

Appendix A

Acronyms and Abbreviations

AAG Association of American Geographers

AED Annual Electricity Demand

BOD Biochemical Oxygen Demand

Btu British Thermal Unit

C Carbon

CACP Clean Air Cool Planet

CAED Commercial Annual Electricity Demand

CFB Circulated Fluidized-Bed Boilers

CFC Chlorofluorocarbon

CH₄ Methane

CMT Commuter Miles Traveled

CNG Compressed Natural Gas

CO Carbon Monoxide

CO₂ Carbon Dioxide

EIA Energy Information Administration

EIIP Emissions Inventorying Improvement Program

EPA United States Environmental Protection Agency

FCCC Framework Convention on Climate Change

g gram

GHG Greenhouse Gas

GWP Global Warming Potential

ha hectare

HCFC Hydrochlorofluorocarbon

HFC Hydrofluorocarbons

IEA International Energy Agency

IPCC Intergovernmental Panel on Climate Change

kWh kilowatt hours

lbs pounds

mcf thousand cubic feet

MCF Methane Conversion Factor

mmBtu Million British Thermal Units

mmcf million cubic feet

MTCO₂E Metric Tons of Carbon Dioxide Equivalent

mton metric ton

mtons metric tons

N Nitrogen

N₂O Nitrous Oxide

NASA National Aeronautics and Space Administration

NCF Nitrogen Conversion Factor

NMVOC Non-methane Volatile Organic Compounds

NO_x Nitrogen Oxides

O₃ Ozone

ODS Ozone Depleting Substance

OH-Hydroxyl radical

P Phosphorous

PFC Perfluorocarbons

SF₆ Sulfur Hexafluoride

SUV Sport Utility Vehicle

TAM Typical Animal Mass

TAZ Transportation Analysis Zone

UN United Nations

UNEP United Nations Environment Program

UNFCCC United Nations Framework Convention on Climate Change

VMT Vehicle Miles Traveled

VS Volatile Solid

WMO World Meteorological Organization

Appendix B

Common Conversion Factors

Permutations of SI Units

1 gC = 1 gram carbon (C)

1 GgC = gigagram carbon (C) = 1,000 metric tons carbon (C)

1 TgC = 1 teragram carbon (C) = 1 million metric tons carbon

1 PgC = 1 petagram carbon (C) = 1 billion metric tons carbon

1 ppmv = 1 part per million by volume in the atmosphere

1 ppbv = 1 part per billion by volume in the atmosphere

1 pptv = 1 part per trillion by volume in the atmosphere

Density

1 thousand cubic feet of methane = 42.28 pounds

1 thousand cubic feet carbon dioxide = 115.97 pounds

1 metric ton natural gas liquids = 11.6 barrels

1 metric ton unfinished oils = 7.46 barrels

1 metric ton alcohol = 7.94 barrels

1 metric ton liquefied petroleum gas = 11.6 barrels

1 metric ton aviation gasoline = 8.9 barrels

1 metric ton naphtha jet fuel = 8.27 barrels

1 metric ton kerosene jet fuel = 7.93 barrels

1 metric ton motor gasoline = 8.53 barrels

1 metric ton kerosene = 7.73 barrels

1 metric ton naphtha = 8.22 barrels

1 metric ton distillate = 7.46 barrels

1 metric ton residual oil = 6.66 barrels

1 metric ton lubricants = 7.06 barrels

1 metric ton bitumen = 6.06 barrels

1 metric ton waxes = 7.87 barrels

1 metric ton petroleum coke = 5.51 barrels

1 metric ton petrochemical feedstocks = 7.46 barrels

1 metric ton special naphtha = 8.53 barrels

1 metric ton miscellaneous products = 8.00 barrels

Alternative Measures of Greenhouse Gases

1 pound methane, measured in carbon units (CH₄-C) = 1.333 pounds methane, measured at full molecular weight (CH₄)

1 pound carbon dioxide, measured in carbon units (CO₂-C) = 3.6667 pounds carbon dioxide, measured at full molecular weight (CO₂)

1 pound carbon monoxide, measured in carbon units (CO-C) = 2.333 pounds carbon monoxide, measured at full molecular weight (CO)

1 pound nitrous oxide, measured in nitrogen units (N₂O-N) = 1.571 pounds nitrous oxide, measured at full molecular weight (N₂O)

