Electrification Scenarios for North Carolina's Energy Future

Executive Summary

Summary

In partnership with Duke Energy and the North Carolina Electric Membership Corporation (NCEMC), the Electric Power Research Institute (EPRI) investigated, under multiple scenarios, the potential for adoption of electric technologies in three end-use sectors – buildings, transportation, and industry – and the corresponding impact on electricity generation and carbon dioxide (CO_2) emissions in North Carolina during the period from 2015 to 2050. Using the United States Regional Economy, Greenhouse Gas and Energy (US-REGEN) model, EPRI conducted a state-wide analysis of the potential for efficient electrification – the economic adoption of electric end-use technologies – under nine scenarios. The study finds that key electrification outcomes, such as load growth and reductions in final energy and economy-wide CO_2 emissions, depend on a range of policy, economic, and technology factors (Figure 1).

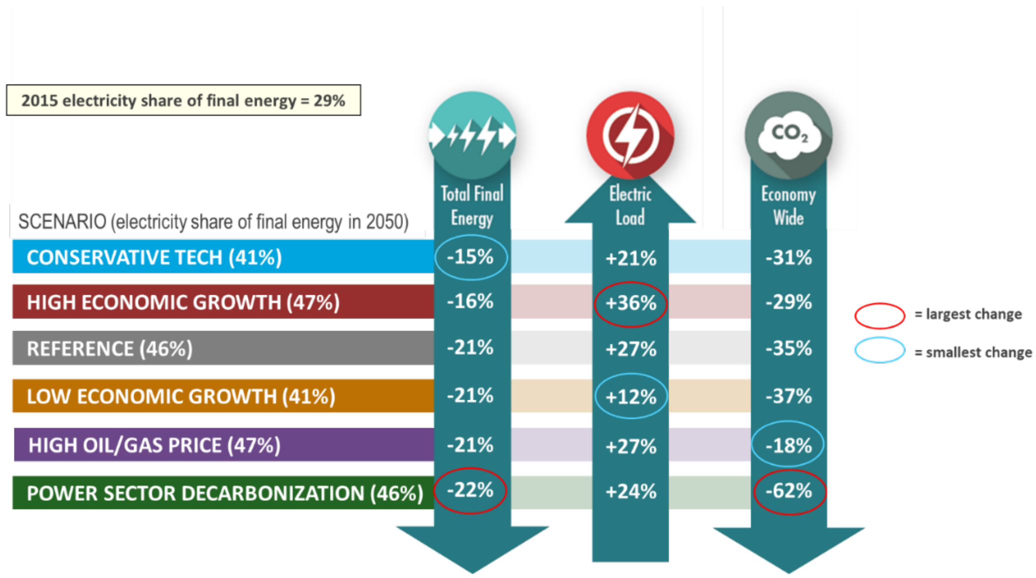

Figure 1. Projected changes in key model outputs across select scenarios. Percent changes reflect difference between 2015 and 2050.

Key findings from this analysis include: (1) Efficient electrification is observed across all scenarios with electricity constituting 41-47% of total final energy by 2050; (2) Light-duty vehicle electrification is the largest contributor to load growth in North Carolina, but the extent depends on future electric vehicle costs; (3) Building loads decline through energy efficiency and displacement of electric resistance heating with more efficient heat pumps; (4) Electrification will impact electric sector resource planning in North Carolina, particularly by significantly increasing winter peak loads. However, load management programs could largely mitigate these impacts; (5) Future generation and capacity mixes in North Carolina are sensitive to future fuel prices, climate policy, and technology availability; (6) Electrification is accompanied by falling final energy and economy-wide CO_2 emissions; and (7) Natural gas remains an important fuel for energy end-uses and power supply.

Introduction

EPRI has underway an Efficient Electrification research initiative to help the electric power sector and related stakeholders identify cost-effective and resilient strategies to produce and use clean energy. This study evaluates the potential for efficient electrification in North Carolina, assesses key drivers, and identifies opportunities and challenges. Funders for this project include Duke Energy and NCEMC.

EPRI's *U.S. National Electrification Assessment* (US NEA) (EPRI, 2018a) highlighted the economic potential for electrification – the adoption of electric end-use technologies – across residential, commercial, industrial, and transport sectors to create value for consumers and society. This study applies the same analytical tools for an in-depth exploration of state-specific opportunities for North Carolina. This report presents the results for the Task 1 energy system assessment in which EPRI conducted a rigorous scenario analysis to explore alternate energy system pathways in North Carolina through 2050. Insights presented here are based on analysis conducted at the state level and could vary geographically within the state.

The analysis employs state-of-the-art modeling through EPRI's U.S. Regional Economy, Greenhouse Gas, and Energy (US-REGEN)[1] framework. US-REGEN is an energy-economy model that combines a detailed electric sector capacity planning and dispatch model with a uniquely capable end-use model. Task 1 examines the evolution of the North Carolina energy system under a range of scenarios (Table 1) that explore uncertainties around future fuel prices, technology cost and performance, the policy environment, and load management strategies. These scenarios are used to understand the implications of these uncertainties for electrification, resource planning, and environmental outcomes. Adoption of electro-technologies in the model is driven by economic incentives faced by consumers and firms, so electricity demand for specific end uses represent cost-effective technology choices under the scenario assumptions. These scenarios and the insights derived from them demonstrate how electrification can influence electricity consumption, economy-wide CO_2 emissions, and final energy consumption.[2]

Efficient Electrification

For many applications, from transportation to heating to manufacturing, electricity can provide a **more efficient and economical alternative, with lower environmental impact, for the same or better quality service**. Electricity currently represents nearly one third of final energy in North Carolina, but rapidly changing technologies and other drivers create new opportunities across the energy economy and may accelerate the trend toward higher electricity shares.

The next section briefly outlines the scenarios used in this analysis. This section is followed by descriptions of the seven key insights derived from the assessment. The final section provides some background on the modeling approach. For additional information and results from Task 1, refer to the annotated slide decks that accompany this executive summary.

[1] More information about the structure and assumptions of US-REGEN can be found in the model documentation (EPRI, 2018b) and in the final section of this executive summary.

