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CO_2 -MONITORING IN GERMAN INDUSTRY: TARGET ACHIEVEMENT IN 1997

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Abstract

German Industry and Trade entered into a voluntary commitment, to make special efforts to reduce its specific CO_2 emissions and its specific energy consumption by 20% by the year 2005 (base 1990). To verify the obligations taken on, it was agreed that there should be accompanying CO_2 monitoring where the reduction results would be presented at annual intervals and verified for conformity with the targets. The Rhine-Westphalia Institute for Economic Research (RWI) was appointed to perform this monitoring.

In 1997 RWI presented the first monitoring report, dealing with the special methodical and empirical or statistical problems and the target achievement in 1995 and 1996. The second report, based on the development in 1997 contains a detailed analysis of the growing energy efficiency in the different sectors of German industry and points out the specific importance of structural change and business cycle fluctuations for the absolute target achievement in 1997. This report demonstrates that these variables both are of great importance for the target achievement, especially in case of an absolute CO_2-reduction target. Above this a large number of actions could be identified which document the special efforts to reduce CO_2 emissions. Even if the actions cannot be attributed to the voluntary obligation alone, they still document the intensive efforts to achieve a more rational use of energy and a reduction in CO_2. The comparison of the declared objectives with the efficiency improvements or CO_2 reductions already achieved shows that in some industries - even more than in 1996 - the target was almost achieved as early as 1997. This should be an incentive to reconsider the targets.

1 Content of Declaration

The voluntary commitment of German industry is based on the declarations from a series of associations organised in the Federation of German Industries (BDI), the Federal Association of the German Gas and Water Industry (BGW), the Association of German Electricity Works (VDEW), the Association of Energy and Power Industries (VIK) and the Association of Municipal Enterprises (VKU).2 The businesses grouped together in these associations represent more

Schedule 1

Updated and Extended Climate Protection Declaration by German Industry and Trade

Sector and Association	Base-year	Reference Variable	Reduction in %
Potassium: Kaliverein	1990	t CO_2/t Raw Salt	66
	1990	mil. t CO_2	78
Cement: Vereinigung Deutscher Zementwerke	1987	kJ Fuel/kg Cement	20
Limestone: Bundesverband der Deutschen Kalkindustrie [1]	1987	kJ Fuel/t Lime	15-20
Ceramic tiles and panels: Bundesverband keramische Fliesen und Platten	1990	kg CO_2 /t Tiles and Slabs	25
	1990	kWh/t Tiles and Slabs	20
Brickworks: Bundesverband der Deutschen Ziegelindustrie	1990	kJ/kg Bricks	28
Refractory/fireproofing: Bundesverband der Feuerfest-Industrie [1]	1987	kg CO_2/t Refractory Products	15-20
Steel: Wirtschaftsvereinigung Stahl	1990	kg CO_2/t Rolled Steel	16-17
	1990	mil. t CO_2	21-27
Non-ferrous Metals: Wirtschaftsvereinigung Metalle	1990	GJ/t NF-Metals	22
Chemical Industry [2]: Verband der Chemischen Industrie	1990	Energy Index/Production Index	30
	1987	mil. t CO_2	44
Paper & Pulp Paper: Verband Deutscher Papierfabriken	1990	kg CO_2/t Paper	22
	1990	GJ/t Paper	20
Glass and Mineral Fibre: Bundesverband der Deutschen Glasindustrie und Mineralfaserindustrie	1987	kg CO_2/t Glass	25
	1987	GJ/t Glass	22
Textile Industry: Gesamtverband der Textilindustrie	1987	PJ/a	20
Sugar Industry: Verein der Zuckerindustrie	1990[1]	kWh/dt Beet Processing	20
Public Electricity Supply: Vereinigung Deutscher Elektrizitätswerke [3]	1990	mil. t CO_2	12
Petroleum Industry: Mineralölwirtschaftsverband	1990	Litres Heating Oil/m^2 Residential Accommodation	25
Gas Industry: Bundesverband der deutschen Gas- und Wasserwirtschaft	1990	kg CO_2/kWh Net Energy	34
Municipal Energy Supply: Verband kommunaler Unternehmen	1990	mil. t CO_2	25

