rationing seems unavoidable: this rationing can basically take the form of either price (tax) rationing or quantities (permits) rationing. From this point of view the issue of acceptability of rationing is an identical precondition for the two instruments and needs at least information campaign and political willpower in order to introduce any emission control measure. This is the first step which needs to be achieved. This is in this context of “accepted rationing” that we can evaluate the relative acceptability of permits.

If we consider again the French case study, this system with a free allocation on a per capita basis penalises high income households more than others: the data from 1997 (Hivert, 1999) show that the average per kilometre mileage for each vehicle increases fairly steadily with income, from slightly more than 12,000 km for the lowest income brackets (less than 11.4 thousand euros per year) to almost 16,000 km for the highest income brackets (more than 61 thousand euros per year).

Lastly, the initial free allocation avoids imposing an excessive burden on consumers, particularly the least well off. The average annual consumption of cars varies from slightly more than 900 litres (for the lowest incomes) to 1300 or 1400 litres (for the highest incomes), while the proportion of mileage that is covered on home-to-work trips varies between 24% (for the lowest incomes) and 30 or even 39% for the highest income groups. These figures show that “necessary” travel would generally not be affected. However, this average data should not conceal a possible existence of situations of fragility, for example the “rural poor” who have no alternative but the car: such situations would require ad hoc compensation.

4.3. Conclusion

This system has the advantage of simplicity, as the unit of exchange is the permit for each litre of fuel that is consumed. The amounts consumed or exchanged are therefore monitored when fuel is purchased, and all persons who purchase fuel for a private use can participate in the market: monitoring is therefore straightforward as it only involves fuel purchases. The possibility of freely exchanging permits will discourage any tendency for a black market to develop.

The free allocation of emission rights creates an income which is distributed between the consumers of fuel. In addition, these consumers are strongly encouraged to reduce their consumption as they can make a real and tangible profit from selling their unused permits.

5. TRADABLE FUEL RIGHTS FOR FREIGHT TRANSPORTATION

As previously explained, environmental effectiveness and economic efficiency pleads to target directly the consumption of fossil fuels: targeting intermediate behaviours (ton-kilometres, vehicle-kilometres, load rate or empty journeys) with specific quantitative objectives, would be at the same time expensive in terms of information for the regulator and source of efficiency loss.

Here again the design of a system of CO_2 emissions rights for freight transportation implies the identification of the agents holding these quotas and to discuss the method of allocation. Then the discussion follows with the issues of geographic and sector-based coverage of the scheme, and then monitoring and transaction costs. Based on this discussion a final proposal is presented, followed by concluding remarks on potential environmental and border effects.

5.1. Rights holders, obligations and allocation

Which entities will hold, exchange and have to return the rights for the generated emissions? And, consequently, which actors will have to bear the emissions reduction burden? This question is due to the fact that freight transport activity and its consequences as regards CO_2 emissions are the output of a whole of decisions taken by agents, shippers and carriers, with sometimes divergent economic logic: this multiplicity of agents corresponds to as many different decision-making centres with unequal capacities of negotiation.

The targeting of the fuel consumption naturally results in putting the incentives on the carriers. However, the current operation of the logistic chain leaves them only limited margin for manoeuvre. Shippers, because of their requirements in terms of schedules, logistic constraints and required services, impose a framework with which the carriers must comply. Is it possible to involve the agents upstream of the logistic chain, in order to guarantee the effectiveness of the incentives?

For a firm carrying goods on its own the problem does not seem insurmountable, given the integration of decisions within the firm. The firm will optimise its activity, including its industrial and geographical structure of production and distribution. For for-hire carriers, the question is a little more complex being given the situation of current vassalage of the carrier vis-à-vis the shipper. It would be appreciable to work out a system which makes it possible to share out efforts of reduction between shippers and carriers, taking into account their respective margin for manoeuvre.

One way to involve the shippers in the responsibility of fuel consumption is to devise a relevant mechanism of fuel rights allocation to them. Two main types of initial allocation, namely auction or free allocation can be proposed. The first has the advantage of avoiding complex computations, requiring sometimes expensive information to obtain. It also avoids implying the authorities in a difficult negotiation with the agents, by letting the market arbitrate.

The auction of permits offers other advantages, vis-à-vis the method of free allocation mostly used, that of “grandfather rights”. This last method which allocates rights in proportion of the past activity, gives a premium to “bad pupils”: those which use old and polluting technologies would get, other things being equal, more quotas than others more virtuous. Moreover, this method of free allocation encourages the entities to delay their actions of pollution reduction, since they can anticipate the implementation of such a system, whose preparation takes several years in general: for instance in anticipation carriers could use “dirty” trucks in order to get a higher allocation. Lastly, the auctioning of the initial allocation also makes it possible to treat new entities entering the sector on an equal basis with the existing firms.

However, this auctioning is to be perceived as an additional tax, which would undermine its acceptability. This is why we explored the possibility of a free allocation. Several free allocation methods were tested by in-depth interviews with a sample of carriers and shippers (N=20, for details see Raux and Alligier, 2007). These methods included “benchmarking” allocation either to the carriers or to the shippers (with reference to the average ratio of total CO_2 emissions per ton-kilometre of the freight transport sector), and a “grand-fathering” allocation to the shipper, based on their past individual ratio of CO_2 emissions per ton-kilometre.