[2] "Final energy" is a measure of the energy consumed at the end use. It does not include the energy consumed in processes upstream from the end user, such as the energy used for electricity generation or fuel refining.

Scenarios

This study examines the evolution of the North Carolina energy system under nine scenarios (Table 1) using EPRI's US-REGEN model. The scenarios are not constructed to achieve a specific outcome regarding the extent of economy-wide electrification or decarbonization. Rather, scenario analysis explores how the electricity and energy systems in North Carolina evolve under different input assumptions and compares results across these future 'states of the world', without suggesting one pathway is preferable to another. By using this approach, the study can provide important insights to utilities, policy makers and market players on the different energy futures that may result from different technology, policy, economic and/or market developments.

Table 1.Scenario matrix for Task 1 of the North Carolina state electrification assessment

	Economic Growth	Oil/Gas Prices	Technology Optimism	Load Management[1]	Policy
Reference	Reference	Low	Reference	No Load Management	State RPS + existing ITC
Load Management[1]	Reference	Low	Reference	Load Management (50% participation in programs)	State RPS + existing ITC
Power Sector Decarbonization	Reference	Low	Reference	No Load Management	50% by 2030 90% by 2050
Power Sector Decarbonization + Load Management	Reference	Low	Reference	Load Management (90% adoption)	50% by 2030 90% by 2050
High Oil/Gas Price	Reference	High	Reference	No Load Management	State RPS + existing ITC
Power Sector Decarbonization + No New Nuclear	Reference	Low	No New Nuclear	No Load Management	50% by 2030 90% by 2050
Conservative Tech	Reference	Low	Slow Efficiency & Cost Improvements	No Load Management	State RPS + existing ITC
High Economic Growth	High	Low	Reference	No Load Management	State RPS + existing ITC
Low Economic Growth	Low	Low	Slow Efficiency & Cost Improvements	No Load Management	State RPS + existing ITC

[1]Load management includes coordinated EV charging, space conditioning, and water heating; scenarios explored 20-90% participation in load management programs, but 50% participation was chosen for load management scenarios

Key assumptions used in the US-REGEN electric sector model include the following:

- Fuel prices, population growth, and GDP growth are based on the U.S. Energy Information Administration's *Annual Energy Outlook (AEO) 2019*
- Hourly regional renewable output and resource potentials are based on analysis and data by EPRI and NASA's MERRA-2 dataset using 2015 as the model base year
- Technology costs and performance are based on research from EPRI's *Integrated Generation Technology Options Report* (EPRI, 2018)
- Regional Greenhouse Gas Initiative (RGGI) caps and renewable portfolio standards (RPS) for all states are enforced. The federal Investment Tax Credit (ITC), Production Tax Credit (PTC) and Clean Air Act §111(b) are also enforced.
- There are no forced retirements of existing coal or nuclear plants and new coal without CCS cannot be built; economic retirements are allowed.
- The model uses a discount rate of 5% to evaluate investment decisions and system costs over the long-term time horizon through 2050

The scenarios in Table 1 explore uncertainties across the following five dimensions: future economic growth, future oil/gas prices, technology optimism, load management, and climate policy. The *Economic Growth* dimension explores how different assumptions about economic and population growth might impact energy trends in the future. The GDP, population, commercial floor area and industrial output trends are derived from projections from the Energy Information Administration (EIA) 2019 Annual Energy Outlook (AEO) for three distinct scenarios. The annual growth rates for various parameters associated with each *Economic Growth* variant are provided in Table 2.

Table 2. Annual growth rates (2015 – 2050) for parameters related to the *Economic Growth* dimension

	GDP	Population	Residential Floor Area	Commercial Floor Area	Industrial Output	Source
Low	1.5%	0.9%	1.4%	0.9%	1.3%	AEO Low Economic Growth
Reference	1.9%	1.0%	1.5%	1.1%	1.8%	AEO Reference
High	2.4%	1.2%	1.6%	1.4%	2.4%	AEO High Economic Growth

The *Oil/Gas Price* dimension explores how different fuel price projections might impact end-use technology choices as well as the future electricity generation mix. The low fuel price trend follows the projection from the EIA AEO High Oil and Gas Resource & Technology scenario while the high fuel price trend follows the AEO Reference scenario. Fuel prices are different for residential, commercial, industrial, transportation, and power sector customers. Example prices for natural gas in the power sector are provided in Table 3.

Table 3. Power sector gas prices across the Oil/Gas Price dimension (2015$ per mmbtu)

	2015	2050	Source
Low	3.76	3.74	AEO High Oil and Gas Resource & Technology
High	3.76	5.14	AEO Reference

The *Technology Optimism* dimension explores the impact of reduced investment in research and development (R&D) for electric vehicles (EVs) and energy efficiency, leading to slower efficiency and EV cost improvements relative to the reference variant. While the vehicle purchase price of EVs reaches parity with internal combustion engine vehicles (ICEVs) by 2050 in the reference variant, EVs remain about $5000 more expensive than ICEVs in the conservative variant. Energy efficiency improves more slowly for several residential, commercial, and industrial applications. Note that the Low Economic Growth scenario includes the assumption that low economic growth will be accompanied by less R&D investment. The *Technology Optimism* dimension also includes a scenario in which political and societal obstacles preclude the construction of new nuclear power plants.

The *Load Management* dimension explores the potential for coordinated electric vehicle charging, space conditioning and water heating, to influence diurnal load shapes and reduce system peaks. In these scenarios, US-REGEN optimizes the hourly load shape subject to specific constraints. For EV charging, a fixed share of EVs is assigned to each of three charging windows (home, workplace, or autonomous) and daily electricity requirements must be met within this window but can be shifted to improve the load shape. In contrast, space conditioning and water heating loads can only be shifted within 3-hour windows. For the purposes of this study, participation in these programs was assumed to be 50%.[3]

The *Policy* dimension explores the implications of a 50% and 90% reduction in power sector CO_2 emissions (relative to 2005) in 2030 and 2050, respectively. These targets are applied as constraints in all regions so that imports from neighboring regions are similarly decarbonized. CO_2 prices associated with the emission targets can be inferred from the shadow price on the power sector emission constraint. These CO_2 prices are passed to the end-use model so that a consistent price is applied economy-wide.

