The necessity of expensive environmental regulations

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***Abstract*—** These days little attention is being paid to the cost efficiency of the environmental protection policies in the Czech Republic. The paper presents and discusses a possible approach to formulating cost-efficiency policies using the abatement cost concept. For easy understanding the approach is demonstrated on the particular policy case in the Czech Republic: the air quality policy focused on dust emission reduction in the Moravian-Silesian Region. Based on the findings that there exist considerable differences in the abatement costs of the particular measures (in industry, household and transportation) to reduce emissions the paper identifies a significant potential for cutting excessive costs of regulation.

***Keywords*—** Micro simulation, Costs of regulation, Air quality, Policy impact assessment

I. Introduction

ASSESSING Europe's most exposed areas in terms of air quality the Moravian-Silesian Region is generally among the worst affected together with the Po Valley in Italy ones. The term air quality describes the level of air pollution, which may affect human health, vegetation, entire ecosystems and materials. Air pollution is influenced by the emission of pollutants from various sources as a consequence of human activity (e.g. transportation, combustion). Pollutants emitted from a source are transported in the atmosphere and can thus affect the air quality in both the immediate vicinity of the pollution source and the broader territory [1]. The major consequences of the serious pollution are obviously the significant adverse impacts on health such as reduced life expectancy, higher morbidity rates, youth allergies, higher male sterility and more adverse birth defects. There are major pollutants: particulate matter (PM), tropospheric ozone (O_3), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), lead (Pb). They are called criteria air pollutants [2]. Particulate matter (PM) is microscopic solid or liquid matter suspended in the Earth's atmosphere. Generally, the mass of PM falling in two size categories is measured diameter 2.5 µm and less, and diameter between 2.5 µm and 10 µm. PM10 are particles with a diameter of 10 micrometers or less. Unlike other criteria pollutants, PM is not a specific chemical entity but is a mixture of particles from different sources and of different sizes, compositions, and properties. However, the chemical composition of PM is very important and highly variable [2].

At present, intolerable concentrations as defined by law are situations when the 24 hour average PM10 concentration exceeds the limit of 50 $\mu g.m^{-3}$ more than 35 times a year. Then, the 36th PM10 concentration exceeding 50 $\mu g.m^{-3}$ is considered excessive and the air quality is generally considered harmful. Currently, unsatisfactory air quality is a common phenomenon in the Czech Republic as the concentrations exceeded their limits in more than 26.8% of the geographical area of the Czech Republic in 2012 [3]. It is obvious from the following map that the majority of the worst polluted area is located in the Moravian-Silesian Region.

Sources of particles are highly variable. They may be emitted directly to the air from stationary sources, such as factories, power plants, and open burning, and from moving vehicles (known as "mobile sources"), first by direct emissions from internal combustion engines, but also when these and other particles are re-entrained due to the movement of vehicles (e.g. in a "near road" situation) [2]. Given the high intensity of the heavy industry, and transport [4] or biomass based energy generation [5], located in the region, the priority when investing in emission reduction has been given to the industry in the last two decades. However, as most of the low hanging fruit has already been picked, the question of how to invest effectively in air quality is no longer trivial and requires a complex analysis. The second argument in support of a careful consideration is the pollution ratios which have shifted significantly in favour of the industry in the last years while the PM10 emissions from local heating have increased. In the Moravian-Silesian Region, the share of local heating in total PM10 emissions has increased from 15% to 34% in just 3 years. This trend is generally explained by a decrease in both the economic performance and the average income in the region leading to a shift in local heating sources to burning fossil fuels and low-quality fuels. Moreover, the nonpoint emission sources as households are generally more complicated to regulate, which requires a special policy design in order to reach an efficient regulation [6].

