Full-Fuel-Cycle Energy Efficiency Standards

Telling The Full Story
Full-fuel-cycle metrics should be used in building codes and appliance standards to evaluate the energy and environmental impact of consumer fuels and appliances. Policies that require evaluation of technology and fuel options must incorporate a comprehensive methodology, such as full-fuel-cycle metrics, in order to maximize energy efficiency and greenhouse gas (GHG) emission reductions, and to ensure that consumers have access to full range of information on impacts when making energy choices.

Full-Fuel-Cycle Measurement Defined
Full-fuel-cycle energy is the energy consumed by an appliance, system, or building as measured at the building site. It includes: energy consumed in the extraction, processing, and transport of primary fuels such as coal, oil and natural gas; energy losses in thermal combustion in power-generation plants; and energy losses in transmission and distribution to the building site. Full-fuel-cycle therefore includes the total energy consumption and environmental impacts of end-use energy decisions. A full-fuel-cycle-based energy efficiency standard would allow consumers fuller evaluation of fuel and appliance options.

Support for Full-Fuel-Cycle Standards
A 2011 U.S. Department of Energy (DOE) Statement of Policy states that DOE will use full-fuel cycle measures of energy use and emissions when evaluating energy conservation standards for appliances, following the recommendation of the National Academy of Sciences. This approach is also supported by the Natural Resources Defense Council.

Full-Fuel-Cycle vs. Site-Based Standards
Current site-based energy efficiency standards for appliances only account for energy used at the point of consumption, or site, and therefore only measure the efficiency of the appliance itself. Site energy measurement does not take into account the energy used to bring energy to the consumer.

Natural Gas is the Clean, Efficient Choice
The direct use of natural gas in America’s homes and businesses maintains about 92 percent of its usable energy, and a household with natural gas versus all-electric appliances produces 41 percent lower greenhouse gas emissions. In typical home appliances, the direct use of natural gas results in total energy consumption that is 33 percent less than a similar home with all-electric appliances.

To Learn More Visit www.aga.org
or connect with us on Twitter @AGA_naturalgas and facebook.com/naturalgas
Direct Use of Natural Gas

91% From the place where it is extracted from the ground, to appliances in your home, natural gas achieves 91% energy efficiency.

Converting to Electricity

Converting natural gas or any other fossil fuel into electricity to power comparable electric end-use products only maintains 36% of usable energy. This is because of the significant amount of energy lost on the journey from production to customer.

SOURCE ENERGY | EXTRATION, PROCESSING & TRANSPORTATION | GENERATION | DISTRIBUTION | DELIVERED TO CUSTOMER
--- | --- | --- | --- | ---
100 MMBtu | 92 MMBtu | 91 MMBtu | 36 MMBtu
\(\downarrow 7\% \text{ Energy Loss} \) | No energy conversion necessary, therefore no energy is lost | \(\downarrow 5\% \text{ Energy Loss} \) | \(\downarrow 5\% \text{ Energy Loss} \)
Space heating is the dominant space conditioning load in all regions. Ratio of heating to cooling is high in northern regions (over 10:1).

Switching from natural gas to electric space heating faces real-world issues: size of peak seasonal energy delivery, consumer cost impacts, seasonal emission rates, others.

Source: DOE EIA (RECS, 2015)
## Winter Natural Gas Peaks Substantially Greater Than Summer Electric Peaks

### Monthly Energy Consumption In Residential Sector (Six Years)

<table>
<thead>
<tr>
<th>Year</th>
<th>Residential Electric</th>
<th>Residential Natural Gas</th>
<th>Peak Natural Gas: Peak Electric Ratio</th>
<th>% Gas Heating</th>
<th>% Electric Heating</th>
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<tbody>
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<td>CA</td>
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<td>64</td>
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<td>4.6</td>
<td>58</td>
<td>11</td>
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Substantially more natural gas is delivered in a peak month to residential users than electricity. Heating loads are energy intensive.

Monthly residential electric and natural gas consumption (DOE-EIA) on same energy scales. Six years of data.

Source: DOE EIA, U.S. Census
GTI Analysis of Displacing Gas Heating With Electricity In 18 States: Higher Consumer Costs, Negative Environmental Impacts

• Space heating electrification increases annual consumer energy costs by over $15 billion in these 18 states (equal to about 55% of U.S. residential natural gas consumers). **No state demonstrates consumer savings.**

• **CO₂ emissions increase by over 23 million metric tons** using empirically derived winter emission rates from DOE-EIA data (and even higher using the EPA non-baseload emission rates). Three states might see reductions, but would be challenging with major new electric demand increases.

