

# Cooperation in global climate policy: potentialities and limitations

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## Abstract

Since the Kyoto conference the role of the major developing countries (DCs) has been an issue involving a number of conflicting interests. While on the one hand we understand the reasons prompting DCs to refuse obligations to reduce climate gases, their sheer size makes at least the biggest DCs (China, India) major sources of climate gas emissions. Our intention here is to analyze the potentialities for a cooperative solution to this conflict. A conflict model is used to discuss the diverging interests of major DCs and industrialized countries (IC). Concentrating on the power-generation sector, we investigate the conditions for cooperation, i.e. for the DCs' voluntary participation in climate policy in their own interests. In the case of DCs with local environmental goals and ICs interested in joint implementation, secondary benefits provide the basis for cooperation. Thus, the DC's choice of technology becomes the crucial factor in conflict resolution. This enables us to formulate the conditions of cooperation interrelating the DCs' choice of technology and the ICs' investment in joint implementation in such a way as to fulfill both global environmental goals and the DCs' national goals. The example of PR of China illustrates our reasoning. © 2001 Elsevier Science Ltd. All rights reserved.

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## 1. Common but different responsibilities in climate policy

Among the many problems and conflicts besetting the evolving climate protection regime, we concentrate here on the role of the major developing countries and their contribution to a global climate policy. This topic has become a controversial issue since the Kyoto conference 1997 and is central to the future development of the climate protection regime.

It is well known that the 1992 Framework Convention of Climate Change (FCCC) has become a cornerstone of global climate policy representing a compromise between a wide range of different interests among the member countries. The catch-all formula of “common but different responsibilities” provided for different roles for industrialized (ICs) and developing countries (DCs), notably in the obligations imposed on them in connection with climate protection policy.

This led to a grouping of the member states of the FCCC into Annex I, Annex II and non-Annex I coun-

tries, the latter comprising the developing countries with no commitments to reducing climate gases.<sup>1</sup> A further group mainly consisting of Annex I countries was introduced (as Annex B) at the conference of the parties in Kyoto (1997). Annex B countries have agreed to reduce specified amounts of climate gases within a specified time-span (Umwelt, 1998, p. 20).

The conflict underlying this distribution of different obligations has become apparent since the Kyoto conference. The United States insisted that the rules pertaining to the Annex B countries, (i.e. voluntary commitment to reducing climate gases) be extended at least to the major DCs and made this a precondition for the ratification of the Kyoto protocol. The latest conferences of the parties in Buenos Aires (1998) and in Bonn (1999) did not succeed in solving this conflict (Oberthür and Ott, 1999; Umwelt, 1999; Ott, 1998; Simonis, 1998; Benedick, 1998).

<sup>1</sup> Listed in Annex I are: Australia, Austria, *Belarus*, Belgium, *Bulgaria*, Denmark, Germany, *Estonia*, the EU, Finland, France, Greece, Ireland, Iceland, Italy, Japan, Canada, *Latvia*, *Lithuania*, Luxembourg, New Zealand, the Netherlands, Norway, *Poland*, Portugal, *Romania*, *The Russian Federation*, Sweden, Switzerland, *Slovakia*, Spain, *The Czech Republic*, Turkey, *Ukraine*, *Hungary*, USA, Great Britain and Northern Ireland. Annex II is Annex I minus the transformation countries (marked by italics in our list). The new industrializing countries and the developing countries are all countries outside Annex I.

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With this conflict unresolved, it is only to be expected that global climate policy will reach a deadlock exacerbating the underlying danger of a “prisoner’s dilemma” situation: climate protection without the United States and without the important DCs makes the obligations of the other Annex B countries ineffective in even achieving the more modest goal of global emission stabilization.

For this reason we intend to analyze the chances of a cooperative solution to this conflict. In order to specify the conditions for a cooperative solution we attempt to analyze the trade-off between growth and emission targets within a DC and the relation between a DC and an IC. A constellation is termed a cooperative solution if the DCs become active members of the global climate policy by choice and in their own interests and make a contribution of their own to stabilizing climate gases (a contribution yet to be defined).

We define the group of “major” DCs as countries whose emissions — though initially low — are increasing rapidly as a consequence of their high rates of economic growth (e.g. South Korea and Mexico). Likewise, we concentrate on high-population countries with very low levels of emissions per capita but with high contributions to global emissions due to their size (e.g. China and India).

Our paper is organized as follows: in the next section, we discuss the reasons prompting DCs to refuse obligations to reduce climate gases. These are analyzed in the framework of a conflict model enabling us to study the factors influencing the trade-off between a DC’s goal of fostering economic growth and environmental goals like CO<sub>2</sub> reductions. In this section we show that there are good reasons for a DC to refuse emission reduction goals of its own, whereas industrialized countries are in a situation to fulfill both economic and environmental goals.

This divergence of interests between DCs and ICs makes the quest for a cooperative solution even more important but also more difficult. In Section 3, we explicitly introduce the relation between ICs and DCs, accepting their different utility functions and inquiring into mechanisms permitting a link between the different utility functions, thus resulting in indirect modes of cooperation.

To model the decisions of DCs and ICs more realistically, we take one specific country as a point of reference. In our paper, the People’s Republic of China represents the options and limitations available to a DC. In addition, we concentrate on the power-generation sector as a crucial area in global climate policy.

The People’s Republic of China is a good example of the problems of the different roles in the FCCC. On the one hand, the customary indicator of GDP per capita (530 USD) (Brauch, 1998, p. 313) shows the People’s Republic of China to be representative of DCs in general; also, the greenhouse gas emissions per capita are very low. In terms of the “polluters pay” principle in

environmental policy and with respect to limited economic capability, this country has good reasons for refusing obligations for emission reductions. On the other hand, the PR of China is one of the major polluters of the world in absolute terms due to the size of its population and as a consequence of its immense take-off in terms of economic growth (Malik, 1994, p. 53). Without some form of cooperation with the ICs, the goal of stabilizing (let alone reducing) global emissions of greenhouse gases seems to be beyond the limits of feasibility. Without cooperation, the conflicts between economic and environmental goals characterizing this DC will become a general problem.