Weight

1 kilogram = 2.205 pounds

1 short ton = 0.9072 metric tons

1 metric ton = 1.1023 short tons = 2,204.6 pounds

1 cubic meter = 35.3147 cubic feet

1 cubic centimeter = 3.531×10^{-5} cubic feet

Area

1 acre = 0.40468724 hectare (ha) = 4,047 m²

1 hectare (ha) = 10,000 m² = 2.47 acres

1 kilometer = 0.6214 miles

Energy

1 joule = 947.9×10^{-21} quadrillion Btu

1 exajoule = 10^{18} joules = 0.9479 quadrillion Btu

1 quadrillion Btu = 1.0551 exajoule

Source (EIA, 2000)

Appendix C

Default Gross Calorific Values (GCV) / Higher Heating Values (HHVs)^d

Fuel Type	(MJ/kg) ^a			(Thousand Btu/lb) ^a		
	Range	Typical	IPCC Default ^e	Range	Typical	IPCC Default ^e
Coal-based fuels						
Anthracite coal	21-34	29	varies	15-Sep	12	
Bituminous coal	Sep-36	30	varies	15-Apr	13	
Sub-bituminous coal	29-Nov	21	varies	12-May	9	
Lignite coal	23-Jun	16	varies	10-Mar	7	
Coal coke	21-36	29		15-Sep	12	
Patent fuel	14-33	30	varies	14-Jun	13	
BKB	23-Aug	21	varies	10-Mar	9	
Natural gas-based fuels						
Natural gas	38-55	51		16-24	22	
Natural gas (dry)	39-55	52		17-24	22	
Methane	-	55.6			23.9	
Ethane	-	51.9			22.3	
Propane	-	50.4			21.7	
Butane	-	49.5			21.3	
Isobutane	-	49.5			21.3	
n-Butane	-	49.4			21.3	
Natural gas liquids (LNG)	46-55	52	varies	20-24	22	
Petroleum-based fuels						
Crude oil	37-48	46	varies	16-21	20	
Motor gasoline / petrol	46-48	47	47.2	20-21	20	20.3
Aviation gasoline	47-50	48		20-22	21	
Distillate Oil	43-49	46	45.6	19-21	20	19.6
Distillate fuel oil No.1	43-46	46		19-20	20	
Distillate fuel oil No.2	44-49	46		19-21	20	
Distillate fuel oil No.4	45-47	46		19-20	20	
Residual Oil	39-48	43	42.3	17-21	19	18.2
Residual fuel oil No.5	39-47	43		17-20	19	
Residual fuel oil No.6	39-48	43		17-21	19	
Jet kerosene	46-47	46.9	46.9	19.8-20.2	20.2	20.2
Kerosene (other)	46-48	47	47.1	19.8-20.7	20	20.3
Petroleum Coke	29-42	33	32.6	18-Dec	14	14
LPG	45-53	50	49.8	19-23	22	21.4
Naphtha	33-49	47	47.4	14-21	20	20.4
Asphalt / bitumen	41-43	42	42.3	18-19	18	18.2
Pitch	37-41	40		16-18	17	
Lubricants	40-46	43	42.3	17-20	19	18.2
Waxes	44-47	46		19-20	20	
Shale oil (liquid)	36-42	38	37.9	15-18	16	16.3
Oil shale	12-May	10	9.9	5-Feb	4	4.3
Other Fuels						
Peat ^b	13-21	16		9-May	7	
Waste plastics	17-43	30		19-Jul	13	
Tar	22-36	30	29.5	15-Sep	13	12.7
Waste tire derived fuels	27-38	36		16-Dec	15	
Biomass						
Wood (dry)	14-22	20	varies ^f	9-Jun	9	
Wood (wet)	14-Jun	11	varies ^f	6-Mar	5	
Fuelwood (approx. 20% mois	14-19	16	varies ^f	8-Jun	7	
Black liquor	15-Oct	14		6-Apr	6	
Landfill gas ^c	24-Sep	13		10-Apr	6	
Waste water treatment biogas	24-Sep	13		10-Apr	6	
Biodiesel	38-44	40		16-19	17	
Turpentine	39-45	44		17-19	19	
Vegetable oils	32-48	40		17-21	19	

^a Dry unless otherwise noted.

