

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.

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33%

A household with natural gas appliances consumes 33 percent less energy than a household with all-electric appliances.

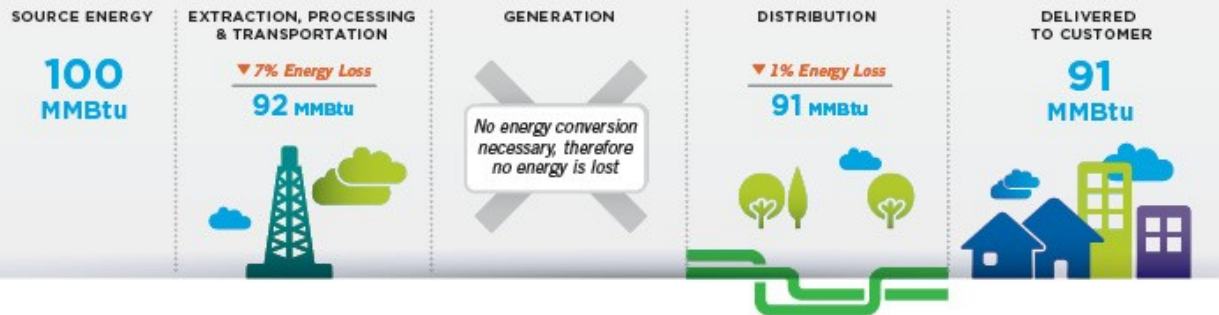
Full-fuel-cycle standards use a more comprehensive measurement of energy efficiency and greenhouse gas emissions.

Consumers should have access to full-fuel-cycle information when making energy choices.

