A WRI/WBCSD GHG Protocol

Initiative Calculation Tool

CO_2 emission of Electricity use

Wajussakorn Kanjana

Thailand Environment Institute (TEI)

Presentation Outline

- Overview of GHG protocol
- GHG calculation of onsite energy production
- GHG calculation of purchased electricity
- Allocation of GHG emission from co-generation
- Exercise

Greenhouse Gases

1. *CO_2* emits from industrial and agricultural sector, especially from fossil fuels combustion

2. *CH_4* causes of emission are organic degradation and combustion such as farming, livestock, landfill, wastewater treatment plant, fossil fuel combustion

3. *N_2O* emits from nitric acid used, fertilizer used, plant burning, fossil fuel combustion

Greenhouse Gases

4. HFCs substituted Chlorofluorocarbons (CFCs) used as refrigerant agent, propellant gas in spray products, cleaning agent for electronic parts, blowing agent in foam manufacturing for making a porous and insulated foam
5. *PFCs* sources of emission are aluminium mining and semiconductor manufacturing
6. SF_6 is used in high voltage electric devices, magnesium manufacturing, semiconductor manufacturing, Insulator manufacturing

Potential Sources of Greenhouse Gas Emissions

Direct Emission (Scope1)

Source	Methodology
On-site energy production	Stationary Combustion protocol
Mobile combustion sources	Mobile combustion guidelines
Waste Disposal	Waste guidelines

Indirect Emission (Scope2 and/or scope3)

Source	Methodology
Electricity purchases	Scope 2 inventory – use Stationary combustion protocol
Waste disposal	scope 3 inventory - use waste guidance
Mobile combustion sources not owned or controlled by the company	scope 3 inventory – use mobile combustion
Production and extraction of imported materials, and outsourced activity	scope 3 inventory as 'production of imported materials' or 'outsourced' activity

Onsite energy production

(Stationary Combustion Protocol)

- The combustion of fuels produces emissions of three greenhouse gases: CO_2, CH_4 and N_2O
- CO_2 typically represents over 99 % of the greenhouse gas emissions from the stationary combustion of fossil fuels.
- CH_4 and N_2O account for about 1% of the stationary combustion emission only.

- Most stationary combustion devices can be classified into one of the following categories:
  - boilers
  - burner
  - turbines
  - heaters
  - furnaces
  - incinerators
  - kilns
  - ovens and dryers
  - internal combustion engines
  - thermal oxidizers
  - open burning (e.g., fireplaces)
  - flares
  - any other equipment or machinery that combusts carbon bearing fuels or waste streams.

- CO_2 emissions can be estimated based on a simple mass balance approach that accounts for the mass of carbon entering the combustion process in the form of CO_2

- A small fraction of the carbon in the fuel can escape oxidation and remain as a solid after combustion in the form of soot or ash.

- Stationary combustion facilities may also emit greenhouse gases from a variety of other sources such as fugitive emissions of methane from fossil fuel (i.e., natural gas, oil, or coal) handling or storage and SF_6 emissions from electrical transmission and distribution equipment. GHG Protocol guidance on these source categories is upcoming.

There are two basic approaches for estimating direct CO_2 emissions from stationary combustion (Scope 1):

1) **Direct measurement of the mass of CO_2 in the exhaust gas**

Usually take the form of a continuous emissions monitoring (CEM) system that records the total flow rate and CO_2 concentration of exhaust gases in a stack or duct

2) **Calculation of CO_2 emissions based on proxy activity data**

Some combustion units may use fuels different than the primary fuel type for start-up or burner ignition. Depending upon the frequency of unit startups, this quantity of fuel could become significant.

Calculation consideration

Biomass

• For national inventories, it is not included in national totals.

• Additions of CO_2 from biomass combustion should be captured by analyzing national land-use and land-use change activities and their associated effects on biomass carbon stocks.

Waste fuels

• Waste products in solid, liquid, and gaseous forms may also be combusted for energy. For emission inventory purposes, waste fuels are treated no differently than other types of fuels.

