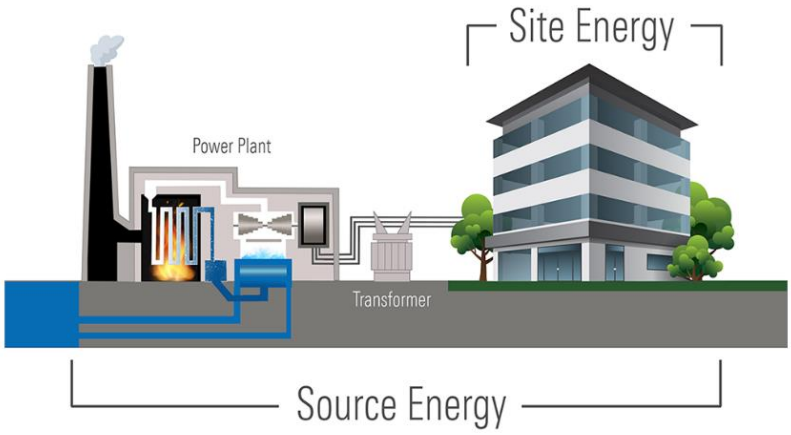
Source vs. Site Energy Solutions

When discussing energy efficiency, decarbonization, and greenhouse gas accounting, the terms* source energy *and* site energy *are often used. What is the difference between source and site energy?

Site energy refers to the amount of energy metered at the point of use (e.g. consumed by a building). Site energy may refer to both *primary* energy (natural gas or fuel consumed on site) and *secondary* energy (heat or electricity created from raw fuel). **Source energy** has a larger scope, referring to the amount of energy produced at a power source for a given end use. Source energy is the amount of primary energy consumed in supplying secondary energy to a building.

The power generation, transmission, and delivery of source energy to the site results in losses. As a result, source energy is nearly always less efficient than site energy. This is important to understand when considering how efficiently energy is consumed, as well as the emissions impacts of energy consumption.