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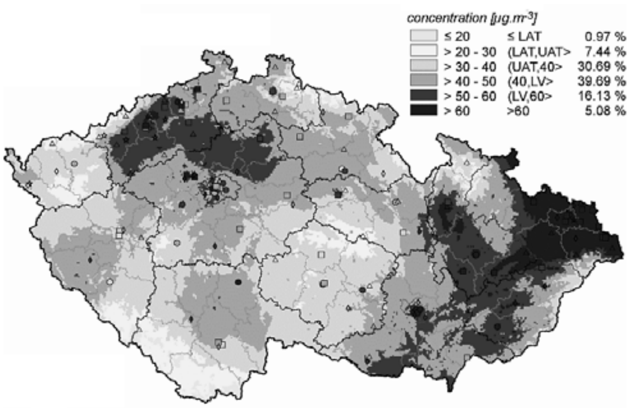

Fig. 1 The 36th highest 24-hour PM10 concentrations in the Czech Republic, 2010 [3]

II. IDENTIFICATION AND ABATEMENT COSTS

The current policy-makers have developed various air quality strategies and action plans at the national, regional and municipal levels and these documents have identified a wide range of measures to improve air quality. Nevertheless, these documents generally only list the potential measures and miss the economic perspective.

Some official documents, such as „Specific measures improving air quality within the district of Ostrava city" [7] even try to estimate the potential costs of the investments; however, the size of the benefit (amount of PM10 saved) is calculated only for 3 measures and still it is up to the reader to recalculate the findings to distinguish between the effective measures and the less effective ones. Important tools of the current environmental policy are economic (market) instruments. However, the design of such instruments should be done in a way to enable the evaluation of their environmental efficiency and economic effectiveness [8]. Reference [9] describes two environmental protection approaches: the institutional ecological economical approach and the free-market approach. Reference [10] compares the various discrete choice models for economic environmental research.

Therefore, our paper aims to suggest a methodology to standardize the economic perspective of the individual measures and make them comparable according to their efficiency. A common approach is an application of the abatement costs concept, which is currently widely used for carbon and its applicability to air quality was theoretically analyzed [11]. Cost-efficiency policies using the abatement cost concept demonstrates and discusses in reference [12].

After designing an effective air policy, a further research should aim at synergies among air quality policy and climate change policy in the region as such analysis has already been undertaken on EU level [13]. These policies are closely linked and regarding the ambitious goals in carbon reduction, the positive indirect impact of the climate change on the air pollutants is being analyzed and estimated worldwide [14]. Environmental Tax Reform in Czech Republic, in the context of the implementation of the EU Energy Tax Directive, and uses this policy as the basis for detailed qualitative research into different stakeholders' understanding of and support for Environmental Tax Reform [15].

III. THE CASE STUDY

Our research is focused on the potential investment measures to improve air quality in the Moravian-Silesian Region and data were gathered within a rigorous study on the same topic for the Ministry of Environment [16]. Every single figure is referenced and discussed in the study. Concerning the accuracy of the findings, that is crucial mainly for the prices and emission factors. The study follows the methodology outlined in this paper and all the important figures are summed up the Table 1 and Table 2.

Measure	Type	Previous heating boiler	Emission factor (kg/GJ)	Emission reduction (t)	Purchase price (CZK)	Abatement cost per tonne of PM (CZK)
New coal boiler	flat	brown coal	0.210	14.1	22 000	52 098
Biomass boiler	flat	brown coal	0.106	17.8	37 500	70 083
Biomass boiler	house	brown coal	0.106	27.2	77 000	94 192
New coal boiler	house	brown coal	0.210	21.5	65 000	100 752
Biomass boiler	flat	wood	0.106	8.2	37 500	153 337
Biomass boiler	house	wood	0.106	12.5	77 000	206 084
Central heat supply	avg.	brown coal	0.024	20.7	215 686	347 082
Central heat supply	avg.	wood	0.024	17.3	215 686	414 664
Biomass boiler	flat	black coal	0.106	2.6	37 500	472 769
Complete lagging	house	brown coal	0.601	15.1	284 170	628 169
Biomass boiler	house	black coal	0.106	4.0	77 000	635 401
Complete lagging	house	wood	0.332	8.3	284 170	1 137 138
Central heat supply	avg.	black coal	0.024	5.5	215 686	1 301 927
Complete lagging	house	black coal	0.179	4.5	284 170	2 109 105