[1] The data refer exclusively to West Germany. – [2] In relation to the year 1990, the Chemicals Industry expects a reduction in absolute CO_2 emissions by 23.8 mil. t. by the year 2005. - [3] Reduction target by the year 2015. By the year 2005, the VDEW expects a CO_2 reduction in the amount of 8 to 10%.

than 70% of final industrial energy consumption. They almost completely cover the field of public and industrial power generation, and represent many of the energy suppliers who provide energy to the residential and commercial sector.

The declaration by the BDI is a compilation of 14 individual declarations. The reduction promises are typically formulated as specific variables, supplemented in some cases by absolute promises to reduce emissions (Schedule 1). The year 1990 now predominates as the base year; only a few associations in the non-metallic minerals industry are still using 1987. With the adoption of 1990 as the base year, most of the declarations were also extended to cover Germany as a whole. The lime and refractories industries

are exceptions here. The reduction obligations, amounting in the General Declaration to the 20% already mentioned, differ greatly from industry to industry (from around 16 % in the steel industry to 66% in the Potassium Association). Both energy consumption and CO_2 emissions are given as specific variables, the reference variable is as a rule the specific production output of the industry measured in physical units. Only the chemicals industry uses an index of net production, since this is the only possible way of sensibly grouping together the extremely heterogeneous product range of that industry. The declaration from the associations organised in the BDI is supplemented by the voluntary obligations of the VDEW, VKU, BGW and VIK, although VIK, as the umbrella association of the industrial energy and power users has consciously omitted to formulate any quantitative reduction target, to avoid double counting. Among the other associations, only the BGW refers to a specific variable, whereas VDEW and VKU have entered into absolute obligations to reduce consumption and emissions.

2 Framework Conditions of CO_2 Emissions

The development of CO_2 emissions is dependent on numerous influencing factors above and beyond the actions of the associations involved in the voluntary commitment. Among these factors the legal and institutional background, the development of energy prices and the short-term economic cycle and temperature fluctuations are of particular importance in the assessment of the CO_2 reductions to be presented. The public law fundamentals include in particular the actions adopted by the Federal Government for the implementation of the climate protection programme, which had already attained the force of law prior to the Declaration of Global Warming Prevention. These actions include in particular the amendments of the thermal insulation ordinance and the ordinance on heating systems and small combustion plants, and the statutory requirements to reduce conventional environmental pollution (13. BImSchV) which have also resulted in a reduction of CO_2 emissions in the field of energy supply. In addition, they include statutory regulations (e.g. Electricity Supply Act) and voluntary agreements on more intensive use of energy sources which conserve the environment and resources.

The influence of energy prices not only on the direct consumption of energy, but above all on the investment behaviour and profitability calculations of businesses are of especial importance to the target achievement. Rising energy prices or additional taxation of energy consumption can be regarded at least in part as the cause of investments in energy saving technologies and actions aimed at CO2 reductions. The actions performed by the associations involved in monitoring in 1997 are therefore to be examined against the background of the energy price developments and perhaps new taxes in this years. It is not to be expected that energy price impulses lead to direct reactions in terms of consumption, but rather that they influence investment decisions by way of medium term expectations. The development of unit energy costs since 1990 is used here as an indicator for these medium term

price expectations, and this variable is constructed by weighting the prices of the individual energy sources with the consumption structure of the 1997 year and then setting them in relation to the production of the same year. These unit energy costs initially rose moderately in all the sectors studied here from the start of the 90s onwards, and have continuously fallen since 1993 (cf. Table 1). Even if this variable is highly influenced by consumption structures specific to individual sectors (in the iron and steel industry, for example, the use of pit coal and pit coal coke predominates, whereas in non-ferrous metal production the consumption of electricity is paramount), it is apparent that the general energy price development since the start of the 90s as already described is a general influencing factor. The decline in electricity prices since 1994 is particularly pronounced. The only exception is the textile industry, with rising unit energy costs as a result of drastic declines in production. With the exception of this sector, however, an additional impetus of energy prices towards more efficient energy consumption and therefore an influence on the actions covered by CO_2 monitoring can be ruled out.

