



Building Efficiency Targeting Tool for Energy Retrofits (BETTER) Greenhouse Gas (GHG) Emissions V.1.0

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Total emissions include direct emissions and indirect emissions, which quantify carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) emissions.

- Direct emissions are emissions from fuels that are directly burned at the building, for example, natural gas combusted to heat the building.
- Indirect emissions are emissions associated with energy purchased from a utility, for example, emissions from electricity generation.

Both direct emissions and indirect emissions are calculated by multiplying the site energy values by emission factors.

For direct emissions, BETTER uses custom factors for the United States (see [Tab: 3. Fossil and 4. Fossil Source Table 1 US](#)). We use Intergovernmental Panel on Climate Change (IPCC) default emission factors for other countries (see [Tab: 3. Fossil and 4. Fossil Source Table 2 International](#)).

$$\begin{aligned} \text{Direct Emissions} &= \text{Direct CO}_2 \text{ emissions} + \text{Direct N}_2\text{O emissions} + \text{Direct CH}_4 \text{ emissions} \\ &= \sum \text{Fuel } i \text{ consumption} * \text{Fuel } i \text{ CO}_2 \text{ emission factor} + \\ &\quad \sum \text{Fuel } i \text{ consumption} * \text{Fuel } i \text{ N}_2\text{O emission factor} + \sum \text{Fuel } i \text{ consumption} * \\ &\quad \text{Fuel } i \text{ CH}_4 \text{ emission factor} \end{aligned}$$

where fuel includes coal, coke, diesel, fuel oil (No.1, 2, 4, 5, and 6), kerosene, natural gas, propane, and wood.

For indirect emissions, particularly emissions associated with the generation of electricity, we collect country-specific emission factors for the following countries (see [Tab: 1. Electricity Table 1. U.S.](#)). For the United States, emission factors of electricity are also regionalized to account for differences within the country (see [Tab: 1. Electricity Table 2. International](#)).

$$\text{Indirect Emissions} = \text{Indirect CO}_2 \text{ emissions} + \text{Indirect N}_2\text{O emissions} + \text{Indirect CH}_4 \text{ emissions}$$

$$= \sum \text{energy } i \text{ consumption} * \text{energy } i \text{ CO}_2 \text{ emission factor} +$$

$$\sum \text{energy } i \text{ consumption} * \text{energy } i \text{ N}_2\text{O emission factor} +$$

$$\sum \text{energy } i \text{ consumption} * \text{energy } i \text{ CH}_4 \text{ emission factor}$$

where energy includes district heating, district cooling, and electricity.

Calculating Direct Emissions:

- All billed or metered site energy consumption for each fuel is converted from native units to thousand British thermal units (kBtu) or kilowatt hours (kWh). Fuels that are delivered, billed, or measured in mass or volume units (i.e., cubic feet, tons, gallons) are converted to energy using standard heat content factors (see [Tab Fuel Conversion Factors](#)).
- Total site energy for each fuel is multiplied by CO₂-equivalent factors that incorporates the IPCC Fourth Assessment Report's 100-year global warming potential of each gas (CO₂=1, CH₄=25, and N₂O= 298)¹
 - In the U.S., these factors are computed at the national level.
 - In other countries, these factors are IPCC default numbers. If an IPCC default can't be found, the U.S. emission factor for that fuel is used.
- Direct emissions are summed together across all fuels.
- Direct emissions are added to indirect emissions to calculate the total GHG emissions.

Calculating Indirect Emissions:

District Heating and Cooling:

- All billed or metered site energy consumption for each fuel is converted from native units to kBtu or kWh. Fuels that are delivered, billed, or measured in mass or volume units (i.e., pounds of steam) are converted to energy using standard heat content factors (see [Tab Fuel Conversion Factors](#)).
- Total site energy for each fuel is multiplied by CO₂-equivalent factors that incorporates IPCC Fourth Assessment Report's 100-year global warming potential of each gas (CO₂=1, CH₄=25, and N₂O= 298)².
 - In the U.S., these factors are computed at the national level, with the exception of electricity where these are regional factors according to the eGRID subregions.³
 - In other countries, these factors are IPCC default numbers, with the exception of electricity where the factors are provided at the national level based on United Nations Framework Convention on Climate Change (UNFCCC) National

¹ IPCC. 2020. "Fourth Assessment Report." <https://www.ipcc.ch/assessment-report/ar4/>

² IPCC. 2020. "Fourth Assessment Report." <https://www.ipcc.ch/assessment-report/ar4/>

³ U.S. Environmental Protection Agency (EPA). 2018. "Emission Factors for Greenhouse Gas Inventories." Washington, D.C.: U.S. EPA. https://www.epa.gov/sites/production/files/2018-03/documents/emission-factors_mar_2018_0.pdf

Inventory Submission⁴ and electricity generation reported by the U.S. Energy Information Agency (EIA).⁵

- Indirect emissions from district energy consumption are added to electric indirect emissions to compute total indirect emissions.
- Direct emissions are added to indirect emissions to calculate the total GHG emissions.

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⁴ UNFCCC. 2019. “National Inventory Submissions 2019.”

<https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2019>

⁵ U.S. EIA. 2020. “International Electricity.” <https://www.eia.gov/international/data/world>