Key Insights

Insight 1: Efficient electrification is observed across all scenarios with electricity constituting 41-47% of total final energy by 2050

Compared to the national average, the electricity share of total final energy consumption in North Carolina is large. In 2015, electricity represented 29% of statewide final energy consumption compared to the United States average of 21%. This analysis projects that efficient electrification, driven by technological change and consumer choice, will continue in North Carolina. The electricity share of total final energy increases to over 40% across all scenarios, suggesting that nearly half of the economy in North Carolina could be electrified by 2050. In contrast, in the US NEA, the national electric share of final energy only exceeds 40% in the Transformation scenario, where a very large carbon price is applied economy-wide[4].

Electricity consumption increases across all scenarios, ranging from 0.3 to 0.9% growth per year between 2015 and 2050 (Figure 2). Load growth is most sensitive to future economic growth (and the associated growth in demands for end-use services) as well as the extent of electric vehicle adoption. Future load growth in North Carolina occurs only in the light-duty vehicle (Insight 2) and industrial sectors, while the already heavily electrified building sector sees declines due to efficiency gains and technology replacement (Insight 3). In the Reference scenario, electricity consumption increases by 27% between 2015 and 2050, corresponding to an annual increase of 0.7%. More optimistic and pessimistic economic growth assumptions could lead to electricity growth as high as 36% or as low as 12% between 2015 and 2050. Note that the Low Economic Growth scenario also includes pessimistic assumptions about future EV costs and thus less transport electrification.

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[3] EPRI investigated the impact of different levels of participation in load management programs in North Carolina, ranging from 20% to 90% of households. In the Reference scenario, winter peak load was 26% higher in 2050 compared to 2015. Limited (20%) to extensive (90%) participation in load management programs yielded reductions in the winter peak of 7-11% in 2050. Beyond 50% participation (10% reduction in winter peak), additional reductions in peak load were small and thus most of the benefit from load management can be achieved with the participation of 50% of households.

[4] In the NEA, the carbon price in the Transformation scenario begins at \$50/ton CO_2 in 2020 and rises annually at a 7% discount rate to reach \$380/ton CO_2 in 2050. Carbon prices are not explicitly applied in the Power Sector Decarbonization scenarios, but the implicit carbon prices in these scenarios never exceed \$90/ton CO_2 in 2050.

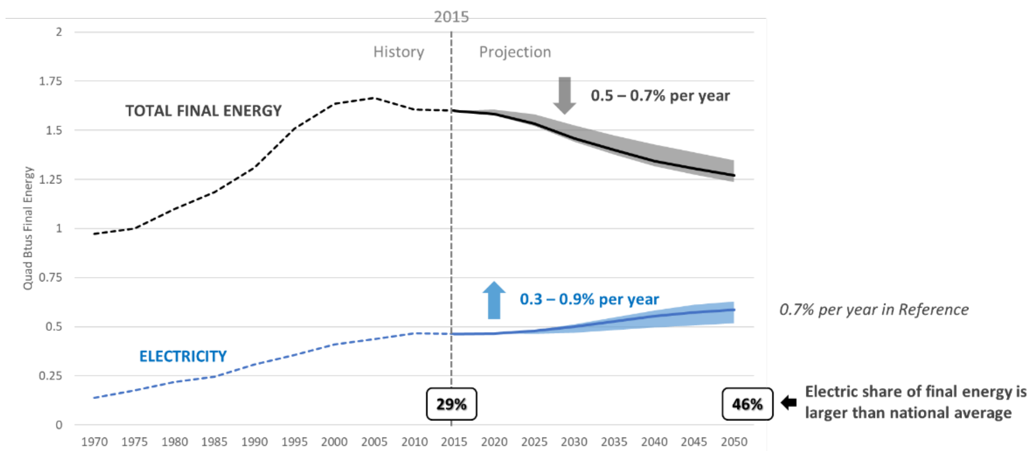

Figure 2. North Carolina final energy and electricity consumption trajectories across all scenarios. The bolded line for each projection represents the Reference scenario.

Insight 2: Light-duty vehicle electrification is the largest contributor to load growth in North Carolina, but the extent depends on future electric vehicle costs

Electrification of light-duty passenger vehicles is the largest driver of load growth in North Carolina. While annual electricity consumption increases by 27% between 2015 and 2050 in the Reference scenario (Figure 3), it would increase by only 4% without transportation electrification (0-13% across all scenarios). This finding suggests that EV deployment accounts for roughly 85% of the change in annual electricity consumption between 2015 and 2050. Industrial electrification is responsible for the remaining load growth.

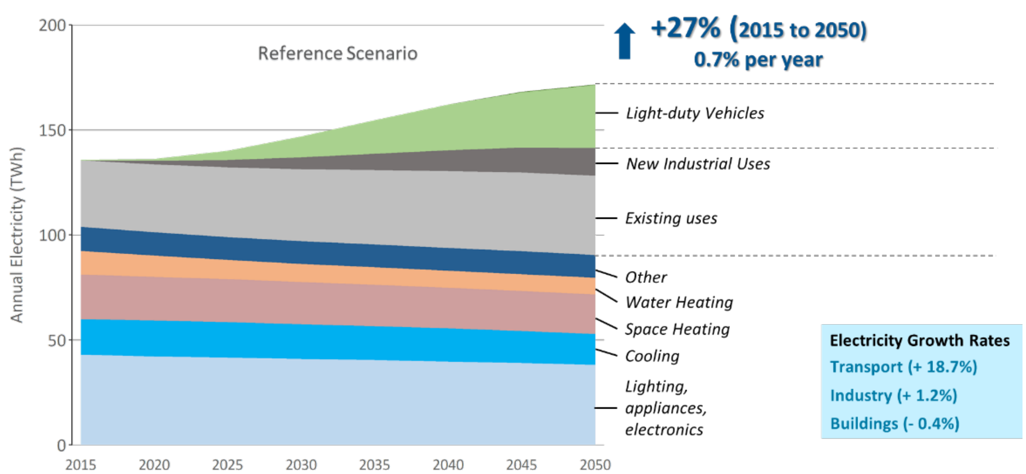

Figure 3. Disaggregation of annual electricity consumption in North Carolina from 2015 to 2050 in the Reference scenario.

