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## Negotiation between authority and polluters: Model for support of decision-making in environmental policy. Principles and experimental case test

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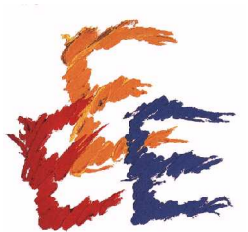
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Fondazione Eni Enrico Mattei

**Negotiation between Authority and Polluters –  
Model for Support of Decision Making  
in Environmental Policy:  
Principles and Experimental Case Test**

Petr Šauer, Antonín Dvořák, Petr Fiala

NOTA DI LAVORO 33.2000

based on a paper presented at  
**World Congress of Environmental and Resource Economists**  
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**Negotiation between Authority and Polluters -  
Model for Support of Decision Making  
In Environmental Policy:  
Principles and Experimental Case Test**

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## **1. Introduction**

A new trend in environmental policy has emerged in the 1990's. This trend is the voluntary participation of business in environmental protection and problem solving. So-called environmental management system principles and standards are being developed and certified in many countries. A reasonable number of corporations have already introduced this system. Voluntary agreements between industry and authorities have occurred and have achieved benefits that are significant to both parties.

This paper contributes to the development of theories and practices that could promote further progress in the field of business participation in environmental protection. It describes a relatively new approach to pollution reduction problem solving that relies on negotiation between polluters and authorities in which traditional economic tools of environmental policies are used.

The results of a negotiation laboratory experiment (air pollution reduction case in a city) are presented to illustrate the approach and the practical applications of this method are discussed.

## **2. Principle of Suggested Approach**

The approach is designed for polluted areas (regions, cities, lakes, river basins etc.), where social and a political consensus exists that the environmental quality is poor or even critical and that some pollution reduction is necessary. This consensus is more likely based on a comparison of the state of the environment in an area with some public health standards and/or on ecological arguments rather than on a standard cost-benefit analysis. The decision to reduce pollution in the area can also be supported by the existence of economic signals that show that the level of pollution is higher than the optimal one. This is the case when social benefits from suggested solutions (environmental protection projects) are considerably higher than the costs connected with these projects.

Typically, the most significant polluters are known or are identifiable. In practice, every polluter has one or more possible (technical) solutions available for partially or completely reducing his negative impact on the environment. These solutions (environmental protection projects) are usually connected with some investment and/or changes in operating costs. It is possible to say that

some solution always exists. For example, polluters can stop their activities and move to another branch or territory, which is also connected with some costs.

Polluters are able to quantify both the gross and net costs of the solutions (integrated environmental protection costs). Every polluter aims to maximize net benefit. Economic tools of environmental policy can influence the amount of integrated environmental protection costs (for integrated environmental protection costs see Šauer 1986; for efficiency of environmental investment see Dvořák 1993).

Polluters' solutions to the pollution reduction problem are connected with different levels of costs. This means that for some polluters it is relatively cheaper to reduce pollution than for others. In economic terms, polluters have different curves of marginal costs of environmental protection. Using economic tools of environmental policy and a negotiation has a potential to lead to a more economically efficient solution than if an authority employs administrative tools.

Negotiation is a frequently used tool for solving of many social problems where there are many participants (stakeholders) with different conflicting interests. There are numerous applications of game and decision theoretic models to explain and support negotiation. Important contributions include Raiffa (1982), Harsanyi and Selten (1988), French (1986) and others. Investigations into the practice of supporting negotiations have grown remarkably in the past decade. Modeling of negotiation processes is being developed by a lot of research teams and scholars.

The essential idea of the suggested model<sup>1</sup> is based on the application of the principle of negotiation between an authority of environmental policy and economic subjects-polluters resulting in binding agreements between participants. This approach is similar to Oskar Lange's idea (Lange & Taylor 1952, Cave & Hare 1981) where the price of capital goods is generated in the process of negotiation between a central authority (Central Planning Board) and corporations (managers). What does not make sense to develop in the field of private goods might make sense to discuss in the field of public environmental goods.

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<sup>1</sup> In the article we use the term „model“ in a classical sense - as a „mind“ simplification of reality which allows the creation of more variants of concrete models based on the same principle. One of these more concrete models in a mathematical form is shown in the part describing the case solution.

The fact that the authority is supposed to use economic tools of environmental policy is another important element of the model. There are two main groups of economic tools that are used in the model. The first one includes various types of environmental payments - charges, fees, etc. - which create revenues that are allocated to an environmental protection fund. Forms of financial contributions from the fund that are used to support the environmental friendly behavior of polluters are the second set of tools. It is important to stress that these two kinds of tools create a system („connected vessels“). These "economic figures", both payments and financial contributions, represent a special price of the nature source. Some additional tools like penalties and other sanctions connected with non-compliance of agreements also can be used.

The payments can theoretically be linked with various objects of charging. Most often emissions per unit of time serve as the basis for these payments. These payments also could be derived from other objects like the amounts of environmentally non-friendly goods that are produced or sold, or from the amount of environmentally non-friendly materials or energy used for the production, etc. What is most important (typical for the model) is that the final rate (for instance payments per one unit of pollution) and the total amount of payments (revenue) can be one of the results of the application of the suggested approach (model). This means that it is the result of a negotiation process between polluters and the authority.

