Implications of Policy-Driven Residential Electrification

An American Gas Association Study Prepared by ICF

Northwest Gas Association

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Policy-Driven Residential Electrification

- **A growing policy strategy to achieve deep decarbonization – 80% by 2050.**
  - Denver: A city task force recommended policies to “shift commercial buildings and 200,000 households off natural gas to heat sources that do not lead to carbon pollution.”
  - Massachusetts: A legislator proposed legislation 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.
  - 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 approached to achieving zero emissions in all new buildings by 2030. Some policies that effectively exclude gas have been initiated.
  - California, Oregon, Washington: Various local and state groups are in active discussion and analysis of residential electrification to reduce GHGs.
- **Is this a viable, cost-effective, strategy?**

Policy-Driven Electrification of Residential Heating Loads

Key Questions the Study Addresses

- Would policy-driven residential electrification actually reduce emissions?
- How would policy-driven residential electrification impact natural gas utility customers?
- What would be the impacts on the power sector and transmission infrastructure?
- What would be the overall cost of policy-driven residential electrification?

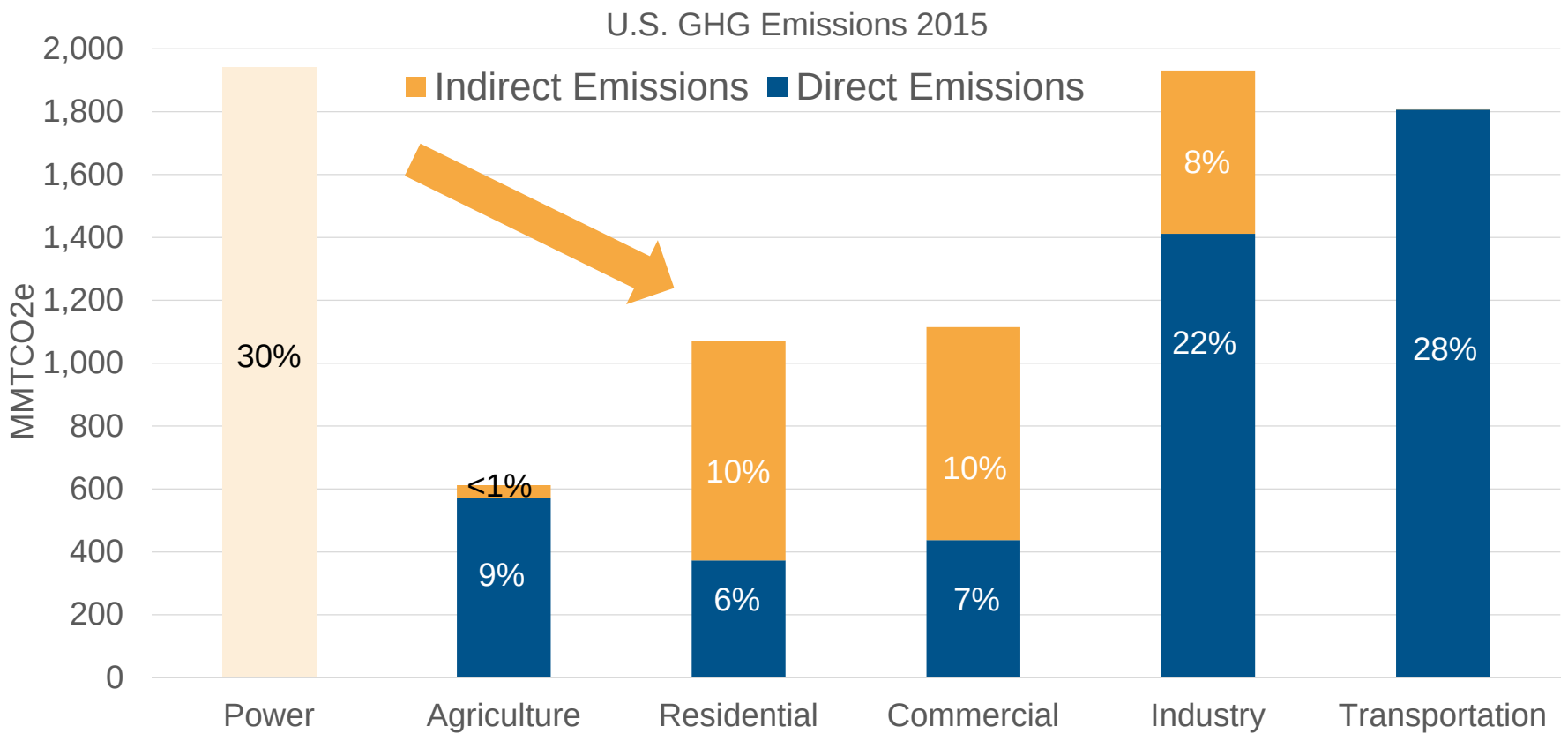
Study Results

	Renewables-Only	Market-Based Generation
Greenhouse Gas Emissions	Annual GHG emissions reduced by 93 Million Metric Tons of CO_2 by 2035 (1.5%)	Annual GHG emissions reduced by 65 Million Metric Tons of CO_2 by 2035 (1.0%)
Residential Households	56.3 million households converted to electricity $760 billion in energy & equipment costs Direct consumer annual cost increase of $910 per household	37.3 million households converted to electricity $415 billion in energy & equipment costs Direct consumer annual cost increase of $750 per household
Electric Generation Market	320 GW of incremental generation capacity required at cost of $319 Billion $107 Billion of associated transmission system upgrades	132 GW of incremental generation capacity required at cost of $102 Billion $53 Billion of associated transmission system upgrades
Total Cost of Emission Reduction	Total costs increase by $1.19 Trillion $21,140 per converted customer $1,420 per year increase in annual energy cost	Total costs increase by $590 Billion $15,830 per converted customer $1,060 per year increase in annual energy cost
Cost per Ton of CO_2	Each ton of CO_2 reduction costs $806	Each ton of CO_2 reduction costs $572

