2017 COMPREHENSIVE ENERGY STRATEGY

Draft: July 26th, 2017

CT GENERAL STATUTES SECTION 16a-3d

Connecticut Department of Energy and Environmental Protection

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EXECUTIVE SUMMARY

The Connecticut Department of Energy and Environmental Protection (DEEP) has prepared this update to Connecticut's Comprehensive Energy Strategy (CES) to advance the State's goal to create a cheaper, cleaner, more reliable energy future for Connecticut's residents and businesses. By statute (see Appendix A), DEEP is required to periodically update the CES to assess and plan for all energy needs in the state, including, but not limited to, electricity, heating, cooling and transportation.

Since the publication of Connecticut's first CES in 2013, the State has advanced policies and programs that have put the State on a path to reduce energy costs, improve system reliability, and minimize environmental impacts for its residents and businesses. Connecticut has achieved significant progress. For example, since 2013 DEEP has:

- Directly procured commitments of renewable energy generation and energy efficiency that equal the generation of a large power plant, at competitive pricing.
    - Specifically, the state has procured over 400 megawatts (MW) of DEEP-solicited small scale renewable energy and energy efficiency resources, and over 400 MW of large-scale renewable energy projects, 90 MW of which will be located in Connecticut.
    - The price of these selected grid scale bids dropped by nearly half compared to procurements in 2012 and 2013.
    - Procurement of energy efficiency as a resource moves the energy efficiency resource standard to a level on par with other generation sources, truly exemplifying the value of efficiency as a resource equivalent to supply.
- Developed a first-in-the-nation statewide microgrid program to build local resiliency for electrical load in critical community operations.
    - Program implementation now includes five operational microgrids and five in development.
- Established a Governor's Council on Climate Change to ensure the State meets its greenhouse gas (GHG) reduction goals.
- Launched a Shared Clean Energy Facility pilot program, with DEEP selecting over 5 MW of solar that will have a dedicated subscription target of low- and moderate-income consumers.

- Advanced development of renewable energy generation and supported lower electricity bills for state, municipal, and agricultural customers through virtual net metering.

- Converted 39,104 residential customers to natural gas for heating, and 12,021 commercial and industrial customers to natural gas for generation or other processes between 2014 and 2016.

- Catalyzed residential and commercial investments in energy efficiency across the state through implementation of Connecticut's award-winning Conservation and Load Management Plan (C&LM Plan), contributing to Connecticut's economy, and fueling an energy efficiency industry with 34,000 jobs in Connecticut.
    - These investments have empowered state residents to collectively save more than $140 million annually, Connecticut's businesses to save more than $115 million annually, and Connecticut's state agencies to save $6 million annually.
    - Investments are spread across millions of projects statewide, including in more than 20,000 low-income homes annually and at thousands of businesses, large and small.
    - Investments include utilities and others providing low or no interest financing for heating equipment with simplified applications and on-bill repayment, and market-based incentives that transform energy use.
    - Connecticut became the first state to implement the U.S. Department of Energy's Home Energy Score labeling system on a statewide voluntary basis, producing over 21,000 scores to date.

- Launched the EVConnecticut program to:
    - Provide grants for charging and alternative fueling stations to make Connecticut a range-confident state, and
    - Deploy point-of-sale vehicle rebates through the Connecticut Hydrogen and Electric Automobile Purchase Rebate (CHEAPR) program—supporting the purchase of 1,300 EVs.

- Launched CT*fastrak* bus rapid transit (BRT) service, doubling the ridership in corridor to between 12,000-16,000 weekday trips and helping riders avoid rush-hour congestion.

- Released Let's Go CT!, Governor Dannel Malloy's transportation Call to Action representing 30-year vision for Connecticut's best-in-class transportation system.

The State will continue to build upon this foundation to transform how we produce, distribute, and consume energy to achieve Connecticut's long-term vision of a zero-carbon economy. This transformation will take many years to implement and requires developing a forward thinking framework with specific plans and recommendations for the near term.

With this in mind, the 2017 update of the CES is guided by the goal of cheaper, cleaner, more reliable energy. Connecticut energy policy must:

- Align with and support the State's broader environmental policies to meet clean air, clean water, land conservation and development, and waste reduction goals;
- Put the State on a clear path to meet the Global Warming Solutions Act to reduce GHG emissions 10 percent below 1990 levels by 2020 and 80 percent below 2001 levels by 2050;
- Focus on grid modernization, strategic electrification, increasing efficiency, and improving reliability and security;
- Increase energy affordability and economic security to help strengthen the State's economy now and into the future;
- Maintain equitable access to the benefits of clean and efficient energy generation and transportation options.

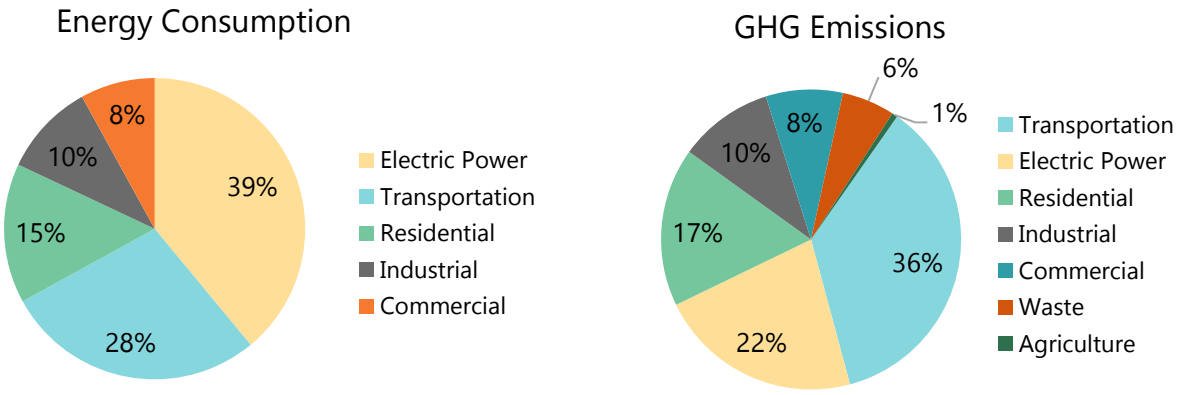
Guided by these principles, this CES offers a series of goals and strategies that reflect lessons learned and respond to new conditions within the three energy end-use sectors; electricity power, buildings, and transportation. These strategies and goals advance the State's long-term vision by calling for continued investment in clean energy resources, grid-modernization, increasing energy efficiency in buildings and transportation, and accelerating progress to decarbonize the energy sector.

Energy Policy that Advances Climate Goals

Energy consumption across all fuels and sectors accounts for 93 percent of the GHG emissions in Connecticut. Across energy usage sectors, transportation is the largest contributor of emissions, accounting for 36 percent, with the electric power sector following at 22 percent (see Figure ES1). As the State's single largest source of emissions, Connecticut's transportation sector emissions are well above the national average where emissions from the transportation sector are 27 percent and the electric power sector makes up 29 percent.[1]

[1] U.S. EPA's inventory of U.S. Greenhouse Gas emissions and Sinks: 1990 -2015, April 2017. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2015

FIGURE ES1: Connecticut Energy Consumption and GHG Emissions by Sector



Source: United States Energy Information Administration

This difference in emissions contributions for the electric power and transportation sectors can be attributed to Connecticut, and the New England region as a whole, transitioning electric power generation from carbon intensive fuel sources such as coal and oil to less carbon intensive fuel sources such as natural gas and renewables.[2] The region's grid operator, ISO New England, attributes this transformation to four primary factors: public policies and programs, economics, innovation, and customer choices.[3]

DEEP's most recent GHG inventory analysis shows that the State has reduced emissions 4 percent below 1990 levels and 14 percent below 2001 levels.[4] Although Connecticut's progress in reducing GHG emissions has been successful, far deeper cuts are needed in the coming decades to meet the Global Warming Solutions Act's (GWSA) 2050 target. The State must continue to move swiftly to decarbonize its energy supply across all sectors.

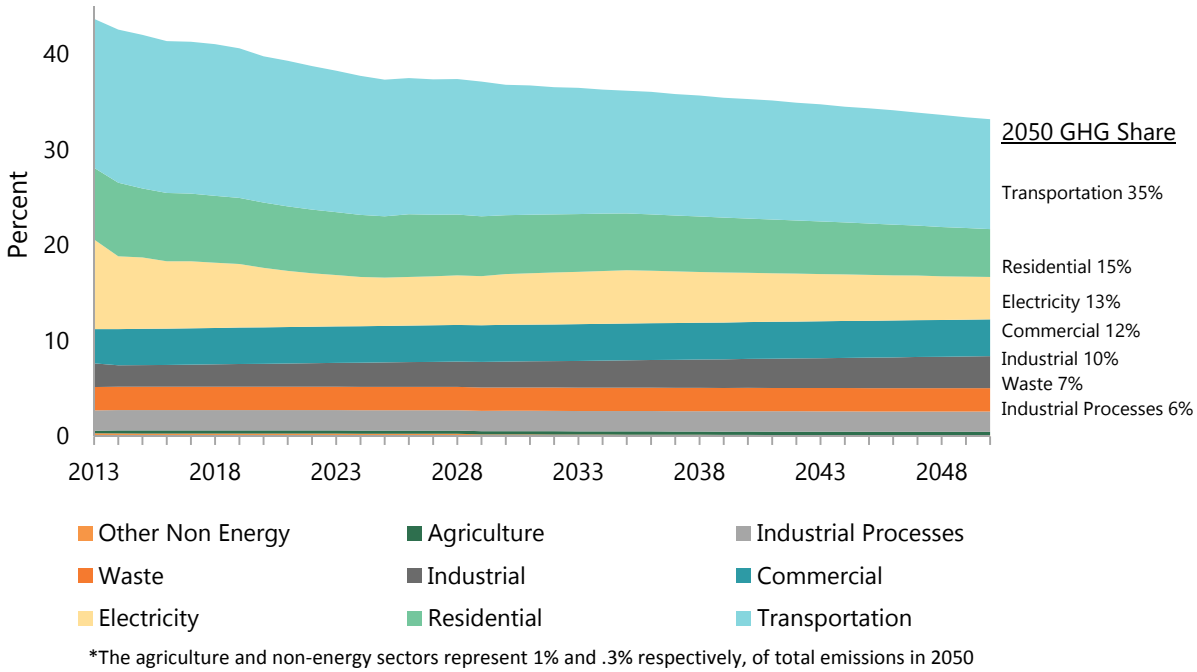
In an analysis completed by the Governor's Council on Climate Change (GC3), the business-as-usual reference case shows emissions from the electric power sector will continue to decline, while

[2] New England Power Grid 2016-2017 Profile, ISO New England, https://www.iso-ne.com/static-assets/documents/2017/01/ne_power_grid_2016_2017_regional_profile.pdf

[3] Grid in Transition: Opportunities and Challenges, ISO New England Regional Outlook, https://www.iso-ne.com/about/regional-electricity-outlook/grid-in-transition-opportunities-and-challenges

[4] 2013 Connecticut Greenhouse Gas Emissions Inventory, CT DEEP, 2016 http://www.ct.gov/deep/lib/deep/climatechange/2012_ghg_inventory_2015/ct_2013_ghg_inventory.pdf

FIGURE ES2: Economy-wide GHG Emissions Business as Usual Reference Case



*The agriculture and non-energy sectors represent 1% and .3% respectively, of total emissions in 2050

emissions from the transportation sector will remain almost constant at 35 percent of economy-wide GHG emissions through 2050.[5] The residential, electric power, commercial, and industrial sectors follow at 15, 13, 12 and 10 percent respectively by 2050 (Figure ES2).

To achieve the long-term vision of a developing a zero-carbon economy, improving building efficiency, and reducing vehicle miles traveled can help decrease the use of carbon-intensive fuels. But ultimately, widespread electrification of building thermal loads (cooling and heating) and the transportation sector is required. Consequently, by 2050 electricity becomes the dominant source for our energy supply and makes decarbonization of the electric power sector the cornerstone to the success of achieving a carbon-free economy.

It is important to note that Connecticut's ambitious emissions reduction goals cannot be achieved by government alone. Private actors including businesses, civic and advocacy groups, private citizens, religious organizations, associations, and colleges and universities play a critical role. Collaborative partnerships, private investment, and technology innovation is paramount to achieving the necessary reductions. Climate change solutions that go beyond government action

[5] Governor Dannel P. Malloy's Executive Order 46 (4-22-15) established the Governor's Council on Climate Change to examine the efficacy of existing policies and regulations designed to reduce GHG emissions and identify new strategies to meet the established emission reduction targets.

Governor's Council on Climate Change

On Earth Day 2015, Governor Malloy issued Executive Order 46, creating the Governor's Council on Climate Change (GC3). The Council is composed of 15 members from state agencies, quasi-state agencies, companies, and nonprofits. Governor Malloy tasked the Council with:

- establishing interim goals that will guide the state to the 2050 emission reduction target;
- annually monitoring statewide GHG emissions to determine if the state is poised to meet its 2050 target and any established interim goal(s);
- examining the efficacy of existing policies and regulations designed to reduce GHG emissions; and
- recommending new policies, regulation, or legislative actions that will assist in achieving established emission-reduction targets.

Council members are currently in the process of analyzing greenhouse gas emission reduction scenarios to inform their recommendations on strategies that lead to long-term emissions reductions and to ensure that the state is on a path to meet its Global Warming Solutions Act goal of 80 percent below 2001 levels by 2050.

For more information on GC3 activities: www.ct.gov/deep/GC3

will help stimulate the economy and build strong, vibrant, and resilient communities across the state.

Pathway to Grid Modernization and Decarbonization

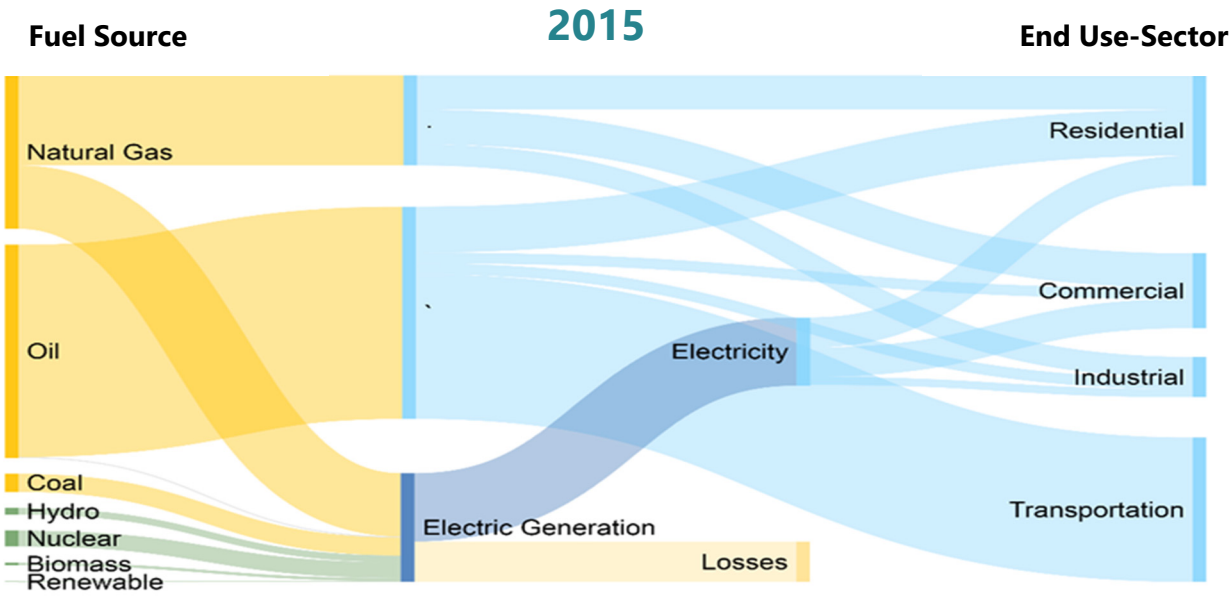
Connecticut's energy vision identifies a pathway for meeting our environmental goals while capturing the benefits of investing in renewable energy sources and minimizing our dependence on commodities subject to price volatility. According to United States Energy Information Administration data for 2015, Connecticut's businesses and residents spend over $13 billion on energy produced from petroleum and natural gas annually. These costs are spread between the residential sector at 36%, the commercial sector at 22%, the industrial sector at 7% and the transportation sector at 35%. Continued reductions in energy consumption from each sector is essential for Connecticut to reach energy affordability and environmental sustainability goals.

The following figure provides illustrative energy flows for 2015 (Figure ES3) showing Connecticut's energy consumption of the regional mix by fuel type for electricity generation, and also depicts energy losses. The left side of the graphic identifies the primary type of energy supply (natural gas, oil, coal, hydro, nuclear, biomass and renewables). The height of each bar

corresponds to the amount of energy from each source. The figure also depicts portions of the energy flow that is transformed into electricity, while others are used directly in end use sector buildings (residential, commercial, industrial and transportation).

To meet its 2050 greenhouse gas emissions reduction target, transformation of these energy flows is necessary, including increased renewable energy generation and energy storage, deployment of electric vehicles, and energy efficiency. As part of this transformation, fossil fuel use will decline over time and be displaced with renewable generation and electric end use increases. These policies are being evaluated by the Governor's Council on Climate Change as they provide a recommendation on an interim greenhouse gas emissions reduction target.[6]

FIGURE ES3: Connecticut Energy Flows in 2015



[6] Connecticut's Global Warming Solutions Act requires the state to reduce greenhouse gas emissions by 10% from 1990 levels by 2020 and 80% from 2001 levels by 2050. Conn. Gen. Stat. Sec. 22a-200a.

Energy Policy that Advances Grid Modernization Goals

Connecticut's grid of the future must achieve the broad goals of delivering cheaper, cleaner and more reliable energy while addressing increased electricity demand. It will need to integrate distributed generation, and expand energy storage and demand response at the lowest cost for electric ratepayers. The grid must therefore be supported by a secure network that can effectively blend both bulk electric grid operations and highly distributed generation, while remaining resilient to weather and climate events, and resistant to cyber assaults. The system will also need to continue supporting community resiliency and enabling new deployment and interconnection of micro-grid systems. Increased deployment and integration of advanced technologies such as energy storage, will enhance flexibility of grid operations. This will also encourage cost savings, especially during times of peak electrical demand, and increase reliability and customer response.

To ensure steady progress in meeting the state's GHG reduction goals and to put the state on a pathway to decarbonize the electric sector, this Strategy assumes that at a minimum, an extension of the Renewable Portfolio Standard (RPS) to 30 percent by 2030 will be required, along with consideration of the role of other carbon-free resources such as nuclear and large-scale hydroelectric.

Key strategies to modernize the grid include:

- Renew progress, with leadership from the Public Utilities Regulatory Authority (PURA), on smart grid implementation, including variable pricing and advanced meters.
- Continue to promote the development of microgrids and energy storage technologies.
- Work with the utility companies to ensure the continual improvement of cyber-security measures.

As Connecticut continues to increase its level of investment in renewables, it must ensure that investments are made cost-effectively and for the benefit of all ratepayers. This Strategy calls for the majority of RPS obligations to be met using grid-scale resources, which have dramatically reduced in price for all ratepayers, and advocates changes to behind-the meter programs that will maximize the impact of ratepayer dollars on the development of renewables, while improving transparency.

Key strategies to deploy renewables and decarbonize the electricity supply:

- Expand the RPS to achieve 30% Class I by 2030.
- Phase down biomass and landfill gas in Class I of the RPS.
- Evaluate the future of zero-carbon resources as they apply to meeting GHG reduction goals.

- Revise the cost-structure for net energy billing to maximize the impact of ratepayer investment, and ensure that investment is sustainable over the long-term.
- Prioritize grid-scale, DEEP-run procurements for renewables and energy efficiency in order to optimize zero-carbon resource deployment at the lowest cost to consumers, and address siting and land-use pressures through the development of a working group.

Energy Efficiency and Strategic Electrification

Today, over 80 percent of Connecticut households and commercial and industrial buildings are heated using fossil fuels.[7] Accomplishing Connecticut's GHG emissions reductions goals will require predictable and sustained investments in reducing energy waste and moving to clean sources of electric power, with substantial electrification of our thermal processes in buildings. Moving our buildings to renewable thermal sources, and to efficient electric thermal technologies will require strategic, phased in deployment.

As electric demand may subsequently increase to meet expanded thermal load needs, the ability to maintain progress in energy efficiency and curb peak energy demand will become increasingly important. Energy efficiency can reduce both consumption and peak demand, avoid transmission and distribution costs (T&D), and mitigate price effects in the wholesale market. Energy savings from efficiency investments are currently being achieved at a cost of about 4.5 cents per kWh of lifetime electric savings.[8] Therefore, not only is it a low-cost energy resource that delivers savings to ratepayers, but also a critical method for offsetting and neutralizing the increased demand from expanded electrification of home heating and cooling.

Accomplishing this transition will involve significant planning, deployment, and changes to both institutional and regulatory frameworks. Key 2017-2020 strategies for energy efficiency include actions that will:

- Continue to predictably and sustainably invest in energy efficiency and prioritize efficiency as a resource through procurement of efficiency as a supply resource, committed investments in the statewide conservation and load management plan, and through selling efficiency gains to meet the regional grid's capacity requirements.
- Enhance the performance of built infrastructure and the energy productivity of industrial processes, including through weatherization, efficiency audits, and building codes.

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[7] Gronli et. al. 2017. *Feasibility of Renewable Thermal Technologies in Connecticut: Market Potential.*

[8] Molina, Maggie, "The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs", Publications, American Council for an Energy-Efficient Economy, 2014, http://aceee.org/research-report/u1402.

- Continue to expand active energy demand management through control technologies, pricing signals, and standardized two-way communication, and access to advanced meters.
- Pursue strategic electrification, including encouraging the utility companies to promote the installation of efficient heat pumps, initially focusing on buildings currently heated by electric-resistance heating systems and on new construction, then eventually replacing combustion heating systems as the electric power sector becomes cleaner.

Clean and Accessible Transportation Options

Transportation is an integral part of Connecticut's socioeconomic fabric. Connecticut's transportation system and infrastructure encompass an extensive range of multimodal elements – from roadways and highway facilities, pedestrian and bicycle accommodations, to bus transit systems, passenger and freight railways, airports, deep water ports, and even ferry landings. This infrastructure connects residents and visitors to families, friends, services, jobs and communities. It also enables the movement of retail goods, raw materials, and other commodities in, out, and around the state. The reliability of the state's transportation system and supporting infrastructure, as well as the energy resources necessary to operate that system have a direct impact on Connecticut's economy and the quality of life for its 3.5 million residents and their local communities. To effectively enhance quality of life, minimize environmental impacts, and foster continued economic growth, it is critical that the state provides a safe, reliable and efficient transportation system that can accommodate future growth in population, tourism, business, and recreation.

Transportation energy consumption and emissions are a function of vehicle fuel efficiency, the carbon content of the fuel source and vehicle miles traveled (VMT). A sustainable and low-carbon transportation energy future will require significant refinements in order to provide increased mobility options to citizens and businesses and ensure that the state achieves its GHG emissions reduction targets. As the state's largest contributor to GHG emissions, steep reductions from the transportation sector will be required to ensure Connecticut meets its Global Warming Solutions Act goal of reducing emissions 80 percent below 2001 levels by 2050.

In this 2017 CES, the transportation recommendations put forth embrace solutions that go beyond adding roadway capacity to address population growth and economic expansion, but rather, aim to put Connecticut on a clear path to achieve state emission reduction targets, increase connectivity, user flexibility, and equitable access to efficient and clean transportation options, improve resilience to fuel price volatility, enhance economic growth, and create desirable communities.

Key 2017-2020 strategies for the transportation sector include:

- Develop an Electric Vehicle Roadmap that takes a comprehensive approach to expanding alternative fueling infrastructure and vehicle purchasing, addresses regulatory frameworks needed to support deployment, and enhances current outreach and education efforts.
- Support current state planning efforts that advance smart-growth and transportation-oriented development.
- Embrace technological advances, innovative models, and creative partnerships that improve access to a wider array of clean transportation options.
- Work with regional partners in the public and private sector to advance a clean, efficient, and accessible transportation network.

Process to develop 2017 Strategy

DEEP held a series of scoping meetings, informational meetings and workshops on specific topics to provide inclusive input on the CES.

- May 24, 2016: DEEP held a scoping meeting to receive stakeholder feedback on the major topics to include in the upcoming CES.
- October 27, 2016: DEEP held an informational meeting on demand resource management at the regional and local level
- November 3, 2016: DEEP held an informational meeting on air- and ground-sourced heat pumps, solar water heating, and biodiesel as thermal fuel in the state and region.
- January 10, 2017: DEEP co-convened with the Department of Agriculture a workshop to discuss state renewable energy programs and their intersection with environmental, agricultural, and land use policies.
- February 15, 2017: DEEP held an informational meeting on implementation of DEEP's strategies to reduce and improve energy use at state buildings.

DEEP received public input on all of these topics and incorporated the feedback into the CES.

OVERVIEW OF RECOMMENDED GOALS & STRATEGIES

The Table below summarizes the recommendations, organized by Chapter and around key goals for each sector and the specific strategies proposed to meet them.

ELECTRIC POWER SECTOR	
Goal 1: Align existing programs supporting renewable and zero carbon resources with renewable portfolio standards and global warming solutions act goals.	
E.1.1	Expand the RPS to achieve 30 percent Class I renewables by 2030.
E.1.2	Phase down biomass and landfill gas RECs in Connecticut's Class I of the RPS.
E.1.3	Achieve a sustainable balance between behind the meter programs and grid-scale procurements supporting Class I Renewables to expand clean energy at the least cost for ratepayers.
E.1.4	Increase transparency and certainty in the cost structure for net energy billing by creating renewable energy tariffs.
E.1.5	Evaluate the conditions around utilizing a diverse zero-carbon generation mix to meet our greenhouse gas emissions reduction goals.
E.1.6	Pursue goals of the shared clean energy facility program through multiple avenues based on lessons learned from the pilot program.
E.1.7	Strengthen voluntary renewable product verification in the competitive electric supplier market.
E.1.8	Convene a working group to implement best practices to optimize siting of renewable facilities on appropriate sites in Connecticut.
Goal 2: Continue to support regional and state reliability and resiliency efforts.	
E.2.1	Support ISO-NE in addressing regional winter natural gas generation reliability issues.
E.2.2	Continue to deploy community microgrids to support statewide resiliency goals in strategic locations and support the Energy Assurance Plan.
E.2.3	Ensure coastal resiliency of substations and other critical grid infrastructure to support DEEP's flood management goals.

E.2.4	Continue to identify and explore grid modernization initiatives.

BUILDINGS SECTOR

Goal 1: Prioritize energy savings as both a financial and energy resource.

B.1.1	Procure energy efficiency as a resource.
B.1.2	Enhance competitiveness of Connecticut's businesses with customized energy efficiency investments.
B.1.3	Reduce the energy affordability gap in low-income households.
B.1.4	Improve financial programs to increase access to clean and efficient energy improvements.
B.1.5	Maximize consumer demand for energy efficiency by increasing awareness and understanding of its value.
B.1.6	Evaluate current cost-effectiveness testing methods for accurate reflection of all resource costs and benefits.
B.1.7	Ensure equitable efficiency investment for delivered heating fuel customers through equitable conservation charges.

Goal 2: Improve the performance and productivity of buildings and industrial processes.

B.2.1	Ensure application of and compliance with current building energy codes and product efficiency standards.
B.2.2	Strategically sequence deployment of cleaner thermal fuel choices to transition buildings from fossil fuels.
B.2.3	Continue increasing the rate of home weatherization and assessment, statewide.
B.2.4	Address the unique needs of multifamily buildings for implementing cost-effective, clean and efficient upgrades.
B.2.5	Reduce energy waste by using combined heat and power, where it is cost-effective, in commercial and industrial applications.
B.2.6	Reduce energy waste at water and wastewater treatment facilities.
B.2.7	Evaluate applicability of district heating and thermal loops in high density areas.
B.2.8	Inventory state buildings and their energy usage patterns to identify greatest energy savings opportunities.

B.2.9	Support diversification of the heating oil delivery industry's products and services.
Goal 3: Continue prioritizing grid load management to reduce peak demand.	
B.3.1	Target peak demand reductions.
B.3.2	Increase and standardize two-way advanced meter communication.
B.3.3	Optimize economic signals and incentives for demand response to recognize shifts in demand from expanding electrification of heating and transportation.
TRANSPORTATION SECTOR	
Goal 1: Put the State on a strategic pathway to decarbonize the transportation sector.	
T.1.1	Develop an Electric Vehicle Roadmap to accelerate the adoption of low and zero-emissions vehicles and strengthen alternative fueling infrastructure.
T.1.2	Advocate for the implementation of federal vehicle fuel economy standards and maintaining LEV, ZEV, and GHG programs.
T.1.3	Educate and engage citizens and employers on the benefits of clean and efficient transportation options, including the advantages of transportation demand management measures.
Goal 2: Facilitate state planning to advance smart-growth, transit-oriented development, and mixed-use planning that leads to energy and emissions reductions.	
T.2.1	Implement Let's Go CT! initiatives and its long-term vision to create a best-in-class transportation system.
T.2.2	Encourage and support smart-growth, transit-oriented development, mixed-use planning, and development efforts that improve connectivity and accessibility to public transit.
Goal 3: Develop and support strategic partnerships to improve access to a wider array of transportation options.	
T.3.1	Embrace technological advances, shared mobility services, and transportation demand partnerships that improve mobility and access to clean modes of transportation.
T.3.2	Participate in regional partnerships and initiatives to advance a clean and efficient transportation network throughout the region.

Chapter One: The Electric Power Sector

INTRODUCTION

New England's power system and wholesale electricity markets are highly complex systems that require coordination between power production and delivery to Connecticut customers. Frequently referred to as the electric grid, the electric power system is comprised -of three key elements: generation, transmission, and distribution. In addition, sophisticated information infrastructure monitors and coordinates the production and delivery. This regional system includes approximately 350 generators, 31,000 megawatts of generation capacity, 600 megawatts of demand response, and 1,700 megawatts of energy efficiency.[9] The regional transmission system includes 8,600 miles of high-voltage transmission lines, and 13 transmission ties to neighboring power systems (New York and Canada). Much has changed in the region's electric system since electric restructuring in the late 1990's-2000 driven by shifting market fundamentals and state public policies. The regional market construct includes three markets: (1) Energy: daily market for electricity, (2) Capacity: annual forward auction for long-term resource availability, with an obligation for one year or seven years for new resources, and (3) Ancillary services: daily market for real-time reliability services.[10]

The nature of the New England electric grid is also changing. Historically, the power grid represented one directional power flow from a central station power plant to consumers. Across New England and in Connecticut, state policies are promoting renewable resource development – both grid-connected and smaller-scale "behind the meter" installations – that collectively are creating a "hybrid-grid" that integrates both central station and distributed generation. Additionally, the shift from coal and oil to natural gas and clean energy resources has reduced greenhouse gas ("GHG") emissions from the electric supply sector over the past 15 years. The transformation already underway provides some perspective on what the grid of the future might look like. This chapter begins to articulate Connecticut's future vision of the evolving grid.

Connecticut's grid of the future must achieve the broad goals of delivering cheaper, cleaner and more reliable electricity. It will need to integrate both central station and distributed generation, and incorporate technologies such as energy storage and demand response. The system will need to continue to support community resiliency and enable additional deployment and interconnection of microgrid systems. Increased deployment of technologies such as energy storage will usher in increased levels of flexibility to grid operations, encouraging cost savings,

[9] State of the Grid: 2016, ISO New England, January 26, 2016
[10] Ibid

especially during times of peak electrical demand. A secure network and an information backbone that is resilient to cyber assaults must support the grid of the future. It will need to enable a seamless integration of a variety of resources, connected with advanced technologies that are flexible in nature, and capable of achieving increased reliability and customer response. In the not too distant future, driven by the need for steep reductions in economy-wide greenhouse gas ("GHG") emissions, an increasing demand for electricity will come from the buildings and transportation sectors. Achieving this vision of the grid of the future will be challenging, and will require additional planning, deployment and changes to both institutional and regulatory frameworks.

Several drivers are likely to change the dominant features of the power grid in the years ahead:

- Electric sales in the short to medium-term, will remain constant, or decrease.
- Renewables will gain steadily in their share of generation, and environmental standards will require power generation to become less carbon intensive.
- New distributed generation ("DG") technologies will emerge, such as smart grids and "intelligent" demand side technologies with two-way communication that enable peak shaving or load shifting.

TABLE OF GOALS AND STRATEGIES FOR 2017 CES

CHAPTER ONE: ELECTRIC POWER SECTOR

Goal 1: Align existing programs supporting renewable and zero carbon resources with renewable portfolio standards and global warming solutions act goals

E.1.1	Expand the RPS to achieve 30 percent Class I renewables by 2030.
E.1.2	Phase down biomass and landfill gas RECs in Connecticut's Class I of the RPS.
E.1.3	Achieve a sustainable balance between behind the meter programs and grid-scale procurements supporting Class I Renewables to expand clean energy at the least cost for ratepayers.
E.1.4	Increase transparency and certainty in the cost structure for net energy billing by creating renewable energy tariffs.
E.1.5	Evaluate the conditions around utilizing a diverse zero-carbon generation mix to meet our greenhouse gas emissions reduction goals.
E.1.6	Pursue goals of the shared clean energy facility program through multiple avenues based on lessons learned from the pilot program.
E.1.7	Strengthen voluntary renewable product verification in the competitive electric supplier market.
E.1.8	Convene a working group to implement best practices to optimize siting of renewable facilities on appropriate sites in Connecticut.

Goal 2: Continue to support regional and state reliability and resiliency efforts

E.2.1	Support ISO-NE in addressing regional winter natural gas generation reliability issues.
E.2.2	Continue to deploy community microgrids to support statewide resiliency goals in strategic locations and support the Energy Assurance Plan.
E.2.3	Ensure coastal resiliency of substations and other critical grid infrastructure to support DEEP's flood management goals.
E.2.4	Continue to identify and explore grid modernization initiatives.

Current State

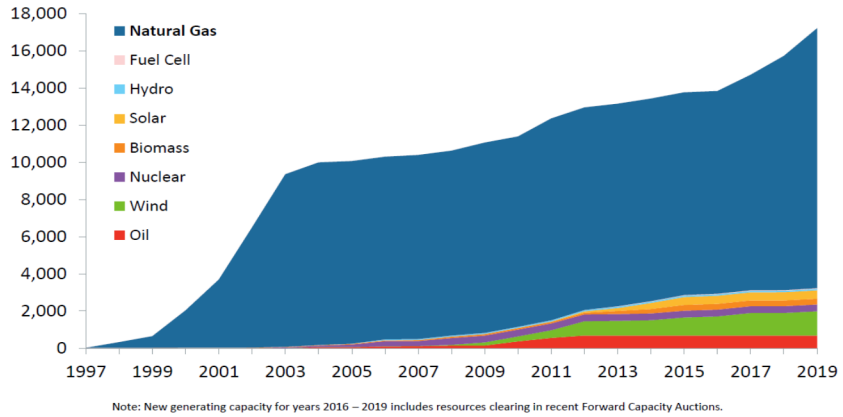
The Independent System Operator, ISO New England, Inc. ("ISO-NE"), operates the region's electric power system, administers the region's competitive wholesale markets and oversees the planning process for the regional power system. The Federal Energy Regulatory Commission, or FERC, is an independent federal agency that regulates the interstate transmission of electricity, natural gas, and oil. FERC also reviews proposals to build liquefied natural gas ("LNG") terminals and interstate natural gas pipelines as well as licensing hydropower projects. The Connecticut Public Utilities Regulatory Authority ("PURA") regulates the electric distribution system in Connecticut.

Shifting Towards Natural Gas as the Primary Fuel for Electric Generation

The most pronounced change in the regional electric power system since electric restructuring occurred has been a shift in the fuel mix, or the type of fuels used to generate electricity in New England. Over the last fifteen years, natural gas has replaced coal and oil as the dominant fuel source in New England. After deregulation, merchant investment in new, highly efficient combined cycle gas generation has increased significantly.

The use of natural gas to generate electricity in the New England region has grown from 15 percent in 2000 to 49 percent today. At the same time, oil and coal have declined from 22 percent and 18 percent in 2000 to 2 percent and 4 percent respectively in 2016. In addition, nuclear power has been an important contributor to electric generation and has remained relatively constant at

FIGURE E1: Cumulative Generating Capacity in New England (MW)

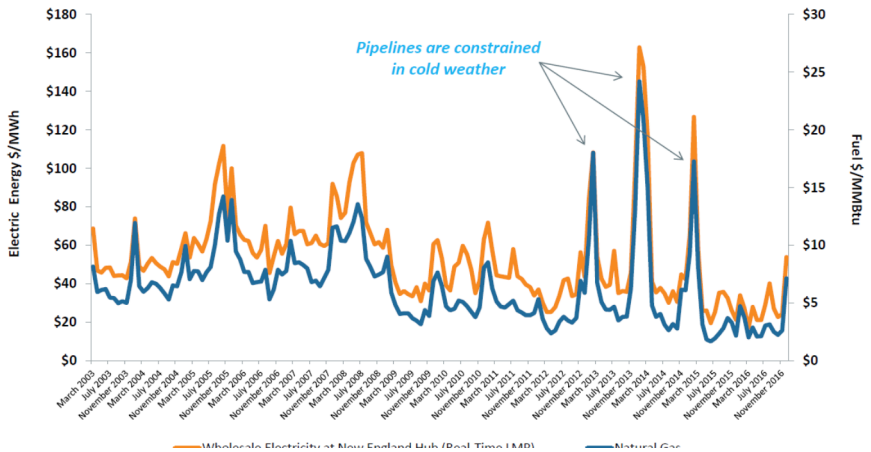


Source: ISO-New England Regional Electricity Outlook, 2017

approximately 30 percent.[11] Ensuring resource adequacy and reliability, the intent of the ISO-NE forward capacity market is to encourage the development of new resources to meet the demand for electricity in New England. However, 80 percent of new capacity since 1997 runs on natural gas and nearly 65 percent of all proposed new generation will use natural gas. The demand for natural gas is rising, yet gas pipelines are constrained during high demand periods, particularly during the winter months. These conditions create grid reliability concerns and price volatility during cold winter months. Renewable generation represents a small but growing amount of new generation.[12]

As shown in Figure E2, wholesale electricity prices in New England are closely correlated with the price of delivered natural gas. Natural gas units are now so predominant that bids into the ISO-NE energy market set the wholesale energy price in approximately 75 percent of the hours of the day.[13]

FIGURE E2: Monthly Average Natural Gas and Wholesale Electricity Prices in New England



Source: ISO-New England Regional Electricity Outlook, 2017

Low energy prices driven by low gas prices and the addition of more renewable generation is putting financial pressure on coal, oil, biomass, refuse and nuclear base load generators. Due to age and declining revenues, some generators have already retired and others may find it necessary to retire in the future. The older units are less flexible than the newer natural gas units,

[11] The December 2014 retirement of the 600, MW Vermont Yankee Plant reduced nuclear generation's share from 34 percent to 30 percent.

[12] *See* ISO-NE Presentation dated January 30, 2017, State of the Grid: 2017, ISO on Background, slide 9, available at https://www.iso-ne.com/static-assets/documents/2017/01/20170130_stateofgrid2017_presentation_pr.pdf

[13] Wholesale energy prices are set by the marginal cost of the most expensive resource needed to supply the demand. This cost is calculated every five minutes. 2015 ISO-NE Electric Generator Air Emissions Report

taking up to 24 hours to reach their full production capabilities, making them less appealing to the ISO for dispatch. This combination of factors has led to, the retirement of several generating units including Norwalk, Bridgeport Unit 2, Mount Tom and Salem Harbor and most recently, Brayton Point. The last remaining coal unit in Connecticut, Bridgeport Unit 3, is expected to retire in 2021.[14] In addition to the retired coal and oil units, several of the nuclear power plants in ISO-NE have closed (Vermont Yankee in 2015) or are closing soon (Pilgrim in 2019).

Cleaner Generation Fleet is Yielding Environmental Benefits

Natural gas-fired power plants have largely displaced older coal- and oil-fired facilities in terms of electricity production. This shift to a cleaner fuel mix has resulted in a decline of pollutants such as CO_2, NO_X and SO_2. According to ISO-NE's 2016 Air Emissions report, between 2001 and 2014, CO_2 emissions from generation dropped by 26 percent, NO_X declined by 66 percent and SO_2 declined by 94 percent. However, in 2015 following the retirement of the Vermont Yankee nuclear plant, New England saw a rise in CO_2 emissions of 2.5 percent over 2014 emissions.[15]

TABLE E1A: Reductions in Aggregate Emissions (ktons/year)

Year	NO_X	SO_2	CO_2
2001	59.73	200.01	52,991
2014	20.49	11.68	39,317
% Reduction, 1999-2014	-66%	-95%	-26%

Source: 2014 ISO New England Electric Generator Air Emissions Report, January 2016

TABLE E1B: (Reductions in Average Emission Rates (lb/MWh)

Year	NO_X	SO_2	CO_2
1999	1.36	4.52	1,009
2014	.38	11.68	39,317
% Reduction, 1999-2014	-72%	-95%	-28%

Source: 2014 ISO New England Electric Generator Air Emissions Report, January 2016

Connecticut is a leader in taking steps to reduce the greenhouse gas emissions related to electric generation. In 2008, Connecticut became one of nine states to implement the Regional Greenhouse Gas Initiative ("RGGI"), the first mandatory carbon dioxide cap and trade program in

[14] Whether Bridgeport Unit 3 retires in 2021 will be determined in FCA 12, which will take place in February 2018.
[15] 2015 ISO-NE Electric Generator Air Emissions Report

the United States. In addition, Connecticut's 2008 Global Warming Solutions Act ("GWSA") sets a goal of reducing greenhouse gas emissions by 80 percent below 2001 levels by 2050.[16] While seeking to develop the renewable energy market and reduce the negative environmental impacts of traditional electric generation, the State has also set very aggressive targets for deploying renewable generation. Connecticut's Renewable Portfolio Standard ("RPS") requires that 20 percent of generation serving state customers be from Class I renewable energy sources by 2020.[17]

Renewable Generation Grows as Costs Decline

Renewable generation has increased significantly in New England over the past 10 years. Much of this increase is due to Renewable Portfolio Standard ("RPS") requirements in Connecticut and in surrounding states. A considerable amount of the generation has come from out-of-state grid-connected projects such as wind and biomass, but there has been a large increase in smaller behind the meter fuel cell and rooftop solar projects over the past few years. Connecticut's net metering, virtual net metering and low-emission renewable energy credit ("LREC") and zero-emission renewable energy credit ("ZREC") incentives have spurred growth in these behind the meter projects. Connecticut has also increasingly used large-scale procurement to help new renewables come online in the region. Over the years, Connecticut has seen the cost of clean energy renewables decline.

Renewable Portfolio Standard

Following the 2013 CES, Public Act 13-303 and Public Act 15-107 provided Connecticut with broad statutory authority to procure grid-scale clean energy. The combination of policies and procurement authority has supported additional deployment of renewables, both grid scale and behind the meter. Connecticut and other New England states have led the region with a suite of programs to substantially increase new renewable development in the region. The foundation for the state's renewable deployment efforts is the state's RPS, which was enacted as part of the state's electric restructuring legislation in 1998. As one of the State's primary policy mechanisms to encourage the development and continued operation of renewable generation in New England, an RPS creates a financial incentive for developers to develop renewable energy projects by requiring electricity suppliers to purchase set quantities of renewable energy over time. The RPS thereby guarantees a market and potential stream of revenue for renewable generators based on the type of resource and whether it qualifies as Class I, Class II, or Class III in the statute.

[16] Conn. Gen. Stat. § 22a-200a.
[17] Conn. Gen. Stat. § 16-245a.

TABLE E2: Connecticut RPS Requirements, (percent of CT total electric use)

Year	Class I	Class II (or Class I additional)	Class III	Total
2013	10%	3%	4%	17%
2014	11%	3%	4%	18%
2015	12.5%	3%	4%	19.5%
2016	14%	3%	4%	21%
2017	15.5%	3%	4%	22.5%
2018	17%	3%	4%	24%
2019	19.5%	3%	4%	26.5%
2020	20%	3%	4%	27%

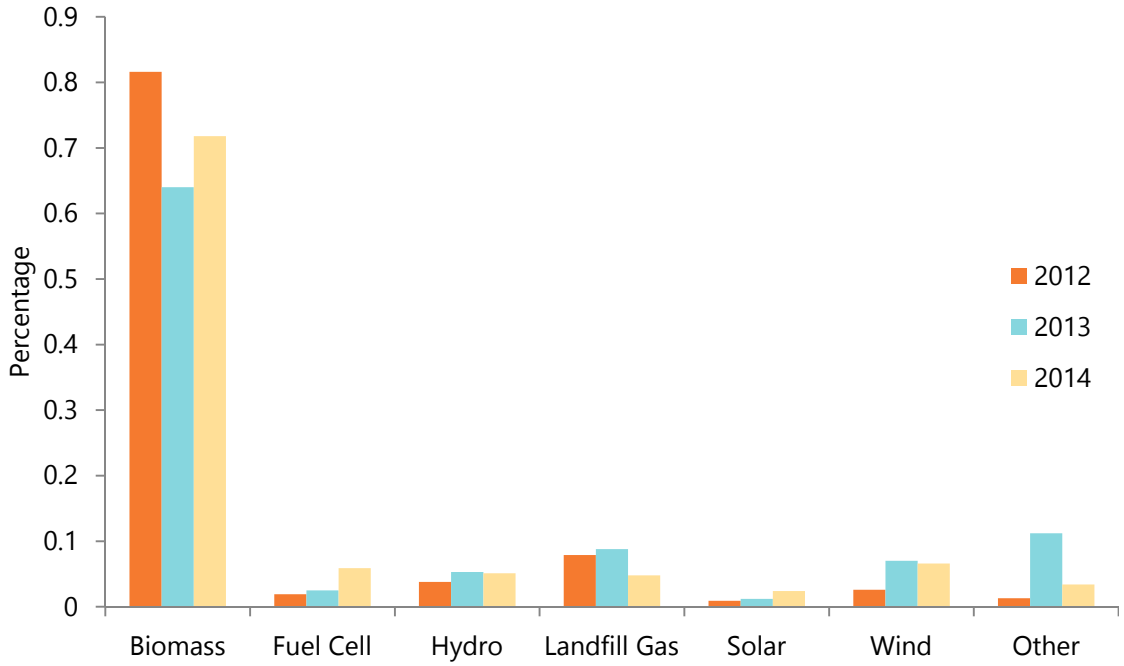
As shown in Table E2 above, Connecticut's current Class I RPS requirement is 15.5 percent in 2017 and increases each year reaching 20 percent in 2020, and remains at 20 percent thereafter. Resources eligible for Class I include both zero carbon resources, such as solar and wind, as well as low-carbon resources, such as fuel cells, landfill methane gas, and biomass that meet certain emissions requirements. Class I renewable energy credits ("RECs") have the highest potential value.[18] The purchase price for Class I RECs to meet the Connecticut RPS is effectively capped at $55 per megawatt-hour, which is the statutorily established value of the Alternative Compliance Payment ("ACP") that electricity suppliers may elect to pay in lieu of purchasing RECs.

The supply of Class I resources has kept pace with the growth in regional demand to date – through State programs, procurements and legacy generation – providing adequate RECs for Connecticut to meet its Class I RPS requirements each year. Most recent analyses indicate that there should be adequate Class I resources available to meet Connecticut's Class I RPS goals to 2020.

Although Connecticut purchases many RECs for solar, wind, and other renewables through its procurements and statewide programs, the RECs that are generated and delivered to the EDCs through these programs are generally re-sold into the regional RPS market. It is the obligation of the EDCs through standard service and retail suppliers to meet the RPS requirements. Due to differences in eligibility requirements and ACP levels between states, Connecticut met the majority of Class I RPS requirement with biomass RECs. In 2014, Connecticut met 76 percent of Class I RPS requirement with biomass and landfill gas RECs (see Figure E3).

[18] One REC is created for every one megawatt of renewable energy generation, which enables the state to track RPS compliance. A REC is a tradeable commodity that allows an entity to hold the legal rights to the environmental benefits associated with renewable energy generation.

FIGURE E3: Connecticut RPS Class I Fuel Source, 2012-2014



Class II and Class III percentages have remained constant at 3 percent and 4 percent respectively. Refuse facilities, biomass and small hydro facilities that do not meet the Class I eligibility requirements generally were eligible for Class II. Class III resources are limited to combined heat and power and electric efficiency projects that do not receive any ratepayer funding. The Class II ACP was also constant at $55/MWh through 2018, while the ACP for Class III is $31/MWh.

Recent legislation restructures the Class II tier of the RPS.[19] Class II RECs will be limited to only waste to energy facilities that support Connecticut's waste management goals to ensure we have sufficient in-state capacity to handle our waste production. In addition, the Class II REC requirement will increase from 3 percent to about 4 percent beginning in compliance year 2018 to support approximately 150 MW of trash to energy facilities located in Connecticut. Further, the ACP will be set at $25/MWh in 2018. This will increase the value of Class II RECs providing needed support to waste to energy facilities in Connecticut. The cost to support the Class II RPS requirement of 4 percent at $25/MWh is approximately $27.5 million annually.

[19] Connecticut General Assembly, Public Act 17-144, *An Act Promoting the Use of Fuel Cells for Electric Distribution System Benefits and Reliability* (2017).

RPS Regional Context

Connecticut's RPS policies must be viewed in a regional context. Electricity providers can satisfy their RPS requirements with RECs purchased from projects located in the ISO-NE control area or with energy imported into ISO-NE from an adjacent control area.

While the geographic eligibility rules are the same across New England, each state's RPS has different eligibility criteria, percentage requirements, and ACP prices. For example, unlike other states, Connecticut considers fuel cells and certain biomass facilities Class I resources and has a lower ACP for Class I. These differences among state's RPS design have important consequences for the type—and price—of renewable generation that electricity providers will buy to comply with Connecticut's RPS. Since the ACP is higher in those states, Connecticut is often the last to receive multi-state qualified RECs such as solar and wind when demand exceeds supply because those resources often get paid a higher price in other states.

Participating in a regional market for RPS compliance fosters lower cost compliance through greater competition and enables Connecticut to access low-cost renewable generation from areas with significant renewable resource potential. At the same time, limiting the RPS market to the same geographic boundaries as our regional electricity market ensures that the renewable generation supported through the RPS will compete with and potentially displace polluting fossil-fired generation in the regional electricity market, ensuring the benefits of lower energy prices, job creation, improved air quality, and economic activity are localized.

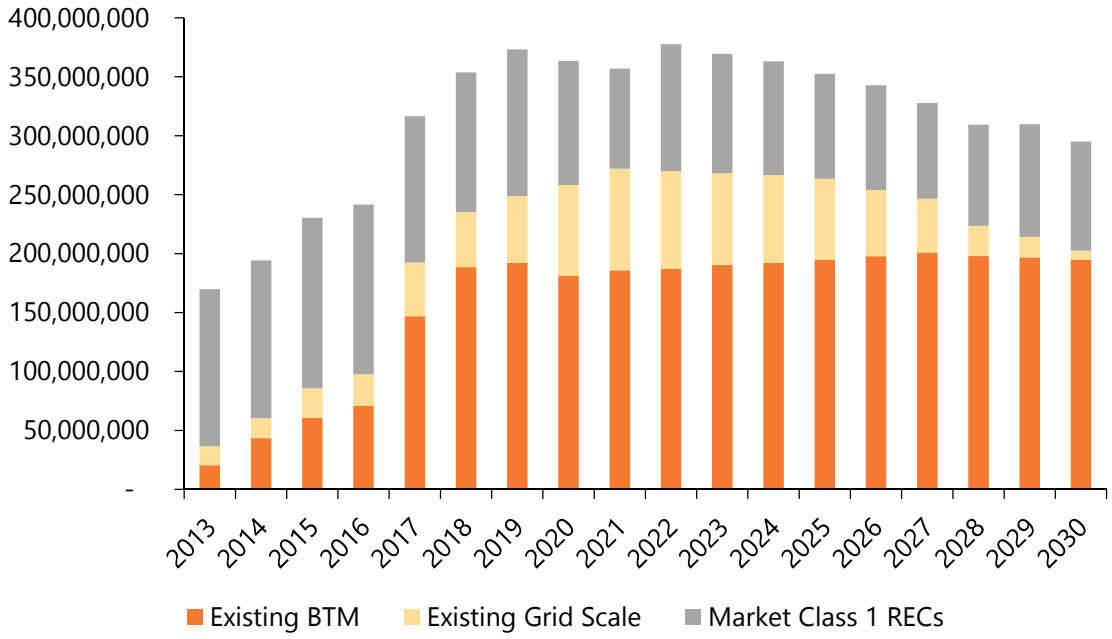
REC values are determined by the supply and demand for each class of resources. Currently there is a surplus supply of Class I so the price of RECs have declined from near the ACP of $55/MWh in the beginning of 2016 to around $30/MWh in the spring of 2017. Class II RECs sell for less than $1/MWh, due to the excess supply in New England. Class III REC prices increased in 2015 and are now selling for approximately $25/MWh due to Public Act 11-80 removing ratepayer funded efficiency programs from qualification as Class III.

When first conceived, RECs were meant to be the primary means to finance renewable generation. In theory, REC revenue plus energy revenues would provide the total revenues necessary to finance renewable projects. However, these markets are volatile and may not be adequate to fund the full cost of renewable generation. Long-term contracts for energy and RECs have taken over as the way to finance new grid-scale renewable projects. State incentive programs and net metering have been the primary way to fund behind the meter projects. The RPS still creates our renewable resource goals and is an effective method to identify, track, and trade attributes.

Renewable Portfolio Standard Costs

The Class I RPS standard is 15.5 percent of load in 2017. DEEP estimates that the annual cost of meeting our Class I RPS requirements is approximately $300 million over the cost of producing the equivalent energy from conventional fossil resources in 2017. This estimate includes the costs associated with both the grid-scale renewable procurements and Connecticut's behind the meter programs – the zero emission and low emission renewable energy credit program ("ZREC/LREC") and the residential solar incentive program ("RSIP") and solar home renewable energy credit program ("SHREC"), plus the net metering or virtual net metering costs associated with resources in those programs. The ongoing annual costs will continue to increase as new projects become operational and the RPS requirements continue to increase (see Figure E4 for the Net Annual Cost of the RPS). The cost is expected to increase to approximately $400 million in the years ahead as the RPS goal increases to 20 percent in 2020 and new projects funded through our state programs and procurements become operational.[20]

FIGURE E4: Net Annual Cost of RPS, 2013-2030, Class I Resources



[20] The estimate of the net cost of the RPS does not include additional new grid or behind the meter programs; it only includes existing or approved programs/projects. The net cost for behind the meter projects was calculated by using the total cost of the projected electric rate (adjusting for the customer service charge), state subsidies, REC costs and then discounting 50% of the projected electric rate to account for avoided costs such as generation, transmission, distribution, etc. For grid scale programs, DEEP utilized the total cost of the PPA, levelized utility cost (if the project was directly constructed by the EDC), additional REC costs, and discounted the projected cost of wholesale energy (i.e., the locational marginal price). These assumptions allowed DEEP to fairly account for the costs that the ratepayer would have incurred regardless of purchasing cleaner generation and properly estimate the actual cost of Connecticut's clean energy programs.

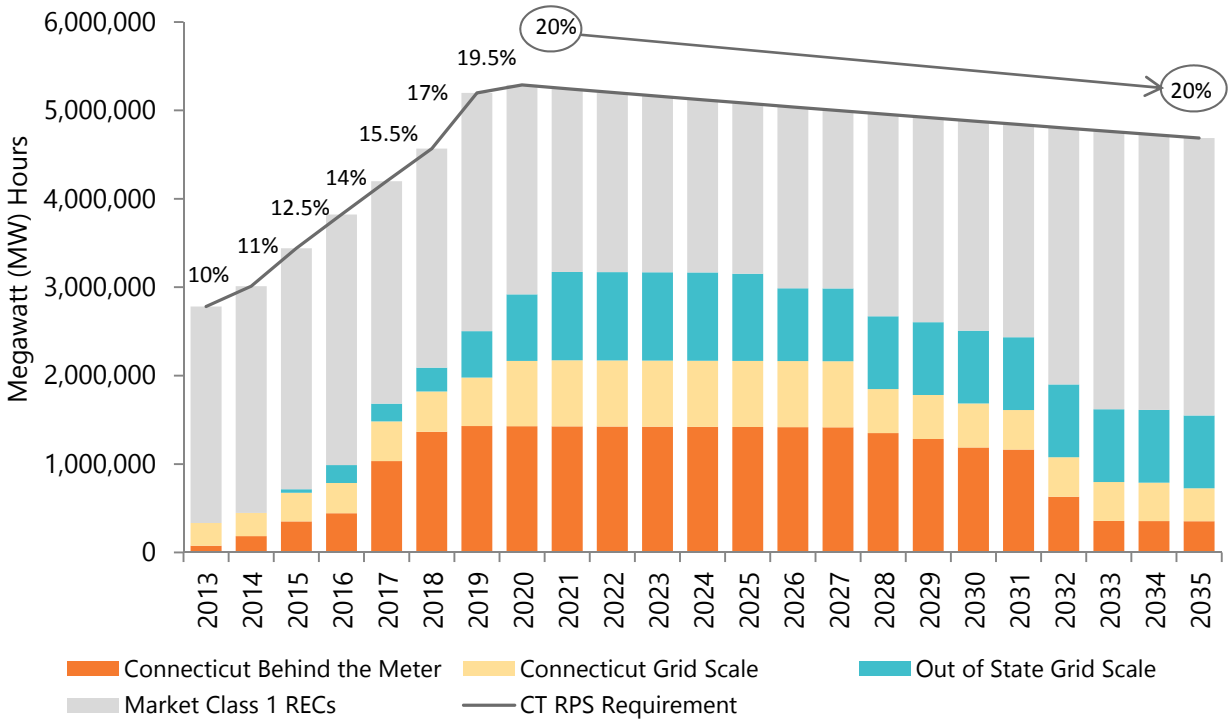
Renewable Generation from Connecticut Sponsored Programs

The amount of renewable generation located in Connecticut has increased significantly since 2013 and will continue to increase in the years ahead. In recent years, there is a growing desire to support local, in-state clean energy resources over out-of-state resources as a way to further in-state job growth, improve system reliability, and to displace local fossil fuel generation.

The chart below shows the expected generation from all Class I renewable generation funded through Connecticut programs and procurements through 2035. The long-term contracts under these programs ensure there are no shortages in the regional RPS market, even though the EDCs may not necessarily retire the RECs from these programs specifically to meet their RPS obligations. The colored bars represent the RECs produced from contracted projects compared to projects supported as part of our current RPS market to meet the requirements of 20 percent by 2020 and beyond. Once the long-term contracts expire, these renewables are still eligible to participate in the regional REC market.

As demonstrated in Figure E5, in 2013, Class I generation from programs directly sponsored by Connecticut represented about 1.2 percent of Connecticut's annual electric load. Most recently in 2016, projects directly sponsored by Connecticut represented about 3.62 percent of load, with 1.6 percent from behind the meter resources and the remaining 2.02 percent from grid scale. When all projects from Public Act 15-107, LREC/ZREC, and RSIP and SHREC become operational, the expected Class I generation from Connecticut sponsored programs represents around 12 percent of load in 2020. When comparing in-state Connecticut sponsored projects, most of the Class I generation comes from behind the meter projects, which will represent around 5 percent of load for most of the forecast period and in-state grid scale projects will represent about 2 to 3 percent of load. Out-of-state Connecticut sponsored projects will hover around 3 to 4 percent of load throughout the forecast period as they become operational in the next few years.

FIGURE E5: In-State v. Out-of-State Production from Connecticut Programs and Contribution to Regional Market Relative to CT Class I RPS Requirements



The installed capacity of in state behind the meter solar has grown to 280 MW (approximately 1.5 percent of load or 410,000 MWH) through 2016.[21] DEEP expects the installed capacity of solar to grow to 650 to 700 MW (approximately 3.8 percent of load or 1.06 million MWh)[22] by 2020, which would include projects already approved or additional capacity that has been authorized.[23] With additional funds from LREC/ZREC that have not yet been exhausted, the amount of solar generation that comes from behind the meter facilities could grow to as much as 750 to 800 MW by 2021 (approximately 4.5 percent of load or 1.24 million MWH).[24] In addition, DEEP recently selected projects that will be located in Connecticut, including 12 grid connected solar projects totaling 201 MW and one wind project of 3.5 MW.

[21] Based on 15 percent capacity factor for Residential (160 MW) and 19 percent capacity factor for C/I projects (120 MW)

[22] Based on 15 percent capacity factor for Residential (300 MW) and 19 percent capacity factor for C/I projects (400 MW)

[23] DGFWG Final 2016 PV Forecast

[24] Based on 15 percent capacity factor for Residential (300 MW) and 19 percent capacity factor for C/I projects (500 MW)

Grid-Scale Renewables

The cost for renewable generation technologies continues to decline. In general, grid-connected renewable projects provide similar benefits at a lower cost to ratepayers compared to behind the meter projects. DEEP has issued multiple solicitations for grid connected clean energy generation and selected the following resources:

TABLE E4: DEEP Solicited Grid-Connected Clean Energy Generation

Authority	Resource(s) and MW Selected
Project 150	Biomass – 30 MW Fuel Cell – 63 MW
Section 127 of P.A. 11-80	Solar – 12.2 MW Wind – 5 MW Fuel Cell – 12.8 MW (5.6 MW operational)
Section 6 of P.A. 13-303	Solar – 20 MW (2013); 240 MW (2016) Wind – 250 MW (2013);[25] 154.8 MW (2016)[26]
Section 8 of P.A. 13-303	Biomass – 29.6 MW
Public Act 15-107	Solar – 324.5 MW Wind – 43.5 MW Passive Demand Response – 34 MW

Successive competitive procurements for renewable energy projects have resulted in significantly declining renewable energy generation prices for the selected winning projects. For instance, in 2011, under Section 127 of Connecticut Public Act 11-80, 10 megawatts of additional renewable generation was added to the state's renewable energy portfolio, with an average price of 22.2 cents/kWh for the two selected solar projects. Subsequently in 2013, under Section 6 of Connecticut Public Act 13-303, the EDCs contractually procured an additional 20 megawatts of solar generation, which resulted in a selected bid price of approximately 12 cents/kWh. The most recent grid connected solar and wind projects selected in the Three State and Small Scale Clean Energy requests for proposals ("RFPs") resulted in a selected bid price of approximately 9 cents/kWh on a levelized basis over the 20-year life of the projects. These grid scale procurements demonstrate that larger volumes of renewable energy can be procured at lower rates. In addition, the recent Small Scale Procurement demonstrates that small solar grid-scale projects can be developed in Connecticut under 10 cents/kWh on a levelized basis.

[25] This facility was procured by DEEP in a 2013 solicitation but will not come online under DEEP's procurement authority because of interconnection issues.
[26] Connecticut procured these facilities through the Three State RFP and will be splitting the output from these projects with Massachusetts.

Connecticut's utilization of long-term contracts or power purchase agreements ("PPAs") as a mechanism to secure development and delivery of renewable power has been an issue for generators as well as ISO-NE, which considers such contracts to be out-of-market subsidies. Connecticut has successfully defended these contracts, however against legal challenges claiming these long-term contracts are not appropriate in unregulated generation markets.[27] Although the federal court upheld the legality of Connecticut's programs, DEEP is engaged in a regional stakeholder process to see if other mechanisms and regional market rules can be developed to accommodate the desired growth in renewable generation through other mechanisms.

Grid-Scale Renewable Siting

While the costs of grid connected clean energy resources have declined, siting larger scale wind and solar projects has raised challenges in balancing the deployment of renewable resources with potential environmental impacts to prime and important farmlands, core forests, protected and endangered species and other environmental/land use considerations. Interconnection and delivery can also be expensive and difficult. Much of the wind potential is offshore, which is likely very expensive, or is in northern New England in areas that do not have adequate transmission facilities to move the power to load centers in southern New England.

In its Three State and Small Scale RFPs pursuant to Sections 6 and 7 of Public Act 13-303 and Public Act 15-107, DEEP collaborated agency-wide to assess the environmental impacts of all proposals submitted. DEEP evaluated the environmental siting impacts as part of the qualitative evaluation of bids, but the majority of DEEP's scoring in its selection process was the quantitative evaluation, or the price of bids. DEEP made pricing such an important factor of the RFPs because one major purpose of P.A. 15-107 was to address electricity price spikes during the winter and related concerns of winter reliability.

In response to DEEP's selection decision in its Three State and Small Scale RFPs, the Council on Environmental Quality released a report with recommendations for better siting of renewable energy facilities to limit impacts on prime and important agricultural and core forests.[28] On January 10, 2017, DEEP and the Connecticut Department of Agriculture co-convened a workshop on the siting of utility-scale clean energy projects as part of its 2016 Comprehensive Energy Strategy proceeding. One major theme resulting from the workshop is that large tracts of flat, cleared land, which often includes farmland, is the most attractive siting location from a developer's perspective because it is the most inexpensive and easiest to develop. However, the state of Connecticut has invested significant time and expense to protect and preserve prime farmland. There needs to be

[27] *Allco Finance Ltd. v. Klee*, 16-2946 (2d Cir. Jun. 28, 2017).
[28] Connecticut Council on Environmental Quality, "Energy Sprawl in Connecticut: Why Farmland and Forests are Being Developed for Electricity Production; Recommendations for Better Siting" (Feb. 3, 2017).

