

Equation 15d	Converting to CO ₂ Equivalent and Determining Total Emissions		
CO₂ Emissions (metric tons CO ₂ e)	=	CO ₂ Emissions (metric tons)	× 1 (GWP)
CH₄ Emissions (metric tons CO ₂ e)	=	CH ₄ Emissions (metric tons)	× 21 (GWP)
N₂O Emissions (metric tons CO ₂ e)	=	N ₂ O Emissions (metric tons)	× 310 (GWP)
Total Emissions (metric tons CO ₂ e)	=	CO ₂ + CH ₄ + N ₂ O (metric tons CO ₂ e)	

15.2 Calculating Indirect GHG Emissions from Imported Steam or District Heating from a Conventional Boiler Plant

Some facilities purchase steam or district heating, such as to provide space heating in the commercial sector or process heating in the industrial sector. This section provides guidance on calculating emissions from imported steam or district heating that is produced at a conventional boiler plant (i.e., not a CHP facility).

To estimate your facility's GHG emissions from imported steam or district heating, follow these four steps:

1. Determine energy obtained from steam or district heating;
2. Determine appropriate emission factors for the steam or district heating;
3. Calculate emissions from imported steam or district heating; and
4. Convert to units of carbon dioxide equivalent, and determine total emissions.

Step 1: Determine energy obtained from steam or district heating.

First, determine the quantity of acquired steam or district heating. You may use metered records of energy use, purchase records, or utility/supplier energy bills to determine annual consumption. Monthly energy bills must be summed over the year to give annual consumption.

Consumption data should be expressed in units of million British thermal units (MMBtu). If your consumption data is expressed in therms, you can convert the values to units of MMBtu by multiplying by 0.1, as shown in Equation 15e.

Equation 15e	Converting Steam Consumption from Therms to MMBtu		
Energy Consumption (MMBtu)	=	Energy Consumption (therms)	× 0.1 (MMBtu/therm)

If your steam consumption is measured in pounds (lbs), you either need to monitor the temperature and pressure of the steam you have received, or request it from the steam supplier. This information can be used with standard steam tables to calculate the steam's energy content.

Calculate the thermal energy of the steam using saturated water at 212°F as the reference (Source: American Petroleum Institute, *Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Gas Industry*, 2001). The thermal energy consumption is calculated as the difference between the enthalpy of the steam at the delivered conditions and the enthalpy (or heat content) of the saturated water at the reference conditions (or heat content).

The enthalpy of the steam can be found in standard steam tables (for example, the *Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam* published by the International Association for the Properties of Water and Steam (IAPWS)). The enthalpy of saturated water at the reference conditions is 180 Btus per pound. The thermal energy consumption for the steam can then be calculated as shown in Equation 15f.

Equation 15f	Converting Steam Consumption from Pounds to MMBtu		
Energy Consumption (MMBtu) =	$[\text{Enthalpy of Delivered Steam (Btu/lb)} - 180 \text{ (Btu/lb)}] \times \text{Steam Consumed (lbs)} \div 1,000,000 \text{ (Btu/MMBtu)}$		

Step 2: Determine the appropriate emission factors for the steam or district heating.

Tier A Method: Actual Emission Factors

Supplied steam or heat is usually generated from direct, known sources of energy. In this case, you should obtain measured emission factors directly from the supplier of heat or steam. Emission factors should be in units of mass per unit of energy (such as tons of CO₂ emitted per MMBtu of heat generated). See Chapter 12, Section 12.2, for information on deriving CO₂ emission factors.

Tier B Method: Efficiency Approach Using Specific Efficiency Factor

If you cannot obtain emission factors directly from suppliers of heat or steam, you can estimate emission factors based on boiler efficiency, fuel mix, and fuel-specific emission factors.

Because emissions vary with fuel type, you must know the type of fuels that are burned in the plant supplying your steam or hot water. You can obtain this information from the plant's energy supplier. Once you know the fuels combusted to generate the steam or hot water, determine the appropriate emission factors for each fuel combusted. The preferred approach is to obtain CO₂ emission factors based on measured characteristics of the fuels combusted, including measured heat content and measured carbon content, from your supplier. If this data is not available, use default emission factors for CO₂, CH₄, and N₂O from Tables 12.1 – 12.9.

Next, you must determine the efficiency of the boiler used to produce the steam or hot water and any transport losses that occur in delivering the steam, and calculate a total efficiency factor using Equation 15g. Boiler efficiency is the ratio of steam output to fuel input, in units of energy, which you should obtain from your steam or heat supplier. If transport losses or boiler efficiency vary seasonally, these factors should

be calculated on a monthly or seasonal basis and summed to yield total annual factors.

Equation 15g Calculating System Efficiency

Total Efficiency Factor (%) = Boiler Efficiency x (100% - Transport Losses) (%) (%)
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Calculate carbon dioxide, methane, and nitrous oxide emission factors that reflect the efficiency and fuel mix of the boiler employed to generate your steam or hot water using Equation 15h.

Tier C Method: Efficiency Approach Using Default Efficiency Factor

If you are unable to obtain the specific system efficiency of the boiler that generated your steam or heat, apply a default total efficiency factor—boiler efficiency and transport losses combined—of 75 percent in Equation 15h.

Equation 15h Calculating Emission Factors

CO₂ Emission Factor (kg CO₂ / MMBtu) = Fuel-Specific Emission Factor ÷ Total Efficiency Factor (kg CO ₂ / MMBtu) (%)
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CH₄ Emission Factor (kg CH₄ / MMBtu) = Fuel-Specific Emission Factor ÷ Total Efficiency Factor (kg CH ₄ / MMBtu) (%)
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N₂O Emission Factor (kg N₂O / MMBtu) = Fuel-Specific Emission Factor ÷ Total Efficiency Factor (kg N ₂ O / MMBtu) (%)

Step 3: Calculate emissions from imported steam or district heating.

Once you have both the value of total energy consumed from Step 1 and the appropriate emission factors from Step 2, use Equation 15i to calculate GHG emissions from imported steam or hot water.