Draft Report of the Progress on Mitigation Strategies Working Group

Governor's Council on Climate Change

State of Connecticut

September 2020

Chapter 1

Introduction

The Governor's Council on Climate Change (GC3) appointed the Progress on Mitigation Strategies Working Group (Mitigation WG) to review recommendations the Council had made in its 2018 report *Building a Low Carbon Future for Connecticut: Achieving a 45% GHG Reduction by 2030*, assess progress made in implementing those recommendations, and advise the Council on additional actions that should be taken. The focus of this work is Connecticut's contribution to reduction of the greenhouse gas emissions that are driving the global climate change implicated in melting of glaciers and ice caps, breaking heat records, exacerbating droughts and floods, fueling wildfires, pumping up hurricanes, pushing numerous species toward extinction, and raising sea level. GC3 assigned the Mitigation WG to address two additional focal points during this work as well: (a) the relationship between climate change mitigation efforts and equity and environmental justice concerns; and (b) the relationship between climate change mitigation and climate change adaptation/resiliency.

The Mitigation WG is composed of members of GC3 and others who were appointed to help flesh out its expertise and diversify its perspectives. The WG assembled five teams corresponding to the division of GHG emissions policies employed in the 2018 report: Buildings, Electricity, Non-energy, Transportation, and Cross-sector. Each team was co-chaired by a WG member or a Connecticut Department of Energy and Environmental Protection (DEEP) staff member and involved both WG members and other stakeholders who volunteered to participate, with DEEP staff (primarily from the Bureau of Energy and Technology Policy) providing support. Members of the teams are listed in an appendix in each chapter. In all, the teams involved 19 Mitigation WG members, 55 other stakeholders, and 10 DEEP staff.

The period between the initial Mitigation WG meeting on February 28, 2020, and mid-September 2020 saw a frenzy of activity. The WG met six times and the teams, collectively, 49 times, often with 20 or more attendees. Individuals and small clusters of team members engaged in research and consultation. The teams interacted and consulted with other GC3 working groups. They prepared reports, each of which underwent multiple rounds of revision and review, both within the WG and within GC3's Equity and Environmental Justice WG and the Science and Technology WG. Altogether, Mitigation WG efforts during this period have involved thousands of person-hours.

The chapters that follow (see bookmarks in bar at left) are a product of the Mitigation WG and team members. The perspectives expressed do not necessarily reflect the perspectives or positions of DEEP. Review and editing of this material continues within the WG even as this draft is published for public comment. The Working Group thanks members of the public who will review this draft and provide feedback. The final report is scheduled to be submitted to Governor Lamont in November 2020.

Chapter 2

Buildings

Chapter overview

Equity & environmental justice – Addressed at beginning of each recommendation

Adaptation & resilience – Addressed at beginning of each recommendation

Progress on 2018 recommendations	**Strategies** Enhancements and new strategies recommended

Accelerate adoption of building thermal energy conservation improvements	• Prioritize building envelope improvements and expand access to thermal energy efficiency measures through innovative financing options for all income levels
	  ○ Create a lockbox for energy-efficiency funds
	  ○ Improve the ability of efficiency programs to overcome health, safety, and legal barriers
	• Ensure building codes are continuously aligned with the most recent International Energy Conservation Code standards
	  ○ Be proactive: Create stretch codes, carbon codes, and all-electric options
	• Reduce GHG emissions from state and municipal buildings, including Lead by Example goals for 2030
	• Review consistency of energy efficiency cost-effectiveness testing with public policy goals
	  ○ Fully align the test with the National Standard Practice Manual
	• Create a state Building Performance Office
	• Harness the power of data to guide, initiate, and track change
	• Engage municipalities as allies to improve energy efficiency
	• Develop the capacity to scale up deep energy retrofits
	• Expand programs to include more building types and sub-systems for permitted use of smart-building controls that align operation and pricing with low GHG emissions and/or resilience objectives

Expand consumer education and awareness efforts to increase uptake of zero- and low- carbon technology measures	• Increase visibility of EnergizeCT resources • Enhance outreach efforts by using social media campaigns, webinars, case studies, testimonials, and customer-engagement platforms • Increase training of real-estate industry professionals on integrating U.S. DOE Home Energy Scores and information on energy efficiency, renewables, and resiliency into real-estate transactions processes • Create a Building Energy Concierge function to advise owners in pursuing a holistic and strategic approach to building performance

Transition building fossil fuel thermal loads to efficient renewable thermal technologies	• Develop sustainable funding mechanisms to incentivize replacement of fossil-fuel space and water heating with efficient renewable-thermal technologies
	  ○ Require delivered fuels companies to contribute to the Energy Efficiency Fund
	  ○ Support municipal-scale RTT investment through Community Choice Aggregation
	• Incentivize installation of renewable thermal technologies in new construction

Improve training and technical capacity of workforce	• Expand training programs to include renewable thermal technology installations and standards
	  ○ Focus training on emerging needs
	  ○ Draw on programs elsewhere in the region

New recommendation Develop a strategic plan for transitioning from fossil fuels to renewable thermal technology	○ Set end dates for expansion of the gas grid and new gas installations on the existing grid

Introduction

The 2018 report presented four broad recommendations regarding buildings:

1. accelerate adoption of building thermal energy conservation improvements;
2. expand consumer education and awareness efforts to increase uptake of zero- and low-carbon technologies[1];
3. transition building fossil fuel thermal loads to efficient renewable thermal technologies; and
4. improve training and technical capacity of workforce

This chapter assesses progress made in implementing each of these recommendations, and it offers additional recommendations, additional strategies, and enhancements.

For each broad recommendation, the chapter discusses equity and environmental justice (EEJ) considerations. EEJ also is addressed for many strategies. The chapter also highlights some of the ways in which the GHG emissions-mitigation measures outlined relate to efforts to help Connecticut adapt to the changing climate and improve resiliency.

[1] This recommendation was in the Cross-sector section of the 2018 report.

The Buildings team was chaired initially by Brenda Watson (Operation Fuel) and then by Bernie Pelletier (People's Action for Clean Energy). It has involved eight other Working Group members and 26 other stakeholders representing environmental organizations, industry, the architecture profession, social-service organizations, universities, and government agencies. The team held 19 electronic meetings between March and August 2020.

Accelerate adoption of building thermal energy conservation improvements

EEJ Considerations – Many building professionals and experts have little training in environmental justice. Historically state policies and programs have been designed by people of relative affluence, and this biases the allocation of funding and resources to middle class and high-income populations. In the matter of climate action, we must take special notice of underrepresented communities' needs, such as access to safe, affordable housing, access to stable and clean energy, safe and affordable clean heating and cooling, and safe public buildings. Appointed officials working on state boards, in state jobs, or as consultants should be required to complete basic equity and energy training to ensure they are aware of the needs of at-risk and underrepresented communities. Additionally, to ensure equity in planning and resource allocation, the state should set guidelines on inclusion of people of color, disabled, elderly, child advocates, and other underrepresented communities for positions which have the ability to plan budgets and for positions as representatives or board members. Reports and metrics should be reported in lay terms and should be publicly available.

Performance of housing and community buildings is deeply important to low- and moderate-income (LMI) communities. Properly constructed or renovated buildings are less expensive to maintain and eliminate many health and safety challenges, such as mold, asbestos, high cost, gas leaks, knob-and-tube wiring, standing water, and lead. Thermal comfort (indoor temperature) is improved if building performance is enhanced. Buildings with stable temperatures are safer places to shelter in place during extreme weather, pandemics, or other extended crises. Many at-risk communities have higher rates of medical issues, and safe, comfortable housing lowers the incidence of asthma and other medical conditions.

Fully 33 percent of Connecticut's housing is rental; and for the state to make progress toward a renewable energy future, its building policies need to devote special attention to these properties.[2] This requires careful consideration of the respective roles of tenants and landlords in order to design approaches that benefit both, while resulting in building improvements that further carbon reductions and climate resilience. Community buildings are also often owned by someone other than the local businesses and nonprofits renting the space.

Properly implemented codes will result in high-performing buildings, which will have lower operating costs, be more functional (e.g., operate year-round), and serve as a healthy example to the surrounding community. Such buildings are important to LMI residents and occupants.

[2] https://www.chfa.org/assets/1/6/Connecticut_Housing_Market_Snapshot.pdf, page 6.

Adaptation and Resilience Considerations – Enhancement of building performance and efficiency will mitigate GHG emissions while at the same time serving the purpose of climate change adaptation by improving buildings' habitability in the face of rising temperatures and humidity.

Strategy – Prioritize building envelope improvements and expand access to thermal energy-efficiency measures through innovative financing options for all income levels

Progress to date – In the two years since this strategy was proposed, progress has been impeded by the diversion of energy-efficiency funds and by the COVID-19 pandemic. The General Assembly's diversion of Energy Efficiency Fund and Green Bank moneys – collected through assessments on consumers' electricity and natural gas bills – to balance the state budget did substantial harm:

1. it seriously disrupted energy-efficiency contractors' work on building envelope improvements by depriving them of financial resources and impairing their ability to keep their workforces intact; and

2. it prevented financial incentives from being provided for improvements in oil-heated homes.

At the same time, the state's energy-efficiency programs confront a chronic problem: efficiency contractors' efforts too often thwarted by physical barriers such as asbestos, lead paint, mold, knob-and-tube wiring. Current incentive programs do not address barriers such as these. Even when incentive money is available, these barriers seriously limit the state's ability to apply this money to properties that often need it most urgently.

Finally, most state efficiency programs and incentives are designed for use by building owners – and fail to serve the large number of residents who are renters.

Enhancement – **Create a lockbox for energy-efficiency funds [PRIORITY]**
The most crucial augmentation to the 2018 strategy is to proactively protect energy-efficiency funds against further diversions. As funds are collected via charges on customers' utility bills or through RGGI, they should flow without interruption to a dedicated Efficiency Fund Lockbox. Transportation funds collected are protected in this manner, and it is important that the same protection be afforded to building-efficiency funds. These monies should be used exclusively to promote building efficiency projects such as those described in this subsection. Transparent annual reporting on use of funds is required to ensure no diversion.[3] In addition to pursuing a constitutional amendment for an Efficiency Fund Lockbox, we recommend that the Governor issue an Executive Order protecting these funds.

LMI communities contribute to the Energy Efficiency Funds. It is imperative that these communities receive services commensurate with their contribution. The most recent fund diversion resulted in LMI communities receiving less than they contributed. Further, serious discussion is needed about devoting more-than-proportionate services to LMI communities in order to enhance the well- being of these populations and reduce their health challenges. The cost-effectiveness test for energy-efficiency programs should take into account savings in healthcare expenses that efficiency improvements

[3] See Section III, article 19 of the Connecticut Constitution:
https://ballotpedia.org/Article_III,_Connecticut_Constitution

produce for the State of Connecticut. By addressing indoor-health barriers and lowering energy use by an estimated 15 percent, the state would save $73 per capita.[4]

Enhancement – **Improve the ability of efficiency programs to overcome health, safety, and legal barriers**

In the residential sector, physical barriers (e.g., asbestos) prevent homeowners and some commercial property owners from completing Home Energy Solutions (HES) and Small Business Energy Advantage (SBEA) audits and impede their ability to pursue energy-conservation measures. Moreover, these programs focus on property *owners,* which means *residents* and *businesses in rental arrangements* are often excluded.

The following specific approaches should be pursued:

- Join New York's EnergieSprong initiative, which has made progress in spite of these barriers. NYSERDA has extended an open invitation for Connecticut to participate in this initiative. Engaging with NY will help Connecticut overcome these barriers.
- A key role of the State Building Performance Office proposed later in this chapter would be to develop economic and technical solutions for these barriers.
- The Building Energy Concierge initiative proposed later in this document would advise owners and rental residents on how to navigate technical, legal, and financial hurdles.
- DEEP and the Energy Efficiency Board should collaborate with related programs that have unique points of access (such as the Children's Medical Center), unique sources of grant funding, and local partnerships. Several such programs are:
    - CTHealthy Homes in the Department of Public Health;
    - Green and Healthy Homes; and
    - One Touch.
- DEEP should periodically identify state-level best practices regarding strategies to overcome energy-efficiency barriers and adopt as appropriate.
- Evaluate current programs for effectiveness and institute enhancement to address unmet needs in the LMI community. For example, low credit scores often mean residents are unable to take advantage of loan and on-bill financing programs. In some cases, monies could be redirected from financing products to grant programs.

[4] Efficiency for All, "Save Energy, Save Lives: How energy efficiency can lower statewide health expenses," https://efficiencyforall.org/wordpress/wp-content/uploads/2019/02/EE-Health_2-18-2019_Flyer.pdf.

Strategy – Ensure building codes are continuously aligned with the most recent International Energy Conservation Code standards [PRIORITY]

Progress to date – Under General Statute § 29-252, building and fire codes (which include energy codes) are adopted and enforced at the state level by the Codes and Standards Committee, the Office of the State Building Inspector, and the Office of the State Fire Marshal. All are part of the Department of Administrative Services's Division of Construction Services. State-mandated and -enforced building codes have been regularly updated to adopt recent versions of the International Code Council's suite of model codes, including the International Energy Conservation Code (e.g., 2016 and 2018). The State is planning to adopt the 2018 IECC in early 2021 (this would have happened in October 2020, had COVID not disrupted the process).

Connecticut's aim has been is to keep current with the IECC, making adjustments as needed, but not use codes as a proactive tool.

Properly established codes strike a balance between function and affordability. It is important to maintain a holistic balance of health, safety, and long-term building performance, on one hand, and added construction cost, on the other. The current code determines "the worst building you are allowed to build." Properly established codes can also ratchet up improvements in rental properties, which is key to helping LMI communities. . Additionally, codes can be an important means of helping the building sector adapt to climate change.

Enhancement – **Be proactive: Create stretch codes, carbon codes, and all-electric options**
There are opportunities to use building code development as an educational tool as well as to allow the state and local communities to stretch more aggressively toward energy efficiency. For example, unlike some other states, Connecticut has no policy regarding *embodied carbon* in buildings. Proactive use of building codes as a tool for GHG mitigation would include the following enabling strategies. See Appendix 3A for a description of comprehensive sustainability measurements that should be included in any high-performance standard so that the transformation required to address greenhouse gas emissions also incorporates measures necessary to achieve a healthy, sustainable, equitable, and resilient Connecticut. The standards are to be accomplished using the following four strategies, which are presented in fuller detail in Appendix 3B:

> *Strategy 1:* In conjunction with the Department of Administrative Services, DEEP creates a task force to develop, oversee, enable, and enforce high-performance building codes.
>
> *Strategy 2:* The state develops a "stretch code" that can be voluntarily adopted by municipalities.
>
> *Strategy 3:* The state updates its High Performance Building Code.
>
> *Strategy 4:* The state adopts a protocol for state-sponsored infrastructure projects that establishes goals, actions, and accounting and reporting procedures on minimizing embodied carbon.

GHG emissions-reduction goals in all the above suggested high-performance standards should incorporate the following measures and the comprehensive sustainability measures listed in Appendices 3A and 3B:

- *Energy-efficient operation:* Demonstrate energy efficiency by performing at or below a maximum *energy use intensity* (EUI) for the project type, with each EUI value validated through energy modeling. We recommend using EUI targets established by the New Building Institute for zero-energy-ready performance for climate zone 5A.

- *Building electrification:* Eliminate direct emissions from combustion in buildings, while improving health.

- *Zero energy:* Offset remaining operating energy use with newly installed onsite or offsite renewable power generation that is funded as part of the project.

- *Zero carbon:* Reduce the embodied carbon associated with building materials and construction, and offset the remaining embodied carbon with certified carbon offsets. Buildings designed to come close to carbon neutral (net zero) can become carbon negative through careful selection of carbon sequestering building materials. Buildings designed to come close to carbon neutral (net zero) can become carbon-negative through specifying use of carbon-sequestering building materials, where appropriate. Whenever feasible, it is important to prioritize rehabilitation of existing buildings over new construction, and especially over demolition followed by new construction.

Strategy – **Reduce GHG emissions from state and municipal buildings, including Lead by Example goals for 2030**

Progress to date – Governor Lamont's Executive Order 1 sets the following goals for State government facilities and operations:

- 45 percent reduction in GHG emissions below 2001 levels by 2030;

- 25 percent reduction in waste disposal below 2020 levels by 2030;

- 10 percent reduction in water consumption between 2020 and 2030; and

- carry out these actions while carefully managing the state's fiscal resources.

Progress toward the GHG emissions-reduction goal can be facilitated by action to achieve the waste-disposal and water-consumption goals.

State leadership can encourage and facilitate local action. However, cost/benefit must be carefully considered (with a long-term focus) so that state revenue is not diverted from social programs to capital projects. It is important from an EEJ standpoint that Connecticut is aggressive both on the technical aspects of green buildings and on developing green jobs.

Strategy – **Review consistency of energy efficiency cost-effectiveness testing with public policy goals [PRIORITY]**

Connecticut's utilities employ cost-effectiveness tests to compare the benefits of a particular program (e.g., a financial incentive program for purchase of heat pumps) to the financial investment needed to achieve those benefits.

In 2017 and 2018, DEEP began an inquiry into the adequacy of the utilities' primary test, and in early 2019 the agency sketched an approach that would begin to bring Connecticut's cost effectiveness testing into alignment with emerging approaches in other progressive states. Such states increasingly are turning to a framework outlined in the National Standard Practice Manual for Assessing Cost-Effectiveness of Energy Efficiency Resources.[5] Connecticut is one of relatively few states still using the Utility Cost Test – which rose to prominence decades ago – as the core of its primary test. Most states have moved to broader tests.[6] Many now have adopted or are actively considering the Manual's "resource value framework" as the basis for their testing programs.[7] Connecticut's primary test excludes (or largely excludes) numerous factors that are central in the resource value framework, such as: public health benefits, basic environmental benefits, economic development benefits; participant benefits (e.g., improved health and safety and economic well-being); and even some utility-system impacts.[8] Systematically integrating such factors into the test would improve the energy-efficiency programs' ability to serve the state's overarching policy objectives, including GHG emissions reduction, protecting EEJ communities, and improving the resilience of Connecticut's building stock.

