

Appendix A. Baseline Energy Forecast

A.1 Purpose

Navigant developed a baseline forecast in order to describe New Hampshire’s energy future under the current portfolio of energy policies, plans, and programs at the state, regional, and national level. Also referred to as the “business as usual” case, it forecasts both energy demand patterns and supply infrastructure absent any new or amended policies.

A.2 Methodology

Navigant’s forecast methodology followed a three step process, as illustrated in Figure 1: Baseline Energy Forecast Methodology.

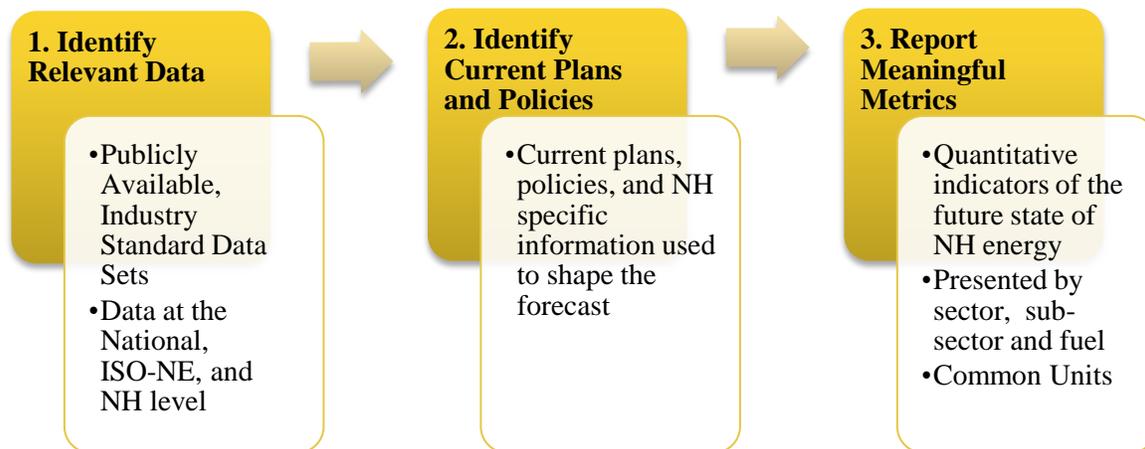


Figure 1: Baseline Energy Forecast Methodology

The baseline energy forecast was developed using publicly available, industry standard sources of data reported at the national, regional, and state level. When those sources of data did not directly report at the state level or account for the most recent plans, policies, and regulations affecting New Hampshire, the forecasts were adjusted and the relevant assumptions documented. A baseline forecast was prepared for the electric, thermal, and transportation sectors, and broken into the residential, commercial, and industrial consumer groups as appropriate. The forecast for each sector captures energy demand, prices, and key changes in infrastructure related to the supply, demand, and distribution of energy in New Hampshire. The forecast metrics were selected to provide insight into key drivers of energy consumption within a given sector as well as to facilitate comparisons between sectors.

A.3 Electric Sector Forecast

New Hampshire’s electric grid is part of a larger network operated by the Independent System Operator of New England (ISO-NE). ISO-NE is a regional transmission organization (RTO) which manages the coordinated dispatch of power generation and directs the flow of electricity across the region’s interstate transmission system. In this network, power generated in New Hampshire may serve electric loads in other states while loads in New Hampshire are served by power generated in

other states. This regional organization provides grid operators with greater flexibility to meet power needs than on a state-by-state basis, increasing the overall reliability and efficiency of the system. It is within this context that New Hampshire’s electric use, production, and policy options must be considered.

Electric Sector Model

Navigant’s proprietary portfolio optimization model (POM) was used to develop a baseline electric sector forecast for New Hampshire individually and for the entire ISO-New England territory, in order to capture the regional nature of supply and demand (as described above) and its impacts on the dispatch and development of power generation assets over time. The POM optimizes the dispatch of power generation assets and the build-out of new power generation units, to meet load requirements and renewable portfolio standards (RPS) while staying within system operating constraints.

The POM relies on input from a variety of publicly available sources of data and existing policies. The sources of data, existing plans and policies, and reporting metrics developed for and derived from POM are highlighted below.

Data Sources	Plans & Policies	Key Metrics
<ul style="list-style-type: none"> • EIA AEO • Ventyx Generation and T&D Database • Energy Velocity • ISO-NE CELT 2012 Report • DSIRE • Navigant Fuel Price Forecast 	<ul style="list-style-type: none"> • NH RPS and Off-Ramps • ISO-NE Regional System Plan 2012 • EPA Rules for SO_x, NO_x, and CO₂ (proposed 2014): assumes no new coal • RGGI-New Cap • Established Contracts (PPAs) for Renewables 	<ul style="list-style-type: none"> • In-State Capacity (MW) • Power Generation (GWh and BBtu) • Fuel Prices (\$/MBtu) • Wholesale Price (\$/kWh) • Load (GWh and BBtu) • Peak Load (MW) • Expenditures (\$Million) • Emissions (MT)

Figure 2: Electric Sector Data Sources, Plans & Policies, and Key Metrics¹

Electric Sector Key Assumptions

In addition to the data sources and existing policies listed above, several key assumptions impact the electric sector model, including:

- RPS – Informed by an analysis of the costs of meeting the RPS as currently formulated, the POM assumes that the costs will be contained through existing mechanisms such as alternative compliance payments (ACPs) and other state actions such as the Public Utilities Commission (PUC) making adjustments to requirements for various classes of renewable energy. The model is agnostic as to the actual mechanism of cost containment, but the end result is that renewable power generation as currently classified by the PUC is forecasted to meet between 60 and 90 percent of current RPS targets, depending on the quantity of Renewable Energy Credits (RECs) sold out of state.
- Carbon Prices – The POM assumes a \$10/ton tax on CO₂ starting in 2018, as proposed by the EPA. For reference, the carbon price per ton in the most recent RGGI auction was \$4.²
- Planned Retirements – The model reflects the retirements of the Vermont Yankee nuclear plant and the Brayton Point coal plant in Massachusetts (both announced in 2013). Other

¹ See A.7 Baseline Energy Forecast – Supporting Data for links to primary data sources

² http://www.rggi.org/docs/Auctions/23/PR030714_Auction23.pdf.

possible retirements were not modeled. The model assumes that the Seabrook Station nuclear power plant receives its pending license extension and remains in operation through 2030.

- Transmission Expansion – The model assumes new transmission capacity will be constructed to provide imported power to New England.

Electric Sector Baseline Forecast Results

Using the methodology described above, Navigant’s forecast of power generation infrastructure in New Hampshire under the “business as usual scenario” is shown in Figure 3: Baseline Forecast of In-State Power Generation.

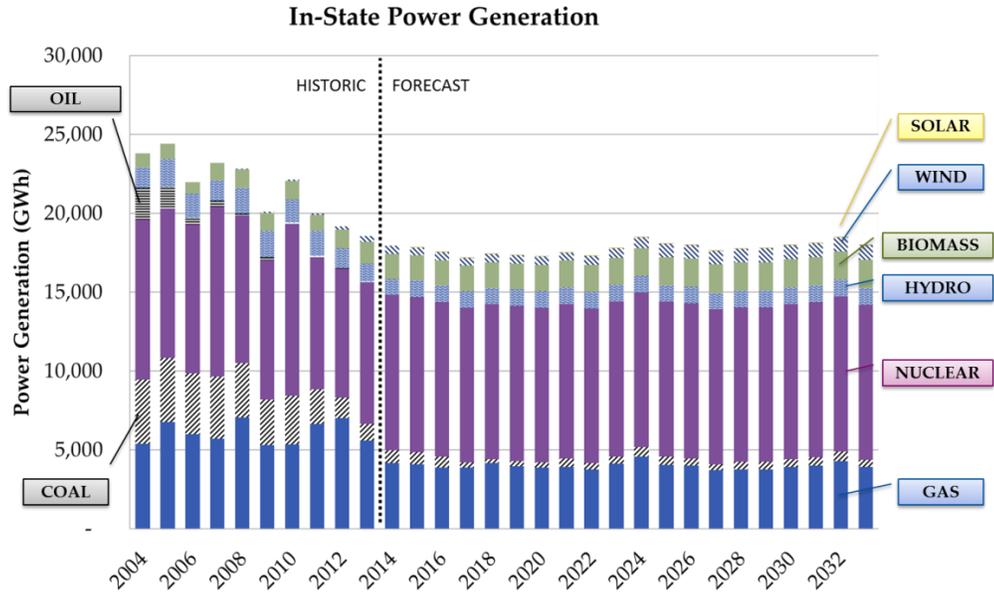


Figure 3: Baseline Forecast of In-State Power Generation³

In the baseline forecast, the utilization of particular power plant technologies is driven primarily by fuel prices and environmental regulations. In recent years, there has been a substantial reduction of oil and coal fired power generation in the region.⁴ Total power generation is expected to remain predominantly flat over the forecast period, as increasing in-state demand is offset by lower net exports, which is attributed to increasing energy efficiency in neighboring states.

The forecast shows that 20.1 percent of in-state power generation will come from renewable resources by 2025, shy of the RPS target of 24.8 percent. This discrepancy may be even greater if the number of RECs sold out of state is higher than forecast. However, as noted above, the RPS is structured so that New Hampshire electric providers (utilities and competitive suppliers) can be in compliance with RPS requirements through the purchase of qualifying RECs from resources elsewhere in the region, or through the payment of ACPs. In addition, it is important to reiterate that because New Hampshire is a part of the regional grid, the in-state generation mix is driven in part by regional needs and policies, such as the forward capacity market and the RPS policies of other states.

³ Baseline forecast of in-state power generation based on Navigant analysis of source data included in A.7 Baseline Energy Forecast – Supporting Data.

⁴ ISO-NE 2013 Regional System Plan – Section 1.2 Overview of the Results of System and Strategic Planning Studies available at: <http://www.iso-ne.com/trans/rsp/>

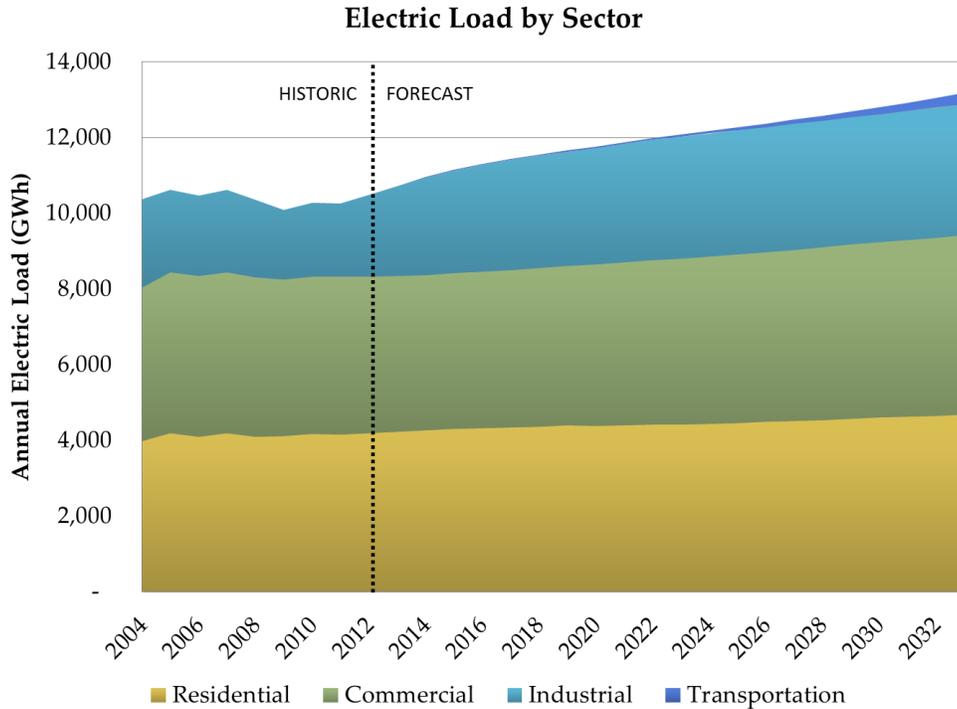


Figure 4: Electric Demand by Sector⁵

In contrast to the relatively flat growth of in-state power generation over the forecast period, demand for electric power in New Hampshire is forecast to rise in all sectors, resulting in lower net exports of electricity through the forecast period. Electric demand in the residential and commercial sectors is expected to grow more slowly than in the industrial sector, as increases in population (0.4 percent annual growth through 2025⁶), housing stock, and commercial building space are offset by modest gains in appliance and building energy efficiency (recent savings of 0.64 percent annually⁷). Despite an economic shift in New Hampshire from manufacturing industries to information technology, the increasing use of electricity to power equipment (replacing other fuels) is expected to increase demand in the industrial sector over the forecast period. Electric vehicles are also expected to contribute to a small increase in demand in the later years of the forecast period.

Despite increasing demand for electricity in New Hampshire, overall emissions associated with power generation are forecast to remain flat through the remainder of the forecast period as the power generation mix becomes cleaner. In recent years, emissions have declined considerably in response to stringent regulations and falling prices for natural gas, which resulted in the retirement of coal-fired power plants in favor of increased regional usage of cleaner-burning gas. In light of the regional nature of energy distribution across ISO-NE, New Hampshire’s emissions from power generation are estimated as a weighted share of total regional emissions, based on the state’s share of regional electricity demand. The resulting emissions forecast is shown in Figure 5: Emissions from Electric Power Generation.

⁵ Baseline forecast of electric demand by sector based on Navigant analysis of source data included in A.7 Baseline Energy Forecast – Supporting Data.

⁶ <http://www.nh.gov/oep/data-center/population-projections.htm>

⁷ <http://www.aceee.org/files/pdf/state-sheet/2013-spending-and-savings-tables.pdf>

**Emissions from Electric Power Generation
(NH demand share of ISO-NE emissions)**

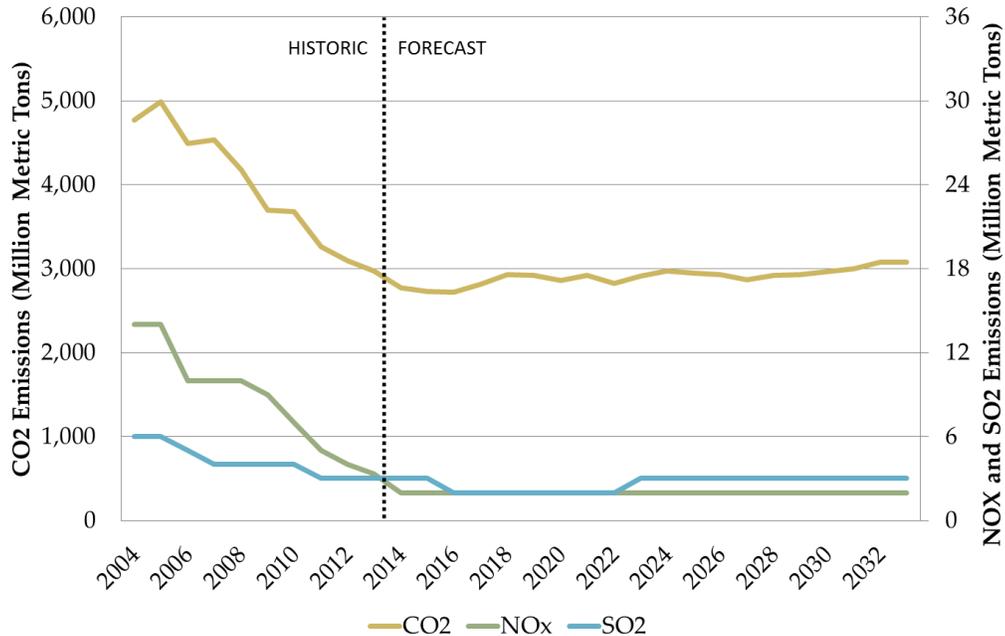


Figure 5: Emissions from Electric Power Generation⁸

Although New Hampshire may have little impact on total regional emissions, reducing in-state demand through energy efficiency and the use of distributed resources represents a valuable opportunity to reduce emissions that is within the control of the state’s policymakers, residents, and businesses.

The interconnected nature of power generation and demand between states in the region, including the interplay between state’s RPS policies, REC pricing, and ACPs, can have a profound impact on the mix of New Hampshire’s in-state power generation. For this reason, it is critical for New Hampshire to continue its active participation in the regional markets at the regional level. Additionally, efforts to promote reduce demand through energy efficiency and as well as promoting the use of smaller, distributed resources are both represent opportunities to reduce emissions that are well within the control of the state’s policymakers, residents, and businesses.

A complete collection of charts detailing the baseline electric forecast can be found in A.7 Baseline Energy Forecast – Supporting Data.

A.4 Thermal Sector Forecast

Thermal Sector Model

The thermal sector forecast relied heavily on the US Department of Energy (DOE) Energy Information Administration (EIA) State Energy Data Set (SEDS) and Annual Energy Outlook (AEO). The forecast was further informed by gas utilities, home heating oil (HHO) distributors, geothermal installers, and those involved with wood pellet heating programs. For the portion of the thermal

⁸ Baseline forecast of emissions from electric power generation based on Navigant analysis of source data included in A.7 Baseline Energy Forecast – Supporting Data.

sector that relies on electricity as an energy source, the forecast used information from the US DOE Building Energy Data Book to identify the fraction of residential and commercial electric demand attributed to thermal applications including space heating, water heating, and cooking.

The data sources, existing programs, and key metrics are listed in Figure 6: Thermal Sector Data Sources, Plans & Policies, and Key Metrics.

Data Sources	Plans & Policies	Key Metrics
<ul style="list-style-type: none"> • EIA AEO • EIA SEDS • BEA • DSIRE • DOE EERE • DOE Building Energy Data Book • Natural Gas & HHO Distribution Interviews 	<ul style="list-style-type: none"> • NH RPS (Thermal Carve-out) • CORE NH Energy Efficiency Programs • NH incentives for biomass, solar, and geothermal 	<ul style="list-style-type: none"> • Consumption (BBtu) • Fuel Price (\$/MBtu) • Expenditures (\$Million) • Emissions (MT)

Figure 6: Thermal Sector Data Sources, Plans & Policies, and Key Metrics⁹

Thermal Sector Key Assumptions

In addition to the data sources and existing plans and policies listed above, several key assumptions impact the thermal sector model. These include:

- Expansion of Natural Gas Distribution – Based on information from New Hampshire’s gas utilities, minimal additional expansion of conventional natural gas distribution infrastructure is expected over the forecast period. Additionally, trucked delivery of natural gas to off-main customers via a “virtual pipeline” is not expected to represent an appreciable quantity of thermal fuel consumption through the forecast period, though the service is expanding in the state.
- Current Levels of Thermal Electrification – The DOE Building Energy Data Book reports the breakdown of thermal demand by application and fuel type (electric and other thermal fuels) on a national level. Given the low market penetration of advanced electric thermal technologies (including both air source and ground source heat pumps), it was assumed that this breakdown is a reasonable estimate for New Hampshire and as such was not changed.

Thermal Sector Baseline Forecast Results

In reaction to increasing fuel prices, thermal energy consumption is forecast to decline in the residential sector owing to gains in energy efficiency. The decline is the greatest for those who use oil heat, and is enabled by fuel switching (primarily to wood) and through the implementation of high efficiency retrofits. Though not as pronounced, demand for oil heat in the commercial sector is also expected to decline over the forecast period. However, in contrast to the residential sector, this decline is more than offset by an increase in the consumption of natural gas due to anticipated growth in the commercial sector in on-main areas. Overall demand for thermal energy in the industrial sector is forecast to remain flat.

