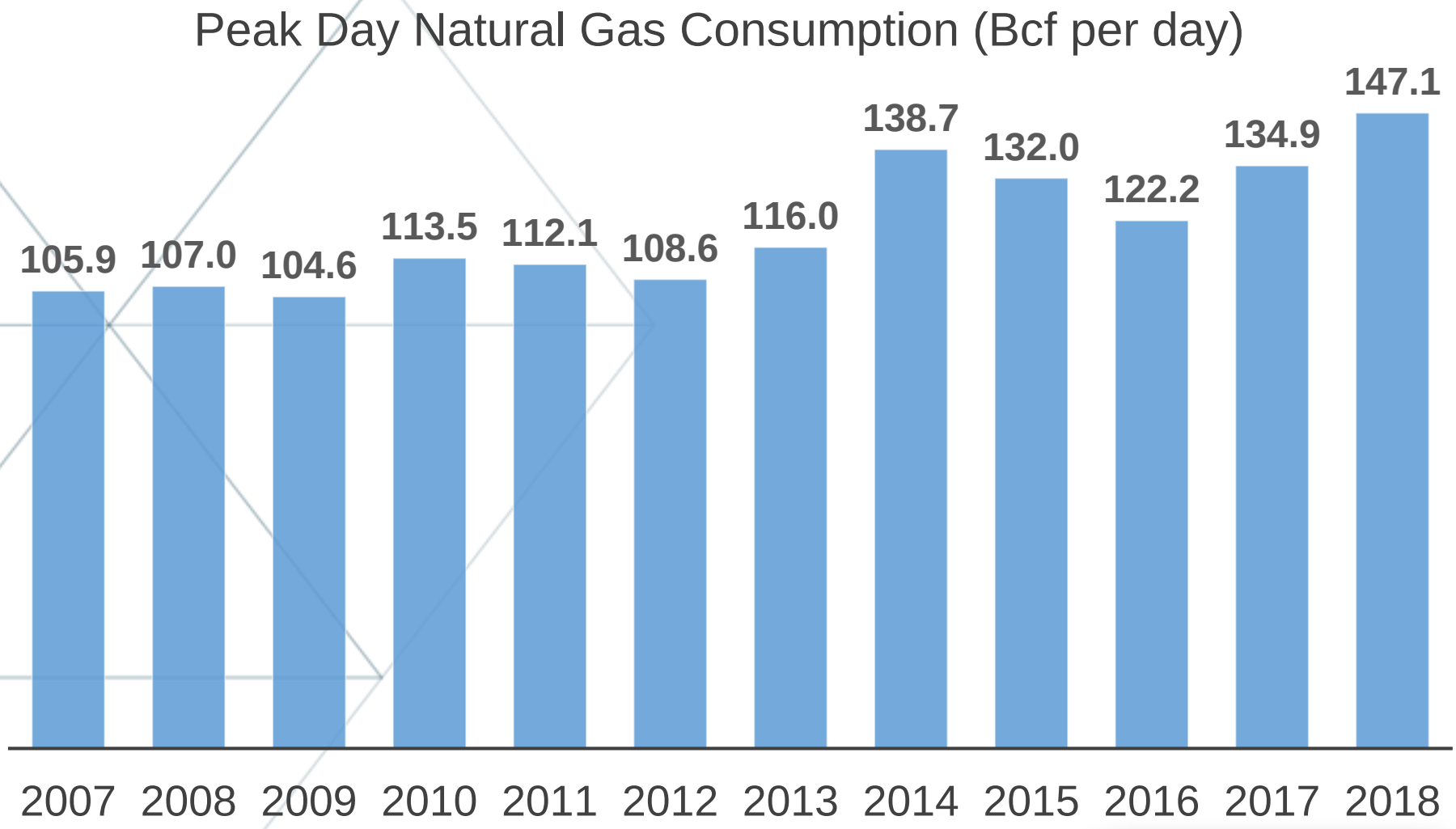
Thoughtful Pathways

Examining the Cost of Policy- Driven Electrification of Domestic Residential Space and Water Heating

Chris McGill
VP Energy Markets, Analysis and Standards
September 2018

US experienced the single-largest gas consuming day in history January 1, 2018.