Table 1

Unit Energy Costs in Manufacturing

	1991	1992	1993	1994	1995	1996	1997
	DM/1000 DM Production						
Total Manufacturing	95,97	95,82	102,43	95,56	93,86	89,38	87,60
Minerals	213,50	195,00	185,41	168,77	178,40	176,22	180,57
Iron and Steel	594,63	606,65	618,46	550,38	552,99	577,30	515,45
NF-Metals	195,31	192,04	207,43	208,91	205,75	195,46	179,47
Chemicals	158,11	152,85	155,97	148,23	145,72	140,84	136,96
Wood, Pulp etc.	389,59	385,31	385,47	366,15	343,30	330,18	303,90
Glas	398,10	377,35	394,36	392,88	388,56	379,23	369,50
Textiles	95,93	103,91	115,59	110,88	113,07	116,14	119,12
	1991=100						
Total Manufacturing	100,0	99,8	106,7	99,6	97,8	93,1	91,3
Minerals	100,0	91,3	86,6	79,0	83,6	82,5	84,6
Iron and Steel	100,0	102,0	104,0	92,6	93,0	97,1	86,7
NF-Metals	100,0	98,3	106,2	107,0	105,3	100,1	91,9
Chemicals	100,0	96,7	98,6	93,8	92,2	89,1	86,6
Wood, Pulp etc.	100,0	98,9	98,9	94,0	88,1	84,8	78,0
Glas	100,0	94,8	99,1	98,7	97,6	95,3	92,8
Textiles	100,0	108,3	120,5	115,6	117,9	121,1	124,2

Own Computations

Temperature plays a considerable part in a large proportion of non-industrial energy consumption, as the overwhelming proportion of that energy is used

to heat homes and commercial premises. The influence of temperature is normally measured with the aid of heating degree days: this measure indicates the number of days on which the average temperature is below a certain level, as a rule 17ø C. 1990 was exceptionally warm in comparison with the long-term average, and the heating period relatively short as a result of the mild winter. Similar conditions applied to 1997, even if that year was colder in general than 1990. In contrast, the temperatures in 1996 were significantly below the long-term average, not only in the first quarter, but also in the entire second half of the year. Compared with 1990 the last two years are significantly colder and - ceteris paribus - energy demand should be remarkably higher than in 1990.

Table 2

Macroeconomic Development

1996 and 1997

Period	Private Consumption	Government Consumption	Equipment	Buildings	Exports	Inputs	Total GDP
			in billion DM				
			1996				
1st Quarter	424	148	57	79	203	202	728
2nd Quarter	435	152	65	108	203	205	753
3rd Quarter	440	154	63	110	206	210	772
4th Quarter	460	164	76	99	222	215	781
			1997				
1st Quarter	423	150	58	79	212	212	735
2nd Quarter	440	153	68	105	230	223	776
3rd Quarter	438	151	65	106	235	231	791
4th Quarter	465	159	79	96	248	234	780
			growth rate in %				
			1996				
1st Quarter	2,2	3,4	-0,2	-13,8	3,8	3,8	0,0
2nd Quarter	0,8	3,5	1,4	-1,7	2,1	0,4	1,1
3rd Quarter	1,8	3,5	2,4	1,2	6,9	3,1	2,2
4th Quarter	1,5	0,7	3,7	0,3	7,7	4,4	1,8
			1997				
1st Quarter	-0,2	1,1	1,7	0,9	4,9	4,8	0,9
2nd Quarter	1,2	0,8	5,0	-2,4	13,5	9,0	3,0
3rd Quarter	-0,2	-1,5	4,3	-4,0	14,1	9,9	2,4
4th Quarter	1,1	-2,9	4,3	-3,5	11,7	8,7	2,4

Federal Statistical Office and own calculations

The German Economy heavily depends on the development of world exports, exchanges rates especially in relation to the US-dollar and import prices. In 1997 all of these factors persistently contributed to a stabilisation of macroeconomic growth. In 1996 and even more in 1997, exports of goods and services of German industry grew with an expanding rate (cf. Table 2). This growth was favoured by expanding global trade, and also partly by the continuous devaluation of the Deutsche Mark against the dollar from mid 1996 onwards. Export orientated sectors like the chemicals industry more than half of whose production is sold on foreign markets or iron and steel production, were thus able to exploit their production capacities significantly better in these years.