In the Reference scenario, 55% of light-duty vehicles are projected to be all electric by 2050 and these EVs account for 74% of vehicle miles traveled (VMT; Figure 4). Electrification of light-duty transportation is driven by declining battery and vehicle costs. When coupled with smaller fuel and maintenance costs, the total cost of owning and operating EVs becomes progressively more competitive with conventional ICEVs for most households and EV adoption accelerates. These dynamics are not unique to North Carolina and similar adoption rates were reported in the US NEA (EPRI, 2018a).

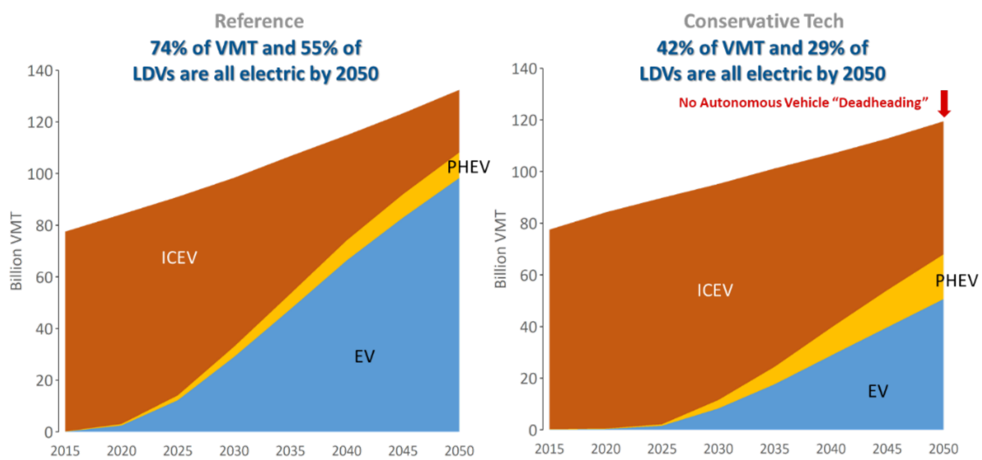

Figure 4. Comparison of vehicle miles traveled by different vehicle types in the Reference scenario (left panel) and Conservative Tech scenario (right panel). Autonomous vehicle (AV) "deadheading" refers to the additional miles AVs travel between passengers. AVs are excluded from the Conservative Tech scenario.

While electric vehicle adoption could significantly increase electric loads, this analysis finds that future adoption is sensitive to assumptions about future electric vehicle costs. In the Conservative Tech scenario, where EV costs decline less rapidly, cost parity between electric vehicles and conventional vehicles is delayed. Consequently, only 29% of light duty vehicles are electrified by 2050 and EVs account for 42% of light-duty VMT (Figure 4). Tempered adoption of electric vehicles moderates load growth in North Carolina. By 2050, electric load has increased by 21% in the Conservative Tech scenario compared to 27% in the Reference scenario.

The extent of light duty vehicle electrification also has impacts on hourly load shapes and economy-wide CO_2 emissions. Electric vehicle charging can exacerbate winter peak loads as workplace charging may coincide with morning space heating loads (Insight 4 and Figure 7). However, there may be opportunities to coordinate vehicle charging to help mitigate these peaks. Less vehicle electrification also reduces the potential for lowering transport-related CO_2 emissions. In the Conservative Tech scenario, transport CO_2 emissions decline by 43% between 2015 and 2050 compared to 57% in the Reference scenario.

Insight 3: Building loads decline through energy efficiency and displacement of electric resistance heating with more efficient heat pumps

In North Carolina, the buildings sector is already highly electrified. About two-thirds of final energy consumption in buildings is electric and more than half of existing space and water heating was electrified in 2015. While heat pump adoption for space heating results in increased electricity consumption by buildings nationally (EPRI, 2018a), 33% of the residential floor area in North Carolina was already heated by heat pumps in 2015 and another 23% was heated by electric resistance (Figure 5). Thus, even though heat pumps expand their market share to 62% by 2050, much of this expansion comes at the expense of less efficient electric resistance heating (9% share in 2050). Consequently, both the total final energy and electricity consumption for space heating declines in North Carolina during the study period (Figure 6).

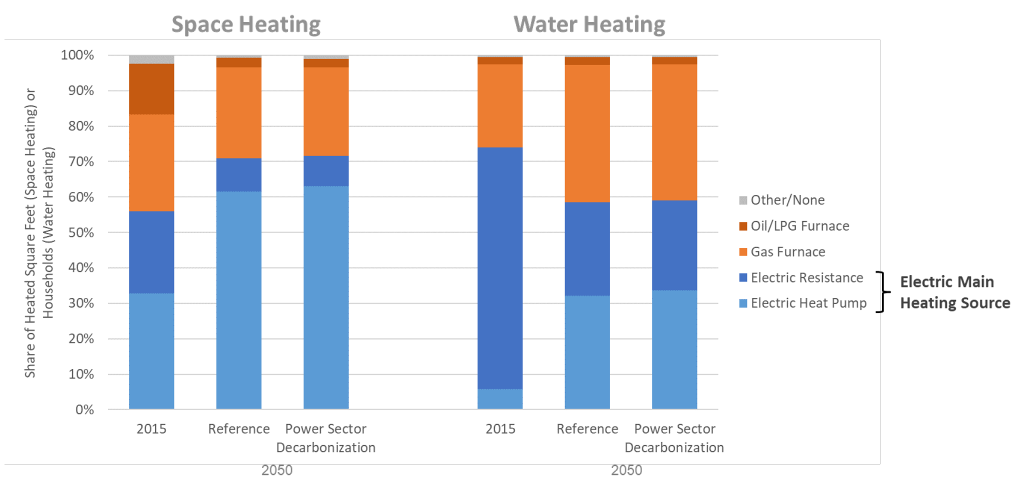

Figure 5. Share of heated floor space in North Carolina by space heating technology and share of households by water heating technology in 2015 and 2050

About 75% of households in North Carolina use electricity for water heating with the vast majority using electric resistance heaters (Figure 5). Electric resistance heaters lose market share to both heat pump and gas water heaters by 2050, resulting in an overall reduction of the share of households using electricity for water heating to 58%. The loss of market share coupled with the improved efficiency of heat pumps results in a significant decrease in the electricity consumed for water heating (Figure 6). The gas share of space heating remains flat while it increases for water heating. Consequently, natural gas consumption and building-related CO_2 emissions increase between 2015 and 2050. Note that the carbon prices resulting from power sector decarbonization have very little impact on space and water heating technology adoption.