^b Value can be significantly effected by moisture content of fuel

^c Value can be significantly effected by fraction of air, CO₂, and moisture in g

^d Gross calorific (higher heating) values have been used because they are more closely related to the carbon content of fuels than net calorific (lower heating) values.

^e IPCC default values have been converted from NCV (LHV) to GCV (HHV) using rule of

^f See Table 1-13 in the Revised IPCC 1996 Guidelines, p. 1.45 for values of various biomass fuels on a NCV basis, including moisture contents.

Reference:

Typical values are based on a compilation of commonly accepted sources such as IPCC, U.S. DOE/EIA, national inventory reports to the UNFCCC, and other sources.

The values are meant only to provide guidance for users who are developing their own values.

Users are encouraged to develop their own values based on the actual characteristics of the fuel being combusted.

"Rule of Thumb" conversion

NCV = GCV x 0.95 for solid/liquid fuels and

NCV = GCV x 0.90 for gaseous fuels

or

LHV = HHV x 0.95 for solid/liquid fuels and

LHV = HHV x 0.90 for gaseous fuels

Appendix D

Default Carbon Content Values

(Based on GCV or HHV)^{a,d}

Fuel Type	(kg C/GJ)			(lb C/Million Btu)		
	Range	Typical	IPCC Default ^e	Range	Typical	IPCC Default ^e
Coal-based fuels						
Anthracite coal	25-30	27	25.5	58-70	63	59.2
Bituminous coal	22-26	24	24.5	51-60	56	57
Sub-bituminous coal	23-28	25	24.9	54-65	58	57.8
Lignite coal	23-29	26	26.2	53-67	60	60.9
Coal coke	26-38	29		60-88	67	
Patent fuel	23-30	25	24.5	53-70	58	57
BKB	23-30	25	24.5	53-70	58	57
Natural gas-based fuels						
Natural gas	13-16	14		30-37	33	
Natural gas (dry)	13-16	14	13.8	30-37	33	32
Methane	-	13.5		-	31.3	
Ethane	-	15.4		-	35.8	
Propane	-	16.2		-	37.7	
Butane	-	16.7		-	38.9	
Isobutane	-	16.7		-	38.9	
n-Butane	-	16.8		-	38.9	
Natural gas liquids (LNG)	13-17	16	16.3	30-40	38	38
Petroleum-based fuels						
Crude oil	17-21	19	19	40-49	44	44.2
Motor gasoline / petrol	17-19	18	18	40-44	42	41.7
Aviation gasoline	17.7-18.0	17.9		41-42	41.6	
Distillate Oil	18-20	19	19.2	42-46	44	44.6
Distillate fuel oil No.1	18-20	19		42-46	44	
Distillate fuel oil No.2	18-20	19		42-46	44	
Distillate fuel oil No.4	18-20	19		42-46	44	
Residual Oil	20-21	20.5	20	46-49	47.6	46.6
Residual fuel oil No.5	20-21	20.5		46-49	47.6	
Residual fuel oil No.6	20-21	20.5		46-49	47.6	
Jet kerosene	18-19	18.5	18.5	42-44	43	43.1
Kerosene (other)	18-19.5	18.6	18.6	42-45	43.3	43.3
Petroleum Coke	24-27	26	26.1	56-63	60	60.7
LPG	15-17	16	16.3	35-40	38	38
Naphtha	17-19	19	19	40-44	44	44.2
Asphalt / bitumen	20-22	21	20.9	46-51	49	48.6
Pitch	20-21	21		46-49	49	
Lubricants	18-21	19	19	42-49	44	44.1
Waxes	18-20	19		42-46	44	
Shale oil (liquid)	17-21	19	19	40-49	44	44.2
Oil shale	24-29	28	27.6	56-67	65	64.2
Other Fuels						
Peat ^b	25-28	27	27.5	58-65	63	63.8
Waste plastics	19-26	22		44-60	51	
Tar	20-22	21		46-51	49	
Waste tire derived fuels	20-29	22		46-67	51	
Biomass						
Wood (dry)	23-29	26		53-67	60	
Wood (wet)	23-29	26		53-67	60	
Fuelwood (approx. 20% moisture)	23-29	26		53-67	60	
Black liquor	22-25	23		51-58	53	
Landfill gas ^c	-	13.5		-	31.3	
Waste water treatment biogas ^c	-	13.5		-	31.3	
Biodiesel	19-24	21		44-56	49	
Turpentine	19-20	19		44-46	44	
Vegetable oils	19-24	21		44-56	49	

^a Dry unless otherwise noted.