⁹ See A.7 Baseline Energy Forecast – Supporting Data for links to primary data sources

Thermal Energy Consumption by Sector

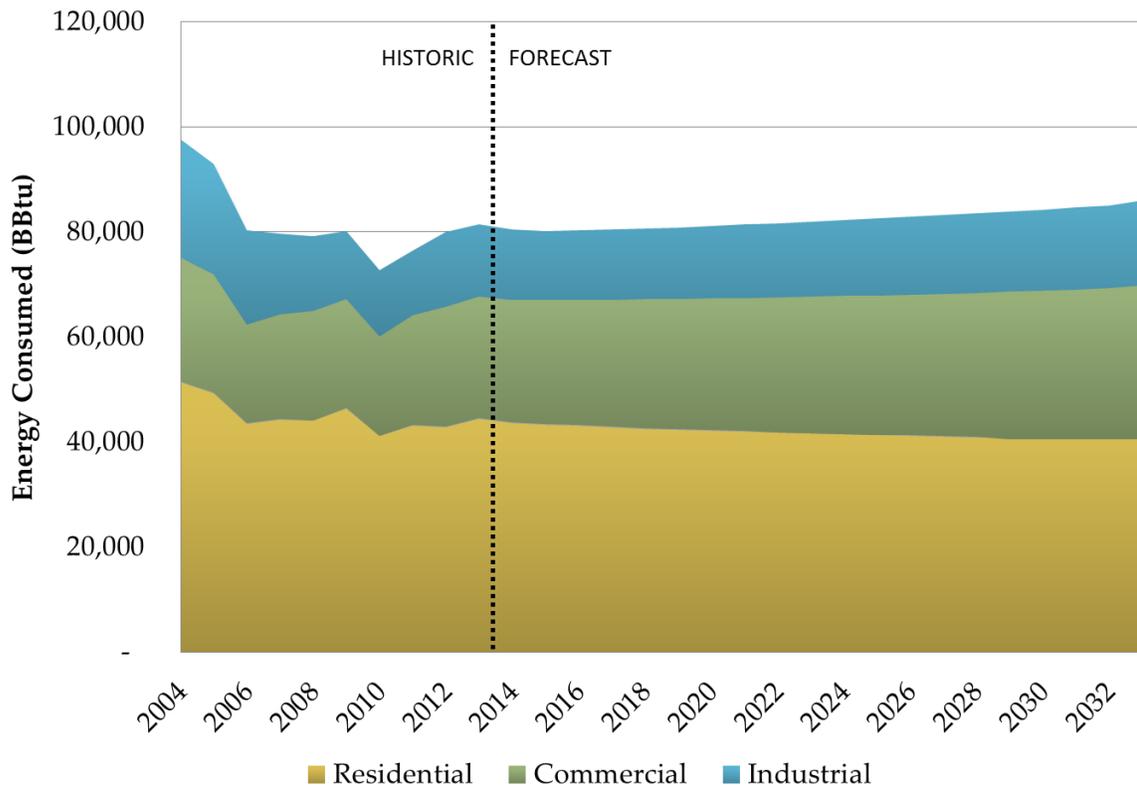


Figure 7: Thermal Energy Consumption by Sector¹⁰

¹⁰ Baseline forecast of thermal energy consumption by sector based on Navigant analysis of source data included in A.7 Baseline Energy Forecast – Supporting Data.

Thermal Fuel Expenditures by Sector

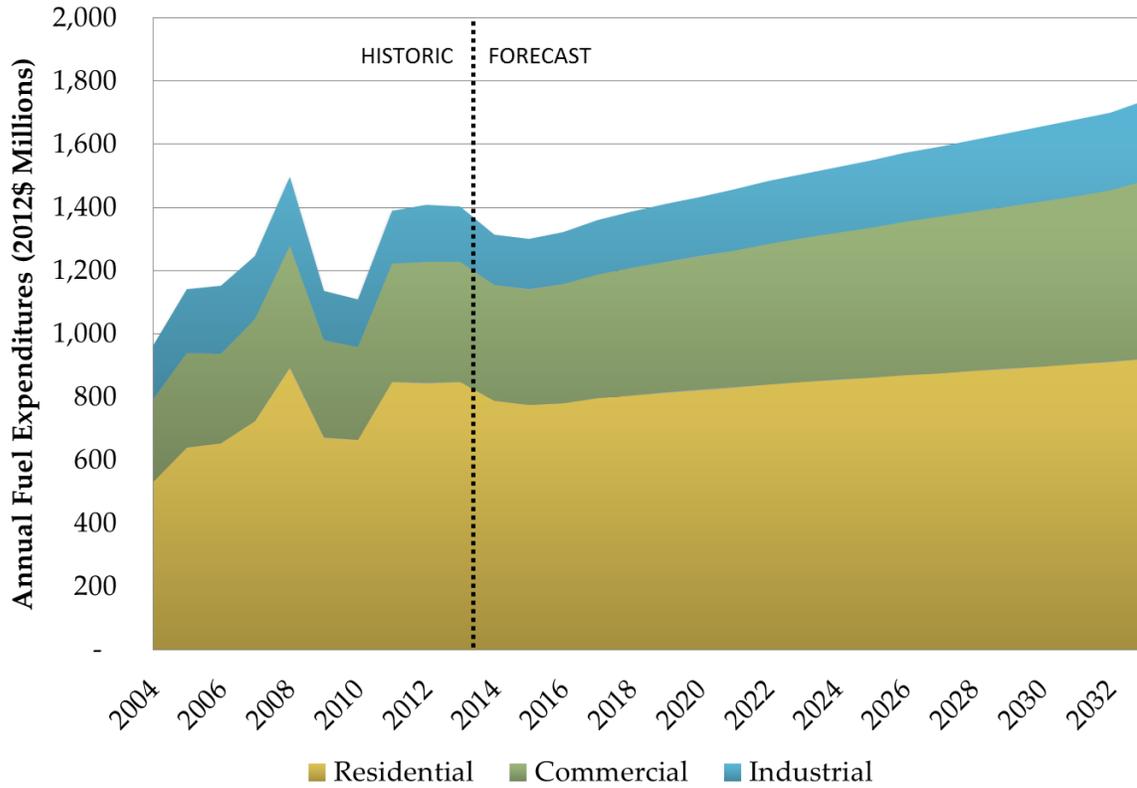


Figure 8: Thermal Fuel Expenditures by Sector¹¹

As shown in Figure 7 and Figure 8, despite flat demand for thermal energy through the forecast period, rising fuel prices are forecast to contribute to substantially higher overall thermal energy expenditures. New Hampshire has little ability to influence fuel prices, but should help contain these rising costs by investing in efficiency and small-scale distributed resources. This will provide residents and businesses in New Hampshire with greater flexibility in meeting their home and business thermal needs and protection from future fuel price volatility.

A complete collection of charts detailing the baseline thermal energy forecast can be found in A.7 Baseline Energy Forecast – Supporting Data.

¹¹ Baseline forecast of thermal fuel expenditures by sector based on Navigant analysis of source data included in A.7 Baseline Energy Forecast – Supporting Data.

A.5 Transportation Sector Forecast

Transportation Sector Model

To forecast the fuel consumption profile for the transportation sector, Navigant used a rolling stock model of New Hampshire’s overall fleet, tracking changes in demographics, vehicle price projections, and available technology. This model relied in part on vehicle registrations from the US and NH Departments of Transportation, fuel consumption information from the EIA AEO, the National Highway Traffic Safety Administration (NHTSA) Summary of Fuel Economy Performance, and information on available transportation technology from DOE’s Office of Energy Efficiency & Renewable Energy (EERE). This model was used in concert with the vehicle miles traveled (VMT) forecast for the state which relied on data from the Federal Highway Administration’s (FHWA) Traffic Volume Trends database, historic and forecasted population from New Hampshire’s Office of Energy and Planning (OEP), and gross state product data from the Bureau of Economic Analysis (BEA).

A complete list of data sources, plans & policies, and key metrics for the transportation sector is shown in Figure 9: Transportation Sector Data Sources, Plans & Policies, and Key Metrics.

Data Sources	Plans & Policies	Key Metrics
<ul style="list-style-type: none"> • EIA AEO • DSIRE • NHSTA • FHWA • BEA • DOE EERE • US and NH DOT 	<ul style="list-style-type: none"> • EPA CAFE Standards • EPA Ethanol Mandate • EV Tax Credits • NH incentives for AFVs 	<ul style="list-style-type: none"> • Fuel Economy (MPG and MPGe) • Expenditures (\$Million) • Price (\$/MBTU) • Fuel Consumption (BBTU) • Emissions (MT) • Vehicle Miles Traveled (VMT)

Figure 9: Transportation Sector Data Sources, Plans & Policies, and Key Metrics¹²

Transportation Sector Key Assumptions

In addition to the data sources and existing policies listed above, several key assumptions impact the transportation sector model. These include:

- Recent trends in the relationship between VMT, population growth, and economic activity continue through the forecast period. Correcting for recent periods of economic fluctuation as derived from the Bureau of Economic Analysis (BEA), Navigant identified a small but upward trend (0.1 percent) for growth in per capita VMT.
- The price premium for alternative fuel vehicles (AFVs) – The price premium for AFV’s is based on a survey of prices for AFVs and their incremental upfront cost relative to industry counterpart conventional fuel (gasoline powered) vehicles. Based on recent trends in price premiums, Navigant assumes a decline in this price premium at a rate of 5 percent annually over the forecast period.

Transportation Sector Baseline Forecast Results

Nearly 90 percent of New Hampshire’s fleet is comprised of light duty gasoline powered vehicles. The fuel economy of this segment, determined by federal corporate average fuel economy (CAFE)

¹² See A.7 Baseline Energy Forecast – Supporting Data for links to primary data sources

standards, represents the single largest driver affecting energy consumption and emissions in the transportation sector. Modest increases in fuel economy over the forecast period are shown in Figure 10: Transportation Fleet Average Fuel Economy.

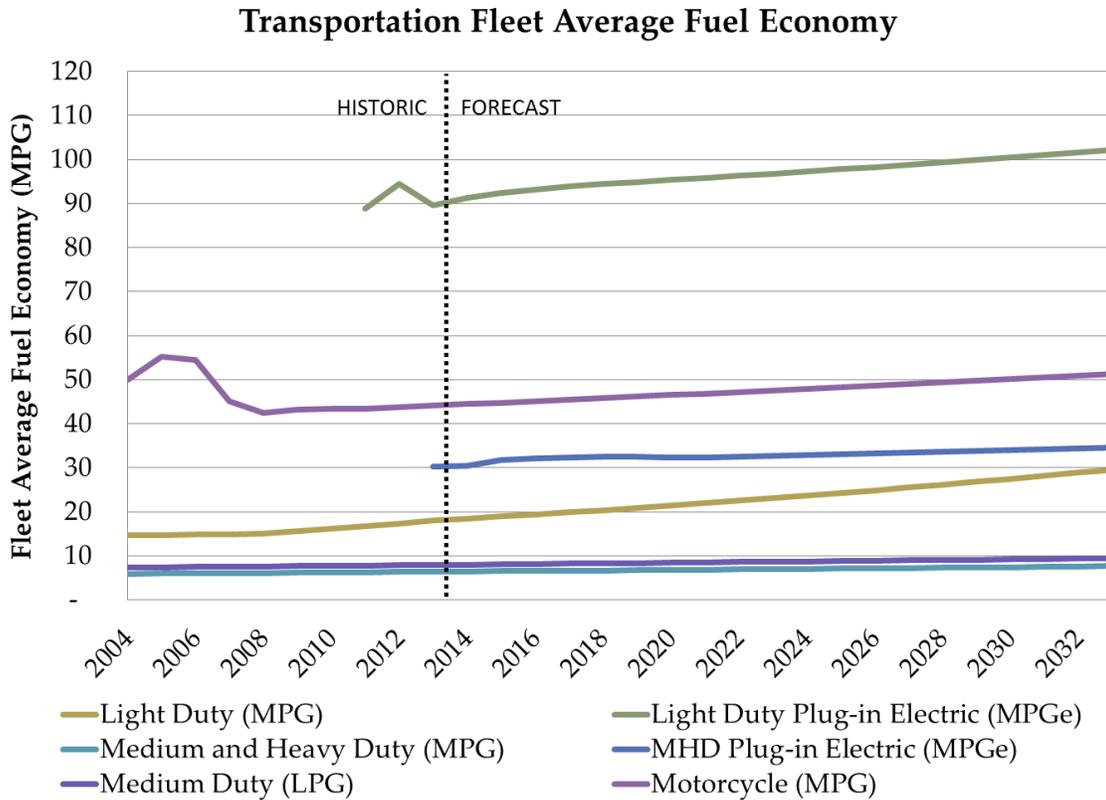


Figure 10: Transportation Fleet Average Fuel Economy¹³

The second largest driver affecting energy consumption and emissions is the use of plug-in electric vehicles. Plug-in electric vehicles dominate the alternative fuel vehicle (AFV) category in the baseline forecast, but only account for a small fraction (7.5 percent) of total vehicle miles traveled by the end of the 20-year forecast period as shown in Figure 11: Transportation Sector Vehicle Miles Traveled.

¹³ Baseline forecast of transportation fleet average fuel economy based on Navigant analysis of source data included in A.7 Baseline Energy Forecast – Supporting Data.

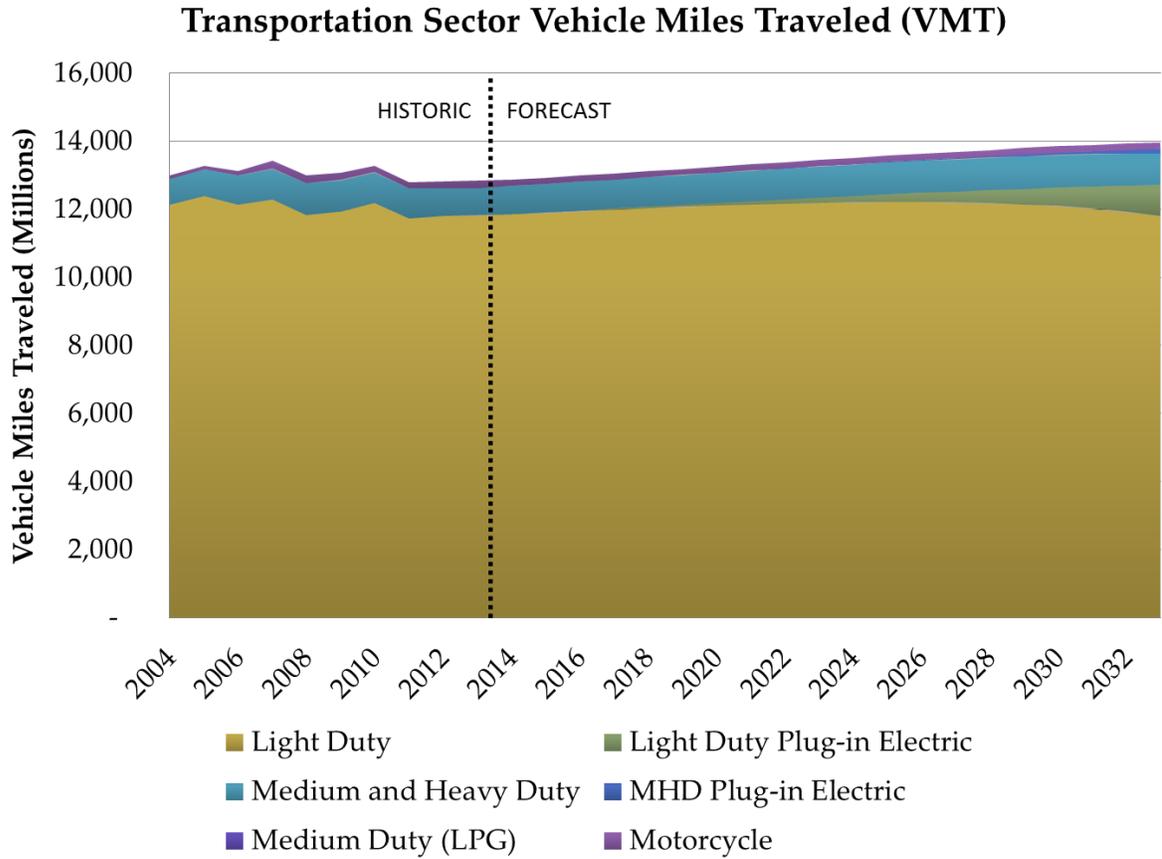


Figure 11: Transportation Sector Vehicle Miles Traveled¹⁴

Despite the improvement in light duty vehicle fuel economy, the modest adoption of alternative fuel vehicles over the forecast period, and the small increase in overall vehicle miles traveled, the total fuel related expenditures are still forecast to rise substantially, topping \$3 billion in 2028 (see Figure 12: Transportation Sector Fuel Expenditures).

¹⁴ Baseline forecast of transportation sector vehicle miles traveled based on Navigant analysis of source data included in A.7 Baseline Energy Forecast – Supporting Data.

Transportation Sector Fuel Expenditures

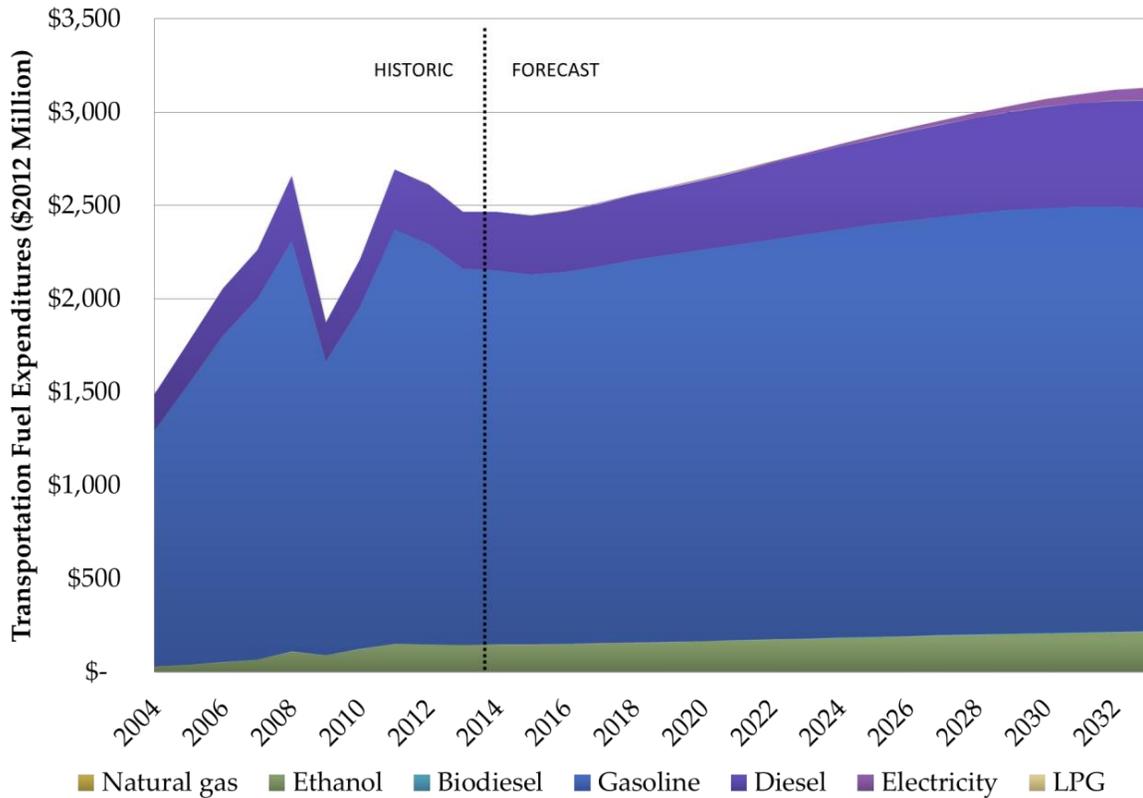


Figure 12: Transportation Sector Fuel Expenditures¹⁵

This is due to the impact of increasing fuel prices on total fuel expenditures through the forecast period, more than offsetting gains in efficiency. The fuel price-driven increase in expenditures makes adopting the highest efficiency vehicles and reducing vehicle miles traveled all the more crucial to managing costs in the transportation sector.

A complete collection of charts detailing the baseline transportation energy forecast can be found in: A.7 Baseline Energy Forecast – Supporting Data.

¹⁵ Baseline forecast of transportation sector fuel expenditures based on Navigant analysis of source data included in A.7 Baseline Energy Forecast – Supporting Data.

A.6 Summary of the Baseline Forecast

New Hampshire’s overall demand for electric and thermal energy is constant during the forecast period, decreasing demand for energy in the transportation sector contributes to an overall decline in total energy demand across the state (see Figure 13: Per Capita Energy Demand by Sector). However, the cost of fuel for power generation, thermal energy, and transportation needs is rising. These rising costs more than offset the decline in demand, leading to higher overall expenditures for consumers (see Figure 14: Per Capita Energy Expenditures by Sector).