Fig. 2 Local heating measures, ranked by abatement cost amount

Measure	Annual mileage (km)	Engine emission factor (g/km)	Annual PM emission (t)	Emission reduction (t)	Price increase (CZK)	Abatement cost per tonne of PM (CZK)
Old bus (EURO II)	60	0.486	29.2	-	-	-
CNG bus	60	0.033	2.0	27.2	5 100 000	12 508 743
Diesel bus (EURO V)	60	0.066	4.0	25.2	4 300 000	11 375 661
Electric bus	60	0.045	2.7	27.2	10 000 000	30 658 683
Trolley bus	60	0.039	2.3	25.2	11 000 000	21 825 397

Fig. 3 Transportation measures, ranked by abatement cost amount

IV. METHODOLOGY AND ASSUMPTIONS

The abatement costs are mainly an environmental regulation concept and its methodology is not firmly anchored in the literature. The main idea behind the abatement costs is to divide the price of each individual measure to improve air quality by the amount of the pollutant saved in the lifespan of the measure.

Abatement costs concept is a widely used concept that is known and applied mainly for the carbon abatement [17]. This methodology has been developed into many variations while some of the methods are relatively robust [18] and exceed the needs of the paper.

An initial step in the analysis is to identify typified investment measures (e.g., a replacement of an old brown coal boiler with an efficient biomass boiler for emission reduction in household heating) to improve air quality.

Then, both the investment and implementation costs, expected time of operation and the amount of the emissions saved are estimated. The amount of the emissions saved is the difference between the default scenario and the emissions after the implementation of the measure. While for industrial measures the current emission concentrations are pretty much known, it is currently impossible to measure emissions of every smaller source as a boiler of the household. Therefore there must be a certain approximation via a set of underlying assumptions concerning the quantification of the measures relating to households and transportation.

Initially, the default scenario considers households with average annual heat consumptions of 55 GJ/year and 36 GJ/year for a single-family house and a flat, respectively. The amount of emissions is crucially dependent on the current type of heating, and thus three types of standardized households are applied: (i) households using brown coal for heating, (ii) households using black coal for heating, and (iii) households using wood for heating. As a portion of the households use electric or gas flow-through heaters for domestic hot water, its production is disregarded due to the high uncertainty about the techniques of domestic hot water production. The price is divided by the time in operation, which yields the CAPEX (capital expenditures) of the technology. A division by the amount of the pollutant saved then yields the abatement cost of the technology, which is very convenient for the comparison.

Surely, there are several simplifications concerning the methodology. The first one is the role of variable costs within the total project costs. As an illustration, an additional end-of-pipe PM10 electrostatic filter increases the electricity consumption and thus the total costs are even higher than the investment costs; on the other hand, a new efficient brown-coal boiler is a measure that decreases the fuel consumption and, thus, the total costs of the measure during the operation time are lower than the investment costs. Even though there are various approaches to the costs modelling [19], given the higher estimation bias of the variables, we choose not to include them in the assessment. This decision can be underpinned by the large differences in the abatement costs (transportation measures are ten times more expensive) and the change in total costs accounted for by variables would usually not influence the prioritization of the measures.

The second potential flaw of the technology is a missing quantification of the impact on the pollution. While the emission of PM10 from a tall chimney is distributed over a large area, the emissions from a city bus imply a direct exposure to local citizens. However, this methodology expansion requires an implementation of the outputs from a suitable specialized air quality model [20].

