Green Technology Application for the Development of Low Carbon Cities (GTALCC)

City-wide GHG accounting

24 March 2021

Welcome back

24 March 2021

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RE-CAP

Module E: Waste

Module E: Waste

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Practical

Practical

	Task	
1	Identify all different types of waste generated across your city from residential (municipal), commercial and industrial sources. List them in Table 1	20m
2	Where does your city's waste go? Identify all waste treatment facilities within your city boundary, and any out of boundary waste treatment facilities used by your city. Complete Table 2	
3	Estimate GHG emissions for all sub-sectors using (a) the CIRIS calculators and (b) by scaling down national waste data from BUR3	40m
4	Record your data in Table 3, clearly documenting methodologies and data sources used. For now, assume all your city's waste is treated outside of your city boundary. Where no GHG emissions occur or are deemed insignificant, use "NO". For scope 3 sources, use "NE".	HW
5	Consolidate the above information into Table 4 and identify what activity data and emission factors you will need to estimate GHG emissions for Waste, and where you will source this from, including (a) quantity of waste generated by waste type, (b) quantity and location of waste treated by treatment type	

Calculations

Estimate GHG emissions for all sub-sectors using:
(a) the CIRIS calculators
(b) by scaling down national waste data from BUR3

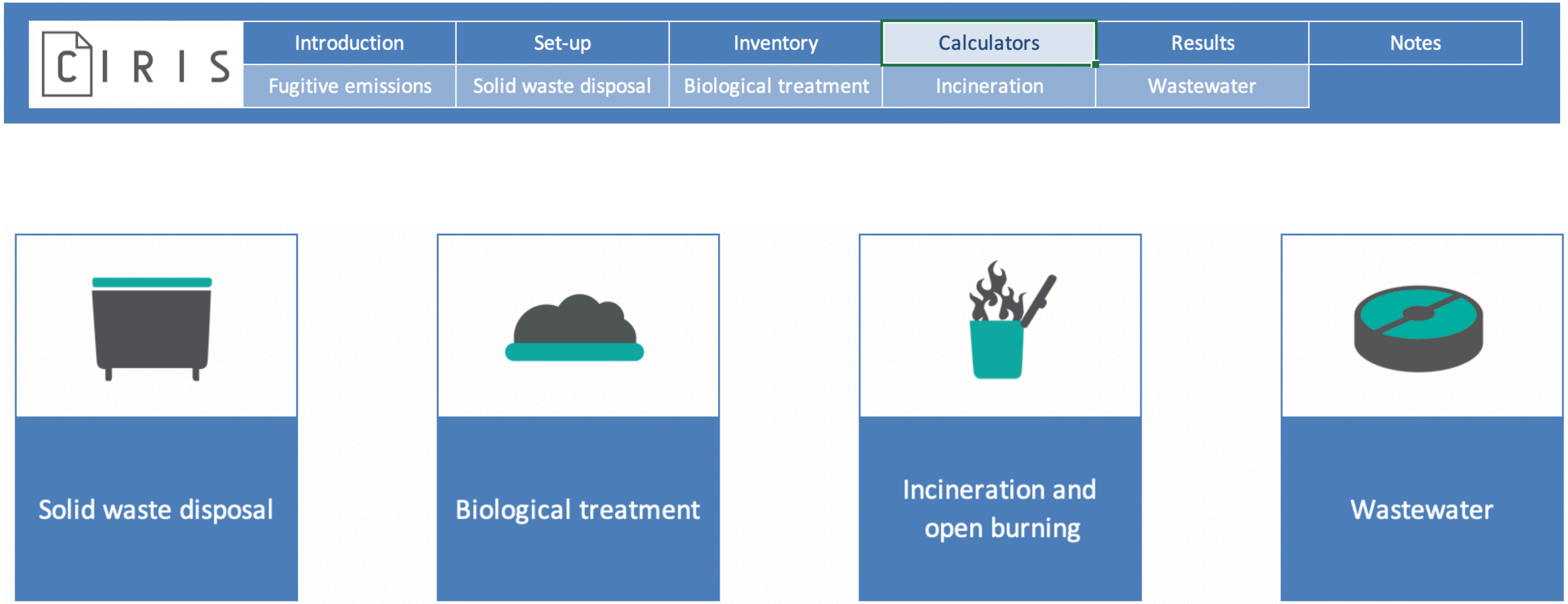
In Module B, we already estimated GHG emissions for all waste sub-sectors using the proxy city approach (Kuala Lumpur)

We'll then compare the different results, discuss any differences and choose a preferred method to use for now

Recommended waste sector methodologies:

- Use local activity data and emission factors
- **Use a proxy city**
- **Scale down from national**
- **Use CIRIS calculators**

(a) Waste calculators



(b) Scale down using national data

Scale down national GHG emissions data from BUR3 for all four GPC sub-sectors using population as a scaling factor:

- Solid Waste Disposal
- Biological treatment of Solid Waste
- Incineration and Open Burning of Waste
- Domestic Wastewater Treatment and Discharge

$$\text{Scaling factor} = \frac{\text{Your population}}{\text{Malaysia population}}$$

Note: Population for Malaysia in 2017 = 31,600,000

(c) Use a proxy city ✓

CITY	INVENTORY YEAR	POPULATION	GDP (MILLION USD)	AREA (KM2)
Kuala Lumpur (Malaysia)	2017	1,793,000	52,097	243

	Scope 1	Scope 2	Scope 3
Kuala Lumpur	**15,548,891**	**8,969,058**	**576,105**
Stationary	**1,472,306**	**8,882,384**	**0**
Residential buildings	182,833	2,365,581	0
Commercial and institutional building and facilities	174,796	5,857,396	0
Manufacturing industries and construction	1,031,904	659,407	0
Energy industries	0	0	0
Agriculture, forestry and fishing activities	0	0	0
Non-specified sources	0	0	0
Fugitive emissions from mining, processing, storage and transportation of coal	0	0	0
Fugitive emissions from oil and natural gas systems	82,773	0	0
Transport	**13,875,481**	**86,674**	**0**
On-road transportation	13,875,481	0	0
Railways	0	86,674	0
Waterborne navigation	0	0	0
Aviation	0	0	0
Off-road transportation	0	0	0
Waste	**201,104**	**0**	**576,105**
Solid waste disposal	0	0	572,481
Biological treatment of waste	0	0	1,355
Incineration and open burning	0	0	2,269
Wastewater treatment and discharge	201,104	0	0

City waste calculations

Let's look at the results

- Different methodologies and data sources yield different results

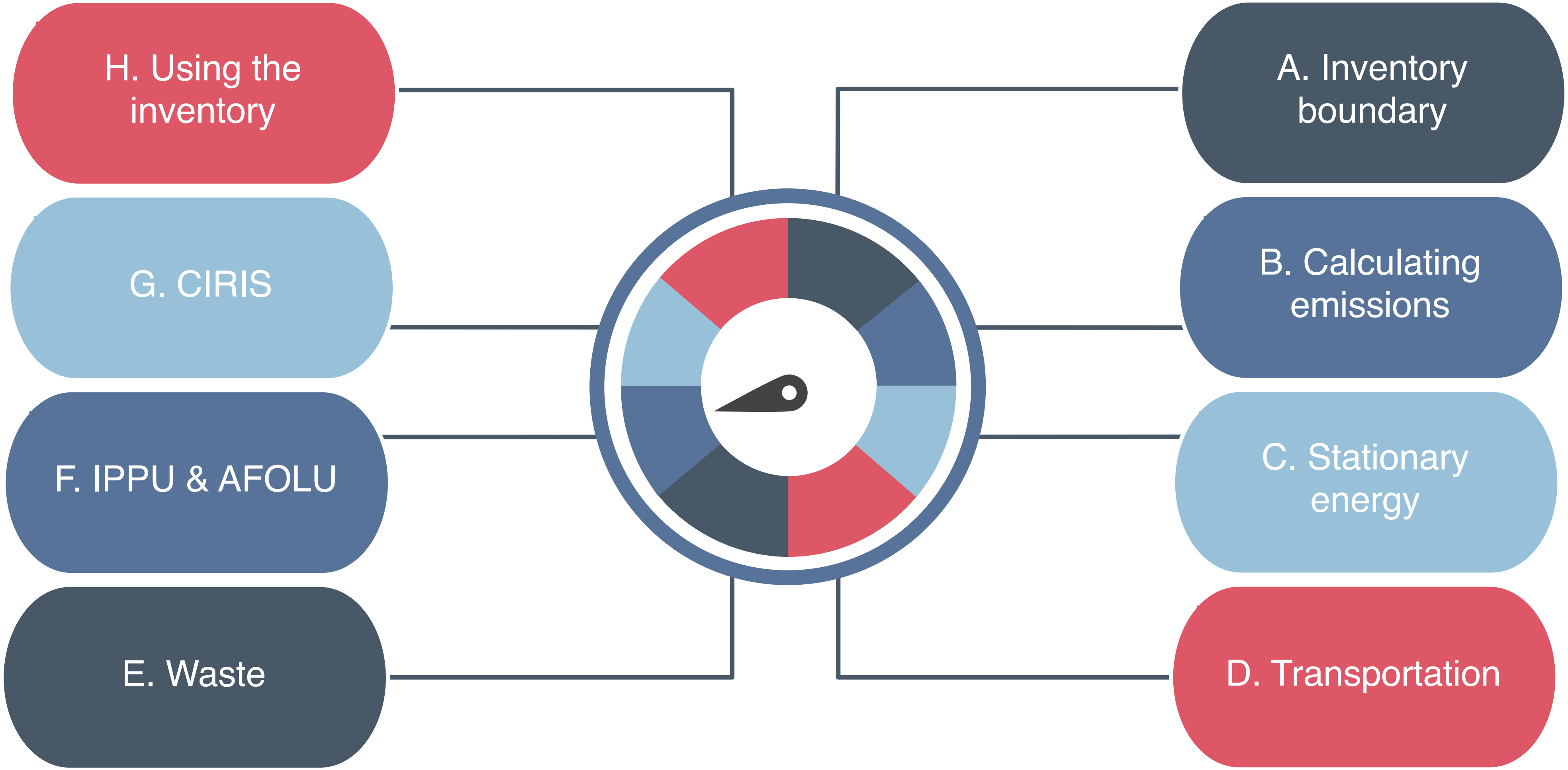
- Big difference for biological treatment. Why?

- Can use different methodologies and data sources for validation

- Next: break emissions down by scope

Results for a city with 1,000,000 residents

	CIRIS calculators	Scale national data	Use proxy city
Landfill			
Biological treatment			
Incineration			
Wastewater			


H. Using the inventory
G. CIRIS
F. IPPU & AFOLU
E. Waste
A. Inventory boundary
B. Calculating emissions
C. Stationary energy
D. Transportation

02
MODULE F

IPPU and AFOLU

Module E: IPPU and AFOLU

01 IPPU

02 Practical (IPPU)

03 AFOLU

04 Practical (AFOLU)

05 Other Scope 3

Module F

IPPU and AFOLU

01

IPPU

Requirements

BASIC	
BASIC+	Cities shall report all emissions from industrial processes and product uses occurring within the city
Territorial	

Categorising emissions

Scope 1	Scope 2	Scope 3
Emissions from industrial processes and product uses occurring within the city	**Not applicable**	**Not applicable**
	All emissions from the use of grid-supplied electricity in industrial or manufacturing facilities within the city boundary shall be reported under scope 2 in Stationary Energy, manufacturing industry and construction (I.3.2)	Emissions from IPPU outside the city are not included in the inventory boundary but may be reported under Other Scope 3 emissions as appropriate.

What is IPPU?

Emissions from industrial activities and product use that are **not** related to energy:

- Industrial processes (e.g. the production of iron and steel)
- Use and disposal of certain products by industry and consumers (e.g. refrigerants and aerosols)
- Non-energy use of fossil fuels (e.g. the manufacture of ammonia from fossil fuels)