## 2. The trade-off between economic and environmental goals

In this section we analyze the basic decision problem focussing a single country aiming to achieve both the economic goal of increasing the net social product and the environmental goal of limiting energy-related emissions. These targets are physically interdependent because the energy supply required to produce an additional unit of social product ( $\Delta W$ ) is linked with an increase in gas emissions ( $\Delta G$ ). This link is mainly determined by technical parameters of power generation, i.e. the kind of primary energy and the type of technology in use. Since for DCs the energy supply operates as a limiting factor in economic growth, this interdependence of welfare and emission goals becomes the basic trade-off in political terms (see Wiesegart (1997, p. 272) for China as an example). DCs prefer economic growth, refusing emission goals which militate against the achievement of the economic goal. This is especially the case if the emission goals are defined for global emissions, allocating the costs of emissions reductions locally and the related benefits globally. In the search for potential cooperative solutions in climate policy, one initial step is to look for ways of resolving the basic trade-off in DCs’ policy options. In the framework of a simple model of a closed economy with a power-generation sector (see Appendix A), the national actor can use the following options to influence the characteristics of the basic trade-off (Fig. 1).

First, there is the option to invest costs  $C$  in power-generation technology with different emission intensities ( $g$ ). Traditional power-generation technology involves higher emission intensity ( $g_1$ ) than the new technologies ( $g_2$ ), i.e.  $g_1 > g_2$ . Thus the national actor may try to change the overall emission intensity of the power-generation sector ( $g$ ) by investing in new power-generation technology. The overall emission intensity becomes a function of allocating available investment (Max  $C$ ) between the old and the new technologies ( $p$ ).

Second, the national actor fosters changes in the overall emission intensity by shutting down old power plants

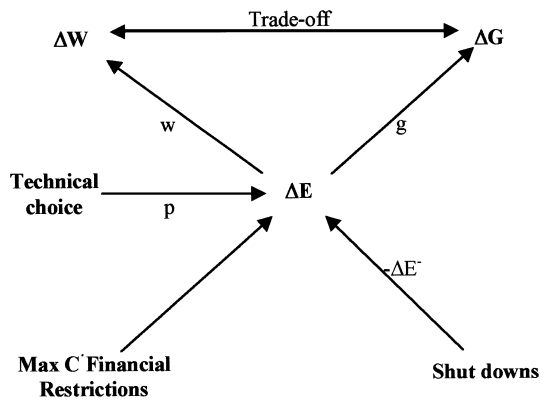


Fig. 1. Model framework.

and replacing them with traditional or modern power-generation installations ( $\Delta E^-$ ).

While energy productivity ( $w$ ) is independent of the technical methods of power generation, the overall emissions intensity is a variable depending on political decisions. In this perspective, the conditions limiting the technical choice become an important element in conflict resolution.

A simple form of dealing with the conditions of technical choice is to introduce the costs of achieving a given economic goal ( $S^W$ ) and an emission goal ( $S^G$ ), respectively.

The necessary costs for the goals  $S^G$  and  $S^W$  are dependent on three types of variables — the level of the politically determined goals, technical variables like emission intensity and energy productivity, and the allocation variable ( $p$ ) (for details see Appendix A).

With constant values for technical and allocation variables, Fig. 2 shows the linear relation of the investment costs and the shutdowns. The intersection of the cost function shows the solution of the trade-off between economic and environmental goals. The existence of an equilibrium depends on the different slopes of the cost functions  $C^W$  and  $C^G$  representing the different emission intensities of old and new power-generation technologies.

There are major differences between the technical parameters of the power-generation sector of ICs and DCs. When the energy productivity ( $w$ ) of the DC's power-generation sector is smaller and the emission intensity ( $g$ ) higher in comparison with the IC, the point of equilibrium shifts toward the frontier of the available option space. Even if the DC and the IC pursue same-level goals, allocate the same proportion of investment to new technologies and act within the same option room, the chances of the DC resolving the trade-off by its own means is comparatively smaller.

1. More important are the different capabilities of ICs and DCs to change the technical parameters of the problem by changing the allocation of investments toward new technologies. On the one hand, the

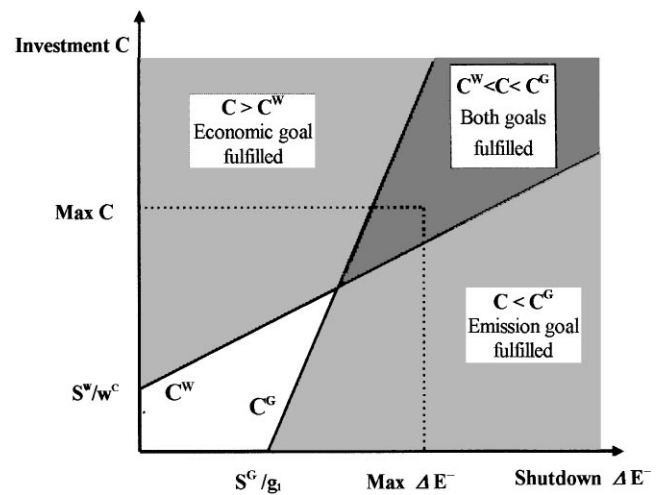


Fig. 2. Emission target costs  $C^G$  and welfare target costs  $C^W$  for dismantled energy  $\Delta E^-$  (source: Scheffran, 1998a).

transition depends on costly technology imports and is limited by the availability of foreign currency. A more technological limitation on the transition process is the necessity for complementary investments to provide the infrastructure for modern power stations, i.e. transport facilities for primary energies like coal and gas and a power grid for the transmission of electricity. These factors keep the  $\text{Max } C$  low for the investment in new power stations and/or diminish the transition ratio ( $p$ ) from traditional to new power technologies.

2. In DCs, the range of the second control variable, the maximum number of shutdowns ( $\text{Max } \Delta E^-$ ), is also severely restricted. Energy supply is often a factor limiting economic growth in DCs. Even where power stations are old, technically inefficient and highly emission intensive, their energy output is of high economic value. In situations like this,  $\Delta E^-$  will be small.