When these space and water heating trends are coupled with efficiency improvements in other applications such as lighting and appliances, building electricity consumption declines as efficiency gains outstrip service demand growth and electrification. In the Reference scenario, building electricity consumption declines approximately 0.4% per year, resulting in a 13% decrease over the study period (9-15% across all scenarios).

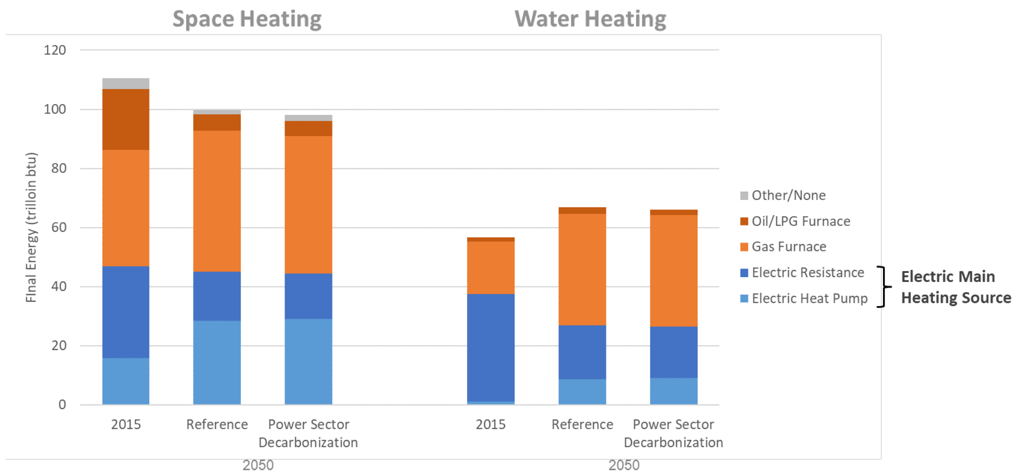

Figure 6. Final energy consumption in 2015 and 2050 by technology for both space and water heating in North Carolina. Power sector decarbonization and associated carbon prices have very little impact on water and space heating technology choice and energy use.

Insight 4: Electrification will impact electric sector resource planning in North Carolina, particularly by significantly increasing winter peak loads. However, load management programs could largely mitigate these impacts

A unique feature of EPRI's modeling framework is the construction of synthetic hourly load shapes from individual end-uses in each time period, which facilitates the assessment of changes to diurnal and seasonal load shapes resulting from electrification (EPRI, 2018b). Electrification and efficiency have important impacts on electric sector resource planning through changes in annual load growth, seasonal trends, and daily load shapes. In addition, electrification has the potential to enhance flexibility and demand response opportunities through active management of these loads.

Electrification exacerbates both summer and winter peak loads with vehicle charging playing the largest role. The winter peak load is particularly impacted as workplace vehicle charging coincides with large space heating loads on cold mornings. In the Reference scenario, the winter peak increases by 26% between 2015 and 2050, resulting in a 2050 winter peak of just over 40 GW (Figure 7). This impact is exacerbated by the fact that low temperatures reduce the efficiency of electric vehicles which further increases charging loads.

However, transport electrification also offers significant demand response potential through active coordination of vehicle charging. Active management of electric vehicle charging, water heating, and space conditioning can reduce the winter peak load by up to 5 GW and thus mitigate much of the impact from vehicle electrification (Figure 8). In addition, coordinated vehicle charging can provide a useful sink for excess mid-day solar output and thus provide additional system flexibility for integrating large-scale solar deployment. This flexibility could help to offset the need for relatively expensive flexible generation and storage investments. Individually, active management of only electric vehicle charging yields larger benefits than managing only space conditioning and water heating, but combined management of both buildings and vehicles yields the largest benefits.

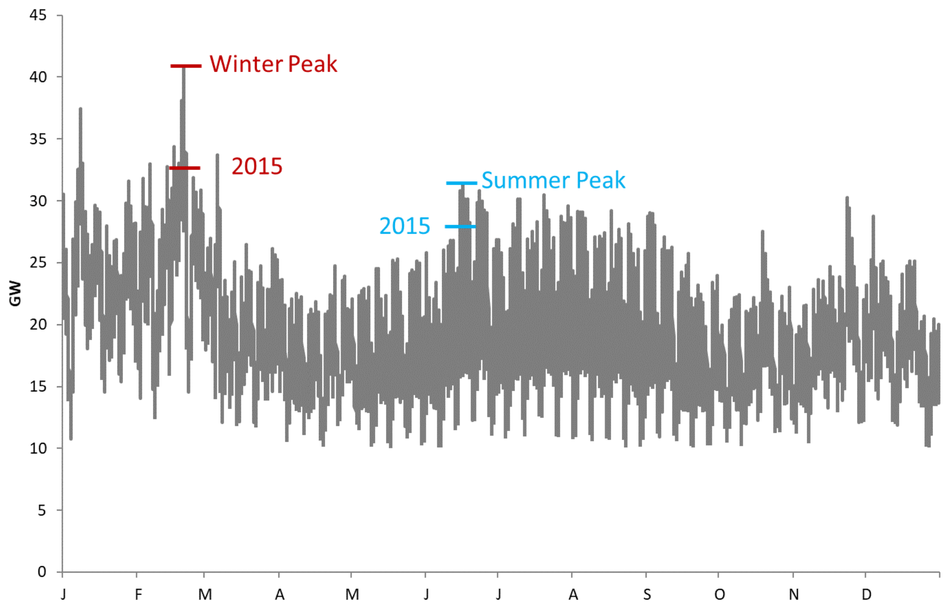

Figure 7. 2050 aggregate load profile for North Carolina with 2015 and 2050 seasonal peaks.

