

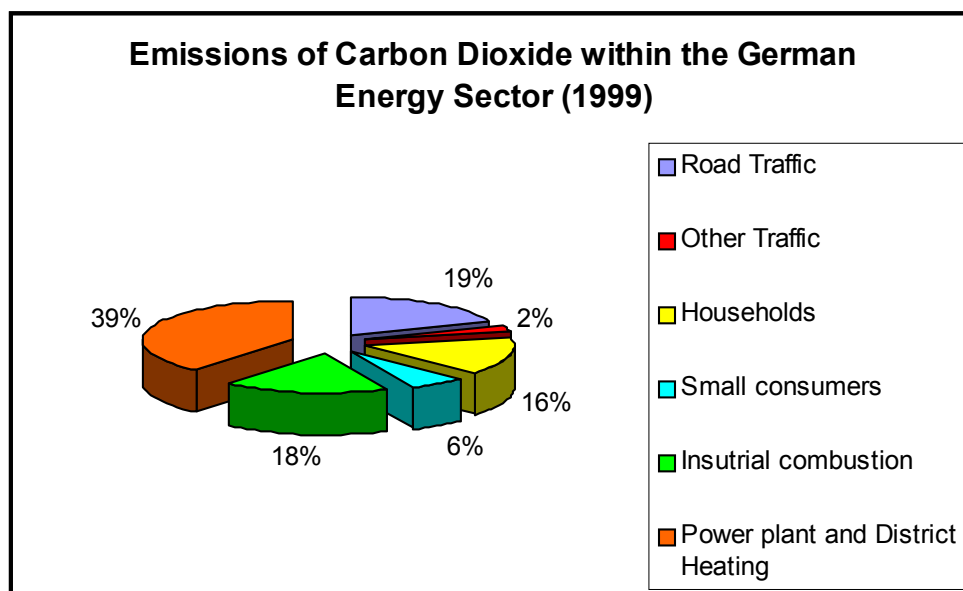
Environmental Sustainability

►Indicator 1: Per Capita Energy Sector Carbon Dioxide Emissions

Climate change, as defined by the United Nations Framework Convention on Climate Change (UNFCCC), is “a change of climate attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable periods” (UNFCCC 2001). Research work by scientists has revealed that climate change is occurring more rapidly because of increases in man made emissions of greenhouse gases (GHG). One of the key GHG is Carbon Dioxide and emissions from the energy sector³ contributes 37.5% of total man made carbon emissions in the world. As a result this is the sector where most efforts to achieve reductions have been focused.

In Germany carbon emissions from the energy sector are approximately 95% with the remaining emissions being generated by large industry and international transport, which emit approximately 3% and 2% of total German carbon emissions respectively. A breakdown of the different players within the German energy sector according to the amount of carbon dioxide emitted is presented in Table 1.1. Since 1990, Germany has achieved a significant downward trend in greenhouse gas emissions. The main reasons for this trend results from East Germany’s integration into the Federal Republic, while in the western states CO₂ emissions have remained essentially stable – a phenomenon sometimes dubbed “wall-fall profits”. As a result, German carbon dioxide emissions from energy and manufacturing industries declined by 83 Tg and 57 Tg respectively between 1990 and 1999. However, the downward trend to a very large extent

Table 1-1



³ The IPCC Define the Energy related emissions as those that are:

- A. Combustion related – energy/transformation, Industry, transport, residential/commercial/institutional users, Other including military users, combustion of biomass
- B. Extraction/distribution of fuels

Large Industry and International transport (that is maritime bunkering and air transport) is not included in the energy sector.

The indicator per capita energy sector carbon dioxide emissions measures a country's contribution to the environmental aspects of sustainable development in terms of national efforts to reduce emissions of carbon dioxide. To calculate the German vector for this HELIO International indicator the following national data was collected. (see table 1.2).

Table 1-2. Data to Calculate Per Capita Energy Sector Carbon Dioxide Emissions

	1990	1999	Change 1990 - 1999
Total Emissions CO ₂ from fossil fuel consumption in Germany (million metric tonnes carbon dioxide)	986.5	833.5	- 15.5%
Total Carbon Emissions (million metric tonnes carbon)	269.02	227.3	-41.72
German Population East Germany*	16.111	N/A	N/A
German Population West Germany	63.254	N/A	N/A
Total German Population (millions)	78.365	82.087	+2.722
Germany's CO ₂ emissions per capita (tonnes carbon per capita)	3.43	2.77	-0.66

