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Administrative incentives for alignment with Kyoto Protocol

Abstract
In the period 1995-2002 average annual growth of CO_2 emission in Croatia was 3.3%. This trend should be stopped in order to meet Kyoto obligations.
Proposed administrative measures aimed for alignment with Kyoto Protocol should provide incentives for investments in environmental protection. The paper analyses proposed measures, with emphasis on provisions enabling reducing a fee for CO_2 emissions depending on the level of investments in environmental protection. Preliminary cost-benefit analysis of different levels of investments in environmental protection and different starting levels of pollution is presented. Based on the analysis, potential effectiveness of proposed measures is examined.

Key words: Kyoto Protocol, Croatia, CO_2 emissions, CO_2 fee

1. Introduction

The focus of this paper is on the possible impacts of application of CO_2 emission fee on reduction of CO_2 emission in Croatia. This impact will be gauged by an analyis of the costs that emerge from introduction of such a fee and by an analysis of the implications of investment in CO_2 reduction on the level of fee.
The paper starts with presentation of Croatia's position in the framework of Kyoto Protocol and its obligations. This is followed with a review of the current trends in GHG emissions in Croatia. The identification of the current situation serves as a point of departure for an analysis of the further preparations of Croatia for meeting Kyoto requirements in the first commitment period. We present domestic measures aimed at mitigating climate change and analyse weather they provide incentive for reducing CO_2 emissions and investments in environmental protection. Based on this analysis, we identify the factors that might provide incentive for meeting Kyoto target, but also the main flaws of the prepared domestic measures.

2. Croatia and the Kyoto Protocol

Croatia signed UN Framework Convention on Climate Change (UNFCCC) in 1992 and ratified it in 1996. It has been added to Annex I of the Convention in 1998 (UNFCC, 2002). As an Annex I country, Croatia signed Kyoto Protocol in 1999 and has pledged in the Annex B of the Kyoto Protocol to reduce its GHG emissions by 5% from the amount released to the atmosphere in 1990. In 2001 Croatia requested recognition of special circumstances under Article 4.6 of the Convention and increase of emission level 14%, or rather 4.46 Mt CO_2 eq for the base year 1990. The special circumstances regard to greenhouse gas emissions from Croatian power plants situated outside its territory. (UNFCC, 2006a) Namely, until break-up of Yugoslavia, Croatian power system owned several power plants in Bosnia and Herzegovina, Serbia and Slovenia (650 MW of installed coal-fired thermal power and 322

MW of nuclear power, for more see Duić et al., 2005). Emissions from these sources are not contained in the greenhouse gas inventory of Croatia, which in the 1990 was 31.12 Mt CO_2 eq (Ministry, 2006b).
In 2005 Conference of Parties (COP) adopted decision that allows Croatia to add 3.5 Mt CO_2 eq to its 1990 level of greenhouse gas emissions (UNFCC, 2006b), which led to ratification of the Kyoto Protocol in Croatian Parliament in May 2007. Conequently, the maximum amount of emissions (measured as the equivalent in carbon dioxide) over the first commitment period, 2008-2012 is 164.4 Mt CO_2 equivalent, or 32.9 annually.

3. Starting position: emission levels and trends in greenhouse gas emissions

CO_2 emission in 2004 (excluding removal by sinks) amounted 29.4 mil t CO_2 eq, which represent 5.4% emission reduction compared to GHG emission in the year 1990. (Table 1, Table 2)

Table 1. Emissions and removals of GHG by gases (1990-1994), Gg eq CO_2

GAS	1990	1991	1992	1993	1994
CO_2	23035	16738	15810	16432	15690
CH4	3233	3007	2826	2771	2564
N2O	3920	3827	3601	3200	3207
HFC	-	-	-	-	-
PFC	937	642	0	0	0
SF6	-	-	-	-	-
Total GHG	31124	24215	22237	22403	21462
Removals	14437	14722	14776	14689	16051
Total (including LULUCF)	16687	9492	7461	7714	5411

Source: Ministry,2006a, p. 11

Table 2. Emissions and removals of GHG by gases (1995-2004), Gg eq CO_2

GAS	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO_2	16250	16941	18024	18915	19702	19417	20434	21498	22883	22551
CH4	2532	2557	2624	2460	2496	2544	2690	2745	2925	3015
N2O	3123	3004	3348	2912	3103	3284	3251	3317	3221	3677
HFC	8	60	91	18	9	23	49	49	194	189
PFC	0	0	0	0	0	0	0	0	0	0
SF6	-	-	-	-	-	-	-	-	-	-
Total GHG	21913	22561	24087	24087	25311	25268	26424	27609	29192	29432
Removals	20535	20589	20832	20446	20280	19285	17777	16796	16648	16321
Total (including LULUCF)	1378	1972	3255	3858	5301	5983	8647	10813	12544	13111

