Supplement: Historical (1750 – 2023) trends of reactive gases and aerosols from the Community Earth atmospheric Data System (CEDS)

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1. How to Navigate the CEDS GitHub site

The CEDS GitHub site contains the entire open source CEDS data system, including all data needed to run the system, except the IEA Energy Statistics (license required) and gridding proxy data, available via the CEDS zenodo (https://zenodo.org/communities/ceds).

The CEDS GitHub wiki includes a CEDS User Guide with helpful details for getting started, a system overviews, and tips for navigating the system. The wiki also includes a description of major data sets and release notes from all CEDS releases.

CEDS User Guide: https://github.com/JGCRI/CEDS/wiki/User_Guide
Data and Assumptions: https://github.com/JGCRI/CEDS/wiki/Data_and_Assumptions

All input data files and assumptions can be found in
https://github.com/JGCRI/CEDS/tree/master/code.
All CEDS Code, organized into Modules, can be found in
https://github.com/JGCRI/CEDS/tree/master/code.
Helpful mapping files such as country and sector mappings can be found in
https://github.com/JGCRI/CEDS/tree/master/input/mappings.

Any issues or questions can be posed through the GitHub Issues page:
https://github.com/JGCRI/CEDS/issues

2. CEDS Sector and Fuel Definitions

Table 1 CEDS to IEA Combustion Sector Mapping

IEA Flow	IEA Flow description	CEDS Sector
AUTOELEC	Autoproducer Electricity Plants	1A1a_Electricity-autoproducer

MAINELEC	Main Activity Producer Electricity Plants	1A1a_Electricity-public
MAINCHP	Main Activity Producer CHP Plants	1A1a_Heat-production
AUTOCHP	Autoproducer CHP Plants	1A1a_Heat-production
MAINHEAT	Main Activity Producer Heat Plants	1A1a_Heat-production
AUTOHEAT	Autoproducer Heat Plants	1A1a_Heat-production
THEAT	Heat Pumps	1A1a_Heat-production
TBOILER	Electric Boilers	1A1a_Heat-production
TELE	Chemical heat for electricity production	1A1a_Heat-production
NONENUSE	Non-Energy Use	1A1bc_Other-feedstocks
IRONSTL	Iron and Steel	1A2a_Ind-Comb-Iron-steel
NONFERR	Non-Ferrous Metals	1A2b_Ind-Comb-Non-ferrous-metals
CHEMICAL	Chemical and Petrochemical	1A2c_Ind-Comb-Chemicals
PAPERPRO	Paper, Pulp and Print	1A2d_Ind-Comb-Pulp-paper
FOODPRO	Food and Tobacco	1A2e_Ind-Comb-Food-tobacco
NONMET	Non-Metallic Minerals	1A2f_Ind-Comb-Non-metalic-minerals
CONSTRUC	Construction	1A2g_Ind-Comb-Construction
MACHINE	Machinery	1A2g_Ind-Comb-machinery
MINING	Mining and Quarrying	1A2g_Ind-Comb-mining-quarying
INONSPEC	Non-specified (Industry)	1A2g_Ind-Comb-other
TEXTILES	Textile and Leather	1A2g_Ind-Comb-textile-leather
TRANSEQ	Transport Equipment	1A2g_Ind-Comb-transpequip
WOODPRO	Wood and Wood Products	1A2g_Ind-Comb-wood-products
AVBUNK	International Aviation Bunkers	1A3ai_International-aviation
DOMESAIR	Domestic Aviation	1A3aii_Domestic-aviation
ROAD	Road	1A3b_Road
RAIL	Rail	1A3c_Rail
MARBUNK	International Marine Bunkers	1A3di_International-shipping
WORLDMAR	World Marine Bunkers	1A3di_International-shipping
DOMESNAV	Domestic Navigation	1A3dii_Domestic-navigation
PIPELINE	Pipeline Transport	1A3eii_Other-transp
TRNONSPE	Non-specified (Transport)	1A3eii_Other-transp
COMMPUB	Commercial and Public Services	1A4a_Commercial-institutional
RESIDENT	Residential	1A4b_Residential
AGRICULT	Agriculture/Forestry	1A4c_Agriculture-forestry-fishing
FISHING	Fishing	1A4c_Agriculture-forestry-fishing
ONONSPEC	Final Consumption not elsewhere specified	1A5_Other-unspecified