The GHGs released can include: CO_2, CH_4, N_2O, **SF_6, HFCs, PFCs and NF_3**

“F-gases” have very high GWP values

Industrial Processes

Chemically or physically transform materials releasing GHGs

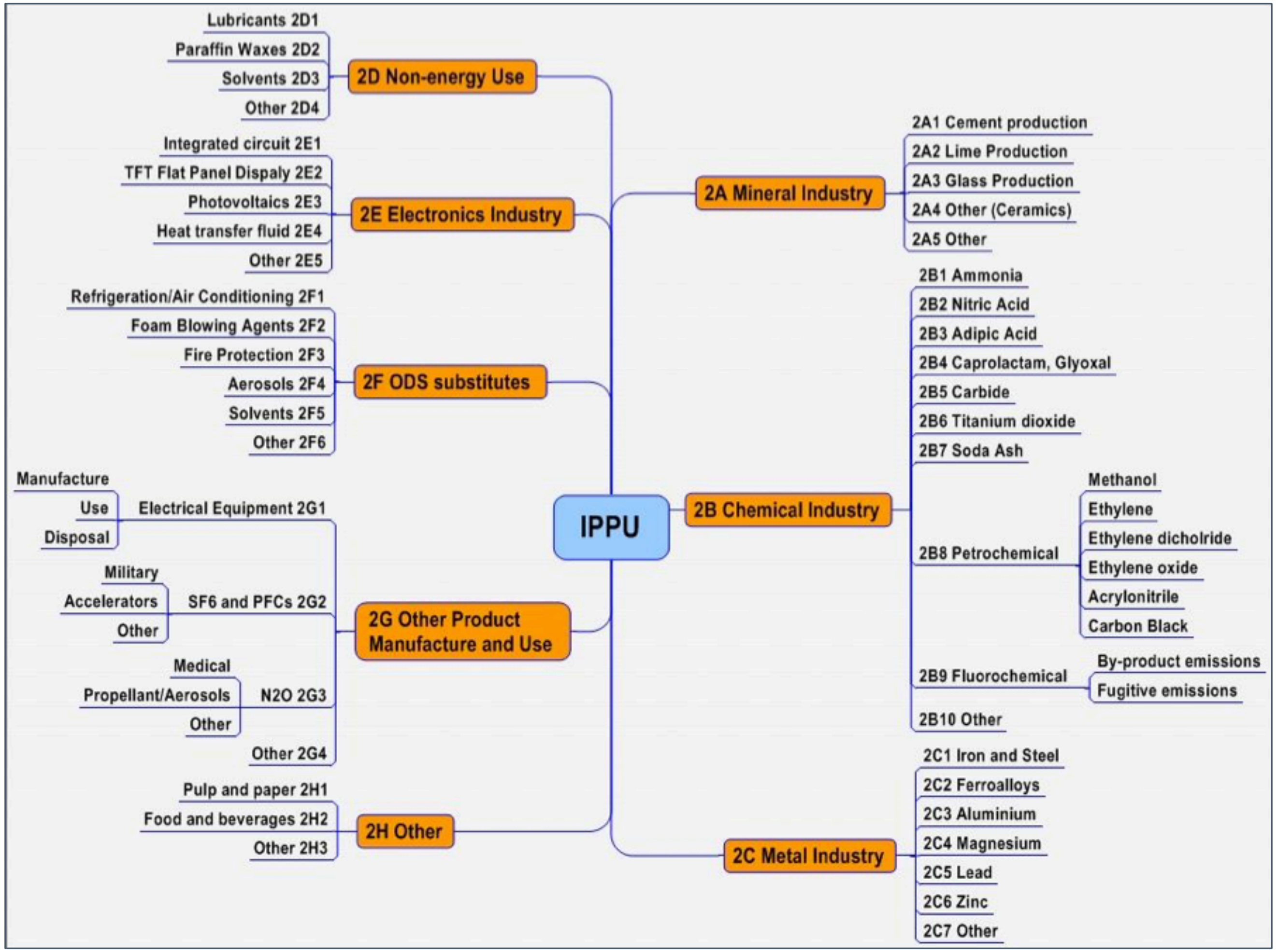
Product Use

GHGs are used in products such as refrigerators, foams or aerosols

Sub-sectors

Sub-sector		Examples	IPPC categories
IV.1	Industrial processes	• Production and use of **mineral products** • Production and use of **chemicals** • Production of **metals**	2A, 2B, 2C
IV.2	Product use	• Lubricants and paraffin waxes used in non-energy products • Fluorinated compounds gases used in electronics production • Fluorinated gases used as substitutes for Ozone depleting substances	2D, 2E 2F, 2G, 2H

Sub-sectors



Source: https://www.ipcc.ch/site/assets/uploads/2019/06/2019-Refinement_IPPU_SBSTA-IPCC_Special-Event.pdf

Overview

IPPU sub-sectors	Scope 1	Scope 2	Scope 3
Industrial processes	IV.1		
Product use	IV.2		

Reporting GHG emissions from IPPU is **optional** for a GPC BASIC / CRF inventory, but is strongly recommended where emissions are deemed significant

BASIC+ (Scope 1)

Other scope 3 (Scope 3)

Industrial processes

GHG emissions are produced from a wide variety of industrial activities.

The main emission sources are releases from industrial processes that chemically or physically transform materials. For example:

- **Chemically**: $NH_3 + O_2 = 0.5\ N_2O\uparrow + 1.5\ H_2O$ (nitric acid production)
- **Physically**: $CaCO_3 + (Heat) = CaO + CO_2\uparrow$ (cement production)

Three industrial process types:

- **Mineral**
- **Chemical**
- **Metal**

Industry type	Process
Mineral Industry	• Cement • Lime • Glass
Chemical Industry	• Ammonia • Nitric acid • Adipic acid • Caprolactam • Glyoxal and glyoxylic acid • Carbide • Titanium dioxide • Sodium carbonate
Metallurgical Industry	• Metallurgical coke • Iron and steel • Alloy iron • Aluminium • Magnesium • Lead • Zinc

Mineral processes

Three industrial processes are highlighted under the mineral industry:

- **Cement** production
- **Lime** production
- **Glass** production

For these processes, the release of CO_2 is the calcination of carbonate compounds, during which—through heating—a metallic oxide is formed

CO_2 = mass mineral produced * emission factor

Calculating mineral process emissions:

Identify major mineral production industries within the city boundary

Determine annual product output and raw material consumption in the industrial process

- Contact operators or owners of industrial facilities
- Contact national inventory compiler to ask specific production data within the city bvoundary

Determine emission factor of raw material or product

Alternatively use 2006 IPCC Guidelines for methodologies and data (Volume 3 Chapter 2)

Chemical processes

GHG emissions (CO_2, CH_4 and N_2O) arise from the production of various inorganic and organic chemicals, including:

- Ammonia
- Nitric acid
- Adipic acid
- Caprolactam, glyoxal, and glyoxylic acid
- Carbide
- Titanium dioxide
- Soda ash

Emissions from the chemical industry depend on the technology used

Emissions can be determined through continious emissions monitoring (CEM), where emissions are directly measured at all times

Calculating chemical process emissions:

Identify major mineral production industries within the city boundary

Determine annual product output and raw material consumption in the industrial process

Determine technology used in the industrial process

Determine emission factor of raw material or product

Alternatively use 2006 IPCC Guidelines for methodologies and data (Volume 3 Chapter 3)

Metal processes

GHG emissions (CO_2, CH_4, SF_6, HFCs) can result from the production of:

- Iron steel and metallurgical coke
- Ferroalloy
- Aluminium
- Magnesium
- Lead
- Zinc

Emissions from the metal industry depend on the technology and raw material used in production processes

Emissions can be determined through continious emissions monitoring (CEM), where emissions are directly measured at all times

Calculating metal process emissions:

Identify major metal production industries within the city boundary

Determine annual product output and raw material consumption in the industrial process

Determine technology used in the industrial process

Determine emission factor of raw material or product

Alternatively use 2006 IPCC Guidelines for methodologies and data (Volume 3 Chapter 4)

Industrial processes

Equation 9.2 Emissions from cement production

$$CO_2 \text{ emissions} = M_d \times EF_d$$

Description			Value
CO_2 emissions	=	CO_2 emissions in tonnes	Computed
M_d	=	Weight (mass) of clinker produced in metric tonnes	User input
EF_d	=	CO_2 per mass unit of clinker produced (e.g., CO_2/tonne clinker)	User input or default value

Equation 9.3 Emissions from lime production

$$CO_2 \text{ emissions} = \sum(EF_{lime,i} \times M_{lime,i})$$

Description			Value
CO_2 emissions	=	CO_2 emissions in tonnes	Computed
M_{lime}	=	Weight (mass) of lime produced of lime type i in metric tonnes	User input
EF_{lime}	=	CO_2 per mass unit of lime produced of lime type i (e.g. CO_2/tonne lime of type i)	User input or default value
i	=	Type of lime	

Equation 9.4 Emissions from glass production

$$CO_2 \text{ emissions} = M_g \times EF \times (1-CR)$$

Description			Value
CO_2 emissions	=	CO_2 emissions in tonnes	Computed
M_d	=	Mass of melted glass of type i (e.g., float, container, fiber glass, etc.), tonnes	User input
EF_d	=	Emission factor for manufacturing of glass of type i, tonnes CO_2/tonne glass melted	User input or default value
CR_i		Cullet ratio[62] for manufacturing of glass of type i	User input or default value

Table 9.5 Metal industry

Emission sources	GHG emissions	Simplest approach for quantifying emissions	Source of active data	Link to default emission factor calculation
Metallurgical coke production	CO_2, CH_4	Assume that all coke made onsite at iron and steel production facilities is used onsite. Multiply default emission factors by coke production to calculate CO_2 and CH_4 emissions	Governmental agencies responsible for manufacturing statistics, business or industry trade associations, or individual iron and steel companies	Table 4.1 and Table 4.2 from Chapter 4 of Volume 3 of *2006 IPCC Guidelines for National Greenhouse Gas Inventories*
Iron and steel production		Multiply default emission factors by iron and steel production data		
Ferroalloy production	CO_2, CH_4	Multiply default emission factors by ferroalloy product type		Table 4.5 and Table 4.7 from Chapter 4 of Volume 3 of *2006 IPCC Guidelines for National Greenhouse Gas Inventories*
Aluminum production	CO_2	Multiply default emission factors by aluminum product by different process	Aluminum production facilities	Table 4.10 from Chapter 4 of Volume 3 of *2006 IPCC Guidelines for National Greenhouse Gas Inventories*
Magnesium production	CO_2	Multiply default emission factors by Magnesium product by raw material type	The magnesium production, casted/handled data and raw material type may be difficult to obtain. Inventory compiler may consult industry associations such as the International Magnesium Association.	Table 4.19 from Chapter 4 of Volume 3 of *2006 IPCC Guidelines for National Greenhouse Gas Inventories*
	SF_6	Assume all SF_6 consumption in the magnesium industry segment is emitted as SF Estimate SF_6 by multiplying default emission factors by total amount of magnesium casted or handled.		Table 4.20 from Chapter 4 of Volume 3 of *2006 IPCC Guidelines for National Greenhouse Gas Inventories*
	HFC and other GHG emissions[63]	For HFC and other GHG gases, collect direct measurements or meaningful indirect data		Not applicable
Lead production	CO_2	Multiply default emission factors by lead products by sources and furnace type	Governmental agencies responsible for manufacturing statistics, business or industry trade associations, or individual lead and zinc producers	Table 4.21 from Chapter 4 of Volume 3 of *2006 IPCC Guidelines for National Greenhouse Gas Inventories*
Zinc production	CO_2	Multiply default emission factors by zinc production		Table 4.24 from Chapter 4 of Volume 3 of *2006 IPCC Guidelines for National Greenhouse Gas Inventories*

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Table B8a: IPPU Background Table for GHG Inventory Year 2016 – 2A Mineral Industry, 2B (2B1-2B8, 2B10) Chemical Industry – CO_2, CH_4 and N_2O

Categories	Activity data			Emissions						
	Production/Consumption quantity			CO_2 (Gg)			CH_4 (Gg)		N_2O (Gg)	
	Description	Quantity	Unit	Emissions	Info. item Captured and Stored	(memo) Other reduction	Emissions	Info. item reduction	Emiss-ions	Info. item reduction
2A Mineral Industry				13,415.57	NE, NO	NE, NO	NA,NE,NO	NA,NE,NO	NO	NO
2A1 Cement production	Prod. of clinker	17,720,000.00	Tonnes	9,125.80	NO	NO	NA	NA		
2A2 Lime production	Prod. of Quicklime	102,671.00	Tonnes	77.00	NO	NO	NA	NA		
2A3 Glass Production	Production of Glass	191,424.37	Tonnes	28.71	NO	NO	NA	NA		
2A4 Other Process Uses of Carbonates				4,184.05	NO	NO	NE, NO	NE, NO		
2A4a Ceramics	NE	NE	NE	NE	NE	NE	NE	NE		
2A4b Other Uses of Soda Ash	NO	NO	NO	NO	NO	NO	NO	NO		
2A4c Non Metallurgical Magnesia Production	NO	NO	NO	NO	NO	NO	NO	NO		
2A4d Other	NO	NO	NO	NO	NO	NO	NO	NO		
2A5 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B Chemical Industry				4,791.70	NO	NO	12.87	NA, NO	NA, NO	NA, NO
2B1 Ammonia Production	Prod. of ammonia	C	Tonnes	1,170.28		NO	NA	NA	NA	NA
2B2 Nitric Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B3 Adipic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B4 Caprolactam, Glyoxal and Glyoxylic Acid Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B5 Carbide Production	Prod. of carbide	34,560.00	Tonnes	38.02	NO	NO	NA	NA	NA	NA
2B6 Titanium Dioxide Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B7 Soda Ash Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B8 Petrochemical and Carbon Black Production				3,583.39	NO	NO	12.87	NO	NA, NO	NO
2B8a Methanol	Conventional Steam Reforming, without primary reformer	C	Tonnes	1,434.07	NO	NO	4.92	NO	NA	NA
2B8b Ethylene	Ethane and Naphtha	C	Tonnes	2,062.94	NO	NO	7.71	NO	NA	NA
2B8c Ethylene Dichloride and Vinyl Chloride Monomer	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B8d Ethylene Oxide	Oxygen Process	C	Tonnes	86.39	NO	NO	0.23	NO	NA	NA
2B8e Acrylonitrile	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2B8f Carbon Black	NO	NO	Tonnes	NO	NO	NO	NO	NO	NO	NO
2B10 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table B8c: IPPU Background Table for GHG Inventory Year 2016 – 2C Metal Industry CO_2, CH_4 and N_2O

Categories	Activity Data			Emissions						
	Production/Consumption quantity			CO_2 (Gg)			CH_4 (Gg)		N_2O (Gg)	
	Description	Quantity	Unit	Emissions	(information) Captured and Stored	(information) Other Reduction	Emissions	(information) Reduction	Emissions	(information) Reduction
2C Metal Industry				2,600.51	NA, NE, NO	NA, NE, NO	0.66	NA, NE, NO	NA, NE, NO	NA, NE, NO
2C1 Iron and Steel Production	Production of iron & steel	3,941,713	tonne	1,384.51	NO	NO	0.66	NO	NA	NA
2C2 Ferroalloys Production	NE	NE	tonne	NE	NE	NE	NE	NE	NE	NE
2C3 Aluminum Production	Production of aluminium	760,000	tonne	1,216.00	NA	NA	NA	NA		
2C4 Magnesium Production	NO	NO	tonne	NO	NO	NO				
2C5 Lead Production	NO	NO	tonne	NO	NO	NO				
2C6 Zinc Production	NO	NO	tonne	NO	NO	NO				
2C7 Other (please specify)	NO	NO	tonne	NO	NO	NO	NO	NO	NO	NO

Source: BUR3

Product use

Products such as **refrigerants**, **foams** or **aerosol cans** can release potent GHG emissions. HFCs, for example, are used as alternatives to ozone depleting substances (ODS) in various types of product applications

Similarly, SF_6 and N_2O are present in a number of products used in industry (e.g. **electrical equipment** and propellants in aerosol products), and used by end-consumers (e.g. **running shoes** and **anesthesia**)

Four product use categories types:

- Non-energy fuel products and use of solvents
- Electronic industry
- Fluorine substitutes for ozone-depleting substances
- Production and use of other products

Product use	Product
Non-energy fuel products and use of solvents	• Lubricant • Paraffin wax • Bitumen, road oil and other petroleum diluents • White spirit, kerosene, some aromatic (solvents)
Electronic industry	• CVD recording and cleaning for semiconductors • Liquid crystal displays and photovoltaic • Heat transfer fluids
Fluorine substitutes for ozone-depleting substances	• Air conditioning units • Refrigerators (commercial, domestic, industrial, transport, stationary, mobile) • Asthma inhalers
Production and use of other products	• Electronic insulator

Non-energy fuel products and use of solvents

Fuel and solvents are consumed in industrial processes.