Many objections were raised by our interlocutors. The feedback from the carriers toward the shippers of the information on consumption and vehicle-kilometres seems particularly difficult: the audits considered would be thus particularly expensive (even if they remain limited to the firms which would voluntarily adhere to the system). The standard of allocation according to an average ratio of quota per ton-kilometre, even individualised by firm, appeared non-relevant and was disputed. The reporting character of this information and the fact of creating rent by this mechanism of free allocation, would make possible some fraudulent behaviour by agreements between carriers and shippers: even if they remained minority, that would undermine the credibility of the mechanism.

As a whole, these drawbacks and the complexity of this mechanism of allocation justified the reserve even the opposition of the majority of our interlocutors shippers.

So there would be no free allocation to shippers. However, some free allocation could be considered for transport operators, at least in the first years, in order to improve the acceptability of the scheme. For road hauliers this free allocation could be a "lump sum" allocation per vehicle in order to avoid complicated computations. For rail and river operators, which are far less numerous, this could be a kind of grand-fathering allocation as it is planned for air carriers in the current project of the European Commission (see above).

5.2. Sector-based and geographic coverage

The effective implementation of such a market for the freight transportation sector should be made on the level of the European Union at least, for obvious reasons of harmonisation of competition between the firms of the various Member States. That would imply in particular that the principle of a free allocation or not and, if a free allocation is adopted, the choice of the method of allocation and the computation of the allocations are decided on the level of the Union.

The environmental effectiveness implies to cover all freight transport modes, namely road, rail, river, maritime and air modes. This effectiveness also implies to cover the other transport sectors, and in particular the private cars, whether by a fuel rights market (see above) or by a CO_2 fuel tax for the sectors or agents not included in the fuel rights market.

It would be socially unacceptable to go suddenly from a system of taxation to a complete fuel rights system. The two systems must thus coexist, while creating a financial incentive to adhere to the permits system.

As mentioned above, a "CO_2 tax" would apply to the fuel consumers not wishing to take part in the fuel rights market. It would also apply as a "full discharge" payment to the participants to the rights market who would have exhausted their initial allocation and could not, or would not buy rights on the market. This CO_2 tax would constitute the upper price of fuel rights on the market and would make it possible for the regulating authority to limit the rise. The entrance into the fuel rights market would be thus on a voluntary basis.

The geographic coverage on the level of the European Union would make it possible to cover all the intra-European international freight transport, including by air, river and sea. However, international air and maritime transport is not yet covered by the Kyoto protocol. Regarding intra-European international air transport, the European Commission proposes its integration in the existing ETS (see above).

5.3. Monitoring and transaction costs

The system effectiveness relies on the possibilities of checking the emissions and managing the fuel rights market, without the transaction costs becoming prohibitive.

As seen above shippers free allocation methods imply important costs of information retrieval and risks of fraudulent deviance of the system, which justified their dismissal. The suppression of free allocation option removes these costs of information and controlling fraud.

Regarding the transactions, the transfers of quotas between shippers and carriers would be part of their contractual relationship, as currently with the carrying out of the transport services. These contractual relations are already the subject of legislative and regulatory provisions, without need for intrusion of the authorities into the commercial relationship: there will be thus no administrative extra cost from this point of view. In the same way, the exchanges of permits on the market would not be bilateral but would pass by a stock market: there would be thus no search cost for a partner for the exchange.

The monitoring would thus be reduced to the transfer of quotas to the regulating authority at the time of fuel purchase. The purchases of fuel for trucks are done either at the pump or out of a tank on the carrier's site. For the purchases from the pump, and particularly with the pumps reserved for the heavy trucks, the driver generally uses a magnetic or chip card. These cards just as the ATM distributors should have their software modified to manage the transfer of rights in proportion to the fuel bought. The participation of the carrier firm to the fuel rights market would suppose an exclusive use of chip cards when fuelling at the pump. As regards the supplies at tank, the invoice of the fuel supplier should include the debit of rights to the carrier firm (or invoicing them if the firm does not take part in the fuel rights market). On the whole, the risks of fraud are particularly reduced.

5.4. Final proposal

The fuel tradable rights would be thus based on quotas of CO_2 calculated from the carbon contained in the fuel (mainly diesel oil for trucks, or gasoline) consumed by any freight vehicle user, i.e. a for-hire carrier or a shipper performing its transport on its own: obligation would be made to him to return to the regulating authority the corresponding rights, which would then be cancelled.

In principle there should be no free allocation to shippers. However in case of full integration in ETS shippers holding ETS quotas could use them for transport.

A free allocation could be devised for transport operators in order to improve the acceptability of the scheme. Given the European scale, the principle of a free allocation or not and, if a free allocation is adopted, the choice of the method of allocation and the calculation of the allocations would be decided on the level of the European Union.