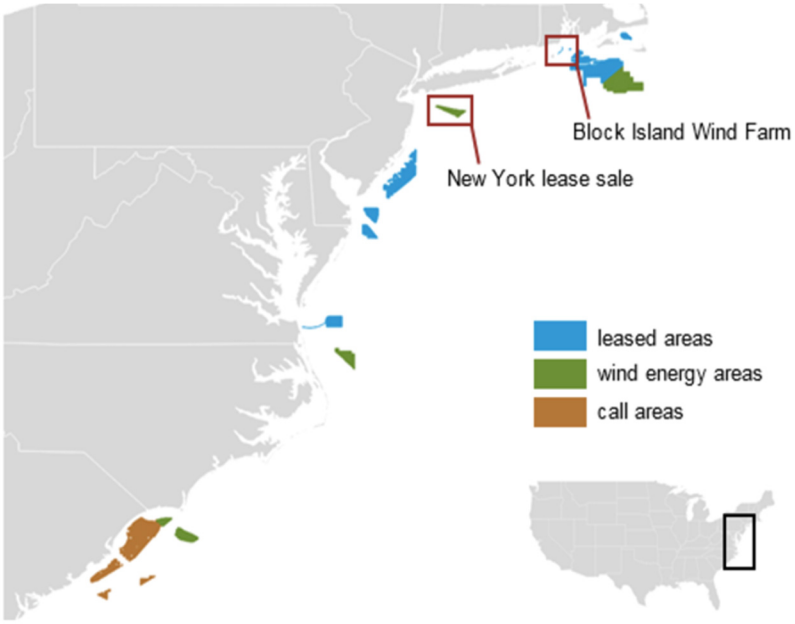
a balance of energy priorities and preservation priorities, while also recognizing the opportunity that clean energy can provide to farmers who may use a portion of their farmland to site renewables and help fund farm operations on the remaining land. In the 2017 session of the General Assembly, both the Energy & Technology and Environment Committees raised bills to address the issue around the siting of renewables, which ranged from requiring DEEP to convene an advisory board to establish a renewable siting plan, to effectively banning the siting of solar PV on prime farmland.[29] The General Assembly passed Public Act 17-218, which requires DEEP to consider certain environmental impacts related to siting in future solicitation and requires the Connecticut Siting Council to consider similar environmental and agricultural land use impacts in its proceedings.

Offshore Wind

Offshore wind can result in grid scale renewables without the renewable siting concerns raised in DEEP's recent grid scale solicitations. The federal government issues leases for offshore wind energy projects as state jurisdiction only extends three nautical miles from the coast. Federal jurisdiction, known as the exclusive economic zone, extends 200 nautical miles from the coast and is managed by the Bureau of Ocean Energy Management ("BOEM"). As of June 2017, BOEM has issued 11 leases for offshore wind development, including sites off the coast of Rhode Island, Massachusetts, New York, and New Jersey.

[29] S.B. 943, *An Act Concerning the Installation of Certain Solar Facilities on Productive Farmland* (2017); H.B. 6547, *An Act Concerning A Connecticut Green Plan and Land Resource and Use Inventory for Energy Infrastructure* (2017).

FIGURE E6: Federal Offshore Wind Leasing Areas along the U.S. Atlantic Coast



Source: U.S. Energy Information Administration, based on Bureau of Ocean Energy Management

Rhode Island has experience navigating the first offshore wind project in the U.S., though a number of other states have also been actively promoting offshore wind development. New York Governor Cuomo proposed to a goal to develop 2,400 MW of offshore wind by 2030. The New York State Energy Research and Development Authority (NYSERDA) will release its Offshore Wind Master Plan in 2017 that will outline guidelines and recommendations for developers, and plans to solicit bids in 2018.

In Massachusetts, the state legislature passed legislation in 2016 for electric utilities to procure up to 1,600 MW of offshore wind energy by 2027. Electric utilities in Massachusetts released a solicitation for 400 MW offshore wind in June 2017, and expect to announce bid winner(s) in May 2018. Other states are allowed to contract for additional capacity as part of the solicitation, so long as Massachusetts ratepayers are not negatively affected. The Massachusetts Clean Energy Center has also conducted several offshore wind studies and can serve as a resource for the region. With the enactment of Public Act 17-144, DEEP has the authority to procure a variety of energy resources, including up to 3 percent of load from offshore wind.

Regional Market Rules Governing Renewables

Existing competitive wholesale energy markets are not currently designed to help achieve state policies, particularly environmental policies. Because of this market deficiency, state legislatures

have implemented legislation that requires the direct purchase of renewable energy and RECs to encourage renewable generation retention and development.[30] Generators have raised concerns that these contracts make renewable generation more competitive than they otherwise would be reducing markets prices, potentially pushing out those generators reliant on market revenues. ISO-NE and FERC have grown concerned that the states are interfering with the market by providing "out-of-market subsidies' through long term contracts and have instituted rules that "mitigate" the effects of these contracts. This mitigation has created a tension between state law and policy, and the "idealized vision of markets free from influence of public policies" held by market proponents.[31] This tension has created uncertainty in the markets and litigation. In an attempt to resolve the tension and provide for a more certain future, the stakeholders have embarked on a process known as Integrating Markets and Public Policy ("IMAPP"). Similarly, FERC conducted a technical conference on May 1 and 2 to receive input on this issue, not only in New England but in the other eastern regional transmission organizations of New York ISO and PJM Interconnection.

The IMAPP process to date has encompassed eight meetings in which stakeholders have put forward several ideas. The ideas that have been put forward in IMAPP can be characterized into two major categories: those that are intended to achieve state policies, and those that intended to accommodate state policies. ISO-NE has also brought forward a proposal known as Competitive Auctions with Subsidized Policy Resources ("CASPR"). The basic concept of CASPR is that generation that receives state contracts and are mitigated by ISO-NE will be able to take the place of retiring resources or other new resources in a secondary auction. Unfortunately, the CASPR proposal currently removes a market rule exemption from mitigation of up to 200 MW per year of renewable resources (excluding most hydro resources). In addition to other concerns, Connecticut strongly objects to the removal of the 200 MW exemption in the ISO-NE proposal. Connecticut, however, continues to work through the stakeholder process to see if the CASPR proposal, and other proposals, can better achieve an effective market that accommodates state policies. Connecticut has made clear that any market rule change that does not allow the states to achieve state policies will ultimately be unsuccessful. Connecticut believes that the market and state policies can coexist and we are committed to the process of finding the best path forward to achieve this goal.

[30] Public Act 13-303, Public Act 15-107; 83A, C, and D of the Massachusetts Green Communities Act, and Chapter 31 of Title 39 of the General Laws of Rhode Island.
[31] FERC Docket No. EL16-92 (2017) Bay, concurring.

Behind the Meter Renewables

In general, behind the meter clean energy resources, unlike grid-scale clean energy resources, produce power that, from the perspective of the regional grid, reduces the electric load of the area where the clean energy facility is located.[32] In addition, the state has a few different programs to support deployment of local clean energy by purchasing the RECs associated with behind the meter systems, like LREC/ZREC for commercial and industrial installations under 2 MW and 1 MW, respectively, and RSIP and SHREC for residential installations. These programs are discussed in more detail below.

DEEP recognizes the benefits that behind the meter renewables provide to the electric grid, including but not limited to reducing system line losses, potentially delaying the need for transmission and distribution infrastructure, reducing electric bills for participating customers, increasing resiliency and energy security, contributing to economic development in Connecticut, and potentially encouraging positive land-use.

Net Metering

Net metering and virtual net metering are administered by the utilities under a PURA approved tariff rather than separate contracts for each project. The tariff structure minimizes the administrative burden because there is no procurement and signing up for a tariff is straightforward for the utility and the generator. Prices adjust automatically when retail rates change.

Net metering is a special tariff available to electric customers who install renewable power generation on their own premises, frequently referred to as "behind the meter" generation. Net metering has been a key incentive in promoting the installation and deployment of Class I behind the meter distributed generation in Connecticut.[33]

In accordance with Section 16-243h of the General Statutes, net metering allows customers with behind the meter renewable energy facilities such as rooftop solar to offset each kWh they use on their electric bill with energy generated by their renewable energy facility. The EDCs are required to offset a customer's bill for electricity generated by the customer from a Class I

[32] In net metering, the building where the generation is located is credited for the reduced load, while in virtual net metering, a building located in a separate location from the generation is credited for the reduced load.

[33] Net metering began in Connecticut in the 1980s. At that time it was primarily for small combined heat and power systems fueled by natural gas. These tariffs are still available today. The size of the system is limited to 50kW and netting is done on a monthly basis. Excess generation is paid at the average monthly wholesale generation rate. In 2000, net energy billing was modified and a new tariff was opened for Class I resources under Connecticut's RPS.

renewable energy source facility that has a nameplate capacity of 2 megawatts or less. The customer is credited by subtracting or "netting" the onsite electricity generation against their electricity consumed in any given month at the full applicable retail rate of electric service, minus the customer service charge that the customer pays for the electricity they purchase from the EDC. This offset or credit of generation allows customers that install a behind the meter generation to reduce their electric bills.

A net metering banking period is permitted for one year. If a customer's generation exceeds their consumption in any given month during the annual period, the credits are rolled over into the following month. Any excess credits at the end of the year are compensated at the avoided cost of wholesale power (equivalent to approximately 3.6 cents/kWh in 2016).[34] Under net energy billing, the tariff compensates the customer for the energy, but not the renewable attributes, which are generally sold into the regional market. Unlike other states, such as Massachusetts, there is currently no cap on the amount (MW or percent load) of Class I resources eligible for net metering in Connecticut.

Virtual Net Metering

In 2011, the legislature enacted virtual net metering. Virtual net metering is limited to specific customer classes: agricultural, state, and municipal customers. Virtual net metering allows multiple customers to net their electric consumption against the generation from a Class I generation facility. The participating customers do not have to be physically connected to the renewable resource. The program initially provided aggregate credits of up to $10 million annually split among the three classes, with no individual class receiving more than 40 percent of the total dollar allocated. Subsequent pieces of legislation provided for an additional $6 million for municipal customers and $3 million for agricultural customers.[35] Virtual net metering has already reached its cap for municipal customers and therefore no additional municipal projects can participate in the program.

Net Metering and Virtual Net Metering Costs

The cost of net metering and virtual net metering is not easily understood and can vary widely based on the customer's rate and service territory. As discussed below, the value of the credits

[34] https://www.eversource.com/Content/docs/default-source/ct---pdfs/rider-n-historic-cash-out-prices.pdf https://www.eversource.com/Content/docs/default-source/ct---pdfs/rider-n-historic-cash-out-prices.pdf. The significantly lower price paid for excess credits incentivizes the sizing of the generation facility to be roughly the same as the location's demand.

[35] Public Act 16-216, An Act Concerning Authorizations Relating to Virtual Net Metering. Public Act 17-218, An Act Concerning the Installation of Certain Solar Facilities on Productive Farmlands, Incentives for the Use of Anaerobic Digesters by Agricultural Customer Hosts, Applications Concerning the Use of Kelp in Certain Biofuels and the Permitting of Waste Conversion Facilities.

vary significantly for essentially the same generation, depending on whether a customer is eligible for net metering or virtual net metering. In addition, since electric rates vary between customer classes and utilities, the savings that customers receive from the generation can vary between the EDCs and the rate class of the customer. Residential rates are higher than commercial and industrial rates, and therefore, residential customers are able to offset higher charges, and effectively are paid more for their solar generation than C&I customers. Rates are also generally higher for United Illuminating ("UI") customers than Eversource. UI residential customers, therefore, are effectively paid more than Eversource customers are for the same generation.

Net metering and virtual net metering rates are also very uncertain over the life of the project since they are based on retail rates that are subject to changes in rate design. These variations in pricing have nothing to do with the costs or benefits of the generation, which is more related to when and where the energy is delivered and the avoided cost, i.e., the costs of distribution and transmission investments foregone as a result of adding a distributed generation resource. When and where generation is delivered are key factors in energy pricing in wholesale markets and power purchase agreements with wholesale generators; however, these factors have little if any impact on the price paid for generation under current net energy billing arrangements.

In addition, most behind the meter projects in Connecticut participate in solar programs offered by the Green Bank or LREC/ZREC, where participants receive additional electric ratepayer funded incentives. These incentives lower the cost to participants, but raise the cost to all other ratepayers that must fund these incentives. When the total cost of net metering and other ratepayer incentives are included, the cost of behind the meter renewable programs is over 20 cents/kWh.

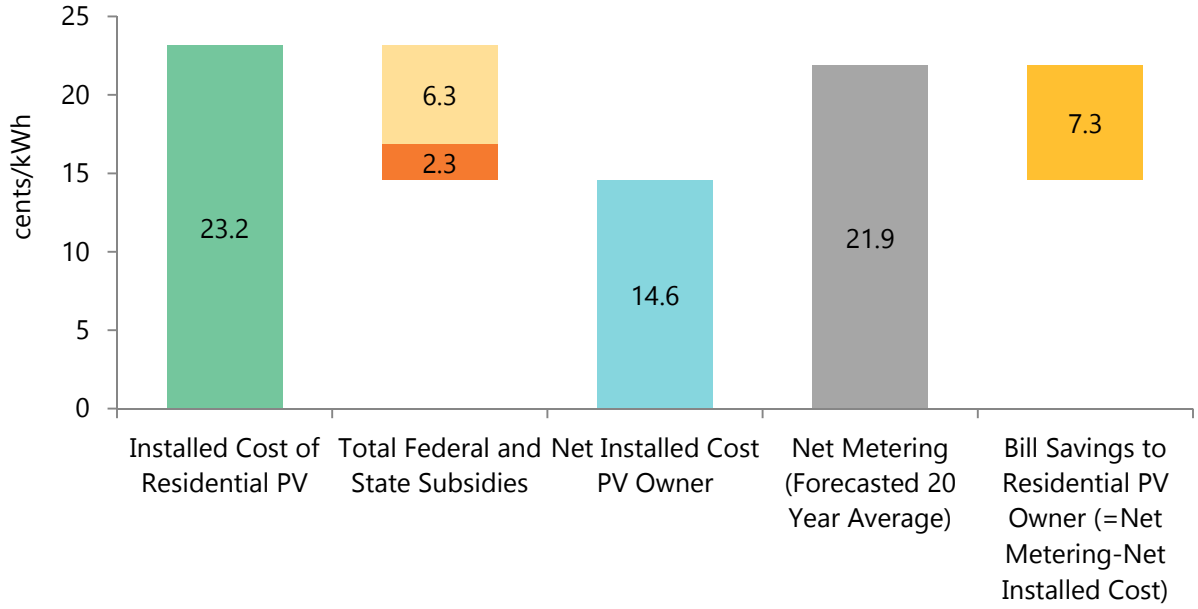
Currently, most behind the meter generation needs additional subsidies beyond net metering, budgets for the LREC/ZREC, RSIP, and SHREC programs that purchase the RECs of the system provide limitations to the number of behind the meter projects that are developed each year. However, if system costs decline then additional subsidies may not be needed and there would be no limit on the amount of behind the meter projects using net energy billing.

Costs of Net Metering:

In 2016, the total installed cost of a 7.5 kW residential rooftop solar system was approximately 23.2 cents/kwh on a levelized basis over 20 years. The net cost for a customer purchasing a rooftop solar system is approximately 14.6 cents/kWh after federal tax incentives and state subsidies. The customer is allowed to offset the generation they use with production from their solar facility at

the full retail electric rate of 21.9 cents/kWh, resulting in a net savings of about 7.3 cents/kWh or $46/month.[36]

FIGURE E7: Cost of Solar, from PV Homeowners Perspectives[37]



Source: DEEP analysis

The offset in retail rates results in significant bill savings to participants. These savings to the participating customer that result from net energy billing provide a substantial return for the participating customer. Through net energy billing, this return is paid through electric bill savings rather than a direct payment. These bill savings in the form of reduced electricity bills, however, are a real cost of rooftop solar that all other ratepayers must pay.

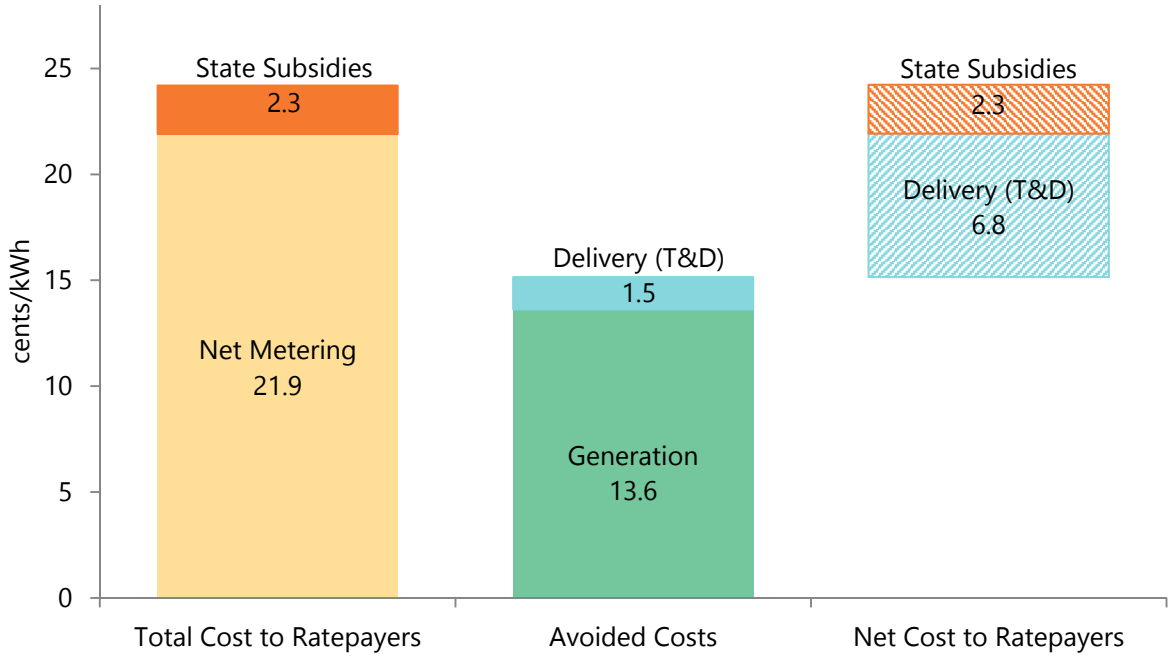
When designing programs, policy makers consider the costs of programs, such as net metering, from the perspective of all ratepayers, and not just the program participants. The total cost to Connecticut ratepayers for rooftop solar is 24.2 cents/kWh. This is the cost of net energy billing, or 21.9 cents/kWh (the retail electricity rate), plus state incentives, or 2.3 cents/kWh[38], to encourage solar development. In contrast, grid scale solar now costs less than 10 cents/kWh on a levelized basis.

[36] DEEP utilized the National Renewable Energy Laboratory's Levelized Cost of Energy Calculator to make these calculations.

[37] This scenario is based on an average PV homeowner-purchased system in 2016, and not on a leased system. Installed cost is levelized at 20 years and 5% discount rate is applied. Net metering rate is a forecasted amount over 20 years.

[38] State incentives are the RSIP subsidy Levelized over 20 years. This subsidy is offered directly by the Green Bank

FIGURE E8: Cost of Behind the Meter Solar from Residential Electric Ratepayer Perspective (20 Year Levelized Cost, Nominal$)[39]



Source: DEEP analysis

As demonstrated in Figure E8 above, the net cost to ratepayers is the cost above the forecasted avoided costs of traditional fossil generation and costs of some distribution and transmission costs that are not avoided by net metering ratepayers that must be collected from other ratepayers. The avoided costs in Figure E8 are the quantifiable monetary benefits that a net metering ratepayer provides to all ratepayers. First, a behind the meter facility provides electric generation to the grid, which avoids the need to generate power from another generation facility. Thus, compensating a net metering ratepayer for this avoided generation does not impose additional costs on the remaining ratepayers.

Second, the net metering ratepayer provides some transmission and distribution ("T&D") benefits to all ratepayers because the electricity is generated close to where it is consumed and thus does not need to travel long distances. However, not all T&D costs are avoided by the behind the meter

[39] DEEP's estimates are based on 20-year Levelized values. DEEP evaluated CL&P and UI's historical generation rates when compared to the total electric rate for residential customers. DEEP determined that the generation portion of the bill accounted for about 62 percent of the total electric rate. DEEP further estimated that the net metering rate was about 21.9 cent/kwh on average during the forecast period. DEEP applied the 62 percent coefficient to the forecasted net metering rate to determine the avoided generation costs over a 20-year period. The associated avoided T&D costs came from the 2015 Avoided Energy Supply Costs Study. Avoided Delivery Costs were calculated by using the expected PV generation from a typical residential solar system in CT and the ISO NE's Seasonal Claimed Capabilty factor for intermittent resources. The remaining portion of the electric rate are assumed to be composed of other delivery charges, which would include C&LM, SBC, Renewables, FMCC-Delivery, etc.

generation because the net metered ratepayer must still have power from the grid delivered for its electric usage, meaning a net metered ratepayer incurs some T&D costs. Most T&D costs are collected from customers through volumetric kWh charges. Under the current net metering structure, distributed generation customers can completely offset these volumetric charges. This means that the net metering ratepayer may not pay for any T&D costs, although they continue to be connected to the grid and rely on the grid when their behind the meter system is not producing electricity.

Finally, the costs collected through the systems benefits charge ("SBC") and the non-bypassable federally mandated congestion charge ("FMCC") are not related to consumption, but they are recovered through volumetric charges and a net metering ratepayer may be able to offset these entire costs as well.

Therefore, most of the T&D costs as well the SBC and FMCC charges are not actually avoided by the net metered generation facility but are nonetheless not paid for by the net metering ratepayer. Because these costs are not avoided and are not paid for by the net metering ratepayer, they must be recovered from remaining ratepayers. Consequently, the unavoided costs are shifted to ratepayers, raising electric rates over time. The net cost of a net metering facility to all ratepayers is approximately 9.1 cents/kWh which is made up of the unavoided T&D, SBC, and FMCC charges of 6.8 cents/kWh plus the cost of Connecticut ratepayer funded incentives of 2.3 cents/kWh.

Since net metering rates are directly tied to electric rates, over time, higher electric rates translate into higher net metering incentives for customers installing behind the meter systems. This dynamic creates a self-perpetuating incentive for customers to shift to the net metering tariff.

Costs of Virtual Net Metering:

While net metering and virtual net metering have a similar billing structure, the pricing for virtual net metering differs from net metering because it limits how customer credits can be allocated to a customer's bill. While virtual net metering credits can apply to 100 percent of generation costs, virtual net metering credits are limited to apply to 40 percent of T&D costs over time. For example in 2016, after offsetting all allowable generation and T&D costs, a VNM customer on Eversource's Rate 35 (Intermediate General Electric Service) would pay approximately 5.62 cents/kWh and offset approximately 8.54 cents/kWh. In comparison, if these customers were allowed to net meter, they could offset the entire electric rate of 13.05 cents/kwh in that same year.[40]

In addition, the cash out for excess generation at the end of the banking year are also different for net metering and virtual net metering. Under virtual net metering, excess generation is credited

[40] Assume a July 1, 2016 electric rate, net of the customer charge for Rate 35.

to the host account at the retail Standard Offer generation rate, which was about 6.03 cents/kWh as of July 1, 2016.[41] In contrast, under net metering, excess generation is credited at the ISO-NE wholesale energy rate, which was about 3.6 cents/kWh.[42]

Behind the Meter Renewables - Residential

Residential Solar Investment Program (RSIP) & the Solar Home Renewable Energy Credit (SHREC)

Connecticut offers several options for residential homeowners to purchase a solar system or lease it from the developer. Generally, when a customer purchases the system, the entire cost of the system is paid up front, either out of pocket from the homeowner or through a financing arrangement. Many vendors also allow customers to lease the system and make a fixed monthly payment to the developer. The developer then installs the solar system on the customer's house. The customer receives credit for each kWh that is produced from the solar system, which offsets kWh's the customer uses when the system is not producing any energy and reduces the customer's electric bill. The savings from lower electric bills provide the incentive for customers to purchase the solar system. In general, leased systems require a smaller upfront investment, and correspondingly result in lower savings.

The Connecticut Green Bank implemented the Residential Solar Investment Program ("RSIP") in 2012, which made solar PV technology more accessible and affordable to households through innovative incentives and financing. As part of its commitment to the residential sector through the RSIP, the CTGB has deployed a website that allows homeowners interested in installing solar PV systems to compare installation prices among contractors who participate in the program. Through 2016, the RSIP has facilitated the installation of more than 20,000 installations consisting of approximately 160 MW of residential solar capacity in Connecticut. With the passage of Public Act 15-197, An Act Concerning the Encouragement of Local Economic Development and Access to Residential Renewable Energy, the CTGB is authorized to offer residential rooftop solar incentives for up to 300 MW through 2021 known as the Solar Home Renewable Energy Credit ("SHREC") program.

Shared Clean Energy Facility Pilot Program

Many homes across Connecticut are not suitable for solar because of the orientation of their home or shading. Others are not eligible because they are renters which may prohibit them from installing solar. Shared clean energy programs (often called "community solar") are intended to provide customer access to the benefits of clean energy that they would otherwise not have. Shared clean energy programs provide these customers an opportunity to generate clean

[41] Weighted average generation charge for Eversource Rate 35, 27, 30, 35, 37, 40, 41, 55, 56, 57, & 58
[42] Cash out rate for PV resources. The Cash out rate for all other renewables is 3.1 cents/kwh.

renewable power to meet their electric needs and lower their electric bills, which is particularly important for low and moderate income customers for whom energy costs (or energy burden) are a significant percentage of their monthly expenses.

Passage of Public Act 15-113, An Act Establishing a Shared Clean Energy Facility Pilot Program provided the statutory framework for shared clean energy programs in Connecticut. DEEP has been working on developing a pilot program since the summer of 2015. The program allows both facility purchase and lease arrangements. The only cost structure difference between the pilot program and traditional net metering and virtual net metering was that rather than crediting production on a kWh basis, the developers are required to provide the credit to participating customers on a cents/kWh basis each year of the contract in their bid proposal. This provides more transparency into the cost of the program and greater certainty to both the developer and participating customers as to the amount of the credit. Fixed purchase rates are more transparent than kWh credits because the value of the credit is known and will not change due to changes to electric rates or rate structure.

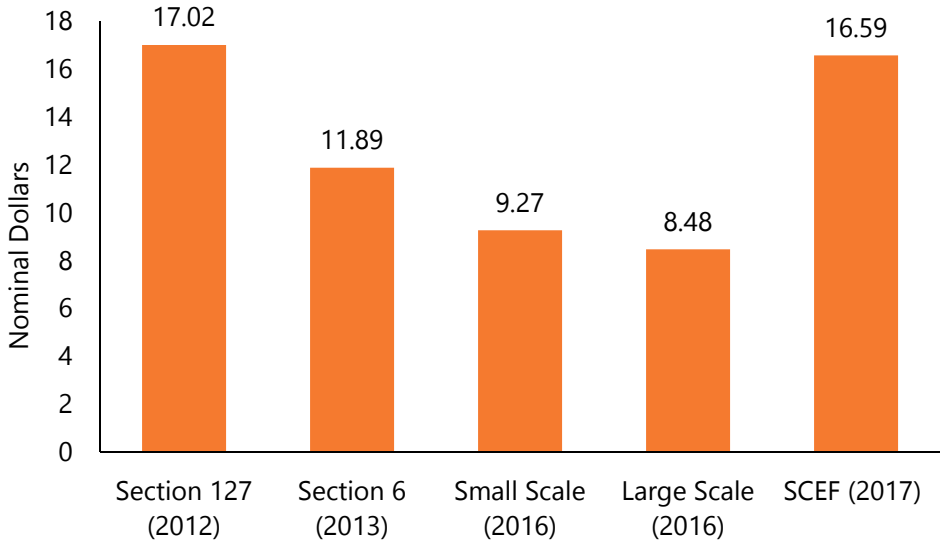
Community solar projects are configured in a manner similar to virtual net metering projects. Both have a centralized renewable generation facility with remote accounts that receive credit based on production. While community solar operates the same as virtual net metering, the relationship between the facility, host and accounts differs. In the existing virtual net metering program, the facility is located on a host's property, or a property leased by the host, and all of the accounts are related to the host. For example, a municipality may locate a solar project at the high school then designate other town buildings as the beneficial accounts. Similarly, a farmer may locate a project on their farm then designate several other farm buildings that are separately metered as the beneficial accounts. In contrast, community solar may be located anywhere, the host need not have an electric load to offset, and subscribing customers generally do not have to have any relationship with the host or each other. However, community solar customers that purchase the solar panels through an upfront payment or a fixed price lease arrangement would help finance the facility. These customers have directly contributed to the development of a renewable energy project and receive a payment or credit on their electric bill similar to those customers purchasing rooftop systems.

In February 2017, after a disappointing response to the initial SCEF RFP, DEEP re-issued the RFP to incorporate several changes. These included: a price cap, restrictions on siting, limitations on the percentage of subscriptions for commercial and industrial customers, minimum percentages of low and moderate income ("LMI") customers, and a move toward an EDC-managed credit structure for the program.

DEEP received nine bids for community solar projects from four developers in response to the re-issued RFP. None of the proposals required an upfront financial payment or other meaningful financial participation by the customers. Participating customers will simply receive a credit for up to 2 cents/kWh or more for their portion of the production from the facility. However, the winning bids in the improved re-issued RFP did come in under the target price, achieved significant levels of participation by LMI customers, and were sited on brownfields or similar underutilized lands that were not prime farmland or core forest.

On June 2017, DEEP selected three projects to move forward, totaling 3.62 MW in Eversource territory and 1.6 MW in UI territory. The average price of the selected projects is 16.59 cents/kWh.

FIGURE E9: Cost of Clean Energy Programs, SCEF and Grid Side (nominal dollars)



Source: DEEP analysis

Behind the Meter Renewables – Commercial

Public Act 11-80 established the LREC and ZREC programs. These programs, launched in the summer of 2012, provide an incentive to commercial and industrial companies to develop behind the meter clean energy projects, where the EDCs enter into long-term contracts with those developers to purchase the renewable energy credits produced from such generation. Under the LREC/ZREC programs, the EDCs purchase only RECs, not energy or capacity from these facilities.

The ZREC program allowed for $720 million in total spending for renewable energy credits from zero-emission Class I renewable energy resources such as solar, wind, and small hydro) to be spent over six years beginning in 2012. Beginning in 2012, EDCs must enter into $8 million worth of long-term (15-year) contracts annually for six years. The final competitive auction for this program

was initiated in April 2017 and will be completed in June. However, passage of Public Act 17-144 extended the ZREC program for one year for up to $4 million worth of long-term contracts.

The LREC program allowed for $300 million in total payments for renewable energy credits from low-emission Class I resources such as fuel cells, biomass, and landfill gas that meet certain emissions standards. The LREC program requires the EDCs to enter into $4 million worth of 15-year contracts annually for LRECs for five years, beginning in 2012. The LREC program, originally authorized until 2016, was extended for one additional year by the General Assembly with the passage of Public Act 16-196, An Act Concerning the Use of Microgrid Grants and Loans for Certain Distributed Energy Generation Projects and Long-Term Contracts for Certain Class I Generation Projects. Public Act 16-196 split the $8 million allocated to the final year of ZREC equally between the LREC and ZREC programs. Public Act 17-144 extended the LREC program for one year for up to $4 million worth of long-term contracts.

To date, the LREC/ZREC program has contracted for RECs totaling approximately 332 MW of capacity. Most of the contracted RECs (about 295 MW) are from solar capacity. The second largest are fuel cell projects, where the LDCs have contracted for a REC equivalent of 35 MW of fuel cell capacity. However, because fuel cells operate at about an 95% capacity factor the 35 MW translates to about 291,270 MWh/yr while the 295 MW of solar at a 15% capacity factor translates to about 387,630 MWh/yr. Solicitations for Year 1 through Year 5 have spent approximately $759 million, which leaves about $261 million remaining for additional projects to be awarded contracts in 2017.[43]

ZREC projects generally have larger capacity than residential solar projects. Since the inception of the LREC/ZREC program, the average size of a Small ZREC project ranged from 39 to 51 kW, the average size of Medium ZREC projects ranges from 170 kW to 210 kW. The average size of Large ZREC Projects range from 536 kW to 749 kW. Active LREC projects had an average size that ranges from 442 KW to 1,523. These projects generally are for commercial, industrial or municipal customers, in comparison to an average project size of approximately 7.5 kW for a residential solar PV installation. ZREC projects are mostly solar, but other technologies like run-of-river hydropower facilities also participate in the program. For example, the City of Meriden and the Connecticut Green Bank developed the Hanover Pond Hydro project using a ZREC contract and security from the Connecticut Green Bank. This hydropower facility is the first in the United States to employ an Archimedes Screw that is a highly efficient hydropower generator, but still allows fish to travel downstream through the screw.

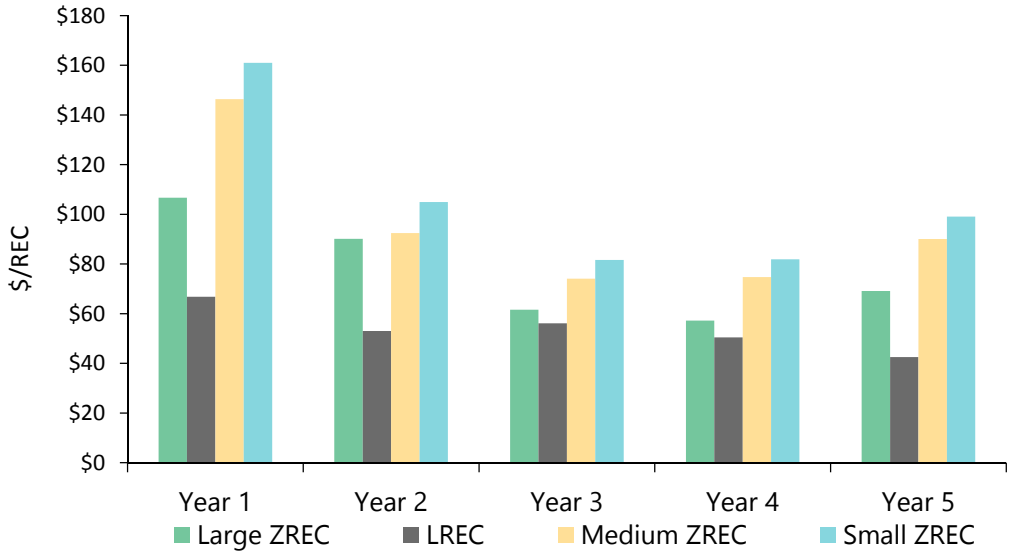
[43] DEEP data inquiry from EDCs

TABLE E4: Average Size of LREC/ZREC Projects (kW)

	Year 1	Year 2	Year 3	Year 4	Year 5
LREC	565	442	793	1,523	673
Large ZREC	536	550	786	749	749
Medium ZREC	170	181	184	180	210
Small ZREC	39	43	51	47	

The LREC/ZREC reverse auction and competitive procurement process has brought down the cost of RECs in the LREC/ZREC program. As noted in Figure E10, the Year five ZREC prices are approximately 35 percent to 39 percent lower than in Year 1. Year five LREC prices are approximately 36 percent lower than in Year 1.

FIGURE E10: Weighted Average REC Prices for Active LREC/ZREC Contracts

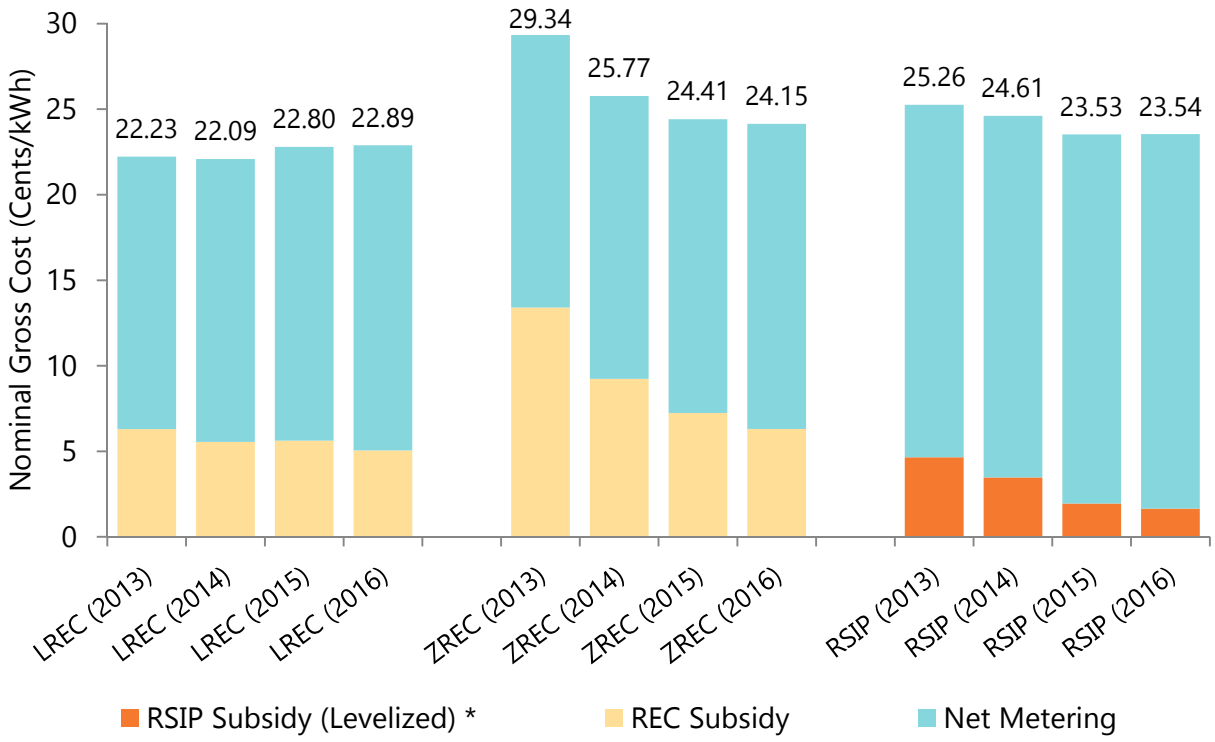


**One REC equals One Megawatt Hour of Energy*

The cost of the REC's, however, is only part of the cost. These projects may also qualify for net metering or virtual net metering. If LREC/ZREC bidders qualify for net metering, they can offset kWhs at the applicable full retail rate, which increases the amount of revenues received for generation. Most projects in these programs use traditional net metering. Therefore, the cost to ratepayers would be the LREC/ZREC subsidy, plus the cost of net metering.

When the costs of net metering and the ZREC are combined, DEEP estimates the cost to ratepayers from projects participating in the first four years of procurements, of the Small, Medium and Large ZREC program to be 26.26 cents/kWh, 25.48 cents/kWh and 23.61 cents/kWh respectively. With respect to LREC projects, the combined net metering and REC cost would be about 22.39 cents/kWh. These figures represent the gross costs of these projects; the impact on rates is less when accounting for avoided costs, such as avoided generation, distribution, transmission, capacity, etc.

FIGURE E11: Cost of Incentives for Behind the Meter Programs Nominal Dollars 2013-2016



** Average cost for RSIP was levelized over 20 years for Purchased Residential PV systems and not leased systems.*

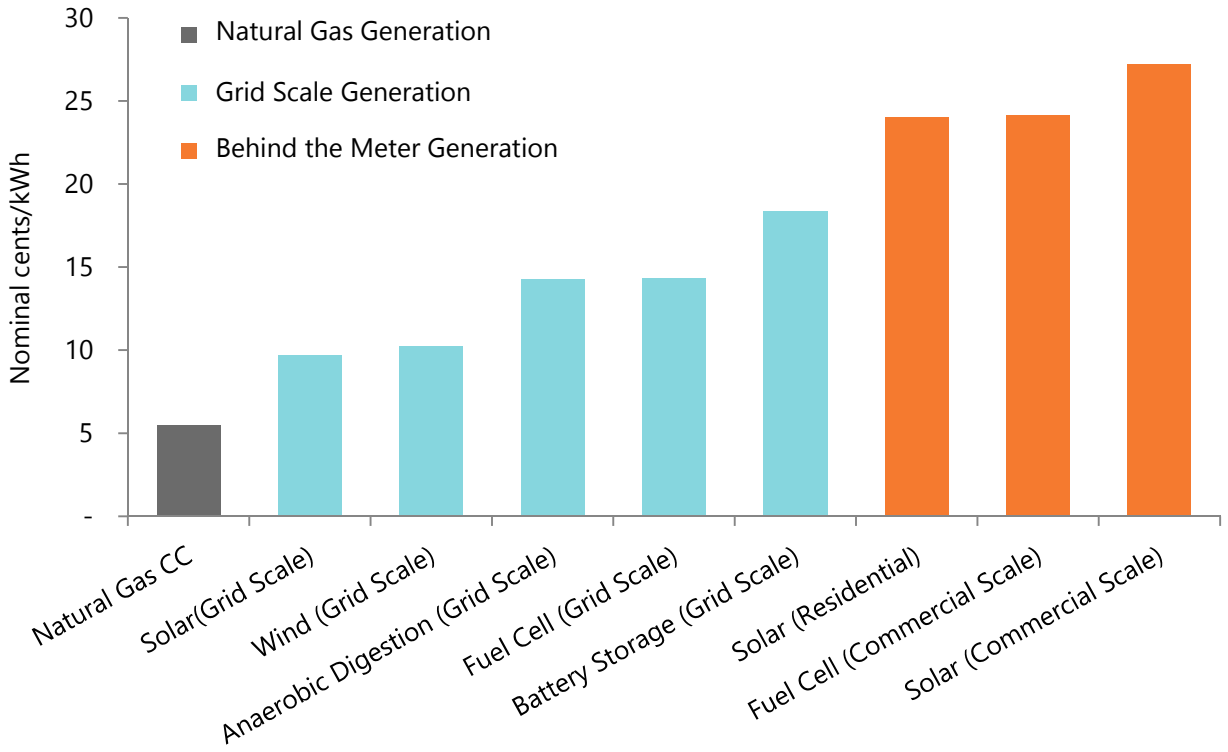
Comparing the Costs of Class I Renewable Programs

DEEP has compiled pricing information for Connecticut's behind the meter (i.e. RSIP and LREC/ZREC) and grid scale clean energy programs. The 2016 pricing information in Figure E12 shows the total levelized costs behind the meter programs and presented alongside the total levelized costs of the projects selected in DEEP's grid-scale procurements.[44] Grid connected Class

[44] All resources (except Natural Gas CC), are based on the lowest 50 percent of the bid prices submitted in the Large and Small Scale Procurement. Individual prices were adjusted using a weighted average for each generation resource.

I renewable generation technologies are generally less expensive than behind the meter projects. As shown in Figure E12, in recent procurements grid side Class I generation cost for wind and solar was less than 10 cents/kWh on a levied basis over 20 years. Behind the meter projects, on the other hand, can cost over 20 cents/kWh when both the ZREC/LREC and the cost of net energy billing is considered. The total costs for Class I generation of other technologies (i.e. anaerobic digestion, fuel cell, battery storage) were higher than grid side solar and wind but still lower than behind the meter programs.

FIGURE E12: Total Levelized Costs of Clean Energy Technologies (nominal dollars, 2016)



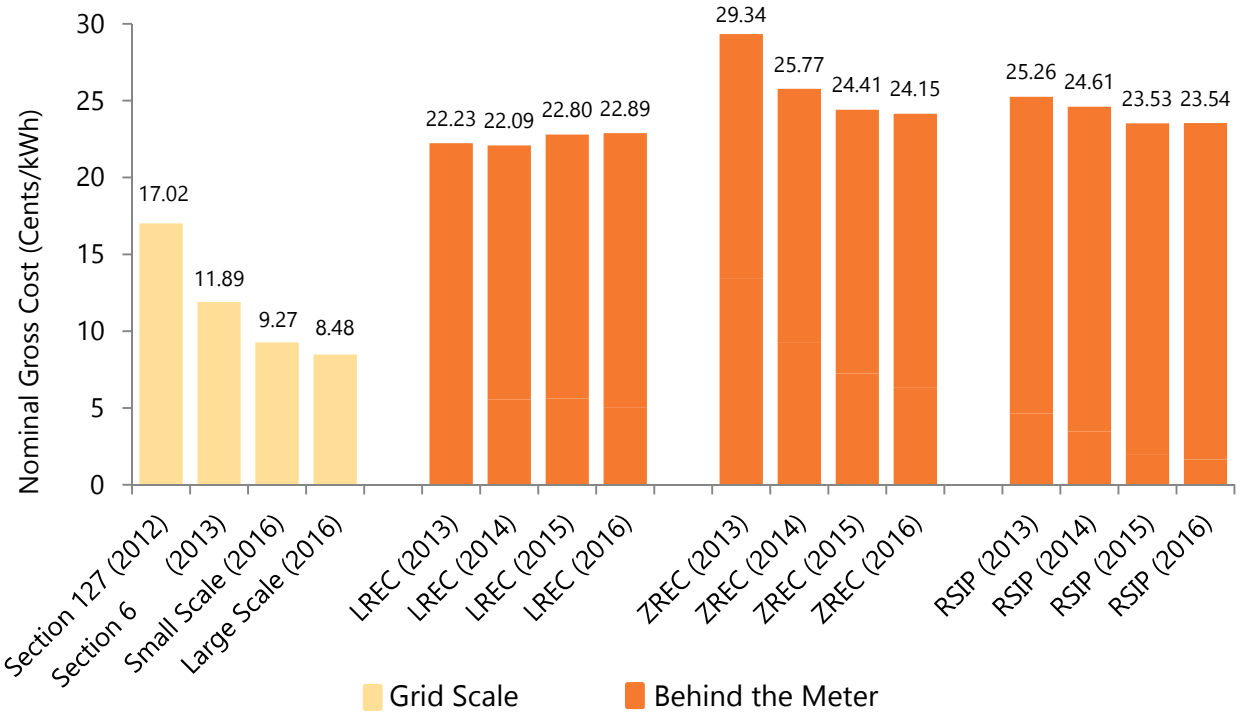
The cost of renewable deployment across Connecticut programs, administered by DEEP, have declined in the recent years. This decline in cost is most dramatic for grid side solar and wind projects. In the procurements conducted under Section 127 of Public Act 11-80, DEEP evaluated small grid side solar projects with a levelized cost of approximately 20 cents/kWh or more. Just five years later the cost of many grid-scale solar projects in the Public Act 15-107 procurements were less than 10 cents/kWh in nominal dollars on a levelized basis for the 20 year life of the contracts. The cost of behind the meter projects has also declined, but not to the same extent as grid-scale projects. The ZREC/LREC prices have declined, but this is offset by higher retail electric

Fuel Cell (Commercial Scale) and Solar (Commercial Scale) are the projected average gross net metering cost for 2016 thru 2030 plus the corresponding REC price for Year 5 of the LREC/ZREC program.

rates. When the cost of net metering is included, the overall reduction for behind the meter programs is not as significant as for grid-scale projects.

The results of DEEP's recent competitive procurements under Public Act 15-107 show that the cost of grid-side solar and wind has dramatically declined over the past few years to levelized prices below 10 cents/kWh. The results indicate that grid-connected projects are often much more cost-effective and can deliver the benefits of renewable power at a lower cost to ratepayers than behind the meter projects. Small grid-side solar and wind in the range of 2MW to 20 MW offered prices similar to much larger grid side projects. DEEP's experience with renewable solicitations suggests that an open, competitive and transparent process incentivizes low bids and hence drives down the cost of the projects.

FIGURE E13: Declining Cost of Clean Energy Programs, Behind the Meter and Grid Side (nominal dollars, 2012-2016)



** Average cost for RSIP was levelized over 20 years for Purchased Residential PV systems and not leased systems.*

Although the behind the meter programs have not seen the declining costs of the grid-connected projects, these programs have several non-price advantages that make investment in these programs worthwhile. Behind the meter programs like LREC/ZREC and RSIP provide many benefits, including but not limited to: (1) helping high energy use customers, like commercial and

industrial customers, reduce their electric costs, which benefits the system overall if peak demand is reduced; (2) generally developing clean energy resources faster than grid-scale projects; and (3) promoting job growth in Connecticut.

Waste Management Goals and the RPS

Class II renewable energy sources include energy derived from resource recovery facilities, biomass facilities that began operation before July 1, 1998 with certain emission levels, and run-of-the-river hydropower up to 5 MW that began operations prior to July 1, 2003. The Class II requirement was initially set at 3 percent and remains constant through 2020. There are currently 123 generating plants across New England that meet the Class II requirement, with a total capacity of 665 MW. More projects could qualify, but do not apply for eligibility because of the low Class II REC prices in Connecticut. The 123 Class II sources include 99 hydropower facilities, 17 resource recovery facilities, and 8 biomass plants. As of 2014, the latest compliance period for the RPS, approximately 857,000 or 89 percent of RECs, used for Class II compliance were produced from generators located in Connecticut.

The current supply of Class II resources significantly exceeds the RPS requirements prior to the 2017 legislative session. Given the state's electric demand in 2016, the Class II RPS requirement could be satisfied by approximately 825,000 RECs. This surplus has driven down prices of Class II RECs to less than $1/MWh. DEEP estimates the cost of Class II RECs to be less than $1 million in 2016. Due to these very low price of Class II RECs, the revenues provided do very little to support existing Class II facilities or encourage the development of new Class II projects.

Connecticut's five active waste-to-energy facilities provide 144 MW of capacity to the grid, as well as a source of fuel diversity. These waste to energy facilities are an integral part of the state's waste management system, providing over 80 percent of disposal capacity for municipal solid waste (MSW). Management of waste via waste-to-energy facilities provides greenhouse gas benefits when compared with landfilling. Maintaining Connecticut's waste-to-energy facilities is necessary until modern waste-conversion processes become viable alternatives.

Connecticut has set an ambitious goal to divert 60 percent of waste from disposal by 2024. Achieving this goal will require both the development of modern waste conversion technologies such as anaerobic digestion, and the installation of advanced sorting equipment at existing waste-to-energy facilities to recover recyclable material from MSW prior to combustion.

DEEP has undertaken an analysis of the waste disposal needs and options in Connecticut as part of the Comprehensive Materials Management Strategy to develop an approach to managing materials that is economically viable and advances the state's economic and environmental goals. DEEP believes that a modest level of support is needed to ensure the continued operation of these

facilities and necessary to meet the state's energy and materials management goals. This support was enacted with the passage of Public Act 17-144, An Act Promoting the Use of Fuel Cells for Electric Distribution System Benefits and Reliability and Amending Various Energy-Related Programs and Requirements. This bill modifies the Class II eligibility requirements to only include waste to energy facilities that support Connecticut's waste management goals, increases the Class II REC requirement from 3 percent to 4 percent, and changes the ACP to $25/MWh. This change could result in up to $27.5 million annually supporting the waste to energy facilities that further our waste management goals.

Similar to the waste to energy sector which integrates the Solid Waste Management planning with the CES energy goals, DEEP also intends to further explore opportunities to integrate biosolids management (sewage sludge) with CES goals. Biosolids are an abundant source of renewable energy. In Connecticut, biosolids are managed through anaerobic digestion and incineration. Either option can be used for distributed electricity generation and/or process & space heating, increasing the energy efficiency of the management facility.

Under current policy, electricity generated using the byproducts from anaerobic digestion of biosolids is eligible for Class I RECS, which provide a revenue stream to incent expand use of biolsolids, which are an abundant source of renewable energy. Additionally, generating electricity by burning the gaseous byproducts of biosolid anaerobic digestion emits less air pollution than incineration. However, there have been few such projects deployed in Connecticut.

The overwhelming majority of biosolids generated in Connecticut are managed through incineration. The state currently depends on five regional (in-state) sludge incineration facilities to meet its current biosolids management needs. The process of incineration generates a significant amount of heat that currently exhausts through smokestacks. If captured and used cost effectively, some of this waste heat could be used for distributed electrical generation, which may create grid reliability benefits for rate payers. In fact, the MDC facility in Hartford generates electricity for use at the plant using waste heat from its biosolids incinerator. Alternatively, the waste heat could be used within the facility or nearby buildings to offset burning fossil fuels for space and process heating, increasing the efficiency of the plant and reducing emissions of air pollution and greenhouse gases from burning fossil fuels.

At present, cost effectively managing the state's biosolids relies on operation of the existing incinerators until such time when anaerobic digestion and other means of sludge management mature. In the very near term, the facilities that operate biosolids incinerators will likely need to make significant capital improvements in order to comply with Clean Air Act and Clean Water Act requirements. There may be opportunities, during the implementation of these necessary improvements, to retrofit existing incinerators to generate electricity, process heat, or both. The

exploration of these opportunities and options for supporting them, as is the case with anaerobic digestion and municipal solid waste incinerators, corresponds to our CES goals in both the electric and building sectors. To advance this conversation, DEEP intends to hold a technical session with the five regional sewage sludge incinerators.

The Role of Combined Heat and Power and Energy Efficiency in Connecticut's Class III RPS

Connecticut's Class III market is comprised of efficiency measures and energy produced by combined heat and power facilities. The Class III requirement started at 1 percent in 2007, and increased by 1 percent each year until reaching 4 percent in 2010, at which point it remains constant through 2020. Class III RECs have a statutory price floor, of 1 cent/kWh and a ceiling of 3.1 cents/kWh, which was implemented in a PURA decision.[45]

Table 6 below shows the Class III requirements and the qualifying Class III RECs between 2007 and 2010. As seen in Table 6, the supply of Class III resources were significantly greater than the requirements. This imbalance resulted in many Class III RECs selling at the price floor of 1 cent/kWh and many not selling at all. DEEP estimated that it cost approximately $12.8 million to meet the Class III RPS requirement in 2012.[46]

Oversupply in the Class III markets resulted largely from continued growth in utility energy efficiency programs, which affected third party conservation efforts. There have been no third party conservation providers selling Class III RECs. Low REC prices also affected CHP units. Prices at the floor level provided little support for existing CHP units and did not encourage new development.

FIGURE E5: Summary of Historical Class III Requirement and Qualifying Resource Output[47]

Year	Class III Supply			Class III Demand (*MWh*)
	CHP *(MWh)*	C&LM *(MWh)*	**Total *(MWh)***	
2007	0	437,854	437,854	338,736
2008	124,331	783,560	907,891	656,600
2009	528,219	1,002,482	1,530,701	951,790
2010	645,978	1,236,626	1,882,604	1,280,838

Source: CLASS III supply as reported in NEPOOL Generation Information System (GIS). Class III demand calculated based on existing RPS targets increasing from 1% in 2007 to 4% by 2010.

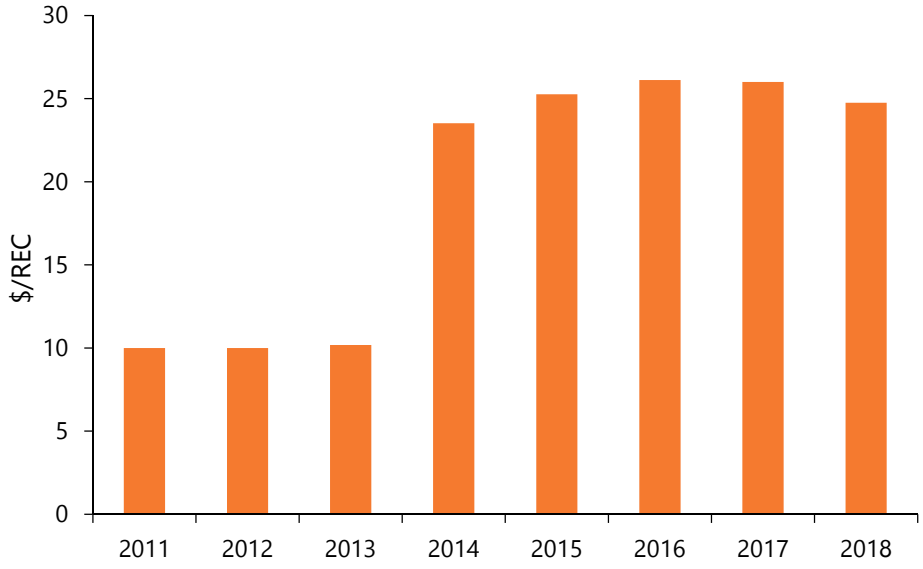
[45] Conn. Gen. Stat. § 16-243t(a). PURA Docket No. 05-07-19RE02.
[46] IRP p. 18-19
[47] IRP p. 18-19

The 2013 RPS Study recommended changes to the Class III eligibility requirements by removing conservation funded by Connecticut ratepayers from eligibility.[48] In 2013, Public Act 13-303 was enacted that changed the eligibility and removed ratepayer funded C&LM from Class III. This change rebalanced the supply and demand for Class III and REC prices increased to approximately $25 MWH.

The changes enacted in 2013 provided a key incentive for the development of CHP and in 2017 all the Class III REC's are supplied by CHP. DEEP now estimates the cost of Class III to be approximately $27.5 million in 2017. This could increase slightly in the years ahead if Class III REC prices increase further. Higher Class III REC prices increase revenues for existing CHP units and provide a greater incentive for new CHP and third party conservation development. The total maximum cost of Class III would be approximately $34.1 million, if the entire 4 percent requirement was met at the ceiling price of 3.1 cents/kWh.

Several incentives are currently available to encourage the development of CHP in Connecticut. Behind the meter CHP helps customers reduce their electric costs, heating, and hot water costs. In addition to Class III RECs, CHP is eligible for net energy billing and for a waiver on their demand ratchets from their companies and a discount of gas prices. Given these incentives and the higher prices for Class III RECs, DEEP believes that there are adequate incentives in place for CHP at this time.

FIGURE E14: Connecticut Average Class III REC Prices, 2012-2018



Source: SEA analysis, "Renewable Energy 101 Training" slide deck

[48] DEEP, "Restructuring Connecticut's Renewable Portfolio Standard" (Apr. 26, 2013).

DEEP will continue to monitors the RPS markets, and if third party conservation and CHP grows to a point where the existing 4 percent requirement is projected to be filled, DEEP would consider whether the requirement should be increased and present its recommendation to the General Assembly.

Challenging Conditions Nationally for Nuclear Generation

Nuclear power plants operate around the clock as base load generation, which means they have high capacity factors. At the same time, these units cannot ramp up and down, meaning they must be either running at or near full capacity or not at all. These units help diversify the fuel mix as a large non-fossil resource. However, issues remain with regard to security and safety, the short and long-term storage of nuclear waste, and the cost to maintain and operate these facilities, which often have large cooling water intake structures. Nuclear plants have high fixed costs, and relatively low fuel and other variable costs. These plants, like all unregulated generation facilities in New England, must recover their costs from revenues they obtain in the ISO-NE energy, capacity and ancillary service markets or through contracts with electric generation service suppliers. Low natural gas prices make cost recovery more difficult, particularly for high capacity factor units like nuclear because they are dependent on energy market revenues rather than capacity market revenues.[49] In the near term, nuclear plant daily energy prices are expected to remain low based on forecasted gas prices and additions of more zero marginal cost renewable generation to the system.[50]

As of 2016, the total nuclear generation capacity in New England was 4,196 MW. Connecticut currently has two operational nuclear electric generating units (Millstone Unit 2 and Unit 3) contributing 2,088 MW of summer capacity, approximately 27.6 percent of the State's peak generating capacity. In terms of energy output, the Millstone facility is the largest generating facility in Connecticut and is equal to approximately 50 percent of the power consumed in the state.[51] In addition to the nuclear power plants in Connecticut, there are two remaining nuclear generation facilities in New England, Seabrook 1 (1,245 MW) and Pilgrim (677 MW), although Pilgrim is scheduled to retire in 2019. Nuclear generation accounted for approximately 12 percent of the generation capacity in New England in 2014 and 34 percent of the energy generated.

[49] EIA data available at https://www.eia.gov/dnav/ng/hist/rngwhhdm.htm
[50] EIA Annual Energy Outlook 2017, available at https://www.eia.gov/outlooks/aeo/

[51] Connecticut's demand is about 30 million MWh/yr. Millstone's generation is about 15-16 million MWh/yr.

Electricity generated from nuclear facilities do not emit SO_X, NO_X, or CO_2 and are thus the largest source of emission free electric generation in New England.[52]

Nationally, the low cost of natural gas is a primary contributor to nuclear plant retirements before the end of their useful lives.[53] This trend has called into question the economic viability of the remaining nuclear units. DEEP has not seen any evidence of an imminent retirement; both Millstone units cleared the most recent ISO-NE forward capacity auction (FCA 11), obligating them to operate through May 31, 2021 or find other generators to take on their obligation. Additionally, Millstone did not submit a retirement or delist bid for either unit in advance of FCA 12, which it would have had to do by March 24, 2017 if it were considering retiring either unit before May 31, 2022. Estimating a plant's going forward costs and profitability is difficult in a deregulated market if plant owners choose not to disclose it, since that type of information is not ordinarily available to state regulators.

Early retirement of Millstone Units 2 and 3 – i.e., well before their license dates of 2035 and 2045 respectively – would result in a considerable loss of generation capacity in Connecticut. The ISO-NE capacity market (if it operates as planned and capacity prices are high enough to attract sufficient capital investment to build new generation) would deliver new generation to replace Millstone. However, that replacement generation would likely be natural gas fired generation without firm fuel supply. Building 2,000 MW of new natural gas capacity on an expedited timeframe to replace a Millstone's output would drive up capacity and energy prices, resulting in higher electric rates in Connecticut. The replacement of nuclear with natural gas also would reduce regional fuel diversity, and add to the winter reliability problem. Additionally, New England's electricity sector CO_2 emissions would increase by an estimated 8 million tons per year or approximately 27% in annual emissions. Increasing GHG emissions resulting from the early retirement of Milestone and its replacement by natural gas would make compliance with Connecticut's GWSA carbon reduction mandates more challenging, and increase the costs of CO_2 allowances in the RGGI market.

Millstone's 2,000 MW would not be immediately replaceable with regional or in-state Class I renewable generation. As a practical matter, it would take years to develop and site in-state or out-of-state clean energy resources. To replace Millstone's 2,000 MW at a 90% capacity factor would require approximately 1,500 onshore wind generators that are 3.5 MW each, or 12,000 MW

[52] Nuclear plants use nuclear fission (a reaction in which uranium atoms split apart) to produce heat, which in turn generates steam, and the steam pressure operates the turbines that spin the generators. Since no step in the process involves combustion (burning), nuclear plants produce electricity with zero air emissions. Pollutants emitted by fossil-fueled plants are avoided, such as sulfur dioxide (SO_X), nitrogen oxides (NO_X), mercury, and carbon monoxide. (SO_X and NO_X contribute to acid rain and smog.) Nuclear plants also do not emit carbon dioxide (CO_2), which is a significant advantage in the effort to curb greenhouse gas emissions.

[53] In 2014, the 619 MW Vermont Yankee facility was retired and the 677 MW Pilgrim facility will retire in 2019.

of solar, which translates to approximately 30,000-60,000 acres at grid scale (over 2 MW), or 2 million homes with average sized rooftop systems. These renewable systems would likely require significant energy storage or baseload generation to help balance the resource's intermittency.

Customer Bills Show Generation Rates Declining, but Other Components Increasing

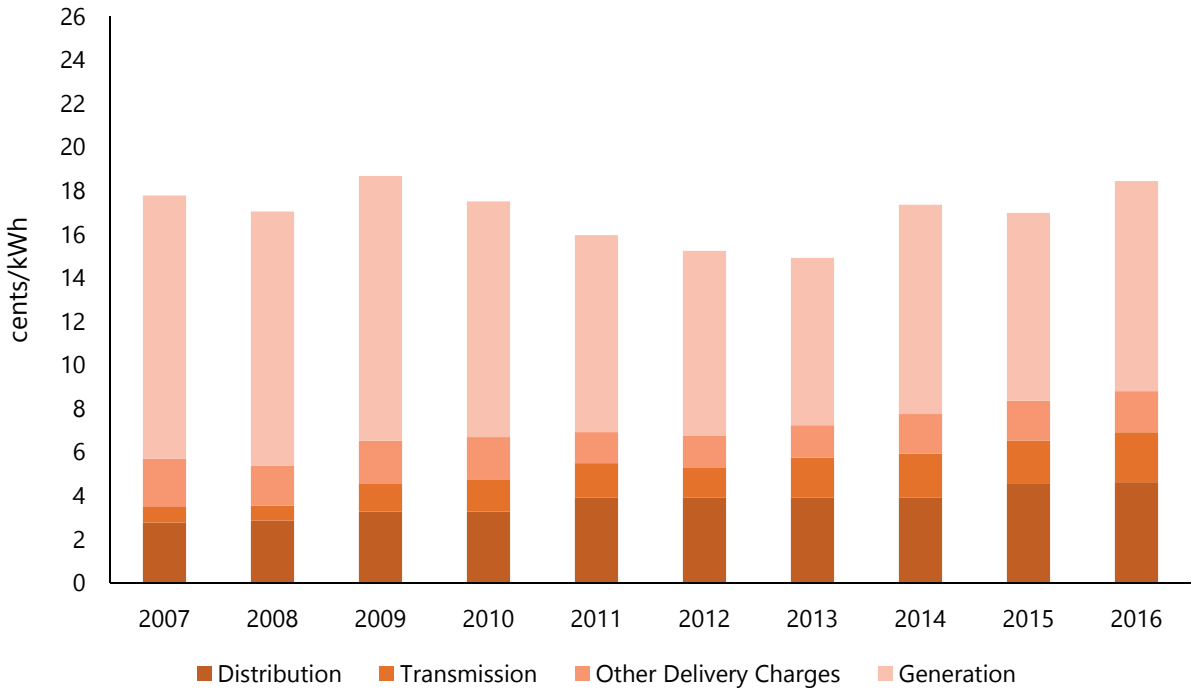
Connecticut's per capita electricity use is among the lowest in the nation according to Energy Information Administration ("EIA"). Demand for air conditioning is small during the relatively mild summer months, and fewer than one in six Connecticut households use electricity as a primary source for home heating in winter. The American Council for an Energy Efficient Economy ("ACEEE") ranked Connecticut fifth nationally in 2016 recognizing the strength of Connecticut's energy efficiency programs.[54] These mature programs have been instrumental in reducing electricity use and peak demand, and in turn, have helped consumers reduce power bills. As a result, Connecticut ranked 27 in overall average electric bills in 2014 compared to other states despite having high retail electricity rates.[55]

Although Connecticut electric bills are in the middle nationally, electric rates in Connecticut are among the highest in the nation. In February 2017, Connecticut ranked 49th highest out of 51 (50 states plus the District of Columbia) in average overall retail electric rates at 17.44 cents/kWh.[56] The average in Connecticut was approximately 70 percent above the national average price of 10.33 cents/kWh. The only states with higher electric rates were Alaska and Hawaii. Excluding Alaska and Hawaii, the states with the highest electric rates are in the Northeast, Middle Atlantic and California.[57] While the rankings change somewhat over time, states in the Northeast and Middle Atlantic are consistently among the highest rates, while the South and Pacific Northwest are the lowest.[58] Connecticut ranked around 45th for most of the 1980's and 1990's.