Payments possess some important features in the model. The amount of these payments can be approximately proportional to the amount of the environmental damage caused by the polluters (it corresponds with a „polluter pays principle“), but it is not necessary to quantify these damages. The sum of revenue from the payments can create the amount that is necessary for the financial support of the goals in environmental protection (pollution reduction) in a region (it can correspond with a „self-financing principle“). The combination of both kinds of tools, payments and financial contributions, and their value (at least theoretically) guarantee that the economic interests of a group of polluters will be able to reduce pollution to a desirable level. And, what is very important, is that in this group of polluters there are polluters that can reduce pollution with the lowest total costs.

The dynamic variants, especially those where returnable (revolving) forms of the financial contributions from the fund (for instance investment loans) are used, are the most useful forms of the model.

Concerning the distribution of financial support by the authority from the fund, the most important aspect is the introduction of the principle of

maximization of positive environmental effects per unit of support (a „min-max principle“). To ensure public interest in this field is a crucial problem. Different objects (indicators) for charging and for setting priorities of environmental protection solutions in the region can be used. This means that an approach with this type of an „asymmetric“ information can be used (see Figure 1).

The creation and utilization of special models is supposed for the support of decision-making and for negotiation of both polluters and the authority. Modified methods of an assessment of efficiency of capital investments and a quantification of integrated environmental protection costs (investment) are the base of the models for the support of the polluters. On the other side, expert methods can be used for designing the models for decision-making of authorities.

The simplified negotiation procedure could be as follows:

In the first step the authority assesses the initial rate of environmental payment per one unit of pollution. This serves as the first type of economic information available to subjects-polluters and enables polluters to quantify their (confidential) amounts of integrated environmental investments. Standard models for microeconomic subject decision making are used. Polluters transmit their offers in terms of pollution reduction and the required amount of the financial support from the fund to the authority (mediator). More techniques can be used for the same purpose.

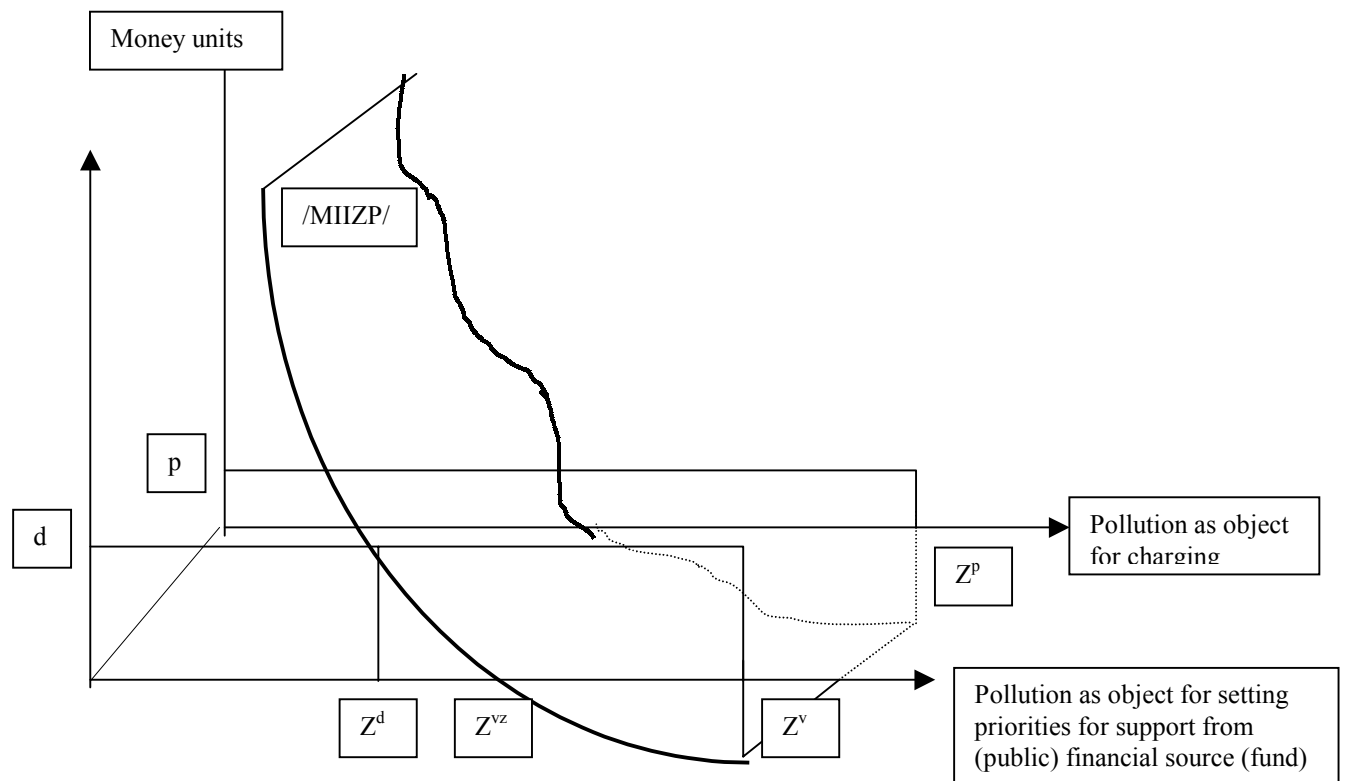
The authority ranks the proposals according to the principle of maximization of the ecological effect of the offered solutions per one unit of resources required from the fund. Second, information about the bidded amount of financial contribution per one unit of selected environmental effect is then communicated to polluters. It serves as further economic information for polluters' decision making. The value of the unit contribution is derived from the amount of sources available in the fund (including external sources if they are available) and a value of the contribution required by the marginal (closing) polluter.