The for-hire carrier (or the transport organiser) would negotiate with the shipper in order to get (or to be paid for) fuel rights in view of the achievement of transport operation. Carriers holding unused rights (after having transferred the required quantity referred to above to the regulating authority) could then sell them to the fuel rights market.

All freight transport modes would be covered, i.e. road, rail, river, maritime and air modes. Other transport sectors or agents not included in the fuel rights market (eventually the private cars, depending on the extension of fuel rights market to them, see above) would be covered at least by a CO_2 tax. The geographical coverage would be on the level of the European Union at least.

Monitoring of quotas to be transferred to the regulating authority would occur at the time of fuel purchase, either at the pump or when filling a tank on the carrier's site.

The entrance into the fuel rights market would be on a voluntary basis. A "CO_2 tax" would apply to the fuel consumers not wishing to take part in the fuel rights market. Participants to the rights market who have exhausted their initial allocation could buy additional rights on the market or pay the CO_2 tax as a "full discharge" payment.

5.5. Potential environmental and border effects

Regarding the possibility of controlling the growth of road freight transport and hence its CO_2 emissions, several counteracting forces are at work, to mention the main ones: for some goods, their value are so high that the variations of transport costs under consideration will have hardly any influence on the distribution practices; the logic of inventory financial optimisation (holding costs) tends to "zero stock" and "just-in-time" deliveries: this logic mainly outclasses the transport-environment optimisation logic; and the growing specialisation of the production lines in the factories which results in multiplying the exchanges between the production sites and thus the kilometres travelled by intermediate goods.

These insights show that different sectors of the economy would have differing responses to whether CO_2 tax or emission trading system. However at the macro level observation shows that the sensitivity of behaviours to the fuel price is not null, given the recent developments in oil price. For instance the total fuel deliveries in France, after a first decline in 2000, are falling since 2002 (SESP, 2006) and this evolution is well correlated with that of the fuel price. This sensitivity affects as well the private cars as the heavy goods vehicles: the total diesel oil consumption for the latter is no more growing and is stable since 1999.

Regarding economic impacts, is there a risk of dominant position on the permits market? Could some agents have a capacity to distort the competition and the mechanisms of price on the permits market? This risk is probably negligible: indeed, considering only transport, the multiplicity of the agents and the dispersion of transport demand between them are such that no agent is likely to have a sufficient power on its own[15].

The sector-based and geographic coverage and the mechanism considered make it possible to claim that there would be no discrimination as regards the market of fuel rights between the firms of the 27 Member States of the European Union, whether they are shippers or carriers.

A legitimate interrogation remains, that of the possible competition of carriers external to the European Union. In fact, the carriage of goods is less prone to economic distortions than the other branches of industry: freight will always have to be loaded in locations within the EU in order to be distributed for use in other locations within the EU, whether processing industries or final goods delivery locations. The only notable incidence would come from carriers being able to load fuel outside the European Union, not submitted to CO_2 taxation or fuel rights, and then carry out a transport within the EU. This competition could be significant in the border countries, but limited through the trade-off between the weight of the carried fuel and the payload.

15 For example Arcelor-Mittal, the first European shipper, generates less than 1% of the ton-kilometres in France (personal communication).

5.6. Concluding comments

Shippers using own-account transport have a direct incentive to minimise their fuel consumption, since they would have to surrender rights in direct proportion to the fuel consumed by their vehicles. Conversely, shippers using for-hire carriage are not directly subject to this restriction. This said, there are two factors that could influence the behaviour of the latter. Firstly, should they fail to make allowances for this constraint on carriers, there is the risk the latter may gradually disappear, which would mean that the economic balance would tip towards transport operators who managed to survive and this alone might persuade reluctant shippers to compromise. The second factor is the increasing trend towards the inclusion of environmental aspects into corporate activity reports to shareholders and the public. This would give shippers an incentive to gear their activity so as to reduce shipment-related emissions.

For their part, hauliers and organisers of third-party transport could "bank" with the rights they negotiate on different orders from shippers. If they have made efforts to minimise their own fuel consumption, by grouping loads and reducing vehicle-kilometres or unitary vehicle consumption, for example, they would pocket the difference. In the same way, regarding railroad combined transport, the fuel consumption for the road transport haul to a rail terminal would be debited to combined transport organisers when they provide the transport service (as well as any diesel consumed on a rail transport leg). Lastly, rail transport operators would receive rights allocations, most of which they could sell on depending on the degree of electrification of the network (and the share of nuclear or renewable energy used to generate their electrical power).

6. TRADABLE DRIVING RIGHTS IN URBAN AREAS

Congestion and pollution caused by automobile traffic are major and recurring concerns in urban agglomerations all over the world. Taking the economist's perspective, these phenomena reflect over-consumption of scarce goods, i.e. the road capacity in the case of traffic congestion or the clean air in the case of atmospheric pollution: this over-consumption is the result of the under-pricing of these goods. Thus the policy measure favoured by economists (Walters, 1961; Vickrey, 1963) is road user charging or congestion charging which are both implemented by road tolls. In spite of the success of the London Congestion Charging scheme (since 2003) or the successful experiment in Stockholm in 2006 followed by implementation in 2007, social and political resistance to congestion pricing is still strong in other cities.