^b Value can be significantly effected by moisture content of fuel

^c Value can be effected by fraction of air, CO₂, and moisture in gas.

^d Gross calorific (higher heating) values have been used because they are more closely related to the carbon content of fuels than net calorific (lower heating) values.

^e IPCC default values have been converted from NCV (LHV) to GCV (HHV) using rule of thumb¹

Reference:

Users are encouraged to develop their own values based on the actual characteristics of the fuel being combusted. Typical values are only provided as a guideline for the sake of comparison.

Appendix E

Default Oxidation Factor Values (Based on GCV or HHV)

Fuel/Technology Type	Range	Typical	IPCC Default
Coal-based fuels	91-100%	99%	98%
Newer boilers		99%	
Older boilers		98%	
Stoker boilers		98%	
Natural gas-based fuels	99-100%	100%	99.50%
Petroleum-based fuels	97.5-100%	100%	99%
Gasoline internal combustion engines		100%	
Diesel internal combustion engines		99%	
Other combustion equipment		99%	
Other Fuels	91-100%	99%	
Peat		99%	99% ^a
Waste plastics		99%	
Tar		99%	
Waste tire derived fuels		99%	
Biomass	90-100%	98%	
Wood (dry)		98%	
Wood (wet)		98%	
Fuelwood (approx. 20% moisture)		98%	
Black liquor		98%	
Landfill gas ^c		100%	
Waste water treatment biogas ^c		100%	
Biodiesel		99%	
Turpentine		100%	
Vegetable oils		99%	

^a 99% for electricity generation and <99% for residential and commercial use.

Reference:

Typical values are based on a compilation of commonly accepted sources such as IPCC, U.S. DOE/EIA, national inventory reports to the UNFCCC, and other sources.

Appendix F

Default CH₄ and N₂O Emission Factors IPCC Tier 1 Uncontrolled Stationary Sources

(Based on GCV or HHV)

Fuel Type / Sector	CH ₄		N ₂ O	
	(kg/GJ)*	(lb/Million Btu)	(kg/GJ)	(lb/Million Btu)
Coal				
Energy Industries	0.001	0.002	0.001	0.003
Manufacturing industries and construction	0.011	0.024	0.001	0.003
Commercial/Institutional	0.011	0.024	0.001	0.003
Residential	0.316	0.734	0.001	0.003
Agriculture/Forestry/Fishing	0.316	0.734	0.001	0.003
Natural gas				
Energy Industries	0.001	0.003	0	0
Manufacturing industries and construction	0.006	0.013	0	0
Commercial/Institutional	0.006	0.013	0	0
Residential	0.006	0.013	0	0
Agriculture/Forestry/Fishing	0.006	0.013	0	0
Petroleum (Oil)				
Energy Industries	0.003	0.007	0.001	0.001
Manufacturing industries and construction	0.002	0.005	0.001	0.001
Commercial/Institutional	0.011	0.024	0.001	0.001
Residential	0.011	0.024	0.001	0.001
Agriculture/Forestry/Fishing	0.011	0.024	0.001	0.001
Wood and wood waste				
Energy Industries	0.032	0.073	0.004	0.01
Manufacturing industries and construction	0.032	0.073	0.004	0.01
Commercial/Institutional	0.316	0.734	0.004	0.01
Residential	0.316	0.734	0.004	0.01
Agriculture/Forestry/Fishing	0.316	0.734	0.004	0.01
Charcoal				
Energy Industries	0.211	0.489	0.004	0.01
Manufacturing industries and construction	0.211	0.489	0.004	0.01
Commercial/Institutional	0.211	0.489	0.001	0.002
Residential	0.211	0.489	0.001	0.002
Agriculture/Forestry/Fishing	0.211	0.489	0.001	0.002
Other biomass and wastes				
Energy Industries	0.032	0.073	0.004	0.01
Manufacturing industries and construction	0.032	0.073	0.004	0.01
Commercial/Institutional	0.316	0.734	0.004	0.01
Residential	0.316	0.734	0.004	0.01
Agriculture/Forestry/Fishing	0.316	0.734	0.004	0.01

*When converting units, it may be necessary to increase the number of significant digits to ensure accuracy in the calculations.