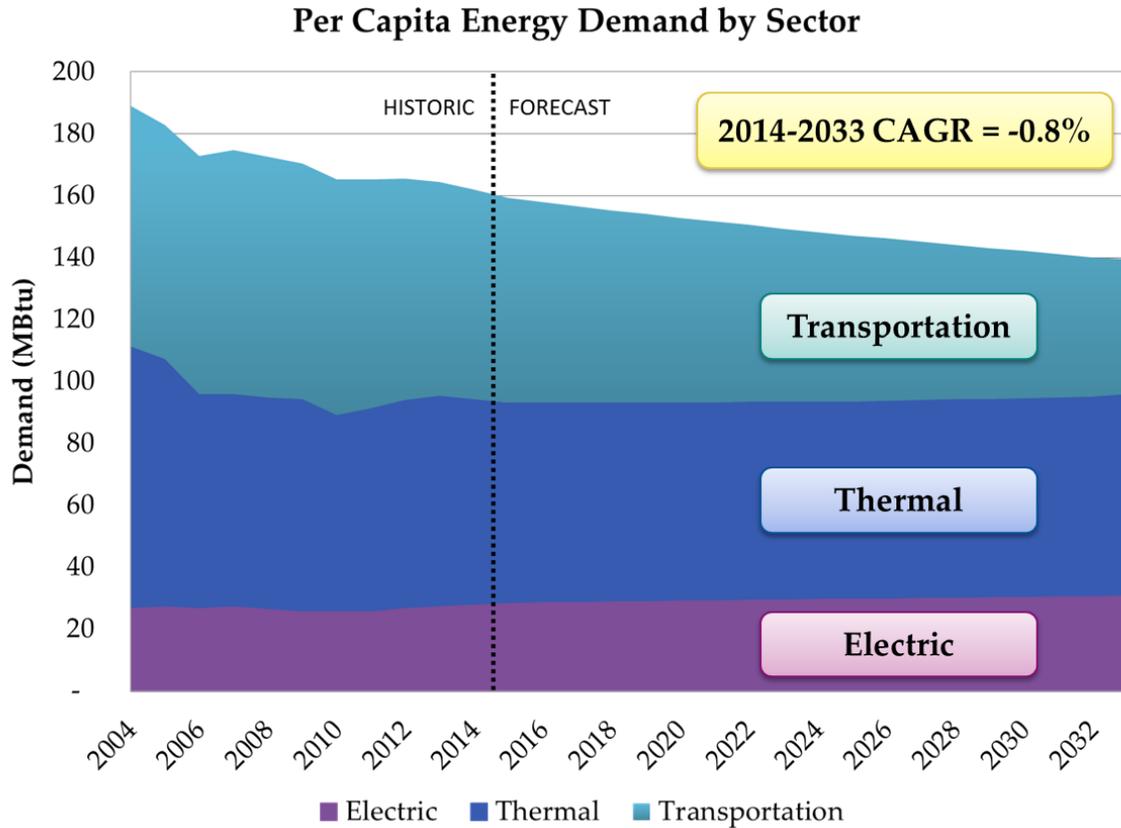


Figure 13: Per Capita Energy Demand by Sector¹⁶

¹⁶ Baseline forecast of per capita energy demand by sector based on Navigant analysis of source data included in A.7 Baseline Energy Forecast – Supporting Data.

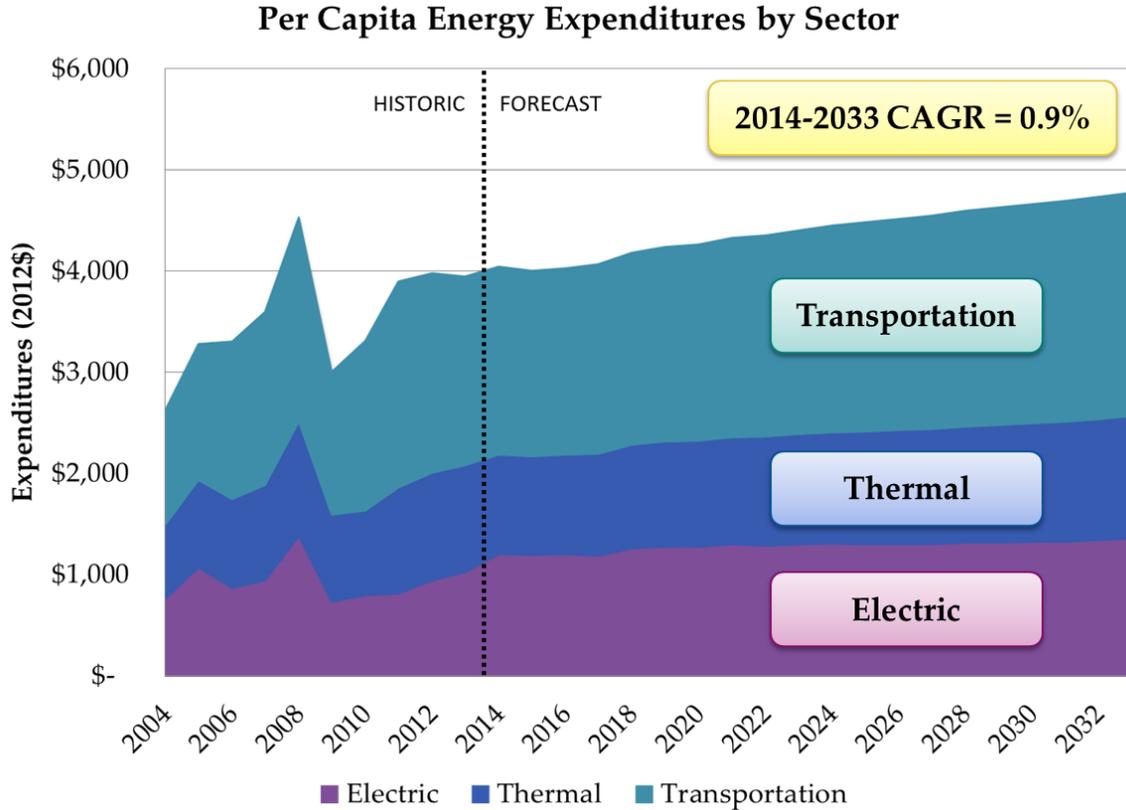


Figure 14: Per Capita Energy Expenditures by Sector¹⁷

These trends are expected to hold throughout the forecast period. In addition to the general upward trend of fuel prices, fuel price volatility poses an additional challenge. New Hampshire’s aging building stock, constrained supply infrastructure, and dispersed population make the state especially vulnerable to short-term price spikes and supply disruptions.

Rising costs and vulnerability to rapid market changes make the goals identified in the energy vision all the more pressing for New Hampshire.

A complete collection of summary charts detailing the baseline energy forecast can be found in A.7 Baseline Energy Forecast – Supporting Data.

¹⁷ Baseline forecast of per capita energy expenditures by sector based on Navigant analysis of source data included in A.7 Baseline Energy Forecast – Supporting Data.

A.7 Baseline Energy Forecast – Supporting Data

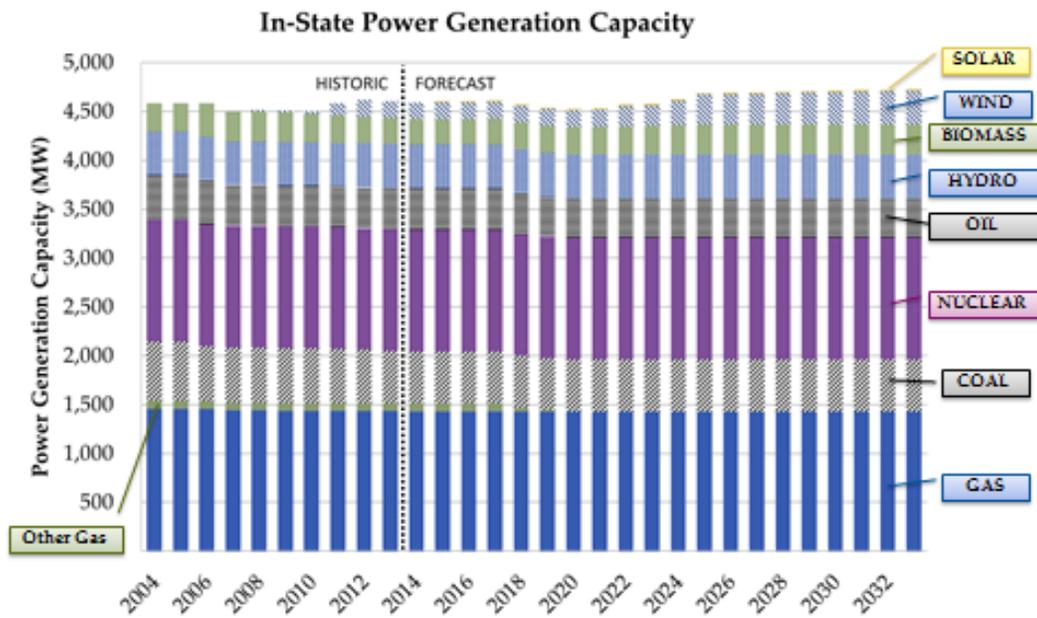
Baseline Forecast Source Data and Plans & Policies

Data Sets	Web Address
EIA AEO	http://www.eia.gov/forecasts/AEO/
BEA	http://www.bea.gov/regional/
DOE Building Energy Data Book	http://buildingsdatabook.eren.doe.gov/
DOE AFDC	http://www.afdc.energy.gov/
DSIRE	http://www.dsireusa.org/
EIA SEDS	http://www.eia.gov/state/seds/
Energy Velocity (Ventyx)	http://www.ventyx.com/en/solutions/energy-markets
FHWA	http://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm
ISO-NE CELT 2012 Report	http://www.iso-ne.com/trans/celt/report/
NHSTA	http://www.nhtsa.gov/NCSA

Plans & Policies	Web Address
NH RPS	http://www.puc.state.nh.us/sustainable%20Energy/Renewable_Portfolio_Standard_Program.htm
ISO-NE Regional System Plan 2012	http://www.iso-ne.com/trans/rsp/
EPA Rules for SO _x , NO _x , and CO ₂	http://www.epa.gov/mats/actions.html
RGGI-New Cap	http://www.rggi.org/design/overview/cap
NH CORE Efficiency Programs	http://www.puc.state.nh.us/electric/coreenergyefficiencyprograms.htm
EPA CAFE Standards	http://www.epa.gov/fueleconomy/regulations.htm
EPA Ethanol Mandate	http://www.epa.gov/OTAQ/fuels/renewablefuels/
Federal EV Tax Credits	http://www.afdc.energy.gov/laws/law/US/409

Electric Sector Charts

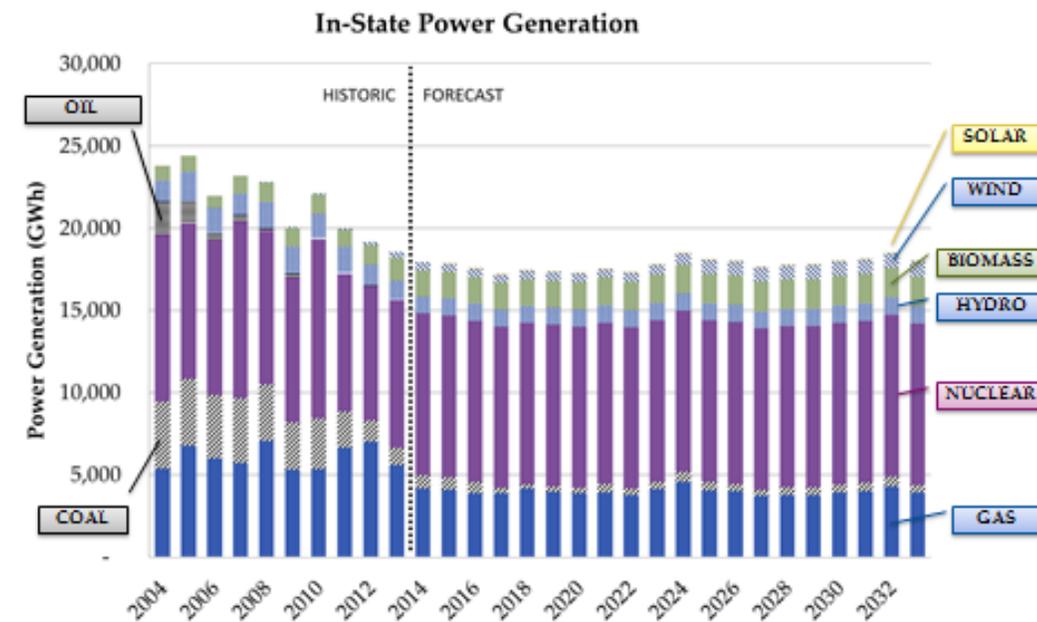
New Hampshire State Energy Strategy » Electric Sector Forecast » Capacity



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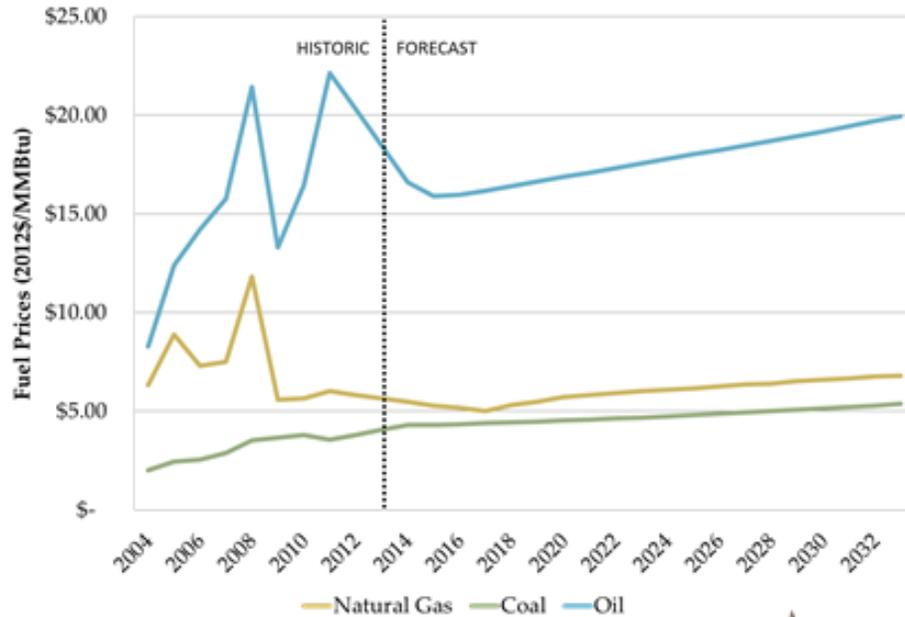
New Hampshire State Energy Strategy » Electric Sector Forecast » Generation



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Price of Fuels used in Power Generation

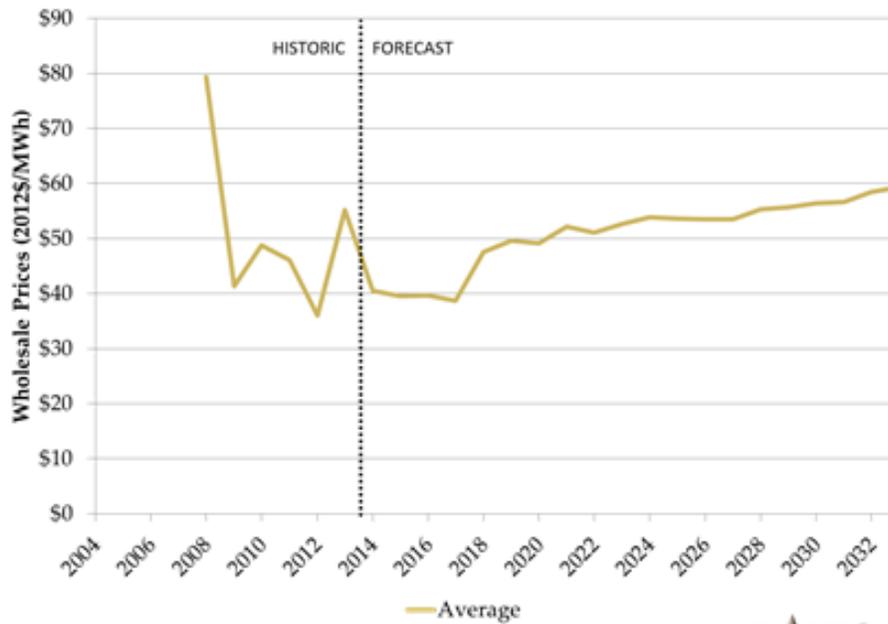


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Average Wholesale Electric Prices

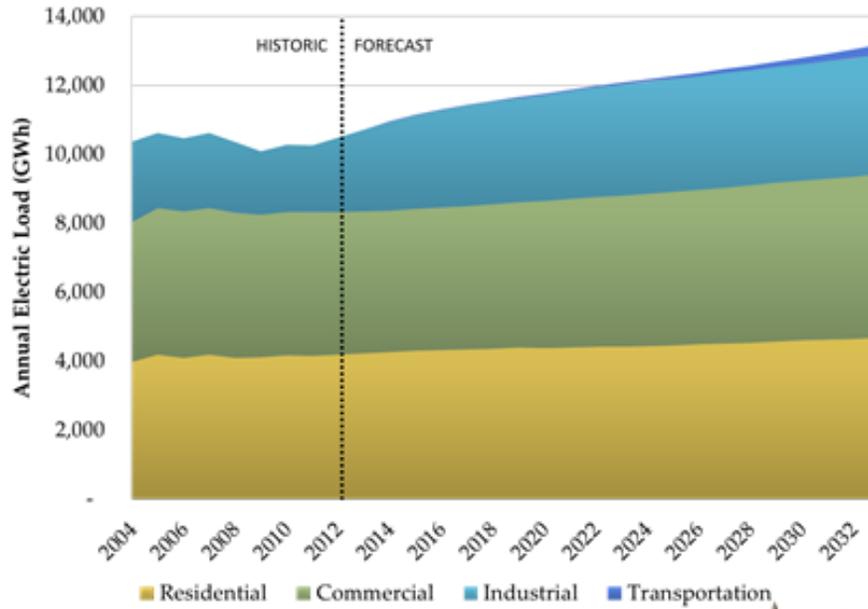


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Electric Load by Sector

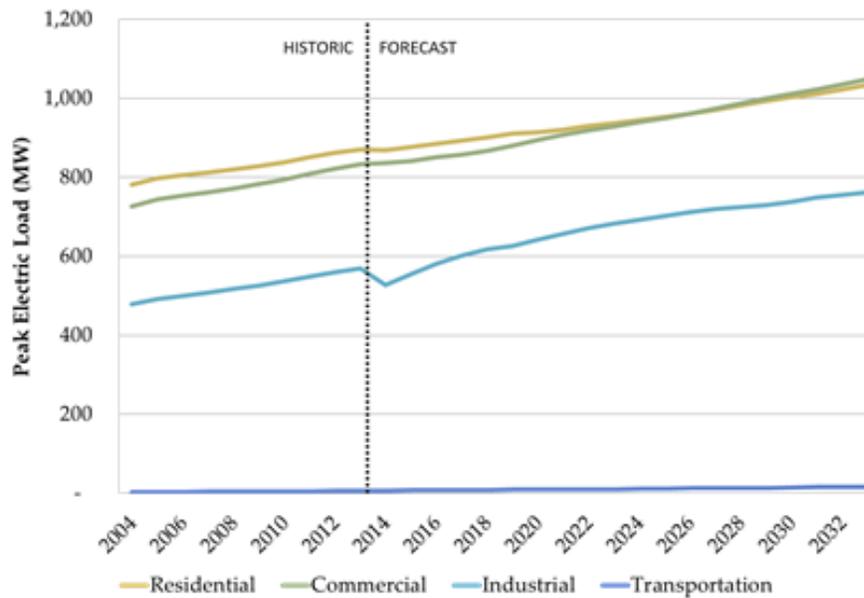


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Peak Load by Sector

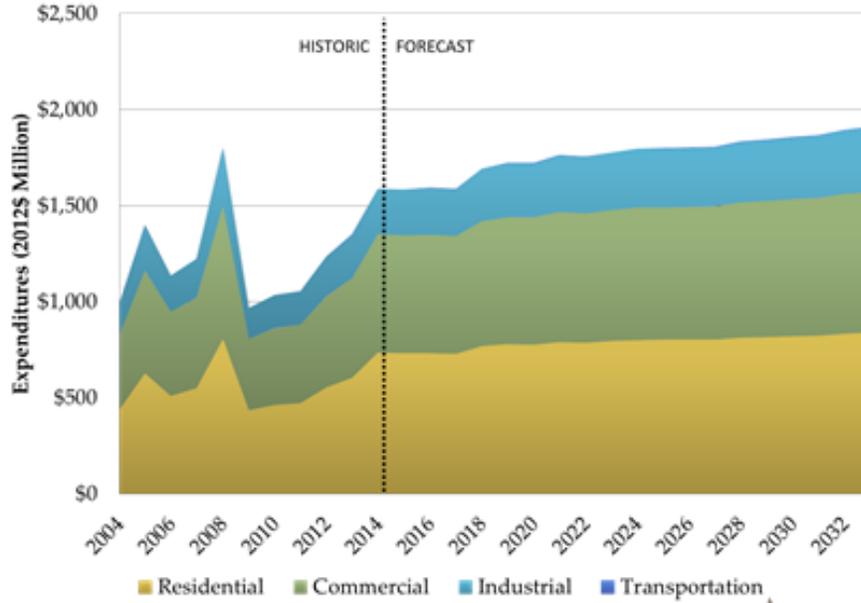


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Annual Electric Expenditures