Source: Ministy, 2006a, p. 11

During the war in Croatia, in the period 1991-1994, economic activities and energy consumption decreased and caused decline in total emissions of greenhouse gases (Table 1). This can be directly linked with phasing out of certain energy intensive industries (e.g. blast furnaces, primary aluminum production and coke plant) (Tišma, S., Pisarović, A., Jurlin, K., 2003). Since 1995 emissions grow. In the 1998 emissions reached 1991 level and continued growing at an average rate of 3.3% per year in the period 1998-2004 (Table 2). If such trend is to be continued, annual ceiling of 32.9 Mt CO_2 eq would be exceeded in 2008 (Table 3).

Table 3: Total GHG emissions projections 2005-2012, Mt CO_2 eq

	2005	2006	2007	2008	2009	2010	2011	2012
Projected emissions	30.403	31.406	32.443	33.514	34.620	35.762	36.942	38.161

Source: authors' calculations

The estimations of future trends in greenhouse gas emissions prepared for the second Croatian communication to the UNFCCC (Ministry, 2006a) consider three scenarios: no measures, with measures and with additional measures. Official projections are prepared before the adoption of decision on the level of emissions for the base year for Croatia. Consequently, they use as a base year emissions 31.12 Mt of CO_2 eq (instead of 34.46) and assigned amount 29.6 Mt of CO_2 (compared with 32.9 in our projections, Table 4)

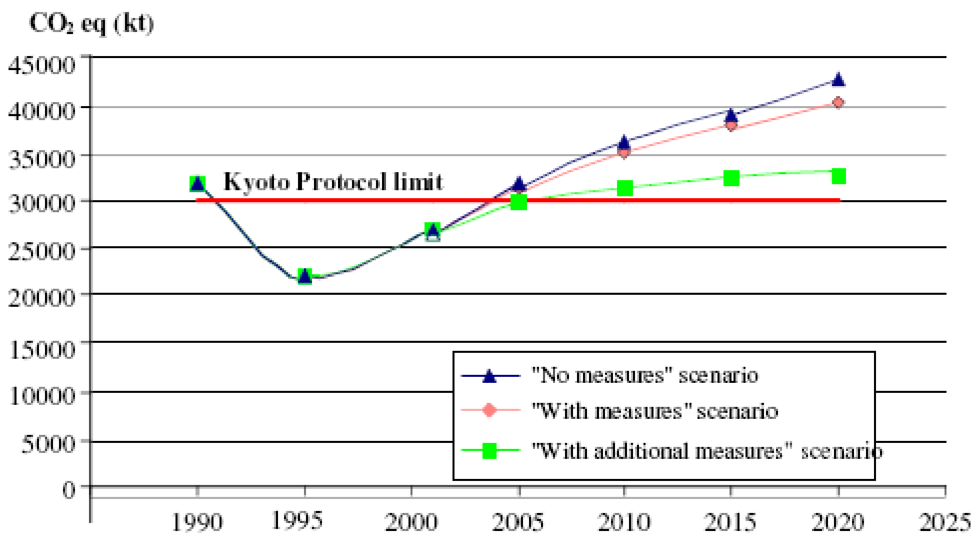
Table 4: Base year emissions and annual assigned amounts, Mt CO_2 eq

	Base year emission	Assigned amount
Before COP 12 decision	31.12	29.564
Based on the COP 12 decision on the level emission*	34.62	32.889

*adopted at conference of the parties (COP 12) in Nairobi, 2006.

Under no measures scenario, Kyoto commitment would be reached in 2006 (Figure 1).

Figure 1. Projections of greenhouse gas emissions in Croatia, 1990-2021



Source: Ministry, 2006a, p. 73

According to the „with measures" scenario, the total emission of greenhouse gases will exceed the Kyoto commitment in 2010 by 5.22 million tonnees CO_2 eq, or by 4.2 if forest sink is included. If effects of the decision to increase level of emission for the base year of Croatia for 3.5 Mt of CO_2 are considered, Kyoto target would still be l exceeded in 2010, but for smaller amounts - 1.9 Mt of CO_2 eq or 0.919 if forest sink is included.