Emissions are included in IPPU when fossil fuels are used for their primary purposes e.g. lubrication or coating, rather than combustion or used as a feedstock or reducing agent which are accounted for in the chemical and metal industries.

Fuel type	Examples of non-energy use
Lubricants	Used in transportation and in industry
Paraffin waxes	Candles, corrugated boxes, paper coating, plate sizing, adhesives, food production, packaging
Bitumen, road oil and other oil thinners	Used in the production of asphalt for road paving
White spirit, kerosene, some aromatics	As solvent, for example for surface coating (paint), dry cleaning

Non-energy fuel products and use of solvents

CO_2 emissions from all product uses can be estimated by following equation:

CO_2 = (NEU * CC * ODU) * 44/12

NEU = Non-energy use of fuel (Tj)
CC = Fuel carbon content (tC / TJ)
ODU = Fraction of carbon Oxidised During Use
44/12 = CO_2 / C mass ratio

In this equation, ODU represents the fraction of fossil fuel carbon that is oxidized during use (ODU), e.g. actual co-combustion of the fraction of lubricants that slips into the combustion chamber of an engine.

To estimate emissions on a mass-balance approach, cities need to know:

- Major fuel and solvent used within the city boundaries
- Annual consumption of fuels and solvent
- Emission factors for different types of fuel and solvent consumption

Cities should obtain facility-specific fuel/solvent consumption data and their respective uses with city specific emission factors:

- Sales data from fuel and solvent suppliers
- National or state inventory data
- National production, import and export data

Electronics industry

Several advanced electronics manufacturing processes utilize fluorinated compounds (FC) for plasma etching intricate patterns, cleaning reactor chambers, and temperature control, all of which emit GHGs:

- Semiconductors
- Thin-film-transistor flat panel displays
- Photovoltaic manufacturing

(collectively termed “electronics industry”)

Calculating fluorinated gas emissions from the electronics industry:

Identify major electronic production industries within the city boundary

Determine annual production capacity of the industrial facilities / contact electronic production facilities to obtain facility-specific emissions data.

FC emission control technology used

Gas fed-in and destroyed by the FC emission control system

Alternatively use 2006 IPCC Guidelines for methodologies and data (Volume # Chapter #)

Fluorine substitutes for ozone-depleting substances

HFCs and, to a very limited extent, PFCs, are serving as alternatives to ozone depleting substances (ODS) being phased out under the Montreal Protocol. Current and expected application areas of HFCs and PFCs include:

- Refrigeration and air conditioning
- Fire suppression and explosion protection
- Aerosols
- Solvent cleaning
- Foam blowing
- Other applications

GHG = Chemical product sale * Emission factor

Activity data:

- Quantities of product purchased by industry
- Quantities of fluorinated substitutes sold

Calculating emissions from ODS:

Identify major industry that uses fluorinated substitutes within the city boundary

Determine fluorinate gas purchase record by the major industry and their application (domestic and imported)

Emission-factor approach:
- Data on chemical sales by application
- Emission factors by application

Mass-balance approach:
- Data on chemical sales by application
- Data on historic and current equipment sales adjusted for import/export by application

Alternatively use national inventory or 2006 IPCC Guidelines for methodologies and data

Energy or IPPU?

Allocation of emissions from the use of fossil fuels between the Stationary Energy and IPPU can be complex.

IPCC Guidelines (2006) define fuel combustion specifically so as to separate:

- **Energy**: "*The combustion of fuels for distinct and productive energy use*"
- **IPPU**: "*The heat released from the use of hydrocarbons in chemical reactions in industrial processes, or from the use of hydrocarbons as industrial products*"

The GPC follows IPCC Guidelines which define "*fuel combustion*" in an industrial process context as:

"*the intentional oxidation of material within an apparatus that is designed to provide heat or mechanical work to a process, or for use away from the apparatus*"

Energy or IPPU?

Therefore:

- If the fuels are combusted for energy use, the emission from fuel uses shall be counted under **Stationary Energy**
- If the derived fuels are transferred for combustion in another source category, emissions shall be reported under **Stationary Energy**
- If combustion emissions from fuels are obtained directly or indirectly from the feedstock, those emissions shall be allocated to **IPPU**
- If heat is released from a chemical reaction, the emissions from that chemical reaction shall be reported as an industrial process in **IPPU**
- Only emissions from industrial activities and product use that are unrelated to energy are reported under **IPPU**

Exercise: Energy or IPPU

Activity	Sector
CO_2 emissions released from a cement plant, through heating $CaCO_3$ to transform into $CaO + CO_2$	
CO_2 emissions released from a cement factory, through burning coal to heat $CaCO_3$	
Purposeful combustion of lubricants in an engine	
CO_2 emissions from natural gas used as raw material during ammonia production	
Burning fuels for energy use	
Burning of wax candles	
Release of emissions from use of wax as a lubricant	
Emissions from a chemical reaction that releases heat	

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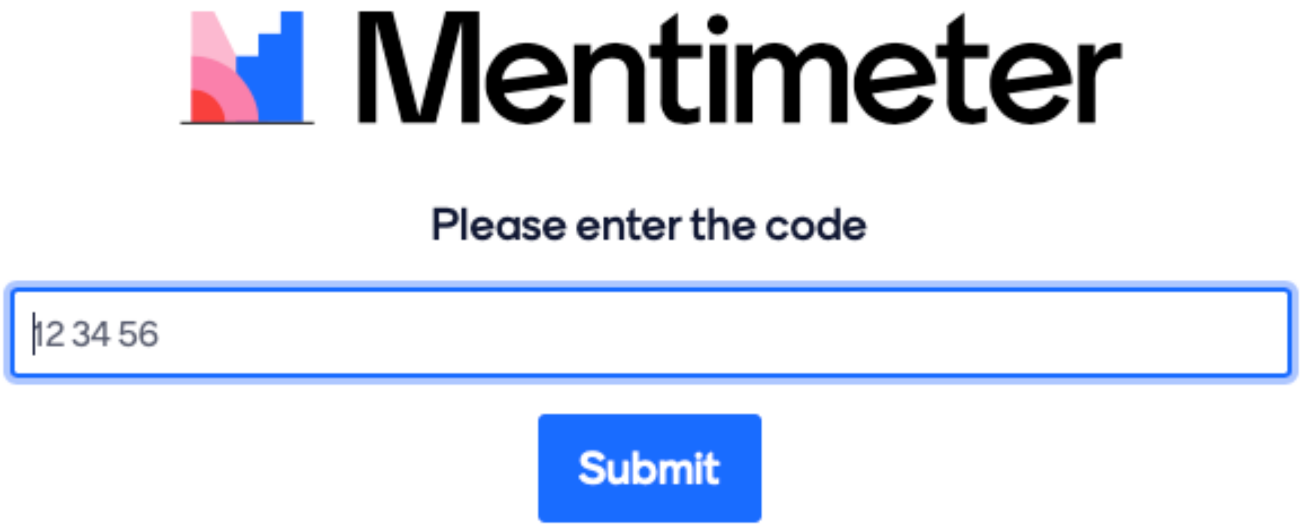


Exercise: Energy or IPPU

Activity	Sector
CO_2 emissions released from a cement plant, through heating $CaCO_3$ to transform into $CaO + CO_2$	IPPU
CO_2 emissions released from a cement factory, through burning coal to heat $CaCO_3$	Stationary energy
Purposeful combustion of lubricants in an engine	Stationary energy
CO_2 emissions from natural gas used as raw material during ammonia production	IPPU
Burning fuels for energy use	Stationary energy
Burning of wax candles	Stationary energy
Release of emissions from use of wax as a lubricant	IPPU
Emissions from a chemical reaction that releases heat	IPPU

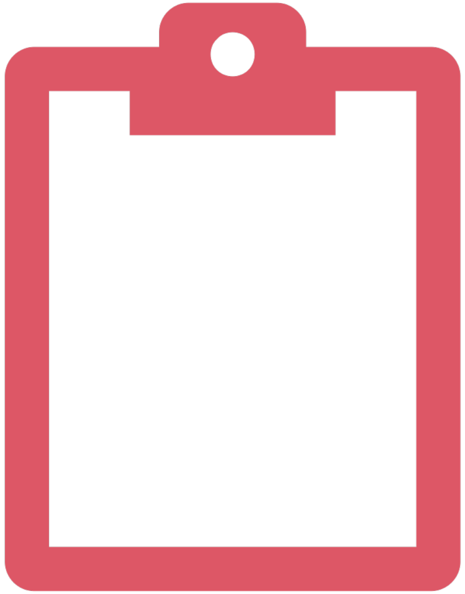
Module F

IPPU and AFOLU

02

Practical (IPPU)

Practical



Practical

Task		
1	Identify all **major industrial facilities** in your city. List them in Table 1	HW
2	Identify **significant product uses** taking plane in your city. List them in Table 1	HW
3	Estimate GHG emissions for product use in your city using the consumption-based method and national data reported in BUR3 Tables B8e – B8j	20m
4	Record your data in Table 3, clearly documenting methodologies and data sources used. For now, assume there are no major industrial facilities in your boundary and as such use "NO" for Industrial processes. For scope 3 sources, use "NE".	HW
5	Consolidate the above information into Table 4 and identify what activity data and emission factors you will need to estimate significant GHG emissions for IPPU, and where you will source this from	HW

Practical

Task		
1	Identify all **major industrial facilities** in your city. List them in Table 1	HW
2	Identify **significant product uses** taking plane in your city. List them in Table 1	HW
3	Estimate GHG emissions for product use in your city using the consumption-based method and national data reported in BUR3 Tables B8e – B8j	20m
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5	Consolidate the above information into Table 4 and identify what activity data and emission factors you will need to estimate significant GHG emissions for IPPU, and where you will source this from	HW

Table 1: IPPU

Sub-sector	
Major industrial facilities	
Significant product uses	

Checklist: Industrial processes

Mineral Industry	Chemical Industry	Metallurgical Industry
Cement	Ammonia	Metallurgical coke
Lime	Nitric acid	Iron and steel
Glass	Adipic acid	Alloy iron
	Caprolactam	Aluminium
	Glyoxal and glyoxylic acid	Magnesium
	Carbide	Lead
	Titanium dioxide	Zinc
	Sodium carbonate	

Checklist: Product use

Non-energy fuel products and use of solvents	Electronic industry	Fluorine substitutes for ODS	Production and use of other products
Lubricant	CVD recording and cleaning for semiconductors	Air conditioning units	Electronic insulator
Paraffin wax	Liquid crystal displays and photovoltaic	Refrigerators	
Bitumen, road oil and other petroleum diluents	Heat transfer fluids	Asthma inhalers	
White spirit, kerosene, some aromatic (solvents)			

Practical

Task		
1	Identify all major industrial facilities in your city. List them in Table 1	HW
2	Identify significant product uses taking plane in your city. List them in Table 1	HW
3	Estimate GHG emissions for product use in your city using the consumption-based method and national data reported in BUR3 Tables B8e – B8j	20m
4	Record your data in Table 3, clearly documenting methodologies and data sources used. For now, assume there are no major industrial facilities in your boundary and as such use “NO” for Industrial processes. For scope 3 sources, use “NE”.	HW
5	Consolidate the above information into Table 4 and identify what activity data and emission factors you will need to estimate significant GHG emissions for IPPU, and where you will source this from	HW

Workbook

GTALCC GHG Accounting - Participant handbook

Exercises	
Module B	Calculating GHG emissions
	Reviewing an inventory
Module C	Stationary energy
Module D	Transportation
Module E	Waste
Module F	IPPU and AFOLU

Tables	
Table 1	GHG emission sources
Table 2	Fuel types
Table 3	GPC
Table 4	Action plan

Reference
GPC
GWP
Notation keys
Checklist

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Non-energy fuel products and use of solvents

Table B8e: IPPU Background Table for GHG Inventory Year 2016 - 2D Non-Energy Products from Fuels and Solvent Use CO_2, CH_4 and N_2O

Categories	Activity Data			Emissions		
	Production/Consumption quantity			CO_2	CH_4	N_2O
	Description	Quantity	Unit	(Gg)	(Gg)	(Gg)
2D Non-Energy Products from Fuels and Solvent Use				NE, NO	NE, NO	NE, NO
2D1 Lubricant Use	Lubricant consumption	NE	tonne	NE		
2D2 Paraffin Wax Use	Wax consumption	NE	tonne	NE	NE	NE
2D3 Solvent Use						
2D4 Other				NO	NO	NO
Product (please specify)	NO	NO	NO	NO	NO	NO
Product (please specify)	NO	NO	NO	NO	NO	NO
Product (please specify)	NO	NO	NO	NO	NO	NO

Source: BUR3

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Electronic industry

Table B8f: IPPU Background Table for GHG Inventory Year 2016 - 2E Electronics Industry HFCs, PFCs, SF_6, NF_3 and other halogenated gases

