combusted.

**Methane and Nitrous Oxide.** Appendix C, Table C.6 presents $CH_4$ and $N_2O$ emission factors by activity sector and fuel type. For petroleum products, emission factors for $CH_4$ and $N_2O$ are provided in kilograms per gallon consumed.

**Step 4: Calculate each fuel's carbon dioxide emissions and convert to metric tons.**

If the fuel consumption is expressed in MMBtu, use Equation III.8b. If fuel is expressed in gallons, use Equation III.8c.

| **Equation III.8b** | **Total $CO_2$ Emissions (Fuel Consumption is in MMBtu)** | | | | | |
|---|---|---|---|---|---|---|
| Total Emissions *(metric tons)* | = | Emission Factor *(kg $CO_2$/Btu)* | x | Fuel Consumed *(MMBtu)* | x | 0.001 *metric tons/kg* |

| **Equation III.8c** | **Total $CO_2$ Emissions (Fuel Consumption is in Gallons)** | | | | | |
|---|---|---|---|---|---|---|
| Total Emissions *(metric tons)* | = | Emission Factor *(kg $CO_2$/gallon)* | x | Fuel Consumed *(gallon)* | x | 0.001 *metric tons/kg* |

**Step 5: If you are reporting methane and nitrous oxide emissions, calculate each fuel's methane and nitrous oxide emissions and convert to metric tons.**

If your fuel consumption is expressed in MMBtu, use Equation III.8d. If it is expressed in gallons, use Equation III.8e. Note, non-$CO_2$ gases may be de minimis.

| **Equation III.8d** | **Total $CH_4$ or $N_2O$ Emissions (Fuel Consumption is in MMBtu)** | | | | | |
|---|---|---|---|---|---|---|
| Total Emissions *(metric tons)* | = | Emission Factor *(kg $CH_4$ or $N_2O$ /MMBtu)* | x | Fuel Consumed *(MMBtu)* | x | 0.001 *metric tons/kg* |

| **Equation III.8e** | **Total $CH_4$ or $N_2O$ Emissions (Fuel Consumption is in Gallons)** | | | | | |
|---|---|---|---|---|---|---|
| Total Emissions *(metric tons)* | = | Emission Factor *(kg $CH_4$ or $N_2O$ /gallon)* | x | Fuel Consumed *(gallon)* | x | 0.001 *metric tons/kg* |

**Step 6: Convert $CH_4$ and $N_2O$ Emissions to $CO_2$e and sum all subtotals.**

Use the IPCC global warming potential factors from Table III.6.1 to convert $CH_4$ and $N_2O$ to $CO_2$ equivalent.

## III.8.5 Allocating Emissions from Co-generation

Accounting for the GHG emissions from a co-generation or combined heat and power (CHP) facility is unique because it produces more than one useful product from the same amount of fuel combusted, namely, electricity and heat or steam. As such, apportionment of the fuel and the GHG emissions between the two different energy streams is useful.[2]

Ultimately, to comply with Registry reporting guidelines, reporters only have to determine absolute emissions from a co-gen plant. This is done in a manner identical with the calculation procedure for non-co-generation plants. That is, to calculate total emissions associated with a co-generation plant participants multiply the fuel input by a fuel specific emission factor. Alternatively participants can allocate emissions according to each final product stream, i.e. electricity or steam. The three most commonly-used methods to allocate emissions of CHP plants between the electric and thermal outputs are:

1. Efficiency method: On the basis of the energy input used to produce the separate steam and electricity products.
2. Energy content method: On the basis of the energy content of the output steam and electricity products.
3. Work potential method: On the basis of the energy content of the steam and electricity products.

### Considerations in Selecting an Approach to CHP Emissions Allocation

**Efficiency Method**

- Allocates 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.