Although it is accepted that introducing congestion pricing increases the welfare of community as a whole, redistribution occurs (Baumol and Oates 1988; Hau 1992). In general the situation of most of the motorists deteriorates, for a minority with high values-of-time it improves, while the government who collect toll revenues become wealthier. So, in general, there is little chance of a congestion charge being accepted, unless motorists are convinced that the government will distribute the resources collected efficiently and equitably.

In the light of these difficulties TPs applied to these specific urban issues might be of interest. The allocation of quotas for trips or vehicle-kilometres to motorists within a given urban area has been proposed, with the possibility of these quotas being tradable (Verhoef and al. 1997; Marlot 1998). A "credit-based congestion pricing" mechanism has been proposed by Kockelman and Kalmanje (2005).

This section will show the types of adverse impact this instrument may be appropriate for in urban areas and what targets may be set. To the best of our knowledge, none of the proposals quoted above is detailed enough for it to be possible to judge whether this type of measure could be applied in urban areas. In this context, however, "the devil is in the detail": from the specification of the implementation of TPs for urban travel demand management, the applicability of this type of instrument will be illustrated by referring to an example of implementation, along with elements of evaluation.

6.1. Specifications

What are the specifications for the implementation of tradable permit markets for urban transport demand management? The purpose is twofold: to limit the increase on the one hand of vehicle-kilometres travelled (VKT), particularly during peak periods, and on the other hand of atmospheric pollutant emissions from vehicles. The ideal, from an efficiency point of view, would be to target VKT with the ability to make distinctions on the basis of time and space (congestion) and the type of vehicle (atmospheric pollutant emissions).

However, the limited possibilities of affordable technology mean that a compromise must be accepted with regard to this objective. Therefore we firstly need to take stock of technological possibilities at the present time and the near future. Secondly the specifications TPs must satisfy to tackle congestion and pollution will be examined.

6.1.1. Existing and conceivable technologies and their costs

The most mature technology at the present time is roadside Electronic Toll Collection (ETC). This is based on an on-board electronic tag which uses Dedicated Short Range Communications (DSRC) to dialogue with roadside readers. This procedure requires prior registering of both vehicles and drivers. A more sophisticated version involves debiting on the fly a preloaded smartcard or credit card that is inserted in the on-board unit (OBU). Objections with regard to the protection of privacy can be overcome by allowing the anonymous purchase of cards which have already been loaded with units. This kind of system is used in Singapore since 1998, with initially 32 gantries and 674,000 in-vehicle units distributed free of charge with a total investment cost of US$ 114 million (Menon, 2000). Annual operating costs stand at US$ 9 million for roughly 6 million daily transactions in 2003 (Menon and Chin, 2004).

A second type of toll collection technology, based on a vehicle positioning system (VPS) that uses satellites (the international GPS system or the European Galileo system), is currently emerging. A well-known example is the TollCollect programme for lorries on the German motorway network. However this technology needs an expensive on-board unit (currently between €200 and €400) while complex and costly manual procedures which duplicate the electronic system are required to process occasional users. Moreover the possibility of permanently tracking vehicles raises obvious issues with regard to protecting the privacy of car drivers.
This is why on the basis of these current technical possibilities and their present-day costs, the most immediate implementation would be based on roadside ETC (RS-ETC) and would cover all motorized vehicle *trips* in the zone covered by the traffic restriction scheme. In order to cover all the vehicle-*kilometres* travelled within the zone covered by the scheme, the second technology based on the satellite vehicle positioning would be required.

6.1.2. Specifications of TPs to tackle congestion and pollution

In order to design these specifications a series of questions must be answered: they are briefly set out below.

The first relates to the specification of the unit to be traded. In view of the stated objectives, this will consist of driving rights (DR). It must be possible to make distinctions with regard to these driving rights on the basis of space and time (congestion) and according to the vehicle's emissions levels (pollution). The mechanism for doing this and its parameters must then be specified.

The second question relates to specifying the entities which will hold and trade quotas and be obliged to return them on the basis of their emissions. This can consist of motorists or inhabitants.

The third question is how these quotas will be allocated. Should they be allocated free of charge? If not, the entities affected by the scheme will have to buy all the permits they need on the market: in the event of the total available quantity on the market being small, it is equivalent to setting up a quota auction. Economically, this is the most efficient solution as it obliges actors to reveal their preferences. It is also consistent with the polluter-pays principle and creates a usable financial resource. However, as with congestion charging it immediately increases the financial burden on the actors involved: this would eliminate the essential acceptability advantage that driving rights could have over congestion charging. Consequently, at least some of the quotas would have to be allocated free of charge as a visible and immediate compensation in order to facilitate this instrument's acceptability.

If the quotas are allocated free of charge, to whom should they be allocated and with what distribution method? The problem is that although in theory these methods do not threaten the efficiency of the instrument, they ultimately determine the financial burden on the participating entities. Will these entities be vehicle owners or inhabitants? Choosing the latter would amount to compensating inhabitants for the consequences of congestion and pollution. This would involve those who drive little or not, pedestrians and public transport users and not only motorists, which would improve the acceptability of the scheme.