The remaining domestic demand, in contrast, only grew moderately. Governmental consumption in particular was overshadowed by the attempts to consolidate public budgets, as the deficit increased significantly in 1996 and could not be reduced in 1997. This resulted both from a loss of income on the one hand and higher expenditure (e.g. pit coal subsidies) on the other.

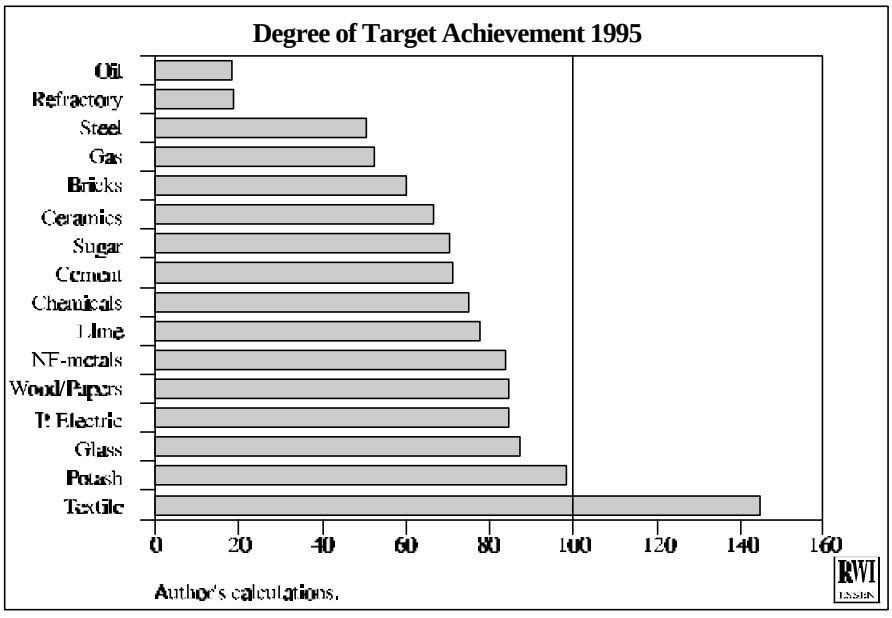
The relatively hard and long winter at the start of 1996 was of significance not only to CO_2 emissions and energy consumption, but also to macroeconomic and sectoral developments. This influence becomes particularly clear with residential building investments, which declined by an above average extent in the first few months of the year. A recovery only commenced at the middle of the year, without however being able to compensate in full for the drop in production in the initial months. Apart from the weather the decline of building investments was surely also a result of the moderate growth in income of private households and the abandonment of subsidies for building private homes in the form of interest deductions at the end of 1994. The construction industry suffered directly from this development and, owing to input inter-linking, the greater part of the non-metallic minerals industry, including cement production, construction ceramics manufacture and the brick industry, and parts of the glass industry were indirectly affected.

3 Target Achievement Until 1995

As mentioned above all actions already been embarked until 1995 would have been implemented even without the voluntary agreement and cannot therefore be accounted for as special efforts. Thus it seems highly important to examine the target achievement until 1995. In general the comparison of the declared objectives with the efficiency improvements or CO_2 reductions until 1995 demonstrates that on average the target has been achieved up to 75% before the declaration of German industry came into force (Figure 1). Nevertheless there are quite important differences between branches: some sectors have arrived at 90% or even more, some others are below 50%. In the textile industry for instance the energy consumption had already fallen below the in tended target, the target achievement was 145% in 1995. This trend is primarily due to structural change in eastern Germany and the drop of textile