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<td>CO₂ Reduction (empirical method)*</td>
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* For reductions greater than 10%; dark green = potential benefits.

GTI analysis using DOE-EIA and EPA data; assumes 92% efficient furnace and 8.4 HSPF air source electric heat pump
Consumer space heating costs increase – with large impacts in colder regions.

This analysis is based on today’s electric prices. In reality, major new investments would be needed in electric generation, transmission, storage, and distribution assets that would likely further raise electric prices and consumer costs.
Reducing full-cycle natural gas methane emissions

Natural Gas Low Greenhouse Gas Pathways

**Near-Term (25-50+%)**
- Expanded use of high-efficiency gas equipment
- Hybrid natural gas furnace/boilers and electric heat pump systems
- Building envelope improvement

**Next-Gen (40-60+%)**
- Natural gas heat pumps for space & water heating
- Micro CHP systems
- Deep building retrofits

**Renewables (Added 10-30%)**
- Renewable gas blends (bio-methane, hydrogen)
- Solar thermal/natural gas space & water heating systems
- Lower Methane Emissions (5-10%)

*Numbers indicate nominal GHG reduction potential*
On a seasonal basis, typical Energy Star electric heat pumps use more primary energy than natural gas furnaces on a seasonal, full-cycle basis.

Electricity use (and primary energy consumption) for electric heat pumps rises markedly at cold temperatures.

Emerging gas heat pumps offer improved full-cycle efficiency and reduced sensitivity to outdoor temperatures.
Affordable and Efficient Hot Water

COMPARING RESIDENTIAL WATER HEATER EFFICIENCY

Tankless Natural Gas

Energy Cost*
$174 (annually)

Full-Fuel-Cycle Energy Consumption*
18.6 MMBtu (annually)

CO₂ Emissions*
1.1 tons (annually)

Natural Gas

Energy Cost*
$249 (annually)

Full-Fuel-Cycle Energy Consumption*
26.64 MMBtu (annually)

CO₂ Emissions*
1.5 tons (annually)

Electric Resistance

Energy Cost*
$613 (annually)

Full-Fuel-Cycle Energy Consumption*
49.8 MMBtu (annually)

CO₂ Emissions*
2.9 tons (annually)

Source: AGA
Large Increases In Peak Winter Electricity Use With Electric Heat Pumps

Switching from gas heating to electric heating would (on average) increase peak residential monthly electricity use by 150% in these 18 states.

Impacts in colder regions are much higher – up to 200 to 300% increase in peak monthly electricity use.

GTI analysis using DOE-EIA and EPA data; assumes 92% efficient furnace and 8.4 HSPF air source electric heat pump
Comparison of Large-Scale Energy Delivery Systems
Natural Gas Transmission Pipelines and Electric Transmission Lines

- Chemically-based energy delivery systems, like natural gas pipelines, have much greater energy delivery capability than electric power lines (10-50+ times higher)
- Gas pipelines are also more cost effective, have improved aesthetics (out of sight), and less vulnerable to weather impacts

Source: DOE EIA (top 80% of interstate gas pipelines).
http://web.ecs.baylor.edu/faculty/grady/13_EE392J_2_Spring11_AEP_Transmission_Facts.pdf
Energy Storage Realities

Former Secretary of Energy Professor Steven Chu as cited by the Australian on 1-30-18

- While the costs of building battery plants were likely to halve over the next decade, the approach would never be cheap enough to accommodate the big seasonal shifts in renewable power production.
- Batteries could prove viable for storing power produced during the day for use during night hours, and “maybe” up to a week later, but not over seasonal timeframes.
- You need other new technologies to convert cheap renewable energy into chemical fuel when the sun is shining or the wind is blowing, he told The Australian. “If you make really cheap hydrogen from renewables and store it underground, then you have something very different.”

Substantial natural gas storage built to address seasonal heating loads. Batteries are insufficient for this type of service.

Source: GTI analysis of DOE EIA data (nominal). Based on underground gas storage and pumped hydro storage data; estimated battery performance assuming 1 GW installed capacity and 25% annual capacity factor.