According to the scenario with additional measures, in the first commitment period emissions of CO_2 eq will fall by 4.8 million tonnes (3.9 Mt by 2010, Table 5) and by 10 million tonnes in 2020. This means that the total emissions will reach 30.864 Mt of CO_2 eq in 2010. Scenario with additional measures includes the use of the total emission redutction potential, and it is is officially estimated as hardly feasible (Ministry, 2006a). Consequently, although the projected CO2 eq emissions are within the frame of Kyoto Protocol, it is not very likely that Croatia will meet its obligations in the first commitment period. [1]

Table 5. Potentials of measures for the reduction of greenhouse gases (kt CO_2 eq), 2010

	Energy	Industrial processes	Agriculture	Waste management
With measures	873.1	0	0	0
With additional measures	2047.2	808.4	722.5	347.1

Source: authors' presentation based on the data in the Second, Third and Fourth National Communication (2006)

Table 6. Potentials of measures for the reduction of greenhouse gases (kt CO_2 eq), 2020

	Energy	Industrial processes	Agriculture	Waste management
With measures	2176.9	-	-	-
With additional measures	5586.5	818.4	6617.9	552.8

Sprice: authors' presentation based on the data in the Second, Third and Fourth National Communication (2006)

To estimate weather it is reasonable to expect that Croatia will meet its obligations in the first commitment period, we analyse wether proposed measures provide sufficient incentives for implementing additional measures for reduction of CO_2.

2.2. Domestic policy measures

In parallel with the negotiations on flexibility for the base year, preparations of domestic measures needed for meeting UNFCC and Kyoto obligations were under way.

[1] In the Second, Third and Fourth National Communication the COP 12 decision concerning increase of base year emission is not taken into consideration. Consequently, it is concluded that under with additional measures scenario Kyoto limits would be exceeded by 1.3 million tonnees of CO_2 eq. With COP 12 decision, projected emissions in 2010 are 2 million tonnees of CO_2 eq below Kyoto limit.

Croatia prepared First National Communication in Response to Commitments under the UNFCCC within a UNDP/GEF project, which enabled capacity-building for preparation of the consequent national communication (second, third and fourth national communication). Uder the European Commission LIFE-Third Countries project „Capacity Building for Implementation of the United Nations Framework Convention on Climate Change and the Kyoto Protocol in the Republic of Croatia", launched in 2005, comprehensive approach for meeting Kyoto obligations has been developed. The key document thath should create framework for mitigation climate change is National Implementation Strategy and Action Plan.

National Implementation Strategy should contain short-, medium- and long-term objectives and targets related to implementation of the UNFCCC and the Kyoto Protocol which will make a framework for the Action plan.

Action Plan should stipulate policy instruments, mitigation measures, organizational scheme, duties/responsibilities, expenditures, financing options and timetable for implementation of the Strategy.

Although the Strategy and Action plan are not adopted yet, several domestic measures that might help mitigate climate change and promote sustainable development are in place.

Such measures include, for instance, adhering to the Energy Community and implementation of the Act on Environmental Protection and Energy Efficiency Fund. By adhering to the Energy Community Croatia committed to implementing market-based mechanisms in the energy sector, thus removing subsidies and other market imperfections in energy sector and its environmentally damaging activities (Boromisa, 2003). Removing subsidies and other market imperfection for environmentally damaging activities is one of the measures recognised by Kyoto Protocol that might help mitigate climate change.[2]

Similarly, the Act on Environmental Protection and Energy Efficiency Fund provides, inter alia, a legal ground for the carbon dioxide fee. Draft regulation on carbon dioxide fee provides for reduction of fee rate provided that CO_2 reduction program is being implemented or if there are significant investments (measured as percentage of profit) in environmental protection and energy efficiency.

These measures might be regareded as domestic action which constitutes a significant element of the effort s in meeting Croatia's commitment under the Kyoto Protocol, enabling thus participation in the mechanisms. The mechanisms, known as joint implementation, the clean development mechanism and emissions trading, can be used to help meeting emissions target provided that UNFCCC Annex I party that has ratified the Protocol can prove that its use of the mechanisms is "supplemental to domestic action", which must constitute "a significant element" of the efforts in meeting its commitments.

In addition to the national measures that are not directely related to implementation of Kyoto Protocol, institutional, legislative and organizational capacities in order to prepare Croatia for implementation of the obligations related to the United Nations Framework Convention on Climate Change (UNFCCC) and for the ratification of the Kyoto Protocol and meeting its

[2] The Protocol provides an indicative list of policies and measures that might help mitigate climate change and promote sustainable development. The list includes:

- Enhancing energy efficiency;
- Protecting and enhancing greenhouse gas sinks;
- Promoting sustainable agriculture;
- Promoting renewable energy, carbon sequestration and other environmentally-sound technologies;
- Removing subsidies and other market imperfections for environmentally-damaging activities;
- Encouraging reforms in relevant sectors to promote emission reductions;
- Tackling transport sector emissions; and,
- Controlling methane emissions through recovery and use in waste management. (UNFCC; 2007)

commitments have to be developed. The necessary measures include assessment of the capacity building needs; development of the implementation Strategy with an Action plan; drafting all the necessary legislation; preparing guidelines for sectoral operational programs; removing barriers in the implementation of programs; establishing effective monitoring system; setting up a system for implementation of the Kyoto flexible mechanisms (Joint Implementation, Clean Development Mechanism, Emission Trading); strengthening international co-operation on climate change issues; and networking relevant institutions and programmess.