Transferred CO_2

If CO_2 resulting from the combustion of fossil fuels is captured and transferred outside the organizational boundaries of a company, then it can be subtracted from the company’s direct (Scope 1) emissions, although it may be reported under Scope 3 or under optional information

CO_2 capture and storage

Since international consensus on accounting for geologic storage (i.e., geologic sequestration) of CO_2 is still emerging; companies should transparently document how they treat the quantities of CO_2 injected into geologic formations in their corporate inventory

Calculate by Activity Data (A), Volume, Mass, Heat Content

E = A x Carbon content x Oxidation factor x (44/12)

Equation 1: Calculation based method for CO_2 emissions

$$E = A_{f,v} \cdot F_{c,v} \cdot F_{ox} \cdot (44/12) \quad \text{or} \quad E = A_{f,m} \cdot F_{c,m} \cdot F_{ox} \cdot (44/12) \quad \text{or} \quad E = A_{f,h} \cdot F_{c,h} \cdot F_{ox} \cdot (44/12)$$

Where,

E =	Mass emissions of CO_2 (short tons or metric tons)
$A_{f,v}$ =	Volume of fuel consumed (e.g., L, gallons, ft^3, m^3)
$A_{f,m}$ =	Mass of fuel consumed (e.g., short tons or metric tons)
$A_{f,h}$ =	Heat content of fuel consumed (GJ or million Btu)
$F_{c,v}$ =	Carbon content of fuel on a volume basis (e.g., short tons C/gallon or metric tons C/m^3)
$F_{c,m}$ =	Carbon content of fuel on a mass basis (e.g., short tons C/short ton or metric tons C/metric ton)
$F_{c,h}$ =	Carbon content of fuel on a heating value basis (e.g., short tons C/million Btu or metric tons C/GJ)
F_{ox} =	Oxidation factor to account for fraction of carbon in fuel that remains as soot or ash
(44/12) =	The ratio of the molecular weight of CO_2 to that of carbon

Note: Activity data and carbon content factors should be in the same basis (i.e., volume, mass, or energy). For gaseous fuel quantities in terms of volume, care should be taken to ensure all data are on a consistent temperature and pressure basis.

Heat Content Calculation

Heat content = Volume or Mass x Calorific value

Equation 2: Calculation of heat content of fuel consumed

$$A_{f,h} = A_{f,v}\, H_v \quad \text{or} \quad A_{f,h} = A_{f,m}\, H_m$$

Where,

$A_{f,h}$ = Heat content of fuel consumed (GJ or million Btu)

$A_{f,v}$ = Volume of fuel consumed (e.g., L, gallons, ft^3, m^3)

$A_{f,m}$ = Mass of fuel consumed (e.g., short tons or metric tons)

H_v = Calorific value (i.e., heat content) of fuel on a volume basis (e.g., million Btu/ft^3 or GJ/L)

H_m = Calorific value (i.e., heat content) of fuel on a mass basis (e.g., million Btu/short ton or GJ/metric ton)

Note: For gaseous fuel quantities in terms of volume, care should be taken to ensure all data are on a consistent temperature and pressure basis.

IPCC Oxidation Factor

Table 4: IPCC national average default values for oxidation factor values (percent)

Fuel type	**IPCC default value**	**Range of likely values**
Coal	98[b]	91 to 100
Oil and oil products	99	97.5 to 100
Gas[a]	99.5	99 to 100
Peat	99 for electricity generation <99 for residential and commercial use	91 to 100

[a] Including natural gas, biogas, and other gaseous fuels.

[b] The default value for the U.S. greenhouse gas inventory and Acid Rain Program is 99 percent.

Direct CH_4 and N_2O emissions from fuel combustion (Scope1)

Unlike for CO_2, the emissions of CH_4 and N_2O from the combustion of biomass fuels should be included with emissions from the combustion of fossil fuels.