[54] http://aceee.org/state-policy/scorecard
[55] EIA Table E18 Coal and Retail Electricity Price and Expenditures Estimates, Ranked by State 2014
[56] U.S. EIA Table 5.6.A Prices of Electricity to Ultimate Customers by End use Sector, by State Feb 2017 and 2016.
[57] U.S. EIA State Energy Profiles
[58] EIA Electric Power Monthly, November 2015.

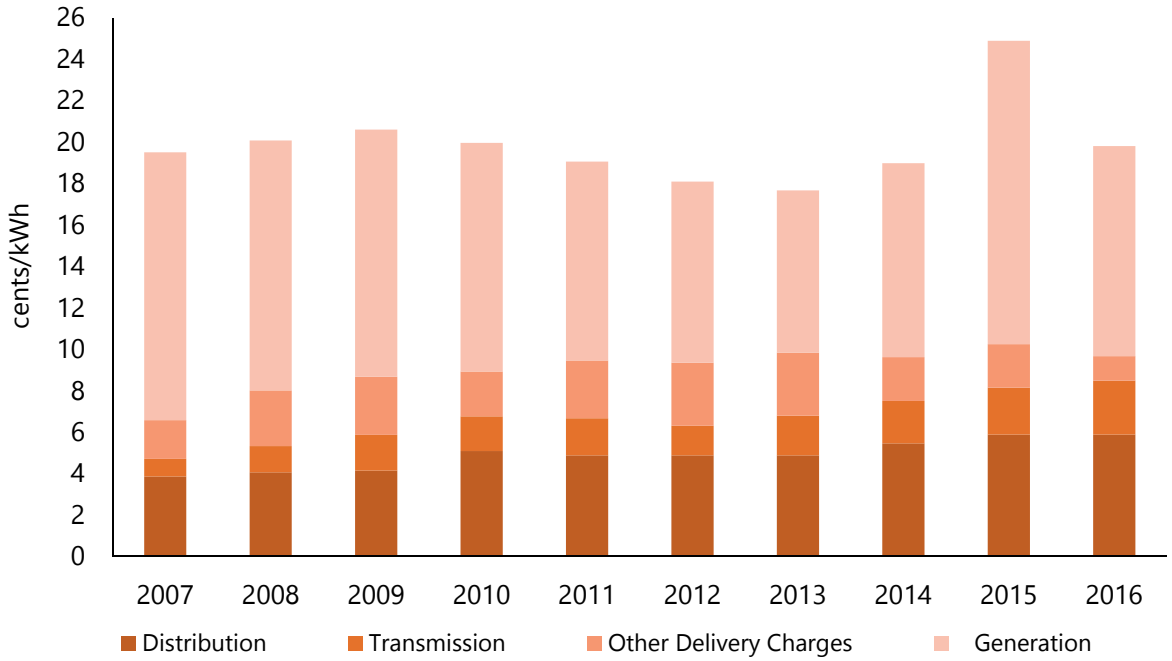
In 2000, Connecticut's average electric rates for all sectors was 13.4 cents/kWh, which ranked 42nd, approximately 32 percent above the national average of 10.2 cents/kWh (2016$). From 2000 to 2009, electric rates rose by approximately 50 percent to 20.2 cents/kWh (2016$), 84 percent higher than the national average of 10.98 cents/kWh (2016$). Due to higher than average rate increases relative to other states, Connecticut's overall ranking dropped to 49th.

FIGURE E15: Eversource Average Electric Rates 2007-Present



Since reaching a peak in 2009, electric rates in Connecticut declined each year from 2009 through 2013 due to lower generation rates driven by lower natural gas prices, the elimination of stranded costs (a legacy of deregulation) and major investments in new generation and transmission that

FIGURE E16: UI Average Electric Rates 2007-Present



reduced capacity and energy prices. Since 2013, electric rates have increased, returning to the levels reached in 2009.

Generation Rates

Generation is one of the largest component of rates, representing just over 50 percent of the total electric rate, followed by distribution and transmission. Before electric restructuring, PURA regulated generation rates based on the cost of service to generate power. Now the competitive market – and the design of that market – determine and influence generation service rates. Customers may purchase generation service from competitive suppliers or from Eversource/UI under the standard service offer. Since restructuring, the price of electricity in Connecticut is highly correlated with the price of natural gas. Eversource's average generation rates for standard/default service have increased from 4.81 cents/kWh in 2000 to a high of 12.1 cents/kWh in 2009. Generation rates then declined in 2010, 2011, 2012 and 2013 before increasing again due to high natural gas costs in the winter. Average generation rates were 9.64 cents/kWh in January 2016 or an increase of 100 percent since 2000. UI's standard/default service generation rates followed a similar pattern. UI's generation rates have increased by 120 percent from 4.63 cents/kwh in 2000 to 10.14 cents/kWh in 2016.

While the generation rate has increased by over 100 percent since 2000, the total cost of generation has not gone up as much as the generation rate increase indicates. Before restructuring, the generation rate was approximately 6.00 cents/kWh. When restructuring began,

some of the generation costs were considered stranded costs and were collected in the Competitive Transition Assessment ("CTA") charge, resulting in a portion of the 6.00 cents/kWh generation rate being allocated to the CTA charge. For UI the CTA was 1.49 cents/kWh in 2000. When the CTA is added to the new generation rate of 4.63 the total average cost of generation was 6.12 cents/kWh for UI in 2000. The CTA for Eversource was 1.02 cents/kWh in 2000 resulting in a total average generation cost of 5.83 cents/kwh.

Competitive Generation Supply

Because of electric restructuring in Connecticut, electric generation services are provided to Connecticut's customers either by the default or Standard Service provided by the state's two EDCs, Eversource and UI, or service by competitive electric suppliers. Section 16-244b of the General Statutes authorized electric customers to choose their own electric suppliers in a competitive generation market, starting July 1, 2000. PURA maintains an official Rate Board on the EnergizeCT website that displays the supplier names, product prices and other features of their products,[59] which allows for "comparison shopping" when a customer is considering switching to competitive generation. PURA also oversees a Supplier Working Group, which includes suppliers, aggregators, EDCs, and representatives of the Office of Consumer Council ("OCC"). This group was established to address, in a collaborative manner, improvements to the Rate Board and any other particular concerns as they arise.

Nearly all of the state's largest commercial and industrial ("C&I") customers purchase their electric power from competitive electric suppliers. A portion of small C&I customers (maximum peak use up to 500 kW) and residential customers have migrated to alternative retail suppliers, but many remain on Connecticut's default service. In this CES, DEEP evaluates the benefits of retail competition in terms of price, quality of service and consumer choice, particularly as it applies to small business and residential customers.

Transmission Rates

While the generation portion of rates have declined in recent years after reaching a peak in 2009, the distribution and transmission charges have steadily increased. Transmission rates recover the cost of the transmission infrastructure used to move electricity from power plants to local distribution systems. Prior to restructuring, PURA regulated and set the transmission rates for Eversource and UI. Because of restructuring, FERC now regulates and ISO-NE administers transmission. Investments to improve system reliability and reduce congestion have translated into rapidly rising regional transmission costs known as the Regional Network Service Rate ("RNS Rate"). FERC regulatory actions have also contributed to the rise in transmission rates by allowing

[59] http://www.energizect.com/compare-energy-suppliers/compare-supplier-options

high rates of return and bonus incentives on transmission investments. Many projects have also been significantly over budget.

In addition, some transmission costs are for local transmission facilities that are not considered part of the regional network. This is called Local Network Service ("LNS") Rate. The RNS and LNS rates are combined to form the transmission rate charged to customers.

Since 2000, Eversource's transmission rates have risen 500 percent from 0.38 cents/kWh to 2.29 cents/kWh in January 2016. UI's transmission rates have risen 250 percent since 2000 from .75 cents/kWh to 2.60 cents/kWh to fund major infrastructure investments to improve system reliability and reduce congestion. Reducing congestion has enabled lower cost generation to move more freely from generation to load centers in Connecticut, which has contributed to lower generation rates (offsetting a portion of the transmission rate increase). Congestion charges, which are recovered through the bypass-able federally mandated congestion charge ("BFMCC") component of generation rates, declined from over 1.11 cents/kWh for UI in 2006 to negative 6 cents/kWh today, resulting in a credit on customer bills.

A number of projects are currently underway or in the planning stages to improve system reliability in Connecticut and the rest of New England. There will also likely be an increased need to invest in transmission infrastructure in the years ahead to expand transmission to move renewable power generated in remote locations to population centers in Connecticut and southern New England to reach our RPS and GWSA goals.

Distribution Rates

Distribution costs for both regulated utilities have increased over the years to recover higher costs of doing business such as rising payroll costs and associated benefits, and the capital cost associated with the replacement of aging distribution system components and improvements to modernize and harden the system to withstand storms. Eversource's distribution rates have increased 82 percent from 2.55 cents/kwh in 2000 to 4.64 cents/kWh in 2016. UI distribution rates have increased by 150 percent from 3.27 cents/kWh to 5.88 cents/kWh. UI's distribution rates are higher than Eversource's because UI has a more urban service territory and therefore more of its facilities are underground. An underground distribution system is more expensive but improves reliability. Grid modernization, strategies to utilize smart devices and appliances to reduce peak demands, and planning efforts to strategically locate distributed generation may help to offset future distribution and transmission cost increases. Grid modernization efforts are discussed in more detail below.

Future Trends in Generation, Transmission and Distribution Costs

While the energy component of generation rates is not expected to rise significantly, this is dependent on continued low natural gas prices. The biggest risk is during cold winter months when gas pipelines are most constrained because customers increasingly use natural gas for home heating and therefore there is less excess capacity available for electric generators that purchase gas in the spot market. In addition, the need to replace and improve distribution and transmission infrastructure will continue, which must be recovered. Significant increases in renewable generation will be critical to achieving Connecticut's greenhouse gas ("GHG") emissions reduction goals of an 80 percent reduction below 2001 levels by 2050 under Connecticut's Global Warming Solutions Act ("GWSA"), which will also come at added an added cost.[60]

High electric rates create challenges for Connecticut customers to pay their electric bills and businesses to remain competitive. PURA provides regulatory oversight to keep rates as low as possible, while allowing the utilities to recover their costs and make a reasonable return so they can provide clean, safe, and reliable service. DEEP and PURA will continue to work with ISO-NE to ensure that the ISO-NE markets provide proper incentives to generators to ensure reliable service at reasonable costs to Connecticut electric customers. DEEP has developed specific strategies to assist customers reduce their electric bills, such as energy efficiency, alternative rate options and demand response programs. In addition, DEEP's focus on mechanisms to minimize the impact on electric rates is reflected in the strategies recommended to increase renewable generation to meet our environmental goals at the lowest cost to ratepayers in the years ahead.

Resource adequacy and distribution reliability are strong, while natural gas dependence can pose winter reliability risks.

Generation Reliability

Resource Adequacy

ISO-NE is charged with ensuring resource adequacy. Resource adequacy in its simplest definition is the condition in which, taking into account transmission constraints, the electric system has enough generation resources to meet electric demand in New England reliably under reasonably anticipated circumstances. This means that the ISO must have enough generation available during the highest expected demand periods. To ensure there are enough generation resources during peak periods, the ISO has instituted a Forward Capacity Market ("FCM"). Generators that participate in the FCM take on what is called a Capacity Supply Obligation ("CSO"), an agreement by the generator to produce a certain amount of electricity if called upon by the ISO. The FCM is

[60] CGS 22a-200(a)

designed to provide generators with the "missing money" that they need but are not able to collect in the energy and ancillary markets to ensure adequate supply.

The FCM is operated through a Forward Capacity Auction ("FCA") three and a half years in advance of the CSO. The ISO conducts the FCA through a descending clock auction where the price offered continues to decline until only enough resources remain in the auction. The FCM is designed so that if a new resource is needed, to meet growing peak demand or to replace a retiring generator, the clearing price will be sufficient to support the financing of the new resource. The FCA does not distinguish between resource types. Accordingly, the resources that offer the lowest prices clear the market.

The ISO has conducted eleven FCAs that have successfully attracted and retained sufficient resources to meet resource requirements. However, all the significant new generation resources have been natural gas fired. Between 2012 and 2020, more than 4,200 MWs of non-natural gas fired generation will retire.[61] The bulk of those MWs were replaced in the FCAs by natural gas fired generation.[62] The remaining coal, oil, and nuclear units are considered at risk of retirement.[63] This presents a significant reliability concern for the region as the region becomes so heavily reliant upon natural gas generation without the necessary natural gas transportation infrastructure.

As of FCA 11, within the FCA for New England as a whole there are three sub-regions (Northern New England, Southeast New England, and Rest of Pool) that have Local Sourcing Requirements ("LSR") to ensure that transmission constraints do not leave any part of the system with insufficient generation to meet peak load conditions.[64] For the past two FCAs, after recent upgrades to the transmission system and new resources recently constructed or expected to be constructed, Connecticut had sufficient local resources not to necessitate its own zone. Because the FCA is conducted three and a half years in advance of when the capacity is needed, Connecticut has enough capacity through June 2021. Absent the retirement of more than 2,000 MWs of supply, there is no expectation that Connecticut will have insufficient local resources for the foreseeable future.

Natural Gas Dependence

In New England, natural gas fired generation is the marginal unit – i.e., the unit turned on to meet the next increment of electric demand – approximately 75 percent of the time. Although the competitive energy markets incentivize the development of low costs resources, the markets do

[61] ISO-NE 2017 Regional Energy Outlook p. 27 available at https://www.iso-ne.com/static-assets/documents/2017/02/2017_reo.pdf
[62] *Id.*
[63] *Id.*
[64] The ISO models transmission constraints before determining the appropriate subzones in each FCA.

not sufficiently incentivize the availability of fuel sources. Generally, gas generators do not purchase long-term firm capacity contracts for gas supply because the costs of doing so for any one generator are very high and will make the unit uncompetitive. Instead, generators rely on excess capacity in the gas transmission system and purchase gas on the spot market. Accordingly, as the market incentivizes more and more natural gas generation, the infrastructure to deliver natural gas has not kept up and the system becomes constrained in during peak demand for natural gas for heating uses, creating a winter price and reliability problem.

When gas is constrained, the system relies on existing coal and oil generation units to supply the region's electricity needs. This makes it difficult to operate the system cleanly and reliably. Many of these units are old, less reliable and are not designed to operate as peaking units. These older units were originally base load units and do not have the ability to be turned on quickly or ramp up and down to meet rising and falling loads. Many of these older non-gas units are retiring or are at risk of retirement. The market, as designed, is replacing the retiring units with more natural gas generation, exacerbating the risks as the demand for gas rises and the available capacity remains relatively constant. This occurs because the markets are "fuel neutral" and natural gas units are generally the least expensive units to build and operate. It should be noted, however, that modern natural gas units tend to be flexible, starting up on short notice and can ramp up and down, which supports intermittent resources. This characteristic is increasingly important with more renewable resources coming onto the system.

ISO-NE Winter Reliability Program

To address potential reliability problems due to natural gas supply constraints for the winter 2015/2016 and 2017/2018, the ISO-NE instituted a "winter reliability program" designed to ensure that enough generation is available on the coldest days of the winter when the natural gas distribution system is heavily constrained and there is less gas available for generation. The program pays oil generators to maintain enough fuel on site to operate for 10 days, and pays natural gas generators to contract for liquefied natural gas ("LNG") to operate for four days, and pays demand response resources to be available for up to 180 hours beyond their obligations in the forward capacity market. After the 2017/2018 winter, the ISO's Pay for Performance ("PfP") FCM construct is intended to ensure reliability. Simply stated, PfP is a market mechanism designed to compensate generators for operating when most needed and penalize generators if they do not operate when called upon. The intent of PfP was to encourage new gas generators to invest in equipment necessary for duel fuel capability so that they would have the ability to also burn oil during times of gas constraints. However, environmental concerns (both from air quality and water use perspectives) restrict the operational capability that new dual fuel (natural gas and oil) units are permitted to operate using oil. PfP also encourages the retirement of the older oil and coal units that are exposed to the punitive aspect of PfP because of their inability to ramp-up quickly.

Despite the institution of PfP, the ISO remains concerned that the system remains overly reliant on natural gas generation without a clear pathway to relieve the constraints on fuel availability.

Natural Gas RFP

In recognition of the risks posed by the lack of natural gas infrastructure, the Connecticut General Assembly enacted Public Act 15-107. This legislation authorizes the DEEP Commissioner to solicit bids for up to 350 MMCF natural gas capacity and clean energy resources to meet winter reliability needs and allows the recovery of costs from electric ratepayers. The 350 MMCF is the equivalent of Connecticut's share of the infrastructure that is necessary to relieve the constraints during the winter peak periods.

DEEP released an RFP on June 2, 2016 seeking bids for natural gas capacity. Bids were received for gas pipelines and liquefied natural gas proposals. However, while this evaluation was underway, the Massachusetts Supreme Judicial Court denied Massachusetts' EDCs the authority to get cost-recovery from electric ratepayers for costs associated with the development of natural gas pipelines. This court decision along with regulatory proceedings in other New England jurisdictions materially reduced the ability for other states to procure gas resources and help share the costs. Cost sharing is critical due to the scale and cost of these natural gas pipeline projects. The problem of inadequate gas infrastructure is greater than one state can solve alone. Regional investment is necessary to ensure that no one state disproportionately bears the costs of addressing what is a problem endemic to our regional electric system. Thus, without a path forward for regional investment, DEEP issued a notice of cancellation of the RFP on October 25, 2016.

Transmission Reliability

From 2004 through 2008, ISO-NE and southern New England stakeholders identified a number of limitations with the flow of power, the west-east movement of power throughout New England, and weaknesses in the transmission system that threatened electric power reliability in Connecticut and southern New England. This was articulated in a study known as the Southern New England Transmission Reliability ("SNTR"). In response, beginning in 2009 a group of related transmission projects, known as the New England East-West Solution ("NEEWS"), were undertaken. The final project, the Interstate Reliability Project, was completed in December 2015 with the addition of a high-voltage transmission line and upgraded substations in Connecticut, Massachusetts, and Rhode Island. With the completion of the NEEWS transmission projects, regional transmission bottlenecks significantly affecting Connecticut were removed.

ISO-NE is currently assessing the need for new transmission facilities to move renewable power from remote areas in Northern Maine to load centers in southern New England. Such projects will

be expensive and therefore will require a regional approach if we are to expand renewable generation significantly in the years ahead.

Distribution Reliability

Many of the regulatory and legislative proceedings that have occurred over the last several years have focused on utility resiliency to make utility company infrastructure more resilient to storm damage, and to promote shorter restoration times following outages from weather-related events. Many of the recommendations from the 2011 Two Storm Report have been implemented, and have improved the EDCs preparedness and response time, most notably with storm Sandy in 2012 and subsequent weather-related outage events in the past few years. Other initiatives, including utility system hardening, reinforcement of substations and investment in distribution lines continues to advance.

EDCs vegetation management plans were expanded and the budgets were significantly increased as a result of the 2011 and 2012 storms. As shown in Fable E6, the Eversource tree trimming budget increased by 50 percent from $26 million in 2011 to $39.5 million in 2015. The UI budget has more than tripled from approximately $4 million in 2011 to nearly $15 million in 2015.[65] The changes in utilities' Vegetation Management Practices are the result of regulatory and stakeholder proceedings to establish best practices that incorporate an environmental perspective which are more sensitive to the needs and wants of the affected local communities in which the work is proceeding.

TABLE E6: EDC Vegetation Management Budgets[66]

Year	Eversource	UI
2011	$26M	$4.3M
2012	$50.8M	$5M
2013	$29.5M	$5.5M
2014	$34.1M	$9M
2015	$39.5M	$15M

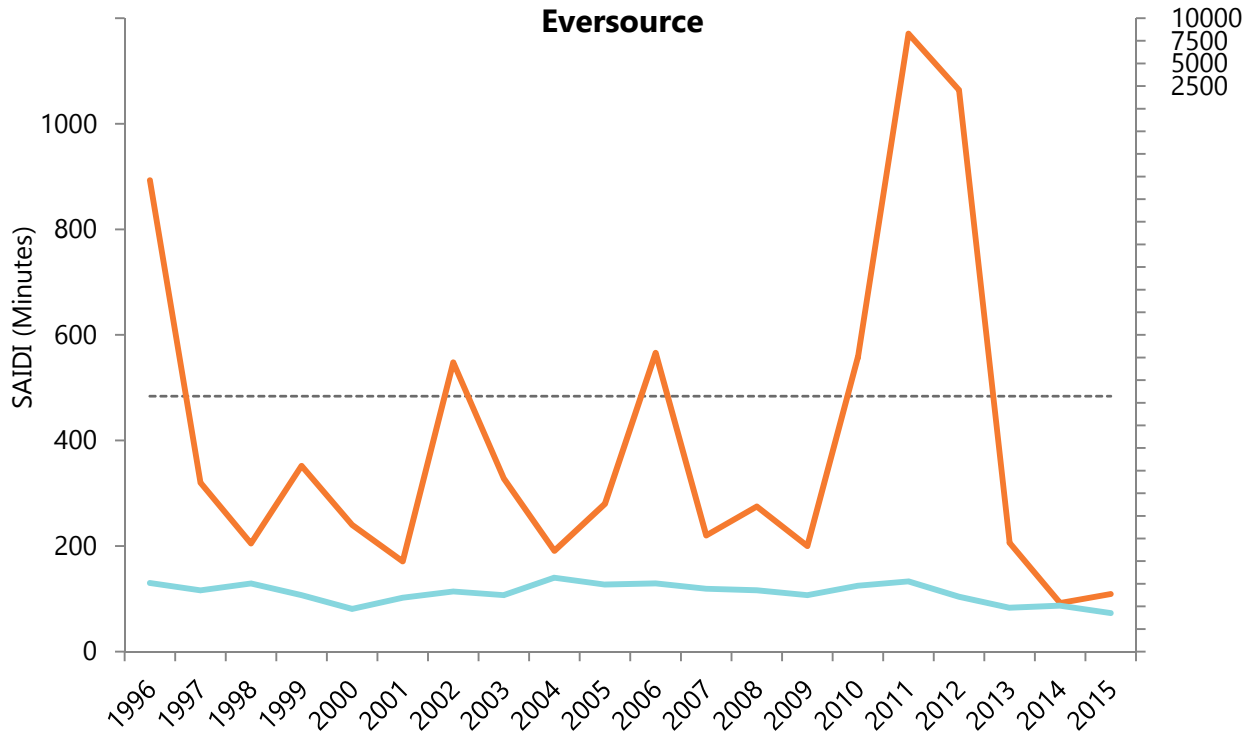
[65] Decision dated June 30, 2010, in Docket No. 09-12-05, Application of The Connecticut Light and Power Company to Amend Its Rate Schedules; Decision dated August 14, 2013, in Docket No. 13-01-19, Application of The United Illuminating Company to Increase Rates and Charges.

[66] PURA Docket No. 86-12-03, *DPUC Investigation of the Connecticut Light and Power Company and The United Illuminating Company Excessive Outages – Long Range Investigation re Adequacy.*

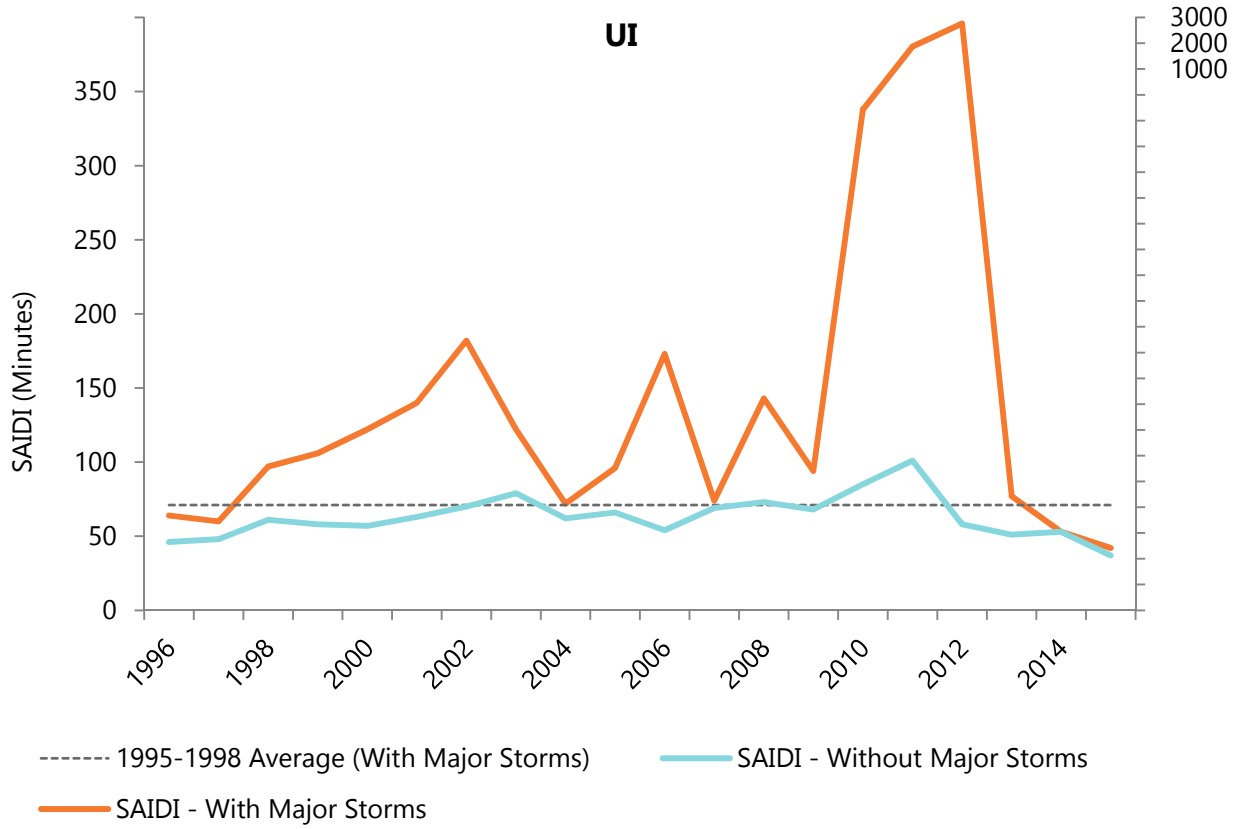
Section 16-245y(a) of the General Statutes requires PURA to submit reliability data, in terms of the System Average Interruption Duration Index ("SAIDI") and System Average Interruption Frequency Index ("SAIFI"), to the General Assembly by January 1 of each year. [67]

The 2016 report to the legislature indicates that UI and Eversource are performing well. Reliability has improved over the past few years since the major storms of 2011 and 2012. Eversource has significantly better than the averages from 1995-1998 just prior to electric restructuring. UI generally has higher reliability than Eversource. Much more of UI's distribution system is underground compared to Eversource that has more rural customers fed by miles of overhead lines that are more susceptible to outages due to vegetation such as falling trees and branches.

FIGURE E17: Eversource and UI SAIDI Results



[67] SAIDI is defined as the sum of customer interruptions in the preceding 12-month period, in minutes, divided by the average number of customers served during that period. Conn. Gen. Stat. §16-245y(a). SAIFI is defined as the total number of customers interrupted in the prior 12-month period divided by the average number of customers served during this period. Id. SAIDI can be viewed as the average outage duration experienced by all customers on an electric distribution company's system (EDC's), and SAIFI can be viewed as the average outage frequency on an EDC's system. Lower SAIDI and SAIFI numbers reflect better reliability performance in terms of outage duration and frequency, respectively



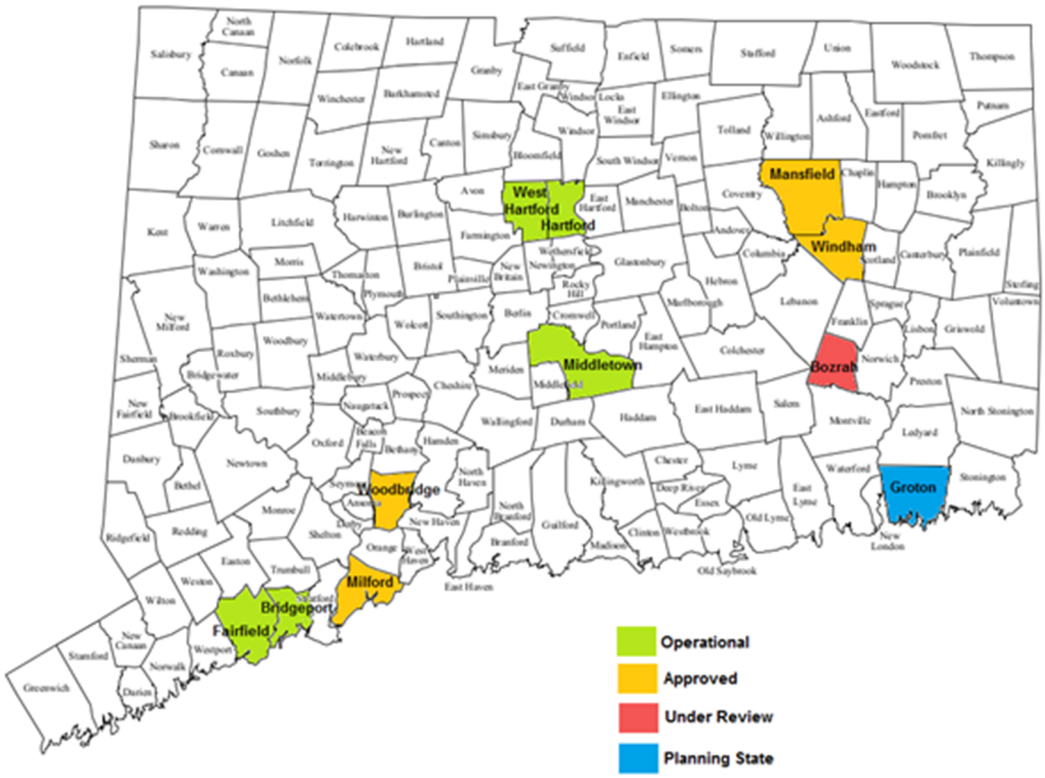
Microgrids

The Microgrid Program was developed in 2012 in response to the recommendation of the Governor's Two Storm Panel regarding the use of microgrids to minimize the impacts to critical infrastructure associated with emergencies, natural disasters, and other events when these cause the larger electricity grid to lose power. Microgrids provide electricity to critical facilities and town centers on a 24/7 basis and will include an isolation system so the microgrid can provide power despite any large-scale outages and support critical facilities.[68]

DEEP conducted two competitive solicitations for microgrid projects and awarded $20.1 million in grants to ten projects.[69] Microgrid projects are being developed along the shoreline from Fairfield to Milford and through interior Connecticut from Woodbridge to Windham. The towns with microgrids are highlighted on the map below (Groton is not a DEEP sponsored program).

[68] Connecticut General Statues, Section 16-243y, as modified by Public Act 13-298, Section 34
[69] The maximum grant to any one project is $3 million

FIGURE E18: Connecticut Microgrid Projects[70]



A variety of critical facilities are being supported including municipal facilities such as police and fire stations, dorms and schools for shelters and private facilities such as a grocery store, gas station and senior housing. To date, five projects are operational and the remaining projects are in various stages of development.

On November 5, 2015, DEEP initiated the third round of the Microgrid Program by issuing a request for applications.[71] DEEP began accepting applications on December 10, 2015. To date, DEEP has received two applications. DEEP has awarded one grant and is currently reviewing the second application.

Public Act 16-196 authorized DEEP to provide matching funds or low interest loans through the microgrid program for energy storage systems or Class I or Class III energy sources provided such

[70] Bridgeport and Middletown each have one operational and one approved project within the town boundaries; all other towns have only one microgrid project in each town. The microgrid project in Groton is not a DEEP sponsored project. Groton is only shown here to represent the total number of microgrids that are or may become operational in Connecticut.

[71] Link to the request for applications on DEEP's website: http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/69dc4ebaa1ebe96285257ed70064d53c?OpenDocument.

projects are first placed in service on or after July 1, 2016. DEEP anticipates releasing a revised request for applications to implement the matching funds or low interest loan option in August 2017.

The addition of generation for microgrids could benefit the system by delaying the upgrade of a substation or distribution lines. Microgrids could also aid in frequency regulation and volt ampere reactive (VAR) support, i.e. provide reactive power to maintain transmission voltages to meet the operating requirements for the New England Transmission System. DEEP encourages the EDCs and MEUs to study the best locations for where microgrids could provide those services.

Coastal Resiliency Within ISO-NE

Connecticut's coastal towns have experienced power disruptions and damage by flooding and storm surge during extreme precipitation events and hurricanes. Flooding near substations has already been a serious problem for UI, which will likely get worse in the future. Rising sea level due to global climate change represents a clear and present danger to the United Illuminating transmission system. The threat was crystalized by weather events such as Tropical Storm Irene and Superstorm Sandy along with revisions to Federal Emergency Management Agency (FEMA) flood maps.[72] In response to these events, UI evaluated the risk and potential impact of a single 100-year coastal flooding event on its seven coastal substations.[73] The study concluded that although all seven UI substations complied with design codes and generally accepted industry flood protection levels when they were originally built, they are now considered deficient when compared to FEMA's significantly revised flood elevations (updated in 2013). According to the study, five of the seven UI coastal substations built adjacent to Long Island Sound are "at-risk" of being destroyed by a FEMA 100-year flood event and could result in a significant and sustained adverse impact to the New England Bulk Electric System (BES) and Connecticut customers.

Much of the physical plant and equipment at UI's at risk coastal sub stations are considered transmission and therefore improvements should be eligible for regional cost sharing through transmission rates. UI is seeking cost recovery through ISO-NE, which is responsible for the transmission system. There are not set procedures to determine which costs relating to necessary upgrades for climate adaptation are eligible for recovery. DEEP will work with PURA, UI, ISO-NE, and the other New England states and stakeholders to develop procedures and so that work can begin on these important improvements to ensure reliability in Connecticut's coastal communities. UI has presented to the ISO-NE Planning and Advisory Committee its proposed

[72] Tropical Storm Irene affected the North East Coastline including UI service territory on August 28, 2011. Superstorm Sandy affected the North East Coastline including UI service territory on October 29 2012.
[73] The 100-year flood has 1 percent risk of happening in any given year, but presents a cumulative risk of occurring over the life of a give an asset.

solutions to the at-risk coastal substations. Significantly, UI is working with state and local partners to leverage a United States Department of Housing and Urban Development resiliency grant to include protection of one of the at risk substations.

Energy Assurance

In 2012, Connecticut developed an Energy Assurance Plan ("EAP") for the state.[74] The EAP describes the state's ongoing efforts towards enhancing energy assurance and securing its energy future. The 2012 EAP outlines the State's efforts -- plans, programs, and initiatives -- that promote energy assurance. The response framework identified in the EAP will help the State prepare for, respond to, recover from, and mitigate the effects of future energy supply disruption events.

The EAP's structure is influenced by the four phases of emergency management – preparedness, response, recovery, and mitigation – to present the many energy assurance efforts in which Connecticut is currently engaged. Connecticut has undertaken a broad array of activities to promote energy assurance throughout all four phases of emergency management-- mitigation, preparedness, response, and recovery. The Department of Emergency Management and Public Protection continues to advance emergency management improvements -- such as, creating a state-level All-Hazards Energy and Utilities Plan ("ESF-12") as an annex to the State Response Framework ("SRF") and improving communications between local and state government and utilities during emergencies.[75]

DEEP continues to advance energy system improvements -- such as applying stricter performance standards for vegetation management increasing RPS goals, and deploying microgrids to support implementation of the EAP. The EAP's purpose of enhancing energy resiliency, reliability, and emergency response aligns with the state goals of promoting cheaper, cleaner, and more reliable energy. In addition to the State's commitment to improving the reliability of its energy supply system, efforts are ongoing to improve energy emergency management capabilities and working collaboratively across state government. Regular and ongoing statewide efforts continue on coordination and implementation of the SRF and ESF-12 to prevent energy supply disruptions and to implement recovery protocols to minimize recovery times in the event of an energy supply disruption.

[74] DEEP, Energy Assurance Plan for Connecticut, Final Draft (Aug. 2012).
[75] Department of Emergency Services and Public Protection, State of Connecticut State Response Framework (Sept. 2014).

Grid Modernization is Progressing, But More Should be Done

Grid modernization can be a critical component of safety and reliability of the grid, in addition to potentially reducing transmission and distribution costs for electric customers and integrating advanced technologies and distributed resources. The structure of the electric system is evolving, and the roles of the state's EDCs, generators, PURA, ISO-NE, and customers are also changing. With this evolution, there are opportunities to explore potential cost savings. The traditional utility model – one in which electricity is centrally generated, transmitted over high voltage power lines, stepped down in voltage, and locally distributed to customers – is facing a new set of challenges and opportunities that could initiate a period of innovation and modernization.

Grid modernization uses communication technologies and infrastructure improvements to make the electric grid more secure, efficient, and reliable. Modernization will enable more effectively integrate distributed energy resources, demand side and renewable resources, and "smart" (real-time, automated, interactive) technologies for metering and communications regarding grid operations and status. Grid modernization includes the deployment and integration of advanced electricity storage and peak-shaving technologies, development of standards for communication and interoperability of appliances and equipment connected to and infrastructure serving the electric grid, and the identification and reduction of barriers to the adoption of smart grid technologies, practices, and services.[76] On the federal level, U.S. Department of Energy ("DOE") has had considerable focus on grid modernization efforts nationally and many of the efforts underway provide valuable context to understand how technologies and practices are advancing in many jurisdictions across the country.

Grid Modernization Efforts on the Federal Level

In November 2014, DOE launched a Grid Modernization Initiative ("GMI") to accelerate efforts to shape the future of the electric grid. The Grid Modernization Multi-Year Program Plan, released in November 2015, outlines GMI's vision of a "future grid [that] will solve the challenges of seamlessly integrating conventional and renewable sources, storage, and central and distributed generation."[77] The Plan provides a roadmap of how to support adoption of grid modernization technologies, tools, and modeling approaches, drawing from the Quadrennial Energy Review, the Quadrennial Technology Review, and other DOE initiatives. The Plan identifies six technical priority areas to achieve GMI's vision:

[76] Title VIII of the Energy Independence and Security Act of 2007. https://www.congress.gov/bill/110th-congress/house-bill/6/text

[77] Grid Modernization Multi-Year Program Plan, November 2015. U.S. Department of Energy. https://energy.gov/sites/prod/files/2016/01/f28/Grid%%-Year%%.pdf

1. Testing individual devices and integrated systems;
2. Developing tools and strategies to improve grid sensing and measurement;
3. Developing new control technologies to support new generation, load, and storage technologies;
4. Creating simulation and modeling planning tools;
5. Planning for physical and cybersecurity challenges and increasing grid resiliency;
6. Providing technical assistance and institutional support.

A central component of the GMI, the Grid Modernization Laboratory Consortium ("GMLC") is awarding $220 million in funding over a three-year period to support 88 research and development projects led by 13 participating DOE National Laboratories. The GMLC serves to coordinate GMI activities between divisions of the DOE and the national laboratories across the country to strengthen partnerships, promote collaboration, and streamline efficient use of resources. GMI held its first peer review event in April 2017 where researchers shared project updates and gained insights from top experts. In the future, the GMLC intends to expand its partnerships to work with universities, utilities, vendors, and other stakeholders.

The $220 million GMI research and development investment covers a wide range of grid modernization initiatives, spanning methods of energy storage, integrating clean energy resources, as well as strategic planning and modeling tools. Twenty-nine of the 88 projects are considered foundational as they address core grid activities and crosscutting research and development by integrating hardware, software, and institutional approaches to grid modernization. For example, a regional project in Vermont aims to use distributed energy resources to allow for increased renewable energy generation as part of an overall strategy to achieve the state's goal to meet 90 percent of its energy needs with renewables by 2050. The remaining 59 projects are program-specific, and are grouped into one of the six technical priority areas outlined above. These program-specific projects are also fall under either grid modeling, solar, or wind categories. One of the solar projects focuses on developing secure, scalable, stable control and communications for distributed solar photovoltaic, building upon the SunShot Systems Integration metrics. The goal of this $2.7 million project is to ensure security and reliability while increasing the amount of generated solar on the grid. A complete list of projects and updates is available on the Grid Modernization Consortium Laboratory's website.[78] In addition to federal level initiatives, several states have actively pursued comprehensive grid modernization efforts, including:

[78] See http://gridmod.labworks.org

- California, through a series of legislative measures, has commenced a comprehensive smart grid initiative as a tool to achieve the state's climate change goals.[79] The integration with the state's environmental goals is a key driver in California's grid modernization approach. California's grid modernization effort also aims to improve its efficiency and reliability, reduce operations and maintenance ("O&M") costs and meet the future demands of new technologies that will be operating on the electric grid.
- The Massachusetts Department of Public Utilities ("MA DPU") has initiated a set of comprehensive and far-reaching requirements for grid modernization. In 2014, the MA DPU issued an Order requiring that each EDC submit a ten-year grid modernization plan.[80] Around the same time, DPU issued an Order supporting time-varying rates and another Order pertaining to electric vehicles.[81]
- In 2014, the New York Public Service Commission (NYPSC) launched the Reforming the Energy Vision (REV) comprehensive energy strategy for the state. As part of REV, EDCs develop plans to improve the distribution system planning and grid modernization to effectively integrate DER and other clean energy technologies, connect customers with new options to manage their energy usage, and facilitate innovation to create tailored customer offerings and support investment decisions.

DEEP continues to review and monitor the depth and breadth of grid modernization work currently underway and will continue to identify opportunities to highlight technology advancements and lessons learned to benefit the ongoing work of the EDCs as well as other stakeholders.

Grid Modernization Efforts in Connecticut

Connecticut has made significant gains in seeking demonstration projects for grid-side system enhancements and seeking proposals for energy storage systems using its procurement authority.[82]

During the June Special Session in 2015, the Connecticut General Assembly passed Public Act 15-5, An Act Implementing Provisions of the State Budget for the Biennium Ending June 30, 2017,

[79] The enabling legislation is found at http://www.energy.ca.gov/research/integration/policy.html
[80] Order 12-76-B, Issued in June 2014.
[81] DPU 14-04 and DPU 13-182, respectively.
[82] A grid-side system enhancement is defined as "an investment in distribution system infrastructure, technology and systems designed to enable the deployment of distributed energy resources and allow for grid management and system balancing, including, but not limited to, energy storage systems, distribution system automation and controls, intelligent field systems, advanced distribution system metering, and communication and systems that enable two-way power flow." Conn. Gen. Stat. § 16-1.

Concerning General Government, Education, Health and Human Services and Bonds of the State ("P.A. 15-5"), which requires the EDCs to submit proposals to DEEP and PURA for approval for grid-side system enhancements, such as energy storage systems. Grid-side system enhancements have the potential to increase grid flexibility and reliability, better integrate clean, distributed generation into the grid, and increase customer participation with the electric grid.

These demonstration projects have mostly focused on comprehensive planning around increased DG penetration from the EDC perspective, through DG forecasting, and from the developer perspective, through hosting capacity maps to identify points along the distribution system that could benefit from DG.

On February 1, 2017, DEEP released a final determination approving the following projects for the EDCs:

- Eversource's DER Customer Portal and Management System, which will allow Eversource to manage an increasing number of interconnection applications;
- DER Hosting Capacity for Eversource and UI, which will provide the maximum amount of distributed generation that each portion of the circuit can accommodate through a visual mapping tool;
- UI's DER Load Forecasting, which will develop load forecasts based on distributed generation projections; and
- UI's Localized Targeting of DERs, which will target distributed energy resources at a specific substation to provide local distribution system benefits.

These projects will form the foundation, through advanced planning and visibility into distributed energy resources, for expanded grid modernization efforts in the future.

Energy storage systems can provide many benefits to the electric grid, including better integration of intermittent DER, shifting load from on-peak to off-peak hours, and avoiding costly capacity upgrades on the distribution system. By shifting load from on-peak to off-peak hours, energy storage can also provide environmental and human health benefits by eliminating the need to run older, dirtier power plants during peak hours.

Both Eversource and UI submitted proposals for energy storage systems in the grid-side system enhancements demonstration projects proceeding. Projects would be located at specific substations to test out the distribution system benefits such system could provide. In its February 1, 2017 final determination, DEEP did not select either project proposal because the potential benefits were not significant enough to justify the high cost.

This is not the end of this process but only the beginning. The EDCs recently submitted their proposals to PURA for review and approval.[83] The EDCs can adjust their original storage proposals or develop new grid modernization proposals. DEEP expects that the lessons learned from these projects and those conducted around the country will provide valuable insight as we begin the transition to a more flexible and distributed electric system.

Energy Storage

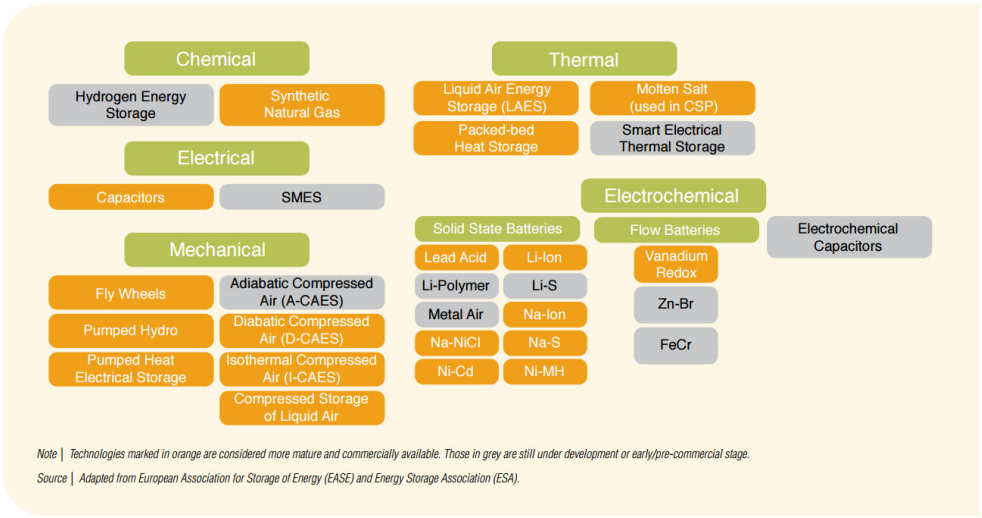
Within the context of grid modernization additional deployment of energy storage can result in fundamental changes to how our electric grid currently operates. Energy storage systems can provide many benefits to the electric grid, including better integration of intermittent DER, shifting load from on-peak to off-peak hours, and avoiding costly capacity upgrades to the distribution system. With an array of energy storage technologies deployed and under development across the country, the industry is growing rapidly and costs continue to decline. Energy storage technologies vary in storage capacity, size, intended application, and design:

- Electrochemical technologies are batteries that convert electricity to chemical storage and then back to electricity again. Lead-acid and nickel-cadmium batteries have been used for years, while lithium-ion and sodium sulfur battery technologies have been introduced more recently.
- Electromechanical technologies consist of various mechanisms that temporarily store energy. Compressed air energy storage (CAES) creates a reservoir of compressed air stored in an underground tank. To meet increased electricity demand, the air expands as it is heated and is directed through an expander or conventional turbine-generator. CAES is one example of an established commercial bulk energy storage solution. The flywheel technology, which stores energy in a rotor to then convert the energy to AC power, is more recent and is most commonly used to ensure uninterrupted supply. Pumped hydro is another form of electromechanical storage that has been used for decades throughout certain regions of the U.S.
- Thermal technologies store energy, either as sensible heat – through hot water tanks or ice – or as latent heat, where energy is released through a phase change (e.g., from a solid to a liquid). On a small scale, thermal storage can be used as a distributed energy resource to provide heating or cooling onsite. Molten salt thermal storage can be paired with large-scale concentrated solar power projects, where the technology is

[83] PURA Docket No. 17-06-02, PURA Review of the Connecticut Light and Power Company's dba Eversource Energy Distributed Energy Resources Proposals; PURA Docket No. 17-06-03, Application for Review of the United Illuminating Company's Distributed Energy Resource Integration Plan.

able to temporarily store solar energy to help meet demand when the sun is not shining.

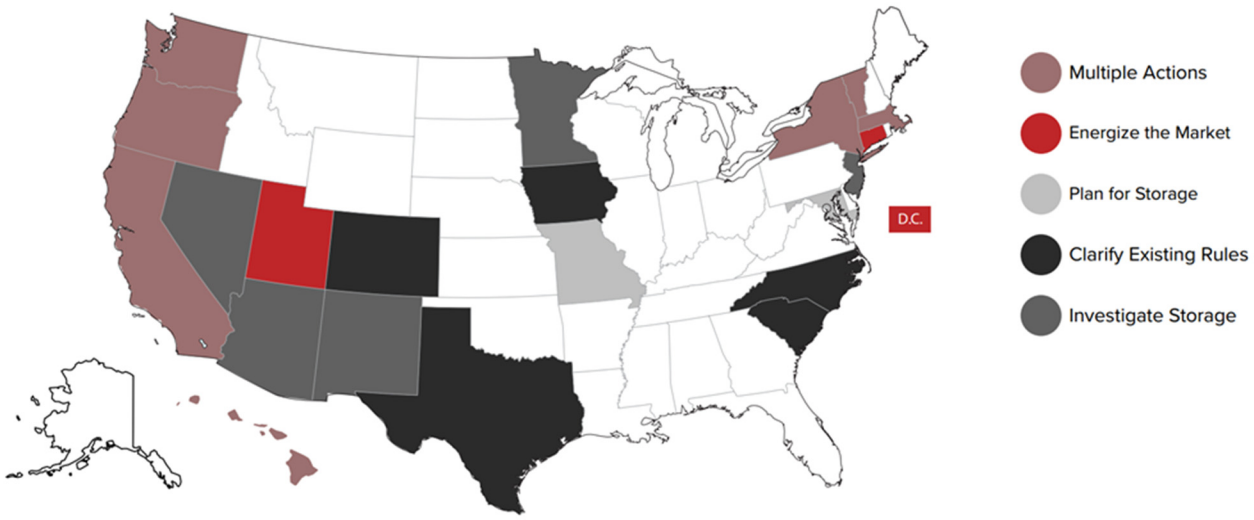
FIGURE E19: Types of Energy Storage Technologies[84]



Interest in supporting the energy storage industry has grown in state legislatures in recent years. Electric utility regulators and other government agencies are also exploring approaches to incorporate storage into their energy programming. Figure E20 captures a snapshot of states pursuing at least one legislative or regulatory approach to integrating energy storage.

[84] Energy sector management assistance program, World Bank. 2015. Available at http://documents.worldbank.org/curated/en/185451468124481422/pdf/949400ESMAP0pa0Up0to0Scale0TR006015.pdf

FIGURE E20: State-level Policies Promoting Energy Storage[85]



Note: Map is not reflective of all state activities on energy storage. Certain early stage policy/regulatory efforts, grant programs and/or pilot projects may not be reflected herein.

Massachusetts began its multi-pronged Energy Storage Initiative ("ESI") in 2015 to help support a transformation of the energy storage market and attract industry players to the state. The Massachusetts Department of Energy Resources ("DOER") allocated $10 million from is 2014 Alternative Compliance Payment Spending Plan to fund energy storage projects, build strategic partnerships, and establish an energy storage market structure. Legislation passed in 2016 allowed DOER to establish targets for electric companies to purchase energy storage systems.[86] DOER is soliciting input from stakeholders and is expected to adopt a target in July 2017. In partnership with the Massachusetts Clean Energy Center, DOER also conducted a study on energy storage that outlined current barriers to energy storage adoptions and included policy and program recommendations. Connecticut continues to monitor efforts in Massachusetts to inform Connecticut's path forward in deploying energy storage.

Federal Energy Storage Efforts

Prior to launching the Grid Modernization Initiative, DOE provided financial and technical support through the national laboratories to advancing the commercial viability of energy storage technologies. The 2009 federal American Recovery and Reinvestment Act included $4.5 billion through DOE to modernize the electric grid. The DOE established two initiatives, the Smart Grid Investment Grant and the Smart Grid Demonstration Program. Under the Smart Grid

[85] For more information, visit the National Renewable Energy Laboratory's Issue brief: A survey of state policies to support utility-scale and distributed-energy storage. September 2014. http://www.nrel.gov/docs/fy14osti/62726.pdf
[86] Enabling legislation and more details about the Energy Storage Initiative available at http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/energy-storage-initiative/.

Demonstration Program, DOE allocated $648 million to support 16 energy storage demonstration projects. These cooperative agreements allowed DOE staff to work collaboratively with project operators and required operators to submit final evaluations and project data by 2016.[87] In addition, DOE maintains a global energy storage database with detailed information on over 1,500 projects, as well as national and global trends, and federal and state-level policies.[88] The Sandia National Laboratory, in collaboration with the National Rural Electric Cooperative Association, published an Electricity Storage Handbook in 2015 to assist utilities and rural cooperatives design and implement energy storage projects.[89]

Cybersecurity

The 2013 Strategy recommended that PURA, working in conjunction with other relevant State agencies, be charged with conducting a review of Connecticut's electricity, natural gas and major water companies to assess the adequacy of their capabilities to deter interruption of service. Subsequent actions by PURA have included reports of such review together with recommended actions to strengthen deterrence of cyber-related attacks.

In 2014, PURA opened Docket 14-05-12, "Cybersecurity Compliance Standards and Oversight Procedures". During the course of 2015, PURA conducted technical meetings with the various utility industries to obtain their input on applicable cybersecurity standards and oversight for each industry. Specifically, PURA held a series of collaborative technical meetings with the state's public utility companies to review the standards and guidelines they currently follow as part of their cybersecurity risk management programs. This process entailed a review of the adequacy of cyber defenses, the prospect of reaching concurrence on standards and holding annual meetings with government participants.

Moving forward, PURA is working on a Public Utility Company Cybersecurity Oversight Program, wherein the utility companies will have the opportunity to demonstrate, through annual meetings with government stakeholders, that they are adequately defending against cyberattacks. Government stakeholders, including the Public Utilities Regulatory Authority and the Division of Emergency Management and Homeland Security Division ("DEMHS"), meet with the utilities on cybersecurity issues and report to the Governor, the General Assembly and the Office of Consumer

[87] Energy storage demonstration project reports are available at https://www.smartgrid.gov/recovery_act/program_impacts/energy_storage_technology_performance_reports.html.
[88] The U.S. Department of Energy's Global Energy Storage Database is available at http://www.energystorageexchange.org/. (Note: As of this writing, the database was last updated in August of 2016.)
[89] The U.S. Department of Energy/Electric Power Research Institute's 2015 Electricity Storage Handbook in Collaboration with the National Rural Electric Cooperative Association is available at http://www.sandia.gov/ess/publications/SAND2015-1002.pdf.

Counsel. During these annual meetings, the companies are expected to report on their cyber defense programs, experiences over the prior year dealing with cyber threats and corrective measures they expect to undertake in the coming year.[90]

There is also quite a bit of movement at FERC on cybersecurity.[91] The proposed Reliability Standards address the cyber security of the bulk electric system and improve upon the current FERC-approved Critical Infrastructure Protection ("CIP") Reliability Standards. In addition, the Commission directs North American Electric Reliability Corporation ("NERC") to develop certain modifications to improve the CIP Reliability Standards.

[90] PURA's Cybersecurity Oversight Program reporting requirements will be limited to annual cybersecurity review meetings and will not require the utilities to submit formal, written reports.

[91] In Docket No. RM15-14-000, FERC approved seven critical infrastructure protection (CIP) Reliability Standards: CIP-003-6 (Security Management Controls), CIP-004-6 (Personnel and Training), CIP-006-6 (Physical Security of BES Cyber Systems), CIP-007-6 (Systems Security Management), CIP-009-6 (Recovery Plans for BES Cyber Systems), CIP-010-2 (Configuration Change Management and Vulnerability Assessments), and CIP-011-2 (Information Protection).

UPDATE ON 2013 CES RECOMMENDATIONS

The 2013 CES advanced ten key recommendations within the electricity sector. Many of these recommendations focused on the creation of new programs for renewables, innovative approaches to financing developed in partnership with the Connecticut Green Bank, and the advancement of reliability and resiliency efforts to harden and protect Connecticut's critical energy infrastructure. Collectively, DEEP along with many key partners have made considerable progress in advancing these key energy policy initiatives. A summary of the State's efforts are summarized below:

1. Engage Vigorously in Regional and Federal Regulatory Processes	
Recommendation Summary: **DEEP's Bureau of Energy & Technology Policy should increase its engagement with other states and regional organizations to help shape policy at FERC and ISO-NE.**	**Key Achievements** • DEEP has increased engagement with other states and regional organizations through regular meetings with ISO-NE, NESCOE, OCC, AGO, and PURA to shape the state's energy policies within the regional context.
2. Work with Municipalities to Expand Programs and Policies that Drive Down the Cost of In-State Renewable Resources	
Recommendation Summary **The State should take steps to ensure that the average installed cost of solar PV falls below residential rates and streamline permitting, siting, and other requirements to help reduce the "soft costs" of solar PV installations.**	**Key Achievements** • Data[92] from the Green Bank demonstrates that the cost of rooftop solar has declined and the Green Bank has seen success with its Solarize Connecticut campaign.
3. Evaluate Options for Waste-To-Energy in Connecticut	
Recommendation Summary **DEEP should monitor waste-to-energy facilities as long-term power purchase agreements end and operating costs increase.**	**Key Achievements** • DEEP has monitored the state of waste-to-energy facilities. H.B. 7036 in the 2017 session increases the Class II RPS requirements to 4 percent and only qualifies waste-to-energy facilities permitted by DEEP as Class II.
4. Expand Virtual Net Metering Opportunities to Promote Deployment of Large-Scale Renewable Systems	
Recommendation Summary **The State should expand existing virtual net metering provisions to include agricultural hosts as well as government entities and lift the cap to $10M.**	**Key Achievements** • Virtual net metering has been expanded to include agricultural hosts and has seen active participation. The cap was increased to $10M, then increased an additional $6M for municipalities in 2016 and $3M for agricultural in 2017.

[92] Data can be found in the Appendix

5. Strengthen the Regional Carbon Dioxide Cap as called for by the RGGI Program Review	
Recommendation Summary **Connecticut should implement changes in RGGI Program Review and lower the regional carbon dioxide cap to ensure RGGI continues to incentivize better environmental outcomes.**	**Key Achievements** • 2016 RGGI Program Review is still ongoing. Expectation is an extension of the annual cap decline.
6. Develop Sub metering Protocols to Promote the Use of Renewable Energy and Combined Heat and Power in Multi-Tenant Buildings	
Recommendation Summary **PURA should establish rules to enable submetering generally with appropriate consumer protections.**	**Key Achievements** • PURA has established standards for submetering at multi-tenant buildings using renewable energy.
7. Develop and Deploy Microgrids to Support Critical Services and Ensure Public Safety During Electricity Outage Crises	
Recommendation Summary **DEEP should continue pursuing microgrid opportunities and work with the General Assembly to provide for flexibility in the program.**	**Key Achievements** • DEEP developed a microgrid program will result in the deployment of up to 20 microgrids. Five microgrids are operational and five are in the development stage. The program is open to new applications and DEEP is now authorized to fund clean distributed generation and energy storage in its microgrid grant program.
8. Implement the Reliability Recommendations of the Two Storm Panel	
Recommendation Summary **The State should implement the reliability recommendation of the Two Storm Panel relevant to DEEP, PURA, the Department of Transportation, the Siting Council, and other agencies.**	**Key Achievements** • Many of the vegetation management recommendations of the Two Storm Panel have been implemented.
9. Charge PURA with Cyber Security Review of State's Public Utilities and Water Companies	
Recommendation Summary **PURA should work with other relevant state agencies to review the state's electric, gas, and water company abilities to deter interruption of service.**	**Key Achievements** • PURA held a series of collaborative meetings on cybersecurity and established a cybersecurity oversight program
10. Transition Current Standard Service Customers to the Competitive Supplier Marketplace	
Recommendation Summary **DEEP and PURA should make tranches with the remaining standard service customers to make them available in the competitive supplier market.**	**Key Achievements** • The idea of dividing standard service customers into tranches for competitive electric suppliers was not supported by the General Assembly and thus did not go forward.

GOALS AND RECOMMENDATIONS

Goal 1: Align existing programs supporting renewable and zero carbon resources with Renewable Portfolio Standards and Global Warming Solutions Act goals.

Over the next thirty-years, Connecticut will need to procure much more clean carbon free power to meet the GWSA goals of reducing emissions by 80 percent by 2050. To do so, Connecticut must consider all reasonable resource options including Class I resources, large-scale hydropower, and nuclear retention, to maximize the potential benefits while minimizing the rate impact to electric customers. The Governor's Council on Climate Change ("GC3") has been analyzing different scenarios and trajectories for changes to the generation mix supplying Connecticut's electricity demand that will be necessary to meet the GWSA goals. Given the time horizon for goals and the rapidly changing costs of renewable generation, the increasing promise of cost-effective electricity storage, the unknown rate of electrification of the transportation and the buildings sectors of the economy, and unknown future technologies, Connecticut has to carefully balance planning in the short to medium time horizon with the less certain future. Therefore, DEEP recommends the following resource plan to support renewable energy sources and zero carbon resources to meet our RPS and GWSA goals.

E.1.1 Expand the RPS to achieve 30 percent Class I renewables by 2030.

Under current law, the Class I RPS requirement increases each year until it reaches 20 percent in 2020 and stays at that level each year after that. Connecticut has made great progress in advancing the state's clean energy goals, yet additional deployment of renewables is necessary to meet Connecticut's GWSA goals. Connecticut also needs to reduce its use of fossil and other emitting fuels to generate electricity. At this time, it is difficult to quantify the amount of Class I renewables that will be needed to meet the 2050 GWSA goal, at which time many facilities built today will be at or near the end of their useful lives.[93] It is clear, however, that over the next 10 years, expansion of Class I renewable generation will be necessary to place Connecticut on the path toward meeting the GWSA goals.

Therefore, DEEP recommends increasing the Class I RPS requirement by 1 percent each year between 2020 and 2030, reaching 30 percent by 2030. For the reasons explained below – and in the Recommendation 1.2 section below that recommends a phase out of biomass and landfill gas from Class I renewables – this trajectory strikes the right balance between ambition in the deployment of Class I renewables, and the relative costs and availability of other non-carbon

[93] http://www.nrel.gov/analysis/tech_footprint.html

generation resources. DEEP believes that 30 percent by 2030 is an appropriate trajectory for Class I resources at this time and flexibility is important for long-term planning. DEEP does not believe that an expansion beyond 30 percent Class I renewables by 2030 is necessary at this time for the reasons articulated below.

First, there are other resources, like nuclear, hydropower, and energy storage, that are not classified as a Class I resource but can help meet our GWSA goals and also diversity our state resource mix. DEEP has existing procurement authority for large-scale hydropower and energy storage to complement the Class I resources and increase the amount of non-carbon resources in Connecticut's fuel mix. Large-scale hydropower is a resource eligible to participate in DEEP's procurements under Section 7 of P.A. 13-303 and P.A. 15-107, of which DEEP has a collective authority of approximately 11.5 percent of load remaining. Large-scale hydropower is carbon free and may be less expensive than other Class I resources.

To bring substantial quantities of incremental large-scale hydropower into New England, it will require new transmission lines and therefore a significant financial commitment by ratepayers. New transmission lines are typically 1,000 MW costing $2 billion or more. Due to the size of these projects, it would be best to coordinate the procurement to share the cost with other New England states. Massachusetts is in the process of soliciting 9,450,000 MWh of large-scale hydropower and other clean energy resources, with bids due July 27, 2017.[94] While DEEP has sufficient authority to procure large-scale hydropower through Section 7 of Public Act 13-303 and Public Act 15-107 in the near-term future, in the next CES, DEEP will explore expanding the RPS to include a separate RPS tier to purchase large-scale hydropower or additional Class I resources in addition to the 30 percent Class 1 renewable energy sources by 2030.

