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Environmental management instruments: topics for atmospheric pollution control strategy

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Abstract

This paper focuses on the analysis of environmental management strategies, covering decision and control, economic and information instruments as well as the fundamental principles of an environmental policy including: the different available tools, their acceptability and applicability, their advantages and disadvantages. Technical measures for control and management are assessed taking into account their implementation, their integration with other measures.

As a study case the analysis of Portuguese atmospheric emissions is presented. Major conclusions are the importance of coastal zone with a contribution of over 80% on total emissions for the most common pollutants. The most relevant emissions sources are power generation, road traffic and industry. Despite of projected economic growth, Portugal still presents a great potential to reduce emissions if an environmental management strategy is defined and implemented. A quantitative approach is needed in order to establish specific measures for the most sensitive areas and to integrate different issues related with scientific, economic and social aspects.

1 Introduction

Environmental management instruments and strategies developed from a passive perspective - that use the load capacity of ecosystems - to a reactive attitude, where the main approach is the use of clean-up technologies. More recently, in the 80s, the integration of the polluter pays principle in the legislation stimulated a proactive perspective and simultaneously new instruments have been developed and applied, particularly those related with market and information.

From the political point of view, the environmental questions have been introduced on the political agenda only quite recently. In fact the fast

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environmental degradation verified in the last 100-150 years, as well as the increase of public information, has woken people up to fight for a better quality of life and the welfare of the population.

Although human activities throughout time have released pollutants into the atmosphere, undoubtedly the most significant impacts were experienced after the Industrial Revolution and mainly due to fuel combustion. Same of the most important atmospheric problems currently identified are:

- acidification related with nitrous oxide (NO_x) and sulphur dioxide (SO_2) emissions;
- photochemical smog related with emissions of NO_x and volatile organic compounds (VOC), specialy as precursors of secondary ozone production in the troposphere;
- eutrophication related with the increase of ammonia (NH_3) and NO_x in the atmosphere;
- depletion of stratospheric ozone concentration due to the emissions of halons such as clorofluorcarbons (CFC's);
- enhanced greenhouse effect due mainly to carbon dioxide (CO_2), methane (CH_4) and halocarbons (SF6, PFC and HFC) emissions and its impact on climate change.

The recognition of these problems was involved on great controversy and results from the outcry of the scientific community, environmental non-governmental associations and the public in general. Thus, the international political class and, more specifically, the governments of different countries assumed the need for a global strategy to solve these problems. Some examples of those commitments are the conventions, protocols and agreements made in different areas and with focus on various objectives and targets. Those commitments have been transposed to the national level, environmental authorities have been created and environmental policies and strategies developed. More recently, new philosophic approaches have been developed and introduced based in economic and on information related instruments.

This paper analises the different type of instruments used in environmental management and pollution control strategies, as well as the technological development applied to pollution control and prevention.

The Portuguese panorama concerning atmospheric emissions is analysed, identifying the current emissions inventory and air quality management strategy, future emissions scenarios and emission control strategies needed to reach the targets agreed in international commitments.

2 Environmental management instruments

The "dilute and disperse" practice used in pre-industrial society was based only on the assimilative capacity of the natural environment. After the Industrial Revolution, this approach seemed to be adequate for atmospheric emissions and wastewater discharges. Nevertheless, the new approach "concentrate and contain" proved to be more successful for solid wastes (EEA [1]).

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From the 1960s onwards, it became obvious that "dilute and disperse" was no longer effective for important point or concentrated sources. The globalisation of environmental problems and the recognition of the planetary effects of pollution, particularly the effects on climate change and on the stratospheric ozone levels, contribute to the development of clean-up technologies, based on end-of-pipe approaches.

At a national level, and resulting from first environmental policies, thousands of regulations applied to air pollution management and control have been produced. Legislation focused on the emissions control and air quality standards and was oriented to the limitations and obligations of the polluters and a strict control by the authorities. This "command and control" strategy had unsatisfactory results due to the need of a heavy bureaucratic system and iniquity in the treatment of different pollutant activities face to their market opportunities.

