BEYOND
SMART CITIES
URBAN GREENHOUSE GAS INVENTORY
SPECIALIST TRAINING COURSE
KRISHNAJI PAWAR, LEED AP BD+C,GSAS CGP,ISO 14001:2015,GCP
GHG AND CLIMATE CHANGE SPECIALIST CURRICULUM

STATIONARY ENERGY
FOR GHG & CLIMATE CHANGE PROFESSIONALS
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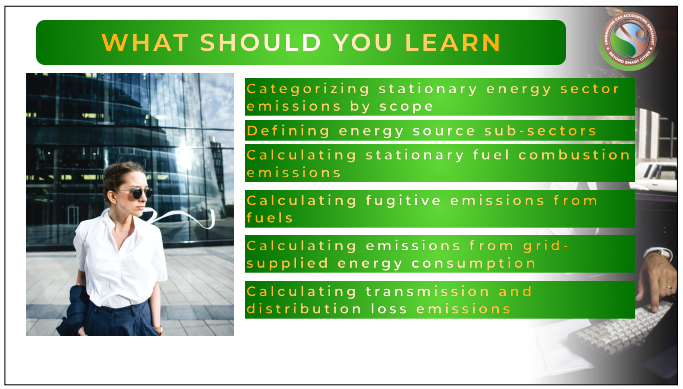

WHAT SHOULD YOU LEARN
Categorizing stationary energy sector emissions by scope
Defining energy source sub-sectors
Calculating stationary fuel combustion emissions
Calculating fugitive emissions from fuels
Calculating emissions from grid-supplied energy consumption
Calculating transmission and distribution loss emissions

STATIONARY ENERGY

Stationary energy sources are one of the largest contributors to a city's GHG emissions. These emissions come from fuel combustion, as well as fugitive emissions released in the process of generating, delivering, and consuming useful forms of energy (such as electricity or heat).

Requirements in this lecture

For BASIC: Cities shall report all GHG emissions from Stationary Energy sources and fugitive emissions in scope 1, and those from use of grid-supplied electricity, steam, heating, and cooling in scope 2.

For BASIC+: Cities shall report all BASIC sources and scope 3 GHG emissions associated with transmission and distribution (T&D) losses from grid-supplied electricity, steam, heating, and cooling. Emissions from energy generation supplied to the grid shall be reported as part of total scope 1 emissions, but not included in BASIC/BASIC+ totals.

CATEGORIZING STATIONARY ENERGY SECTOR EMISSIONS BY SCOPE

Scope 1 (Territorial): Emissions from fuel combustion and fugitive emissions in the city

Scope 2: Emissions from the consumption of grid-supplied electricity, steam, heating and cooling in the city

Scope 3: Distribution losses from grid-supplied electricity, steam, heating and cooling in the city

DEFINING ENERGY SOURCE SUB-SECTORS

GHG Emission Source	Scope 1	Scope 2	Scope 3
STATIONARY ENERGY	Emissions from fuel combustion and fugitive emissions within the city boundary	Emissions from consumption of grid-supplied energy consumed within the city boundary	Transmission and distribution losses from the use of grid-supplied energy
Residential buildings	I.1.1	I.1.2	I.1.3
Commercial and institutional buildings and facilities	I.2.1	I.2.2	I.2.3
Manufacturing industries and construction	I.3.1	I.3.2	I.3.3
Energy industries	I.4.1	I.4.2	I.4.3
Energy generation supplied to the grid	I.4.4		
Agriculture, forestry and fishing activities	I.5.1	I.5.2	I.5.3
Non-specified sources	I.6.1	I.6.2	I.6.3
Fugitive emissions	I.7.1, I.8.1		

Sources required for BASIC reporting
Sources required for BASIC+ reporting
Sources included in Other Scope 3
Sources required for Scope 1 (territorial) total but not for BASIC/BASIC+ reporting (italics)
Non-applicable emissions

The Stationary Energy sector can be divided into eight sub-sectors. Seven of these produce emissions from both energy production and consumption, while the remaining one relates to fugitive emissions from fuel- related activities.