Given these various forms of restrictions in a DC, the existence of an equilibrium solution within the available space is unlikely.

DCs unable to achieve an equilibrium solution have to make a choice between economic and environmental goals, usually favoring the former. They are prepared to invest the maximum costs ( $\text{Max } C$ ) in the power-generation sector at the expense of environmental targets.

A realistic climate policy strategy has to accept the fact that, especially in their take-off period, DCs have different goals from ICs and refuse to commit themselves to emission reductions.<sup>2</sup> This makes the dilemma facing a global climate policy all the more evident. Without

<sup>2</sup> It is important to realize that this resumé is linked to the take-off period of a DC. The conditions change with declining rates of economic growth, increasing technical capacity in the domestic power-generation sector and the related infrastructure.

cooperation between the DCs and the ICs, even the comparatively modest goal of stabilizing the global emission levels may prove to be unattainable.

In the next section we argue that in a DC the existence of a domestic environmental policy plays an important role in establishing links between domestic and global environmental goals.

### 3. Secondary effects of climate policy measures and their impact on national environmental policy

A closer look at DCs' evaluation of environmental problems reveals their preference for policies dealing with local and regional environmental degradation and pollution. Therefore, the DCs' refusal to accept environmental goals on a global level may not be equally applicable to all kinds of environmental goals. We now demonstrate this for the PR of China.

#### 3.1. Environmental goals and programs in the PR of China

In the post-1949 period, environmental protection was more or less a by-product of the predominant policies for combating hunger and illness. But in 1978, environmental protection became part of the constitution of the PR of China and a year later the national environment law was enacted (Schmidkonz, 1996, p. 13; Schüller, 1997, p. 567). As we can see from the specific environmental laws, decrees and standards put in place since then, the PR of China is in a state of transition towards qualitative economic growth with environmental quality regarded as a valuable asset per se.

In the 1990s, some specific steps were introduced to implement the agreed environmental goals, the most important being the Five-Year Plan (1996–2000) to

improve the environment and implement Agenda 21. The National Environmental Protection Agency (NEPA) set up a long-range "Green Project Plan" extending up to the year 2010, with 1500 specific measures to be implemented in 3 five-year stages. Central here are measures to improve the quality of water and air. Also of high priority are SO<sub>2</sub> emissions and acid rain (Wu, 1997).

Agenda 21 combines several specific measures into a national strategy of sustainable development (Wang, 1994, p. 15). The promotion of green technology and energy preservation via improved efficiency of technical equipment are part of this strategy (Kang *et al.*, 1995, p. 167; Wang, 1994, p. 15).

Nevertheless, the implementation of these programs is restricted by a lack of financial resources and shortage of technical equipment and know-how (Rösch *et al.*, 1996, p. 123). In the latest five-year plan, this has led to an emphasis on multilateral cooperation in environmental policy with a view to safeguarding the realization of national environmental goals (Schmidkonz, 1996, p. 15).

These efforts to achieve a national capacity to deal effectively with environmental problems must be seen in relation to the severe environmental damages of about 8% of the national product (NEPA, 1996). Air pollution contributes 32.5% to this aggregate damage, water pollution 41% and contamination of the soil 26.5% (NEPA, 1996, p. 13). Air pollution has an especially severe impact in urban areas, which cover only 0.5% of the country's surface but have 45% of national coal consumption concentrated in them. In these areas, deviation from the national air pollution standards by a factor of 2–4 is normal (Schmidkonz, 1996, p. 15) (for pollution norms see Table 1). The main levels in the pollution norms — which are equivalent to the WHO standards (World Bank, 1997, p. 10) — are SO<sub>2</sub>, NO<sub>2</sub> and the total suspended particulates (TSP).

Table 1  
Standards of air quality in the PR of China and in the Federal Republic of Germany<sup>a</sup>

Parameter	Average per	Standards (µg/m <sup>3</sup> )		
		PR of China	WHO standards	FR of Germany
SO <sub>2</sub>	Year	20	50	—
	Day	50	125	300
	Hour	150	—	—
TSP	Year	80	—	75
	Day	120	120	250
NO <sub>2</sub>	Year	40	30	80
	Day	80	150	—
	Hour	120	400	100
CO	Year	—	—	10,000
	Day	4000	—	10,000
	Hour	10,000	30,000	—
O <sub>3</sub>	Hour	120	150–200	120

<sup>a</sup>Source: Own listing from Environmental Resources Management (1997, p. 109) and TA-Luft (1996).

The power-generation sector is one of the main polluters, three-quarters of primary energy being domestic coal. The power stations are comparatively low in their efficiency, 28% on average, as compared with 37% in ICs like Germany (Rösch *et al.*, 1997; p. 55; Naihu and Heng, 1994; Oberheitmann, 1996, p. 17).

Summarizing this brief review of environmental goals and policies in the PR of China, we can say the following:

1. There is a high degree of emphasis on — and a number of programs designed to deal with — local and regional environmental problems, in contrast to the low emphasis on global environmental goals and programs.
2. Much effort has been invested in increasing the capacity to implement the national environmental goals in a variety of programs but this effort is limited by a lack of financial and technical resources. Hence there is a demand for mutual cooperation between ICs and the PR of China in the field of environmental protection.

### 3.2. Technical choice as a basis for cooperation

An appropriate choice between alternative power-generation technologies may provide a link in implementing both regional and global environmental goals. This points to the importance of the choice of technologies as a factor in reducing emissions both on a regional and a global level.

A technical option providing this dual effect on regional and global environmental goals can be said to have a secondary effect.<sup>3</sup> We use this term in the sense proposed by Ayres and Walter (1991, p. 237) and Pearce (1992, p. 1). While primary effects of policy measures lead to reduced emissions of climate gases and related pollutants, secondary effects reduce damages of other kinds by curbing other technologically related emissions such as SO<sub>2</sub>, NO<sub>x</sub> and particles.