Other issues relate to the period of validity of the quotas and the quota payment obligations. These parameters must be fixed in a way that maintains incentives to reduce consumption of driving rights, particularly during congested periods, and to reduce pollutant emissions.

Last, two questions must receive particular attention. The first is the possibility of keeping the transactions anonymous, which is an obvious factor for the acceptability of a new control mechanism. The second is how to deal with "border effects", in particular the management of occasional users and the anticipation of unforeseen behaviours which might undermine the effectiveness of the programme.

6.2. A system of tradable driving rights for urban areas

From the previous specifications, the features of the system can be designed: the unit to be traded with the computation of driving rights according to congestion and pollution levels, the allocation method, rights trading, period of validity of rights, and then tracking and checks of driving rights consumption.

6.2.1. The unit to be traded

The unit to be traded would be the driving right (DR). In the RS-ETC system, the unit of account for DRs would be the trip, while in the VPS-ETC system it would be the VKT.

An agency in charge of transportation in the conurbation and receiving its powers from the local elected authorities would fix the parameters of the programme. To do this, the agency would make use of a survey system including, for example, Household Travel Surveys and traffic count data (for example from cordon traffic surveys).

The agency would specify the zones (on the basis of population density), the peak and off-peak periods, as well as the vehicle emission classes (using, for example, the Euro standards). These design issues are broadly similar to those of a congestion charging scheme.

These parameters would be used to compute the weighting of the DRs which would be charged to drivers. The DRs would be weighted on the basis of the level of congestion, but also on the basis of the size of the vehicle in passenger car units (PCUs) and its atmospheric pollutant emission class.

All the drivers entering and travelling within the zone covered by the scheme would be liable to return DR quotas to the agency on the basis of a computation method with the following principles.

A first kind of weighting could be set up with respect to standards of pollutants emissions (see for instance in Table 1 the vehicle emission standards in the European Union): the vehicle that pollutes the least (the Euro IV M1 petrol passenger car) would get the lowest weight while "dirtier" vehicles would get higher and higher weight factor according to their Euro (III to I) class.

A second kind of weighting factor could be set up for congestion, making a distinction between the zone of travel (low/high density) and the time of travel (off peak periods / peak periods) as a result of the increase in the level of congestion in these zones and the larger population that is exposed to traffic nuisance in them.

These two weightings, which should be adjusted accurately on the basis of the estimated costs of congestion and pollution, could be combined to derive a public rule for number of DRs to be returned to the regulating authority. These weightings obviously assume the capacity to identify vehicles on road on the basis of their Euro category (see "Tracking and Checking" below).

6.2.2. Allocation

The proportion of the DRs allocated to the inhabitants of the urban zone would be estimated initially by the survey system described above. These DRs would be distributed free of charge equally between all the inhabitants. Data would serve as a basis for the elected representatives to decide what they think it is fair to allocate free of charge to inhabitants. Each inhabitant would have a DR account with the agency, and this account would initially be credited with this free allocation.

The DRs which are not allocated would be sold by the agency. This means those motorists who live outside the conurbation and business users (for example, those making deliveries for firms, tradesmen, doctors, etc), those making through trips, and those inhabitants of the urban zone who have used up their remaining DRs would be able to purchase DRs. The sale of these rights by the agency would resemble conventional congestion charging.

As DRs are allocated to individuals but used by vehicles, there is an obvious incentive for carpooling.

6.2.3. Rights trading

Regarding the trading of rights, a careful approach would be not to leave the management of driving rights entirely to the market: rights which are not allocated free of charge would be sold at a price fixed by the agency, the same price at which the agency would buy back unused rights.

However, nothing would prevent a holder of unused rights from transferring them (or even give them free of charge) to an acquaintance. In practical terms, this would involve simply notifying the agency that rights have been transferred from one account to another (for example by making an electronic transfer on the Internet). Obviously, there would be no black market as sale and purchase would be unrestricted.

Likewise, small business users would be able to use the rights allocated to them as residents of the conurbation for either their private or their business trips. Last, it might be possible for families to combine the rights accounts of their members to form a joint account to which the DR smartcards of the family members would be linked.

6.2.4. Period of validity

At the start of the scheme, each resident in the urban zone would for instance obtain a free allocation amounting to several weeks of rights, so that from the outset they would each be able to use the rights they are allocated variably from one week to another. Next, at the start of each week, the resident would be allocated rights for a period of seven days, thus giving the rights holder the flexibility to distribute them over the week as he/she wishes from the outset. These rights would be valid for one year after they have been allocated. Unused rights could be sold back to the agency at any time, even after their validity has expired.

The balance of a resident's DR account should never be negative. Put another way, as soon as a resident's rights have been completely used up, he or she would have to buy the necessary additional rights at the market price.