References:

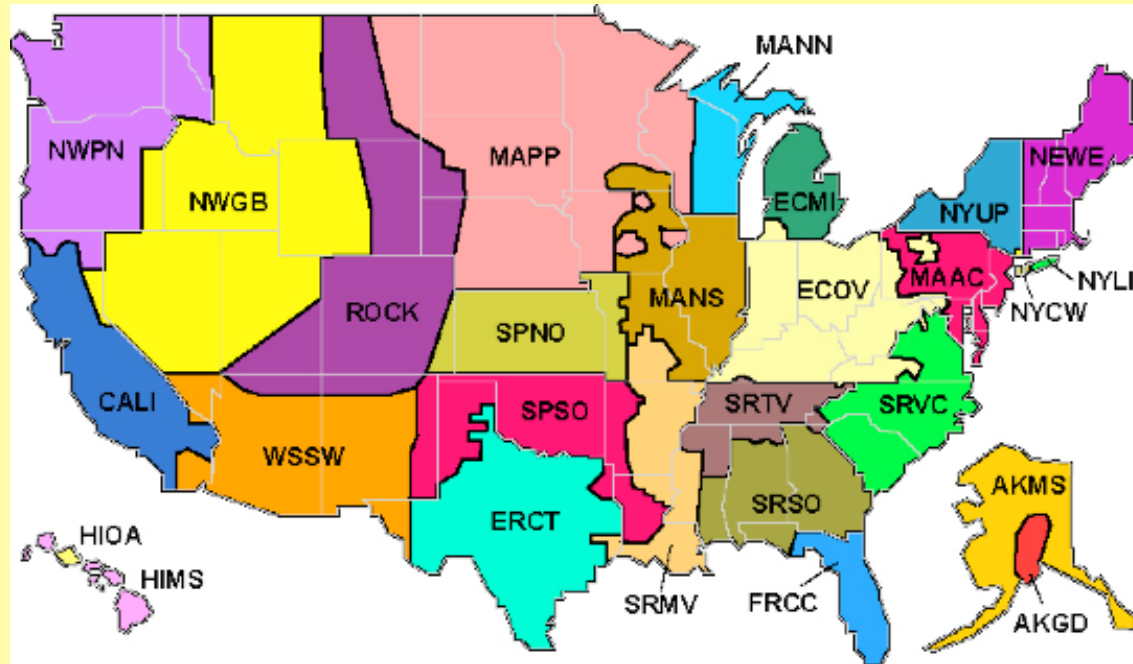
The European Environment Agency's EMEP/Corinair Emission Inventory Guidebook.^[4]

[1] See <http://www.ipcc.ch/pub/guide.htm>

[2] See <http://www.ipcc-nggip.iges.or.jp/EFDB/main.php>

Appendix G

Use the map below to find your eGRID (or "powerpool") Subregion, then refer to the emissions factors below.
If you are unsure of your powerpool, use the EPA Power Profiler at: www.epa.gov/cleanenergy/powpro/screen1.html