Direct Use of Natural Gas

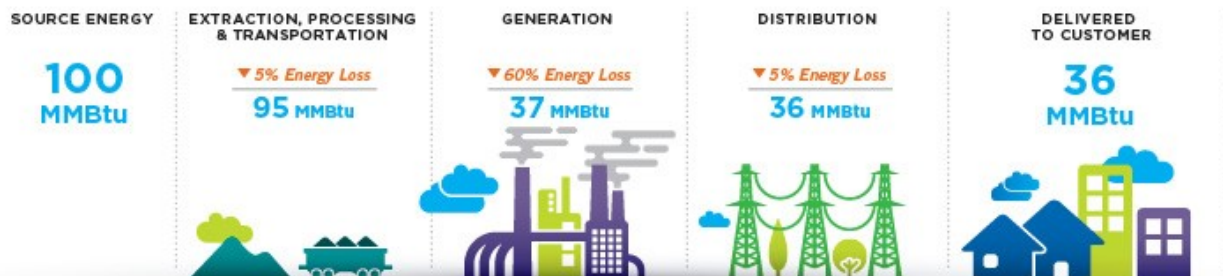
91%

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

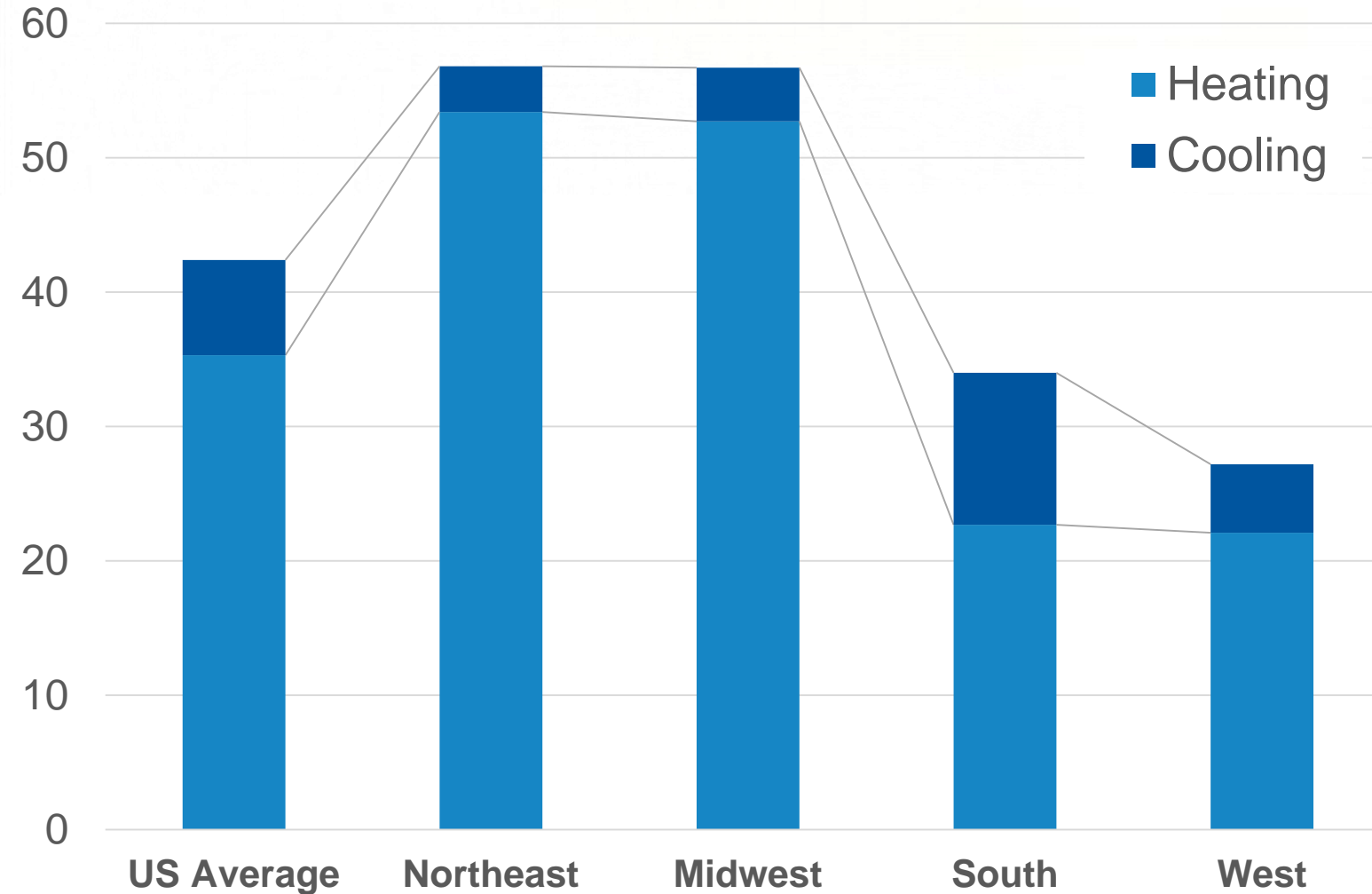


Converting to Electricity

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.



Space Conditioning Loads for U.S. Homes MMBtu/Year



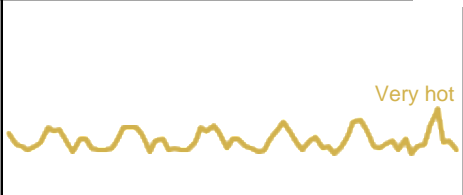
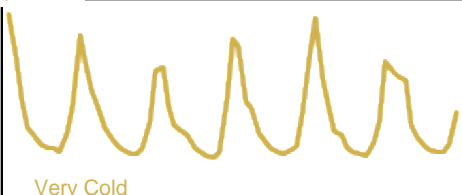