The risk of over-consumption of rights at certain periods during the day, the week or the month would be quite limited for a number of reasons. First, the rate at which DRs are used up increases with the level of congestion and pollution: there would be an opportunity cost for each right since those used up during a congested period will not be used elsewhere or at another time. Next, the use of these rights would be associated with another (transport) expenditure in order to perform an activity whose net utility would have to be positive in order for it to take place. Last, as the agency would be able to buy back unused rights, residents would have no incentive to make additional trips to use up their rights.

6.2.5. Tracking, checks

As said above the VPS-ETC, i.e. a satellite-based vehicle positioning system, is currently prone to some drawbacks which prevent it from a very near-future implementation in urban areas. This is why DR collection system would take the form of RS-ETC.

The on-board unit could be provided free of charge to motorists in order to encourage electronic transactions as much as possible, thus easing traffic flow through the checkpoints. This equipment would identify the type of vehicle and in particular its Euro class. It would permit the automatic debiting of the required number of DRs from a smartcard while vehicles are travelling.

The DR smartcards would be distributed free of charge to those who choose to have the on-board equipment. The cards would be credited with the DRs allocated to or purchased by the motorist.

The number of vehicle detection gantries should be minimised by using natural barriers (for example, rivers or railway lines) and the road network topology (i.e. single ways). The main difficulty is then to detect car "trips"[16] since traffic would be monitored only by detection of vehicles when passing a gantry. The solution would be to link the right to drive to a period of say one hour after the first detection by a

[16] The option of driving *days* rights is dismissed because it is not sufficiently linked to travel intensity and period.

gantry. That is to say, if the car is detected again within this period of one hour, it would be considered as the same trip and no supplementary DR would be debited. Trips of more than one hour duration would be longer distance trip and then it would be fair to debit one more DR.

In order to improve the acceptability of the scheme, a maximum daily number of DRs to be debited would be set, following the example of the maximum daily charge in the Stockholm congestion charging trial.

Coping with occasional users. Potential malfunctions or violations must be detected with the help of video enforcement systems (VES) as previously quoted. The VES can be used to fight fraudulent use of on-board unit by checking randomly the suitability of the tag with the Euro class of the vehicle with the help of vehicle registration database.

The VES can also be used to detect vehicles non equipped with on-board unit either because they only drive occasionally in the zone (for example, visitors) or because they refuse to have on-board unit of any type. This was the policy of the Stockholm congestion charging trial. After having being detected, the driver can pay the charge within a given period (for instance 2 weeks as in the Stockholm case). The payment and recovery mechanism for the invoice could be similar to that in the London or Stockholm scheme (unsolicited payment by Internet, telephone or in shops before a potential fine and recovery by a specialised firm).

In order to minimise the amount of such potential a financial incentive can be offered to register and get the on-board unit. This incentive could be that the regular fee for driving through the scheme area for one day while not being registered would be the equivalent of the maximum daily number of DRs debited applicable to registered users (see above).

6.2.6. An example of implementation

This kind of scheme has been devised for the Lyon urban area (1,200,000 inhabitants including the inner city of Lyon-Villeurbanne with approximately 600,000 inhabitants) and assessed with computation of various economic surpluses (for details on methodology and results see Raux, 2007).

The implementation of DRs would be based on an RS-ETC system as described above which would regulate the number of trips. For the sake of simplicity in the first years of the scheme no particular weighting would be applied to DRs according to Euro standard. The debiting of DRs would be effective only in periods of higher traffic, for instance between 6h and 19h from Monday to Friday: this would be a proxy for weighting DRs according to congestion.
With a limited objective of only capping the current total number of trips made by car during the first years of the scheme for acceptability reasons, TDRs amounting to this level would be allocated for free between the Lyon-Villeurbanne inhabitants: in this case , most of the potential surplus (92%) gained by the local government in the case of conventional road pricing would instead be redistributed between motorists and inhabitants of the inner city. A small proportion of this surplus (8%), corresponding to the share of external traffic without a free allocation of TDRs, would constitute revenue for the local government.

6.3. Concluding comments

Barriers to the implementation of TDR are mostly the same as for conventional urban road pricing as the purpose of both instruments is to regulate transport externalities and hence travel intensity. These barriers have already been identified in the literature (see Jones, 1998; Schlag and Teubel, 1997).

The issue of legal feasibility of regulating urban car travel with TDR is broadly analogous to the one for area or cordon road pricing. The national legal framework must be made compatible if needed, which is not yet achieved in many countries including France.

One of the main barrier to implementation of regulation appealing to the market is equity concerns, summarised as “the poor won’t be able to travel any more”. At this point there is a noticeable difference between TDR and road pricing, since part of the TDR can be allocated for free: this is a guarantee for a minimal travel capability which is not affected by the pricing of rights on the market, even for the drivers not willing or being able to abandon their car. Regarding acceptability this free allocation is an advantage for TDR upon road pricing. The second advantage is that with this free allocation, individuals have a supplementary incentive to save whether trips or distance travelled by car, beyond their initial allocation of driving rights because they can sell unused rights and then get tangible reward for their “virtuous” behaviour.