production since 1990. The potash Industry had already achieved 98.3% of its target in 1995. The efficiency improvements are decisively characterised by the drastic reduction in capacity at the East German locations. Both the gains in efficiency in handling energy and the adjustments to production caused absolute CO_2 output to drop by 77% to roughly 1.1m t. Even if this success was achieved before the Declaration came into force, it should be realised that this reduction would not have been possible without the input of in some cases considerable additional funds and specific skill. Similar results are valid for other German Industries, especially for Cement or Paper Industry. An analysis with chronological and geographical differentiation reveals that the increases in energy productivity are primarily attributable to the commissioning of new, thermally optimised, facilities. This is a result of reunification and to extensive modernisation and restructuring in East Germany, which were already implemented before the issue of the Climate Protection Declaration. Other branches are quite below their target in 1995. In the iron and steel industry the target achievement was only 54%, that target being a reduction in specific CO_2 emissions by 17% to 1,734 kg by the year 2005. On the absolute part of the promise to reduce emissions, the steel industry has already achieved around 45% of its target. In the refractory industry the progress until 1995 is rather modest. This is not surprising since the refractory industry is the only branch of industry apart from lime that, among all the associations involved in the Climate Protection Declaration, limited its reduction target to West Germany and cannot therefore claim CO2 reductions from the restructuring of the production facilities in eastern Germany.

Figure1



4 Progress Made in 1996-1997

As mentioned above changes in energy efficiency depend not only on actions of the members of the voluntary agreement, but are influenced by legislation, energy prices, weather conditions and macroeconomic development. These exogenous determinants may disturb the medium term development in either direction and have to be eliminated from the original data set. This has been done by statistical methods as well as qualitative inspection. If these more erratic fluctuations were extracted from the observed energy consumption and CO_2 -emissions most of the sectors engaged in the voluntary agreement have improved their efficiency and come closer to their target (cf. Table 3). A large number of actions are responsible for this development:

- The most important actions by far concerns the optimisation of existing production units in cement, lime, brick, iron and steel production. For instance capital goods needed for clinker and cement production are generally provided with a long service life of more than 30 years. Against this background large capital investment in the cement industry primarily concern the modernisation of existing rotary kilns. For the environmental protection requirements new cyclone preheaters were installed which replaced the old technology of lower energy efficiency. In addition to this action particularly emphasis was given to the technical possibilities of heat recovering. The construction of a new heating boiler in one case leads to an increasing generation of electrical power from the preheater exhaust gas. Finally a more rational use of energy and a reduction in CO_2 emissions was forced by the insertion of modern grate plates to the clinker cooler. With the adaptation of the continuously evolving level of technology to existing rotary kiln plants German cement industry avoided CO_2 emissions at a level of approximately more than 39 000 t/a.
- Development and improvement of new technologies and replacement of less efficient production units by more efficient appliances. In the glass industry at one furnace the commissioning of an new oxygen generator took place. The combustion of gas with pure oxygen instead of air in the glass melting process led to a 20% decrease in energy consumption. For instance in the ceramic tiles and slabs production a carriage type kiln for tile firing was converted to the roller kiln system. In that type of kiln, it is no longer necessary to heat the carriage bearing the firing material to 1,200°C, and therefore in this specific case it was possible to save more than 50% fuel. With the aim of energy saving the sugar industry has commissioned a new press for mechanical pulp dewatering. The application of an additional pulp press leds to higher dry substance content with the result that oil consumption of the following evaporating drying unit decreased by 1 600 t per year. A great part of the reduction in specific energy requirement results from the optimisation of exhaust steam utilisation in the process of sugar production. Energy conservation activities in the sugar industry leds to an remarkable decreasing: Specific

energy consumption fell from some 36 kWh/100 kg of beet in 1990 to 31 kwh/100 kg of beet in 1997.