In addition, as discussed in more detail in Recommendation 1.5 below, DEEP will examine whether there is a need to contract with Millstone to ensure the continued operation of that facility. Contracting with Millstone for its energy and environmental attributes could add a large amount of carbon free generation to Connecticut's resource mix. Hydropower may provide a similar profile of carbon-free baseload power that Millstone currently provides, which can help meet any interim GWSA goals and plan for Millstone replacement either post-relicensing date or sooner.

Second, DEEP expects to learn more through the Governor's Council on Climate Change ("GC3") process about further measures that may be necessary in the electric sector to achieve its GWSA goals. DEEP intends to analyze the effectiveness of the current RPS structure in meeting state policy goals like the GWSA in the future, either through the GC3 process or in the next CES or IRP.

[94] MA issued the RFP pursuant to Section 83D of Chapter 169 of the Acts of 2008, as amended by Chapter 188 of the Acts of 2016.

Finally, through the regional IMAPP process, stakeholders are discussing new methods to integrate and retain renewable power that allows the states to achieve their policies and continues to receive the benefits of the competitive wholesale markets. Changes to the market rules could make renewable energy deployment and emissions reductions achievable through mechanisms outside of the RPS. In the meantime, DEEP believes that the 30 percent increase in the RPS is appropriate at this time to continue on the path towards reducing greenhouse gas emissions.

E.1.2 Phase down biomass and landfill gas RECs in Connecticut's Class I RPS.

In 2014, 76 percent of Connecticut's Class I RPS requirements were met with biomass and landfill gas. While these facilities provide certain societal benefits, most are existing resources that began operation before the RPS began in 2003. DEEP believes that our first priority should be to restructure the eligible Class I technologies to focus on the development of new renewable resources in New England. As recommended in the 2014 IRP and consistent with Section 5 of P.A. 13-303, DEEP will begin phasing down the REC value of biomass in 2019 over a five-year period.

Since the 2013 CES, the supply of renewables has increased due to state programs and energy procurements, particularly by Connecticut and Massachusetts. Regional renewable generation supply situation now looks to be in a surplus though 2020. In addition, the overall capacity situation in New England is also projected to be in a surplus position. DEEP therefore believes that it is a good time to begin the phasedown in the value of biomass and landfill gas REC's. Doing so will reduce the emissions of the resources that Connecticut purchases for Class 1 RPS compliance to help us fulfill the goals of the GWSA and provide opportunities for other renewable energy sources.

The value of Class I biomass and landfill gas REC's will be reduced after 20 years for new facilities and 15 years for existing facilities from the time they were approved as a Class I renewable energy source in Connecticut. By statute, new facilities are those that began operation after 2003 or meet the investment and/or other criteria established by PURA to qualify as a new facility. Existing facilities are those that began operation prior to 2003. Many existing facilities made significant investments for emission control equipment to qualify as a Class I renewable energy source. This phase down schedule will provide both new and existing facilities reasonable time to amortize their investments.

After the initial license period ends, the amount of generation eligible as a Class 1 resource will be reduced for each biomass and landfill gas project. The amount of generation eligible as a Class 1 resource in Connecticut will decline to 50 percent of the generation output from the facility. The

other 50 percent of the generation output that is not eligible in Connecticut would still be eligible in other states, depending upon their RPS requirements.

This type of phase-down will have much less of an impact on the capacity and Class I REC market than if the value of all Class I REC's were phased down at the same time for all biomass and landfill gas projects. Under this methodology, some biomass facilities would see a reduction in their Class I REC eligibility in 2020 while others not until around 2030. Projects would still be able to qualify to sell REC's for their remaining generation in other states where biomass and landfill gas is eligible in their RPS. Facilities may continue to operate if the revenues generated by the RECs are adequate to remain financially viable after the initial license period. In the next IRP, DEEP will examine further the impact on these facilities, which are listed in DEEP's 2013 RPS Study, based on when they were registered with PURA and whether they are considered new or existing facilities.[95] In future proceedings, DEEP will determine if the phase down should continue beyond 50 percent.

E.1.3 Achieve a sustainable balance between behind the meter programs and grid-scale procurements supporting Class I renewables to expand clean energy at the least cost for ratepayers.

With the expansion of the RPS at 1 percent each year until 2030, DEEP believes that existing programs supporting Class I renewables can be structured to meet the increased targets in a way that does not dramatically increase costs to ratepayers. DEEP has seen a significant reduction in grid-connected clean energy costs through its competitive procurements, as compared to the costs of behind the meter programs.

Despite the higher cost, some behind the meter renewable energy generation should continue to be included as part of Connecticut's energy portfolio. Behind the meter renewables can provide additional benefits beyond those provided by grid-connected projects, such as reducing system line losses, potentially delaying the need for transmission and distribution infrastructure, reducing electric bills for participating customers, increasing resiliency and energy security, and contributing to economic development in Connecticut. Residential or commercial rooftops also do not present the same land-use tensions and siting concerns that grid-scale projects can face. However, the addition of behind the meter renewable capacity also places integration and

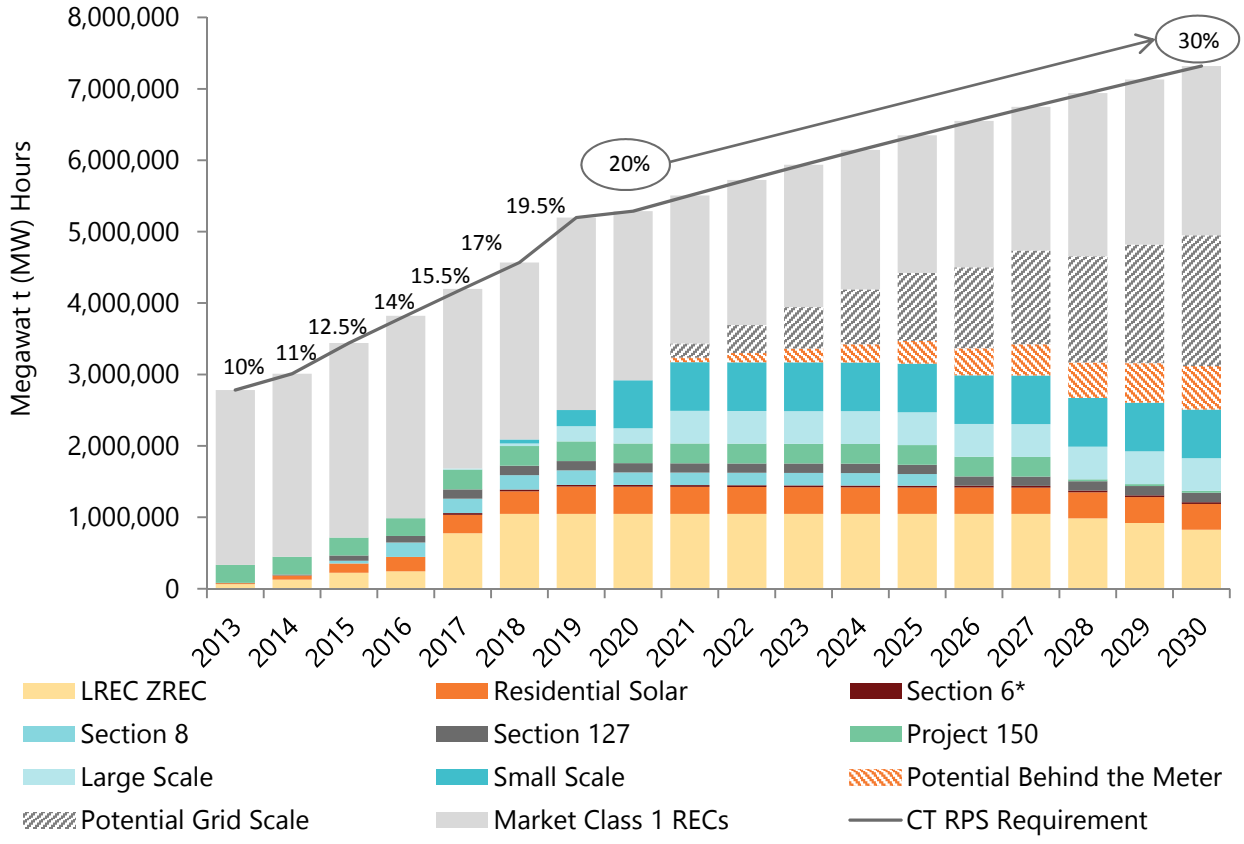
[95] DEEP, "Restructuring Connecticut's Renewable Portfolio Standard: Appendix II, Eligibility Issues and Options, Connecticut Class I RPS, A White Paper," at 19, Table 7 (Apr. 23, 2013).

administrative costs on the electric grid, including cost shifting to non-participants that results from net energy billing.

Reaching the state's GHG and renewable energy goals, while maintaining reliability and minimizing the cost to all ratepayers, will require a planned, deliberate approach to incentives and procurements for renewable resources.

To achieve a sustainable balance between grid-scale and behind the meter renewables, DEEP recommends that 0.25 percent of the 1 percent annual RPS increase be allocated to purchasing the energy and RECs from in-state behind the meter, based on new tariff structures elaborated in Recommendation E.1.4. The chart below splits the additional 1 percent growth per year until 2030 in the Class I RPS between 0.25 percent for behind the meter programs and 0.75 percent for grid-scale procurements. By 2030, the behind the meter portion would represent an additional 2.5 percent of Connecticut's electric load and the grid scale portion would represent about 7.5 percent of Connecticut's electric load. As of 2016, Connecticut's installed behind the meter resources equal approximately 1.6 percent of load.

FIGURE E21: Proposed RPS Goal, 30 Percent by 2030, Expanded Behind the Meter and Grid Scale Scenario



To achieve this balance, DEEP would establish the schedule and amount for both grid-scale and behind the meter resource mix and pricing caps, as applicable, in the IRP. The EDCs would run the procurement for the behind the meter resources, similar to the existing LREC/ZREC program. In addition, for residential solar, the Green Bank would maintain its role in interfacing between potential customers and developers to leverage existing program best practices and ensure a smooth transition. The behind the meter resource mix established in the IRP could have separate buckets each year for the resources or customers eligible to participate in LREC, ZREC, RSIP/SHREC, and virtual net metering, as provided in more detail in the following table:

TABLE E7: Recommended Participation Eligibility Requirements by Program

Customer	Existing Program Participation (Energy and RECs)	New Program Eligibility (Energy and RECs)
C&I	Net metering and LREC	On-site low-emission Class I technologies
	Net metering and ZREC	On-site large/medium zero-emission Class I technologies
Residential	Net metering and RSIP/SHREC	On-site small zero-emission Class I technologies
Municipality	Virtual net metering and LREC	Standalone or on-site Class I facility
	Virtual net metering and ZREC	
State	Virtual net metering and LREC	
	Virtual net metering and ZREC	
Agriculture	Virtual net metering and LREC	
	Virtual net metering and ZREC	

This procurement for behind the meter resources would follow the recommendations made in Recommendation E.1.4 below and provides for successor programs for LREC/ZREC and RSIP, and net metering and virtual net metering.

This procurement for 0.25 percent of load annually from behind the meter resources results in approximately 68,750 MWh allocated to behind the meter installations annually, which translates to an annual procurement for 20,000 kW of behind the meter solar and 5,000 kW of behind the meter fuel cells, if it is divided evenly. Over the past 5 years, the LREC/ZREC and RSIP programs resulted in approximately 0.25 percent of load in the initial year and approximately 1 percent of load in the most recent year. Given the new structure of procuring clean energy resources, as explained in more detail in Recommendation 1.4 below, DEEP believes this 0.25 percent/0.75 percent split is the balanced approach for now because grid-scale renewables are currently more cost-effective than behind the meter resources, though a price premium for behind the meter

renewables may be justified for other benefits they provide. In the future, DEEP will re-assess the 0.25 percent/0.75 percent split after a few years of procurements under this model to determine if the price of behind the meter resources has reduced enough compared to grid-scale resources to change the percentage procured.

DEEP would procure the remaining 0.75 percent, which is approximately 206,250 MWh annually, in the market using grid-connected Class I renewables or energy efficiency as needed. DEEP currently has sufficient authority to meet its RPS needs beyond 2020 but could need additional authority later in the decade. In future IRPs, DEEP will continue to assess the state's electric sector and will identify if there is a need for additional renewable energy sources or zero carbon resources to meet our RPS and GWSA goals.

In addition, DEEP will assess and identify in future IRPs if there is a need for additional capacity to meet electric load for the forecasted period that would warrant a procurement under the Public Utility Regulatory Policies Act ("PURPA"). Given the active docket at PURA to amend its regulations implementing PURPA to reflect the state's restructured electric industry, DEEP will submit specific recommendations to amend these regulations.[96] Similar to the process run by the former Department of Public Utility Control, the IRP will assess whether the forecast identifies a specific need for capacity that cannot be met through the regional competitive market and recommend whether PURA should initiate a procurement for those resources.

E.1.4 Increase transparency and certainty in the cost structure for net energy billing by creating renewable energy tariffs.

As discussed in the Behind the Meter section above, the cost of net energy billing is not easily understood and can vary considerably for the same energy. Customers with solar projects are compensated through net energy billing based on retail electric rates that are 18 cents kWh or more for energy produced from residential projects. In addition, they often receive incentives from the RSIP/SHREC or LREC/ZREC programs, bringing the total cost to over 20 cents/kWh on a levelized basis over the life of the project. Since electric rates vary between customer classes and utilities, the amount that customers receive for their generation can vary significantly between the EDCs and the rate class of the customer.

Given that the cost of renewable generation is declining, the additional incentives from LREC/ZREC or RSIP/SHREC programs may not be needed to achieve the clean energy levels required by the RPS in a few years. Once the cost declines below the retail rate, there will be no limitation on the

[96] PURA Docket No. 16-09-26, *PURA Review of Connecticut PURPA Regulations*.

number of projects that would be economic from the participant's perspective to develop. These projects, however, would likely still be much more expensive than grid-scale projects.

Currently, the net metering and virtual net metering tariffs are not based on either the value that such resources provide to the system, or the compensation required by the owner of the system to produce such generation. While DEEP recognizes the importance of expanding clean energy resources and the value that behind the meter resources can play in the diversity of our electric system, DEEP has also seen the benefit of utilizing competitive procurements to drive down the cost of these clean energy resource for ratepayers. Therefore, the best way to meet our GWSA goals, control costs, and make pricing more equitable and transparent for behind the meter resources would be to restructure net energy billing and implement renewable energy tariffs for both the energy and RECs for these resources.

A renewable energy production tariff is essentially a PPA in which the EDC would pay a fixed price, in cents/kWh, for each kWh produced by the renewable project for a set term of the contract. The EDC would purchase the energy and RECs of up to 0.25 percent of load annually and there would be no need for any other incentives, like LREC/ZREC or RSIP/SHREC. Rates could be fixed for a term up to 20 years. Bonus payments (often called "adders" in this context) could be established if desired to meet other policy objectives, such as encouraging renewable development on brownfields, supporting waste management goals, deferring distribution system upgrades, or addressing peak loads.

The customer utilizing the renewable energy tariff would purchase all the electricity they consume at standard retail rates. The payments for renewable generation could then be netted against the payments owed by the customer on their electric bill. This is how DEEP structured the re-issued RFP for the SCEF pilot program. Renewable energy tariffs would also provide greater certainty to those developing behind the meter projects and eliminate the potential changes to the net metering compensation that can occur from changes in the rate structure of retail electric rates.

DEEP recommends that the existing net metering and virtual net metering laws be modified to establish the proper regulatory and competitive framework for renewable energy tariffs for behind the meter renewable generation using the same eligibility criteria for those resources. Customers currently eligible for the net metering and LREC/ZREC/RSIP programs should be required to co-locate the Class I renewable energy source at the billing meter receiving the benefit of the renewable energy tariff to make efficient use of renewable energy siting locations, like rooftops for solar PV. The renewable source should be sized to meet no more than the load of the billing meter receiving the tariff benefit. Customers currently eligible for virtual net metering, specifically state, municipal, and agricultural customers, should be able to co-locate the Class I renewable energy source or have such source be a standalone facility, provided such source is sized to meet

no more than the load of the designated host billing meter account. This structure preserves the existing policy structure of the virtual net metering program while also shifting to the competitive framework articulated in this recommendation to get the same renewable energy at a lower cost for all ratepayers.

This recommendation would require a legislative change and subsequent PURA proceeding(s) to implement the administrative processes and procedures. The annual procurement of these resources would follow the 0.25/0.75 percent split between behind the meter/grid scale resources established in Recommendation 1.3.

Larger behind the meter installations, between 100 kW and 2,000 kW, would compete in an annual or semi-annual competitive solicitation using a reverse auction process, similar to the current LREC/ZREC structure. This process will set a price for the energy and RECs for behind the meter Class I projects for that auction. As discussed above, competitive procurements for grid-scale clean energy have yielded significant price reductions over the years. Many states have conducted an analysis of the value of clean energy resources, which account for and monetize the benefits that such resources can provide to the grid. However, through competition, the market can deliver those same clean energy resources at a cheaper price for ratepayers, provided markets are effectively monitored to ensure that they are competitive, and that sufficient authority is available to regulators to adjust market structures to sharpen competition and manage ratepayer risk, particularly in light of rapid declines in technology costs. There is a difference between the value of generation from a distributed resource and compensation required by the customer producing such generation. In order to maximize the net benefits to Connecticut's ratepayers, Connecticut needs to procure clean energy at a low cost.

In addition, smaller installations under 100 kW, like rooftop solar installations, may not be suitable to participate in a competitive process. These smaller installations, although they may be more expensive, create opportunities for residents and small businesses to site clean energy on their properties. Therefore, DEEP recommends that these systems have access to a set price renewable energy tariff, subject to the limitations per year established in the IRP, consistent with Recommendation 1.3. The set price could be established in one of two ways. First, similar to the Small ZREC tariff, the set price could be based on the results of the competitive auction for larger behind the meter resources with an adder, like 10 percent.

Alternatively, PURA, with input from DEEP on policy indicators, could set a rate based on the costs and benefits the particular clean energy resource provides. Recently, PURA indicated that it would study the value, including the costs and benefits, provided by distributed energy resources in a docketed proceeding that should result in a better alignment of programs costs and program

benefits.[97] Under this model for establishing a set rate for small behind the meter clean energy resources, compensation should be based on the value of the avoided costs and not just be the summation of all the benefits. Specifically, the actual value to the electric system and ratepayers of distributed resources are the avoided costs, i.e., the costs and investments foregone as a result of adding such resources. These include energy and capacity for generation, and a portion of distribution and transmission. There are also societal, environmental, and economic development benefits associated with distributed renewable generation. Other factors must be considered, such as the impact on rates and the cost and benefits of alternative projects that provide similar benefits. The results of the PURA investigation into the value of behind the meter resources will provide valuable information for setting the level of compensation such resources should receive.

In fairness to existing projects using net metering and virtual net metering, DEEP recommends that they be grandfathered and allowed to use their current tariff for up to 20 years from their in-service date. After the 20 years for both the grandfathered projects and project utilizing the new renewable energy tariffs, the customers would get a lower set rate, like the standard service or wholesale generation rate, as determined by PURA in the development of the tariff(s).

If the state were to continue to use a similar structure to the LREC/ZREC program combined with net energy billing, and if the allocation to commercial and industrial customers was about 46,000 MWh/yr, the annual incremental ratepayer cost would be approximately $7 million in year 2020. By 2030, the incremental cost to ratepayers would increase to about $65 million as the load share of these projects peaks at 1.68 percent of load. In comparison, if DEEP utilized a competitive structure (i.e. PPA for energy and RECs), based on the price reductions DEEP has seen in its grid scale procurements, DEEP anticipates that the net cost to ratepayers would be lower for the same amount of resources because bidders would be encouraged to minimize their costs.

This structure would not only provide a long-term stream of guaranteed revenues for the developers of clean energy for the power they generate and sell to the EDCs, but it would also allow Connecticut's ratepayers to hedge against higher wholesale energy cost in the future. For example, forecasts used by DEEP in its recent solicitations estimate that the wholesale cost of energy will rise to about 11.3 cents/kWh in 2035. If the Department were to procure clean energy using a 20 year PPA (energy plus RECs) below that amount, then ratepayers would actually be purchasing zero carbon power at a lower rate than fossil fuel based power. Although Connecticut's ratepayers will pay a premium in the near and medium term due to its higher cost, DEEP remains committed to purchasing clean energy at the lowest cost possible to Connecticut's ratepayers to meet the state's clean energy and GWSA goals.

[97] PURA Correspondence, Temporary Suspension of Docket, PURA Docket No. 16-02-30, PURA Review of the Electric Distribution Companies Cost of Service Study Methodologies and Rate Design (Apr. 3, 2017).

E.1.5 Evaluate the conditions around utilizing a diverse zero-carbon generation mix to meet our greenhouse gas emissions reduction goals.

Ensuring sufficient zero-carbon resources and the continued operation of in-state nuclear generation is an important strategy that meets all of our key objectives to provide cleaner, cheaper and more reliable power to Connecticut citizens. Early retirement of Millstone will likely result in the replacement of its 2,000 MW with natural gas fired generation, and would cause significant disruption in the ISO-NE markets, significant costs borne by Connecticut ratepayers, and significant increases in GHG emissions. Additionally, ensuring the continued operation of the nuclear power plants will help Connecticut meet greenhouse gas emissions reductions goals that would be unlikely to be achievable with premature retirement of these units.

However, several key questions remain, including: (1) the financial need for assistance; (2) potential impacts to the competitive wholesale market; (3) the potential impact to the retail market in Connecticut; and (4) the impact on ratepayers and Connecticut's ability to meet its GWSA goals. Before any retention mechanisms are used, an open and transparent process to assess scenario's around the risk of the retirement of nuclear units, the financial needs of these units, and potential policy options is essential.

DEEP believes it should investigate scenarios for nuclear retirement and retention, and evaluate the rate impact and environmental impacts for Connecticut under those scenarios. The investigation should include an analysis of at least the following potential policy options:

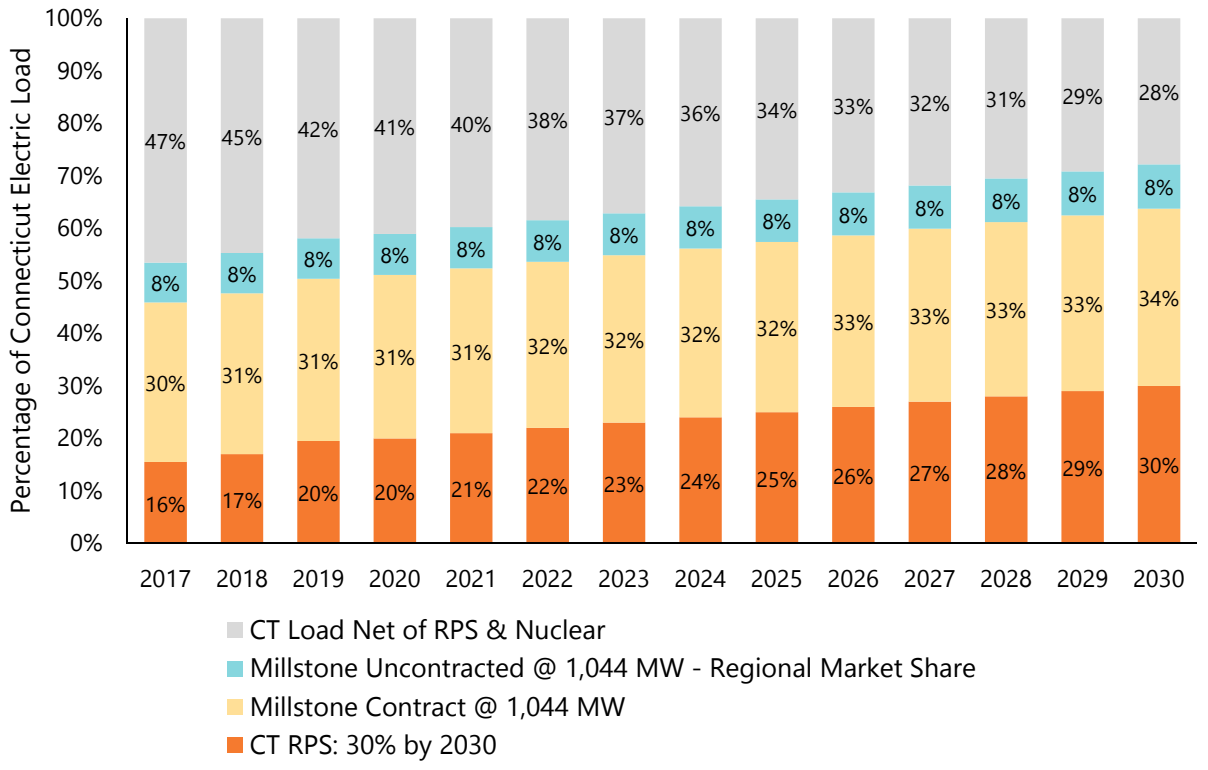
1. DEEP could implement legislation that gives the Commissioner the discretion to procure zero carbon resources like Millstone or large-scale hydropower, with a standard being that any procurement is in the best interest of ratepayers and there is a clear demonstration of need based on forward operating costs and market revenues.
2. PURA could consider offering longer-term contracts under its standard service rate.
3. DEEP and/or PURA create a clean energy standard, potentially similar to the mechanisms in New York, that compensates zero carbon resources for the benefits they provide the state. This final mechanism would require the development of a tracking capability for the carbon attributes from clean generation like nuclear that are not currently tracked by the existing system to harmonize accounting rules with those in other states to protect against double counting.

If Connecticut alone were to purchase the output from Millstone, then it would be appropriate to claim all the environmental attributes associated with the power purchased. A contractual

purchase could also justify a shift in electrical accounting with who claims what environmental attributes, while not changing the emissions in the regional system.

For example, if ratepayers provide funding through a long-term contract to support one of the Millstone units, this would represent approximately 28 percent of Connecticut's load using zero carbon power. After this contracted-for 28 percent is added to 20 percent Class I in 2020 and our regional market load share of the other Millstone unit (7 percent) and Seabrook (7 percent), our carbon free power could quickly jump to 62 percent. By 2030, the percent of carbon free power would grow to 72 percent if the RPS were increased to 30 percent by 2030. In addition to retention of the environmental attributes, a long-term contract with Millstone could be paired with using the purchased power to meet load obligations of standard service or of retail suppliers and not sold back to the market, which is commonly done today with contracted renewable power. This, however, would require the PURA and EDCs to change the way standard service is currently procured, which could disrupt the competitive supplier market.

FIGURE E22: Connecticut Generation Scenario, 30 Percent RPS and 50 Percent Nuclear Contract



As an illustrative example, Figure E22 above shows a hypothetical of what the state's resource mix would look like with the 30 percent by 2030 expansion of the RPS and a contract with Millstone for 50 percent of the output from both units. Under this scenario, the equivalent of 70 percent of

Connecticut's electric load in 2030 would be met with low or zero carbon resources. As mentioned above, further analysis is needed to understand the impacts to the wholesale and retail markets.

DEEP will closely monitor the markets and trends and is prepared to take action if a significant carbon free resource is in jeopardy of leaving the market and such exit would not be in the interest of ratepayers.

E.1.6 Pursue goals of the shared clean energy facility program through multiple avenues based on lessons learned from the pilot program.

DEEP is committed to achieving the objectives identified in the Shared Clean Energy Facility ("SCEF") pilot program: providing access to solar purchasing options for customers who cannot site solar on their own homes, with a focus on low-and-moderate income customers. The pilot demonstrated the viability of a renewable energy tariff-style pricing structure articulated in Recommendation E.1.4 with a price cap on proposals. The pilot also saw meaningful participation by LMI customers and attracted proposals sited on brownfields and other underutilized lands – and not on prime farmland or core forest, avoiding the siting issues present with some grid-scale projects. However, the proposals under the pilot program required no meaningful commitment on the part of participating subscribers. None of the proposals required the purchase or lease of a portion of the system; rather, participating customers simply receive a credit from the EDC and pass a portion of that along to the solar developer.

With rooftop solar and net metering, a customer has an interest in the array because they purchase the system or lease the system through fixed monthly payments. In addition to this financial commitment, the project is sited on the customer's home or property. Similarly, with virtual net metering, the host has a financial interest through a purchase or lease, and the project is sited on their property. When community solar is offered to subscribers without requiring any meaningful commitment or lease agreement from the subscriber, the system is functioning the same as a grid-scale installation but with an added cost to non-participant ratepayers to pay for administering and delivering credits to subscribers that have not provided any support to the system. Credits to participating customers raise the cost of the project that are ultimately borne by other ratepayers. Based on DEEP's experience with competitive solicitations, small grid side renewable projects, similar in size to community solar projects, can be developed in Connecticut more cost-effectively than through the shared solar pilot structure, and provide the same benefits for *all* ratepayers, not just the subscribers.

DEEP therefore recommends that a model used in the pilot program be modified in any statewide rollout of the SCEF program. At a minimum, any new statewide SCEF program should require that

all participating customers purchase solar panels or a percentage of the facility output and pay the full cost upfront, or enter into a long-term lease arrangement that requires a fixed payment each month that is not tied to the actual monthly output of the facility. This fixed payment contributes to the development of the clean energy system and limits the rate impact on non-participant ratepayers. This lease arrangement can be structured to provide a flat rate over the lease term, which may be more expensive in the early years, but hedges against future electricity price increases. This enables participants to replicate the value of owning a PV system without the burden of installation and maintenance with the ability to obtain electric bill credits in return for their support of the system. Credits would continue to be paid from the EDC to the customer on a fixed cents/kWh basis for each kWh produced by the facility. These improvements would add value for the credits obtained by subscribers.

Using this approach to structure subscriber participation, the procurement schedule discussed in Recommendation E.1.3 could specify that a portion of the 0.25 percent of load procured per year for behind the meter resources could be dedicated to SCEF customers, functionally making them a fourth "virtual net metering" type of tariff consumer group, alongside state, municipal and agricultural customers, who can use a standalone Class I renewable energy facility to deliver electric bill credits. The SCEF pilot's successful use of an energy-and-RECs bid design closely resembles the renewable energy tariff structure in Recommendation E.1.3, making for clearer alignment and consistency across renewables programs.

Alternatively, the objectives of SCEF could be achieved through a stronger voluntary renewable energy product offered by utilities, preventing cost-shifting and focusing on customer goals such as supporting new in-state or local projects. This requires that voluntary renewable products are tracked and verified consistent with Recommendation E.1.7 below.

E.1.7 Strengthen voluntary renewable product verification in the competitive electric supplier market.

Through DEEP's experience with the shared clean energy facility pilot program, there is a growing desire among residents to support local, in-state clean energy. Although several competitive electric suppliers offer voluntary renewable energy choices, the product offerings of many suppliers fall far short of the standards of the Connecticut Clean Energy Options ("CCEO") program in terms of the sourcing of renewable energy to benefit Connecticut customers (types and geographic location of generation), product disclosure, a consistent REC-based product, and REC verification standards. DEEP recommends that PURA's new regulations for voluntary renewable energy products, to be drafted in Docket No. 16-08-23, require competitive renewable product offerings to meet the supplier standards of the CCEO program.

Specifically, PURA should establish a market for voluntary REC offerings. Competitive suppliers offering such voluntary REC products should be required to unbundle these REC offerings from the generation supply that meets the RPS requirements. Any such supplier should disclose the product, renewable energy sources and geographic location of clean energy that benefit Connecticut residents. Products should be limited to the ISO-NE and PJM regions to support local clean energy and product offerings should be limited to 50% and 100% renewable for ease of administration. In addition, the EDCs should implement a tracking and verification process for the voluntary clean energy attributes to ensure that customers are getting the benefit of the renewable they are purchasing.

E.1.8 Convene a working group to implement best practices to optimize siting of renewable facilities on appropriate sites in Connecticut.

With the passage of Public Act 17-218, DEEP is entering new territory with regard to the siting of renewables. This new legislation has updated the Siting Council process to reflect the emerging reality of grid-scale renewable installations in Connecticut. DEEP will monitor how the Siting Council process develops, and whether or not the General Assembly struck the right balance between meeting our renewable policy goals, and meeting our open space, core forest, and farmland preservation goals. DEEP recommends that DEEP and the Department of Agriculture provide the Siting Council with standards to determine whether a proposed project materially affects the status of the land as a core forest or prime agricultural soil, based on their respective expertise and policy planning documents.

In addition, DEEP recommends identifying priority areas around the state, like brownfields, state properties, or previously developed sites, which would benefit from hosting Class I renewable energy sources or minimize siting issues. DEEP will work with the Department of Agriculture, the Office of Policy and Management, the Department of Economic and Community Development, and the EDCs to ensure these priority areas are identified with land use considerations, including consistency with the Conservation and Development Policies Plan, and the electric distribution system in mind. In addition, DEEP will outline specific siting criteria in any future RFPs issued by DEEP and make these siting criteria a threshold requirement, meaning any proposal that does not meet these siting requirements will not be evaluated or considered under the RFP.

Goal 2: Continue to support regional and state reliability and resiliency efforts.

E.2.1 Support ISO-NE in addressing regional winter natural gas generation reliability issues.

For various reasons, not all New England states are in a position to share the costs of the necessary infrastructure investments to provide firm, reliable natural gas to gas generators. Connecticut is not able to resolve the gas generator winter reliability problems on its own. The solution requires the participation of all six New England states.

ISO-NE has taken the position that it does not have the authority to directly address the region's infrastructure needs. ISO-NE has indicated that it is looking for "market based incentives" to help ensure fuel security. It has floated ideas such as providing incentives for generators to obtain firm fuel contracts and signing contracts with non-gas generators to avoid retirements.

Going forward, DEEP remains committed to utilizing its authority if necessary under all sections of Public Act 15-107, in coordination with other states, to secure more reliable and affordable electric service for the benefit of Connecticut's electric ratepayers and to meet the State's energy and environmental goals and policies. DEEP, however, believes that ISO-NE, not the states, should take the lead in this important regional issue. All the New England states are dependent on the gas generation fleet and will benefit from improved reliability. It is ISO-NE primary mission to ensure reliability of the electric grid in New England. ISO-NE is in the process of studying the interaction of natural gas capacity and the energy markets at the Planning and Advisory Committee with a goal of finding market mechanisms to ensure reliability. Connecticut will work with other stakeholders and ISO-NE to ensure regional reliability is maintained at a reasonable cost.

E.2.2 Continue to deploy community microgrids to support statewide resiliency goals in strategic locations and support the Energy Assurance Plan.

DEEP will continue outreach on the value and importance of community microgrids to municipal employees and officials either individually or in partnership with the Connecticut Conference of Municipalities, Council of Small Towns or the Connecticut Center for the Advancement of Technology. DEEP supported legislation to expand the expenses that may be reimbursed by the program. In 2016, the microgrid program funding ability was expanded to provide matching funds or low interest loans for an energy storage system or clean distributed energy generation projects for a microgrid. DEEP will also explore the possibility of funding the interconnection infrastructure with matching funds and having the applicant contribute funds to those costs.

The original enabling legislation requires DEEP to distribute the funds to small, medium and large municipalities, to the extent possible. To scale the microgrid program across the state, DEEP encourages the electric distribution companies (EDC) and the municipal electric utilities (MEU) to identify locations where critical facilities are located within geographic proximity of each other and share this information with municipal officials and employees. This will also be an important element of the implementation of Public Act 17-144, which requires the EDCs to present a plan to PURA for the deployment of up to 30 MW of grid-enhancing fuel cells, which could include fuel cells within microgrids that would enhance reliability of the larger grid. DEEP will participate in meetings between the EDC or MEU and the effected municipality to provide assistance to the municipality in understanding the benefits and costs of the microgrid. Additionally, DEEP will work with the Division of Emergency Management and Homeland Security to develop a comprehensive microgrid deployment strategy for the state and increase outreach in areas without a microgrid nearby, like the northwest area of the state.

E.2.3 Ensure coastal resiliency of substations and other critical grid infrastructure to support DEEP's flood management goals.

The current ISO-NE rules do not have clear guidelines for when it is appropriate for transmission operators to take action to address challenges arising from climate change where the impacts are regional. Rather transmission operators bring issues to NEPOOL and ISO-NE on an ad hoc basis with the hope that they can convince stakeholders and the ISO that identified resilience issues that affect the bulk transmission system is an "asset condition" that needs to be addressed. If the transmission operator is successful, the costs of the project are regionalized; if not successful, the transmission operator can either bring it to the local regulator for local allocation of costs or not complete the project. There are, however, no standards on what constitutes an "asset condition" in the context of resiliency and climate adaptation. Connecticut is working through the NEPOOL process to encourage the development of standardized guidelines for addressing threats to the electric grid from climate change. DEEP will continue to work through this process and work for a timely resolution to this issue and establish a clear standard to follow for future regional resiliency issues.

E.2.4 Continue to identify and explore grid modernization initiatives.

Distributed generation and other non-wires alternatives can be a way to avoid the need for distribution system upgrades, like substation upgrades, and potentially lower costs for ratepayers. On the federal level, DOE and the national labs through the Grid Modernization Lab Initiative (GMLI) continue to play a pivotal role in advancing grid modernization efforts in several jurisdictions. DEEP will continue to engage directly with DOE, and the national labs, to share the outcomes of the relevant 88 grid modernization projects with Connecticut's utilities and other

stakeholders. DEEP will evaluate opportunities to host specific proceedings or the utilization of other tools to disseminate information and lessons learned within DOE's six identified priority areas for advancing grid modernization. DEEP will continue to collaborate with DOE and the Connecticut utilities and other stakeholders with the goal of exploring opportunities to leverage federal efforts, including federal funding, as well as utilizing the results of the efforts of the Grid Modernization National lab Consortium's testing and evaluation of tools, technologies and systems included in the 88 federal projects.

In addition to DEEP's efforts working with DOE and the national labs on grid modernization, the EDCs should continue to consider alternatives to traditional distribution system planning in their processes before PURA. Going forward, DEEP recommends that PURA initiate a generic proceeding on grid modernization and adaptation of the utility business models to reflect the modern grid. This proceeding could investigate, among other topics, (1) the feasibility of requiring the EDCs to conduct an alternatives analysis in distribution system planning, like distributed generation alternatives; (2) dynamic pricing and robust time of use rates for both Eversource and UI to maximize the benefit of distributed resources; (3) the role that energy storage systems can play to lower costs to ratepayers, efficiently integrate intermittent distributed energy resources, and potentially defer distribution upgrade expenses;[98] (4) the EDC role with respect to grid-enhancing elements of the system (such as storage and microgrids), and whether it includes ownership, operation and dispatch. Finally, DEEP encourages the EDCs to submit energy storage proposals pursuant to Section 16-244w of the General Statutes, taking into consideration DEEP's feedback on its previous energy storage proposals, to take advantage of this opportunity to pilot the operation and integration of such resources into the distribution system.

[98] While DEEP did not approve any energy storage proposals submitted by the EDCs pursuant to Section 103 of June Special Session Public Act 15-5, DEEP believes it is important to explore the benefits that energy storage systems can provide to the electric system, and how storage can help integrate more clean energy and distributed generation.

Chapter Two: The Building Sector

INTRODUCTION

The built environment we live and work in comprises an important component of Connecticut's energy infrastructure. The energy demands of our buildings directly correlate to our energy supply and grid management. Even though Connecticut's per capita energy consumption is below the national average, relatively high energy rates mean that energy represents a major expense for many Connecticut households and businesses.[99]

> *"Energy efficiency works. It means local jobs. It means money is invested locally in the value of homes and businesses. It improves the health and safety of residents and by empowering cost control it improves the competitiveness of Connecticut's businesses."* – *Commissioner Rob Klee, CT DEEP*

Energy efficiency is the most effective tool customers have to control these costs. Not only does it reduce consumption and deliver cost savings for our businesses and residents, it can hedge against volatile energy supply costs of supply resources. It is a low-cost energy resource because the cheapest unit of energy is the one not used. Energy savings from efficiency investments in Connecticut are currently being achieved at a cost of about 4.5 cents per kWh of lifetime electric savings, and less than 50 cents per therm of lifetime natural gas savings, less than the cost of other energy resources.[100] Energy efficiency does not require ecologically impactful extraction methods or require cleanup after processing or spills, and could effectively eliminate over 4.2 million metric tons of CO_2 emissions from use in the buildings and industrial sector by 2025.[101] Energy efficiency also provides grid benefits such as avoided transmission and distribution (T&D) costs, peak demand reduction, price mitigation effects in wholesale markets, as well as the effects of reinvestment of local dollars into local jobs and industries. While energy generation supply sources exist at various price points, none provide the level of system-wide benefits at the price of energy efficiency.

[99] "Average Price of Electricity to Ultimate Customers by End-Use Sector, by State, December 2016 and 2015 (Cents per Kilowatt hour)", *United States Energy Information Agency,* February 24th, 2017, http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a.

[100] Molina, Maggie, "The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs", Publications, American Council for an Energy-Efficient Economy, 2014, http://aceee.org/research-report/u1402.

[101] "Greenhouse Gas Equivalencies Calculator" *United States Environmental Protection Agency,* May 2014, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

Energy efficiency additionally invests money back into the local economy in the form of skilled jobs, and the value of our homes and businesses. It improves the health and safety for building occupants and empowers ratepayers to control their energy costs. Our ability to achieve a cheaper, cleaner, more reliable energy future will depend on millions of building owners and occupants seizing the clean and efficient energy opportunities available to them. This chapter examines both the challenges and solutions to maximizing the accessibility and scale of these energy opportunities. By fully valuing energy efficiency as a resource, we can holistically examine how to strengthen and improve Connecticut's economic competitiveness and the quality of life for residents.

The key goals in the Buildings Sector, and the strategies to achieve those goals are summarized in the table below. The recommendations include continuations of the strategies articulated in the 2013 Comprehensive Energy Strategy, as well as certain refinements and areas where continued focus is needed to ensure we reduce energy waste and optimally manage energy demand in the context of strategically expanding electrification.

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TABLE OF GOALS AND STRATEGIES FOR 2017 CES

CHAPTER TWO: BUILDINGS SECTOR	
Goal 1: Prioritize energy savings as both a financial and energy resource.	
B.1.1	Procure energy efficiency as a resource.
B.1.2	Enhance competitiveness of Connecticut's businesses with customized energy efficiency investments.
B.1.3	Reduce the energy affordability gap in low-income households.
B.1.4	Improve financial programs to increase access to clean and efficient energy improvements.
B.1.5	Maximize consumer demand for energy efficiency by increasing awareness and understanding of its value.
B.1.6	Evaluate current cost-effectiveness testing methods for accurate reflection of all resource costs and benefits.
B.1.7	Ensure equitable efficiency investment for delivered heating fuel customers through equitable conservation charges.
Goal 2: Improve the performance and productivity of buildings and industrial.	
B.2.1	Ensure application of and compliance with current building energy codes and product efficiency standards.
B.2.2	Strategically sequence deployment of cleaner thermal fuel choices to transition buildings from fossil fuels.
B.2.3	Continue increasing the rate of home weatherization and assessment, statewide.
B.2.4	Address the unique needs of multifamily buildings for implementing cost-effective, clean and efficient upgrades.
B.2.5	Reduce energy waste by using combined heat and power, where it is cost-effective, in commercial and industrial applications.
B.2.6	Reduce energy waste at water and wastewater treatment facilities.

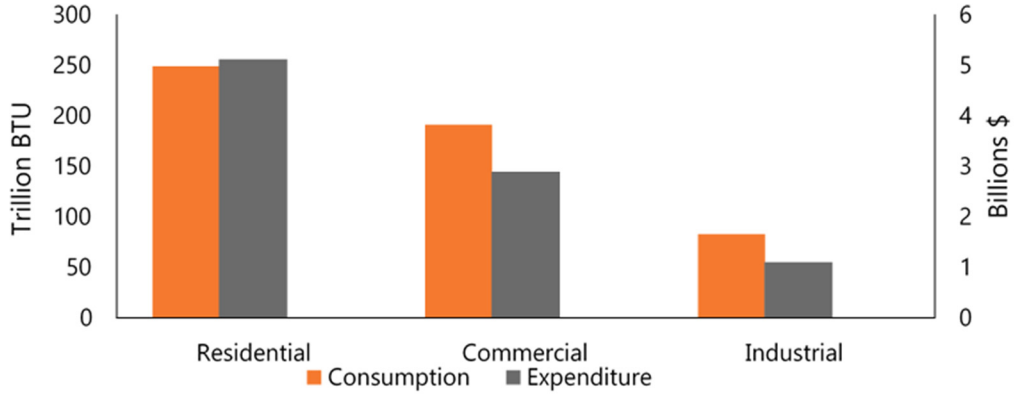
B.2.7	Evaluate applicability of district heating and thermal loops in high density areas.
B.2.8	Inventory state buildings and their energy usage patterns to identify greatest energy savings opportunities.
B.2.9	Support diversification of the heating oil delivery industry's products and services.
Goal 3: Continue prioritizing grid load management to reduce peak demand	
B.3.1	Target peak demand reductions.
B.3.2	Increase and standardize two-way advanced meter communication.
B.3.3	Optimize economic signals and incentives for demand response to recognize shifts in demand from expanding electrification of heating and transportation.

CURRENT TRENDS IN BUILDING ENERGY USAGE AND ENERGY EFFICIENCY INVESTMENT

Energy Usage

To identify the most cost-effective energy strategies for our buildings, it is important to understand how we currently use energy. Today, Connecticut's 1.4 million households and 140,000 businesses together account for more than 70 percent of Connecticut's 750 trillion BTU of annual energy consumption, approximately 523 trillion BTU.102 However, buildings do not all consume energy in the same way.

FIGURE B1: Connecticut Building Sector Energy Consumption & Expenditures



Source: U.S. EIA *Connecticut State Profile and Energy Estimates*, 2017.

Residential Energy Consumption

The residential segment consumed nearly half of the building sector's energy in 2014 at 249 trillion BTUs, and Connecticut residents spent $5.12 billion (Figure B1).[103] Since the peak of energy use in

[102] United States Energy Information Administration "Energy Consumption Overview: Estimates by Energy Source and End-Use Sector, 2014", 2014, http://www.eia.gov/state/seds/data.php#ConsumptionExpenditures.

[103] It is important to keep the total number of customers in each sector in mind when thinking about energy demand and expenditures since the average industrial customer will of course consume more energy than the average home.

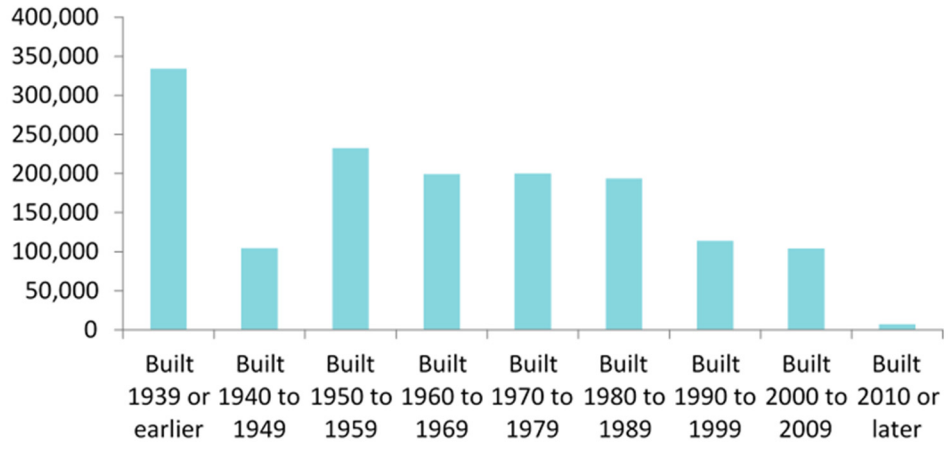
United States Energy Information Administration, "Energy Consumption Estimates by End-Use Sector, Ranked by State" 2014, http://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_sum/html/rank_use.html&sid=US.

United States Energy Information Administration, "Connecticut State Profile and Energy Estimates", 2017, http://www.eia.gov/state/data.php?sid=CT#ConsumptionExpenditures

2004, total residential BTU consumption has fallen by about 17 percent overall but has been slowly on the rise since 2011, primarily due to increased natural gas consumption.[104]

This level of consumption is a result of a combination of trends in Connecticut's housing stock. Almost 72 percent of Connecticut's housing units were built before 1979 (Figure B2). Statistically, older homes are less insulated, and use outdated and less efficient appliances and equipment, which results in higher energy costs. Additionally, fossil fuels, particularly fuel oil, are heavily used for thermal fuel in Connecticut homes, especially in older homes (Figure B3). Over 40 percent of Connecticut housing units use fuel oil for space heating, compared to just 5 percent nationwide (Figure B4).

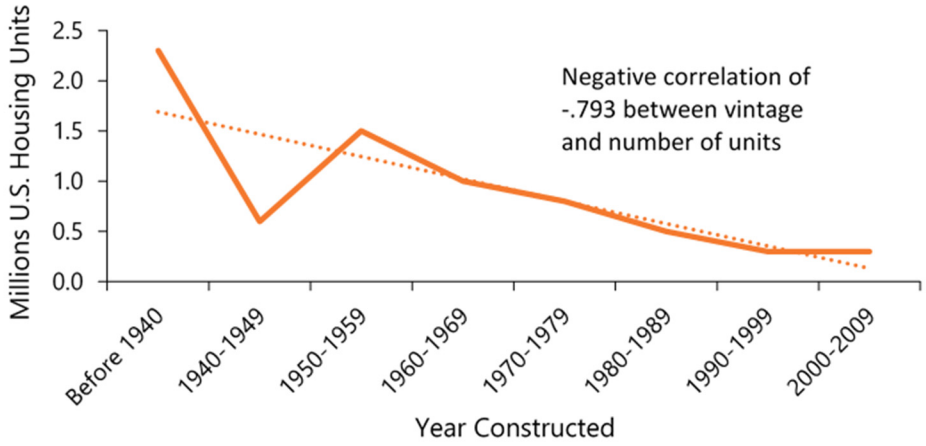
FIGURE B2: Connecticut Housing Stock by Vintage



Source: United States Census Bureau. 2015. *Connecticut Selected Housing Characteristics 2011-2015 American Community Survey 5-Year Estimates.*

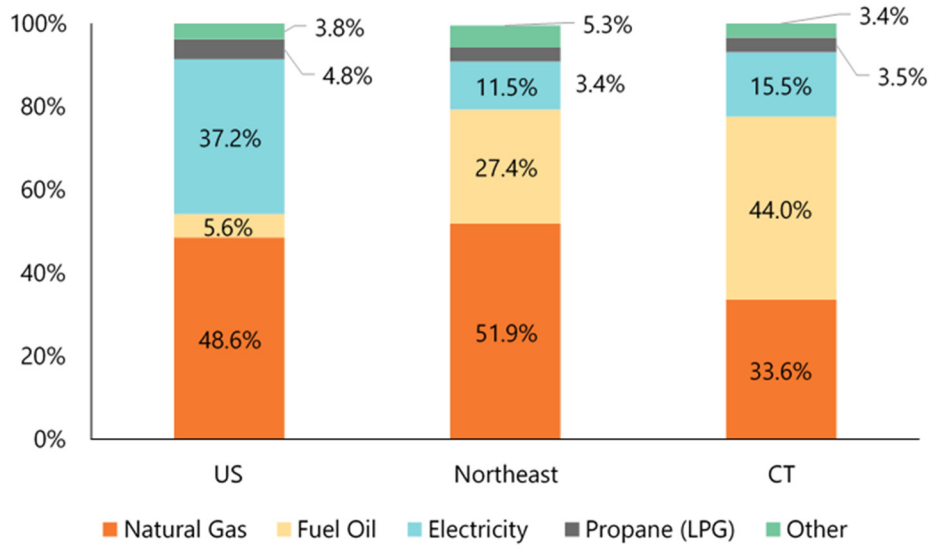
[104] United States Energy Information Administration, "Table C1. Energy Consumption Overview: Estimates by Energy Source and End-Use Sector, 2014), *U.S. States State Profiles and Energy Estimates* , 2014, https://www.eia.gov/state/seds/data.php.

FIGURE B3: Fuel Oil Used For Space Heating By Housing Vintage (U.S.)



Source: U.S. EIA. 2013. *2009 Residential Energy Consumption Survey: Table HC1.3*

FIGURE B4: Energy Source Used for Home Heating by Percent of Total Households



Source: U.S. EIA *Connecticut State Profile and Energy Estimates*, 2017.

Connecticut is often characterized as rural, but also suburban and very wealthy. On the contrary, it is the fourth most densely populated state in the US and approximately 88 percent of the population lives in an urban area with a range of income classes throughout the state.[105] Approximately one third of Connecticut's occupied housing units are rentals which limits the direct

[105] Connecticut Department of Public Health. 2012. *Connecticut Healthy Homes Data Book*. Connecticut Department of Public Health.

control residents have over their energy choices and costs. This is particularly true in multifamily housing in which the units are often not owner-occupied.[106]

There exists a strong and recognizable correlation between energy, income, health and safety. Energy bills in low-income households constitute greater proportions of household income, lowering available capital for other household needs. Low-income homes are often older, are not as well insulated, and have maintenance challenges, including health and safety issues that hinder completion of weatherization improvements. In many of the state's existing low-income programs, such as Energize Connecticut's Home Energy Solutions- Income Eligible (HES-IE) program, the federal Weatherization Assistance Program, and the Department of Social Services' Energy Assistance Program, the threshold income level for participants is set at the higher of either 200 percent of the Federal Poverty Level or 60 percent of the State Median Income.[107] Over one third of total residential units and more than a million Connecticut residents meet these criteria.[108]

These trends, combined with current rates and energy prices, have resulted in Connecticut residents maintaining some of the highest annual energy bills in the nation, even while Connecticut's residents consume energy at a relatively low per capita rate.[109] Operation Fuel's 2016 report on Home Energy Affordability in Connecticut estimated an "affordable" energy cost burden to be 6 percent of household income, yet many Connecticut residents spend from 8 percent to 36 percent of household income on energy.[110] This is particularly apparent in Connecticut's 322,000 low-income households whose average affordability gap is around $1,241.[111] In aggregate, this gap exceeds $399 million and occurs despite a 15 percent decline in the gap from 2015 to 2016 due to the decrease in fossil fuel prices during that timeframe. For many homes, energy expenses compete with housing, food, and medical care. Even with support from programs such as the federal Low-Income Home Energy Assistance Program (LIHEAP) and

[106] (Connecticut Green Bank 2016) Connecticut Green Bank, "Comprehensive Plan Fiscal Years 2017 and 2018", *Connecticut Green Bank,* 2016, http://www.ctgreenbank.com/wp-content/uploads/2016/07/CTGreenBank-Comprehensive-Plan-Fiscal-Years-2017-2018.pdf.

[107] Connecticut Department of Social Services. 2016. "Selected Annual Federal Poverty and State Median Income Guidelines." *www.ct.gov/dss.* 1 July. http://www.ct.gov/dss/lib/dss/pdfs/povsmi.pdf.

[108] Connecticut Green Bank. 2014. Memo to Connecticut Green Bank Board of Directors: Role of a Green Bank – Low Income solar Deployment. The Connecticut Green Bank.

[109] "Household Energy Use in Massachusetts." *www.eia.gov.* 2009, http://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/ma.pdf.

[110] Colton, Roger D. 2016. "Home Energy Affordability in Connecticut: The Affordability Gap, Prepared for Operation Fuel."

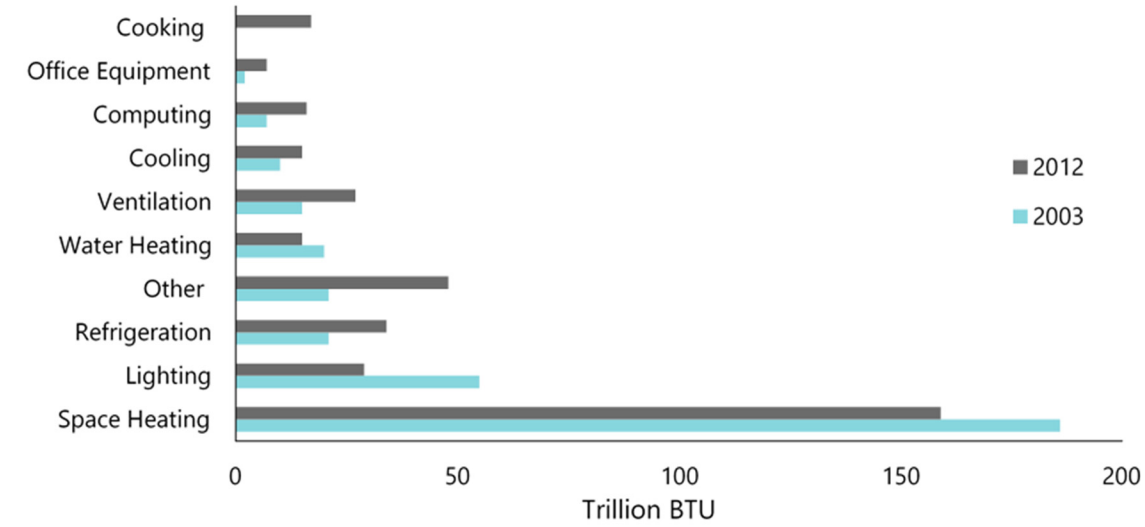
[111] This number does not represent the total energy costs per household but rather the portion beyond the affordable amount. The 2015 ACS identified this number of households as at or below 200 percent of the Federal poverty level.

utility administered matching payment plans, low-income households often must choose between vital necessities.

Commercial & Industrial Consumption

The commercial and industrial segments individually consume less than the residential segment, though together the commercial and industrial segments spent almost $4 billion on energy by consuming 274 trillion BTU in 2014; just under half of the Building sector's total expenditure. As in the residential segment, space heating and lighting are the top energy end-uses in commercial and industrial buildings, constituting about half of total consumption nationwide, and one third of consumption in New England.[112] However, compared to the 2003 U.S. Energy Information Administration (EIA) Commercial Building Energy Consumption Survey (CBECS), space heating and lighting energy consumption have decreased by 14 percent and 46 percent respectively in New England commercial and industrial buildings. This is primarily due to warmer winters and the increased market penetration of compact fluorescent (CFL) and light emitting diode (LED) bulbs (as shown in Figure B5). Coincidentally, while lighting and space heating energy usage has decreased since 2003, other end uses such as ventilation, cooling, and refrigeration have grown.

FIGURE B5: New England Commercial and Industrial Energy End-Use 2003 vs. 2012



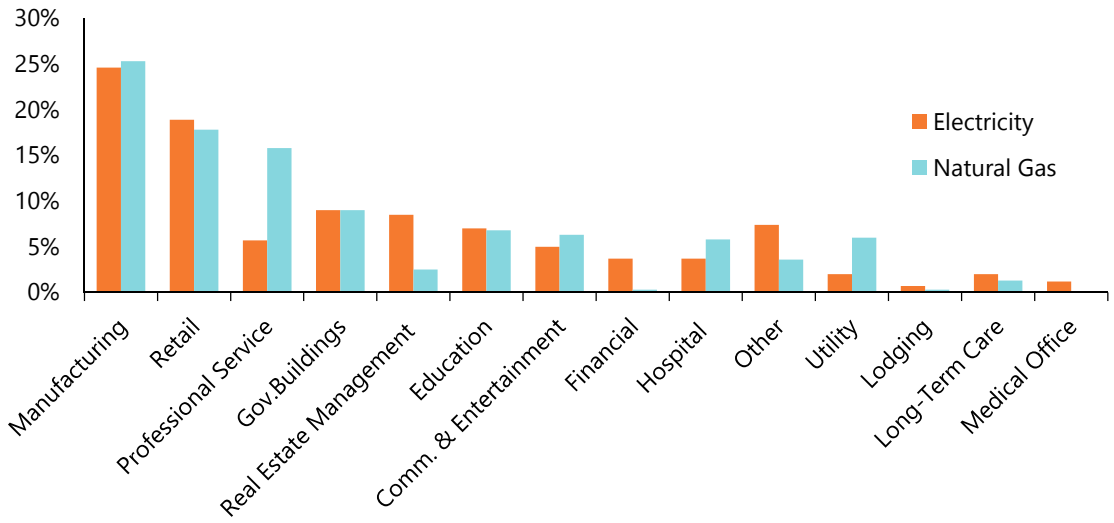
Source: U.S. EIA 2003. *2003 Commercial Buildings Energy Consumption Survey (CBECS).* U.S. EIA 2013, *2012 CBECS.*

Commercial energy customers vary greatly in size and energy intensity. In fact, only a small number of large businesses consume the majority of energy used by businesses in Connecticut. According to Eversource Energy, a small group of large businesses, primarily manufacturers,

[112] United States Energy Information Administration, *2012 Commercial Buildings Energy Consumption Survey (CBECS).* 18 March. http://www.eia.gov/consumption/commercial/reports/2012/energyusage/index.php.

comprise this top 25 percent of the Eversource load. The middle 50 percent of energy users is a larger group of customers and includes government agencies, commercial office buildings, education, and large retail buildings. Manufacturing and retail buildings comprise the largest consuming sub-segments of the commercial and building sector (Figure B6).

FIGURE B6: Connecticut Commercial and Industrial Electricity and Natural Gas Consumption by Industry



Source: DEEP's Analysis of the 2016-2018 C&LM Plan Market Segmentation Data

Another quarter of consumption results from the majority of businesses, which on an individual company basis consumes lesser amounts of energy, yet in the aggregate consume 25 percent of total electricity and natural gas. This group is comprised of primarily small businesses such as retail stores and office buildings. While per-company energy savings potential from these users may be relatively small, their overall, large volume creates a major opportunity for aggregated energy and cost savings.

The government segment alone represents approximately 13 percent of the commercial and industrial sector's electric and natural gas consumption in Connecticut.[113] Approximately 3,800 state-owned and state-leased buildings represent 70 million square feet of building space. Many state and municipal buildings in Connecticut are well over 50 years old and are in need of efficiency and maintenance upgrades.

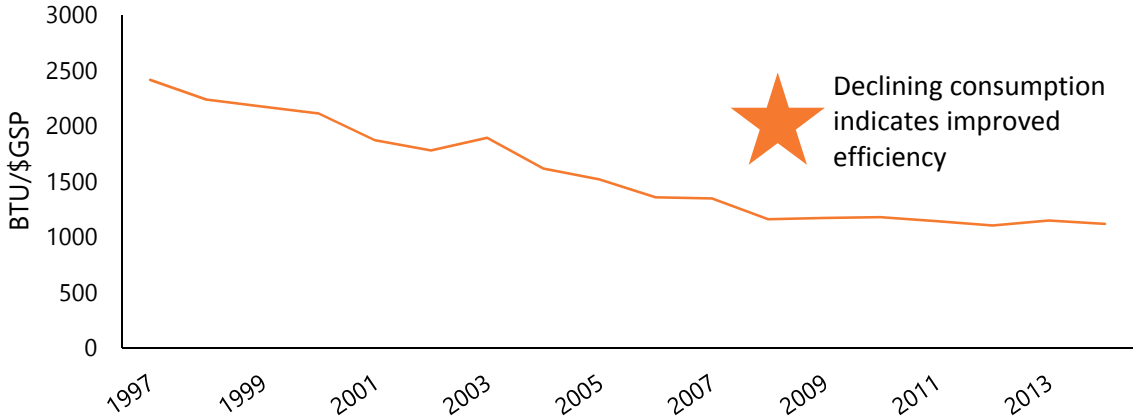
[113] The government segment includes federal, state, and municipal buildings as well as state colleges and universities.

Overall, energy expenditure in the commercial and industrial sector has increased by 73 percent since the early 2000s while consumption and energy intensity, the amount of energy required to produce our annual gross state product (BTU/GSP), has declined, as shown in Figure B7.[114] In 1990, energy consumption averaged around 2,500 BTU/$ GSP but has fallen by 54 percent as of 2014 to only about 1,100 BTU/$GSP. This decline in indexed consumption is a positive trend. This means that Connecticut's businesses are using less energy to produce an increasing quantity of goods and services. Reducing energy usage is a critical strategy businesses can continue employing to control costs and increase energy productivity.

Connecticut's Energy Workforce

Changes in the economy have signaled a shift towards energy efficiency as an industry both nationally and in Connecticut. The United States Department of Energy noted in its January 2017 report on employment in the energy industry that 14 percent of the nation's job growth was seen in the traditional energy and energy efficiency fields.115 Over 6.4 million Americans worked in these fields in 2016, which equated to a 300,000 job increase. The federal report noted that the design, installation, and manufacture of energy efficiency products and services in Connecticut accounted for nearly 34,000 jobs. In fact, Connecticut has been a leader in growing energy efficiency jobs, representing 1.6 percent of all energy efficiency jobs nationally. The largest number of these employees work in high efficiency HVAC and renewable heating and cooling

FIGURE B7: Connecticut Energy Consumption per $ Gross State Product (BTU/GSP)

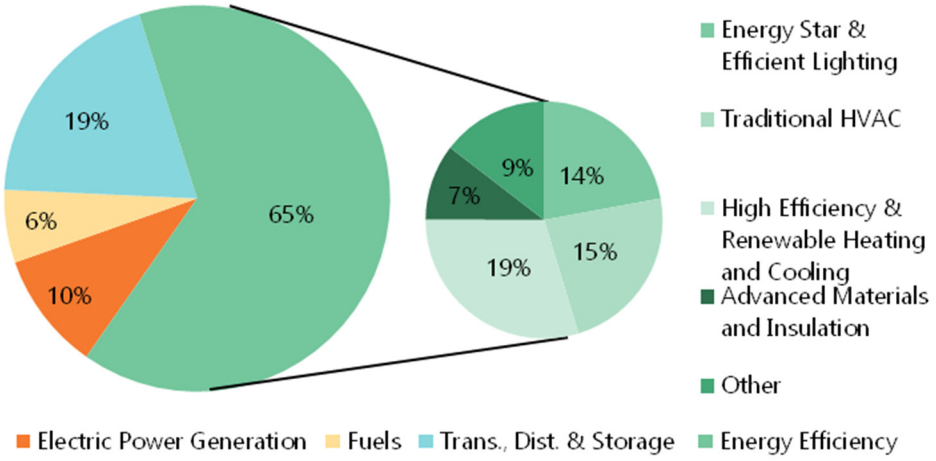


Sources: (United States Energy Information Administration 2017) (Federal Reserve Economic Data 2017) U.S. EIA "Connecticut State Profile and Energy Estimates", 2017.