Categories	CO_2	N_2O	HFC-23	HFC-32	Other HFCs (please specify)	Total HFCs	CF_4	C_2F_6	C_3F_8	$c\text{-}C_4F_8$	Other PFCs (please specify)	Total PFCs	SF_6	NF_3	Other halogenated gases (please specify)
CO_2 equivalent conversion factors [Source of the factor: IPCC AR4]	1	298	14,800	675			7,390	12,200	8,830	10,300			22,800	17,200	
Emissions in original mass unit (tonne)															
2E Electronics Industry	NA	NA	0.00	NA, NO	NA, NO		0.18	0.08	0.00	NA, NO	NA, NO		0.01	0.00	NA, NO
2E1 Integrated Circuit or Semiconductor	NA	NA	0.00	NA	NA		0.07	0.07	0.00	NA	NA		0.01	0.00	NA
2E2 TFT Flat Panel Display			NO	NO	NO		NO	NO	NO	NO	NO		NO	NO	NO
2E3 Photovoltaics			NA	NA	NA		0.12	0.00	NA	NA	NA		NA	NA	NA
2E4 Heat Transfer Fluid															NO
2E5 Other (please specify)		NO	NO	NO	NO		NO	NO	NO	NO	NO		NO	NO	NO
Emissions in CO_2 equivalent unit (Gg-CO_2)															
2E Electronics Industry			43.75	NA, NO	NA, NO	43.75	1,366.72	959.48	32.63	NA, NO	NA, NO	2,358.83	337.03	50.85	NA, NO
2E1 Integrated Circuit or Semiconductor			43.75	NA	NA	43.75	491.57	901.69	32.63	NA	NA	1,425.89	337.03	50.85	NA
2E2 TFT Flat Panel Display			NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2E3 Photovoltaics			NA	NA	NA	NA	875.15	57.79	NA	NA	NA	932.95	NA	NA	NA
2E4 Heat Transfer Fluid															NO
2E5 Other (please specify)			NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Source: BUR3

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Fluorine substitutes for ozone-depleting substances

Table B8g: IPPU Background Table for GHG Inventory Year 2016 - 2F Product Uses as Substitutes for Ozone Depleting Substances HFCs, PFCs and other halogenated gases

Categories	CO_2	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	HFC-227ea	HFC-236fa	HFC-245fa	HFC-365mfc	HFC-43-10mee	Other HFCs (please specify)	Total HFCs	CF_4	C_2F_6	C_3F_8	C_4F_{10}	Other PFCs (please specify)	Total PFCs	Other halogenated gases (please specify)
CO_2 equivalent conversion factors [Source of the factor: IPCC AR4]	1	14,800	675	3,500	1,430	4,470	124	3,220	9,810	1,030	794	1,640			7,390	12,200	8,830	8,860			
Emissions in original mass unit (tonne)																					
2F Product Uses as Substitutes for Ozone Depleting Substances	NA, NE	NA, NE, NO	NA, NE, NO	NA, NE, NO	0.50	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO		NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO		NA, NE, NO
2F1 Refrigeration and Air Conditioning	NA, NE	NA, NE	NA, NE	NA, NE	0.50	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE		NA, NE	NA, NE	NA, NE	NA, NE	NA, NE		NA, NE
2F1a Refrigeration and Stationary Air Conditioning	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F1b Mobile Air Conditioning	NA	NA	NA	NA	0.50	NA	NA	NA	NA	NA	NA	NA	NA		NA	NA	NA	NA	NA		NA
2F2 Foam Blowing Agents	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F3 Fire Protection	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F4 Aerosols		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F5 Solvents		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE	NE	NE	NE		NE
2F6 Other Applications		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO	NO	NO	NO		NO
Emissions in CO_2 equivalent unit (Gg-CO_2)																					
2F Product Uses as Substitutes for Ozone Depleting Substances		NA, NE, NO	NA, NE, NO	NA, NE, NO	713.25	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	713.25	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO	NA, NE, NO
2F1 Refrigeration and Air Conditioning		NA, NE	NA, NE	NA, NE	713.25	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	713.25	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE	NA, NE
2F1a Refrigeration and Stationary Air Conditioning		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F1b Mobile Air Conditioning		NA	NA	NA	713.25	NA	NA	NA	NA	NA	NA	NA	NA	713.25	NA	NA	NA	NA	NA	NA	NA
2F2 Foam Blowing Agents		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F3 Fire Protection		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F4 Aerosols		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F5 Solvents		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2F6 Other Applications		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Source: BUR3

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Production and use of other products

Table B8h: IPPU Background Table or GHG Inventory Year 2016 - 2G (2G1, 2G2, 2G4) Other Product Manufacture and Use – PFCs, SF_6 and other halogenated gases

Categories	CF_4	C_2F_6	C_3F_8	C_4F_{10}	$c\text{-}C_4F_8$	C_5F_{12}	C_6F_{14}	Other PFCs (please specify)	Total PFCs	SF_6	Other halogen-ated gases (please specify)
CO_2 equivalent conversion factors [Source of the factor: IPCC AR4]	7,390	12,200	8,830	8,860	10,300	9,160	9,300			22,800	
Emissions in original mass unit (tonne)											
2G Other Product Manufacture and Use	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO		0.00	NE, NO
2G1 Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE		0.00	NE
2G1a Manufacture of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
(information) Reduced amount	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
2G1b Use of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE		0.00	NE
(information) Reduced amount	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
2G1c Disposal of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
(information) Reduced amount	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
2G2 SF_6 and PFCs from Other Product Uses	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
2G2a Military Applications	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
(information) Reduced amount	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
2G2b Accelerators	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
University and Research Particle Accelerators	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
(information) Reduced amount	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
Industrial and Medical Particle Accelerators	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
(information) Reduced amount	NE	NE	NE	NE	NE	NE	NE	NE		NE	NE
2G2c Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
(information) Reduced amount	NO	NO	NO	NO	NO	NO	NO	NO		NO	NO
2G4 Other (please specify)											NO
(information) Reduced amount											NO
Emissions in CO_2 equivalent unit (Gg-CO_2)											
2G Other Product Manufacture and Use	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	11.49	NE, NO
2G1 Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE	NE	11.49	NE
2G1a Manufacture of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2G1b Use of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE	NE	11.14	NE
2G1c Disposal of Electrical Equipment	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2G2 SF_6 and PFCs from Other Product Uses	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2G2a Military Applications (AWACS)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2G2b Accelerators	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
University and Research Particle Accelerators	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Industrial and Medical Particle Accelerators	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2G2c Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2G4 Other (please specify)											NO

Source: BUR3

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Production and use of other products

Table B8i: IPPU Background Table for GHG Inventory Year 2016 - 2G (2G3, 2G4) Other Product Manufacture and Use – N_2O, CO_2, CH_4

Categories		Activity Data			Emissions					
					N_2O (Gg)		CO_2 (Gg)		CH_4 (Gg)	
		Description	Quantity	Unit	Emissions	Information Reduction	Emissions	Information Reduction	Emissions	Information Reduction
2G3	N_2O from Product Uses				0.24	NO				
	2G3a Medical Applications	N_2O supplied	237.24	tonne	0.24	NO				
	2G3b Propellant for Pressure and Aerosol Products	N_2O supplied	NE	tonne	NE	NO				
	2G3c Other (please specify)	N_2O supplied	NO	tonne	NO	NO				
2G4	Other (please specify)	NO	NO	tonne			NO	NO	NO	NO

Table B8j: IPPU Background Table for GHG Inventory Year 2016 - 2H Other

Categories		Activity Data		Emissions					
				CO_2 (Gg)		CH_4 (Gg)		N_2O (Gg)	
		Quantity	Unit	Emissions	(information) Reduction	Emissions	(information) Reduction	Emissions	(information) Reduction
2H	Other			NE, NO	NO	NE, NO	NO	NO	NO
	2H1 Pulp and Paper Industry	NE	NE	NE	NO	NE	NO		
	2H2 Food and Beverages Industry	NE	NE	NE	NO	NE	NO		
	2H3 Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO

Source: BUR3

Practical

	Task	
1	Identify all major industrial facilities in your city. List them in Table 1	HW
2	Identify significant product uses taking plane in your city. List them in Table 1	HW
3	Estimate GHG emissions for product use in your city using the consumption-based method and national data reported in BUR3 Tables B8e – B8j	20m
4	Record your data in Table 3, clearly documenting methodologies and data sources used. For now, assume there are no major industrial facilities in your boundary and as such use "NO" for Industrial processes. For scope 3 sources, use "NE".	HW
5	Consolidate the above information into Table 4 and identify what activity data and emission factors you will need to estimate significant GHG emissions for IPPU, and where you will source this from	HW

Table 3: GPC table

Sub-sector		Scope 1	Scope 2	Scope 3
IV.1	Industrial processes			
IV.2	Product use			

BASIC+

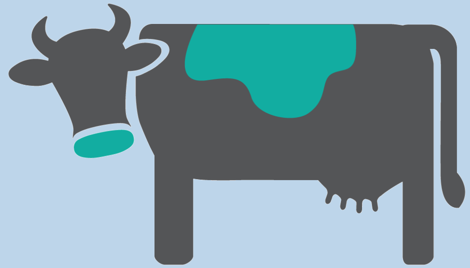
Other scope 3

Table 4: Action plan

GPC	Data	Where from?	Action	Lead
Industrial processes				
Product use				

Module F

IPPU and AFOLU



03

AFOLU

Requirements

BASIC	
BASIC+	Cities shall report all GHG emissions resulting from the AFOLU sector within the city boundary in scope 1
Territorial	

Categorising emissions

Scope 1	Scope 2	Scope 3
In-boundary emissions from agricultural activity, land use and land use change within the city boundary	**Not applicable**	**Not applicable**
GHG emissions associated with the manufacture of nitrogen fertilizers, which account for a large portion of agricultural emissions, are not counted under AFOLU. IPCC Guidelines allocates these emissions to IPPU.	Emissions from use of grid-supplied energy in buildings and vehicles in farms or other agricultural areas shall be reported in Stationary Energy and Transportation, respectively	Emissions from land-use activities outside the city (e.g. agricultural products imported for consumption within the city boundary) are not covered in the GPC under BASIC/ BASIC+ but may be reported as Other Scope 3.

What is AFOLU?

AFOLU stands for **Agriculture, Forestry and Other Land Use**

Given the highly variable nature of land-use and agricultural emissions across geographies, GHG emissions from AFOLU are amongst the most complex categories for GHG accounting.

Some cities, where there are no measurable agricultural activities or managed lands within the city boundary, may have no significant sources of AFOLU emissions. Other cities may have significant agricultural activities and managed lands.

IPCC Guidelines divides AFOLU activities into three categories:

- **Livestock**
- **Land**
- **Aggregate sources and non-CO2 emissions sources on land**

Multiple methodologies can be used to quantify AFOLU emissions. Country-specific data should be used if readily available. Otherwise the GPC recommends using default IPCC data.

Sub-sectors

Sub-sector		Description	IPPC categories
V.1	Livestock	Livestock via enteric fermentation and manure management	3A
V.2	Land	Land use and land use changes, such as forested land being deforested or settled	3B
V.3	Aggregate sources	Other AFOLU (aggregate sources), such as fertilizer application and rice cultivation	3C

Overview

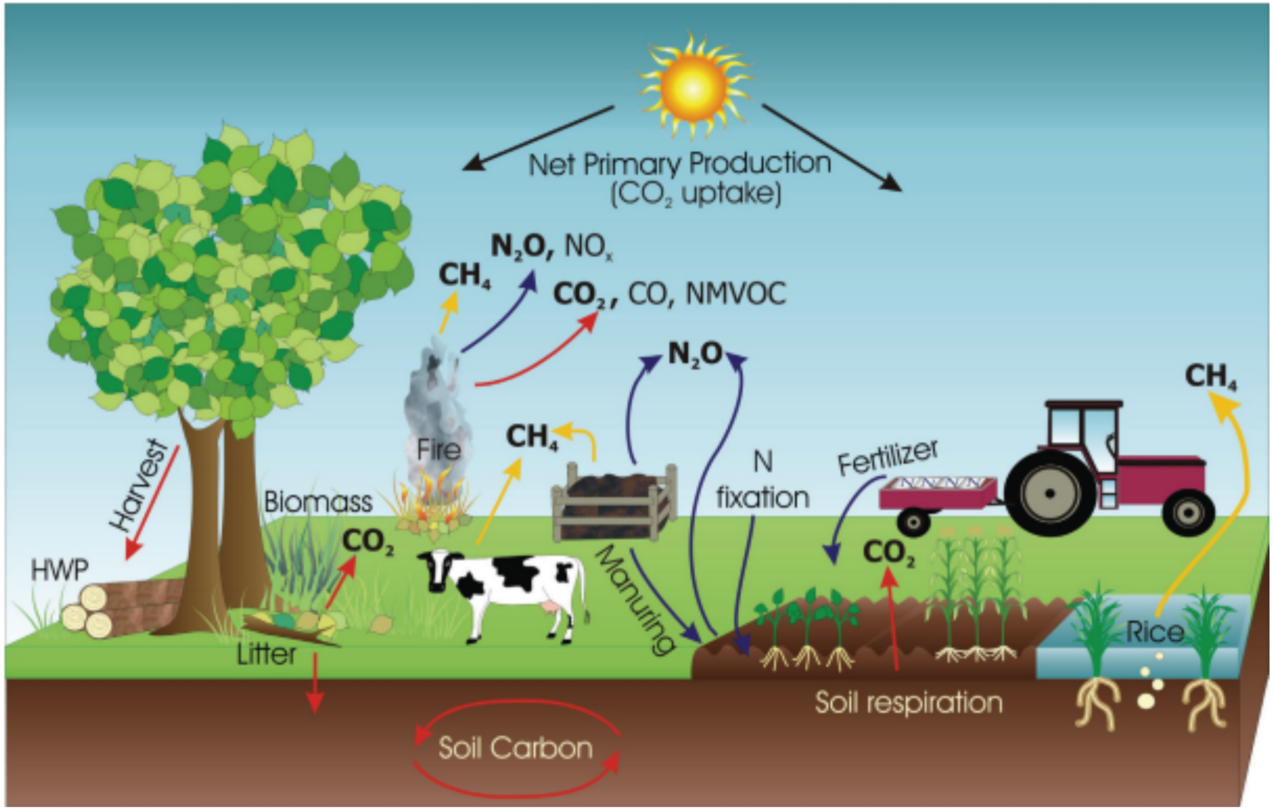
AFOLU sub-sectors	Scope 1	Scope 2	Scope 3
Livestock	V.1		
Land	V.2		
Aggregate sources and non-CO_2 emissions on land	V.3		