These measures are in various stages of preparation. In the following section we draw particular emphasis to the draft regulation of CO_2 emission fee and analyse weather it constitutes "a significant element" fostering reduction of CO_2 emissions and investing in energy efficiency.

Carbon dioxide fee

Although there are some previous calculations and estimations (Tišma, S., Pisarović, A, Jurlin, K., 2003), draft regulation on the carbon dioxide fee has been prepared in the framework of the European Commission LIFE-Third Countries project „Capacity Building for Implementation of the United Nations Framework Convention on Climate Change and the Kyoto Protocol in the Republic of Croatia" (Minstry, 2004). Its legal ground is the Act on Environmental Protection and Energy Efficiency Fund, which was adopted in 2003 (Official gazette, 1072003), i.e. before ratification of the the Kyoto Protocol.
Since the CO_2 is the largest anthropogenic contributor to GHG emissions in Croatia, with share of 77% in total GHG emissions (data for 2004, NIR, 2006, see tables 1 and 2), CO2 fee might be important instrument for mitigation of climate change.[3]
According to the draft regulation, CO_2 fee will be applied for all sources of CO_2 whose individual emission exceeds 30 tonnes annually, and calculated as follows:

$N = N_1 \text{ x } Q \text{ x } k_k$ (1), where

N – CO_2 fee CO_2 in Kuna
N_1 – fee per 1 tonne of CO_2 emission
Q – Total emission of CO_2 (in tonnes) during calendar year
k_k – corrective coefficient, depending on the source and quantity of emission
.

Corrective coefficient k_k depends on the amount and source of emission, and is calculated as

$k_k = k_1 \text{ x } k_2 \text{ x } k_3 \text{ x } k_4$ (2) where

- k_1 – Incentive coefficient, depending on the annual CO_2 emission (Table 7),
- k_2 – Corrective coefficient depending on the source of emission (Table 8)
- k_3 – Corrective coefficient, depending on the investment in environmental protection, energy efficiency and renewables (relation 3)
- k_4 – corrective incentive coefficient, depending on the implementation of the CO_2 reduction program.

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[3] This is a judgement that still needs support in a more through anaysis, part of which is included in this paper.

According to the annual CO_2 emissions there are five categories of individual sources: sorces with annual emission lower than 30t (identified as R0), sources with annual CO_2 emission between 50,000 and 100,000 t (R1), sources with annual CO_2 emission between 100,000 and 500,000 t (R2) and sources whose annual emission exceeds 500,000 t (R4) (Table 7).

There is no carbon dioxide fee for the category R0. For other categories, incentive coefficient k_1 is smallest (0.65) for biggest emission sources that pay relatively smaller carbon dioxide fee per tone of emission, i.e the fee is regressive.

Table 7. k_1 in relation with CO_2 annual emmission,

Category	Emission range (tonne/year)	k_1
R0	$Q\ CO_2 <30$	0
R1	$30 < Q\ CO_2 < 50.000$	1
R2	$50.000 \leq Q\ CO_2 <100.000$	0.85
R3	$100.000\leq Q\ CO_2 <500.000$	0.75
R4	$Q\ CO_2 \geq 500.000$	0.65

There are two values of coefficient k2 depending on source of the emission CO2. It emissions are result of fossil fuels combustion the coefficient k2 is 1, while if it is result of tehnological process or waste management, the coefficient is 0.1 I.e. energy sector will pay 10 times higher fee than other emission sources.

Table 8. k_2 depending on source of the emission CO_2

Emission source	k_2
Fossil fuels	1.00
Emission from technological process for non-energy purposes or waste management	0.10

Energy is also the most important IPCC sector in Croatia and accounts for 74.9% of the total national emission of GHG. In the period 2000-2004 average annual growth of CO_2 emission in Croatia was faster (3.8% per year) than in the economy as a whole (3.7% per year). Next, as tables 5 and 6 show, energy sector has the greatest potential for reduction of greenhouse gases. Estimated potential for reduction of CO_2 in energy sector for scenario with measures is 869.4 kt of CO_2 eq by 2010 and 2168.2 by 2020. Comparable potential for reduction in other sectors (namely industrial processes, agriculture and waste management) does not exist in a longer run (by 2010), and in a short run requires additional measures. Implementation of additional measures in energy sectors increases potential for emission reduction potential twice, to 5586.5 kt CO_2 eq in 2020 (Table 5, Table 6). In addition,energy sector is the only one that has a strategy of document to regulate the measures for mitigation of effets of climate change. These are the reason to focus the analysis on the fossil sources of emission, i. e. energy sector.