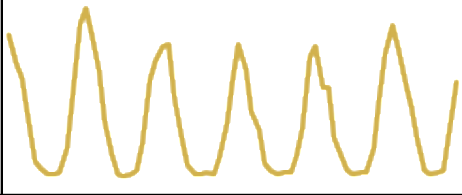
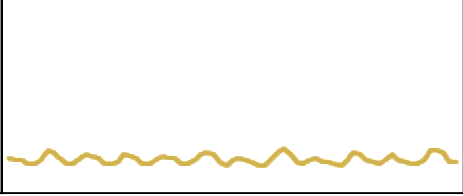
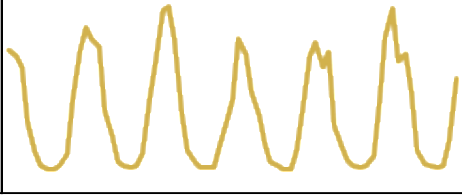
Space heating is the dominant space conditioning load in all regions. Ratio of heating to cooling is high in northern regions (over 10:1).

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.



Winter Natural Gas Peaks Substantially Greater Than Summer Electric Peaks

Monthly Energy Consumption In Residential Sector (Six Years)

2013 - 2018	Residential Electric	Residential Natural Gas	Peak Natural Gas: Peak Electric Ratio	% Gas Heating	% Electric Heating
CA			2.2	64	27
IL			5.6	78	16
MN			3.6	66	17
NY			4.6	58	11

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.

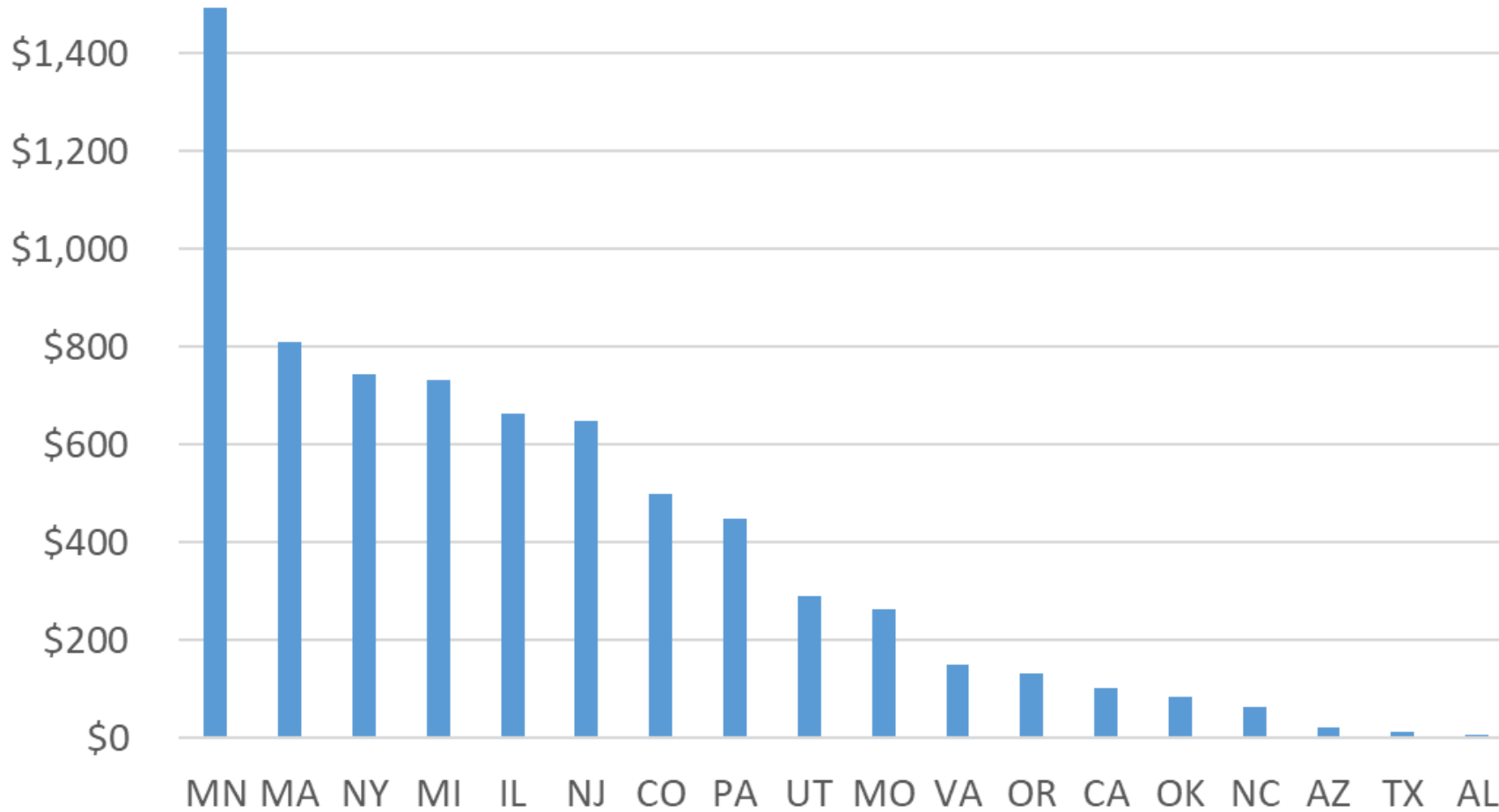
GTI Analysis of Displacing Gas Heating With Electricity In 18 States: Higher Consumer Costs, Negative Environmental Impacts