Reporting GHG emissions from AFOLU is **optional** for a GPC BASIC / CRF inventory, but is strongly recommended where emissions are deemed significant

BASIC+

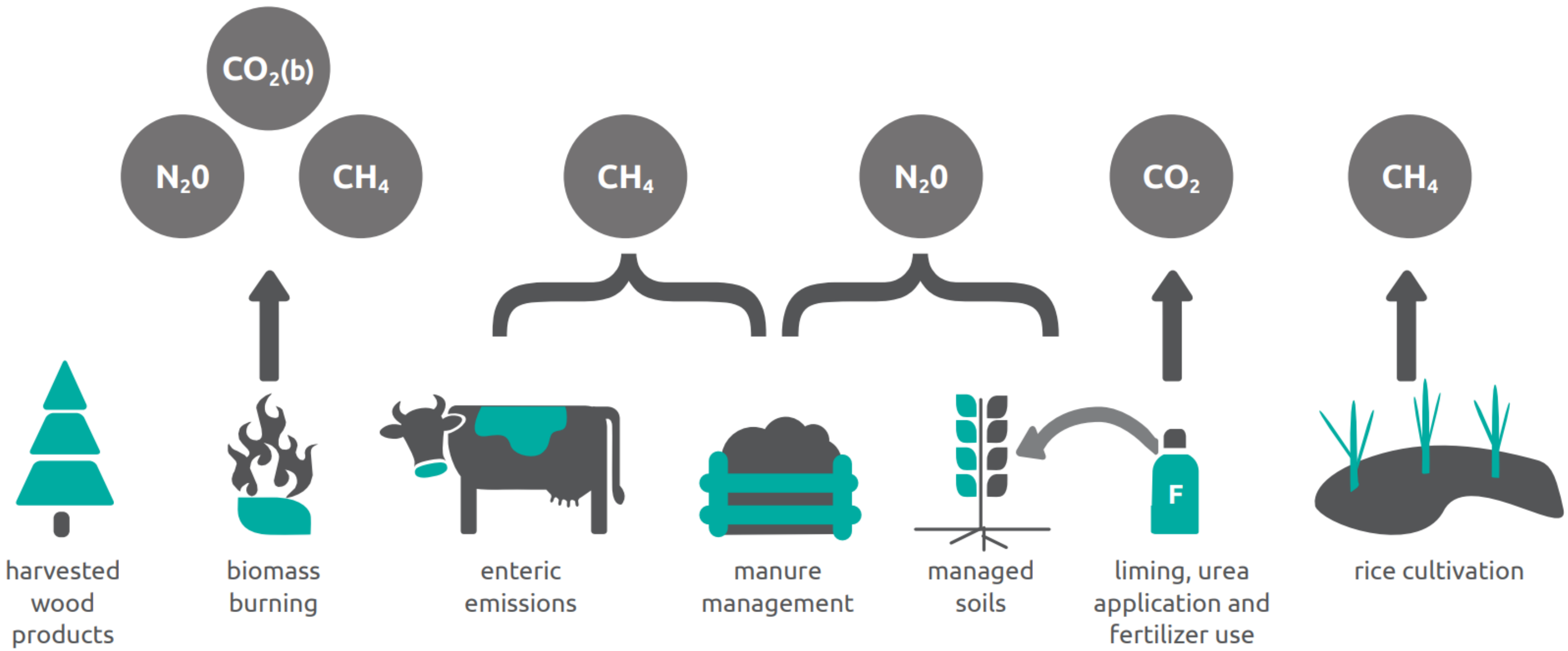
Other scope 3

Overview



(Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 1)

Main GHG emissions and sources



Data needs

Sub-sector		Enteric fermen-tation	Manure manage-ment	Forest land	Cropland	Wetland	Settlement	Others
V.1	Livestock	Number of animals						
V.2	Land			Area of current land type and area of original land type if converted to other land type within the last 20 years				

Sub-sector		Biomass Burning	Liming	Urea Application	N_2O from managed soils	N_2O from manure managemen t	Rice cultivation	Harvested Wood Products
V.3	Aggregate sources and non-CO_2 emissions on land	Land area where biomass is burnt	Amount (tonnes) of carbonate containing lime applied annually	Amount (tonnes) of urea applied annually	Application of fertilizers and animal waste applied to soil	Number of heads of livestock	Annual harvested area of rice (ha) and the cultivation period of rice (days) for different conditions	Annual production, imports or exports for solid wood and paper products

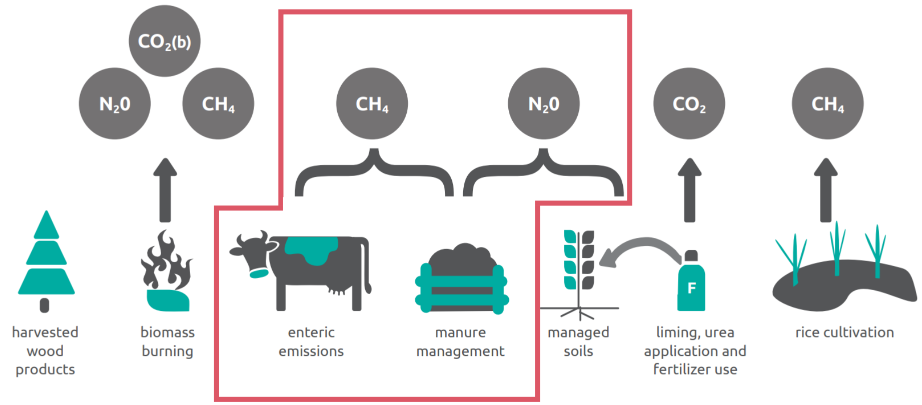
V.1 Livestock

Livestock production emits:

- CH_4 through **enteric fermentation**
- CH_4 and N_2O through management of their **manure**

CO_2 emissions from livestock are not estimated because annual net CO_2 emissions are assumed to be zero—the CO_2 photosynthesized by plants is returned to the atmosphere as respired CO_2.

A portion of the C is returned as CH_4 and for this reason CH_4 requires separate consideration.



Enteric emissions

Enteric fermentation is a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the blood stream. A result of this process is the release of CH_4.

The amount of CH_4 emitted by enteric fermentation is driven primarily by three factors:

- **Number of animals**
- **Type of digestive system**
- **Type and amount of feed consumed**

CH_4 emissions can be estimated by multiplying the number of livestock for each animal type by an emission factor

Animal type (count) * Emission factor ($kgCH_4$ per head) = GHG

Activity data on livestock can be obtained from various sources, including government and agricultural industry. If such data are not available, estimates may be made based on survey and land-use data.

Livestock should be disaggregated by animal type, consistent with IPCC categorization: Cattle (dairy and other), Buffalo, Sheep, Goats, Camels, Horses, Mules and Asses, Deer, Alpacas, Swine, Poultry, and Other.

Country-specific **emission factors** should be used, where available. Alternatively, default IPCC emission factors may be used.

Enteric emissions: Emission factors (IPCC)

Table 6

Enteric fermentation emission factors for cattle

Regional Characteristics	Cattle Type	Emissions Factor kg/head/yr	Comments
North America: Highly productive commercialized dairy sector feeding high quality forage and grain.. Separate beef cow herd, primarily grazing with feed supplements seasonally. Fast-growing beef steers/heifers finished in feedlots on grain. Dairy cows are a small part of the population.	Dairy Non-dairy	118 47	Average milk production of 6,700 kg/head/yr. Includes beef cows, bulls, calves, growing steers/heifers, and feedlot cattle.
Western Europe: Highly productive commercialized dairy sector feeding high quality forage and grain. Dairy cows also used for beef calf production. Very small beef cow herd. Minor amount of feedlot feeding with grains.	Dairy Non-dairy	100 48	Average milk production of 4,200 kg/head/yr. Includes bulls, calves, and growing steers/heifers.
Eastern Europe: Commercialized dairy sector feeding mostly forages. Separate beef cow herd, primarily grazing. Minor amount of feedlot feeding with grains.	Dairy Non-dairy	81 56	Average milk production of 2,550 kg/head/yr. Includes beef cows, bulls, and young.
Oceania: Commercialized dairy sector based on grazing. Separate beef cow herd, primarily grazing rangelands of widely varying quality. growing amount of feedlot feeding with grains. Dairy cows are a small part of the population.	Dairy Non-dairy	68 53	Average milk production of 1,700 kg/head/yr. Includes beef cows, bulls, and young.
Latin America: Commercialized dairy sector based on grazing. Separate beef cow herd grazing pastures and rangelands. Minor amount of feedlot feeding with grains. Growing non-dairy cattle comprise a large portion of the population..	Dairy Non-dairy	57 49	Average milk production of 800 kg/head/yr. Includes beef cows, bulls, and young.
Asia: Small commercialized dairy sector. Most cattle are multi-purpose providing draft power and some milk within farming regions. Small grazing population. Cattle of all types are smaller than those found in most other regions.	Dairy Non-dairy	56 44	Average milk production of 1,650 kg/head/yr. Includes multi-purpose cows, bulls, and young.
Africa and Middle East: Commercialized dairy sector based on grazing with low production per cow. Most cattle are multi-purpose, providing draft and some milk within farming regions. Some cattle graze over very large areas. Cattle of all types are smaller than those found in most other	Dairy Non-dairy	36 32	Average milk production of 475 kg/head/yr. Includes multi-purpose cows, bulls, and young.
Indian Subcontinent: Commercialized dairy sector based on crop by-product feeding with low production per cow. Most bullocks provide draft power and cows provide some milk in farming regions. Small grazing population. Cattle in this region are the smallest compared to cattle found in all other regions.	Dairy Non-dairy	46 25	Average milk production of 900 kg/head/yr. Includes cows, bulls, and young. Young comprise a large portion of the population.

Source: IPCC (1996).

Table 7

Enteric fermentation emissions factors (kg per head per year)f

Livestock	Developed Countries	Developing Countries
Buffalo	55	55
Sheep	8	5
Goats	5	5
Camels	46	46
Horses	18	18
Mules and Asses	10	10
Swine	1.5	1
Poultry	Not Estimated	Not Estimated

All estimates are +/- 20%

Source: Emissions factors for buffalo and camels from Gibbs and Johnson (1993). Emissions factors for other livestock from Crutzen et. al. (1986).

Note different emission factors between dairy and non-dairy cattle and between regions

Source: https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/4_1_CH4_Enteric_Fermentation.pdf

Enteric emissions: Activity data (BUR3)

Table B9a: AFOLU Background Table for GHG Inventory Year 2016 - 3A1 - 3A2 Agriculture/Livestock

Categories	Activity data	Emissions	
		CH_4	N_2O
	(number of animals)	(Gg)	
3A Livestock		75.04	0.44
3A1 Enteric Fermentation		54.82	
3A1a Cattle	738,774	43.76	
3A1ai Dairy Cows	46,238	3.14	
3A1aii Other Cattle	692,536	40.62	
3A1b Buffalo	119,133	6.55	
3A1c Sheep	138,479	0.69	
3A1d Goats	416,529	2.08	
3A1e Camels	NE	NE	
3A1f Horses	4,145	0.07	
3A1g Mules and Asses	NE	NE	
3A1h Swine	1,654,381	1.65	
3A1j Other (please specify)	NO	NO	
3A2 Manure Management		20.23	0.44
3A2a Cattle	738,774	2.29	0.09
3A2ai Dairy Cows	46,238	1.43	0.01
3A2aii Other Cattle	692,536	0.86	0.09
3A2b Buffalo	119,133	0.24	0.00
3A2c Sheep	138,479	0.03	0.01
3A2d Goats	416,529	0.09	0.02
3A2e Camels	NE	NE	NE
3A2f Horses	4,145	0.01	0.00
3A2g Mules and Asses	NE	NE	NE
3A2h Swine	1,654,381	11.58	0.02
3A2i Poultry	299,299,187	5.99	0.28
3A2j Other (please specify)	NO	NO	NO

Source: BUR3

V.1 Manure management

Manure includes both dung and urine (i.e., the solids and the liquids) produced by livestock

Manure management takes place during the storage and treatment of manure before it is applied to land or otherwise used for feed, fuel, or construction purposes

CH_4 and N_2O emissions are generated during the manure management process:

- **CH_4**: Decomposition of manure under anaerobic conditions, during storage and treatment
- **N_2O**: Combined nitrification and denitrification of nitrogen contained in the manure

Activity data

- Real activity data from government and agricultural industry
- If data is not available, estimates may be made based on survey and land use data

Emission factor

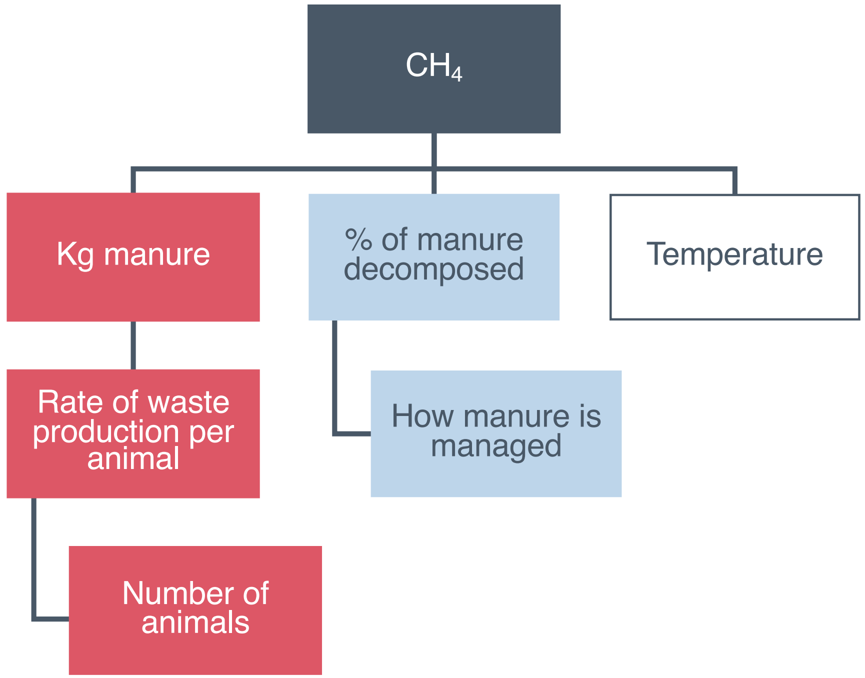
- Medium quality: Country-specific emission factors should be used, where available
- Low quality: Alternatively default IPCC emission factors may be used

CH_4 from manure management

The main factors affecting CH4 emissions are the amount of manure produced and the portion of the manure that decomposes anaerobically. The former depends on the rate of waste production per animal and the number of animals, and the latter on how the manure is managed

CH4 emissions from manure management systems are **temperature dependent**. Country-specific temperature-dependent emission factors should therefore be used, where available; alternatively, default IPCC emission factors may be used.