Corrective incentive coefficient k_3 is related with the investment in the energy efficiency and renewables,[4] leading to the reduction of CO_2 emission, including environment protection programs. If considerable investments (measured as percentage of profit) in environmental protection programmes are made, the fee can be halved:

k_3 is calculated as

$$k_3 = \frac{P\text{-}I}{P} \qquad (3)$$

Where:
P = profit before tax
I = investment in energy efficiency, renewables and environmental protection

Coefficient k_3 ranges between 0.5 and 1. If investments in environmental protection are greater than 50% of profit before tax, value of 0.5 is used for calculation of CO_2 fee.

Implementation of the incentive coefficient k_4 is related with implementation of the CO_2 emission reduction program. The program, enabling fee reduction has to include:

- list of individual stationary emission sources owned or used CO_2 emissions trends for each emission source since 1990, up to the latest available data;
- review and technical analysis of the measures for CO_2 emission reductions;
- analysis of the emission reduction potential and costs of applied emission reduction measures ;
- emissions projections, with measures, for at least three years from the adoption of the program;
- implementation plan, including timetable, implementing measures, progress indices and reporting rules

The coefficient k_4, calculated as

$$k_4 = \frac{N_{1,1}}{N_{1,n}} \qquad (4)$$

Where $N_{1,1}$ = basic fee for tonne of CO_2 in the first year of the application of the fee
$N_{1,n}$ = fee for tonne of CO_2 in the current year,

should be applied from the beginning of the second year of the carbon dioxide fee application. However, the coefficient will not be applied if necessary administrative measures are not approved or implemented. I.e. for application of the incentive coefficient k_4 in the following year programme for CO_2 reduction has to be submitted to the Ministry of environmental protection, physical planning and construction by the end of September. Ministry has to

[4] According to the available infomation, it is discussed that the k3 will be related with investment in energy efficiency (excluding renewables). If this is the case, the benchmark value of k3 we use in our analysis later on should be revised.

approve the programme, and Environmental and Energy efficiency Fund monitors its application.

According to the current carbon dioxide fee proposal, basic fee will increase form 9 Kuna (€ 1.2) to 12 Kuna (€ 1.6) 15 Kuna (€ 2) in the first, second and the third year of carbon dioxide fee application, respectively.

Implementation costs

Carbon dioxide fee creates costs. The reduced rate might provide incentive for reduction of CO2 based on programme and/or investment in energy efficiency. To estimate potential benefits of increased investment in energy efficiency measures, first we estimate cost of application of CO_2 fee. Since energy sector contributes to 75% of CO_2 emissions, we focus on fossil-fuel emission sources (i.e. consider only the case where k2=1). It is also assumed that application of carbon dioxide fee will start in 2008.

Impact of coefficient k1

To analyse effects of the k1 coefficient we analyse total fee to be paid for different categories of emission sources. For each category of of carbon dioxide emission, we calculate minimum and maximum fee to be paid in the first three years of the carbon dioxide fee application. To separate other effect, we keep other coefficients constant. We consider only energy secor (i.e k2=1). K3 is estimated on the basis of national oil and gas company's data and used as a proxy for energy sector in Croatia.[5], while k4 is not applied.

The range of total fee costs (N) for individual emission source in the first, second and third year of application of CO_2 fee are presented in the tables 9, 10 and 11.

Table 9. Costs of CO2 fee for the 1st year of application, business as usual scenario

Category	k_1	k_2	k_3	k_4	N_1	$P= k_1xk_2xk_3xk_4xN_1$	N_{min}	N_{max}
R1	1	1	0.8	1	9	7.2	216	360000
R2	0.85	1	0.8	1	9	6.1	306000	612000
R3	0.75	1	0.8	1	9	5.4	540000	2700000
R4	0.65	1	0.8	1	9	4.7	2340000	0

Source: Author's calculation

Table 9 shows that in the first year of CO2 fee application (assumed to be 2008), price per tonne ranges between 4.7 Kuna and 7.2 Kuna depending on total annual emission. The absolute amont of the fee that can be paid for R1 source category (i.e. emission range between 30 and 50,000 t/year) in some cases might be greater than the amount paid by sources with higher annual emission, but in the next category (R2).The same holds for the

[5] We use publicly available data on investments in environmental protection and profit from national oil and gas company, INA, in 2005. In 2005 INA invested 198 million kuna in different environmental protection projects (Ina, 2006a) and profit before fee was 1,115 million kuna (Ina, financial report 2006b.) Using Ina's coefficient as as a proxy for energy sector in Croatia is arbitrary. However, INA and HEP are responsible for almost all energy sector CO2 emissions and HEP's data on investment in energy efficiency and renewables are not available. Conseqently, we used available data as a point of departure for analysing the size and direction of changes depending on the level of investment.

categories R2 and R3. If emission reaches 42,361 t/year, or 88,235 t/year for R2, or 433,333 t/year it is cheaper to increase than to reduce emissions. To illustrate, by increasing emission from 42500 t CO_2 tp 50000 t 54,000 kn can be saved in the first year of application of CO2 emission fee. In the second year of application, fee per tonne of CO2 increases, and the perverse incentive becomes stronger (Table 10).