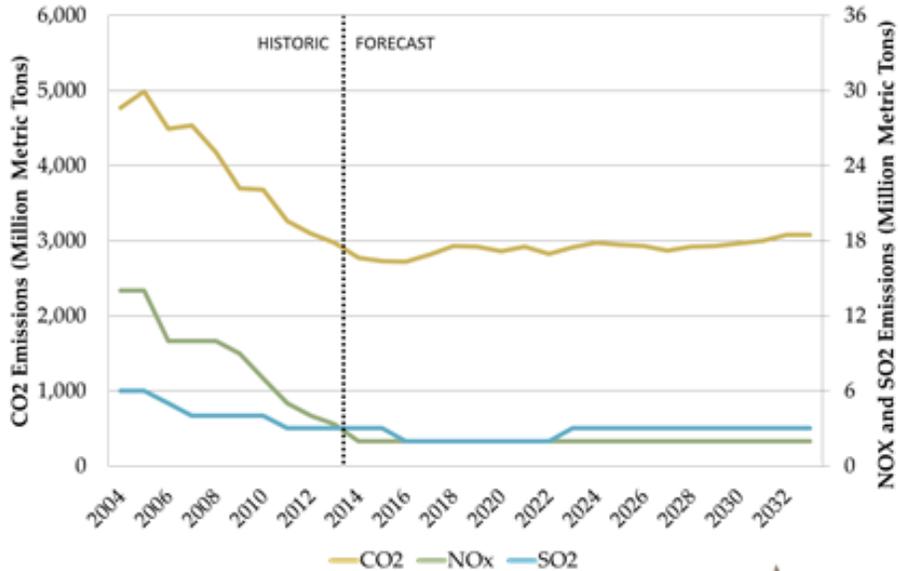


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Emissions from Electric Power Generation
(NH demand share of ISO-NE emissions)



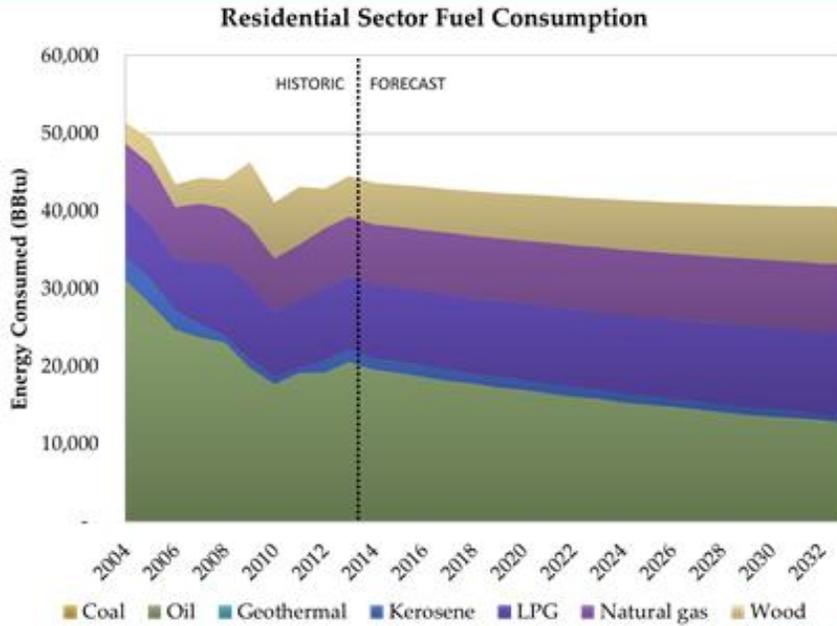
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Thermal Sector Charts

New Hampshire State Energy Strategy » Thermal Sector Forecast » Residential Consumption

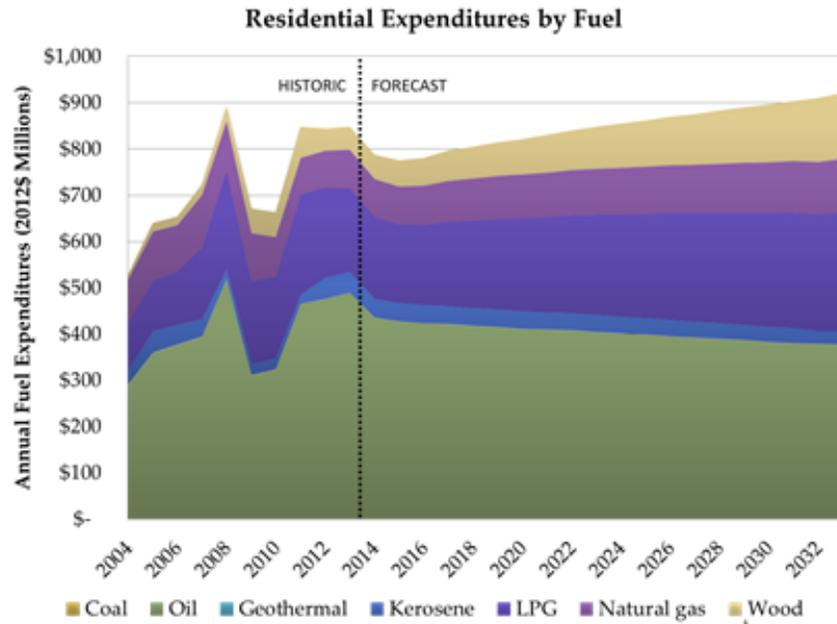


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New Hampshire State Energy Strategy » Thermal Sector Forecast » Residential Expenditures

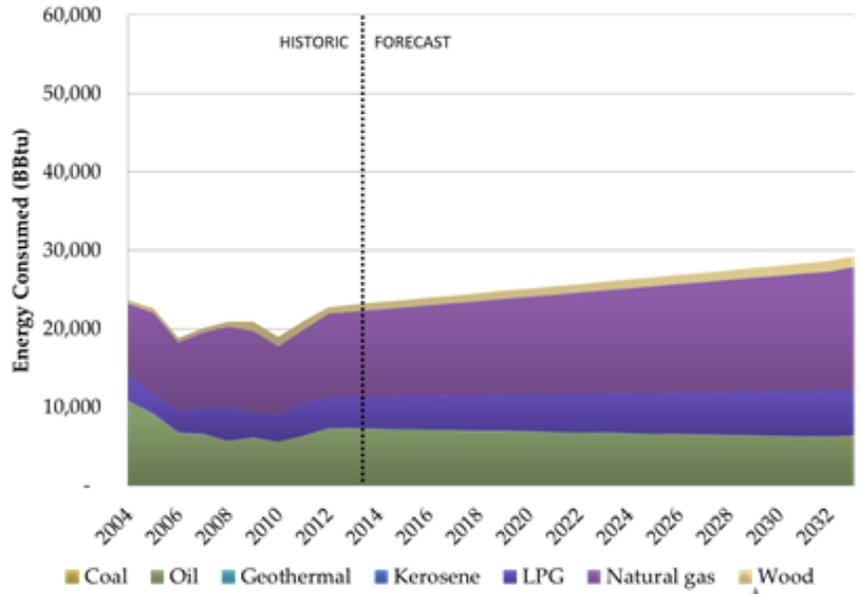


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Commercial Sector Fuel Consumption

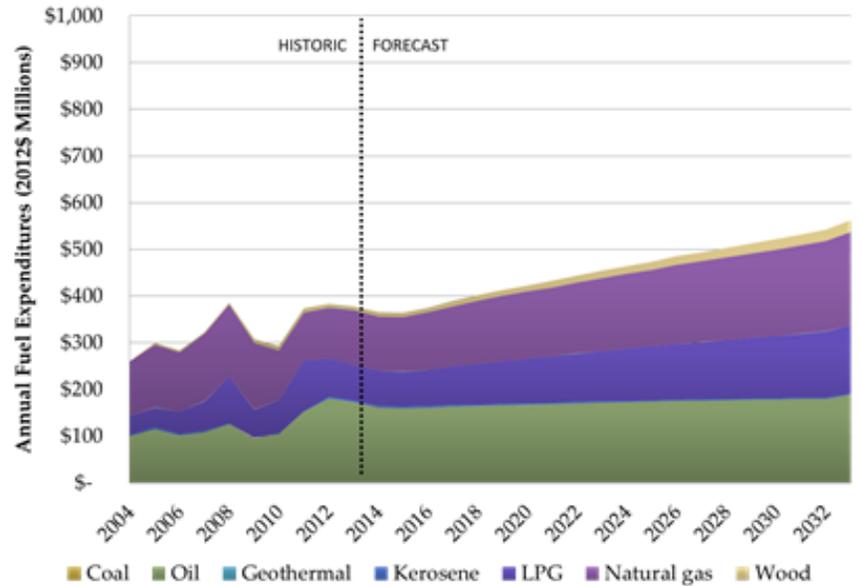


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Commercial Expenditures by Fuel

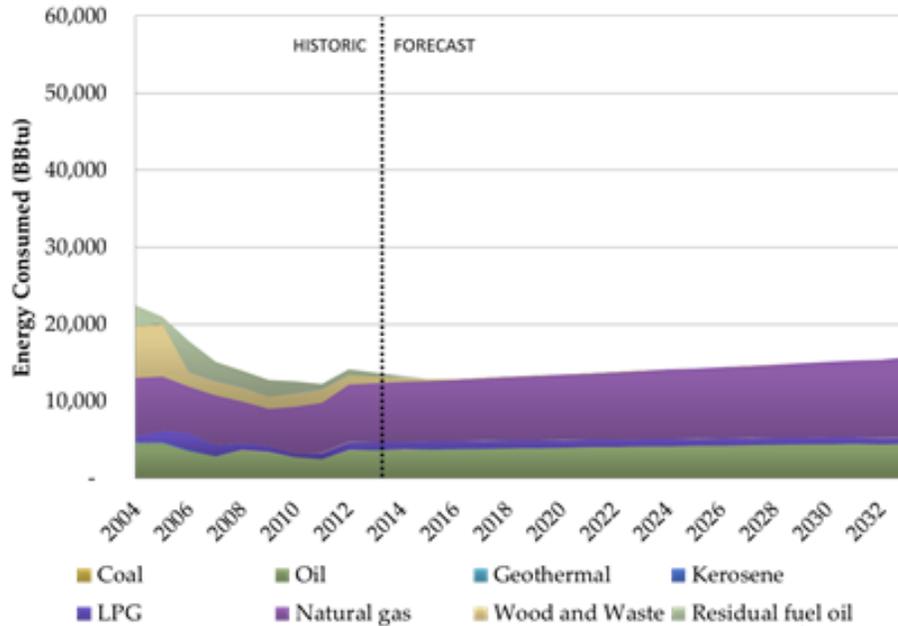


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Industrial Sector Fuel Consumption

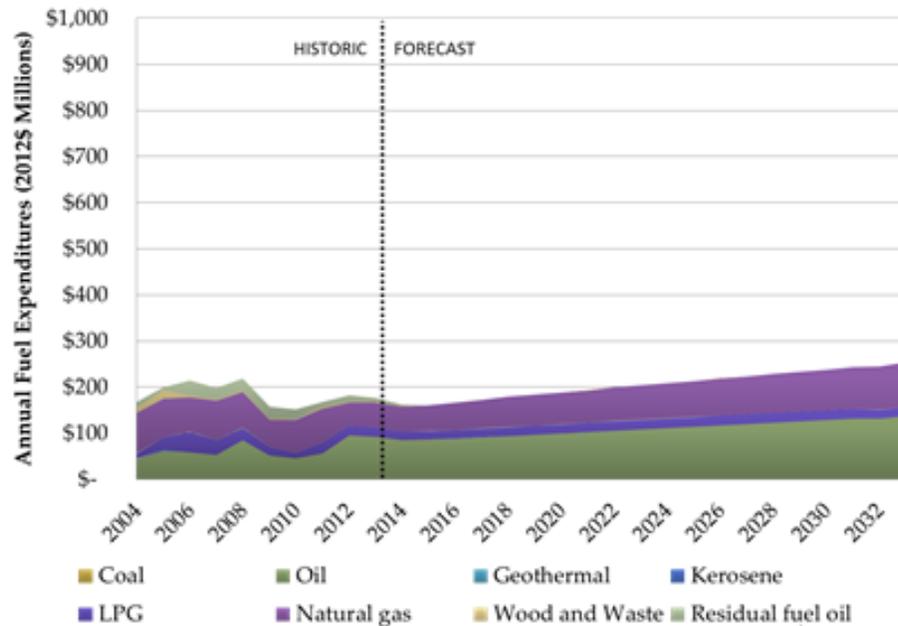


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Industrial Expenditures by Fuel

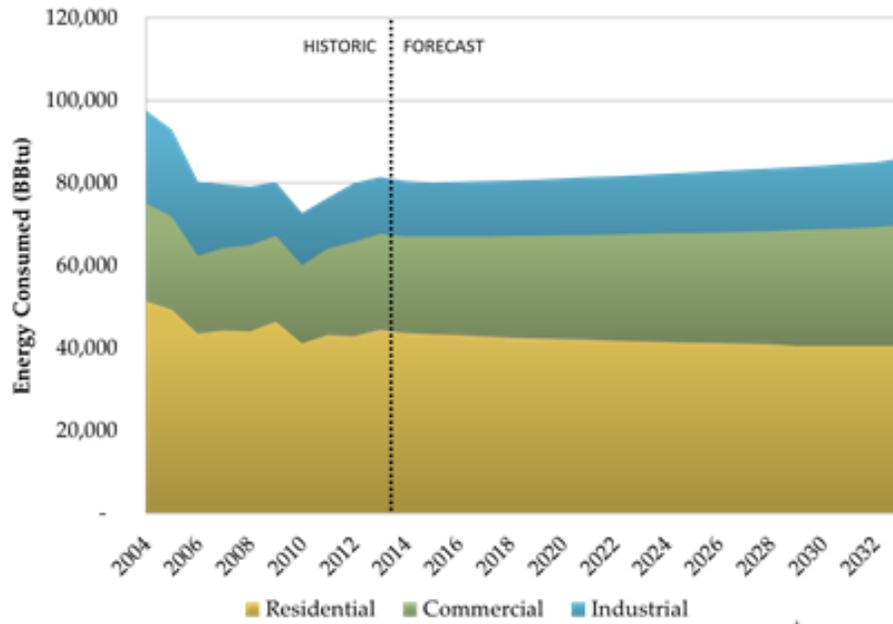


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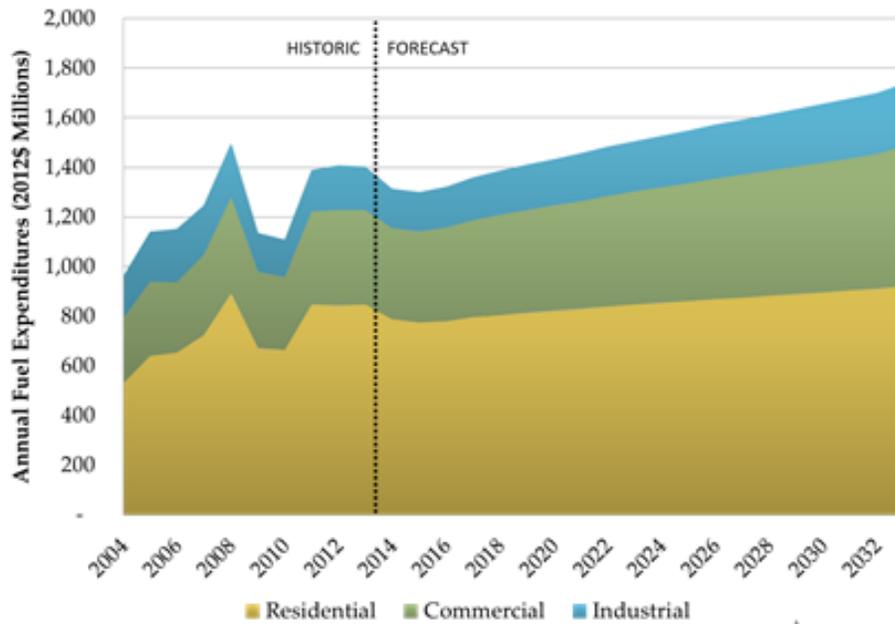
Thermal Energy Consumption by Sector



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Thermal Fuel Expenditures by Sector



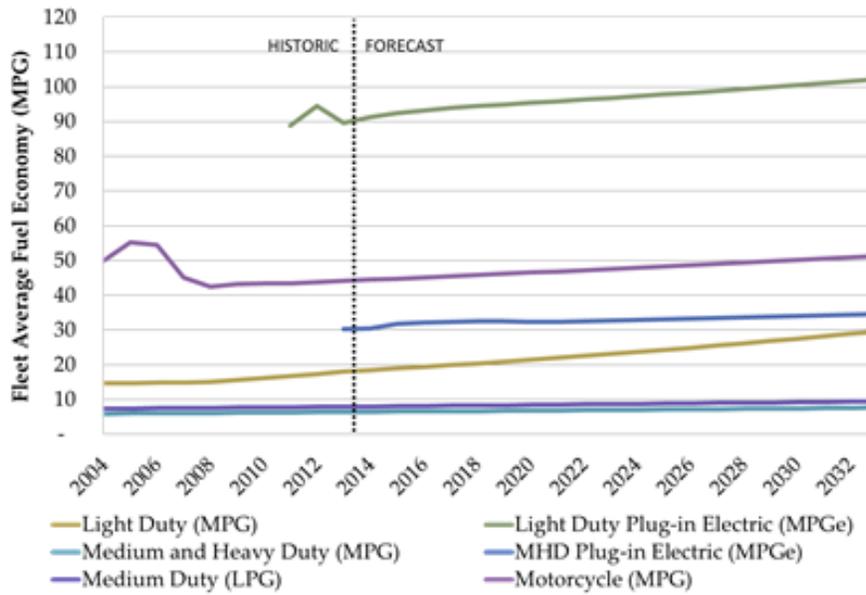
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Transportation Sector Charts

New Hampshire State Energy Strategy » Transportation Sector Forecast » Fuel Economy

Transportation Fleet Average Fuel Economy

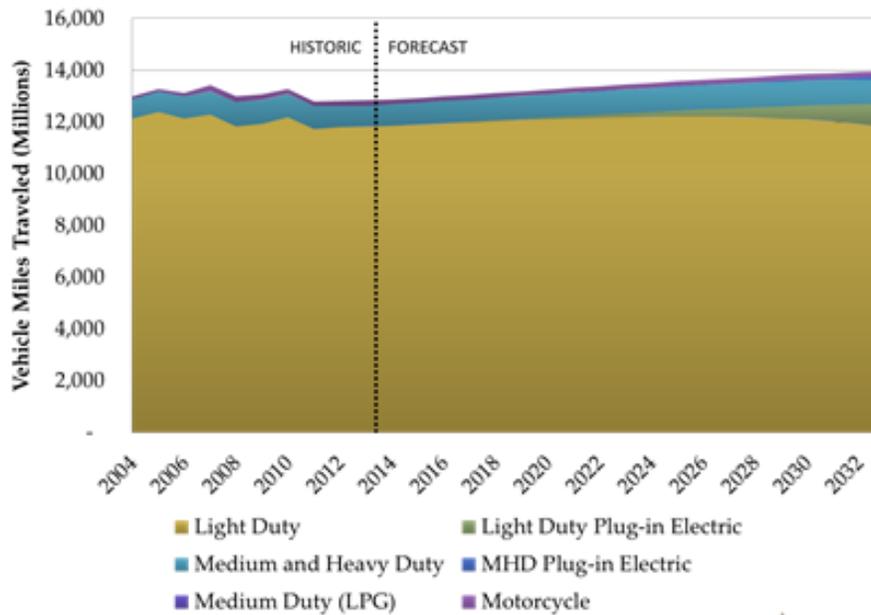


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New Hampshire State Energy Strategy » Transportation Sector Forecast » VMT

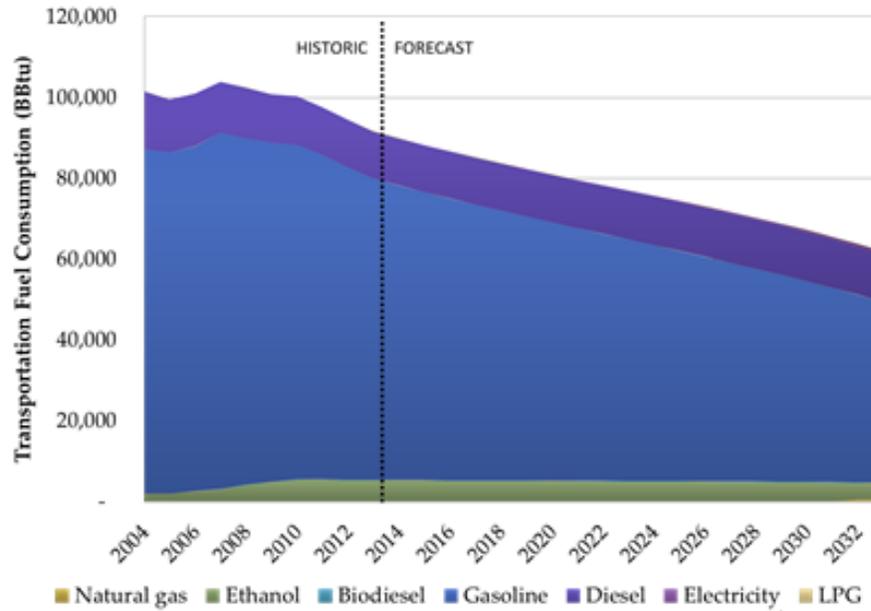
Transportation Sector Vehicle Miles Traveled (VMT)