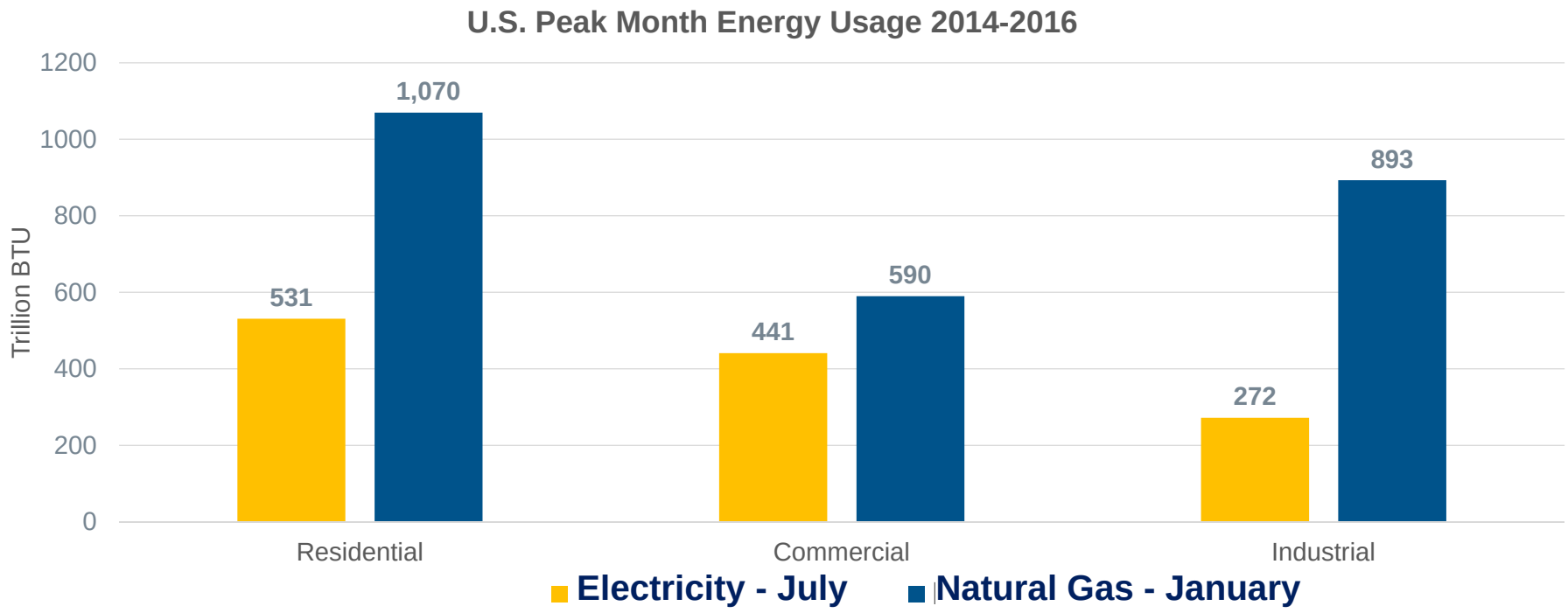
Key Factors in Assessing Electrification

- **Grid emissions**
- **Electric technology (heat pump) performance**
  - High efficiency heat pumps are necessary to offset inherent inefficiency of electricity generation and transmission.
- **Local climate (impact on heat pump performance)**
- **Appliance and retrofit costs**
- **Local gas and electricity rates**
- **Peak load impact on electric grid**

Residential Direct Use is a Small GHG Source



The U.S. Relies on Natural Gas to Meet Energy Requirements During Peak Winter Periods



Policy-Driven Electrification of Residential Heating Loads

Overview of Approach

- Study Baseline
- Residential Electrification Policy
- Customer Equipment Replacement Options
- Customer Costs
- Power Grid Expansion Policy
- Energy Infrastructure Costs
- Regional Aggregation

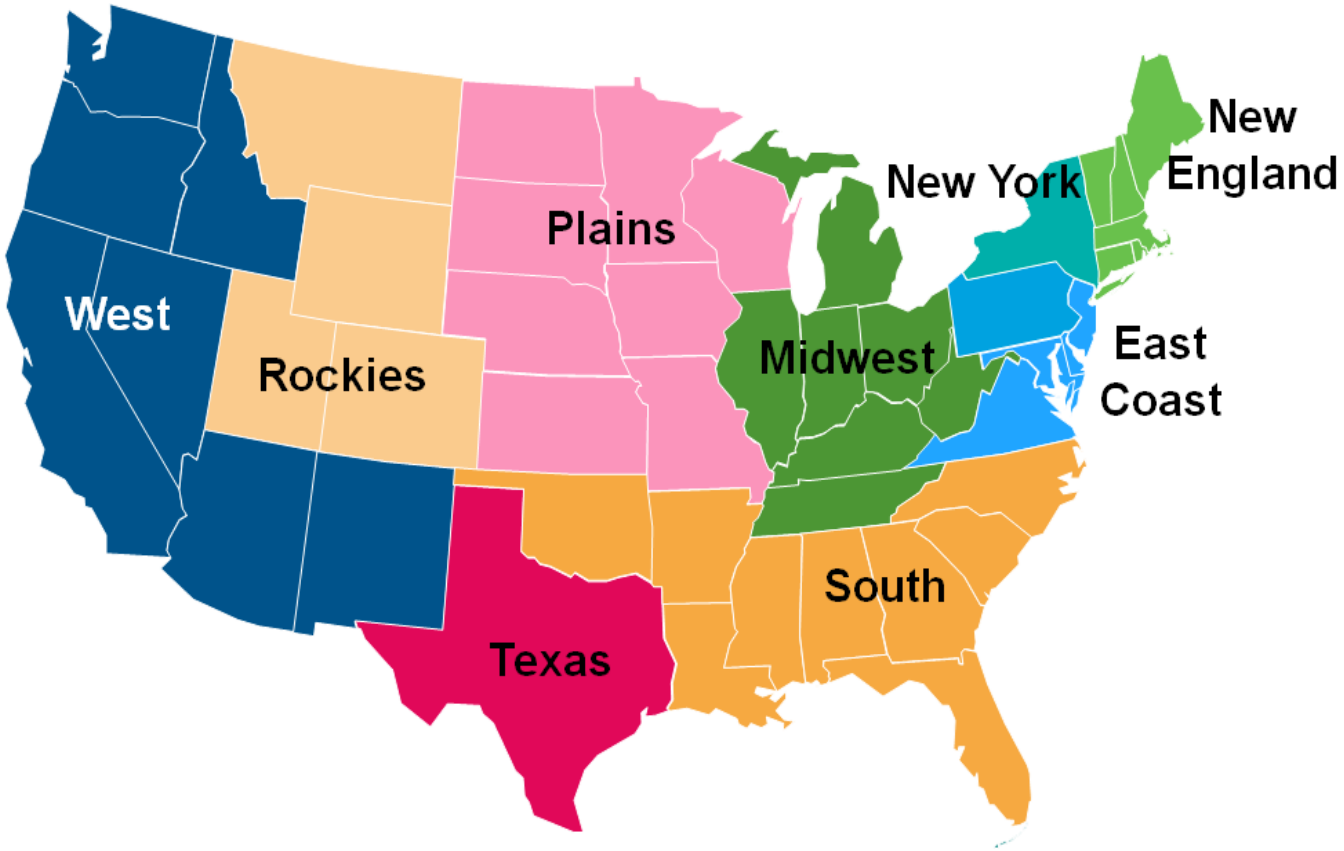
Assumed Residential Electrification Policy

