COMPARISON OF EUROPEAN NATIONAL LEGISLATIONS EFFICIENCY ON THE REDUCTION OF AIR POLLUTANT EMISSIONS

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ABSTRACT

Since 1995, IDAD – Institute for Environment and Development has carried more than 300 stack samples in various point sources of Portuguese industries. A coherent database was made with the collected results. The limit values fixed by the legal documents consulted – Portuguese, Spanish, French, Italian and Dutch emissions legislation – were applied to the IDAD stack sampling inventory to evaluate the efficiency of atmospheric emissions control and reduction, regarding the most important air pollutants: NO_x, SO_2 and particulate matter.

It was concluded that the Portuguese legislation is little restrictive and not much efficient as regards emissions reduction. In opposition, the Dutch and Italian legislations are quite restrictive and efficient concerning emission control for the three pollutants analysed.

INTRODUCTION

The atmospheric emissions in the actual Portuguese legislative framework are regulated by two diplomas: one settles the stack sampling standards (*Decreto-Lei 352/90*) and the other defines the limit values for some atmospheric pollutants (*Portaria 286/93*).

The control of point source emissions is defined by emission limit values settled in the document *Portaria 286/93* referred above. This legislation is based on the specification of limit values expressed as $mg.Nm^{-3}$, a measure of the concentration of pollutant or of the quality of the gaseous effluent. National legislations of other countries base the limit of atmospheric emissions on the establishment of a mass flow and one or two limit values. Below the mass flow there is no limit value to respect or, in some cases, there is a limit value higher than the one imposed above the mass flow limit.

The analysis of data presented in this paper has 3 objectives:

- Verify the compliance to the Portuguese legislation;
- Compare the Portuguese standards with other published in European countries;
- To discuss about the efficiency of the different diplomas on reducing atmospheric pollutants emissions.

SAMPLE CHARACTERIZATION

Since 1995 the Stack Sampling Laboratory of IDAD performed more than 300 samples in *circa* 70 different industrial plants. A total of approximately 180 stacks were sampled with 40% of them representing combustion processes. Samples were taken in every part of Portugal but having a clear geographical predominance of plants from the central region of the country, due to the location of the Institute headquarters.

It is important to refer that the samples were obtained in small and medium enterprises - emissions from large sources such as power plants are not included in this analysis.

A specific database was created, compiling the data included in each individual bulletin. Emissions values for particulate matter (PM), SO_2, NO_x and volatile organic compounds (VOC) were incorporated in the database. Results were adimensionalized taking into account the limit emission values specified by the legislation (Measured Concentration/Emission Limit Value - MCEL). As a consequence of this procedure a value of MCEL below 1.0 indicates that the stack is in compliance with the legislation and a value above 1.0 shows that an industrial unit is operating above the specifications of the law.

PORTUGUESE LEGISLATION

The first legal diploma defining emission limit values was published in Portugal in 1993. The *Portaria 286/93* represents a major breakthrough on the environmental law in Portugal and was the outcome of more than 3 years of intense negotiations with the industry representatives. In any case this legislation has never been strongly enforced and there is a public feeling that a large number of industries do not comply with legal standards.

Compliance

The verification of the compliance with the Portuguese legislation for the different atmospheric pollutants considered is summarized in Table 1.

Table 1 - Percentage of samples in compliance of the *Portaria 286/93*.

Pollutant	% of samples in compliance
PM	51
SO_2	80
NO_x	96
VOC	48

This table shows that only a minor percentage (3%) of samples do not fulfil the legal requirements concerning the emissions of NO_x. On the opposite side, the same results indicate that one in every 2 stacks emits, either particulate matter or VOC above the limit emission value. A more detailed analysis of the processes that are responsible for the non-compliance shows that in 83% of the cases, combustion sources are responsible for the emission of PM above legal specifications. In other hand the non-compliance of VOC are caused by industrial processes in 56% of the cases.

Further analysis of the compliance of the national legislation is represented in Figure 1, where, for each pollutant, the fraction of stacks emitting below a certain level is plotted.