[114] United States Energy Information Administration, *Connecticut State Profile and Energy Estimates*

[115] United States Department of Energy. 2017. "U.S. Energy and Employment Report." *https://energy.gov.* January. https://energy.gov/sites/prod/files/2017/01/f34/2017%20US%20Energy%20and%20Jobs%20Report_0.pdf.

FIGURE B8: Connecticut Energy Employment by Major Technology



Source: United States Department of Energy, 2017

technologies, followed by traditional HVAC (Figure B8). The growth of the industry is strengthened by the predictable investments in energy efficiency across the state's economy.

Energy Efficiency Investment

Focusing on energy efficiency as a primary means for achieving Connecticut's energy goals in the building segment is not a new strategy, but rather a continuation of ongoing efforts statewide. Connecticut's keystone energy efficiency programs, administered since 1999 by the major electric and natural gas companies as an initiative known since 2013 as "Energize Connecticut," a collaboration of the major utilities (the utility companies), DEEP, the Connecticut Green Bank, and the Connecticut Energy Efficiency Fund (CEEF). The website, EnergizeCT.com, serves as a consolidated source of energy information for residents, communities, and businesses.[116] The programs are developed and described in the Electric and Natural Gas Conservation and Load Management Plan (the C&LM Plan), which is revised every three years, pursuant to Connecticut General Statutes Section 16-245m. The C&LM Plan is implemented by the State's major electric and natural gas distribution companies, Eversource and United Illuminating (Avangrid), and guided by the Connecticut Energy Efficiency Board, a citizens' advisory board. The programs and solutions provided under the Energize Connecticut approach provides a wide range of energy efficiency and energy demand reduction programs for residential, commercial and industrial customers. Connecticut municipal energy cooperatives and companies similarly invest in efficiency

[116] The Companies include the Connecticut Light and Power Company (CL&P) doing business as Eversource Energy (Eversource), The United Illuminating Company (UI), the Connecticut Natural Gas Corporation (CNG), the Southern Connecticut Gas Company (SCG), and Yankee Gas Services Company (Yankee Gas) doing business as Eversource Energy.

2014-2016 Energize Connecticut Achievements

Residential Programs Savings:

- $130.4 million on an annual basis
- $1.5 billion over lifetime of upgrade
- 541.7 million annual kWh
- 9.1 million annual CCF natural gas
- 5.5 million gallons of fuel oil
- Spread across 3.2 million projects

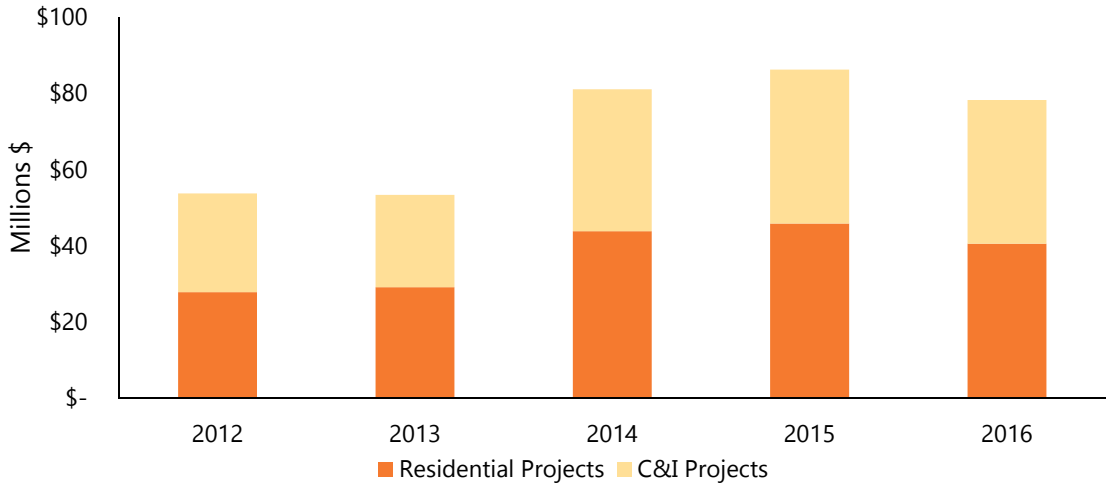
Commercial & Industrial Savings:

- $115.3 million on an annual basis
- $1.4 billion over lifetime of upgrades
- 724 million kWh annually
- 9.6 million CCF natural gas annual
- Spread across 6,528 projects

for their customers. DEEP reviews the three-year C&LM Plan, to ensure that investments are equitably distributed across all residential, commercial, and industrial customers across the state. This C&LM Plan for 2016-2018 represents $2.1 billion in benefits over the lives of the installed upgrades. The energy savings will be achieved at a cost of about 4.5 cents per kWh of lifetime electric savings, and less than 50 cents per therm of lifetime natural gas savings— making efficiency less expensive than other energy resources.[117]

Following the recommendation of the 2013 CES, Connecticut increased its commitment to energy efficiency. Public Act 13-298 amended Connecticut General Statutes Section 16-245m(d) to require approval of a budget capable of funding the Electric and Natural Gas Conservation and Load Management plan through a fully reconciling Conservation

FIGURE B9: Annual Statewide Energy Efficiency Fund Projects Total Energy Cost Savings



Source: Connecticut Energy Efficiency Board. "Annual Legislative Reports". www.energizect.com.

[117] Molina, Maggie, "The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs", Publications, American Council for an Energy-Efficient Economy, 2014, http://aceee.org/research-report/u1402

Adjustment Mechanism (CAM) of $0.003/kWh and $0.046/ccf natural gas supplementing the Connecticut C&LM Fund (the Connecticut Energy Efficiency Fund). Subsequently, the increased investments resulted in increased savings (Figure B9).

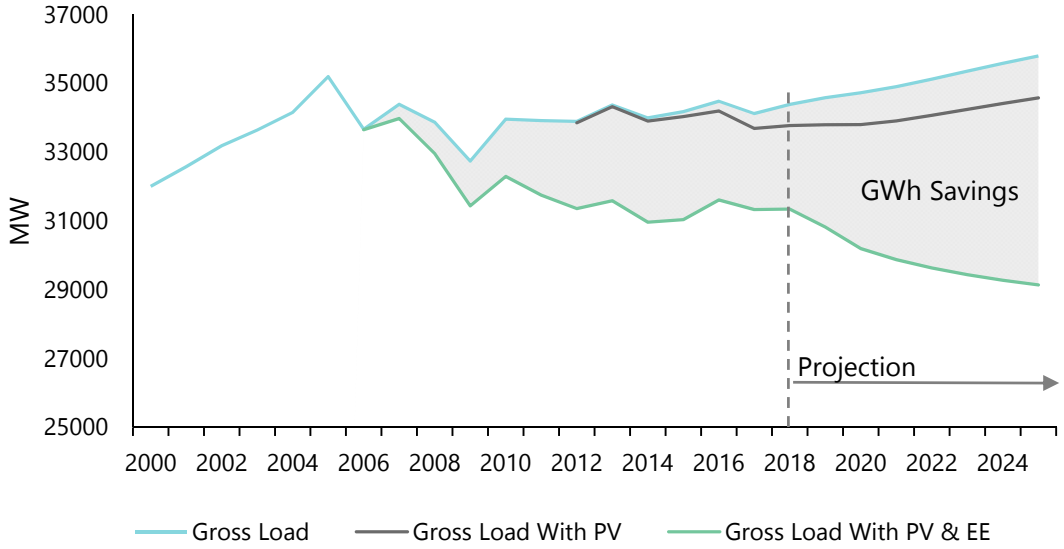
Increased funding has resulted in greater energy savings statewide. Over 80 percent of the funds collected through the CAM are reinvested back into residential, commercial, and industrial customers' homes and businesses. Since 2013, annual savings have increased by 45 percent, and the total number of projects have increased by 95 percent, allowing greater distribution of benefits statewide.[118] Continuing this investment will be necessary to maintain savings.

As highlighted in the 2013 CES, a critical next step for the C&LM Plan is to motivate residents and businesses to take deeper efficiency measures. As deeper measures can be more expensive, programs will need to continue to be refined to suit the needs of different market participants. This will inform the design of energy solution programs to address challenges such as inadequacies in access to capital among different segments, various structural, health and safety barriers, and other challenges unique to each building segment and classification.

ISO New England (ISO-NE) has projected system demand both with (the top blue line) and without energy efficiency (the bottom green line), described in Figure B10. Due to energy efficiency investments, energy demand has begun to flatten, helping to relieve pressure on the grid and minimize peak periods of fuel-intensive power generation. Importantly, over the next ten years, energy efficiency efforts are expected to eliminate growth in peak demand in Connecticut, decreasing it by about -0.4 percent annually as shown in Figure B11.

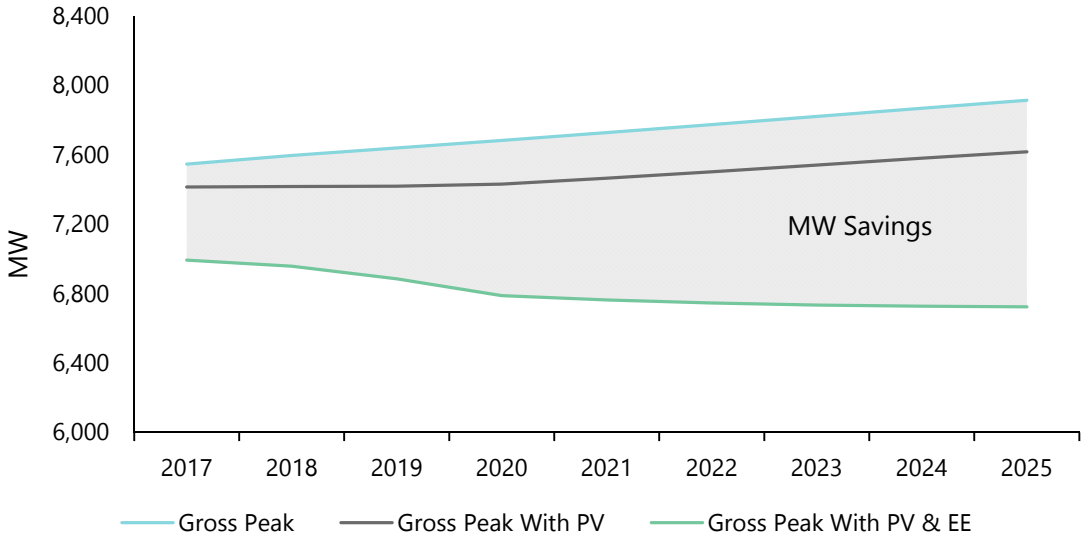
[118] Connecticut Energy Efficiency Board " Annual Legislative Reports." *www.energizect.com.* https://www.energizect.com/connecticut-energy-efficiency-board/about-energy-efficiency-board/annualreports.

FIGURE B10: Connecticut Annual Energy Demand With and Without Energy Efficiency (EE) and Solar (PV) Savings



Source: ISO New England, 2017, *2017 Capacity, Energy, Loads, and Transmission (CELT) Report.*

FIGURE B11: Connecticut Forecasted Summer Peak Demand With and Without EE & PV Savings



Continuing to reduce peak demand will become even more critical as the transportation sector is electrified to meet Connecticut's Global Warming Solutions Act targets in 2020 and 2050. Similarly, the electrification of heating systems will likely increase load and will need to be controlled, particularly during peak demand periods. Strategies that use buildings as resources to manage peak demand will therefore play an increasingly important role in Connecticut's approach to managing its energy needs.

Connecticut was recently ranked 5th out of all 50 states on the American Council for an Energy Efficiency Economy's (ACEEE) State Energy Efficiency scorecard in 2016 and 6th in 2015.[119] This ranking recognizes the State's commitment to achieving cost-effective energy efficiency goals across all sectors and the state's leadership in treating energy efficiency as a resource equally valuable as other generation sources.

[119] American Council for an Energy-Efficient Economy, "The State Energy Efficiency Scorecard", 2016, *aceee.org.* http://aceee.org/state-policy/scorecard.

PROGRESS OF 2013 CES RECOMMENDATIONS

1. Provide sufficient and consistent long-term funding for efficiency programs	
Recommendation Summary: **In order to capture the energy efficiency gains in buildings, the 2013 CES recommended increasing the funding for electric energy efficiency programs to $206 million, and natural gas efficiency to $75 million annually over the coming years. It also recommended that the State ensure that energy efficiency programs address "all fuels."**	**Key Achievements and Ongoing Plans:** • **2013:** Public Act 13-298 established fully reconciling Conservation Adjustment Mechanism (CAM) of $0.003/kWh and $0.046/ccf natural gas effectively increasing the 2014 Energy Efficiency Fund by 47 percent over 2013, bringing the total to $223.5 million. Programs amended to allow participation regardless of fuel type.
2. Revamp existing efficiency fund programs to ensure maximum impact for each ratepayer dollar spent	
Recommendation Summary **Existing and new efficiency programs should be evaluated using consistent metrics that drive innovation to reduce costs, spur participation, and extend the reach of the efficiency investments undertaken. Incentives should be continually reviewed and adjusted to provide the minimal incentive necessary to overcome barriers to participation. Additionally, private capital should be leveraged to support ratepayer funds.**	**Key Achievements and Ongoing Plans:** • **2013-PRESENT:** Programs were updated and customized to reflect customer segmentation. Energize Connecticut message and webpage are implemented to simplify and spur participation. Evaluation of incentives is ongoing. Increased statewide participation leverages increased use of private capital to complete deeper efficiency measures like insulation and efficient HVAC.
3. Develop financing programs to make residential clean energy investments more affordable	
Recommendation Summary: **The State should explore financing tools such as "on-bill" financing, low or no interest rate loan programs, and "with the Meter" debt obligation in order to relieve some financing burdens and barriers to participation in energy efficiency.**	**Key Achievements and Ongoing Plans:** • **2014-PRESENT:** Several Financing elements have been implemented, including: The utility companies begin offering Energize Connecticut Heating Loan, providing low or no interest financing for heating equipment, with electric bill repayment history serving as the only form of qualification. The utility companies also begin offering on-bill repayment, low or no-interest financing for small businesses. CHIF (now d.b.a. Capital4Change) began offering financing products for certain residential segments based on income levels and credit scores. Connecticut Green Bank offers Smart-E Loan with no money down and low interest rates for a large variety of residential energy improvements.

4. Establish commercial property assessed clean energy districts in municipalities across the state	
Recommendation Summary: **Municipalities should work with the Green Bank to pass resolutions through their legislative bodies that will enable their business and commercial residential property owners to access CPACE. Additionally, the General Assembly should consider authorizing municipalities to provide property tax exemptions for increased value of properties resulting from clean and/or efficient upgrades.**	**Key Achievements and Ongoing Plans:** • **2016:** The Connecticut Green Bank released its most current C-PACE guidelines which updated the eligibility requirements for participation, creating a provision for multifamily properties of five or more units. An opt-in statewide program for municipalities became available provided that the interested municipality passes a resolution through their legislative body and enters into a Legal Agreement with the Green Bank.
5. Develop programs to address health and safety pre-weatherization measures	
Recommendation Summary: **DEEP should work with the EEB, the utility companies, and low income advocates to develop remediation of "pre-weatherization" barriers so that owners of older housing units are able to participate in the State's energy efficiency programs.**	**Key Achievements and Ongoing Plans:** • **2015:** The utility companies began tracking occurrence and type of barriered homes during Home Energy Solutions assessments. • **2016:** The utility companies kick off Clean Energy Healthy Homes Initiative (CEHHI) barrier remediation program with $1.5 million fund and a soft cap of $10,000 per project • **2017:** DEEP and CGB participated in US DOE Clean Energy for Low Income Communities Accelerator to identify other sources of funding for barrier remediation (among other topics). DEEP, the EEB, and CGB will continue to seek financing solutions for remediation.
6. Incorporate energy efficiency measures into upgrades of state-administered housing	
Recommendation Summary: **DEEP, CEEF and the Green Bank will work to enforce energy efficiency standards in conjunction with Section 8 Housing Quality Standards to ensure that building occupants are afforded a higher quality living environment and can save money on energy costs.**	**Key Achievements and Ongoing Plans:** • **2013:** DECD received $5 million in Energy Conservation Loan Program funds, budgeted $30 million in state bond financing to assist public housing agencies to bring their residents energy improvements, established that all new units must meeting state building and energy codes, and includes "green" buildings in the growth criteria for its Responsible Growth, Livability Initiatives, and Community Impact goals.
7. Improve existing means-tested energy assistance programs	
Recommendation Summary: **Consideration should be given to modifying the Matching Payment Program for low income utility**	**Key Achievements and Ongoing Plans:** • **2013-PRESENT:** In collaboration with the Low Income Energy Advisory Board, the utility companies work to

customers to build on its best attributes and improving the program overall.	continuously improve the matching payment plan and other energy assistance programs.
8. Target funding to address split incentives	
Recommendation Summary: **DEEP will work to develop tools that promote efficient and/or clean energy improvements in multifamily properties while equitably managing the split of benefits between the owners and tenants. Such incentives could be tied to implementation of a set level of efficiency and may require some level of owner contribution and limits on raising rents**	**Key Achievements and Ongoing Plans:** • **2014:** CT Green Bank, DEEP, CT Dept. of Housing, CHFA and the utility companies initiate partnership to increase coordination CHFA and CT Green Bank announced 5 property multifamily energy efficiency pilot • **2015:** Interagency working group completed continuous improvement Lean process and capitalized on $300 million capital plan opportunity through the Governor. The utility companies modified participation agreements to increase predictability earlier in project developments • **2016:** Multifamily Partnership initiative program launched and Green Bank hired consultant to benchmark properties EEB evaluation administrator completed R157 Multifamily Initiative Process Evaluation to assess if the initiative was functioning properly and found landlords were overall highly satisfied with the program. • **2017:** 43 loans closed to date at $18.4 million with lifetime savings of more than 69 million kWh and 8 million CCF natural gas
9. Expand outreach and financing options for businesses in low-income communities to achieve energy efficiency	
Recommendation Summary: **Coordinate programs with the Office of Energy Efficient Business, the Connecticut Center for Advanced Technology, and Operation Fuel to ensure that small, largely-minority owned businesses in urban centers have access to energy efficiency opportunities that can economically benefit them.**	**Key Achievements and Ongoing Plans:** • **2013-Present:** Office of Energy Efficient Business DEEP and the utility companies provide a consolidated information source for businesses at EnergizeCT.com, and, in partnership with the Connecticut Center for Advanced Technology, Operation Fuel, and the Connecticut Green Bank, administer targeted outreach initiatives that provide individualized education regarding energy billing, explain available energy reduction programs, and conduct basic energy audits at small businesses in targeted communities, including distressed communities.
10. implement decoupling to align natural gas utility incentives with energy efficiency	
Recommendation Summary: **Public Act 07-242 decoupled electric revenues from volume of sales, but no decoupling mechanism was**	**Key Achievements and Ongoing Plans** • Electric Decoupling completed • Natural Gas Decoupling underway

implemented for the natural gas utilities. Flip the incentive to separate the utility companies' revenues from their sales by volume, so as to remove the disincentive for them to promote efficiency. This should be accomplished through performance incentives or a performance-based return on equity.	
11. Adopt and enforce latest codes and standards to ensure high-performing buildings	
Recommendation Summary: **The State must adopt and enforce the latest International Energy Conservation Code for residential buildings and the American Society of Heating, Refrigerating and Air Conditioning Engineers Standard 90.1 for commercial buildings as required by statute. Additionally the state should work to provide adequate training to local building inspectors on a regular basis to ensure uniform enforcement statewide.**	**Key Achievements and Ongoing Plans:** **2016-2017:** Effective Oct. 1, 2016 Connecticut adopted the 2012 International Energy Conservation Code (IECC) and is in the process of adopting the 2015 IECC.
12. Work with regional organizations to support stricter federal product efficiency standards	
Recommendation Summary: **DEEP will take a more active role within the Northeast Energy Efficiency Partnership's role in reviewing proposed Federal standards for recommendation of the strictest practical standards**	**Key Achievements and Ongoing Plans:** • **2017:** Connecticut reaffirmed its partnership and support of the Northeast Energy Efficiency Partnerships in January 2017 by providing funding and research advocacy across a range of energy topics including product efficiency standards.
13. Empower consumers with information about efficiency benefits	
Recommendation Summary: **Residential marketing efforts should focus on increasing awareness about the Home energy Solutions program, engaging home performance contractors, available programs and contractor networks, low cost financing, and the benefits of these services, towards homeowners, landlords, and tenants to inform them about the relative efficiency of their home and opportunities to improve it.**	**Key Achievements and Ongoing Plans:** • **2013-2015:** 2013-2015 C&LM Plan outlined multiple push/pull marketing mechanisms for residential programs • **2015:** 2016-2018 C&LM Plan is released and outlines both marketing strategies and contractor training, education, and outreach programs relevant to residential projects. • **2016:** The utility companies and CT Green Bank launch comprehensive and enhanced marketing program to drive performance of residential energy programs and increase their uptake.
14. Train professionals on code compliance and efficient building design and constructions	
Recommendation Summary: **The Strategy supports continued funding of educational and training efforts and collaboration with higher education institutions and regional**	**Key Achievements and Ongoing Plans:** • **2013:** 2013-2015 C&LM Plan outlined strategies for increasing energy workforce development.

organizations to ensure building code training is comprehensive and widely distributed.	• **2015:** Governor declared October 12-18 as Careers in Energy Week and collaborated with Connecticut Energy Workforce Consortium • **2015:** DEEP completed Clean Energy Workforce Assessment to inventory training programs and identify gaps in availability of training and certification • **2016:** The Utility companies implemented 2016-2018 C&LM Plan outlining workforce development strategies for technical high schools, and technical and professional training
15. Empower building owners to market their energy efficiency improvements	
Recommendation Summary: **The Strategy recommends the development and use of a residential building energy use labeling program on a voluntary, pilot basis to help buyers make informed decisions and reward homeowners that invest in efficiency. Additionally, legislation should be considered that requires landlords to provide energy cost data to tenants in units where the tenant pays the energy bill. An energy performance label for both residential and commercial buildings should also be adopted.**	**Key Achievements and Ongoing Plans:** • **2015:** Connecticut became a partnering state in the Northeast Energy Efficiency Partnerships' Home Energy Labeling Information Exchange (HELIX) program. This three year process will result in a platform that allows the exchange of energy data generated through efficiency projects to be used in the real estate market. • **2016:** Continued work on HELIX program and teams with CT Green Bank to begin delivering education and outreach to local realtor associations and the MLSs. CT became the first state to implement the Department of Energy's Home Energy Score labeling system on a statewide voluntary basis through the utility HES and HES-IE programs. • **2017:** NEEP released RFP to begin design phase of HELIX. Connecticut surpassed 21,000 DOE Home Energy Scores

GOALS AND RECOMMENDATIONS

The Comprehensive Energy Strategy goals for Connecticut's building sector primarily focus on the efficiency of building systems and capitalizing on innovative strategies to meet the state's targets. The goals point to supporting both the continuation of existing practices, and the advancement of advanced opportunities to continue Connecticut's leadership in smart energy use.

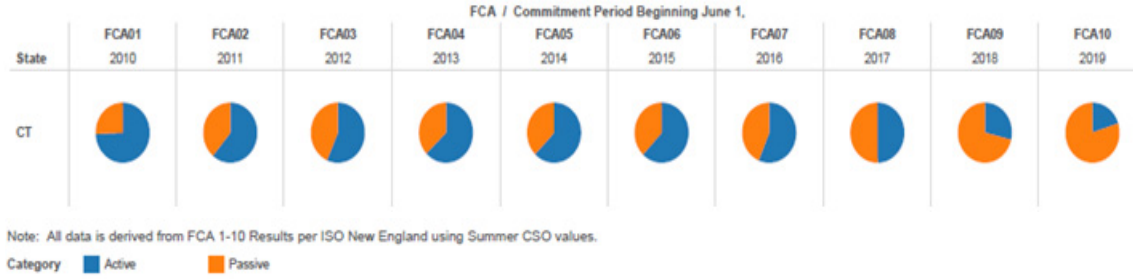
Goal 1: Prioritize energy savings as both a financial and energy resource.

B.1.1 Procure energy efficiency as a resource.

Continue Supplying Energy Efficiency as a generation resource to the Forward Capacity Market

The ISO-New England counts Connecticut's energy efficiency commitments toward the region's installed capacity requirement (ICR)120 in the same way the capacity sold by generators is counted. The 50 megawatts annually committed from Connecticut's utilities to the regional grid from the ISO-New England Forward Capacity Market (FCM) auctions in February each year are based on energy efficiency investments in Connecticut's homes and businesses that deliver savings for multiple years. The ISO-New England Forward Capacity Market by design brings a diverse mix of the lowest cost energy sources to the market. Energy efficiency (also known as passive demand response) and active demand response provide beneficial energy resources at competitive prices to the regional electricity grid through the FCM reconciliation process.

FIGURE B12: Connecticut Active/Passive Demand Response over Time



Source: ISO New England, n.d., *Forward Capacity Market,* https://www.iso-ne.com/markets-operations/markets/forward-capacity-market.

[120] The ICR measures the installed electricity resources projected to be necessary to meet reliability standards and satisfy peak demand for New England.

Connecticut energy efficiency achievements generate revenue in the FCM, and ratepayers benefit due to reduced infrastructure demand, which can drive down energy rates.

In October 2015, the United States Supreme Court affirmed FERC Order 745 and held that FERC does have authority to set compensation rules for demand response resources bidding into the market.[121] This ruling held that the megawatt hours of electricity avoided through energy efficiency will receive compensation equal to that received by the megawatt hours of electricity generated by power plants.

Connecticut has consistently increased its commitments to passive demand response (DR) through energy efficiency year over year since 2010, and should continue that trend (Figure B12) as well as continuing to expand active demand response or management programs.

Active demand response reduces the demand for electricity from the bulk power system by using strategies like installing energy-efficient equipment, controls powering down or shutting off equipment, and using on-site electricity generation.[122] Improvements in two-way communication are providing increasingly customizable demand response programs that have the potential to reduce demand. The combination of energy efficiency and demand response programs has the potential to realistically reduce growth in consumption. Provided sustainable financing and commitments are kept in place, ensuring certainty for energy efficiency and demand response programs, the consumption growth rate can be reduced.

Continue Including Energy Efficiency in Procurements of Utility Scale Clean Energy

Connecticut General Statutes Section 16a-3a, which requires Connecticut to implement an Integrated Resources Plan, requires the acquisition of energy resources in an ordered priority. Specifically, the law requires that energy resource needs "shall first be met through all available energy efficiency and demand reduction resources that are cost-effective, reliable and feasible. The projected customer cost impact of any demand-side resources considered pursuant to this subsection shall be reviewed on an equitable basis with non-demand-side resources." This efficiency resource standard means that energy efficiency is on equal footing for consideration as other sources of energy supply. Connecticut General Statutes Section 16-245m further requires that the state's Electric and Natural Gas C&LM Plan "shall include a detailed budget sufficient to fund all energy efficiency that is cost-effective or lower cost than acquisition of equivalent supply, and shall be reviewed and approved by the [DEEP] commissioner."

[121] FERC v. Electric Power Supply Ass'n, 577 U.S. ___ (2016)

[122] ISO New England, n.d., *Glossary and Acronyms,* https://www.iso-ne.com/participate/support/glossary-acronyms#d.

While such direction has resulted in important investments in efficiency, an even more direct manifestation of the role of efficiency in managing energy demand is occurring through the direct procurement of energy efficiency as a resource to meet Connecticut's energy demand. In May 2016, DEEP issued a request for proposals (RFP) for long term contracts of renewable projects less than 20MW or energy efficiency projects of any size. Out of 100 submitted bids, 25 were selected, providing a total of 401.99 MW of clean energy capacity, with 34 MW from energy efficiency projects. Bringing efficiency procurements into our generation mix allows for a more equitable distribution of benefits to those who contribute to the Energy Efficiency Fund. DEEP recommends that future RFPs for clean energy procurement continue to seek and consider energy efficiency projects and increase the participation of such projects.

B.1.2 Enhance competitiveness of Connecticut's businesses with customized energy efficiency investments.

Connecticut's commercial and industrial businesses spend nearly $4 billion annually on energy costs. Investment in energy efficiency upgrades presents an opportunity to lower these costs and improve bottom lines, or to use these cost savings as capital investment in other improvements. The United States Environmental Protection Agency's ENERGY STAR program estimates that businesses can cut energy costs by 10 to 30 percent by investing in technologies like high efficiency HVAC, lighting upgrades, building management systems, strategic building design, and more.[i] These upgrades can also improve longevity of equipment by reducing idling time, and reduce GHG emissions. They can also have additional benefits in improved productivity and healthier work environments.

However, each business faces different challenges and requirements based on their location, financial status, energy usage, and business type. By segmenting commercial and industrial businesses based on these characteristics, contractors can better understand these challenges and can customize how to help Connecticut businesses find the most cost-effective energy efficiency improvements that will produce the greatest energy savings.

Additionally, segmentation provides insight for correlating total energy savings with how each segment of commercial and industrial customers is pursuing energy efficiency. This allows policy makers to allocate appropriate funding to individual commercial and industrial, such as energy intensive manufacturers, or targeting sectors that are growing rapidly. By focusing on improving these segments' energy efficiency, Connecticut can help commercial and industrial customers to save money on their utility bills, increasing Connecticut's competitive edge in business and industry. Understanding these customer segments and their different barriers is the first step in recommending strategies to reduce energy demand.

B.1.3 Reduce the energy affordability gap in low-income households.

Many entities provide energy bill assistance and financing for efficiency projects for low and median income households. The utility companies, the federal and state housing departments, the Connecticut Housing and Finance Authority, and other entities such as Capital 4 Change, Operation Fuel, and the Connecticut Green Bank all focus on closing the affordability gap for low-income residents.[123] Through continued coordination of these resources, Connecticut will simultaneously improve access to energy efficiency and clean energy, reduce energy consumption and reduce the affordability gap, while drastically improving the lives of many of its at-risk citizens.

Coordinate Energy Assistance and Energy Efficiency Investment to Maximize Affordability Gap Reduction

Coordination of service delivery between energy assistance and energy efficiency providers is essential to sustainably reducing energy bills in low-income homes. Continued data sharing will help to and identify gaps in services so that more homes can be reached. The HES-IE program currently assesses and provides on the spot air sealing and efficiency upgrades to approximately 20,000 low-income homes each year. Using data sharing to better target such efficiency programs to the Low-Income Home Energy Assistance Program (LIHEAP) homes with the highest home energy consumption levels would enhance efforts to reach homes with the highest energy burdens. Recent work on such data sharing by the utility companies and the Department of Social Services is expected to enhance an understanding of the energy burden of the state's low-income residents, and such efforts must be supported and continued. Coordination between the utility energy assistance and efficiency programs to work more proactively with low-income households that have high energy burdens to resolve affordability problems before they become bill payment problems is a strategy recommended by a 2016 report prepared for Operation Fuel, Inc.[124] that would help close the affordability gap.

[123] Several programs provide aid to low income households in energy saving improvements, including the US Department of Energy's Weatherization Assistance Program for Low-Income persons (WAP), administered by CT DEEP, the US Department of Health and Human Services' Low-Income Home Energy Assistance Program (LIHEAP), administered by the Connecticut Department of Social Services, and the Energize Connecticut HES-IE home weatherization program, administered by the electric and natural gas utilities (Eversource and United Illuminating/Avangrid), as well as non-profit organizations such as Operation Fuel.

[124] Applied Public Policy Research Institute for Study and Evaluation. 2016. *Meeting the Energy Needs of Low-Income Households in Connecticut.* Operation Fuel, Inc.

Increase Access to Affordable Clean Energy in Low-Income Communities

Connecticut's Renewable Portfolio Standard's (RPS) goal of 20 percent Class I renewable power by 2020 is inclusive of all Connecticut communities.[125] Renewable energy can help to significantly reduce or even eliminate energy bills in households struggling with energy affordability. In 2015, DEEP was authorized to procure renewable energy on behalf of all electric customers. Such procurements provide a cost-effective source of renewable energy, ensuring that all customers are participating in the use of utility-scale renewable energy. Additionally in 2016, Connecticut began offering an affordable financing and solar lease product through the Connecticut Green Bank. This product combines energy efficiency and renewable energy generation installation to maximize energy and cost savings without high upfront costs. DEEP continues to move forward with the implementation of a shared clean energy pilot program to evaluate a broader framework to deploy clean energy to low-income households.

Additionally, Connecticut has been a key participant in the Clean Energy for Low-Income Communities Accelerator (CELICA), sponsored by the federal DOE and the National Renewable Energy Laboratory (NREL). This program has provided an avenue for states to share policy outcomes and work together to increase availability to vulnerable communities. Participation in the Accelerator has enriched Connecticut's ability to better target multifamily customers as a way to reach the low to moderate income customer base and improve energy affordability for the households in it. DEEP and the Connecticut Green Bank will continue to represent Connecticut in this federal Accelerator initiative to move towards even greater equitable distribution of renewable energy integrated with energy efficiency across the state.

Allocate a Portion of Federal Energy Assistance Funds to Invest in Energy Efficiency

Currently, the U.S. Department of Health and Human Services provides funding to states to help decrease the energy affordability gap in qualifying homes through the Low-Income Home Energy Assistance Program (LIHEAP), by providing income-based assistance to pay energy bills. DEEP recommends allocating a portion of available funding towards energy efficiency and related health and safety issues to help these households weatherize their homes. This will reduce the extent of energy assistance needed in the future and help to stretch limited federal dollars.

[125] See C.G.S. §16-1(a)(20) for definition of Class I renewable energy.

B.1.4 Improve financing programs to increase access to clean and efficient energy improvements.

Mainstream Avoided Costs as a Financing Resource

The avoided energy costs produced through energy efficiency investments are more than just a benefit, they provide a valuable financial resource that can be reinvested into building upgrades to produce even greater savings. Making that message clear in financing projects can help increase access and participation in energy efficiency programs. In particular, consistent with national practices, guaranteed energy savings performance contracts should be recognized as cost neutral, to ensure flexibility in the range of financing products used in such work.

Encourage Integration of Energy Efficiency Product Financing With Renewables to Achieve the Most Cost-Effective Savings

As more Connecticut residents and businesses turn to renewable energy to meet their needs, energy efficiency should be promoted as a companion strategy. By first reducing energy consumption through energy efficiency measures, renewable generation system can be properly sized without adding more cost than needed. Currently, to use solar installation incentives, the Green Bank requires homeowners to first participate in an energy assessment before actually installing the system. However, as solar becomes more affordable, consumers may begin to rely less on such incentives, and therefore may skip this step simply out of lack of awareness. Any such public financing should continue to implement the current practice of coordinating with the utility energy efficiency contractors to ensure that energy efficiency assessments by qualified providers are conducted prior to financing with public funds and prior to installation of renewable energy generation sources.

It is important that Connecticut's solar installation industry and the Connecticut Green Bank continue to educate residents on the importance of this integration when preparing financing packages to maintain energy consumption reductions, and to save residents money. Connecticut should advance education and outreach efforts to ensure programs are integrated to foster the implementation of deeper energy savings measures as this is necessary for achieving our energy and greenhouse gas emission goals.

Continue Targeting Upstream Incentives at the Most Effective Point in the Supply Chain

In order to mainstream the availability of the most efficiency equipment and technologies in insulation, HVAC, water heating, and more, DEEP recommends that incentive and rebate programs are carefully evaluated to identify the point in the supply chain that will catalyze the greatest demand. Providing upstream incentives can help offset retailers' time, promotional efforts, and

improve margins, thus reaching more consumers, driving demand and creating greater access to these products.[126] Additionally, transitioning retail products to an upstream model can more cost-effectively deliver a higher quantity of products, further benefiting ratepayers.

Support Implementation of Residential Property Assessed Clean Energy (R-PACE), Coupled with Energy Efficiency Provisions

DEEP encourages the Connecticut Green Bank to continue making progress towards establishing residential property assessed clean energy (R-PACE) in Connecticut. In it's 2016-2017 Comprehensive Plan, the Connecticut Green Bank recommended an R-PACE program that is closely modeled after the established Commercial Property Assessed Energy Program (C-PACE).[127] R-PACE could benefit residents by addressing residential financing gaps not yet filled by other clean and efficient energy financing tools, provided consumer protections are in place and residents are fully informed of all obligations and alternative options. Any such policy should incorporate US Department of Energy guidelines for R-PACE and should continue to implement the current practice of coordinating with the utility energy efficiency contractors to ensure that energy efficiency assessments by qualified providers are conducted prior to financing with public funds and prior to installation of renewable energy generation sources.

Customize Financial Mechanisms for Commercial and Industrial Subsegments

Energy efficiency and clean energy investment on the commercial and industrial level are often on a larger scale and require greater investment. Appropriate financing solutions should be provided to each commercial and industrial subsegment to maximize access to the savings measures businesses can use to decrease and manage their energy use.

- Small-Scale Commercial and Industrial Energy Efficiency Projects

  For small businesses, the utility based incentive program, Small Business Energy Advantage, has been highly successful for businesses to complete simple and short-term payback energy efficiency projects. However, this program is designed mostly for single measure projects with a two to four year return on investment, and has a cap per energy account, which does not allow for more measures to be implemented. Additional capitalization is needed to fully serve potential participants. While the utility companies have traditionally sought and provided capital for financing these small-scale projects, the

[126] U.S. Environmental Protection Agency, n.d., *How to Use Midstream Incentives to Promote ENERGY STAR Certified Consumer Electronics,* www.energystar.gov.

[127] Through C-PACE, property owners can access financing for clean and efficient energy upgrades to their buildings through a charge on their property tax bill. It spreads the payment of the costs over the expected life of the improvement and since payments are tied to the property tax bill, payments are considered to be secure, less risky, and can be achieved with little or no financing.

Connecticut Green Bank could also take on this task of capital provision as part of its role in providing financing for clean and efficient energy for Connecticut. Together, the Connecticut Green Bank and the utility companies should continue to identify alternative capital investment sources to lower costs, promote more comprehensive projects, and have longer-term payback measures. Additionally the Energy Efficiency Board and utility program administrators must continue to improve the experience of businesses that are not currently participating in energy efficiency programs with the Customer Engagement Platform tool the utility companies have developed.

- Medium to Large Commercial and Industrial Energy Efficiency Projects

Continued investment in deep energy efficiency improvements for medium to large businesses requires customized incentives and financing strategies that identify and address these customers' barriers to participation. This identification will improve and ensure cost-effectiveness of this segment's energy investments. Increasing the savings for the medium and large businesses will allow them to benefit from the efficiency programs' financing support, and will encourage projects to be more comprehensive. Lastly, Connecticut should continue integrating energy efficiency, demand management programs and Connecticut Green Bank financing products to acquire cost-effective energy efficiency and renewable deployment. This can be accomplished through attractive financing incentives for bundling measures, or continued education and increased awareness of the benefits of these integrations for this subsegments building owners and operators.

- Government Buildings

Many government agencies at the federal, state, and local level lack the technical and financial resources to identify and implement sustainable investments in efficiency upgrades. The government segment has different capital limitations than other commercial and industrial customers including statutory limitations on how and when capital can be raised. These constrain government buildings from accessing energy-efficiency funding and requires customized financing solutions.

Energy efficiency investments have saved Connecticut's state agencies millions of dollars annually, and should be advanced at a larger scale. We need sustained investment at the state level to continue these savings. To achieve savings, DEEP should maintain an interagency working group with the Department of Administrative Services and the Office of Policy and Management, the key state agencies charged with managing state properties, to allow DEEP to implement the state plan to reduce energy consumption in state buildings. DEEP and the Connecticut Green Bank, in collaboration with the Office of the Treasurer, must identify a sustainable financing mechanism that will increase the

investment in energy efficiency and reduce energy waste in state facilities. DEEP should consider following the federal energy management program's practice of using guaranteed energy savings performance contracting to finance comprehensive projects, treating such financing as cost neutral. Continued action is needed from the Connecticut Green Bank to develop financing mechanisms for guaranteed energy savings performance contracts as well as financing mechanisms for small and medium scale energy saving projects and renewable generation installations at state facilities.

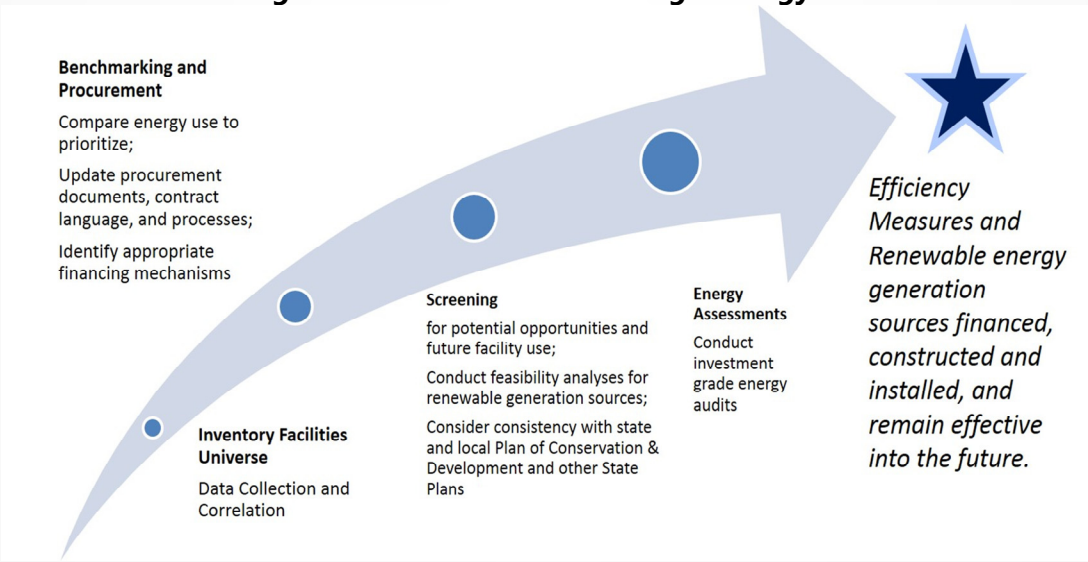
Additionally, the Connecticut Energy Efficiency Board and the Connecticut Green Bank board should support statewide investment in energy data management improvements, and work to increase electronic state energy-use data transfer between the utility companies and the state's data analysis platform as well as U.S. EPA's Portfolio Manager Platform. This would build upon the recent accomplishment of data transfer capability that the utility companies have achieved in electronically feeding data to the U.S. EPA's Portfolio Manager Platform and into the state's platform for state buildings.

Finally, DEEP and the Connecticut Green Bank should continue planning for financing renewable generation sources such as anaerobic digestion, geothermal, and solar generation facilities, combined with storage, as well as financing feasibility analyses. DEEP remains committed to ensuring that development of renewable generation sources at state properties are consistent with local and state Plans of Conservation and Development.

Lead By Example

As part of a broader effort to model environmentally preferable practices, since 2013, the inter-agency team of DEEP, the Department of Administrative Services, the Attorney General's Office, the Office of the Treasurer, the Office of Policy and Management, the Connecticut Green Bank, the companies, and others, have advanced the "Lead by Example" energy management programs, including customized initiatives and financing mechanisms to reduce energy use in state buildings. DEEP has developed an implementation pathway to reduce energy costs from state buildings, as illustrated below (Figure B13)

FIGURE B13: Reducing Connecticut's State Buildings' Energy Costs



Source: Connecticut Department of Energy and Environmental Protection, 2016.

- Municipalities and Clean Energy Communities

The companies' Clean Energy Communities program has helped the 154 participating communities together have saved more than 1.7 billion kWh and 18.6 million ccf from their energy efficiency and renewable energy efforts.[128] This has resulted in 926,806 tons of avoided emissions of CO_2.[129] DEEP recommends continuing this approach to engaging municipalities, and encouraging continuous improvement of the approach through feedback from municipalities will ensure that municipalities achieve their goals.

[128] This program provides technical benchmarking support and energy-efficiency expertise to municipal buildings and boards of education as well as hands on training for building analytics and energy intensity reporting, as well as training in US EPA Portfolio Manager.

[129] Connecticut Energy Efficiency Fund. 2016. *Energy Efficiency Board 2015 Programs and Operations Report.* Energize Connecticut.

B.1.5 Maximize consumer demand for energy efficiency by increasing awareness and understanding of its value.

The Customer Engagement Platform

The Customer Engagement Platform (CEP), an on-line tool provided by Eversource and United Illuminated that allows businesses and residents to create a profile, receive energy saving recommendations, and access Energize Connecticut programs. This tool allows businesses and residents to compare their current energy consumption to other similar businesses to see how well their building is performing.

The CEP tool is designed to cost-effectively prompt actions that produce the most energy savings and investments in energy efficiency. This tool empowers businesses to take control of their energy usage and make smart decisions on how to increase their energy efficiency. The CEP will contribute towards educating the public and improving the awareness of energy efficiency programs that are offered while increasing customer satisfaction.

In order to keep the momentum Connecticut has gained in energy efficiency, it is imperative that market demand remains high. Trends point to a healthy growth in consumer demand for energy efficiency, but there are still obstacles to overcome and opportunities for policymakers to catalyze this progress.

Marketing and Education Outreach Programs

Connecticut's tools and opportunities to change the energy future for its residential buildings are numerous and robust. However, they are also complex to the average person. The final link is in educational outreach and marketing to its citizens. Ultimately, they are the ones who decide to install energy efficient measures. They are motivated to do so by classic market drivers like price points, advertising, and interactive programs. Bringing the market to the desired scale will be challenging if the customers do not understand the value. Greater marketing investments have been approved through the C&LM plan to reach mass business and residential markets and target specific ones. Media channels include radio, television, and internet advertisements, events, co-ops, direct response, and public relations and the Customer Engagement Platform (CEP). DEEP supports the increased promotion of energy efficiency programs and public education campaigns on how consumers can take control of their energy use.

Real Estate Market Integration

The Value of Energy Efficiency in the Real Estate Market

Multiple studies have found measurable, beneficial impacts of energy efficiency on the residential real estate market. Their findings are summarized below

- **Griffin (2009):** Certified homes in Portland, OR, sold for an average of 4.2 percent more and 18 days faster compared to non-certified.
- **Mosrie (2011):** Green buildings resist downward housing trends and their prices per square foot have steadily increased since 2007
- **Kok, Nils & Kohn (2012):** Home energy efficiency is more valuable at time of sale in extreme climates compared to more mild ones.
- **Springer (2015):** Every $1 of annual energy savings equates to $15-$20 at the time of sale
- **Elevate Energy (2015):** Study on Chicago homes found that homes that disclosed energy costs spent 43 days on the market and a 66 percent closing rate while homes that did not spent 63 days at a 53 percent closing rate.
- **National Association of Realtors (2015):** Energy improvements are investments found to bring "joy" in addition to increased comfort and financial benefits.

Residential real estate in particular poses one of these opportunities. Recently, an increasing amount of research is revealing that more and more homebuyers are willing to pay a premium for energy efficient homes.[130] Energy efficient improvements are not just a cost-saving or safety measure, but a value-adding home improvement in the way that installing a granite countertop or a swimming pool might be. In fact, studies have shown energy efficient certified homes can sell at 3 percent to 20 percent more than comparable properties.[131] The more people recognize this, the more energy efficiency upgrades increase and thus energy consumption, prices and emissions can fall.

The problem that remains is how to value these improvements, and translate that value to realtors, appraisers and home buyers. A lack of or false representation of a residential property's energy elements can cause it to be underpriced or overpaid for.[132] Many energy-saving improvements like insulation and air sealing are virtually invisible until a homebuyer sees the utility bills, and they may not ask to see those before buying. Even if they do, appraisers and realtors may not know how to inspect for these features or be able to provide

[130] Salzman, Maddy . 2016. *Green Labels in Real Estate Literature Review.* United States Department of Energy.

[131] United States Department of Energy Better Buildings. 2015. *Capturing Energy Efficiency in Residential Real Estate Transactions* . United States Department of Energy.

[132] The Green MLS. 2012. *Step-by-Step Recommended Process.* http://www.greenthemls.org/step-step-process.

information, due to a lack of standardized reporting, third-party verified certification and education.

The goal is that buyers will expect the home they want to be energy efficient and have affordable energy bills in the same way they expect the foundation to be structurally sound and the plumbing to work. Encouraging and empowering homeowners to improve their energy efficiency, and therefore their competitiveness in the real estate market, will help to increase the scope and scale of energy efficiency benefits. The following recommendations aim to achieve this:

- Track Inventory of Energy Efficient Homes and Coordinate with State Programs

  By tracking the quantity of energy efficient homes, or homes with energy efficient or clean energy features, it will be much easier to demonstrate the growth in demand to real estate professionals. With the utility companies already tracking the number of participants through the HES and HES-IE programs, efficiency rebate and financing uptake, HEScore, and more, Connecticut is on track to build up this inventory and should continue to do so.

  More importantly, the utility companies should begin to prepare the housing stock for integration into more sophisticated data reports by acquiring homeowners' authorization to share energy related information about their homes. DOE recommends offering an "opt-out" option to homeowners at the time of their HEScore in order to maximize participation and to build up the stock of data.

- Collaborate with the MLS to Integrate Energy Efficiency Data Fields

  The next step is for Connecticut's energy efficiency programs to partner with the local Multiple Listing Service (MLS) to develop fields where energy and efficiency data can be recorded about a property, including, but not limited to, the HEScore. The Appraisal Institute's Residential Green and Energy Efficiency Addendum identifies six elements of homes' green features with over 35 fields for data input that can be used in this intention.[133] The MLS is the primary property listing platform nationwide and provides a swift channel to integrating energy efficiency into real estate sales. All stakeholders need to be engaged, often in different methods in order to fully capture the potential market driver this can provide. In order to establish these fields, energy efficiency program administrators should build a relationship with a leader in the local real estate community

[133] Appraisal Institute . 2013. "Residential Green and Energy Efficient Addendum ." *https://www.appraisalinstitute.org.* January. https://www.appraisalinstitute.org/assets/1/7/AI_820_04-Residential_Green_and_Energy_Effecient_Addendum.pdf.

who is dedicated to selling the value of energy efficiency in home buying. This relationship will help to facilitate communication with the local Board of Realtors and thus, the MLS.

The National Association of REALTORS® (NAR) and NAR's Green REsource Council Green MLS Implementation Guide outlines actions states can take to identify and technical needs of MLS staff and how to implement the green entry data fields defined by the Real Estate Transaction Standard (RETS) Data Dictionary. It bridges the gap between the Green MLS Tool Kit, which is designed for real estate professionals, and the Data Dictionary, which is used by technology experts. Connecticut should refer to this guide and implement its recommendations as it advances its real estate industry.

- Develop IT Solutions to Efficiently Transfer Data

DEEP anticipates that there will be technological challenges during initial set up of the Green Fields in the MLS. The enormous variety of features, materials, designs, appliances, etc. can create complications not only when designing a set of green fields, but also with trying to keep pace as practices and technologies evolve. Extra awareness and solutions should be prepared that will allow flexibility and adaptability for the fields.

The Green MLS Implementation Guide recommends a set of preliminary actions for public records aggregators to auto-populate fields through data collection from third-party certifications such as LEED for Homes or BPI-2101Standard Requirements for a Certificate of Completion for Whole-House Energy Efficiency upgrades. Streamlining data entry from these sources can accelerate and improve the efficiency of this process by avoiding the need to repeat efforts.

- Build Relationships with Other Key Real Estate Industry Participants through Education and Other Services

Likewise, a relationship with the real estate community as a whole should be made. For any score or piece of data on a home's energy consumption to be useful, it needs to be understood. This Strategy recommends design and implementation of educational programs for realtors and appraisers on valuing and translating this data. In 2016 the Department, the Energy Efficiency Board, the Connecticut Green Bank, and the utility companies initiated sessions with the Greater Hartford Association of Realtors. A more focused lesson plan for understanding the HEScore and other energy efficiency home technology should be prepared and taken statewide. Additionally, a resources page should be made available to this community on the EnergizeCT website that can direct them to resources such as presentations, studies, educational opportunities and other tools.

Education is vital to the success of this recommendation and maintaining market demand, but should also provide some kind of incentive to real estate professionals to encourage participation. Recognition for completing education should be given to these professionals as it will also help homeowners to find and use green real estate agents, appraisers and inspectors when buying and selling a home.

- Coordinate the Current Workforce Development Plan with Real Estate Integration to Expand the Professional Network Support System

As demand and understanding of energy efficiency increases across all fields, the workforce capacity must also increase at the same rate. The 2016-2018 C&LM plan outlines the utility companies' plan for workforce development of technically skilled energy management professionals. For the State to truly operate as an energy efficient economy, Connecticut should prepare people for careers as green realtors, green assessors and building inspectors.

For example, DOE, DEEP and the utility companies plan to utilize workforce development funds to offer Building Performance Institute (BPI) certification training course in conjunction with 2012 IECC training for building inspectors, ensuring that inspection of Connecticut's residential building stock for energy code compliance is distributed across a greater number of qualified building professionals.

B.1.6 Evaluate current cost-effectiveness testing methods for accurate reflection of all resource costs and benefits.

Cost-benefit testing procedures strongly influences understanding of the cost-effectiveness of existing and proposed energy efficiency measures. Improvements in these testing procedures can provide greater transparency of Connecticut's energy-efficiency policies and programs. Connecticut's testing procedures need to more fully reflect the state's energy and environmental goals. The emerging "resource value" framework is an approach that could be employed to evaluate the effectiveness not just of energy efficiency as a supply resource but ultimately other energy sources as well.

Connecticut currently uses the Utility Cost Test, supplemented with variants of the Modified Utility Cost Test and Total Resource Cost Test. Nationally, reforms in cost-benefit testing have been initiated by numerous regulated utilities in the Northeast as well as development of a new conceptual framework in the *National Standard Practice Manual* issued by the National Efficiency

Screening Project in early 2017.[134] DEEP expects to continue assessing the various approaches other states have developed and will provide direction to the Energy Efficiency Board and the utility companies prior to the development of the next three–year C&LM Plan.

Indicating that they "support improvements to their cost-effectiveness methodology to account for all benefits derived from energy-efficiency measures and programs," Connecticut's utilities are prepared to undertake significant improvements in testing procedures, guided by the state's energy policy and by the Energy Efficiency Board and DEEP. The utility companies have pledged to identify and quantify non-energy impacts that could be incorporated in other programs.[135]

A process is needed for continuous improvement of Connecticut's testing method in light of recommendations in the *National Standard Practice Manual,* which outlines a framework for documenting the policy goals and identifying universal principles such as transparency, symmetry in accounting for costs and benefits. DEEP should work with the utility companies, the Energy Efficiency Board, and stakeholders to monitor regional and nationwide developments and further inform the utility companies' cost-benefit testing procedures to make them capable of more fully supporting the state's overall energy efficiency and emissions goals.[136]

B.1.7 Ensure equitable efficiency investment for delivered heating fuel customers through equitable conservation charges.

To provide equitable investment in efficiency programs that benefit buildings using oil and other deliverable fuels, an additional contribution plan for these customers should be implemented. Currently, electric and natural gas customers pay a small monthly fee on their bills to support efficiency programs that help families and businesses take steps to reduce their monthly bill for power and heat.

Oil and propane heat customers currently benefit from access to efficiency measures through the Electric and Natural Gas Conservation and Load Management Plan, however they do not contribute into the Connecticut Energy Efficiency Fund for their heat as customers who pay for electric and gas heat do. Heating oil and propane customers are therefore subsidized by

[134]National Efficiency Screening Project, National Standard Practice Manual for Assessing Cost-Effectiveness *of Energy Efficiency Resources,* 2017, https://nationalefficiencyscreening.org/national-standard-practice-manual/.

[135] Eversource Energy; The United Illuminating Company; Connecticut Natural Gas Corporation; The Southern Connecticut Gas Company. 2015. *Connecticut General Statutes Section 16-245m(d) 2016-2018 Electric and Natural Gas Conservation & Load Management Plan.*

[136] This effort began with a regional cost-effectiveness screening workshop sponsored by the Northeast Energy Efficiency Partnerships and the CT Energy Efficiency Board and hosted by DEEP in June 2017. It is expected to continue with a state-level review throughout 2017, with the potential for revisions to the current Conservation and Load Management Plan in fall 2017, or for the next three-year plan in 2018.

customers of electric and natural gas utilities, because propane and heating oil customers are not paying into that fund for their heating consumption. This raises an equity issue as electric and gas customers are subsidizing efficiency work for oil and propane customers in an inequitable fashion, particularly given that approximately 44% of Connecticut residents currently heat with heating oil.

To provide equitable distribution of efficiency programs and investments for homes using oil and other deliverable fuels, an additional contribution plan for these residents should be implemented. This more equitable approach would assess a conservation charge on oil and propane consumption. In 2013, DEEP recommended this, noting that the "most logical way to achieve this [equitable] result might be for the fuel oil and propane dealers to establish a voluntary efficiency fund that they would contribute to at levels commensurate with the efficiency funding provided by natural gas and electric-heated homes." The existing recommendation has not yet been acted upon, yet it is necessary to implement to ensure equitable access to waste reduction opportunities for oil and propane customers.

Current energy efficiency investment through the State's C&LM programs is approximately 2% and could serve as a reasonable baseline for establishing the assessment on deliverable fuel consumption, for example, 5 cents per gallon. DEEP will consult with delivered fuel industry representatives on the specific logistics for collecting the assessment. For administrative simplicity the conservation charge assessed on delivered fuels could be consolidated in the Connecticut Energy Efficiency Fund and incorporated into the funding for the Conservation and Load Management Plan.

This commitment to equitable energy efficiency investment not only could enable more equitably funded efficiency upgrades for oil and propane customers, but could provide access to more equitably and sustainably funded programs.

Goal 2: Improve the performance and productivity of buildings and industrial processes.

B.2.1 Ensure application of and compliance with current building energy codes and product efficiency standards.

To achieve all cost-effective energy efficiency, Connecticut must continue adopting and maintaining current and stringent building codes and product efficiency standards, and working with regional organizations to support federal product efficiency standards. These not only keep our buildings safer and healthier, but allows them to operate more cost-effectively in the future.

This can also give them a competitive edge in the real estate market, and provide a more consistent expectation of their impact on the grid and environment.[137]

Building Codes

Building energy codes are most commonly focused on new buildings but they are also applied to existing buildings, usually during renovations. By adopting current building codes, policy makers can ensure a certain level of expected energy savings, regardless of other programs in operation. It is estimated that between 2008 and 2025, the impacts of existing codes and standards alone can achieve a 3.6 percent to 8.6 percent reduction in building electricity use, nationwide.[138] DOE estimates that energy cost savings for Connecticut resulting from updated building energy codes are on the order of $76 million annually by 2030.[139]

Effective October 1, 2016, Connecticut adopted the 2012 International Energy Conservation Code (IECC). Currently Connecticut is in the process of updating the State Building Code to include the 2015 IECC code. This revision of state regulations is estimated to be completed by 2018. The state will need to continue to regularly revise state building code regulations to ensure adoption of the most current published editions of the model codes.

The 2012 IECC commercial requirements are stricter compared to the 2009 IECC, with a major change to incorporate an additional efficiency option in a project, and adding a new section for system commissioning. Likewise, the 2015 IECC requirements will be stricter and more specific

Table B1: Connecticut Average Economic Impact per Residential Unit by Adopting 2015 IECC

Metric	Compared to 2009 IECC
Life-cycle cost savings of the 2015 IECC	$8,175.03
Simple payback period of the 2015 IECC	3.5 years
Net annual consumer cash flow in the first year of the 2015 IECC	$423.80
Annual (first year) energy cost savings of the 2015 IECC ($)	$552.97
Annual (first year) energy cost savings of the 2015 IECC (%)	19.6%

Source: Mendon et. al,. 2016. "Cost-Effectiveness Analysis of the Residential Provisions of the 2015 IECC for Connecticut." *www.energycodes.gov.*

[137] ENERGY STAR calculates that a 10 percent decrease in energy use could lead to a 1.5 percent increase in net operating income (NOI) — with greater potential as savings grow. In commercial real estate valuation, the use of the capitalization rate (NOI divided by sales price/property value) demonstrates that the greater the NOI, the more valuable the property. (ENERGY STAR n.d.)

[138] Rohmund, Ingrid, Anthony Duer, Sharon Yoshida, Jan Borstein, Lisa Wood, and Adam Cooper. 2011. *Assessment of Electricity Savings in the U.S. Achievable through New Appliance/Equipment Efficiency Standards and Building Efficiency Codes (2010-2025).* Institute for Electric Efficiency.

[139] Hogan, Kathleen . 2013. "Letter to Governor Malloy: State Certification of Residential and Commercial Building Energy Codes." 31 May.

than the 2012 IECC when they are adopted. They will include equipment and systems that were not covered in previous IECCs, will have options in the building envelope sections that will have lighting system design requirements, and have additional efficiency options. A 2016 DOE analysis concluded that moving to this code would provide cost-effective savings for residential buildings in all climate zones in Connecticut, as shown in Table B1.

Additionally, the codes provide guidance for preparing our homes and buildings for further strategic electrification such as the incorporation of electric vehicle charging capabilities into new building design. While this is not a specific requirement of new buildings or construction, Connecticut supports inclusion of these capabilities as this CES also recommends electrification of our vehicles.

Connecticut should also continue to enforce state statutes that require state-funded major renovations and new construction to comply with the U.S. EPA ENERGY STAR's High Performance Building standards and to meet the minimum specified ENERGY STAR Score. Connecticut partners with U.S. EPA and Connecticut's major utilities to benchmark municipal and other buildings and recognize those buildings that have achieved ENERGY STAR certification for the building's energy efficiency status.

Encourage Selection of Efficient Products

Connecticut participates as a member of the Northeast Energy Efficiency Partnership's (NEEP) Appliance Efficiency Standards Policy Project, which advocates for the enactment of state and federal efficiency standards for a wide variety of products and appliances. Primarily, Connecticut builds its appliance and product energy efficiency standards off those defined by the California Code of Regulations' State Appliance Energy Efficiency Standards, Title 20, and preempted federal regulations included in the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007. The specific requirements for individual product types are outlined in C.G.S. Section 16a-48.[140] Products that do not meet these standards cannot be sold or installed in Connecticut on or

[140] American Council for an Energy-Efficient Economy. 2016 . *Appliance Standards Summary* . http://database.aceee.org/state/appliance-standards-summary.

after the effective date of the standard, unless federal efficiency standard regulations are in place, which preempt state standards. Connecticut last updated its appliance standards statutorily in 2011 and is developing recommendations for regulatory updates in the near future. Specifically, Connecticut supports and encourages residents and businesses to select appliances and products that meet U.S. EPA ENERGY STAR and WaterSense product efficiency certifications.

Connecticut has continued to push appliance efficiency outside of the regulatory sphere through the incentive and rebate programs provided through Energize Connecticut. As technology advances, the C&LM plans reflect these advances and have increased the product efficiency thresholds required for ratepayers to receive rebates. Through the C&LM Plan implementation Connecticut is able to encourage market demand for the most efficient products available while remaining cost-effective for customers.[141] For example, as the electric vehicle market expands, Connecticut supports the incorporation of electric vehicle charging capabilities into new building design.

B.2.2 Strategically sequence deployment of cleaner thermal fuel choices to transition buildings from fossil fuels.

Improving thermal efficiency of Connecticut's buildings is the primary and most effective measure for generating cost savings and emissions reductions. Not only is space heating the largest energy end user in buildings, accounting for about half of annual energy use, energy used for thermal purposes generates the largest amount of GHG emissions.[142] Improving building envelopes and upgrading to more efficient thermal mechanical equipment will provide the bulk of these savings.

In Connecticut's residential sector, the greatest potential for savings and improvement is in homes heated with fuel oil. With nearly half of all housing units using fuel oil for space heating there is a significant opportunity for better insulation, fuel switching, and equipment efficiency improvements. However, we also stand on the brink of a market shift towards renewable thermal technology, especially in homes currently using baseboard electric heating. Likewise, in the commercial and industrial sectors, improved HVAC technology and transitions to more efficient and clean thermal energy sources present major energy savings opportunities (see also Figure B5).