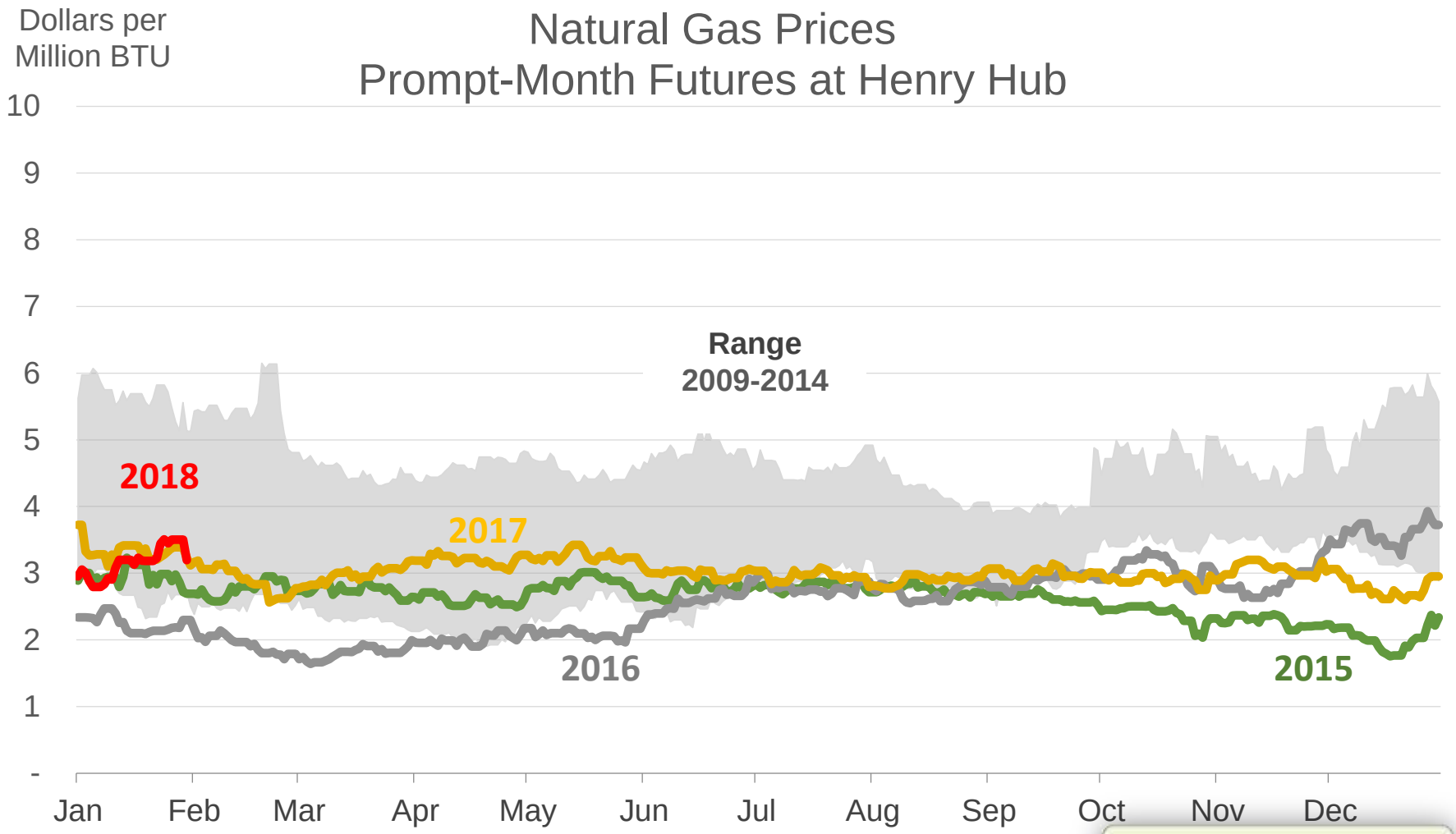
January 2018
What was the Test this Time?

New Single Day Natural Gas Consumption Record for the lower-48 states – 147.1 Bcf on January 1, 2018.

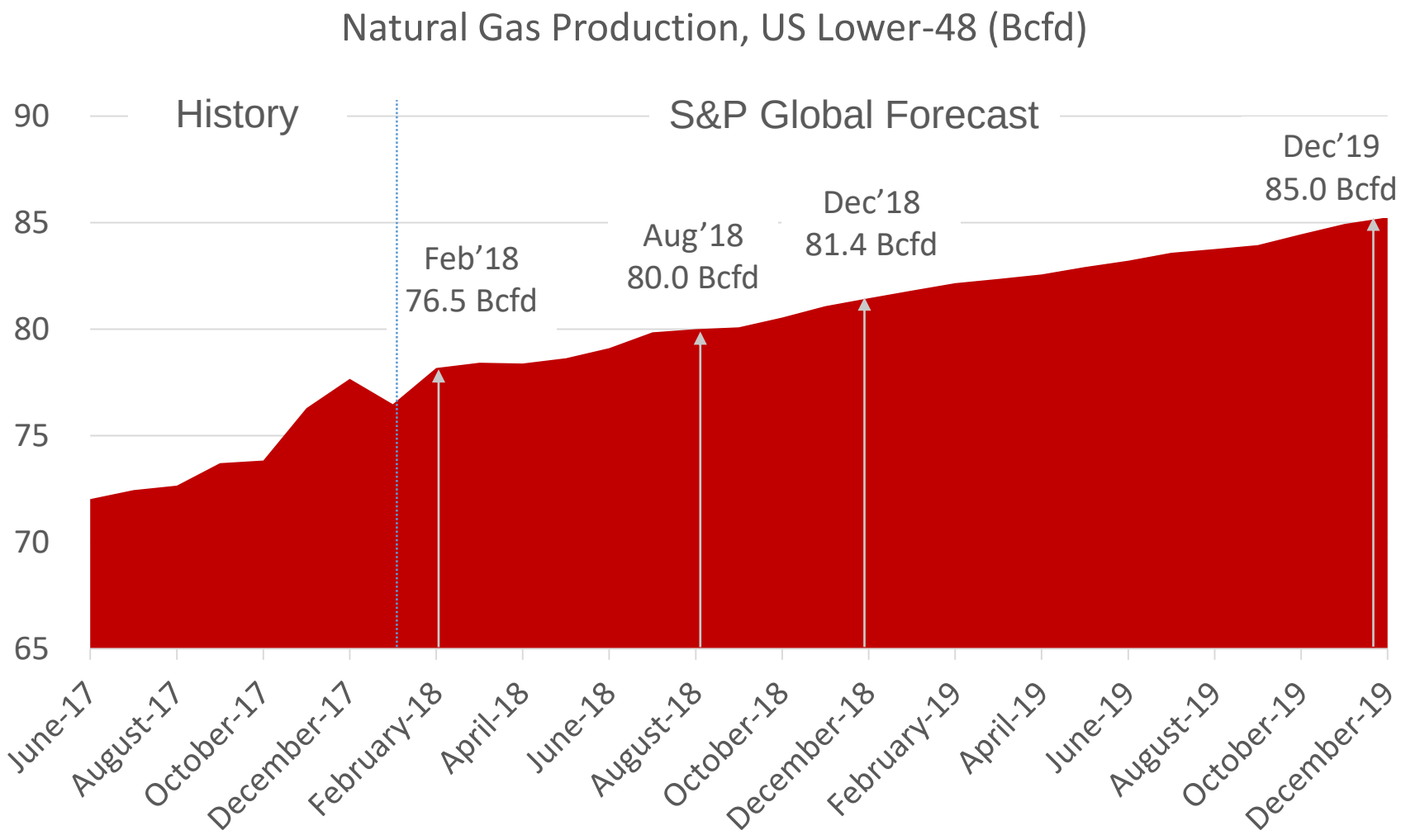
Domestic Consumption – 14 straight days of consumer demand (less exports) in excess of 100 Bcf.