Animal type (count) * Emission factor (kgCH4 per head) = GHG



N_2O from manure management

Direct emissions of N_2O occur via combined nitrification and denitrification of nitrogen within the manure

Estimates of N_2O emissions involve the total amount of excretion and the type of manure management system

To estimate N_2O emissions from manure management systems involves multiplying the total amount of N excretion (from all livestock categories) in each type of manure management system by an emission factor for that type of manure management system

Data from:

- National inventory
- Agricultural industry
- Scientific literature
- Proxy cities
- IPCC

Note, N_2O emissions associated with the burning of dung for fuel are reported under Stationary Energy (Chapter 6), or under Waste (Chapter 8) if burned without energy recovery.

N_2O from manure management

- Collect livestock data by animal type (T)
- Determine the annual average nitrogen excretion rate per head ($Nex_{(T)}$) for each defined livestock category T
- Determine the fraction of total annual nitrogen excretion for each livestock category T that is managed in each manure management system S ($MS_{(T),(S)}$)
- Obtain N_2O emission factors for each manure management system S ($EF_{(S)}$)
- For each manure management system type S, multiply its emission factor ($EF_{(S)}$) by the total amount of nitrogen managed (from all livestock categories) in that system

Equation 10.3 N_2O emissions from manure management

$$N_2O = [\Sigma_S [\Sigma_T (N_{(T)} \times Nex_{(T)} \times MS_{(T),(S)})] \times EF_{(S)}] \times 44/28 \times 10^{-3}$$

N_2O	=	N_2O emissions in tonnes
S	=	Manure management system (MMS)
T	=	Livestock category
$N_{(T)}$	=	Number of animals for each livestock category
$Nex_{(t)}$	=	Annual N excretion for livestock category T, kg N per animal per year (see Equation 10.4)
MS	=	Fraction of total annual nitrogen excretion managed in MMS for each livestock category
$EF_{(s)}$	=	Emission factor for direct N_2O-N emissions from MMS, kg N_2O-N per kg N in MSS
44/28	=	Conversion of N_2O-N emissions to N_2O emissions

Source: Equation adapted from 2006 IPCC Guidelines for *National Greenhouse Gas Inventories* Volume 4 Agriculture, Forestry and Other Land Use available at: www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

Equation 10.4 Annual N excretion rates

$$Nex_{(T)} = N_{rate(T)} \times TAM_{(T)} \times 10^{-3} \times 365$$

$Nex_{(T)}$	=	Annual N excretion for livestock category T, kg N per animal per year
$N_{rate(T)}$	=	Default N excretion rate, kg N per 1000kg animal per day
$TAM_{(T)}$	=	Typical animal mass for livestock category T, kg per animal

Source: Equation adapted from *2006 IPCC Guidelines for National Greenhouse Gas Inventories* Volume 4 Agriculture, Forestry and Other Land Use available at: www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

V.2 Land use and land-use change

IPCC divides land-use into six categories:

- Forest land
- Cropland
- Grassland
- Wetlands
- Settlements
- Other

All land should be assigned to one of the above categories. Some lands can be classified into one or more categories due to multiple uses that meet the criteria of more than one definition.

A ranking has been developed for assigning these cases into a single land-use category:

Settlements > Cropland > Forest land > Grassland > Wetlands > Other land

Emissions and removals of CO_2 are based on changes in ecosystem carbon (C) stocks and are estimated for each land-use category

This includes both land remaining in a land-use category as well as land converted to another use within the last 20 years

C stocks consist of above-ground and below-ground biomass, dead organic matter (dead wood and litter), and soil organic matter

All changes in carbon stock are summed across all categories and multiplied by 44/12 to covert to CO_2 emissions

Land use and land-use change

Land use category	Description
Settlements	All developed lands, including transport infrastructure and human settlements of any size
Cropland	Cultivated land, including rice fields, and agroforestry systems where the vegetation structure is below the limits for forest land
Forest areas	All woodland areas consistent with the limits used to define forest areas in the national inventory
Grassland	Pasture lands and pastures that are not considered arable land, and systems with woody vegetation and other vegetation not grass that falls below the limit for forest land
Wetlands	Areas of peat extraction and land covered or saturated by water during all or part of the year
Other	Bare soil, rock, ice and all land areas that do not fall into any of the other five categories

Land use and land-use change

Table 10.4 Land use categories

	Forest land	Cropland	Grassland	Wetlands	Settlements	Other
Forest Land	Forest land remaining Forest land	Forest land converted to Cropland	Forest land converted to Grassland	Forest land converted to Wetlands	Forest land converted to Settlements	Forest land converted to Other land
Cropland	Cropland converted to Forest land	Cropland remaining Cropland	Cropland converted to Grassland	Cropland converted to Wetlands	Cropland converted to Settlements	Cropland converted to Other land
Grassland	Grassland converted to Forest land	Grassland converted to Cropland	Grassland remaining Grassland	Grassland converted to Wetlands	Grassland converted to Settlements	Grassland to Other land
Wetlands	Wetlands converted to Forest land	Wetlands converted to Cropland	Wetlands converted to Grassland	Wetlands remaining Wetlands	Wetlands converted to Settlements	Wetlands converted to Other land
Settlements	Settlements converted to Forest land	Settlements converted to Cropland	Settlements converted to Grassland	Settlements converted to Wetlands	Settlements remaining Settlements	Settlements converted to Other land
Other	Other land converted to Forest land	Other land converted to Cropland	Other land converted to Grassland	Other land converted to Wetlands	Other land converted to Settlements	Other land remaining Forest land

Land use and land-use change

To estimate CO_2 emissions, average annual carbon stock change data per hectare for all relevant land-use categories need to be determined and multiplied by the corresponding surface area of that land use. Changes are summed across all categories and multiplied by 44/12 to covert to CO_2 emissions

- Default data on annual carbon stock change can be obtained from the country's national inventory reporting body, IPCC, and other peer-reviewed sources.
- Land-use categorization by surface area can be obtained from national agencies or local government using land zoning or remote sensing data.

Equation 10.6 CO_2 emissions from land use and land-use change

$$CO_2 = \Sigma_{LU}[Flux_{LU} \times Area_{LU}] \times 44/12$$

CO_2	=	GHG emissions in tonnes CO_2
Area	=	Surface area of city by land-use category, hectare
Flux	=	Net annual rate of change in carbon stocks per hectare, tonnes C per hectare per year
LU	=	Land-use category
44/12	=	Conversion of C stock changes to CO_2 emissions

Equation 10.5 Carbon emissions from land use and land-use change

$$\Delta C_{AFOLU} = \Delta C_{FL} + \Delta C_{CL} + \Delta C_{GL} + \Delta C_{WL} + \Delta C_{SL} + \Delta C_{OL}$$

ΔC	=	Change in carbon stock
AFOLU	=	Agriculture, Forestry and Other Land Use
FL	=	Forest land
CL	=	Cropland
GL	=	Grassland
WL	=	Wetlands
SL	=	Settlements
OL	=	Other land

Source: Equation adapted from *2006 IPCC Guidelines for National Greenhouse Gas Inventories* , Volume 4 Agriculture, Forestry and Other Land Use, Section 2.2.1, eq 2.1. Available at: www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

Land use and land-use change

Large quantities of GHG emissions can result as a consequence of a change in land use. Examples include change of use from Forest land to Cropland or Settlements. When the land use is changed, soil carbon and carbon stock in vegetation can be lost as emissions of CO_2.

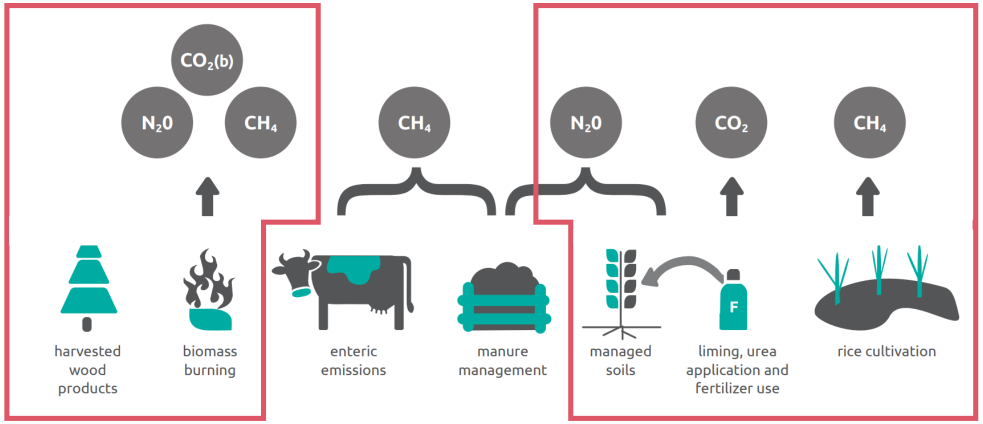
Therefore, in addition to the current land use, any land-use changes within the last 20 years will need to be determined. If the land-use change took place less than 20 years prior to undertaking the assessment, that land is considered to have been converted, based on the current and most recent use before conversion.

In this case, assessment of GHG emissions takes place on the basis of equal allocation to each year of the 20-year period.

V.3 Aggregate sources

Other sources of GHG emissions from land are captured under Aggregate sources. These can make up a significant portion of a city's AFOLU emissions:

- GHG emissions from biomass burning
- Liming
- Urea application
- Direct N2O from managed soils
- Indirect N2O from managed soils
- Indirect N2O from manure management
- Rice cultivation (releases CH4)
- Harvested wood products



Aggregate sources

Emission sources	Description
GHG emissions from biomass burning	Burning of biomass without energy recovery, such as periodic burning of land or accidental wildfires
Liming	Liming is used to reduce soil acidity and improve plant growth, particularly in agricultural lands and managed forests. Adding carbonates to soils in the form of lime (CaCO3 or CaMg(CO3)2) leads to CO2 emissions as the carbonate limes dissolve and release bicarbonate (2HCO3-), which evolves into CO2 and water (H2O).
Urea application	The use of urea (CO(NH2)2) as fertilizer leads to emissions of CO2 that were fixed during the industrial production process. Urea in the presence of water and urease enzymes is converted into ammonium (NH4+), hydroxyl ion (OH), and bicarbonate (HCO3–). The bicarbonate then evolves into CO2 and water.
Direct N_2O from managed soils	Agricultural emissions of N2O result directly from the soils to which N is added/released and indirectly through the volatilization, biomass burning, leaching and runoff of N from managed soils.

Aggregate sources

Emission sources	Description
Indirect N_2O from managed soils	N2O emissions also take place through volatilization of N as NH3 and oxides of N (NOx), and leaching and runoff from agricultural N additions to managed lands.
Indirect N_2O from manure management	Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of NH3 and NOx.
Rice cultivation (releases CH_4)	Anaerobic decomposition of organic material in flooded rice fields produces methane (CH4), which escapes to the atmosphere primarily by transport through rice plants
Harvested wood products	Harvested wood products (HWP) include all wood material that leaves harvest sites and constitutes a carbon reservoir (the time carbon is held in products will vary depending on the product and its uses e.g. fuel wood, paper, wood panels). IPCC Guidelines allow for net emissions from HWP to be reported as zero, if it is judged that the annual change in carbon in HWP stocks is insignificant.

All IPCC formulas provided in GPC

Biomass burning

Where biomass is burned for energy, the resulting non-CO2 emissions shall be reported under scope 1 for Stationary Energy while the CO2 emissions are reported separately as biogenic CO2.

However, where biomass is burned without energy recovery, such as periodic burning of land or accidental wildfires, and these activities aren't included in any land-use change calculations, GHG emissions should be reported under Aggregate Sources.