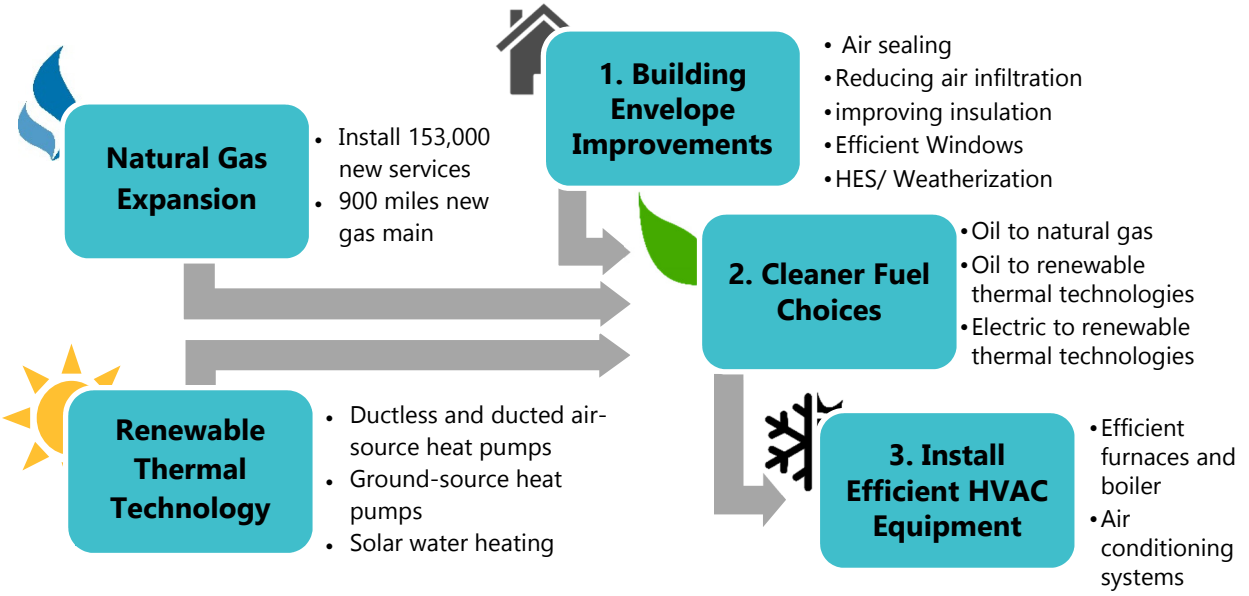
Connecticut General Statutes Section 16a-48. 2005. *Regulations and Procedures for Establishing Energy Efficiency Standards for Certain Appliances and Porducts.* Connecticut, September 2005.

[141] Eversource Energy; The United Illuminating Company; Connecticut Natural Gas Corporation; The Southern Connecticut Gas Company. 2015. *Connecticut General Statutes Section 16-245m(d) 2016-2018 Electric and Natural Gas Conservation & Load Management Plan .* 1 October.

[142] *EIA table CE3.2* HYPERLINK "https://www.eia.gov/consumption/residential/data/2009

Transitioning Connecticut's buildings to cleaner thermal technology will require a variety of measures and technologies that can be implemented, and should be approached in a strategic, step-by-step process, in order to achieve maximum efficiency gains and cost savings. Figure B13, below, outlines that process.

FIGURE B13: Thermal Efficiency Strategy for Connecticut Buildings



Source: DEEP Analysis

Building Envelope Improvement and Insulation

In the hierarchical decision-making process of making a home's space heating cleaner and more efficient, the first step is to improve the building shell, with a focus on air sealing and insulation improvements. This is consistent with the majority of Connecticut's energy programs and the recommendations in this Strategy. Before considering a switch to cleaner fuel or more efficient equipment, it is important to first minimize the amount of fuel needed, so as to properly size the system and achieve the greatest efficiency. Reducing air infiltration and improving insulation can save the average single family home 12 percent of baseline MMBTU in the first year of installation.[143]

The utility companies have been successfully motivating deeper measure-adoption in the form of insulation through the utility-administered Home Energy Solutions (HES) and Home Energy Solutions-Income Eligible (HES-IE) programs. At the completion of a HES assessment, the

[143] NMR Group, Inc. 2016. *R15: Connectiuct Single-Family Potential Study.* NMR Group, Inc.

technician can recommend and offer rebates for HVAC, insulation, windows, water heaters, and appliances. Insulation uptake has constituted nearly two thirds of total completed upgrades through these recommendations, and averages a 40 percent uptake rate since 2012.[144] However, the uptake rate and achievable potential are influenced by program incentives which offers incentive amounts up to 50 percent of the install cost.[145] The utility companies and Energy Efficiency Board should continue to incentivize shell improvements as part of the C&LM Plan.

Cleaner Fuel Choices

The next step is to select the cleanest thermal fuel available to a home. However, this can sometimes come with its own challenges. Moving to renewable thermal technologies may involve choosing between lower overall costs [installation plus operating costs] over the operating life a heating system, which may not appear as cost-effective as choosing a system that has a lower installation cost, and some residents may not be prepared to shift their heating budget from combustion fuels to electric systems. Additionally, if choosing relatively cleaner combustion energy choices, such as natural gas or propane, the availability of such delivered fuels must be considered. For example, while the LDCs continue to expand their distribution system throughout Connecticut and move into new franchise territories, many customers will still not have access to natural gas. Some customers are too far from a gas main, rendering it not cost-effective to expand the system to their home or business. Currently there are more than 50 towns where the LDCs do not provide natural gas service to residents or businesses. Determining what alternative heating options are available and how to make them cost-effective for these 665,000 residential, commercial and industrial customers that will not be able to convert to gas is a key challenge.[146]

In order to ensure optimal fuel choices are made, all customers will need improved awareness of, and access to cost-effective clean heating options such as air-source or ground-source heat pumps. This is necessary in retrofits of existing homes, but even more relevant during new construction. As discussed earlier in the chapter, there is a correlation between home vintage and use of fuel oil. New development should continue to be encouraged and educated to empower

[144] n.d. *Connecticut Statewide Energy Efficiency Dashboard .*

Uptake rate is calculated as the ratio of completed upgrades to recommendations for that upgrade. For example, 224 completed appliance upgrades of 10.515 recommended appliance upgrades would equate to a 2 percent uptake rate.

[145] The Connecticut Light and Power Company; The United Illuminating Company; Yankee Gas Services Company, Connecticut Natural Gas Corporation; Southern Connecticut Gas Company . 2012. "2013-2015 Electric and Natural Gas Conservation and Load Management Plan." 1 November.

[146] Connecticut Department of Energy and Environmental Protection. 2013. "2013 Comprehensive Energy Strategy for Connecticut."

consumers to make cleaner and cost-effective fuel choices that consider the long-term operating costs as well as the installation costs of heating systems.

Installing Efficient HVAC

After choosing the cleanest and most cost-effective fuel available to a home, HVAC equipment should be upgraded to the most efficient, corresponding technology. This means Connecticut must continue to improve access to information and financing for energy saving and cost-effective alternative solutions to these residents. Encouraging residents to replace outdated, inefficient equipment not only captures a measurable level of energy savings, but it can also open the gateway to further energy efficiency measures being taken. This is particularly the case when there is equipment failure or retirement. Using that opportunity to improve furnaces, boilers, air conditioning systems, etc. is imperative, given the long useful life terms of heating and cooling equipment. This also means encompassing externalized and related costs, such as providing financing for homes that move away from oil and need assistance with tank removal. DEEP supports development of such financing protocols that will help to remove barriers to fuel switching.

Connecticut must also ensure that higher efficiency equipment is available in the market, that installers are trained in proper installation, and that customers analyze options based on a simple life cycle analysis to account for both operating and installation costs to lock in efficient equipment for decades that will achieve the resulting energy savings.

Natural Gas Expansion

The expansion of our natural gas system for thermal use was a critical strategy of the 2013 CES. Natural gas provides a cleaner alternative to other thermal fuels. When compared to oil, gas is cleaner, emitting about 25 percent fewer CO2 emissions than fuel oil.[147] Natural gas is also more convenient to transport, where the customer does not need to worry about having their fuel oil delivered at a certain time. Further natural gas is a regulated fuel choice, with PURA regulating gas supply, distribution, and transportation costs. While not as efficient or environmentally beneficial as renewable thermal technologies (e.g. heat pumps), natural gas is an important component and step towards achieving our energy and emissions goals. The regulatory plan established in the 2013 CES also provided various mitigation factors to protect gas ratepayers from rate impacts and ensure a reliable supply of gas for the state's residential, and commercial and industrial customers.

[147] U.S. Energy Information Administration. 2017. "How much carbon dioxide is produced when different fuels are burned?" www.eia.gov.

Over the 10 year life of the Natural Gas Expansion Plan, Connecticut's local distribution companies (LDCs) plan to install approximately 153,000 new services and close to 900 miles of new gas main. In 2016, they installed a combined 152 miles of new gas mains and over 2017-2018 period an additional 170 miles may be installed.

From 2014 through 2016, 39,104 residential customers converted to gas heating, in addition to 12,021 commercial and industrial customers converting for generation, or other processes. Given the narrowing in the differential prices between natural gas and fuel oil, the demand for gas has decreased significantly, especially in the residential sector. In turn, despite the fact that main installation and gas conversions are still occurring at rates higher than in the past, the actual miles of main installed and gas conversions have not materialized at the amount that the LDCs estimated. However, the lower amount of main installation and gas conversions is evident of the intent of the plan because LDCs are only installing gas mains to meet the current and near future customer demand (i.e. they are not overbuilding the gas distribution system) and customers are only converting if it is cost-effective for them. With the expanded use of fuel cells and distributed generation in the state, much of the anticipated residential load is also being shifted to the commercial and industrial sector where there is greater demand. For example, most Low Emissions Renewable Energy Credit (LREC) contracts in coming years will make use of the LDCs' distribution system and help offset some of the costs of gas expansion. At this time, natural gas provides a cost-effective, relatively cleaner energy supply that Connecticut should continue count on as we build up our renewable options.

Strategic Electrification and Renewable Thermal Technology

Connecticut's large consumption of energy for thermal purposes positions it to significantly benefit from renewable thermal technologies (RTTs), especially air-source heat pumps, ground-source heat pumps, and solar water heating. These technologies use thermal resources from the sun, air, and ground, allowing them to provide extremely efficient heating and cooling. Therefore, these technologies offer important means to decrease our reliance on fossil fuels and sharply reduce residential, commercial, and industrial GHG emissions.[148] This potential—and the need for deep GHG emissions reductions in these sectors to meet the 2050 target spelled out in the Global

[148] Meister Constultants Group . 2015. "Waking the Sleeping Giant: Next Generation Policy Instruments for Renewable Heating & Cooling In Commercial Builidngs (RES-H Next)." *iea-retd.org.* February . http://iea-retd.org/wp-content/uploads/2015/02/RES-H-NEXT.pdf.

International Energy Agency. 2014. "Heating Without Global Warming: Market Developments and Policy Considerations for Renewable Heat." *www.iea.org* . https://www.iea.org/publications/freepublications/publication/FeaturedInsight_HeatingWithoutGlobalWarming_FINAL.pdf.

Warming Solutions Act—means Connecticut needs to begin pursuing RTTs deployment within the buildings sector.

- Whole-Building Strategies

A recent analysis performed by Yale University on behalf of the Connecticut Green Bank and the major the utility companies found that, given today's energy market conditions, excluding available rebates, heat pumps and solar water heating generally are cost-effective — have positive net present value for the customer — as whole-building substitutes for electric-resistance units for space and water heating.149 However, with fossil fuel prices currently low, it is economically efficient to fully convert only a narrow segment of Connecticut buildings to RTTs. As shown in Table 2, all five types of RTTs are cost-effective in just electrically heated buildings at this time. Replacing electric-resistance

TABLE B2: Connecticut Cost-Effectiveness of Whole-Building RTTs as Substitutes for Space Heating and Cooling in a Variety of Building Types

RTT	As Substitute For	Building Type Applicability						
		Single-Family	Apartment Building	School	Restaurant	Hospital	Hotel	Office Building
ASHP space heating & cooling with no ductwork	Electricity	■	■	■	■	■	■	■
	Fuel Oil							
	Natural Gas							
ASHP space heating & cooling with ductwork	Electricity	■	■	(Not Evaluated)				
	Fuel Oil							
	Natural Gas							
ASHP water heating	Electricity	■	■					
	Fuel Oil							
	Natural Gas							
Ground-source heat pump space heating & cooling	Electricity	■	■	■		■		
	Fuel Oil							
	Natural Gas							
Solar water heating	Electricity	■	■		■	■		
	Fuel Oil							
	Natural Gas							

■ *Cost-effective (NPV≥1) in light of cost to finance, install, operate, and maintain in present market conditions and without accounting for available financial incentives*

Source: Gronli, et al. 2017. "Feasibility of Renewable Thermal Technologies in Connecticut: Market Potential."

[149] The calculation accounted for cost of installing, financing, operating, and maintaining HVAC equipment. It excluded non-energy benefits such as reduced social cost of carbon, enhanced comfort, and improved air quality.

333units with RTTs would provide a return on investment in less than 15 years in most of these contexts and less than 5 years in some.[150]

With today's fuel prices, and excluding available rebates, RTTs are not yet cost-effective substitutes for fuel oil and natural gas systems that provide space and water heating in the vast majority of Connecticut's homes and commercial buildings. For most of Connecticut's residential and commercial buildings, a return on investment in whole-building RTT systems would take longer than 15 years.[151] Therefore, on a general basis, Connecticut should encourage the installation of RTT in its buildings, but specifically target those that are electrically heated until market conditions make transitioning cost-effective for other fuel types.

In the short term, then, Connecticut needs to focus its RTT whole-building conversion strategy on the approximately 15 percent of single-family homes that rely primarily on electric-resistance technologies for space and water heating, while preparing to expand this focus as changes in fuel costs, equipment costs, equipment efficiency, thermal demand, and interest rates make RTTs cost-effective in a wider range of buildings.

DEEP recommends that in order to maintain forward momentum and better understanding of strategic deployment of RTT's, a pilot program be developed in the near future to address full replacement of oil and propane-fired furnaces with high-efficiency ducted heat pumps. This pilot can be used to assess what potential we have to fully heat a home with RTT such that residents do not need to keep fossil fuel equipment, and whether homes with central air can successfully be retrofitted with ducted heat pumps using the existing ductwork.

As this potential is better understood, DEEP also recommends an investigation of the impact that enhanced RTT rebates through existing programs, like HES, could have on the rate of replacement of fossil fuel-heated space and water with RTT. This will enable Connecticut to better determine the level of rebate needed to promote equitable access

[150] Gronli, Helle, Fairuz Loutfi, Iliana Lazarova, Paul Molta, Prabudh Goel, Philip Picotte, and Tanveer Chawla. 2017. "Feasibility of Renewable Thermal Technologies in Connecticut: Market Potential." www.cbey.yale.eud. March. http://cbey.yale.edu/sites/default/files/FORTT_Market%20Potential.pdf.

This study's sensitivity analysis indicated that rebates capable of reducing the initial cost of heat pumps and solar hot water by 25 percent — considerably more than current rebates accomplish — would make these RTTs cost effective as replacements for electric-resistance heating in additional kinds of commercial buildings. However, under the study's assumptions, even these hefty rebates would not make the RTTs cost-effective replacements for fuel oil or natural gas systems in residential or commercial buildings (table 18, p. 76)..

[151] Gronli, et al. 2017. "Feasibility of Renewable Thermal Technologies in Connecticut: Market Potential."

to renewable thermal technology, and how to adapt to market demand in the future. In the meantime, the costs and benefits associated with whole-building conversion to RTT should be reassessed periodically.

- Partial-Building Strategy

Connecticut should simultaneously promote a particular RTT that is becoming a suitable *partial* substitute for conventional HVAC units in single-family homes. The Yale assessment of RTT market conditions examined only RTTs sized to satisfy 100 percent of buildings' heating loads.[152] This assumption does not reflect the market for a key form of RTT: ductless air-source heat pumps (ASHPs), the RTT that is making the strongest inroads in New England's HVAC market. Ductless air-source heat pumps typically are installed to heat or cool a single room or zone rather than an entire building. A recent study by Cadmus Group—focusing on the cost of operating RTTs—found that these units, and especially versions optimized for cold climates, routinely are being cost-effectively operated in single-family homes in Massachusetts and Rhode Island, which have climates and energy prices comparable to Connecticut's. Cadmus found air-source heat pumps are always more cost-effective than both propane and electric-resistance heating, while air-source heat pumps optimized for cold climates are more cost-effective than oil heating except during periods of extreme cold.[153] An important consideration here is that in New England, about 30 percent of ductless air-source heat pumps are being installed primarily to provide cooling and about 65 percent for both heating and cooling. [154]

[152] Gronli, et al. 2017. "Feasibility of Renewable Thermal Technologies in Connecticut: Market Potential."

[153] The Cadmus Group, Inc. 2016. "Ductless Mini-Split Heat Pump Impact Evaluation ." *www.ma-eeac.org.* December. http://ma-eeac.org/wordpress/wp-content/uploads/Ductless-Mini-Split-Heat-Pump-Impact-Evaluation.pdf.

In 2016, cold-climate ASHPs were more cost-effective than oil heat down to temperatures as low as 26 degrees F.; and especially efficient cold-climate units (HSPF 13) were more cost-effective than oil down to 15 degrees F. The latter units were more cost effective than even natural gas heating down to 28 degrees F. Crucially, this cost-effectiveness is routinely achieved even in the absence of sophisticated control technologies (which are only now emerging) that can maximize customer savings through integrated management of both RTT and conventional fossil-fuel-based HVAC equipment.

[154] National Climate Assessment. U.S. Global Change Research Program. n.d. *www.globalchange.gov .* http://nca2014.globalchange.gov/report/regions/northeast.

DEEP analysis of National Oceanic and Atmospheric Administration data from the Bradley Airport weather station indicates that the number of cooling-degree days in Connecticut has increased about 30 percent since 1905, while the annual number of days with high temperatures over 90°F has trended upward from about 8 to more than 20. The National Climate Assessment predicts that with continued rapid increases in global atmospheric concentrations of greenhouse gases, parts of Connecticut routinely will see 30-40 days per year over 90°F in the middle of the century—on par with the very hottest summers of the 20th Century.

Especially with annual cooling-degree days and the incidence of extremely hot weather increasing as the region's climate warms, the state should promote awareness that ductless air-source heat pumps can often cost-effectively displace conventional air conditioning in the warm months but also propane heating during the entire heating season and oil heating during significant portions of the heating season.[155] DEEP, Energize Connecticut, and the Connecticut Green Bank should take advantage of growing customer demand for space cooling to strategically encourage the installation and use of ductless air source heat pumps (especially models optimized for cold climates) that in the summer can provide efficient cooling and in the winter can cost-effectively displace some of the heating loads now provided by oil, propane, or electric resistance.[156]

- General Strategies

To facilitate the whole-building strategy, the partial-building strategy, and development of a more comprehensive approach for RTTs overall, several broader strategies are warranted:

➢ Improve RTT economics:

(a) With RTTs still struggling for market acceptance, EnergizeCT financial incentives for RTTs should be put on par with –and as stringently as— the most aggressive RTT incentives in New England. At present, they often lag.[157]
(b) DEEP will collaborate with others to explore efforts to make more favorable financing for RTTs readily available, including loans that finance up-front costs.
(c) DEEP will collaborate with others to explore ways to encourage customers to bundle heat pumps with solar photovoltaics, which could significantly improve RTT operating costs by supplying the units with less expensive electricity.

[155] Ibid

DEEP analysis of National Oceanic and Atmospheric Administration data indicates that the number of cooling-degree days in Connecticut has increased about 30 percent since 1905, while the annual number of days with high temperatures over 90°F has trended upward from about 8 to more than 20. The National Climate Assessment predicts that with continued rapid increases in global atmospheric concentrations of greenhouse gases, parts of Connecticut routinely will see 30-40 days per year over 90°F in the middle of the century—on par with the very hottest summers of the 20th century.

[156] The R1617 study commissioned by the Energy Efficiency Board and now being conducted by the Board's Evaluation Administrator will provide further insights into the economics of ductless ASHPs in Connecticut.

[157] Northeast Energy Efficiency Partnership . 2016. "2016 Air-Source Heat pump Incentive Summary ." *www.neep.org.* http://www.neep.org/sites/default/files/resources/2016%20ASHP%20Snapshot.LateOctoberUpdate_2.pdf.

(d) DEEP could collaborate with others to explore the potential of financing approaches to reduce RTT soft costs, perhaps modeled on grouped buying programs for residential solar photovoltaic systems.
(e) DEEP should closely monitor the effectiveness of state programs in Massachusetts and New Hampshire that expand the range of RTTs eligible under state Renewable Portfolio Standards. At present the only thermal resources covered in Connecticut's REC program are combined heat and power, geothermal (excluding the ground-source heat pumps discussed here), and ocean thermal systems.
(f) DEEP and its EnergizeCT partners should work with Northeast Energy Efficiency Partnerships to encourage development and adoption of control systems that effectively integrate management of RTTs and conventional fossil-fuel systems to maximize customer savings and GHG emissions reductions.[158]

- Improve stakeholder awareness of and trust in RTTs, where Energize Connecticut should:

(a) Enhance its RTT consumer-education initiatives;
(b) Increase its efforts to promote dealer and installer training for effective marketing and deployment of RTTs;
(c) Continue its efforts to document the performance of RTTs and to publicize the results; and
(d) Commit to providing consumer incentives for RTTs for an extended period.[159]

- Harness willingness to seek non-financial benefits:

Environmentally attuned consumers and businesses motivated by awareness of the adverse environmental impacts of fossil fuel emissions and implicitly inclined to accept short-term local costs to achieve long-term global benefits may find RTTs are already widely cost-effective. State, utility, and Connecticut Green Bank programs should avoid sending a signal that only readily monetized costs and benefits are meaningful.

[158] Gronli, et al. 2017. "Feasibility of Renewable Thermal Technologies in Connecticut: Market Potential."

[159] Gronli, Helle H. , Joseph Schiavo, Philip Picotte, and Amir Mehr. 2017. "Renewable Thermal Technologies in Connecticut: A Field Study on Barriers and Drivers." *www.cbey.yale.edu.* March . http://cbey.yale.edu/sites/default/files/FORTT_Barriers%20and%20Drivers.pdf.

- Evaluate the potential of biofuels to offset fossil fuels:

  Biodiesel and wood-based fuels have the potential to partially displace fossil fuels for space and water heating, sometimes cost-effectively.[160] This potential, and its ability to help the state meet goals such as those set in the Global Warming Solutions Act, needs to be carefully evaluated in light of both environmental benefits and environmental costs.

B.2.3 Continue increasing the rate of home weatherization and assessment, statewide.

As one of the oldest and most densely populated states, and existing in one of the most varied climate regions in the nation, Connecticut maintains a very diverse building stock with both standard and unique challenges. For example, Connecticut homes can be segmented by vintage, thermal fuel type, ownership structure, multifamily vs. single family, and income level. With this diversity, there is no one-size-fits-all set of energy efficiency solutions. Each one of these subsegments has a unique set of characteristics and barriers to energy efficiency, and oftentimes, individual buildings can fall into more than one subsegment. For example, a home could fall into the rental, multifamily, and electrically-heated homes subsegments, each of which have their own needs and challenges. In order to capture the full efficiency potential in our buildings, we must identify these individual subsegments and their characteristics. Then, we can identify what the most cost-effective and deepest-energy-saving solutions available are, and how to fill any unresolved solution gaps.

Sustain the Current Trajectory towards State Goals

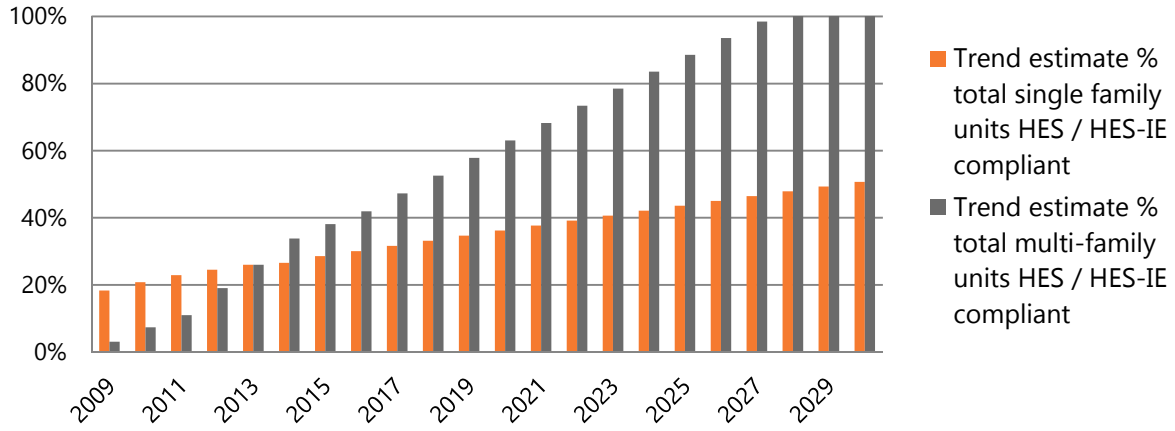
Connecticut has an established goal of weatherizing 80 percent of all residential units by 2030. Per CGS §16-245m, any conservation and load management plan must include steps towards achieving this goal. The utility companies have been tracking the progress since 2011 and have outlined a projected rate of weatherization completion over the next fifteen years. Using home energy assessments completed through the Home Energy Solution (HES) and Home Energy Solutions- Income Eligible (HES-IE) program as a proxy, as well as statistics on homes built or renovated to current energy code and DECD demolition rates, Connecticut is on track to meet the weatherization goal, with 100 percent of multifamily units to have completed energy assessments

[160] Gronli, et al. 2017. "Feasibility of Renewable Thermal Technologies in Connecticut: Market Potential."

by 2027, and 51 percent of single family units by 2030 (Figure B14).[161] Connecticut must continue to maintain at least the current level of investment to continue on this path.

This expectation assumes that the number of homes weatherized each year will increase at a growing rate and that the CEEF will stay at the current contribution levels. Therefore, in order to accomplish this, Connecticut must continue to maintain its energy efficiency funding mechanisms, ensure effective marketing and outreach, and implement sustainable solutions to weatherization obstacles.

FIGURE B14: HES/HES-IE Completion Rate towards 2030 Weatherization Goal Trend Analysis



Source: Eversource and United Illuminating Analysis, 2016

Locate and Establish Sustainable Funding Sources for Health and Safety Barrier Remediation

Consistently, one of the primary obstacles preventing homes from implementing energy efficiency and becoming weatherized are health and safety barriers. These includes mold, asbestos-like material, and antiquated wiring. In 2016, Eversource initiated data collections that indicated 25 percent of homes participating in utility administered home energy assessments have at least one health and safety issue limiting weatherization services. As more information is collected, it is likely we will find that this number is even higher statewide.[162] Not only do these conditions leave some customers in potentially unsafe homes, but they prevent them from accessing energy savings and can deter them from implementing energy efficiency improvements in the future and building the value of their property.

Many low-income units are also some of the oldest units in the state, and many are difficult to retrofit. It is less likely for efficiency measures or necessary safety upgrades to be installed in low

[161] (Eversource and United Illuminating 2016) Eversource and United Illuminating . 2016 . "Trend Analysis of HES/HES-IE Compliance Rate Towards 2030 Weatherization Goal ."

[162] This number also includes homes with ventilation barriers preventing blower-door testing.

income housing due to the increased likelihood of health and safety barriers, and lack of capital and affordable financing. According to EnergyEfficiencyForAll.org "Affordable housing in poor condition increases residents' risk of exposure to several environmental health threats. Inadequate insulation, obsolete HVAC systems, indoor mold growth, or malfunctioning combustion appliances are prevalent environmental complaints."[163] It is necessary that any financing solutions for health and safety barrier remediation are accessible to low income households. This not only can improve living conditions but can help open the door to energy saving opportunities not previously available to low-income households. However, remediation of these barriers can be highly complex and expensive, making them even more difficult to resolve for low income households. Barriers often "snowball" together as further assessment is done and total costs can grow exponentially.[164] There is no standard estimated cost for remediation as each project has many variables, making programmatic solution development even more challenging.

Currently, per CGS Section 16-245m(d)(1), all CEEF-funded programs must meet cost-effectiveness requirements, but these do not include the quantifiable effects of health and safety issues in cost-benefit tests. Additionally, there is no predictably sustainable funding on a comprehensive scale to aid in the often costly remediation of these issues. Assistance is currently limited to aiding certain qualifying low income homes through programs such as the federal Low-Income Heating Energy Assistance Program [beginning in 2017] and at a small scale through the federal Weatherization Assistance Program. The utility companies' Clean Energy & Healthy Homes Initiative (CEHHI) is funded with a one-time grant. Bundled financing options such as the Connecticut Green Bank's Smart-E loan allows up to 25 percent of the clean energy loan amount to go towards remediation for qualified customers.[165] DEEP, the Connecticut Green Bank, and the utility companies are in the process of developing a revolving loan financing mechanism to assist households in making homes ready to be weatherized. If the pilot proves effective the scale will need to be increased in the future.

While remediating health and safety barriers falls in a separate category than accomplishing energy efficiency performance goals, both goals are interrelated. DEEP recommends the development of sustainable funding and financing programs that can address the costs of remediation to catalyze progress and ensure that homes are ready to be weatherized. A possible solution to consider is the establishment of a revolving fund specifically for financing remediation

[163] Energy Efficiency for All . 2015. "Clean Power Plan Opportuntities for Energy Efficiency in Affordable Housing." September . http://energyefficiencyforall.org/sites/default/files/CPPBrief.pdf.

[164] Utility RFP

[165] As a result of the 2014 Northeast Utilities-NSTAR merger, funds were allocated to address financing health and safety barrier remediation.

costs. Financial tools for issues like this already exist in the form of predevelopment loans for multifamily properties through the CT Green Bank and for single family homes through the utility companies' revolving Energize Connecticut Heating Loan fund. These financing tools have shown to be effective by providing on-bill financing repayment.[166] Beginning in 2014, this program has provided low or interest-free on-bill financing of new energy efficient heating equipment. This allows participants to pay off the equipment over 10 years through the energy savings realized from the upgrade, and requires a down payment and requires that customers have six consecutive months of timely utility payments and no more than two late payments in the last twelve months. Since its initiation, this program has had a total cost-effectiveness of 2.64 across fuel types, loaned over $43 million in over 155 towns and to customers in every income class, and has had a loan loss of only .23 percent.[167]

Additionally, DEEP concurs with recommendations from the Low-Income Energy Advisory Board that recommend the use of up to 2 percent of LIHEAP allocations to address health and safety barriers in homes that need weatherization assistance. Specifically, this approach would assist low-income households and extend participation in the Connecticut Low-Income Weatherization Assistance Program (WAP) by removing health and safety barriers that prevent the provision of services through WAP and the utility-administered HES and HES-IE programs. While some states allocate as much as 15 to 20 percent of the LIHEAP budget towards the Weatherization Assistance Program, DEEP recognizes the policy dilemma associated with using a portion of LIHEAP funds currently used for short term energy assistance for long term energy efficiency improvements. Therefore, DEEP recommends institutionalizing the practice with a modest percentage not to exceed the recommended 2 percent of the overall statewide allocation of financial energy assistance from LIEHAP. The LIHEAP Allocation Plan could also include a statement stating that in years where funds are not fully expended, an additional percentage of the carried over funds will be allocated to address energy efficiency upgrades. It is important to note that addressing health and safety barriers to weatherization has non-energy related health benefits for clients much like the energy assistance dollars do.

In other states, LIHEAP funds are utilized to extend energy assistance dollars in the long term by preventing energy waste through energy efficiency improvements.[168] Currently Connecticut is one of a handful of states that does not use LIHEAP funds to supplement the federal weatherization assistance program for low-income households. Investing in energy efficiency, such as through

[166] This is technically funded by the Systems Benefit Charge but as it is repaid back over time and then used to fund other loans, essentially acting as a revolving fund.

[167] Steve Bruno on behalf of Eversource . 2016. "Data Transfer." 27 December.

[168] Applied Public Policy Research Institute for Study and Evaluation. 2016. *Meeting the Energy Needs of Low-Income Households in Connecticut.*

weatherization of residential units and removing barriers to weatherization means that valuable energy assistance dollars are prevented from being lost to inefficient residential properties.

Based on programs like these, the potential exists to fund the remediation of these barriers. Data collection throughout 2016 and 2017 will reveal more detailed trends of these barriers in homes and estimated fund amounts to achieve this statewide. This financing may benefit from being managed by an infrastructure bank or non-profit to address the ratepayer fund cost-effectiveness issue. Additionally, financing can and should only be offered to those seeking weatherization to maintain the energy efficiency context. This also can dually function as a gateway program for customers that had not initially been seeking energy-efficiency financing programs, and for those who had not planned for energy efficiency at all.

Standardize Metrics for Measuring Weatherization Goal Progress Tracking

An additional barrier to measuring progress in weatherization relates to defining a weatherized home. Broadly, weatherization refers to the installation of energy-efficient measures to improve the building envelope, its heating and cooling systems, its electrical system and energy consumption. In 2014, a baseline assessment study was conducted by NMR Group, Inc. for the Connecticut Energy Efficiency Board to provide a snapshot of the status of weatherization statewide for single family homes. Using a performance-based modeling approach to determining weatherization, the study found that of the sampled homes, only about 26 percent met the requirements. Overwhelmingly, new homes, non-low income homes, and homes heated with electric resistance had much higher compliance rates, pointing to their counterparts as major opportunities to increase weatherization rates.[169] However, without a universally agreed-upon weatherization definition, it was challenging to accurately estimate progress towards the goal. Much debate has revolved around this issue that Connecticut's 1.5 million homes are so diverse, it is impossible to apply a "one size fits all" definition.

With conversation and analysis still in progress, DEEP typically considers homes that have taken measures to improve the thermal efficiency (i.e., participated in HES, installed insulation, etc.) "treated." DEEP uses "treated" homes as a proxy for measuring Connecticut's progress towards its weatherization goals. Of course, this could leave some energy savings potential out, but it also allows Connecticut to continue its efforts towards weatherization without excluding or disregarding various channels for participation. However, establishing a mutually-agreed upon, standardized process for determining if a house is "weatherized" will allow to Connecticut to more effectively and accurately determine goal achievement progress, and justify program support (like HES). DEEP recommends that stakeholders work together (and consider the use of a contractor)

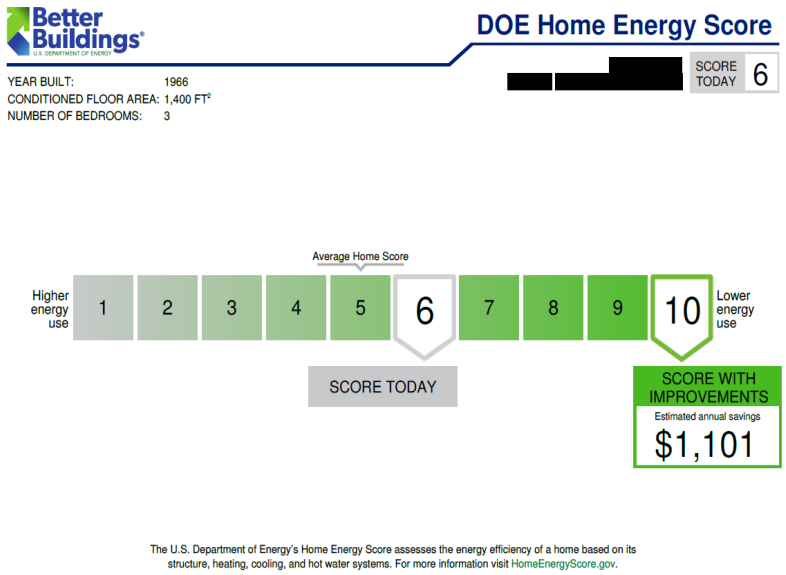
[169] NMR Group, Inc. 2014. *Single-Family Weatherization Baseline Assessment (R5).* Connecticut Energy Efficiency Board.

to develop a comprehensive, statewide model for evaluating weatherization in Connecticut for preparation of a progress report by 2020.

Scale Up Standardized Communication of Home Energy Performance

In 2015 Connecticut became the first state to fully adopt the use of the U.S. DOE's Home Energy Score in its energy efficiency assessment programs. The most effective way to make these "invisible" energy efficiency measures clear to homeowners is to utilize standardized documentation methods. Connecticut has taken some initial steps in this process, particularly in addressing standardizing reporting and third-party certification. In April, 2015 it became the first state to partner with the Department of Energy in its Home Energy Score ("HEScore") pilot labeling program (Figure B15 for sample). This program is designed to be a nationally standardized "miles-per-gallon" score of a home's energy efficiency and to expose the invisible value of efficiency improvements.[170] In Connecticut, when a homeowner has a home energy solutions (HES) assessment performed, the technician will provide a HEScore using a mobile application that incorporates data gathered during the assessment. This is an important step because it provides a tangible product that homeowners can understand and that sellers and realtors can market towards buyers. Connecticut has completed over 21,000 HEScores to date.

FIGURE B15: Sample DOE Home Energy Score



Source: U.S. Department of Energy, n.d. *Home Energy Score.*

[170] U.S. Department of Energy . n.d. *Home Energy Score.* https://betterbuildingssolutioncenter.energy.gov/home-energy-score.

Standardize Professional Qualifications through Registration

The many different home performance certifications such as the Building Performance Institute certification, utility home energy performance professionals qualifications, the federal Weatherization Assistance Program (WAP), the DOE Home Energy Score, etc., suggest that standardization of what constitutes a home energy performance professional may be needed. Statewide registration of such professionals could improve the opportunity to recognize quality work and level the playing field and DEEP will explore the feasibility of this approach with partner agencies. This will also reallocate some of the administrative duties of the utility companies and allow the State to maintain a more comprehensive universe of qualified professionals in the field.

B.2.4 Address the unique needs of multifamily buildings for implementing cost-effective, clean and efficient energy upgrades.

The multifamily residential category, until recently, has remained a relatively untapped source of energy efficiency potential. However, accessing this residential category will require a much different approach than single family. These buildings often are not owner-occupied, and that technically speaking, upgrades can be treated similarly to commercial buildings. This creates challenges in communication and financing projects. Furthermore, multifamily energy consumption has not been studied or tracked in Connecticut as intensely as single family buildings making it difficult to prescribe direct energy savings measures. Additionally multifamily properties can vary greatly in characteristics statewide. A 2016 ACEEE report outlined five major typologies of multifamily buildings presented in Table 3.

TABLE 3: Typologies of Multifamily Markets

Typology	Variations
Type of Rental Housing Market	Affordable vs. Market Rate
Type of Building and Size	Small Properties, High Rises, Town Houses, Complexes
Type of Resident	General Population, Seniors, Students
Type of Ownership	Single Owner, Corporate Owner, Local Public Housing Authority
Type of Utility Metering Method	Master Metered vs. Individually Metered

Source: Ross et. al, 2016. *Reaching More Residents: Opportunities for Increasing Participation in Multifamily Energy Efficiency Programs.*

Each of these typologies requires tailored approaches to implementation. The type of rental housing market will need to account for the challenges that low-income residents face. Likewise, the type of resident and type of ownership will need to address the fact that, for example, students live for very short periods of time in rental properties owned by their school or a landlord and will

have limited control over energy and efficiency measures. DEEP and its energy efficiency partners have created or are developing effective solutions to reach these customers.

In the Connecticut Green Bank's 2017-2018 Comprehensive Plan, it evaluated the current Connecticut housing market. It found that of the approximately 445,000 low income households in Connecticut, 64 percent were rentals, and that of that 58 percent were multifamily buildings of five or more units.[171] Approximately 90 percent of larger multifamily buildings (20+ unit) are concentrated in 38 municipalities and about 50 percent are in five core municipalities (Stamford, Hartford, New Haven, Bridgeport and Waterbury).[172] DEEP continues to support ongoing coordinated efforts to increase energy efficiency in multifamily housing, which are currently being administered by the utility companies, the Connecticut Green Bank, and CHFA.

Target Building Owners and Property Managers

The types of properties served by the Multi-Family Initiatives of the utility-administered program and the Connecticut Green Bank financing products cover the full range of properties, from old converted single family homes to large apartment and condo complexes. Many of these buildings are not owner-occupied, meaning targeting the actual residents is nearly useless. Contacting the right person with program information is imperative to successful authorization of energy efficiency improvements.

Split incentives are also important in this context because they result from the property owner providing the investment, but not necessarily receiving all the benefits, as a single-family owner might. It is important that multifamily program staff and vendors highlight the non-energy benefits of efficiency improvements like enhanced comfort and aesthetics, increased tenant satisfaction and retention, and in the case of affordable housing, lower energy bills equates to a lower cost of living, and a higher likelihood that rents will be paid. Development of utility allowance structures and sub metering strategies that encourage property owners to participate and reduce tenants' high energy burdens can help with this.[173]

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[171] Connecticut Green Bank. 2016. "Comprehensive Plan Fiscal Years 2017 and 2018."

[172] Connecticut Housing Finance Authority. 2013. *Connecticut Affordable Housing Market Inventory Study.* Rocky Hill, CT : Connecticut Housing Finance Authority .

[173] Bell, Casey J., Stephanie Sienkowski, and Sameer Kwatra. 2013. "Financing for Multi-Tenant Building Efficiency: Why This Market is Underserved and What can Be Done to Reach It." *aceee.org.* August. http://aceee.org/sites/default/files/publications/researchreports/e13e.pdf.

NMR Group, Inc. 2016. *R157 Multifamily Initiative Process Evaluation .* Connecticut Energy Efficiency Board, Eversource, and United Illuminating .

Provide Simplified and Streamlined Access to Programs

The utility companies have embarked on a customized approach to implementing efficiency measures at multifamily properties that is catalyzing activity in this subsegment. This approach includes coordinating with the Connecticut Housing Finance Authority (CHFA) and the Connecticut Green Bank to ensure that utility incentives, CHFA opportunities, and Connecticut Green Bank financing products are optimized and coordinated early in the project development process.

From initiation through project completion, the implementation of energy efficiency measures can be a complex and daunting process for building owners and managers. In pursuit of simplifying and streamlining the process of financing multifamily capital improvement projects with an energy efficiency and conservation component, several programs have been developed or improved as a result of interagency collaboration, and such streamlining and coordination must continue.

Increase Market Penetration of Comprehensive, Deeper Measures in Energy Improvements and Encourage Efficient Water Use

Connecticut is committed to leveraging clean energy savings as a resource to fund and finance comprehensive, deeper and more durable energy upgrades as well as health and safety measures and other capital needs in Connecticut's old and aging housing stock.

This commitment means that we will continue our focus on integrating energy efficiency, renewables plus storage, and optimized incentives and customized financing. We will also implement building energy and sustainability and resiliency standards through a combination of incentives and requirements – including, but not limited to, U.S. EPA ENERGY STAR and WaterSense Certifications for products and buildings, recognition of LEED certifications, and focusing on the ultimate goal of zero net energy buildings. We will continue to integrate housing, health, sustainability and resiliency policies and programs with energy policy and programs.

Increasing the efficiency of our water treatment, distribution, and wastewater treatment infrastructure is increasingly critical. The more efficiently we manage water the more sustainable our water and energy infrastructure. DEEP will look for opportunities to collaborate with water companies on water conservation strategies and to integrate with energy policy and programs the findings and recommendations of Connecticut's State Water Plan when it is delivered to the legislature in 2018.

B.2.5 Reduce energy waste by using combined heat and power (CHP), where it is cost-effective, in commercial and industrial applications.

Combined heat and power (CHP), also known as cogeneration, works by capturing excess heat from generation and processes and using that to heat a facility. CHP has been used in the United States over 100 years but currently only account for approximately 8 percent of capacity whereas in other countries use it at the level of 30 percent or greater. There are several forms of commercially available CHP technologies, including gas turbines, micro-turbines, steam turbines, and hydrogen fuel cells. Encouraging their use achieves multiple policy objectives by reducing energy waste and encouraging distributed generation. DEEP recommends installing CHP systems where they are most cost-effective to maximize these benefits. A summary of the investments in CHP that have occurred in Connecticut since 2013 is included in the Electricity Generation and Energy Infrastructure chapter, along with recommendations going forward.

B.2.6 Reduce energy waste at water and wastewater treatment facilities.

Managing energy waste at water and wastewater treatment facilities poses a unique opportunity for Connecticut's municipalities, water companies, and large manufacturers to cut energy costs and achieve GHG emissions and pollution reduction goals. According to the U.S. EPA, wastewater and water systems use 3-4 percent of the total energy used nationally, and produce over 45 million tons of GHGs annually. These facilities operate 24 hours a day, seven days a week, and use many energy-intensive components such as pumps and motors. It is estimated that a 10 percent reduction in the energy used by these facilities could save about $400 million, or 5 billion kWh, annually.[174]

There are 233 water and wastewater treatment plants in Connecticut that process both surface and subsurface wastewater, and potable water.[175] The U.S. EPA outlines

[174] United States Environmental Protection Agency . 2013. *Energy Efficiency in Water and Wastewater Facilities .* United States Environmental Protection Agency .

[175] United States Environmental Protection Agency. n.d. *Connecticut Final Individual NPDES Permits.* https://www3.epa.gov/region1/npdes/permits_listing_ct.html.

specific recommendations for each component of the water treatment cycle for improving efficiency and reducing energy needs. These improvements have the potential not only to reduce energy waste and energy costs, but extend the life of the equipment, support economic growth, protect public health, and demonstrate community leadership. In 2014 and 2015, the utility companies collaborated with the EPA to discuss best practices of bringing energy efficiency to wastewater and water treatment facilities in Connecticut and overcoming barriers[176] and prioritized this critical infrastructure for focused investment through the C&LM Plan. DEEP supports and recommends the continued use of these targeted strategies for the increased implementation of wastewater and water treatment facility energy efficiency upgrades in Connecticut.

In 2016 the utility companies, two municipalities (Waterbury and Milford), and DEEP joined a three-year effort known as the Sustainable Wastewater Infrastructure of the Future (SWIFT) U.S. DOE Accelerator[177]. This focused collaboration will catalyze the adoption of best practices in energy data management, efficient technologies, and financing for infrastructure improvement. Participating partners across the nation, including these in Connecticut, commit to improving the energy efficiency of their facilities by at least 30 percent and integrate at least one resource recovery measure, such as an anaerobic digester, into their facility's energy management plan. DEEP will work to share these learnings with water companies and wastewater treatment facilities.

Equipment Upgrades

At multiple steps in the water use cycle, pumps and motors are used to deliver water. Installing efficient pumping and motor systems like variable frequency pumps, and storage systems that reduce the need for constant pumping can reduce energy costs at nearly every step. Installing energy efficient disinfection equipment such as UV-based systems, and upgrading aeration equipment can also reduce energy need and GHG emissions. Wastewater treatment facilities should also consider alternative mixing methods and odor control systems.

Additionally, a critical and standard equipment upgrade practice is reducing or eliminating leaks in water supply distribution systems; and reducing infiltration, inflow, and illicit connections to wastewater collection systems. Not only does this minimize drinking water waste, and minimize waste water treatment needs, but also energy waste. Energy used to move water through a pipe or pump that is leaking, is equally as wasteful. Facilities should commit to minimizing leakage at the site, and also promoting awareness and leakage prevention at water end uses as well.

[176] Eversource Energy; The United Illuminating Company; Connecticut Natural Gas Corporation; The Southern Connecticut Gas Company. 2015. *2016-2018 Electric and Natural Gas Conservation & Load Management Plan.*

[177] https://betterbuildingsinitiative.energy.gov/accelerators/wastewater-infrastructure

Operational Improvements

On the operational side, facilities can employ software such as SCADA software which can further reduce energy costs by shifting energy loads during peak and off-peak hours and optimizing process efficiency. Such software can also give treatment facilities better ability to monitor their systems, collect and store data, and identify the most beneficial opportunities for energy efficiency upgrades while protecting water quality. Recovering energy from wastewater treatment sludge through installation of anaerobic digesters will reduce energy and pollution from other sludge management technologies (such as incinerators or long-haul shipping) and will reduce waste volume, which is becoming more important as water treatment standards and processes increase the volume of biosolids. It is important for sewage sludge biosolids digesters to be developed separately from the digester infrastructure being developed for managing source-separated organic materials (SSOM, primarily inedible food waste). The addition of sewage biosolids must not contaminate SSOM/food waste digestion processes to preserve the value of the product of the SSOM/food waste digesters.

Facility Building Modifications

While most energy saving recommendations for wastewater and water treatment facilities focus on process and equipment improvements, there are still building level opportunities for the facilities to benefit from. Encouraging energy assessments, lighting upgrades, HVAC improvements, and opportunities for CHP or renewable cogeneration at these facilities can even further cut costs and improve profitability.

B.2.7 Evaluate applicability of district heating and thermal loops in high density areas.

As defined by state statute, district heating and cooling is a local system that provides hot water, chilled water, or steam from one or more sources to multiple buildings. These systems are often highly effective in high density areas where they can often link offsite generation sources to many buildings, providing thermal energy.

Currently, there are several state laws that relate to district heating: Public Act 15-5 which requires Connecticut's natural gas companies to design incentive programs for systems in their territories; Public Act 12-116 which allowed municipal or commercial property managers to participate in the Connecticut Green Bank's C-PACE financing program; and Public Act 09-15 which authorized the state's purchase of the capitol area system in Hartford. DEEP recommends that further evaluation be conducted to assess the potential for equitable incentives and pricing for district heating statewide and the role of such loops to improve resiliency, efficiency, and reliability.

B.2.8 Inventory state buildings and their energy usage patterns to identify the greatest energy savings opportunities.

DEEP has made substantial progress in assessing energy use at state facilities as part of the implementation plan to reduce energy use in state buildings. DEEP is developing a comprehensive inventory of all state facilities by contacting each state agency to get a list of all their owned buildings and comparing their list with the Office of Policy and Management state building inventory database, known as JESTIR, to see which buildings still exist, which are new, or are no longer state property.

Along with inventorying state facilities, all energy accounts for all state agencies need to be identified and then must be correlated to the correct buildings to identify the energy consumption and expenditure for a specific state building. Data-driven decision making, benchmarking of buildings, and collaboration with state agencies have led to important energy efficiency upgrades and other clean energy installations that will help to save the state money and reduce harmful environmental impacts. For example, a web-based data analyses platform has been procured and customized to reflect state energy invoice data and account-to-buildings-to-meters correlations; electronic data feeds have been established for major utility data; and benchmarking in EPA's Portfolio Manager has been completed for almost 300 state buildings. Additional cooperation from state agencies will be needed to ensure that DEEP can complete the process of correlating each building with its energy account data. DEEP has facilitated continuing inter-agency collaboration on many levels to ensure the program's success: on the Commissioner level for policy decision-making, on the staff level for informed collaboration, and with agencies' finance and facilities staff.

By collecting this data, the State can mitigate its impacts on the grid by identifying the most cost-effective projects that will generate the greatest demand savings. These projects can also enable peak-demand reduction technology installations that will help to cut energy use during times of high peak demand. This information can also inform the Connecticut Green Bank's efforts to identify sustainable financing mechanisms for the government market segment.

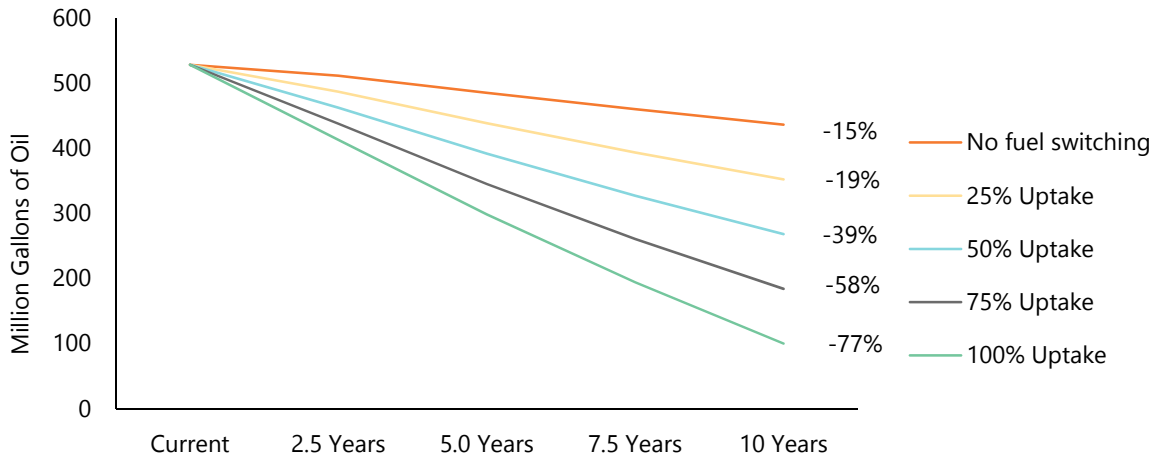
B.2.9 Support diversification of the heating oil delivery industry's products and services.

Declining Demand for Oil

Current trends show that due to improved energy efficiency and more affordable thermal resources becoming available, oil consumption is expected to decline over the next ten years. American domestic oil prices are down 64 percent since their peak in mid-2008 as a reflection of increased supply and decreasing demand.[178] Fuel oil consumption is currently declining at a rate of -2.1 percent per year, yet efficient electric heat pumps and efficient gas equipment are growing by 1 percent and 0.7 percent.[179] A 2016 study of Connecticut Single-Family buildings reflected this change in demand by projecting that over the next ten years, changing to natural gas or efficient electric without utility incentives in single family homes could decrease heating fuel oil consumption by 77 percent, as shown by Figure B16.[180] Even if Connecticut takes no action to advance less carbon intensive fuel choices, consumption is still expected to decrease by 15 percent of the next ten years.

This anticipated shift in residential heating fuel oil consumption represents an opportunity for the delivered fuel oil industry to advance and adapt to changing economic and technological climates and to fill a niche not yet expanded upon.

FIGURE B16: Projected Changes in Fuel Oil Consumption with Fuel Switching Over Time



Source: NMR Group, Inc. 2016. *R15: Connectiuct Single-Family Potential Study.*

[178] United States Energy Information Administration. 2017. *Petroleum and Other Liquids.* 1 March. https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=F000000__3&f=M.

[179] NMR Group, Inc. 2016. R15: Connectiuct Single-Family Potential Study.

[180] Ibid

Opportunities for Diversification of Products and Services

The shift in residential fuel oil consumption creates a strategic opportunity for the industry to diversify its services. In its 2016 paper on Oil and Gas Trends, the Price Waterhouse Cooper (PWC) "*Strategy&*" consulting team recommended that the oil industry "seriously consider incremental diversification," and "moving gradually into low-carbon technologies to manage the evolution of products as fossil fuels are phased out."[181]

Given the proper tools and alignment, this can have important beneficial effects on Connecticut's environment and economy. The residential heating fuel oil industry has already begun to diversify and reposition itself with workforce development training programs focused on the energy efficiency industry and over 600 local fuel oil retailers advancing renewable thermal technology like biodiesel distribution through recycled cooking oil collection and bioheat delivery statewide.[182]

Opportunities for Workforce Retraining and Skill Expansion

Biofuel is a positive development away from carbon intensive fuels, but it is not emission free. There is an opportunity for certain fuel delivery companies to integrate themselves into the energy efficiency industry through building performance training, expanding business operations to include sales and installation of clean energy, and more. In 2015, the CT Workforce Development Consortium, CT Business and Industry Association Education Foundation, and DEEP prepared an Energy Workforce Assessment Report identifying five energy priority areas that need a well-trained workforce, with energy efficiency and industrial energy management training needs at the top. This plan also identified almost fifty energy related job titles that this industry could potentially incorporate into its business models; including Home Performance with ENERGY STAR inspector, weatherization installer, and more. [183]

Just as the fuel oil industry evolved in the early twentieth century out of the ice and coal delivery service as technology advanced, DEEP has great confidence in its ability to adapt into a key player of the clean energy economy.

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[181] Clark, Andrew, and Adrian del Maestro. 2016. *2016 Oil and Gas Trends.* http://www.strategyand.pwc.com/trends/2016-oil-and-gas-trends.

[182]Connecticut Energy Marketers Association (CEMA). n.d. *Consumer Information about Oil Heat.* http://www.ctema.com/consumerInfoOilHeat/.

Connecticut Energy Marketers Association. 2016. *Bioheat.* http://www.bioheatnow.com/#

[183] Burns, Thomas J. 2015. *Connecticut Energy Workforce Assessment: Building the Future Energy Workforce .* Connecticut Department of Energy and Environmental Protection .

Goal 3: Continue prioritizing grid load management to reduce peak demand.

The traditional energy grid has existed as a linear path: from generation, to transmission and distribution, to consumption by buildings and their occupants. However, the future represents a much more complex, interconnected grid that allows buildings to adjust their consumption and demand, as well as be suppliers of energy. Demand for electricity can be managed and reduced through greater participation in demand response programs, targeting demand reduction as part of the State's energy efficiency programs, behavioral change supported by advances in technology and dynamic time of use (TOU) and demand response rates. These efforts can reduce the need to build new generating capacity, avoid new transmission costs, provide a buffer against rate increases driven by high natural gas prices during peak winter months, lower capacity payments, and improve the environment. Demand management techniques also pose a significant opportunity to reduce energy costs, and environmental impacts while increasing resiliency and reliability of our energy resources. This opportunity is brought into even sharper relief by the fact that in 2013, more than one third of the generating capacity procured by ISO New England was used to provide only 10 percent of hours of electricity.[184] In 2015, over 39 percent of generating capacity was used to supply only 10 percent of the hours of electricity used that year.[185]

Demand response curtails demand for electricity based on market signals. Passive demand response, more commonly referred to as energy efficiency, enables electricity consumption to be continuously reduced, for example by installing more efficient light bulbs or an energy efficient refrigerator. These strategies reduce demand overall throughout the day. As previously discussed, energy efficiency is the cheapest, and cleanest energy source.

Alternatively, active demand response is used only when peak demand is anticipated to be reached, typically in the middle of the day in the hot summer months when customers receive a signal shortly before the electric grid is about to experience a period of heightened demand and rather than continuously reducing their demand, customers who provide active demand response

[184] ISO New England, Inc. 2013. *2013-2022 Forecast Report of Capacity, Energy, Loads, and Transmission.* ISO New England.

ISO New England, Inc. 2014. "Hourly Zonal Information, 2013 SMD Hourly Data." *www.iso-ne.com.* May. http://www.iso-ne.com/markets/hstdata/znl_info/hourly/2013_smd_hourly.xls.

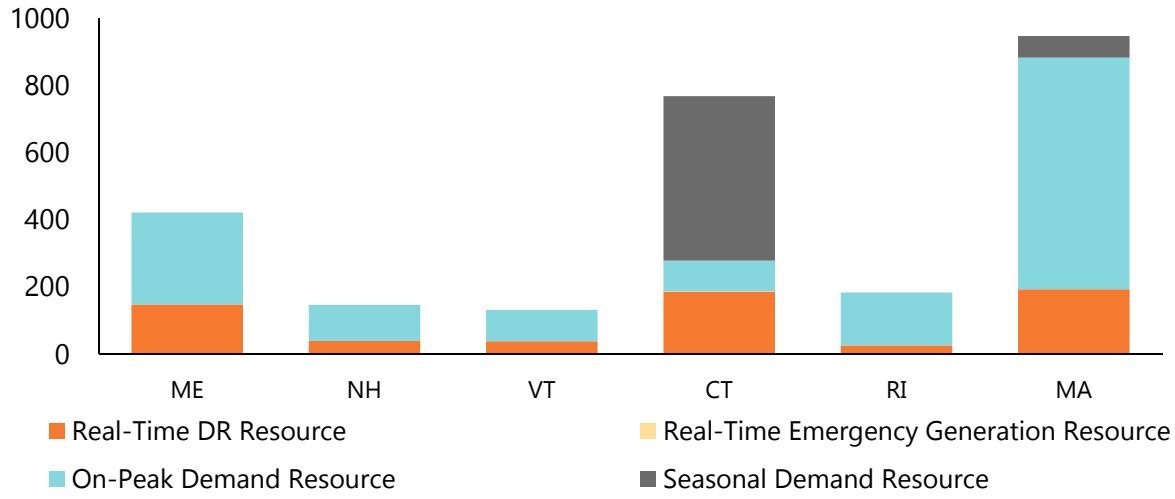
[185] ISO New England, Inc. 2015. *2015-2024 Forecast Report of Capacity, Energy, Loads, and Transmission.* ISO New England .

ISO New England, Inc. 2016. "Hourly Zonal Information 2015 SMD Hourly Data." *www.iso-ne.com.* May. http://www.iso-ne.com/isoexpress/web/reports/pricing/-/tree/zone-info.

resources will limit their electricity consumption only during that period. Active demand response can reduce peak demand, and subsequently, overall system costs by preventing a less efficient power plant from needing to generate, benefiting all customers.[186]

There are a number of different strategies that can be used to catalyze active demand response under current market conditions, both within the forward capacity market and outside of it.

FIGURE B17: Demand Resource Asset Enrolled By Resource Type and Load Zone



Source: ISO New England, 2017. "Demand Resources Working Group."

Though Connecticut actively uses multiple demand response resources to catalyze active demand response under current market conditions as shown in Figure B17, there are two types of active demand response that are best employed by our residential, commercial and industrial buildings– real time demand response and real time emergency generation. Connecticut needs to improve accessibility and usability by buildings of these technologies in order to maximize the potential benefits of demand response.

[186] Order 745 provided certainty for the first time that DR resources could participate in the forward capacity market on a level playing field. However, almost as soon as Order 745 was issued in 2011, it faced litigation creating renewed uncertainty about the future of DR in the FCM. In 2014, the D.C. Circuit Court vacated Order 745, ruling that FERC did not have authority to regulate DR. Published shortly after the Circuit Court's ruling, the 2014 IRP articulated the value of DR and asserted DEEP's ongoing commitment to utilizing DR to reduce costs in the capacity market.

In October 2015, the Supreme Court reversed the Circuit Court's decision on FERC Order 745 and held that FERC does have authority to set compensation rules for DR resources bidding into the market. This ruling established once and for all, that the megawatt hours of electricity avoided through DR will receive compensation equal to that received by the megawatt hours of electricity generated by power plants.

B.3.1 Target peak demand reductions.

One of DEEP's major energy focuses is on not just reducing overall energy demand, but reducing peak demand. The 2014 IRP stated that Connecticut's energy policies should help to reduce peak demand growth to .5 percent per year. Due to energy efficiency investment, energy demand has also begun to flatten, helping to relieve the grid and minimize periods of peak demand which require fuel-intensive power generation. As of 2017, Connecticut has surpassed this goal and is expected to decrease peak demand by -0.4 percent annually between 2017 and 2026, as shown previously in this chapter in Figure B11. However, maintaining focus on reducing peak demand will become even more critical as this projection assumes that Connecticut's energy efficiency and renewable investments will continue at the current rates. Connecticut energy efficiency programs must continue this rigorous pace, especially as the electrification of heating systems and the electrification of vehicles will likely increase load and will need to be controlled, particularly during peak demand periods.

Benefits of demand response do not only apply to summer peak demand. Winter peaks are also a concern giving the procurement practices of natural gas fired generators. The reduction of winter peaks must be an ongoing priority in both the electric and gas conservation programs.

This Strategy therefore recommends that Electric Conservation programs more aggressively pursue peak summer and winter demand reductions. Strategies that use buildings as a resource to manage peak demand will therefore play an increasing role in Connecticut's approach to managing peak energy demand.

B.3.2 Increase and standardize two-way advanced meter communication.

In order for demand response to effectively expand and integrate into the grid, our communication systems between generation and consumption need to evolve in a standardized and systematic process.

Phase-In Deployment of Advanced Meters

The term "smart grid" is defined as technologies that allow for two-way communication and computerized automation of the electrical grid system. This not only allows for faster active demand response with the grid directly communicating with advanced meters (often referred to as "smart meters") that control building energy use, but also allows ratepayers to centrally manage their building processes and appliances' energy usage. Consumers can see how much electricity they are using and in real-time costs, improve the efficiency of transmission, reduce O&M costs

which can drive down rates, and allow for the integration of greater behind the meter renewable energy.

UI retrofitted its current meters with one-way cellular communications capability during the 1990s. This allows UI to read its meters remotely and frequently (i.e. on an hourly basis). As a result, UI's current meters can support time-of-use rates for all customer classes without UI needing to replace the meter, or visit the meter to reprogram it. This allows any customer to be placed on a time-of-use rate without UI incurring additional costs to do so.

Currently, UI is in the process of replacing its current meters with more advanced technology as its metering infrastructure is approaching the end of its useful life. In addition to supporting time-of-use pricing these new meters can support other dynamic rate structures, like hourly rates (i.e., 24 hourly price points), can communicate with smart appliances and provide real-time consumption data to UI and its customers. These differences mean that UI is better positioned to provide its customers with the opportunity to control their use and costs in the near term by promoting existing TOU rate options and developing new dynamic demand response price options.

Comparatively, Eversource customers utilize Automated Meter Reading (AMR) systems that allows Eversource to read customers' meters using a drive-by, one-way radio signal technology. This reduces meter reading costs by eliminating the use of pedestrian meter readers but, these meters do not currently have the capacity to support dynamic pricing strategies like time-of-use rates, unless a customer specifically requests a more advanced AMR meter that can. A 2009 pilot deployment of advanced meters by CL&P (now Eversource), and plan proposal to implement advanced metering infrastructure for all customers by 2016 was halted in 2011 due to concerns that abandoning the current metering system would result in over $100 million of stranded costs, and replacing them would cost about $300 million.