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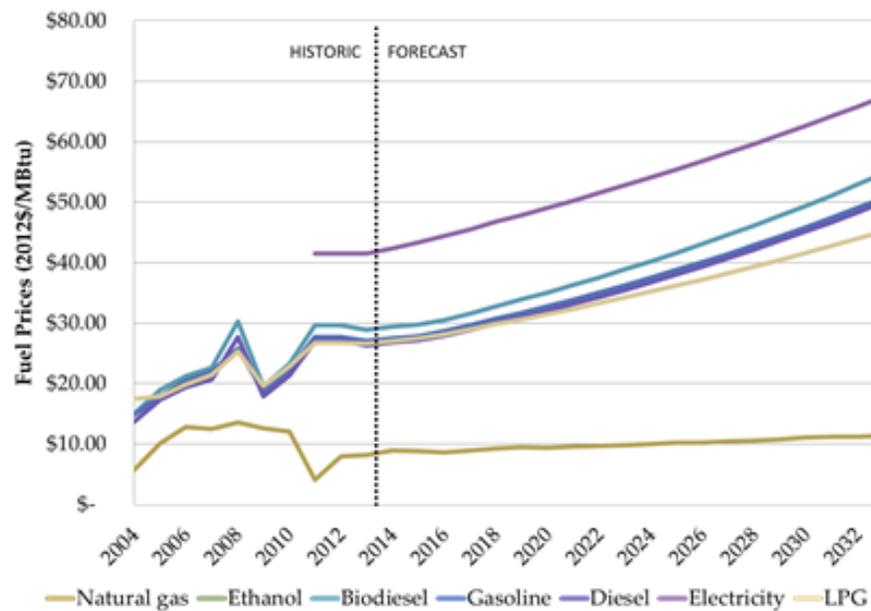
Transportation Sector Fuel Consumption



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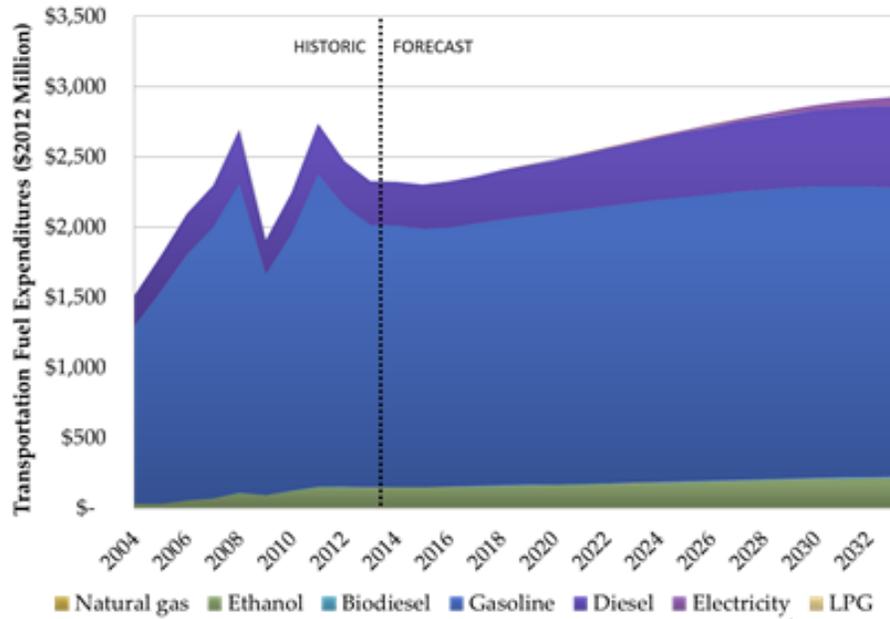
Transportation Sector Fuel Prices



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Transportation Sector Fuel Expenditures

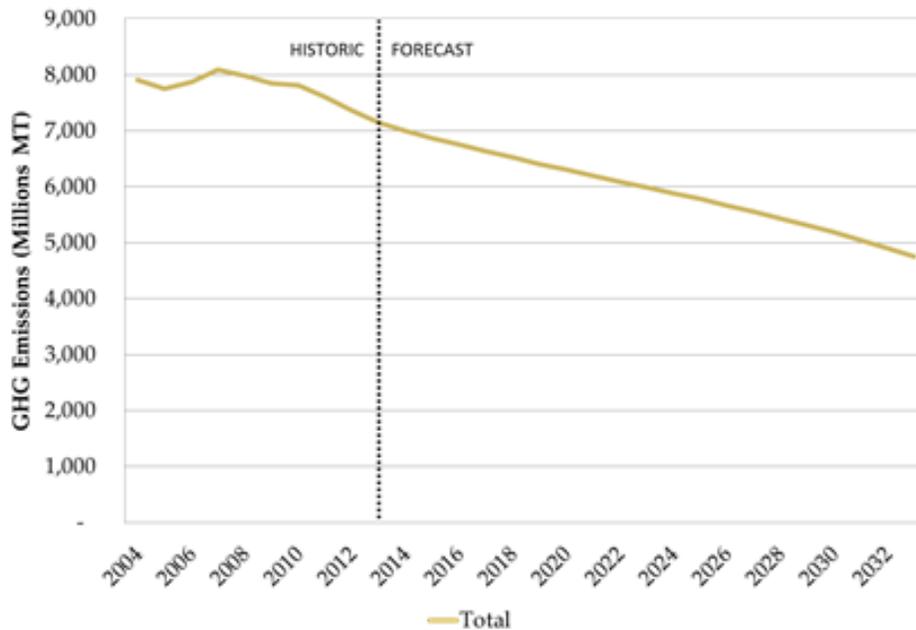


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Transportation Sector Emissions



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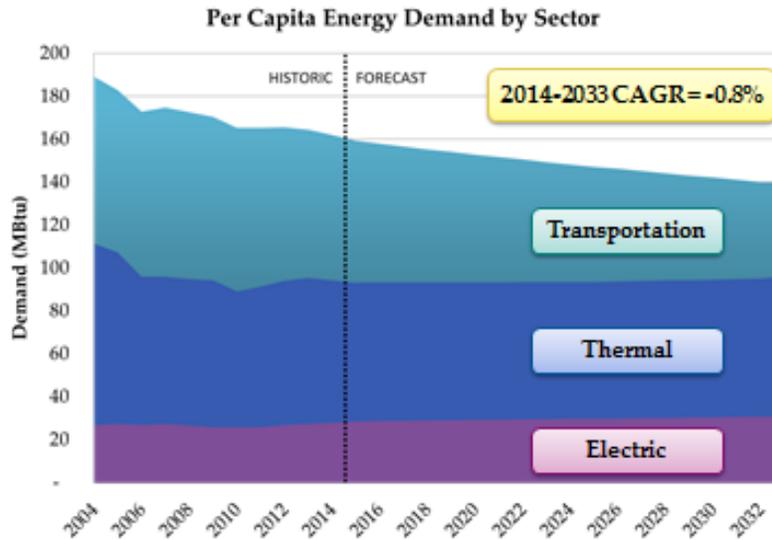
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Summary Charts

New Hampshire State Energy Strategy » Baseline Revisions » Per Capita Consumption

While per capita demand for transportation fuels is forecast to drop, both thermal and electric demand are forecast to hold steady.



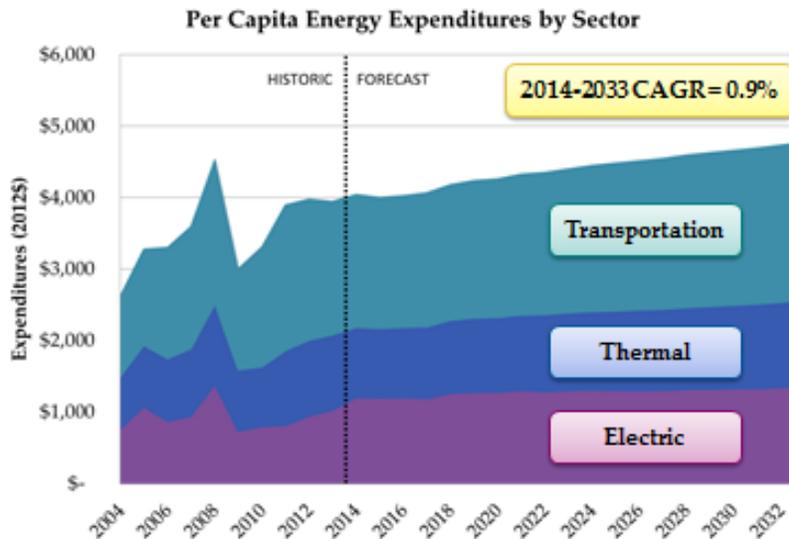
Source: Navigant Analysis

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New Hampshire State Energy Strategy » Baseline Revisions » Per Capita Expenditures

Despite shrinking demand in transportation, the forecast rise in fuel prices contributes to an overall increase in total expenditures.

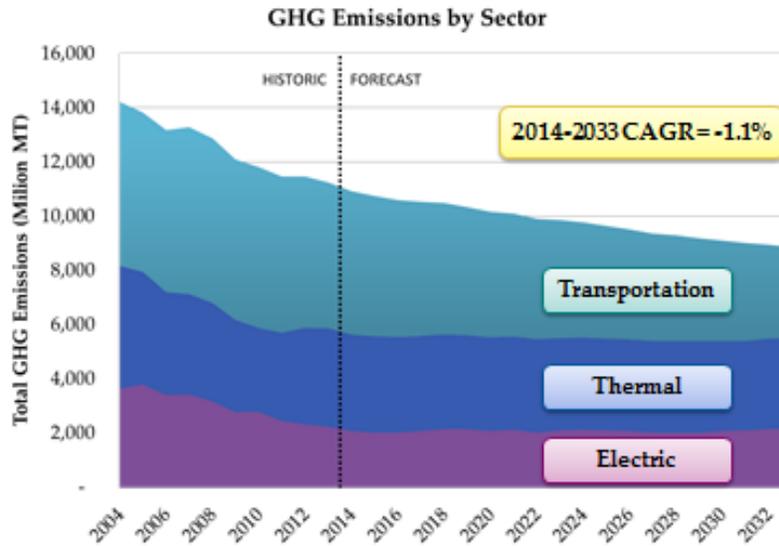


Source: Navigant Analysis

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Similarly, per capita emissions are forecast to decline for the transportation sector, but hold steady for the electric and thermal sectors.



Source: Navigant Analysis

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Appendix B. Energy Vision

B.1 Purpose

The energy vision describes an ideal energy future for New Hampshire. In contrast to the baseline forecast, which indicates where the state is expected to be absent new or amended policies, an energy vision serves to define an ambitious, yet realistic, alternative future for New Hampshire. This vision helps guide recommendations for the state energy strategy.

B.2 Methodology

The energy vision was developed with input from the advisory council in advance of conducting the resource potential study to keep the vision aspirational, and followed a five step process:

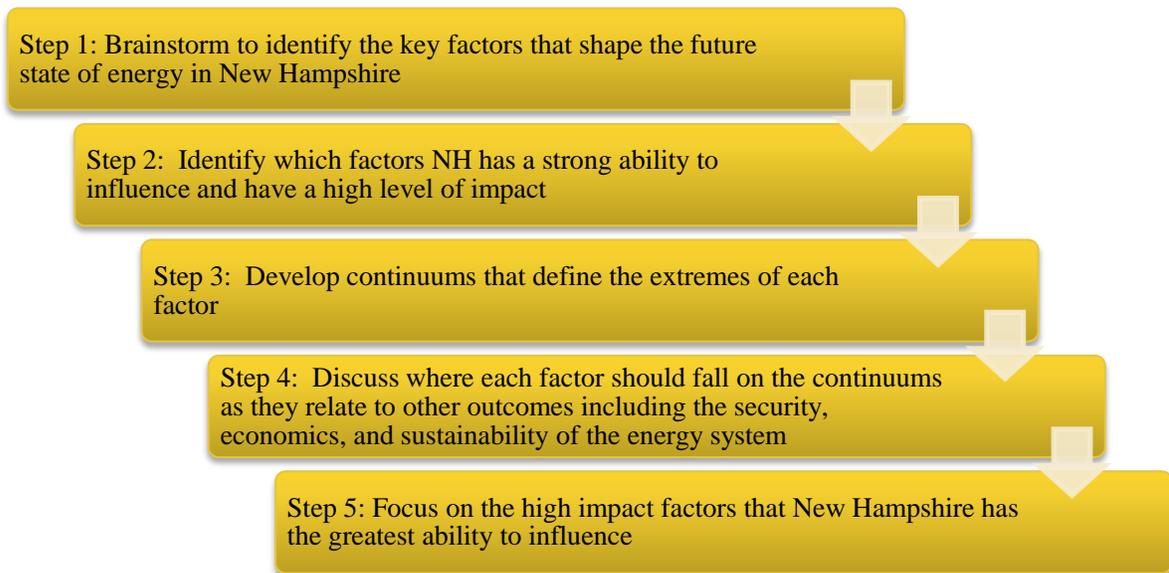


Figure 15: Energy Vision Development Process

Based on topics discussed with the advisory council and information gained through the development of the baseline energy forecast, Navigant identified eight key factors in defining New Hampshire’s energy future. The eight factors include:

- The efficiency of NH’s building stock and the potential to reduce energy expenditures;
- The mix of renewable power generation and use of smaller scale distributed generation (DG);
- Consumer choice and the availability of alternative fuels;
- Alternative options in transportation;
- Grid modernization efforts;
- Regional issues including demand and supply dynamics, and the interrelationship between the state’s energy needs and policies;
- Fuel prices; and
- Emissions regulations.

Each of these factors was mapped based on its relative impact on various metrics related to energy security, economics, and sustainability and the degree to which New Hampshire has the ability to exercise influence over it. This helps to focus efforts on those factors for which new or amended policies and strategic goals could have the greatest positive effect. The results of the mapping are shown in Figure 16: Relative Impact and Influence of Key Factors. For example, regional demand dynamics and fuel prices have large relative impacts on energy issues in New Hampshire, but New Hampshire has less influence over those issues than over others that are directly within the state’s control such as energy efficiency and clean small scale generation (renewable power generation).

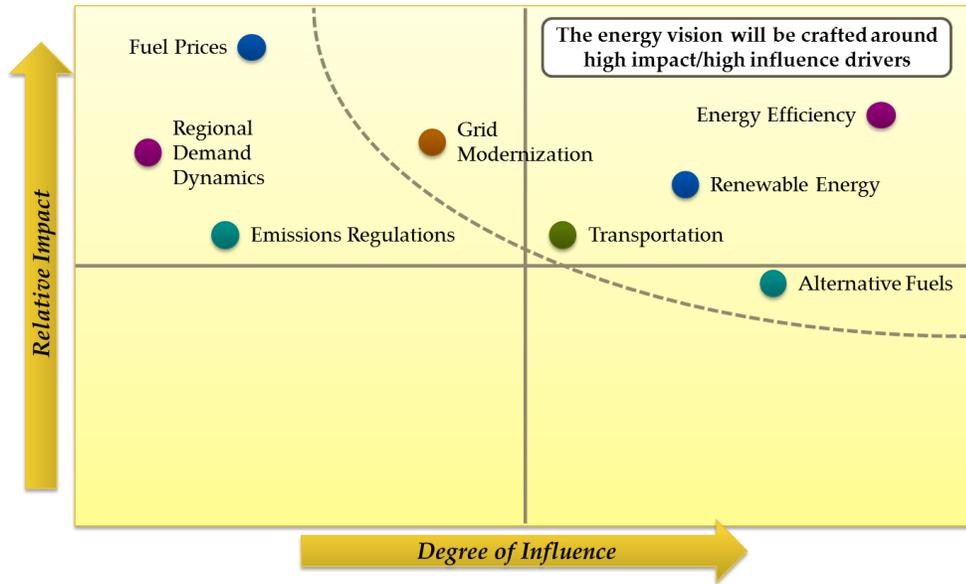


Figure 16: Relative Impact and Influence of Key Factors

Navigant elicited feedback from the advisory council and stakeholders on the relative importance of each key factor and how each factor might look in the future. Each participant was asked to put themselves in the year 2025 and envision what the energy landscape might look like. The factors were placed on the continuum as shown in Figure 17: Continuum of Key Factors Included in the Energy Vision and the draft energy vision was defined as follows.

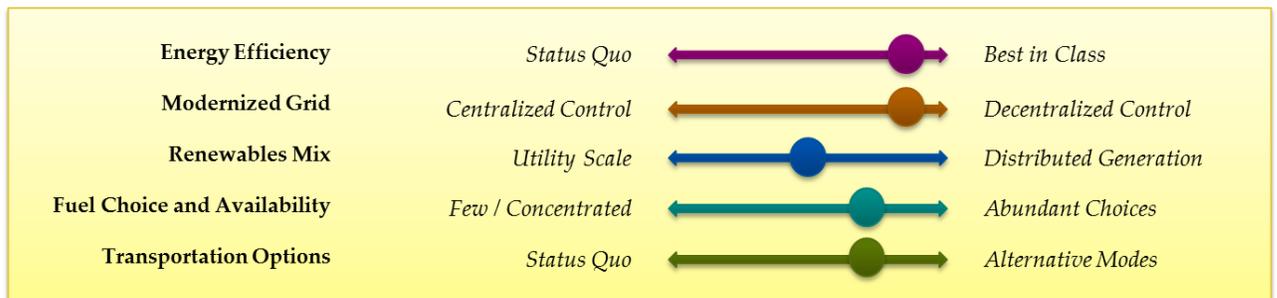


Figure 17: Continuum of Key Factors Included in the Energy Vision

B.3 The Draft Energy Vision

Summary

In 2025, consumers are empowered to manage their energy use by taking full advantage of the information, market mechanisms, energy efficient technologies, diverse fuel sources, and transportation options available to them. These services extend from the city centers and coastal areas of Southern New Hampshire to the rural corners of the Western regions and the North Country - closing the gap in disparity of energy services across the state. The results of these widespread consumer empowerment initiatives are lower energy bills, greater choice for the consumer, increased self-reliance, and a cleaner, more sustainable and resilient energy system.

From an economic perspective, New Hampshire's stable energy policies leverage public funds ten to one – inspiring investor confidence, creating high quality jobs, and attracting new residents and businesses to the state. Efficient transit systems help make New Hampshire tourist friendly and the state's high efficiency building stock, skilled workforce, and well managed natural resources make it regionally competitive and help keep dollars in state. As an active participant in New England's broader energy economy, in-state suppliers of energy services receive the proper signals to drive their business decisions toward creating an efficient and secure energy system that delivers cost-effective, clean energy to all.

Energy Efficiency

Across New Hampshire, many of the newest homes as well as commercial and public buildings produce as much energy as they consume - putting the state on track to meet a net-zero energy code in later years. Additionally, many older buildings have benefited from deep energy retrofits, owing to an informed consumer base that understands what drives their energy bills and appropriately values the short and long term benefits of higher efficiency homes and businesses. These efforts incorporate the latest in energy efficient technologies, resulting from flexible policies and diverse market-based financing mechanisms that allow customers of all income levels to access the technologies they wish to use. Because of these efforts, every dollar spent on energy in New Hampshire adds value to the lives of its residents and the prosperity of its businesses.

Grid Modernization

Beyond simply using less energy, many of the energy saving technologies embedded in New Hampshire's homes and businesses provide consumers with valuable information about their energy consumption while protecting their privacy. This gives consumers both peace of mind and the power to effectively manage their bills and contain costs. By opening lines of communication with grid operators, consumers may choose to manage their energy themselves or rely on third party providers of energy management services to respond in real time to changing energy prices and other market conditions to help them further reduce their energy bills. Access to real time data and open communications also contribute to greater reliability of New Hampshire's energy infrastructure, providing timely information to consumers so that they may plan and respond accordingly to unanticipated events and help isolate outages.

Renewable Power Generation

In addition to saving energy, many individual households and businesses produce power themselves - participating in dynamic local energy markets powered by distributed generation. These localized energy systems provide an additional measure of resilience against grid outages and other supply disruptions by seamlessly switching between various fuels and stored power. Further, by relying on renewable resources, they reduce reliance on imported fuels and foster self-sufficiency within

communities across the state. In 2025, the combination of reduced demand and further development of diverse renewable power generation assets helps New Hampshire achieve its renewable portfolio standard target level.

Fuel Choice and Availability

In 2025, the residents and businesses of New Hampshire have many choices in the fuels they use for power, heat, and transportation. Consumer's options for home heating are no longer strictly limited by their geographic location, offering residents greater peace of mind in the face of fluctuating fuel prices. Additionally, consumers use the diversity of available fuels and the interconnected relationship of energy used across the electric, thermal, and transportation sectors to their benefit – storing electricity in the batteries of their electric vehicles, or powering air-source heat pumps with energy generated from their rooftop solar panels as examples. By embracing a diverse and interconnected set of energy solutions, these systems promote the self-reliance of both individual communities and New Hampshire as a whole. The options for both power generation and building heating are enhanced by a boom in home-grown clean energy from New Hampshire - keeping dollars in state and reducing pollution.

Transportation Options

In the transportation sector in 2025, widespread vehicle charging infrastructure is the norm across the state and fueling stations supporting the latest technology and alternative fuels dot the highways. Using this infrastructure, residents and business take advantage of the many options for electric vehicles, plug-in hybrids, and other new transportation technologies. Access to these technologies is granted through creative financing mechanisms and new business models. Walking communities, ride shares, and enhanced public transit options exist to benefit residents of all ages (including New Hampshire's aging population as well as its youth). These options return both time and money to the communities of New Hampshire and contribute to improved air quality in city centers. New Hampshire's public transit options also benefit those visiting the state, ferrying skiers and hikers alike to the state's many resorts and abundant outdoor attractions and further bolstering the state's tourism industry. Most importantly, residents of New Hampshire get where they need to go without sending money out of state, or overseas.

Appendix C. Resource Potential Analysis

C.1 Purpose

Navigant analyzed thirty-two separate demand and supply side resources to help identify the best way to move from the baseline energy forecast toward the end state defined in the energy vision. This study informed discussions of policy initiatives by focusing attention on the biggest opportunities for change that are both economically justified and technologically feasible. The resources analyzed are categorized as energy efficiency, thermal & transportation fuels, or power generation & energy infrastructure (illustrated in Figure 18: Demand and Supply Side Energy Resources).

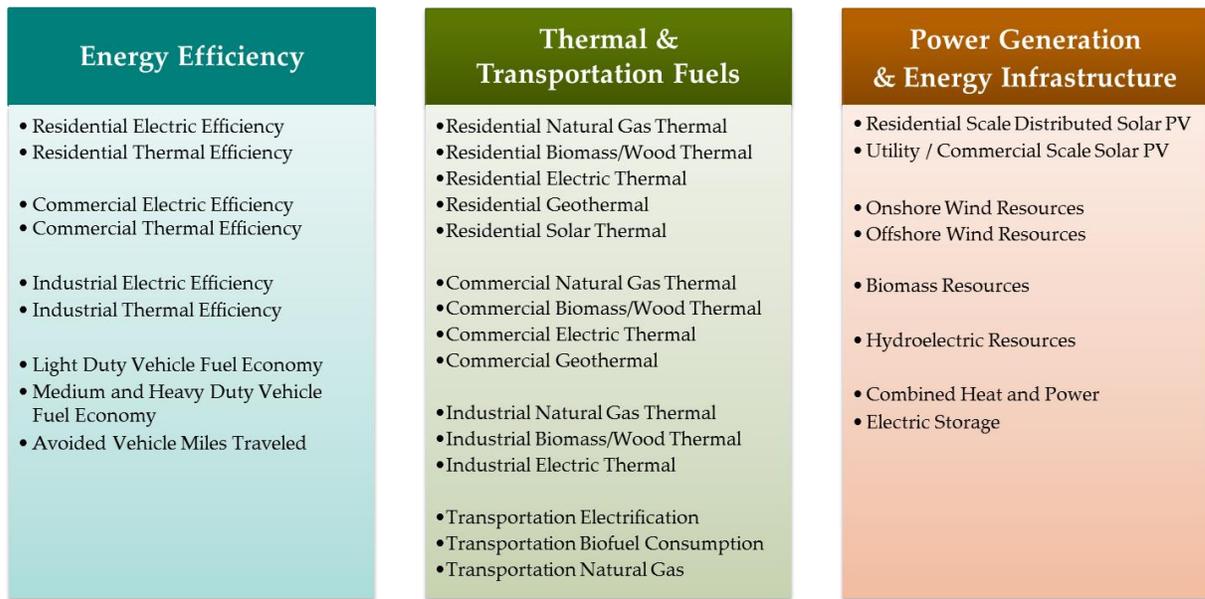


Figure 18: Demand and Supply Side Energy Resources

C.2 Methodology

Like the baseline energy forecast, the resource potential study utilized publicly available sources of data and existing resource potential studies to estimate the technical, economic, and market potential of various demand and supply side resources in 2025. The year 2025 was selected to coincide with the target year of the energy vision and to allow adequate time for resource changeover. For example, given rates of fleet turnover in the transportation sector, or the required time to permit and build new power generation assets, it would be unreasonable to suggest significant change in either of these resources in the span of one year. A time horizon of ten years provides adequate time for changes in policy to take effect and produce results.

For the purpose of the resource potential study, Navigant focused on the technical and economic potential as defined by the National Renewable Energy Lab (NREL) and illustrated in Figure 19: Resource Potential Levels¹⁸.

¹⁸ NREL - U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis, July 2012

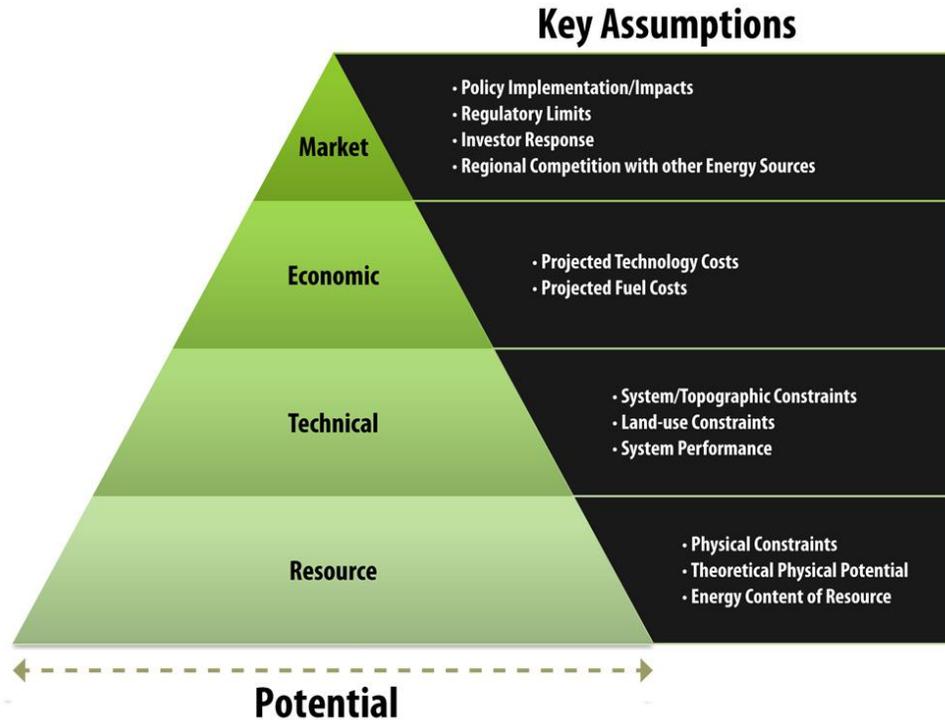


Figure 19: Resource Potential Levels¹⁸

Where possible, the technical and economic potential values were taken directly from existing studies of resource potential. For instances in which direct data was unavailable or out of date, Navigant calculated the technical and economic potential and documented the underlying assumptions. For the market potential estimate, Navigant used the projected 2025 values for each resource from the baseline forecast. This coincides with what is expected of the market absent any amended policies or new initiatives affecting a given resource. An estimate of the total resource potential was omitted from the study as constraints on technology largely render this figure unattainable. *The data tables for the resource potential study can be found in C.6 Resource Potential - Supporting Data.*

While the technical, economic, and market potential of resources are important, the comparison of these levels is of particular importance in developing an energy strategy as it not only helps to identify the biggest opportunities available, but also provides a high level indication of the types of barriers affecting each resource. For each resource, the difference between the market potential and economic potential can be attributed to the limitations of policies, regulations, market inefficiency, and consumer awareness. For example, New Hampshire has not implemented all of the cost-effective energy efficiency measures that are available for a variety of reasons related to regulatory barriers, consumer education, and lack of access to financing.

In contrast, the difference between the economic potential and the technical potential can be attributed to the cost of technology, factoring in the relative price of fuels and competing technologies. Resources with a large difference between the technical and economic potential, or technical gap, may present significant opportunities in the future as the cost of technology drops or competing fuel prices rise. For example, as the cost of solar panels fall, they become more economically accessible, closing the gap between the economic potential and technical potential. Similarly, as the cost of gasoline rises, electric vehicles and plug-in hybrids become more economical purchases because the upfront costs are offset by greater fuel savings.

However, since New Hampshire has little ability to influence fuel prices or the cost of technology, the technical gap should mostly be a secondary priority for the state. New Hampshire’s first priority should be addressing the difference between economic potential and market potential, over which the state has greater control. See Figure 20 for an example interpretation of economic and technical gaps.

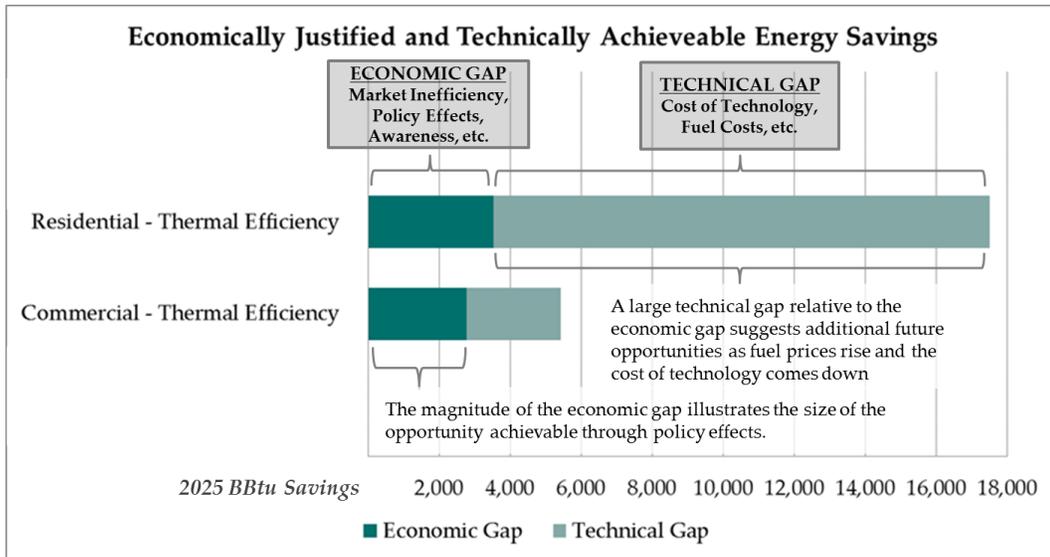


Figure 20: Technical and Economic Potential Overview and Interpretation

C.3 Energy Efficiency Potential

Residential, Commercial, and Industrial Energy Efficiency

The resource potential study of energy efficiency across the residential, commercial, and industrial sectors relied heavily on a report prepared for the PUC by GDS Associates, Inc., titled “Additional Opportunities for Energy Efficiency in New Hampshire,” published in January 2009.¹⁹ This report presented the technical, economic, and market potential of energy efficiency gains in 2018. Navigant calculated the proposed 2018 savings cited in the GDS report as a percentage of demand for the residential, commercial, and industrial sectors. See Table 1 and Table 2 for the market, economic, and technical potential for each sector.

Sector	Market Potential	Economic Potential	Technical Potential
Residential	12.5%	20.9%	31.7%
Commercial	9.2%	19.9%	29.8%
Industrial	10.2%	21.2%	24.5%

Table 1: Electric Energy Savings Potential Estimates²⁰

¹⁹ <http://www.puc.state.nh.us/Electric/GDS%20Report/NH%20Additional%20EE%20Opportunities%20Study%202-19-09%20-%20Final.pdf>

²⁰ Electric and thermal energy savings potential estimates based on Navigant analysis of the baseline forecast and the GDS Associates, Inc. report titled “Additional Opportunities for Energy Efficiency in New Hampshire,” which is available at: <http://www.puc.state.nh.us/Electric/GDS%20Report/NH%20Additional%20EE%20Opportunities%20Study%202-19-09%20-%20Final.pdf>

Sector	Market Potential	Economic Potential	Technical Potential
Residential	10.7%	18.7%	50.0%
Commercial	7.2%	17.0%	26.4%
Industrial	4.4%	9.0%	11.2%

Table 2: Thermal Energy Savings Potential Estimates²⁰

To estimate the potential savings in 2025, Navigant applied these same percentages to the 2025 demand figures from the baseline energy forecast. This projection hinges on the assumption that comparable savings can be achieved between 2009 and 2018 (as expressed in the GDS report) and between 2014 and 2025 (the time horizon for this resource potential study). Several factors could contribute to comparatively higher or lower savings, including the emergence of higher efficiency technology or the shrinking residual opportunity for efficiency improvement due to gains made from 2009 to the present. The results of this analysis are presented in Figure 21: Potential for Residential, Commercial, and Industrial Energy Efficiency.

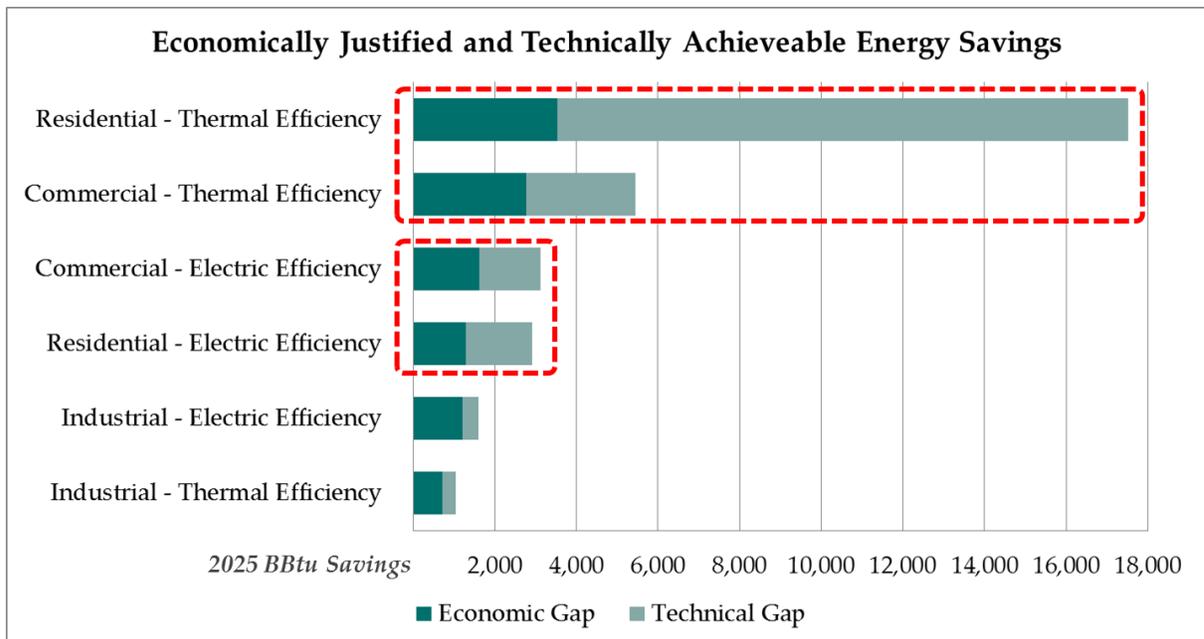


Figure 21: Potential for Residential, Commercial, and Industrial Energy Efficiency²⁰

The analysis shows that the residential and commercial sectors offer substantial opportunities for additional economically justified thermal efficiency. In both sectors, the remaining economic potential for thermal efficiency is roughly twice that for electric efficiency. This disparity can be attributed to multiple sources. The primary reason is that New Hampshire uses more than twice (2.4 times) as much thermal energy as it does electric energy. Additionally, the higher upfront costs associated with high efficiency thermal retrofits, relative to electric efficiency upgrades, makes them comparatively more challenging investments for many consumers despite shorter payback periods.

What is perhaps most striking about these results is that while the remaining economic potential for residential and commercial thermal efficiency are of similar size, the additional technical potential in the residential sector is more than five times that in the commercial sector. The age of housing stock and the high cost of capital in the residential sector contribute to its sizable technical potential. In contrast, the additional technical potential in electric efficiency for both the residential and commercial sectors is considerably smaller, owing to the relatively lower upfront cost and higher

turnover of electric appliances and the smaller fraction of total building energy demand associated with electrical systems (as compared to thermal systems).

This analysis points to the need for a state energy strategy to address the economically achievable gains in thermal efficiency in the residential and commercial sectors. The substantial technical potential in residential thermal efficiency highlights the need for flexible policies that prepare for decreasing technology costs or rising fuel prices, either of which would increase the economic viability of more advanced thermal efficiency measures.

Transportation Energy Efficiency

In the transportation sector, Navigant analyzed energy savings enabled by gains in light, medium, and heavy duty vehicle fuel economy, as well as through reductions in vehicle miles traveled (VMT). The analysis for fuel economy was informed by modifying assumptions in the vehicle stock model used to develop the baseline forecast. Because all new vehicles could be replaced with their most efficiency counterpart, the technical potential for fuel economy is limited only by the vehicle turnover between 2014 and 2025. In contrast, the economic potential assumes that equivalent gasoline powered stock is only replaced with higher efficiency hybrid and electric vehicles when the breakeven period for ownership (the time at which accumulated fuel savings offset the price premium for a more efficient vehicle) is below 10 years (the average life of a vehicle).

The technical potential for energy savings from VMT reduction relied on the “Summary of U.S. VMT Reduction Strategies” published by the Rocky Mountain Institute in 2011, which presents high and low estimates of VMT reduction for several initiatives.²¹ Many of the strategies are more applicable to areas of high congestion or where alternative means of transportation exist. Given New Hampshire’s small number of urban centers, the low-end estimate from this study was used to estimate the technical potential for the state. The Rocky Mountain Institute divides the effects of VMT reduction strategies into four categories: smart growth, pricing systems to discourage VMT, alternative commuting (including car sharing, carpooling, and telecommuting), and system efficiency. The conservative (low) estimate suggests that up to a 46 percent reduction in VMT is technically achievable.

The economic potential was estimated using VMT reduction plans from Denver and Sacramento, as these plans target VMT reduction levels that do not adversely impact the economy. Recognizing that these plans are for relatively population-dense areas, the VMT reduction targets (10.0 percent and 13.2 percent respectively) were applied only to the VMT traveled by New Hampshire’s population living in cities larger than 20,000 people. This results in an economically viable 3.9 percent reduction in VMT. The gap analysis of these resources is illustrated in Figure 22: Potential for Transportation Energy Efficiency.