Table 10. Costs of CO2 fee for the 2nd year of application, business as usual scenario..

Category	k_1	k_2	k_3	k_4	N_1	P= $k_1 x k_2 x k_3 x k_4 x N_1$, kn/t	N_{min} , kn	N_{max}, kn
R1	1	1	0.8	1	12	9.6	288	480000
R2	0.85	1	0.8	1	12	8.2	408000	816000
R3	0.75	1	0.8	1	12	7.2	720000	3600000
R4	0.65	1	0.8	1	12	6.2	3120000	0

Source: Author's calculation

Using the same example in the second year, by increasing emission from 42500 t CO_2 annually to 50,000 t/year, savings reach 72000 KN.

In the third year the price per tonne of CO2 further increases and consequently potential saving from increased emission: potential savings from increased emission from 42500 t CO_2 annually to 50000 t reach 90000 kn.

Table 11. Costs of CO2 fee for the 3rd year of application, business as usual scenario

Category	k_1	k_2	k_3	k_4	N_1	P= $k_1 x k_2 x k_3 x k_4 x N_1$, kn/t	N_{min} , kn	N_{max}, kn
R1	1	1	0.8	1	15	12.0	360	600000
R2	0.85	1	0.8	1	15	10.2	510000	1020000
R3	0.75	1	0.8	1	15	9.0	900000	4500000
R4	0.65	1	0.8	1	15	7.8	3900000	0

Potential savings are the biggest for changing category from R3 to R4. E.g. potential savings from increasing emission from 433,333 t/year to 500,000 t/year are 360,000 kn in the first, 480,000 kn in the second and 600,000 kn in the third year of application of carbon dioxide fee.

Hence, savings can be made by increasing emission, which is contrary to the aims of the carbon dioxide fee, to create incentives for CO2 reduction.

Weather this effect is significant for the emission level in Croatia requires further analysis, which is not included in this paper. Here we will analyse incentive to prepare and implement CO2 reduction programmes (impact of coefficient k4) and incentive to increase investment in energy efficiency (impact of coefficient k3).

Our analysis considers three scenarios: business as usual scenario, with measures scenario and scenario with additional measures, as in the second Croatian communication under UNFCCC (Ministry, 2006a). We analyse impact of application of the CO2 fee in energy sector, since it is main source of CO2 emissions and there are estimates of potential savings with measures and witn additional measures (Ministry, 2006a, see also tables 5 and 6). We also assume that increase or decrease of emission does not have impact on change of the source category (and k1 coefficient).

Under *business as usual scenario* annual increase of emissions is 3.3%, in line with emission growh observed in the period 1995-2004.I.e. initial emission $Q_{2008\ g}$ grows at 3.3% annually:

$Q_{2009} = Q_{2008} \times 1.033$ (5)

$Q_{2010} = Q_{2009} \times 1.033 = Q_{2008} \cdot 1.033^2$ (6)

K4 is not applied, since it is assumed that under this scenario there is no specific emission reduction programme.

The *scenario with measures* is based on the presumption that program for CO_2 reduction is in place, so that coefficient k5 can be applied. Implementation of measures foreseen within the program for CO_2 reduction leads to the decrease of emissions in third year of application (2010) by 3.5% compared to the scenario without measures. (Ministry, 2006a)

I.e.

$$Q_{2009} = Q_{2008\cdot} \cdot 1.033$$

$$Q_{2010} = Q_{2009\cdot} \cdot 1.033 \cdot 0.965 \quad (7)$$

The *scenario with additional measures* is based on the presumption that there are increased investments in environmental protection and energy efficiency. We analyze three levels of investments as percentage of profit: 30%, 40% and 50%, and consequently k3=0.7, 0.6 and 0.5 Since the cost of emission reduction can significantly vary depending on the source and type of the emission source, we assume that emission reduction in 2010 reaches 8.2% compared to the scenario without measures.

By comparing scenario with measures with business as usual scenario, we analyse impact and effectiveness of the k2 coefficient.

