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Abstract

MARKET SOLUTIONS FOR SUSTAINABLE CITIES

Sustainable development has become a globally accepted policy objective. It is however, increasingly recognized that the implementation of sustainability strategies has to take place at a decentralized level. This has also provoked the idea of urban sustainability.

The notion of sustainable city is indeed nowadays gaining increasing importance and policy interest. However, it falls short in providing a basis for effective urban policy, unless two conditions are fulfilled.

- the specification of manageable urban sustainability indicators and related critical threshold values.
- the identification of an evaluation mechanism as a basis for urban policies which can boost public support.

In principle, several policy orientations can be imagined for ensuring a sustainable urban development. They may range from command and control policies to market-based policies. In practice, urban policies seem to be instigated by the confidence in environmental standards as an effective policy vehicle. But the question on economic efficiency is hardly taken care of.

The paper aims to offer a refreshing contribution by making a plea for market solutions for urban sustainability problems. Particular attention is given to the potential contribution of tradeable permits for various polluting activities (air pollution, water pollution, congestion, energy consumption etcetera). The idea is that such market strategies may favour efficiency, equity and environmental quality in the city. An overview of various possibilities is given, followed by policy guidelines and conclusions.

The paper argues that Pareto-optimal solutions may be achieved by getting all actors in the urban space involved in sustainability strategies through the possibility of using the price mechanism for tradeable permits for polluting activities, taking for granted that - based on measurable environmental quality indicators - it is possible to identify critical threshold values for urban environmental quality.

In the paper, a wide range of market solutions for tradeable permits is given and critically reviewed. The paper concludes with various policy guidelines.

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1. Introduction

It is increasingly recognized that modern cities - or urban regions - are dynamic and self-organizing artifacts; they are the result of creative design, architectural implementation, land use policy and management of human resources within a cohesive framework imposed by their cultural and political history. Modern cities have become multi-faceted economic, social, cultural and environmental systems making up an organic assembly of multiple interacting subsystems. At the same time, cities have to struggle for survival and continuity, a task sometimes denoted by the concept of urban sustainability. As a result, cities exhibit complex evolutionary patterns in which growth and decline are in turn present. Thus the life cycle of cities seems to demonstrate a stimulus-response dynamics which is omnipresent in business life. Therefore, it makes sense to interpret urban dynamics in terms of a Schumpeterian search for new strategies that ensure continuity in changing - and often competitive - conditions. Clearly, seen from this perspective, innovative behaviour in the city is a *sine qua non*, in order to (i) remain at least at a competitive edge or (ii) to curb a process of urban decline. Deliberate innovative strategies to rejuvenate city life are necessary as the challenges and problems facing cities are numerous, complex and difficult to manage. Examples are: the governance of balanced human co-existence in the city (e.g., a multi-cultural community, social exclusion, high unemployment rates); the management of urban capacity and density problems (e.g., urban environmental sustainability, urban traffic); or the policy response to globalisation processes impacting on the urban territory (e.g., urban network design, urban in-migration)(cf. Newman and Thornley 1994).

It has become customary to speak of the 'urban crisis' or the 'urban malaise' in order to denote the problematic position of modern cities which are paralysed by the burden of managing the urban space with its multiplicity of conflicts. We observe crisis syndromes originating from alienation problems, urban financial crises and high criminality rates (cf. Businaro 1994).

In light of the great many challenges (threats and opportunities) of the modern city, there is also a tendency to emphasize the new role of the city as the creator of a portfolio of locational opportunities (e.g., the agora city, the 'glocal' city, the resourceful city etc.). The main question is of course whether sufficient and effective governance strategies - in both the public and the private sector - can be developed that guarantee sustainable urban development (see also Camagni et al. 1995). In this context, it ought to be recognized that a proper organisation and use of the urban space should exploit the fact that the city is a privileged spatial -

economic actor as a result of scale and urbanisation advantages. A city is in principle able to produce positive externalities which favour innovative behaviour (see Davelaar, 1991), in particular if multifunctionality, openness and spatial interaction are present. Thus the functional network character of the city is decisive for its innovative potential.

It is therefore also clear that in a dynamic competitive environment the absorption and generation of new technology in an urban economy is of paramount importance for the future role of that city. Economic development is a *sine qua non* for a strong economic position of the city, but at the same time a strict environmental policy is needed to prevent that the basis for sustainability is eroded: non-sustainable urban growth implies by necessity that the whole urban economy will witness a process of socio-economic (and environmental) decay in the long run. Consequently, the urban carrying capacity has to be respected in urban development strategies, with sufficient attention for a balanced choice out of the portfolio of innovative capabilities of the city (and of the firms located in that city). In this context, a dedicated policy focused on urban sustainability is needed. Thus far, the results of urban environmental policies have not been overwhelmingly impressive, despite strict regulatory systems. This paper will explore the potential of more market based policy strategies and will argue that tradeable permits may be new promising instruments to ensure urban sustainability.