- Replacement of small scale production units by more efficient and large scale appliances. For instance in iron and steel production the replacement of three small blast furnaces by the new construction of a modern large scale and the replacement of the blast furnace/oxygen steel works production method by commissioning of electric furnace steel works at three different locations is responsible for the CO2 reduction of the iron and steel industry in 1995 and 1996 by 2.2m t. Similar results hold for public electricity generation, paper production and cement works.

- The most important actions by far concern the construction of new power stations, replacing conventional industrial power stations and steam generators by modern combined cycle installations (some of which are operated with co-generation facilities). These actions facilitate a significant reduction in fuel input for the generation of process steam and electrical energy in the chemicals, paper, iron and steel and sugar industry. Together with the improvements in efficiency, fuels rich in carbon have been replaced by lower carbon fuels, with the result that the industry's CO2 output has been reduced even further than the increases in efficiency permitted. In the field of co-generation, the industry has increased its power generation, for instance by installing gas turbines or converting back pressure turbines. This action is especially worthy of note, because the live steam demand has continuously fallen in recent years as a result of energy saving measures (installation of heat exchangers, utilisation of waste heat steam, etc.). The falling demand for thermal energy does however limit the power generation in classical co-generation back pressure systems, and therefore the co-generation potentials are limited.

Table 3

Specific Energy Consumption					
Association	Base year	1996	1997	reduction	target
	development of the reference variable			in %	
Potash Industry	0.091	0.031	0.030	67.6	102.5
Cement Industry[1]	3 510	2 995	2 976	15.2	75.3
Lime Industry[1,2]	5 631	4 667	4 746	15.7	78.6
Ceramic Tiles and Slabs	594	523	469	21.1	87.0
Brick Industry	2 274	1 924	1 878	17.4	62.1
Refractory Industry[1,2]	307	292	238	22.3	112.4
Iron and Steel Industry	2 089	1 856	1 836	12.1	71.2
Non-ferrous Metals Industry	36.55	30.35	31.28	17.2	78.1
Chemicals Industry	100.0	76.1	75.8	24.2	80.7
Wood pulp, Paper and Cardboard Industry	1 130	865	838	25.8	117.2
Glass Industry[1]	1 040	818	856	17.7	70.8
Textile Industry	89.4	61.5	60.2	32.6	163.2
Sugar Industry	36.6	33.8	31.0	12.9	64.5

[1] Base year 1987. [2] West Germany.

Even if the actions cannot be attributed to the voluntary obligation alone, they still document the intensive efforts to achieve a more rational use of energy and a reduction in CO2 emissions. The efforts are directed both at the optimisation of individual production processes, and at energy supply in general. It becomes clear that isolated improvements of individual production processes are increasingly running up against technical and physical limits, and a further increase in energy efficiency therefore hardly appears possible or is associated with unreasonably high costs. It can be deduced from this finding that integrated supply strategies are an attractive opportunity to use energy as rationally as possible and jointly. A typical example is recycling of foundry sand, which is created as a residue in the new large scale blast furnace, in the cement manufacturing process of a cement works nearby. The foundry sand is a substitute for energy-intensive burnt clinker in the cement industry, with the result that 600,000 t CO2 can be avoided each year in the cement industry. Examples of this integrated supply strategy are provided not only by the steel and cement industry, but above all by the consulting

initiative of the VIK. Even if this initiative was only called into being last year, the results already achieved indicate that co-operation between various associations and companies will be able to bring about a tangible increase in the use of residual heat from industrial plant and significantly improve the CO2 balance. This took place without the involvement of legislation or additional taxes.

5 CO2-Balance

The Climate Protection Declaration from German industry was conceived and adopted as an instrument to reduce CO2 emissions. The yardstick for the effectiveness of this instrument is therefore in the analysis of CO2 emissions. As a result of the possibility of double counting mentioned at the beginning of this paper and the treatment of electricity consumption, the CO2 reductions achieved cannot however be calculated as the sum of the individual reductions. It is also to be taken into account that sector production changes in individual cases can change the picture in favour of or to the detriment of absolute CO2 emissions. In spite of these limitations, the overall balance will surely provide an impression of the effectiveness of the voluntary commitment.