This procedure continues for several rounds until an equilibrium solution is received. Three or four rounds are usually enough to receive the solution. Discussions about macroeconomic, ecological and social consequences of the received results can follow. The negotiation process can be repeated if necessary.

An official final binding agreement between the polluters and the authority seems to be an important tool. Such an agreement can contain a statement about the realization of environmental project(s), pollution reductions or limits of pollution in concrete scheduled time horizons, penalties paid in the case of non-compliance from the side of polluters and a financial and/or another kind of support from the side of authority.

A simplified idea of the principle of the approach is visible in the following picture:

**Figure 1: Principle of the approach**



Where

$MIIZP$  are marginal integrated environmental investment,

$p$  is environmental charge per one unit of pollution as object for charging,

$d$  is financial support (subsidy) from the fund per one unit of pollution reduction as object for setting priorities for support from the fund,

$Z^p$  is initial level of pollution (as object for charging),

$Z^v - Z^d$  is (minimal) pollution reduction received after the negotiation,

$Z^v - Z^{vz}$  is pollution reduction in the interest of polluters without the support from the fund,

$Z^v$  is initial level of pollution (as object for setting priorities from the support)



and where

$$p * Z^p = d * (Z^v - Z^d)$$

is a theoretical equilibrium solution as a result of the negotiation.

The second approach (strategy) to the negotiation that is possible to design is that one where

$$P * Z^p = \frac{Z^{vz}}{Z^d} \int /MIIZP/.$$

In this case the extra profit of polluters is minimized by a procedure of a "market segmentation" in the process of negotiation by the authority. In this case it is possible to achieve better environmental standards with the same amount of financial support from the fund.

### 3. City of Uhelno nad Labem - Experimental Case

#### *Case Description*

The city of „Uhelno nad Labem“<sup>2</sup> faces several important environmental problems, the most critical of which is air pollution. Concentrations of sulfur dioxide and several other pollutants exceed public health standards for an annual average and for 24-hour limits. Combustion of lignite is regarded as the main cause of this pollution. Since Uhelno is located within a deep river valley of the Labe, atmospheric inversions occur several times a year. In winter periods, peak levels of SO<sub>2</sub> pollution reach 500-1000 µg.m<sup>-3</sup> for several days. A high-level of lung-related illness among area residents has been attributed to the excess of airborne pollutants and the inversions that create „London-type“ smog. Emission reduction at least by 30 % would lead to receiving public health standards in the area.

The lignite that is used by large (over 5 megawatt power output), medium (200 kilowatt to 5 megawatt) and small (less then 200 kilowatt) polluters in the

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<sup>2</sup> An ideal case of Uhelno nad Labem was created based on realistic data taken especially from the case study of Decin (see Andrews at al 1994 and Šauer at al 1995).

city contains about 3 % of sulfur. This means that approximately 60 kg of SO<sub>2</sub> is emitted to the atmosphere by burning of 1 t of this coal. The total annual amount of emissions discharged into the atmosphere in the city is estimated as: 2 100 tuns of sulfur dioxide, 1 300 tuns of dust (particulates) and 860 tuns of nitrogen oxides. Almost 50 000 tuns of ash are being dumped at municipal landfills every year. The causes of air pollution problems in Uhelno are primarily local with about 80 % of the emissions coming from large and medium sources of pollution. As estimated by Foundation Project North, roughly 85 % of pollution comes from sources within the municipal boundaries where there are 15 large and medium sources of air pollution. Table 1 lists these sources and the amounts of selected pollutants they produce (in t/year). The remaining pollution probably comes from large power plants located in the North Bohemia and in Germany near the Czech-German boarder.

**Table 1 Emissions from Large and Medium Sources in Uhelno**  
(Annual average for 5 years; in tons)

<b>Source of Pollution</b>	<b>SO<sub>2</sub></b>	<b>Dust</b>	<b>NO<sub>x</sub></b>	<b>Ash</b>
<b>A – Housing enterprise</b>	39	5	5	1200
<b>B – Public transport corp.</b>	9	9	2	200
<b>C – Housing enterprise</b>	153	107	38	3830
<b>D – Housing enterprise</b>	12	3	12	0
<b>E – Food production corp.</b>	12	10	1	160
<b>F – Transport enterprise</b>	205	135	130	5140
<b>G - Iron works</b>	300	160	170	7500
<b>H -Heating plant</b>	152	106	38	4195
<b>I - Machine industry company</b>	250	170	150	7500
<b>J - Housing enterprise</b>	56	24	25	2869
<b>K - Food company</b>	107	5	17	0
<b>L - Machine industry company</b>	31	6	9	180
<b>M - Machine industry company</b>	340	190	55	2980
<b>N - Machine industry corp.</b>	96	82	8	0
<b>O - Repairing plant</b>	59	30	9	0
<b>T o t a l</b>	1821	1042	669	35754

Environmental fees for all pollutants listed above are introduced (see Table 2). The rates of the fees correspond to the Czech environmental laws concerning the air pollution and waste treatment (Act No. 212/1994 Coll. and Act No. 62/1992 Coll.).