2. Environmental Policy and Space Conflicts

As mentioned above, in recent years the attention for urban areas in the sustainable development debate has grown rapidly (see Nijkamp and Perrels 1994). Many international organisations published policy documents with recommendations on strategies to reach urban sustainable development. A huge number of these reports strongly advocate a compact city solution to the urban sustainability problem (CEC 1990; Elkin et al 1991). Consequently, many urban governments advocate nowadays the compact city solution in their strategic urban plans. A compact city is a city which has a high density and a concentration of socio-economic functions in order to reduce energy use environmental decay and urban sprawl.

There are indeed many advantages involved in high urban density living (see Haughton and Hunter 1994). High density living is more efficient than low density living in terms of lower rates of domestic consumption of energy for heating, electricity and water. Scale economies can result in lower infrastructure costs, and critical mass thresholds are more likely to be reached to justify the provision of energy efficient modes of public transport (underground metros, trams, etc.). In addition, higher density urban development is regarded to economize on street lighting and to reduce transport needs, particularly where cities are arranged in such a way that people can readily walk or cycle to their work and services, such as schools and shops. A further positive feature concerns the range of functions which well-designed neighbourhoods can support with high concentration of population,

in terms of healthcare, schools, shops and so on. Newman and Kenworthy (1989) have even found a strong correlation between the density of the urban area and the energy use in it. The higher the density of the city the less energy is used. Some other authors however argue that, although there is a strong correlation, also many other factors are involved like the size and the urban form (Breheny 1990).

The advantages of concentrating urban functions in a compact city may be summarised as follows (Rosdorff et al 1994):

- (1) positive environmental effects for the region; by concentrating the functions in the city, the entire area affected by the pollution or environmental decay is smaller;
- (2) a reduction of environmental stress per activity due to scale economies as a result of improved efficiency.

However, the compact city has also a big disadvantage. By concentrating the functions of the city, also the spatial concentration of environmental pollution is higher: because environmental stress is more concentrated, the environmental problems are more severe as well. This influences the quality of life of people in the compact city. This situation is also called the *paradox of the compact city* (Breheny 1990). We may thus argue that the paradox of the compact city is an allocation problem of environmental assets (clean air, clean water, etc.) to space and time (Rosdorff et al 1994). In the compact city the environmental assets are overused in order to reduce the use of environmental assets outside this area.

In light of the tension between economic efficiency, social equity and environmental sustainability in a compact city model, it is clear that many policy initiatives have been launched which were seeking for an improvement of urban quality of life through more strict regulation (e.g. environmental standards etc.)

In many countries (including the Netherlands), the government works predominantly with norms for environmental pollution (e.g. for noise dBA, for air pollution $\mu\text{g}/\text{m}^3$). In terms of strict efficiency, local standards would appear preferable to the adoption of nation-wide emission standards. The latter do not guarantee that the marginal costs of environmental improvement will be equalized across urban areas and, in consequence, the uniform standard will be too generous for some cities and too severe for others (Button and Pearce 1989).

With the present legislation a company is not allowed to produce pollution exceeding the norm. The norms however, are more or less equal for an industrial area and for a natural park. This means that sometimes it is not possible to locate the industrial companies close together, because the norm of the area is exceeded. The result is that in some areas the development is halted, because it is not possible to locate there, whereas in 'clean' areas the development has started to grow. A new industrial company is not allowed to locate near an existing industrial area and as a result the pollution gets more dispersed. Given the present legislation in many countries it is thus difficult to reach a compact city.

An other disadvantage of the present legislation is that there are no incentives for companies to reduce their pollution level below the norm, even if the company is able to do this at low costs. Consequently, it seems meaningful to look for a policy which is more flexible and offers companies more incentives to reduce their

pollution. Flexibility is then needed to concentrate the pollution problems and efficiency is needed to reduce these environmental problems at the lowest costs possible. In the USA several initiatives have started to find a solution to these problems, mainly based on market principles with a particular emphasis on the idea of emission trading. This system will concisely be described in the next section.

3. The System of Marketable Emissions Permits¹

At present emission trading is a system which is only used on limited scale in the United States. It is a relatively new instrument in environmental policy. In a marketable emission permit system the government (or an environmental authority) allocates or sells emission permits to companies, which can trade their emissions afterwards. Some companies will be able to reduce their emissions (or the impact of the emissions) at relatively low costs (low marginal abatement costs). They can then trade the emission permits which they do not use, to companies which are not able to reduce their emissions due to relatively high marginal abatement costs. In a perfect market the emission permits will be traded until the marginal abatement costs of the companies are equal to the price of the emission permits. This means that the reduction of the emissions are allocated between the emittents in such a way that the reduction is realised at the lowest costs (Montgomery 1972). Clearly, this outcome is only reached in a perfect market. The requirements for a competitive tradeable permit market are (Hahn 1984):

- (1) the existence of a large number of potential traders;
- (2) an 'arm length' (non-dependent) relationship among polluters in their product markets to prevent subversion of permit trading through product market threats;
- (3) sufficient differences in abatement costs among the potential traders to make trading worthwhile.