The existence of a technical option with this kind of secondary effect is dependent on the physical and technical characteristics of the specific problem under investigation.<sup>4</sup> With respect to the emission of CO<sub>2</sub> and the regional emissions NO<sub>x</sub> and SO<sub>2</sub>, two factors determine the amount of emissions: the amount of coal input and the technical devices of different kinds of power generation. Thus, improving the technical efficiency of power generation always reduces the emission intensity (*g*) of both global and regional emissions. On the other side we have technologies in the form of additional devices of a power station (as in Table 2) which allow the reduction of one specific type of emission.

<sup>3</sup> Secondary effects are often referred to as a bundle of benefits connected with technical cooperation like joint implementation, transfer of capital, technical know-how, etc. We use the term in a narrower sense.

<sup>4</sup> The range of the technical options in power generation has been described in Bräuer *et al.* (1999, p. 70).

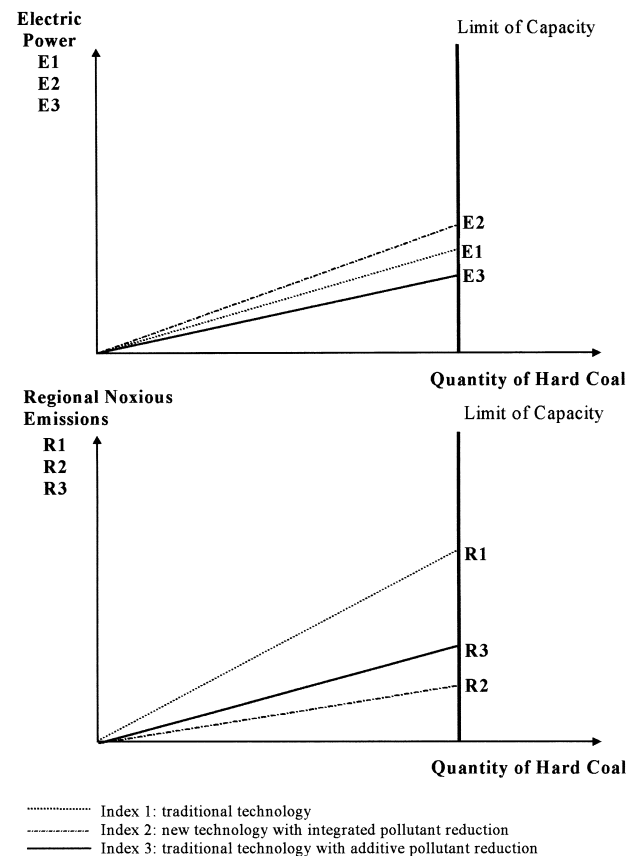


Fig. 3. Description of additive and integrated pollution reduction with energy production functions of fossil power stations.

This kind of technology is *additive*, while the reduction of emission intensities via increased efficiency integrates environmental protection and can hence be called an *integrated* technology.

The main difference is in the effect these options have on the efficiency of a power station. While additive technologies tend to lower the degree of efficiency, integrated technologies result in an overall increase in efficiency (see Fig. 3). The amount of CO<sub>2</sub> emissions from a fossil power station depends solely on the chemically bound carbon inside the fuel used. Therefore, the characteristic line of the carbon emissions is equal for all described plants (see Tables 2 and 3).

Given this, we can say that a technical choice in favor of additive emission-reducing devices produces a trade-off between global and regional environmental goals. While additive technology reduces specific regional emissions, it simultaneously reduces the overall efficiency of the power stations and thus increases the emission intensity of other coal-dependent gases like CO<sub>2</sub>. Fig. 3 illustrates the different effects. Only integrated power-generation technologies allow a reduction of the different kinds of emissions simultaneously, via increased effectiveness. Decisions in favor of integrated power-generation techniques link the different environmental goals

Table 2  
Comparison of different fossil power stations<sup>a</sup>

Kind of power station	Efficiency (%)	Fuel and additives (g/kWh)			Emissions (g/kWh)			Specific investment costs (DM/kW)
		Hard coal	Natural gas	Limestone <sup>a</sup>	CO <sub>2</sub>	SO <sub>2</sub>	NO <sub>2</sub>	
Out of date hard coal steam power station without desulfurization and DENOX (E1/R1)	30	405		—	1150	8	3	Approx. 2030
Out of date hard coal steam power station with desulfurization and DENOX (E3/R3)	27–28	434			1200	1	1	Approx. 2180
Up to date steam power station with adjusted desulfurization and DENOX (E2/R2)	38	308		12	876	0.69	0.69	2200
	45	260		10	740	0.58	0.58	Approx. 2375 for reequipping constellations dependently
Combined power station with pressure fluidized bed combustion for hard coal (E2/R2)	43	335		25	810	0.59	0.59	
Compound power station with natural gas turbine and hard coal steam generator (E2/R2)	46	220	47	8	660	0.38	0.27	2812
Combined power station with integrated hard coal gasification (E2/R2)	46	310			760	0.15	0.30	2625
Gas and steam combined power station with natural gas firing (E2/R2)	52–55		140		380	—	0.35	Approx. 1600

<sup>a</sup>Source: Bräuer et al. (1999, p. 115). Limestone is necessary for desulfurization.

Table 3  
Comparison of the emissions from different energy technologies

Input referred to 1 kg of hardcoal						
Technology	Hard coal (kg)	CO <sub>2</sub> emissions (kg)	Electrical energy (kWh)	SO <sub>2</sub> emissions (g)	NO <sub>2</sub> emissions (g)	
Traditional technology	1	2.84	2.7	21.6	8.1	
Traditional technology provided additive	1	2.84	2.3	3	3	
New technology	1	2.84	3.25	2.25	2.25	
New technology under optimal conditions	1	2.84	3.85	2.25	2.25	
Output referred to 1 kWh electrical energy						
Technology	Hard coal (g)	CO <sub>2</sub> emissions (kg)	Electrical energy (kWh)	SO <sub>2</sub> emissions (g)	NO <sub>2</sub> emissions (g)	
Traditional technology	405	1150	1	8	3	
Traditional technology provided additive	434	1200	1	1.3	1.3	
New technology	308	876	1	0.69	0.69	
New technology under optimal conditions	260	740	1	0.58	0.58	

technologically and make them mutually supportive. In this sense, the choice of technology becomes the basis for cooperation. If we take  $S_1^G$  as global and  $S_2^G$  as regional environmental goals, we can link these two goals

with a coupling factor determined by the choice of technology.