Sustained pipeline and LNG exports at 5-7 Bcf per day.

Natural gas prices have remained low compared to history.

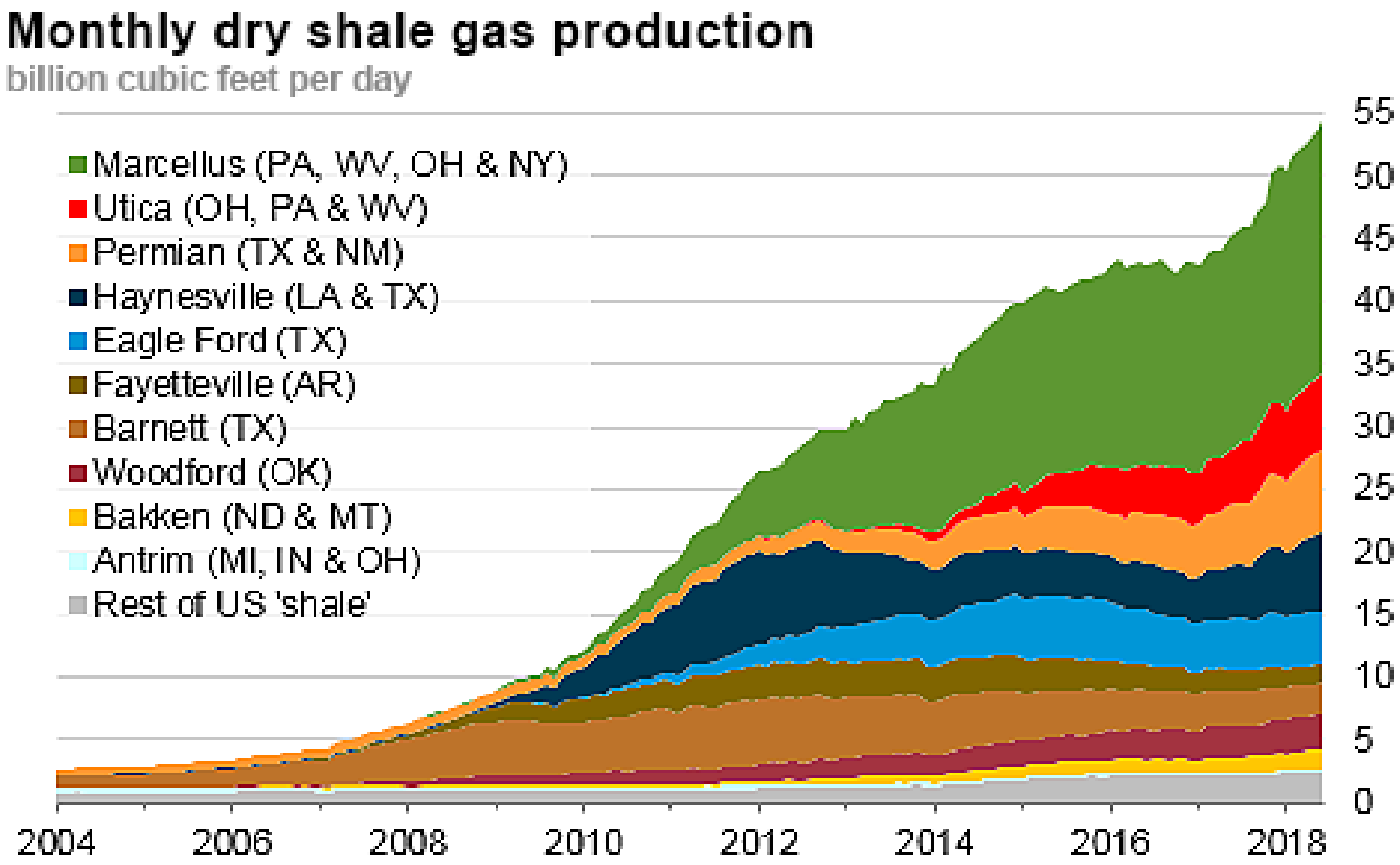


Domestic natural gas production is increasing.



S&P Global Forecast

Domestic Shale Gas Production



Sources: EIA derived from state administrative data collected by DrillingInfo Inc. Data are through June 2018 and represent EIA's official tight gas estimates, but are not survey data. State abbreviations indicate primary state(s).