Equation 9: Equation for estimating CH_4 and N_2O emissions from stationary combustion

$$E = A \cdot EF \cdot (1 - C / 100)$$

Where,

E = Emissions (kg)

A = Activity level (e.g., GJ of fuel combusted)

EF = Emission factor (kg of pollutant/GJ of fuel combusted)

C = Control efficiency/utilization of any emission control equipment (percent)

The preferred approach for determining a fuel's heating value is to sample the fuel being combusted and complete a chemical analysis of it.. These analyses can be performed by outside laboratories or analogous data may be available from fuel suppliers. While it is not common for fuel suppliers to be able to provide carbon content factors, most suppliers should be able to provide information on their fuel's heating value on a volume or mass basis.

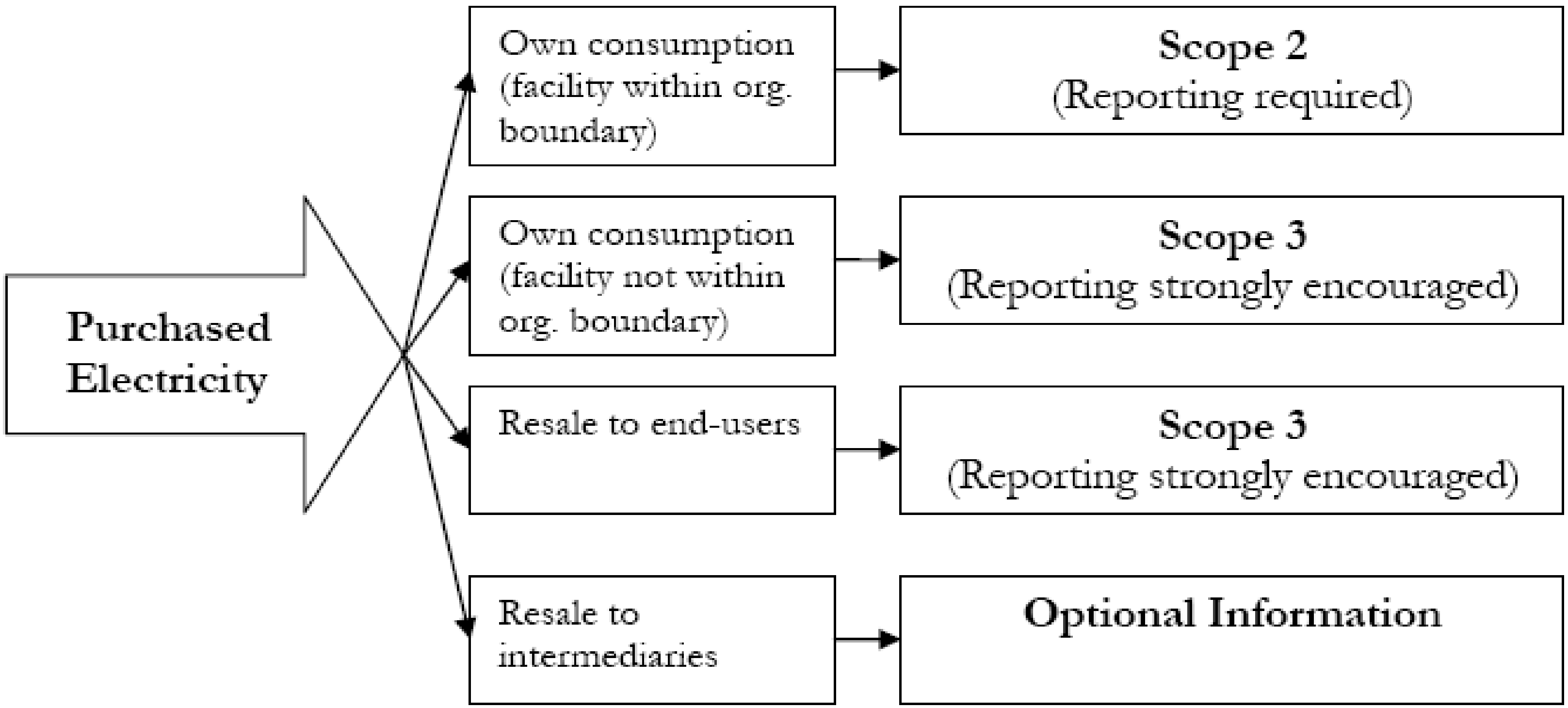
Ref. : Stationary_combustion_tool_(version_4[1].0)