Enhancement – **Fully align the test with the National Standard Practice Manual's resource value framework**

Connecticut needs a modernized cost-effectiveness test that aligns its incentive programs with its policy goals (e.g., Executive Order Number 3, the Global Warming Solutions Act) and accounts for important participant, societal, and utility benefits and costs. This will allow for holistic and consistent approaches to energy, climate, and societal challenges. DEEP, PURA, the OCC, and the EEB should restart the dialogue that was begun two years ago.[9] As outlined in the National Standard Practice Manual, the agencies should:

1. Identify and articulate the state's applicable policy goals.
2. Include all utility system costs and benefits
3. Decide which non-utility (participant and social) impacts to include, based on applicable policy goals.
4. Ensure that the test is symmetrical, even-handedly considering both costs and benefits.
5. Ensure the test is forward-looking.

[5] See also https://www.nationalenergyscreeningproject.org/wp-content/uploads/2019/06/APEX-NSPM-BCA-Models.pdf.

[6] See https://www.aceee.org/sites/default/files/he-ce-tests-121318.pdf

[7] https://www.nationalenergyscreeningproject.org/resources/state-references/

[8] https://www.nationalenergyscreeningproject.org/wp-content/uploads/2019/08/CT-Info-Factsheet.pdf

[9] See https://app.box.com/s/c2i2h73dcmurmthja465j1gwguymga5w/file/383671803669.

6. Develop methodologies to account for all relevant impacts, including hard-to-quantify impacts.
7. Ensure transparency in presenting the test's inputs and results.

New strategy – Create a state Building Performance Office

The state should create a Building Performance Office (BPO) to bring together, in one place, efforts to reduce GHG emissions from buildings. These are characterized below, and further details are presented in Appendix 6.

The BPO would be charged with:

- Creating, maintaining, and updating the database and providing access to policymakers, utilities, and contractors (as a complement to DEEP's Home Energy Labeling Information Exchange building database, which tracks Home Energy Solutions and related data[10]).
- Developing GHG-emissions targets and performance data for each building (see New York City plan).
- Assisting the EEB and others in prioritizing where efficiency dollars could best be spent and assisting in remediating issues in LMI communities.
- Bringing together utilities, trade associations, non-profit organizations, technology companies, and property owners to find technical and financial solutions for particular energy problems and facilitate their rapid deployment.
- Creating a Building Energy Concierge function to advise owners in pursuing a holistic and strategic approach to building performance (the Concierge is described more fully later in this chapter).
- Creating a standing Citizens Advisory Board to connect architects, builders, landlords, activists, renter's groups, and other relevant groups to provide GC3 and the EEB with advice on building energy issues.

It would seem best to have the BPO located within DEEP or another state agency, such as a reconstituted Energy Efficiency Board. The BPO would develop a standing advisory panel to include local and national experts on building science and GHG emissions, as well as representatives of diverse stakeholder groups, including people of color, members of vulnerable communities, renters, and individuals with low or fixed incomes.

Locating the BPO within DEEP would have the advantage of starting immediately and drawing together and building upon expertise among existing staff members. Locating the BPO within the EEB, while desirable, would require legislative action to reconstitute the EEB's membership, which could lead to

[10] See https://neep.org/sites/default/files/resources/HELIX%20one%20page%20-%2006-25-18%20update_0.pdf.

considerable delays in implementation. Initially, starting the BPO immediately, within DEEP, and starting the process of reconstituting the EEB could be done in tandem to conserve time and resources.

New strategy – Harness the power of data to guide, initiate, and track change [PRIORITY]

DEEP has worked with utilities and energy contractors to gather data on energy efficiency activity. Most recently, the agency has approved Compliance 18, which specifies additional reporting requirements on Conservation and Load Management programs produced on a quarterly basis.[11]

A significantly more aggressive, three-part strategy is warranted:

Component 1: Develop a statewide inventory of every building in Connecticut. This database would contain basic information such as square feet of living space, number of stories, fuel type, heating type, construction type, and year built. This data is available from Warren Group for $16,500/year or could expand DEEP's existing HELIX database. The data fields available from Warren are in Appendix 4. This database would be used to:

- record information on energy-efficiency upgrades (insulation, retrofits, equipment upgrade, etc.) so progress could be tracked and communicated;
- develop a sub-inventory of buildings in which barriers to energy-efficiency improvements (e.g., asbestos, lead, mold) are present;
- developing an Energy Utilization Intensity statistic for each building; and
- establish goals for the rate and intensity of upgrades needed to achieve statutory GHG-emissions reductions from the building sector;

Component 2: Support and expand the proposed 2020 Senate Bill 177, which would require annual energy reporting for buildings over a given size and for all buildings when they are sold. Expand reporting to include water use and creation of a Home Energy Score when a building is put up for sale. Appendix 2 provides a summary of the bill.

Component 3: Require delivered-fuel dealers to report annual sales by town and class of customer (residential vs. commercial). Having current statistics for delivered fuel consumption (oil, kerosene, propane) would make it possible to authoritatively gauge progress on GHG-emissions reduction mitigation activities in the building sector. DEEP would annually publish data on fuel consumed and associated GHG emissions by fuel type, municipality, and building sector (residential/commercial). This would be analogous to what Connecticut's major utilities currently report on electric and natural gas consumption at the municipal level. Using delivered-fuel data in conjunction with existing utility-reported data would enable municipalities to have a comprehensive view of their energy consumption and associated GHG emissions from the building sector.

[11] http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/8525797c00471adb852585970065e7a0/$FILE/Condition%20of%20Approval%20Item%20No.18%20-%20Quarterly%20Reports%20-%20Extended.docx

Components 1 and 3 of this strategy – buildings inventory and delivered-fuel data – would support EEJ initiatives tracking where upgrades are taking place and identifying where they are most needed. Component 2 would be a useful source of information for new homebuyers and renters searching for property and would be especially valuable for LMI households.

New strategy – Engage municipalities as allies [PRIORITY]

GC3's 2018 report identified only state-level participants for efforts to enhance building energy performance. We believe it is crucial to directly engage Connecticut's municipalities in the work as well. A top-down approach works best when there is a complementary bottom-up counterpart.

The recommended strategy has three components:

Component 1: Create Energy Development Zone (EDZ) enabling legislation that would authorize municipalities to adopt energy-efficiency policies targeted toward LMI neighborhoods. Connecticut has almost 1.4 million households, of which 36 percent are cost-burdened, essentially in the LMI category.[12] If a municipality adopts EDZ legislation, it would be able to provide incentives and requirements designed to motivate property owners – especially owners of rental properties – to undertake energy assessments (baseline and guidance) and energy efficiency retrofits, with an emphasis on renewable thermal technologies. EDZ legislation also would establish workforce training facilities within – and serve jobseekers living in – the EDZs (see Appendix 5 for details).

Component 2: Create enabling legislation to permit local control of efficiency services and local load aggregation services through Community Choice Aggregation (CCA):

- PURA is conducting a study of CCA as a local mechanism for aggregating residential energy demand and adoption of renewable thermal technology;
- DEEP, EEB, and the BPO would study Cape Light Compact and other programs that have used CCA successfully to target energy-efficiency work for maximum impact in local communities.

Component 3: Connecticut's urban centers produce a significant heat island effect that leads to higher energy bills, accelerated GHG emissions, and poor health. And in extreme heat events, the effect leads to more residents of these areas being hospitalized as well as increased mortality. To fight the heat island effect, we recommend that municipalities takes steps such as: deploying cool roofs and green roofs; urban tree planting; greater utilization of bioswales; deployment of cool pavement; and creating thermal breaks between buildings and pavement.

This strategy – EDZs, CCA to facilitate efficiency, and a municipal focus on combatting heat island – could be helpful to LMI communities that suffer most from heat island effects and could benefit most from a proactive municipal response.

[12] https://www.ctdatahaven.org/data-resources/connecticut-city-neighborhood-profiles

New strategy – **Develop the capacity to scale up deep energy retrofits**

The following actions should be undertaken by the Building Performance Office:

- partner with NYSERDA on EnergieSprong;
- systematically engage and embedRocky Mountain Institute's retrofit tool kit;
- replicate Neighborhood Housing Services of New Haven's "I Heart My Home" program in other communities;
- execute the "Path to Zero Energy Pilot" at full scale as considered by Eversource/UI with a dedicated customer Project Manager/Building Energy Concierge to guide clients further;
- facilitate customer coaching for whole-building-system renovation use phased approaches as building conditions/project support and allow comprehensive incentives to continue with the project timing;
- assure all equipment needed for strategic thermal electrification is incentivized for a comprehensive electrification system;
- review portfolios of buildings with comprehensive/deep retrofit managers and comparing them against the building database outlined above;
- enable Concierges to evaluate a building database with National Renewable Energy Laboratory's ResStock program for energy-efficiency opportunities in Eversource/UI territory as a resource for the state-wide contractor network; and
- formalize alignment between Energize CT's incentives for heat pumps and Northeast Energy Efficiency Partnership's cold-climate heat pump specification.

New strategy – **Expand programs to include more building types and sub-systems for permitted use of smart-building controls that align operation and pricing with low GHG emissions and/or resilience objectives**

Enhance opportunities for permitted use of smart-building controls to align operation and pricing with low-GHG energy:

- Require utilities to work with any application for Grid-Interactive Enabled Buildings located within their distribution system.
- Send automatic control signals to local DER and building controls (i.e., ADR, smart thermostats, etc.) to apply time-based GHG emissions and vary building loads accordingly (i.e., using API with WattTime or similar). This could apply to residential or commercial heat pumps, energy storage, EV charging, hot water heaters, etc.

- Evaluate heat pumps in the context of full-year performance (lowering summer peak) as well as decarbonizing winter energy peak.

Control systems that are easy to use are increasingly important as diverse technologies are installed in homes (e.g., back up fossil fuel equipment, heat pumps, and ventilation equipment). Demand response may be a valuable form of adaptation as there are more and more temperature extremes.

Expand consumer education and awareness efforts to increase the uptake of zero- and low- carbon technology measures

Equity and environmental justice – EnergizeCT is exploring the effectiveness of its outreach strategy. It is often the case that LMI neighborhoods have the most need for energy improvements and yet are the most challenged because of physical, communication, and financial barriers. Most recently the EEB has eliminated the cost for HES audits and continued the policy of zero cost HES audits for LMI population.

Strategy – Increase visibility of EnergizeCT resources

Progress to date – The state's utilities have offered webinars. PURA and the utilities have conducted multiple outreach campaigns – focused on LMI communities – that have given limited attention to energy efficiency. EnergizeCT has conducted a marketing deep dive and reviewed the effectiveness of its marketing channels.[13]

However, due to the diversion of energy-efficiency funds to help balance the state budget, the Energize CT Center has been closed and the Energize CT website update was deferred by a year. Surrounding states (Mass, VT, Maine) have examples of effective websites. EEB is currently reviewing our website. In an effort to restart the HES process after the fund diversion, the HES co-pay was reduced to $75 for all fuel types and recently has been reduced to zero. It is crucial that we not repeat this same error even in the pandemic driven budget deficit. Also, it is important to consider not only the average effectiveness of marketing – but also *what it will take to make a difference for LMI communities.* If social media and television are not effective, Energize CT should consider door-to-door marketing or marketing through community organizations.

In the case of MassCEC, it runs a Clean Energy Live Here campaign and encourages others to become Amplifiers, Coalition Partners, or Campaign Administrators for its residential-based deep home decarbonization path and guidance, which is largely applicable with the overlapping presence of Eversource.

[13] See https://app.box.com/s/p9gjuclpvb19vzwcm46v83gp0f0exrxd/file/631680800237.

Strategy – Enhance outreach efforts by using social media campaigns, webinars, case studies, testimonials, and customer-engagement platforms

Progress to date – EnergizeCT has made progress using social media campaigns, webinars, case studies, testimonials, and customer engagement platforms. UI and Eversource have reported their budgets and results to the EEB.

On February 11, 2020, the EEB received a consultant report on training and education.[14] The report described training and education for the public, students, and the workforce, as well as specific topic training (e.g., air infiltration). Just over the border in Massachusetts, where Eversource also operates, MassCEC has launched Clean Energy Lives Here, an aggressive marketing campaign that provides a useful model for Energize CT digital marketing and a program for residential deep home decarbonization.

It should be determined whether additional forms of outreach (e.g., door to door, town-based marketing, and landlord-focused education) need to be added to the mix to effectively reach LMI communities.

Strategy – Increase training of real-estate industry professionals on integrating U.S. DOE Home Energy Scores and information on energy efficiency, renewables, and resiliency into real-estate transactions processes

Progress to date – The real estate industry continues to resist voluntary action to improve the transparency of energy efficiency and renewable energy in property markets. If the Home Energy Score were required as proposed in 2020 Senate Bill 177, such transparency would be obligatory rather than voluntary. Meanwhile, DEEP is participating in a multistate effort to populate and utilize the Home Energy Labelling Information Exchange (HELIX) database,[15] which will serve as repository for residential energy information (solar, HES, weatherization, etc.) and will feed the MLS (Multiple Listing Service) used by realtors.

New strategy – Create a Building Energy Concierge function to advise owners in pursuing a holistic and strategic approach to building performance

Building owners (especially residential building owners) have difficulty in improving their building performance because:

- Many aspects of building performance are technical in nature and owners are not equipped to understand the choices available.
- Incentives for upgrades are often not apparent to owners and contractors because they change frequently and are in many forms (e.g., rebates, tax credits, pilot programs).

[14] https://app.box.com/s/dgmng2iby8f2p0f9ipza33o231c55ucj/file/614912421408
[15] https://neep.org/home-energy-labeling-information-exchange-helix

- Often the impetus for an upgrade is the failure of a building component (siding, furnace, windows, etc.) and the building owner is forced to act quickly without evaluating all options.

- Often improvements are done on a "one off" basis instead of being viewed comprehensively as steps along a continuous path to building improvement.

A Building Energy Concierge function would help remedy these difficulties. It would use a one-stop-shop approach. When a building owner is considering making an improvement, the Concierge would analyze the building's performance, advise the owner regarding available technical and financial options (generally with a HES audit as the first step), explore the potential for complementary actions, and guide the owner through an iterative process to make energy improvements as time, resources, and the owner's needs allow. This approach has been used successfully for commercial accounts.

The Concierge function would augment the capacity of energy-efficiency contractors in the residential sector by helping them become more effective in service delivery and more consistent in scheduled work. It could also be an entry point to introduce EEJ perspectives in the building-upgrade process. This process is exemplified by the "I Heart My Home" program in New Haven, a partnership between Neighborhood Housing Services of New Haven and a company called System Smart.

Transition building fossil fuel thermal loads to efficient renewable thermal technologies

Equity and environmental justice – Replacement of fossil fuel heating and cooling with renewable thermal technologies (RTTs) would make a major contribution to reducing GHG emissions in Connecticut, especially as the carbon intensity of the electricity grid continues to rapidly decline. RTT offers important environmental, health, and safety benefits, but the upfront costs for equipment and installation can create a hurdle to making the switch, particularly for LMI customers. It is highly recommended that the building shell be assessed and appropriately improved so that RTT is as cost-effective as possible. Low-income incentives do include a bonus for comprehensive measures like building-shell improvements, but these improvements are not required. In general – but especially in LMI communities – it is recommended that special care be paid to training residents in the proper operation and maintenance of RTT equipment.

Progress to date – Connecticut has a rebate program to support deployment of heat pump (HP) technology. Connecticut recently increased its heat pump incentives, which are now generally on par with those of other New England states.[16] The source of revenue for incentives (as for other programs of the Conservation and Load Management Plan) is the Combined Public Benefits Charge on electricity and natural gas bills. Currently incentives range from $200 to $500 on qualifying HP units. In addition, the utilities are currently running a pilot program offering extra incentives for installation of HPs in homes heated with oil, propane, or resistance heat.

[16] https://www.energizect.com/your-home/solutions-list/ductless-split-heat-pump-rebates

Strategy – Develop sustainable funding mechanisms to incentivize replacement of fossil-fuel space and water heating with efficient renewable-thermal technologies

Progress to date – Approximately 70 percent of RGGI funds are devoted to EE programs (the balance going primarily to renewable electricity programs). In addition the Connecticut Energy Efficiency Fund is funded by a conservation charge on natural gas and electricity bills. Connecticut has a rebate program in place to support deployment of HP technology. Recently HP incentives have been increased. The EEB receives a quarterly report on the number of heat pumps installed.

The need to avoid future diversion of energy-efficiency funds was addressed earlier in this chapter.

Enhancement – **Require delivered fuels companies to contribute to the Energy Efficiency Fund**

Require companies that deliver fuel oil and propane to contribute funds to energy efficiency programs on the same $/BTU (or on the same $/unit of CO_2e) basis as the natural gas utilities. This would allow some of the cross-subsidization of delivered fossil fuels by electricity and natural gas to be reduced and more money available for RTT deployment.

Enhancement – **Support municipal-scale RTT investment through Community Choice Aggregation**

Authorizing municipalities to adopt CCA (as described earlier) would provide a financial and administrative platform for systematic local investment in deployment of HPs and other RTTs via group purchase.

Strategy – Incentivize installation of renewable thermal technologies in new construction

Progress to date – Incentives for RTTs for new residential, commercial, and industrial buildings are available through the Residential New Construction program and Energy Conscious Blueprint (ECB) program. These programs focus on comprehensiveness and provide incentives to builders, design teams, and homeowners who integrate advanced energy-efficient building construction and technologies into a new construction or gut-rehab project. The ECB program covers energy-efficient equipment that performs better than code, including heat pumps, variable refrigerant flow systems, equipment controls, energy recovery systems, etc. The program offers multiple pathways through which customers can participate, based on the project's complexity or stage of design. New program updates will be rolled out with the next code adoption. These program updates are intended to drive the new-construction marketplace toward zero-energy buildings with low operational EUI ratings. New program offerings will support integrated design and whole-building energy modeling at the feasibility phase and will offer incentives to customers who incorporate energy-reduction strategies through post occupancy.[17]

[17] See: https://www.energizect.com/sites/default/files/All%20Electric%20Home%20Bonus%20Incentive.pdf; https://www.energizect.com/your-home/solutions-list/residential-new-construction-program; and https://www.energizect.com/your-business/solutions-list/Energy-Conscious-Blueprint.