The observation of this Figure indicates that the most critical situation concerns the atmospheric emissions of VOC's. As it was previously stated more than 50% of the samples do not follow the legal requirements published for this pollutant. In fact, in 20% of the stacks, emissions 10 fold above the legal limits were measured. A similar scenario, even if not so extreme, is obtained analysing the distribution of the compliance for particulate matter. In this case, 55% of the samples present emissions above the legal limits, with 35 and 15% emitting, respectively, 2 and 4 times more than what is legally allowed.

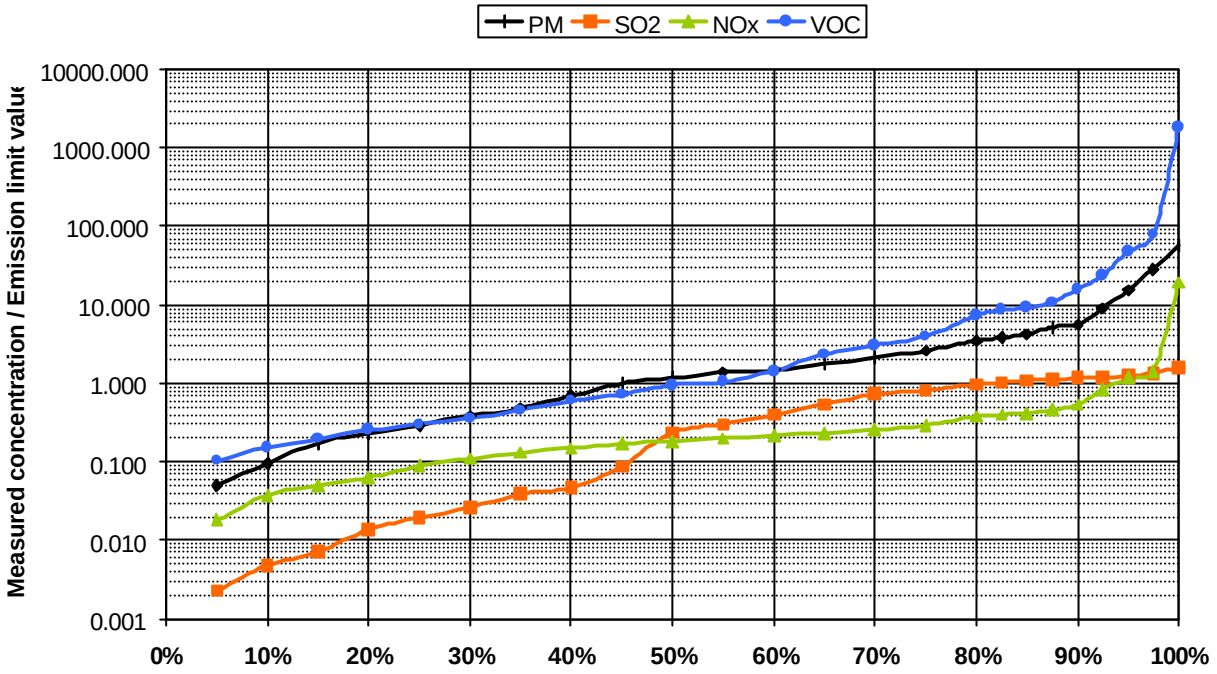

Figure 1 - Distribution of the compliance of the emission limit values specified by the *Portaria 286/93*.

The situation for the SO_2 and NO_x emissions is significantly different, with the vast majority of samples in compliance of the legal definitions. Stacks emitting above the legal specifications are very close to the compliance limit values.

Efficiency on the reduction of air pollution

The objective of the legislation developed for the control of the emissions of atmospheric pollutants is to prevent the degradation of the environmental quality through the limitation of the total amount of pollutants released into the atmosphere. The *Portaria 286/93* defines objectives for the maximum concentration of pollutants in the stack in $mg.m^{-3}$ without specifying any limit for the actual quantity released. This quantity would be expressed in mass/time units. With the aim of analysing the effectiveness of the enforcement of the national legislation on the reduction of the pollutants emissions, Figures 2 to 5 present the relation between the adimensional value MCEL and the actual amount of pollutants emitted into the atmosphere for each sample.