Thus, a new philosophic approach has been developed and introduced based on economic instruments, which promotes the decrease of wastes production, based on cost-effectiveness options and the development of more eco-efficient and eco-effectiveness products. In fact, these instruments incentive pollution reduction to a balanced level between pollution control costs and environmental costs (externalities) which results sometimes in higher pollution reduction levels than the application only of "command and control" instruments. On the other hand this type of instruments integrates the polluter pays principle quite well and agrees with the concept of sustainable development. In fact, the improvements on production processes or even on the life cycle of products induced by this type of instruments results in saving on raw materials and energy which leads to an increase of economic profits (EPA [2]). The list of economic instruments includes taxes, revenues, incentives and charges.

Due to their environmental performance, the European Union (EU) in the 5th Environmental Action Program, started in 1992 recommended the use of economic instruments. Nevertheless, and despite of the little progress registered since then in member states, in the last 5-6 years the use of environmental taxes has increased, particularly in Scandinavian countries (EEA [3]).

More recently, voluntary information-related instruments have been developed taking into account the increase of public information on environmental issues and, on the other hand, new consumption patterns where environmental performance of products and economic activities plays an important role. As a result of this new approach, polluters need to improve their market image in order to satisfy a more ecologically-conscience consumer. Information instruments for this purpose includes eco-labelling and environmental management standards like ISO 14000 and EMAS.

The co-ordination of these three types of instruments together in the definition of an environmental strategy results to be more effective in both environmental and economic senses than when they are applied in separate, since polluters are stimulated to reach environmental targets in a cost-effective and flexible way.

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3 Technology applied to environment management

The evolution of technical solutions for environmental problems agrees with the conceptual evolution from early environmental attitudes over clean-up approaches towards precautionary and prevention principles included in sustainable development concept.

The first technological approach, which results from the reactive concept of environmental management, focused on end-of-pipe systems. Since the 1960s a whole technology and business was developed to install purification units at the end of emission pipes of various production processes in order to reduce the impact of discharges on the environment. But purification units works on the basis of chemical, physical and biological processes which, in the end, generate new sub-products that need to be treated. So this approach results in a continuous cyclical transference of pollution which combined with the increase in population and use of natural resources has became unsustainable. On the other hand, end-of-pipe technologies have revealed to be expensive and sometimes the costs are also unsustainable due to a strong competitiveness market.

Along with the introduction of the polluter pays principle into legislation, some improvements have been registered in the technological field. A more holistic approach of environmental issues has been implemented and new challenges have been posed to the scientific community in order to look at environmental problems in a more integrated way and to refuse the undesirable pollution transference from air to water and from water to soil and so on.

In the last 10 to 15 years, new pro-active ideas have emerged oriented wards pollution prevention and waste minimisation. These new ideas are integrated in the concept of cleaner production which is a preventive, integrated, continuous strategy for modifying products, processes or services to enhance effectiveness, which improves environmental performance and reduces costs. In fact, the major goal of cleaner production is to reduce the quantities of inputs of raw materials and energy and get the same or even greater output (EEA [1]). Cleaner production includes technological measures like life cycle assessment, best available technologies, eco-design and industrial symbiosis.

4 Portuguese atmospheric emissions control and management

In Portugal, the first steps on air quality management began with the institution, in 1966, of the so-called Working Group of Atmospheric Pollution, whose main purpose was the development of a program to fight against atmospheric pollution in most problematic places. In the 1970s, the Services for Environmental Studies were implemented.

From the strategic point of view, the first instrument for air quality management was the creation in 1980 of five Air Management Commissions, with jurisdiction over five mainly urban and/or industrialised-stressed regions (Lisbon, Barreiro/Seixal, Porto, Estarreja and Sines).

Currently, the major authority is the Ministry of Environment that is made up of General Directorate of the Environment, five Regional Delegations one for

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each of NUT II territory unit (North, Centre, Lisbon and Tagus Valley, Alentejo and Algarve), four thematic Institutes (Nature conservation, Water, Solid wastes, and Environmental promotion) and the Inspection of Environment.

In the legislative field, during the last 15-20 years, several legal diplomas have been produced and EU Directives transposed. First of all was the Basic Law of the Environment that cover all environmental fields including the need for an environmental impact assessment for big new projects and construction. Further legislation and regulation on the atmospheric field has included air quality standards, air emission standards and more recently, in 1999, the implementation of a fiscal incentive for investments made in clean-up technology.