Source : Adapted from Bundesministerium für Wirtschaft, 2001

** Source taken from Mainz &Ullrich research by Berlin University für Bundesministerium*

Calculation of Indicator 1 vector value

W⁴ = the global average emissions of CO₂ per capita = 1,130 Kg Carbon per capita

X (1990) = Germany's per capita emissions 1990 = 3,430 Kg Carbon per capita

X (1999) = Germany's per capita emissions 1999 = 2,770 Kg Carbon per capita

Y = 3/10 W = 339 Kg Carbon per capita

Z = 7/10 W = 791 Kg Carbon per capita

Indicator Vector (I) = (X -Y) ÷ Z

I (1990) = (3,430 - 339) ÷ 791 = 3.91

I (1999) = (2,770 - 339) ÷ 791 = 3.07

⁴ Figure for W provided within the HELIO International data within the Guidelines for Observers

►Indicator 2: Most Significant Energy Related Local Pollutant

The main pollutants from energy related sectors in Germany include CO, CO₂, NO_x, SO₂, particulates, lead and mercury as well as the indirect pollutant ozone, that is generated from the chemical reaction between NO_x and VOCs in the presence of sunlight. The energy sectors included in the vector calculation include private and public traffic, industrial processes, local households and power and heat plants. Indicator 4 was calculated for CO, SO₂ and NO_x. The rationale for choosing these pollutants is first because these pollutants cover all major energy-relevant sectors taking into account both urban and rural allocation and second because of the existence of reliable and available data sources for these pollutants.

According to the guidelines for the HELIO International observers report, data for all three pollutants are collected and then combined to create one single vector for Germany.

Indices are defined as follows:

- I: Relative value of the combined index from CO, SO₂ and NO_x
- X: Actual emission of either CO, SO₂ or NO_x (for the most recent year for which data is available, here 1999)
- Y: Represents the national objective where sustainability is achieved
- Z: is the 0 to 1 segment and equals W-Y

The unit mass/capita is used for the calculation instead of ambient pollution.

Table 2-1. Local pollutants (SO₂, NO_x, CO) in Kt

Sector	1990			1999		
	SO ₂	NO _x	CO	SO ₂	NO _x	CO
Traffic	113	1541	6936	31	1045	2992
Power and Heat Plants	2780	576	155	409	250	102
Industry	1980	483	1755	315	260	1262
Local Households	449	106	2366	76	82	796
Total	5322	2706	11213	831	1637	4952

Source: *Environmental Data 2000, published by the Federal State Environmental Agency 2000, www.umweltbundesamt.de*

Table 2- 2. Data for calculation of per capita local pollutants

	1990	1999	Change
Total German population *	79.365 million	82.087 million	+ 2.722 million
Per capita SO ₂ emissions	67.057 kg (W)	10.123 kg (X)	- 56.934 kg
Per capita NO _x emissions	34.096 kg (W)	19.942 kg (X)	- 14.154 kg
Per capita CO emissions	136.599 kg (W)	60.326 kg (X)	- 76.273 kg

Source: *www.demographie.de/info/epub/pdfdateien/depop.pdf

Calculation of Vector 2 for local pollutant SO₂

The '1' circle equals the 1990 value which is 67.057 kg SO₂/capita

Y = 67.057 kg SO₂/capita * 0.1 kg SO₂/capita = 6.7057 kg SO₂ / capita → equals the sustainability objective

Z = 67.057 kg SO₂/capita * 0.9 kg SO₂/capita = 60.351 kg SO₂ / capita

County's per capita SO₂ emissions in year 1999

$$X = 10.123 \text{ SO}_2 / \text{capita}$$

Actual calculation of the vector I_{SO₂} for year 1999

Formula: $(X-Y) / Z$

$$I_{\text{SO}_2} = (10.123 - 6.7057) / 60.351 = \mathbf{0.057 \text{ kg SO}_2 / \text{capita}} (1999)$$

Optional vector calculation for 1990

$$I_{\text{SO}_2} = (67.057 - 6.7057) / 60.351 = 1 \text{ kg SO}_2 / \text{kg}$$

Calculation of Vector 2 for local pollutant NO_x

The '1' circle equals the 1990 value which is 34.096 kg NO_x/capita

$Y = 34.096 \text{ kg NO}_x / \text{capita} * 0.1 \text{ kg NO}_x / \text{capita} = 3.4096 \text{ kg NO}_x / \text{capita} \rightarrow$ equals the sustainability objective

$$Z = 34.096 \text{ kg NO}_x / \text{capita} * 0,9 \text{ kg NO}_x / \text{capita} = 30.6864 \text{ kg NO}_x / \text{capita}$$