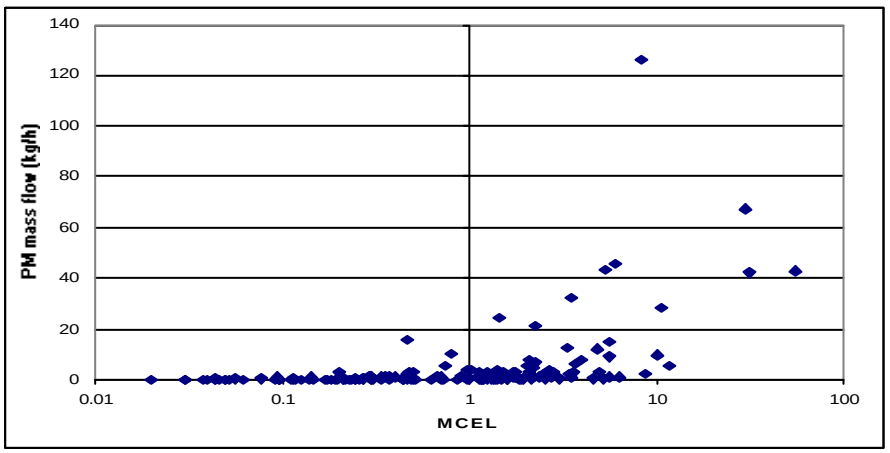

Figure 2 – Relation between the particulate matter mass flow and the adimensional parameter MCEL for the Portuguese legislation.

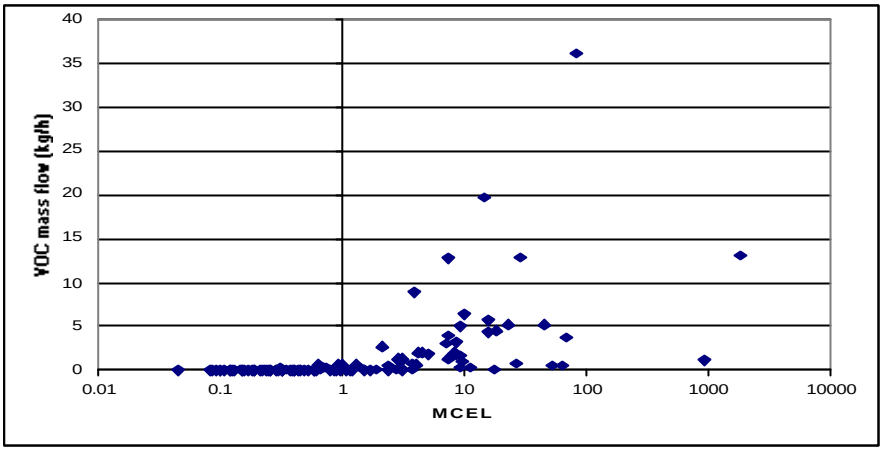

Figure 3 – Relation between the VOC's mass flow and the adimensional parameter MCEL for the Portuguese legislation.

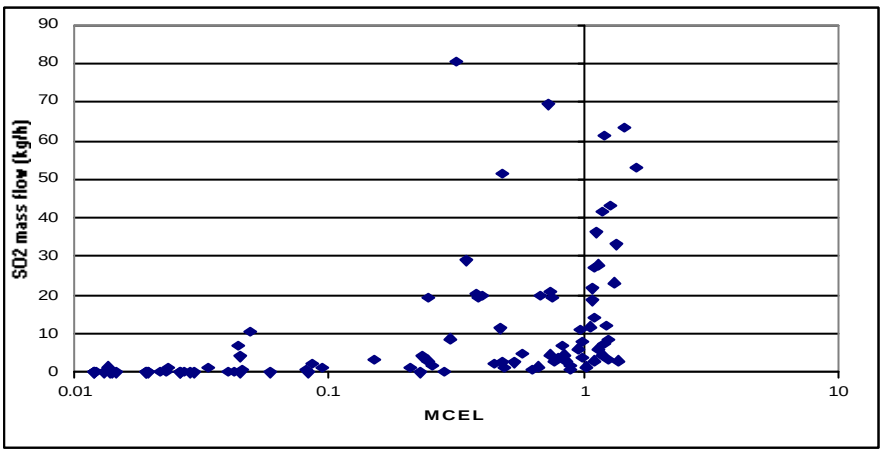

Figure 4 – Relation between the SO_2 mass flow and the adimensional parameter MCEL for the Portuguese legislation.