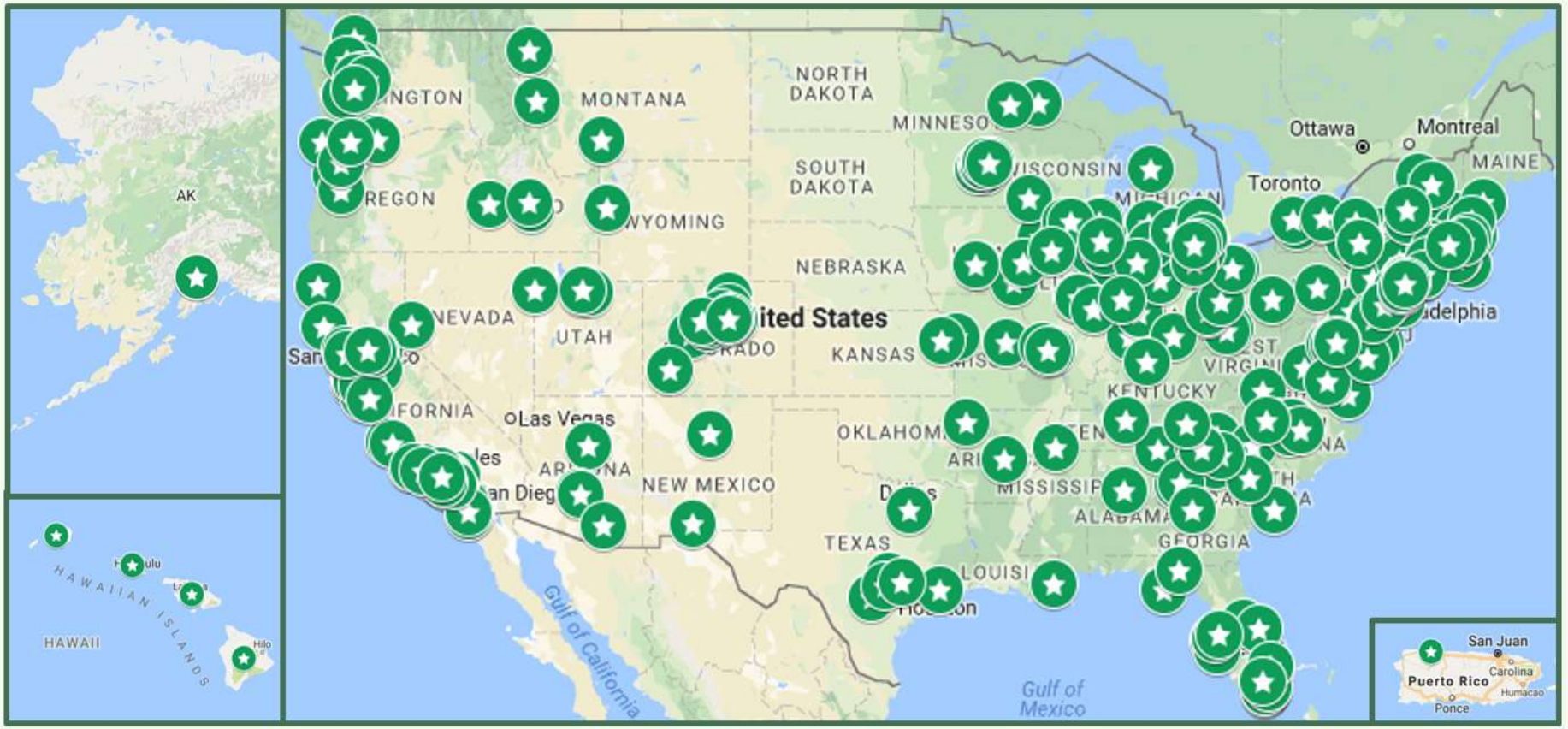
As the grid decarbonizes, calls to “electrify everything” grow.

States and municipalities committing to pursue clean energy goals.

Mayors representing 70 million Americans, commit to uphold the Paris Agreement goals