- 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.

	AL	AZ	CA	CO	IL	MA	MI	MN	MO	NC	NJ	NY	OK	OR	PA	TX	UT	VA
Annualized Energy Cost Savings																		
CO2 Reduction (empirical method)*																		
CO2 Reduction (EPA method)*																		

* For reductions greater than 10%; dark green = potential benefits.

Annualized Cost Per Home Converting Natural Gas Space Heating to Electric



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.

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)

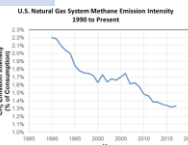


Solar thermal/natural gas space & water heating systems

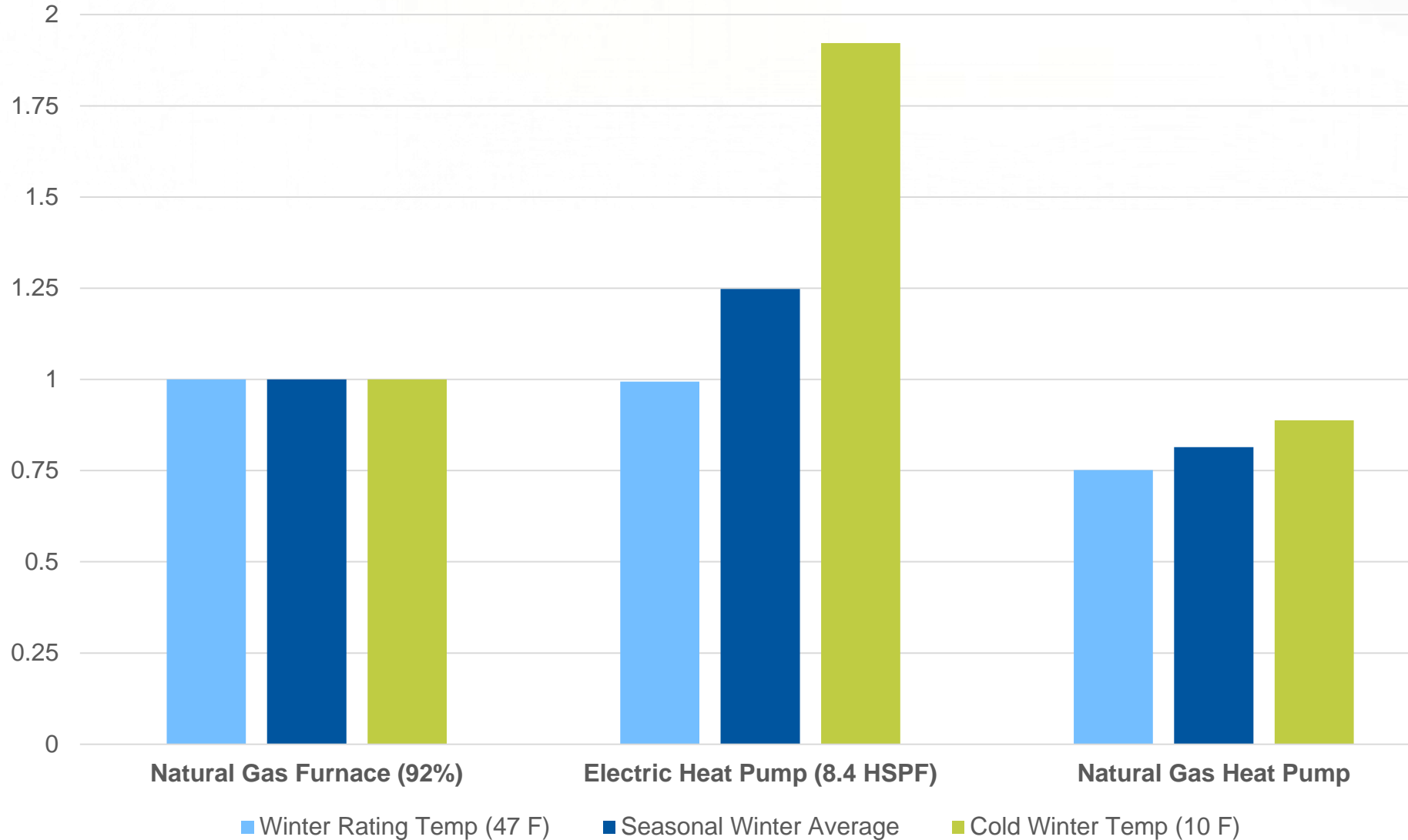


Lower Methane Emissions
(5-10%)

Reducing full-cycle natural gas methane emissions



Relative Primary Energy Consumption Rates for Space Heating (Including Full-Cycle Source Energy Efficiency Losses)



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)