The scenario with additional measures is used to analyse potential incentive effects of the k3 coefficient. We conduct analyisis for four emission categories (R1,R2, R3 and R4)

Impact of coefficient k4

Table 12 Costs of CO2 fee for the 1st year of application, scenario with measures

Category	k_1	k_2	k_3	k_4	N_1	$P= k_1 x k_2 x k_3 x k_4 x N_1$, kn/t	N_{min} , kn	$N_{max,}$ kn
R1	1	1	0.8	1	9	7.2	216	360000
R2	0.85	1	0.8	1	9	6.1	306000	612000
R3	0.75	1	0.8	1	9	5.4	540000	2700000
R4	0.65	1	0.8	1	9	4.7	2340000	0

Source: authors' calculations

Table 13 Costs of CO2 fee for the 2nd year of application, scenario with measures

Category	k_1	k_2	k_3	k_4	N_1	$P= k_1 x k_2 x k_3 x k_4 x N_1$, kn/t	N_{min} , kn	$N_{max,}$ kn
R1	1	1	0.8	0.75	12	7.2	216	360000
R2	0.85	1	0.8	0.75	12	6.1	306000	612000
R3	0.75	1	0.8	0.75	12	5.4	540000	2700000
R4	0.65	1	0.8	0.75	12	4.7	2340000	

Source: authors' calculations

Table 14 Costs of CO2 fee for the 3rd year of application, scenario with measures

Category	k_1	k_2	k_3	k_4	N_1	$P= k_1 x k_2 x k_3 x k_4 x N_1$, kn/t	N_{min} , kn	$N_{max,}$ kn
R1	1	1	0.8	0.6	15	7.2	216	360000
R2	0.85	1	0.8	0.6	15	6.1	306000	612000
R3	0.75	1	0.8	0.6	15	5.4	540000	2700000
R4	0.65	1	0.8	0.6	15	4.7	2340000	0

Source: authors' calculations

As shown in tables 9-14 the costs can be presented as P*Q, where Q is emission in a calendar year, and P_i.price per ton of CO2 in the year *i.*
Under business as usual scenario, the emissions grow annually at 3.3%. Total fee paid during the period 2008-2010 equals

$P_Q = P_{2008}\ Q_{2008} + P_{2009}\,Q_{2009} + P_{2010}\ Q_{2010} = P'\ Q_{2008}$ (8)

P_i for individual source are presented in column 7 of tables 9-11, while quantities of emission are calculated according to the equations (5) and (6), depending on the initial emission level Consequently, fees paid in the three year period under business as usual scenario are presented in Table 15, column 2. For sources whose emissions are between 30 and 50000 tonnes/year (R1), the costs of CO_2 fee by 2010, under business as usual scenario is estimated as 29.92 Q_{2008}, where Q_{2008} emission of CO_2 in the first year of application of fee (2008).

Table 15 P' for the three year period, total fee / $Q_{2008,}$ kn/t

	Business as usual	With measures	With additional measures			
			k3=0.8	K3=0.7	k3=0.6	K3=0.5
R1	29.92	21.69	21.47	18.96	16.25	13.54
R2	25.43	18.43	18.25	16.12	13.81	11.51
R3	22.44	16.27	16.10	14.22	12.19	10.16
R4	19.44	14.10	13.95	12.32	10.56	8.80

Source: authors' calculations

Scenario with measures is based on the presumption that administrative measures, needed for implementation of the incentive coefficient k_4 are in place, while the other parameters being as in business as usual scenario. In the first year of CO_2 fee application (2008), the costs are the same under business as usual and scenario with measures. In the second year of application, incentive coefficient k_4, according to the (3) equals k_4=9/12= 0.75 and in the third 0.6 (column 5, tables 12-14). Consequently, in the second year and third year of of fee application, the fee per tonne of CO_2 remains stable[6], since the k4 is applied. It is assumed that emission grows at the rate of 3.3%, and consequently the cost of CO_2 fee 1.033 times greater than fee in the first year. In line with starting hypotheses, in the third year of application of CO_2 reduction programme, results start showing. It is assumed that in 2010 levels of the emissions are 3.5% lower than without measures.[7] Consequently, total amount of the fee paid in the third year is 1.03 of the price in the first year[8].(column 3, Table 15).

By comparing total costs within three years period for each emission category we analyse weather weather coefficient k4 creates incentive for adoption and implementation emission reduction programme. Under business as usual scenario, total fee to be paid in three years

[6] As compared with the first year. The price, compared with the second year under business as usual scenario, decreases.

[7] The projections from national communication. Absolute values (table 5) are calculated as % of the initial emission.