Table 14.2 below provides detailed descriptions of Stationary Energy source sub-sectors. Cities may adopt additional city- or country-specific categories where data allows, but should clearly describe the differences and assumptions in inventories. Cities may further subdivide these sub-sectors into sub-categories that are more useful for mitigation action planning.

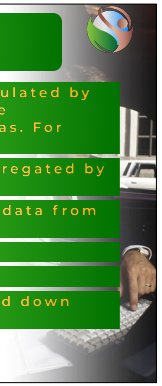
DEFINITIONS OF STATIONARY ENERGY SOURCE SUB-SECTORS

Sub-sectors	Definition
Emissions from stationary energy production and use	Emissions from the intentional oxidation of materials within a stationary apparatus that is designed to raise heat and provide it either as heat or as mechanical work to a process, or for use away from the apparatus
1.1 Residential buildings	All emissions from energy use in households
1.2 Commercial buildings and facilities	All emissions from energy use in commercial buildings and facilities
1.2 Institutional buildings and facilities	All emissions from energy use in public buildings such as schools, hospitals, government offices, highway street lighting, and other public facilities
1.3 Manufacturing industries and construction	All emissions from energy use in industrial facilities and construction activities, except those included in energy industries sub-sector. This also includes combustion for the generation of electricity and heat for own use in these industries.
1.4 Energy industries	All emissions from energy production and energy use in energy industries
1.4.4 Energy generation supplied to the grid	All emissions from the generation of energy for grid-distributed electricity, steam, heat and cooling
1.5 Agriculture, forestry, and fishing activities	All emissions from energy use in agriculture, forestry, and fishing activities
1.6 Non-specified sources	All remaining emissions from facilities producing or consuming energy not specified elsewhere
1.7 Fugitive emissions from fuel	Includes all intentional and unintentional emissions from the extraction, processing, storage and transport of fuel to the point of final use *Note:* Some product uses may also give rise to emissions termed as "fugitive," such as the release of refrigerants and fire suppressants. These shall be reported in IPPU.

CALCULATING STATIONARY FUEL COMBUSTION EMISSIONS

Emissions from Stationary Energy sources are calculated by multiplying fuel consumption (activity data) by the corresponding emission factors for each fuel, by gas. For activity data, cities should aim to obtain:

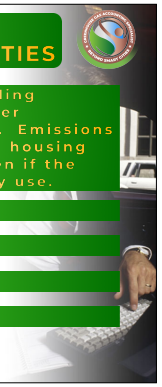
- ☑ Real consumption data for each fuel type, disaggregated by sub-sector.
- ☑ A representative sample set of real consumption data from surveys.
- ☑ Modeled energy consumption data.
- ☑ Incomplete or aggregate real consumption data:
- ☑ Regional or national fuel consumption data scaled down using population or other indicators.



RESIDENTIAL, COMMERCIAL, AND INSTITUTIONAL BUILDINGS AND FACILITIES

While the GPC recommends that cities report building emissions in relevant sub-sectors, cities may further subdivide these into more detailed sub-categories. Emissions from energy used in informal settlements or social housing shall be reported in the residential sub-sector, even if the settlements' local government pays for that energy use.

- ☑ Mixed use buildings
- ☑ Office buildings in industrial establishments
- ☑ Workers' quarters in industrial establishments
- ☑ Residential units in agricultural farms



MANUFACTURING INDUSTRIES AND CONSTRUCTION

Table 6.4 Detailed sub-categories of manufacturing industries and construction sub-sector, from the International Standard Industrial Classification (ISIC)[25]