Improve training and technical capacity of workforce

Strategy – Expand training programs to include renewable thermal technology installations and standards

Progress to date – Increasing technology awareness and training among Heating, Ventilation, and Air Conditioning (HVAC) contractors about RTT and new building standards is essential for widespread deployment at the scale needed to meet Connecticut's GHG goals. Equipment installers must possess strong knowledge of the available energy-efficient technologies and how to effectively integrate them into new and existing buildings. The number and diversity of RTT options is increasing, and HVAC-industry professionals must have the knowledge and experience necessary to service the technologies regardless of manufacturer or equipment model. The expertise needed includes proper equipment selection, right-sizing of equipment, and customer education to optimize the efficiency of building energy systems. For example, heat pump or water heater thermostats should be programmed to communicate with adaptive building energy management systems to facilitate demand response and grid flexibility, and HP systems can be paired with photovoltaic (solar PV) and energy-storage systems to minimize the incremental cost of RTT.

Training programs exist in community colleges and elsewhere.[18] But training challenges are significant. Contractors' abilities to install and evaluate installations vary widely. Successful, cost-effective installation often requires phased project scopes or pre-requisite system changes. And new RTTs (e.g., air-to-water heat pump technology) emerge frequently.

Enhancement – **Focus training on emerging needs**

- Encourage on-demand training to align with customer timing of projects. In this way, contractors can receive training with a specific customer's application and goal in mind rather than theoretical training. This type of on-the-job training can lead to lower costs to businesses and higher retention of skills with hands-on work.

- Itemize and recognize hydronic heat pump conversions in all financing programs.

Enhancement – **Draw on programs elsewhere in the region**

- Examine existing Green Professional Building Skills training program (GPRO) certifications. Look at regional training programs (MassSave; NYSERDA) for integrated heat pump controls and retrofits, including applications that optimize existing fossil fuel-based systems to offset fossil fuel usage in colder months.

[18] E.g., see: https://www.esyoh.com/request-information/?z=06515&sc=gateway&d=hvacclasses.org&pc=GES793&user_id=15991567418148 HVAC-R Certified Technician Program. Gateway Community College; https://www.nyserda.ny.gov/All-Programs/Programs/Clean-Energy-Workforce-Development/Directory-of-Free-Online-Resources, Directory Free Online Clean Energy Training. Search "heat pumps"; and https://www.heatspring.com/courses/hydronics-for-high-efficiency-biomass-boilers-sponsored-by-nyserda#sts=Instructor. Hydronics for High Efficiency Biomass Boilers - Sponsored by NYSERDA - Self Study.

Enhancement – **Work with HES contractors to identify current and expected job needs.**

- Connecticut is currently facing a lack of qualified workers for available energy-efficiency vacancies in our state. These roles include insulation staff, lead auditors, HES support techs, office administrators, window installers, and billers. EEB and DEEP should work with HES contractors to make work force projections.

Enhancement – **Create a fast track for critical work skills. Allocate some funds to help contractors train new workers.**

- Contractors need support on the cost of obtaining certifications. Cost sharing startup training would help develop the workforce

Enhancement – **Review licensing requirements to (prudently) increase talent flow through the work force "pipeline."**

- Review the number of hours of on the job training required for certification and assess whether a reduction may be feasible.

Job training is crucial to the EEJ community. In this regard the proposal for workforce development/job training located within, and directed toward, the LMI workforce resident in an Energy Development Zone is a crucial component of the original 2018 strategy. Ensure that programs align with the U. S. Department of Labor Workforce Investment Board program and the job funnel. These programs service at-risk communities (under-employed individuals, etc.). These need to be restored to the level that existed before the latest diversion of energy-efficiency funds. For LMI households, a tiered system should allocate larger rebates to these households for heat pump installation. We recommend the U.S. Department of Health and Human Services Low Income Home Energy Assistance Program home system replacement program be expanded to include conversion from deliverable fuel to heat pumps. Urban League, Knox Park Foundation, Habitat for Humanity, and CT Energy Marketers Association are organizations we recommend to serve as a training funnel. Connecticut needs a formal apprenticeship program to enable us to access federal dollars.

New recommendation – Develop a strategic plan for transitioning from fossil fuels to renewable thermal technology

To reduce greenhouse gas emissions from the buildings sector, Connecticut must transition from fossil fuels to net-zero, all-electric buildings. Reaching "deep decarbonization" goals of 75 percent or greater reduction in greenhouse gas emissions will require eliminating most of the CO_2 produced by furnaces, boilers, and water heaters across the country, alongside other measures across the economy.[19]

Because of the large scope of this undertaking and because it holds major, intertwined implications for the electricity grid, the natural gas grid, and the delivered fuels industries, it is essential to develop an integrated transition plan.

[19] https://rmi.org/insight/the-economics-of-electrifying-buildings/

To successfully transition in a cost-effective, equitable, and orderly fashion, Connecticut must develop a programmatic transition plan that:

- coordinates the transition from natural gas and other fossil fuels to electricity, apace with the greening of the electricity grid;
- coordinates buildings thermal load readiness for adoption of RTT;
- ensures an equitable adoption of strategic electrification and mitigates increasing costs for natural gas customers as use of the gas distribution system dwindles;
- institutes a cost of carbon in the buildings sector and an incentive to transition from fossil fuel, by enacting a tax on each gallon of heating oil that declines as the content of sustainably sourced biodiesel increases (B100 pays no tax)[20];
- supports a Renewable Thermal Portfolio Standard that comprehensively investigates and develops all *practical* pathways to zero- or low-GHG thermal energy, including biodiesel[21];
- details required labor force requirements and retraining opportunities;
- develops a timeline for both electric and gas transitions that considers grid upgrades and remaining life of equipment;
- ensures orderly maintenance and safety of the gas distribution system as the system is replaced by electric infrastructure;
- where financial barriers exist, provides access to financing and incentives enabling the adoption of electric and other low-GHG technologies;
- identifies the technical limitations now and in the coming decades and provides technical/procedural/operational solutions to cope with these barriers;
- minimizes stranded assets; and
- models and solves the "winter peak" issue attributed to thermal electrification.

A just transition must account for price, availability, and health impacts on LMI residents. Critical equity questions must be addressed in a transition plan, including equitable adoption of high-efficiency electric technologies and mitigating stranded assets. Under a high-electrification strategy, remaining natural gas customers face high costs.[22] Solving these challenges will benefit children, the elderly, and low-income people who are most at risk of air pollution from combustion appliances. UCLA researchers found that the use of kitchen appliances for supplemental heating – which evidence suggests is more common in low-income and minority households – increases the risk of exposure to unsafe air.

[20] A tax of 3.4 cents/gallon is recommended. "Sustainably sourced" means that producers reveal their source of feedstocks. The Distillate Advisory Board established under CGA 296 Sec. 16a-21b Subsection (c) (1) would determine the sustainability of feedstocks

[21] Several members of the team expressed concern about including biodiesel. The possibility of a thermal RPS program is currently under review by DEEP.

[22] https://www.ethree.com/at-cec-e3-highlights-need-for-gas-transition-strategy-in-california/

Some team members have expressed concern that electrification in large commercial and industrial settings is not technically or economically feasible. Also, some team members have expressed concern about including biodiesel in the recommendation. A "minority report" is in Appendix 7.

New strategy – **Set end dates for expansion of the gas grid and new gas installations on the existing grid**

- Prohibit the installation of fossil fuel infrastructure in new buildings and major retrofits; align strategic electrification plans to fill needs for new buildings.

- End state- and ratepayer-funded incentives to convert customers to gas, and for fossil fuel combustion equipment and appliances. Incentives should be redirected to high-efficiency electric alternatives. Align strategic electrification plans to fill needs for high-efficiency electric alternatives. Address different needs of residential and commercial markets. Note: The natural gas utility companies are not in agreement with prohibiting fossil fuel use, ending incentives, or avoiding stranded assets and have supplied the language in Appendix 7.

Appendices	
Appendix 1	Members of the buildings team
Appendix 2	Proposed Legislation Referenced
Appendix 3A	Comprehensive Sustainability Measures to include in High Performance Codes and Standards and Stretch Code
Appendix 3B	Strategies for Achieving High Performance Standards
Appendix 4	Data fields for Inventory of Building Structures
Appendix 5	Energy Development Zones: Proposed Legislation
Appendix 6	Building Performance Office and Equity and Environmental Justice
Appendix 7	Minority report regarding strategy on natural gas distribution system
Appendix 8	Acronyms and abbreviations
Appendix 9	Preliminary glossary of terms

Appendix 1: The Buildings team

Chairs	
Brenda Watson	Operation Fuel
Bernie Pelletier	People's Action for Clean Energy
Working Group	
Paolo Campos	Patriquin Architects
Jillian Corley	Eversource
Sam Dynowski	Sierra Club
Patrice Gillespie	CT Clean Water Fund / CT Energy Network
Melissa Kops	Pirie Associates
Pat McDonnell	United Illuminating (Avangrid)
Stanley McMillen	UConn
Robert Schmitt	Green Bank
Other Stakeholders	
Ray Albrecht	Connecticut Energy Marketers Association
Henry Auer	New Haven Energy Task Force
Karla Butterfield	Steven Winter Associates
Ginger Chapman	Yale Office of Sustainability
David Chu	Connecticut Energy Marketers Association
Leticia Colon de Mejias	Energy Efficiency Solutions
Evan Dantos	Robinson & Cole
John DiModica	United Technologies
Kathy Fay	Neighborhood Housing Services of New Haven
Jeff Harrison	Building Tech Services
Chris Herb	Connecticut Energy Marketers Association
Doris Johnson	DEEP Commissioner's Office
Elsa Loehmann	(Environmental engineer)
Bob Maddox	Sterling Planet, USGBC, LEED, CTGBC
David Mann	Sustainable Westport
Amy McLean Salls	Acadia
Peter Millman	Eastern CT Green Action
Jane Montanaro	Preservation CT
Chris Phelps	Environment Connecticut
Connor Rockett	New England Forestry Foundation
Matt Rusteika	Acadia
Mark Scully	People's Action for Clean Energy
Jen Shakun	New England Forestry Foundation
Jon Slifka	Department of Aging and Disability Services
Kai Starn	Steven Winter Associates
Charlie Weedon	Eastern CT Green Action and Pomfret Green Team
DEEP support staff	
Jeff Howard	Bureau of Energy & Technology Policy
Donna Wells	Bureau of Energy & Technology Policy

Appendix 2
Reference for SB1777

2020 Senate Bill 177 AN ACT CONCERNING ENERGY CONSUMPTION DATA AND LABELING. To require (1) nonresidential property owners of buildings greater than or equal to fifty thousand gross square feet, or two or more buildings on the same parcel that are greater than or equal to one hundred thousand gross square feet, report the previous calendar year's energy consumption data to the Department of Energy and Environmental Protection, and (2) residential property owners to disclose, upon request at the time the property is publicly listed for sale or rent, the previous calendar year's energy bills.

2020 Governor's Bill House Bill 5008 AN ACT CONCERNING THE ESTABLISHMENT OF HIGH PERFORMANCE GREEN BUILDING STANDARDS FOR VOLUNTARY ADOPTION BY MUNICIPALITIES.

Appendix 3A
Comprehensive Sustainability Measures to include in High Performance Codes and Standards and Stretch Code

- **Indoor health and wellbeing**: Promote good indoor health and wellbeing through the specification of low-emitting, nontoxic materials, providing above code levels of fresh air with energy recovery, MERV 13 filtration, no on-site combustion, air quality monitoring, and natural daylighting.
- **Water conservation**: Reduce water consumption by using strategies such as but not limited to EPA WaterSense low-flow fixtures, rainwater capture, greywater reuse, compost toilets, and separate drains from greywater and blackwater sources.
- **Site ecology**: Promote healthy site ecology by restoring natural habitat, infiltrating stormwater onsite, using black-sky compliant lighting, and reducing heat island effect.
- **Process**: Use an integrated design process by having a sustainability design charette with all major disciplines at the outset of the project.
- **Historic preservation**: prioritize renovation over new construction, and establish standards for deep energy retrofits that also comply with the Secretary of the Interior's Standards for Rehabilitation.
- **Resilience**: Implement modern codes that improve building resilience to natural disasters.
- **Alternate compliance paths**: evaluate third-party rating systems for demonstrating compliance with the project requirements listed above, and to shift enforcement responsibility to third party auditors. Examples include but are not limited to:
  - LEED for various project types and including LEED Zero.
  - ILFI various programs including Living Building and Community Challenges, Zero Carbon, Zero Energy, and CORE Green Building Standard.
  - WELL Building/ Fitwel
  - Passive House
  - Maximum HERS Rating
  - EPA Energy Star, Water Sense, Indoor AirPlus
  - DOE Zero Energy Homes
  - National Green Building Standard
  - Green Enterprise Communities

Appendix 3B
Strategies for Achieving High Performance Standards

Strategy 1 Create a Code Task Force:
We recommend that DEEP in conjunction with DAS create a standing task force that includes building officials, members of the State Codes and Standards Committee, industry professionals, and environmental advocates to accomplish the goals outlined below. This task force could operate under the aegis of the BPO, DEEP, the GC3, or DAS. Its function would be to provide a forum for the state, the utilities, trade groups, architects and others to work together toward effective high performance code structures and implementation. The task force would bring technical expertise as well as diverse viewpoints to the important tasks of code development, code implementation, identification of compliance routes, developing training programs for these skill sets, and finding funding sources to support this work.

Strategy 2 Develop a Stretch Code for Adoption by Connecticut Municipalities
Develop a stretch code for residential and commercial new construction and substantial renovations that requires all-electric (with limited exceptions), energy-efficient operation, and a zero-carbon profile (energy and embodied carbon) in addition to other comprehensive sustainability measures. (A minority report on this strategy is attached).) See Appendix 1 for referenced proposed legislation.

1. The stretch code would be voluntary for municipalities, and/or energy districts.
2. The stretch code should meet all the performance standards listed for the proposed State Building Standards (see below)
3. For commercial and large multi-family buildings of five units or more, the code would be the same (with amendments only if necessary) as the State Building Standards for simplicity.
4. A different code should be developed for the particular needs of smaller scale residential projects that also addresses deep energy retrofits.

Strategy 3 Update the High-Performance State Building Standards
We recommend that the State of Connecticut, in order to truly "Lead by Example," update the High-Performance Standards to create State Building Standards as already required by Public Act 19-35, and in addition that it require all-electric, energy-efficient operation, and a zero carbon profile (energy and embodied carbon), along with other comprehensive sustainability measures. (A minority report on this strategy is attached).

Strategy 4 State Embodied Carbon Standards
We recommend that State agencies consider the reduction of embodied carbon of materials and construction as a criterion when contracting for state-funded projects such as infrastructure projects. We further recommend that the state develop guidance and policies on embodied carbon for all building projects in the state. The greenhouse gas emissions associated with new construction can account for up to three quarters of a building's total GHG emissions over the first ten years of operation. Concrete alone contributes up to 8% of total global greenhouse gas emissions, and there are proven strategies that can reduce those emissions. The state has an opportunity to significantly reduce greenhouse gas emissions by addressing embodied carbon.

Appendix 4
Data fields for Inventory of Building Structures

The file produced by the Warren Group contains every building (Residential, Commercial, Industrial) in Connecticut.

The file contains the following fields (list is a summarized view of the database)

Record type

Property ID

Owner name

State, County, Town, Street address, Zip Code

Census tract

Census block

Latitude, Longitude

Property use

Owner Mail

Type of Construction

Assessed value

Type of Roof

Heating type

Heating Fuel

Various areas - lot, gross living area, size of rooms etc.

Number of rooms

Year built

Owner occupied or rental

Appendix 5
Energy Development Zones: Proposed Legislation

This legislation authorizes the establishment of Energy Development Zones (EDZs) in LMI neighborhoods, wards, or census tracts in a municipality, for the purpose of promoting in the EDZ a) deep energy retrofits of existing housing and b) new construction incorporating energy efficiency features; in both cases the municipality may promote or require EE features that stretch beyond the extant Connecticut building code. The EE projects will start with HES surveys; then upgrading thermal sealing and insulation of the residences, for example by following the recommendations of the HES; and finally by requiring installation of all-electric heating and cooling equipment (RTT). The state shall, and the municipality may, provide financial and regulatory incentives to property owners to promote undertaking these projects.

An additional feature of the legislation is the establishment of facilities in the EDZs for workforce development. Its objective is specifically to provide training for EDZ residents for employment in the skilled vocations required for EE retrofits and new construction specified above. The facilities are to be supported by state funds and by financing from local financial institutions and nonprofit organizations.

Appendix 6
Building Performance Office and Equity and Environmental Justice

The Connecticut Energy Efficiency Board (the EEB) "is a group of advisors who utilize their experience and expertise with energy issues to evaluate, advise, and assist the state's utility companies in developing and implementing comprehensive, cost-effective energy conservation and market transformation plans to help Connecticut consumers reduce energy use in their homes and businesses and to help Connecticut meet its changing and growing energy needs."[1] The EEB is created under CG state statute 16-245m. It may be possible to revise the EEB charter to include the concept of the BPO.

Creating the BPO will require careful evaluation of existing institutions. If the BPO is created properly, it can avoid duplication and focus resources intensively where needed. We need to examine the charter for the EEB to see if this is part of their charge, i.e. does their mission include programmatically improving the building stock at a given pace to mitigate climate change?

Review of the BPO function should include a full review of diversity in board members and seek to increase coordination in planning and spending among the EEB, LIHEAP, WAP, the Green Bank, and other nonprofits that work to improve Connecticut's building stock (e.g. Green and Healthy home).

