Implications of Policy-Driven Residential Electrification study
Frequently Asked Questions

What is policy-driven residential electrification?
Policy-driven residential electrification refers to direct or indirect regulatory or legislative actions that would require the elimination of natural gas, propane, and fuel oil as options to meet residential space heating, water heating, and other uses in favor of electric appliances.

Why was this study done?
While policy-driven residential electrification has been discussed in multiple venues, there has been little or no analysis of the overall costs, benefits, and implications of such policies. The American Gas Association (AGA) engaged ICF to develop this analysis of electrification policies.

What are the key questions addressed in this study?
This study sets out to answer several key questions regarding the potential costs and benefits of these residential electrification policies. These questions include:

- Will policy-driven residential electrification actually reduce emissions?
- How will policy-driven residential electrification impact natural gas utility customers?
- What will be the impacts on the power sector and on electric transmission infrastructure requirements?
- What will be the overall cost of policy-driven residential electrification?
- How do the costs of policy-driven residential electrification compare to other approaches to reducing greenhouse gas emissions?

What are the major findings of the study?

- Total potential greenhouse gas reductions from policy-driven residential electrification are small. The potential reduction in emissions from the residential sector is partially offset by an increase in emissions from the power generation sector, even in a case where all incremental generating capacity is renewable.
- Policy-driven electrification would increase the average residential household-energy related costs and would require significant investments in electricity infrastructure. The study found that total costs would increase between $590 billion to $1.2 trillion

depending on the power generation scenario, or $15,830 to $21,140 per converted household on average over the lifetime of the heating equipment.

- Policy-driven residential electrification could have profound impacts (and costs) on the electric sector, including significant increases in peak electric demand. Electrifying all residential natural gas space heating could nearly double the U.S. electric grid's peak hourly demand.

- Policy-driven residential electrification could shift the U.S. electric grid from summer peaking to winter peaking in every region of the country, resulting in the need for major new investments in the electric grid including generation, transmission, and distribution capacity.

- Policy-driven residential electrification would be a very costly approach to emissions reduction: The average cost of U.S. GHG emissions reductions achieved by policy-driven residential electrification is between $572 and $806 per metric ton of CO2 reduced, which is very high relative to other GHG reduction options.

What are the major assumptions in the study?

The residential electrification policy evaluated for this study assumed that no new fossil fuel furnaces or water heaters would be allowed in residential households starting in 2023 in regions of the country where the policy would lead to reductions in net CO2 emissions (where the reduction in residential sector CO2 emissions would be greater than the increase in power generation sector emissions). Energy prices, equipment conversion costs, and energy consumption were projected based on regional data from the EIA AEO 2017 and other public sources.

Two generation scenarios were developed to meet residential electrification policy:

- *Renewables-Only Case*: In this case, the electric system was constrained from adding new fossil fuel capacity to meet the incremental electricity demand from electrification. The requirement for additional generating capacity was met by a combination of renewable generation and battery storage.

- *Market-Based Generation Case*: The Market-Based Generation Case was developed to evaluate a lower-cost residential electrification case, compared to the Renewables-Only Case. In this case, the electric system was allowed to meet the incremental electricity requirements in the most cost-effective way, without limits on fuel choice.

What impacts were not analyzed in this study?

The study did not conduct a detailed examination of the impacts (and costs) associated with:

- *Natural gas distribution system costs* – As the number of residential customers connected to the natural gas distribution system declines, costs will shift to customers remaining on the natural gas system.

- *Electric distribution system costs* – While the study includes an assessment of the costs likely to be incurred to meet the growth in electricity demand for generation and transmission assets, the incremental costs of expanding the electric distribution system to meet the increase in loads have not been addressed, including anticipated growth in electric vehicle demand. These costs are potentially substantial.

What kinds of households were analyzed?
All households were assumed to be single-family households to simplify the study given the wide range of cost uncertainties in converting other residential households (duplexes, manufactured homes, and large residential housing, etc.). Temperature data from 220 different geographic points were used to estimate effective heat pump efficiency during peak periods, and heat pump efficiencies used in this study are well above what is currently considered a high-efficiency system. Electric water heater systems used a heat pump water heater with an average efficiency of 200 percent.