- **For this analysis, it was assumed that an electrification policy would be established in 2020 with the requirements starting in 2023.**
- **All new homes after 2023 are built with electric space and water heating appliances only.**
- **Starting in 2023 any existing direct-fuel use space and water heating systems would be replaced with electric systems at the end of the effective-life of the current system.**
  - Although the primary focus of this analysis is natural gas, it was assumed that the residential electrification policy would also impact fuel oil and propane systems.
- **The analysis of the impacts of the policy was conducted through 2035, and considered the lifetime costs and benefits through 2050 of all of the households converted to electricity between 2023 and 2035.**
- **This study does not address electrification of commercial, industrial, or other sectors.**

Three Cases

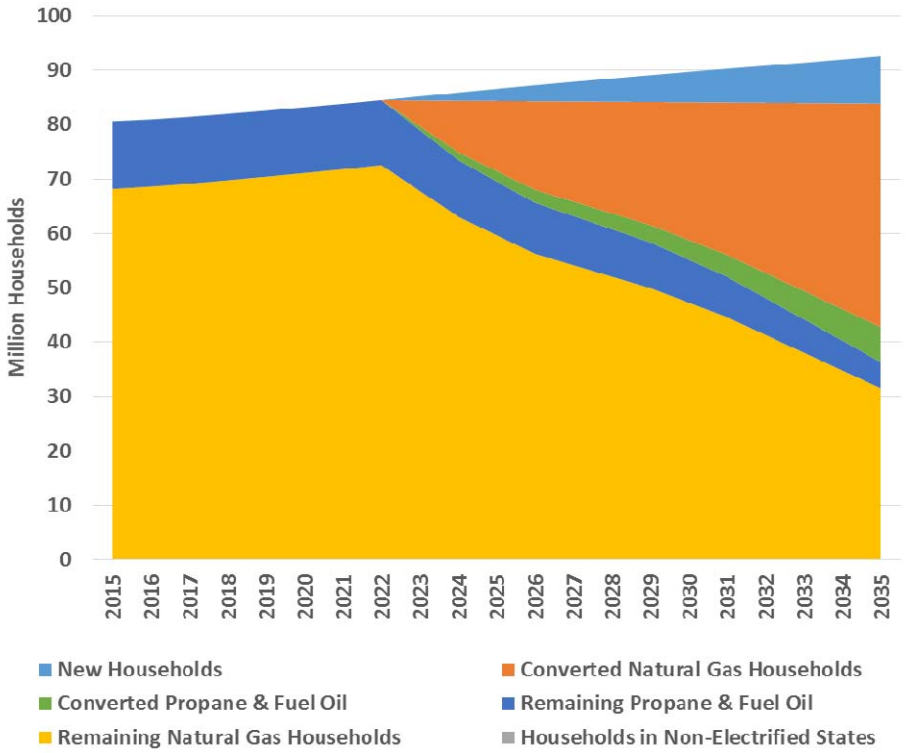
- Base Case – Based on EIA Annual Energy Outlook 2017 with Clean Power Plan.
- Renewables-Only Case – No new fossil-fueled generating capacity allowed in response to electrification. All lower-48 states included in policy.
- Market-Based Generation Case – New capacity based on lowest cost options. Policy not applied where electrification would result in increased emissions (Rockies, Plains, Midwest).