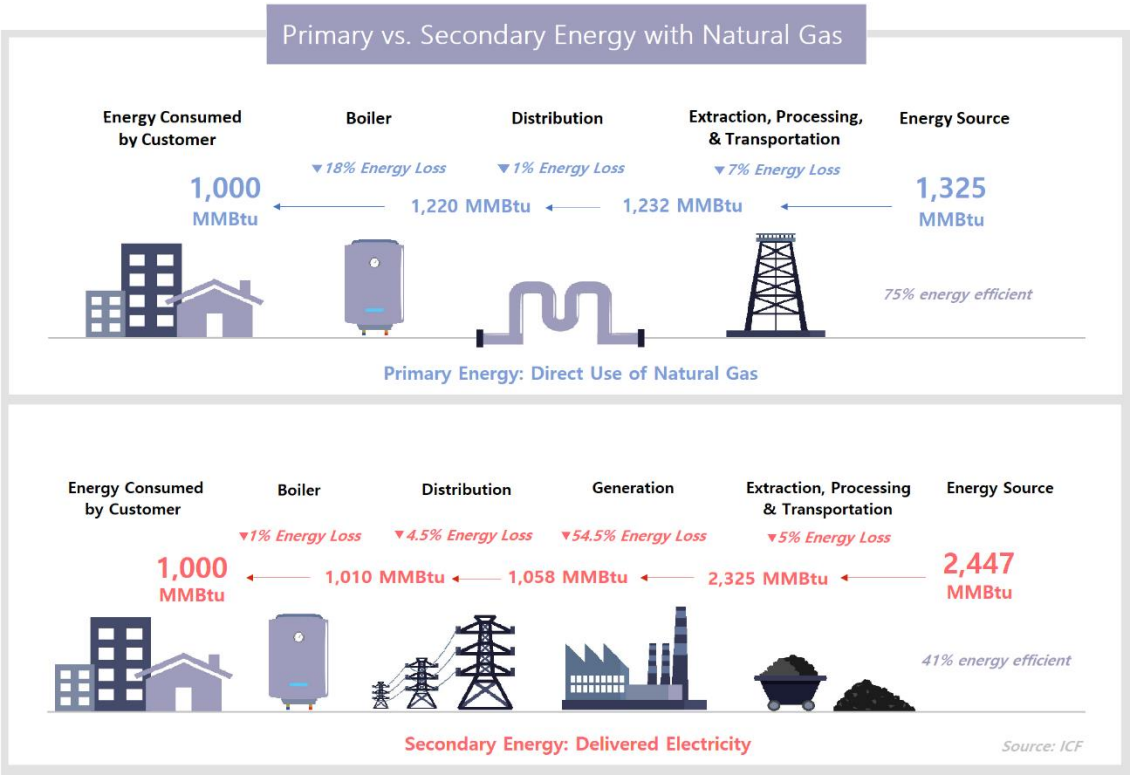
Source: EPA ENERGY STAR

Natural Gas is the most widely used fuel for primary energy in the U.S. The energy consumed for extraction, processing, transportation and distribution reduces the efficiency of direct natural gas usage by approximately 8%[1]. Once natural gas reaches the consumer, it is combusted and often connected to a furnace or boiler system to create hot air, hot water or steam (with a typical efficiency of 82%). In total, direct use of natural gas is 75% energy efficient including source losses.

As a secondary energy source, natural gas is combusted and connected to turbines or engines which generate electricity that is transmitted via power lines. The extraction, processing, and transportation of resources for electricity generation causes 5% energy loss. The production of electricity results in 54.5% of the remaining energy lost as heat waste. Additional losses from distribution (and, often, a boiler) reduce efficiency a further 5.5%. In total, delivered electricity is 41% efficient.

In the figure below, both pathways are illustrated to highlight the difference in energy required for an onsite boiler fueled by natural gas for primary energy, versus electricity produced from natural gas for secondary energy, using average values for efficiencies and losses. The amount of energy required for secondary energy (via electricity production) is nearly double that of primary energy. If the same fuel is used for both primary and secondary energy, the carbon emissions from secondary energy with electricity production would be nearly double that of primary energy with direct site utilization.

[1] American Gas Association



When comparing primary and secondary energy emissions with delivered electricity, one must consider the sources of electricity from the grid. Most greenhouse gas accounting methods use average grid emissions, which include baseload nuclear, hydroelectric, and renewable resources (zero emissions) as well as fossil fuel resources. Projects that impact grid electricity requirements affect the use of *marginal* grid resources, which are most often fossil fuel generators. In 2021, the eGRID average CO_2 emissions rate was 852 lb/MWh, while the "non-baseload" CO_2 emissions rate was 1,410 lb/MWh.[2] The non-baseload rate represents generators used to serve periodic shifts in grid demand. This rate can be used to approximate marginal grid emissions. The table below shows the difference in emissions between an 82% efficient gas boiler and a 99% efficient electric boiler, using both eGRID emissions rates and considering average grid losses (4.5%).[3]

	Energy Used (MMBtu)	Energy Required (MMBtu)	On-Site CO_2 Emissions (lbs)	Off-Site CO_2 Emissions (lbs)	Total CO_2 Emissions (lbs)
Gas Boiler ***Direct Use of Natural Gas***	1,000	1,220	142,317	11,385	153,702
Electric Boiler ***2021 eGRID Average***	1,000	1,010	0	276,856	276,856
Electric Boiler ***2021 eGRID Non-Baseload***	1,000	1,010	0	458,016	458,016

Losses from electricity generation and delivery tend to result in higher source energy emissions compared to direct use of natural gas. Consumers can install high-efficiency HVAC systems, electric heat pumps, gas heat pumps, or combined heat & power (CHP) systems to improve efficiency and reduce greenhouse gas emissions associated with both source and site energy.

[2] Emissions & Generation Resource Integrated Database (eGRID) | US EPA
[3] Ibid.