**Energy Content Method**

- Allocates emissions according to the useful energy contained in each CHP output stream.
- Need information regarding the intended use of the heat energy.
- Best suited where heat can be characterized as useful energy, e.g., for process or district heating.
- May not be appropriate where heat used for mechanical work because it may overstate the amount of useful energy in the heat, resulting in a low

2 Many CHP systems capture the waste-heat from the primary electricity generating pathway and use it for non-electricity purposes. When the waste-heat is used directly to drive a thermal generator or to make steam that in turn drives an electric generator, these combined electricity production processes are grouped as a unit and called a combined cycle power plant. (The Registry treats emissions resulting from combined cycle power plants as stationary combustion emissions.)

emissions factor associated with the heat stream.

**Work Potential Method**

- Allocates emissions based on the useful energy represented by electric power and heat, and defines useful energy on the ability of heat to perform work.
- Appropriate when heat is to be used for producing mechanical work (where much of the heat energy will not be characterized as useful energy).
- May not be appropriate for systems that sell hot water because hot water cannot be used, as steam can, to perform mechanical work.

In order to insure a consistent approach in allocating GHG emissions in CHP applications, the Registry recommends the use of the efficiency method. A default quantification methodology is provided below for this method. For more information on alternative CHP methods, see the GHG Protocol.[3]

### Using the Efficiency Method to Allocate Emissions from CHP Facilities

For this method, emissions are allocated based on the separate efficiencies of steam and electricity production. You will need to know the total emissions from the CHP plant, the total steam (or heat) and electricity production, and the steam (or heat) and electicity efficiency of the facility. Use the following steps to determine the share of $CO_2$ emissions attributable to steam (or heat) and electricity production:

**Step 1: Determine the total direct emissions from the CHP system.**

Calculate total direct GHG emissions using Equation III.8b or III.8c, above. Like the guidance for non-cogeneration stationary combustion, calculating total emissions from CHP sources is based on fuel input values.

**Step 2: Determine the total steam and electricity output for the CHP system.**

To determine the total energy output of the CHP plant attributable to steam production, use published steam tables that provide energy content (enthalpy) values for steam at different temperature and pressure conditions. Obtain steam energy content values from the IAPWS-IF97 steam tables.[4] Energy content values multiplied by the quantity of steam produced at the temperature and pressure of the CHP plant yield energy output values; express in units of MMBtu.

Alternatively, use Equation III.9a to determine the total net heat steam (or heat) production.

To convert total electricity production from MWh to MMBtu, multiply by 3.415.[5]

**Step 3: Determine the efficiencies of steam and electricity production.**

Identify steam (or heat) and electricity production efficiencies. If actual efficiencies of the CHP plant are not known, use a default value of 80% for steam and a default value of 35% for electricity.[6]

**Step 4: Determine the fraction of total emissions to allocate to steam and electricity production.**

Allocate the emissions from the CHP plant to the steam and electricity product streams by using Equation III.8f.

where:

$E_H$ = Emissions allocated to steam production
H = Total steam (or heat) output (MMBtu)
$e_H$ = Efficiency of steam (or heat) production
P = Total electricity output (MMBtu)
$e_P$ = Efficiency of electricity generation
$E_T$ = Total direct emissions of the CHP system
$E_P$ = Emissions allocated to electricity production

**Equation III.8f** — **Steam and Electricity Emissions Allocation**

$$E_H = \frac{H/e_H}{H/e_H + P/e_P} \times E_T$$

$$\text{and} \quad E_P = E_T - E_H$$

3 GHG Protocol, 2004 .

4 IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam (IAPWS-IF97), International Association for the Properties of Water and Steam. This publication replaces IFC-67.

5 MWh to MMBtu conversion source – EIA, Annual Energy Review 1995, DOE/EIA-0384(95) (Washington, DC, July 1996), Appendix B.

6 The use of default efficiency values may, in some cases, violate the energy balance constraints of some CHP systems. However, total emissions will still be allocated between the energy outputs. If the constraints are not satisfied the efficiencies of the steam and electricity can be modified until constraints are met.