Table 2 CEDS to IEA Fuel Mapping

CEDS Fuel	IEA Fuel Product
biomass	Industrial waste (TJ-net) Municipal waste (renewable) (TJ-net) Municipal waste (non-renewable) (TJ-net) Primary solid biofuels (TJ-net) Non-specified primary biofuels/waste (TJ-net) Charcoal (kt)
brown_coal	Brown coal (if no detail) (kt) Lignite (kt) Peat (kt) Peat products (kt)
coal_coke	Coke oven coke (kt)
diesel_oil	Gas/diesel oil excl. biofuels (kt) Lubricants (kt) Biodiesels (kt)
hard_coal	Hard coal (if no detail) (kt) Anthracite (kt) Coking coal (kt) Other bituminous coal (kt) Sub-bituminous coal (kt) Patent fuel (kt) Gas coke (kt) Coal tar (kt) BKB (kt)
heavy_oil	Oil shale and oil sands (kt) Crude/NGL/feedstocks (if no detail) (kt) Crude oil (kt) Fuel oil (kt) Bitumen (kt) Paraffin waxes (kt) Petroleum coke (kt) Other oil products (kt)
light_oil	Refinery feedstocks (kt) Additives/blending components (kt) Other hydrocarbons (kt) Ethane (kt) Liquefied petroleum gases (LPG) (kt) Motor gasoline excl. biofuels (kt) Aviation gasoline (kt) Gasoline type jet fuel (kt) Kerosene type jet fuel excl. biofuels (kt) Bio jet kerosene (kt) Other kerosene (kt) Naphtha (kt) White spirit & SBP (kt) Biogasoline (kt) Other liquid biofuels (kt)

natural_gas	Natural gas liquids (kt) Gas works gas (TJ-gross) Coke oven gas (TJ-gross) Blast furnace gas (TJ-gross) Other recovered gases (TJ-gross) Natural gas (TJ-gross) Refinery gas (kt) Biogases (TJ-net)

More detail on CEDS sector definitions can be found in the data system on github at: https://github.com/JGCRI/CEDS/blob/master/input/mappings/CEDS_Sector_Definitions%20(CEIP_IEA).xlsx

3. EDGAR to CEDS Scaling Definitions

Table 3 EDGAR to CEDS Scaling Mapping

EDGAR Sector	EDGAR Description	Intermediate Scaling Sector	CEDS Sector	CEDS Sector Type
1A1a	Public electricity and heat production		1A1a_Electricity-public	comb
			1A1a_Electricity-autoproducer	comb
		1A1a	1A1a_Heat-production	comb
1A1bc	Other Energy Industries	1A1bc	1A1bc_Other-transformation	NC
1A2	Manufacturing Industries and Construction		1A2a_Ind-Comb-Iron-steel	comb
			1A2b_Ind-Comb-Non-ferrous-metals	comb
			1A2c_Ind-Comb-Chemicals	comb
			1A2d_Ind-Comb-Pulp-paper	comb
			1A2e_Ind-Comb-Food-tobacco	comb
			1A2f_Ind-Comb-Non-metalic-minerals	comb
			1A2g_Ind-Comb-Construction	comb
			1A2g_Ind-Comb-transpequip	comb
			1A2g_Ind-Comb-machinery	comb
			1A2g_Ind-Comb-mining-quarying	comb
			1A2g_Ind-Comb-wood-products	comb
			1A2g_Ind-Comb-textile-leather	comb
		1A2	1A2g_Ind-Comb-other	comb
1A3a	Domestic aviation	1A3a	1A3aii_Domestic-aviation	comb
1A3b	Road transportation		1A3b_Road	comb
1A3b_noRES	Road transportation no resuspension		1A3b_Road	comb
1A3b_RES	Road transportation resuspension	1A3b	1A3b_Road	comb
1A3c	Rail transportation	1A3c	1A3c_Rail	comb
1A3d	Inland navigation	1A3d	1A3dii_Domestic-navigation	comb