[8] Emmissions in the third year, according to the business as usual scenario would reach 1.067 of the initial level. Application of measures leads to the 3.5% decrease, i.e 1.03 increase compared to the 2008 level.

period is between 29.92 Q_{2008} and 19.22Q_{2008} (column 2, table 15). The total cost with measures ranges between is 21.69 Q_{2008} and 14.10 Q_{2008} (column 3, table 14). Consequenty, in the short run (i.e. by 2010) coefficient k4 creates incentive for adoption and implementation of emission reduction programme provided that cost of designing, implementing and administering programme does not exceed 8.23 Q_{2008} for emission category R1, 6.99 Q_{2008} for emission category R2, 6.17 Q_{2008} for emission category R3, 5.35 Q_{2008} for emission category R4 (Table 16).

Table 16. Acceptable cost of emission reduction programme, for each emission category, kn/t and examples of acceptable cost (kn)

category	Cost/Q_{2008}	Examples of acceptable costs , kn	
R1	8.23	246.94	411561.83
R2	7.00	349827.55	699655.11
R3	6.17	617342.74	3086713.70
R4	5.35	2675151.88	0.00

Source: authors' calculations

Hence, for source of 30t/year acceptable cost of programme implementaition is rougly 259 kn, and for the biggest source failing int category R1 (50000 t/year) rougly 412 kn. For R2 category acceptable programme cost ranges between 350,000 (for smallest) and 700,000 kn for biggest sources failing into R2 category.For R3 sources all costs below 620000 kn are acceptable, while for the biggest sources thay can reach 3,090,000 kn.

Finally, for the biggest sources, the acceptable programme cost can be as high as 2,675,000 kn.

Impact of coefficient k3

As mentioned earlier, the scenario with additional measures is used to analyse potential incentive effects of the k3 coefficient. We conduct analyisis for four emission categories (R1, R2, R3 and R4) and the level of investment corresponding to four levels of coefficient k: 0.8, 0.7, 0.6 and 0.5. It is assumed that additional measures, regardless of thief financial weight, have potential for 8.25% reducing emissions compared to business as usual scenario.

Table 15 shows changes of costs within 3-year period depending on the level of investment. To estimate weather k3 provides incentive for investments, we analyse total costs of CO2 reduction in the three year period as

Cost = I+ N,

where

I is total amount of investments in tree year period, and

N total fee paid in the same period.

We assume that k3 creates investment for additional investments provided that total cost (i.e I+N) is lower than under business as usual scenario. I.e.if total fee paid for three years period and additional investment are smaller than fee paid for three years period without investment, k3 can be considered as incentive.

The results

Table 17. Acceptable cost of emission reduction programme and additional investment, for each emission category, kn/t

	K3=0.7	K3=0.6	k3=0.5

R1	10.96	13.67	16.38
R2	9.32	11.62	13.92
R3	8.22	10.25	12.28
R4	7.13	8.89	10.65

Source: authors' calculations

In terms of money, it means that for smallest sources (i.e. 30t/year) acceptable cost of investment and programme is 329 kn. Based on the analysis of the acceptable programme cost (247 kn), there is limited scope for additional investment in energy efficiency. For all sources categories, incentive for additional investment is limited, since it represents roughly 1/3 of the acceptable cost for programme design and implementation. However, it should be noted that in the longer run the benefits might exceed costs. However, in order to develop such detailed analysis, it is necessary to calculate the whole range of common social benefits which emerge from the proposed programme, and which surpass the scope of this work (Tišma, S., Čulo K., Bosnić, Blagaš, P., 2006).

5. Conclusions

The CO_2 fee that is planned to be implemented in Croatia is will create cost for owners and users of emission sources with annuall emission exceeding 30t.
The analyis of the draft regulation on carbon dioxide fee shows that some of so-called "incentive coefficients" do not create incentive for CO_2 emission.
There are 4 categories of sources, depending on their size. For bigger emission sources, fee per tonne of CO_2 is lower than for small sources. This can provide incentive to increase emissions in cases where emission is close to the threshold, or to maintain existing emissions. Weather this is of considerable impact on the national level requires further analysis.
There is strong incentive to apply with administrative requirenments, i.e. to create and implement CO_2 reduction programme. In order to be effective, approving of such programme should be based on precise criteria, and the monitoring capacities of the Energy Efficiency and Environmetal Protection Fund should be developed. The adoption of National Implementation Strategy and Action Plan would be quite helpful in this respect.
The incentive for additional investment in energy efficiency is rather limited, accounting for 1/3 of the acceptable cost for designing, implementing and administering emission reduction programme.
Based on the analysis of the proposed regulation for CO_2 emission fee we conclude that it provides incentive for implementing measures for CO_2 reduction. However, incentive for additional measures is rather weak. Consequently, it is not reasonable to expect that Croatia will meet its obligations in the first commitment period

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