

The Eight Indicators

►Indicator 1: Per Capita Energy Sector Carbon Emissions

	Per Capita Energy Sector Carbon Emissions
1990	0.957967
1991	1.231017
1992	1.159863
1993	1.114713
1994	1.128625
1995	1.151602
1996	1.164808
1997	1.219209
1998	1.327702
1999	1.390102

	Population	CO2('000 t)	C(Mt)	kgC/cap
1990	9877500	39721.62	1083316	1096.752
1991	9864900	47483.3	12949990	1312.734
1992	9869200	45467.31	12400175	1256.452
1993	9892200	44174.93	12047708	1220.738
1994	9912100	44766.89	12209151	1231.742
1995	9920800	45467.31	12400175	1249.917
1996	9934100	45908.78	12520576	1260.363
1997	9957300	47587.05	12978286	1303.394
1998	9979500	50833.35	13863640	1389.212
1999	9997600	52734.92	14382250	1438.57

Throughout the decade, albeit with an almost stagnating population, CO₂ emissions from the energy sector have increased at alarming rates. This is partly due to increased economic growth during the decade, but the fact already mentioned in the introduction that energy intensity has actually increased during the same period leads us to believe that a great part of the emission increase stems from economic growth not accompanied by the necessary de-linking from energy use. In the next years, as the coverage of the natural gas network extends, it is likely that per capita emissions relating strictly to the energy sector may decelerate or decline.

The figures are taken from the IPCC submitted national inventories. Energy sector emissions relate to all emissions from energy generation activities.

► Indicator 2: Local energy-related pollutants

	Population	SO ₂ (kilos)	SO ₂ /cap	Nox(kilos)	NOx/cap	indicador2(NOx/SO ₂)
1990	9877500	322950000	32.69552	275420000	27.883574	1
1991	9864900	316070000	32.03986	290500000	29.44784	1.02
1992	9869200	376780000	38.17736	310980000	31.510153	1.17
1993	9892200	334400000	33.80441	305980000	30.931441	1.08
1994	9912100	311020000	31.37781	310090000	31.283986	1.05
1995	9920800	342850000	34.5587	320720000	32.328038	1.12
1996	9934100	298370000	30.03493	315690000	31.77842	1.03
1997	9957300	314550000	31.58989	325120000	32.651422	1.08
1998	9979500	314550000	31.51962	346360000	34.70715	1.12
1999	9997600	346660000	34.67432	363250000	36.33372	1.20

Sulphur dioxide and nitrous oxides are two particularly important local pollutants from the energy sector. It must be noted that local pollution from energy production has not, to date, been a major concern for the Portuguese environmental authorities. This is partly due to the low levels of pollution and the high levels of dispersion of pollutants in the vicinity of most power stations. Furthermore, upgrading of facilities at most power stations has led to a relative decrease of sulphur emissions. NOx emissions stem mostly from fossil-fuel combustion in transportation systems. The marked rise of NOx as a local pollutant can be observed and is directly related to the growth in car ownership. Moreover, transportation-related pollution from the Lisbon area (ozone and NOx) has now been measured in concentrations in excess of legally allowable limits as far away as Santiago do Cacem (rural area approximately 120 kms south of Lisbon center). It was decided therefore that a more accurate picture of the evolution of local pollution would be given by incorporating both SO₂ and NOx in the calculations.

The indicator is calculated as a weighted (0.5 each) average of per capita values for SO₂ and NOx.

► **Indicator 3: Households with Access to Electricity**

No information was obtained on percentages of households with access of electricity. However, it is generally believed that there is now almost universal coverage by the electricity grid, with only isolated instances in the most remote areas of inland Northern Portugal, where small villages have not yet been connected. For practical purposes, it can be assumed that the coverage was near 100%.