However, since the time advanced meters were last examined, new technologies have been developed and other issues may have been resolved. DEEP recommends that PURA reopen the docket and that the utility companies prepare an updated analysis of the costs and benefits of advanced meters and consider available technologies that can be phased-in over time.[187] A phased-in approach would minimize rate impacts, and prioritize adoption by customers most likely to benefit from their use. The plan should target meters as they fail or otherwise need to be replaced and target different customer classes, based primarily upon which classes (such as high use residential customers) are most likely to benefit from advanced meters.

[187] Docket 05-10-03RE04

Advanced metering technologies and capabilities are evolving, so a thoughtful strategy must avoid adopting systems that may become obsolete within a few years. It should be tied to time-of-use rate and dynamic pricing options to ensure that customers have appropriate and fair incentives to use power at optimal times. New rate options provide energy and capacity benefits by reducing demands and shifting energy consumption to off peak periods. It can also enhance revenue collection, improve communications during outages, and streamline utility operations and system reliability. It is important to examine all of these costs and benefits of advanced meters. As policymakers strive to increase electric vehicles and distributed generation, advanced metering technologies offer important features that could be utilized to send proper price signals to customers, improve service, and reduce costs.

Promote Use of Smart Grid Standards to Protect Ratepayers and Infrastructure

One of the primary concerns that arose during the 2009 pilot was that advanced meters allowed utilities to learn private information about their ratepayers, like sleeping patterns or when they are home. This led to greater concerns that data could be used in burglary, fraud, or corporate espionage. Connecticut should consider legislation that protects ratepayers from these risks and minimizes utility liability. In 2011, the California legislature adopted SB 674 which prevents utilities from sharing or disclosing a customer' electrical meter data to any third-party without the consent of the customer, allowing ratepayers to have access and control of their data for their own use, but also over how anyone else uses it. When considering statewide deployment of advanced meters, DEEP recommends the adoption of similar legislation or at a minimum, continuation of similar current standard practices.

Additionally, if we treat buildings and appliances as resources for the grid, then we will need to consult and incorporate national standards into advanced grid planning to ensure a secure, common, and stable basis for communicating information and moving power in both directions. Examples of such standards include the National Institute of Standards and Technology (NIST) Smart Grid Standards, the American National Standards Institute (ANSI)/ National Electrical Manufacturers Association (NEMA) SG-ICE 1 *Smart Grid Interoperable and Conformant Testing and Certification Scheme Operator Guidelines,* and the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) *Facility Smart Grid Information Model*.

B.3.3 Optimize economic signals and incentives for demand response to recognize shifts in demand from expanding electrification of heating and transportation.

Promote Dynamic Time of Use Rates and Peak Time Incentives

For advanced meters to be cost-effective for residential and small commercial they must be utilized by as many customers as possible. DEEP believes that mandatory time of use (TOU) rates with optional dynamic rates may be the best way to do this. TOU rates and demand response rates can help motivate behavioral changes of energy usage. Dynamic pricing refers to all rates that are time-differentiated to encourage load shifting or load curtailment. These efforts can reduce the need to build new generating capacity, avoid new transmission costs, provide a buffer against rate increases driven by high natural gas prices during peak winter months, lower capacity payments, and improve the environment.

Both Eversource and UI have offered TOU rates in the past, but were often only made available to commercial and industrial customers. However, more recently, new rates have been developed for the same purpose but are structured to encourage smaller customers to curtail their loads. Deployment of such rates and use of the rate is critically important. Critical Peak pricing is an example in which customers pay a very high price on a kWh basis for just a few peak hours a year. The high price provides an incentive for customers to reduce their consumption during the critical peak hours. Another example United Illuminating is implementing on a pilot basis is Critical Peak Rebates where, rather than charging customers a high price during peak hours, customers are paid a rebate if they reduce their consumption during these hours. Some utilities, including Eversource, have tested shorter hours for the on-peak period and greater on and off-peak differentials to improve participation and the effectiveness of TOU rates.

Incorporating new technologies to automatically control electric usage can improve effectiveness of dynamic rates. Recent advances in information technology for smart meters, controls, appliances, and equipment are beginning to knit the grid, its sources of supply, and its sources of demand, into an intelligent, better-integrated system that can be controlled in a far more dynamic fashion than is possible today. Integrating TOU rate programs with advanced meters allows for two-way communication between grid operators and loads, as previously discussed, and can modulate demand as needed or desired. Without advanced meters, customers may be limited in their ability to take advantage of dynamic pricing and the enhanced demand management opportunities that emerging technologies may provide.

This Strategy recommends that UI continue to promote sufficiently differentiated time-of-use rates to all of its residential and small business customers. UI should develop new dynamic price

options and provide customers with information about how TOU rates can shift consumption to off peak periods for its customers. UI should continue its new practice of providing peak time rebate payments and also continue providing incentives and assistance for technologies to automatically control appliances and thermostats to help customers on TOU rates reduce their electric consumption during on-peak periods by better aligning their rate programs with their conservation program.

Likewise, Eversource should offer time differential components of the electric bill such as distribution and transmission charges to create a larger difference between on and off peak rates. This would create a better incentive for customers to shift usage to off peak periods. Time differentiating Transmission and Distribution charges would also create TOU incentives for customers that obtain generation service from competitive suppliers.

Central to any meter deployment strategy is pricing that reflects the cost of procuring electricity (which is higher during periods of peak demand and lower when demand is low) to provide commensurately positive and negative signals to customers. If DEEP's recommended advanced meter policy is deployed statewide, DEEP believes that a mandatory time-of-use policy should be activated and optional TOU and other dynamic rate options should be available and promoted for all customer classes. If however, Connecticut does not move forward with advanced meters, this Strategy recommends that Eversource strengthen their promotion of time-of-use rates as a voluntary option for its residential and small commercial customers using their current metering technology.

Evaluate Real Time Demand Response Pilots and Their Scalability

Real time demand response refers to when customers reduce their electricity consumption – for example by turning down air conditioning during a summer peak. Industry often contributes to real time demand response by choosing to delay an energy intensive processes until after periods of high energy have passed. Traditionally, this has been a behavior-based method, but with the introduction of "smart" technologies like Wi-Fi thermostats and HVAC systems that can receive and respond to these signals directly, buildings can provide significant, direct benefits to the energy grids without manual adjustments.

Additionally, timing is critical to effective demand response strategies. In Connecticut, daily peak demand occurs in summer during the afternoon, typically from about one or two p.m. to seven or eight p.m. The highest peak occurs during the summer months when electricity is being used around the state not only to power appliances and lights, but cooling systems. Winter peak demand typically occurs from four p.m. to seven p.m., reflecting the increased use of residential lighting during this time period in the winter months, coinciding with the lack of solar generation contributions during that period to offset demand. Demand response strategies heavily consider

these peak period patterns and incorporate these conditions into the demand response planning. To be responsive in the future, it is important to recognize the shift in overall load and peak load timing that may occur as more heat pumps are used, as more electric vehicles replace fossil fuel vehicles, and as renewable generation sources and energy storage units offset the peak loads at different times.

Promote Onsite Generation

In contrast, customers who provide active demand response through on-site generation do not reduce their electricity consumption but instead turn to standby generation located on their property. By consuming energy from onsite generation, these facilities effectively reduce demand on the electric grid. Increasing renewable generation sources for onsite generation, such as solar, wind, anaerobic digestion, and cleaner generation sources such as fuel cells can enable participation in active demand response programs without turning to diesel generators for standby generation for non-critical and critical infrastructure buildings. Doing so could increase the opportunities for cleaner active demand response participation at such buildings.

Critical facilities, such as hospitals, that have emergency generation are those that need to be able to operate during times of power outages. These emergency generation units are often fueled by diesel which can be stored on site, but as technology advances, facilities could consider less polluting options like hydrogen fuel cells, or renewable and energy storage combinations for use during emergency generation periods.

On a smaller scale, residential buildings can reduce, or even eliminate, their grid load demand by generating their own energy through renewables, particularly solar photovoltaics. The ability for homeowners to put solar panels on their roofs allows them to directly link to the grid and sell back the energy they do not need; yet another way to reduce the load on current generators. Capturing the actual net cost of this demand reduction to ensure that the cost of interconnection and two-way communication from multiple individual homes does not result in shifting system costs to others will be necessary to ensure equitable distribution of system reliability costs.

DEEP recommends that onsite generation is promoted at facilities seeking greater energy reliability on site, but also recommends that advanced meter technologies and energy storage be integrated to improve efficiency and effectiveness of this generation. Priority should be placed on renewable onsite generation as technology costs decline and Connecticut continues to pursue its Renewable Portfolio Standard's goals of 20 percent Class I by 2020, although natural gas back up generation can also be cost-effective and cleaner than other fossil fuel options.

Evaluate and Prepare for Energy Storage

Such expansion of behind the meter renewable technologies further demonstrates Connecticut's leadership in deploying cleaner energy generation technologies, but policymakers must also carefully consider the impacts that such integration, whether indirectly or directly, can place on the grid and ratepayers. Just as peak energy demand exceeding the capacity threshold on a hot, summer day can cause brown or black-outs, the reverse is also true. Facilities or homes that can generate their own energy can, at times, find themselves with greater amounts of generated energy than they need. Sending this excess out to the grid is an option, but this leaves the potential for overloading the grid, rendering it unstable.[188] Another option exists in energy storage. If a facility or building uses onsite renewables, storage would allow them to have reliable power if the sun is not shining or the wind is not blowing. If they use backup generation in coincidence with TOU rates, they can cut consumption during a period of peak demand and high energy rates and rely on stored energy.

In 2015, the Massachusetts Department of Energy Resources prepared a study on energy storage. It stated that "the need to size all grid infrastructure to the highest peak results in system inefficiencies, underutilization of assets, and high costs to ratepayers," and "energy storage is the only technology that can use energy generated during low cost off peak periods to serve load during expensive peak periods."[189] Figure B19 demonstrates that effect below.

Commercial-scale energy storage costs have declined by over 70 percent since 2010 and are continuing to improve.[190] This technology is still undergoing research and development, but early designs do currently exist in the forms of batteries, flywheels, thermal storage, and pumped hydroelectric storage.[191] These are capable of deploying energy within seconds. For example, as noted in the 2016-2018 C&LM Plan:

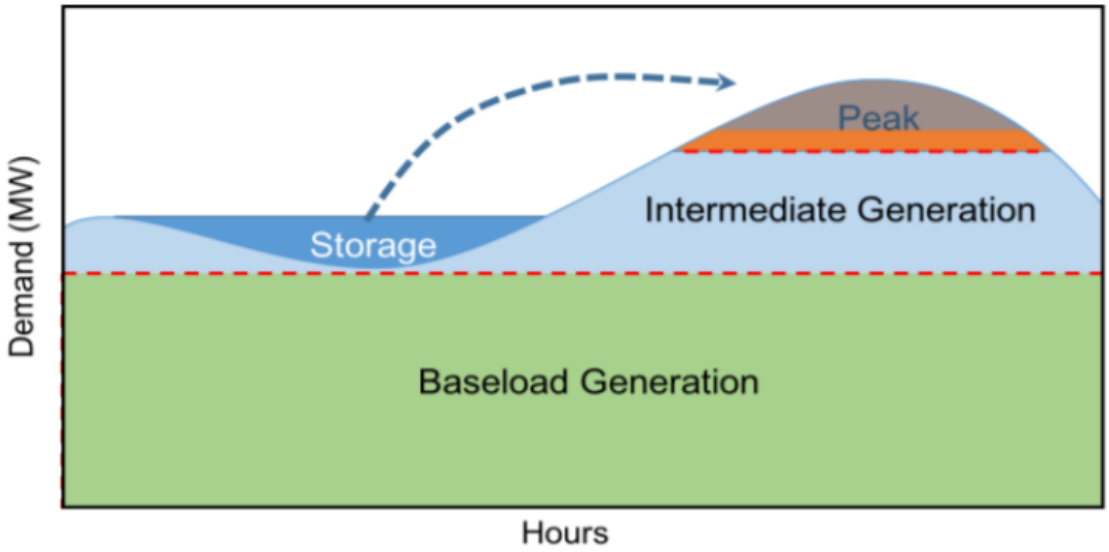
[188] Institute for Energy Research. 2013. *Germany's Green Energy Destabilizing Electric Loads.* 23 January. http://instituteforenergyresearch.org/analysis/germanys-green-energy-destabilizing-electric-grids/#.

[189] Massachusetts Department of Energy Resources. 2015. *Massachusetts Energy Storage Initiative.* Massachusetts Executive Office of energy and Environmental Affairs.

[190] Mckinsey & Company . 2016. *The New Economics of Energy Storage.* August. http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/the-new-economics-of-energy-storage.

[191] Massachusetts Department of Energy Resources. 2015. *Massachusetts Energy Storage Initiative.*

FIGURE 18: How Energy Storage Can Offset Peak Energy during Times of High Demand



Source: Massachusetts Department of Energy Resources. 2015. *Massachusetts Energy Storage Initiative.*

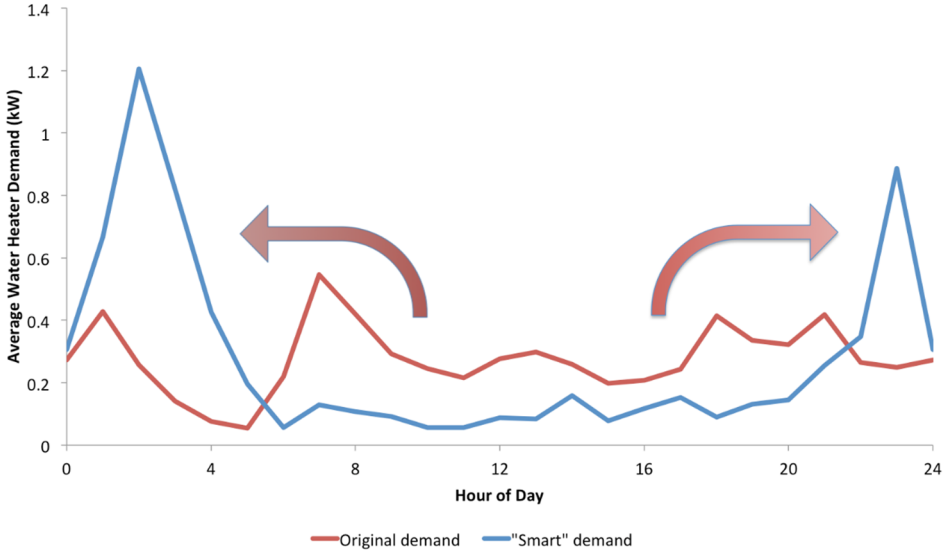
> *"Phase Change Materials ("PCMs") are products that store and release thermal energy during the process of melting and freezing; while changing from one phase to another. When PCMs freeze, they release energy in the form of latent heat of fusion, or energy of crystallization. As PCMs melt and change from a solid to a liquid, an equal amount of energy is absorbed from the immediate environment. These materials have applications as temporary energy storage units, and can bridge the gap between energy requirement and energy use. A thermal storage application may involve a 24-hour, weekly, or seasonal storage cycle dependent upon the system design requirements, and innovative new PCMs could help reduce daily and seasonal peak loads."*[192]

While residential-level storage options are beginning to appear on the market like the Tesla Wallpack, other options include turning electric water heaters and electric vehicles into energy storage devices. Conventional storage water heating typically operates by maintaining the water temperature in the water tank at approximately 120° F. This means that these systems continually demand electricity to maintain this water temperature, with the amount of electricity required highly dependent on how effectively the water tank is insulated. Traditional storage water tanks can be converted into active demand response resources, however, by installing what is called a grid-interactive water heater which enables water to be heated to a higher temperature in advance of when a period of peak demand is predicted to occur. Then, if warm water is needed during the peak, this hotter water can be combined with cooler water to produce water out of the tap at the

[192] Eversource Energy; The United Illuminating Company; Connecticut Natural Gas Corporation; The Southern Connecticut Gas Company. 2015. *2016-2018 Electric and Natural Gas Conservation & Load Management Plan.*

appropriate temperature without requiring any electricity to heat the water. The load shifting opportunity of grid-interactive water heaters is shown in Figure B19.

FIGURE B19: Load Shifting of Grid-Interactive Water Heaters



Source: Crofton, Karen, and Mark Dyson. 2015. *Why Tankless Water Heaters Might Not Hold Water.* Rocky Mountain Institute.

Likewise, as Connecticut seeks to electrify its transportation systems, electric vehicle fleets will increase and while they can increase energy demand, they can serve as storage devices. Homes or buildings that utilize onsite generation, whether emergency or general, can store and use excess generation in the batteries of electric vehicles. Preparing our buildings to accommodate such a solution is recommended not only to advance Connecticut's transportation goals but to expand affordable storage opportunities as battery technology works towards improved affordability. DEEP recommends continued investigation of the achievable potential of water heaters and electric vehicles as energy storage units in residential buildings, especially those that have been weatherized, and are using renewables to power their homes. This could help reduce grid loads, costs to consumers and emissions reductions.

Outlook for Future Demand Management

Connecticut has been a leader in energy efficiency policy and deployment as it advances towards its ambitious energy and greenhouse gas emissions reductions goals. The building sector in particular presents significant opportunity for energy savings and permanent grid load reductions as more and more residents and businesses recognize the value of energy efficiency.

Measuring demand load reductions will need to consider metrics that account for the permanence of market transformations such as efficient building codes, product efficiency standards, and high efficiency lighting, while recognizing the potential for future technological improvements in building and lighting controls that will be needed to offset future demand as the transportation sector is electrified.

Energy efficiency not only helps Connecticut achieve its policy goals, but provides a wide spectrum of benefits to its residents and businesses. These benefits range from cost savings, to health and safety improvements, to permanent regional grid load relief. Even with Connecticut's incredibly diverse housing and building stock and wide variety of businesses, there are thermal, electric, and/or industrial processes opportunities for everyone to save money and energy. The growing energy efficiency industry produces local jobs with a range of skill levels.

Connecticut has consistently increased its commitments to passive demand response through energy efficiency in recent years, and should continue that trend as well as continuing to expand active demand response and demand management programs. Ensuring the interoperability of demand response communications between the electric grid and buildings will require disciplined attention to international standards.

The future of energy demand management will require continuing and expanding investments in energy efficiency, including direct procurement of efficiency as a resource, while also increasing investments in strategies such as strategic electrification, electric vehicle-ready buildings, deployment of advanced meters, and expanded implementation of distribution level demand response. The use of building asset scores, as well as the broadening use of time varying rates, critical peak pricing, and peak demand rebates will increasingly need to be used to send economic signals regarding the value of energy to residents and businesses. As Connecticut builds on its approach to buildings as an efficient energy resource and recognizes that energy productivity increases the competitiveness of our businesses, our energy infrastructure will become cleaner, stronger, and more resilient.

Chapter Three: The Transportation Sector

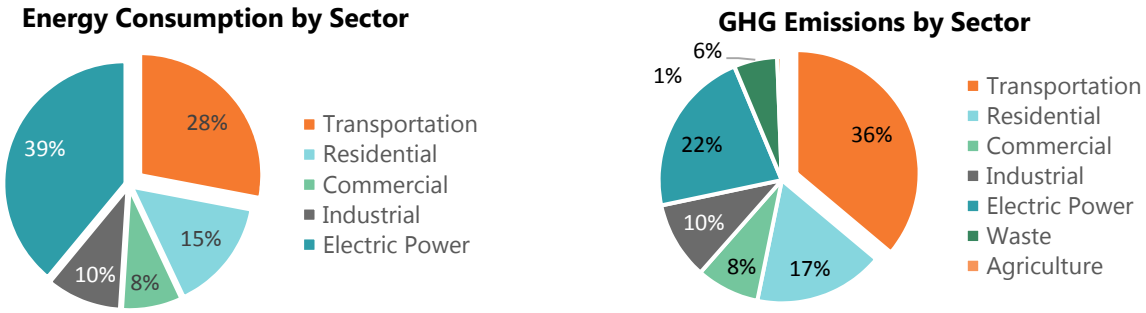
INTRODUCTION

Transportation is an integral part of Connecticut's socioeconomic fabric. Connecticut's transportation system and infrastructure encompass an extensive range of multimodal elements – from roadways and highway facilities, pedestrian and bicycle accommodations, to bus transit systems, passenger and freight railways, airports, deep water ports, and even ferry landings. This infrastructure connects residents and visitors to families, friends, services, jobs and communities. It also enables the movement of retail goods, raw materials, and other commodities in, out, and around the state. The reliability of the state's transportation system and supporting infrastructure, as well as the energy resources necessary to operate that system have a direct impact on Connecticut's economy and the quality of life for its 3.5 million residents and their local communities. To effectively enhance quality of life, minimize environmental impacts, and foster continued economic growth, it is critical that the state provides a safe, reliable and efficient transportation system that can accommodate future growth in population, tourism, business, and recreation.

Transportation-related energy use is dependent on the types of fuels used, the vehicles or other modes of transport used, and the number of vehicle miles traveled (VMT). A sustainable and low-carbon transportation energy future will require significant refinements to this system in order to provide increased mobility options to citizens and businesses and ensure that the state achieves its greenhouse gas (GHG) emissions reduction targets. As the state's largest contributor to GHG emissions (see Figure T1), steep reductions from the transportation sector will be required to ensure Connecticut meets its Global Warming Solutions Act of reducing emissions 80 percent below 2001 levels by 2050 and any mid-term target recommended by the Governor's Council on Climate Change (GC3).[193]

193 The Governor's Council on Climate Change is tasked with recommending an interim statewide GHG reduction target for the years between 2020-2050 and identifying short- and long-term strategies to achieve the necessary reductions. The Office of Governor Dannel P. Malloy, "Executive Order No. 46," April 22, 2015, http://portal.ct.gov/en/Office-of-the-Governor/Pages/Press-Room/Executive-Orders?SearchKeyword=&Month=by+Month&Year=2015.

FIGURE T1: Connecticut Energy Consumption and GHG Emissions by Sector



Source: U.S. Energy Information Administration, *Connecticut State Energy Profile*

Connecticut's approach to transportation must embrace solutions that go beyond adding roadway capacity to address population growth and economic expansion. Solutions should involve comprehensive strategies that maximize benefits from limited new construction and improve operational efficiency for public transit and railways while increasing connectivity, user flexibility, and equitable access. Considerable effort should be placed on implementing strategies that not only reduce costs and grow mobility options for people and businesses, but also improve local air quality and advance the State's GHG emissions reduction goals.

Connecticut's transportation systems should enhance the quality of life for residents, sustain the character of local communities, and enrich the state's economy now and in the future. Linking transportation planning and decision-making to economic growth and sustainable development will not only enhance the well-being of Connecticut residents, but also make the state a more desirable place to live and work.[194] This 2017 CES, informed by the prior recommendations of the 2013 CES, reflects DEEP's continuing effort to integrate transportation considerations into the State's overall energy and environmental planning efforts.

It is important to note that the State has limited authority in some of the areas that have the most impact on transportation energy use and emission reductions. For example, historically, federal laws largely determine vehicle efficiency standards, funding for much of the state's infrastructure and transit, and the composition of fuels. Further, municipalities have jurisdiction over land use and development patterns at the local level. Therefore, in this updated CES, DEEP's transportation sector recommendations focus on achieving distinct long-term goals that are expected to support the State's commitment to develop a cheaper, cleaner, more reliable and sustainable transportation system.

194 Let's Go CT!, the Department of Economic and Community Development's 2015 Strategic Plan, and the current draft of Connecticut's Conservation and Development Policies Plan (2018-2023) mutually reinforce these long-term goals for Connecticut's transportation infrastructure.

TABLE OF GOALS AND STRATEGIES FOR 2017 CES

CHAPTER THREE: TRANSPORTATION SECTOR

Goal 1: Put the State on a strategic pathway to decarbonize the transportation sector

T.1.1	Develop an Electric Vehicle Roadmap to accelerate the adoption of low and zero-emissions vehicles and strengthen alternative fueling infrastructure.
T.1.2	Advocate for the implementation of federal vehicle fuel economy standards and maintaining LEV, ZEV, and GHG programs.
T.1.3	Educate and engage citizens and employers on the benefits of clean and efficient transportation options.

Goal 2: Facilitate state planning to advance smart-growth, transit-oriented development, and mixed-use planning that leads to energy and emissions reductions.

T.2.1	Implement Let's Go CT! initiatives and its long-term vision to create a best-in-class transportation system.
T.2.2	Encourage and support smart-growth, transportation-oriented development, mixed-use planning, and development efforts that improve connectivity and accessibility to public transit.

Goal 3: Develop and support strategic partnerships to improve access to a wider array of transportation options

T.3.1	Embrace technological advances, shared mobility services, and transportation demand partnerships that improve mobility and access to clean modes of transportation.
T.3.2	Participate in regional partnerships and initiatives to advance a clean and efficient transportation network throughout the region.

CURRENT TRENDS IN THE TRANSPORTATION SECTOR

Energy Consumption and Expenditure

Connecticut uses 28 percent of its total energy each year to move people and goods.[195] (See Figure 1) This includes utilizing multiple modes of transport, from personal vehicles and large trucks to public transportation to airplanes, freight trains, and boats.

Connecticut's citizens and businesses continue to rely on traditional internal combustion engine (ICE) vehicles, and the use of petroleum-based fossil fuel to power them, as their primary means for mobile transit. Motor gasoline, at 77 percent, represents the largest share of energy consumed within the transportation sector, mostly by passenger cars and light trucks (see Figure T2). The economic and energy security implications of this dependency on a single fuel source puts the Connecticut economy at risk to market forces largely out of the control of the State. In addition to this, GHG emissions from the transportation sector account for 36 percent of economy-wide emissions. This makes the transportation sector the largest source of the state's GHG emissions.[196]

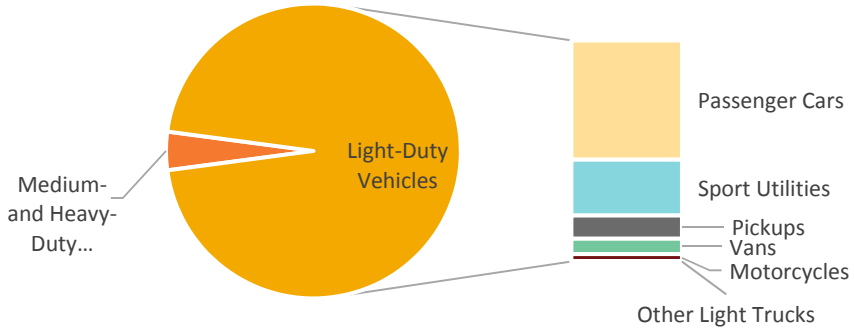
Connecticut Transportation Sector Key Facts

- 91 percent of the state's households have at least one registered vehicle.
- 95 percent of vehicles registered in Connecticut are light-duty vehicles, consisting of passenger vehicles and light-duty trucks (vans, pickups and SUVs).
- 87 percent of the state's residents at or above driving age are licensed drivers.
- Nearly 80 percent of commuters in the state drive to work alone.
- The average commute time in Connecticut is 24.8 minutes.
- Slightly more than half of Connecticut commuters travel less than 10 miles to get to work, while 30 percent travel between 10-24 miles.

[195] U.S. Energy Information Administration, State Energy Data System (2013 data).

[196] Connecticut Department of Energy and Environmental Protection, *2013 Connecticut Greenhouse Gas Emissions Inventory*, 2016, http://www.ct.gov/deep/lib/deep/climatechange/2012_ghg_inventory_2015/ct_2013_ghg_inventory.pdf.

FIGURE T2: Vehicle Registrations in CT in 2013



In 2013, Connecticut had about 1.47 million passenger cars and 1.17 million light trucks (vans, pickups and sport utility vehicles) on its roads, and about 120,000 buses, tractor-trailers, and other medium- and heavy-duty vehicles.

Source: Atlas Public Policy and The Cadmus Group, Inc., Moving Forward with Green Energy: Market Potential Assessment for Alternative Fuel Vehicles in Connecticut, p. 16, September 2016.

As a spending category, transportation accounts for an average of 17 percent of a U.S. consumer's expenditures in 2015. This ranks second only to housing.[197] Of that transportation cost, 22 percent was spent toward gasoline and fuel oil to power vehicles. (See Table T1.)

TABLE T1: U.S. Average Annual Expenditures in Gasoline & Fuel Oil and Vehicle Purchases per Consumer Unit in 2015

Expenditures	$/Unit	Percent
All transportation expenditures	$9,503	100%
Gasoline & Fuel Oil	$2,090	22%
Vehicle Purchases	$3,997	42.1%

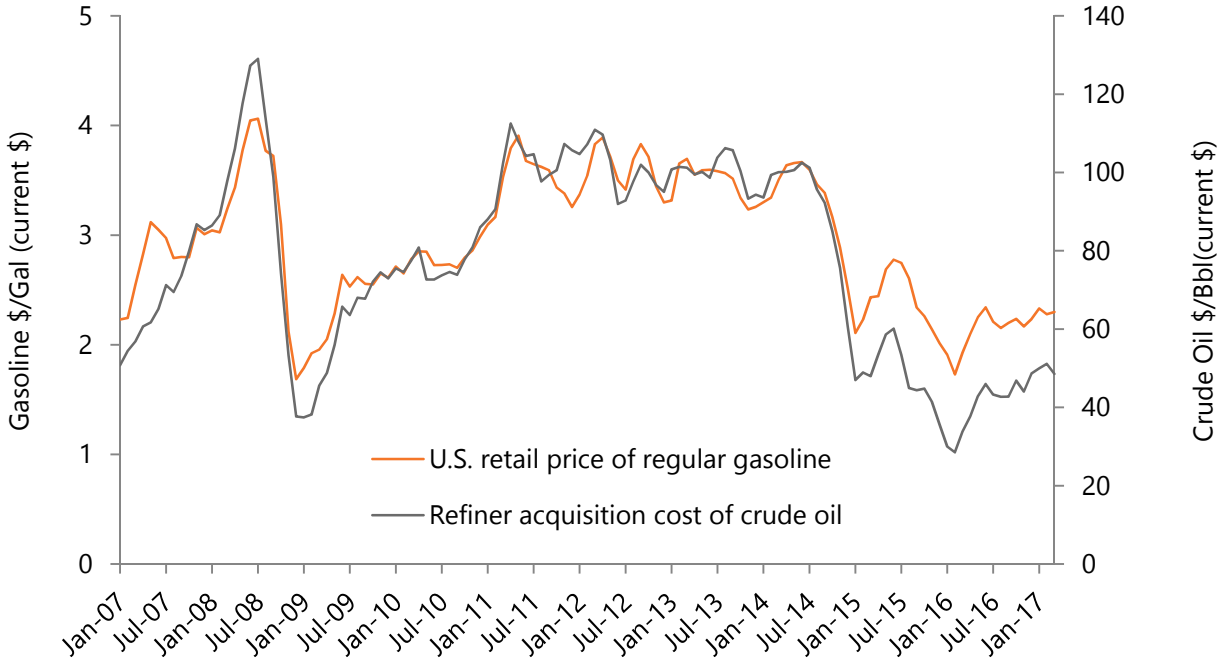
Source: Consumer Expenditures – 2015, U.S. Bureau of Labor Statistics ***(8/30/2016).***

In recent years, low gasoline and fuel oil prices have helped consumers lower their transportation expenditures. However, a dependence on petroleum-based fossil fuels exposes Connecticut residents and businesses to potential price spikes that could destabilize budgets and bottom lines. Crude oil – which is processed in refineries to make gasoline, diesel, heating oil, jet fuel, lubricants, petrochemical feedstocks and other petroleum products – remains the most economically and politically volatile of all energy resources. Prices for these petroleum products tend to fluctuate in

197 U.S. Department of Labor, Bureau of Labor Statistics, "Consumer Expenditures – 2015," August 30, 2016, 2, https://www.bls.gov/news.release/pdf/cesan.pdf.

line with crude oil prices, as shown for regular gasoline prices in Figure T3, albeit with some variation due to seasonality, product-specific market factors, or refining outages.[198]

FIGURE T3: U.S. Regular Retail Gasoline Prices and U.S. Refiner Crude Oil Acquisition Costs



Source: U.S. Energy Information Administration

During 2013, drivers traveled about 31 billion miles on Connecticut's roadways, mostly on interstates, freeways, expressways, and arterial roads.[199] As shown by Figure T4, average daily VMT statewide in Connecticut has largely trended upward since the 1970s, but experienced a period of decline in 2007 due to the recession, higher gasoline prices, and an increase in mass transit ridership. Today, statewide average daily VMT is approximately 85.5 million miles per day. Based on the Connecticut Department of Transportation's (CTDOT) projections, average daily VMT in the state is expected to increase to 104.1 million miles per day by the year 2040.[200]

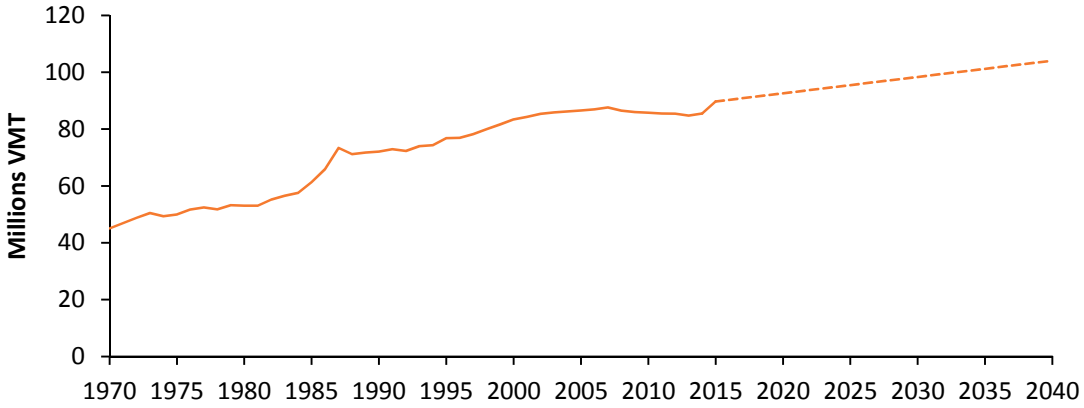
[198] U.S. Energy Information Administration, "What drives crude oil prices: Spot Prices," accessed November 2, 2016, https://www.eia.gov/finance/markets/crudeoil/spot_prices.php.

[199] Atlas Public Policy and The Cadmus Group Inc., *Moving Forward with Green Energy: Market Potential Assessment for Alternative Fuel Vehicles in Connecticut*, September 2016, 18, http://atlaspolicy.com/wp-content/uploads/2016/11/2016-09-01_Moving_Forward_with_Green_Energy.pdf.

[200] Connecticut Department of Transportation response to DEEP data request

Despite encouraging signs of increased public transit use, Connecticut anticipates that its populace will likely continue to rely on personal motorized vehicles for their transportation needs. One possible contributing factor to this is low gasoline prices, which is correlated with a recent uptick in VMT in Connecticut for travel needs.

FIGURE T4: Average Daily VMT Statewide (All Vehicles Combined)



Source: CTDOT

The Hartford, Bridgeport/Stamford, and New Haven urban areas accounted for the highest numbers of average daily VMT in the state during 2015, at 23.5 million miles per day, 20.6 million miles per day, and 13.9 million miles per day, respectively.201 Combined, passenger vehicles and light duty trucks make up nearly 90 percent of all statewide VMT, while motorcycles, buses, single-unit trucks and combination trucks contribute the remaining 10 percent. (See Figure T5.) Increased VMT on Connecticut's roadways contributes to congestion, causing delays, added costs, increased emissions, and frustration for residents, businesses, and visitors. Nearly 50 percent of all in-state travel occurs along 652 miles of interstate and limited access highways, a mere 3 percent of Connecticut's roadways.202 In its May 2017 report, TRIP estimated that congested roads and bridges cost Connecticut's drivers an estimated $6.1 billion, comprised of $2.2 billion in additional vehicle operating costs, $2.4 billion in congestion-related delays (i.e., lost time and wasted fuel), and $1.5 billion in costs from traffic crashes in which roadway design was likely a contributing factor.203,204 Each driver in Connecticut sits in traffic approximately 45 hours per year, costing

201 Connecticut Department of Transportation response to DEEP data request (May 8, 2017).

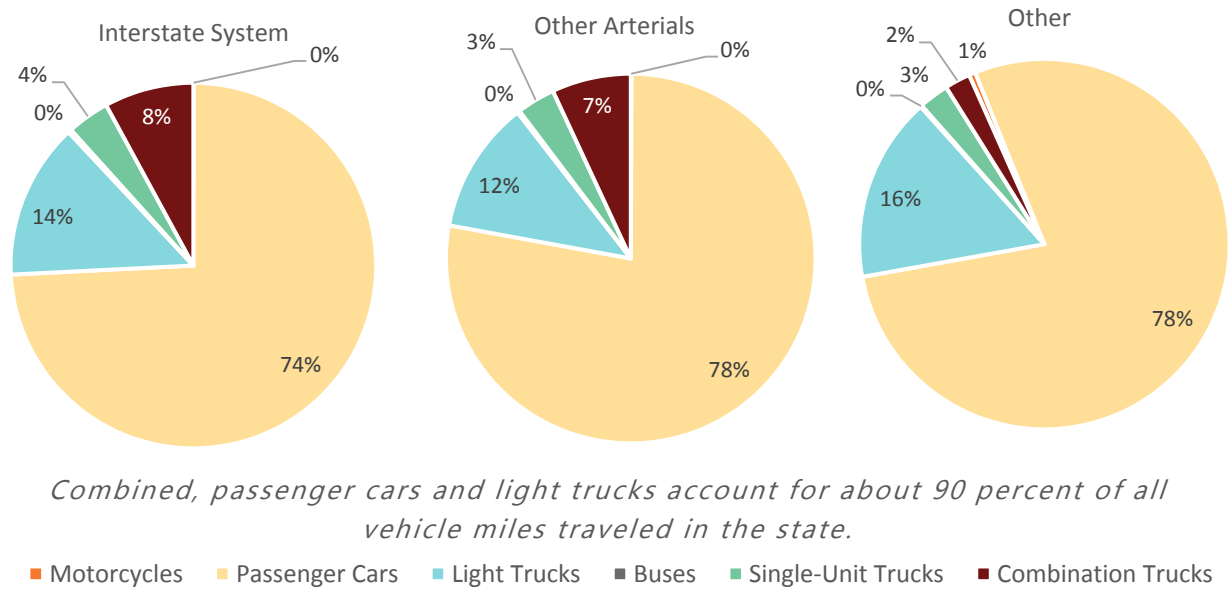
202 Connecticut Department of Transportation, "Let's GO CT! Fact Sheets: Connecticut's Traffic Bottlenecks," March 2015, http://www.transformct.info/img/documents/Lets%20Go%20CT-%20Fact%20Sheets%2020150313.pdf.

203 Founded in 1971, TRIP is a private nonprofit organization that researches, evaluates and distributes economic and technical data on surface transportation issues.

204 TRIP, *Connecticut Transportation by the Numbers: Meeting the State's Need for Safe and Efficient Mobility*, May 2017, 2, http://www.tripnet.org/docs/CT_Transportation_by_the_Numbers_TRIP_Report_May_2017.pdf.

approximately $1000 annually.205 (See Figure T6.) Table T2 outlines the average cost per driver for congestion-related delays and the average number of hours wasted in traffic per driver in Connecticut's three largest urban areas. Notably, 45 percent of businesses surveyed by the Connecticut Business & Industry Association believe that road congestion in the state restricts or limits the territory of their market.[206]

FIGURE T5: Percent of Daily Miles Traveled by Vehicle in 2013



Combined, passenger cars and light trucks account for about 90 percent of all vehicle miles traveled in the state.

Source: Atlas Public Policy and The Cadmus Group, Inc., Moving Forward with Green Energy: Market Potential Assessment for Alternative Fuel Vehicles in Connecticut, p. 18, September 2016.

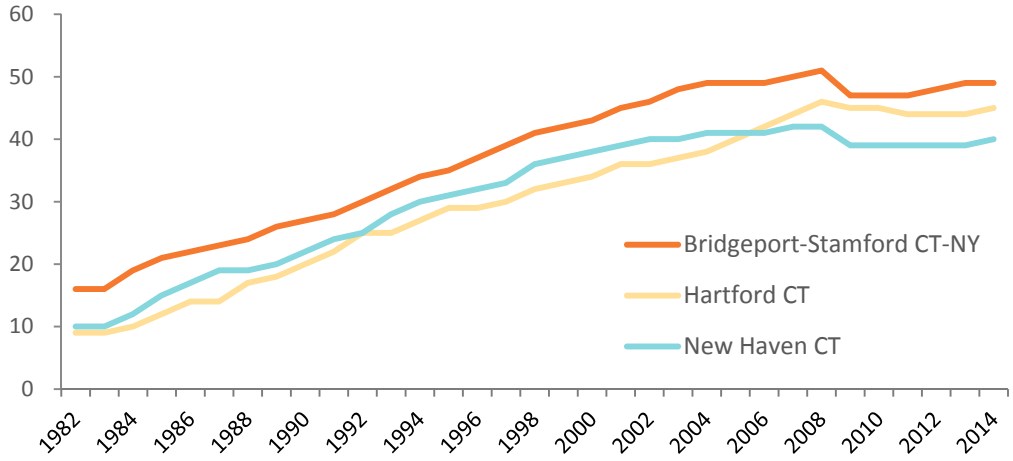
TABLE T2: Congestion-related Costs and Hours Wasted

Urban Area	Average Cost of Congested-related Delays per Driver	Average Number of Hours Wasted in Traffic
Bridgeport/Stamford	$1,174/year	49 hours/year
Hartford	$1,038/year	45 hours/year
New Haven	$932/year	40 hours/year

205 Texas A&M Transportation Institute, "2015 Urban Mobility Scorecard," August 2015, 20, https://static.tti.tamu.edu/tti.tamu.edu/documents/mobility-scorecard-2015-wappx.pdf.

206 Connecticut Business & Industry Association, "2013 Connecticut Transportation Survey," https://www.cbia.com/resources/economy/reports-surveys/2013-connecticut-transportation-survey/.

FIGURE T6: Hours of Delay Per Commuter in Connecticut (1982 to 2014)



Source: Texas A&M Transportation Institute

Air Pollution and Climate Change

Petroleum-based fossil fuels for transportation are a significant contributor to air pollution and GHG emissions in Connecticut. Poor air quality exacerbates respiratory and cardiovascular health conditions, heightens the risk of cancer, and burdens our health care system with considerable medical costs. For example, the state's asthma rate has been higher than the national prevalence rate since the year 2000.[207]

Connecticut has two nonattainment areas that have failed to meet the U.S. Environmental Protection Agency (EPA) 2008 national ambient air quality standards for ozone. Both areas have now been reclassified from "marginal" to "moderate" nonattainment status and face a new compliance deadline of July 2018.[208] This reclassification requires Connecticut to revise its state implementation plan (SIP) under the Clean Air Act, in order to describe the control measures that will be implemented to achieve compliance. Moreover, EPA adopted a more stringent ozone standard in 2015.[209] As a result, Connecticut will be designated as "nonattainment" for the revised

207 Connecticut Department of Public Health, *The Burden of Asthma in Connecticut: 2012 Surveillance Report*, 3, http://www.ct.gov/dph/lib/dph/hems/asthma/pdf/full_report_with_cover.pdf.

208 Environmental Protection Agency, Rules and Regulations, "Determinations of Attainment by the Attainment Date, Extensions of the Attainment Date, and Reclassification of Several Areas for the 2008 Ozone National Ambient Air Quality Standards," *Federal Register* 81, no. 86, (May 4, 2016): 26697, http://www.ct.gov/deep/lib/deep/air/ozone/ozoneplanningefforts/2016-reclassifications_for_2008_ozone_naaqs.pdf.

209 U.S. Environmental Protection Agency, Rules and Regulations, "National Ambient Air Quality Standards for Ozone," *Federal Register* 80, no. 206, (October 26, 2015): 65292, https://www.gpo.gov/fdsys/pkg/FR-2015-10-26/pdf/2015-26594.pdf.

standard when issued. This requires DEEP to adopt even more stringent emission control programs to achieve timely compliance with the new standard.

Passenger vehicles and heavy-duty trucks account for a majority of air pollutants, which includes ozone, particulate matter, and other smog-forming emissions. Transportation contributes 75 percent of emissions of oxides of nitrogen (NO_x) and 40 percent of volatile organic compound (VOC) emissions, the component parts of ground level ozone.[210] In 2011, heavy duty vehicles accounted for about 24 percent of all transportation related emissions of NO_x.[211]

The transportation sector continues to be single largest source of GHG emissions in the state, contributing 36 percent, principally from the use of fossil fuels in passenger cars and light-duty trucks. Due to improvements in vehicle efficiency, emissions have dropped 13 percent since 2001. However, recent trends show transportation sector emissions flat-lining along with VMT.[212] In the coming decades, improvements in vehicle fuel economy for all class sizes, deployment of low- and zero-emission vehicles, increased car and ride sharing, and expanded use of public transit will be needed to significantly reduce emissions from this sector.

Transportation Infrastructure

Energy consumption for transportation needs is intrinsically linked to the design, construction, maintenance, and improvement of the state's transportation infrastructure. For example, energy use and GHG emissions associated with the construction, operation, and lifetime maintenance of a road can be significant. GHG emissions are estimated at between 26 and 67 percent of the total emissions from the construction phase, depending on materials and conditions of the maintenance regime. Further, during operation, energy consumption and GHG emissions result primarily from electricity used for lighting, signals and signage. Road transport infrastructure as a whole, is estimated to account for between 8 and 18 percent of the full life cycle energy requirements and GHG emission from road transport.[213]

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[210] U.S. Environmental Protection Agency, *2011 National Emissions Inventory, version 2, Technical Support Document*, August 2015.

[211] de la Torre Klausmeier Consulting, Inc., Cambridge Systematics, and Eastern Research Group, *Development of a Strategic Plan for Reducing Emissions Associated with Freight Movement in Connecticut*, March 28, 2013, 7; http://www.ct.gov/deep/lib/deep/air/diesel/freightreport_03_28_2013.pdf.

[212] Connecticut Department of Energy and Environmental Protection, *2013 Connecticut Greenhouse Gas Emissions Inventory*, 2016, http://www.ct.gov/deep/lib/deep/climatechange/2012_ghg_inventory_2015/ct_2013_ghg_inventory.pdf.

[213] IEA, Energy Technology Systems Analysis Programme, *Road Transport Infrastructure*, 2, August 2011, https://iea-etsap.org/E-TechDS/PDF/T14_Road%20Transport%20Infrastructure_v4_Final.pdf.

As a small, densely populated state with through traffic from neighboring states, Connecticut requires a safe and reliable network of roads, rail lines, shipping ports, and airports. The state's road system consists of 21,508 miles of public roadways including 1,392 miles of interstate and other National Highway System roadways, and numerous state highways, bypasses and service ramps.[214] Among the most heavily used highway system in the nation, Connecticut's three major highways (I-95, I-91, I-84) serve 100,000 to 170,000 vehicles per day, and heavy truck volumes comprise 10-15 percent of that traffic.[215] Maintaining a state of good repair of this road system infrastructure makes travel more efficient for users by reducing congestion and fuel consumption. Unfortunately, 47 percent of the state's roadways are rated in poor or fair condition.[216] Deficient roadways result in $2.6 billion in spending on higher operating costs, fuel consumption, and traffic accidents each year.

The rail system in Connecticut consists of 628.5 miles of active rail segments. Currently, three passenger rail lines operate in the state – CTDOT's Shore Line East, Metro-North Railroad's New Haven Line, and Amtrak. Several freight railroads, ranging from a large Class 1 railroad to shorter regional and local railroads, provide for the shipment of goods. Safe, reliable, and efficient passenger and freight rail infrastructure provides opportunities to divert the movement of people and goods from cars and trucks to rail, saving fuel and reducing emissions.

Two commercial airports operate in the state – Bradley International Airport in Windsor Locks, the second largest airport in New England, and Tweed New Haven Airport. Three reliever airports, eight general aviation airports, and seven other public-use airports provide additional aviation services in the state.

The three deep water ports in Connecticut are located in Bridgeport, New Haven and New London. Ships utilizing the state's deep water ports help to reduce fuel consumption and emissions by lessening the need for tractor trailers in the transport of goods in and out of the state. The energy saving impacts of these ports can be further realized when infrastructure is in place that connects each port to a freight rail line.

Transportation Infrastructure Funding

Connecticut's ability to finance necessary infrastructure repair and future build out depends on the availability of federal and state funds. Support from the U.S. Department of Transportation

[214] Connecticut Department of Transportation, "Connecticut… on the move! Transportation Fast Facts 2015," 18, http://www.ct.gov/dot/lib/dot/documents/dcommunications/2015_ct_fastfacts_final.pdf.

[215] Connecticut Department of Transportation, "Connecticut… on the move! Transportation Fast Facts 2015," 18, http://www.ct.gov/dot/lib/dot/documents/dcommunications/2015_ct_fastfacts_final.pdf.

[216] Connecticut Department of Transportation, "Connecticut… on the move! Transportation Fast Facts 2015," 21, http://www.ct.gov/dot/lib/dot/documents/dcommunications/2015_ct_fastfacts_final.pdf.

and revenues from the State gasoline tax, which have funded the construction and maintenance of roads, bridges, and railroad systems have declined sharply in recent years and is expected to continue to decrease. For the United States as a whole, the Congressional Budget Office forecasts that gasoline tax revenues will drop about 21 percent by 2040 due to improved fuel economy.[217] Within the State transportation budget, annual fuel tax revenue will be reduced by an estimated $357 million by 2040 due to increased fuel efficiency, when compared to current fuel tax revenues.[218]

Progress in achieving transportation policies targeted to reduce energy consumption creates a transportation policy challenge. Notably, the more Connecticut vehicle owners increase their fuel efficiency, reduce their vehicle miles traveled, and transition to alternative fueling sources, the larger the transportation revenue gap will become. Alternative options for funding necessary transportation infrastructure projects and enhanced public transit present a critical challenge that must be addressed to achieve the State's energy and climate policy goals while also ensuring a safe and reliable transportation system.

In February 2015, Governor Malloy released the Let's Go CT! Plan, a 30-year vision for the state's transportation system. The Plan, aimed to make Connecticut's transportation system best-in-class, included developing a transportation "Lock Box" which would help to ensure that all funding designated for transportation projects is only spent on transportation projects. While the recommendation to create a mechanism such as the "Lock Box" to secure funding is a step in the right direction, alternative funding mechanisms need to be developed to establish sustainable funding that is sufficient to support a clean, efficient, safe, and well-maintained transportation infrastructure.

217 Ed Regan, "The Motor Fuel Tax: A Critical System at Risk, Framing the Problem for Connecticut" (white paper), February 13, 2017, https://www.cga.ct.gov/2017/tradata/od/2-24-17%20The%20Motor%20Fuel%20Tax%20Ed%20Regan.pdf.

218 The estimated fuels tax revenue assumes no change in the effective gas tax rate. Fuel efficiency is based on the EIA "Reference Case" MPG forecast.

CT*fastrak*

Launched by CTDOT on March 28 2015, CT*fastrak* is Connecticut's first Bus Rapid Transit system. Featuring a regional network of service utilizing a 9.4 mile dedicated bus only roadway, distinctive stations, branded buses, new technologies, and most of all, a significant improvement in frequent, reliable bus service, CT*fastrak* is changing the landscape of public transportation in Connecticut.

The routes are integrated with the CT*transit* system making it easier for riders to connect, transfer, and pay for fares. The system provides direct service to and from Waterbury, Cheshire, Southington, Bristol, Plainville, New Britain, Newington, West Hartford, Hartford, East Hartford and Manchester with routes that take advantage of the bus-only CT*fastrak* roadway.

In its first year of operation CT*fastrak* surpassed its first year ridership goal of 11,180 daily passenger trips and has doubled the daily ridership in the corridor.

Mass Transit Services

Mass transit services – buses and rail services – provide important alternate modes of travel for the state's commuters that can ease road congestion, reduce vehicle related accidents, decrease GHG emissions, and improve air quality. Bus transit service is the foundation of Connecticut's transit system and is the primary commuting method for urban, transit-dependent workers while also serving as the mode of choice for many suburban commuters who use the express buses. Bus services also play an important role in the transportation of the elderly, those with disabilities, the young and those who wish to use public transportation rather than a personal vehicle. In urban areas with rail service, buses play a critical role in connecting rail passengers to their final destination which is often located beyond walking distance from the train station.

Connecticut's bus system serves multiple functions and geographic areas, and has increased ridership from 40 million passengers a year in 2013 to just over 42 million passengers a year in 2015.[219] (See Figure T7.)

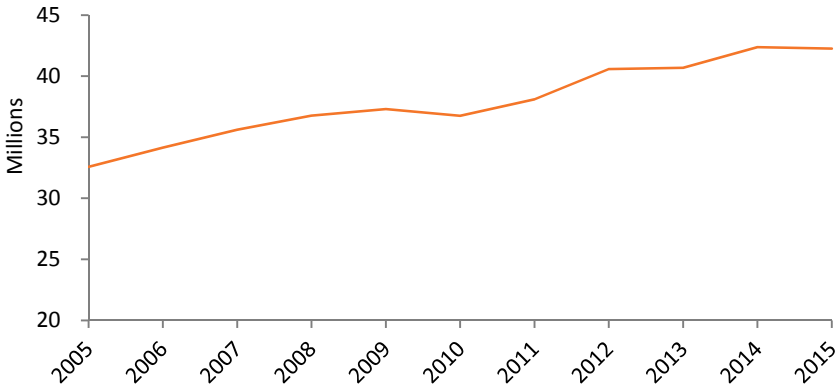
In March 2015, CT*transit* expanded its bus transit with the launch of the CT*fastrak* bus rapid transit (BRT) service. This is a system of bus routes that utilize a bus-only roadway for all or a portion of trips making it easier for riders to connect, transfer, and pay. Ridership in the corridor before CT*fastrak* opened was approximately 8,000 weekday passenger trips. Weekday passenger trips

[219] Connecticut Department of Transportation, "Let's GO CT! Fact Sheets: Connecticut's Bus System," March 2015, http://www.transformct.info/img/documents/Lets%20Go%20CT-%20Fact%20Sheets%2020150313.pdf.

now average between 12,000 and 16,000 trips, doubling the previous daily ridership in the corridor. [220]

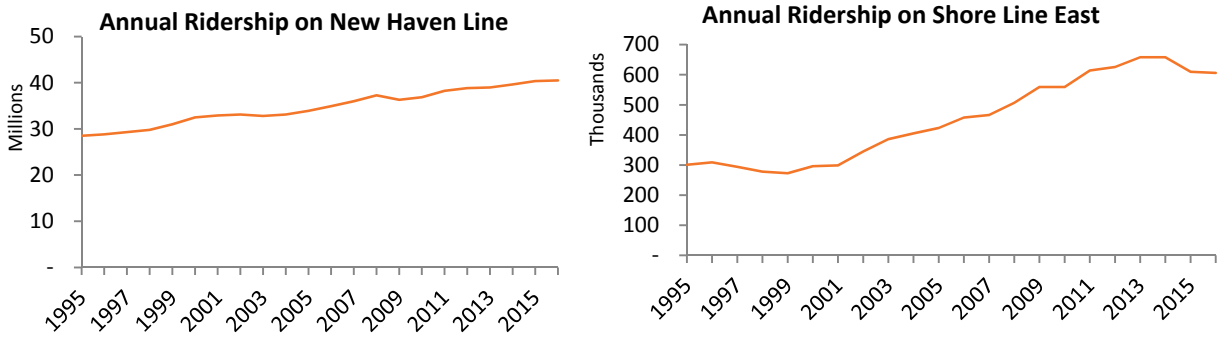
Connecticut is served by three primary rail services: Shore Line East (SLE), the New Haven Line (NHL), and Amtrak. With over 40 million trips per year, the NHL is the busiest commuter rail corridor in the country.[221] Each weekday, the NHL serves approximately 115,000 commuters, 80,000 of which originate in Connecticut.[222] Ridership for both the NHL and SLE has increased by approximately 10 percent between 2009 and 2016. (See Figure T8.)

FIGURE T7: Statewide Total Bus Transit Ridership



Source: Connecticut Department of Transportation

FIGURE T8: Annual Ridership on Connecticut Rail Services



Source: Connecticut Department of Transportation

[220] Connecticut Department of Transportation, *CTfastrak Year One Report*, March 26, 2016, 4, http://www.ct.gov/dot/lib/dot/documents/dcommunications/press_release/ctfastrak_year_one_report.pdf.

[221] Connecticut Department of Transportation, "Let's GO CT! Fact Sheets: Rail Bridge Conditions and Needs on New Haven Line," March 2015, http://www.transformct.info/img/documents/Lets%20Go%20CT-%20Fact%20Sheets%2020150313.pdf.

[222] "New Haven Line," Connecticut Department of Transportation, accessed June 28, 2017, http://www.ct.gov/dot/cwp/view.asp?a=1390&q=316752.

Over the past three years, transit service improvements have helped make public transit more accessible, which will ultimately lead to economic development within the state's transit corridors. By building on the foundation of these improvements, the State will continue to make it possible for thousands more Connecticut residents to travel by rail or bus, cutting vehicle miles traveled and reducing emissions.

Transit-Oriented Development and Connectivity

Compact, mixed use, pedestrian-oriented development around existing and planned public transportation hubs is critical to enhancing connectivity between communities. A combination of land use and transportation planning, transit-oriented development (TOD) makes all modes of transportation more accessible, leading to reduced individual car travel and traffic congestion, both of which contribute to local air quality issues and GHG emissions. This type of development can provide residents with easier access to jobs, education, recreational opportunities, and other day-to-day activities. Developing vibrant communities around transit hubs revitalizes neighborhoods and areas designated as brownfields, and can have positive impacts on property values. Businesses benefit from TOD by seeing increased foot traffic around their establishments. Residents living in TOD communities may also have more discretionary income to spend at local businesses because the percentage of income spent on transportation is typically lower for residents who are not heavily reliant on a personal vehicle.

As a principal recommendation in the 2013 CES, the State developed and supported a variety of initiatives to facilitate TOD to increase mobility, reduce emissions, and create more livable communities in Connecticut. For example, the Office of Policy and Management selected a total of 31 TOD and responsible growth projects to receive funding under the TOD Planning Grant Program, and the Responsible Growth and TOD Grant Program.[223] In addition to this, the Let's Go CT! Plan articulates and recognizes the role of TOD along the New Haven Line, the Hartford Line, and the CT*fastrak* corridors. Continued support for TOD will create more livable communities and provide residents with greater opportunities to use alternative forms of transportation.

Infrastructure that supports non-motorized travel is essential to enhancing connectivity and is a key component of TOD. Walking and cycling are zero-emission alternatives to motor vehicle use,

223 Transit-Oriented Development (TOD) Planning Grant Program, Office of Policy and Management, accessed June 28, 2017, http://www.ct.gov/opm/cwp/view.asp?a=2985&q=567428; and The Office of Governor Dannel P. Malloy, "Gov. Malloy Announces State Grants to Encourage Transit-Oriented Development and Responsible Growth Across Connecticut," June 8, 2016, http://portal.ct.gov/office-of-the-governor/press-room/press-releases/2016/06-2016/gov-malloy-announces-state-grants-to-encourage-transit-oriented-dev-and-responsible-growth-across-cy.

especially for short distance trips, and provide a health benefit for people who chose to utilize them.

CTDOT's adoption of the "Complete Streets" policy in 2014 has furthered the integration of safe on-road access for all users – pedestrians, bicyclists, motor vehicle operators, and transit users.[224, 225] The policy requires that cyclists, pedestrians, and transit users are considered in the design and planning of all roads. Typical characteristics of a complete street include bike and walking paths, highly visible crosswalks, curb extensions, and streetlights. Eight municipalities have also adopted Complete Streets plans, ordinances and/or policies formalizing their intent to plan, design, and maintain streets so they are safer for all users regardless of the mode of transportation.[226] Used in conjunction with land use planning, smart growth, and transit-oriented development ideals, the Complete Streets approach has helped create dynamic communities and urban areas with improved connectivity across the state.

Communities that are designed to rely primarily on the use of cars to get to work, home, places of worship, and recreational and healthcare facilities tend to drive more annual miles, consume more fuel, and produce more pollution. Connecticut should continue to incentivize, support and promote TOD and smart-growth strategies that create more accessible, multi-modal communities. Improving regional accessibility, density, mix-use, street connectivity, walkability, and public transit proximity will increase economic, social, and environmental benefits across the state.

Fuel and Vehicle Standards

Fuel and vehicle standards adopted by the U.S. Environmental Protection Agency (EPA), the National Highway Traffic Safety Administration (NHTSA), and the California Air Resources Board (CARB) advance our nation's goals to address climate change and reduce our dependence on petroleum-based fossil fuels for transportation. These standards lead to reductions in fuel use from on-highway transportation sources, which improves energy security, increases fuel savings, conserves billions of barrels of oil, reduces GHG and other air emissions, and provides regulatory certainty for automakers.

When CARB adopted the Advanced Clean Cars (ACC) program in 2012, the agency committed to conduct a comprehensive midterm review of three elements of the program - the zero-emission

224 "Complete Streets" is a transportation policy and design approach to roadways that enables safe, convenient and comfortable travel and access for users of all ages and abilities regardless of their mode of transportation.

225 Connecticut Department of Transportation, "Policy Statement, Policy No. EX.O. – 31," October 23, 2014, http://www.ct.gov/dot/lib/dot/plng_plans/bikepedplan/cs-exo31-signed.pdf.

226 Enfield, Hartford, Middletown, New Haven, Portland, Stamford, South Windsor, and West Hartford have passed Complete Street policies and/or ordinances.

vehicle (ZEV) regulation, the 1 milligram per mile (mg/mi) particulate matter (PM) standard, and the light-duty vehicle GHG standards for 2022 and later model years (MY). CARB also worked with EPA and NHTSA on the national level midterm review as the California program closely mirrors the national program for these model years. On March 24, 2017, CARB made a determination, set out in Resolution 17-3, finding among other things, the technical and economic evidence supporting the 2022-2025 MY LEV III GHG standards to be definitive and conclusive. Resultantly, CARB made no adjustments to the stringency of these rules, which Connecticut adopted in 2013.[227]

While the CARB program (along with the Section 177 States[228]) covers almost 35% of the nation's light duty fleet, the EPA and the NHTSA jointly developed a National Program for GHG emissions and fuel economy standards applicable to the remaining light-duty cars and trucks in model years 2012-2016 (first phase) and 2017-2025 (second phase). The EPA has projected that the final standards will achieve an average industry fleet-wide emission level of 163 grams/mile of carbon dioxide (CO2) in model year 2025, which is equivalent to 54.5 miles per gallon (mpg) if achieved exclusively through fuel economy improvements.[229] As part of the 2017-2025 standards rulemaking, the EPA made a regulatory commitment to conduct, in coordination with the NHTSA and CARB, a Midterm Evaluation of the longer-term standards for model years 2022-2025. The EPA made a final determination in December 2016, declaring the GHG emissions standards remain feasible, practical and appropriate under the federal Clean Air Act and were achievable at lower costs than previously estimated using widely available technology. Based on an extensive technical record, EPA determined the standards should remain unchanged.[230] However, on March 15, 2017 EPA and NHTSA announced that EPA intends to reconsider this final determination.[231]

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[227] California Air Resources Board, "Advance Clean Cars Midterm Review, Resolution 17-3," March 24, 2017, https://www.arb.ca.gov/msprog/acc/mtr/res17-3.pdf.

[228] Section 177 of the Clean Air Act authorizes other States to choose to adopt California's standards in lieu of federal requirements. Currently, 15 States have done so: Connecticut, Delaware, Georgia, Maine, Maryland, Massachusetts, New Jersey, New Mexico, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington.

[229] U.S. Environmental Protection Agency, "Regulations for Greenhouse Gas Emissions from Passenger Cars and Trucks," accessed July 12, 2017, https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-greenhouse-gas-emissions-passenger-cars-and.

[230] EPA Final Determination on the Appropriateness of Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation, January 2017, https://www.epa.gov/nscep.

[231] U.S. Department of Transportation, National Highway Traffic Safety Administration, and Environmental Protection Agency, "Notice of Intention to Reconsider the Final Determination of the Mid-Term Evaluation of Greenhouse Gas Emissions Standards for Model Year 2022-2025 Light Duty Vehicles," *Federal Register* 82, no. 54, (March 22, 2017): 14671, https://www.gpo.gov/fdsys/pkg/FR-2017-03-22/pdf/2017-05316.pdf.

Heavy Duty Vehicle Regulations

Emissions from heavy-duty vehicles also impact energy use and air quality and are primarily regulated by the EPA. EPA took a significant leap forward in 2001 by deciding to regulate heavy-duty vehicles and their fuel as a single system effective with the 2007 MY. This effort lead to the use of ultra-low sulfur diesel (ULSD) today and accounts for significant reduction in both sulfur dioxide (SO_2) and PM emissions from all sources that use ULSD. In 2007, EPA began to phase in the 2001 standards, which reduced harmful air pollution, in combination with ULSD, from heavy duty vehicles by more than 90 percent.[232] In June 2016 several states and cities, including Connecticut, petitioned EPA to adopt these standards nationally. In 2011, EPA and NHTSA adopted the first phase of a comprehensive program to reduce GHG emissions and fuel consumption from heavy-duty highway vehicles, including combination tractors; and heavy-duty pickup trucks and vans for MY 2014-2018. In 2016, EPA and NHTSA adopted the second phase of GHG standards for 2018-2027 MY for certain trailers and MY 2021-2027 for semi-trucks, large pickup trucks, vans, and all types and sizes of buses and work trucks, The second phase of this program will significantly reduce carbon emissions and improve the fuel efficiency of heavy-duty vehicles, helping to address the challenges of global climate change and energy security.