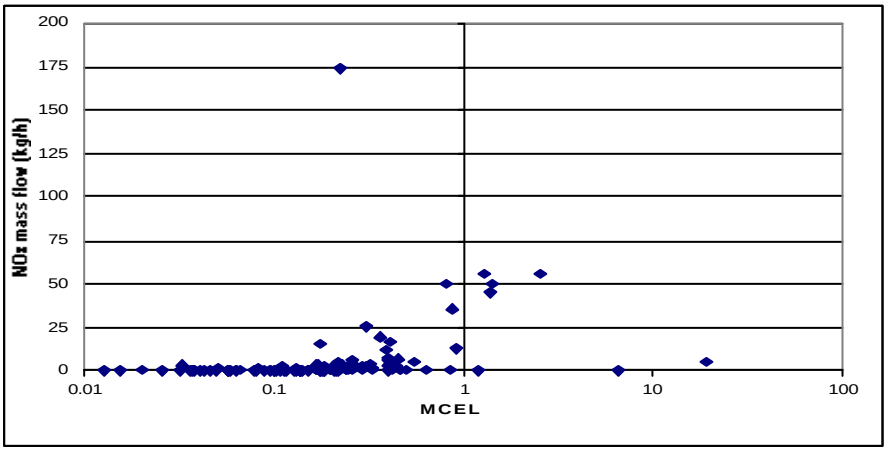

Figure 5 – Relation between the NO_x mass flow and the adimensional parameter MCEL for the Portuguese legislation.

Observation of Figures 2 and 3 shows that there is a positive correlation between sources that do not comply with the legal limits of PM and VOC's and the highest amounts emitted. A different situation is obtained when the same analysis is applied for the SO_2 and NO_x emissions, depicted respectively, in Figures 4 and 5. Some of the sources that emit the largest quantities of these pollutants are complying with the legal emission limits indicating a certain inefficiency of the regulating scheme. On the other hand, for all the pollutants there is an important number of small sources, with a minor significance in terms of the quantity released that are operating above emission standards.

COMPARISON WITH LEGISLATION OF OTHER EUROPEAN COUNTRIES

The second stage of this project is the comparison of the Portuguese legislation concerning emissions of atmospheric pollutants with the regulations applied in other European countries. A research based in the Internet and in the exploration of official contacts with local authorities provided access to the full text of the following legal diplomas:

- Spain: "*Decreto 833/1975 de 6 de Febrero*";
- France: "*Arrêté du 2 février 1998 relatif aux prélèvements et à la consommation d´eau ainsi qu´aux émissions de toute nature des installations classées pour la protection de l´environnement soumises à autorisation*";
- Italy: "*Decreto Ministeriale del 12 Iuglio 1990 (Linee guida per il contenimento delle emissioni degli impianti industriali e la fissazione dei valori minimi di emissione)*";
- The Netherlands: "NeR – Netherlands Emission Regulations of May 1992".

Research was limited to the legislation of these countries due to difficulties of the authors to handle German and Scandinavian documents. The authors were not able to reach the national legislations of the UK and Ireland.

Table 2 summarizes in a very compacted way the specifications of the legislation of Portugal, Spain, France, Italy and the Netherlands for PM, SO_2 and NO_x. Volatile organic compounds were excluded at this stage due to the large diversity of specifications. From this table it is visible a large range of limit values:

- Particulate matter – 10 to 300 $mg.Nm^{-3}$;
- SO_2 – 200 to 4300 $mg.Nm^{-3}$;
- NO_x – 200 to 1500 $mg.Nm^{-3}$.

Table 2 – Emission limits for SO_2, NO_X and particulate matter (PM) specified in the national regulations of Portugal, Spain, France, Italy and the Netherlands.