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[1] https://www.energizect.com/connecticut-energy-efficiency-board

Appendix 7
Minority report regarding strategy on natural gas distribution system

Pat McDonell represents Avangrid/United Illuminating/Southern Connecticut Gas on the Mitigation Progress Working Group. He opposed the buildings team's proposed strategy of developing a plan to cease expanding the natural gas distribution system and submitted the following comment.

- Electrification of transportation and building heating will be a key element in reducing GHG emissions in Connecticut.

- The current energy efficiency programs are a great platform to achieve that goal[,] and the program metrics should be expanded to redirect those programs.

- In order to successfully make this transition, it is critical that the public is informed about the advantages and availability of electric technologies so that they can make an informed choice.

- It is also important to provide access to those technologies, through a trained and skilled supply chain, and in the case of electric vehicles adequate charging infrastructure.

- Where financial barriers exist, access to financing and incentives is critically important to aid in the selection of electric technologies.

- Consumers should be directed to make the appropriate selections, but it is premature to impose prohibitions on any specific resources since electric technology is not yet ubiquitous. Also, there are still some circumstances that make efficient electric buildings impossible.

- Any electrification plan should also examine the economic impact on low- and moderate-income consumers to avoid any additional burdens on this segment of the population.

- Gas system leakage should be managed not only to ensure safety, but to also reduce leakage from gas distribution systems for environmental considerations.

Appendix 8: Acronyms and Abbreviations

Term	Full Name	Term	Full Name
ADR	Automatic Data Recording?	**HES**	Home Energy Solutions
API	Application Programming Interface	**HH**	Household
BEM	Whole-building energy modeling	**HP**	Heat pump
BETP	Bureau of Energy and Technology Policy (DEEP)	**HVAC**	Heating, ventilation, and air conditioning
BPO	Building Performance Office	**ICC**	International Code Council
BTU	British thermal unit	**IECC**	International Energy Conservation Code
CAS	Connecticut Codes and Standards Committee	**IgCC**	International Green Construction Code
CCA	Community Choice Aggregation	**LIHEAP**	U.S. Department of Health & Human Services Low Income Home Energy Assistance Program
CGA	Connecticut General Assembly	**LMI**	Low-to-middle income (households)
C&LM	Conservation and Load Management	**MUCT**	Modified Utility Cost Test
CO2	Carbon dioxide	**MERV**	Minimum Efficiency Reporting Value
DAS	Connecticut Department of Administrative Services	**NEEP**	Northeast Energy Efficiency Partnerships
DCS	Connecticut Division of Construction Services, a part of DAS	**NREL**	National Renewable Energy Laboratory
DEEP	Connecticut Department of Energy and Environmental Protection	**NYSERDA**	New York State Energy Research and Development Authority
DER	Distributed energy resource	**OCC**	Connecticut Office of Consumer Council
DOE	U. S. Department of Energy	**OSBI**	Connecticut Office of the State Building Inspector
DPH	Connecticut Department of Public Health	**OSFM**	Connecticut Office of the State Fire Marshal

ECB	Energy Conscious Blueprint	**PURA**	Connecticut Public Utilities Regulatory Authority
EDZ	Energy Development Zone	**RGGI**	Regional Greenhouse Gas Initiative
EE	Energy efficiency	**RMI**	Rocky Mountain Institute
EEB	Connecticut Energy Efficiency Board	**RTT**	Renewable thermal technologies
EEJ	Equity and Environmental Justice	**SBEA**	Small Business Energy Advantage
EPA	U. S. Environmental Protection Agency	**UCLA**	University of California Los Angeles
EUI	Energy Utilization Intensity	**UCT**	Utility Cost Test
EV	Electric vehicle	**UI**	United Illuminating Company
GC3	Governor's Council on Climate Change	**VRF**	Variable refrigerant flow
GHG	Greenhouse gas	**WAP**	U. S. Department of Energy Weatherization Assistance Program
GEB	Grid-Interactive Enabled Building	**WIB**	U. S. Department of Labor Workforce Investment Board program
GPRO	Green Professional Building Skills training program		

Appendix 9: Preliminary glossary of Terms

Term	Definition	Term	Definition
Community Choice Aggregation	A program that allows municipalities to procure electricity on behalf of constituents while still receiving distribution from the local utility.	**Low-to-middle income**	
Connecticut Green Bank	Established by the Connecticut General Assembly as a part of Public Act 11-80 to work with private-sector investors to create low-cost, long-term sustainable financing to maximize the use of public funds.	**Minimum Efficiency Reporting Value**	
Distributed energy resource		**Modified Utility Cost Test**	
Energy Development Zone		**Renewable thermal technologies**	
Energy Utilization Intensity		**Stretch Code**	
Fuel thermal loads		**Utility Cost Test**	
Green Professional Building Skills training program		**Weatherization Assistance Program**	
Grid-Interactive Enabled Building		**Whole-building energy modeling**	
Home Energy Solutions			

Chapter 3

Electricity

Chapter overview	
Equity & environmental justice overview – Addressed in multiple sections	
Adaptation & resilience	
Progress on 2018 recommendations	**Strategies** Enhancements and new strategies recommended
Commit at least 50 megawatts of demand reduction per year to the ISO-New England forward capacity market	• Reduce electricity consumption by 1-2 million megawatt hours by replacing existing inefficient electric resistance space- and water-heating equipment with high-efficiency renewable thermal technology • Invest in electric measures that reduce peak demand such as exterior lighting, retail lighting, lighting in state buildings, and high-efficiency refrigeration • Utilize battery storage as a peak demand reduction and load flexibility strategy
Achieve at least 66 percent zero-carbon electricity generation by 2030	• Meet the RPS target of 40 percent Class I renewable energy sources by 2030, with an aim to reduce the carbon intensity of the RPS • Ensure a transparent and predictable compensation framework to maintain at least the historical annual average 40-90 megawatts of residential behind-the-meter renewable energy resources • Deploy at least 50 megawatts per year of larger distributed solar and 10 megawatts per year of distributed fuel cells, with optimum utilization of available siting locations • Maintain in-state zero-carbon nuclear generation and develop a long-term zero-carbon replacement strategy equivalent to 2100 megawatts • Implement a shared clean energy program deploying at least 25 megawatts per year, with a focus on low- and moderate-income customers • Exercise procurement authority for zero-carbon energy through competitive bidding processes that drive down prices • Establish clear targets for off-shore wind procurement – in concert with IRP recommendations and in balance with other renewable energy sources – to foster its significant potential to help meet zero-carbon goals • Address the role of new transmission or transmission constraints
Optimize grid management strategies to reduce carbon emissions	• Increase adoption of smart-management technologies to optimize flexibility of distributed energy resources • Over the next 2-5 years, research and identify opportunities to integrate battery storage and distributed renewable energy technologies to reduce and displace carbon emissions • Reduce petroleum use by power plants needed to serve winter peak demand

Introduction

The electricity sector accounts for 21 percent of Connecticut's economy-wide greenhouse gas (GHG) emissions, the second highest source after transportation.[1] Decarbonizing this sector is imperative. Connecticut has taken numerous actions to accelerate the transition toward a cleaner energy future while reducing energy costs, improving system reliability, and minimizing negative environmental impacts.

To achieve the state's ambitious interim goal of 45 percent GHG reductions by 2030, the electricity sector will need to reduce its emissions 71 percent below 2014 levels. The 2018 GC3 report outlined three recommended actions the state could take to meet this target, and offered a highly impactful suite of strategies to make the recommendations actionable. The recommendations included committing demand reduction savings to the IS0-New England Forward Capacity Market, increasing the amount of zero-carbon energy generation, and optimizing grid management strategies to reduce carbon. The state has made progress on each of these actionable recommendations.

Since the release of the last report, new market and policy developments have occurred, warranting a revision of the scope and recommendations to address current issues. Some of these developments include conducting multiple competitive procurements for zero-carbon resources, enacting of landmark legislation authorizing DEEP to procure up to 2,000 MW of offshore wind (OSW), and on September 3, 2019, Governor Lamont signing Executive Order No. 3 to direct DEEP, in consultation with the Public Utilities Regulatory Authority (PURA) as appropriate, to "analyze pathways and recommend strategies for achieving a 100 percent zero-carbon target for the electric sector by 2040."

An increased focus on equity and environmental justice (EEJ) initiatives also warranted a reexamination of the 2018 recommendations to ensure an equitable decarbonization transition. Studies show that LMI and minority communities are disproportionately affected by electricity generation and endure a range of negative impacts without necessarily experiencing the benefits of electrification.[2] Updated recommendations include strategies to benefit LMI residents, create jobs and spur workforce development, and site new zero-carbon electric generation to displace fossil fuels in an equitable manner.

Additionally, as the building and transportation sectors move toward electrification, zero-carbon electricity generation will play an even more crucial role in creating a low-carbon future. This can be achieved by reducing demand through energy efficiency[3] and conservation, increasing zero-carbon[4]

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[1] Connecticut DEEP, "2017 Connecticut Greenhouse Gas Emissions Inventory," issued 2020, https://portal.ct.gov/-/media/DEEP/climatechange/2017_GHG_Inventory/2017_GHG_Inventory.pdf.

[2] See for instance: https://www.pnas.org/content/116/13/6001; https://www.naacp.org/wp-content/uploads/2016/04/CoalBlooded.pdf

[3] Making buildings more energy efficient will be a critical to achieving Connecticut's emissions reduction targets. Specific recommendations and strategies for improving energy efficiency in the built environment are more fully addressed in the transportation chapter.

[4] While most forms of generation are associated with a certain amount of embedded carbon and lifecycle emissions, the term "zero-carbon" generation here refers to renewable energy sources that do not directly produce emissions from electricity generation.

generation, and optimizing the grid to reduce peak demand and carbon emissions. A significant portion of Connecticut's current zero-carbon electricity is derived from nuclear resources. The following sections outline the recommendations and strategies introduced in the 2018 GC3 report, discuss progress towards their achievement, and address any gaps and challenges with a particular focus on equity.

Equity and Environmental Justice

The Department of Energy and Environmental Protection (DEEP) is committed to ensuring an equitable and just transition to a zero-carbon future. The electricity generation sector has a number of equity and environmental justice (EEJ) barriers that can be addressed with appropriate policy. Power generation facilities are a significant source of harmful air pollutants such as ground-level ozone, carbon monoxide, lead, sulfur dioxide, and nitrogen dioxide; particulate matter; and noise pollution that can negatively impact public health and wellbeing of residents in surrounding communities. The negative impacts of power generation are disproportionately felt by populations in close proximity to generation facilities. In many cases, these communities are minority, low income, or underserved areas.

A report by the American Council for an Energy Efficient Economy found that residents with low income, African Americans, Latinos, and renters often pay up to three times more of their annual household income on energy than do middle and higher income households.[5] Not only do these populations bear a disproportionate burden from power generation, they also pay disproportionately more for their energy. When customers are unable to pay their bills, they begin to accrue past-due bills and are left vulnerable to shut offs and credit collections. Additionally, during extremely hot days, heat-related deaths spike and hospital admissions for heat-related illnesses rise, especially among elderly adults and other vulnerable groups[6].

Building and vehicle electrification reduce on-site carbon generation but shift it and all associated externalities to the communities surrounding electricity plants, exacerbating these energy and environmental justice issues. Even low and zero-carbon energy sources such as biomass, wind, solar, and nuclear have negative externalities that can harm local residents.

However, proper planning and policy can create equitable outcomes for the host community and state as a whole. Dispersing facilities throughout the state will ensure that any negative externalities are not concentrated in certain areas and will also create a more resilient grid. New facilities should be sited to avoid "greenfield" development and prioritize brownfields and land that cannot support other uses.

Siting new renewable power generation facilities can create jobs and open opportunities to develop the workforce and invest in the community. For example, port cities near offshore wind farms will grow to meet the needs of the facility and the influx of new workers, benefitting many levels of the local economy.

Moving forward, updated plans must also account for current and future disruptions related to COVID-19. Aid or deferment of utility bill payments will help consumers, and keep families in their homes

[5] https://www.aceee.org/sites/default/files/publications/researchreports/u1602.pdf
[6] https://www.ucsusa.org/sites/default/files/attach/2019/07/killer-heat-analysis-full-report.pdf

during a national pandemic and recession. Extra incentives can stimulate the energy efficiency economy and job creation.

In 2018, GC3 identified three broad recommendations:

1. Commit at least 50 megawatts of demand reduction per year to the ISO-New England forward capacity market
2. Achieve at least 66 percent zero-carbon electricity generation by 2030
3. Optimize grid management strategies to reduce carbon emissions

This updated report re-examines these recommendations, discusses progress in these areas, examines equity and environmental justice issues, and identifies further recommendations.

Connecticut uses an integrated resource planning approach to make use of every tool available to achieve significant decarbonization, and many of the recommendations in the following sections will be made actionable by the state's Integrated Resources Plan (IRP). It is "integrated" in the sense that it looks at demand side resources (conservation and energy efficiency) as well as traditional energy generation and grid-side optimization.

The IRP, which is updated every two years, is the predominant assessment of future electricity usage and strategies to meet them. The most recent IRP proceeding was initiated in late 2018 in order to address new market and policy developments, including new direction from Executive Order No. 3, as well as increase the focus on EEJ initiatives. Although the IRP is still in development with a planned release in fall 2020, DEEP will work to align the recommendations in this report with the outcome of that proceeding.

In the late 1990s, Connecticut undertook efforts to restructure its electric industry with the intent of harnessing the benefits of competition. In the decades since those markets were first established, the design of the New England markets has evolved—at times over Connecticut's strong objection—from a tool for the achievement of shared reliability and cost savings to a system that impairs substantially Connecticut's ability to achieve environmental and clean generation goals in a cost effective manner. These changes include the application of minimum offer price rules that require Connecticut consumers to pay twice to meet the same resource need, while propping up facilities that the State seeks to replace through investment in new, clean generation. At the same time, the ISO New England (ISO-NE)-administered capacity market has driven over-reliance on a single fuel type—natural gas—that is neither sustainable from a reliability perspective nor consistent with Connecticut's long term goals.

For example, Connecticut will soon be home to the Killingly Energy Center, a new natural gas-fired power plant that will provide energy to the ISO-New England service area. Even though Connecticut has stated its commitment to achieving 100 percent zero-carbon energy by 2040, this goal alone does not necessarily bar the construction of the new power plant, which will serve the entire ISO-New England Region and was sited in Connecticut due to the state's significant natural gas pipeline infrastructure. The Connecticut Siting Council has the authority to prevent construction, the Council approved Killingley's application for a Certificate of Environmental Compatibility and Public Need in June 2019. Although

Killingly will be significantly less polluting than the oil and coal-fired power plants it replaces and help to meet the region's energy needs, it does not align with Connecticut's decarbonization policy objectives.

Adaptation and resiliency considerations – The Connecticut electricity sector needs to adapt and prepare for the stressors that climate change threatens to create. We are already seeing its impacts today. Increased severity and frequency of extreme weather events such as hurricanes and heat waves, and rising sea levels jeopardize the physical grid infrastructure, leading to damaged equipment, blackouts, power outages, and potentially dangerous hazards like fire. As a coastal state, Connecticut is prone to changes in sea level rise and more powerful storm surges. Extreme hot and cold weather events will place a greater strain on energy grids as more air conditioners come online and heating equipment works overtime to maintain comfortable temperatures. Connecticut is already experiencing unprecedented climatic events and actions taken now can better prepare the state to face this urgent challenge and the impacts to come.

Key areas that make the grid more resilient are (a.) to secure and strengthen infrastructure, for example with retaining walls, flood prevention techniques, and underground wiring where feasible and cost-effective, (b.) proactive management to remove potential hazards such as trimming tree limbs along transmission paths, and (c.) developing grid integrated buildings, micro grids and smart grids. During implementation, it is important to ensure that LMI ratepayers, who may have fewer trees near their residences or live in multifamily dwellings with more efficient electricity deliver, do not pay disproportionately for these investments.

The city of Bridgeport, CT was awarded a $54.2 million competitive federal grant to support infrastructure disaster resilience. The money will be divided among numerous resiliency projects with the most going toward the Bridgeport Eastern South End Storm Surge Protection project. Strategies in the project include surge water management, a flood defense system composed of natural/green and fortified/gray infrastructure, and community education.[7] This will be a model for protecting grid infrastructure resources across the state and the region.

The grid can be optimized to mitigate the extent of damage from natural events. Grid-connected buildings, microgrids, and smart grids create a resilient network of two way communication between the electricity system/consumers and the grid operators. Grid-connected buildings and microgrids can work with the system to store, generate, and shift load. A grid-integrated building can communicate with the grid to delay or run certain functions like HVAC and water heating to accommodate peak demand events and in some cases act like a battery by dispatching energy. Smart grids continuously perform self-assessments that inspect, analyze, and automatically respond to problems allowing for rapid identification of damage and rerouting of electricity to reduce the impact of a blackout. These solutions both reduce the impacts of damage and enable faster recovery after an event, and have been successfully deployed in parts of Europe and Asia.[8]

[7] https://portal.ct.gov/-/media/DOH/Resilient-Bridgeport-Final-EIS-Chapters-September-2019-Technical-Correction-11-21-2019.pdf

[8] See, for instance: Smart Grid Around the World. Energy Information Administration. 2011. https://www.eia.gov/analysis/studies/electricity/pdf/intl_sg.pdf

The Electricity team was chaired by Mike Li (CT DEEP) and involved five other Working Group members and 17 other stakeholders representing business, industry, higher education, environmental organizations, social-service organizations, and government agencies.[9] The team held five electronic meetings between March and August 2020.

Commit at least 50 megawatts of demand reduction per year to the ISO-New England forward capacity market

Electric energy efficiency investments have begun to flatten Connecticut's electric demand, relieving pressure on the grid and minimizing peak periods of carbon-intensive power generation. Over the next 10 years, Connecticut expects to eliminate growth in peak demand by decreasing it 0.4 percent annually. Continuing to reduce peak demand becomes even more important as the building and transportation sectors electrify.