CLIMATE MAYORS

CLIMATEMAYORS.ORG

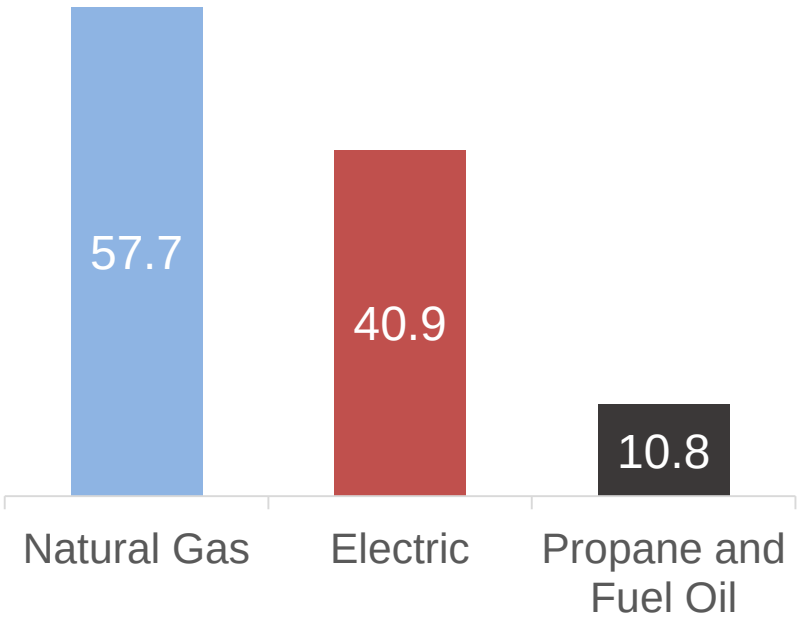


Source: climatemayors.org

A Closer Look at the Residential Market

Natural gas is the primary source for heating homes

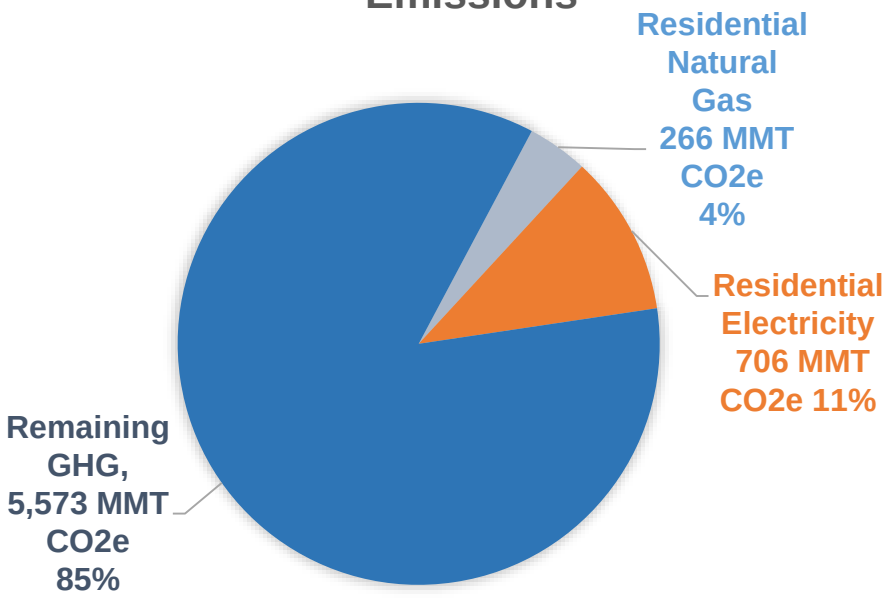
US Heating Systems by Fuel
(Millions of Housing Units)



Source: EIA Residential Energy Consumption Survey, 2015

Residential natural gas use accounts for only 4% of U.S. greenhouse gas emissions.

Share of US Greenhouse Gas Emissions



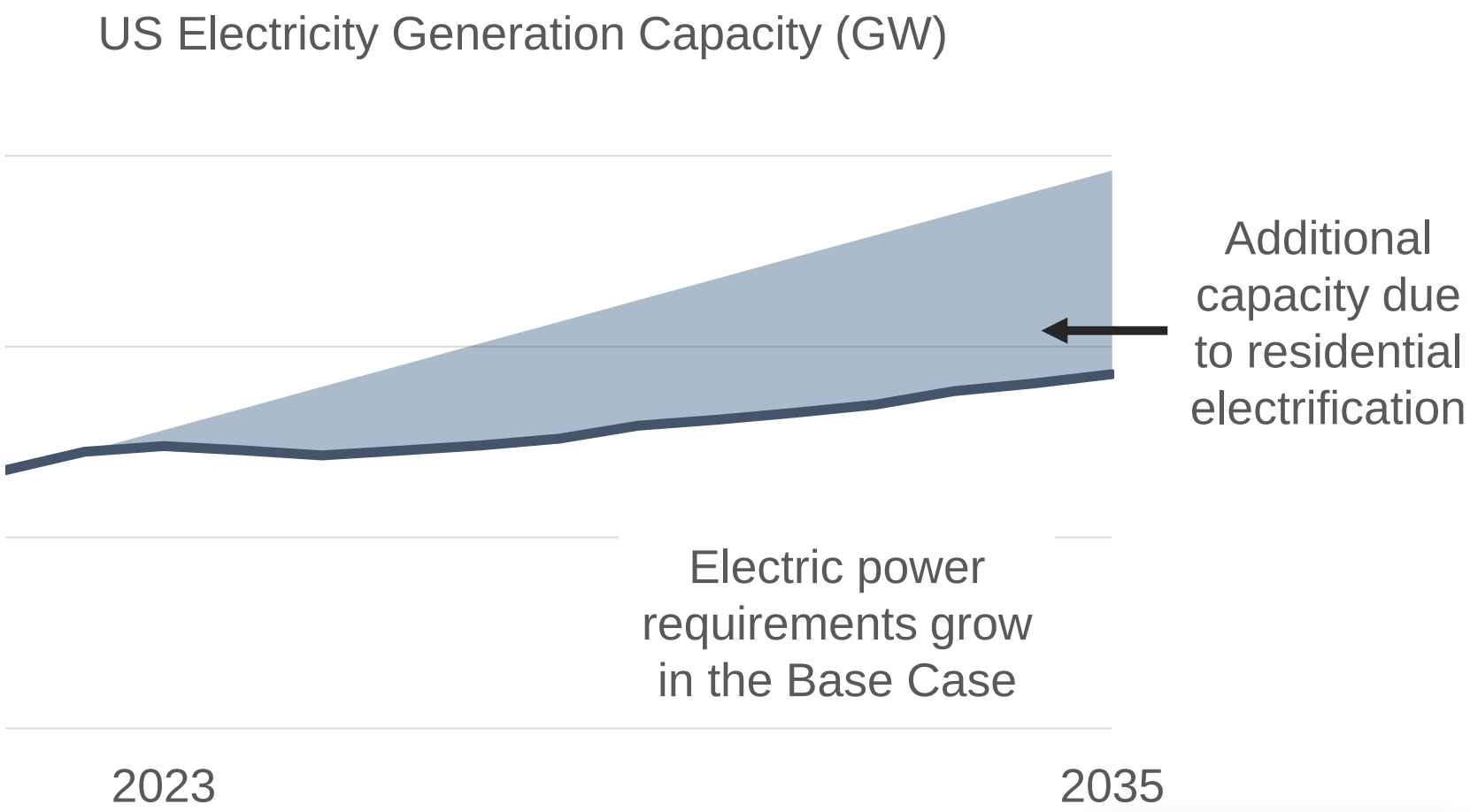
EPA Inventory of Greenhouse Gas Emissions & Sinks 2018 draft, data for 2016
Residential gas methane share based on gas consumption
Residential electricity methane share based on gas for electricity consumption & residential electricity
Shares of upstream natural gas system methane emissions allocated based on consumption by end-use

