Technological Sustainability

▸Indicator 7: Energy Productivity (energy consumption / GDP)

Energy productivity refers to the quantities of economic activity per unit of energy consumed. In order to calculate this indicator figures for commercial energy consumption must be divided by a measurement of economic activity, which is usually expressed in terms of Gross Domestic or National Product (GDP or GNP). However, as recommended in the *HELIO International Guidelines for Reporters/Observers*, GDP output at purchasing power parity rates is preferable to GDP, since it has been shown to be a better indicator for comparisons that include developing nations.

When considering energy consumption, care must be taken to ensure that statistics for energy consumption incorporate all energy products and not just primary energy sources such as oil, coal and gas. For the purposes of this report a distinction is made between *Commercial Energy Consumption* that does not include products such as biomass, waste etc and *Real Energy Consumption* which includes data for energy generation from biomass, waste, gas, sludges etc. A summary of the data collected for the calculation of this indicator is given in Table 7.1.

Table 7-1. Data for the Calculation of Energy Productivity in Germany

	1990	**1992**	**1994**	**1996**	**1998**	**2000[1]**
Commercial Energy Consumption PJ[2]	14,783	14,200	13,997	14,575	14,218	12,934
Real Consumption PJ[3]	14,912	14,314	14,182	14,745	14,461	14,180
GNP (billion US$) [4]	1,016	1,397	1,496	1,613	1,698	1,783
GDP (billion DM)	2,426.0	3,155.2	3,394.4	3,586.8	3,784.4	3,982.0
PPP (OECD Figs)	1.07	1.06	1.06	1.04	0.992	0.952
GDP PPP billion US$	**2,267**	**2,977**	**3,202**	**3,449**	**3,815**	**4,183**

Sources : Zahlen und Fakten (2001) Bundesministerium für Wirtschaft und Technologies and OECD PPP Information (2001).

1. First estimates, not yet confirmed figures

2. Commercial energy figures include mineral oil, coal, gas, nuclear, hydro and wind (from 1995) .

3. Real energy consumption figures are the same as 1 but includes biomass, sludge, wood, waste and others

4. € converted to $ using rate of 1 €: 0.8832 US$

Calculation of Indicator 7 Vector Value

Energy Productivity for 1990 and 1999 is calculated according to the following equation:

Energy Productivity = Total energy consumption ÷ economic activity (GDP PPP) = **X**

Using the data from Table 7.1 it is possible to calculate values for X(1990) and X (2000).

Table 7-2. Energy Productivity in Germany

	X (1990)	**X (2000)**
Energy Productivity	6.58 MJ/$ GDP	3.39 MJ/$ GDP

Standard parameters based on the international average energy productivity are given by HELIO International and are:

W = Average energy consumption in 1990 correlates to the "1" circle = 10.64 MJ/US$
Y = W/ 10 = 1.06 MJ/$
Z = W – Z = 9.58 MJ/$

The Vector **I** is calculated as follows: (**X** – 1.06) / 9.58

Therefore the vector **I** (1990) = 0.58
I (2000) = 0.24

Discussion of the Vector

Energy consumption in Germany is below the world average of 10.64 MJ/US$, but does not yet meet the target of 1.06 MJ/$ as set by HELIO International. However, the trend is progressive and Germany has made substantial progress in terms of reducing wasteful energy consumption which reflects the strong emphasis in Germany on energy efficiency.

▸Indicator 8: Renewable Energy Deployment

In the year 2000 the share of total renewable energy consumption from total primary energy consumption in Germany was 2.2%. Within the power- and heat sector, renewable energy made up a larger proportion than in the traffic sector. The traffic sector renewable energy source share was from bio diesel (rape seed methyl ester, RME) and totalled a mere 0.1% of the total. The table below presents the share of all renewables in the total renewable primary energy consumption.