Electricity purchases

(Scope 2 –

Stationary Combustion Protocol)

Figure 1. Accounting for indirect GHG emissions associated with purchased electricity



GHG accounting from the sale and purchase of electricity

Own consumption

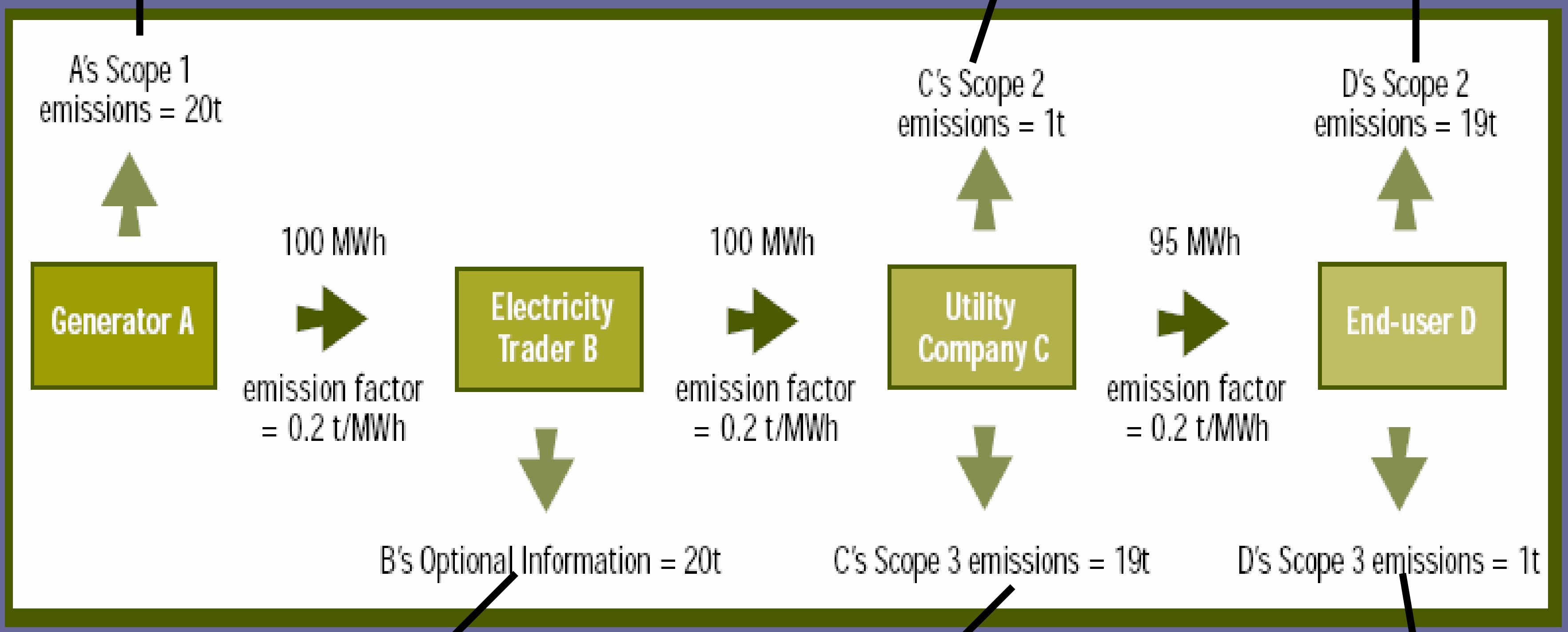
Indirect emission

T&D Electricity use

Direct emission

Own consumption

Indirect emission



Resale to intermediary

Resale to end-user

Indirect emission from T&D of company C

This tool uses the emission factor-based methodology

Activity Data x Emission Factor (kgCO2/Act. data) = CO_2 Emissions

1. Actual electricity or fuel use records method

- the most accurate data collection method.
- monthly electric bills or electric meter readings
- for tenants of leased space, particularly in office buildings, electricity costs are frequently included as part of rental payments and accurate electricity use data is often difficult to obtain, as monthly electric bills or electric meter readings may not be available. In this instance, it may be necessary to estimate electricity consumption by following one of the three estimation methods provided below.
- for heat or steam purchases, purchase records should provide the necessary activity data. Please note that the three estimation methods described below are not applicable for heat or steam purchases.