4.1 Analysis of air pollutant emissions inventory

The last national air pollutant emission inventory published in Portugal with more detailed information was CORINAIR 90 and it is the basis of the analysis presented in this paper. Taking into account the major level of spatial downscale of emissions, which is the NUT III territorial units, further developments were made in order to obtain emissions at municipal (NUT IV) and sub-municipal levels (NUT V). This downscaling exercise was based on specific factors related with source activities, such as fuel consumption and population statistical data (Borrego et al. [5]).

Figure 1 presents the spatial distribution of NO_x and SO_2 annual emissions associated with mobile sources and all other sources excluding traffic and large point sources, calculated for the NUT V level. The analysis of both maps shows that major anthropogenic emissions are near the coastline corresponding to preferential distribution of population and economic activities, including large point sources, on the coast. This heterogeneous distribution has been discussed in previous work (Borrego and Lopes [4]) and following world tendencies.

The most relevant sources in the national emission budget of major pollutants (CO_2, SO_2, NO_x) are those related with combustion processes such as public power production and co-generation, district heating, industrial combustion, road traffic and other mobile sources (figure 2). Agriculture, nature and waste treatment and disposal are significant sources of non-methane organic compounds (NMHC), CH_4 and nitrous oxide (N_2O). In the Portuguese national panorama, the 29 large point sources classified according to CORINAIR guidelines (that include paper pulp production plants, refineries, power plants, petrochemical industry, cement plants, nitric acid production plants, sulphur acid production plants and steel production), have a major contribution on CO_2, SO_2 and NO_x emissions with, respectively, 45%, 80% and 30%.

It must be noted that according to the European Environmental Agency (EEA [6]) Portugal had the lowest CO_2 emissions per capita but the 3rd highest value of CO_2 emissions per unit of GDP in 1994. This fact could be explained by the outdated technology used in a great number of production and combustion processes that are less efficient from the environmental and economic point of view.

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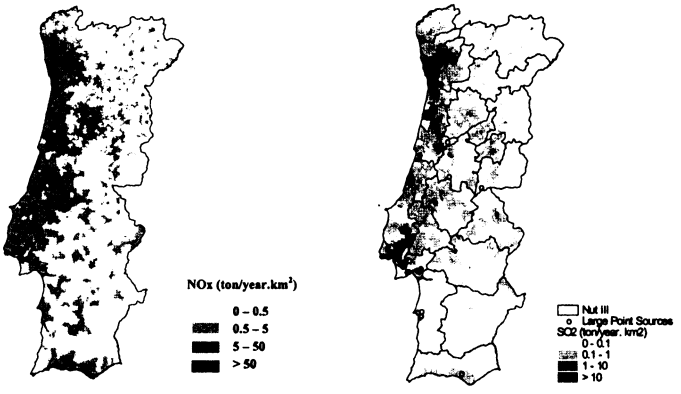

(a) (b)

Figure 1: Spatial distribution of Portuguese large point sources and area emissions for the year 1990: (a) NO_x emissions from mobile sources; (b) SO_2 from all anthropogenic activities excluding mobile sources, agriculture and large point sources.