Study Regions

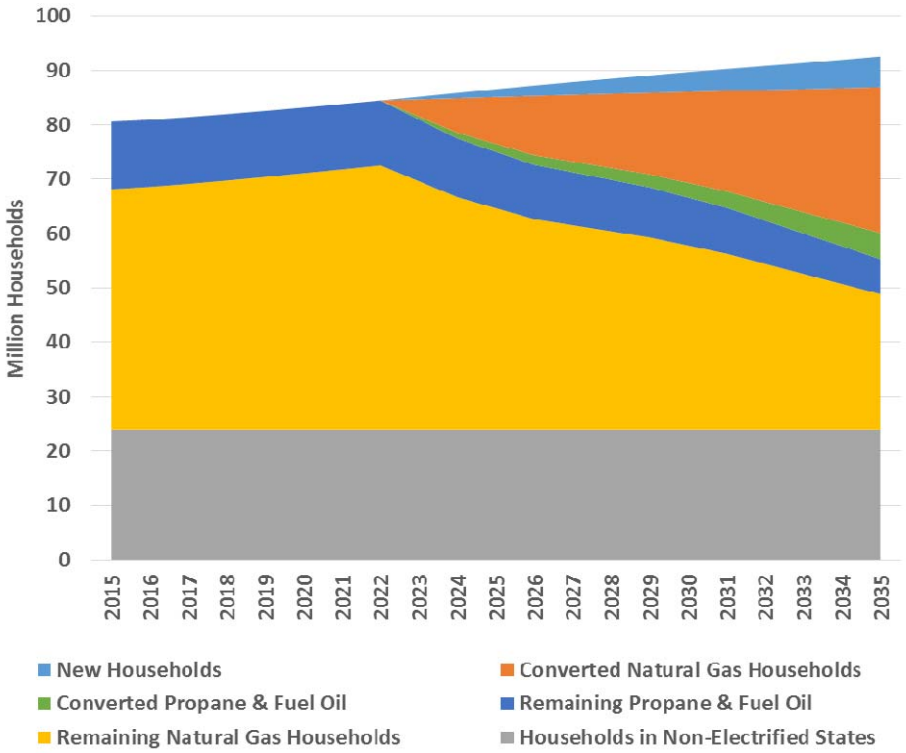


Household Conversions for Electrification

Renewables-Only Case Household Conversions



Market-Based Generation Case Household Conversions



Equipment Replacement and Customer Costs

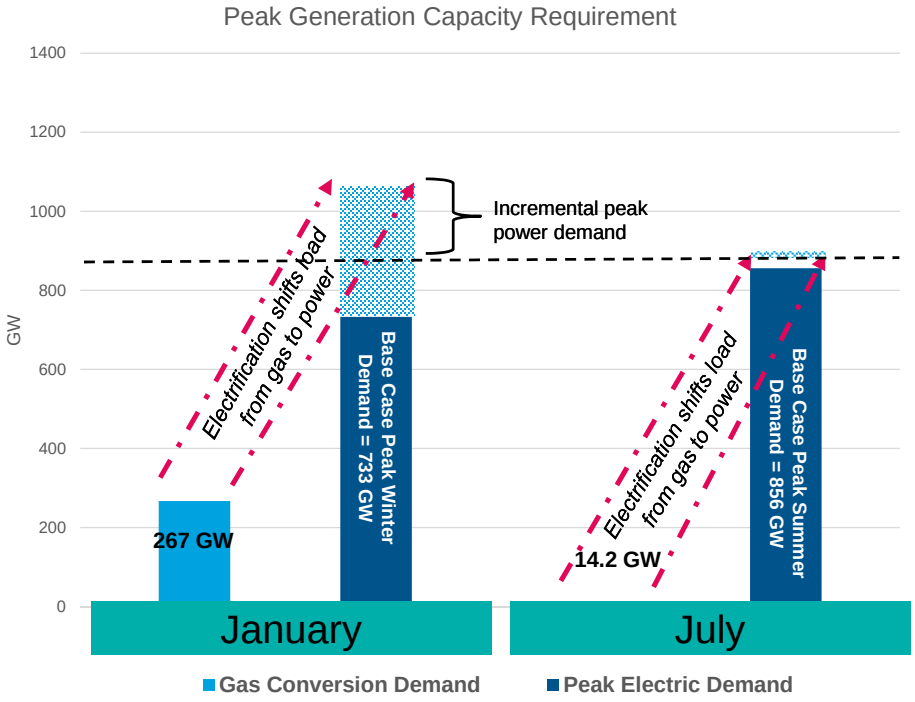
- For each new and existing household converted from one of the fossil fuels to electricity, the study included a projection of the life-cycle differences in equipment costs, the costs of electrical upgrades in existing homes, the changes in annual fossil fuel and electricity consumption and energy costs, and the changes in annual and peak period electricity required adjusted for local climate.
- Energy prices, equipment conversion costs, and energy consumption were projected based on regional data from the EIA AEO 2017 and other public sources.
- *The analysis did not include the impact to natural gas or electric rates, nor the cost of local electricity distribution system upgrades due to the very site-specific nature of such upgrades.*

National Installation Costs and Annual Fuel Costs (2035) by Household Heating & Cooling System Type (Real $2016)

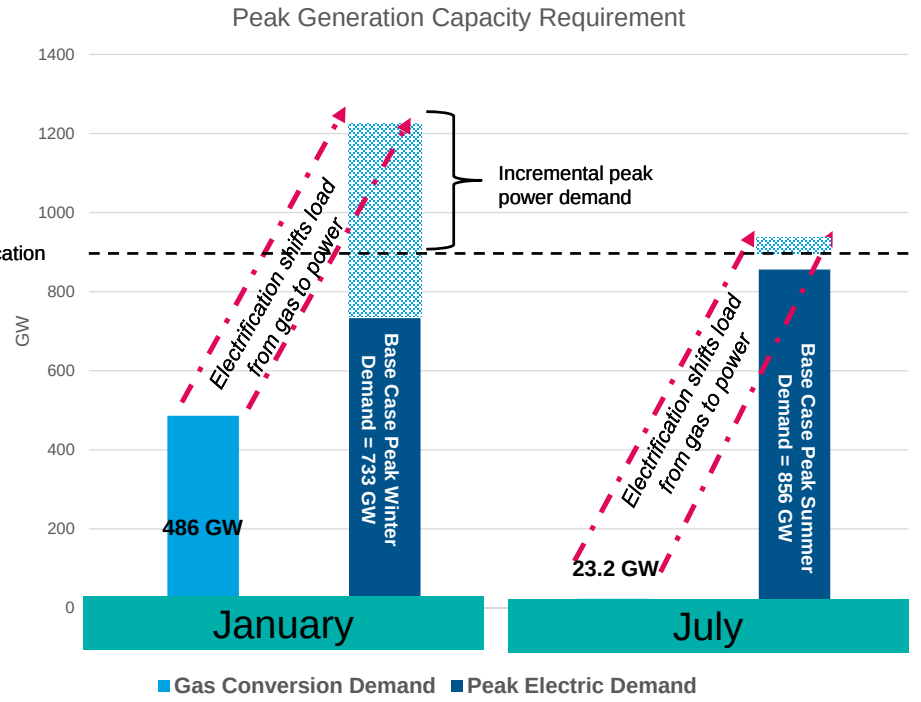
Household Heating & Cooling System Type	New Household Gas Furnace & AC unit		New Household ASHP[1]		Replacement - Gas Furnace & AC unit		Conversion of Forced Air Furnace		Conversion of Hydronic System	
	Gas Furnace	A/C Unit	ASHP		Gas Furnace	A/C Unit	ASHP (Existing A/C)	ASHP (No Existing A/C)	ASHP (Existing A/C)	ASHP (No Existing A/C)
Purchase Cost (Capital)	$1,973	$2,522	$3,903		$1,973	$2,522	$4,065	$4,065	$4,065	$4,065
Total Installation & Upgrade Costs (1-Year Cost)	$6,281		$5,991		$6,858		$6,993	$10,909	$8,637	$11,509
Annual Heating-Fuel Expense (2035 Rates)[2]	$998		$1,475		$998		$1,475	$1,475	$1,475	$1,475

Policy-Driven Residential Electrification Impact on New Peak Generating Capacity Drives Power and Infrastructure Impacts

Market-Based Case

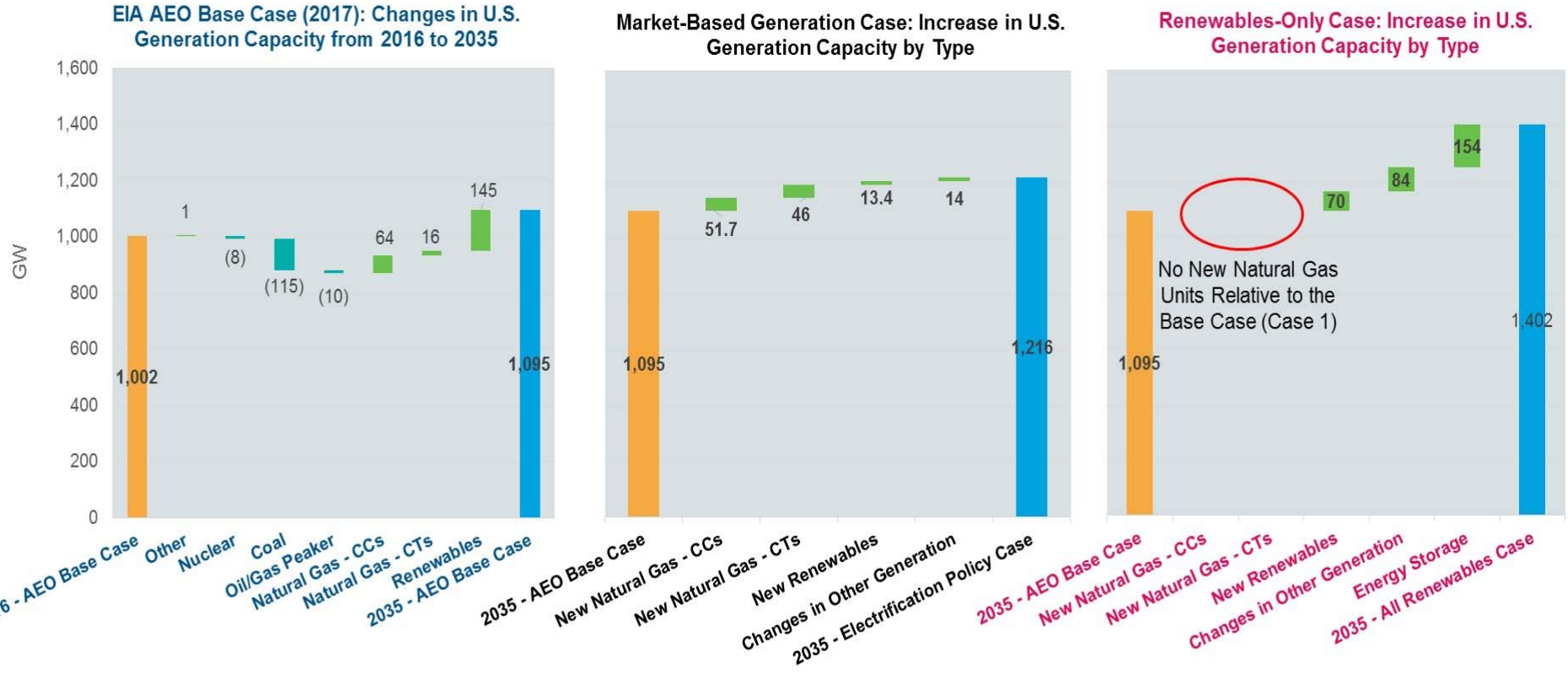


Renewables-Only Case



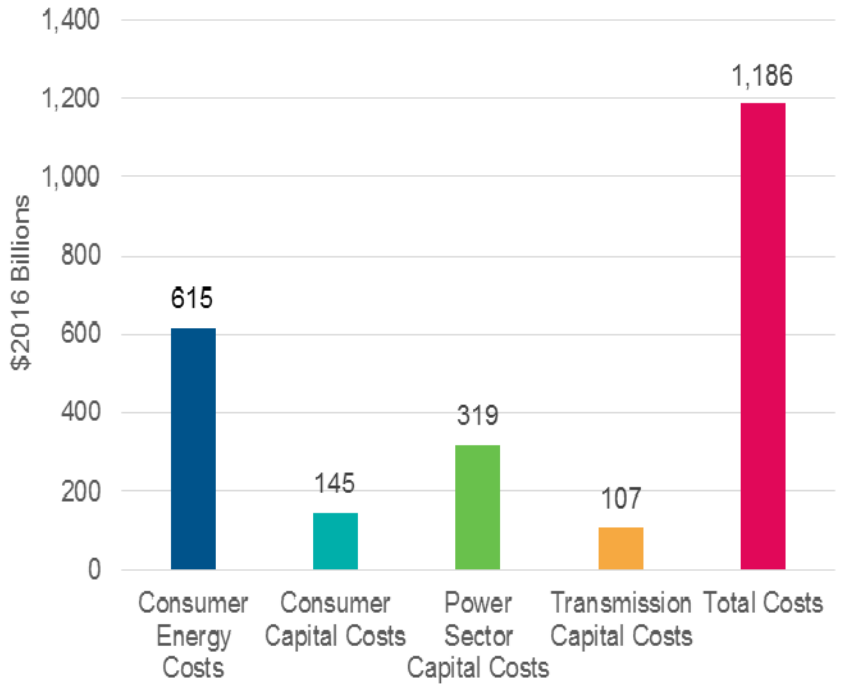
Electrification moves U.S. electricity market from summer peaking to winter peaking

Changes in U.S. Generating Capacity Due to Electrification

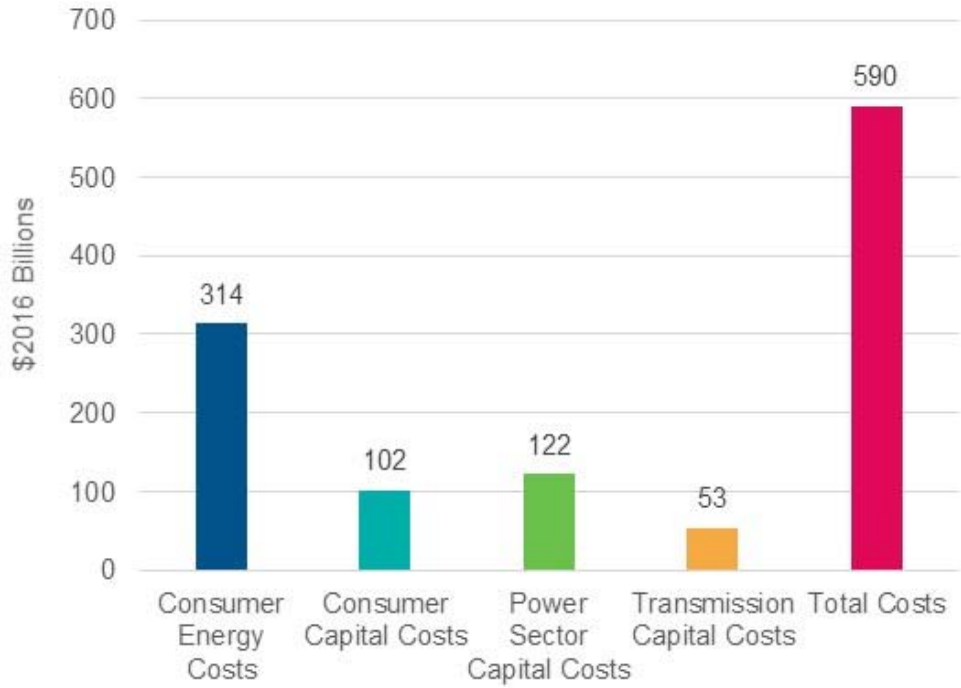


Total Cost of Electrification*

Renewables-Only Case



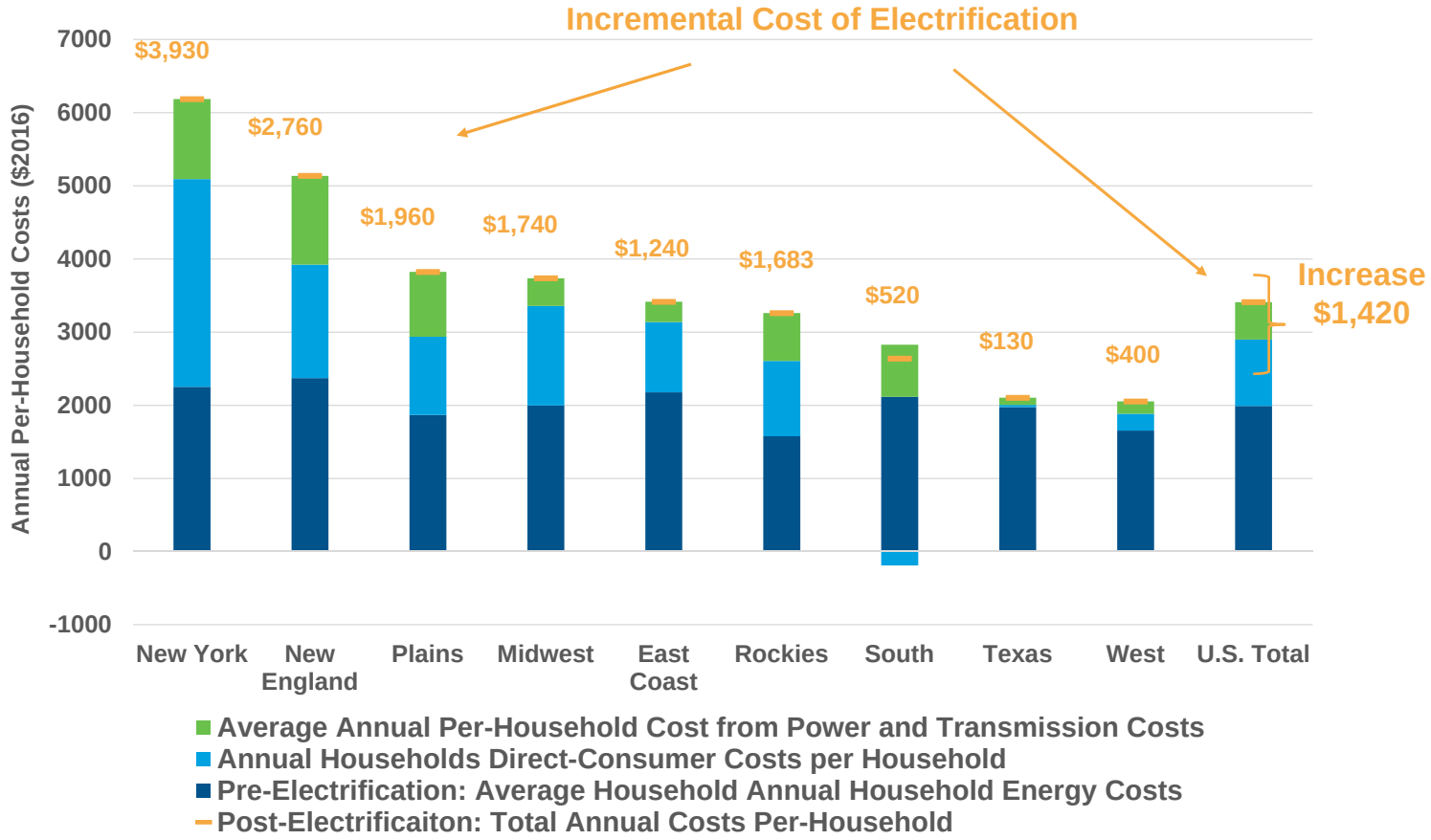
Market-Based Generation



*Does not include cost of changes to electric distribution systems.

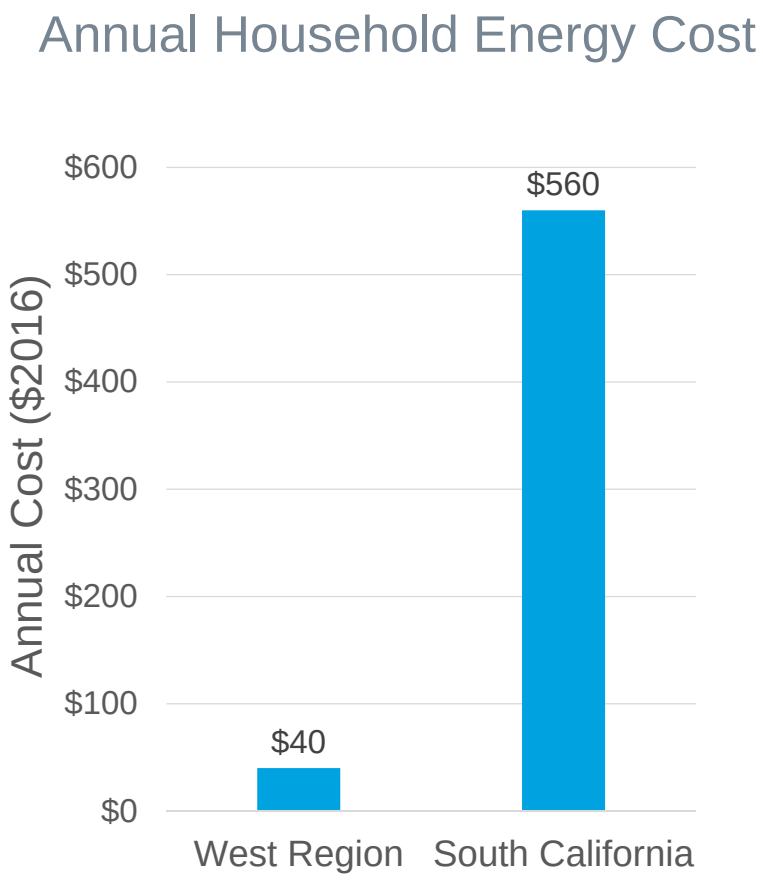
Annual Per-Household Cost of Electrification Policy (Renewables-Only)

Residential Electrification is Costly to Consumers and to the Economy

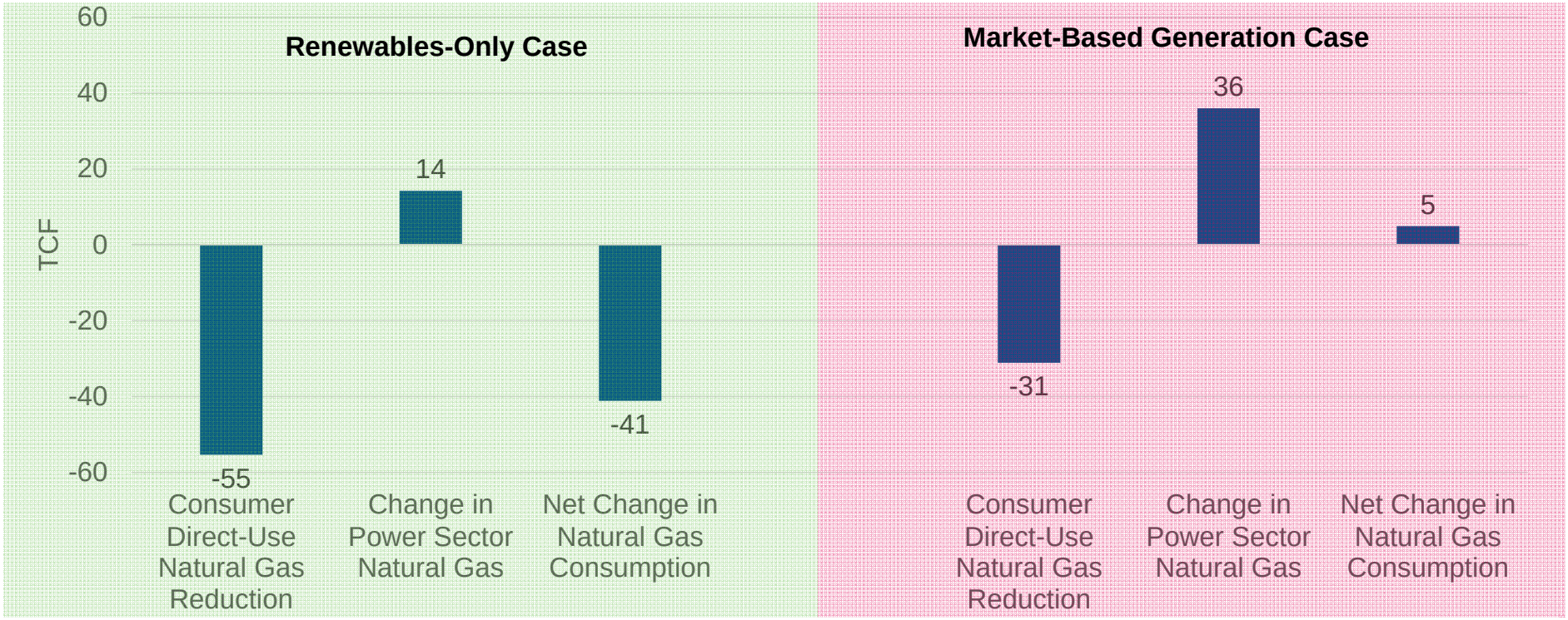


Intra-Regional Variation

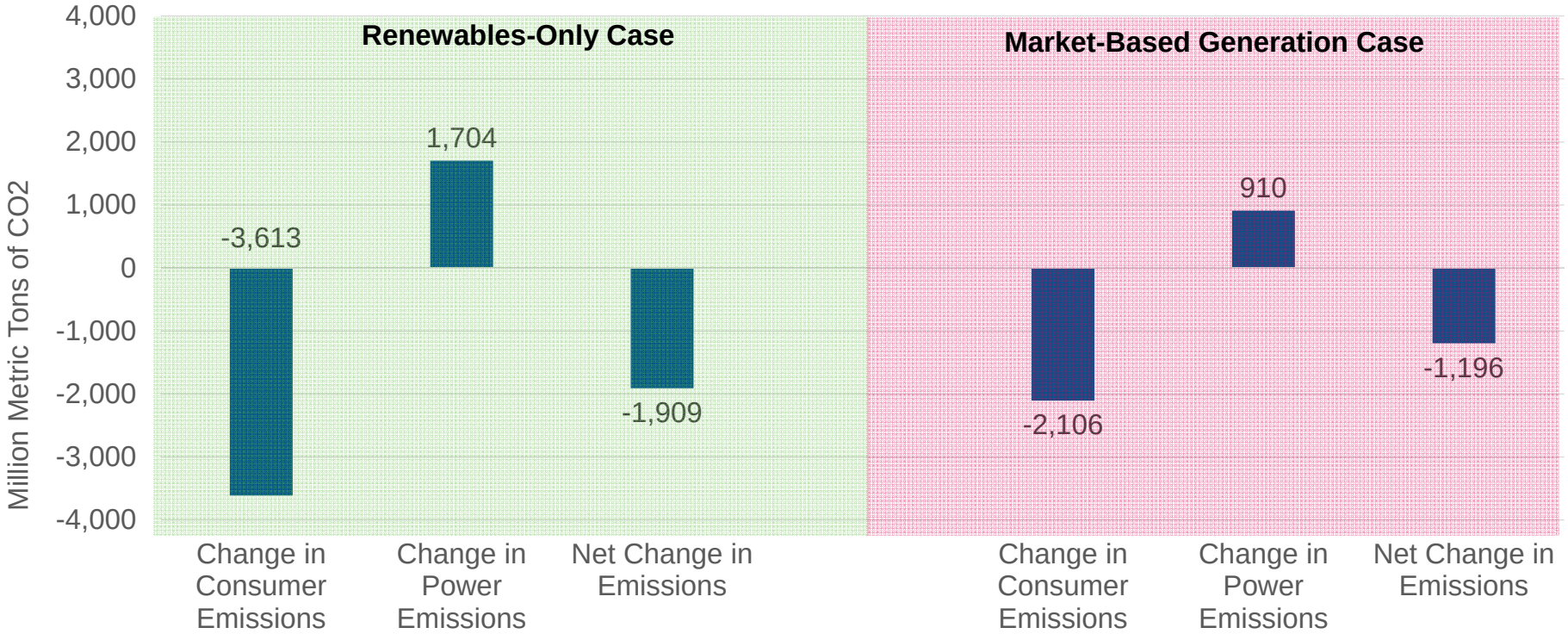
- The regions were based on electric grid, climate, demographic and other considerations.
- There is still potential for intra-regional variation in the larger regions, such as West.
- For example, the annual household cost using Southern California utility rates is over ten times higher than using the West region rates.
- Other regional variables can have similar effects.



Change in Cumulative Gas Consumption – 2023 to 2050



Cumulative GHG Emissions Reductions by Electrification Case - 2023 to 2050



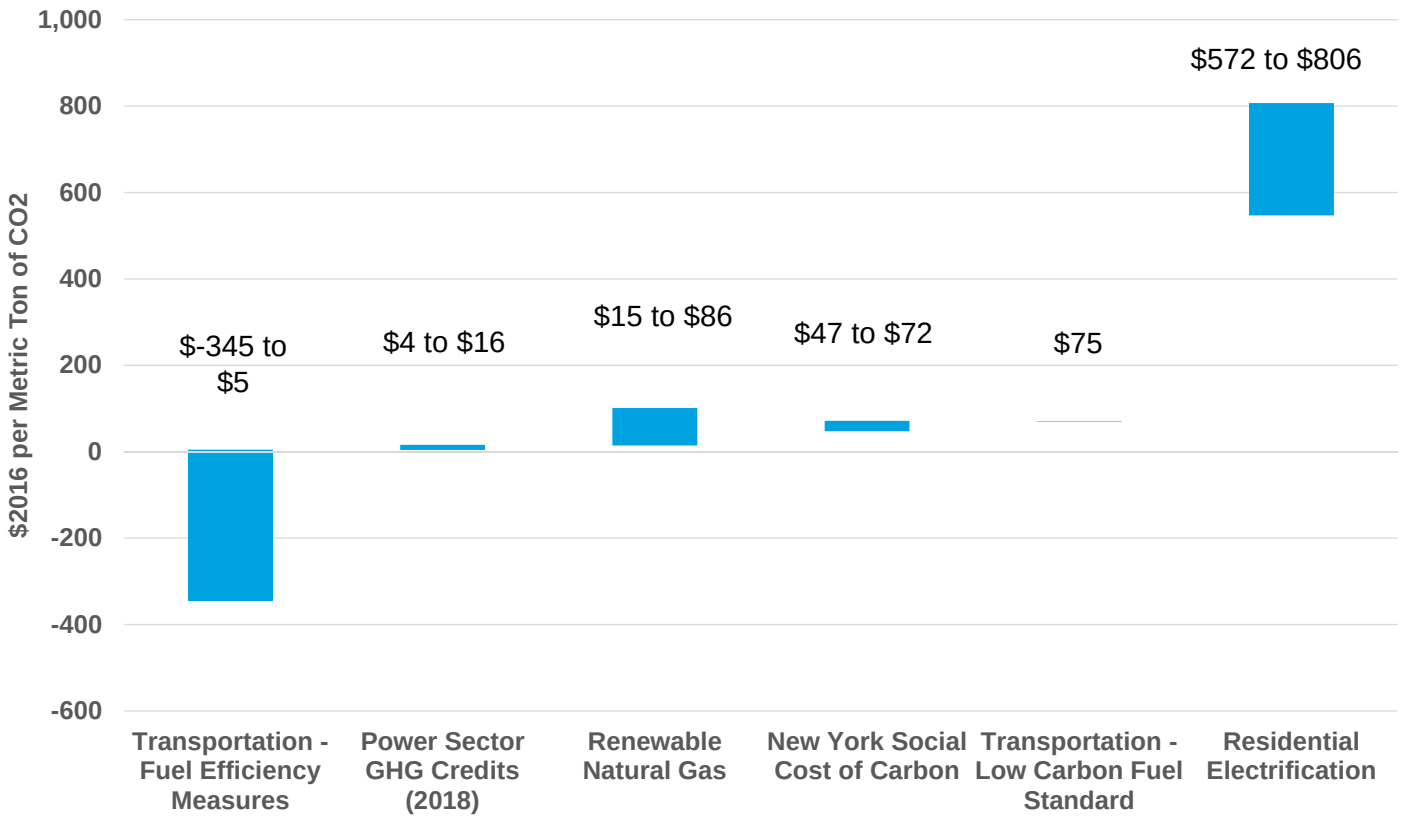
Policy-Driven Residential Electrification is an Expensive Option for Emission Reductions

Region	Cost of Emissions Reduction (Discounted to 2023) ($2016 per Metric Ton of CO_2)	
	Renewables-Only Case: Cost of Net Emissions Reductions	Market-Based Case: Cost of Net Emissions Reductions
Units		
East Coast	635	391
Midwest	N/A*	Not Modelled
New England	N/A*	1,081
New York	8,784	6,450
Plains	230	Not Modelled
Rockies	794	Not Modelled
South	218	63
Texas	251	54
West	749	485
Total	806	572

**No emissions reductions within this region in the Renewables-Only Case*

Residential Electrification is a Much More Expensive Approach to Reducing Emissions than other Available Alternatives

Emissions Reductions Costs for Alternative Approaches to Reducing CO_2 Emissions



Key Messages

1. N**atural gas is an important 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% to 1.5%

   of U.S. GHG emission in 2035.
3. **Policy-Driven Electrification will be significant to customers:** Average residential household energy costs (utility bills and equipment/ renovation costs) increase by

   38 % to 46% (National average of $750 to $910 per year in direct costs)

Key Messages

4. **And to the economy—** The total increase in energy costs range from

   $590 Billion to **$1.2** Trillion (real $2016)

5. **With significant impacts (and costs) on the electric sector:**

   $150 to **$425** billion in investment in new generating and transmission assets.

6. **Policy-driven residential electrification would be a very costly approach to emissions reduction:**

   $572 to **$806** per Metric Ton of CO2 reduced - very high relative to other GHG reduction options.

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