1A3e	Other transportation	1A3e	1A3eii_Other-transp	comb
1A4	Residential and other sectors	1A4	1A4a_Commercial-institutional	comb
			1A4b_Residential	comb
			1A4c_Agriculture-forestry-fishing	comb
1A5	Other Energy Industries	1A5		comb
1B1	Fugitive emissions from solid fuels (fossil fuels)	1B1	1B1_Fugitive-solid-fuels	NC
1B1x	Fugitive emissions from solid fuels (biofuels)	1B1	1B1_Fugitive-solid-fuels	NC
1B2	Fugitive emissions from oil and gas (fossil fuels)	1B2	1B2_Fugitive-petr	NC
1B2	Fugitive emissions from gaseous fuels (fossil fuels)		1B2b_Fugitive-NG-prod	NC
1B2	Fugitive emissions from liquid fuels		1B2b_Fugitive-NG-distr	NC
1B2x	Fugitive emissions from oil and gas (biofuels)			NC
1B2x	Fugitive emissions from gaseous fuels (biofuels)			NC
			1B2d_Fugitive-other-energy	NC
1C1	Memo: International aviation	1C1	1A3ai_International-aviation	comb
1C2	Memo: International navigation	1C2	1A3di_International-shipping	comb
2A1	Cement production	2A1	2A1_Cement-production	NC
2A2	Lime production	2A2	2A2_Lime-production	NC
2A3	Limestone and dolomite use	2A6	2A6_Other-minerals	NC
2A4	Soda ash production and use		2A6_Other-minerals	NC
2A7	Production of other minerals		2A6_Other-minerals	NC
2B	Production of chemicals	2B	2B_Chemical-industry	NC
2C	Production of metals	2C	2C1_Iron-steel-alloy-prod	NC
2D	Production of pulp/paper/food/drink	2D	2H_Pulp-and-paper-food-beverage-wood	NC
2E	Production of halocarbons and SF6			NC
2F1	Refrigeration and Air Conditioning			NC
2F2	Foam Blowing			NC
2F3	Fire Extinguishers			NC
2F4	Aerosols			NC
2F5	F-gas as Solvent			NC
2F7	Semiconductor/Electronics Manufacture			NC
2F8	Electrical Equipment			NC
2F9	Other F-gas use			NC
2G	Non-energy use of lubricants/waxes (CO2)	Other	6B_Other-not-in-total	NC
3A	Solvent and other product use: paint	2E	2D_Paint-application	NC
3B	Solvent and other product use: degrease	2F	2D_Degreasing-Cleaning	NC
3C	Solvent and other product use: chemicals	2G	2D3_Chemical-products-manufacture-processing	NC

3D	Solvent and other product use: other		2D3_Other-product-use	NC
4A	Enteric fermentation	3A	3E_Enteric-fermentation	NC
4B	Manure management	3B	3B_Manure-management	NC
4C	Rice cultivation	3C	3D_Rice-Cultivation	NC
4D1	Direct soil emissions	3D	3D_Soil-emissions	NC
4D2	Manure in pasture/range/paddock		3B_Manure-management	NC
4D3	Indirect N2O from agriculture			EMFeedback
4D4	Other direct soil emissions		3D_Soil-emissions	NC
4E	Other-in-total	4E	6A_Other-in-total	NC
4F	Agricultural waste burning	4F	3F_Agricultural-residue-burning-on-fields	OpenBurn
5A	Forest fires	5A	11B_Forest-fires	OpenBurn
5C	Grassland fires	5C	11C_Other-natural	NaturalEM
5D	Peat fires and decay of drained peatland	5D	11C_Other-natural	NaturalEM
5F2	Forest Fires-Post burn decay			NaturalEM
6A	Solid waste disposal on land	6A	5A_Solid-waste-disposal	NC
6B	Wastewater handling	6B	5D_Wastewater-handling	NC
6C	Waste incineration	6C	5C_Waste-incineration	NC
6D	Other waste handling		5E_Other-waste-handling	NC
7A	Fossil fuel fires	7A	7A_Fossil-fuel-fires	NC
7B	Indirect N2O from non-agricultural NOx		7BC_Indirect-N2O-non-agricultural-N	NC
7C	Indirect N2O from non-agricultural NH3		7BC_Indirect-N2O-non-agricultural-N	NC
7D	Other sources	Other	2L_Other-process-emissions	NC
			1A1bc_Other-feedstocks	NC