There are two forms of permit markets. In the Ambient Permit System (APS)² the permits do not concern a source emission, but refer to the impact of these emissions at the level of pollution at a particular point (a receptor point). Environmental quality norms are made for each receptor point and competitive bidding for these permits per receptor points would then generate an equilibrium solution that satisfies the conditions for the minimization of total abatement costs (Montgomery 1972). A main advantage of this system is the simplicity of the system for the environmental authority. In particular, officials need no information

¹ The term Marketable-Emission-Permit-System is sometimes also denoted as Tradeable-Emission-Permit-System or in short Permit-System

² Also called the Ambient Differentiated Permit (ADP)

or whatsoever regarding abatement costs; they simply issue the prescribed number of permits at each receptor point, and competitive bidding takes care of matters from there. But a great disadvantage is that it is extremely cumbersome for polluters. The polluters have to make a portfolio of permits from each of the receptor points that is effected by their emissions. When there is a large number of receptor points, each with its specific environmental norm, a huge number of markets will exist. The transaction costs for polluters may then be high (Baumol and Oates 1988). A second disadvantage of the APS is that the receptor points tend to become institutionalized. They all have their specific markets and the displacement of a receptor point to adapt it to a new pattern of pollution would create dislocations. The APS form of the permit market is thus not without serious problems (Baumol and Oates 1988).

The second form of permit markets is the Emission Permit System (EPS).³ The EPS can simplify life significantly for polluters. Instead of assembling the necessary portfolio of permits from different receptor markets, each source would find itself assigned to a single zone within which emissions entitlements would exchange one-for-one, but no transfers are permitted between the zones. However, the EPS cannot, in general, achieve the least-cost solution, and it places high demands on an administering agency that aims to approximate this solution. Since polluters with somewhat varying dispersion coefficients are aggregated into the same zone, one for one trades of pollution entitlements will ignore the differences in the concentrations contributed by their respective emissions. In short, the price of emissions for each polluter will not correspond accurately to the shadow price of the binding pollution constraint (Tietenberg 1980).

For the initial allocation the environmental authority needs to know the abatement cost functions of the polluters in order to achieve the least cost solution (Baumol and Oates 1988). Secondly, even if the control authority would have this extraordinary large amount of information, it would have only one distribution of permits which would be consistent with the least cost solution (as opposed to the infinite number of initial APS allocations which are consistent with the least cost solution). Even in the rather unlikely case that the control authority is able to discover this single initial EPS allocation, it would have no flexibility in trying to distribute the costs fairly (Tietenberg 1980).

Both systems are based upon source zones. The number of source zones and their size is a variable which can be manipulated by the control authority when the system is designed. Since the administrative complexity of the system rises with the number of zones, it is tempting to use very large zones (hence only a few of them) to characterize a particular geographic area. This temptation would have to be resisted however, since an increase in the size of the zone will introduce the possibility that 'hot spots' or high pollution levels will occur within the zone, since one-for-one transfers within the zone may result in clustering of emitters. On the other hand, in the EPS smaller zones reduce the transferability of permits, a prime source of cost reductions (Tietenberg 1980).

³ This is also called the Emission Discharge Permit (EDP)

4. The Offset and Bubble Policy

As shown above, both the APS and EPS forms of marketable permit systems are then subject to some serious problems. In short, APS is cumbersome for polluters, whereas EPS is cumbersome to the environmental agency. Therefore, marketable permits schemes are rarely, if ever, introduced in their textbook form, and consequently a number of hybrid systems has emerged. One of these hybrid systems is the pollution offset-system (PO).

The emission offset policy was originally designed as a means for allowing economic growth in non-attainment areas while insuring no further degradation of their air quality. In this approach, permits are defined in terms of emissions (e.g. the permit allows the discharge of X ton of the pollutant, say, per month). However, sources are not allowed to trade permits on a one-to-one basis. More specifically, transfers of permits under the PO scheme are subject to the restriction that the transfer does not result in a violation of the environmental quality standard at any receptor point. The new source must for instance always use the 'lowest achievable emission rate'-technology.

The advantages of this hybrid system are significant. The PO system shares with the APS the important property that mutually beneficial trades among sources can lead to the least cost solution, a result which is independent of the initial allocation of the permits. The PO scheme makes modest information demands on the environmental authority. Officials need to know the dispersion characteristics of emissions within the zone, but need not have no information on source abatement costs. The authority does not have to solve the cost minimization problem to determine the initial allocation of permits; any allocation will do.

Unlike the APS the PO system does not require sources to trade in a multitude of separate permit markets. Instead, a firm purchases emission permits directly from other sources. The PO scheme thus promises substantial savings in transaction costs to sources relative to APS. In addition, it is not subject (as is APS) to the requirement that a fixed and 'institutionalized' set of receptor points be established (Baumol and Oates 1988).

An other related concept which has emerged is the *bubble concept*. The bubble concept specifically allows emitters to propose modifications in their emission standards, based on the substitution of a more stringent degree of control to an another source of the same pollutant. The attention is not focused on one source only but on a group of sources. The pollution by the group of sources - rather than a single source - should not exceed the total norm. In the bubble concept a bubble is put over the group of sources and within the bubble the companies are free in how far they want to realize the norm for the bubble. These substitutions can, under certain circumstances, take place between plants or even between firms.⁴ This design feature carries the bubble policy a long way toward a

⁴ The possibility of compensating sources within the own company is also a form of a bubble and is often called *netting*

fully transferable permit system. The aim, of course, is to allow a firm to meet its emission reduction goal as flexible and cheaply as possible while insuring that the air quality is not degraded by the substitution (Tietenberg 1980).