**Table 2 Environmental fees paid by large and medium polluters (in Czech crowns)**

<b>Polluting substance</b>	<b>Environmental fees (CK per 1 ton)</b>
<b>Sulfur dioxide</b>	1000
<b>Dust (particulates)</b>	3000
<b>Nitrogen oxides</b>	800
<b>Ash (solid)</b>	50

For setting priorities for funding environmental projects from public environmental protection (financial) funds, some coefficients of harmfulness or the risks posed on people and the environment could be used. An alternative version of the coefficients is shown in Table 3 (see Halouzka at al 1988):

**Table 3 Coefficients of Harmfulness**

<b>Polluting substance</b>	<b>Coefficient of harmfulness</b>
<b>Sulfur dioxide</b>	22
<b>Dust (particulates)</b>	70
<b>Nitrogen oxides</b>	42
<b>Ash (solid)</b>	2

Every polluter that is listed above could reduce pollution or engage in an environmental protection project without stopping business activities. However, these solutions have both positive and negative economic impacts (benefits and costs) for the polluters. These impacts are known by polluters but they are not available to environmental protection authorities, other authorities, or other polluters.

A polluter's decision about whether to make capital investments is based on a comparison of a concrete level of some indicator of the project efficiency with some minimally required level of the efficiency. These minimally required levels of criterion indicators of concrete projects belong to confidential information also.

The initial reactions of polluters show that their environmental protection projects bring some positive economic impacts to some of polluters. But these effects are not big enough to stimulate polluters to invest in desirable environmental protection in the city. Several exceptions may exist, but authorities are not able to recognize it.

The Ministry of the Environment of the country has made it possible to conduct experiments on regional (decentralized) environmental policies. The rules for such experiments are as follows:

- it is possible to disregard the individual emission limits for large and medium sources of air pollution if the target emission reduction is received in the region (city),
- it is possible not to transfer emission fees to the central environmental protection fund and use it for a financial support (subsidizing, etc.) from a local environmental protection fund,
- it is possible to solve the situation by negotiation between polluters and a local environmental protection authority.

The environmental goal for Uhelno nad Labem is to reduce pollution from all sources at least by about 30-40 % and to reduce pollution from medium and large sources by at least 40-50 % both in terms of recalculated emissions and individual pollutant levels.

More concretely, the experiment can consist of an agreement between a central environmental protection authority (ministry of the environment) and a local authority which might declare: the emission limits and centrally set environmental fees will not be used for 10 years in the case that emissions in the region will be reduced to target amounts (and/or public health standards for concentrations of pollutants in the ground-level layer of the atmosphere measured in the annual arithmetic means are achieved). Both limits and environmental fees will be in operation if an agreement between polluters and the local authority is not achieved in certain period of time, including a penalty in the amount of  $x$  percent of the fee paid in delay. The time for concluding the negotiated voluntary agreement between the local authority and pollutees is specified to be 12 months.

### ***Experiment Design***

An experimental game was designed for 16 participants. One person played the role of representative of the (local) authority and the remaining participants played the roles of managers of polluting companies. The economic negotiation experiment was done by the teacher and students of a master's course on „Environmental Economics and Policy“ at the Department of Environmental Economics, University of Economics, Prague in April 1998.

*Polluter's (student's) set of materials*

A set of materials for students playing the role of polluters was prepared. The materials consisted of the following:

- a) A case description (see above) including description of the procedure of the experiment and including formulas for a quantification of integrated environmental investments (= minimal investment subsidies required from the fund in the experiment). In this simple case, pay back of investment was taken as the criterional indicator of efficiency of the (environmental protection) projects. The pay back was quantified very simply - as quotient of (environmental protection) investment costs and a total annual average change of cash flow of the polluter caused by the project.
- b) A sheet with information about the firms-polluters and their solutions (environmental investment projects). Most of this information has a confidential character and was distributed to individual polluters only. This material contains information as follows:
  - name of the firm,
  - sort of activity (type of production etc.),
  - impact on the environment (annual amount of pollution),
  - basic economic data about the company (annually profit, cash flow, environmental fees paid),
  - environmental effects of the environmental protection projects (pollution reduction),
  - economic parameters of the projects (investment costs, change of operating costs, change of profit, cash flow, environmental fees reduction, payback of investment cost,
  - maximal payback to be required in the experiment.
- c) Communication sheet prepared for the communication between the polluter and the authority in the process of negotiation. The sheet was designed for 7 time-periods of negotiation with 3-5 rounds in each of them. The sheet contains two peaces of information:
  - pollution reduction (environmental impacts) offered by the polluter,
  - subsidy required by the polluter from the environmental protection fund.
- d) Sheet for recording the polluter's side of the history of the negotiation.

### *Authority's (teacher's) materials*

- a) The same case description as in the student's materials (see above).
- a) Specimens of the rest of the student's materials.
- b) Sheet for recording the authority's side of the history of the negotiation.
- c) Table containing data for avoiding critical numerical mistakes of participants which probably never would occur in practice (like mistakes caused by missetting to formulas).
- d) Software for the negotiation. Simple PC spreadsheet software for the support of decision making of the authority was prepared.

### *Real Money Introduction*

Real money was introduced to the experiment to increase the interest of participants on rational behavior during the game. Real economic figures used in the case amount from tens of thousands to tens of millions of Czech crowns. Experimental game money was recalculated in the ratio of 1:100 000 (i.e., one Czech crown was paid in the experimental game for every 100 000 Czech crowns occurring in the real case). This money was initially distributed to students-polluters by the teacher to be used for paying the environmental fees to the fund and later for providing environmental protection subsidies from the fund.

### *Procedure of the experimental game*

In the case of our experiment we considered a system in which an ecological (governance) authority „*A*“ collects payments for environmental pollution and creates an environmental fund of amount „*F*“. The fund was used as a source of financial subsidy support of polluters' environmental protection investments.

The total level of pollution (which is calculated as „recalculated units of emissions“) depends on factors as follows: the sort of pollutants, the amount of emissions, the level of harm to public health and to the environment.

The system consists of 15 polluters:  $P_1, P_2, \dots, P_{15}$ . The levels of pollution are denoted by  $z_1, z_2, \dots, z_{15}$ . The authority knows the levels of pollution. All polluters have two decision alternatives: to realize the environmental investment project or to continue in the current situation. The realization of the projects causes environmental effects  $e_1, e_2, \dots, e_{15}$  (which are offered to the

authority in the process of negotiation) and needs investments  $i_1, i_2, \dots, i_{15}$ . Polluters could have full or partial or no economic interests in the realization of the projects. Polluters then can request the subsidy support from authority  $A$ . The authority has no information about the environmental projects (especially about the economic side of them) and has no possibility for computing motivated subsidy supports  $D_1, D_2, \dots, D_{15}$ .

The problem is solved in several time periods. A vector of payments  $p$  per unit of pollution is taken from environmental laws of the country and is supposed to be constant over time. In a time period  $t$  polluters  $P_i$  request the subsidy support  $R_i^{(t,r)}$ ,  $i = 1, 2, \dots, 15$ . In a time period  $t$ , there are realized  $r$  negotiation rounds. In the rounds, the authority  $A$  states and proposes a unit of the subsidy support per unit reduction of recalculated emissions  $d^{(t,r)}$ . Polluters  $P_i$  request the subsidy support  $R_i^{(t,r)}$ ,  $i = 1, 2, \dots, 15$ , based on their computations. The motivated subsidy supports  $D_i$  and requested subsidy supports in time periods and rounds  $R_i^{(t,r)}$  can be different. But the motivated subsidy support never must be lower than the requested one.

The goal is to find the best distribution of subsidy support from the fund  $F$  to polluters. The criterion of that is to minimize the subsidy per one unit of environmental effect (or to maximize environmental effect per one unit of subsidy).

Pollution reduction of the amount  $E$  in the region was required, both in terms of recalculated emissions and individual pollutant levels.

The negotiation process is described in the following steps:

1. To start the negotiation process let us set time period  $t = 1$ .
2. The authority  $A$  states the unit payment  $p$  and computes the amount of the fund in time period  $t = 1$

$$F^{(1)} = \sum_{i=1}^{15} p z_i^{(1)} \quad (1)$$

3. Polluters  $P_i$  compute the motivated subsidy supports  $D_i$ . The motivated subsidy support depends on the unit payment  $p$  and economic parameters of projects.

4. In time period  $t$  a negotiation round  $r$  is realized. Polluters propose environmental projects. Polluters give information about the reduction of pollution  $e_i$  and request the subsidy support  $R_i^{(t,r)}$ .
5. The authority evaluates information from polluters  $(e_i, R_i^{(t,r)})$ ,  $i = 1, 2, \dots, 15$ , and sorts projects by the requested subsidy support on the unit environmental effect

$$\frac{R_{[1]}^{(t,r)}}{e_{[1]}} \leq \frac{R_{[2]}^{(t,r)}}{e_{[2]}} \leq \dots \leq \frac{R_{[15]}^{(t,r)}}{e_{[15]}} \quad (2)$$

**Remark:** We use brackets to indicate positions in sequence. Thus  $[i] = j$  means that the polluter  $j$  is on the position  $i$  in the sequence of values  $\frac{R_{[i]}^{(t,r)}}{e_{[i]}}$ .

6. It is possible to subsidize only some polluters. We assume that the last supported polluter is in place  $k$  in the above sequence. Then it holds

$$\sum_{[i]=[1]}^{[k]} R_{[i]}^{(t,r)} \leq F^{(t)} \quad (3)$$

We denote the rest of unused amount of fund  $S$  in time period  $t$  as

$$S^{(t)} = F^{(t)} - \sum_{[i]=[1]}^{[k]} R_{[i]}^{(t,r)} \quad (4)$$

The authority computes the unit subsidy support  $d^{(t,r)}$  as the requested subsidy support on the unit environmental effect for the last supported polluter in the above sequence (2) that by this unit support the amount of the whole proposed support is not greater than the amount of the fund.