The ISO-New England Forward Capacity Market (FCM) permits energy efficiency resources to be bid into the annual auctions as a reliable and predictable energy source. Connecticut electric utilities have bid in demand reduction resources procured through the state's Conservation and Load Management (C&LM) program. The FCM payments are then re-invested into the C&LM programs as a sustainable source of energy efficiency funding. In 2017, revenue from the FCM comprised over 12 percent of the total C&LM budget. Connecticut should continue to commit at least 50 megawatts (MW) of demand reduction resources per year to the FCM. Strategies to continue obtaining demand reduction resources are below.

Strategy – Reduce electricity consumption by 1-2 million megawatt hours by replacing existing inefficient electric resistance space- and water-heating equipment with high-efficiency renewable thermal technology

Inefficient electric space and water heating equipment should be replaced with high-efficiency renewable thermal technologies such as air and ground source heat pumps and solar hot water. According to a recent Yale study, *Feasibility of Renewable Thermal Technologies in Connecticut: Market Potential*, replacement of conventional electric technologies with RTTs for space and water heating are financially beneficial across all customer groups.[10] While replacing fossil fuel heating systems with RTTs reduces carbon emissions, it adds greater strain on the electric grid. Thus, Connecticut should first focus on buildings with inefficient electric heating equipment. These conversions result in significant carbon emission reductions and energy and cost savings for the consumer.

DEEP has: (a) issued a compliance order to the utilities in the 2020 C&LM plan regarding replacement of electric resistance heating; (b) issued a compliance order directing utilities to identify ways to collect

[9] See Appendix 1.
[10] https://cbey.yale.edu/research/feasibility-of-renewable-thermal-technologies-in-connecticut-market-potential

information on the reliability of heat pump water heaters installed through programs; (c) increased incentives for ground source and air source heat pumps to boost customer adoption of the technologies; and (d) increased incentives for insulation for residential customers. In addition, for 2020, home energy audits are free for all customers, the vast majority of them eligible to have the cost covered by the program. This last directive is to stimulate the economy coming out of the stay-at-home order in response to COVID-19. During the pandemic and associated economic downturn, utilities have made a concerted effort to increase participation in energy efficiency programs and awareness of increased incentives. Their outreach strategy includes local community engagement, direct mailing to hardship customers, re-engaging past participants to encourage deeper improvements, leveraging trade allies for multifamily outreach, distributing promotional inserts at food banks, creating efficiency packages for distance learners, and other marketing and awareness campaigns.

Equity and environmental justice – Each year, the C&LM plan issues an equitable-distribution report that tracks fund collections and incentives paid out for distressed census tracts. DEEP ordered that, for 2020, incentives for commercial and industrial customers could exceed the standard incentive rate if customers are located in a distressed area. The C&LM plan should develop a strategy to track incentives paid out by race/ethnicity so that the state can assess the distribution of program funds from a broader equity lens. In August 2020, DEEP initiated an Equitable Energy Efficiency proceeding to define equity in the context of the state's energy efficiency and load management programs and expand the inclusion and participation of individuals in underserved communities, such as minorities, customers with limited incomes, veterans, renters, and certain business customers. The scope of the proceeding will include, among other things, an exploration of new metrics (beyond income) to evaluate the distribution of program dollars.[11]

Strategy – Invest in electric measures that reduce peak demand such as exterior lighting, retail lighting, lighting in state buildings, and high-efficiency refrigeration

Electric energy efficiency helps reduce emissions by lowering overall system demand, but it can have an even greater impact by reducing peak demand. When an electric system reaches peak demand, grid operators need to call on inefficient, expensive, and carbon-intensive generation facilities. Lowering peak demand via energy efficiency reduces the need for highly polluting energy sources and provides cleaner and cheaper electricity. To effectively maximize peak demand reductions, C&LM programs should continue with a targeted approach, deploying efficient electric measures for lighting and networked lighting control systems with demand response capability, replacing inefficient window cooling units with efficient RTTs, and deploying high-efficiency refrigeration. In February 2020, DEEP issued and Approval with Conditions for the 2020 C&LM Plan Update as part of its approval process.

[11] http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/12c36ce3c4b5a80c852585d80046845f?OpenDocument

These conditions included, among other things, directives for utilities to develop strategies for increasing the adoption of energy-saving measures including heat pumps and smart thermostats.[12]

In Connecticut peak demand is in July. As the region experiences more frequent and intense summer temperature extremes, reductions in peak demand will be harder to achieve without significant investment in high-efficiency refrigeration and air conditioning. Consideration should be made to change this strategy to an approach that minimizes GHG emissions associated with peak demand. Under this new strategy, all cost effective solutions could be considered including demand response, energy efficiency, storage, and grid integrated buildings.

Equity and environmental justice – As the state implements this strategy, it will be necessary to identify relevant market segments and develop strategies to reach the most impactful populations. DEEP's Equitable Energy Efficiency Proceeding (discussed above) aims to improve how the state identifies and reaches these populations.

New strategy – Utilize battery storage as a peak demand reduction and load flexibility strategy

Battery storage is increasingly becoming a key strategy to shift electricity demand and increase system resiliency. By storing energy during periods of low demand and providing energy during periods of high demand the grid avoids using inefficient, costly and dirty generation facilities. DEEP and PURA are investigating the value associated with battery storage in a Value of Distributed Energy Resources study which is now under way. For a greater description on battery storage see the strategy 2 under the *Optimize Grid Management Strategies to Reduce Carbon Emissions* recommendation below.

Achieve at least 66 percent zero-carbon electricity generation by 2030

In late 2019, Governor Lamont signed Executive Order No. 3 directing DEEP, in consultation with PURA, to analyze pathways and strategies for achieving 100 percent zero-carbon electricity generation by 2040 in the new IRP. The preliminary results for some modeling scenarios in the IRP were released in May 2020 and the draft plan will be released in fall 2020. As the building and transportation sectors electrify, it is imperative that the electric supply reduce its carbon footprint.

[12] The 24 conditions for approval can be found here: https://www.energizect.com/sites/default/files/Approval%20of%20CLM%202020%20Plan%20Update_Conditions%20of%20Approval.pdf
More information on Connecticut's energy efficiency programs and priorities can be found in the 2020 Plan Update to the 2019-2021 Conservation and Load Management Plan: https://portal.ct.gov/-/media/DEEP/energy/ConserLoadMgmt/Final-2020-Plan-Update-Text-11-1-19.pdf?la=en

Strategy – Meet the RPS target of 40 percent Class I renewable energy sources by 2030, with an aim to reduce the carbon intensity of the RPS

The 2020 IRP, which is planned for release in fall 2020, will help guide Connecticut in selecting strategies to meet and exceed the 40 percent by 2030 target. In the meantime, Connecticut's Renewable Portfolio Standard (RPS) will help the state remain on track towards achieving its decarbonization goals. The RPS is a state policy that requires electric providers to obtain a specific percentage or amount of energy they generate or sell from renewable sources. Owners of renewable electricity generation projects receive one renewable energy certificate (REC) for every megawatt-hour of electricity they produce. Those RECs are traded in a regional market for state RPS compliance. The state establishes required annual REC percentages from three classes of renewable energy resources.[13]

Connecticut is on a track toward its 2030 RPS goal by increasing the Class I percentage by 1.5 percent per year until 2022. After 2022, it will increase by 2 percent annually until 2030 when it hits the 40 percent target. Given the current trends through 2017, Connecticut is on track to meet the 40 percent target. PURA reports that between 2015 and 2017, there has been both an increase in the number of electric suppliers in compliance with the RPS requirements and a steady decline in the total amount of alternative compliance payments. This indicates that electric suppliers are successfully able to settle the necessary amount of renewable energy certificates in each class, even as RPS percentage requirements increase, because of increased deployment of renewable energy resources. These developments coincide with a declining aggregate electric load since 2015, at about 2 percent per year.

Although the RPS has been successful in diversifying Connecticut's energy resource fleet, the existing RPS structure is insufficient to achieve the state's goal of achieving 100 percent zero-carbon electricity generation by 2040. Connecticut's Class I renewable energy resource definition includes carbon-emitting resources like fuel cells and biomass.[14]

Reliance on natural gas-supported fuel cells is not aligned with the state's emissions goals; however, Connecticut's fuel cell industry is important to the state's economic development. Unlike fuel cells, most of the facilities that support Connecticut Class I biomass generation are located out of state and do not support any of Connecticut's other broader policy goals.[15] Consistent with Public Act 13-303 and the 2018 Comprehensive Energy Strategy, Connecticut should phase down the value of biomass RECs eligible as a Class I renewable energy source. While biomass accounted for a majority of Class I RECs as recently as 2013, declining energy market revenues and other challenges have made them a less significant portion of Class I RECs settled in Connecticut in recent years.

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[13] More information on the RPS and classes of renewable energy resources can be found here: https://portal.ct.gov/PURA/RPS/Renewable-Portfolio-Standards-Overview

[14] https://portal.ct.gov/PURA/RPS/Renewable-Portfolio-Standards-Overview

[15] There is currently one in-state eligible biomass plant with a nameplate capacity of 42 MW (of the approximately 470 MW of eligible Connecticut Class I biomass generation located throughout New England.
ISO New England. 2019. 2019 Capacity, Energy, Loads and Transmission Report. Available at https://www.iso-ne.com/system-planning/system-plans-studies/celt

Strategy – Ensure a transparent and predictable compensation framework to maintain at least the historical annual average 40-90 megawatts of residential behind-the-meter renewable energy resources

As retail electricity rates continue to rise, the state must develop a transparent and consistent compensation structure for behind-the-meter renewable energy generation to enable future renewable deployment. The compensation structure implemented should be consistent and easy to understand, and it should ensure a reasonable rate of return for customers and project developers that continues to incentivize deployment of distributed generation sources to facilitate grid decarbonization.

PURA initiated a proceeding to begin developing the successor tariff in July 2020, which must be offered by January 1, 2022. The successor tariff is an uncapped offering for electric utilities to purchase all energy and associated RECs associated with Class I renewables 25 kW or less on a residential customer's premises.

Public Act 19-35 extended net metering and Residential Solar Incentive Program (RSIP) to allow for orderly transition to a successor tariff. Net metering will be available until December 2021. The program currently includes any Class I renewable resources located on a residence which is 2 MW or less. There is no cap on the program and it is offered through December 2021. While the residential net metering program provides compensation based on energy produced, participation is limited to those customers that have the means and ability to install a Class I renewable energy resource (like a solar panel) on their property.

RSIP, which will be available until it reaches 350 MW, provides one way to address this barrier by providing financial incentives for residential customers to install solar PVs and purchase the associated RECs. The Connecticut Green Bank, which administers the RSIP program, has been working to increase participation in underserved communities.

For customers that are unable to physically site renewable energy resources on their property, virtual net metering (VNM) provides an alternative. VNM is available to municipal, state, or agricultural hosts generating power from Class I or Class III renewable energy resources of 3MW or less. Energy produced goes to reducing the electric consumption of the Customer Host (the customer that operates the energy resource) and any surplus production is virtually assigned to reduce the electric bills of other metered accounts that are not physically connected to the generator (also known as Beneficial Accounts).

While Public Acts 11-80 and 13-298 currently limit Customer Hosts to municipal, state, or agricultural customers, some states, including California, have expanded their VNM programs to include multi-meter property owners, including multifamily housing. With VNM, multi-tenant building owners can install a single resource (like a solar PV) to cover the electricity load of the entire building. The energy produced does not go directly to tenants, but feeds back onto the grid. The utility then allocates those kilowatt hours of monetary credits associated with the produced energy to both the building owner's account (to cover common areas) and individual tenant accounts, based on a pre-arranged allocation agreement. In

this way, building owners are incentivized to install renewable energy systems to bring down their own costs, and tenants are able to receive direct benefits from those systems as well.[16]

Expanding eligible Customer Hosts and Beneficial Accounts for VNM could remove some of the barriers that prevent renters, residents of multifamily housing, and others from accessing renewable energy. However it is also important to recognize that the costs of VNM accrue to all ratepayers. Balancing the objectives of increasing access to renewable energy resources and maintaining affordability is a necessary consideration.

Equity and environmental justice – Consideration must be given to ensure that the successor tariff is equitably deployed as, at the moment, there are no targeted programs and additional incentives. Additional incentives could be created such as the RSIP LMI incentives to facilitate equitable solar deployment.

Strategy – Deploy at least 50 megawatts per year of larger distributed solar and 10 megawatts per year of distributed fuel cells, with optimum utilization of available siting locations

Since 2012, state utilities have been required to procure Class 1 RECs under 15-year contracts through an annual auction under the Low and Zero Emission Renewable Energy Credit (LREC/ZREC) Program. Given the program's success, Public Act 19-35 extended the LREC/ZREC Program by $8 million per year through 2021. The successor procurement begins in 2022, with 50 MW per year for ZREC resources and 10 MW per year for LREC resources. Public Act 18-50 created a new auction opportunity for larger distributed generation like commercial, industrial, and virtual net-metering eligible customers. The new auction asks projects to bid in the full project cost, and in turn selected bidders are compensated at a fixed price for both RECs and energy. Declining solar prices makes procurement an attractive option to support the state's clean energy goals. The final LREC/ZREC procurement under its existing structure is scheduled to occur in 2021.

Natural gas-supported fuel cells are eligible for Class I RECs, which may comprise the state's ability to meet its goal of attaining 100 percent zero-carbon generation by 2040. A more thorough discussion of this issue may be found under the first strategy in this section (*Meeting the RPS target of 40 percent of Class I renewable energy sources by 2030, with an aim to reduce the carbon intensity of the RPS*).

In order to meet its emissions reduction goals, the state will need to deploy energy storage technologies in order to smooth out the production load of zero-carbon resources so that they are in line with customer demand. PURA is allowed to set an adder for distributed generation resources, like solar, that are paired with storage under the successor tariff, Energy storage is a complex new technology that may require additional workforce training.

[16] California Public Utilities Commission. Virtual Net Metering. 2020. https://www.cpuc.ca.gov/General.aspx?id=5408#:~:text=Virtual%20Net%20Energy%20Metering%20(VNM,system%27s%20energy%20credits%20to%20tenants.&text=On%20April%2019%2C%202012%20Energy,large%20electric%20IOUs%27%20VNM%20tariffs.

Strategy – *Maintain in-state zero-carbon nuclear generation and develop a long-term zero-carbon replacement strategy equivalent to 2100 megawatts*

Connecticut receives 25 percent of its electric load from carbon-free nuclear power generated at the Millstone 2 and 3 units in Connecticut and the Seabrook plant in New Hampshire. These power plants are critical to Connecticut and the regions' GHG emission reduction goals. The state must retain zero-carbon nuclear power as it develops a transition plan to replace it with zero-carbon renewables. A transition plan must consider the costs of nuclear retirement borne by ratepayers, the diverse mix of replacement energy sources, and economic, environmental, health, and social impacts of replacement. In late 2018, Connecticut secured the at-risk Millstone Power Station through the zero-carbon RFP. DEEP selected a 10-year bid for about 50 percent of the output at 4.99 cents/kWh.

Faced with the potential 2029 retirement of Millstone, DEEP is assessing various paths to achieving 100 percent zero-carbon electricity generation by 2040 without this major resource.

Millstone's retirement could have significant impacts on state and regional emissions, and avoiding these emissions increase with new zero-carbon generation will be costly. A joint study by DEEP and the Public Utilities Regulatory Authority (PURA) found that Millstone's retirement would increase carbon dioxide emissions in New England by 25 percent and that replacing Connecticut's 25 percent share of Millstone with zero-carbon resources would cost taxpayers an estimated $1.8 billion. If other New England states do not replace the energy they receive from Millstone with zero-carbon sources, emissions in the region would increase by 20 percent.[17]

When planning the transition away from nuclear, economic and job impacts must be considered. In 2018, DEEP and PURA released a joint resource assessment of the Millstone plant. The agencies noted that Millstone employs approximately 1,100 workers (average salary about $167,000) and perhaps 400 more contractors. Studies show the Millstone units provide economic benefits of $1.3-1.5B in the state and that direct and secondary employment amounted to 3,900 jobs. Waterford, the location of the plant, receives roughly $30 million annually in property tax payments.

Strategy – **Implement a shared clean energy program deploying at least 25 megawatts per year, with a focus on low- and moderate-income customers**

A shared clean energy program provides access to solar electricity for customers who cannot host an onsite solar PV array. In December 2019, PURA approved a 25 megawatts per year program called the Shared Clean Energy Facilities (SCEF) program. It builds on a six MW pilot conducted in 2017. During the pilot phase, DEEP selected three projects for a total of 5.22 MW, one of which is already online and two that are predicted to come online in 2020. The SCEF program will seek new or incremental Class I renewable generation projects of 100-4,000 kW for a 20-year tariff term. Up to 25 MW of eligible projects will be chosen through competitive bidding each year for six years.

[17] http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/cbc977effc0e623985258227005d607e/$FILE/DEEP-PURA%20FINAL%20Report%20and%20Determination%202-1-18.pdf

Under program requirements, utilities must enroll 20 percent of the estimated annual output from low-income customers and an additional 40 percent from a combination of: (a) LMI customers, (b) landlords or entities responsible for an affordable housing facility, (c) affordable housing facilities, or (d) customers who qualify as low-income service organizations. The LMI population is more likely to face barriers to participation in behind-the-meter programs, whether physical or financial. This requirement is important because it provides LMI customers equitable access to pathways that lower their energy bills.

At 25 MWs per year, and assuming 80 percent of the output goes to residential customers and 20 percent goes to small-business customers, the SCEF program will reach an estimated 36,000 residential customers and nearly 1,000 small-business customers per year. This is a conservative estimate.[18]

In Connecticut, community solar developers (including those participating in the SCEF program) receive a fixed rate of compensation from the utility that is higher than the market rate for energy. The utility passes on that additional cost to their ratepayers, regardless of whether they participate in the program. While it is true that non-participants see some benefits, including better air quality and potentially lower prices from reduced peak demand, they are ultimately paying disproportionately more than program participants. Connecticut should work to drive down the price paid for these resources to limit non-participant rate impacts and focus participant benefits on low- to moderate-income customers.