Geographical equity is also a crucial issue when drivers living inside the charging zone get free allocation while those living outside would have to buy driving rights. In the London congestion charging scheme, where discount fees are delivered to inhabitants, or for cordon schemes like in Oslo or Stockholm, where those driving inside can do it for free, this issue has been resolved by agreements between local governments of the charging and surrounding areas about the allocation of revenues from pricing. A similar agreement must be reached in the case of TDR.

More generally, the allocation of free TDRs creates a kind of rights on the urban rent which are shared among the inhabitants rather than being captured by the local government. These characteristics make free TDRs essentially different from conventional urban road pricing even with special discounts for some users.

Conventional congestion charging involves a transfer from motorists to the community, which is able to use the revenue as it judges best, while the free allocation of tradable driving rights confines a certain proportion of the transfers to within the group of motorists and population. This loss of revenue for the public authorities represents the price that must be paid for the acceptability of congestion charging, and this price may seem very high.

A possible strategy would be to introduce a capping mechanism on free allocation and keep this quantitative level constant from year to year. As demand increases with the growth of the agglomeration, purchases of the additional TDRs which are required would provide revenue for the transport authority. Thus transport users would reveal their preferences, providing a signal to the community to invest in a cost-efficient manner in developing the supply of transport, but not necessarily road transport.

Finally, TDRs could coexist with tradable fuel rights schemes: while the latter target the consumption of fossil fuel at the country level, TDR are restricted to urban zones and target congestion and atmospheric pollution. TDRs are of course an alternative to conventional congestion charging. Existing parking control systems could, however, be maintained.

7. POTENTIAL PITFALLS AND IMPLEMENTATION ISSUES

Europe's experience with the ETS has identified the pitfalls to be avoided: this section shows how the above proposals can respond to these concerns. Opening up these fuel rights markets to other countries or sectors of the economy is a second issue addressed. Lastly, the issue of the co-ordinated launch of these different markets is discussed.

7.1. Pitfalls to avoid in the light of the European Emissions Trading Scheme

The experience gained from the first phase of the ETS (2005-2007) has been instructive in many respects: much criticism has been levelled at the ETS in particular (cf. Open Europe, 2007) and at emissions trading markets in general with respect to their ability to meet the challenge of curbing greenhouse gas emissions.

A first criticism often encountered is that this « market » never actually worked in the first place, as can be seen from the collapse in the price of the permit per tonne of CO2 in 2006 from the point when Member States first began to declare their actual emissions, which turned out to be lower than the initial allocations. Furthermore, when it became clear that the allowances held in this first phase would not be valid for the second phase (2008-2012) the market price plummeted again. On the contrary, all of this shows that the market played its equilibrium price setting role perfectly given the surfeit of, by then, worthless allowances.

The over-generous allocation of allowances which precipitated the collapse of the market price can be put down to Member States, most of which clearly sought to favour their own industries: the latter captured the decision-making process after intensive lobbying (Godard, 2005).

One possible way of counteracting these effects would be to centralise decisions on allocations at European Union level, reversing the subsidiarity principle. That is why, should there be a market with free allocation of fuel rights for freight transport, we propose that not only the principle but also the calculation of the free allowance be centralised. However, there are grounds for fearing that centralising these decisions in Brussels may not make them immune to intensive lobbying by industry organisations or to a degree of opacity in the European decision-making process.

Lastly, another criticism, the costs of administering and declaring emissions would be high for small emitters, i.e. structures managing only a few stationary installations affected (for example, a boiler in a hospital).

It may legitimately be said that these failings stem essentially from the principle and method of free allocation adopted. The above proposals on fuel rights are aimed at avoiding these failings.

In the case of fuel rights for drivers, the principle of a set free-of-charge allocation is proposed. As it is a set allocation, it avoids the need for complicated calculations that are costly to administer on an individualised basis. The simplicity of the allocation principle proposed and the transparency of the calculation as well as the fact that it applies to the entire population, reduces any risk of government decision-making being captured by private interest groups.

For freight transport, it is proposed that there be no free allocation to shippers, which eliminates any reason to lobby for allocations and the adverse consequences that might have. Clearly, this principle runs counter to the free allocation principle applicable currently in the ETS, to which fuel rights programmes will have to conform one way or another: moreover several authoritative voices are questioning the principle of free allocation in the ETS today and are arguing for allocations to be auctioned. On the other hand, as stated previously, fuel rights could be allocated as a set allowance free of charge for road freight vehicles: in order to reduce the risks of escalating allocations if Member States pursue a beggar-my-neighbour policy, the flat-rate allocation method should be regulated in detail at European Union level.

As a general rule, the principle of set, cost-free allocations, which avoid complicated calculations, sharply reduces the administrative costs of these programmes. There would still be the costs of monitoring emissions and managing fuel rights transactions, which the proposals above have sought to keep as low as possible.

One last and more basic problem is the volatility of the price of CO_2 observed on the European market. This volatility is compounded by uncertainty about the shape that the ETS will take after 2012. Price volatility runs directly counter to the need for a clear and continuing long-term signal on CO_2 prices which can steer the required investment decisions in the right direction to achieve significant reductions in emissions over several decades. This said, the problem is not specific to tradable permits as an instrument, it also affects tax instruments. Whatever the incentive instruments used, strong political will must emerge if a long-term signal is to be sent.