The authority proposes the unit subsidy support  $d^{(t,r)}$  to the polluters. Polluters evaluate the subsidy supports. If there is the last round of negotiations in time period  $t$ , we go to the step 7. If there is not the last round, we set  $r = r + 1$  and go to the step 4.



7. A discussion of the proposed solution from the point of view of the entire region takes place.

The proposed solution is accepted from an environmental point of view, if it holds

$$\sum_{[i]=[1]}^{[k]} e_{[i]} \geq E . \quad (5)$$

If the proposed solution is accepted from the environmental point of view, the negotiation process ends with a consensus.

If the proposed solution is not accepted from the environmental point of view we move to the next time period and set

$$z_{[i]}^{(t+1)} = z_{[i]}^{(t)} - e_{[i]}$$

$$F^{(t+1)} = \sum_{i=1}^{15} p z_i^{(t+1)} + S^{(t)} \quad (6)$$

$$t = t + 1$$

and go to the step 4.

### ***Experiment Results***

An annual pollution reduction in the region in the amount of 96135 recalculated units was achieved in the end of the negotiation. It consists of SO<sub>2</sub> pollution reduction by 717,5 t/year, dust by 429 t/year, NO<sub>x</sub> by 339,5 t/year and ash by 18 030 t/year. For more results in pollution reduction see Table 4.

**Table 4 Pollution reduction achieved (in t/year)**

<b>Pollution</b>	1 <sup>st</sup> time-	2 <sup>nd</sup> time-	3 <sup>rd</sup> time-	4 <sup>th</sup> time-	5 <sup>th</sup> time-
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	period	period	period	period	period
Per time-period					
SO <sub>2</sub>	222,5	0	200	0	295
Dust	134	0	135	0	160
NO <sub>x</sub>	54,5	0	120	0	165
Ash	5390	0	5140	0	7500
Recalc. Units	27345	0	29170	0	39620
Cumulative					
SO <sub>2</sub>	222,5	222,5	422,5	422,5	717,5
Dust	134	134	269	269	429
NO <sub>x</sub>	54,5	54,5	174,5	174,5	339,5
Ash	5390	5390	10530	10530	18030
Recalc. Units	27345	27345	56515	56515	96135

The pollution reduction shown above represents over 45 % of present amount of pollution from large and medium sources and over 35 % from all sources of air pollution in the city. Pollution by SO<sub>2</sub> from all sources located in the city (including small and non-point sources of pollution) was reduced by 34,2 %, pollution by dust by 33 %, by NO<sub>x</sub> by 39,5 % and production of ash was reduced by 36,1 %. The ratio of pollution reduction from large and medium sources is shown in Table 5.

**Table 5 Pollution reduction achieved**  
(in % from large and medium sources)

<b>Pollution</b>	1 <sup>st</sup> time-period	2 <sup>nd</sup> time-period	3 <sup>rd</sup> time-period	4 <sup>th</sup> time-period	5 <sup>th</sup> time-period
Per time-period					
SO <sub>2</sub>	12,2	0	11,0	0	16,2
Dust	12,9	0	13,0	0	15,4
NO <sub>x</sub>	8,1	0	17,9	0	24,7
Ash	15,1	0	14,4	0	21,0
Recalc. Units	12,9	0	13,7	0	18,6
Cumulative					
SO <sub>2</sub>	12,2	12,2	23,2	23,2	39,4
Dust	12,9	12,9	25,9	25,9	41,3
NO <sub>x</sub>	8,1	8,1	26,0	26,0	50,7
Ash	15,1	15,1	29,5	29,5	50,5
Recalc. Units	12,9	12,9	26,6	26,6	45,2

Seven environmental protection projects have been supported (subsidized) from the environmental protection fund governed by the authority. Total amount of revenues from environmental fees of 30 657,1 thousands CK was collected in the fund within the time period of the experiment. Total amount of subsidies of 35 526,4 thousands CK was used for stimulation of polluters to realize their environmental protection projects. (The difference was covered by a short-term-loan.) The history of the authority (environmental protection fund) in the experimental game is visible from the Table 6.

**Table 6 History of the Fund in the Experimental Game**

(monetary units in thousands CK)

Time-period	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>
Initial State	0	2673,5	9005,8	2358,1	7719,4
Revenues from fees	7269,9	6332,3	6332,3	5361,3	5361,3
Disposable sources	7269,9	9005,8	15338,1	7719,4	13080,7
Expenditures (subsidies) <sup>3</sup>	4596,4	0	12980,0	0	17950
Final State	2673,5	9005,8	2358,1	7719,4	-4869,3 <sup>4</sup>
Names of polluters who received subsidies	C,B,D, A,E	-	F	-	G
Marginal subsidy provided (per rec. Unit)	0,25	-	0,44	-	0,45

The approach leading to establishing the equilibrium level of the unit subsidy  $u$  was used during the negotiation. The second approach was used when making final agreements and segmentation was done for different time periods.