Equity and environmental justice – As the SCEF program evolves, DEEP believes it is important to support energy equity and relieve energy burden for vulnerable populations. Working towards a 100 percent LMI subscribership goal for the SCEF program would ensure that resources are being deployed to the areas of greatest need and impact.

Strategy – Exercise procurement authority for zero-carbon energy through competitive bidding processes that drive down prices

As the state works to meet its RPS targets and reduce the carbon intensity of the RPS (see the first recommendation in this section for more detail), competitive procurement of zero-carbon resources will accelerate decarbonization in the electricity sector while driving down costs. To this end, DEEP should exercise its procurement authority for grid-scale zero-carbon energy.

Connecticut is already well on its way to electric sector decarbonization by providing support needed for zero-carbon resources to come online, including support for 304 MW of offshore wind from Revolution Wind and 804 MW from Park City Wind, and the state's long-term contract with the Millstone nuclear power plant. Public Act 19-71 mandates the procurement of off-shore wind (OSW) projects up to 2,000

[18] Conservative estimate because: (1) low-income and multifamily housing customers may have lower usage than the average residential customer used in this calculation; and (2) the calculation assumes only solar projects win in the SCEF procurement competition, but if some fuel-cell projects win, this would increase the output and thus increase the amount available for subscriptions. (Fuel cells typically produce more MWHs per MW of nameplate capacity.)

MW by 2030. Connecticut will continue to conduct competitive procurements of zero-carbon energy in accordance and sequence to the findings of the IRP to achieve 100 percent zero-carbon energy by 2040.

While competitive procurements are an effective strategy for deploying resources at the least cost for ratepayers, there are other factors beyond cost that should drive the deployment of zero-carbon resources. It is important to site these facilities in a sustainable manner, consistent with conservation and other environmental policy goals, particularly for more land-intensive resources like grid-scale solar.

New strategy – Establish clear targets for off-shore wind procurement – in concert with IRP recommendations, in balance with other renewable energy sources – to foster its significant potential to help meet zero-carbon goals

In order to meet mandates of the Global Warming Solutions Act and Executive Order 3, Connecticut has actively evaluated and procured OSW resources, including three projects totaling 1,108 MW, which now account for approximately 19 percent of the state's EDC load.

OSW is an important part of the state's electricity portfolio, not just because it is a large source of zero-carbon electricity, but also because its significant economic development potential. While balancing the costs of various electricity resources is important, consideration should also be given to other factors that make a resource like offshore wind worthy of investment. DEEP and the Department of Economic Community Development should develop a long-term economic development and job creation plan supported by investment in OSW. The state's recently-selected project, Park City Wind, could generate upwards of $1.6 billion in direct economic benefits and create as many as 12,000 direct, indirect, and induced full-time equivalent (FTE) job years across the state.

The significant grid and transmission challenges associated with large-scale OSW procurements are discussed in more detail in the next section.

Equity and environmental justice – The development of OSW and its supply chain has the potential to drive significant investments in port communities like New London and Bridgeport where the majority of residents are Black or Hispanic. These port cities will be the access points to the wind farms and will have opportunities to grow to support the increased work force and needs of the zero carbon resource. Policy can be put in place to ensure a percentage of workers are local to stimulate development of the community. Workforce development, including investments in training and education programs, will be key to ensuring Connecticut has the workers suited to the job.

New strategy – Address the role of new transmission or transmission constraints

DEEP should examine whether or not transmission expansion is needed to support achieving a zero-carbon emissions electric grid. Given that the development of high voltage transmission lines typically requires the acquisition of land, DEEP should perform a study that examines the environmental impact of building new transmission as one component to determine its benefit.

DEEP should actively address grid constraints to OSW by exploring, assessing and pursuing the most appropriate and feasible solution or solutions (e.g. open ocean grid). DEEP should also assure that OSW has equal access to the power markets that are controlled by ISO-NE including fair consideration of true costs, fees and other measures associated with selection of new energy sources to fulfill power requirements and reliability. And finally, effort should be made with federal, state and other partners, to pro-actively establish environmental standards for OSW that protect marine life and provide clarity and consistency to energy developers thereby helping to expedite environmentally sound offshore wind development.

Since 2015, Connecticut has been a net exporter of energy, and over 50 percent of generated energy is from natural gas[19]. While working to reduce demand, expansion of the natural gas infrastructure would not serve to help achieve state emission goals, particularly given estimates of leakage in distribution[20]. It is recommended that the State identify goals and complete planning to specifically address the multiple issues associated with transitioning from heavy reliance on natural gas to carbon-neutral energy sources.

Optimize grid management strategies to reduce carbon emissions

Strategy – Increase adoption of smart-management technologies to optimize flexibility of distributed energy resources

Grid modernization is important to better accommodate zero-energy and low-carbon generation sources and increase system safety, reliability, security, and resiliency in a cost-effective manner. It enables two-way communications between consumers and grid operators and facilitates bi-directional flows of energy to reduce peak demand and integrate distributed energy resources. This becomes even more essential as buildings and transportation electrify with efficient and 'smart' technologies and more distributed energy resources come online.

PURA is in phase three of its investigation into Distribution System Planning of the Electric Distribution Companies (Docket 17-12-03). This investigation focuses on various aspects of grid modernization including energy affordability, advanced metering infrastructure (AMI), electric storage, non-wires alternatives, resilience and reliability standards and programs, and distributed energy resource analysis. Accelerating the deployment of AMI infrastructure enables optimal grid management and enhances grid resiliency. AMI allows for greater communication between consumers and the utilities, and allows for time-of-use (TOU) rate programs and other incentives to reduce peak demand. It also enables demand response technologies such as utilizing EVs as energy storage capacity, which can store energy when overall energy demand is low and draw energy when demand is high. This type of storage is increasingly beneficial as more renewable energy resources are deployed. This can reduce peak demand and provide cost savings to all consumers.

[19] https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_use/total/use_tot_CTcb.html&sid=CT
[20] https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019GL082635

Strategy – Over the next 2-5 years, research and identify opportunities to integrate battery storage and distributed renewable energy technologies to reduce and displace carbon emissions

The 2020 IRP will assess various paths to achieving 100 percent zero-carbon electricity generation by 2040. This analysis includes the incorporation of battery storage as a zero-carbon resource that improves system reliability as Connecticut transitions to more variable energy resources. Battery storage is an energy resource with flexible capacity that enhances the reliability of the transmission and distribution system and minimized peak demand. Batteries can reduce, defer, or replace the need to build additional generation capacity by storing energy when demand is low and energy is cheap and providing energy when demand is high. Emission reductions can be maximized by pairing battery storage with renewable energy to offset the need for dirtier fuels. The demand for battery storage and technological improvements in materials and manufacturing of batteries has reduced the cost of battery storage by 87 percent from 2010 to 2019[21].

The 2019-2021 C&LM plan allows Eversource & United Illuminating to incentivize storage in demand response programs. PURA Docket 17-12-03 includes RFPs for statewide storage incentive programs. And H.B. 5351 (2020) would establish a 1,000 MW target for behind-the-meter storage by the end of 2030.

Equity and environmental justice – Energy storage programs have the potential to provide direct benefits to environmental justice communities. By shifting demand, batteries can reduce reliance on "peaker" plants, which tend to use more polluting fuel sources and are often located in low-income communities that already face air quality challenges. Batteries can also reduce expenses for community facilities and affordable housing owners that often pay the same rates as commercial customers and are subject to demand charges. Additionally, batteries can enhance community resilience by ensuring that critical facilities, including hospitals and first responders, remain operational during power outages. In order to realize these benefits, the Union of Concerned Scientists created a suite of recommendations for storage program design, including establishing community-centered outcomes, including public participation, and reducing barriers to programs that are meant to benefit underserved communities.[22]

New strategy – Reduce petroleum use by power plants needed to serve winter peak demand

According to the Energy Information Administration (EIA), while petroleum makes up only 1 percent of the state's net generation, it is used as a replacement for natural gas in dual fuel plants when natural gas supply is constrained.[23] This is usually during periods of winter peak power demand. Petroleum is dirtier and more expensive. A dual fuel power plant produces ~27 percent more carbon when burning

[21] https://www.nrel.gov/docs/fy20osti/75385.pdf

[22] https://www.ucsusa.org/sites/default/files/2019-11/Ensure-Energy-Storage-Policies-Equitable-Brief.pdf. How to Ensure Energy Storage Policies are Equitable. Union of Concerned Scientists. 2019.

[23] https://www.eia.gov/state/analysis.php?sid=CT

petroleum fuel instead of natural gas.[24] Given the negative health impacts resulting from burning fossil fuels, and the disproportionate burden low income and people of color shoulder by living close to these facilities, DEEP should consider the health impacts, along with cost and carbon emissions of using oil to meet electricity demand, and evaluate the expansion of a winter demand response program.

New strategy – Identify ways to increase local involvement in energy decision-making such as targeting energy efficiency dollars based on local priorities and increasing local governments' ability to procure zero-carbon energy

PURA recently launched study of Community Choice Aggregation (CCA, also known as Community Power), a policy tool that could further the above objectives.[25] Based on the outcomes of this proceeding, the docket may result in legislation to bring this tool to Connecticut as a means of increasing local involvement, targeting efficiency dollars based on local imperatives, accelerating the deployment of distributed energy resources, and increasing options for town procurement of green energy.

Nine states, including Massachusetts, New Hampshire, New York, and Rhode Island, have enacted laws to enable CCA.[26] In these states, local entities are allowed to replace the distribution utility as the default provider of electricity and customer services. The distribution utility continues to deliver power over its poles and wires, while the CCA can offer modern energy services and products that can reduce demand and save money for customers, and any unsatisfied customers are free to choose an alternative supplier. By aggregating demand, local authorities can create CCA programs that reflect community priorities such as affordability, emissions reductions, or local economic development.

According to a February 2019 report[27] by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL), a key CCA feature is a requirement for its customers to automatically enroll unless they actively opt out of the program. This requirement increases program participation and allows a CCA's relatively larger customer base to take advantage of economies of scale and increased buying power in the wholesale electric market.

"A CCA can decide whether it wants to focus on providing its customers with the lowest possible rates or meeting other goals, such as encouraging a greater use of clean energy. When deciding to use more clean energy a CCA must still maintain cost competitiveness or risk losing customers. Nevertheless, as CCAs continue to develop (into "Version 3.0") they may generate new ways for communities to directly finance and develop their own clean energy projects and other related initiatives."[28] CCAs have shown

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[24] The EPA's continuous emissions monitoring system (CEMS) shows that New England dual fuel power plants emit 117 pounds of CO2/MMBtu on natural gas and 161 pounds of CO2/MMBtu on petroleum

[25] See PURA docket 20-05-13 PURA Study of Community Choice Aggregation: http://www.dpuc.state.ct.us/dockcurr.nsf/(Web%20Main%20View%5CAll%20Dockets)?OpenView&Start=120&Count=30&Collapse=120.1.1#120.1.1

[26] https://leanenergyus.org/cca-by-state/ CCA by State. Local Energy Aggregation Network.

[27] https://www.nrel.gov/docs/fy19osti/72195.pdf Community Choice Aggregation: Challenges, Opportunities, and Impacts on Renewable Energy Markets. 2019.

[28] https://www.cga.ct.gov/olr/ Community Choice Aggregation. December 23, 2019 | 2019-R-0293

deployment-led innovation in grid modernization at local levels to develop resilience and reduce carbon emissions. CCAs have led programs and developed projects including: energy storage, solar plus storage, microgrids, demand response, energy efficiency, community solar, electric vehicle charging, and more.[29] 30313233

Equity and environmental justice – Depending upon the program structure, CCAs could allow customers to utilize renewable energy products without having to actually install a distributed energy resource at their residence. Many customers, particularly low-to-moderate income customers and renters, face financial and logistical barriers to installing DERs such as solar panels. CCAs could also have the flexibility to create programs specifically for low-to-moderate income customers. For example, MCE Clean Energy (an operational CCA in California) offers energy efficiency programs for low-income, multi-family, and small commercial customers and assists low-income customers with solar installation. However, sufficient consumer protections must be put in place to safeguard participants, particularly vulnerable populations. In addition, further analysis should be done to explore the goals of a CCA program and whether program structures already exist that meet those same goals, like the Connecticut Clean Energy Options Program, shared clean energy facilities program, and voluntary renewable energy offerings by electric suppliers, which is in the process of being adjusted to align with state policy goals in PURA Docket No. 16-12-29.

[29] https://www.utilitydive.com/news/as-ccas-take-over-utility-customers-local-generation-emerges-as-the-next-b/564422/ As CCAs take over utility customers, local renewable generation emerges as the next big growth driver. Utility Dive. Oct 2019.

[30] https://www.utilitydive.com/news/increasing-renewables-and-der-demand-new-reliability-approach-but-californ/575498/ Increasing renewables and DER demand new reliability approach, but California is falling short, groups say. Utility Dive. April 2020.

[31] https://ebce.org/news-and-events/an-inside-look-at-a-groundbreaking-solar-storage-procurement-in-california/ An Inside Look At a Groundbreaking Solar-Storage Procurement In California. Nov 2019.

[32] https://ebce.org/news-and-events/pg-e-proposes-lithium-ion-battery-projects-to-replace-oakland-fossil-fuel-plant/PG&E Proposes Lithium-Ion Battery Projects to Replace Oakland Fossil Fuel Plant. April 2020.

[33] https://www.greentechmedia.com/articles/read/in-new-york-a-new-way-for-stay-at-home-customers-to-get-paid-for-shaving-peak-energy In New York, a New Way for Stay-at-Home Customers to Get Paid for Shaving Peak Energy. April 2020.

Appendices	
Appendix 1	Members of the Electricity team
Appendix 2	Acronyms and abbreviations
Appendix 3	Preliminary glossary

Appendix 1: Members of the Electricity team

Chair	
Mike Li	Bureau of Energy & Technology Policy
Working Group	
Jillian Corley	Eversource
Pat McDonnell	United Illuminating (Avangrid)
Stanley McMillen	UConn
Rob Schmitt	Connecticut Green Bank
Tom Swarr	GC3 Equity & Environmental Justice Working Group
Other Stakeholders	
Tyler Anderson	Robinson & Cole
Fred Behringer	
Lynne Bonnett	New Haven Energy Task Force
Sten Caspersson	CT Academy of Science & Engineering
Leticia Colon de Mejias	Energy Efficiency Solutions
Kathy Fay	Neighborhood Housing Services of New Haven
Nathan Frohling	Nature Conservancy
Elsa Loehmann	(environmental engineer)
Gannon Long	Operation Fuel
Peter Millman	Eastern CT Green Action
Andrew Minikowski	Office of Consumer Counsel
Chris Phelps	Environment Connecticut
Jane Lano	United Illuminating
Jon Slifka	Department of Aging and Disability Services
David Sutherland	Nature Conservancy
Michael Uhl	(engineer)
Sena Wazer	Sunrise CT
DEEP support staff	
Jeff Howard	Bureau of Energy & Technology Policy
Julia Dumaine	Bureau of Energy & Technology Policy
Kate Donatelli	Bureau of Energy & Technology Policy
Lauren Savidge	Bureau of Energy & Technology Policy
Doris Johnson	Commissioner's Office
Brian Basso	Intern
Mike Malmrose	Bureau of Energy & Technology Policy
Raagan Wicken	Bureau of Energy & Technology Policy
Spencer Kinyon	Bureau of Energy & Technology Policy

Appendix 2: Acronyms and Abbreviations

Term	Full Name	Term	Full Name
AMI	Advanced Metering Infrastructure	**LREC**	Low Emission Renewable Energy Credit
C&LM	Conservation and Load Management	**MW**	Megawatt
CCA	Community Choice Aggregation	**NREL**	National Renewable Energy Laboratory
COVID-19	Coronavirus Disease 2019	**OSW**	Offshore wind
DEEP	Connecticut Department of Energy and Environmental Protection	**PURA**	Public Utilities Regulating Authority
EEJ	Equity and Environmental Justice	**PV**	Photovoltaic
EIA	Energy Information Administration	**REC**	Renewable Energy Certificate
FCM	Forward Capacity Market	**RPS**	Renewable Portfolio Standard
FTE	Full-Time Equivalent	**RSIP**	Residential Solar Incentive Program
GC3	Governor's Council on Climate Change	**RTT**	Renewable Thermal Technology
GHG	Greenhouse Gas	**SCEF**	Shared Clean Energy Facilities
IRP	Integrated Resource Plan	**TOU**	Time-of-Use
ISO	Independent System Operator	**VNM**	Virtual Net Metering
LMI	Low to Moderate Income	**ZREC**	Zero Emission Renewable Energy Credit

Appendix 3: Preliminary glossary

Term	Definition	Term	Definition
Carbon footprint	The amount of Carbon Dioxide equivalent emissions required to build and maintain infrastructure.	**Low and zero-carbon resources**	Sources of electric generation that have a lower carbon footprint (PV, nuclear power, Wind energy, hydroelectric etc.)
Community Choice Aggregation	A program that allows municipalities to procure electricity on behalf of constituents while still receiving transmission and distribution from the local utility.	**Micro grids**	
Community Solar	Subscription based service to obtain solar energy from off-site energy provider	**Net Metering**	
Decarbonize	The act of shifting energy generation from methods that results in high GHG emissions to methods with lower emissions	**Peak demand**	
Forward Capacity Market		**Renewable Energy Certificate**	
Grid integrated buildings		**Smart grids**	

IS0-New England	**Virtual Net Metering**

Chapter 4

Non-energy GHG emissions

Chapter overview	
Equity & environmental justice – Addressed in multiple sections	
Adaptation & resilience – Addressed in multiple sections	
Progress on 2018 recommendations	**Strategies** Enhancements and new strategies recommended
Implement the short-lived climate pollutant reduction strategies outlined in the U.S. Climate Alliance SLCP Challenge to Action Roadmap	• Develop regulations to reduce methane emissions from the natural gas distribution • Reduce methane emissions from agriculture • Develop regulations for hydrofluorocarbons that set achievable timelines for a transition to climate-friendly, HFC-free technologies and HFC substitutes in refrigerators, air-conditioning equipment, and vehicle air-conditioning systems
Protect natural and working lands — forests, farms, rangelands, and wetlands — that sequester and store carbon and support Connecticut's economy, communities, and ecosystems	• Develop markets for beneficial use of wood and woody waste • Work with land trusts, forest owners, and working lands managers to adopt carbon-accounting methodologies that further support sustainable land-use practices • Take advantage of short-term opportunities
Additional recommendations	
Establish/transform Plans of Conservation and Development as sustainability plans *Promote responsible and just materials management*	

Promote urban and suburban tree planting	

Introduction

Non-energy greenhouse gas (GHG) emissions – from waste, agriculture and natural gas leakage – account for approximately six percent of the state's greenhouse emissions inventory.[1] While this is a relatively small fraction of the state's overall emissions, addressing these emissions will be necessary to meet our overarching climate goals and present opportunities for capturing economic value that is currently being lost.

