

CO₂ and other environmental emissions data

Details of the CO₂ emissions associated with the construction and use of each of the RE technologies and comparisons with the emissions from conventional technologies are presented in Tables 7A to 7C. Details of other environmental emissions associated with the construction and use of RE technologies are given in Table 7D. Further information on environmental emissions is given in the individual RE Technology Modules.

These emissions data are based largely on information contained in a recent publication from the International Energy Agency [8], and supplemented with specific information for particular technologies where appropriate.

Some of the key points to note in connection with the CO₂ data are :

- many of the renewable energy technologies produce zero CO₂ emissions during operation
- some CO₂ emissions are produced during the manufacture and construction of renewable energy plant but, in general, these emissions are at least one order of magnitude lower than those from conventional fossil fuel technologies in terms of CO₂ per TJ of generated energy

Key points to note in connection with the other emissions data are :

- SO₂ emissions from most RE technologies are lower by at least an order of magnitude than those from coal or diesel, but not less than from natural gas which is essentially SO₂ free.
- NO_x emissions are produced from the combustion of biomass, biofuels, and wastes. However, there is no reason why these should be any greater than from the combustion of conventional fuels provided that adequate efforts are put into the development of biomass combustion plants.

Table 7A : Summary of CO₂ emissions for electricity generating technologies

Technology	Operational emissions of CO ₂ Tons / TJ	Emissions of CO ₂ during construction Tons / TJ
Wind	0	2
PV	0	4 - 20
Solar Th. Elec :		
Trough	0	10
Solar Tower	0	7
Solar Dishes	0	8
¹ Biomass - Elect. :		
Gasification	4	1
Co-firing	NA	NA
Steam Cycle	6	1
Waste Combustion	100	1
¹ Biogas: AD	3	NA
¹ Biogas: Landfill	0	19
Geothermal : Elect.	0 - 20	3
Small Hydro	0	2
Wave	0	7
Tidal	2	5
Fossil Fuel Electricity Generation²		
Coal fired electricity generation (with FGD & low NO _x burners)	247	NA
Gas fired electricity - CCGT	136	NA
Oil fired electricity generation	204	NA
Diesel power generation	191	NA

NA - Not Available

¹ For “biomass” technologies, CO₂ emissions are for “non-biomass” sources, since biomass is taken to be CO₂ neutral.

² Emissions for fossil fuel plant are for operation only. Emissions during construction are negligible for these technologies.

Table 7B : Summary of CO₂ emissions for heat producing technologies

Technology	Operational emissions of CO ₂ Tons / TJ	Emissions of CO ₂ during construction Tons / TJ
Solar Thermal Heat	0	4 -111
Biomass - Heat	2	0.2
Geothermal : Heat	2	0.3
Fossil fuel heat production		
Industrial coal boiler	110	
Industrial gas boiler	65	

For “biomass” technologies, CO₂ emissions are for “non-biomass” sources, since biomass is taken to be CO₂ neutral.

Table 7C : Summary of CO₂ emissions from liquid transport fuels

Technology	Operational emissions of CO ₂ Tons / TJ	Emissions of CO ₂ during preparation Tons / TJ
Liquid Biofuels ¹ :		
Biodiesel	0	32
Bioethanol	0	49
Transport fuels²		
Diesel	68	7

¹ For biofuels preparation, the emissions from crop production through to fuel production are included.

² Diesel emissions during preparation are for extraction, refining and distribution of fuels.

Table 7D : Summary of other environmental emissions data for RE technologies

Technology Areas	Operational Emissions (kg/TJ)			Emissions during construction (kg/TJ)		
	SO ₂	NO _x	Particulates	VOCs*	SO ₂	NO _x
Wind	0	0	0	0	4.2	5.6
PV	0	0	0	0	75-95	61-83
Solar Thermal Heat	0	0	0	0	27-78	12-35
Solar Th. Elec :						
Trough	0	0	0	0	76	36
Solar Tower	0	0	0	0	58	23
Solar Dishes	0	0	0	0	36	17
Biomass - Elect. : Gasification						
Co-firing	13	118	10	3.6	6	2.3
Steam Cycle	NA	NA	NA	NA	NA	NA
Biomass - Heat	23.5	497	238	333	6	2.3
Waste Combustion	5.3-7.8	38.4-166	2.5-79..3	7.3-111	1.9	0.7
Liquid Biofuels ¹ :						
Biodiesel	697	843	73	47	10	4
Bioethanol	140.4	150.3	21.2	159.6		
Biogas: AD	148	170.4	16.1	279.2		
Biogas: Landfill	100	220	8	190		
Geothermal : Heat	83	580	28	580	15	200
Geothermal : Elect.	0	0	0		1	9
Small Hydro	0	0	0	0	6	78
Wave	0	0	0	0	7	19
Tidal	0	0	0	0	67	28
	19	5		<<1	52	23
Fossil Fuel Electricity Generation²						
Coal fired electricity generation (with FGD & low NO _x burners)	320	725	45	7	NA	NA
Gas - CCGT	0	3	0	2	NA	NA
Oil plant	3,750	1003	108	9	NA	NA
Diesel	301	3,279	30	170	NA	NA
Fossil fuel heat production						
Industrial coal boiler	1396	236	208	2		
Industrial gas boiler	0	126	0	2		

* VOCs - Non-methane Volatile Organic Compounds

NA - Not Available

¹For biofuels, the emissions from crop production through to fuel production are included. Fuel utilisation is excluded.

² Emissions for fossil fuel plant are for operation only. Coal plant is assumed to burn high (1.5%) sulphur coal, and the oil to have a sulphur content of 3%.