#### 4. Some Practical Applications Discussed

The first application is the situation where the agreement could be achieved in the process of a voluntary negotiation between polluters and an authority when the authority does not know the microeconomic data about polluter's solutions (there is information asymmetry here)<sup>5</sup>. This is the case that was described in

<sup>3</sup> Zero transaction costs were considered to keep the case simple.

<sup>4</sup> Short-term loan was provided by Jara Cimrman Eco-Bank Prague (interest 15 %). The loan will be paid back from revenues from environmental fees paid in the next time periods (the revenue from the fees is supposed to be 4 079,3 CK in the 6th time-period, the rest will be paid at the beginning of the 7th time-period).

<sup>5</sup> Although it is a very strong precondition that will be only rarely accomplished in practice, it is possible that the situation could arise where microeconomic information about solutions *is* available to the authority. Independent consultation firms are sometimes able to provide such information. Firms of this sort exist and create environmental engineering databases, including items concerning costs of environmental protection solutions. In this case it is possible to think about several computations on the model for various values of exogenous variables. It could serve for an appraisal of environmental pollution charges in combination with some principles of financial support of environmental investments from public financial sources. This computation could be made on a representative sample of solutions where there is some

the previous parts. This situation seems to be more realistic in the future, especially in connection with extending the voluntary introduction of so called environmental management systems (EMS, ISO 14000) by companies (EMAS 1993, EMS 1995, Kubátová et al 1996). For instance, there seems to be a chance to increase a number of voluntary agreements between authorities (public sector) and industry (private sector) concerning energy consumption reduction or pollution reduction.<sup>6</sup> Theoretically such negotiations could be initiated, for instance, by some (state) environmental protection funds.

In some cases the “authority” should not necessarily be a governmental institution. A special institution could be created by participants of the negotiation and could serve more as a mediator than a „powerful“ bureaucratic subject. It is also possible to think about establishing an environmental protection fund as an organization that is privately owned by polluters taking part in the negotiation.

Applications within single corporations are also possible especially where there are more sources of pollution that are controlled by different managements within a single firm. The model can serve as a powerful tool in the situation when the corporation is faced with the goal to reduce pollution from its sources by some amount. It could work for instance in a case when the corporation wants to conclude a voluntary unilateral commitment. The approach could be useful for solving the principal-agents problem where the manager's and owner's utility functions are different.

The negotiation could be organized as a voluntary experimental workshop of selected polluters to receive an information that is important for

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possibility to quantify environmental protection costs connected with these solutions. The model enables (because of the structure of information) the verification of some additional approaches and tools of environmental policy like pollution permit trading. In this case it is, for instance, possible to derive a supply curve on pollution permits in a region etc.

<sup>6</sup> The terminology in this field is still fluctuating. In the scholar discussions and practical case descriptions, different authors use different terms for these interactive forms of governance in the field of environmental protection and natural resource management. For instance Grey speaks about „collaborative management“ (Grey 1989). Van Vliet speaks about „communicative governance“, Glasbergen uses the term of „network management“ and Lafferty and Meadowcroft have come up with a term of „cooperative management regimes“ (see Glasbergen 1995). Leveque distinguishes three main categories of "voluntary approaches" as "unilateral commitments", "public voluntary schemes" and negotiated agreements" (see Leveque 1997).

environmental policy decision making (i.e., a rough estimation of the environmental pollution charges mentioned above etc.).

A generation of quality microeconomic information about the environmental protection projects is an important problem. The introduction of Environmental Management Systems in companies, including improved corporate environmental information systems, promises to improve this generation of information. Corporations typically encounter two major obstacles for generating and providing environmental information. The first obstacle is that many companies do not want to make this type of information publicly available. The proposed negotiation approach is able to overcome this problem because the microeconomic information can be fruitfully used without requiring that the data be made public. The second problem, based on the authors' experience from the Czech Republic, is that many companies do not generate environmental information for their internal usage because in the absence of the environmental management system this type of data collection is expensive.

The space for practical applications of the approach is limited in the case where pollution limits are introduced. It is the same problem as with economic tools of environmental policy in general.

For practical use, it is also useful to discuss the possibility of the formation of coalitions. This could lead to more effective solutions in the cases where some synergistic effects from common environmental investment projects can occur. This common solution could be more effective from both economic and environmental points of view than isolated solutions realized by single polluters.

Discussions with experts from fields of environmental science both from the Czech Republic and abroad indicate that there are some promising fields for practical applications of the approach. More promising are those connected with solving pollution problems of single environmental components (like air, water, soil etc.) where there is more chance to synthesize environmental effects of the solutions. The sequence corresponding to the chance seems to be as follows: water pollution in river basins, air pollution in selected regions and probably some cases of soil degradation. Regional application is more likely than application within a whole country.