Additive technologies for reducing specific types of regional emissions make the coupling factor negative,

thus producing a trade-off between  $S_1^G$  and  $S_2^G$ . On the other hand, integrated technologies make for a positive factor and allow a resolution of the trade-off.

To illustrate the magnitude of this effect we consider the following example. An out-of-date hard coal steam power station without desulfurization and without denitrification and with an efficiency of 30%, needs 405 g hard coal for the production of 1 kWh of electrical energy (2.7 kWh of electrical energy can be produced with 1 kg hard coal). As by-products 2.84 kg CO<sub>2</sub>, 21.6 g SO<sub>2</sub> and 8.1 g NO<sub>2</sub> are released. If this power plant is equipped additively with desulfurization and with DENOX, the efficiency of the system drops by about 2%. Thus 1 kg of burned hard coal now produces only 2.3 kWh of electric power. Accordingly, this releases 2.84 kg CO<sub>2</sub>, but only 1 g SO<sub>2</sub> and 1 g NO<sub>2</sub> emissions. In other words, the production of 1 kWh of electrical work now releases 50 g more CO<sub>2</sub>. With today's integrated technology and under optimal conditions it is possible to produce 1 kWh using 260 g hard coal with related CO<sub>2</sub> emissions of 740 g/kWh to achieve 0.6 g SO<sub>2</sub> and 0.6 g NO<sub>2</sub>. For this reason with an appropriate technology choice in relation to the described case it would be possible to save 460 g CO<sub>2</sub> emissions. For the comparison of the different cases see Table 3 and Fig. 3.

Therefore, in order to organize cooperation, i.e. the voluntary participation of a DC in global climate policy, we need to find ways of influencing the DCs' readiness to opt for integrated technologies.

#### 4. Conditions for cooperation

##### 4.1. Two countries with different economic and environmental goals

Drawing on the model in section 2 and Appendix A describing the conflict between economic and environmental goals, we now discuss the relation between two countries  $i = 1, 2$  with  $i = 1$  representing an IC and  $i = 2$  a DC (Scheffran, 1998a). Both countries allocate costs  $C_i$  for investment in traditional energy technology ( $k = 1$ ) or new energy technology ( $k = 2$ ) in order to achieve economic goals ( $S_i^W$ ) and environmental goals ( $S_i^G$ ). They also control the number of shutdowns of old power-generation facilities ( $\Delta E_i^-$ ). The question now is what conditions would make it beneficial for both to cooperate in a program to achieve their goals jointly.

The countries are interrelated in the following way: the IC may have the option to invest a fraction  $z_1$  of its investment in joint activities with the DC,<sup>5</sup> which in

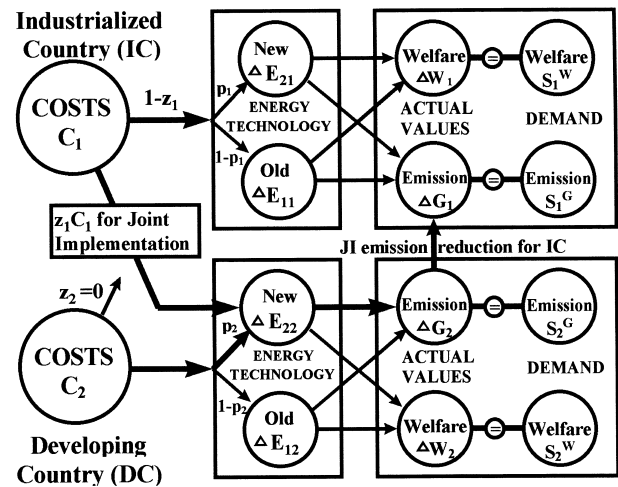


Fig. 4. Distribution of energy costs in an industrialized and a developing country with welfare and emission goals for two energy paths (source: Scheffran, 1998a).

return is prepared to invest a higher fraction  $p_2$  of its costs in new low-emission technologies. As an incentive, the emission reduction in the DC is partly accounted to the IC, which can thus save investment costs, while the DC would profit from finance and technology transfer and a reduced emission of harmful gases into the regional environment. The other link between the two countries comes from the flow of emissions and the coupling of the emission goals as discussed above.

Fig. 4 illustrates these possible interrelations. Via the emission link, the DC's allocation  $p_2$  directly influences the global level of emissions and indirectly influences the IC's capacity and costs for achieving the necessary reduction of the global emissions. On the other side, the IC's decision on  $z_1$  has an impact on  $p_2$  and thus on the level of regional emissions in the DC. The decisions of both countries are interdependent. Two cases are distinguished, depending on the control variables of both countries reflecting the preferences for the two technology options:

- *Non-cooperative case* ( $z_1 = 0, p_2 = 0$ ; status quo): In this case IC does not invest in the DC and the DC does not invest in new energy technology.
- *Cooperative case* ( $z_1 > 0, p_2 > 0$ ): Both countries increase their control variables jointly if it is beneficial for both to do so, i.e. if the cost of achieving their respective goals can be reduced by coordinated decisions.

In a non-cooperative relation,  $z_1$  and  $p_2$  are zero and no financial means are supplied by the IC for joint implementation projects. Therefore, the DC will not itself invest in integrated technologies.

<sup>5</sup> Joint activities may include various cooperative actions between two countries, including joint implementation projects and clean development measures.

As a consequence, the power-generation sector of the DC consists of out-of-date steam power stations with additive technologies to meet the regional environmental goals, and a consequent trade-off between the DC's and IC's environmental goals. The question is what conditions make it possible to avoid this vicious circle and achieve a cooperative solution? What combination of  $0 \leq z_1 \leq 1$  and  $0 \leq p_2 \leq 1$  will enable both countries to realize their goals at lowest possible cost?