Sub-categories[26]	ISIC Classification	Description
Iron and steel	ISIC Group 271 and Class 2731	Manufacture of primary iron and steel products, including the operation of blast furnaces, steel converters, rolling and finishing mills, and casting
Non-ferrous metals	ISIC Group 272 and Class 2732	Production, smelting, and refinement of precious metals and other non-ferrous metals from ore or scrap
Chemicals	ISIC Division 24	The manufacture of basic chemicals, fertilizer and nitrogen compounds, plastics, synthetic rubber, agro-chemical products, paints and coatings, pharmaceuticals, cleaning agents, synthetic fibers, and other chemical products
Pulp, paper and print	ISIC Divisions 21 and 22	Pulp, paper, paperboard, paper products, publishing and reproduction of recorded media
Food processing, beverages, and tobacco	ISIC Divisions 15 and 16	Production, processing, and preservation of food and food products, beverages, and tobacco products
Non-metallic minerals	ISIC Division 26	Manufacture and production of glass and glass products, ceramics, cements, plasters, and stone
Transport equipment	ISIC Divisions 34 and 35	Motor vehicles, trailers, accessories and components, sea vessels, railway vehicles, aircraft and spacecraft, and cycles
Machinery	ISIC Divisions 28, 29, 30, 31, 32	Fabricated metal products, machinery and equipment, electrical machinery and apparatuses, communications equipment, and associated goods
Mining (excluding fuels) and quarrying	ISIC Divisions 13 and 14	Mining of iron, non-ferrous ores, salt, and other minerals; quarrying of stone, sand, and clay
Wood and wood products	ISIC Division 20	Sawmilling and planing of wood; the production of wood products and cork, straw, and other wood-based materials
Construction	ISIC Division 45	Site preparation, construction installation, building completion, and construction equipment
Textile and leather	ISIC Division 17, 18, 19	Spinning, weaving, dyeing, of textiles and manufacture of apparel, tanning and manufacture of leather and footwear
Non-specific industries	Activities not included above	Any main.dusturing industry/construction not included above, including water collection, treatment, supply; wastewater treatment and disposal, and waste collection, treatment, and disposal

25. Further descriptions of each subcategory can be found in the International Standard Industrial Classification (ISIC) of All Economic Activities, Revision 5.

26. 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Type of premises	Temporary	Permanent
Industries	Quarters built and demolished within a period shorter than 12 months (an inventory cycle)	Quarters that exist for more than 12 months
Construction	All workers' quarters for construction activities should be considered temporary	Not applicable unless otherwise specified in local regulations

This sub sector includes energy use in manufacturing industries and construction activities. Fuel combustion occurs in stationary equipment, including boilers, furnaces, burners, turbines, heaters, incinerators, engines, flares, etc. Where data are available, GHG emissions from relevant sub-categories should be reported using the 11 sub-categories identified in the IPCC Guidelines under the manufacturing industries and construction sub-sectors.

- Relationship between manufacture of transport equipment and Transportation sector
- Relationship between on-road and off-road transportation
- Relationship between water supply system, solid waste, and wastewater treatment and disposal facilities

Table 6.5 Overview of reporting guidance for off-road transportation activities

Type of off-road activities	Reporting guidance
Off-road vehicle and mobile machinery within industrial premises and construction sites	Report as a Stationary Energy source under manufacturing industries and construction sub-sector or energy industries sub-sector as appropriate
Off-road vehicle and mobile machinery within agriculture farms, forests, and aquaculture farms	Report as a Stationary Energy source under agriculture, forestry, and fishing activities sub-sector
Off-road vehicle and mobile machinery within the transportation facility premises such as airports, harbors, bus terminals, and train stations	Report as a Transportation source under off-road transportation sub-sector
Off-road vehicle and mobile machinery within military premises	Report as a Stationary Energy source under unidentified activities sub-sector

ENERGY INDUSTRIES

Energy industries include three basic types of activities

Table 6.6 Detailed sub-categories of energy industries sub-sector[26]