The main difference between the bubble and the offset policy is that the latter allows the transfer of emission reductions from existing sources to new sources, as long as there is a net improvement in the environmental quality, whereas the bubble policy allows transfers only among existing emitters and does not ask for a net improvement of environmental quality.

The key difference between the existing system (with the bubble concept and the pollution offset system) and a system with full transferability lies in the fact, that in the latter the control authority allows all sources to participate in the trades and allows all emission reductions to be traded in a regulated market. In contrast, the bubble and offset policies have restrictions on which emission reductions can be traded (e.g. only those additional reductions above the standard in the offset policy) and on which sources can participate in trades (e.g., only existing sources in areas demonstrating attainment in the bubble policy) (Tietenberg 1980).

It is interesting that in the existing policy there is also a possibility to *bank the credit*. With the possibility to trade the emission rights, a market is created. Because supply and demand are not always equal, there is need for a possibility to store the emission reduction credits for later use. A banking system has to be created to store the emission reduction credits. In order to apply for a reduction credit at a bank or in order to trade, there are some constraints (EPA 1980):

- (1) a reduction of the emission can only be used as a credit and banked when the reduction is exceeding the norm for reduction;
- (2) the reduction should be permanent. This means that the reduction should not be temporary, intermittent, or short-lived (e.g. emissions reductions from car-pooling are frequently only temporary);
- (3) the reduction must be real. This means that *actual* emissions should be reduced. Methods to measure the reduction should be the same as the measures used before the reduction;
- (4) the reduction should be enforceable. This means that the emission is more than a promise of reduction. It must be an action and a commitment that is legally binding and enforceable in the courts and by the regulatory agency. Then the company has the opportunity to use the credit later and to sell it to an other company or to use the credit later when the firm wants to expand in a non-attainment area. The credit can thus be used to 'bubble' or to 'offset' later.

5. The Policy of Marketable Emissions and Urban Sustainable Development

It is now an interesting question whether policy of marketable emissions is consistent with the concept of urban sustainable development. Sustainable development is a development in which the critical environmental quality level should be sustained through modified economic growth (OECD 1990). The policy of marketable emissions sets standards for the environmental quality in a specific area, and these standards may be high when the interest in urban environmental quality is high. It is thus in principle possible to reach urban sustainable development with modified economic growth through the policy of marketable permits.

An important advantage of the marketable emissions concept is that we only have to know until which point we want to pollute or use scarce natural resources. We simply set standards at these points without the difficult task of valuing the environment. With other policies (like the "polluter pays" policy) we have to know the value in order to calculate the tax for the firm. Thus the simplicity of the policy of marketable emissions makes it an attractive policy (Howe 1994).

Furthermore, it is noteworthy that sustainable development is an integrative process. The policy of marketable emissions tries to integrate environmental concerns into the economic system: the environment is seen as a scarce resource.

In Section 2 the compact city was mentioned as a solution to the problem of urban sustainable development. Theoretically a policy of tradeable emissions leads to a state where the environmental goals are reached at the lowest costs (see Montgomery 1972; Baumol and Oates 1988). So that the system of tradeable emissions is efficient in reducing the urban environmental problems. Clearly this policy is not the only policy that achieves environmental goals at lowest costs. The system of effluent fees also has this advantage. But a major advantage of marketable permits over effluent fees is that permits promise to reduce the uncertainty and adjustment costs involved in attaining legally required levels of environmental quality. The environmental authority is normally never entirely certain of the response of polluters to a particular level of an effluent charge. The fee may have to be raised and then altered again to generate an iterative path converging toward the target level of emissions⁵. In contrast, under a permit scheme, the environmental authority directly sets the total quantity of emissions at the allowable standard; there is, in principle, no problem in achieving the target (Baumol and Oates 1988).

Next a tradeable emission policy is flexible, as it allows the environmental agency to set different standards for different geographical locations. In this way it is possible to have areas with higher attention to the natural environment, and other areas with higher attention to economic growth. With the system of emission trading it is also possible for a firm to expand or relocate to areas where this was

⁵ This is also the case with, for instance, an inflation. Under a system of permits, market forces automatically accommodate themselves to inflation and growth with no increase in pollution

previously not possible with the present legislation. The system has the possibility for financial substitution of the emission reduction. With the possibility to buy, sell or bank the emission reduction credits there are many incentives for firms to reduce their emissions. Like all policies the concept of marketable emissions embodies also a couple of disadvantages. First, by storing the emission reduction credits at a bank a right to pollute is created. The idea that someone (a company) can earn a right to pollute and therefore can get a right to hurt third parties with their pollution is somewhat counter-intuitive. But there is an important distinction between the "emission reductions" (the *physical* reduction of emissions by a source) and Emission Reduction Credits (the *commodity* that is to be banked). The simple fact that a source reduces its emissions by 100 tons, does not necessarily mean that either itself or another source that purchases these credits has the right to pollute an additional 100 tons. The use of Emission Reduction Credits is subject to the rules governing the particular permit context (e.g., offsets or bubble applications) to which it is applied. In order to avoid confusion between the physical pollution units and the intangible commodity which is banked and ultimately used, the former ones are termed emission reduction and the latter are termed Emission Reduction Credits. Credits will entitle sources to meet certain requirements for either obtaining new source permits or for meeting emissions limits at existing sources. The use of ERCs must meet sufficiency and equivalent tests. Credits do not automatically entitle sources to increase their pollution; nor are these credits absolute entitlements or property rights of interminable duration.