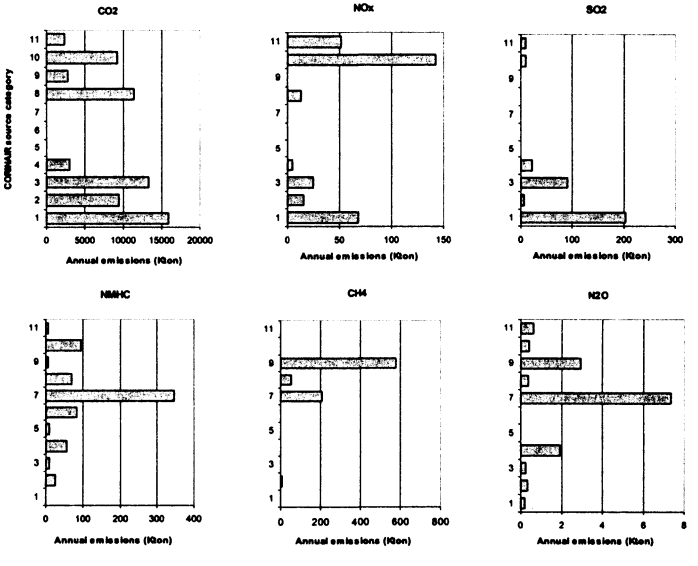

Figure 2: 1990 Annual emissions by pollutant and CORINAIR source category: 1- public production and co-generation; 2 – District heating; 3 – Industrial combustion; 4 – Industrial processes; 5 – Fuel extraction and distribution; 6 – solvent use; 7 – Agriculture; 8 – Nature; 9 – Waste treatment and disposal; 10 – Road transport; 11 – Other mobile sources.

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4.2 Portuguese targets related with air pollutant emissions

Portugal is a signatory country of various internationals Conventions and protocols such as for example:

- The 1979 Convention on Long-Range Transboundary Air Pollution;
- The Sofia Convention (1985) for the Protection of Stratospheric Ozone;
- The Framework Convention on Climate Change (1992);
- The Protocol of Montreal (1987) on substances that cause depletion in the ozone layer;
- The Agenda 21 (1992), a political statement concerning environmental development and co-operation.
- The Sofia Protocol (1988) related to the Convention on Long-Range Transboundary Air Pollution;
- The Kyoto Protocol (1997) concerning the emission mitigation of 6 specific greenhouse gases (GHG);
- The Gothenburg Protocol (1999) to the Convention on Long-Range Transboundary Air Pollution to abate acidification, eutrophication and ground-level ozone;

As a member-state of the EU, Portugal has assumed the responsibilities, obligation and guidelines proposed and approved by the European Commission and Parliament, including the application of EU Directives.

At national, regional and local levels, Portuguese government promotes specific measures conducive to the accomplishment of those targets. Despite this attempt at improving the quality of the environment, economic development is still the priority in order to increase the welfare of the population and to achieve the average quality of life levels of the EU. The integration of these two issues is often quite difficult.

From the air quality management point of view, this type of contradiction could be found on the commitments assumed in recent protocols. For example, according to the targets assumed in Kyoto and in the scope of EU "burden sharing" agreement, Portugal undertook, as a national objective, a 27% limit on the increase of GHG and a 40% increase limit concerning CO_2 emissions from the 1990 "baseline" level, until the 2008-2012 period. In the Gothenburg Protocol, Portugal agreed to reach specific national emission ceilings (NEC) for four pollutants (SO_2, NOx, NH_3 and VOC) and more recently the European Commission proposed a Directive on NEC for the same pollutants (COM(99)125), to limit the negative impacts of acidification, eutrophication and tropospheric ozone which is still under discussion (see table 1).

Looking across all those targets, the results appear to be contradictory and difficult to harmonise. In fact, some of the involved pollutants such as CO_2 and NO_x are produced by the same activities like fuel combustion. Furthermore, the projected emission for the year 2010 (figure 3) indicates an increasing tendency on CO_2 emissions for the 3 analysed scenarios (low, medium and high economic development). According to those projections, Portugal is close to reaching or even surpassing the values agreed upon in Kyoto (Borrego et al [7]). This increase in CO_2 emissions due to the development of economic activities

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indicates an increase on other atmospheric pollutants released by the same sources of CO_2. But the NEC proposal under discussion intends to be more ambitious than the Gothenburg Protocol with a reduction that reaches up to 65 % for the same period.

Table 1. Emission levels for 1990, emission ceilings and percentage of reduction for the pollutants covered by the Gothenburg Protocol and the NEC Directive proposal.

Pollutant	Emission levels in 1990	Emission ceilings for 2010 (kton)		Percentage on emission change	
		Gothenburg Protocol	NEC Proposal	Gothenburg Protocol	NEC Proposal
SO_2	344	170	141	- 51 %	- 59 %
NO_x	303	260	144	- 14 %	- 52 %
NH_3	77	108	67	40 %	- 13 %
VOC	294	202	102	- 31 %	- 65 %

Thus, there is no doubt that an enormous political and strategic exercise must be done in the next few years. An integrated approach between NEC and Kyoto is needed in order to develop a strategic plan for mitigation of atmospheric emissions. On the other hand this strategic plan must be focused not on the pollutant itself but on the pollution-related sources which are fuel combustion, in particular on power plants and industry, and road traffic.