Country	PM	SO_2	NO_X (as NO_2)
Portugal	300 mg/Nm^3	2 700 mg/Nm^3	1500 mg/Nm^3
Spain	150 mg/Nm^3	4300 mg/Nm^3	300 mg/Nm^3
France	≤1 kg/h: 100 mg/Nm^3 >1 kg/h: 40 mg/Nm^3	>25 kg/h: 300 mg/Nm^3	>25 kg/h: 500 mg/Nm^3
Italy	>0,1 e <0,5 kg/h: 150 mg/Nm^3 ≥0,5 kg/h: 50 mg/Nm^3	>5 kg/h: 500 mg/Nm^3	>5 kg/h: 500 mg/Nm^3
The Netherlands	<0,5 kg/h: 50 mg/Nm^3 (with filters) 10 mg/Nm^3 (without filters) ≥0,5 kg/h: 10 mg/Nm^3 (with filters) 25 mg/Nm^3 (without filters)	>5kg/h: 200 mg/Nm^3	>5kg/h: 200 mg/Nm^3

To consider in an adequate form the emissions of small sources, legal standards developed in France, Italy and the Netherlands include a limit mass flow below which no concentration limit is defined or a larger concentration limit is allowed. Consistency between these countries standards on the mass flow limits was not found either. In fact, each

country developed its own set of specifications and there isn't a single similarity between them. Dutch regulations are the most restrictive for the 3 pollutants considered in this study.

Compliance

The following step of this work consists on the simulation of the application of the different sets of legislation to the emission database previously described. The percentages of samples of the IDAD database that comply with the referred legislations are presented in Table 3.

Table 3 – Percentage of sources included in IDAD database that comply with legal emission limits.

Country	PM	SO_2	NO_X	Sources in total compliance
Portugal	51%	80%	96%	39%
Spain	41%	93%	55%	21%
France	29%	89%	95%	25%
Italy	31%	67%	89%	18%
The Netherlands	16%	67%	86%	9%

PM standards are less strict in the Portuguese legislation with 51% of stacks in compliance. In the opposite side only 16% of the samples have emissions below Dutch standards. In the case of SO_2, 80% of the sources comply with the specifications of Portuguese legislation, against a maximum of 93% for the Spanish regulations that are particularly permissive. If the same analysis is applied to NO_x, Portuguese legislation appears once more as the less strict followed very close by the French emission standards. For this pollutant, regulations developed by Spanish authorities are the most severe, which represents a strong inconsistency with results obtained for PM and SO_2.

The percentage of sources that are in total compliance with the law regarding, simultaneously, the 3 pollutants can be calculated through the product of the compliance for PM, SO_2, NO_x and is included in the last column of Table 3. The calculation of this parameter indicates that even if Portuguese standards are the least strict, only 39% of the sources included in IDAD database are in total compliance of the law. If Dutch regulations would be enforced in Portugal, the fraction of stacks in total compliance would be reduced to 9%.

Costs of compliance and environmental benefits

At this moment it is important to stress that the enforcement of the law represents costs not only for the industry about also for the regional and national administration. As a result of this, it is recommended that the emission standards act as an efficient screening method to tackle the real polluters.

With the data available it is possible to estimate and compare the environmental benefits measured as a reduction of atmospheric pollutants emissions, obtained by the full enforcement of the different laws. Table 4 presents the percentage of emission reduction obtained by the full application of the law for each studied country to the database of IDAD. Data included in Table 4 shows that the lowest reduction of pollutants release is obtained through the application of Portuguese regulations, with the exception of SO_2 where the application of Spanish regulations would have almost effect. Legislation from the Netherlands presents some of the highest reduction for the 3 pollutants considered. For PM the application of French standards would cause the maximum reduction.

In the same Table, a measure of the efficiency of the law was estimates by the relation between the fraction of emission reduction and the fraction of sources that must be controlled to achieve this reduction. For instance, an efficiency of 2.50 (Portugal, NO_x) indicates that if 1% of the sources above the law were obliged to follow the legal rules, a reduction of 2.50% in the emission of atmospheric pollutants would be obtained.

Table 4 – Environmental benefits and efficiency of national legislations.

	PM			SO_2			NO_x		
Country	Reduction	Controlled sources	Efficiency	Reduction	Controlled sources	Efficiency	Reduction	Controlled sources	Efficiency
Portugal	67%	49%	1.37	10%	20%	0.50	10%	4%	2.50
Espanha	81%	59%	1.37	3%	7%	0.42	48%	45%	1.07
França	92%	71%	1.29	53%	11%	4.80	31%	5%	6.20
Itália	83%	69%	1.20	72%	33%	2.18	34%	11%	3.09
Holanda	90%	84%	1.07	83%	33%	2.51	58%	14%	4.14

For the case of PM, the efficiency is very similar for all the legislations. This situation could be explained by the fact that the emissions of PM are particularly high and, consequently, any enforcement would be welcome and equally efficient. In the cases of SO_2 and NO_x, a clear gap between Portugal and Spain and the other 3 countries appears. Portuguese and Spanish regulations are extremely inefficient compared to others due to the absence of a mass flow limit. Estimates presented in Table 4 suggest that the screening principles included in the French legislation are particularly efficient. It is important to refer that these conclusions cannot be generalized and are only valid for the database used in this paper.