A second disadvantage of the marketable emission system is that it is not entirely fair to newcomers in an area who have to pay for permits, while the already existing companies do not have to pay for it. This is only the case when the initial distribution is done by grandfathering. Grandfathering means that the sources which are in the area, are given the permits at the initial distribution (usually on the basis of historical emissions). Trades between the holders will result in an equilibrium solution that satisfies the conditions for the minimization of total abatement costs. An other system that could be applied, is that the permits are sold at the initial distribution. Auctioning the permits results in an efficient initial allocation of the permits. In this latter system, the costs for the initial allocation may be high for the sources in the area; therefore, grandfathering has the advantage that it is much more politically feasible. In all cases where they work with tradeable emission permits, the initial distribution was done through grandfathering. Another possibility is that the authority reserves a share of permits for possible newcomers in the area. This is done in a Swedish study, in which 80% of the permits are distributed through grandfathering and 20% are sold. The permits that are distributed through grandfathering have to pay a yearly tax over the permits they own. But this system of paying taxes eventually is the same as when the permits would be sold initially (MEZ 1992).

A final usually mentioned disadvantage against the bubble policy is the danger of filling up the norms. Within the bubble companies are free to choose how they realize the norms. Consequently, the norms are totally used up, because a reduction credit may be sold or used to fill up the norms. But it is questionable whether this is really a disadvantage of the system. The norms are related to the number of

permits that exist in an area. When the norms are set high enough and are adjusted in the future, the problem of filling up the norm is not necessarily a problem. As was mentioned above, in order to offset, the total environmental quality must be improved. It is thus not entirely true that the emission reduction credits may be used to fill up the norm.

6. Urban Sustainability and Emission Trading of Air Pollution

6.1.Introduction

The possibility to implement a system of tradeable emissions for different environmental problems in the urban area would administratively be easier, if all types of pollutants could be handled within the context of one general market. The problem of this approach is however, that the final amount of each pollutant is determined by the emitters; the control authority will then lose the capability to control each pollutant (Tietenberg 1980). Therefore, it is better to use separate markets for separate pollutants, provided the number of different markets is not too high. With many different markets, the administration costs will be high and subsequently also the transaction costs for the polluters. Therefore, it seems more plausible to distinguish different markets for different pollutants in the urban area. The first step in designing a permit system is to define a basis for what will be traded. Theoretically, there are three ways to control environmental problems;

- (1) a control of the input that causes the pollution;
- (2) a control of the emissions of the pollution;
- (3) a control of the impact of the pollution on the environment.

We have to keep in mind the following criteria for the base of the permit (MEZ 1992);

- (1) the system should not be too difficult to implement; important aspects are the information required and the costs of control.
- (2) the policy instrument must be effective, which means for the permit that there must be a direct relation with the goal of reducing the pollution.
- (3) the system must have the possibility to control different pollutants within the same market; which means that the number of different markets should be low.
- (4) the system should be dynamically efficient, which means that developments of new technologies to reduce the pollution are to be stimulated through the use of the permit.

We will illustrate the above observations by taking a closer look at urban air pollution. From the viewpoint of minimizing administration costs and transaction costs, it would be desirable that all different air pollutants were traded in the same market. Macintosh (1973) suggests choosing the weights for determining the

equivalency between different pollutants on the basis of their historical contribution to pollution in the local area. The permits in his study cover particles, sulphur oxides and carbon monoxide. He uses the emission of the different air pollutants as the base for the permit. The disadvantage is that the weights that have to be chosen are difficult to establish, and may change over time. A control on each pollutant will be lost, since substitution between the pollutants is possible. A second disadvantage is that some air pollutants have a more local character than others. This could cause certain hot spots in some areas.

It may also be interesting to take a look at the sources of pollution. We can see from Table 1 that most air pollutants are in one way or another related to the use of fossil fuels for energy. A trading system based on the use of fossil fuels might therefore, also reduce the concentration of different air pollutants. When the fossil fuels are completely combusted, there is a direct relation with the emission of CO₂ in the air. With an incomplete combustion the emission of CO₂ is less, but the emission of CO and VOC's is higher.

An advantage in using fossil fuels as a base for the urban permit system is that the system is far easier to control than a system in which the emission of pollution is controlled, since registration of the emission from all sources is a difficult task. The big advantage in choosing carbon based fuels as a base is that data on production, import and consumption of carbon based fuels are usually available from the energy company or the gas company (MEZ 1992). A second advantage of using fossil fuels as the base is that we do not have to use different markets for all air pollutants. There is also a rather straight forward connection with the quantity of air pollution, while the system is rather flexible.