Why did the study only choose to evaluate residential space and water heating?
This study does not address the electrification of commercial, industrial, or other sectors, which have a multitude of possible end uses and building types. Similarly, the study's scope was limited to evaluate only those energy loads associated with residential space and water heating; a more comprehensive study would be needed to evaluate the impacts of other natural gas end uses in the residential sector.

What is the difference between this analysis and other studies on residential electrification?
This study represents the most comprehensive effort to date to evaluate the overall costs, benefits, and implications of policies to electricity residential space and water heating. This study employed a bottom-up approach that analyzed peak energy requirements, household costs, energy rates, and electricity infrastructure requirements throughout the entire lower-48 United States, including sub-regional evaluations where possible. Electric generation and transmission requirements are based on the ICF Integrated Planning Model, a detailed engineering/economic capacity expansion and production-costing model of the power and industrial sectors supported by a database of every boiler and generator in the nation.

Are there any electrification policies currently in place?
In recent years there has been a shift in the types of policies being proposed to reduce greenhouse gas emissions. Many recent greenhouse gas policy initiatives have been proposed and debated include electrification of the building sector.

Examples of policy initiatives include:

- In 2016, the *United States Mid-Century Strategy for Deep Decarbonization* presented a vision of how to achieve significant reductions in U.S. greenhouse gases. One of the pillars of the plan is "electrifying end uses" in the building sector.

- Denver: A city task force has recommended policies to "shift commercial buildings and 200,000 households off natural gas to heat sources that do not lead to carbon pollution."

- Massachusetts: Legislation has been proposed to require the conversion of residential fossil fuel use to electricity. The state has also proposed establishing targets for 100 percent renewable generation levels in efforts to decarbonize its economy.

- California, Oregon, Washington: Various local and state groups are in active discussion regarding the potential for residential electrification policies to reduce GHG emissions.

- Ontario: Various non-governmental organizations promoted residential electrification, which was then aggressively pursued by the provincial environmental agency.

- Vancouver, British Columbia: City council plans to position Vancouver as the greenest city in the world include establishing 100 percent renewable energy targets before 2050 and implementing a phased approach to achieving zero emissions in all new buildings by 2030. Some policies that effectively exclude natural gas have been initiated.

Was the study peer-reviewed?
The report was not officially peer-reviewed, as required of a submission to a scientific journal. ICF, the consulting firm engaged for this report, has a cross-discipline team of experts with knowledge in the relevant areas of necessary to complete an analysis of this level of complexity. The study is the culmination of eleven months of work that included extensive input from an AGA member company-led Steering Committee.

Were methane emissions considered in the greenhouse gas impact analysis?
This study did not include upstream of life-cycle emissions from any of the fuels consumed on-site or for electricity generation. Doing so would have required a broader analysis of life-cycle emissions for all fuels through 2050, which was outside the scope of this study. While some studies have included only the upstream emissions of methane associated with on-site gas use, they neglect both the upstream impact on electricity generation and the effect on other fossil fuels.

An assessment of upstream methane emissions increases the GHG emissions for natural gas for on-site and electricity generation. In the market-based case, net natural gas consumption increases, so including methane emissions reduces the net emissions reductions and increases the cost per ton of reduction. In the renewables-only case, the emissions reductions would have been 12 percent to 17 percent greater based on GWP_{100} values, reducing the cost per ton of emissions reductions by an equivalent amount. Neither change affects the fundamental conclusions or significantly changes the cost-effectiveness relative to other greenhouse gas emissions reduction options.

How applicable are the study's conclusions to specific policy proposals at the state and local level?

While the analysis employed a bottom-up approach, this study focused on broad regional and national markets. Different variations of the basic policy will have costs and benefits associated with the scenarios evaluated in this study. The results of a similar analysis conducted for a specific state or utility service territory within a region may differ significantly from the regional results shown in this report due to differences in:

- Natural gas and electricity prices even within the same region
- Housing stocks
- The composition of the electric grid
- The inclusion of distribution system cost impacts and other factors

While the ICF study methodology can be applied at the state or utility service territory level, this was beyond the scope of the study. A more localized study likely need to consider many costs that were beyond the scope of the study, such as electric distribution costs, natural gas and electric rate impacts, and other local considerations not included in this study.