The 2018 GC3 report did not contain explicit, discrete recommendations for non-energy emissions, but it did identify several broad areas of action that the state should pursue. This chapter recasts the 2018 Report's statements as specific recommendations, provides a status review, and offers additional recommendations.

The Non-energy GHG Emissions team was chaired by Charles Rothenberger (Save the Sound) and involved eight other Working Group members and 15 other stakeholders representing business, industry, higher education, environmental organizations, social-service organizations, and government agencies.[2] The team held 19 electronic meetings between March and August 2020.

Implement the short-lived climate pollutant reduction strategies outlined in the U.S. Climate Alliance Short-Lived Climate Pollutants Challenge to Action Roadmap

Connecticut is a member of the U.S. Climate Alliance (USCA) and in 2018 joined other alliance states in issuing the Short-lived Climate Pollutant (SLCP) Challenge to Action Roadmap.[3]

Strategy – Develop regulations to reduce methane emissions from natural gas distribution

Progress to date – Among the policy recommendations in SLCP Challenge to Action Roadmap are several focusing on methane emissions from natural gas distribution systems:

- cap fugitive emissions from natural gas distribution – establish a declining emissions limit;

[1] Connecticut DEEP, 2017 Connecticut Greenhouse Gas Emissions Inventory (released 2020). Available at <https://portal.ct.gov/-/media/DEEP/climatechange/2017_GHG_Inventory/2017_GHG_Inventory.pdf>.

[2] See Appendix 1.

[3] See USCA, "U.S. Climate Alliance Statement on Leadership," Sept. 13, 2018, http://www.usclimatealliance.org/publications/2018/9/26/us-climate-alliance-statement-on-leadership.

- require utility company reporting of natural gas emission data and implement best management practices; and

- replace old, leak prone pipes – explore incentives and negative revenue adjustments and mandated targets.

In 2019, the administration submitted legislation addressing one of the recommendations identified above. HB 5350, *An Act Concerning Natural Gas Infrastructure*, would have required the Public Utilities Regulatory Authority to initiate dockets to evaluate whether a gas company should accelerate its existing schedule for the repair and replacement of aging infrastructure.

In an ongoing docket, PURA is pursuing regulations on Uniform Gas Leak Classification. The Authority has proposed: a definition for "environmentally significant leak"; a uniform standard for repairing such leaks as well as Grade 2 and Grade 3 leaks; uniform limits for Grade 2 and Grade 3 leaks; and a schedule for reassessment of leak classifications.[4]

Strategy – Develop regulations for hydrofluorocarbons that set achievable timelines for a transition to climate-friendly, HFC-free technologies and HFC substitutes in refrigerators, air-conditioning equipment, and vehicle air-conditioning systems

Hydrofluorocarbons (HFCs) are a class of synthetic chemicals used in refrigeration, air conditioning, and insulation. Their global warming potentials (GWPs) are up to 9,000 times higher than that of carbon dioxide.[5] Global action to reduce and eliminate HFCs resulted in the 2016 Kigali Agreement, which began to have an impact on global HFC use in 2019. A 2015 U.S. EPA rule restricting HFC production and importation was struck down by a U.S. Court of Appeals in 2017 and subsequently abandoned by EPA, but several refrigeration and chemical manufacturers made clear their intentions to continue seeking to eliminate HFCs from their products.

Progress to date – Among the policy recommendations in the SLCP Challenge to Action Roadmap are the following:

- adopt state-level requirements to transition away from HFCs;

- limit use of High-GWP refrigerants in existing equipment;

- restrict in-state sales of the most polluting refrigerants;

- develop state or utility incentives to encourage adoption of new refrigerant technologies and transition away from HFCs in supermarkets, homes, and commercial buildings;

- establish a Refrigerant Management Strategy for handling, recycling, and disposing of dangerous refrigerants – when equipment is installed, repaired, or decommissioned, proper care needs to be taken;

[4] PURA Docket 20-02-19, PURA Investigation into a uniform natural gas leak classification, http://www.dpuc.state.ct.us/dockcurr.nsf/(Web+Main+View/All+Dockets)?OpenView&StartKey=20-02-19.
[5] That is, on a pound-for-pound basis, they produce up to 9,000 times more global warming than CO_2.

- Establish state and municipal standards requiring procurement of low-GWP alternatives;
- account for HFCs in building code and energy-efficiency programs; and
- provide technical assistance and audits to help businesses identify opportunities to reduce HFC emissions and costs.

In Sept. 2018, Gov. Malloy instructed DEEP to develop regulations that would phase out HFCs.[6] This work so far has not proceeded under Gov. Lamont.

HFCs are a significant component of Connecticut's GHG inventory, and along with three related industrial chemicals represent about 4 percent of annual statewide CO_2e emissions. Emissions of HFCs are projected to grow rapidly in the coming decades, and left unchecked these emissions could represent up to 25 percent of Connecticut's 2050 target of 9.8 $MMTCO_2e$. A 2050 HFC target of 0.4 $MMTCO_2e$ would be consistent with the states' overall 2050 target.

Successful reduction of HFC emissions requires two primary activities: (1) replacement of high GWP HFCs with zero or low GHG alternatives; and (2) mitigation of potential HFC related impacts associated with legacy refrigeration and air conditioning equipment leaks and end-of-life decommissioning:

(1) Replacement of high-GWP HFCs with zero- or low-GWP alternatives

The chemical refrigerant industry is working to develop replacements for HFCs, but there is no simple replacement of existing HFCs with zero- or low-GWP substitutions. Refrigeration and air conditioning equipment employs a range of mechanical designs and usage configurations. Diverse equipment specifications and equally diverse chemical flammability and toxicity characteristics of substitute refrigerants combine to make HFC replacement technologically challenging. Progress is ongoing. Current replacements fall into four general categories, including natural refrigerants (such as CO_2), HFCs with lower GWP (such as R32), hydrofluoroolefins (HFOs), and HFC-HFO blends.

- Absent any federal legislation or national rule, Connecticut should adopt requirements prohibiting the sale of specific HFCs when an applicable zero- or low-GWP alternative becomes available on the market.
- The transition from HFCs to lower-GWP alternatives will not always include simple choices where a replacement chemical provides unambiguously superior operating performance in all circumstances. Consequently, Connecticut should develop state or utility incentive programs that encourage adoption of lower-GWP HFC replacements even when less climate impactful alternatives remain under development. The incentive program should recognize that new refrigerants are r simple "drop in" chemicals that require no equipment changes; and in many cases the incentives will be needed to help offset the cost of substantial refrigeration and air-conditioning equipment modification or replacement.

[6] CT DEEP press release, Sept. 13, 2018, https://portal.ct.gov/Malloy-Archive/Press-Room/Press-Releases/2018/09-2018/Gov-Malloy-Joins-Connecticut-in-Coalition-Committed-to-Phasing-out-Coal-Power.

- Connecticut should include requirements for acquisition of zero- or low-GWP refrigeration systems in state procurement rules governing new and replacement refrigeration and air conditioning systems.

- Connecticut should leverage the success of its utility-based energy-efficiency technical support programs to make available to make information about HFC replacement and management available to the state's businesses and residents

(2) Mitigation of potential HFC related impacts associated with legacy refrigeration and air conditioning equipment leaks and end-of-life decommissioning

EPA estimates that about 90 percent of GHG emissions associated with refrigerants comes from end-of-life equipment leakage and mismanagement of decommissioning. Under Section 608 of the Clean Air Act, EPA established regulations (40CFR, Part 82, Subparts A and F) governing management of air conditioning and refrigeration equipment to mitigate the ozone-depleting impacts of refrigerants. EPA has not established similar rules targeting elimination of HFC impacts on the climate, and Connecticut should implement its own HFC management strategy mandating the training and practices necessary to eliminate HFC leaks during equipment installation, charging, operation, repair, and decommissioning. The strategy should also define requirements for HFC disposal and destruction.

Significant volumes of HFCs are also incorporated in various forms of insulation, including foams and other matrices found in building envelopes and appliances such as refrigerators. HFCs in insulation are routinely released to the environment during building demolition and repair and appliance decommissioning and recycling. Connecticut's HFC strategy should include requirements that will eliminate the release of HFCs through these activities.

Strategy – **Reduce methane emissions from agriculture**

Progress to date – Among the policy recommendations in the SLCP Challenge to Action Roadmap are the following:

- incorporate methane emissions reductions into funding criteria for agricultural programs; and

- improve predictability of revenue streams for renewable gas.

In 2019, the administration submitted legislation that would begin addressing this issue. House Bill 5350, *An Act Concerning Natural Gas Infrastructure*, would have authorized the Commissioner of Energy and Environmental Protection, in consultation with the Office of Consumer Counsel and the Attorney General, to solicit proposals from anaerobic digestion facilities that produce biogas of a quality suitable for injection into the natural-gas distribution system. The bill would have authorized selection of proposals from such facilities up to an amount of biogas that would be generated by 300,000 tons of organic waste annually. In procuring such resources, the legislation would have required consideration of whether the action is consistent with existing statutory requirements to reduce GHG emissions.

Protect natural and working lands – forests, farms, rangelands, and wetlands – that sequester and store carbon and support Connecticut's economy, communities, and ecosystems

Equity & Environmental Justice Considerations– Trees in urban areas can improve air and water quality, mitigate the heat-island effect, and help alleviate noise. Residential and urban trees and forests also shade and cool buildings in summer and insulate them in winter, which significantly reduces energy use (and costs) of air conditioning and heating. And, generally, forests provide excellent recreational opportunities for Connecticut residents. Meanwhile, urban community gardens can provide youth engagement and educational opportunities, as well as providing a source of nutritious natural foods in communities where access may otherwise be limited.

Adaptation and Resilience Considerations – Natural and working lands can serve as carbon sinks, and provide important adaptation and resiliency functions, such as attenuating flooding, reducing heat-island effects, and providing natural cooling and insulating functions for buildings.

Strategy – Develop markets for beneficial use of wood and woody waste

Progress to date – Trees are a renewable resource, and in New England, where conditions usually allow seeds to take root and regenerate, working forests can also supply a local source of wood products. Connecticut consumes an estimated 80.4 million board feet of roundwood or about 22.8 board feet per person each year (Hochholzer, 2015, p. 52). For a relative measure, building a typical 2,000-square-foot home would require about 16,000 board feet of roundwood (NAHB).

Depending on the goals and desired outcomes of private or public owners of forests, cutting some trees according to a variety of silvicultural practices or prescriptions, can enhance the health and vigor of remaining trees, generate income from the sale of timber to produce wood products for human needs, and benefit specific wildlife species by creating early successional habitat.

Harvesting timber grown sustainably in our own region can help reduce transport emissions and global deforestation by avoiding pressure to harvest primary forests in other nations with less stringent environmental policies. In its 2015 report, the North East State Foresters Association estimated Connecticut's forest products and forest recreation industries produce an annual gross output of $3.38 billion and almost 13,000 jobs (figure below).

Gross State Output (sales), Forest-based Manufacturing & Recreation, Connecticut, 2013			
		millions of $	jobs
Forestry & logging		25	450
Wood products manufacturing		154	1,300
Furniture and related product manufacturing		418	2,802
Paper manufacturing		1,573	3,550
Wood energy		7	40
Christmas trees and maple syrup		4	58
Total Forest Products		2,181	8,200
Forest Recreation sales		1,200	4,600
	Total	$ 3,381	12,800

Long-lived wood products – from your grandmother's antique desk to the cabinets in your renovated kitchen – also lock up and store carbon until the wood decomposes. From paper to plywood and barrels to baseball bats, some wood products are well known; other forest products such as rayon, mulch, medicines, fiber, gums, resins and tannins (such as witch hazel) are less obvious (New England Forestry Foundation, USDA Forest Service). Lumber can also be reclaimed from old structures and recycled into new uses for furniture or building materials, keeping carbon out of the atmosphere longer.

Strategy – Work with land trusts, forest owners, and working lands managers to adopt carbon-accounting methodologies that further support sustainable land-use practices

Working and natural lands like forests have a significant role in mitigating GHG. According to the U.S. Climate Alliance, in Connecticut and the other 24 states that have committed to the alliance's Natural and Working Lands Challenge, "natural and working lands offset 16 percent of the GHG emissions from energy, transportation, and other sources in 2016."

Enhancement **– Take advantage of short-term opportunities**

Several short-term opportunities are available to incorporate the carbon-accounting information with land trusts and other landowners and managers:

- The state's Green Plan, which directs Connecticut's land-acquisition priorities, is up for renewal in 2021. The Green Plan should place a higher priority on protecting properties that provide maximum opportunities for CO_2 sequestration and storage.

- Updating Connecticut's land-protection priorities will allow the state to invest – through the Open Space and Watershed Land Acquisition Grant Program – in properties that have the highest impact on mitigating GHG emissions.

- At the same time, land protection professionals at DEEP and non-profit organizations such as the Connecticut Land Conservation Council should provide guidance to land trusts in how to account for carbon and maximize its sequestration and storage in their land-acquisition and -management practices.

The ability of trees to sequester and store carbon dioxide, turning it to wood, provides significant potential to mitigate climate change by retaining existing forests and improved forest management. A study in the Proceedings of the National Academy of Sciences finds that "natural climate solutions" could provide more than a third (37 percent) of needed emissions reductions to keep global temperatures at or below 2 degrees Celsius by 2030. "Avoided forest conversion" and "natural forest management" are among the low-cost natural solutions that, along with reforestation (replanting trees to restore degraded forests), represent easily available and effective solutions (Griscom et al., 2017).

New recommendation – Establish/transform plans of conservation and development as sustainability plans

Connecticut's state Plan of Conservation and Development (POCD) promotes development that can "create and maintain conditions under which [humans] and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Connecticut residents."[7] Yet the well-being of CT residents is strongly correlated with their zip code, and future generations are likely to inherit unfunded pension liabilities. State law stipulates a process for comparing municipal, regional, and state plans to identify and reconcile differences and leverage assets at different levels for the overall benefit of the state economy and population. However, there is no statutory requirement that municipal plans comply with the regional or state POCD.

Sustainable development strives to meet the needs of the present generation without compromising the ability of future generations to meet their needs. Achieving this goal will critically depend on effective action to mitigate climate change and facilitate resilience enabling our communities to adapt to a changing climate. Connecticut's strong Home Rule authority provides cities and towns with control over most land-use decisions that directly affect these goals.

State statutes stipulate the elements that should be covered in a municipal POCD, including: the need for affordable housing; protection of existing and potential public surface and ground drinking water supplies; energy-efficient patterns of development; energy conservation and use of solar and other renewable forms of energy; and the most recent sea level change scenario.[8] The plan also must be submitted to the municipality's regional planning council for review, and the council is required to issue an advisory report with comments, including a finding on its consistency with the regional POCD.

The statutes also stipulate elements to be considered in a regional POCD, such as energy-efficient development, abatement of air and water pollution, and transit-oriented development.[9] Regional plans must be reviewed by the state Office of Policy Management (OPM) for consistency with the state plan. There is no statutory requirement for consistency, but OPM is to identify inconsistencies and the reasons for them.

The statutes provide a process that theoretically is capable of developing integrated planning across state, regional, and local levels of government. However, there is no guarantee that decisions taken by

[7] CT OPM, Conservation & Development Policies: The Plan for Connecticut, 2018 – 2023 – Revised Draft https://portal.ct.gov/-/media/OPM/IGP/ORG/cdplan/20190214--Formatted-Document--20182023-Revised-State-CD-Plan.pdf.

[8] CT General Statutes, Section 8-23(d). https://www.cga.ct.gov/current/pub/chap_126.htm#sec_8-23.

[9] CT General Statutes, Section 8-35a. https://www.cga.ct.gov/current/pub/chap_127.htm#sec_8-35a.

169 separate towns will collectively produce effective climate action or redress environmental and social injustices across the state. Although the regulations call for public outreach and engagement in the planning process, underserved residents remain underrepresented.

Given the importance of local decisions in Connecticut, a bottom-up process to build consensus for a coherent roadmap toward a more inclusive and environmentally sustainable economy seems the most productive approach. It is particularly important to align local decisions for effective climate action.

The following recommendations could be approached in one of two ways. First, they could be framed as extensions of the six growth-management principles of the state POCD, which promotes integrated planning across all levels of government. The recommendations would ensure measurable progress toward GHG emissions-reduction goals and would facilitate transparency and broader public engagement in the climate-planning process. Alternatively, the statutes could be revised to incorporate a seventh growth-management principle in the state POCD: climate protection and the intrinsic need for protection of public health and safety. This new section of the state POCD would be an easily referenced set of planning guidelines that lesser jurisdictions could emulate and would recap GC3's envisioned GHG emissions-reduction measures.

Recommendations:

- The statutes require that POCDs "take into consideration the state's greenhouse gas reduction goals."[10] This requirement should be strengthened to require POCDs to document how proposed actions support the state's GHG emissions-reduction goals and to clearly identify any actions that are inconsistent with the goals and justify such inconsistencies.