Table 1. Sources of the air pollutants

Air pollutants	Source
Carbon dioxide	Combustion of fossil fuels
Nitrogen oxide	Transport sector, industrial sector, energy sector
Carbon monoxide	Incomplete combustion of fossil fuels
Volatile organic compounds (VOC)	Incomplete combustion of fossil fuels
Particulate matter	Sources include fine asbestos and other particles stemming from wear and tear of tires and brakes as well as matter resulting from engine, especially diesel engine, combustion
Sulphur dioxide	Coal fired electricity generation, and for a small part the transport sector (5%)

The second step in designing an urban permit market is to distribute the permits to the actors in the market. In the energy market, we can basically identify three groups of consumers:

- (1) the transport sector;
- (2) the industrial sector;
- (3) the residential and commercial sector

A trading system with one market for the different consumers of energy is difficult to design, since the difference in consumption of energy is significant. In the residential sector the number of participants is large, but the amount they use is relatively low. In the industrial sector the number of consumers is relatively low, but the consumption on the other hand is high. A trading system in which all actors participate is thus cumbersome, because of the different sizes of the permits. For the practicability of the system of tradeable emissions, the costs of control and the required information should must not be too high, as otherwise the administration and transaction costs will be too high. Therefore it seems better to use separate markets for different consumers of energy.

6.2.The industrial sector

One of the main energy consumers in the urban area is the industrial sector. The share of the total amount of energy consumed by industries in OECD countries, is about one third (OECD 1993). This share has declined in the past 25 years (from 40.1% in 1970 to 32.1 % in 1991). This is partly due to a more efficient energy use, but also because of a structural shift in the economic base of most industrialised countries to a more service-oriented economy. The environmental problems directly caused by energy use of the industry are the depletion of the energy resources and the air pollution. The share of the different emissions of gases is shown in Table 2 (IEA 1991).

Table 2.
Share of the industrial sector in emission of gasses

Carbon dioxide	34.1 %
Nitrogen dioxide	22 %
Carbon monoxide	1 %
Sulphur dioxide	65.3 %

A permit system for the energy use by the industrial sector will reduce the amount of emissions of gases that are released by the combustion of fossil fuels. The costs of control are relatively low, since most data on the use of gas and the use of fossil fuels are available (MEZ 1992). Thus certain number of 'fossil fuel

use permits' can be identified to meet air quality standards. These may be distributed through grandfathering or may be sold.

As earlier, a distribution through grandfathering is politically more feasible. After the initial distribution, the participants in the market can sell, buy, rent or lease the permits. When a company is able to increase its efficiency in energy use, it needs less permits and the company can sell the permits.

A system in which the fossil fuel permits are traded without any restrictions may result in an increase of pollution in local areas. Therefore, some trading rules should be used to prevent adverse air quality impacts. With the help of zones in which different air quality standards are chosen, the environmental authority can control the air pollution in the urban area. By setting different standards for different areas, the diffusion of pollution may be reduced, and a more compact city solution to the problem of urban sustainable development can be implemented. In non-attainment areas the trades might be limited in order to meet the air quality standards for a local area. This might could be done through an offset and a bubble policy, as was explained above.

The result of such a trading system is that - because of the restriction of the energy use - the industrial sector gets incentives to use the fossil fuels more efficiently and/or that it seeks for cleaner ways to produce energy (e.g., through the use of renewable energy). A company will reduce the use of fossil fuels when the marginal costs of the reduction is lower than the price of a permit on the market.

6.3.Commercial / residential sector

The residential and the commercial sector use energy mainly for space heating, water heating, lighting, and more specifically in the residential sector for refrigeration and cooking. The residential sector used in 1991 about 18.8 % (in OECD countries) of the total energy demand (IEA 1994). More than half of the energy is used for space heating.

The number of consumers is large and the amount of energy use per consumer is relatively low. When the distribution is done through grandfathering, the actors in the market need to trade in order to arrive at an efficient allocation of the permits. The transaction and administration costs for this permit system will be too high in relation to the number of permits to be traded. It is thus not very likely that an optimal allocation, after grandfathering the permits, will take place.

Another possibility is that the permits are sold through auctioning, so that the actors in the market do not have to trade because the initial allocation is already efficient. But also when the permits are distributed through an auction, the transaction costs will be high because of the large number of participants. The costs for consumers will be too high to make the system politically feasible.

The permits however, do not necessarily have to be bought by the consumers of the fossil fuels. They can also be bought by the producers and importers, who have often a regional or urban orientation who can raise the prices for the fossil fuels to account for the permits they bought. The number of producers and importers of fossil fuels is rather low (in the Netherlands 40 to 50), and the

transaction costs per permit will be lower. Secondly, the costs of control will be much lower. The environmental authority only needs to control the producers and importers who hold the permit (MEZ 1992). Since with this system the price for fossil fuels will rise, the consumers will receive clear incentives to economize on energy use. A difficult element in this system is to set the price that the consumers have to pay extra for the fossil fuels that they use.