Rational actors might calculate the effects of the non-cooperative versus the cooperative case to achieve their own goals. The IC is prepared to invest in joint implementation projects if it saves abatement costs, while the DC's incentive for integrated power-generation technology is cost saving to meet the regional environmental goals. This two-fold cost condition creates incentives which are compatible with cooperation. Cooperation means that the respective cost condition of a country is only achievable by the other country's activity. In this case, a cooperation surplus exists equivalent to the sum of the IC's and the DC's avoided abatement costs.

But even with a positive cooperation surplus, the evolution of cooperation is not self-evident. The cooperation surplus is an ex post gain present from ongoing cooperation and is hence uncertain. A positive cooperation surplus is more likely to function as an incentive if the uncertainty of future gains is limited. There are two ways of limiting the risks. The first one is related to the size of the expected gain. The bigger the expected surplus the smaller the risk that exogeneous shocks beyond the control of the actors will significantly eliminate the gains thus making the cooperation unattractive. Hence the actors need information about the crucial factors determining the size of the expected surplus. The second kind of risk is to prevent the cooperation partners playing defective since the existence of a surplus depends on simultaneous actions by both actors. So each actor needs to know whether there is a prisoner's dilemma inherent in the game they are planning to play. To further clarify these conditions for cooperation we now discuss the following case.

4.2. The case of goals with asymmetric priorities

The general case of two goals for two countries each is now specified to analyze an asymmetric situation corresponding to the current emission obligations under the FCCC. IC invests costs to pursue its primary goal of achieving a given emission reduction, while DC pursues its primary goal of economic growth without the obligation to reduce emissions, though ofcourse its environment would profit from regional emission reductions. The secondary goals are to be achieved by the remaining control variable of energy shutdown. Thus, we study the projection of the four-dimensional space of goals on the

two dimensions of primary goals, without neglecting the complexity of the problem.

It is further assumed that IC only invests its costs  $C_1$  in new energy technology ( $p_1 = 1$ ) and in the new technology of DC (with share  $z_1$ ), while DC would initially have no incentive to invest in new costlier technologies with fewer emissions ( $p_2 = 0$ ). Achievement of the two goals is now a function of the costs of both countries according to Eqs. (A.11) and (A.12) in Appendix A.

Similar to the analysis in Section 2, the two equations correspond to two target lines  $\tilde{C}_1$  and  $\tilde{C}_2$  in cost space, for which each of the countries achieves its primary goal (see Fig. 5). As long as one of the countries is off its target line, it has an incentive to move towards this line, leading to a hypothetical dynamic in cost space (represented here by the arrows starting from its initial values  $C_i^0$ ). Both countries can only achieve their goals at the same time if a stable intersection point exists for both lines within the admissible cost  $0 \leq C_i \leq \text{Max } C_i$ . An essential condition is that the determinant of the interaction matrix is positive, which is an indication of the stability of interaction between IC and DC (see Appendix A). Since the slopes of both lines depend on the technical parameters  $g, w$  and  $c$ , the control variables  $z_1$  and  $p_2$  and the primary goals  $S_1^G, S_2^W$ , the question is for which of these combinations an intersection point exists at the lowest possible cost. Since the countries cannot directly influence each other's control variables, cost optimization can only be achieved in cooperation with the other country.

The situation can also be examined from a game-theoretic perspective. The non-cooperative case  $z_1 = 0$  and  $p_2 = 0$  is a cost optimum if a small deviation results in cost increases for both countries. It is a Nash equilibrium if no country can reduce costs by unilateral action. Finally, the non-cooperative case would be a saddle point if both actors would not achieve cost reductions

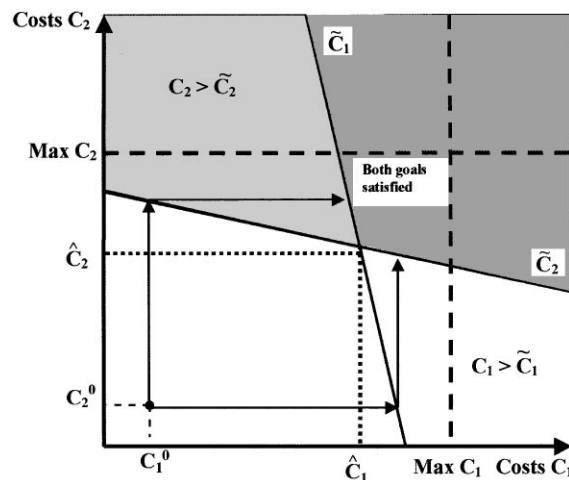


Fig. 5. Target lines  $\tilde{C}_1$  and  $\tilde{C}_2$  and intersection point  $(\hat{C}_1, \hat{C}_2)$  in cost space of two countries (source: Scheffran, 1998a).

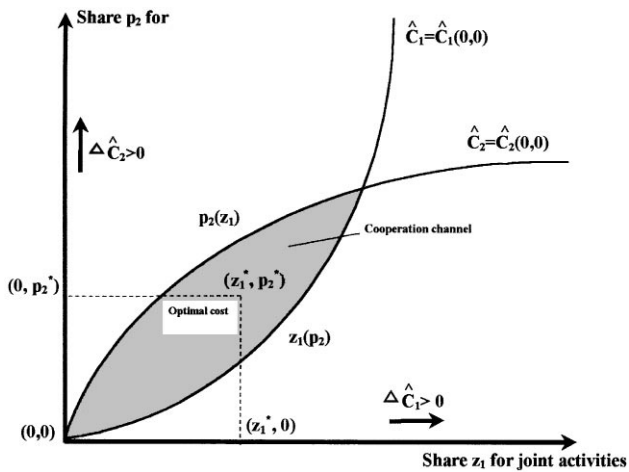


Fig. 6. Cooperation channel in preference space  $(z_1, p_2)$ .