Sub-categories	Descriptions	Detailed breakdown
Energy industries (including electricity, steam, heat/cooling	Emissions from main activity producers of electricity generation, combined heat and power generation, and heat plants. Main activity producers (often termed public utilities) own a set of plants whose primary activity is to supply energy to the public, but the organization may be under public or private ownership. Emissions from the use of fuel should be included. However, emissions from autoproducers (which generate electricity/heat wholly or partly for their own use, as an activity that supports their primary activity) should be excluded from this category where they were generated (such as industrial, or institutional). Autoproducers may be under public or private ownership.	**Energy generation sold and distributed** comprises emissions from all fuel use for electricity generation from main activity producers (reported under 1.A.1a) except those from combined heat and power plants (see CHP below). This includes emissions from the incineration of waste or waste byproducts for the purpose of energy generation. This is a mandatory sub-sector required for scope 1 (territorial) reporting, but not BASIC/BASIC+. **Auxiliary energy use** on the site of energy production facilities (e.g., a small administrative office adjacent to a power plant). Energy used in auxiliary activities is assumed to be the energy consumed before being sold and distributed to a grid (reported under 1.A.1.1). It is therefore not grid-distributed energy consumption. Auxiliary energy use and sold/distributed energy should together add up to total emissions from fuel combusted for energy generation. **Combined heat and power generation (CHP)** Emissions from production of both heat and electrical power from main activity producers for sale to the public, at a single CHP facility. **Heat plants** Production of heat for city-wide district heating or industrial usage. Distributed by pipe network.
Petroleum refining	All combustion activities supporting the refining of petroleum products, including on-site combustion for the generation of electricity and heat for own use.	N/A
Manufacture of solid fuels and other energy industries	This includes combustion emissions from fuel use during the manufacture of secondary and tertiary products from solid fuels (e.g., charcoal, coke, and BKB). Emissions from own-use fuel use should be included. Also includes combustion for the generation of electricity and heat for own use in these industries.	**Manufacture of solid fuels** Emissions arising from fuel combustion for the production of coke, brown coal briquettes and patent fuel. **Other energy industries** Combustion emissions arising from the energy-producing industries over (on-site) energy use not mentioned above or for which separate data are not available. This includes emissions from on-site fuel use for the production of charcoal, liquefaction of coal, cotton cakes and carbonizing of biofuels as well as fuel used for coal mining, oil and gas extraction and the processing and upgrading of natural gas. This category also includes emissions from pre-combustion processing for CO_2 capture and storage.

- Primary fuel production (e.g., coal mining, and oil and gas extraction)
- Fuel processing and conversion (e.g., crude oil to petroleum products in refineries, coal to coke and coke oven gas in coke ovens)
- Energy production supplied to a grid (e.g., electricity generation and district heating) or used on-site for auxiliary energy use

Where applicable and possible, cities should follow IPCC Guidelines and disaggregate accounting and reporting of energy industries sub-sector into different sub-categories as detailed in Table 6.6.

COGENERATION AND TRI-GENERATION

Cogeneration, or combined heat and power (CHP), is the use of power plant or heat engine systems to simultaneously generate electricity and useful heat.

Trigeneration, or combined cooling, heat and power (CCHP), refers to the simultaneous generation of electricity, heat, and cooling. GHG emissions from these facilities should be calculated based on the quantity of fuel combusted.

WASTE-TO-ENERGY AND BIOENERGY

Where waste is used to generate energy, emissions are counted as Stationary Energy sources. This includes energy recovered from landfill gas or waste combustion.

Table 6.7 provides an overview of principles to help avoid double counting between Waste, Stationary Energy, and AFOLU sectors.

AN OVERVIEW OF REPORTING CATEGORISATION FOR WASTE-TO-ENERGY AND BIOENERGY EMISSIONS

Table 6.7 An overview of reporting categorization for waste-to-energy and bioenergy emissions

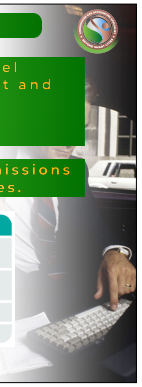
Activity	Purpose	CO_2	CH_4 and N_2O
Landfill gas combustion	As part of waste disposal process	Report biogenic CO_2 emissions under Waste sector (separately from any fossil CO_2 emissions)	Report emissions under Waste sector
	Energy generation	Report biogenic CO_2 under Stationary Energy sector (separately from any fossil CO_2 emissions)	Report emissions under Stationary Energy sector
Waste incineration	Waste disposal (no energy recovery)	Report CO_2 emissions under Waste sector (with biogenic CO_2 reported separately from any fossil CO_2 emissions)	Report emissions as Waste sector
	Energy generation	Report CO_2 emissions under Stationary Energy sector (with biogenic CO_2 reported separately from any fossil CO_2 emissions)	Report emissions under Stationary Energy sector
Biomass incineration	Waste disposal	Report biogenic CO_2 emissions under Waste sector (separately from any fossil CO_2 emissions)	Report emissions under Waste sector
	Energy generation	Report biogenic CO_2 emissions under Stationary Energy sector (separately from any fossil CO_2 emissions)	Report emissions under Stationary Energy sector