►Indicator 4: Investment in Clean Energy

	ind 4
1995	0.726724217
1996	0.681724748
1997	0.608872703
1998	0.611663724

The reason this indicator is only presented from 1995 onwards relates to the fact that no statistics were available on clean energy investments, prior to the implementation of the Second Community Support Framework, i.e. the second structural plan presented to the European Commission for funding. Under this CSF, Programme ENERGIA in particular funded the development of endogenous resources and the development of the links to the international natural gas grid. This results in the fact that we have assumed that prior to the implementation of that programme no investment was being made in clean energy in Portugal. This is a crude assumption, but it nevertheless remains true that ENERGIA was the spur of all public and private investments in renewable resources from the period from 1995 to 1999. Data on investment in other energy sub-systems is also presented (data from the Energy Directorate).

Anos	Electricity	Oil	Coal	Gas	Energy Sector	Total FCGF	%
unit: billion PTE current							
	(1)	(2)	(3)	(4)	(5)=(1)+(2)+(3)+(4)	(6)	(7)=(5)/(6)
1990	105328	35454	129	641	141552	2719800	5.2%
1991	125238	48953	72	1744	176007	2966500	5.9%
1992	135952	91573	53	3935	231513	3194000	7.2%
1993	124719	103405	16	2961	231101	3146600	7.3%
1994	125928	43763	0	48432	218123	3438600	6.3%
1995	139756	50370	0	39776	229902	3742700	6.1%
1996	124080	61158	0	46024	231262	4005100	5.8%
1997	124841	76998	0	42578	244417	4515600	5.4%
1998(*)	98726	75225	0	50187	224138	4992100	4.5%

As can be seen, investment in coal has disappeared, as the last remaining mines were shut down in 1994. Gas amalgamates natural gas and other gases. Nevertheless, the boom in investment in the natural gas infrastructure can be seen, starting from 1994. Finally, the relatively high levels of investment in the electricity sector throughout the period refer to both upgrading of the general grid, but also to investments in auxiliary services (customer service, etc..). For good measure, the numbers of public support for alternative, endogenous sources of energy is reflected in the accompanying table (also in billion PTE):

1995	60110
1996	29928
1997	77049
1998	28893

The current boom in wind development and the commitments under the Renewables Directive will have, since 1998, changed somewhat the picture.

►Indicator 5: Energy trade – Economic Resilience

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Primary Energy Consumption	16410	16604	17781	17529	18083	19165	19087	20581	21863
Coal	2760	2906	2950	3142	3328	3604	3430	3513	3232
Oil	11731	11767	13148	12479	12637	13649	13147	14445	15624
Electricity	804	798	552	768	1001	811	1379	1390	1159
Natural gas	0	0	0	0	0	0	0	96	698
Others	1115	1133	1131	1139	1117	1102	1130	1137	1150
Domestic production	2030	2034	1659	1973	2102	1834	2414	2278	2285
Coal	115	111	91	81	60				
	0								
Electricity from RES	800	790	437	753	925	732	1284	1141	1135
Others	1115	1133	1131	1139	1117	1102	1130	1137	1150
Net imports	15501	15426	16706	16232	16358	18243	17024	19023	20255
Coal	2991	2721	2840	3059	3220	3813	3357	3692	3268
Oil	12507	12697	13750	13158	13061	14351	13572	14972	16266
Electricity	3	8	115	15	77	79	95	249	24
Natural gas	0	0	0	0	0	0	0	110	697
Inputs for electricity generation	5109	5383	5900	5675	5369	6222	5493	5724	6711
Coal	2027	2159	2208	2419	2578	2918	2710	2893	2688
Oil	2113	2200	3046	2275	1658	2382	1323	1466	2303
Renewables (incl. Large hydro)	800	790	437	753	925	732	1284	1141	1135
Natural gas								27	375
Others	169	214	209	228	209	190	176	197	210
Losses	3820	3860	4577	4221	4154	4820	4053	4618	4975
Final Energy Consumption Total	12590	12744	13204	13308	13929	14345	15034	15963	17030
non-renewable imports	15498	15418	16590	16217	16281	18164	16929	18774	20231
non-renewable consumption	14491	14673	16098	15621	15965	17253	16577	18054	19554
Vector calculation	1.07	1.05	1.03	1.04	1.02	1.05	1.02	1.04	1.03