From 1990 to 1997, the CO2 emissions from the industrial associations taking part in monitoring were reduced by 34.8 m t or 17 % (cf. Table 4). In relation to 1996, where CO2-emission have been reduced by 42.3 m t, the target achievement has fallen down by roughly 4 %. Even if the highest contributions were made by the chemicals industry and the steel industry, these sectors are responsible for the growth of CO_2 -emissions in 1997. For instance between 1996 and 1997 iron and steel production increased by 4 mill. t and also CO_2 -emissions by roughly 7 mill. t. The public electricity supply sector was able to reduce its CO_2 balance by 28m t between 1990 and 1997, although (gross) power

Table 4

Voluntary Obligation Declaration and CO_2-Reduction					
Association	Base year	1996	1997	Reduction	
	mil. t CO_2			mil. t CO_2	%
Potash Industry	4.8	1.1	1.1	3.7	77.7
Cement Industry[1]	13.0	10.2	10.0	3.0	23.0
Lime Industry[1,2]	2.7	2.4	2.5	0.3	9,2
Ceramic Tiles and Slabs	0.7	0.5	0.4	0.2	35.2
Brick Industry	2.4	2.3	2.2	0.2	6.6
Refractory Industry[1,2]	0.4	0.3	0.3	0.1	28.2
Iron and Steel Industry	69.9	57,9	63,4	6.5	9.3
Non-ferrous Metals Industry	14.6	12.7	13.4	1.2	8.4
Chemicals Industry	65.5	49.2	51.1	14.4	22.1
Wood pulp, Paper and Cardboard Industry	14.4	13.2	13.5	0.9	6.2
Glass Industry[1]	6.4	6.0	6.2	0.2	2.5
Textile Industry	5.8	3.9	3.9	1.9	33.4
Sugar Industry	4.5	2.6	2.3	2.2	48.0
Total	205.1	162.3	170.3	34.8	17.0
Public Electricity Supply	289.0	264.0	261.0	28.0	9.7
[1] Base year 1987. [2] West Germany.					

generation adjusted for fluctuations in capacity utilisation and temperature remained almost constant.

6 Conclusions

Even if a period of not quite three years' experience with the Voluntary Commitment from German Industry and the monitoring report is relatively short, the two reports nevertheless permit a number of conclusions that may be of significance for the final success of this instrument.

It has first to be noted that the report from the associations contains a large number of actions that document the special efforts to reduce CO2 emissions.

Even if the actions cannot be attributed to the voluntary obligation alone, they still document the intensive efforts to achieve a more rational use of energy and a reduction in CO2 emissions. The voluntary obligation and CO2 monitoring are still in the experimental phase. It can not therefore be regarded as surprising that the monitoring process itself and its results are still in need of improvement. This concerns, among other factors, the reports from the associations involved in monitoring. In comparison, for example, with taxes or levies, this instrument demands a higher degree of preparedness to disclose information on actions intended to increase energy efficiency. This requires not only staff capacities to perform this function, but also as a rule demands access to internal data and information from within companies. This could explain, at least in part, the heterogeneous nature of the descriptions of actions on which this monitoring report is based. In spite of these information problems, it is surely indisputable that the presentation of the actions is an essential part of the monitoring process and the voluntary obligation. Only with transparent presentation of the actions taken can the objective of monitoring be fulfilled.

The comparison of the declared objectives with the efficiency improvements or CO2 reductions already achieved shows that in some industries the target was almost achieved as early as 1995. This should be an incentive to reconsider the targets. A linear extrapolation of the CO2 reductions achieved between 1990 and 1995 would not be appropriate, as the savings achieved in East Germany certainly cannot be repeated to the same extent. It is also to be taken into account that, when one remembers that energy consumption and capital input is complementary, the increases in efficiency are tied to investment cycles and can therefore take place intermittently. Nevertheless, degrees of target achievement of 85 or higher point to additional savings potentials, which should lead to a corresponding redefinition to document the effectiveness of this instrument.

Curriculum vitae

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- sectoral and regional effects of ecological tax reform.

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