Another approach that can be used to compare the efficiency of the different legal standards is presented in Figure 6. In this Figure, the environmental benefits, i.e., reduction of emissions, are plotted against the costs of compliance, i.e., fraction of sources controlled. The implementation of an ideal regulation would cause the maximum environmental benefits with the minimum costs of enforcement. On the opposite side, an absurd legal standard would oblige a large number of sources to control its emissions without any practical consequence.

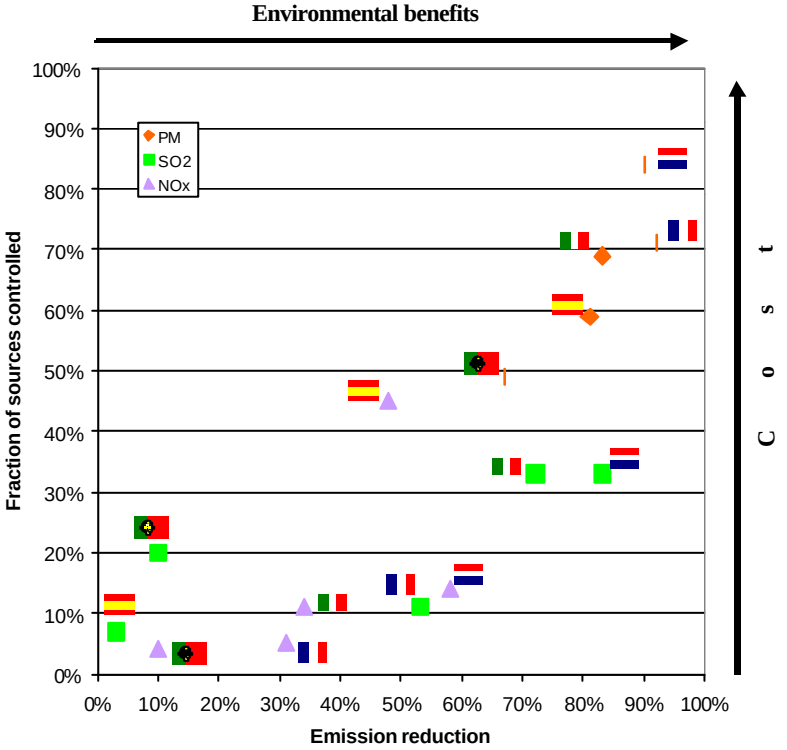

Figure 6 - Environmental benefits *versus* cost of compliance.

From the observation of this Figure it is evident that independently from the target of the policy-maker, either define an environmental quality objective or establish a financial ceiling for the enforcement of the legislation, it is necessary to develop an optimisation procedure that maximizes the efficiency of the implementation of the legal regulations.

CONCLUSIONS

Taking into consideration the objectives of this paper, the most important conclusion, is the need to revise the Portuguese legislation concerning the emission of atmospheric pollutants. The future legislation should include an emission limit (mass/time) below which industries could emit at any concentration. Above this emission limit it is necessary to define a stricter concentration limit (mass/volume) that would guaranty the quality of the gaseous effluent. Without a correct specification of a limit mass flow it is not possible to develop an efficient environmental policy that establish a good balance between environmental benefits and costs of enforcement of the law.

Another significant observation of this work is that in the large and complex legal building of the European Union there is an absence concerning a common legislation focusing on the atmospheric pollutants emissions of small and medium industries. National legislations of each country are constructed based on particular concepts, creating a large diversity of standards.

It is important to mention that air quality is directly affected by emissions but there is non-linear interactions involving meteorological and topographical local conditions that have to be considered to estimate the environmental impact of the pollutant release to the atmosphere. Moreover it is acceptable to have different legal standards in different countries if the industrial dimension and spatial distribution of the sources are significantly diverse.

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