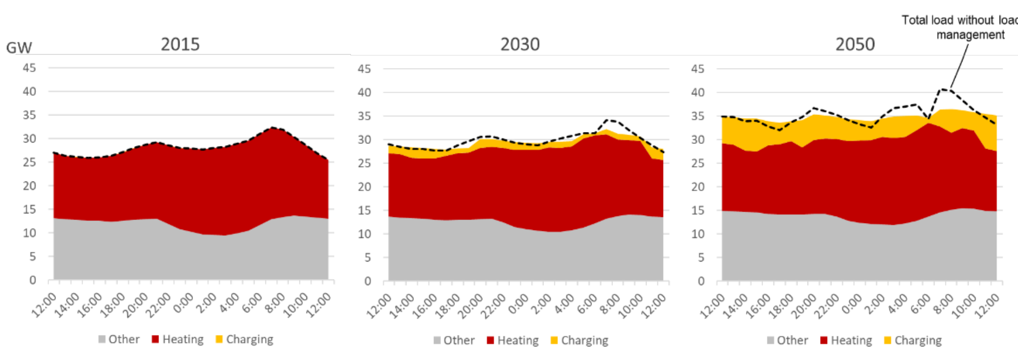

Figure 8. Hourly load profiles for space heating, vehicle charging, and other loads during the 24 hours containing the February winter peak with 50% participation in load management programs. Dotted line shows total load for the same period without managed load.

The analysis also shows how load management can smooth load shapes and reduce the variability of hourly load throughout a given year. By smoothing load, load management increases the utilization of natural gas combined cycle (NGCC) power plants and accelerates the retirement of coal plants. By improving plant utilization and reducing peak loads, load management also reduces overall investment requirements in new capacity, particularly for NGCCs and gas turbines. As a result, both overall system costs and wholesale electricity costs are smaller with managed load. This study did not investigate the implications of load management for transmission and distribution investments, but a reduction in peak loads would likely reduce these investments as well.

Insight 5: Future electricity capacity and generation mixes in North Carolina are sensitive to future fuel prices, climate policy, and technology availability.

Electricity in North Carolina in 2015 was primarily generated by natural gas, coal, and nuclear power plants with less than 5% of generation from renewables. The composition of future capacity and generation mixes in the state are sensitive to the evolution of policy, technology, and market factors, such as fuel prices, CO_2 emission targets, and technology availability.

In the Reference scenario, which assumes low gas prices throughout the study period, natural gas and nuclear remain important fuels for electricity generation as coal-fired units are displaced by gas-fired units over the next decade. By 2050, without any electric sector CO_2 emission targets, natural gas and existing nuclear[5] dominate the generation mix (Figure 9). Conversely, coal continues to play a significant role in the generation mix if gas prices rise.

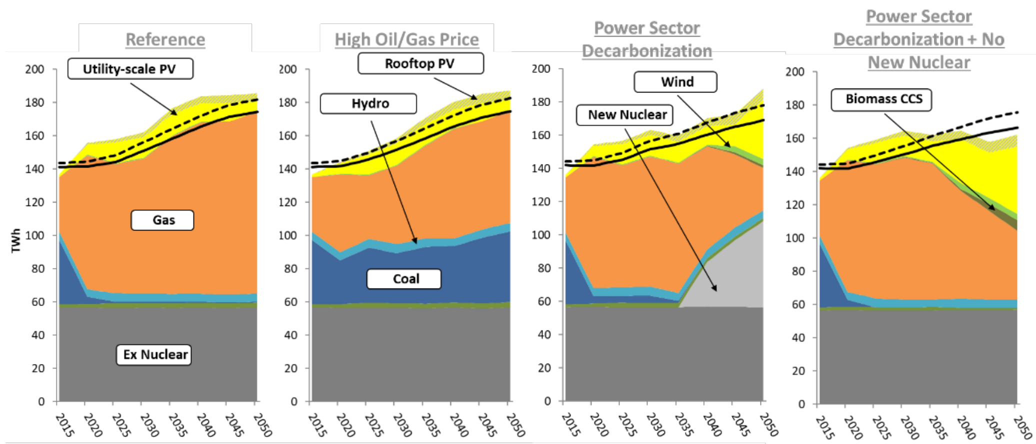

Figure 9. Generation mix between 2015 and 2050 in North Carolina across select scenarios.

Fuel switching from coal to natural gas reduces power sector emissions by 50% by 2030 (relative to 2005) in most scenarios even without explicit emission targets. As a result, if low gas prices are anticipated, capacity investments through 2030 are remarkably similar across scenarios, involving building 10-12 GW of new NGCC while retiring 9-10 GW of existing coal (Figure 10). Only when high gas prices are anticipated does the North Carolina power system see less fuel switching from coal to gas and fewer new gas builds.

To achieve a 90% reduction in power sector CO_2 emissions by 2050, large investments in nuclear and utility-scale solar are required. If nuclear cannot be built, the system relies on additional utility-scale solar and greater imports to achieve the target. North Carolina becomes a net importer of electricity after 2040 when nuclear is unavailable because low-carbon generation can be accessed at lower cost outside the state.

[5] 15 TWh of existing nuclear imported from South Carolina is considered in-state generation in this study.