Main Questions the Study Addresses

AGA Study

- **Will residential electrification actually reduce emissions?**
- **How will residential electrification impact natural gas utility customers?**
- **What are the impacts on the Power Sector and Transmission infrastructure?**
- **What is the overall cost of residential electrification?**
- **https://www.aga.org/research/reports/implications-of-policy-driven-residential-electrification/**

Electrification will require significant capacity additions.



Initial Findings from Study

1. **Natural gas is a critical residential energy source: Residential natural gas demand in January is more than twice electricity demand in July**

2. **Total GHG reduction potential from policy-driven residential electrification is small: Ranging from 1.0 to 1.5 % of U.S. GHG emission in 2035.**

3. **Policy-Driven Electrification will be burdensome to customers: average residential household energy costs (utility bills and equipment/renovation costs) increase by 38 to 46 %.**

Implications of Policy-Driven Electrification of Residential Gas Use, AGA, July 2018.

Initial Findings from Study

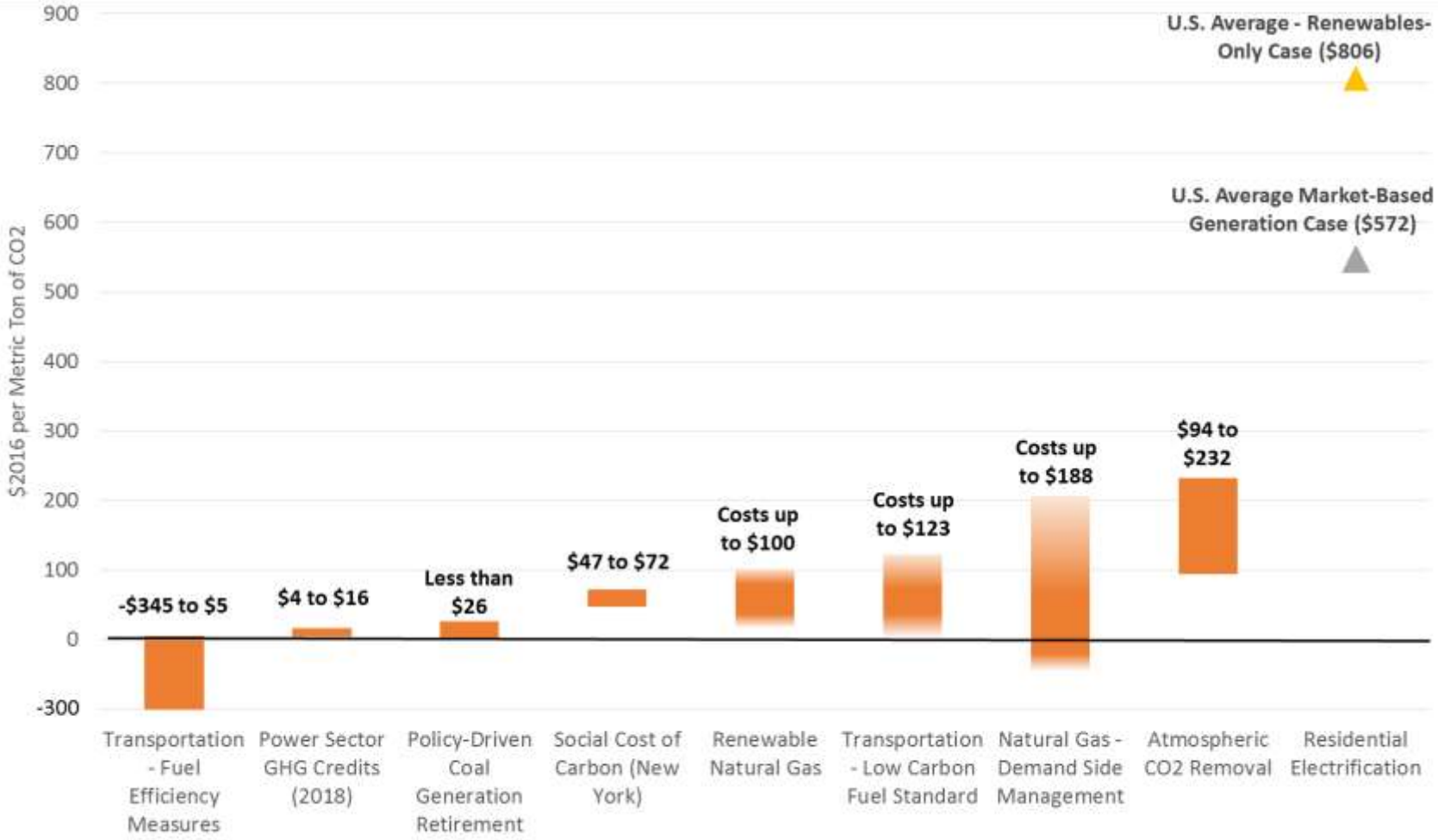
4. A policy-driven residential space and water heating strategy is expensive to the economy - $590 Billion to $1.2 Trillion in total incremental energy costs.