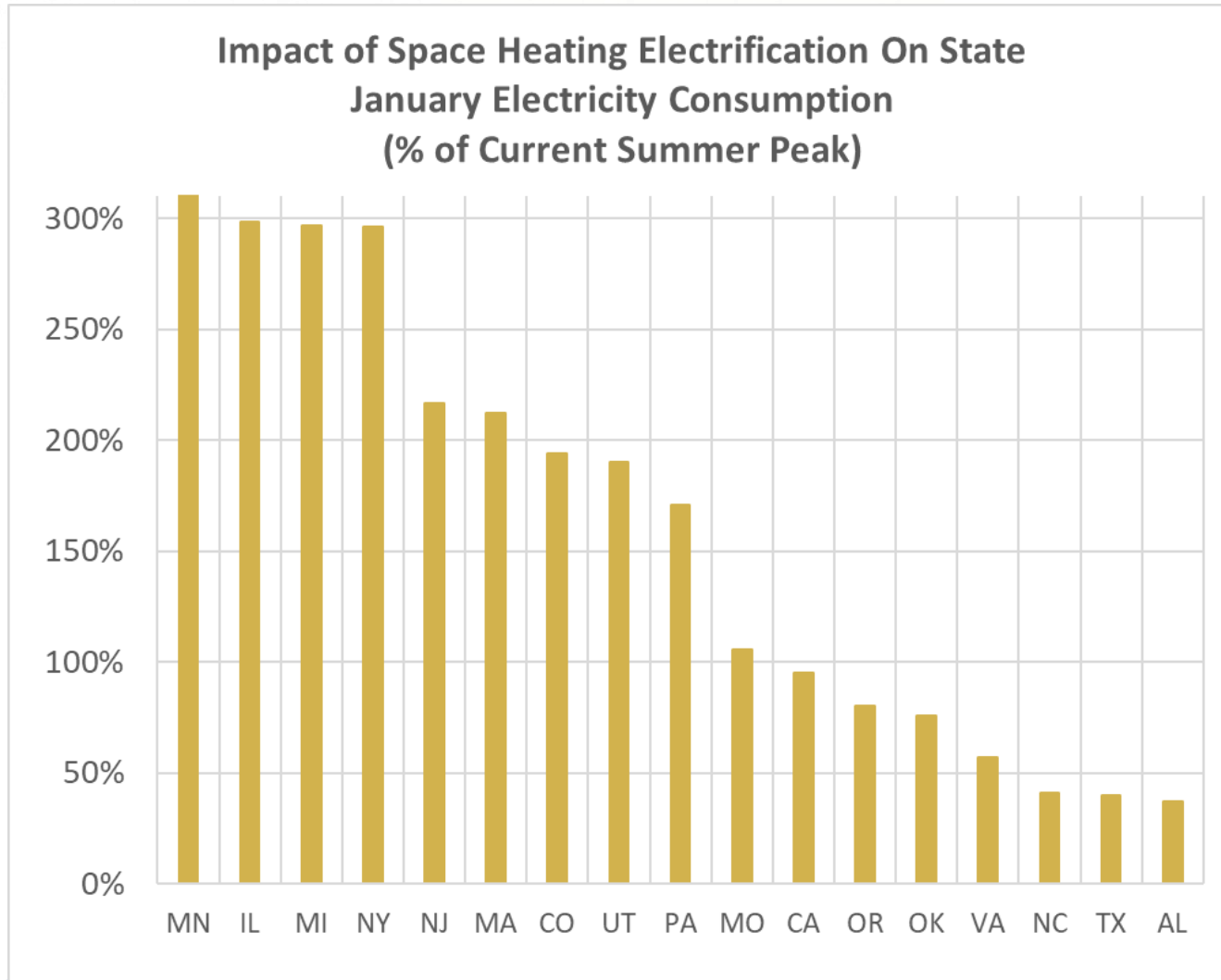
Full-Fuel-Cycle Energy
Consumption*

49.8 MMBtu
(annually)

CO₂ Emissions*

2.9 tons
(annually)

Large Increases In Peak Winter Electricity Use With Electric Heat Pumps



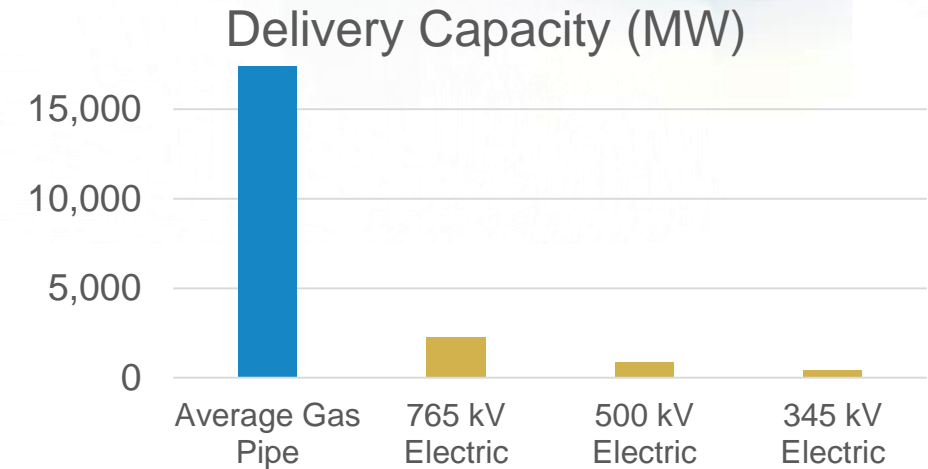
Switching from gas heating to electric heating would (on average) increase peak residential monthly electricity use by 150% in these 18 states.