7.2. International and cross-sector issues

Should the fuel right market for the transport sector be operated at a national or an international level?

Tradable fuel consumption rights for private vehicles could at the beginning operate mainly on a domestic basis: it would be viable in view of the generally short distances involved in car trips and if we ignore the impact of “tank tourism” at borders. The risk of the latter should be quite limited for countries whose neighbours are also committed to reduce their emissions within the EU bubble: these countries will also have to implement either a “CO2 tax” or a permit system. However the autonomy of each central government in fuel taxation is limited by the behaviour of its neighbouring countries as shown by the current difficulties in fuel taxation harmonisation within the EU.

On the opposite tradable fuel consumption rights for freight transportation should operate at the EU scale, given the high level of international competition in this sector. It should be underlined that implementation of TPs for transportation, like ETS, does not need an unanimous approval of UE member states unlike fiscal policy.

Should the fuel right market for the transport sector be closed or open to cross-sector permit market?

By closing the market, i.e. preventing CO2 emission permits to be bought by transport users from say ETS or to be sold by transport users to the ETS, the governments or the EU can manage a different level of abatement burden in the transport sector when compared with other economic sectors.

In general, if markets are closed to each other, the marginal costs of reducing CO2 emissions are likely not to be the same in different sectors. Distortions of this type will reduce the efficiency of the policy. Although this could be justified regarding the transport sector for a variety of social or political reasons, closure of the market should be considered as a temporary measure. Ultimately, the permits market system should be open, that is to say that everyone in the country emitting GHGs in different sectors of activity would be able to exchange rights on the same market.

Quite clearly, downstream tradable permits markets would replace any upstream permit market for energy producers. They would also make a tradable permit market for automobile manufacturers based on unitary emissions from the vehicles they sell pointless and redundant. True, vehicle buyers would be confronted with a degree of rigidity in energy efficient supply in the short term. This is a constraint which could be alleviated by two measures. First, the reduction in rights allocations each year could be very gradual in order to facilitate initial changes in driver behaviour. Second, the announcement of a mechanism for reducing allocations over several years would send a clear long-term signal to car manufacturers so they would rapidly develop highly energy-efficient vehicles: in fact, manufacturers would be relatively certain that these vehicles would find customers, in contrast to the situation at present.

7.3. Phased, co-ordinated implementation

Let us first stress that fuel rights markets in the transport sector could be phased in. The fact that a market is open does not mean that it will gain the support of all of the stakeholders overnight. Rights transaction operations -- for instance, debiting procedures at the pump -- will require physical modifications which inevitably take time. This said, the necessary modifications might well happen quickly as fuel distributors will wish to attract customers who want to participate in the rights market.

If stakeholders are free to enter the market, the incentive for them to do so will implicitly be the existence of a « CO_2 tax», provided that the latter, driven by governments, remains higher than the price of fuel rights on the market. The other role of the « CO2 tax» is to ensure fair treatment while avoiding ways around emission reduction requirements.

For political and practical reasons, the different fuel rights markets could be introduced separately, i.e. on different dates for the freight transport and private car sectors. The crucial point is that as soon as at least one of the markets is introduced a general «CO_2 tax» is established for all of the players not yet concerned. To ensure the acceptability of these measures, the tax should be reasonably low to begin with, with increases to be phased in over several years announced in advance. This will mean that both markets will have to be established within a short timeframe.

8. CONCLUSION

Decentralised permit markets in the transport sector have advantages, in theory, given the need to reduce transport nuisances and, in particular, to include the sector in the global effort to reduce CO_2 emissions. They also allow us to separate the issue of the economic efficiency of nuisance reduction programmes from the issue of their equity.

Their application to the problem of congestion and atmospheric pollutant emissions in urban areas seems feasible and effective at reducing kilometres travelled while encouraging the use of cleaner vehicles. The free allocation of driving rights to the residents of the area concerned rather than generating toll revenues for local authorities is perhaps the price we have to pay to make this type of regulation acceptable and applicable in practice.

As regards CO_2 emissions, the free allocation of fuel consumption rights is a more pragmatic response to concerns about fairness than taxation alone. Moreover, given the current high levels of fuel taxes, for example, in Europe, this type of allocation would make a programme to ration fuel by quantity rather than price more acceptable.

In addition, the free allocation would provide a strong incentive to reduce fossil fuel consumption because of the tangible advantages to be gained by anyone who cuts their consumption to a level below their initial rights allocation.

The basic objection to the implementation of decentralised rights markets in the transport sector is that the costs of implementation would be much too high for the desired results given the very large number of actors concerned. The proposals set out above, for both private vehicle users and freight transport are intended to reduce these costs as much as possible: they avoid complex allocation calculations. The only remaining costs are the costs of monitoring emissions and managing fuel rights transactions by electronic procedures for purchases at the pump.

Admittedly, the cost of operating fuel rights markets would be higher than simply extending current taxes on fuel. That may be the price to be paid for the actual implementation of a programme to reduce emissions by transport users.

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