2. Building-specific data estimation method

• the reporting company leases office space in a building owned by another entity

• allocate by using the entire buildings energy use assuming that all occupants of the building have similar energy consuming habits.

(Area of Company's Space ÷ Total Building Area) x Total Building Electricity Use ÷ Building Occupancy Rate = Approximate kWh or MWh Electricity Used

3. Similar building/facility estimation method

• electricity consumption using actual data extrapolated from other similar buildings/facilities owned by the reporting company.

• this method should only be used if the reporting company has multiple buildings/facilities of a similar type, with similar electricity use patterns

4. Generic building space data method

- Number 2, 3 of electricity use estimation cannot be obtained

- it may be possible to collect default data on kWh used per area of generic office space in a particular country from a published source

- CO_2 emissions from electricity use in office space represent a very large percentage of the company's total GHG emissions, this method should not be used.

Order of Preference

Order of Preference	Activity Data Collection Method Name	Activity Being Measured/Estimated	Worksheet to Use
1	Actual electricity or fuel use records method	Electricity, heat, and/or steam use	Worksheet 1- Standard Method
2	Building-specific data estimation method	Electricity use	Worksheet 2- Building Estimation
3	Similar building/facility estimation method	Electricity use	Worksheet 1- Standard Method
4	Generic building space data method	Electricity use	Worksheet 1- Standard Method

Emission Factor (EF) of Electricity

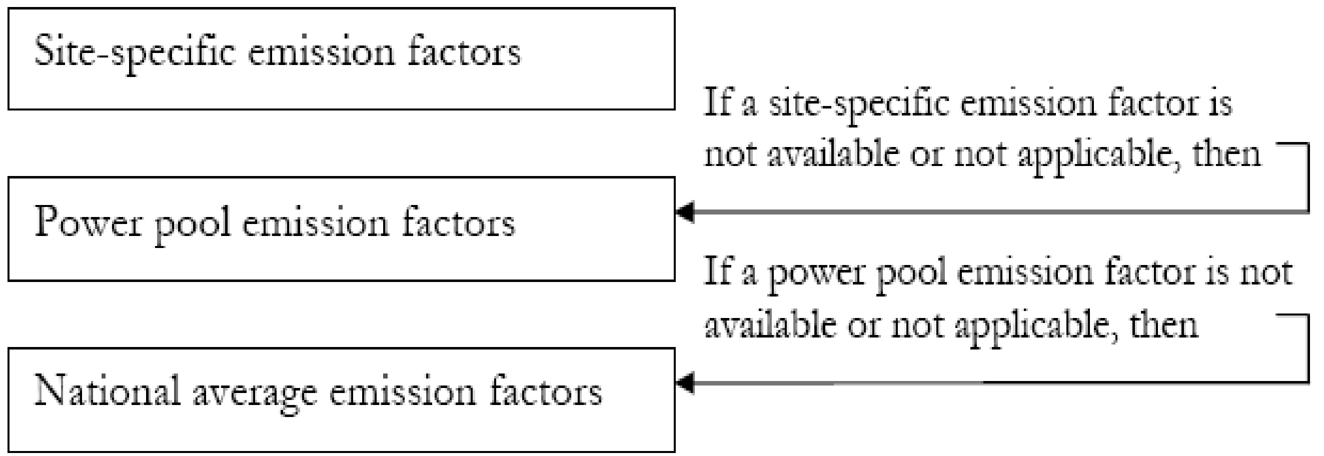
1. Site-specific data

$$\text{Emission Factor} = \frac{\text{Emission of stationary combustion (kgCO}_2\text{)}}{\text{Energy produced (kWh or Joule or BTU)}}$$