AGRICULTURE, FORESTRY, AND FISHING ACTIVITIES

This sub-sector covers GHG emissions from direct fuel combustion in agricultural activities, including plant and animal cultivation, afforestation and reforestation activities, and fishery activities (e.g., fishing and aquaculture).

Table 6.8 provides reporting guidance for typical emissions sources in agriculture, forestry, and fishing activities.

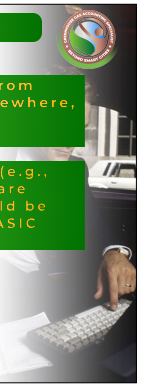
Sources of emission	Reporting guidance
Off-road vehicles and machinery (stationary and mobile) used for agriculture, forestry, and fishing activities	Report as a Stationary Energy source under agriculture, forestry, and fishing activities sub-sector
On-road transportation to and from the locations of agriculture, forestry, and fishing activities	Report under Transportation sector
Burning of agricultural residues	Report under AFOLU sector
Enteric fermentation and manure management	Report under AFOLU sector



NON-SPECIFIED SOURCES

This subcategory includes all remaining emissions from Stationary Energy sources that are not specified elsewhere, including emissions from direct fuel combustion for stationary units in military establishments.

Non-technical losses during electricity distribution (e.g., theft) must be reported in cities where such losses are significant, and data is available. These losses should be reported in scope 2, so that it can be reflected in BASIC totals.



CALCULATING FUGITIVE EMISSIONS FROM FUELS

A small portion of emissions from the energy sector frequently arises as fugitive emissions, which typically occur during extraction, transformation, and transportation of primary fossil fuels. Where applicable, cities should account for fugitive emissions from the following sub-sectors: 1) mining, processing, storage, and transportation of coal; and 2) oil and natural gas systems.

When calculating fugitive emissions, cities should take into account any fugitive emission removals or sequestration that may be required by law.

- ☑ Mining, processing, storage, and transportation of coal
- ☑ Oil and natural gas systems

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- ☑ Oil and natural gas systems

CALCULATING EMISSIONS FROM GRID-SUPPLIED ENERGY CONSUMPTION

Scope 2 represents all grid-supplied electricity, steam, heating and cooling consumed within the city boundary. Electricity is the most common form of grid-supplied energy, used in almost all homes, offices, other buildings, and outdoor lighting. Grid-supplied energy in the form of direct steam (heating) and/or chilled water (cooling) is typically provided by district energy systems, which may cover a smaller geographic area than electricity grids, which are typically regional. In all cases, using grid-supplied energy entails emissions produced at generation facilities off-site from the consumption facilities.

- ☑ Location-based and market- based calculation methods
- ☑ Relationship between energy generation (scope 1) and energy consumption (scope 2)
- ☑ Calculating grid-supplied electricity emissions
- ☑ Calculating grid-supplied steam, heating and cooling emissions

THE MARKET-BASED METHOD FOR SCOPE 2 ACCOUNTING

As described in the GHG Protocol Scope 2 Guidance, the market-based method for scope 2 based on allocating emissions from energy generators to consumers based on "contractual instruments" such as utility-specific emission factors, energy attribute certificates, or other contracts.

The method reflects contractual relationships between energy suppliers and customers, so a city-wide market-based scope 2 total would reflect emissions from only those resources that individual consumers have matched with contractual instruments.

CALCULATING TRANSMISSION AND DISTRIBUTION LOSS EMISSIONS

During the transmission and distribution of electricity, steam, heating and cooling on a grid, some of the energy produced at the power station is lost during delivery to end consumers.

Emissions associated with these transmission and distribution losses are reported in scope 3 as part of out-of-boundary emissions associated with city activities.

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