The data from the table above, taken from a publication from the Energy Directorate in Portugal, turn out an awkward result – non-renewable energy imports were, over the decade, higher than the actual consumption of non-renewable energy. This is no doubt due to statistical errors. What is relevant in the calculation, nevertheless, is the very high degree of dependency of Portugal on foreign non-renewable energy sources, both as fuel imports and as inputs into electricity generation. This dependency will not be mitigated by the expansion of the natural gas. In fact, by stimulating the growth of natural gas, the Portuguese Government has possibly provided a disincentive for further investment in renewable, endogenous sources.

► Indicator 6: Burden of Energy Investment

	Electricity	Oil	Coal	Gas	Energy Sector	Total Fixed Capital Formation	GDP	%	Ind 6
unit: million PTE									
	(1)	(2)	(3)	(4)	(5)=(1)+(2)+(3)+(4)	(6)		(7)=(5)/(6)	
1990	105328	35454	129	641	141552	2719800	9838000	5.2%	0.14
1991	125238	48953	72	1744	176007	2966500	11306700	5.9%	0.16
1992	135952	91573	53	3935	231513	3194000	12743200	7.2%	0.18
1993	124719	103405	16	2961	231101	3146600	13445500	7.3%	0.17
1994	125928	43763	0	48432	218123	3438600	14616900	6.3%	0.15
1995	139756	50370	0	39776	229902	3742700	15802100	6.1%	0.15
1996	124080	61158	0	46024	231262	4005100	16808700	5.8%	0.14
1997	124841	76998	0	42578	244417	4515600	17858500	5.4%	0.14
1998(*)	98726	75225	0	50187	224138	4992100	19245700	4.5%	0.12

► Indicator 7: Energy Intensity

As reported previously in the Introduction, one of the most difficult exercises has been to retrieve credible figures for the indicator on energy productivity. The report that has been used as the main source of information provided us with totally inconsistent figures, that showed Portugal to have the highest energy intensity of the EU by far. While this could eventually be the case, the numbers did not seem credible. We therefore resorted to using numbers provided in the IEA Energy Policy Review of 2000. Unfortunately, this report only provides us with numbers with respect to the years 1997 and 1998 (and the base-year 1990). The numbers are provided below, along with the vector calculation.

	TPES	GDP	TPES/GDP	MJ/ US\$	Ind 7
1990	16.42	69.13	0.24	9.94	0.93
1997	20.16	80.63	0.25	10.47	0.98
1998	21.85	83.8	0.26	10.92	1.03

The numbers reflect the fact that, over the decade, Portugal has increasingly had a bad performance in the energy sector, in particular with relation to energy conservation. While the absolute figure per se might not look disturbing, its trend is staggering – a 10% increase in the energy requirements per unit of output.

►Indicator 8: Deployment of Renewables

	Primary Energy Consumption (in ktoe)	Renewable Energy Production (in ktoe)		ind 8
1990	16410	800	0.05	1.043596
1991	16604	790	0.05	1.044953
1992	17781	437	0.02	1.071588
1993	17529	753	0.04	1.050304
1994	18083	925	0.05	1.040814
1995	19165	732	0.04	1.055819
1996	19087	1284	0.07	1.02215
1997	20581	1141	0.06	1.035851
1998	21863	1135	0.05	1.039933

The figures above include large hydroelectrical power stations. It was not possible to get a breakdown of hydroelectrical power plants into small and large-hydro. It can be safely assumed that “new renewables constitute only a tiny fraction of the total, as is patent in the graph included in the General Discussion. The graph below exemplifies the situation at the end of 1998, in terms of established generation capacity:

