REMI Analysis of Policy Based Electrification

October 11, 2018

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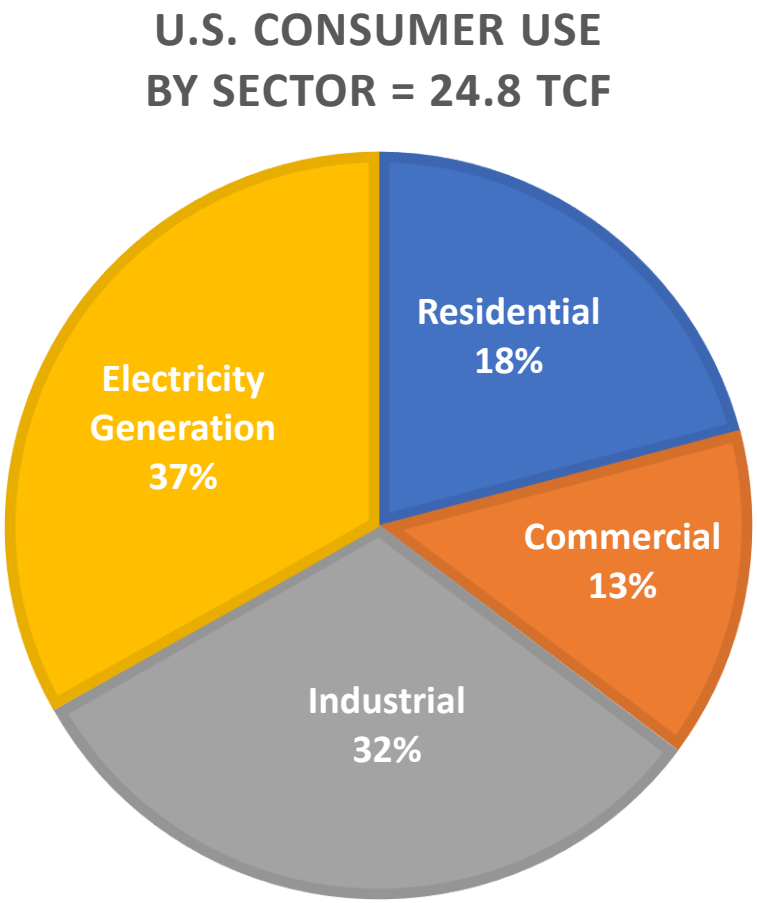
Clean Natural Gas

Touching Every Segment of American Life

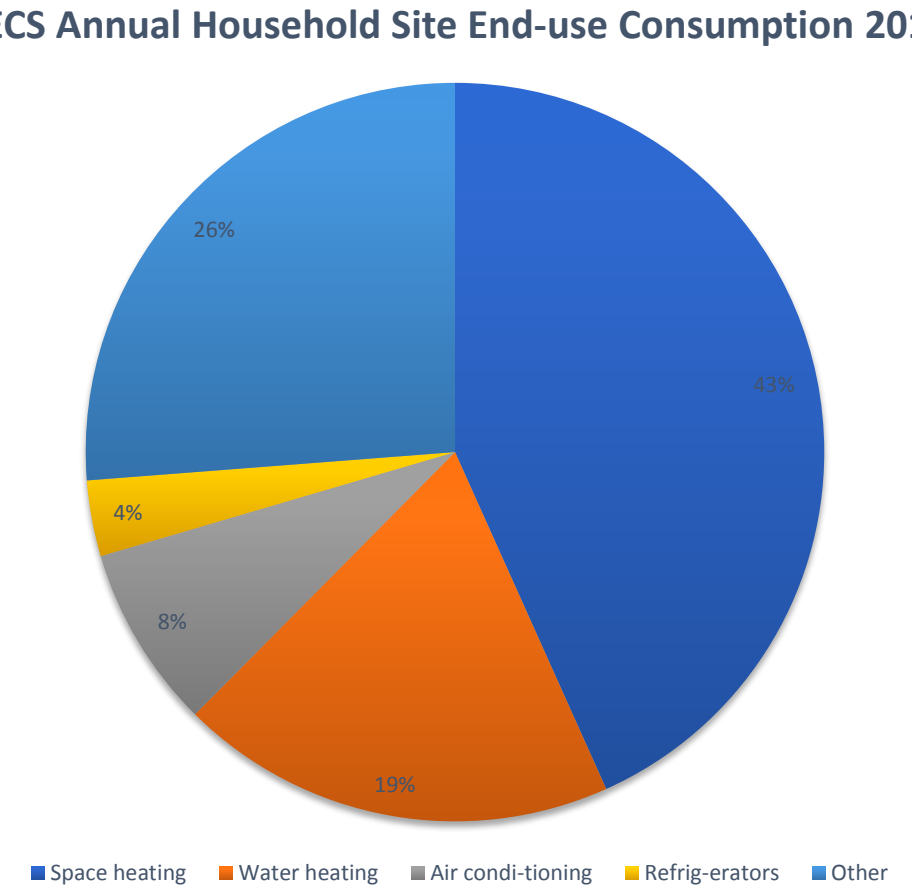
Natural gas is the dominant source of energy for heat, hot water and cooking in homes and businesses in the U.S. and is used to manufacture everyday products such as cell phones, credit cards, tires and trash bags.

2017 Natural Gas



Source: Energy Information Administration

Shares of Energy End Use

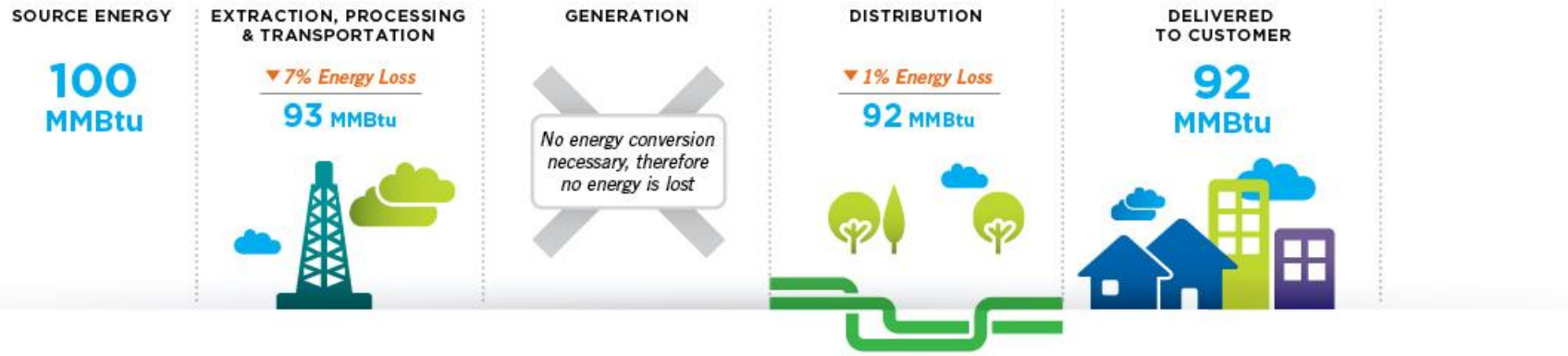


Source: Energy Information Administration

Direct Use of Natural Gas

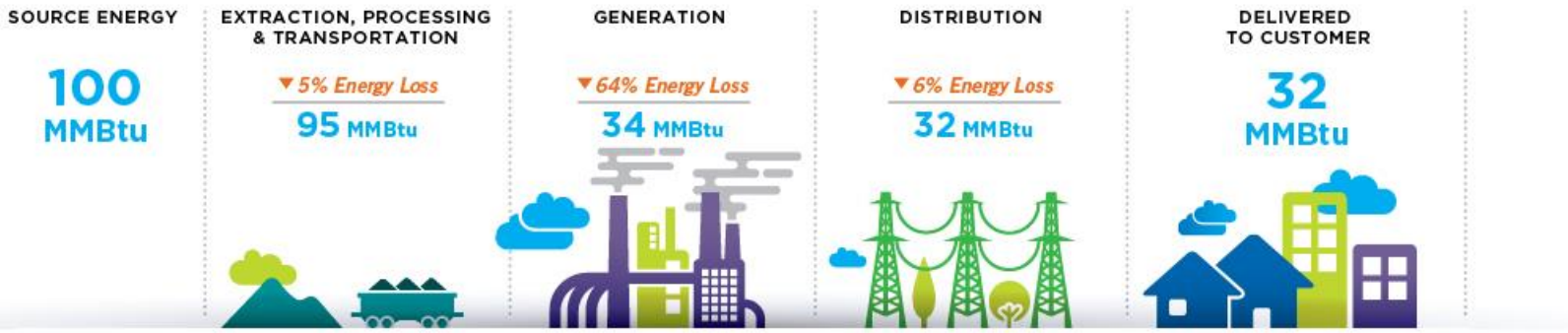
92%

From the place where it is extracted from the ground, to appliances in your home, natural gas achieves 92% energy efficiency.



Converting to Electricity

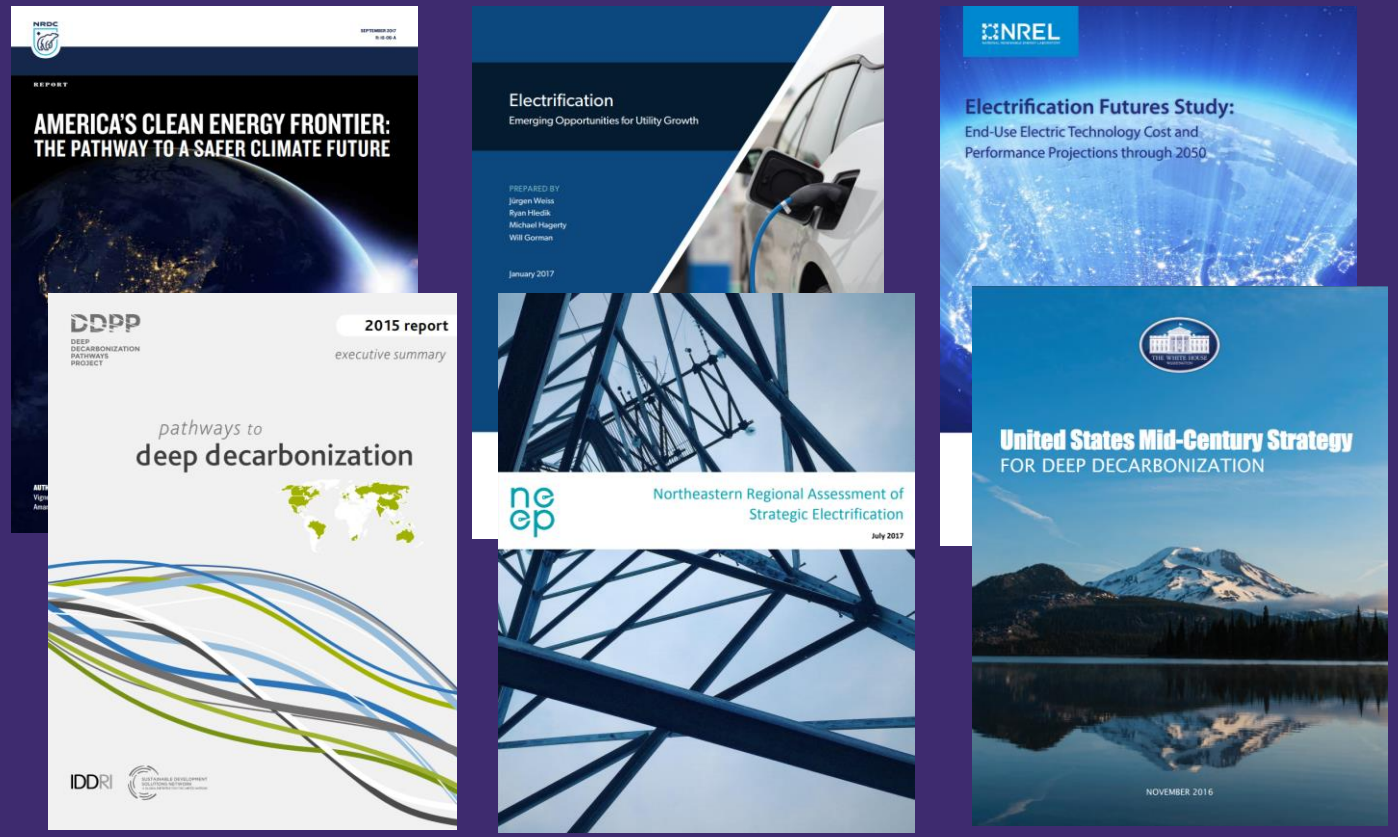
Converting natural gas or any other fossil fuel into electricity to power comparable electric end-use products only maintains 32% of usable energy. This is because of the significant amount of energy lost on the journey from production to customer.



*Based on most recent actual generation mix of all energy sources from 2012

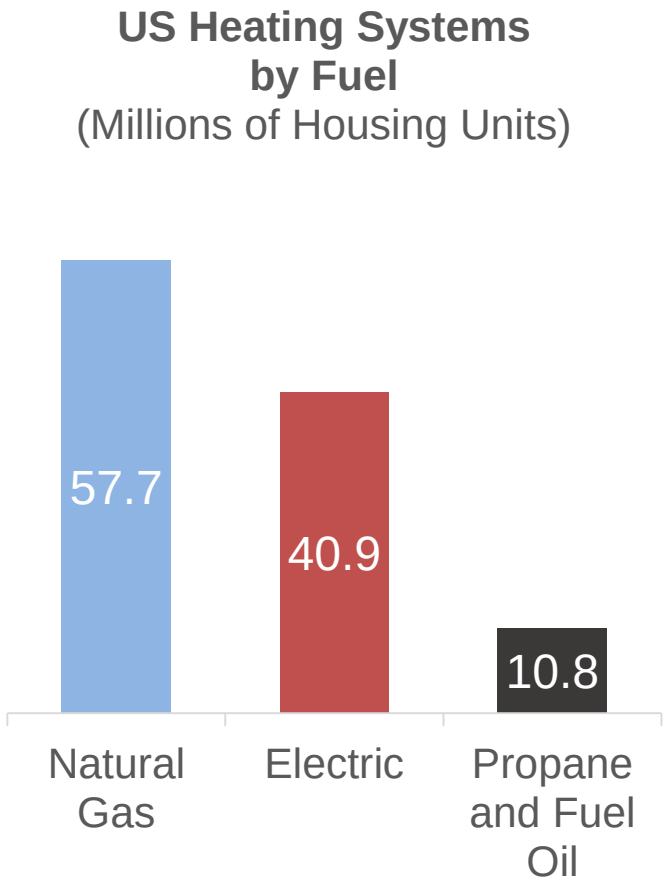
Proposals to reduce greenhouse gas emissions take many forms

Studies may assume electrification of building energy loads to be a pathway to decarbonization

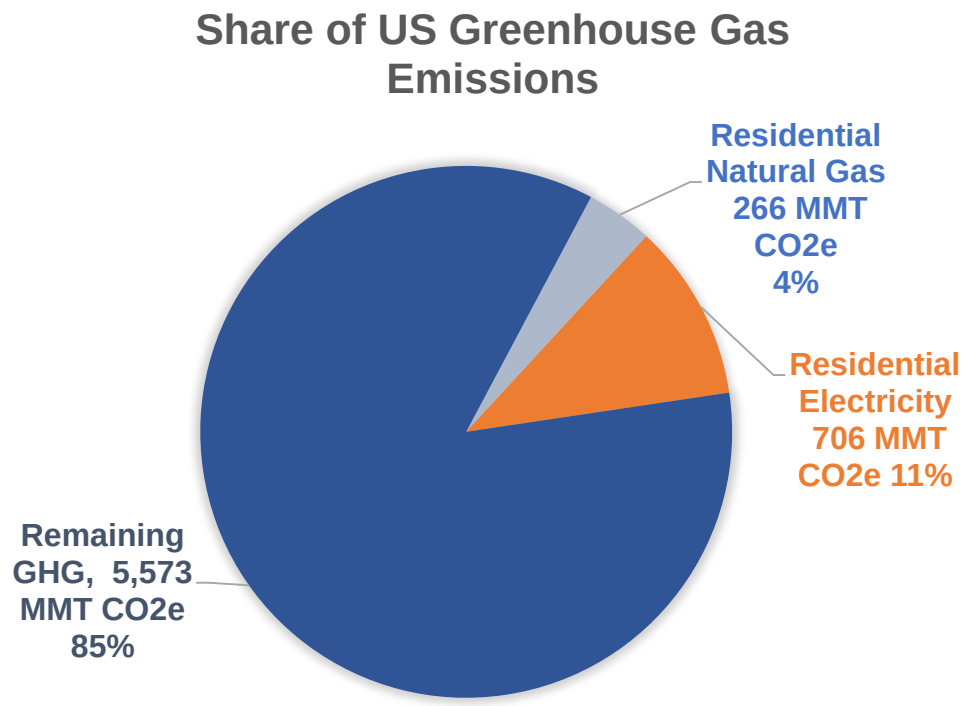


A Closer Look at the Residential Market

Natural gas provides energy to a majority of households,
but accounts for only 4% of US annual greenhouse gas emissions.



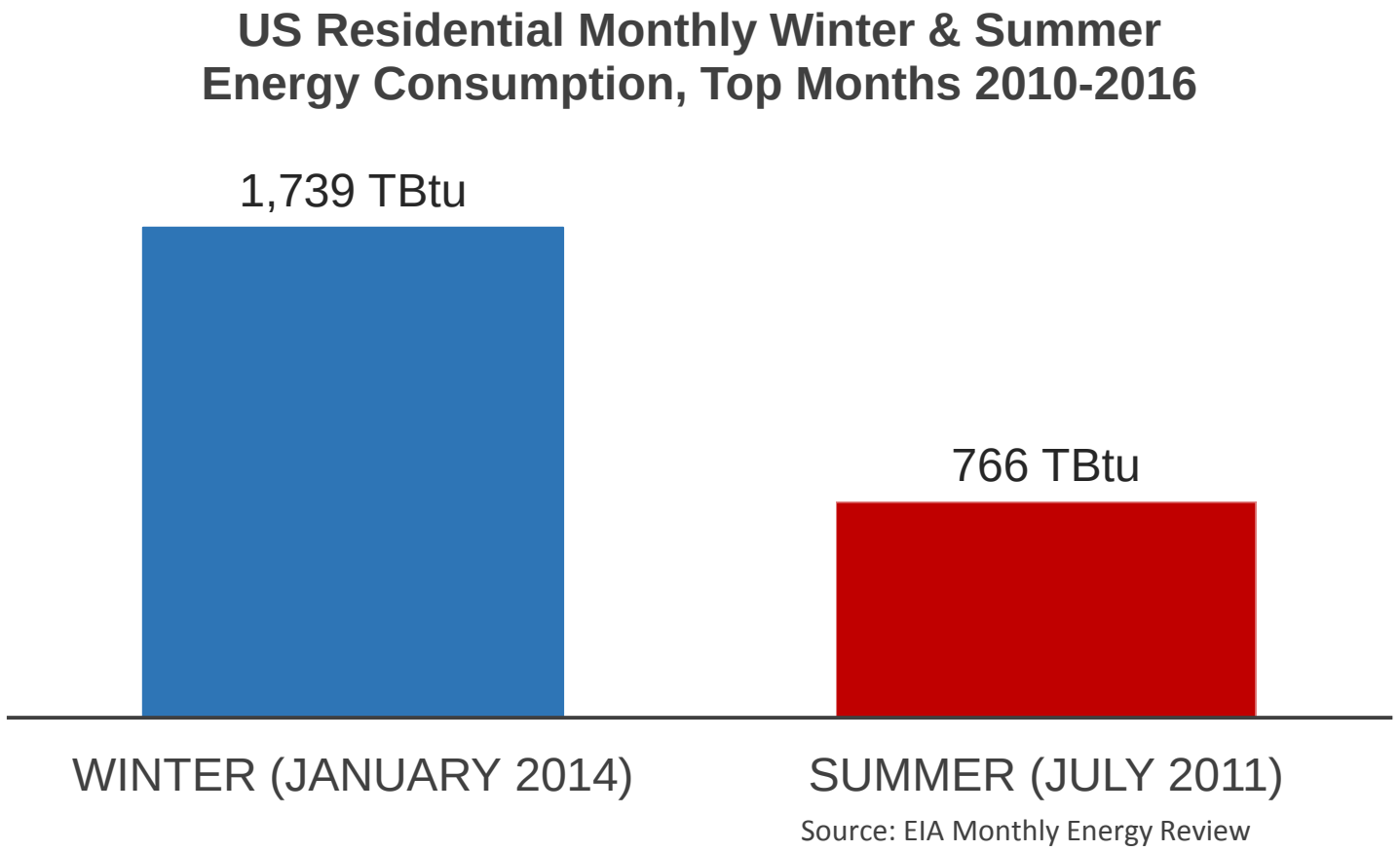
Source: Residential Energy Consumption Survey, 2015



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 sector sales,

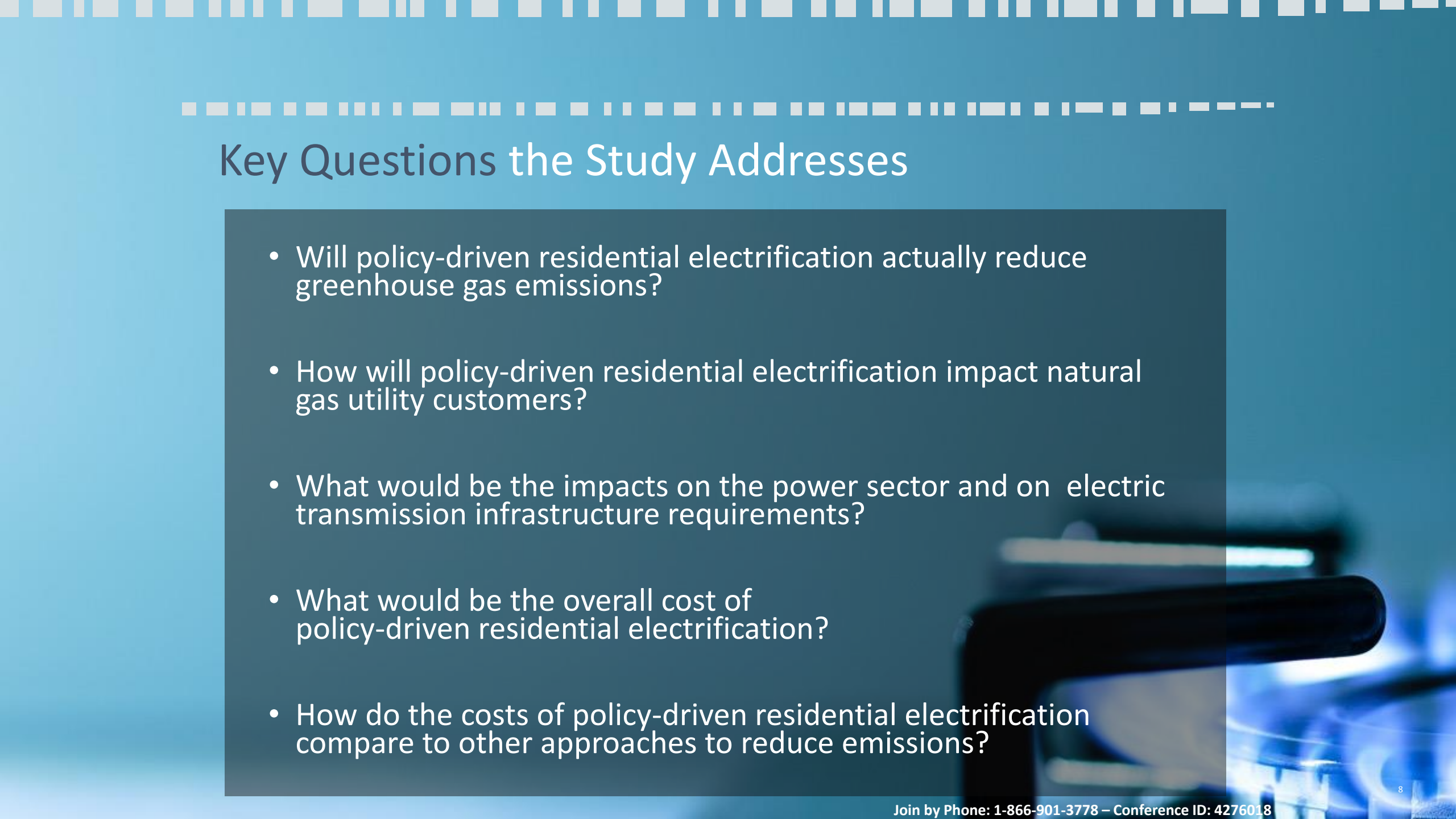
Foundational Findings

- Winter generally requires much more energy than summer
- Must evaluate peak requirements



Key Questions the Study Addresses

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



Key study inputs

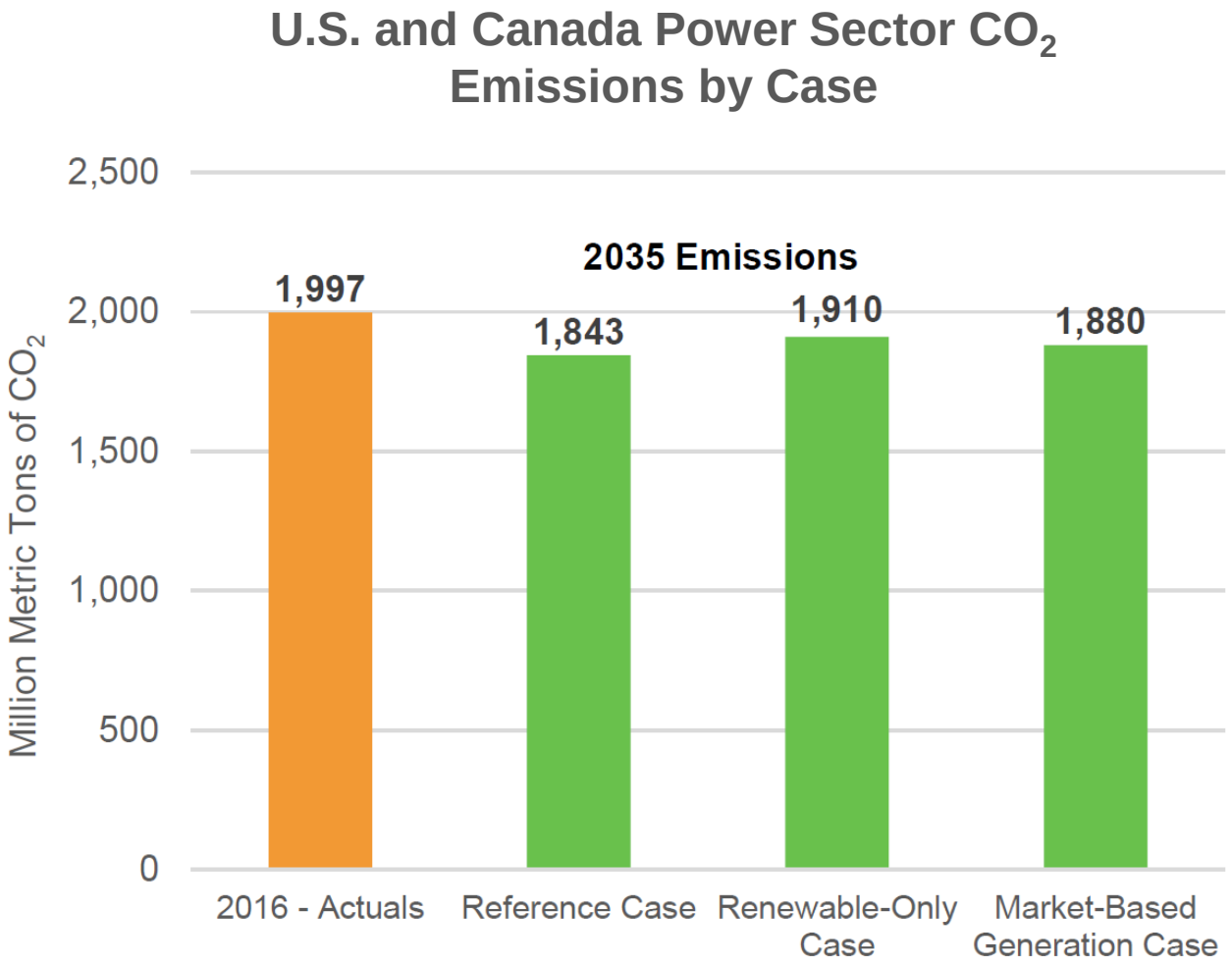
1. 2017 AEO Reference Case
2. Peak & annual residential heating load for 220 locations.
3. Projected equipment costs for space and water heating.
4. Two electric generation cases:

   Renewables-only &
   Market-based.

Electrification Policy Assumptions

- Starting in 2023, all new homes are built with electric space and water heating equipment
- Starting in 2023, direct-fuel use space and water heating systems would be replaced with electric systems at end of the effective-life of the current system.

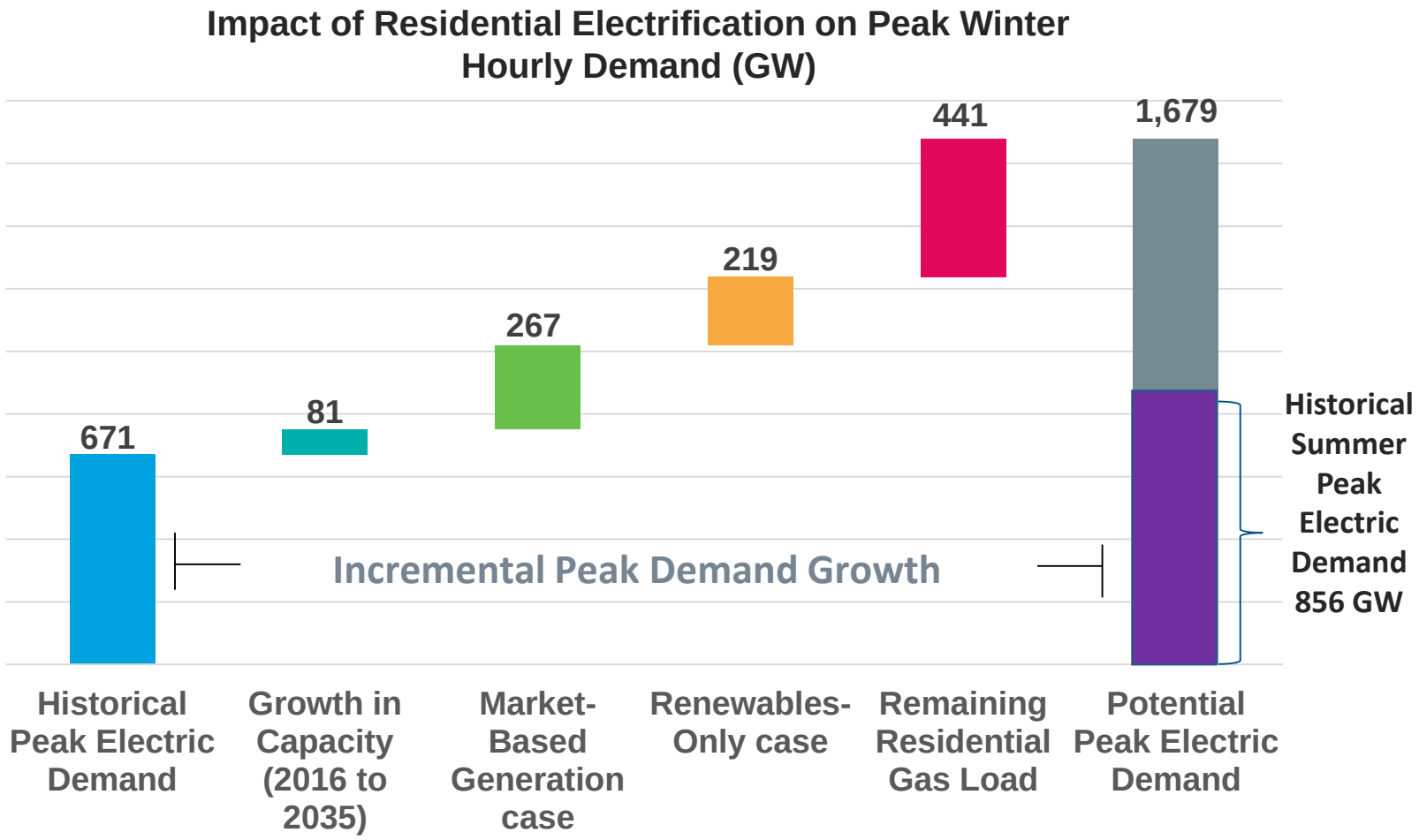
Total GHG reduction potential from policy-driven residential electrification is small



Reductions from aggressive policy-driven residential electrification would reduce GHG emissions by only 1% to 1.5% of U.S. GHG emissions in 2035.

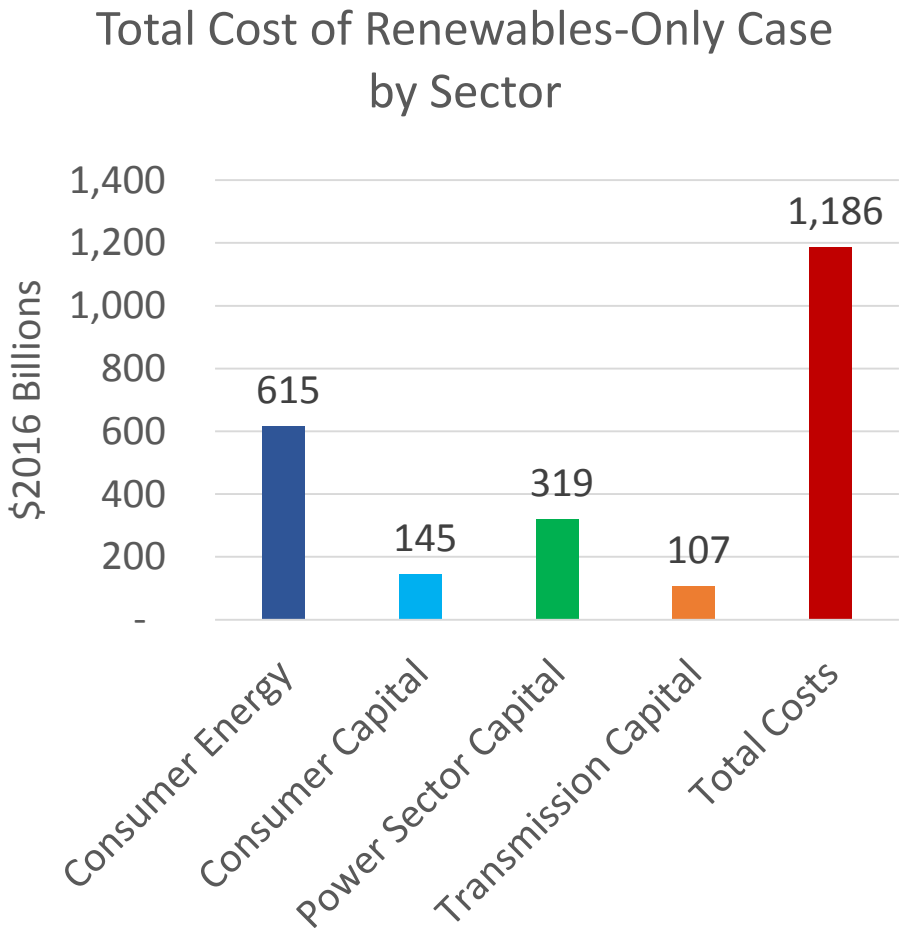
Source: Implications of Policy-Driven Residential Electrification, 2018

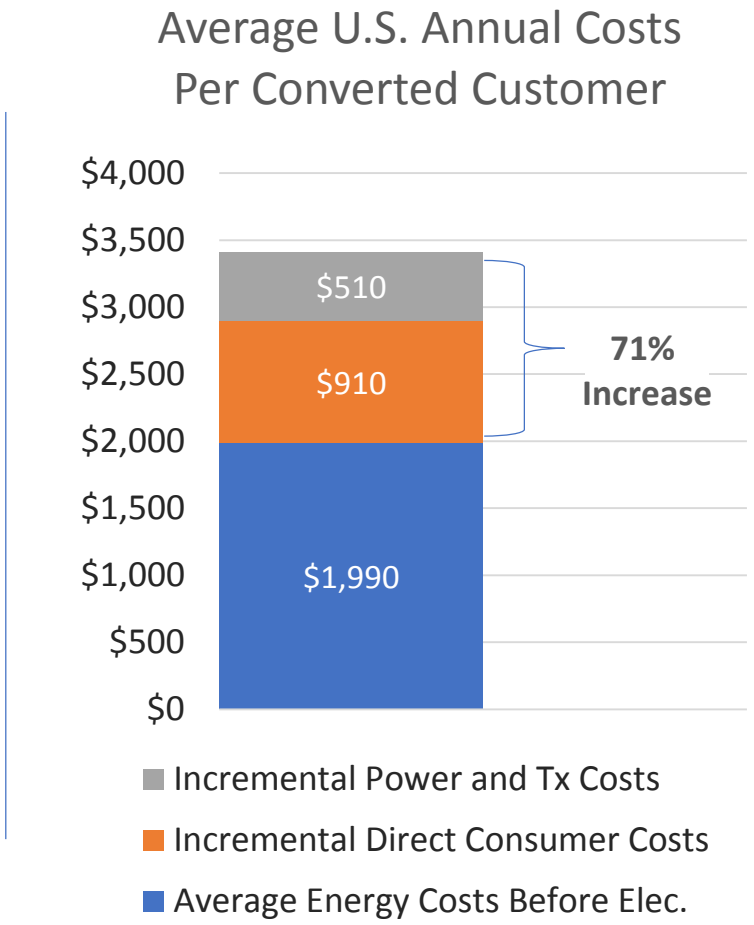
Electrifying the entire residential sector would nearly double the U.S. electric grid's peak hourly demand



Source: Implications of Policy-Driven Residential Electrification, 2018

Policy-driven residential electrification will be burdensome to the economy and consumers





Source: Implications of Policy-Driven Residential Electrification, 2018

Observations on the Renewables-Only Generation Case

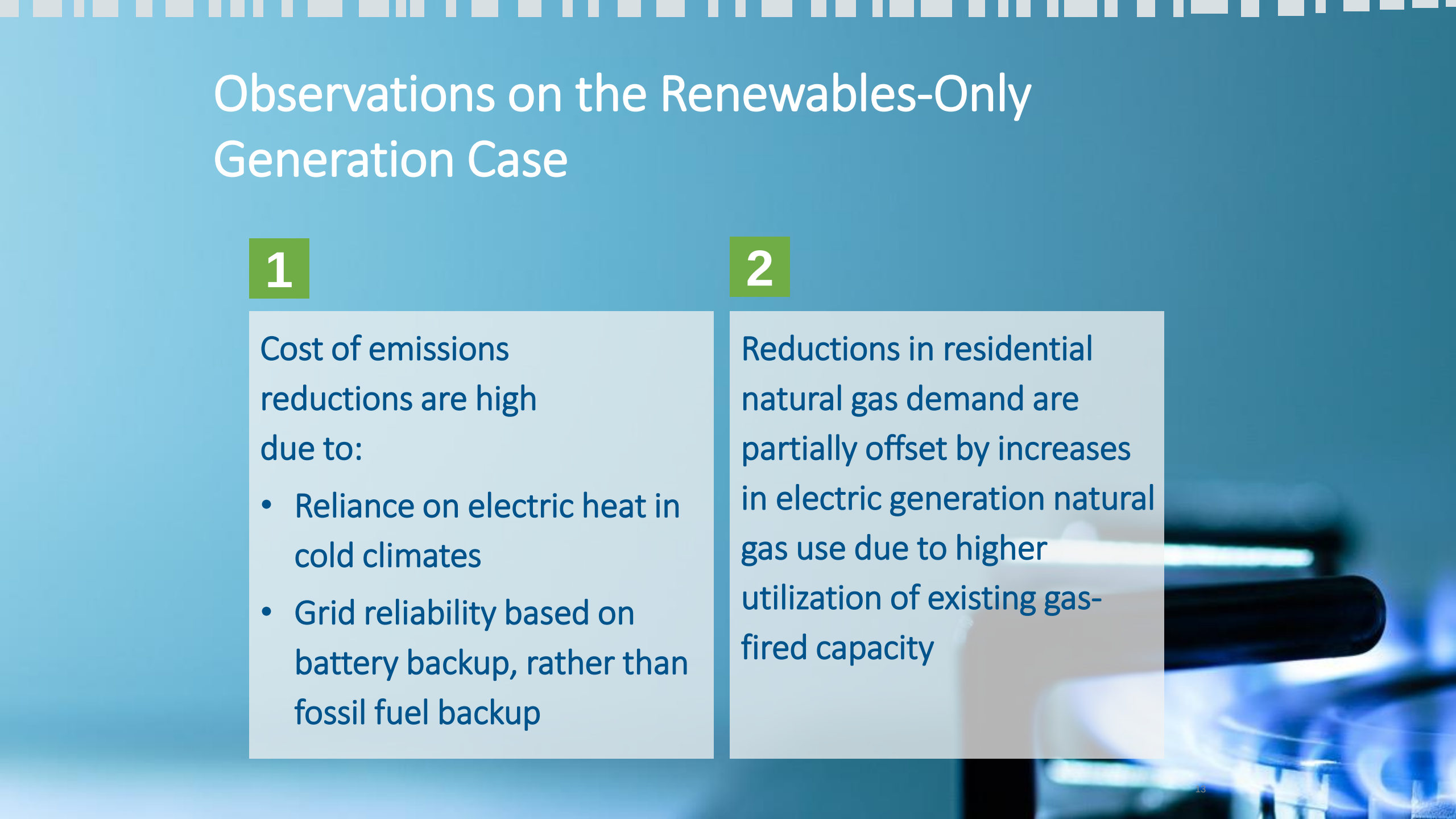
1

Cost of emissions reductions are high due to:

- Reliance on electric heat in cold climates
- Grid reliability based on battery backup, rather than fossil fuel backup

2

Reductions in residential natural gas demand are partially offset by increases in electric generation natural gas use due to higher utilization of existing gas-fired capacity



Observations on the Market-Based Generation Case

1

The market-based case achieves a lower-cost emission reduction, despite more fossil-fuel based generation, by focusing on regions where conversions are more cost effective and limiting incremental power sector costs.

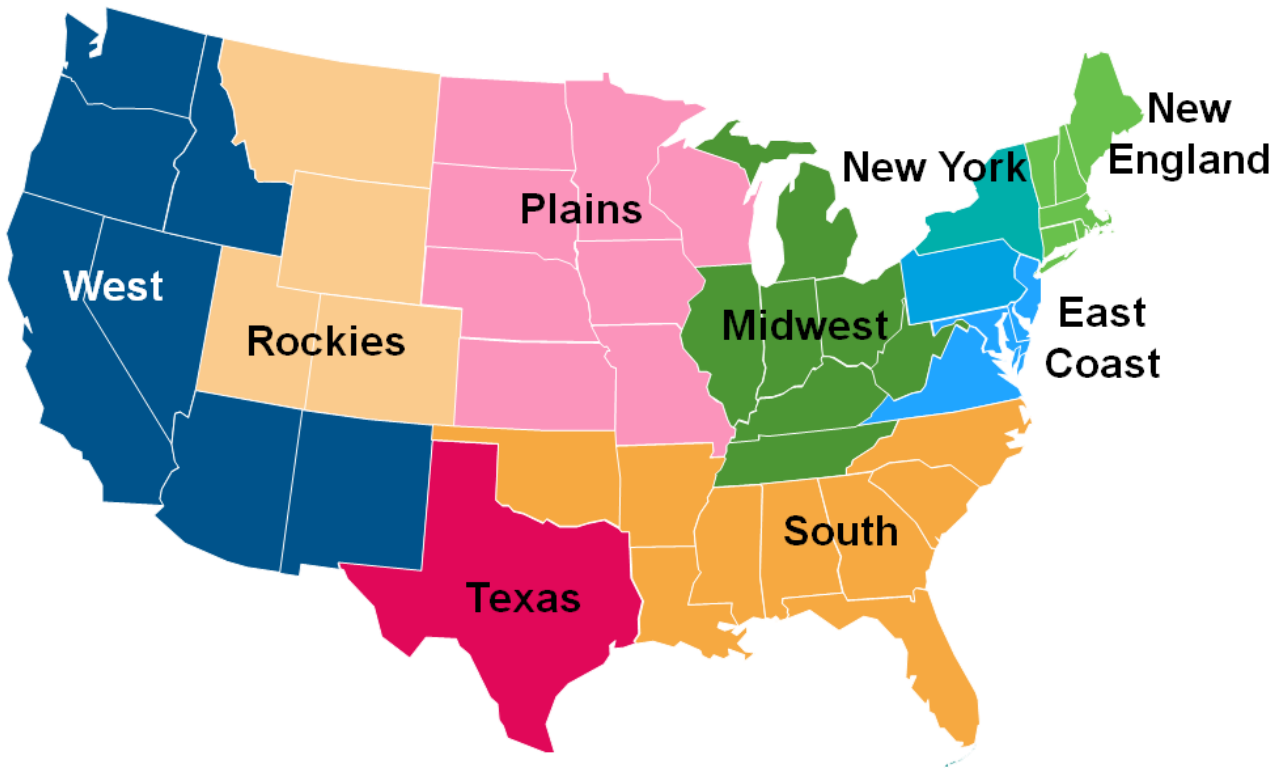
2

Declines in natural gas demand in the residential sector are offset by growth in natural gas demand in the power sector.

Regional outputs based on a detailed bottom-up analysis

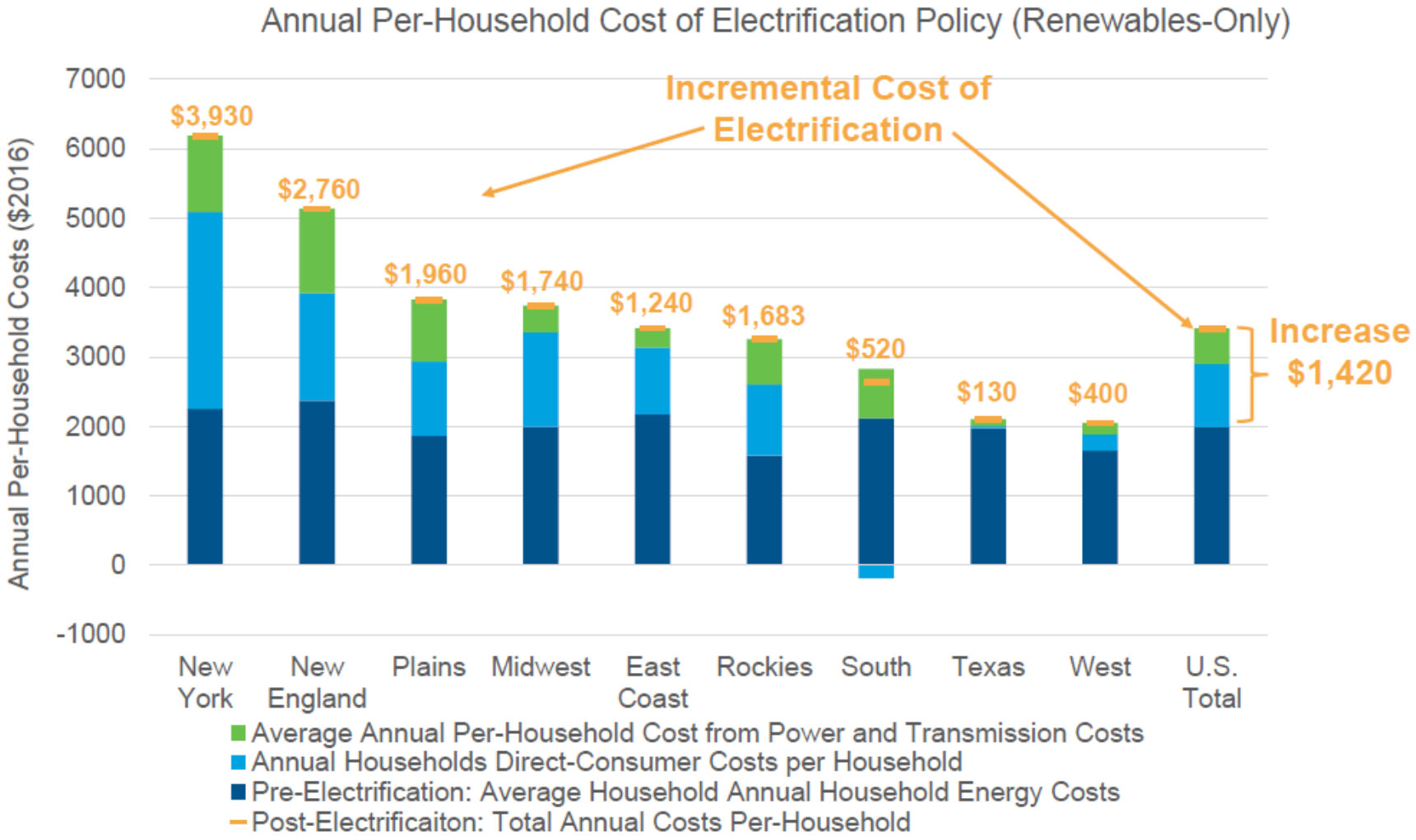
Regions were created based on state characteristics and input from the study Steering Committee. Factors included:

- Electric power pool and grid interconnections
- Natural gas Consumption Profiles
- Regional Climate and Weather Conditions
- Electric Grid Emissions (2035)



Source: Implications of Policy-Driven Residential Electrification, 2018

Regional Breakdown of Study Results



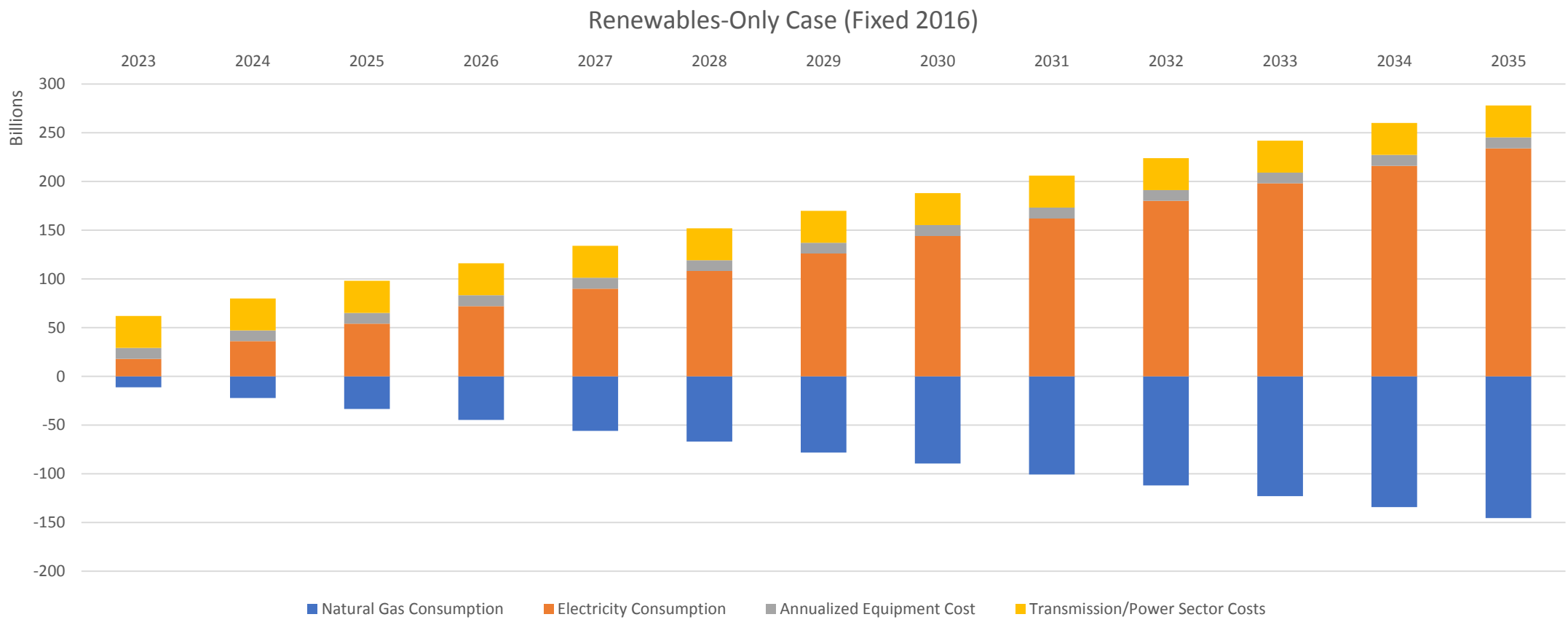
Source: Implications of Policy-Driven Residential Electrification, 2018

REMI Model Inputs Summary

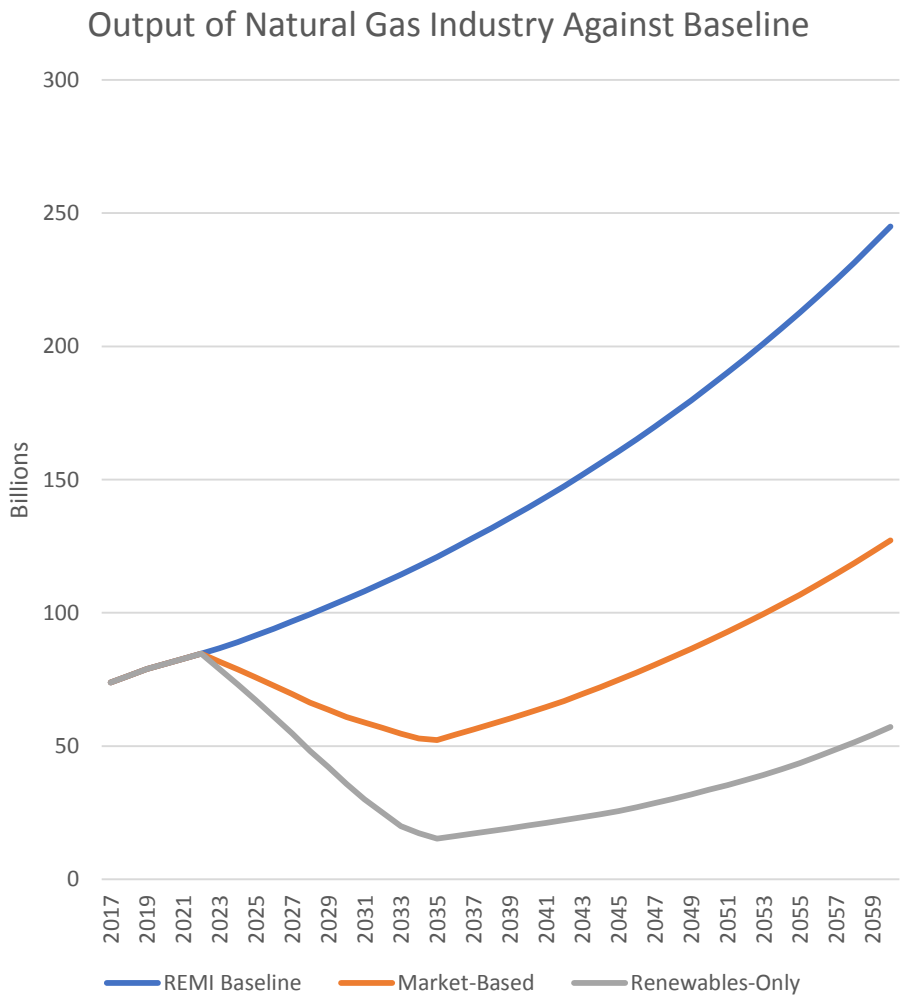
Total National Changes from aggregated 2023-2035 Baseline in Fixed 2016 $Billions

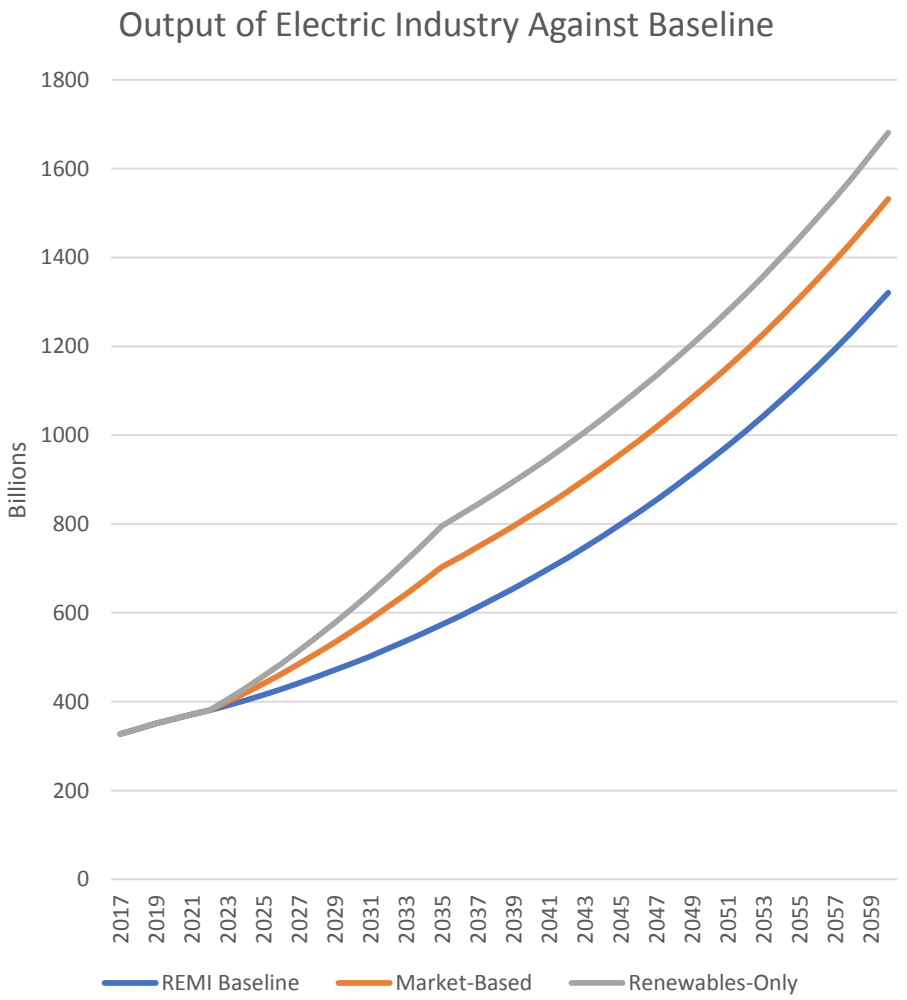
	Market-Based	Renewables-Only
Direct Use of Natural Gas	-655.6	-1,018.2
Use of Electricity	+969.1	+1,637.7
Exchange in Appliances	+101.9	+144.7
Improvemenst to Grid	+174.7	+426.2
Reallocation of Consumption	-590.1	-1,190.4

Combined Impact of Electrification Study

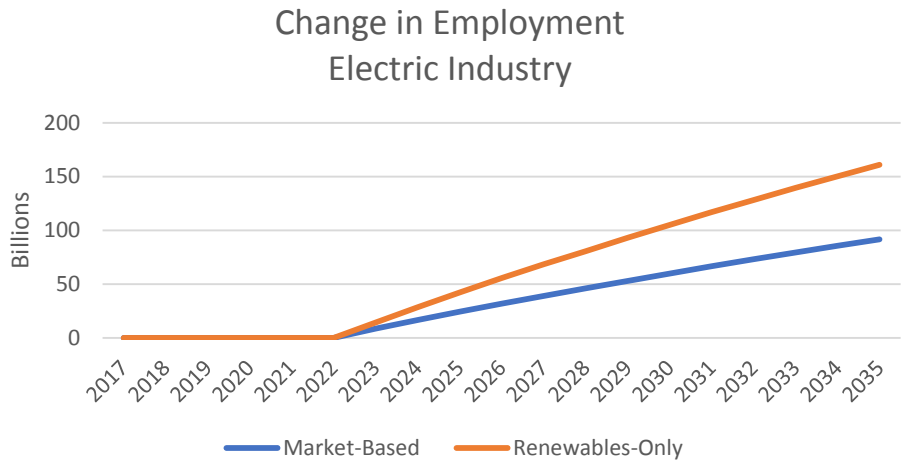


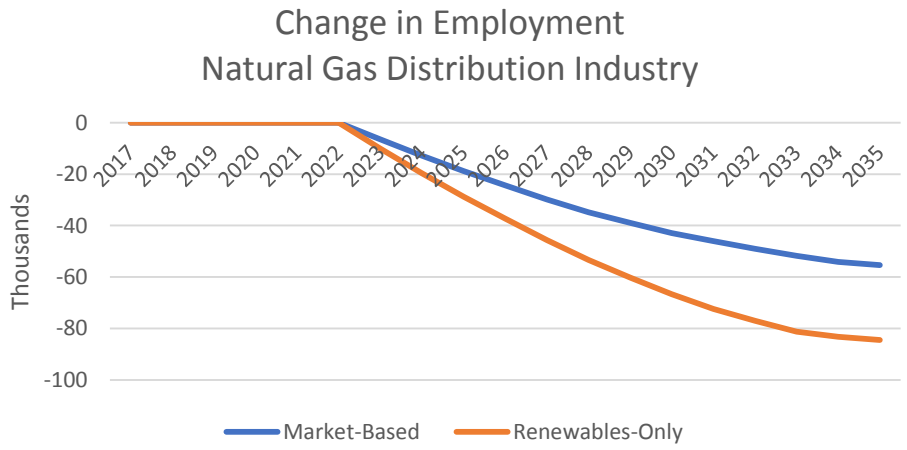
Change in Industry Output

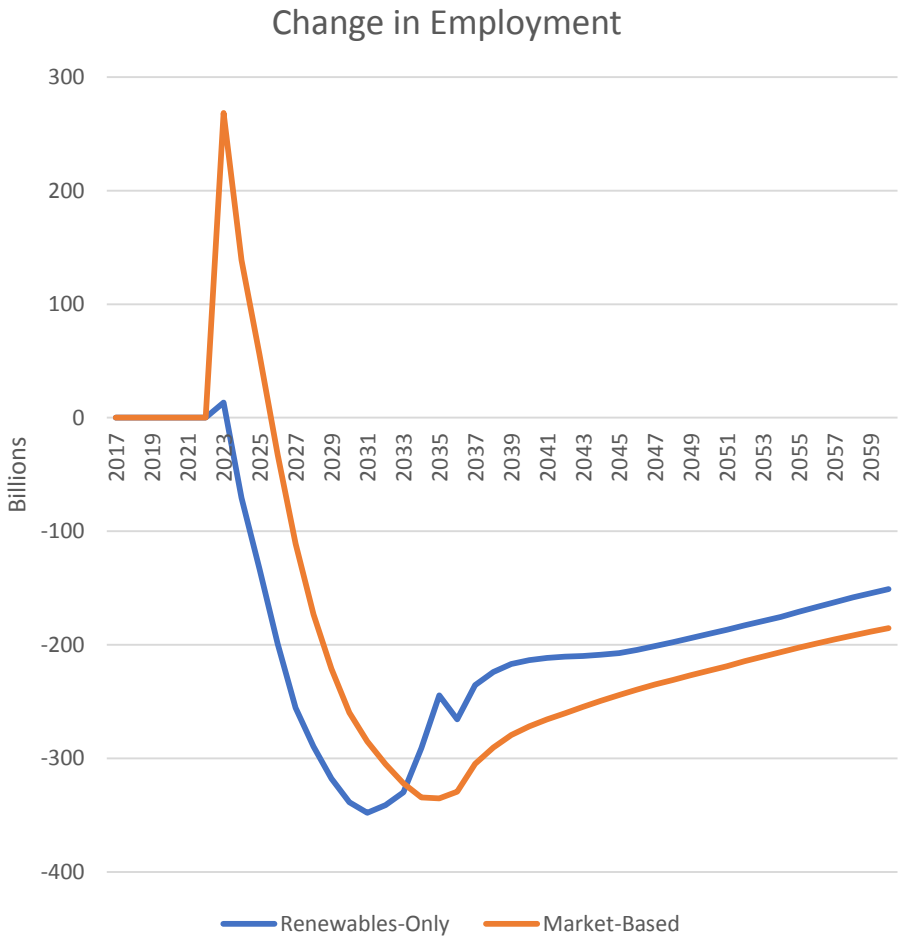




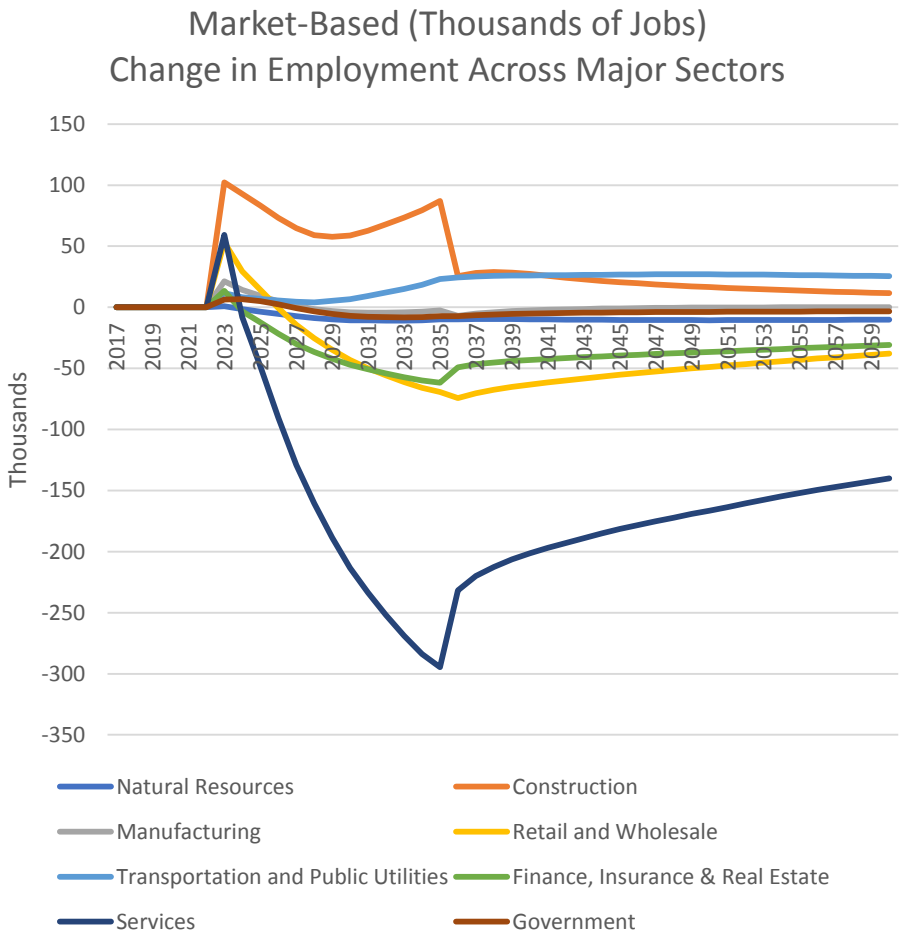
Change in Employment

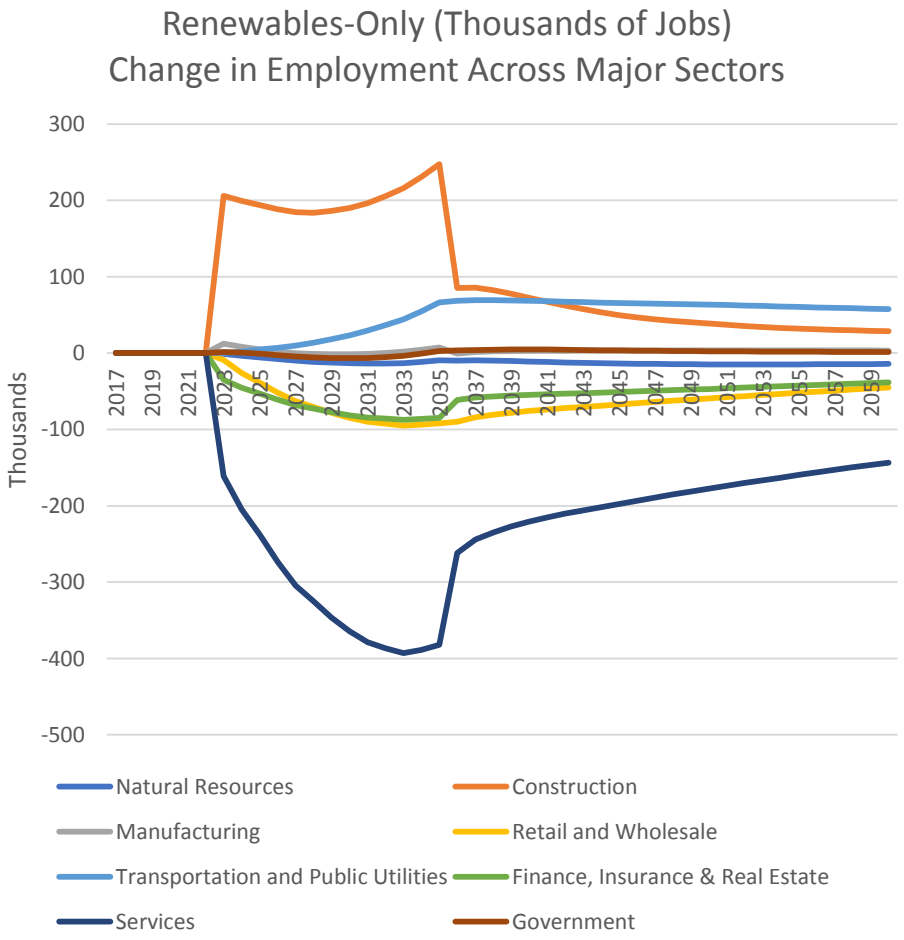




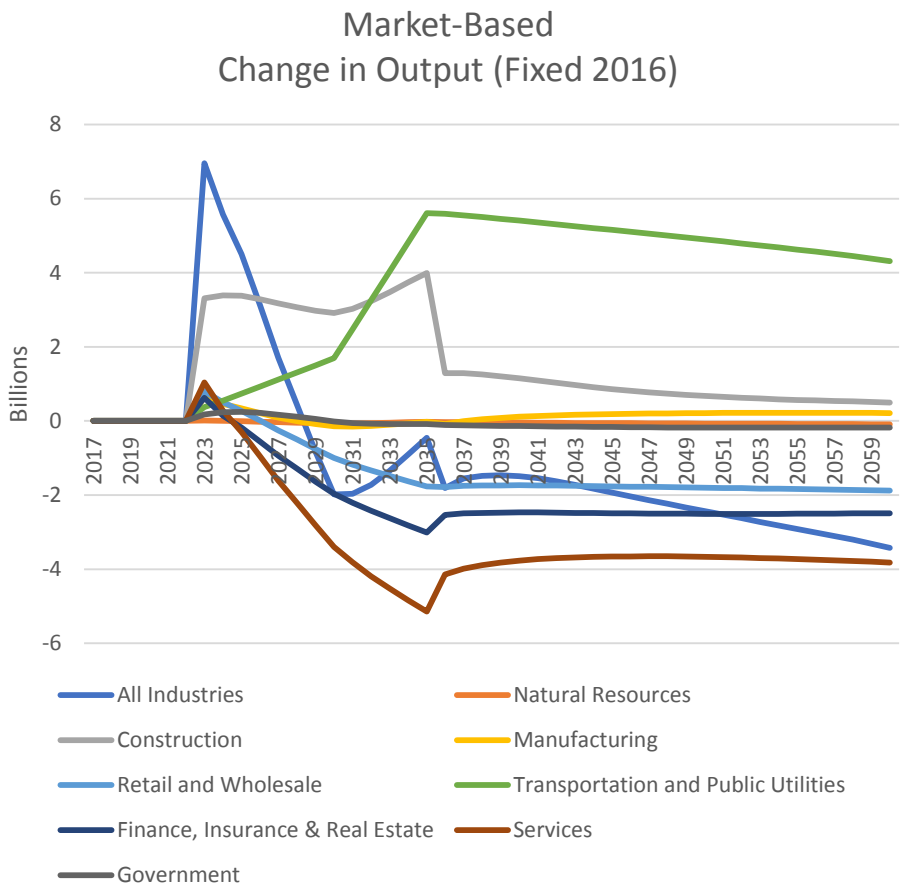


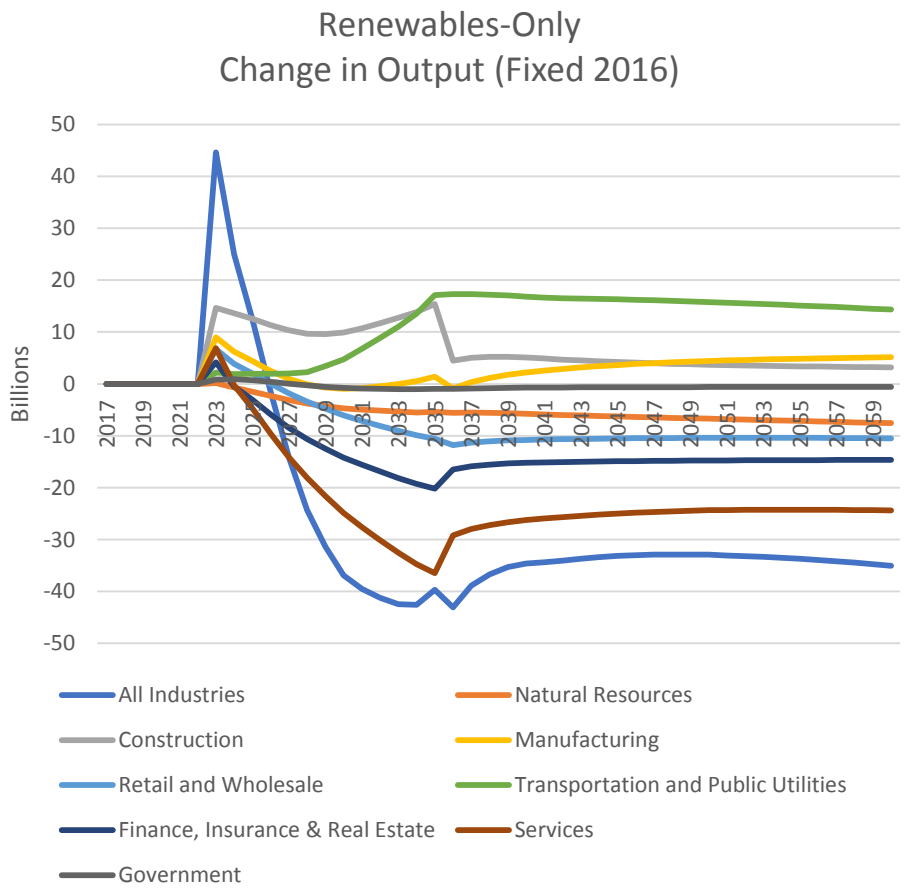
Change in Employment (Cont.)





Change in Output for all Sectors

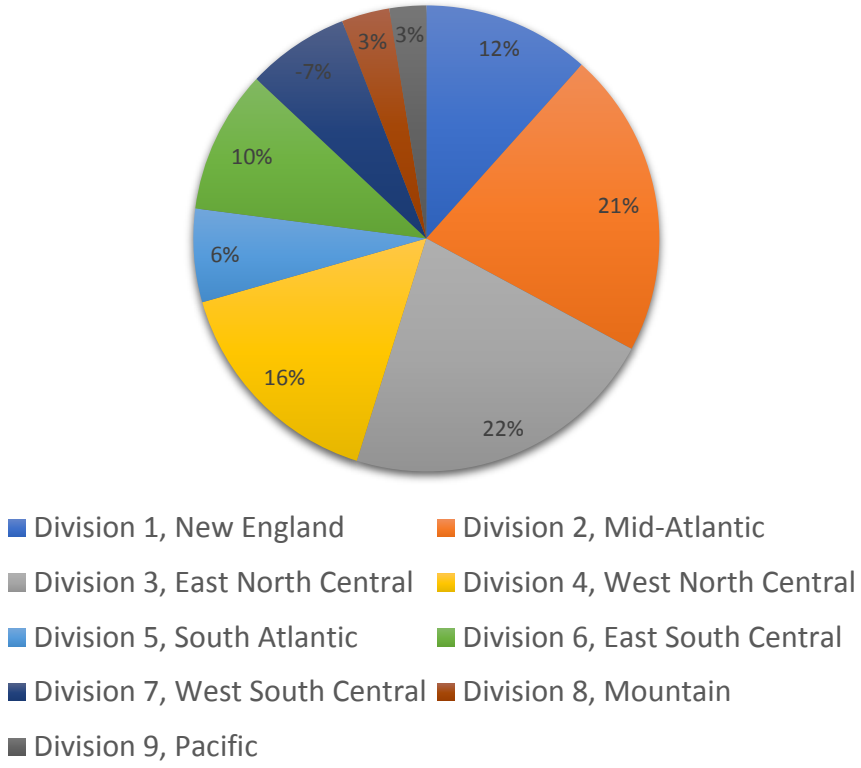




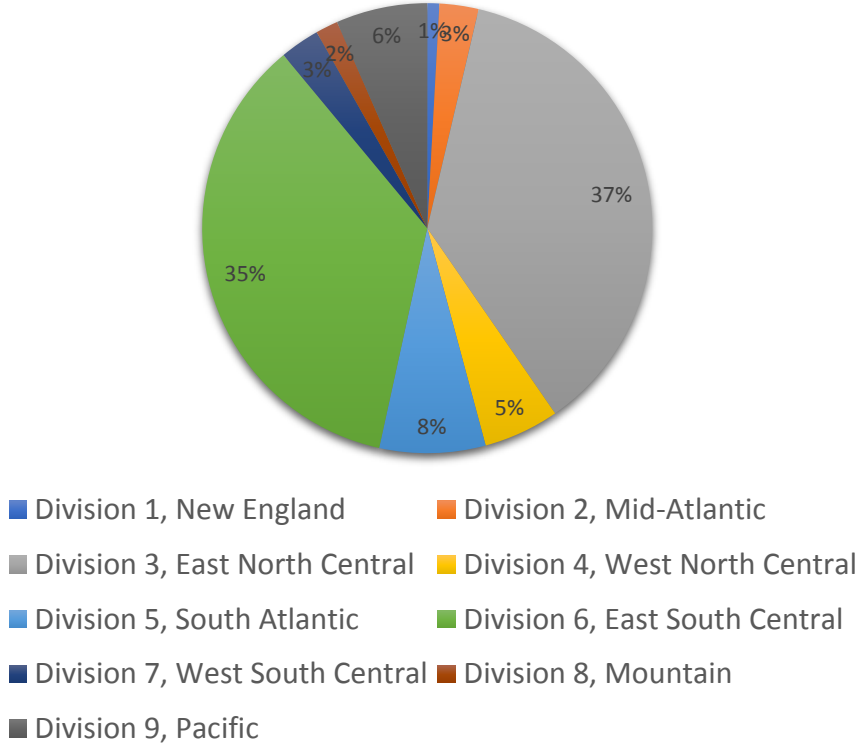
Regional Benefit to Relevant Industries

For Years while Policy is Active (2023-2035)

Share of Regional Increase in Construction Output (Fixed 2016)

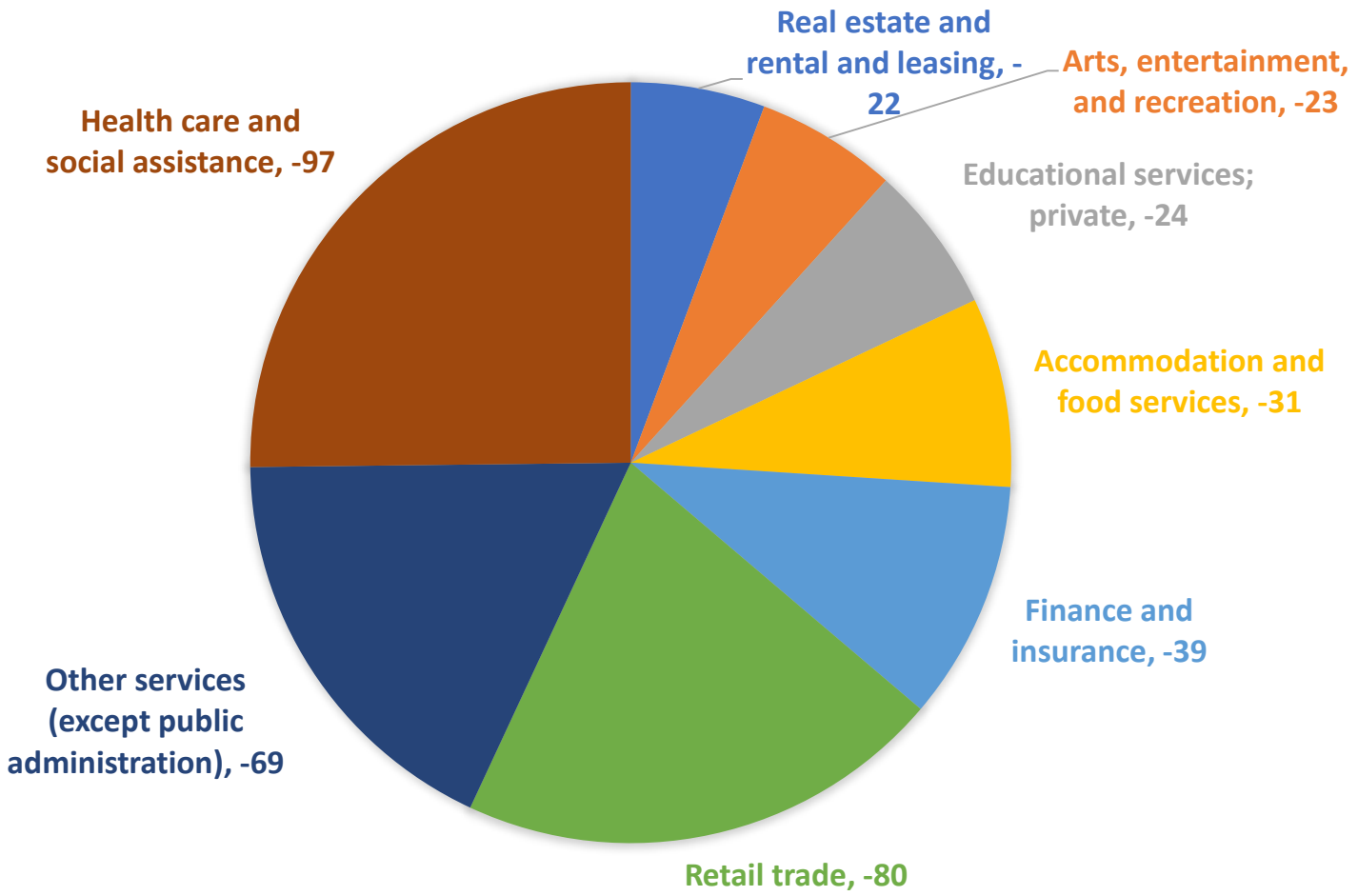


Share of Regional Increase in Appliance Manufacturing Output (Fixed 2016)



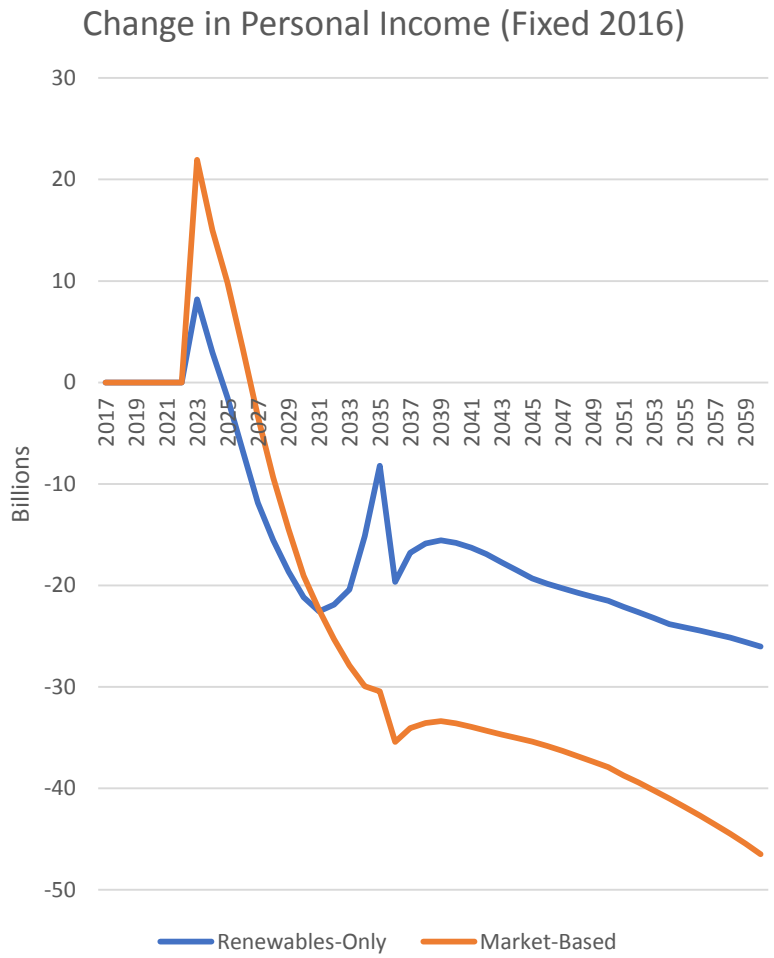
Sub-Sector Losses to Other Industries

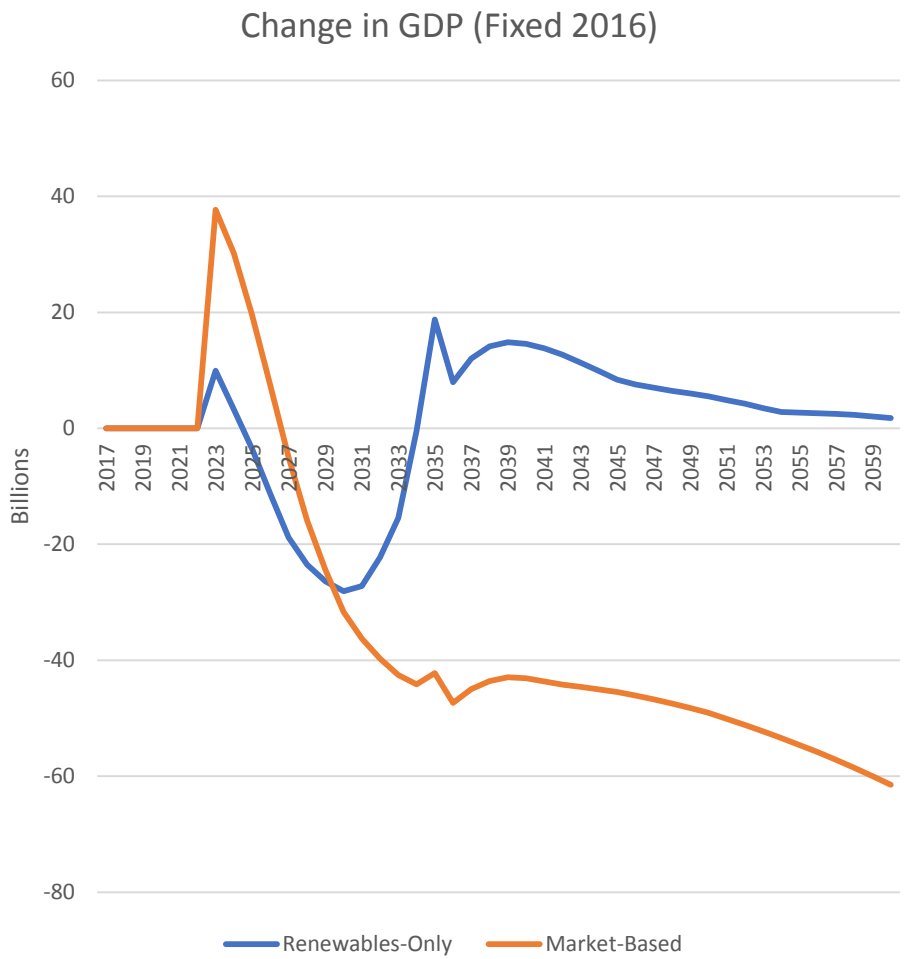
Total Losses in $Billions of Output (Fixed 2016) Year AFTER End of Policy Period



*Renewables-Only

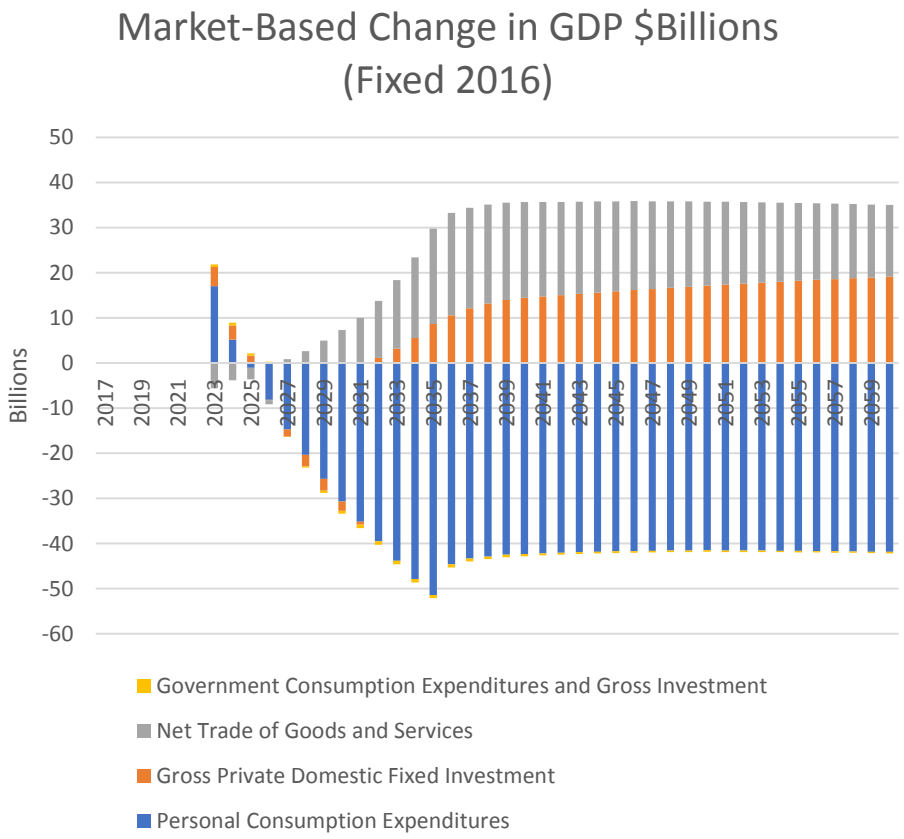
Change in Personal Income and GDP

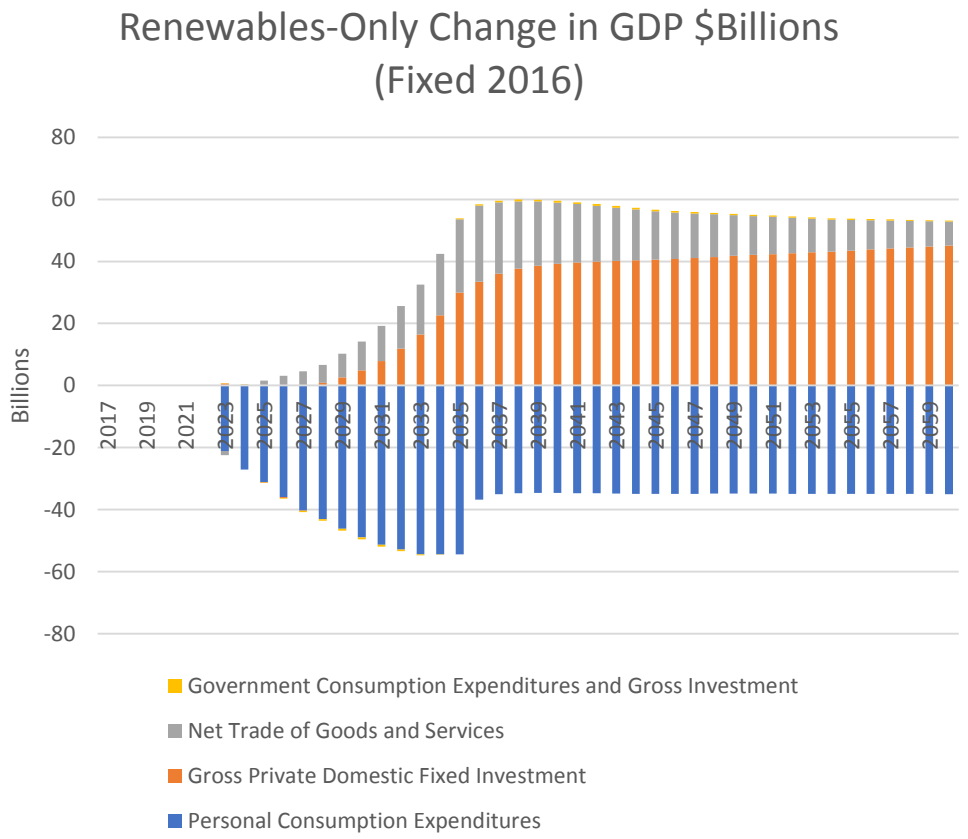




Breakdown of Four GDP Components

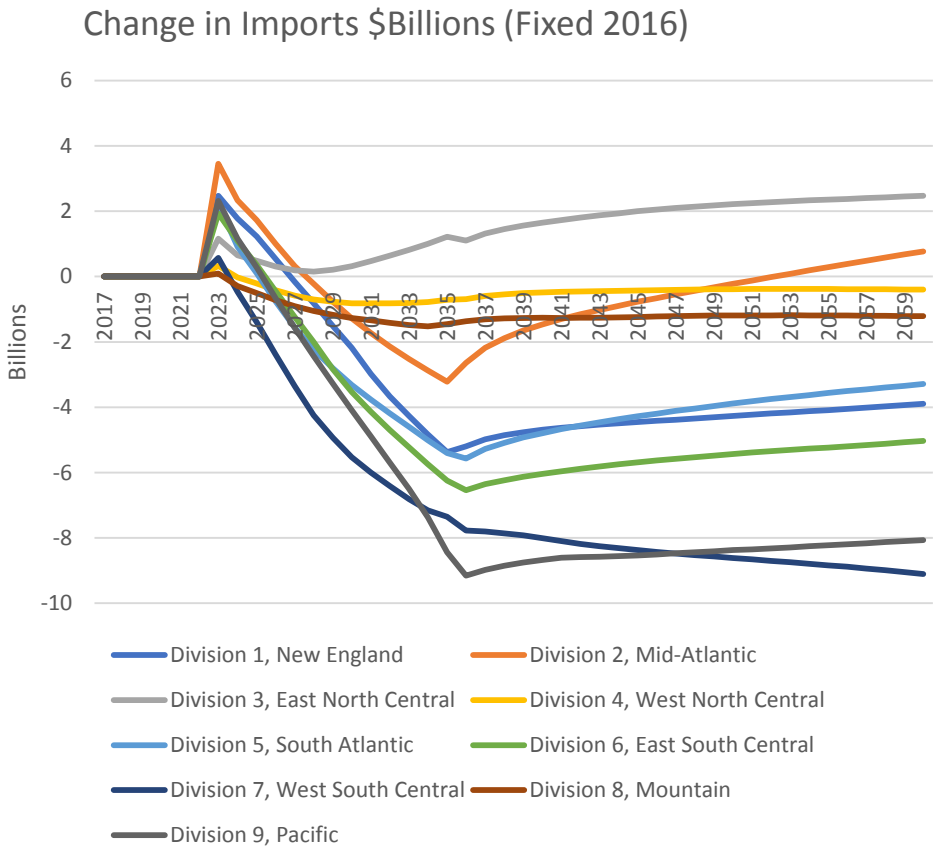
Total Loss/Gains in $Billions (Fixed 2016)

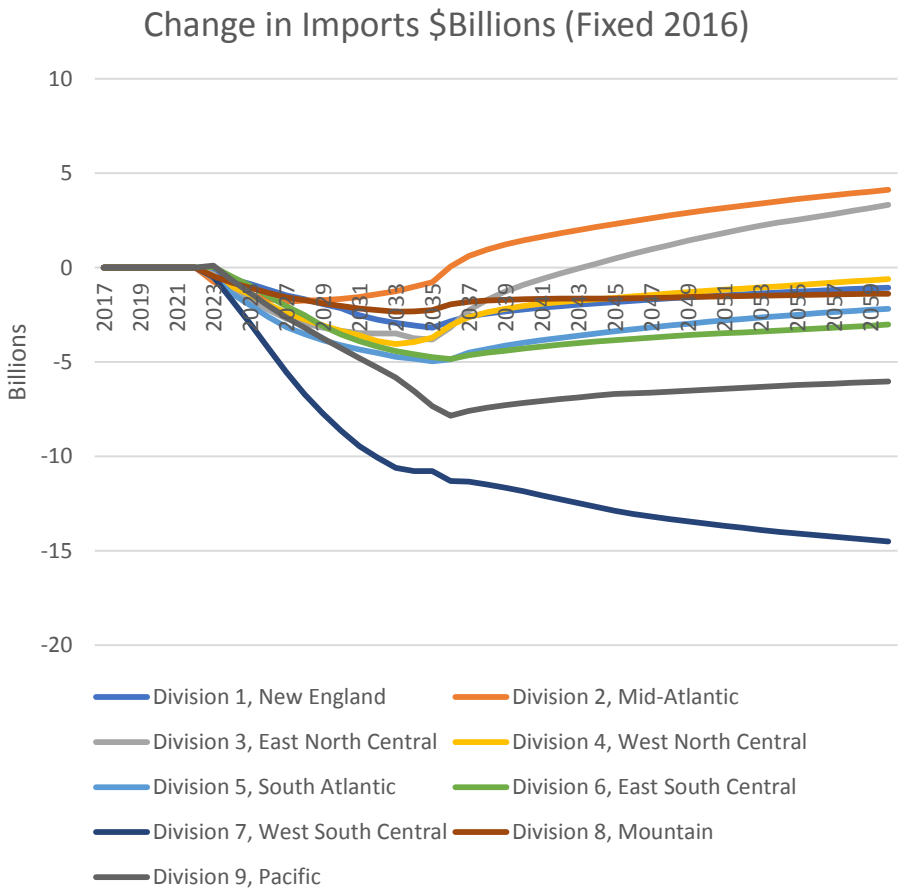




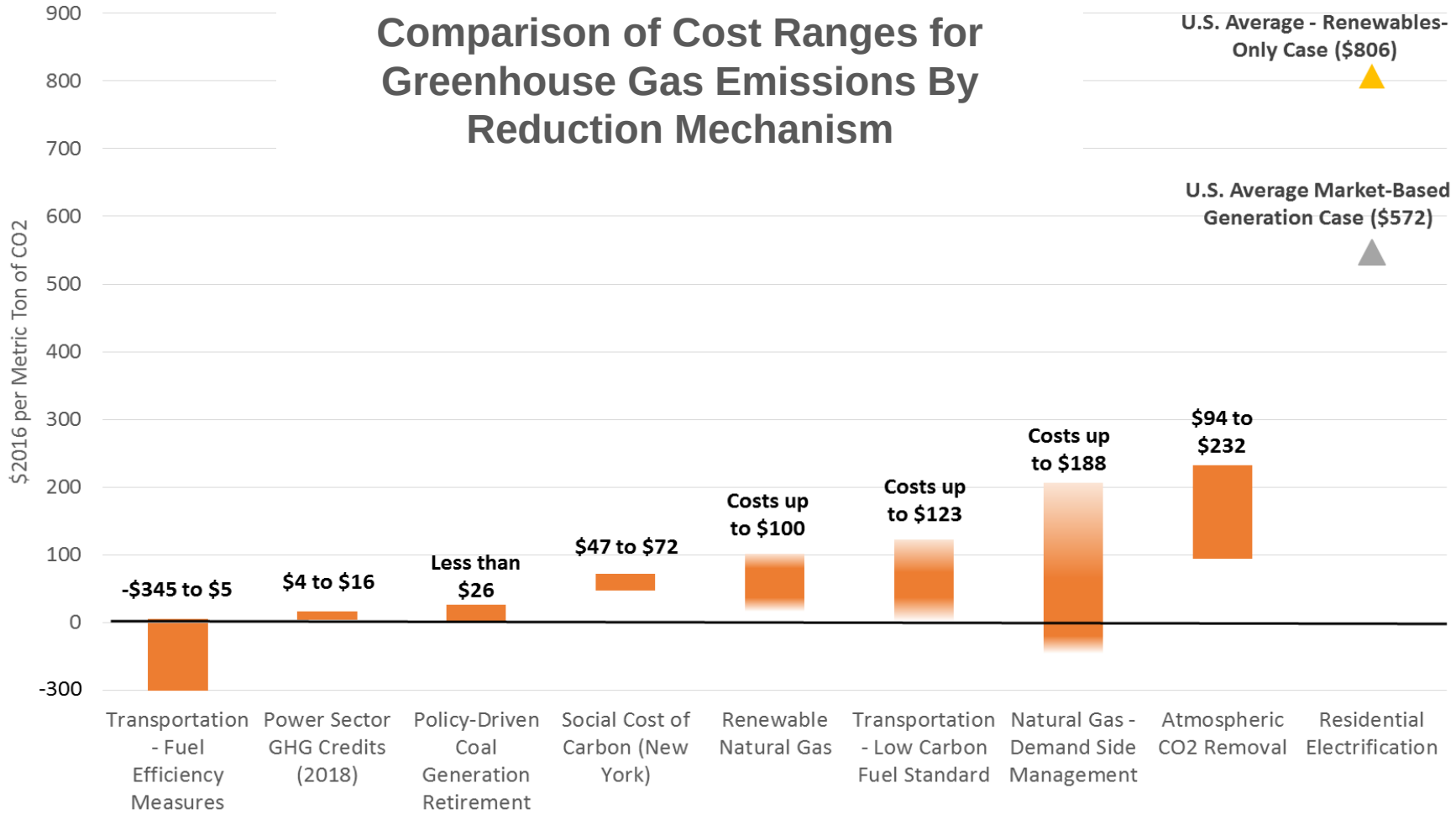
In both cases the net trade of goods has positive effect
because of a high reduction in imported goods driven by a reduction in consumption

Regional Change in Imports





Policy-driven residential electrification would be a very costly approach to emissions reduction



Source: Implications of Policy-Driven Residential Electrification, 2018

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