2. Secondary data

Regional or national data

Figure 2. Hierarchy of emission factor choices



Ref. : ElectricityHeatStreamPurchase_Tool2.[1].0

Allocation of GHG Emission from Combined Heat and Power Plant "CHP Plant" or "Co-generation"

• all of the electricity and steam from a CHP plant, or purchasing or selling the various output streams in the same proportions as they are generated, then an average emission factor will be sufficient

• in cases where only a portion of the electricity and steam outputs from a CHP plant are purchased or sold, it is necessary to allocate total emissions to the each output stream.

Efficiency Method

• Allocates GHG emissions according to the amount of fuel energy used to produce each final energy stream.

• Assumes that conversion of fuel energy to steam energy is more efficient than converting fuel to electricity. Thus, focuses on the initial fuel-to-steam conversion process.

• Actual efficiencies of heat and of power production will not be fully characterized, necessitating the use of assumed values.

Ref. : CHP_tool_v1[1].0

Exercise

1. ข้อมูลทั่วไปในโรงงานและสำนักงาน

- Operating Hours 24 hours/day
- Operating Days 350 days/year

2. การใช้ไฟฟ้าในกระบวนการผลิต

- ซื้อไฟฟ้าจาก EGAT เท่ากับ 175 MWh/year (CO_2 emission factor ใช้ข้อมูลค่า EF ของประเทศไทย ปี 2005 Source: IEA, 2007)
- ผลิตไฟฟ้าจาก CHP (Co-generation) โดยใช้เชื้อเพลิงเป็น

  ก๊าซธรรมชาติ 563,387 MMBTU/year ผลิตไอน้ำร้อนได้ 306,134 MMBTU และผลิตไฟฟ้าได้ 40,228.40 MWh (1 kWh = 0.003412 MMBTU)

นำไอน้ำและไฟฟ้ามาใช้ในกระบวนการผลิตเท่ากับ 174.88 MMBTU/day

และ 34,481.5 kWh/day ส่วนที่เหลือขายต่อให้ end-user

Exercise

3. การใช้ไฟฟ้าในสำนักงาน (เช่าพื้นที่) Operating days = 350 days/year

- ปริมาณไฟฟ้าจาก EGAT ที่ใช้ในอาคารสำนักงานทั้งหมด 670 kWh/day (CO_2 emission factor ใช้ข้อมูลค่า EF ของประเทศไทย ปี 2005 Source: IEA, 2007)
- พื้นที่ของอาคารสำนักงานทั้งหมด 520 ตร.ม.
- พื้นที่สำนักงานของโรงงาน 180 ตร.ม.
- พื้นที่ใช้สอยของอาคารสำนักงานเท่ากับ 65%

CO_2 Emission (Scope 1) of Electricity use = ???

CO_2 Emission (Scope 2) of Electricity use = ???

CO_2 Emission (Scope 3) of Electricity use = ???

Answer

CO_2 Emission (Scope 1) of Electricity use

Stationary Combustion

- **All CO_2 emission from CHP = 33,380.08 tonCO_2e/year**
- **EF Steam of CHP = 0.05 tonCO_2e/MMBTU**
- **EF Elec. of CHP = 0.12 tonCO_2e/MMBTU**
- **Allocated CO_2 emission from CHP**

(174. 88*350*0.05)+(34481.5*0.003412*350*0.12) = 8,001.74 tonCO_2e/year

CO_2 Emission (Scope 2) of Electricity use

- **CO_2 of Manufacturing process = 92.98 tonCO_2e/year**
- **CO_2 of leased office = 66.35 ton CO_2e/year**

SUM CO_2 Emission (Scope 1&2) of Electricity use = 8,161.07 tonCO_2e/year

Answer

CO_2 Emission (Scope 3) of Electricity use

- **CO_2 emission of electricity to end-user**

= 33,380.08 – 8,001.74 = 25,378.34 tonCO_2e/year