²¹ Rocky Mountain Institute Summary of U.S. VMT reduction strategies available at: http://www.rmi.org/RFGraph-Summary_of_US_VMT_reduction_strategies

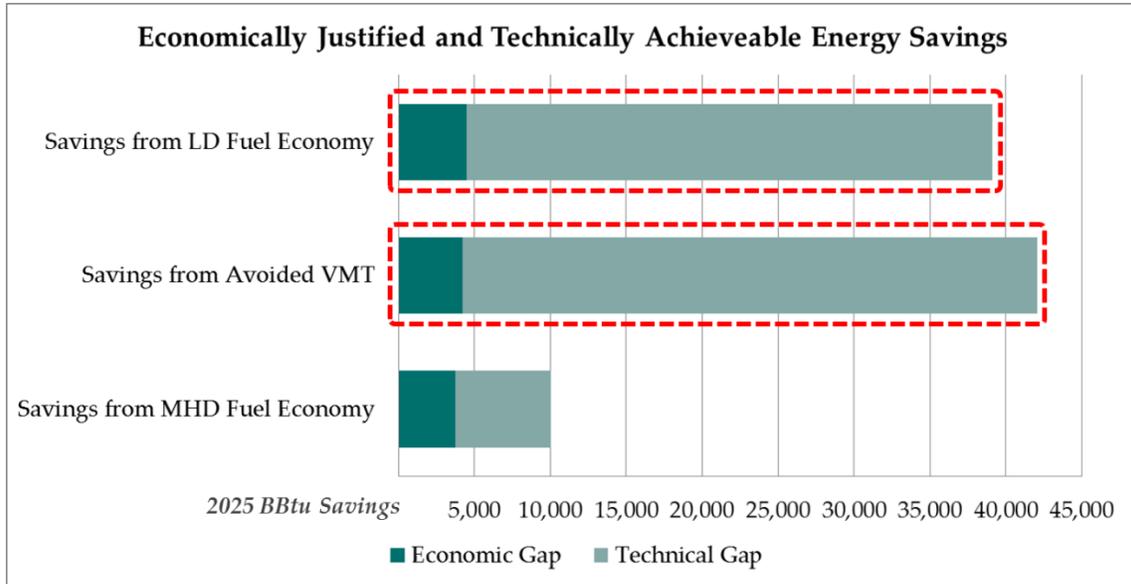


Figure 22: Potential for Transportation Energy Efficiency²²

While the remaining economic potential is approximately the same size for the three resources analyzed, the technical potential of both light duty fuel economy and VMT reduction strategies make these the most promising long-term solutions to promote energy efficiency in the transportation sector. The sizeable gaps between economic and technical potential suggests a tremendous opportunity for savings amid rising fuel costs and falling prices for high efficiency hybrids and plug-in electric vehicles. However, significant effort will be required to provide the necessary market mechanisms and infrastructure to capitalize on these opportunities.

C.4 Thermal and Transportation Fuels Potential

The resource potential study for thermal and transportation fuels relied on a variety of sources specific to each fuel considered. The fuel types are discussed individually in the following sections.

Natural Gas

Navigant’s estimates of the technical and economic potential for natural gas transmission and pipeline expansion relied heavily on the integrated resource plans of New Hampshire’s gas utilities^{23,24} and a study by ICF International titled “Assessment of Growth for National Grid’s NH Natural Gas Utility”²⁵ published in October 2012. These documents suggest that no large infrastructure upgrades are expected to expand natural gas distribution networks significantly within New Hampshire over the next decade. However, if a large natural gas distribution project for the region of New England (for example the Northeast Expansion Project Pipeline proposal and Spectra Energy’s Atlantic Bridge

²² Source data and reports used in estimating the potential for transportation energy efficiency are detailed in C.6 Resource Potential - Supporting Data.

²³ Liberty’s Integrated Resource Plan: <http://www.puc.nh.gov/Regulatory/Docketbk/2013/13-313/INITIAL%20FILING%20-%20PETITION/13-313%202013-11-01%20ENGI%20DBA%20LIBERTY%20INTEGRATED%20RESOURCE%20PLAN.PDF>

²⁴ Northern Utilities Testimony on Integrated Resource Plan: <http://www.puc.nh.gov/Regulatory/Docketbk/2013/13-086/INITIAL%20FILING%20-%20PETITION/13-086%202013-04-15%20NORTHERN%20UTILITIES%20TESTIMONY%20T%20MEISSNER.PDF>

²⁵ ICF - Assessment of New England’s Natural Gas Pipeline Capacity available at: <http://www.icfi.com/insights/projects/energy/assessment-of-new-england-natural-gas-pipeline-capacity>

project) is completed during this timeframe, it could spur the development of line extensions to new service territories within the state, increasing the technical and economic potential.

Because the future of projects such as these is uncertain, for the residential sector Navigant limited the technical potential of natural gas consumption to residences within current service territories. The economic potential model assumes that all on-main residences convert to natural gas, but that only 10 percent of off-main residences within the utilities' service territories do so. The assumptions informing natural gas expansion in the commercial sector are similar, but assume that it would be economical to switch to gas for 30 percent of off-main businesses within the utilities' service territories. Because of the higher demand per customer in the commercial and industrial sections, the barriers to gas expansion (such as upfront cost) are less significant than in the residential sector. Unlike the residential and commercial sectors, the technical potential of natural gas consumption in the industrial sector is not limited to existing service territories. The high demand from industrial customers makes them an attractive target for trucked CNG, technically extending natural gas delivery to all industry in the state. The economic potential is estimated as 50 percent of current off-main industrial customers within the utility's service territories and 25 percent of industrial customers outside of current service territories.

Biomass

For biomass, the potential for thermal conversion in each sector was initially limited to the technical potential of the sustainably harvested resource as determined using data from the Department of Environmental Services (DES) Climate Action Plan (Appendix 8: The Wood Biomass Wedge in New Hampshire: Data Sources and Basic Approach)²⁶. The technical potential was further reduced based on thermal load and the technical fit with each sector. Because of concerns over particulate emissions in more densely populated areas, the technical potential of biomass in the residential sector was reduced to the fraction of the population located in rural areas (55 percent as determined using US census data²⁷) and outside of the gas utilities' service territories. Because of the current pricing of competitive fuels, the economic potential of biomass heat in the residential sector was further limited to the fraction of residences currently using electric heating (12 percent), fuel oil (27 percent), propane (3 percent) and kerosene (1 percent).

In the commercial and industrial sectors, the technical potential of biomass was limited to the thermal load of New Hampshire businesses located outside of gas utilities' service territories. The economic potential for these sectors was further limited to the fraction of commercial building stock constructed before 1989 (39 percent), after which building practices favored higher efficiency systems not well suited to conversion to biomass heat.

Ground Source Heat Pumps

Estimates of the technical and economic potential for geothermal energy in the residential and commercial sectors in New Hampshire were informed by a Navigant study prepared for the US Department of Energy titled "Ground Source Heat Pumps: Overview of Market Status, Barriers to Adoption, and Options for Overcoming Barriers,"²⁸ and interviews with ground source heat pump installers in New Hampshire. Because of land use requirements for ground source heat pumps, the technical potential in both sectors is limited to the space heating thermal load in less densely populated areas, as determined using US census data (55 percent of the total)²⁷. The economic potential was based on the fraction of installations that would achieve a pay-back period of less than 3 years (15 percent) as indicated by information gathered through installer interviews.

²⁶ http://des.nh.gov/organization/divisions/air/tsb/tps/climate/action_plan/documents/032509_nhccptf_appendix_8.pdf

²⁷ http://www.ers.usda.gov/datafiles/Rural_Definitions/StateLevel_Maps/NH.pdf

²⁸ http://www1.eere.energy.gov/geothermal/pdfs/gshp_overview.pdf

Air Source Heat Pumps

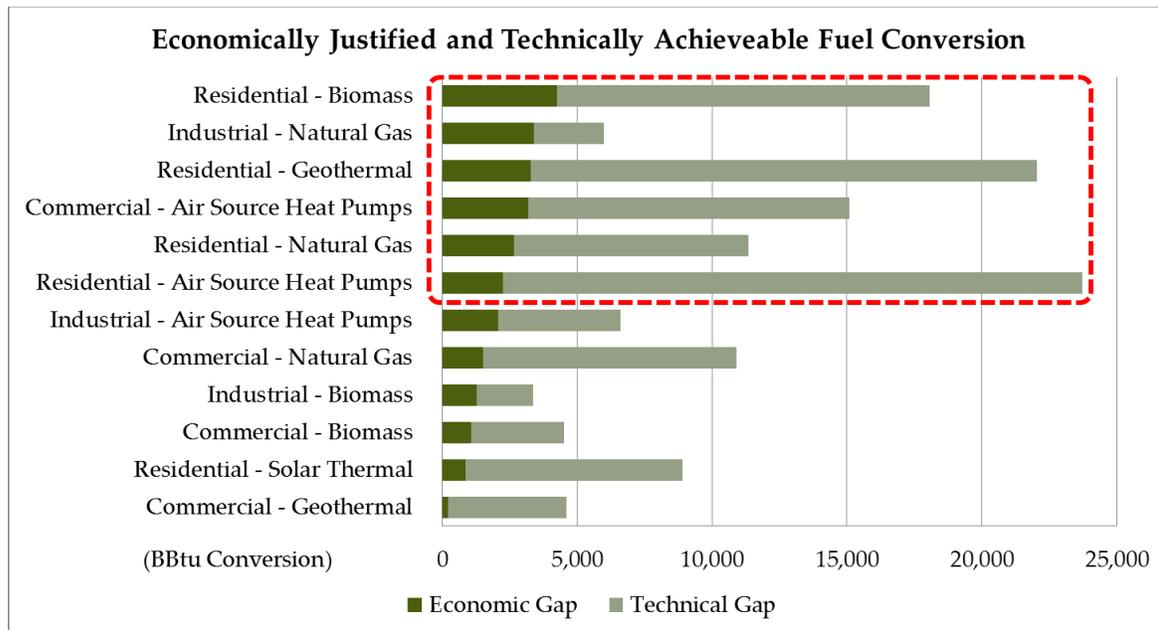
The technical potential for air source heat pumps across the residential, commercial, and industrial sectors was limited to the space heating thermal load in each sector as determined from the DOE Building Energy Data Book³². To account for the technical limitations of current air source heat pump technology, Navigant used the percentage of heating degree days²⁹ above 10° F; when the temperature falls below 10° F, a supplemental heat source is required. In the residential sector, the economic potential is limited by the fraction of housing stock with existing duct heating systems that are not heated with gas, of which 75 percent are estimated to represent economically viable opportunities for this technology.³⁰ Without existing ducting, air source heat pumps are limited to ductless mini-split systems. In the commercial and industrial sectors, the estimate of the economic potential follows a similar methodology as that used for biomass, by examining the age of building stock and screening out buildings constructed before 1960 and after 1989³¹.

Solar Thermal

The technical and economic potential of solar thermal was estimated using the DOE Building Energy Data book³² and information gathered through interviews with solar thermal installers based in New Hampshire. This estimate starts with the total residential thermal load associated with both space conditioning and water heating and is adjusted to reflect the portion of residential buildings that have adequate roof structure, orientation, and little or no shading (50 percent). The economic potential is further limited to installations that are estimated to have a payback period of less than 20 years for space heating applications and less than 5 years for water heating applications (10 percent).

Summary Results

The technical and economic potentials determined by the analysis of thermal fuels are presented in Figure 23: Economically Justified and Technically Achievable Fuel Conversion.



²⁹ <http://www.degreedays.net/#generate>, BERLIN MUNICIPAL AIRPORT, NH, US (71.18W,44.58N)

³⁰ U.S. Energy Information Administration, Residential Energy Consumption Survey (RECS), Table HC6.8 Space Heating in U.S. Homes in Northeast Region, Divisions, and States, 2009 <http://www.eia.gov/consumption/residential/data/2009/>

³¹ DOE Buildings Energy Data Book, Table 3.2.4, Share of Commercial Floor space, by Census Region and Vintage, as of 2003 (Percent) <http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx>

³² US DOE Buildings Energy Data Book <http://buildingsdatabook.eren.doe.gov/ChapterIntro2.aspx>

Figure 23: Potential for Thermal Fuel Adoption³³

Because of the large rural population in New Hampshire located outside of gas utilities service territory, and the relatively low cost of biomass, wood-fired heat is the most economically viable opportunity for fuel conversion in the residential sector. In contrast, the technical requirements of the commercial and industrial sectors, where many processes require fuels with a considerably higher heat rate, result in significantly lower potential for additional biomass. Conversion to natural gas is economically justified for these sectors, and trucked CNG provides opportunities for natural gas as a source of thermal energy for off-main industries.

In addition to biomass and natural gas, existing incentives present substantial opportunities for economically viable installations of ground and air source heat pumps in the residential sector. The technical potential for either technology in this sector is significant and the gap between what is economically viable and technically possible will narrow as the cost of installation drops and/or competing fuel prices rise. Air source heat pumps also have substantial technical and economic potential in the commercial sector. The technical potential of this technology in both the residential and commercial sectors suggests this to be a promising opportunity as the cost of technology decreases. This is especially important given the anticipated shift in New Hampshire's economy from manufacturing industries to information technology. Programs incenting the adoption of air source heat pumps in the commercial sector should be in place throughout this period of economic transformation to ensure that this technology is not overlooked.

Transportation Fuels

Navigant analyzed the technical, economic, and market potential for three alternative fuels in the transportation sector: biofuels, natural gas, and electricity.

The biofuels analyzed include ethanol and bio-diesel. Bio-gasoline and bio-gas were rejected due to uncertainty over the availability of these fuels, as they are both still largely in the development phase. While the technical potential for biofuels is limited to some extent by fleet turnover (the rate at which vehicles are replaced), there are also significant supply constraints for these resources. Accordingly, the technical potential for ethanol was determined by the ratio of current production (13 billion gallons³⁴) to target production for 2022 (21 billion gallons³⁵), or an increase in availability of 60%. The technical potential for bio-diesel used an extrapolated forecast of biodiesel production in the US. This forecast estimates 2025 production at roughly two times (190%) that of present day production. These estimates were made using information from the US DOE's Alternative Fuels Data Center³⁶ and are based upon on the assumption that the availability of biofuels in New Hampshire follows a similar trajectory as the rest of the US. The economic potential of both of the biofuels assumes that ethanol consumption surpasses the E10 blend wall,³⁷ reaching 12% of gasoline consumption by 2025, and that diesel moves to B20 blends (20% biodiesel).

In contrast to biofuels, which are largely limited by the availability of feedstock for fuel production, natural gas consumption in the transportation sector is limited by distribution. At present, there is only one station offering CNG to the public in New Hampshire. However, since CNG can use distribution infrastructure similar to existing refueling stations, this barrier will be reduced over time as existing stations can be permitted and retrofitted to offer CNG. As such, Navigant's estimate of

³³ Source data and reports used in estimating the potential for fuel conversion are detailed in C.6 Resource Potential - Supporting Data.

³⁴ <http://ethanolrfa.org/pages/monthly-fuel-ethanol-production-demand>

³⁵ http://www.eia.gov/forecasts/aeo/MT_liquidfuels.cfm

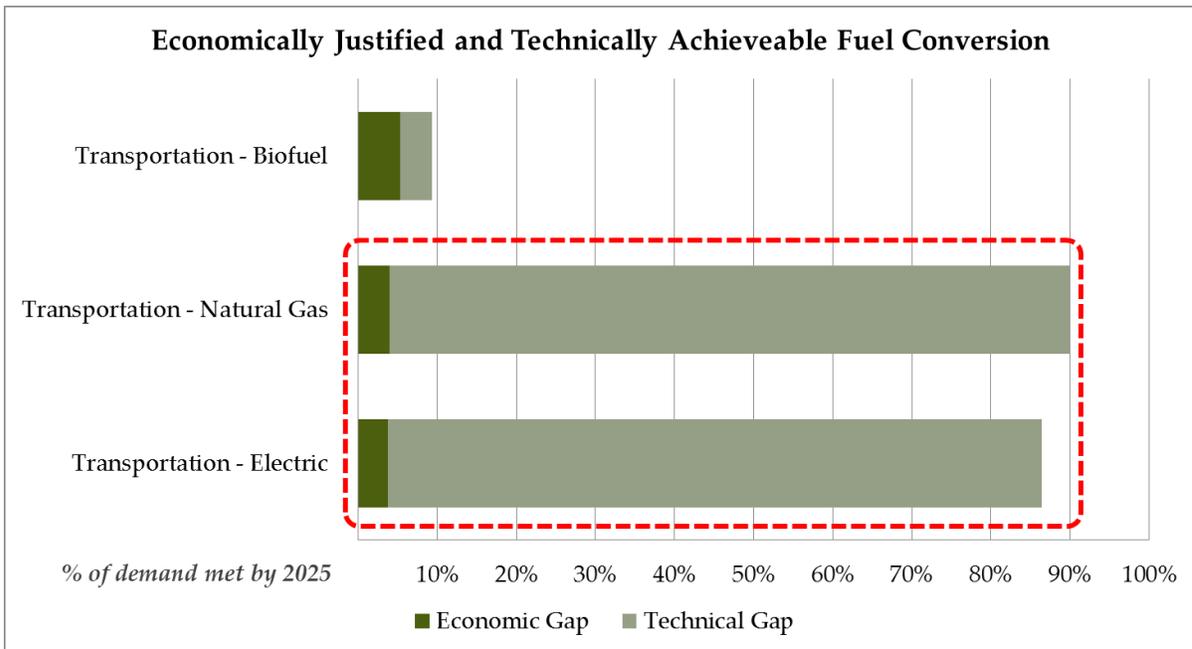
³⁶ <http://www.afdc.energy.gov/data/search?q=biodiesel>

³⁷ <http://www.eia.gov/oog/info/twip/twiparch/100708/twipprint.html>

the technical potential of natural gas in the transportation sector was limited only by fleet turnover. As with the estimate of light duty vehicle fuel economy, the economic potential assumes that equivalent gasoline powered stock is only replaced with CNG vehicles offering a payback period below 10 years (the average life of a vehicle). The vehicle price premiums for CNG vehicles relative to their conventional gasoline powered counterparts were taken from a presentation made to the DOE EIA in 2013, titled “The Future of Natural Gas as a Transportation Fuel.”³⁸

For estimates of the technical and economic potential of vehicle electrification, Navigant followed a similar approach as for CNG, limiting the technical potential by fleet turnover, and limiting the economic potential to the fraction of vehicles that would achieve a payback period within the 10 year average vehicle lifetime. For both CNG and electric vehicles, Navigant did not limit the technical potential based on availability of these vehicles in the current market, assuming that automakers and dealers would respond to consumer demand. However, the current lack of availability of alternative fuel vehicles in the New Hampshire market certainly presents a barrier to developing consumer awareness and driving widespread market adoption.

Figure 24: Potential for Alternative Transportation Fuels illustrates the economic and technical potential for alternative fuels in transportation. Based on this analysis, while biofuels offer a more economical alternative, the magnitude of the technical potential for both natural gas and electric vehicles makes them more attractive targets for policies to drive market adoption of alternative fuel vehicles (AFVs).



³⁸ <http://www.eia.gov/conference/2013/pdf/presentations/gallagher.pdf>

Figure 24: Potential for Alternative Transportation Fuels³⁹

C.5 Power Generation & Energy Infrastructure Potential

Power Generation

All fossil fuels used for power generation in New Hampshire come from out of state. As such, greater investment in renewable energy reduces reliance on imported fuels, fosters self-sufficiency, and keeps spending in-state. To promote development on this front, New Hampshire adopted an RPS in 2007. The current standard specifies the total amount of power that must be procured from all classes is 24.8% by 2025.⁴⁰

Navigant analyzed the technical and economic potential of each of the following renewable power generation resources to examine opportunities to reduce reliance on fossil fuels for power generation. Navigant's estimate of the technical potential for renewable power generation utilized the National Renewable Energy Lab (NREL) study "U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis."⁴¹ This report presented the technical potential for installed capacity and power generation for 11 classes of renewables, including:

- Urban Utility-scale PV
- Rural Utility-scale PV
- Rooftop PV
- Concentrated Solar Power (CSP)
- Onshore Wind
- Offshore Wind
- Biopower-Solid
- Biopower-Gaseous
- Geothermal Hydrothermal
- Enhanced Geothermal Systems (EGS)
- Hydropower

For the purposes of the resource potential study, Navigant combined the classes of utility-scale PV and bio-power into one class for each resource. Additionally, Navigant did not consider the technical potential for EGS geothermal power generation. Only one plant of this type is in operation in the US, so the future inclusion of this category will depend on further information about the suitability of EGS technology for power generation in New Hampshire.

In light of the recent price trends for solar technology, the estimate of economic potential for solar PV is based upon unsubsidized levels of solar development at true grid parity⁴², i.e. without incentives, but with a 20 percent utility cap, as estimated by the Institute for Local Self-Reliance. The solar PV nameplate capacity was translated into actual power generation using the same ratio of solar PV capacity to power generation as indicated in the NREL study of technical potential.

For biomass, the economic potential for power generation was estimated using data from the DES Climate Action Plan (Appendix 8: The Wood Biomass Wedge in New Hampshire: Data Sources and Basic Approach)⁴³ and the 2012 Regional Assessment of Woody Biomass Physical Availability as an

³⁹ Source data and reports used in estimating the potential for alternative transportation fuels are detailed in C.6 Resource Potential - Supporting Data.

⁴⁰ http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NH09R

⁴¹ <http://www.nrel.gov/docs/fy12osti/51946.pdf>

⁴² <http://www.ilsr.org/projects/solarparitymap/>

⁴³ http://des.nh.gov/organization/divisions/air/tsb/tps/climate/action_plan/documents/032509_nhccptf_appendix_8.pdf

Energy Feedstock for Combined Combustion in the US Northern Region⁴⁴ as published in the Journal of Forestry. The latter study corrects for merchantability and estimates an available 738,000 metric dry tons a year in New Hampshire. These estimates assume expansion of biomass fueled power generation using only feedstock grown in-state.