Table 8-1. German primary energy supply from renewable energy sources in 2000

	(PJ)	(% of total)
solid biomass	165.09	52.49
bio fuels	14.83	4.72
Biogas	8.43	2.68
sewage gas*	0.46	0.15
landfill gas*	6.8	2.16
geothermal energy	1.71	0.54
solar thermal energy	4.77	1.52
Photovoltaic	0.32	0.10
Wind	33.12	10.53
Water	78.97	25.11
Total	314.5	100

**** figure from 1999***
Source: /Erneuerbare Energien 2001/

The implementation of the "Erneuerbare Energien Gesetz (EEG) – Renewable Energy Sources act" in the year 2000 and the "biomass energy regulation" in 2001, fixed the minimum rate of reimbursement in renewable energy and guaranteed entry to the grid for power from renewable energy sources. These regulations have therefore reduced risks associated with renewable energy investments. As a result, Germany is now expecting an accelerated increase in power generation from renewable energy sources and especially from wind and biomass power generation.

Table 8.2 shows that even before these laws production of power from renewable energy sources has doubled over the last 10 years in Germany. Hydro power is the most established renewable energy technology and remains the most important in terms of quantity of electricity produced. Windpower has experienced a rapid increase since 1990 and now contributes approximately 30 % of total power generation from renewables. Biomass power generation has also accelerated and now contributes 4,5 % of total renewable power generation. Photovoltaic use in Germany has been stimulated by an investment subsidy, the so-called "100.000 photovoltaic roofs program", but still remains a minor energy source.

Table 8-2. Produced electricity from renewable energy (GWh)

	1990		2000	
Water	15,580	98.34%	21,930	67.03%
Biomass	222	1.40%	1,500	4.8%
Wind	40	0.25%	9,200	28.12%
Photovoltaic	1	0.01%	89	0.27%
geothermal power	0	0.00%	0	0.00%
Total	15,843	100,.%	32,719	100.0%

Source: /Erneuerbare Energien 2001/

Heat production from renewables in Germany is dominated by biomass (96%). In contrast, both solar and geothermal heating contributed just 4% to total heat production in 2000.

Table 8-3. Heat from renewables (GWh)

	1990		2000	
biomass – solid fuels	12,880	99.31%	41,600	94.5%
biomass – liquid fuels			63	0.1 %
biomass – gaseous fuels			720	1.6 %
solar thermal heating	90	0.69%	1,200	2.73 %
geothermal heating	0	0.00%	436	0.99 %
Total	12,970	100.0%	44,019	100.00%

Source: /Erneuerbare Energien 2001/

Further substantial increase in the use of Biomass is expected over the next few years. However, the increase of some renewable sources, such as solar heating over the last ten years (1990: 257.785 m², 2000: 3.267.483 m² installed solar collectors, 600.000 in 2000 only), is primarily due to subsidies for investments in renewable energy technologies ("Marked stimulation program for the introduction of renewable energy technologies"). Further increases in the use of solar will largely depend on the continuation of these subsidies because of the relatively high specific costs of this technology. The potential to utilise geothermal sources for heating is considerable for both near surface heat as well as in the deep geothermal energy production, however, at present the overall contribution to heat production is negligible and more research and development is required before these sources can be utilised.

Calculation of Indicator 8 requires the collection of data on total renewable energy consumption and total primary energy consumption. The data is shown in table 8.4.

Table 8-4. Data for Vector Calculation

	1990	**2000**
Total renewable energy consumption in PJ	180	314.5
Total primary energy consumption in PJ	14911.9	14295.5

Source: /Erneuerbare Energien 2001/

Calculating the Vector for Indicator 8

The parameters for the calculations are:

Y (1990) = 95% = 0.9500

Y (2000) = 95% = 0.9500

X (1990) = 1.2% = 0.012

X (2000) = 2.2% = 0.022

Z (1990) = 0.8636

The German values for indicator 8 are calculated using (Y-X) ÷ Z [13]as follows:

I(1990) = (Y 1990 - X 1990)/Z 1990 = (0.9500-0.012)/0.8636 = 1,0862

I(2000) = (Y 2000- X 2000)/Z 1990 = (0.9500-0.022)/0.8636 = 1,0746

[13] Since no country can have a value of less than zero percent renewable energy, the usual equation (X-Y) ÷ Z is multiplied by – to give (Y-X) ÷ Z.