In any case, the interests of polluters in this approach seem to be the most critical problem. What would attract them to take part in this kind of solution? Some of them can be attracted by the possibility of having a chance to receive

the financial contribution, which can be very attractive for some of them because of the surplus over integrated costs of environmental protection. Some of them may feel that they have a chance to promote better contacts with authorities. On the opposite side, there are those subjects that know that, most likely, they will (only) pay without a chance of receiving additional sources. It is not always true in the case where some environmental charges are already introduced (like it is in the Czech Republic and another countries). In this case polluters that take part in the negotiation process more likely will benefit from it than suffer a loss. Taking part in some application of the negotiation gives polluters a chance to be better prepared for lobbying in the process of preparing environmental laws.

A privilege of the approach seems to be that it gives more chance to ecologists and other specialists from the field of environmental science to take part in the process of decision making. They play a non-substitutable role, especially in the process of ranking solutions. The procedure can be more transparent. NGO's and other stakeholders could also play an important role in it. Although primarily based on economic principals, the approach can serve as a tool for building a bridge between economy and ecology. We also should not forget that the intellectual capacity of people who are involved in corporate management could and should be used to substantially help with solving environmental problems.

The approach is able to stimulate research and development in the field of environmental protection. It could be useful in two areas. It could help search for already existing technical solutions on the one side and with creating a demand for developing new solutions for environmental protection that are less costly on the other. These new solutions can lead to a reduction in the economic optimal pollution and to the mitigation of the environmental burden of the economy (Šauer, 1988). The promoted technical progress can also lead to transaction cost reduction and to a more rapid generation of solutions based on improving property rights in the field of environmental protection.

## **5. Concluding Remarks**

An approach based on a mix of a negotiation between an authority and polluters and using economic tools of environmental policy seems to be promising for solving some of the complicated environmental pollution problems. The fact that no microeconomic information about pollution reduction solutions is available to the authority belongs to the advantages of this approach.

The approach was tested several times as a laboratory economic experiment (experimental game) in a university course of Environmental Economics and Policy at the Department of Environmental Economics, University of Economics Prague. The cases posed the situation of a region where some pollution reduction was necessary. The equilibrium solution was always achieved in the experiments. One of the experimental solutions is shown in the case described above.

New experiments are being prepared. These experiments concern practical cases with more components of the environment. They should enable verification of other variants of the model techniques and promote deep discussions on environmental policy aspects of practical implementation of the approach.

The "practical" figures received in the experiments seem to be interesting. But it is important to stress that the most important result of the experiment is a step toward a verification of the hypothesis of a possibility to establish the suggested approach as a new institution for environmental pollution management in practice. It also shows the usefulness of laboratory environmental policy experiments both for the research and teaching.

There is no tool of environmental policy that could serve as a „all-purpose medicine“ for all kinds of environmental problems. Different instruments or instrument mixes are appropriate for solving different problems. It is our belief that our approach could contribute to solving some of them.

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**Short Abstract**

The paper describes a relatively new approach to pollution reduction problem solving that relies on negotiation between polluters and authorities in which traditional economic tools of environmental policies are used and where there is the economic information asymmetry between the polluters and the authority. The approach can result in negotiated voluntary environmental agreements between authorities and polluters.

Design and results of a laboratory environmental policy experiment on air pollution reduction in a city is presented in the paper to illustrate the efficacy of the suggested approach. The case is created based on field data. A step toward a verification of the hypothesis of a possibility to establish the suggested approach as a new institution for environmental pollution management in practice is the most important result. The case also shows the usefulness of laboratory environmental policy experiments both for research and teaching. Some problems of practical applications of this kind of environmental policy tool mix are also discussed in the paper.

**Abstract (longer)**

A new trend in environmental policy has emerged in the 1990's. This trend is the voluntary participation of business in environmental protection and problem solving. So-called environmental management system principles and standards are being developed and certified in many countries. A reasonable number of corporations have already introduced this system. Voluntary agreements between industry and authorities have occurred and have achieved benefits that are significant to both parties.

This paper contributes to a progress in the field of business participation in environmental protection. It describes a relatively new approach to pollution reduction problem solving that relies on negotiation between polluters and authorities in which traditional economic tools of environmental policies are used and where there is the economic information asymmetry between the polluters and the authority. An approach based on a mix of a negotiation between an authority and polluters and using economic tools of environmental policy seems to be promising for solving some of the complicated environmental pollution problems. The fact that no microeconomic information about pollution reduction solutions is not necessarily to be available to the authority belongs to strong advantages of this approach. The approach can result in negotiated environmental agreements concluded between authorities and polluters.

The approach was tested several times as a laboratory economic experiment (experimental game) in a university course of Environmental Economics and Policy at the Department of Environmental Economics, University of Economics Prague. The cases posed the situation of a region where some pollution reduction was necessary. The equilibrium solution was always achieved in the experiments. Design and results of a laboratory economic experiment on air pollution reduction in a city is presented in the paper to illustrate the efficacy of this approach. The case also shows the usefulness of laboratory environmental policy experiments both for research and for teaching. Some problems of practical applications of this method are also discussed in the paper.

New experiments are being prepared. These experiments concern practical cases with more components of the environment. They should enable

verification of other variants of the model techniques and promote deep discussions on environmental policy aspects of practical implementation of the approach.

There is no tool of environmental policy that could serve as a "all-purpose medicine" for all kinds of environmental problems. Different instruments or instrument mixes are appropriate for solving different problems. It is our belief that our approach could contribute to solving some of them.