6.4.The transport sector

The transport sector plays an important role in western society. Transport allows personal mobility for both work and leisure activities. Transport also provides a vital lubricant to trade and has permitted the advantages of geographical specialisation in production to be more fully exploited (Button and Rothengatter 1993). These advantages however, are also the cause of many environmental problems. Many people regard the transport sector as the main contributor to environmental problems in the urban area. The transportation sector is responsible for approx. 28% of global carbon dioxide emissions, about 54% of the nitrogen dioxide emissions and about 90% of all carbon monoxide emissions. In 1991 the transport sector was responsible for 30,8 % of the energy consumption, up from a level of 23,8 % in 1970 (OECD 1993).

Like in the residential and commercial sector the number of consumers in the transport sector is very large. The amount of fossil fuel per consumer is again relatively low. Grandfathering of the permits in the transport sector, has thus the same disadvantage as in the residential and commercial sector. Also when the permits are sold the transaction costs will be high, because of the large number of consumers (see also Vleugel 1995).

A possible solution will be to use the same system as suggested above for the residential and commercial sector. The permits might be sold to the vehicle producers and importers. Consequently the prices of fossil fuels would increase, because the producers and importers would have to pay for these permits. Trade of permits in the transport sector will then not take place among car drivers since these users are not the holders of the permits.

6.5.An Integrated Energy Permit Market

As argued above, it is difficult to establish a permit market in the residential / commercial sector and the transport sector on the basis of a permit for the fossil fuels used by the consumers. Nevertheless it may be possible to create one overall fossil fuel permit market for the three sectors distinguished above. As mentioned above the costs of control and transaction are too high with many participants using relatively small amounts of fossil fuels. In the industrial sector we do not have these problems, so that permits in this market may be distributed through grandfathering, leading ultimately to a minimization of the costs of abatement. Since the transaction costs in the other two sectors will be high in relation to the amount

traded, the result of trading will not be that the costs of abatement will be minimized.

A possible solution may then be that the permits for the two other sectors are sold to the producers and importers at the level of the initial distribution. The permits distributed through grandfathering in the industrial sector can then also be sold to the importers and producers of fossil fuels when the industrial company has to buy fossil fuels from them. A big advantage of such a system is that the environmental authority has to control only a limited amount of permit holders, namely the producers and the importers of fossil fuels. In the Netherlands this would mean that approx. 35 % of the fossil fuel permits would be distributed through grandfathering and the rest would be sold to importers and producers (MEZ 1992). In most industrialized countries the energy used by the industrial sector is approximately the same. As said before a trading market in the industrial sector will result in an efficient use of fossil fuels and/or the use of renewable resources. But also the importers and producers of fossil fuels will have these incentives. When these actors are able to reduce the fossil fuels in the residential/commercial sector and the transportation sector, they can sell their permits to the industrial sector. Information provision on energy saving techniques to the residential sector is important in this respect. Of course, the industrial sector might also sell permits to producers and importers, when it is cheaper for the industrial sector to reduce the use of fossil fuels. Clearly this is something else than giving the permits to the producers and importers when the industrial company buys the fossil fuels. The system for the entire fossil fuel permit market is shown in figure 1.

7. Tradeable Emissions for Other Pollutants in the Urban Area

7.1.Tradeable emission markets for water pollution

The control of water pollution through an urban emission permit system is difficult. Usually it is necessary to control water pollution on a larger scale (for instance, all polluters in a river). This is done, for instance, in the Fox River in Wisconsin (US). This project demonstrates that water pollution control strategies allowing transfers between dischargers can be both cost effective and capable of maintaining any desired water quality standard. Transferable permits appear to be as appropriate for national water quality as offsets and bubbles have been for air policy (O'Neill et al. 1983). A permit system with the input as the base is difficult to implement, since there is no unique input for all the pollutants. Therefore, a permit on the emissions is here more appropriate. The permit system for controlling water quality is not further described here, because the quality of water is in any case difficult to control on an urban scale.

Figure 1. The Integrated Energy Permit Market

7.2. Tradeable emission markets for solid waste disposal

An interesting proposal for a tradeable permit system for solid waste disposal is currently considered by the State of Minnesota (Howe 1994). The State would set an upper boundary on the tonnage of (heterogeneous) solid waste to be accepted by disposal facilities state-wide. The base for the permit would thus be the tonnage of solid waste. The traders in the system are the producers of relatively large sums of waste, while households do not participate in this system. This system may easily be controlled, since the amount of solid waste can be measured by the disposal facilities. Participants in the trade can buy permits when they want to increase their waste disposal, from other participants who can reduce their amount of waste disposed.

The system may have the effect that the participants will recycle their waste, since buying permits may be more expensive. Results from the study in Minnesota

are not yet available, but the system seems a good policy since the administration costs and the costs for control are relatively low.

7.3. Tradeable emission markets for noise disturbance

A permit market for noise disturbance is not totally new. In the present Dutch legislation, norms are already imposed for critical limits in some industrial areas. The noise levels should not exceed the norms on these borders and the companies within this zone are responsible for reaching this norm. This policy is not really a permit market, since the participants do not hold permits which they can trade. Noise disturbance has a highly local character in contrast to, for instance, greenhouse gases. A tradeable permit system on a large scale in which the participants can trade also with other areas is therefore, not possible. Since such a tradeable permit system should be implemented on a local scale, the danger arises that the number of participants is too low to establish a market. As mentioned above one of the requirements to establish a permit market is the existence of a large number of potential traders. A permit system for noise disturbance does therefore not likely reach an efficient allocation among the traders.