unilaterally but a move by one country would reduce costs for the other country. In this case, values exist in the decision space  $(z_1, p_2)$  for which both countries can cooperatively achieve cost reductions compared to the non-cooperative case (see Fig. 6). Such a “cooperation channel” exists if the difference of emission intensities  $\Delta g = g_1 - g_2$  between new and old technology is sufficiently large and the cost difference  $\Delta c = c_2 - c_1$  is small. These differences in the emission intensities and the respective costs of alternative technologies provide the criteria for estimating the size of the available cooperation gain. Within this region of mutual benefit, the countries can identify the optimal cost allocation  $(z_1^*, p_2^*)$  providing the minimum cost for the coalition of the two countries. Since in Fig. 6 the non-cooperative case is a Nash equilibrium, both countries would only move towards the optimal case jointly, that is, they have to negotiate and then fix the best combination for both. The situation corresponds to a prisoner’s dilemma game, which implies that the transition from non-cooperation  $(0, 0)$  to cooperation  $(z_1^*, p_2^*)$  requires adequate control and verification measures to ensure that no country would seek unilateral gains from non-cooperation, i.e. playing defective.

The risk of playing defective is further diminished if the DC pursues its own regional environmental goals as discussed in Section 3.

## 5. Concluding remarks on institutions for cooperation

We started out by looking at the problems and conflicts inherent in the catch-all formula of “common but different obligations” for FCCC member countries and inquiring into the possibilities for a cooperative solution. If we assume that the cooperative case does in principle exist, what are the consequences for the respective obligations of ICs and DCs?

Fundamentally, this is a question of creating institutions which are supportive to the cooperative case. There will be no demand for joint implementation projects from the ICs if there are no well-defined pollution rights and no allocation of them to specific actors within an IC. Only a pollution tax or the establishment of an emission trade market allows for a compensation of pollution credits from abroad against domestic obligations. It is well known that this institutional precondition is non-existent in the majority of the Annex B countries. This may indicate that these countries plan to fulfill their emission targets under status quo conditions of technical progress and sectoral shifts. If this is the case, the imposition of global emission reductions on DCs has no legitimacy and can be expected to create conflicts. As we have shown above, a DC will not *per se* have the capability to meet both its economic and global environmental goals without internal conflicts. The resulting trade-off will be an obstacle to cooperation.

From the DC’s perspective, the supply conditions of joint implementation projects are important. Fundamental to this supply is the realization of the DC’s own environmental goals. As long as environmental policy is only of symbolic value, we may expect the supply of joint implementation projects to be low. Thus creating an institutional capacity for a national environmental policy is an important precondition for cooperation. Our considerations on the conditions for cooperation in climate policy open up a new perspective on the crucial question of the DC’s baseline. Taking the obligations from domestic emission standards seriously (i.e. emission reduction to national standards within a defined timetable), the DC’s decision on cost allocation in the non-cooperative case  $(p_2 = 0)$  implicitly defines a (sectoral) baseline for global emissions too.

If joint implementation activities succeed in switching the implementation of national goals toward integrated environmental technologies  $(p_2 > 0)$ , this can be said to create an additional reduction of climate gases which can be credited.<sup>6</sup>

## Appendix A. Outline of the interaction model with regard to energy use

### A.1. Single country

The analysis in Sections 2 and 4 is based on a model describing the interaction between countries allocating financial resources means to the energy sector to satisfy economic and environmental demands. It is assumed that in a given time period a certain amount of energy

<sup>6</sup> Problems of the distribution of the cooperative surplus are analyzed in Pickl (1998).

$E$  is used to produce both economic output  $W(E)$  (welfare) and emissions  $G(E)$ :<sup>7</sup>

$$W(E) = wE \quad (\text{ceteris paribus}), \quad (\text{A.1})$$

$$G(E) = gE, \quad (\text{A.2})$$

where  $w$  is the average energy productivity and  $g$  the related emission intensity, which are treated here as technological constants during the time period. The other production factors (especially capital and labor) are dealt with as given.<sup>8</sup> An additional supply of energy ( $\Delta E$ ) in the next period stems from investment in new power stations, with absolute investment costs ( $C$ ) and specific investment costs ( $c$ ) per energy unit, given full capacity utilization rates of the existing power stations:

$$C = c\Delta E. \quad (\text{A.3})$$

The increase of the national product ( $\Delta W$ ) and the related increase of emissions ( $\Delta G$ ) can thus be linked to the investment costs:

$$\Delta W = w\Delta E = w^c C, \quad (\text{A.4})$$

$$\Delta G = g\Delta E = g^c C \quad (\text{A.5})$$

with  $w^c = w/c$  representing the specific investment costs of producing an additional unit of social product and  $g^c = g/c$  the related emission intensity.

Each country is assumed to have a choice between different energy paths, denoted by  $k = 1, \dots, m$ . In the simple model of two options ( $k = 1, 2$ ), the player allocates a part  $p_k$  of the investment costs to the technical option  $k$ , such that  $\Delta E_k = p_k C / c_k$  is the amount of new power produced for option  $k$ . For a given cost allocation  $p_2 = p$  and  $p_1 = 1 - p$  the additional energy supply is given as

$$\Delta E = \Delta E_1 + \Delta E_2 = (1 - p)C/c_1 + pC/c_2 \quad (\text{A.6})$$

with  $0 \leq p \leq 1$  the share invested in new technology (option 2) and  $c_{1,2}$  the specific investment costs for technologies 1 and 2. The second control variable available to a country is the shutdown of power stations with older technologies ( $\Delta E^-$ ). Dependent on the decisions on cost allocation and shutdowns, the changes in related emissions ( $\Delta G$ ) are

$$\Delta G = g_1 \Delta E_1 + g_2 \Delta E_2 - g_1 \Delta E^- = g_p^c C - g_1 \Delta E^- \quad (\text{A.7})$$

with  $g_k^c = g_k/c_k$  the cost-specific emissions of the technologies ( $k = 1, 2$ ) and  $g_p^c = (1 - p)g_1^c + pg_2^c = g_1^c + p\Delta g_2^c$  the cost-specific emissions as a function of the cost allocation  $0 \leq p \leq 1$ . Accordingly,  $\Delta g_2^c = g_2^c - g_1^c$  are the cost-specific emission changes related to the shift between technologies 1 and 2.