For light-duty vehicles, Connecticut has adopted three California regulatory programs – the Low Emission Vehicle (LEV) II program (adopted in 2004) and the Zero Emission Vehicle (ZEV) program (adopted in 2013) – that empower the State's clean vehicle platform. The LEV program requires manufacturers to meet fleet average emissions requirements for the light-duty vehicle (LDV) and medium-duty vehicle (MDV) sectors. The LEV III program, adopted in 2013 and which takes effect in model years 2015-2025, is expected to reduce emissions for smog-forming pollutants by 75 percent (compared to 2015 levels) and 34 percent for GHG emissions.[233] Under the ZEV program, automakers are required to deliver a certain portion of their fleet as ZEV vehicles in an effort to improve commercialization of advanced technology vehicles, which are typically lower emitting than comparable conventional vehicles. As part of the midterm review under the ACC, CARB made a determination on April 14, 2017 to maintain the current ZEV volumes through 2025 and to re-

[232] U.S. Environmental Protection Agency, "EPA Final Rule for Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements," https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-air-pollution-new-motor-vehicles-heavy.

[233] California Air Resources Board, "The California Low-Emission Vehicle Regulations," https://www.arb.ca.gov/msprog/levprog/cleandoc/cleancomplete%20lev-ghg%20regs%204-13.pdf.

commit to ending the "travel provision" for all battery electric ZEVs in the California rule, resulting in the delivery of greater numbers of ZEVs to the Section 177 states beginning in 2017.[234]

Volkswagen Settlement

In 2015, a federal multi-state investigation uncovered that Volkswagen AG, Audi AG, and Porsche (collectively, VW) installed emissions defeat devices in approximately 600,000 of their 2.0L and 3.0L diesel light vehicles, starting with model year 2009 through model year 2015. The investigation, for which Connecticut served in a leadership role, ultimately revealed a deliberate strategy by VW to circumvent the U.S. emissions standards for diesels resulting in vehicle emissions of up to 40 times the legal limit.

The parties reached a series of settlement agreements totaling over $20 billion.[235] These settlement agreements include various funds and programs which benefit the state of Connecticut and its citizens. In particular, VW established a $2.7 billion Environmental Mitigation Trust (Trust) to fund replacement of diesel engines with cleaner technology and to mitigate the continuing NOx emissions from the VWs violating 2.0L vehicles. VW added an additional $225 million to the Trust when it settled the claims regarding its 3.0L vehicles.

Of the $2.7 billion, Connecticut will be allocated almost $56 million. The use of Connecticut's allocation is controlled by Appendix D of the Consent Decree, which specifies that up to fifteen percent of these funds may be used for electric vehicle infrastructure, while the remainder of the funds must be used for the replacement or repowering of a wide array of on-road (e.g., class 4-8 freight trucks (model years (MY) 1992-2009), school buses (MY 2009 and older), transit buses (MY 2009 and older), and non-road diesel powered vehicles and other sources (e.g., commercial marine engines, locomotive engines, airport ground service equipment, forklifts, port handling equipment, etc.). In order to access the available monies, as authorized by the Trust, Connecticut must first be designated as a beneficiary under the Trust and must draft and submit for approval a beneficiary mitigation plan that describes the types of mitigation actions or projects eligible for funding along with a general description of the expected ranges of emission benefits.[236] Once the

234 A clause in the California Zero Emission Vehicle regulation, called the "travel provision," allows vehicle manufacturers to earn credits in every state for ZEVs that are sold in any ZEV-program state. As a result, manufacturers have focused on selling ZEVs primarily in California, due to the size and strength of its market. The provision expires at the end of 2017.

235 "Volkswagen Clean Air Act Civil Settlement," U.S. Environmental Protection Agency, accessed June 30, 2017, https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement.

236 Connecticut Department of Energy and Environmental Protection, "Proposed State of Connecticut Mitigation Plan under Volkswagen 2.0L Vehicle Partial Consent Decree, Appendix D," http://www.ct.gov/deep/lib/deep/air/mobile/vw/CT_VW_Proposed_State_Mitigation_Plan_-_PREPROPOSAL.pdf.

Trust Effective Date is established by the federal court overseeing the VW litigation, Connecticut has sixty days to submit a certification to become a beneficiary under the Trust. The beneficiary mitigation plan is due ninety days after Connecticut's certification is approved. Connecticut DEEP has initiated the process of developing a beneficiary mitigation plan by drafting and releasing an initial plan for comment and feedback from Connecticut stakeholders.[237]

In addition to the establishment of the Environmental Mitigation Trust, through its Electrify America LLC a subsidiary, VW is investing $2 billion over the next 10 years in ZEV infrastructure and education to support the adoption of ZEV technology. Of the $2 billion, $1.2 billion will be invested nationwide, while $800 million will be invested solely in California.[238] The $1.2 billion will be spent in $300 million increments over four 30-month cycles.

In the recently announced first investment cycle, Electrify America committed to three primary initiatives: 1) installing charging infrastructure, 2) public education initiatives, and 3) ZEV access initiatives. The installation of charging infrastructure will primarily consist of community charging and a long distance highway network. In the first investment cycle, selected investments included establishing a network of 2,500 non-proprietary EV chargers along high-traffic corridors between major metropolitan areas and community charging infrastructure in 11 metropolitan areas including New York City and Boston.[239]

On a rolling basis, Electrify America is accepting comments, recommendations, and proposals on development and implementation of the ZEV Investment Plans. Future investment cycles may include hydrogen fueling stations, national ZEV car-sharing or ride-sharing services. In early 2019, the State should work to evaluate opportunities to submit a state and/or regional proposal to advance its efforts to advance EV infrastructure.

Alternative Fuel Vehicles and Infrastructure

Connecticut has a long history of implementing policies and programs that support the deployment of alternative fuel vehicles and the associated infrastructure. This history includes utilizing a 5 percent biofuel additive and piloting fuel cell buses in the statewide bus fleet; promoting the use of clean diesel; funding initiatives that support the deployment of compressed natural gas (CNG) and LNG vehicles and fueling stations; converting school buses to cleaner

[237] "VW Settlement Information," Department of Energy and Environmental Protection, accessed June 30, 2017, http://www.ct.gov/deep/cwp/view.asp?a=2684&q=587294&deepNav_GID=1619.

[238] Volkswagen Group of America, "National ZEV Investment Plan: Cycle 1," April 9, 2017, 1, https://www.epa.gov/sites/production/files/2017-04/documents/nationalzevinvestmentplan.pdf.

[239] Volkswagen Group of America, "National ZEV Investment Plan: Cycle 1," April 9, 2017, 17, https://www.epa.gov/sites/production/files/2017-04/documents/nationalzevinvestmentplan.pdf.

burning propane; and providing financial incentives for the purchase of hybrids, electric vehicles, and charging stations. Since the release of the 2013 CES, the State has continued its efforts to advance the adoption of alternative fuel vehicles.

In October 2013, Connecticut signed the Zero Emissions Vehicle Memorandum of Understanding (ZEV MOU). This multi-state initiative commits all seven participating states to collectively deploy 3.3 million EVs by 2025 and to take coordinated action to ensure the successful deployment of these vehicles.[240] Connecticut's portion of this commitment is approximately 150,000 EVs. The MOU identifies joint cooperative action which spurred the development of the Multi-state ZEV Action Plan, released in May 2014.[241] Connecticut continues to implement the eleven key actions outlined in the plan to further accelerate the adoption of EVs in the state (see Appendix for eleven key actions).

As a part of the State's 2013 CES recommendations to support the deployment of clean fuel/vehicles and to meet its ZEV MOU commitment, DEEP launched the EVConnecticut Program. The program was established to promote the environmental and economic opportunities presented by increased ownership of electric vehicles.

CHEAPR

The Connecticut Hydrogen and Electric Automobile Purchase Rebate (CHEAPR) provides a cash rebate for residents, businesses, and municipalities who purchase or lease a battery electric, fuel cell, or plug-in hybrid vehicle. Fuel cell powered EVs receive the largest rebate of $5,000, while plug-in hybrid and full battery electric EVs receive incentives ranging from $750 to $3,000, based on battery size. The rebate amount can be credited at the point of sale or lease of the eligible vehicle, lowering the cost of the car immediately.

There are currently over 30 eligible vehicles available and the list continues to grow as manufacturers release new models.

Since the launch of CHEAPR in May 2015, 2.9 million dollars have been issued for the purchase of 1,300 EVs in Connecticut. The consistent utilization of the rebates and the increased uptick in EV purchases in the state demonstrate the ongoing success of CHEAPR.

[240] On October 24, 2013 Governor Malloy signed the State Zero-Emission Vehicle Program Memorandum of Understanding with seven other states (California, Maryland, Massachusetts, New York, Oregon, Rhode Island and Vermont). "State Zero-Emission Vehicle Program Memorandum of Understanding," October 23, 2013, http://www.ct.gov/deep/lib/deep/air/zeromeissionvehicle_mou.pdf.

[241] The Multi-state ZEV Action Plan assists in developing consistent and complementary measures within and across all ZEV MOU states to foster efficient market development and maximize the ownership experience for consumers. ZEV Program Implementation Task Force, "Multi-state ZEV Action Plan," May 2014, http://www.ct.gov/deep/lib/deep/air/electric_vehicle/path/multi-state_zev_action_plan_may2014.pdf.

CHEAPR Participant Survey

Fifty-five percent of CHEAPR participating consumers (655 responses) have completed a brief survey about EV adoption motivators and adopter demographics. More than 87 percent of drivers said that the CHEAPR rebate was an "extremely" or "very" important factor in the decision making process, with over two-thirds of participants responding that they would not have purchased or leased their EV without the CHEAPR rebate. Other responses of note indicate the median anticipated utilization of BEVs is 10,000 miles/year and 12,000 miles/year for PHEVs.

Also of note with respect to the anticipated utilization of vehicles supported by CHEAPR is that for 76 percent of participating consumers, CHEAPR is supporting the replacement of a primary household vehicle. In other words, CHEAPR vehicles are not third cars or 'commuter cars' and as such will be utilized as primary vehicles.

To increase awareness and educate consumers, the EVConnecticut website was developed to serve as a clearinghouse for information on incentives, charging infrastructure, program statistics, regional and national EV commitments, and news and events. With 70,000 page views, the website serves as a one-stop-shop portal for residents to gather information about electric vehicles.

In May 2015, DEEP launched the Connecticut Hydrogen and Electric Automobile Purchase Rebate (CHEAPR) program. CHEAPR provides Connecticut residents with a point-of-sale rebate on the purchase or lease of new ZEVs up to $5,000. Rebates are offered on a sliding scale based on battery capacity and vehicle technology. CHEAPR has disbursed over $2.9 million for 1,300 new vehicle leases and purchases.[242] DEEP also partnered with the Connecticut Automotive Retailers Association to establish a dealer recognition and cash bonus award, both of which incentivize dealers to actively sell EVs. This private-public partnership has also encouraged auto dealers to install free public EV charging at their local dealerships.

The CHEAPR program is continually evaluated to ensure that it is reactive to developments in battery technology and changing consumer market demands. For example, rebate levels were adjusted after the first year of operation to ensure the best performing models in each respective technology category (Plug-in Hybrid Electric Vehicles (PHEV), Battery Electric Vehicles (BEV), Fuel Cell Electric Vehicles (FCEV)) were eligible for the highest rebate amounts while optimizing current and future program funding.

[242] Administered by the Center for Sustainable Energy, the CHEAPR program is funded through a commitment by Eversource as part of a broader funding commitment to energy efficiency and related initiatives set forth in a settlement agreement related to the NU/NSTAR merger.

Rebate recipients are also asked to complete a follow up survey that investigates the purchaser's primary purchase motivation and importance of CHEAPR. These survey results help inform future CHEAPR program modifications.

To further educate consumers about the costs and benefits of EVs, DEEP collaborated with Plug-In America to host four Ride and Drives at large workplaces throughout Connecticut. From these four events, over 500 surveys were collected and results showed that more than 85 percent of all participants who rode or drove a plug-in vehicle walked away with a better opinion on EVs. DEEP has also begun planning efforts with Clean Cities and Plug-In America to host additional Ride and Drives at several different venues in 2017.

Utilizing a more traditional marketing approach, DEEP developed a Public Service Announcement (Honey, We Should Get an Electric Car) to address the top concerns potential buyers have expressed about purchasing EVs. The PSA has been distributed by several municipalities for local broadcast and used by a variety of outreach groups to educate the public about misconceptions surrounding EVs.

In 1993, the U.S. DOE launched the Clean Cities program to provide technical expertise, information, and funding assistance to regulated fleets and voluntary adopters of alternative fuels. Its express mission is to reduce petroleum dependence and to strengthen economic, environmental, and energy security through public and private stakeholder engagement.

Starting in 1994, U.S. DOE officially designated four Clean Cities coalitions in Connecticut: Greater New Haven Clean Cities Coalition, Capitol Clean Cities of Connecticut, Connecticut Southwestern Area Clean Cities, and Norwich Clean Cities.[243] Through their partnerships with business owners,

TABLE T3: Clean Cities Coalition 2015 Program Statistics

	Annual Petroleum Savings (in gge)	Annual GHG Emission Avoided (tons of CO2)
Capitol CC	1,781,832	6,172
Greater New Haven CC	2,390,374	14,139
Norwich CC	224,901	1,297
SW CT CC	527,561	1,613
Totals	4,924,668	22,221

Source: Department of Energy, Clean Cities

[243] "Clean Cities Coalitions," U.S. Department of Energy, Energy Efficiency & Renewable Energy, accessed on June 30, 2017, https://cleancities.energy.gov/coalitions/designation.

alternative fuel providers, fleet managers, local and state government agencies, and vehicle manufacturers, the Connecticut Clean Cities coalitions have helped advanced the deployment of alternative and renewable fuels, emerging transportation technologies, fuel economy improvements, and idle-reduction measures. More recently, these non-profit coalitions have been instrumental in the adoption of propane fuel buses by a growing number of school districts, and the promotion and demonstration of plug-in electric vehicle use through local showcases.

Medium and Heavy Duty Trucks

There are limited opportunities to cost effectively reduce emissions in the medium- and heavy-duty truck classes.[244] Diesel substitutes like biodiesel and renewable diesel can be used in any diesel vehicle type, although some engine manufacturers may void warranties in biodiesel blends over 20 percent.[245] However, most categories of trucks have CNG and propane versions, or versions that can run on renewable natural gas (RNG). Retrofit companies can also install CNG or propane tanks and engines on most truck types. For example, Connecticut AAA is converting its 28-truck fleet to run on both propane and gasoline, a setup known as "bi-fuel". With a payback period of 9 to 11 months per truck, the switch to propane will save the company money and reduce emissions.[246]

While several demonstration or prototype vehicles have been built for electric and hydrogen fuel cell medium- and heavy-duty vehicles, these offerings are much more limited.[247] For instance, two specific emerging applications for medium- and heavy-duty vehicle electrification include waste trucks and transit buses. Cities and companies across the U.S. have implemented pilot programs to identify and demonstrate cost savings and emissions reductions associated with both applications.

In a pilot program to test electric garbage trucks, the city of Chicago replaced 20 of its conventional diesel trucks with electric powered truck technology developed by Motiv. This has

[244] Atlas Public Policy and The Cadmus Group Inc., *Moving Forward with Green Energy: Market Potential Assessment for Alternative Fuel Vehicles in Connecticut*, September 2016, 49, http://atlaspolicy.com/wp-content/uploads/2016/11/2016-09-01_Moving_Forward_with_Green_Energy.pdf.

[245] National Biodiesel Board, "Biodiesel standard (ASTM D 6751)," accessed May 4, 2016, http://biodiesel.org/using-biodiesel/oem-information.

[246] Matt Pilon, "CT AAA club converting truck fleet to propane," *Hartford Business Journal*, April 21, 2016, accessed June 30, 2017, http://www.hartfordbusiness.com/article/20160421/NEWS01/160429982/ct-aaa-club-converting-truck-fleet-to-propane.

[247] Atlas Public Policy and The Cadmus Group Inc., *Moving Forward with Green Energy: Market Potential Assessment for Alternative Fuel Vehicles in Connecticut*, September 2016, 27, http://atlaspolicy.com/wp-content/uploads/2016/11/2016-09-01_Moving_Forward_with_Green_Energy.pdf.

saved the city 2,668 gallons of fuel a year and reduced GHG emissions by 68 tons (per truck).[248] At the June 2017 WasteExpo, Mack Trucks unveiled its version of an electric garbage truck which included a powertrain developed by Tesla Motors.[249] As additional models come into the market place and the prices drop, garbage truck electrification may make a lot of sense for waste management companies. The stop-and-go movements of trash pick-up allows for the braking system in the electric drivetrain to recapture the energy, the quiet nature of the drivetrain also makes early morning trash-pick up less disruptive to neighborhoods, and the reduction in tailpipe emissions improves the local air quality. While the capital costs for these trucks are currently high, fuel and maintenance savings make this technology a viable option for waste truck fleet conversions.

Currently, several companies are manufacturing and deploying Battery Electric Buses (BEBs) in the United States. Successful demonstrations of BEBs in cities, towns, and college campuses around the country are proving that the cost savings and technology are beneficial. BEBs are able to charge quickly at fixed stops along routes and are able to operate virtually continuously. In an analysis conducted by Columbia University for the New York City Transit, the purchase, maintenance, and fuel costs of an electric bus was compared to that of a diesel powered bus. The analysis found that BEBs generally cost about $300K more than a diesel bus, however, the fuel and maintenance savings could more than offset the upfront difference in purchase prices over the lifetime of the vehicle. The analysis also found that if the city converted its full bus fleet to BEBs, it would result in a savings of nearly 500,000 metric tons of GHG emissions.[250] As current bus fleets age and retire, and BEB technologies improve, BEBs are poised to become a viable option for transit fleets due to their fuel and maintenance savings, and GHG reduction potential.

[248] Emily MacRae, "What Toronto can learn from Chicago's electric garbage truck," *Torontoist*, August 20, 2016, accessed June 30, 2017, http://torontoist.com/2016/08/what-toronto-can-learn-from-chicago/.

[249] Carina Ockedahl, "Tesla veteran helps Mack create an electric garbage truck," *Trucks.com*, June 7, 2016, accessed June 30, 2017, https://www.trucks.com/2016/06/07/mack-trucks-shows-electric-garbage-truck/.

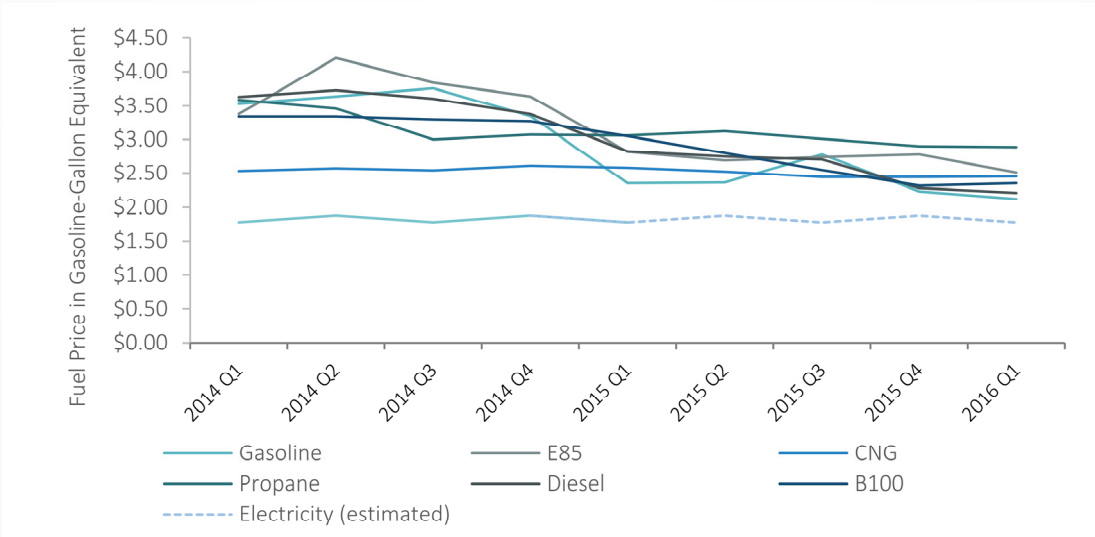
[250] Judah Aber; Columbia University, *Electric Bus Analysis for New York City Transit*, May 2016, 27, http://www.columbia.edu/~ja3041/Electric%20Bus%20Analysis%20for%20NYC%20Transit%20by%20J%20Aber%20Columbia%20University%20-%20May%202016.pdf.

Fuel Price Considerations

Price volatility in the alternative fuel market can vary greatly by region and fuel type, with the exception of electricity since its price is often regulated. Prices for E85 and biodiesel tend to follow swings of petroleum prices in part because these fuels often compete directly with gasoline and diesel, respectively. The price of CNG can vary greatly by region, while the price volatility tends to be low. For example, CNG prices ranged between $2.09 and $2.17 per gallon of gasoline equivalent (gge) nationally between 2014 and 2016. In the Rocky Mountain states, prices were as low as $1.79 per gge during this period and as high as $2.61 per gge in New England.

In Connecticut and New England, more broadly, fuel prices have generally followed the national trend since the first quarter of 2014. While electricity remains the least expensive transportation fuel, its lead over other fuels has decreased significantly. Other alternative fuels, including E85, CNG, propane, and B100, are more expensive than gasoline and diesel on an equivalent basis as of the first quarter of 2016. Propane has consistently been the most expensive transportation fuel since the first quarter of 2014. Supply chains for renewable diesel and hydrogen have not been established in Connecticut – current selling price in California for these fuels as of early 2016 is $2.39 per gallon and $13.59 per kilogram, respectively.

Source: Atlas Public Policy and The Cadmus Group Inc., Moving Forward with Green Energy: Market Potential Assessment for Alternative Fuel Vehicles in Connecticut, pp. 18-19, September 2016.:



2014 electricity prices are for Connecticut only and 2015 electricity prices were estimated based on historical prices.

Source: U.S. DOE "Fuel Prices" Available: http://www.afdc.energy.gov/fuels/prices.html.

EV and Alternate Fueling Infrastructure

As the makeup of the state's vehicle fleet shifts toward cleaner alternatively fueled vehicles, the necessity to expand alternative-fueling infrastructure increases. There are currently 395 public and private alternate fueling stations in operation throughout the state.[251] (See Table T4.) The alternative fuel options offered include biodiesel (B20 and above), compressed natural gas (CNG), Electric (Electric Vehicles Supply Equipment or EVSE), E85 (ethanol flex fuel), hydrogen, liquefied natural gas (LNG), and liquefied petroleum gas (LPG or propane). The vast majority of these stations are electric charging stations – 298 public and 46 private stations, offering a total of 653 public and 96 private charging outlets.[252]

TABLE T4: Alternative Fueling Stations in Connecticut

Fuel Type	Public	Private
Biodiesel	1	1
CNG	9	12
EVSE	298	46
E85 (Ethanol)	3	1
Hydrogen	1	1
LNG	1	0
LPG (Propane0	20	1

Source: DOE, Alternative Fuels Data Center

Connecticut has been pursuing the development of its electric vehicle charging infrastructure through the EVConnecticut municipal and business charging station grant programs.[253] The grant programs covered varying costs of the installation of electric charging stations in public locations making them accessible to all Connecticut residents at no cost.

Momentum for the build out of EV chargers caught on quickly with initial demand for EV charging centered on Level 1 & 2 charging.[254] Working to developing a stronger EV charging network, DEEP

[251] U.S. Department of Energy, "Alternative Fuels Data Center: Alternative Fueling Station Counts by State," accessed May 5, 2017, https://www.afdc.energy.gov/fuels/stations_counts.html.

[252] Totals indicate the total number of stations for all fuel types combined. Individual stations are counted multiple times if the station offers multiple types of fuel. The total numbers for electric charging stations include legacy chargers, but do not include residential electric charging stations.

[253] Under the EVConnecticut municipal and business charging station grants program, a total of 331 Level 2 charging plugs and 4 DC fast chargers have been deployed at 157 locations.

[254] Level 1 charging is the technical jargon for plugging your car into an ordinary household outlet. Level 2 supplies 240V similar to the electrical use of a household dryer. DC Fast Charging is the fastest type of charging currently available. It provides up to 40 miles of range for every 10 minutes of charging.

also worked with CTDOT to initiate a DC Fast Charger Pilot project that placed DC fast chargers at several Connecticut travel plazas along main transportation corridors in the state.

As a result of these efforts, EV infrastructure installations have far outpaced the 2013 Comprehensive Energy Strategy goal of 50 new, publically available, Level 2 EV chargers. Public and private demand along with increased funding support from other sources has yielded over 200 additional public chargers from the number installed in 2013 which has greatly expanded the infrastructure and helped to reduce range anxiety barriers.

In partnership with the Connecticut Center for Advanced Technology, Inc. (CCAT), EVConnecticut issued a request for proposals (RFP) seeking to award up to $400,000 to establish two hydrogen fueling stations in the greater Hartford area to support the first commercially available model year of light duty Fuel Cell Electric Vehicles (FCEVs) in Connecticut. During the RFP process, it became known that a hydrogen fueling station was already planned for the greater Hartford area and is anticipated to commence operation in mid-2017. This station will be operated by Air Liquide who, in collaboration with Toyota Motor Sales USA, plans to build the first of twelve hydrogen fueling stations in the Northeast. Upon substantial completion of the Hartford area hydrogen fueling station, EVConnecticut plans to re-assess the 2015 Hydrogen Refueling Infrastructure Development (H2Fuels) grant program, including funding levels, to strategically support additional hydrogen fueling stations in Connecticut. Supporting the development of redundant hydrogen fueling infrastructure is critical to the successful early market penetration of FCEVs throughout Connecticut.

The need to continue on the path to decarbonize the transportation sector is demonstrated in an economy-wide analysis of GHG mitigation scenarios completed by the GC3. The analysis shows that in order for the state to meet its 2050 GHG reduction target, just over 2 million ZEVs need to be deployed by 2050.[255] Collaboration by state regulators and policy makers as well as public and private entities is essential for the State to actualize these numbers and successfully decarbonize the transportation sector.

Emerging Mobility Services

Over the past few years, several new mobility services have been established in Connecticut changing the transportation marketplace for consumers. Ease of use and flexibility for consumers

[255] Connecticut Department of Energy and Environmental Protection, "Meeting of the Governor's Council on Climate Change (GC3) - September 8, 2016," http://www.ct.gov/deep/lib/deep/climatechange/gc3/gc3_mitigationwedges_09_08_2016.pdf.

to choose how they move from place to place have made these mobility options popular. These services include new ways of planning trips, shared cars and bikes, and ride-hailing.

Shared mobility has evolved into newer service categories beyond typical transit services and carpooling programs to meet commuting needs. Enabled through recent technological advances in smartphones, GPS navigation and social networking, car-sharing services (e.g., ZipCar and Streetcar) and ride-hailing services (e.g., Uber and Lyft) have established themselves across several urban locations throughout the state. These services have provided Connecticut citizens with fresh and innovative mobility options. The ease-of-use of these services is shifting consumer dependency on single-occupancy driving, especially for consumers under the age of 30. Car-sharing services are ideal for individuals who may only need a vehicle occasionally for a few days or even a few hours, and can be significantly less expensive than vehicle ownership. Typically, car-sharing services charge a fee to use a vehicle for a designated period of time, and includes insurance coverage and fuel in their membership costs.

CTDOT's CTrides has partnered with NuRide, a national program that utilizes a web-based platform to seamlessly connect members to facilitate shared trips leading to reduced VMT. The NuRide program also rewards members for selecting alternative modes of transportation such as walking, biking, telecommuting, carpooling or using public transportation. To encourage alternatives to single-occupancy driving, CTrides has also begun facilitating partnerships between employers and private providers of commuter vanpooling services operating in Connecticut, such as vRide, Inc. and The Rideshare Company.

These new mobility services provide consumers with a variety of choices to move from place to place without using single-occupancy vehicles. A combined approach utilizing shared mobility, alternative fuels, and TOD strategies may reduce consumer spending on transportation needs and lead to significant VMT and GHG emissions reductions. The State should continue to explore and identify how these dynamic services play a role in decarbonizing the transportation sector.

Freight

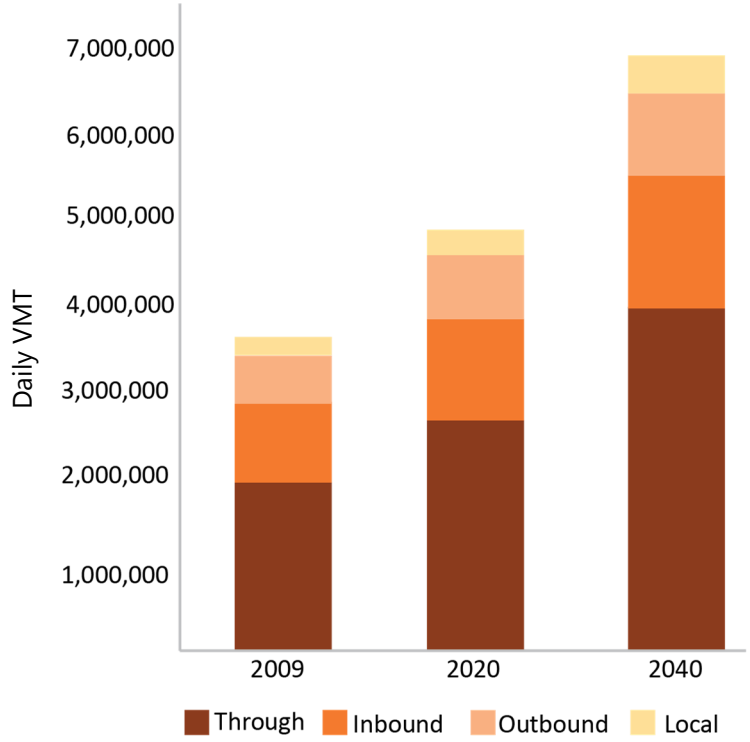
Movement of goods by truck, train, ship and aircraft is essential to Connecticut's economy. Freight mobility allows for the delivery of goods to end users in the state and enables Connecticut businesses to ship their goods out of state. The movement of these goods consumes large amounts of energy, predominantly from fossil fuels, heavily contributing to transportation-related emissions.

According to a 2013 study prepared for DEEP entitled "Development of a Strategic Plan for Reducing Emissions Associated with Freight Movement in Connecticut," on-road trucks move over 90 percent of the freight in Connecticut while rail and water move 2 and 6 percent respectively.

As a result of this dependence on on-road trucks, and the diesel fuel that powers them, they are responsible for almost all the emissions associated with freight movement. [256]

Of the 3.7 million VMT per day attributed to freight movement in Connecticut in 2009, 53 percent consists of through freight. Inbound and outbound freight comprise 25 percent and 15 percent, respectively. With 6 percent of statewide VMT in 2009, local transport makes up the smallest share.

FIGURE T9: Truck VMT Projections 2009-2040



Source: Development of a Strategic Plan for Reducing Emissions Associated with Freight Movement in Connecticut

In addition to this, total freight VMT is expected to grow by 88 percent from 2009 to 2040. Through freight represents the majority of this increase at a predicted 103 percent from 2009 to 2040 (see Figure 9).[257] Further air quality issues stemming from this growth will require significant changes in Connecticut's freight management.

In 2015, DEEP became a SmartWay® Affiliate. SmartWay® is an innovative partnership of the U.S. Environmental Protection Agency that reduces greenhouse gases and other air pollutants and

[256] de la Torre Klausmeier Consulting, Inc., Cambridge Systematics, and Eastern Research Group, *Development of a Strategic Plan for Reducing Emissions Associated with Freight Movement in Connecticut*, March 28, 2013, 7; http://www.ct.gov/deep/lib/deep/air/diesel/freightreport_03_28_2013.pdf.

[257] de la Torre Klausmeier Consulting, Inc., Cambridge Systematics, and Eastern Research Group, *Development of a Strategic Plan for Reducing Emissions Associated with Freight Movement in Connecticut*, March 28, 2013, 8; http://www.ct.gov/deep/lib/deep/air/diesel/freightreport_03_28_2013.pdf.

improves fuel efficiency using market-driven partnerships to help businesses move goods in the cleanest most efficient way possible. By providing a consistent set of tools and information needed to make informed transportation choices, the program enables companies across the supply chain to exchange performance data in ways that protect the environment, enhance our nation's energy security and foster economic vitality. To encourage continued improvement, SmartWay® provides incentives and recognition for top performers. Twelve businesses in Connecticut are currently registered as SmartWay® partners. As an Affiliate of the program DEEP actively promotes the program and educates stakeholders in the state about the benefits of becoming a SmartWay® partner.

To further reduce emissions associated with movement of freight, the State should continue analyze and identify opportunities to pursue the four emission reduction strategies outlined in the "Development of a Strategic Plan for Reducing Emissions Associated with Freight Movement in Connecticut," which include: technological improvements that reduce emissions per ton-mile, reducing freight-miles traveled, mode shifting, and system efficiency improvements.[258]

GOALS AND RECOMMENDATIONS:

Goal 1: Put the state on a strategic pathway to decarbonize the transportation sector.

T.1.1 Develop an EV roadmap to accelerate the adoption of low and zero-emission vehicles and strengthen alternative fueling infrastructure.

Connecticut recognizes that many of its residents and businesses will likely depend on the use of automobiles for years to come. Given that motor gasoline powers 77 percent of the energy consumed by the transportation sector, Connecticut must accelerate the deployment of zero- and low-carbon vehicles to achieve meaningful emissions reductions and to increase energy reliability and security.

With light-duty vehicles accounting for 95 percent of Connecticut's vehicle stock and 70 percent of the state's on-road energy consumption, electric drive vehicles powered by rechargeable batteries or hydrogen fuel cells currently present the strongest potential to significantly reduce

[258] de la Torre Klausmeier Consulting, Inc., Cambridge Systematics, and Eastern Research Group, *Development of a Strategic Plan for Reducing Emissions Associated with Freight Movement in Connecticut*, March 28, 2013; http://www.ct.gov/deep/lib/deep/air/diesel/freightreport_03_28_2013.pdf.

greenhouse gas emissions in the transportation sector. Especially when the electricity and hydrogen comes from low-carbon feedstocks.[259]

Furthermore, according to an analysis completed by the Governor's Council on Climate Change, by 2050, approximately 92 percent of Connecticut's passenger and light-duty fleet needs to consist of electric vehicles in order to ensure meeting the Global Warming Solutions Act.[260] This transformational change requires the State to continue to develop and implement programs and policies that mainstream the adoption of electric vehicles and adequately develop the infrastructure needed to support them.

Fortunately, auto manufacturers have responded to energy and environmental regulatory drivers for increased deployment of low- and zero-emission vehicles by significantly increasing investments in the design and production of plug-in vehicle technologies, including battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), collectively referred to as electric vehicles (EVs). With over 35 EVs available in a variety of styles from small to medium to SUVs, second generation EVs are providing more diverse model options that meet a variety of lifestyle needs. For instances, PHEVs now on the market have an electric range of 13-53 miles, while BEVs have an electric range of 62-335 miles.[261] Advances in technology have also led to larger batteries at lower costs, thereby reducing the overall price tag for EVs and improving consumer range confidence.[262] In addition to declining battery costs, the cost per mile to operate an electric passenger vehicle is about one-quarter the cost of the average conventional vehicle due to the EV's highly efficient drivetrain. This, along with reduced maintenance costs, decreases the overall cost of car ownership for consumers. With a wider array of vehicle models available, reduced capital costs, and extended drive ranges, demand for EVs will certainly rise.

Hydrogen-powered fuel cell electric vehicles (FCEVs) are also a promising technology poised to reduce emissions associated with fossil fuel light-duty vehicles. FCEVs offer an effective driving range of over 300 miles, emit only water and offer a three- to five-minute refueling experience, similar to conventional gasoline vehicle fueling. While the initial adoption of FCEVs outside of California will be challenged by high vehicle cost and limited fueling infrastructure, OEMs are

259 Atlas Public Policy and The Cadmus Group Inc., *Moving Forward with Green Energy: Market Potential Assessment for Alternative Fuel Vehicles in Connecticut*, September 2016, 48, http://atlaspolicy.com/wp-content/uploads/2016/11/2016-09-01_Moving_Forward_with_Green_Energy.pdf.

260 Connecticut Department of Energy and Environmental Protection, "Governor's Council on Climate Change (GC3) Meeting Minutes - March 7, 2017 Meeting," http://www.ct.gov/deep/lib/deep/climatechange/gc3/3_7_17_gc3_meeting/gc3_meeting_3_7_2017.pdf.

261 "Find Plug-In Vehicles," Plug In America, accessed March 30, 2017, http://www.pluginamerica.org/vehicles.

262 Bloomberg New Energy Finance, "Electric vehicles to be 35% of global new car sales by 2040," February 25, 2016, https://about.bnef.com/blog/electric-vehicles-to-be-35-of-global-new-car-sales-by-2040/.

partnering with hydrogen suppliers and providing leasing options that include fuel.[263] These leasing options should be available in Connecticut when adequate fueling infrastructure is available.

DEEP also supports continuing efforts by H2USA and the implementation of the H2USA plan for FCEV re-fueling infrastructure[264] and FCEV deployment.[265] The Northeast States for Coordinated Air Use Management is coordinating a planning process with the OEMs to develop a northeast hydrogen network of similar scale to the California program. Air Liquid and Toyota have partnered to build 12 hydrogen stations within the Northeast, the first of which is under development in Hartford and is expected to open and be ready to serve FCEVs in Connecticut in 2018.

Given the compelling environmental benefits of FCEVs, Connecticut should maintain support for FCEVs as the industry works to both increase vehicle availability and reduce hydrogen fuel cost with the long term goal of producing an array of FCEVs that are cost competitive with gasoline powered vehicles.

Connecticut's adoption of the California ZEV rule in 2013 has the potential to deploy an increasing number of ZEVs in the state. The rule requires automakers to attain an increasing amount of zero emission vehicle credits based on the number of vehicles produced and delivered for sale in participating states.[266] However, due to a clause in the regulation, called the "travel provision," vehicle manufacturers can earn credits in every state for ZEVs that are sold in any ZEV-program state. As a result, manufacturers have focused on selling ZEVs primarily in California, due to the size and strength of its market.

Despite the travel provision, according to the Northeast States Coordinated Air Use Management (NESCAUM), EV sales in ZEV states, other than California, increased 60 percent in 2016 over the previous year. These numbers show that consumer access to state and federal incentives, education and awareness about the environmental and financial benefits, and the expanding availability of reliable infrastructure is starting to pay off. The travel provision will expire at the end of 2017, when more aggressive ZEV-sale levels come into effect. This expiration will likely lead to

263 The Toyota Mirai FCEV has a manufacturer's suggested retail price (MSRP) of $57,500 and the Honda Clarity, due out in 2017, is expected to be similarly priced. "The 2017 Toyota Mirai Fuel Cell Vehicle," Toyota, accessed April 5, 2017, https://ssl.toyota.com/mirai/fcv.html.

264 http://h2usa.org/sites/default/files/H2USA_LRWG_NEFactsheet.pdf

265 http://h2usa.org/sites/default/files/2017_Regional_H2_Fleet.pdf (in particular, see Appendix I, Figure 3).

266 The California Zero Emission Vehicle Program has been adopted by nine states (California, Connecticut, Oregon, Massachusetts, Maryland, Maine, New Jersey, New York, and Vermont) and requires automakers to produce zero emission vehicles to improve local air quality and reduce GHG emissions.

an increase in ZEV sales in Connecticut and participating New England states. It is anticipated that this will support increased market penetration of EVs in the years ahead.

The de-carbonization of medium- and heavy-duty vehicles and rail freight poses the greatest challenge and relies primarily on increased efficiency, mode shifting and low-carbon fuel stocks such as biofuels and hydrogen. For instance, introducing alternative fuels to medium- and heavy-duty vehicles can be more complex and costly than doing so for passenger vehicles. Unlike passenger vehicles, their engines, chassis, and supplementary equipment are rarely all designed and manufactured by a single firm, making systems integration a key challenge. Additionally, these vehicles have a much greater diversity in body types, weight classes, drive cycles, and uses than passenger vehicles, so identifying a single strategy to achieve emission and petroleum reductions is challenging. [267] For these reasons, a targeted approach within a single vehicle category (e.g., trash truck or transit bus) is the most appropriate tactic to increase fuel diversity and reduce emissions for medium- and heavy-duty vehicles.

In concert with accelerating the deployment of low- and zero-emission vehicles, Connecticut will build on its current strategies to support and advance the deployment of alternative fueling infrastructure. This includes harmonizing infrastructure deployment with the U.S. DOT's recent establishment of alternative fuel corridors in strategic locations along major highways.[268] This will help to improve the mobility of alternative fuel vehicles and promote the build out of a national network.

Even with an increasing demand, a growing list of available vehicles, and adequate infrastructure in place, the EV market is still maturing. To further support the development of a self-sustaining EV market and to ensure that an increased electric demand from EV deployment is a benefit rather than an impairment to the electric grid, Connecticut should develop an EV Roadmap that investigates and recommends Connecticut specific policies, programs, and strategies the State should pursue to optimize the deployment of EVs and associated infrastructure. DEEP will initiate the EV Roadmap process beginning in 2018. The Roadmap will include the following:

- Build on the State's current "Lead by Example" program by developing an EV LBE program that outlines a multi-agency strategy that accelerates the adoption of EVs for the State fleet.

267 Atlas Public Policy and The Cadmus Group Inc., *Moving Forward with Green Energy: Market Potential Assessment for Alternative Fuel Vehicles in Connecticut*, September 2016, 16, http://atlaspolicy.com/wp-content/uploads/2016/11/2016-09-01_Moving_Forward_with_Green_Energy.pdf.

268 "Alternative Fuels Corridors," U.S. Department of Transportation, Federal Highway Administration, accessed June 30, 2017, https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/.

- Evaluate opportunities for statewide deployment of slow and fast charging EV infrastructure with appropriate access for suburban and urban areas, single and multi-unit dwellings, business and recreational facilities.
- Evaluate appropriate time-of-use rate structures that support the adoption of EVs.
- Evaluate appropriate role of utility companies in the deployment of electric charging stations, including ownership and other models.
- Pursue sustainable funding needs for the CHEAPR program with an intention to ensure emissions reductions and a strategy to ramp down incentives as the market matures.
- Investigate strategic approaches to address equity and access to EV technologies for low to moderate income residents as the market matures.
- Review targeted approaches to medium- and heavy-duty vehicle electrification, including an analysis of the benefits of converting transit buses and waste truck fleets.
- Identify opportunities to expand current consumer awareness and education efforts to a wider audience.
- Evaluate and identify potential opportunities to submit proposals to Electrify America's investment Cycle 2 (Q3 2019—Q4 2021 $300 million).
- Evaluate and identify strategic opportunities to invest the allowable fifteen percent of the VW Appendix D funds in electric vehicle infrastructure.

T.1.2 Advocate for the implementation of federal vehicle fuel economy standards and maintaining LEV, ZEV, and GHG programs.

To ensure Connecticut meets its climate and clean air goals, the State will continue to advocate for aggressive national vehicle efficiency standards while maintaining its commitment to implement the California LEV, ZEV and GHG programs that will result in cleaner, more efficient vehicles being deployed in the state. Connecticut will continue to advocate for robust federal fuel efficiency standards as well as the diversification of, and funding for, alternative fueling infrastructure. Specific interests include, but are not limited to, more stringent emission standards, more robust efficiency requirements, support for electrification, and investment in hydrogen and other alternative fueling infrastructure.

Of particular challenge are recent efforts by the federal government to roll back the energy and environmental standards that underpin the technology forcing nature of the national regulatory framework for vehicle emission standards and fuel economy standards. The State must closely monitor such counterproductive developments and, in cooperation with the Connecticut Attorney General's office and our state partners, continue to support ongoing legal challenges and actively

confront those federal actions found to negatively impact Connecticut's public health, environment or economy.

T.1.3 Educate and engage citizens and employers on the benefits of clean and efficient transportation options.

Outreach, Communication, & Social Media

It is important for the State to leverage opportunities to further the public's awareness about clean transportation options and the social and economic benefits of more efficient modes of travel. This includes maintaining current outreach and awareness approaches such as developing print and online information and tools, organizing public events and workshops, increasing exposure to new types and modes of transportation, and highly visible demonstration projects. Moreover, the virtual ubiquity of the internet and the growing popularity of social media will help augment and amplify traditional outreach efforts, especially as more and more people rely on the internet and social media for their information.

Highly efficient cars and light trucks in every vehicle class are already on the market, but many customers are not aware of their availability and benefits. In coordination with the Department of Motor Vehicles (DMV) and CTDOT, DEEP will continue to disseminate updated information on state websites and in DMV communications. The information should educate the public about the relative efficiency of vehicles within each vehicle class and encourage the purchase of low and zero-emission vehicles. Site visitors should be able to access information and programs easily and intuitively.

DEEP should also continue to conduct outreach via the Energize Connecticut[SM] campaign.[269] The Energize Connecticut[SM] web portal has grown into an important online resource that provides Connecticut consumers, businesses and communities the tools and information they need to more easily realize energy savings. This portal currently does provide access to transportation-focused energy information when using the search feature; however, it should be improved to provide direct access to that material from the main page.

Social media has become a primary means for people to gather information, especially for young adults between the ages of 18-29.[270] The State should utilize social media platforms, such as Facebook and Twitter, as an additional way to reach the public. Social media campaigns should include advertising and promoting webinars, print materials, and videos that aim to educate and

[269] Energize Connecticut[SM] is an initiative of the Connecticut Energy Efficiency Fund, the Connecticut Green Bank, the State, and local electric and gas utilities. The initiative has funding support from a charge on customer energy bills.

[270] Shannon Greenwood, Andrew Perrin and Maeve Duggan, "Social Media Update 2016," Pew Research Center, http://www.pewinternet.org/2016/11/11/social-media-update-2016/.

engage consumers on the benefits of clean and efficient transportation options. This will help inform and motivate consumers to make sustainable transportation choices.

Several studies have found that consumers that have exposure to EVs are more likely to value the benefits of EV ownership and as a result are more inclined to consider purchasing an EV in the future.[271,272] Within available resources, the State should continue pursue opportunities to increase the public's exposure to EVs through events such as Ride and Drives. Partnering with companies, non-profits, municipalities and state agencies to host these types of events provide consumers with a first-hand experience driving an EV and an opportunity to ask questions that may alleviate some of the perceived barriers to EV ownership.

Many of Connecticut municipalities have created "Clean Energy Task Forces" to improve energy efficiency and deploy renewable energy technologies in their communities. This network of volunteers has proven to be a valuable asset for promoting clean energy options. DEEP should work with Clean Energy Task Forces to identify opportunities to educate and engage citizens on the benefits of EVs and alternative modes of transportation in their communities.

Electrification Toolkit

DEEP and the Connecticut Green Bank will disseminate and promote the recently released Transportation Electrification Toolkit. A joint development from Atlas Public Policy, Connecticut Green Bank, and DEEP, this publically available online resource serves as a dynamic tool for policy makers, municipalities, and businesses to develop strategies to encourage transportation electrification through the pairing of EVs and residential solar photovoltaic systems and electric shared-use mobility solutions. The toolkit consists of summaries of each transportation electrification concept, a case study of the concept from outside Connecticut, and potential approaches to deploy the concept for policymakers. The toolkit also consists of a resource library and interactive data dashboards that provide quick access to relevant information on transportation electrification in Connecticut.[273]

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271 Zeinab Rezvani, Johan Jannson, and Jan Bodin, "Advances in consumer electric vehicle adoption research: A review and research agenda," *Transportation Research Part D: Transport and Environment*, Volume 34, January 2015, 122-136, http://www.sciencedirect.com/science/article/pii/S1361920914001515.

272 Kenneth S. Kurani, Nicolette Caperello, & Jennifer TyreeHageman, *New Car Buyers' Valuation of Zero-emission Vehicles: California*, Institute of Transportation Studies, University of California Davis, March 2016, https://www.arb.ca.gov/research/apr/past/12-332.pdf.

273 "Transportation Electrification Toolkit for Connecticut," Atlas Public Policy, accessed June 30, 2017, http://atlaspolicy.com/rand/transportation-electrification-toolkit-for-connecticut/.

Goal 2: Facilitate state planning to advance smart-growth, transit-oriented development, and mixed-use planning that leads to energy and emissions reductions.

T.2.1 Implement Let's Go CT! initiatives and its long-term vision to create a best-in-class transportation system.

CTDOT, OPM, DECD, DOH and DEEP will collaborate to support state-wide efforts to implement strategies that are consistent with State statutes and the implementation of Connecticut's long-term transportation plan, Let's Go CT! The plan, which is a 30 year vision, requires the joining of urban, suburban, and rural communities into a single system to maximize mobility and efficiency in the movements of goods and people. The strategies and initiatives laid out in the plan will result in increased efficiency, lower GHG emissions, increased mobility options, and will have a positive economic impact on the state.

The plan calls for preserving and enhancing the state's roads, highways, and bridges. A key goal of the plan is to have a highway network exist without bottlenecks or other unnecessary delay. Delay on the state's roadways increases fuel consumption, is a contributor to the state's GHG emissions, and is expensive for its residents. In order for the state to meet its emission goals and to make its transportation system as efficient as possible, improvement and preservation of the state's roadways are essential.

Pavement preservation has a positive environmental impact beyond reduced emissions from better roadway conditions. It has been shown that to minimize energy use and GHG emissions over the life of a pavement, all preservation treatments should be utilized as appropriate to the maximum extent possible for the existing pavement conditions.[274]

Public transit will be enhanced and expanded as part of the long term transportation plan. For example, CT*fastrak* will be extended east of the Connecticut River, and the SLE will be extended into Rhode Island. The plan also includes a high speed rail connecting New Haven, Harford, and Springfield. Expansion and enhancement of the state's public transportation system will help to facilitate TOD, which in turn will provide residents with more mobility options, particularly walking and biking. Furthermore, the plan aims to complete gaps in regional trails, and to enhance

[274] Jim Chehovits and Larry Galehouse, "Energy Usage and Greenhouse Gas Emissions of Pavement Preservation Processes for Asphalt Concrete Pavements," Compendium of Papers from the First International Conference on Pavement Preservation, 41, http://centralcoast.apwa.net/Content/Chapters/centralcoast.apwa.net/Documents/Energy%20Usage%20and%20Greenhouse%20Gas%20Emissions%20of%20Pavement%20Preservation%20Processes%20for%20Asphalt%20Concrete%20Pavements.pdf

walkability in urban centers. All of these public transit enhancements will improve resident's access to alternative modes of transportation and reduce VMTs. DEEP, along with other state agencies, will help support these initiative by promoting and encouraging the use of public transportation and non-motorized travel.

The plan also calls for enhancements to the state's airport and deep water port system. It is important that the State continue to support the movement of freight via air and water in order to reduce the number of freight trucks on the state's roads. Coupled with the improved rail system, the state's ports and rail system will play a key role in reducing emissions and energy consumption associated with the movement of freight within the state.

Sustainable transportation funding is critical to developing transportation network that is clean, efficient and safe. Mechanisms to ensure funding availability such as a transportation lock-box and travel demand technologies including, but not limited to, electronic congestion pricing should be considered as viable ways to provide funding sufficient to sustain current transportation infrastructure needs and to enhance mobility options that reduce the negative economic and environmental impacts of transportation.

In order for the State to meet its greenhouse gas emission targets and to maintain the highest level of energy efficiency in the transportation sector, it must support the measures for preservation and improvement laid forth in the Let's Go CT! long-term vision for the state's transportation system.

T.2.2 Encourage and support smart-growth, transportation-oriented development, mixed-use planning, and development efforts that improve connectivity and accessibility to public transit.

The ability for people to safely, reliably, and conveniently reach everyday destinations such as grocery stores, health care facilities, jobs, schools, and recreational opportunities is critical for creating prosperous and healthy communities. Connectivity measures that help to achieve this include integrating transportation and land use planning, improving local pedestrian and bicycle infrastructure, and managing the transportation system for efficiency and accessibility.

Land-use planning and TOD concepts reduce congestion by eliminating cars on the road, promote active transportation, and reduce the cost of transportation by reducing fuel use and vehicle wear, while increasing foot traffic to local businesses, and can lead to the revitalization of neighborhoods and brownfields. Likewise, businesses benefit by gaining greater access to suppliers, markets, and labor. By lessening or eliminating the need for an automobile, location-

efficient communities also help to decrease GHG emissions and other harmful pollutants associated with the combustion of fossil fuels.

Connecticut has been at the forefront developing a statewide TOD program that promotes economic development, mitigates traffic congestion, improves access, and enhances mobility options. To further align reinvestment potential with transit investment, the Interagency TOD work group will continue to evaluate and identify opportunities to support the state's TOD needs.[275]

In addition to this, the Office of Policy and Management's (OPM) Conservation & Development Policies (C&DP) plan for 2013-2018 promotes concentrated development around transportation nodes and along major transportation corridors to support the viability of transportation options. More specifically, the C&DP plan calls for state policies to:

- Promote compact, pedestrian-oriented, mixed use development patterns around existing and planned public transportation stations and other viable locations within transportation corridors and village centers;
- Encourage a network of pedestrian and bicycle paths and greenways that provide convenient inter- and intra-town access, including access to the regional public transportation network;
- Ensure that the planning, design, construction, and operation of state and local highways accommodates municipal plans and the needs of all users, to the extent possible;
- Improve transit service and linkages to attract more customers through better integration of all transportation options and advances in technology, while providing convenience, reliability, safety and competitive modal choices;
- Coordinate with host municipalities on supportive land use regulations, such as transit-oriented development zones and freight villages where practical, to make the most effective use of transportation facilities for the movement of people and/or goods; and
- Identify brownfields and other strategic sites that are (1) within one-half mile or walking distance of public transportation facilities and/or (2) near other inter-modal transportation nodes and facilities, and consider them for designation as pre-approved development areas.[276]

275 Governor Malloy created the Interagency TOD work group in 2012 to address the transit oriented development needs of the state. Led by DECD, work group membership includes CTDOT, OPM, and DEEP.

276 Connecticut Office of Policy and Management, *Conservation & Development Policies: The Plan for Connecticut 2013-2018*, June 5, 2013, 15-16, http://www.ct.gov/opm/lib/opm/igp/org/cdupdate/2013-2018_final_cd_plan_(rev._june_2017).pdf.

For public transportation to be a viable and attractive option for commuters the issue of the "first and last mile" (FM/LM) must be addressed. One of the longest running challenges facing transit users, the FM/LM problem is how to effectively get riders from their front door to the nearest transit stop. Unless the proper infrastructure is in place, this final portion of the commute can be a deterrent to some commuters wishing to use public transportation.

The adoption of a Complete Streets policy can serve as a comprehensive solution to the FM/LM challenge. Implementing a Complete Streets policy helps to ensure that streets are safe for all users especially cyclists, pedestrians, and public transit users. Safe walking paths and bikeways connect system users to public transit hubs, making a commuter more likely to consider public transit as an option. Along with CTDOT, ten municipalities have already adopted a Complete Streets policy. The State will continue the efforts of CTDOT and others to implement Public Act 09-154, Connecticut Complete Streets Law, and other policies and practices that ensure safe bicycle and pedestrian access.

Shared use mobility services such as car and bike sharing or ride hailing can also help to solve the FM/LM barrier. A user can hail a ride for a short distance using a service like Uber or Lyft, or could rent a car or bike from a car sharing service like Zipcar or Motivate. Non-traditional solutions such as shared mobility services may prove to be an innovative approach to improve user connectivity.

Expanding and enhancing the efficiency of public transportation, promoting non-motorized travel, and supporting compact, mixed use transit-oriented development must remain a priority for Connecticut in order for the state to continue to improve quality of life for its residents and meet its GHG reduction goals.

Goal 3: Develop and support strategic partnerships to improve access to a wider array of clean transportation options.

T.3.1 Embrace technological advances, shared mobility services, and transportation demand partnerships that improve mobility and access to clean modes of transportation..

Advances in technology and the sharing economy may provide policy makers and planners with innovative models that reduce the energy intensity of the transportation sector.[277] Smartphone

[277] In its paper *The Current and Future State of the Sharing Economy,* Brookings Institution defines the sharing economy as "the peer-to-peer based activity of obtaining, giving, or sharing access to good and services." Niam Yaraghi and Shamika Ravi, *The Current and Future State of the Sharing Economy*, December 29, 2016, https://www.brookings.edu/research/the-current-and-future-state-of-the-sharing-economy/.

apps and access to real-time information enables users to more easily track the location of transportation services and assess the speed of travel to get from location to location, both of which serve as critical information for users to select alternative modes of transportation. This same information also helps to optimize traffic system capacity and improve passenger experience. Smartphone apps are also simplifying transport payment making travel faster and a more seamless experience for users. This improved access to real-time information allows users to more easily utilize alternative modes of transportation including public transit and a variety of shared mobility services.

The transportation sector has been particularly impacted by the sharing economy. Shared mobility services have provided people with an alternative to individual car ownership. Car-sharing, ride-sharing, and bike-sharing services have the potential to advance energy and emission reduction goals by reducing VMTs and utilizing clean end efficient vehicles.

In addition to optimizing technological advances and shared mobility services, testing programs that pair clean energy technologies may provide the state with useful insights on innovative solutions that improve mobility and access to clean modes of transportation.

Shared Mobility Services

The personal automobile has been the primary mode of transport for Connecticut residents for many decades. However, with growing interest in urban living and participation in the shared economy, there is an increasing demand for transportation options that offer an alternative to vehicle ownership. A host of opportunities enabled by technology and entrepreneurial innovation are resulting in new mobility models that can reduce costs for consumers and address environmental challenges such as climate change.

Over the past decade there has been an explosion of technology-enable "shared mobility" services. Car-sharing, bike-sharing, and ride-hailing services provide people with an alternative to individual car ownership. The State should further explore and support innovative shared mobility services that reduce consumer travel costs and environmental impacts. For instance, the city of New Haven is partnering with Smart Mobility to launch the city's bike-share program. Thirty bike stations with 10 bikes each will be located around the city. Utilizing a per-user fee structure that includes membership and pay-as-you-go models, New Haven residents will be able to utilize the bikes to get to and from work, run errands, or get around town generally.[278]

Another example of an innovative shared mobility service is that of *BlueIndy*. In 2015, through a partnership between the City of Indianapolis, the local electric utility Indianapolis Power and Light (IPL), and the Bolloré Group, the largest electric car sharing service in the United States was

[278] Markeshia Ricks, "Bike Share Rolling Into Town," New Haven Independent, January 18, 2017, http://www.newhavenindependent.org/index.php/archives/entry/bikeshare/.

launched. The program, called *BlueIndy,* aims to provide its users with convenient access to an environmentally-friendly car that is less expensive than owning a vehicle. With several membership options, from one day to yearly, members can access an electric vehicle at one station location and drop it off at another. With approximately 240 vehicles and 80 charging stations members are able to easily plan their zero-emission vehicle trips to move around the city. The city of LA recently announced that it has also signed a contract with the Bolloré Group to operate an electric car-sharing services called *BlueLA.*[279]

Both of these examples provide municipalities with proven and successful shared mobility service models that may be worthy of pursuing as a way to provide residents with increased access to affordable and clean transportation options. The State should help to facilitate and develop these partnerships by sharing best practices and providing municipalities with public recognition for their leadership in testing innovative, clean mobility models.

Group purchase models and pairing clean energy technologies

Group purchase models such as "Solarize" have proven to be a successful model for deploying solar on homes and businesses in Connecticut and across the country. The model's success can be attributed to its ability to tackle three major market barriers: cost, complexity, and customer inertia.[280] Solarize campaigns, using locally organized outreach efforts, facilitate a critical mass of customers to purchase or lease solar systems by offering a limited-time offer. The model leverages group-purchasing power so that customers realize cost savings through a bulk purchase. The limited-time offer motivates people to follow through with the transaction so they don't miss out on a good deal.

In 2015, several communities in Colorado and Utah adapted this model to promote the deployment and purchase of EVs. Working directly with an EV car manufacturer and local car dealers, communities were able to secure significant discounts on the suggested retail price of the EV (discounts between $2,000-$8,500). After combining the retail discount with federal and state incentives participants of the programs where able to purchase an EV at a substantial discount. The programs led to dramatic increases in EV sales – up to 300 percent community wide.

279 Stephen Edelstein, "BlueLA expands French electric-car sharing service to California," Green Car Reports, December 21, 2016, http://www.greencarreports.com/news/1107918_bluela-expands-french-electric-car-sharing-service-to-california.

280 U.S. Department of Energy, *The Solarize Guidebook: A community guide to collective purchasing of residential PV systems*, http://www.nrel.gov/docs/fy12osti/54738.pdf.

In addition to this, a survey of the 330 participants revealed that 72 percent had not intended to purchase an EV prior to the promotion.[281]

One of the EV purchase programs mentioned above also piloted a joint EV-solar purchase program. The program tested the idea that there is a significant overlap between people who are interested in purchasing solar are also interested in purchasing an EV. The joint purchase pilot resulted in 15 percent of EV customers also purchasing a solar system. Another insight of the joint-purchase program was that it provided co-marketing opportunities for both solar installers and dealerships, potentially expanding the customer base for both. An EV-solar purchase program that deploys solar and EVs has the potential to help consumers realize the economic and environmental value of powering a home with solar and driving an EV.

Following the best practices identified by the Utah and Colorado EV and EV-Solar power purchase programs, the State should pursue a pilot-program in Connecticut to evaluate the effectiveness, costs, and benefits of both an EV purchase and EV-Solar purchase program. A pilot program could specifically evaluate: the cost to run the program; how auto manufacturers, dealers and solar companies would participate in the program; if the program increases sales of EVs; and customer and community participation.

Transportation Demand Management Partnerships

It is essential for Connecticut to continue to support and promote programs and services that facilitate the adoption of transportation demand management (TDM) strategies. Typically implemented by public agencies, employers, or via public-private partnerships, TDM includes strategies that increase system efficiency by encouraging a shift from single-occupant vehicle (SOV) to non-SOV modes, such as ridesharing, telecommuting, public transportation and non-motorized travel like biking or walking. Reducing single occupancy vehicle trips leads to a decrease in VMT and associated GHG emissions.

Connecticut must take advantage of opportunities to partner with private sector businesses and organizations to engage their employees toward understanding and embracing the economic and environmental value of alternative travel modes. For instance, CTDOT facilitates the CTrides program, which promotes TDM to employers by offering worksite assessments, traffic demand management plans, parking management, carpool and vanpool events, and lunch and learn functions. Over 200 companies within the state have already partnered with CTrides. These partnerships increase the potential for reductions in consumer travel costs, VMT, emissions and congestion. The State should continue to support and promote the CTrides program by helping to recognize Connecticut employers that are actively working with CTrides to implement

[281] *Southwest Energy Efficiency Project, The Electric Vehicle and Photovoltaic Power Purchase Handbook: A toolkit for developing electric vehicle and rooftop solar group purchase programs*, http://www.swenergy.org/data/sites/1/media/documents/publications/documents/Power_Purchase_Handbook.pdf.

transportation demand strategies. In partnership with CTrides, DEEP will also help to develop new innovative partnerships that encourage employers to promote and incentivize alternative transportation options for their employees.

T.3.2 Participate in regional partnerships and initiatives to advance a clean and efficient transportation network throughout the region.

Connecticut's transportation systems is part of a larger regional network that requires coordination on transportation planning and infrastructure beyond the state's borders. While the regional transportation networks serving Connecticut do not have one overarching regulating entity, the State actively participates in several regional initiatives to address transportation issues on a larger scale. In the absence of this type of regional collaboration, the efficient movement of goods, people, and services throughout Northeast could come to a grinding halt.

Transportation for the Coalition of Northeastern Governors

Governor Malloy continues to serve as the Lead Governor for Transportation for the Coalition of Northeastern Governors. Through this initiative, the northeastern states work together to plan for safe and dependable commuter rail for the region; ensure federal funding for an integrated transportation system; and coordinate transportation assets, such as passenger and freight rail systems.

Transportation & Climate Initiative

Connecticut is also a founding member of the Georgetown Transportation & Climate Initiative (TCI). A regional collaboration of 12 Northeast and Mid-Atlantic jurisdictions, TCI seeks to develop the clean energy economy and reduce greenhouse gas emissions in the transportation sector.[282] Connecticut will continue to work with TCI participating states to take action on initiatives in four core areas: clean vehicles and fuels, sustainable communities, freight efficiency, and information and communication technologies.

ZEV Task Force

As a signatory of the ZEV MOU, Connecticut will continue to actively participate in the ZEV Task Force. Facilitated by the Northeast States Coordinated Air Use Management (NESCAUM), the Task Force works to implement the Multi-state ZEV Action Plan. This includes coordinating and collaborating on full range of program development efforts and implementation issues to promote effective and efficient implementation of ZEV regulatory initiatives.

282 Participating jurisdictions in the Transportation & Climate Initiative are: Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

I-95 Corridor Coalition

Connecticut will also continue to participate in the I-95 Corridor Coalition. The coalition is an alliance of transportation agencies, toll authorities, and related organizations, including public safety, from the State of Maine to the State of Florida, with affiliate members in Canada. The Coalition provides a forum for key decision and policy makers to address transportation management and operations issues of common interest.

Through these partnerships, Connecticut, and the other member states are able to plan, research, and coordinate the implementation of multi-state initiatives. Connecticut will continue to actively participate in regional initiatives, such as these, that help to advance a clean and efficient transportation network throughout the region.