Equation 10.7 GHG emissions from biomass burning

$$GHG = A \times M_B \times CF \times EF \times 10^{-3}$$

GHG	=	GHG emissions in tonnes of CO_2 equivalent
A	=	Area of burnt land in hectares
M_B	=	Mass of fuel available for combustion, tonnes per hectare. This includes biomass, ground litter and dead wood. NB The latter two may be assumed to be zero except where this is a land-use change.
CF	=	Combustion factor (a measure of the proportion of the fuel that is actually combusted)
EF	=	Emission factor, g GHG per kg of dry matter burnt

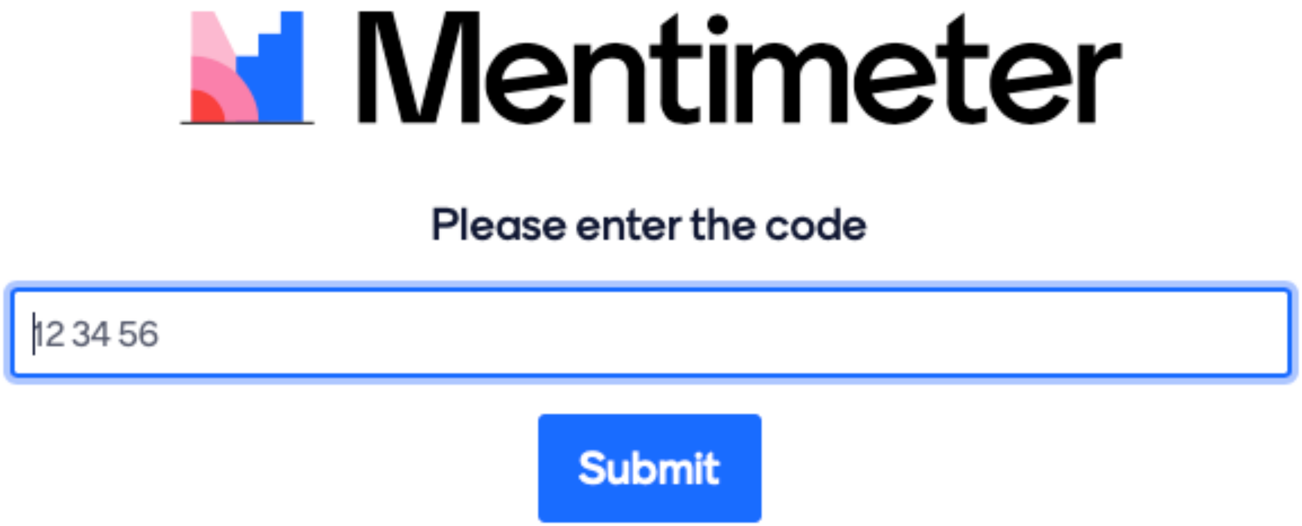
Source: Equation adapted from *2006 IPCC Guidelines for National Greenhouse Gas Inventories* Volume 4 Agriculture, Forestry and Other Land Use available at: www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

Exercise: Energy or AFOLU

Activity	Sector
Steam plant generating electricity from sugarcane	
Periodic burning of land	
Domestic wood burning	
Accidental wildfire	
Burning of biomass pellets	
Wood-fired pizza oven	
Shrub clearance	
Bonfire	

Menti

Go to www.menti.com
Enter code: 7178 8265

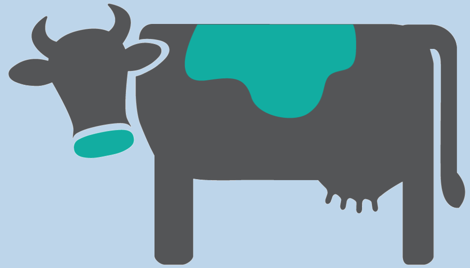


Exercise: Energy or AFOLU

Activity	Sector
Steam plant generating electricity from sugarcane	Stationary energy
Periodic burning of land	AFOLU
Domestic wood burning	Stationary energy
Accidental wildfire	AFOLU
Burning of biomass pellets	Stationary energy
Wood-fired pizza oven	Stationary energy
Shrub clearance	AFOLU
Bonfire	AFOLU

Module F

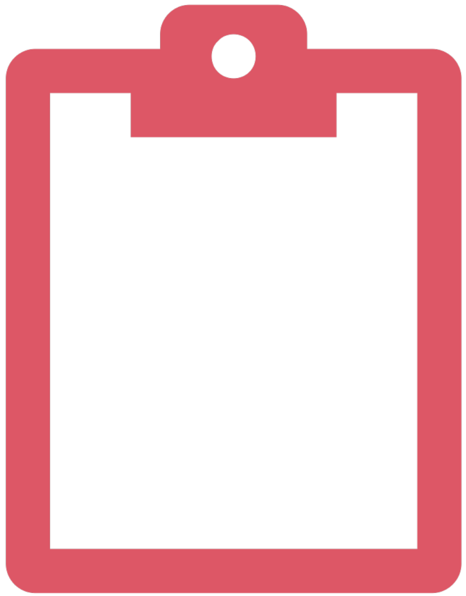
IPPU and AFOLU



04

Practical (AFOLU)

Practical



Practical

Task		
1	Identify all significant livestock activity in your city. List them in Table 1	HW
2	Identify all land uses and land use changes within the last 2 years in your city. List them in Table 1	HW
3	Estimate CH_4 emissions from enteric fermentation and manure management for an illustrative sample of livestock, using emission factors provided in BUR3 Table A2	20m
4	Record your data in Table 3, clearly documenting methodologies and data sources used. For now, assume there are no significant emissions from land use or activities covered by Aggregate sources. Where no GHG emissions occur or are deemed insignificant, use "NO". For scope 3 sources, use "NE".	HW
5	Consolidate the above information into Table 4 and identify what activity data and emission factors you will need to estimate significant GHG emissions for AFOLU, and where you will source this from	HW

Practical

Task		
1	Identify all significant livestock activity in your city. List them in Table 1	HW
2	Identify all land uses and land use changes within the last 2 years in your city. List them in Table 1	HW
3	Estimate CH_4 emissions from enteric fermentation and manure management for an illustrative sample of livestock, using emission factors provided in BUR3 Table A2	20m
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5	Consolidate the above information into Table 4 and identify what activity data and emission factors you will need to estimate significant GHG emissions for AFOLU, and where you will source this from	HW

Table 1: AFOLU

Sub-sector	
Livestock	
Land use or land use change	
Aggregate sources	

Checklist: AFOLU

Livestock	
Cattle dairy	Mules
Cattle other	Asses
Buffalo	Deer
Sheep	Alpacas
Goats	Swine
Camels	Poultry
Horses	Other

Land use categories
Settlements
Cropland
Forest areas
Grassland
Wetlands
Other

Practical

	Task	
1	Identify all significant livestock activity in your city. List them in Table 1	HW
2	Identify all land uses and land use changes within the last 2 years in your city. List them in Table 1	HW
3	Estimate CH4 emissions from enteric fermentation and manure management for an illustrative sample of livestock, using emission factors provided in BUR3 Table A2	20m
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5	Consolidate the above information into Table 4 and identify what activity data and emission factors you will need to estimate significant GHG emissions for AFOLU, and where you will source this from	HW

Workbook

GTALCC GHG Accounting - Participant handbook

Exercises	
Module B	Calculating GHG emissions
	Reviewing an inventory
Module C	Stationary energy
Module D	Transportation
Module E	Waste
Module F	IPPU and AFOLU

Tables	
Table 1	GHG emission sources
Table 2	Fuel types
Table 3	GPC
Table 4	Action plan

Reference
GPC
GWP
Notation keys
Checklist

Biennial Update Report 3

		Emission factors								
		CO_2 (tC/TJ)	CH_4 (kg/TJ)	N_2O (kg/TJ)	HFCs	PFCs	SF_6	NF_3	NO_x	CO
AGRICULTURE, FORESTRY, AND OTHER LAND USE										
3A Livestock			Kg/head/yr							
3A1	Enteric Fermentation		Dairy cattle: 68 Other cattle: 58.65 Buffalo: 55 Sheep: 5							
			Goat: 5 Horse: 18 Swine: 1 Poultry: 0							
3A2	Manure Management Anaerobic lagoons Solid storage		**Kg CH_4/ (Head Year)** Dairy cattle: 31 Other cattle: 124 Buffalo: 2 Sheep: 0.2 Goat: 0.22 Horse: 2.19 Swine: 7 Poultry (chicken): 0.02 Poutry (duck) : 0.02	Kg N_2O/-N (kg N in MMS) 0.000 0.005						
	3.A.3 Poultry Manure with litter			0.001						
	3.A.4 Poultry Manure without Litter			0.001						

Source: BUR3

Practical

	Task	
1	Identify all significant livestock activity in your city. List them in Table 1	HW
2	Identify all land uses and land use changes within the last 2 years in your city. List them in Table 1	HW
3	Estimate CH_4 emissions from enteric fermentation and manure management for an illustrative sample of livestock, using emission factors provided in BUR3 Table A2	20m
4	Record your data in Table 3, clearly documenting methodologies and data sources used. For now, assume there are no significant emissions from land use or activities covered by Aggregate sources. Where no GHG emissions occur or are deemed insignificant, use "NO". For scope 3 sources, use "NE".	HW
5	Consolidate the above information into Table 4 and identify what activity data and emission factors you will need to estimate significant GHG emissions for AFOLU, and where you will source this from	HW

Table 3: GPC table

Sub-sector		Scope 1	Scope 2	Scope 3
V.1	Livestock			
V.2	Land			
V.3	Aggregate sources			

BASIC+

Other scope 3

Table 4: Action plan

GPC	Data	Where from?	Action	Lead
Livestock				
Land				
Aggregate sources				

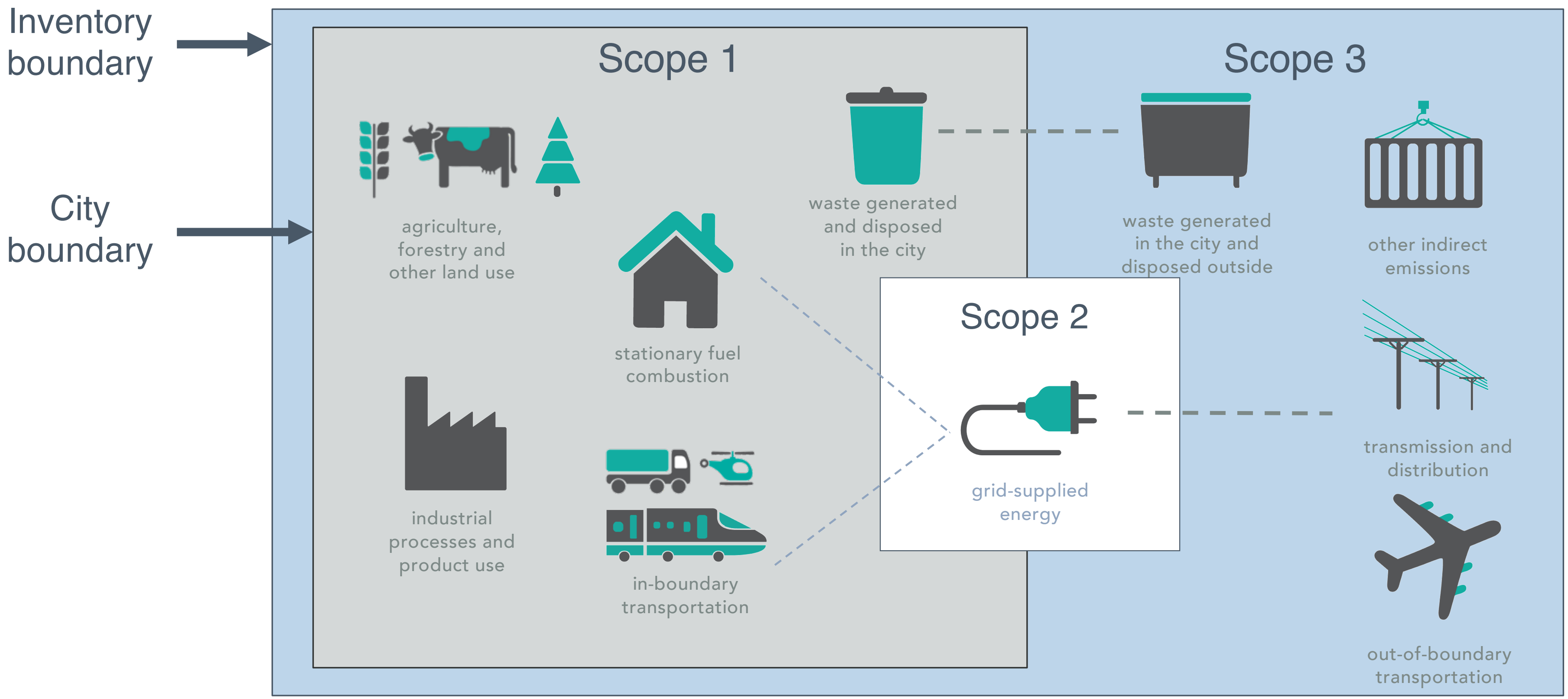
Module F

IPPU and AFOLU

05

Other scope 3

Scope 3 (other indirect emissions)

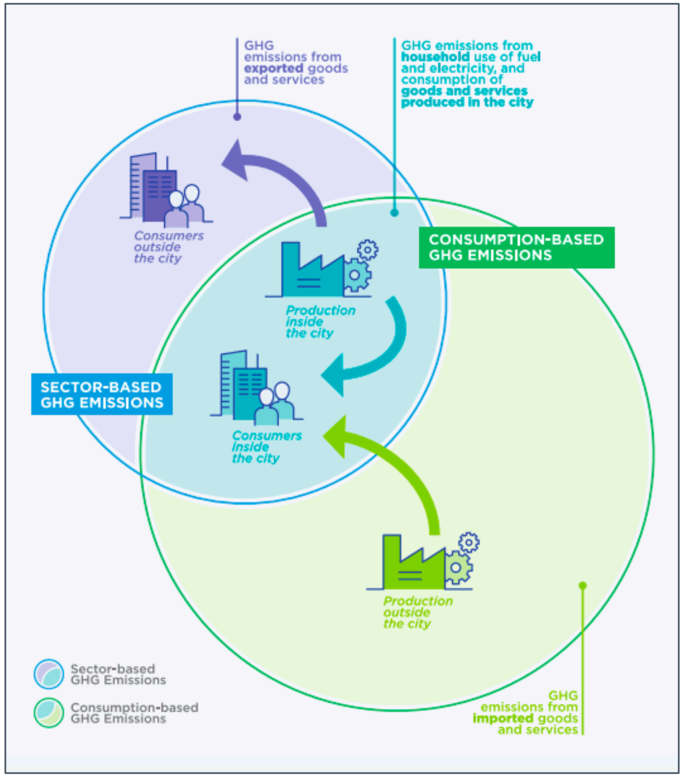


Other scope 3

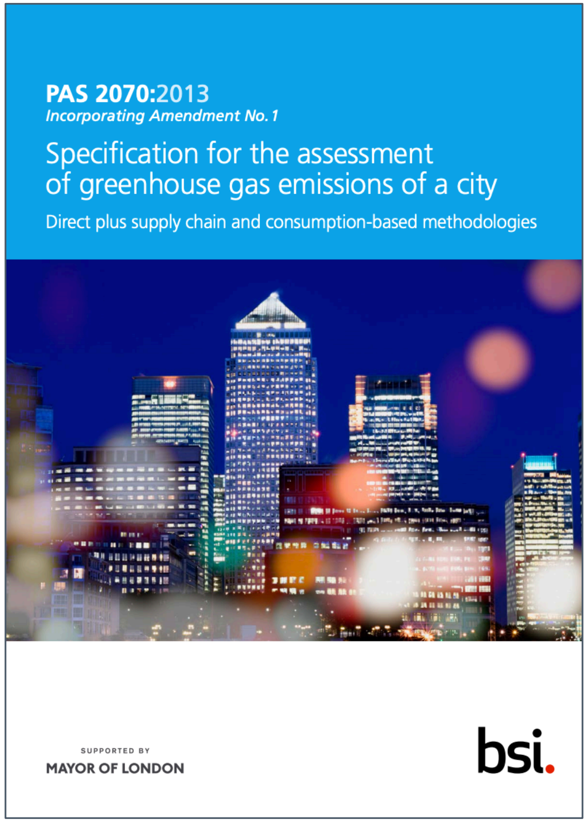
Cities, by virtue of their size, give rise to GHG emissions beyond their boundaries. Measuring these emissions allows cities to take a more holistic approach to tackling climate change by assessing the GHG impact of their supply chains,.