7.4. Tradeable emission markets for congestion

It is clear that the transport sector is an important component of sustainable development policy, because it has both economic and environmental effects. The present situation of the transport sector in many urban areas is clearly unsustainable, and future developments show us that the number of cars will continue grow. For an urban area it is important, for both the quality of life the economic progress of the city, to put restrictions on the use of cars. The traffic speeds in some cities (for example, Athens) are now as low as 7 to 8 km per hour, while in Paris it is 18 km per hour and 20 km per hour in London (Button and Rothengatter 1993).

Some cities have already put restrictions on the use of cars by closing the inner city (Milan), or by allowing car use on only some designated days (Athens, Mexico City). However, with the closing of the inner city the effect on the surrounding areas has worsened, because of an increase of cars in these areas (STOA 1994). And by allowing to use the cars on only specific days, many people have incentives to buy other cars to use them on the other days. A good illustration of this is the case of Mexico city where the effect on the natural environment even worsened (Goddard 1994). Such restrictions do apparently not offer a solution to the problem of the increase of cars in the city.

Other policy recommendations for controlling traffic congestion focus on the use of road pricing techniques (see Nijkamp et al 1995). Indeed, with advances in electronic technologies, there are experiments and applications in which road authorities collect toll charges with the use of these technologies. For an urban area such a system would not be feasible, because of the complicated technical requirements needed for a control on such a system.

A permit system as explained above with fossil fuels as the base for the

permit system is likely not sufficient when the goal is to reduce also the congestion in the urban area. Since the transport sector and in particular private car use is rather inelastic, a rise in the price of fossil fuels will likely not produce the desired effect of reducing the congestion in and around urban areas. In this context it is interesting to refer to a recent paper by Goddard (1994) who describes a tradeable permit system for large cities (e.g. Mexico City). The base for the permits which he uses is the number of days someone can use the car. A permit system with a limitation on the number of days for driving the car is able to have the capability to reduce the number of cars in the urban area in both the short run and the long run. The basic idea is to set the total supply of permits to achieve specified targets for ambient air quality and congestion reduction. These permits may be sold or distributed through grandfathering. The grandfathering of existing vehicles avoids serious political resistance to this mechanism. Everyone has a permit to use the car on, for instance, three days only. When someone wants to use the car on more days, or when he wants to buy a new car, he has to buy a permit from someone else. The permits can be bought and sold, leased, rented and lent. In this way the total amount of cars used is limited both in the present and in the future, since the number of permits is fixed.

The system will require enforcement, but a judicious choice of the magnitude of fines and a reasonable probability of being caught should be enough to encourage substantial compliance (Goddard 1994). The system will however require a fair amount of administration of all transactions. The danger of this system is thus that the transactions do not take place because of insurmountable transaction costs. This is an important issue that needs to be studied further.

The permit system as described above may be an interesting policy to put restrictions on car use in the urban area, but at this point the system is still largely conceptual in nature.

7.5. Tradeable emission markets for depletion of energy resources

An other important aspect of sustainable development is that the resources should not be overused in order to offer also the next generations the ability to meet their welfare needs. With a permit system based on the use of fossil fuels the depletion of the energy resources will be significantly reduced, as shown already above.

7.6. Conclusion

In Table 3 the different permit markets are shown, in relation to their effects on the reduction of pollution. Clearly for some pollutants the reductions may be more significant than for others. A few final remarks are still in order.

A fossil fuel permit market seems a promising solution for both the problem of air pollution and the use of fossil fuels. It provides good incentives to favour renewable energy and to use the fossil fuel more efficiently. Such a system may be

implemented at various levels ranging from the urban scale to the national scale. The system may be made flexible with the help of different air quality standards for different areas, and with the help of offset and bubble policies, in order to prevent the dispersion of polluting activities to relative 'clean' areas.

Table 3. Overview of different urban permit markets

Permit market	Reduction of environmental problems
Fossil fuel permit market	<ul style="list-style-type: none"> - air pollution (CO₂, NO_x, CO, VOC and SO₂) - depletion of energy resources
Vehicle use permit market	<ul style="list-style-type: none"> - air pollution (CO₂, NO_x, CO, VOC and SO₂ and Particles) - depletion of energy resources - congestion - noise disturbance
Water pollution permit market	<ul style="list-style-type: none"> - water pollution (on a larger scale)
Solid waste permit market	<ul style="list-style-type: none"> - solid waste disposal

A permit market for vehicle use in the urban area has a great many advantages, but the concept until now is mainly theoretical. There are several issues that still need to be evaluated before such a system can be implemented, the most important one being the administration of the system.

A water pollution permit market is only possible on a larger scale, like the one for the Fox River in Wisconsin. The system for the Fox River shows that it is possible to reduce the pollution in such a system.

A solid waste permit market may be relatively easily applied in an urban area. The number of participants is large enough and zones are not needed. The control is relatively easy (except when participants take their waste to other areas where there are no restrictions on waste disposal).

In conclusion, the system of marketable permits for achieving urban sustainability looks rather promising. Several field experiments would have to be undertaken to test the feasibility of this idea in an actual urban setting.

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