The economic potential of terrestrial wind was informed by an NREL study titled “An Analysis of the Technical and Economic Potential for Mid-Scale Distributed Wind,” which examines the potential for distributed wind (smaller than utility scale) to address the needs of large commercial and industrial customers, and potentially municipalities.⁴⁵ Navigant scaled the findings of this study to address residential demand as well. For offshore wind development, the economic potential used Cape Wind as a reference point and scaled this value based on the relative offshore wind resources of New Hampshire and Massachusetts.

The technical and market potentials for in-state hydroelectric power are small in comparison to other resources (852 MW technical and 455 MW market). The economic potential for hydroelectric power was estimated based on its ability to economically compete with other types of power generation through the forecast period. This was estimated as the percent increase in the cost of competing fuels for power generation through the forecast period, equating to a 10 percent increase in economically justified in-state hydroelectric capacity. It is important to note that new hydroelectric projects, as well as existing hydroelectric projects over 5 megawatts, do not currently qualify for the RPS.⁴⁶

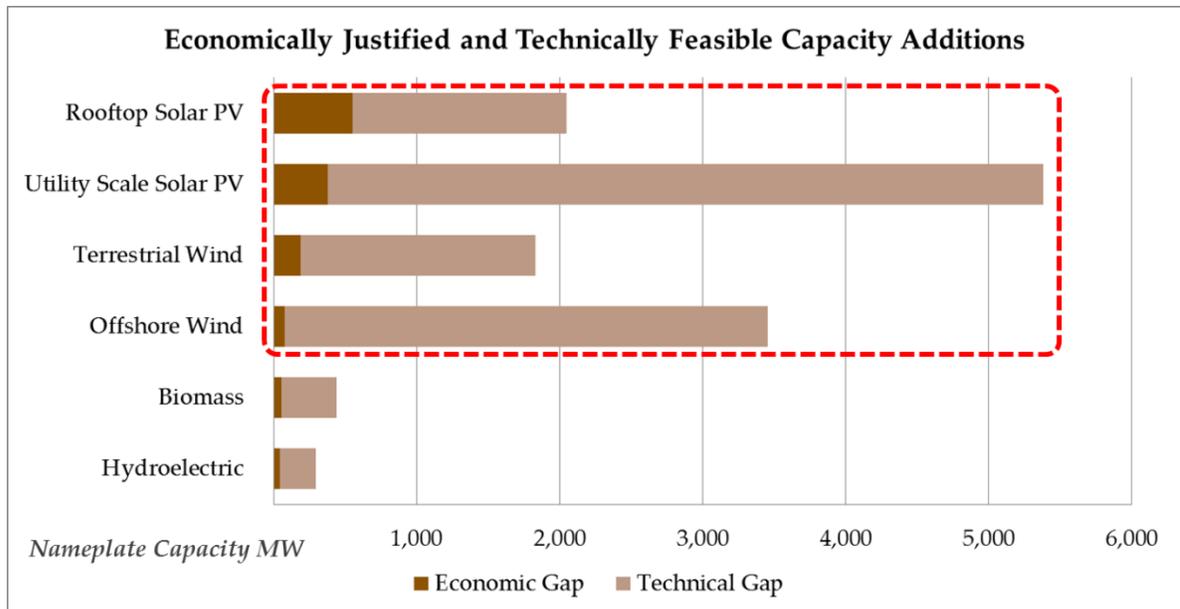


Figure 25: Potential for Renewable Energy Capacity⁴⁷

⁴⁴ http://www.nrs.fs.fed.us/pubs/jrnl/2012/nrs_2012_goerndt_001.pdf

⁴⁵ http://www.nrel.gov/wind/pdfs/midscale_analysis.pdf

⁴⁶ http://www.puc.state.nh.us/sustainable%20Energy/Renewable_Portfolio_Standard_Program.htm

⁴⁷ Source data and reports used in estimating the potential for alternative transportation fuels are detailed in C.6 Resource Potential - Supporting Data.

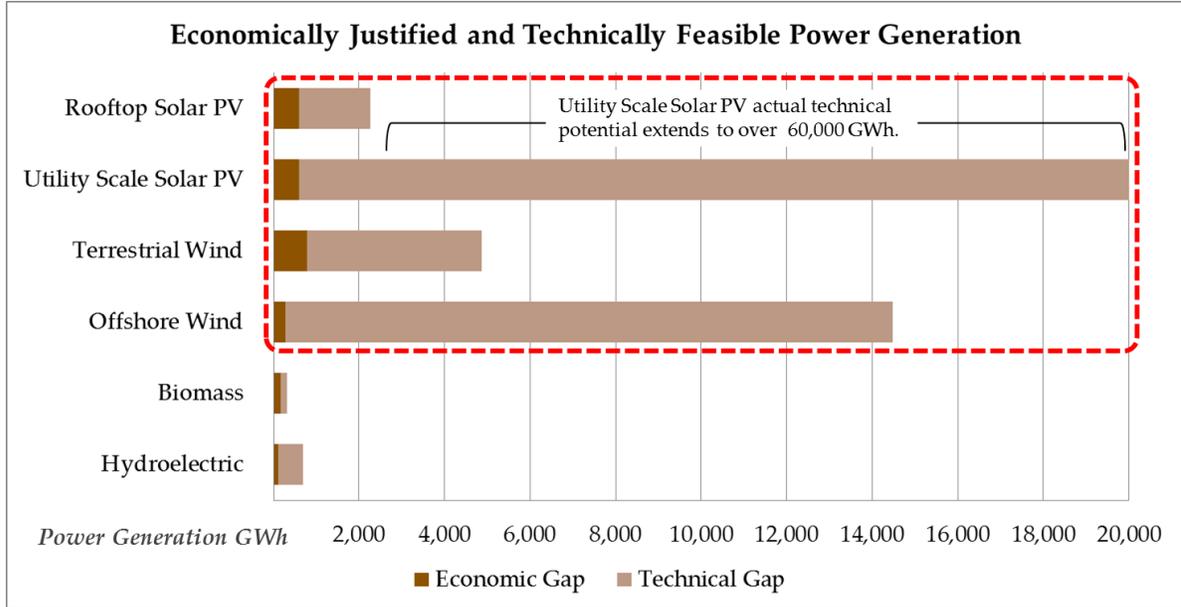


Figure 26: Potential for Renewable Power Generation⁴⁷

What clearly stands out from this analysis is the magnitude of technical potential for utility scale PV and offshore wind makes them especially attractive as the cost of technology comes down. The analysis also shows significant remaining technical potential for mid- scale terrestrial wind and rooftop PV. Given the relative capacity factors for wind and solar, the remaining economic potential for additional terrestrial wind power generation is actually higher than that of either solar technology making continued development of these resources the most economically viable opportunity to expand in-state renewable power generation in the near term. As electric rates rise, and additional attention is given to distributed generation as a means to foster grid reliability, a policy landscape that fosters innovation will play a critical role in helping all of these resources achieve their full economic potential.

Electric Infrastructure

Two resources were analyzed within the electric infrastructure category: combined heat and power (CHP) and electric storage. It should be noted that these resources are not in competition with one another, as they provide significantly different benefits. CHP capitalizes on collocated electric and thermal loads, generating both electric power and thermal energy. In contrast, electric storage provides a variety of benefits including load shifting, frequency regulation, and backup power, as well as helping with the integration of intermittent renewable resources with the grid.

The technical potential for CHP in New Hampshire was estimated using information gained from a report on CHP for Commercial Buildings Benefits Analysis prepared by Arthur D. Little, Inc.⁴⁸ It was estimated that 25% of the target sectors’ (commercial and industrial) thermal and electric loads were collocated in a way that CHP would provide benefits. The economic potential was further limited to only those applications with adequate scale to justify installation. Current CHP installations in New Hampshire vary from 10 kilowatts to 12 megawatts and are fueled by oil (50% of capacity), natural gas (40% of capacity) and wood (10% of capacity)⁴⁹.

⁴⁸ https://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_benefits_commercial_buildings.pdf

⁴⁹ <http://www.eea-inc.com/chpdata/States/NH.html>

The estimate of technical potential for electric storage was based on the economic benefits of daily load smoothing. Load smoothing helps reduce the cost of peak electricity by shifting loads away from times of peak demand. This is accomplished by storing power generated during off-peak times, and deploying this stored power during peak events. Using historical data from ISO New England⁵⁰, one half of the difference between the average minimum and maximum daily demand was used to estimate the total storage needed to smooth loads. To estimate the economic potential, Navigant examined energy storage as it is typically deployed. At present, most electric storage is economically justified based on its ability to smooth loads attributed to intermittent resources. In markets with significant renewable power generation, intermittent resources are firmed with storage at 25 percent of nameplate capacity. This figure was applied to the baseline forecast for renewables in New Hampshire and served as the basis for the estimated economic potential of electric storage. The amount of storage required will increase with greater deployment of renewable power generation.

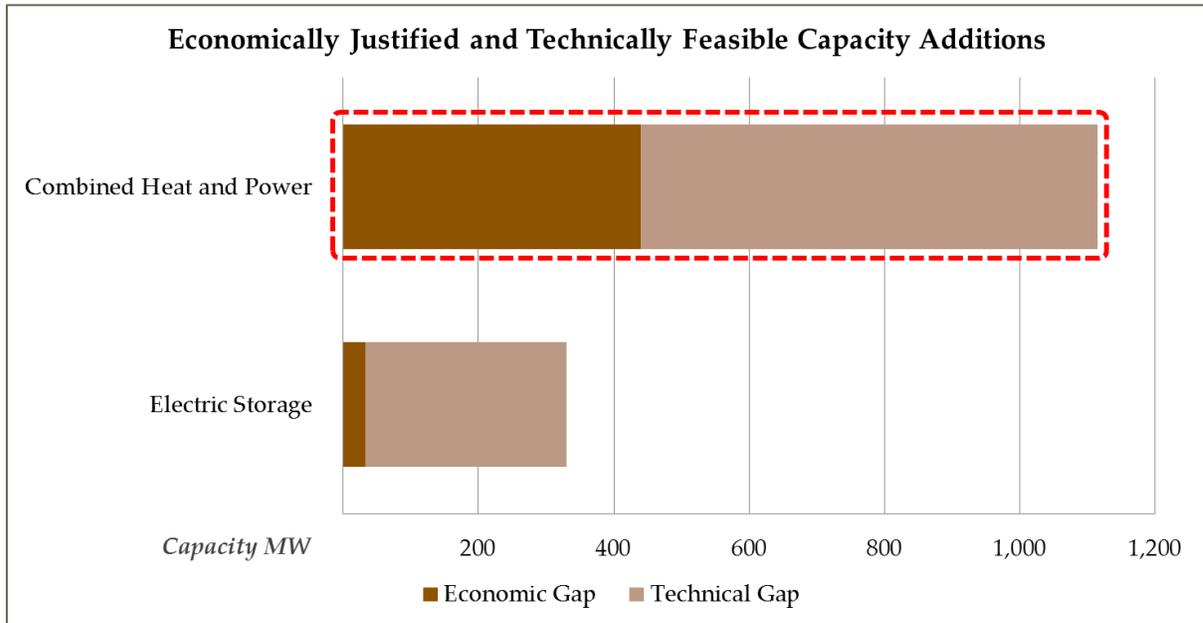


Figure 27: Electric Infrastructure Capacity⁵¹

As indicated in Figure 27: Electric Infrastructure Capacity, the technical and economic potential for CHP systems surpasses the potential for electric storage. This can be attributed to the clear economic benefits of efficiency gains with CHP systems, compared to the benefits of storage which are more difficult to quantify and are affected by the limited penetration of renewable power generation in-state. However, additional gains in storage technology are important for reducing costs during peak usage times and balancing intermittent renewables.

The economic and technical potentials of these infrastructure technologies, and those of the renewable power generation resources, will help guide policy development by highlighting the most significant opportunities for further resource development.

⁵⁰ http://www.iso-ne.com/markets/hst_rpts/hstRpts.do?category=Hourly

⁵¹ Source data and reports used in estimating the potential for alternative transportation fuels are detailed in C.6 Resource Potential - Supporting Data.

C.6 Resource Potential - Supporting Data

Resource Potential Source Data

Report / Data Set	Web Address
GDS Associates, Inc., “Additional Opportunities for Energy Efficiency in New Hampshire,”	http://www.puc.state.nh.us/Electric/GDS%20Report/NH%20Additional%20EE%20Opportunities%20Study%202-19-09%20-%20Final.pdf
DOE: Building Energy Data Book	http://buildingsdatabook.eren.doe.gov/
2013 ORNL Energy Data Book	http://cta.ornl.gov/data/index.shtml
Idaho National Laboratory EV Project Data	http://avt.inel.gov/evproject.shtml
Federal Highway Authority Fleet Statistics	https://www.fhwa.dot.gov/ohim/onh00/onh2p3.htm
Rocky Mountain Institute, Summary of U.S. VMT reduction strategies	http://www.rmi.org/RFGraph-Summary_of_US_VMT_reduction_strategies

Table 3: Energy Efficiency Resource Potential Source Data

Report / Data Set	Web Address
Unitil Gas Rates	http://unitil.com/energy-for-residents/gas-information/rates http://unitil.com/energy-for-businesses/gas-information/rates
National Grid: Renewable Gas Vision for a Sustainable Gas Network	http://www.nationalgridus.com/non_html/ng_renewable_wp.pdf
EnergyNorth Natural Gas: Integrated Resource Plan	http://www.puc.nh.gov/Regulatory/Docketbk/2013/13-313/INITIAL%20FILING%20-%20PETITION/13-313%202013-11-01%20ENGI%20DBA%20LIBERTY%20INTEGRATED%20RESOURCE%20PLAN.PDF
Northern Utilities, Inc. Testimony	http://www.puc.nh.gov/Regulatory/docketbk-2013.html
United States Census Bureau State & County QuickFacts: New Hampshire	http://quickfacts.census.gov/qfd/states/33000.html
Massachusetts Department of Energy Resources: Commonwealth Accelerated Renewable Thermal Strategy	http://www.mass.gov/eea/docs/doer/renewables/thermal/carts-report.pdf
Navigant Report on Ground-Source Heat Pumps: Overview of Market Status, Barriers to Adoption, and Options for Overcoming Barriers	http://www1.eere.energy.gov/geothermal/pdfs/gshp_overview.pdf
USDA: Economic Research Service: Atlas of Rural and Small-Town America	http://www.ers.usda.gov/datafiles/Rural_Definitions/StateLevel_Maps/NH.pdf
DOE Energy Saver: Active Solar Heating	http://energy.gov/energysaver/articles/active-solar-heating
EIA: Residential Energy Consumption Survey 2009 & Commercial Buildings Energy Consumption Survey 2012	http://www.eia.gov/consumption/residential/data/2009/
DOE: Building Energy Data Book	http://buildingsdatabook.eren.doe.gov/
WeatherUnderground.com / DegreeDays.net	http://www.degree-days.net/#generate , BERLIN MUNICIPAL AIRPORT, NH, US (71.18W,44.58N)
DOE Alternative Fuels Data Center	http://www.afdc.energy.gov/
Renewable Fuels Association: Monthly U.S. Fuel Ethanol Production/Demand	http://ethanolrfa.org/pages/monthly-fuel-ethanol-production-demand
2013 ORNL Energy Data Book	http://cta.ornl.gov/data/index.shtml
Idaho National Laboratory: EV Project Data	http://avt.inel.gov/evproject.shtml
Federal Highway Authority: Fleet Statistics	https://www.fhwa.dot.gov/ohim/onh00/onh2p3.htm

Table 4: Alternative Fuels Resource Potential Source Data

Report / Data Set	Web Address
NREL: U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis	http://www.nrel.gov/gis/re_potential.html
Institute for Local Self Reliance: Commercial Rooftop Revolution	http://www.ilsr.org/commercial-roofop-revolution/
Interstate Renewable Energy Council: National Report on Solar Installation Trends	http://www.irecusa.org/2013/07/national-report-on-solar-installation-trends-offers-insight-and-analysis/
DOE: WINDEXchange – Wind Resource Potential	http://apps2.eere.energy.gov/wind/windexchange/windmaps/resource_potential.asp
NREL: An Analysis of the Technical and Economic Potential for Mid-Scale Distributed Wind	http://www.nrel.gov/wind/pdfs/midscale_analysis.pdf
WindAction: U.S. Average Annual Capacity factors by project and State	http://www.windaction.org/posts/37255-u-s-average-annual-capacity-factors-by-project-and-state#.U_uZ1vldWSq
NREL: Offshore Wind Resource Characterization	http://www.nrel.gov/wind/offshore_resource_characterization.html
CapeWind	http://www.capewind.org/index.php
DES: New Hampshire Climate Action Plan	http://des.nh.gov/organization/divisions/air/tsb/tps/climate/action_plan/documents/032509_nhccptf_appendix_8.pdf
USDA Forest Service Journal of Forestry: Regional Assessment of Woody Biomass Physical Availability as an Energy Feedstock for Combined Combustion in the US Northern Region.	http://www.nrs.fs.fed.us/pubs/jrnl/2012/nrs_2012_goerndt_001.pdf
ICF: Combined Heat and Power Units located in New Hampshire	http://www.eea-inc.com/chpdata/States/NH.html
ISO-NE Pricing and Energy, Load, and Demand Reports	http://www.iso-ne.com/isoexpress/web/reports/pricing?category=Hourly http://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/net-ener-peak-load

Table 5: Power Generation & Energy Infrastructure Resource Potential Source Data

Resource Potential Data Tables

Subsector - Resource	Units	Technical	Economic	BAU
Residential - Thermal Efficiency	BBtu	22,300	8,322	4,789
Residential - Electric Efficiency	BBtu	4,816	3,183	1,898
Industrial - Thermal Efficiency	BBtu	1,701	1,372	663
Industrial - Electric Efficiency	BBtu	2,744	2,357	1,138
Commercial - Thermal Efficiency	BBtu	7,463	4,803	2,026
Commercial - Electric Efficiency	BBtu	4,525	3,021	1,393

Table 6: Electric and Thermal Energy Efficiency Resource Potential Data (BBtu Savings)

Resource	Units	Technical	Economic	BAU
Medium & Heavy Duty Vehicles	BBtu	10,516	4,217	456
Light Duty Vehicles	BBtu	57,377	22,758	18,284
VMT Reduction	BBtu	41,370	3,516	(708)

Table 7: Transportation Energy Efficiency Resource Potential Data (BBtu Savings)

Subsector - Resource	Units	Technical	Economic	BAU
Commercial - Ground Source HP	BBtu	4,612	231	-
Residential - Solar Thermal	BBtu	8,920	892	9
Commercial - Biomass	BBtu	5,647	2,199	1,132
Industrial - Biomass	BBtu	3,419	1,331	40
Residential - Air Source HP	BBtu	31,388	6,173	4,764
Commercial - Natural Gas	BBtu	24,481	15,087	13,562
Industrial - Air Source HP	BBtu	7,398	2,880	796
Residential - Natural Gas	BBtu	19,820	11,144	8,469
Commercial - Air Source HP	BBtu	19,515	7,598	4,412
Residential - Ground Source HP	BBtu	22,078	3,312	33
Industrial - Natural Gas	BBtu	15,194	12,589	9,190
Residential - Biomass	BBtu	24,531	10,732	6,467

Table 8: Alternative Thermal Fuels Resource Potential Data (BBtu)

Resource	Units	Technical	Economic	BAU
Electric	%	88.3%	5.7%	1.9%
Natural Gas	%	90.1%	4.1%	0.2%
Biofuel	%	15.8%	11.8%	6.5%

Table 9: Alternative Transportation Fuels Resource Potential Data (% of demand)

Resource	Units	Technical	Economic	BAU
Utility Scale Solar PV	GWh	61,154	635	34
Offshore Wind	GWh	14,478	270	-
Terrestrial Wind	GWh	5,706	1,612	835
Rooftop Solar PV	GWh	2,299	635	34
Biomass	GWh	2,097	1,938	1,780
Hydroelectric	GWh	1,741	1,157	1,052

Table 10: Renewable Energy Generation Resource Potential Data (GWh)

Subsector - Resource	Units	Technical	Economic	BAU
Utility Scale Solar PV	MW	37,928	394	16
Offshore Wind	MW	3,456	76	-
Terrestrial Wind	MW	2,135	492	304
Rooftop Solar PV	MW	2,062	570	16
Hydroelectric	MW	753	501	455
Biomass	MW	747	358	304

Table 11: Renewable Energy Capacity Resource Potential Data (MW)

Resource	Units	Technical	Economic	BAU
Electric Storage	MW	376	80	47
Combined Heat and Power	MW	1,173	499	59

Table 12: Energy Storage and CHP Resource Potential Data (MW)