5. Such a policy may require infrastructure investments of $150 to $425 Billion for generation capacity and transmission.

6. Policy-driven electrification of the residential sector is an expensive tool for greenhouse gas emissions reductions - $572 to $806 per ton CO2.

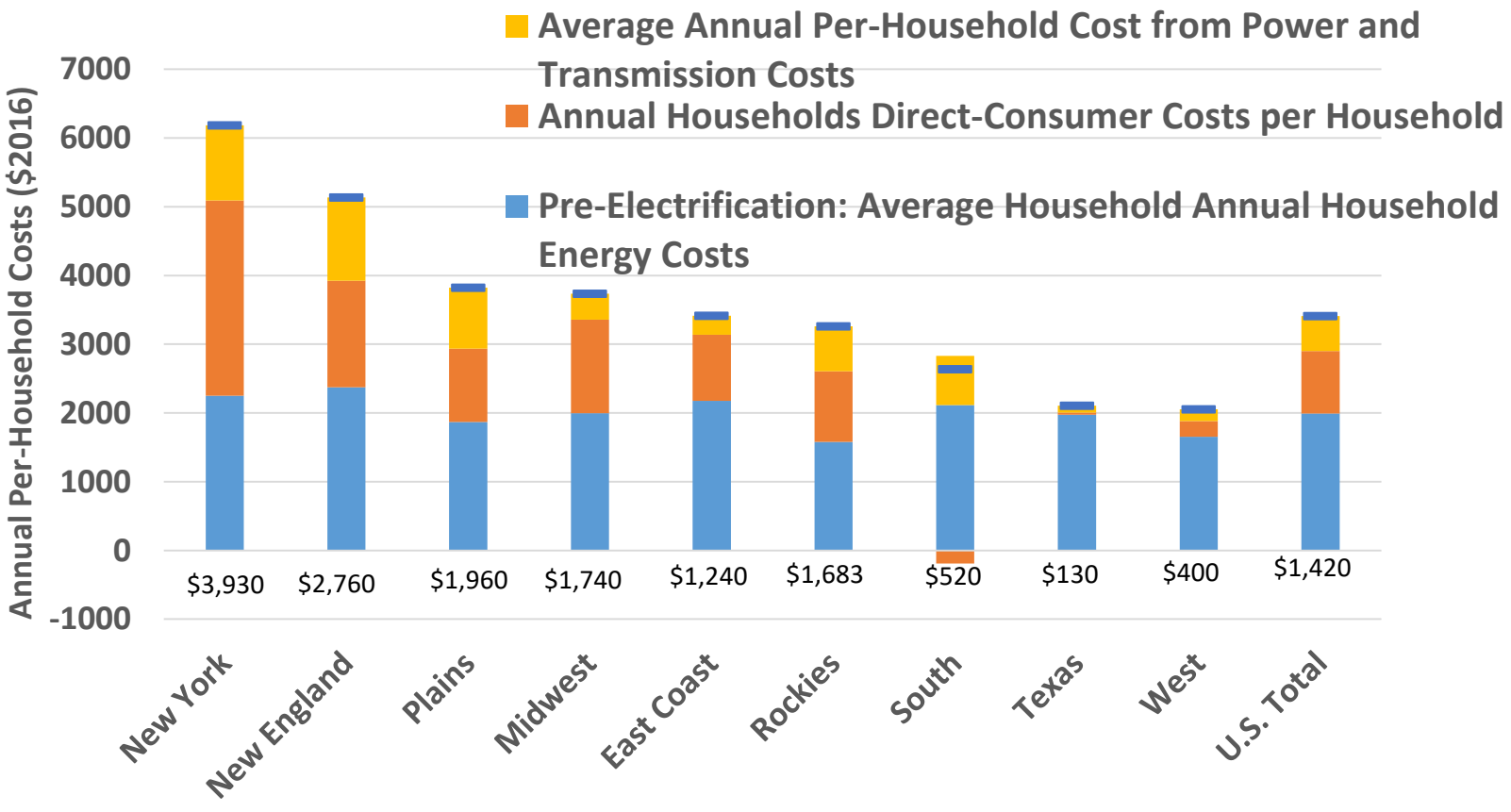
Implications of Policy-Driven Electrification of Residential Gas Use, AGA, July 2018.

Emissions Reductions Costs for Alternative Approaches to Reducing CO2 Emissions



Source: Implications of Policy-Driven Electrification of Residential Gas Use, AGA, July 2018.

Costs to Consumers By Region



Source: Implications of Policy-Driven Electrification of Residential Gas Use, AGA, July 2018.

Advance and Deploy Emerging Technologies in the Home

Space Cooling, up to 45%
Space Heating, up to 40%

- Gas heat pump

Building Efficiency, 10-45%

- IoT based thermostat
- Building Envelope

Water heating, up to 55%

- Absorption heat pump

Cooking, minimal change

- Gas stove
- Gas oven

Laundry, 55%

- Gas dryer
- Ozone washing

25-40% GHG reduction potential on a customer basis

Source: Enovation Partners, May 2018

Emerging gas technologies can make substantial and cost-effective contributions to GHG reduction goals

~100

Innovative Gas Technologies for Residential / Small Commercial identified in our global search

25-40%

GHG reduction potential on a customer basis by integration of these technologies and other efficiency practices

60-80%

GHG reduction – sufficient to meet COP 21 goals – with inclusion of future CHP technologies and Renewable Gas

- Policy goals for sustainable energy can be achieved at significantly lower consumer cost through integrating innovative gas solutions into long-term resource planning, while offering customers more choice and improved affordability, reliability and comfort.
- Gas technologies can enhance energy system reliability (system-wide and as a local backup) and efficiency, while reducing the need for new electric generation and T&D infrastructure and preserving the future value of gas infrastructure.
- Electric technologies will also improve, and are supported by incentives, but their GHG impacts depend on the generation fuel mix. In some regions electrification may increase GHG emissions through the 2030s.