Simultaneously, the decisions on the two control variables provide an increase in the economic output

$$\Delta W = w(\Delta E - \Delta E^-) = w^c C - w\Delta E^- \quad (\text{A.8})$$

with  $w^c = w/c$  and assuming a homogeneous growth effect from the different power-generation technologies.

In our simple model, a player selects a fixed target for emission reduction  $\Delta G = S^G < 0$  and simultaneously a specific economic target  $\Delta W = S^W > 0$ . Eqs. (A.7) and (A.8) give the necessary investment costs for achieving  $S^G$ :

$$C^G = \frac{S^G + g_1 \Delta E^-}{g_p^c}, \quad (\text{A.9})$$

where  $C^G$  is the investment cost in the power-generation sector compatible with emission target  $S^G$ . In the same way, the necessary investment for achieving the economic target  $S^W$  is given as

$$C^W = \frac{S^W + w\Delta E^-}{w^c}. \quad (\text{A.10})$$

With given values of  $g_p^c$  and  $w^c$ , Fig. 2 shows the linear relation of the investment costs and the shutdowns for the case that an intersection point exists within the feasible action space ( $0 \leq C \leq \text{Max } C^*$  and  $0 \leq \Delta E^- \leq \text{Max } \Delta E^-$ ). The existence of an equilibrium depends on the different slopes of the cost functions  $C^W(\Delta E^-)$  and  $C^G(\Delta E^-)$  and on the economic and emission targets  $S^W$  and  $S^G$ . The differences in the slope of the cost functions are due to the different emission intensities of the technologies 1 and 2.

## A.2. Two countries

The basic analysis for a single country is now extended to the interaction between two countries  $i = 1, 2$ , with country 1 representing an IC and country 2 a DC.<sup>9</sup> Both countries can allocate a fraction  $p_{ki}$  of their investment  $C_i$  to old energy technology ( $k = 1$ ) or new energy technology ( $k = 2$ ) in order to achieve economic goals ( $S_i^W$ ) and environmental goals ( $S_i^G$ ). They also control the number of shutdowns of old power-generation facilities ( $\Delta E_i^-$ ). In addition, the IC may have the option to invest a fraction  $z_1$  of its costs in joint activities with the DC.

Fig. 4 illustrates these possible interrelations. Depending on IC's investment share for joint activities

<sup>7</sup> This model has been developed by Scheffran (1998a, b).

<sup>8</sup> A more detailed analysis would include a non-linear relation between the different input factors, including the energy input (see Kümmel et al., 1997).

<sup>9</sup> The following is based on a more detailed mathematical analysis described in Scheffran (1998a).

$0 \leq z_1 \leq 1$  and DC's investment share for new energy technologies  $0 \leq p_2 \leq 1$ , which are the major control variables of both countries, we distinguish between the *non-cooperative case*  $z_1 = 0, p_2 = 0$  (status quo) and the *cooperative case*  $z_1 > 0, p_2 > 0$ . In accordance with Section 4.2, we analyze the case where IC allocates investment  $C_1$  to pursue its primary goal of emission reduction  $\Delta G_1 = S_1^G < 0$ , while DC allocates investment  $C_2$  to pursue its primary goal of economic growth  $\Delta W_1 = S_1^W > 0$ , and energy shutdown  $\Delta E_i$  is adapted to the secondary goals ( $i = 1, 2$ ). Achievement of the two goals is now a function of the costs of both countries according to the following equations:

$$-\Delta G_1 = sc_{11} C_1 + sc_{12} C_2 + S_1^U = -S_1^G, \quad (\text{A.11})$$

$$\Delta W_2 = sc_{22} C_2 + sc_{21} C_1 + S_2^U = S_2^W. \quad (\text{A.12})$$

The negative sign for  $\Delta G_1$  and  $S_1^G$  reflects the fact that the increase of emissions is regarded as a negative value (as opposed to economic growth, which is regarded as a positive value), i.e. the aim is a specific emission reduction  $S_1^G < 0$ . The interaction coefficients  $sc_{ij}$  represent the effect of costs invested by country  $j = 1, 2$  on the goal of country  $i = 1, 2$ .  $sc_{11}$  and  $sc_{22}$  stand for the self-induced effects of each country on itself,  $sc_{12}$  and  $sc_{21}$  are the effects on the other country. These interaction coefficients are functions of the parameters  $g, w$  and  $c$  of the energy technologies of both countries and of the control variables  $z_1$  and  $p_2$ . The terms  $S_i^U$  contain all the non-cost-related impacts on the goal functions, especially the shutdown of old power stations  $\Delta E_i^-$ .

Eqs. (A.11) and (A.12) correspond to two target lines  $\tilde{C}_1 = C_1^G$  and  $\tilde{C}_2 = C_2^W$  in cost space (see Fig. 5). Both goals can be achieved at the intersection point of both lines with the coordinates

$$\hat{C}_i = \frac{sc_{jj} \hat{S}_i - sc_{ij} \hat{S}_j}{D}, \quad i = 1, 2, \quad (\text{A.13})$$

where  $\hat{S}_1 = -S_1^G - S_1^U, \hat{S}_2 = S_2^W - S_2^U$  and  $D = sc_{11} sc_{22} - sc_{12} sc_{21}$  is the determinant of the matrix of interaction coefficients. The existence of this equilibrium point in feasible cost space  $0 \leq C_i \leq \text{Max } C_i^*$  depends on the interaction coefficients  $sc_{ij}$  and thus on the major control variable of each country. The point is to find technical parameters  $g, w, c$  and control variables  $z_1$  and  $p_2$  for which both countries can achieve their goals  $S_1^G$  and  $S_2^W$  at lowest possible equilibrium cost. The transition from the non-cooperative case ( $z_1 = 0, p_2 = 0$ ) to the cooperative case ( $z_1 > 0, p_2 > 0$ ) is discussed qualitatively in Section 4 (Fig. 6).

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