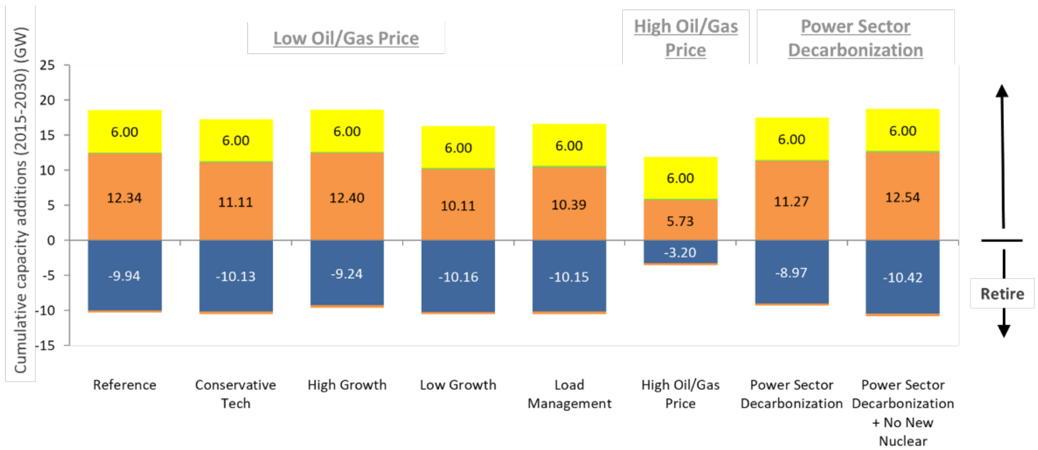

Figure 10. Cumulative capacity additions in North Carolina between 2016 and 2030[6].

Insight 6: Electrification is accompanied by falling final energy and economy-wide CO_2 emissions[7]

While electricity consumption increases across scenarios, the corresponding final energy consumption in North Carolina decreases at a rate of 0.5 to 0.7% per year (Figure 2). The decline in total final energy is primarily caused by a reduction in petroleum consumption from transport electrification as EVs are more efficient at converting energy to mobility. However, energy efficiency improvements and electrification in other sectors also contribute to the reduction in final energy consumption over the study period.

The decline in final energy consumption leads to a corresponding reduction in economy-wide CO_2 emissions in North Carolina, ranging from 0.6 to 2.7% per year (Figure 11). The magnitude of emission reductions is most sensitive to the degree to which the power sector is decarbonized, the extent of transportation electrification, and future gas prices. An increase in natural gas prices would limit economy-wide emission reductions by tempering fuel switching from coal to natural gas.

In the Reference scenario, widespread adoption of EVs and the replacement of coal-fired generation with gas lead to economy-wide CO_2 emissions in 2050 that are nearly 50% smaller than emissions in 2005. However, reducing power sector emissions by 90% can increase emission reductions by an additional twenty percentage points, suggesting that power sector decarbonization is critical for achieving deep emission reductions.

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[6] The new solar capacity in this figure is capacity that is already planned for construction. It is important to note that this decision is not considered optimal and that the model would likely choose to build less solar capacity in this timeframe across all scenarios.
[7] This study only investigates changes to CO_2 emissions. Although not explicitly evaluated in this study, electrification, particularly of transportation, could lead to reduction of criteria pollutant emissions and improvements to local air quality. There may be additional public and private benefits (e.g., productivity, water use, product quality) from end-use electrification that are not quantified in this analysis but may encourage adoption.

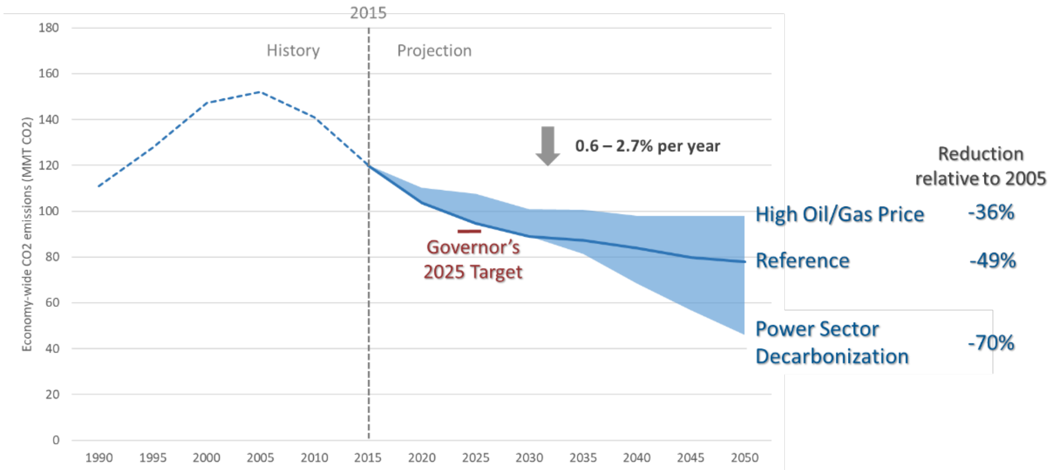

Figure 11. Economy-wide CO_2 reductions in North Carolina across scenarios. No scenario achieves the Governor's target of a 40% reduction in economy-wide emissions by 2025.

Insight 7: Natural gas remains an important fuel for energy end-uses and power supply

Although this study found significant electrification across all sectors, natural gas remains an important fuel in North Carolina for not only energy end-uses but also for electricity generation. Natural gas consumption for end-uses is projected to grow by approximately 30% across all scenarios. This growth occurs primarily in building end-uses where gas-based appliances remain competitive with electric options, such as water heating and cooking (Figure 6).

Low natural gas prices also ensure that gas-fired generation remains cheaper than coal-fired generation and, as a result, gas-fired generation more than triples over the study period in the Reference scenario (Figure 9). Although this trend is sensitive to the gas price and emission targets, gas-based generation still doubles even when larger gas prices are assumed.

EPRI's Unique Modeling Framework: US-REGEN

The North Carolina Electrification analysis uses EPRI's US-REGEN[8] modeling system, which combines a state-of-the-art electric sector capacity planning and dispatch model with a uniquely capable end-use model (EPRI, 2018b; Blanford, et al., 2018). Distinguishing features of the model include:

- Detailed disaggregation of sectors, activities, end-uses, and technologies (Figure 12), and explicit tracking of structural classes including building type and size, building and equipment vintage, household attributes, and annual temperature profile
- Endogenous end-use technology adoption based on economic and operational characteristics for specific applications over time
- Synchronized equilibrium of hourly load profiles and prices between electricity supply and energy use (Figure 13)

These features enable US-REGEN to systematically represent many important dimensions of end-use technology tradeoffs that are omitted by other models, such as the significant heterogeneity of applications and interactions with the electric generation sector.