Enovation Partners, May 2018.

Innovative technologies were assessed, prioritized and aligned with relevant end use pathways

High priority technologies by major end use, Enovation Partners, May 2018

- Low-cost residential gas absorption heat pump (GAHP) combination
- Condensing furnace
- Transport Membrane Humidifier (TMH)

- Tankless water heater - Maintenance-free approaches for tankless water heaters
- Solar-assisted heating - PV assisted domestic hot water heater (potable)
- Unplugged power burners - Two-Phase Thermo-Syphoning (TPTS) technology
- Combined Space and Water Heating Systems*

- Ozone and cold water washing

- High production fryers
- Boilerless steamer - Multistacked convention steamer for high volume cooking
- Combination steam and heat oven

- IoT thermostats (i.e. Nest, Honeywell)
- Building envelope (insulation, windows, building materials)
- Demand controls for HW systems
- Thermostatically controlled low flow shower head

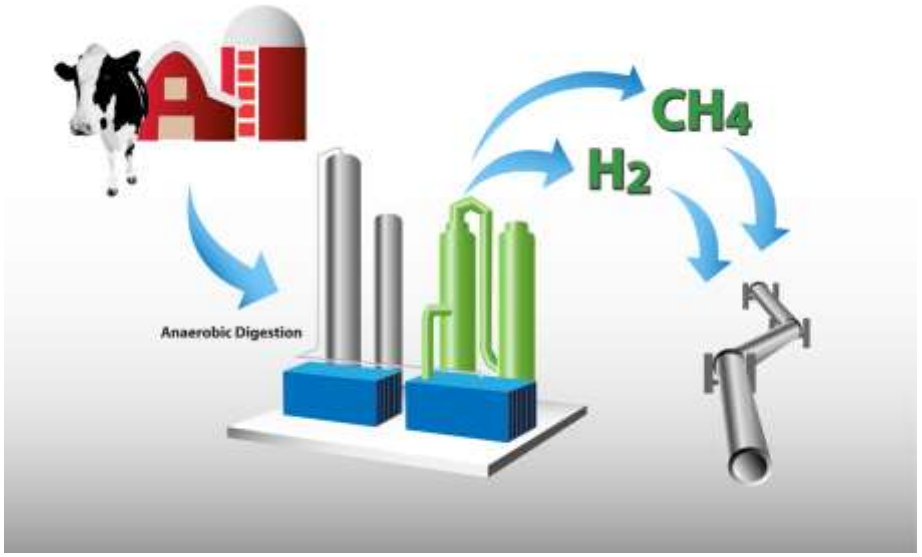
- Solid oxide fuel cells*
- Micro CHP – gas recip, sterling engine*

- Fuel cell electric vehicles (hydrogen)
- Commercial CNG vehicles

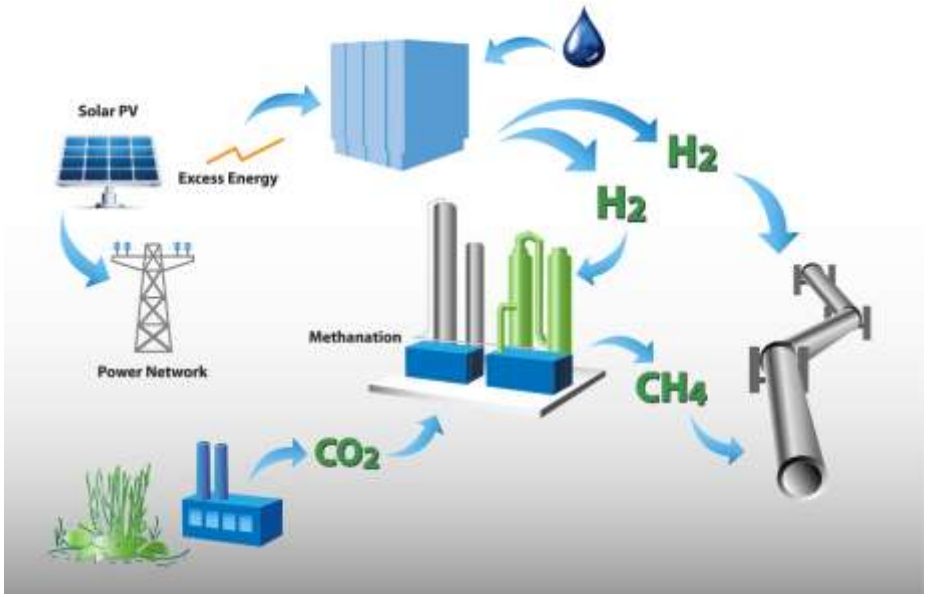
Note: All technologies were independently evaluated and scored by several SMEs; evaluation criteria primarily considered GHG impact and time to market; aggregated scores were consistent among experts and robust against multiple weightings; * designates technology with multiple end-uses, but listed only once

Advance Renewable Sources of Supply

Renewable Natural Gas (RNG)



Power to Gas (P2G)



Questions?

Chris McGill
VP Energy Markets, Analysis and Standards
American Gas Association
cmcgill@aga.org