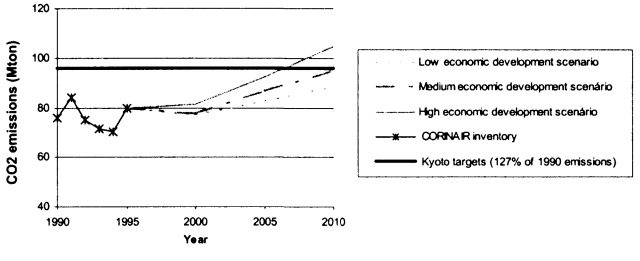

Figure 3: Projected scenarios of CO_2 emissions (Borrego et al. [7]).

4.3 Technical and management measures to mitigate atmospheric emissions

According to international commitments and EU orientations Portugal must control the increase or even reduce their atmospheric emissions. A more detailed analysis of most important economic activities, such as industry, shows that the majority of industrial processes are outdated from the technological point of view. Along with the technological improvement, investments in end-of-pipe technology must be made in the upcoming years, in order to reach short-term targets of environmental air quality. According to the 6th Interim Report related

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with the cost-effective control of acidification and ground-level ozone (IIASA [8]), Portugal still has great potential to reduce NEC pollutants in a cost-effective perspective. Some strategic options include the implementation of EU Directives and Programmes, technological improvement using best available technologies, implementation of end-of-pipe treatment systems, fuel substitution and more efficient use of energy.

The implementation of the cleaner production concept and the application of some related techniques such as life cycle assessment and eco-design could produce good results and promote a more sustainable development.

From a source-oriented point of view, voluntary agreements between government and economical groups should be implemented with specific economic activities to promote sectorial targets, specific goals and mitigation measures to be adopted according to the most realistic time schedule. Governments also play an important role in what concerns the implementation of existing regulation, promotion of an efficient inspection system and development of financial and fiscal incentives for specific investments on technological improvements.

Economic instruments should have an important role in an integrated strategic plan that conciliates climatic and NEC targets. Although some economic instruments have been implemented in Portugal in the last years they are more oriented to the energy products than to environmental issues, and the income taxes has been canalised to the national budget. Thus, their impact on the public and polluters in particular has been low. The application of new pollution oriented taxes such as SO_2 or CO_2 emission taxes has a great potential specially if implemented in conjunction with a revenue taxes system, where the income is directly administrated by a commission and applied to technological improvement or to more energetic efficient activities.

The abatement measures for NEC pollutants would have necessarily beneficial effects on CO_2 and other GHG emissions. On the other hand, taking into account that the next step on the climate change international policy agrees with recent developments in the adoption and implementation of market mechanisms foreseen in the Kyoto Protocol, this indirect mitigation effect creates an extra emission quota that could be used in future negotiations for an emissions trade system.

5 Conclusions

In what concerns atmospheric emissions, Portugal presents a very complex panorama. The analysis of emissions inventory shows that emissions and related sources are concentrated in coastal areas according to the preferential distribution of population and economic activities. Sources of major concern are fuel combustion, particularly associated with power plants and industrial combustion, road transport and industrial processes. The projected scenarios show that air emission tends to increase quickly in the next decade due to the need for the economic development of the country in order to reach EU average levels.

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Portugal also assumed specific commitments in international conventions and protocols that are conducive to a limitation on the increase (Kyoto protocol) or even reduction (Gothenburg Protocol) of some specific pollutants. Furthermore the new EU NEC Directive currently under discussion, proposes a more restricted target for the same pollutants. To achieve those goals some key issues are: technological update using BAT, implementation of environmental taxes, a more efficient use of energy and a fuel switch to less pollutant fuels. The co-ordination of all those targets will be an enormous political exercise that must be put in practice as soon as possible. Nevertheless the development of a strategic integrated plan oriented for the sustainable development of economic activities and supported by emission reduction measures, could be an add-value for the negotiation on an international emission trade system.

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