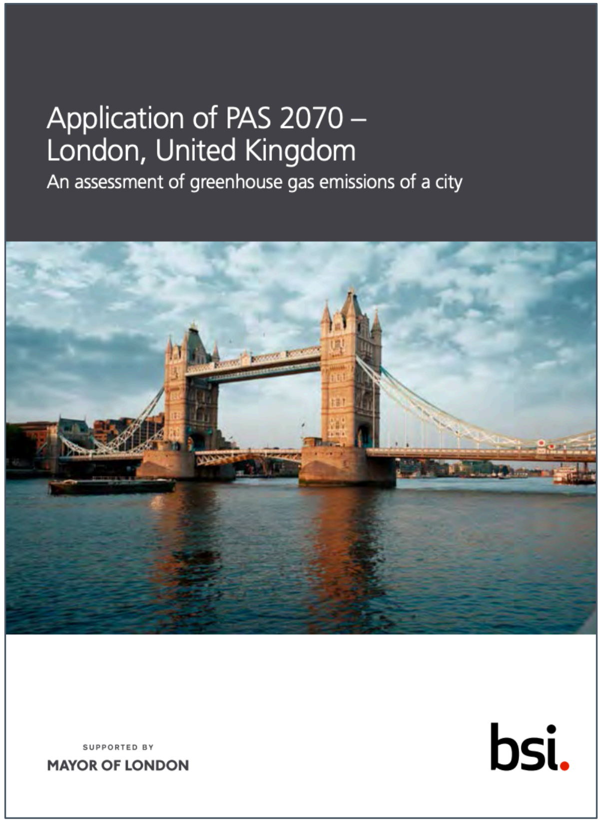
The GPC includes scope 3 accounting for a limited number of emission sources, including transmission and distribution losses associated with grid-supplied energy, and waste disposal and treatment outside the city boundary and transboundary transportation.

Cities may optionally report Other Scope 3 sources associated with activity in a city—such as GHG emissions embodied in fuels, water, food and construction materials.



PAS 2070


PAS 2070:2013
Incorporating Amendment No. 1
Specification for the assessment of greenhouse gas emissions of a city
Direct plus supply chain and consumption-based methodologies
SUPPORTED BY
MAYOR OF LONDON
bsi.


Application of PAS 2070 – London, United Kingdom
An assessment of greenhouse gas emissions of a city
SUPPORTED BY
MAYOR OF LONDON
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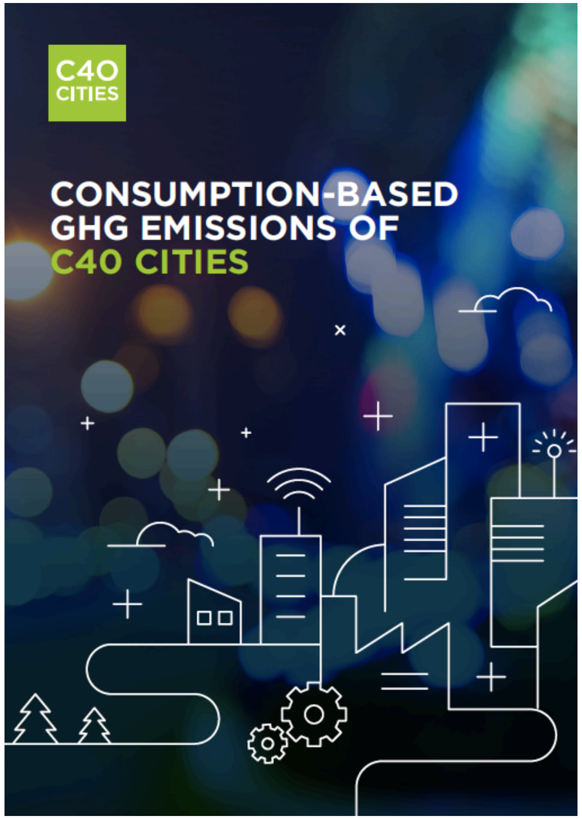

C40 CITIES
CONSUMPTION-BASED GHG EMISSIONS OF C40 CITIES

03
SUMMARY

Module F: IPPU and AFOLU

Module E: IPPU and AFOLU

- 01 IPPU
- 02 Practical (IPPU)
- 03 AFOLU
- 04 Practical (AFOLU)
- 05 Other Scope 3

GPC minimum requirements

Figure 2 **Sources and scopes covered by the GPC**

Sectors and sub-sectors	Scope 1	Scope 2	Scope 3
STATIONARY ENERGY			
Residential buildings	✓	✓	✓
Commercial and institutional buildings and facilities	✓	✓	✓
Manufacturing industries and construction	✓	✓	✓
Energy industries	✓	✓	✓
Energy generation supplied to the grid	✓		
Agriculture, forestry, and fishing activities	✓	✓	✓
Non-specified sources	✓	✓	✓
Fugitive emissions from mining, processing, storage, and transportation of coal	✓		
Fugitive emissions from oil and natural gas systems	✓		
TRANSPORTATION			
On-road	✓	✓	✓
Railways	✓	✓	✓
Waterborne navigation	✓	✓	✓
Aviation	✓	✓	✓
Off-road	✓	✓	
WASTE			
Disposal of solid waste generated in the city	✓		✓
Disposal of solid waste generated outside the city	✓		
Biological treatment of waste generated in the city	✓		✓
Biological treatment of waste generated outside the city	✓		
Incineration and open burning of waste generated in the city	✓		✓
Incineration and open burning of waste generated outside the city	✓		
Wastewater generated in the city	✓		✓
Wastewater generated outside the city	✓		
INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)			
Industrial processes	✓		
Product use	✓		
AGRICULTURE, FORESTRY AND OTHER LAND USE (AFOLU)			
Livestock	✓		
Land	✓		
Aggregate sources and non-CO_2 emission sources on land	✓		
OTHER SCOPE 3			
Other Scope 3			

✓ Sources covered by the GPC
Sources required for BASIC reporting
+ Sources required for BASIC+ reporting
Sources required for territorial total but not for BASIC/BASIC+ reporting (*italics*)
Sources included in Other Scope 3
Non-applicable emissions

Congratulations

Table 3: Stationary energy

Sub-sector		Scope 1	Scope 2	Scope 3
I.1	Residential buildings	######	######	NE
I.2	Commercial and institutional buildings and facilities	######	######	NE
I.3	Manufacturing industries and construction	######	######	NE
I.4	Energy industries	NO	NO	NE
I.4.4	*Energy generation supplied to the grid*	NO		
I.5	Agriculture, forestry, and fishing activities	NO	NO	NE
I.6	Non-specified sources	NO	NO	NE
I.7	Fugitive emissions from coal	NO		NE
I.8	Fugitive emissions from oil and natural gas systems	NO		NE

Table 3: Transportation

Sub-sector		Scope 1	Scope 2	Scope 3
II.1	On-road	######	IE (I.1.2)	NE
II.2	Railways	NO	######	NE
II.3	Waterborne navigation	NO	NO	NE
II.4	Aviation	NO	NO	NE
II.5	Off-road	IE (II.1.1)	IE (II.1.2)	NE

Table 3: Waste

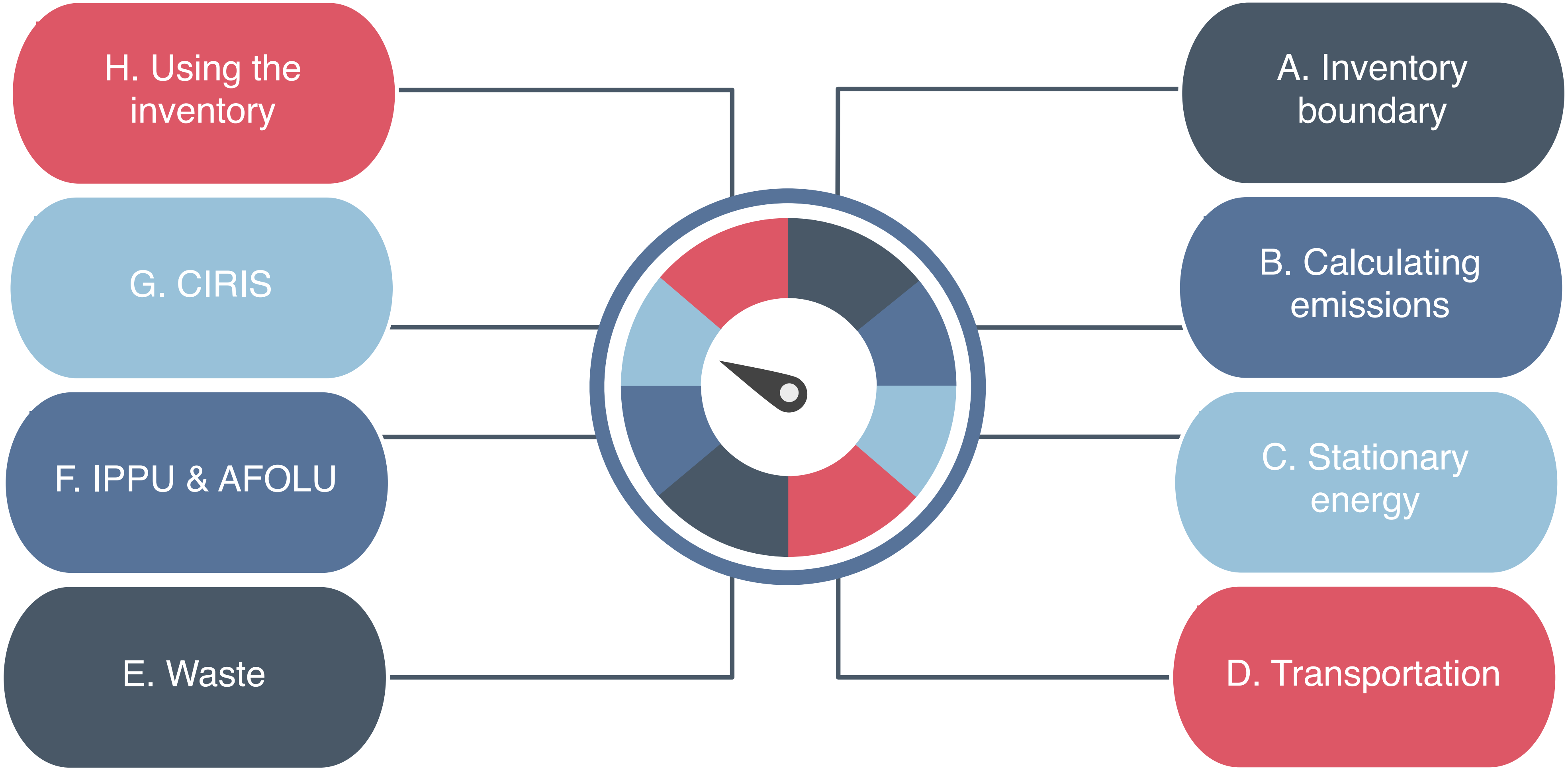
Sub-sector		Scope 1	Scope 2	Scope 3
III.1	Solid waste generated in the city and disposed in landfills			
	Solid waste generated outside the city and disposed in landfills			
III.2	Solid waste generated in the city that is biologically treated			
	Solid waste generated outside the city that is biologically treated			
III.3	Solid waste generated in the city that is incinerated			
	Solid waste generated outside the city that is incinerated			
III.4	Wastewater generated in the city			
	Wastewater generated outside the city			

Table 3: IPPU

Sub-sector		Scope 1	Scope 2	Scope 3
IV.1	Industrial processes			
IV.2	Product use			

Table 3: AFOLU

Sub-sector		Scope 1	Scope 2	Scope 3
V.1	Livestock			
V.2	Land			
V.3	Aggregate sources			


H. Using the inventory
G. CIRIS
F. IPPU & AFOLU
E. Waste
A. Inventory boundary
B. Calculating emissions
C. Stationary energy
D. Transportation

The end

Next time (Monday 1 March): CIRIS