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

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

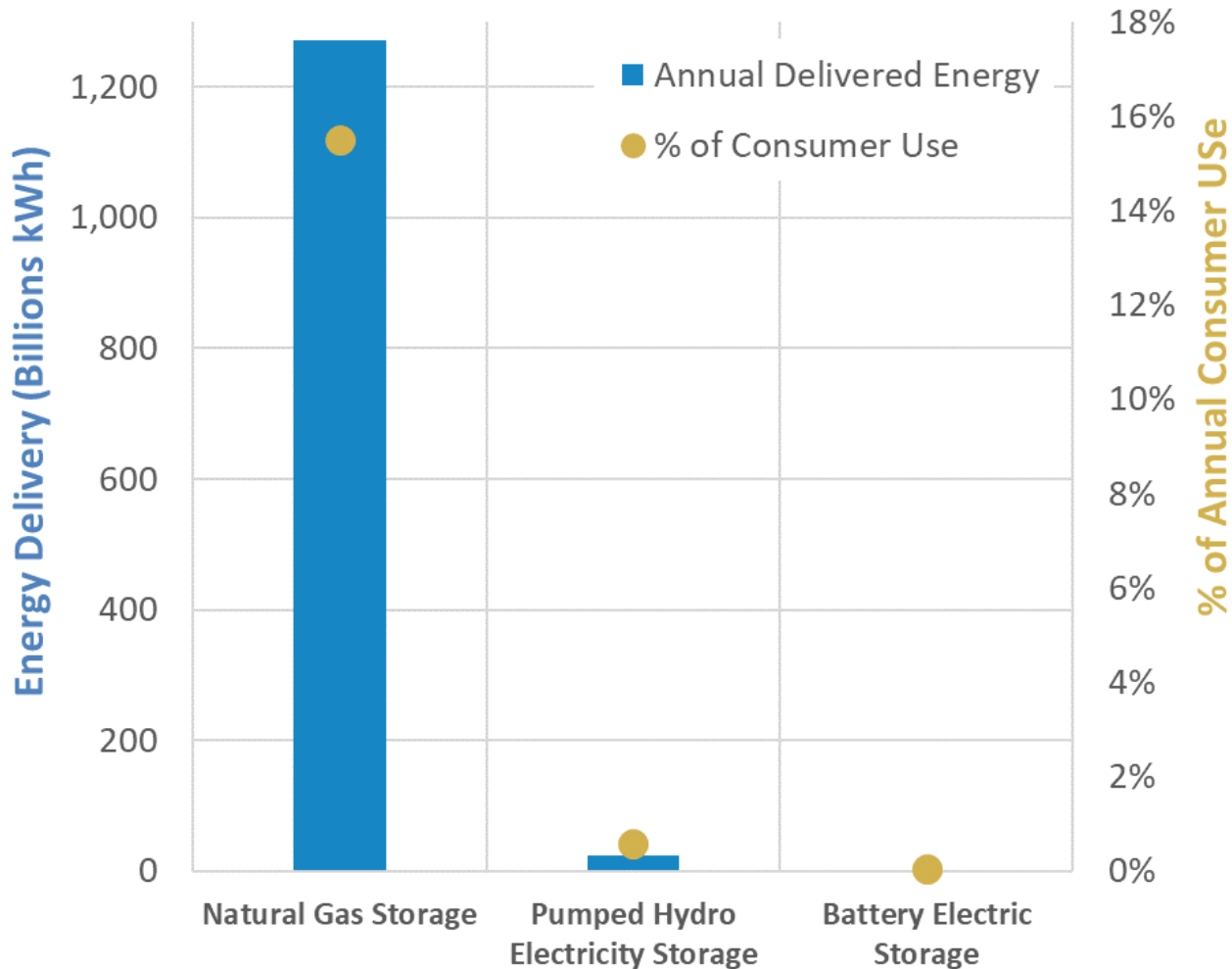


350 U.S. Gas Transmission Pipelines	Delivery Capacity, MW
Average Gas Pipeline	17,386
90 th %-tile	~32,000
Electric Transmission	Nominal Capacity, MW
765 kV Line	2,300
500 kV Line	900
345 kV Line	400





Energy Storage Comparison Natural Gas & Electricity



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.