V. RESULTS AND INTERPRETATION

The comparison of the abatement costs among the individual investment measures can be summarized as follows. The most effective way of decreasing emissions among the analyzed measures is investment in new brown coal boilers replacing old brown coal boilers. For a typified household, such an investment can decrease the PM10 emissions by one tonne at the price of CZK 52,000. On the contrary, the most expensive among the analyzed measures is to invest in the complete lagging of a house. The estimated price per tonne is more than CZK 2 million. The replacement of local heating boilers with new ones is generally more effective than lagging, which agrees with common sense: while a complete insulation decreases the heat consumption and thus proportionally also the emissions by dozens of percent, a new boiler can cut the emissions by units of percent of the previous emissions. Joining a central heating system instead of running own local heating boilers is a measure with an average effectiveness, the prices ranging from CZK 347,000 to 1,140,000.

Interestingly, all these measures are recognizably cheaper than any average measure in the transportation sector. As Appendix 2 shows in detail, transportation measures are 5 to 15 times more expensive than the most expensive ones in the housing sector.

The chart 1 depicts the individual measures for households. The first name describes the reference scenario (heating with wood, black coal (Bl) or brown coal (Br) and afterwards also the measure (boiler, lagging, etc.). A regulator striving for an effective regulation should always prefer the measures with the lowest abatement costs so that the measures most left are realized as the first ones.

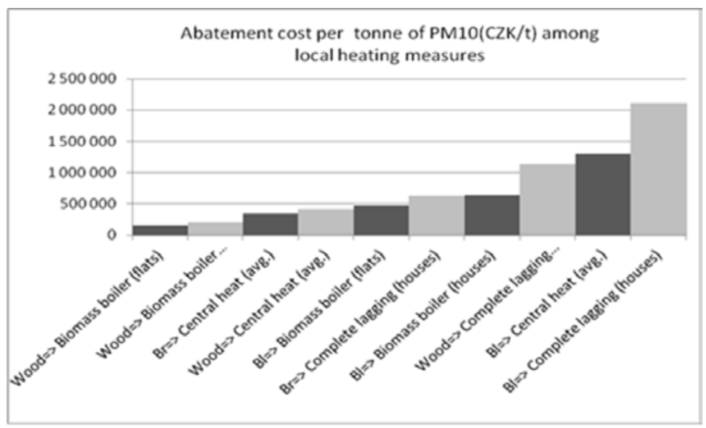

Fig. 3 Unit costs of PM10 emission abatement in households by the measure [16]

VI. DISCUSSION AND CONCLUSIONS

Currently, the air quality is the most significant environmental issue in the Czech Republic. As a result, air quality is both being regulated with increasing intensity and being a recipient of large amount of environmental subsidies. Nevertheless, in spite of all the strategies and action plans on the national, regional and local level, there is no clear and conceptual analytical framework for assessing the effectiveness of the money spent.

Our paper proposes to employ the abatement costs concept which allows comparing various air quality improving measures and it is also relatively easy to calculate. Even though the range of the measures included in the paper can still be considered more illustrative than complete, the concrete examples clearly show the need for a comparable indicator capturing the effectiveness of individual measures. The abatement costs concept, for instance, reveals that all the measures in the transportation sector are about 5 to 15 times more expensive than the most expensive ones in the housing sector.

Thus, the air policy should, e.g., first target the low-hanging fruit represented by measures in households. This would lead to avoidance of the excessive costs of regulation as the measures within the transportation sector would be realized only after the potential within the housing sector has been exhausted. Secondly, the abatement costs concept should be applied in calculations in the strategic documents as it would clearly reveal the desirable prioritization of the individual steps.

Nowadays, almost three years from the research introduces above, some results for the air quality policy in the region can be identified. Based on the analysis the policy makers realized the disproportionality of the pressure to the large (mostly metal) industry and launched some subsidy schemes for the exchange of the household boilers used for the household heating.

The potential of the cost savings has been therefore at least partly realized. Specifically, there were are about 4000 household boilers subsidized at the end of 2013 in the Moravian Silesian region while the total subsidy reached 60 million CZK. This implies that the annual PM10 reduction can be estimated as 600 tonnes of PM10. Compared to the alternatives as e.g. investment to the electrical buses (reduction of about 16.2 tonnes of PM10 per 60 million CZK invested), subsidizing low emission local heating can be assessed as very effective regulation.

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