NERC Region/eGRID Subregion	eGRID Subregion Acronym	1996		1997		1998		1999		2000	
		lbs CO ₂ / kWh	grams CO ₂ / kWh	lbs CO ₂ / kWh	grams CO ₂ / kWh	lbs CO ₂ / kWh	grams CO ₂ / kWh	lbs CO ₂ / kWh	grams CO ₂ / kWh	lbs CO ₂ / kWh	grams CO ₂ / kWh
ASCC	ASCC	1.269	575.4	1.266	574.1	n/a	n/a	n/a	n/a	n/a	n/a
ASCC Alaska Grid	AKGD	n/a	n/a	n/a	n/a	1.501	680.8	1.286	583.2	1.4	635
ASCC Miscellaneous	AKMS	n/a	n/a	n/a	n/a	1.083	491	1.079	489.6	0.758	343.7
ECAR	ECAR	2.001	907.8	1.973	895	n/a	n/a	n/a	n/a	n/a	n/a
ECAR Michigan	ECMI	n/a	n/a	n/a	n/a	1.71	775.7	1.651	748.9	1.632	740.3
ECAR Ohio Valley	ECOV	n/a	n/a	n/a	n/a	2.074	940.9	2.043	926.9	1.967	892
ERCOT All	ERCT	1.498	679.3	1.488	674.7	1.417	642.6	1.412	640.3	1.408	638.8
FRCC All	FRCC	1.68	761.8	1.693	768.2	1.478	670.2	1.499	679.7	1.39	630.5
HICC	HICC	1.597	724.4	1.805	818.9	n/a	n/a	n/a	n/a	n/a	n/a
HICC Miscellaneous	HIMS	n/a	n/a	n/a	n/a	1.39	630.3	1.459	661.7	1.703	772.4
HICC Oahu	HIOA	n/a	n/a	n/a	n/a	1.648	747.5	1.8	816.5	1.722	781
MAAC All	MAAC	1.344	609.4	1.301	590.3	1.199	543.9	1.153	522.8	1.098	497.9
MAIN	MAIN	1.427	647.1	1.622	735.7	n/a	n/a	n/a	n/a	n/a	n/a
MAIN North	MANN	n/a	n/a	n/a	n/a	1.83	830.2	1.774	804.5	1.761	798.8
MAIN South	MANS	n/a	n/a	n/a	n/a	1.464	663.9	1.284	582.3	1.237	561.2
MAPP All	MAPP	1.842	835.7	1.856	841.8	1.949	884.1	1.818	824.6	1.839	834.1
Off-Grid	OFFG	n/a	n/a	n/a	n/a	2.479	1,124.30	1.376	624.1	1.707	774.2
NPCC	NPCC	0.974	441.6	1.098	498.1	n/a	n/a	n/a	n/a	n/a	n/a
NPCC Long Island	NYLI	n/a	n/a	n/a	n/a	1.281	581.2	1.817	824.4	1.66	752.9
NPCC New England	NEWE	n/a	n/a	n/a	n/a	1.119	507.4	1.057	479.6	0.897	406.9
NPCC NYC/Westchester	NYCW	n/a	n/a	n/a	n/a	0.999	453.2	0.851	386.2	1.09	494.5
NPCC Upstate NY	NYUP	n/a	n/a	n/a	n/a	0.897	406.7	0.863	391.4	0.843	382.4
SERC	SERC	1.368	620.5	1.384	627.8	n/a	n/a	n/a	n/a	n/a	n/a
SERC Mississippi Valley	SRMV	n/a	n/a	n/a	n/a	1.285	583	1.344	609.6	1.331	603.9
SERC South	SRSO	n/a	n/a	n/a	n/a	1.549	702.6	1.541	699	1.562	708.3
SERC Tennessee Valley	SRTV	n/a	n/a	n/a	n/a	1.23	557.9	1.329	603.1	1.373	622.7
SERC Virginia/Carolina	SRVC	n/a	n/a	n/a	n/a	1.15	521.6	1.16	526.2	1.164	528.1
SPP	SPP	1.643	745.2	1.67	757.3	n/a	n/a	n/a	n/a	n/a	n/a
SPP North	SPNO	n/a	n/a	n/a	n/a	1.883	854.1	1.98	898	2.011	912.3
SPP South	SPSO	n/a	n/a	n/a	n/a	1.84	834.7	1.853	840.7	1.937	878.5
WECC	WECC	0.99	448.9	1.001	453.9	n/a	n/a	n/a	n/a	n/a	n/a
WECC California	CALI	n/a	n/a	n/a	n/a	0.671	304.4	0.738	334.8	0.805	364.9
WECC Great Basin	NWGB	n/a	n/a	n/a	n/a	1.048	475.6	0.788	357.6	0.852	386.6
WECC Pacific Northwest	NWPN	n/a	n/a	n/a	n/a	0.686	311.3	0.632	286.7	0.671	304.4
WECC Rockies	ROCK	n/a	n/a	n/a	n/a	1.792	813	1.79	811.8	1.873	849.4
WECC Southwest	WSSW	n/a	n/a	n/a	n/a	1.423	645.7	1.423	645.5	1.424	645.9

**"NERC" is the North American Electric Reliability Council, a not-for-profit corporation that coordinates electric grid integration. Only data from NERC Regions is available for 1996-97. From 1998 on, data is available at the smaller and more accurate eGRID Subregion level.

Source: eGRID: Emissions and Generated Resource Integrated Database, Data Years 1996-2000, Version 2.01. US EPA Office of Atmospheric Programs. Prepared by E.H. Pechan & Associates, Inc. May 2003. <http://www.epa.gov/cleanenergy/egrid.htm>