County's per capita SO₂ emissions in year 1999

$$X = 19.942 \text{ NO}_x / \text{capita}$$

Actual calculation of the vector for year 1999

$$I_{\text{NO}_x} = (19.942 - 3.409) / 30.686 = \mathbf{0.538 \text{ NO}_x / \text{capita}} (1999)$$

Optional vector calculation for 1990

$$I_{\text{NO}_x} = (34.096 - 3.4096) / 30.686 = 1 \text{ kg NO}_x / \text{kg}$$

Calculation of Vector 2 for local pollutant CO

The '1' circle equals the 1990 value which is 136.599 kg CO/capita

$Y = 136.599 \text{ kg CO/capita} * 0.1 \text{ kg CO/capita} = 13.66 \text{ kg CO} / \text{capita} \rightarrow$ equals the sustainability objective

$$Z = 136.599 \text{ kg CO/capita} * 0,9 \text{ kg CO/capita} = 122.939 \text{ kg CO} / \text{capita}$$

County's per capita CO emissions in year 1999

$$X = 60.329 / \text{capita}$$

Actual calculation of the vector I_{SO₂} for year 1999

Formula: $(X-Y) / Z$

$$I_{\text{CO}} = (60.326 - 13.66) / 122.939 = \mathbf{0.38 \text{ kg CO} / \text{capita}} (1999)$$

Optional vector calculation for 1990

$$I_{\text{CO}} = (136.599 - 13.66) / 122.939 = 1 \text{ kg CO/kg}$$

Combination of SO₂, NO_x and CO to a single index for indicator 2

According to the guidelines for the observers report the metric of the indicator 1 is set 100% for each pollutant and indicator 0 is set 20% for each pollutant. Therefore the following values for W, Y, X and Z apply:

1990 emissions:

$$W (\text{SO}_2) = 67.057 \text{ kg/capita}$$

$$W (\text{NO}_x) = 34.096 \text{ kg/capita}$$

$$W (\text{CO}) = 136.599 \text{ kg/capita}$$

Objectives to achieve:

$$Y (\text{SO}_2) = 20\% * 67.057 = 13.411 \text{ kg/capita}$$

$$Y (\text{NO}_x) = 20\% * 34.096 = 6.819 \text{ kg/capita}$$

$$Y (\text{CO}) = 20\% * 136.599 = 27.32 \text{ kg/capita}$$

1999 emissions:

$$X (\text{SO}_2) = 10.123 \text{ kg/capita}$$

$$X (\text{NO}_x) = 19.942 \text{ kg/capita}$$

$$X (\text{CO}) = 60.326 \text{ kg/capita}$$

The segment $Z = W - Y$:

$$Z (\text{SO}_2) = 67.057 - 13.411 = 53.646 \text{ kg/capita}$$

$$Z (\text{NO}_x) = 34.096 - 6.819 = 27.283 \text{ kg/capita}$$

$$Z (\text{CO}) = 136.599 - 27.32 = 109.279 \text{ kg/capita}$$

The vector values in 1999 are

$$I_{(\text{SO}_2)} = (X - Y) / Z = (10.123 - 13.411) / 53.646 = -6.13 \text{ E-5}$$

$$I_{(\text{NO}_x)} = (X - Y) / Z = (19.942 - 6.819) / 27.283 = 0.48$$

$$I_{(\text{CO})} = (X - Y) / Z = (60.326 - 27.32) / 109.279 = 0.302$$

Average value of vector (1999):

$$\mathbf{I} = (I_{\text{SO}_2} + I_{\text{NO}_x} + I_{\text{CO}}) / 3 = \mathbf{0.26 \text{ kg pollutant/capita}}$$

Average value of vector (1990)

$$\mathbf{I} = \mathbf{1.0 \text{ kg pollutant/capita}}$$

Discussion of the Indicator

The indicator shows that Germany has reduced emissions of Sulphur Dioxide, Nitrogen Dioxide and Carbon Monoxide. However, the average of the emission reductions are not sufficient to register Germany as reaching a sustainable level of emissions overall although Germany has achieved sustainable levels of sulphur dioxide emissions. Since the indicator works with an average, and the levels of NOx and CO are insufficient to qualify as sustainable level of emissions the average figure indicates that emissions are all currently unsustainable. This is a weakness of this indicator.

The positive emissions levels for sulphur dioxide, primarily reflect increased efficiencies achieved in the energy sector following stricter enforcement of the Federal Emissions Control Act and the Large Furnaces Ordinance following re-unification, as well as the significant shift away from heavy fuel oil, and lignite fuels (especially in Eastern Germany) to natural gas. The less positive results for NOx and CO are primarily a reflection of the general difficulty to reduce emissions of these pollutants.