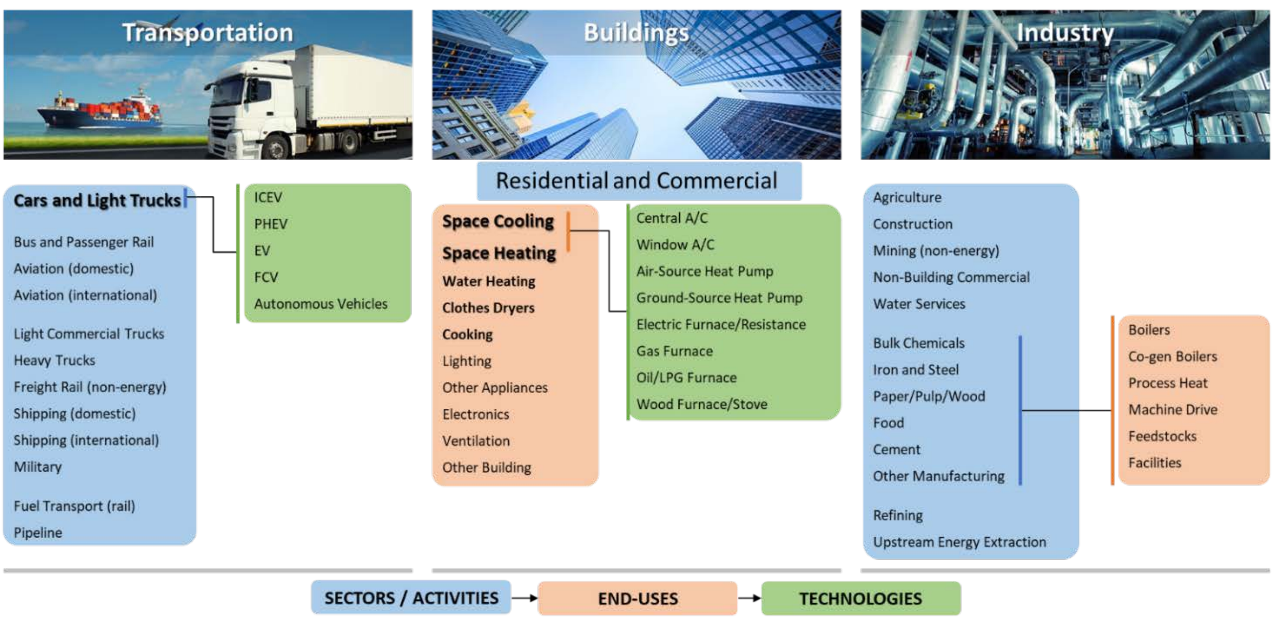

Figure 12. US-REGEN end-use model level of detail by sector.

The model develops projections of energy use across the economy over time based on assumptions about the cost and performance of technology, fuel prices, and policy incentives. US-REGEN simulates technology adoption by consumer segment for an array of energy services, with an emphasis on services for which fuel substitution is possible or likely (e.g., passenger vehicles, space heating).

[8] Selected model publications and model documentation are available at: http://eea.epri.com/.

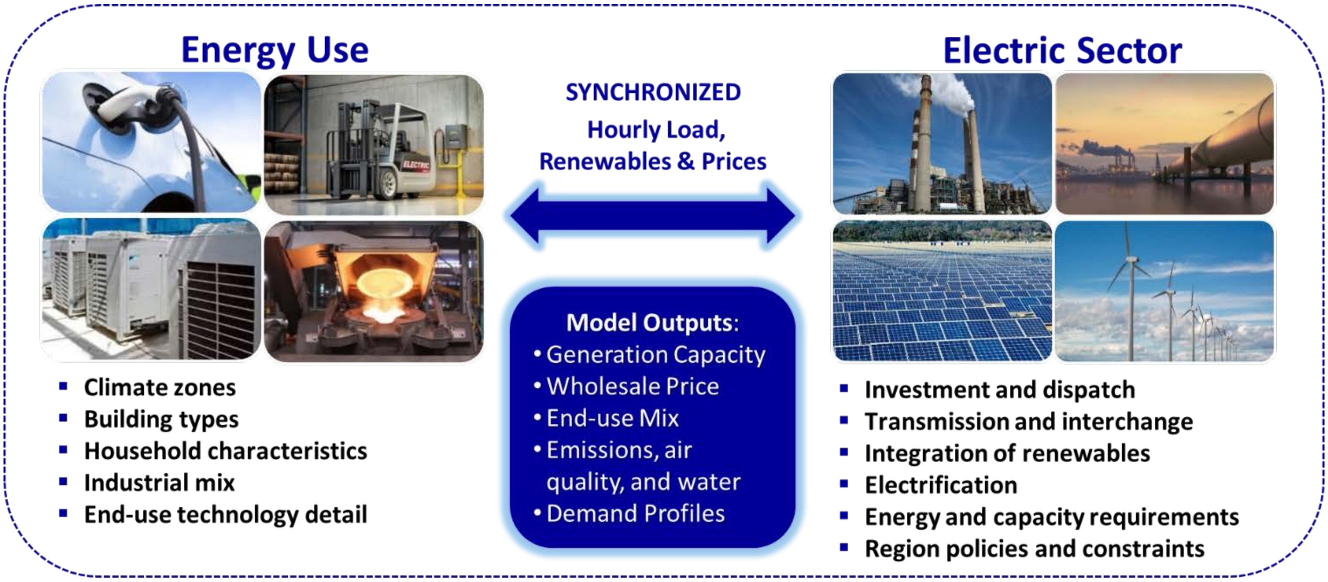

Figure 13. US-REGEN model coverage and interactions between the electric sector and end-use models.

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Additional Information

For additional information about this analysis, contact Nils Johnson (njohnson@epri.com) or Francisco de la Chesnaye (fdelachesnaye@epri.com). In addition to the energy system assessment (Task 1) described in this report, the project also includes an electrification potential and implementation plan at the utility service territory level (Task 2).

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