- The current process requires municipal plans to identify inconsistencies with the regional plan, and it requires the regional plan to identify inconsistencies with the state plan. The state OPM should provide a standardized format for reporting these inconsistencies and post the findings on the state web site to facilitate review by the general public.

- State POCD Attachment F provides examples of performance indicators for measuring progress. Data-tracking that shows how well the goals of sustainable development are being met should be added and highlighted in a town-by-town format similar to the Energy Efficiency Board's annual legislative reports (see the 2019 report, pages 8-10[11]). Consideration should also be given to aligning these measures with the environmental-justice index proposed by the Equity and Environmental Justice Working Group.

- OPM should form a working group with partners such as Sustainable CT, Connecticut Association of Conservation and Inland Wetlands Commissions, and the CT Energy Network of local energy committees to develop better templates and actionable recommendations for sustainable development. This working group plus various subject-matter experts would also create succinct guidelines for state-of-the-art energy management — siting of

[10] CT General Statutes. Section 16a-27(h)(4). https://www.cga.ct.gov/current/pub/chap_297.htm#sec_16a-27.
[11] https://www.energizect.com/sites/default/files/Final-2019-Annual-Legislative-Report-WEB02262020_2.pdf.

distributed renewable energy generation, energy security, energy efficiency, etc. — for regional and municipal POCDs. Such content should become part of the state POCD.

New recommendation – Promote responsible and just materials management

Waste management is typically considered a minor contributor to Connecticut's GHG emissions, because the state's GHG accounting considers only the direct emissions of in-state waste disposal operations. It is responsible for about 4.9 percent of statewide emissions. Some of the benefits of improved resource management are captured in other parts of the inventory, and the main benefits come from waste reduction and recycling occur outside the state boundaries and hence outside the scope of the inventory. Waste facilities also present significant environmental justice issues, and health impacts of other pollutants can be of more immediate concern than future climate impacts.

Waste contributed ~2 MMT CO2e in the most recent inventory, or just under 5% of the total. Roughly 80% was associated with solid waste and 20% with waste water treatment. Waste is considered a minor contributor and thus, receives limited attention in climate action planning. Waste was not mentioned in the 2018 report. Forty years ago, CT took a leadership position in developing waste to energy (WTE) facilities to minimize landfill disposal. However, the large incinerators in Bridgeport and Hartford impose significant environmental damage and health impacts on poor urban communities of color. Forty years later, WTE is no longer considered a sound environmental solution for waste disposal. Over the past few years, there has been little progress in reducing the amount of waste generated or recovery of materials for recycling. The failure of the proposed project to replace the Materials and Innovation Recycling Authority (MIRA) capacity presents a potential public health crisis.

The Metropolitan District (MDC) Clean Water Project is investing $2 billion to expand the sewer system and wastewater treatment capacity to reduce combined sewer overflows during rain storm events and comply with a federal consent decree and a Connecticut DEEP consent order to achieve Federal Clean Water Act goals. The increased capacity results in increased amounts of sewage sludge for disposal.

A narrow focus only on the GHG impacts of in- state waste disposal will yield suboptimal solutions and fail to address the environmental justice concerns. Evaluation of waste disposal options must address the full range of environmental impacts. Proposed projects to site or expand waste management facilities should conduct a cost benefit analysis that considers the health effects of criteria pollutants, especially particulates, heavy metals, and persistent, bioaccumulative and toxic (PBT) chemicals.

Developing a long-term plan for sustainable materials management should address the full life cycle and a broad range of environmental concerns. The emphasis should be on ensuring CT has the capacity to responsibly manage waste generated within its borders, driving behaviors to support waste reduction and recycling to minimize any residues sent for final disposal. The collapse of markets for recovered plastics and mixed paper has complicated recycling efforts. Wholesale electricity prices no longer provide a meaningful subsidy to WTE facilities. These trends have exposed the true cost of waste disposal, which was formerly hidden by these subsidies. CT will need to evaluate the current state- of-the- art in material sorting technologies and waste disposal treatments as core elements of an emerging call for more circular economies. Waste management, or more appropriately strategic materials

management will require incentives for the recovery of materials and economic development incentives for secondary processing of recovered materials into higher value added materials or finished products that can be sold back into the market. The state could establish a commission to determine the best options, with an emphasis on protecting human health and the environment.

The following recommendations are provided to help promote responsible and just materials management:

- Proposed construction, modification, or expansion of any solid/sewage waste disposal facility should be required to conduct a cost- benefit analysis that includes all relevant social, environmental, and economic aspects. The project should include host community benefits that are commensurate with the uncompensated social and environmental costs.
- Waste management goals should be set to minimize the residues sent for final disposal rather than based on diversion rates.
- The waste hierarchy should be modified to drive efforts to first reduce the amount generated, recover useful materials, recover fuels in solid, liquid or gaseous form, recover heat, and finally as last resort combust to generate electricity or landfill.
- A disposal tax based on an estimate of the GHG emissions of the final disposal process should be imposed to fund incentives for a more sustainable waste management system.
- The CT Academy of Science and Engineering should be commissioned to study the materials imports and exports and develop options for a more circular economy in CT.
- CT should conduct a study of alternative waste disposal solutions. Any evaluation of technology options should be conducted by an independent third-party entity.
- The state's environmental justice process should be strengthened.

With respect to methane emissions related to organics, we recommend the following:

- Develop zero waste strategy designed to separate organics from MSW, increase quantity and quality of recyclables, and reduce residues sent for final disposal (waste to energy facility or landfilll).
- Mandate or incentivize the diversion of organic materials from landfill disposal stream.
- Create markets to support organics diversion.
- Develop and implement food rescue and recovery programs.
- Accelerate development of infrastructure to utilize diverted organic material.
- Capture opportunities at wastewater facilities. Require methane recovery technologies; use of anaerobic digesters to capture and use methane to generate renewable electricity.
- Deploy advanced thermal gasification / pyrolysis processes to reduce environmental impacts of waste disposal & yield more valuable co- products, such as transportation fuels & chemical feedstocks.

New recommendation – Promote urban and suburban tree planting

A different type of carbon pool exists in the urban forest. Connecticut is a heavily urbanized state. According to Forest Service analysis, 36.4 % of the land area of the state is urban (1.13 million acres), with 87.7% of the population, nearly 3 million people, living in these urban areas (FIA). Despite the high population concentration in these areas, these same lands have a fairly high degree of tree cover, with tree canopy cover estimated at nearly 50%. These urban trees are storing about 22.5 million tons of carbon and continue to sequester carbon at the rate of about 744 thousand tons per year (FIA), and the

importance of urban trees is magnified by the proximity to people and the important co-benefits that trees provide to human health.

Because of higher light levels and reduced competition from other trees, edge forests and residential and urban treescapes typically contain larger trees, on average, and therefore store more carbon per tree or area of forest than do interior forests and trees.[12] Hence their climate mitigation value is disproportionately large and should be reflected in the level of protection that they are afforded. Residential and urban trees and forests also shade and cool buildings in summer and insulate them in winter, which significantly reduces energy levels of air conditioning and heating fuel and associated carbon emissions.[13] Moreover, large trees reduce airborne pollutants (i.e., carbon monoxide, Sulfur dioxide, nitrogen dioxide, ozone, and particulate matter) to a much greater extent than do small trees. For example, a large tree ≥30 inches in diameter at breast height (dbh) removes an estimated 60-70 times the pollutants as a small tree <3 inches in dbh.[14]

Urban trees and other natural systems provide a range of physical health benefits. Trees can improve air and water quality, mitigate the heat island effect, and help alleviate noise (Nowak and others 2010). Trees can shield people from ultraviolet (UV) radia-tion, the cause or contributing factor for three types of skin cancer (Nowak and Heisler 2010). Urban ecosystems are increasingly recommended by national and State envi-ronmental protection agencies to mitigate the harmful impacts of air and water pollutants, harmful emissions, and the negative effects of urban heat and noise (Wolf and Robbins 2015). Trees also help reduce flooding by slowing rainwater runoff.

The impacts of climate change on health and health inequities are moderated by individual and community vulnerability and resilience. Interventions that improve the social determinants of health and population health and reduce health inequities can significantly reduce vulnerability and increase resilience to climate change, at the individual and community-levels. Increasing resilience to climate change will require investing significantly in the public sphere, including in social determinants of health and in public health infrastructure.

Many climate actions bring significant health co-benefits, but some may have significant adverse health consequences and/or increase health inequities. Some health interventions also have climate co-benefits. Thoughtful implementation of actions to reduce greenhouse gas emissions and adapt to climate impacts will help maximize co-benefits and minimize co-harms.

[12] [i] Reinmann, A. B., & Hutyra, L. R. (2017). Edge effects enhance carbon uptake and its vulnerability to climate change in temperate broadleaf forests. *Proceedings of the National Academy of Sciences*, *114*(1), 107-112. Nowak, D.J., Crane, D.E., 2002. Carbon storage and sequestration by urban trees in the USA. Environmental Pollution 116 (3), 381e389.

[13] https://www.itreetools.org/.

[14] Nowak, D.J., 1994. Air pollution removal by Chicago's urban forest. In: McPherson, E.G., Nowak, D.J., Rowntree, R.A. (Eds.), Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. USDA Forest Service General Technical Report NE- 186, Radnor, PA, pp. 63-81.

Appendices	
Appendix 1	Members of the Non-Energy Team
Appendix 2	Acronyms and abbreviations
Appendix 3	Preliminary glossary

Appendix 1: The Non-energy team

Chair	
Charles Rothenberger	CT Fund for the Environment
Working Group	
Patrick Carleton	Metropolitan Council of Governments
Tony Cherolis	Transport Hartford Academy at the Center for Latino Progress
Bill Finch	Discovery Museum & Planetarium
Deb Geyer	Stanley Black & Decker
Patrice Gillespie	CT Clean Water Fund / CT Energy Network
Stanley McMillen	UConn
Bernie Pelletier	People's Action for Clean Energy
Tom Swarr	GC3 Equity & Environmental Justice Working Group
Other Stakeholders	
Lynne Bonnett	New Haven Energy Task Force
Sten Caspersson	CT Academy of Science & Engineering
Evan Dantos	Robinson & Cole
Eric Hammerling	Connecticut Forest & Park Association
Lisa Hayden	New England Forestry
Wilhemina Krahn	Metropolitan Council of Governments
Diane Lauricella	CT Green Building Council
Elsa Loehmann	(environmental engineer)
Richard Love	Raytheon
Cary Lynch	Nature Conservancy
Denise Savageau	CT Council on Soil and Water Conservation
Mark Scully	People's Action for Clean Energy
Anji Seth	UConn Geography/GC3 Science & Technology Working Group
Jon Slifka	Department of Aging and Disability Services
David Sutherland	Nature Conservancy
DEEP support staff	
Jeff Howard	Bureau of Energy & Technology Policy
Doris Johnson	Commissioner's Office
Brian Basso	Intern

Appendix 2: Acronyms and Abbreviations

Term	Full Name	Term	Full Name
CO_2	Carbon Dioxide	**MDC**	Metropolitan District
CO_2e	Carbon Dioxide Equivalent	**MSW**	Municipal Solid Waste
CT	Connecticut	**NAHB**	?
DBH	Diameter at Breast Height	**OPM**	Office of Policy Management
DEEP	Connecticut Department of Energy and Environmental Protection	**PBT**	Persistent Bioaccumulative and Toxic Chemicals
EPA	Environmental Protection Agency	**POCD**	Connecticut's state Plan of Conservation and Development
FIA	?	**PURA**	Connecticut Public Utilities Regulatory Authority
GC3	Governor's Council on Climate Change	**SLCP**	Short-Lived Climate Pollutant
GHG	Greenhouse Gas	**USCA**	US Climate Alliance
GWP	Global Warming Potential	**USDA**	United States Department of Agriculture
HFC	Hydrofluorocarbon	**UV**	Ultraviolet Radiation
HFO	Hydrofluoroolefin	**WTE**	Waste to Energy

Appendix 3: Preliminary glossary

Term	Definition	Term	Definition
Complete Streets	Transportation policy and design approach for communities to help "ensure streets are safe for people of all ages and abilities, balance the needs of different modes, and support local land uses, economies, cultures, and natural environments."	**Hydrofluorocarbons**	Common chemical refrigerant that has high Global Warming Potential
Connecticut Green Plan	Comprehensive Open Space Acquisition Plan. Directs the State's land acquisition priorities to meet a goal of conserving 21% of Connecticut's land base as open space by year 2023	**Hydrofluoroolefins**	An alternative refrigerant to HFCs with reduced Global Warming Potential compared to HFCs.
CO2e	The amount of carbon-dioxide emission that would have the equivalent global warming potential of a given greenhouse gas	**Non-Energy Greenhouse Gas Emissions**	Emission of greenhouse gases into the atmosphere that is not directly tied to energy generation, e.g., methane leaks in a natural gas transmission pipe
Diameter at Breast Height	The diameter of a tree at approximately 4.5 feet from ground level	**Persistent, Bioaccumulative and Toxic Chemicals**	Toxic chemicals that break down slowly in the environment and therefore accumulate inside living tissue.
Environmentally Significant Leak	PURA defined threshold for prioritizing mitigation of gas leaks	**Short Lived Climate Pollutant**	Pollutants that spend less time than Co2 in the atmosphere on average, but

			have higher global warming potentials
Equity and Environmental Justice	Ensuring that no segment of the population should, because of its racial or economic makeup, bear a disproportionate share of the risks and consequences of environmental pollution or be denied equal access to environmental benefits.	**Social Determinants of Health**	The conditions in the environment in which people are born, develop, live, work, and age that impact public health.
Global Warming Potential	A measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (EPA.gov)		
Heat Island Effect	The result of an urbanized area being significantly warmer than the surrounding area due to human activity		

Chapter 5

Transportation

Chapter overview	
Equity & environmental justice overview	
Adaptation & resilience overview	
Progress on 2018 recommendations	**Strategies** Enhancements and new strategies recommended
Maintain increasing fuel economy and low- and zero-emission standards	• Maintain adherence to Corporate Average Fuel Economy and GHG emission standards mid-term review 2016 final determination. • Maintain adherence to California low-emissions and zero-emission vehicle requirements. • Establish emissions standards for medium- and heavy-duty vehicles, including school buses.
Increase light-duty ZEV penetration rate to at least 20 percent by 2030	• Implement price signals to incentivize EV adoption and reduce electric system impacts • Expand EV charging network to ensure consumer confidence and reduce range anxiety • Develop a State fleet transportation Lead by Example program that sets annual emissions-reduction targets and enables increasing adoption of zero-emission vehicles • Establish specific ZEV targets that align with the ZEV MOU and the 20 percent by 2030 target • Expand the Lead By Example approach to encourage electrification of municipal fleets • Establish statewide goals for zero-emission medium- and heavy-duty trucks and for school transportation • Establish new sources of funding for EV rebate programs • Expand/strengthen the market for the full-range of electric vehicles
Advance initiatives that eliminate VMT growth by 2030	• Implement Transit-Oriented Development projects and adopt state policies and local zoning regulations that support walkable, mixed-use, and sustainable urban and suburban development in areas served by transit. • Encourage, incentivize, and support alternative modes and active transportation that reduce single-occupant vehicle driving. • Remove the legislative barrier to exploration of a mileage-based user fee • Transit benefit, parking cash-out, and telecommuting for state employees • Implement state and regional policies designed to reduce VMT
Develop sustainable funding for transportation electrification and transit infrastructure	• Implement a multi-state cap-and-invest program that: sets a limit on transportation sector emissions and reinvests program proceeds in measures that reduce emissions; provides benefits to citizens, especially LMI communities; protects existing transportation funding; generates sufficient additional funding to support transportation infrastructure and operation; and mitigates costs to consumers.

	○ Continue and expand surveys, public meetings, and public engagement on this proposal throughout 2020 and into 2021, including intentional outreach to rural communities and low-income communities. • Implement transportation user fees -- market mechanisms to reduce traffic congestion and improve efficiency of travel for all drivers.
New recommendation – Explore/emphasize strategies to reduce total number of vehicles on the road	• Explore car-share options for municipal and state fleets as a complement to electrification
New recommendation – Reduce emissions from freight transportation	• Address GHG emissions in state-level freight planning • Seek opportunities to shift freight from trucks to rail and ports • Expand waste reduction and recycling programs

Introduction

The transportation sector is responsible for nearly 40 percent of Connecticut's greenhouse gas (GHG) emissions.[1] Even as other sectors have reduced emissions in the last decade, transportation emissions have remained consistently high for several years. This chapter reviews the four broad transportation-related recommendations in GC3's 2018 report and the corresponding strategies proposed for each.[2] For each, the chapter assesses progress, identifies challenges and gaps, and outlines enhancements and additional strategies and recommendations for achieving the broader objectives in that area. Recognizing that a key intersection of transportation policy and climate policy is impact on low- and moderate-income (LMI) communities and communities of color, the chapter highlights the equity and environmental justice (EEJ) considerations of all the policies under review. It also briefly explores which of these strategies can advance both climate mitigation and climate adaptation and resiliency.

Equity and environmental justice overview

Vehicle emissions are the major contributor to poor air quality in Connecticut's urban areas.[3] LMI, rural, and marginalized communities should share in the benefits of a clean energy transportation system. LMI and marginalized communities often abut major corridors and transportation centers, therefore bearing a disproportionate public health impact from transportation-related pollution. Grant programs and

[1] DEEP, 2017 Connecticut Greenhouse Gas Emissions Inventory, https://www.ct.gov/deep/lib/deep/climatechange/publications/2017_ghg_inventory_date_edited.pdf.
[2] This report was written by the Transportation Sector Team of the GC3's Progress on Mitigation Strategies Working Group, with input from a number stakeholders. Appendix 1 provides a list of team members and stakeholders.
[3] DEEP, 2020 Electric Vehicle Roadmap for Connecticut: A Policy Framework to Accelerate Electric Vehicle Adoption, p. 12.

other initiatives focused on replacing medium- to heavy-duty fossil fuel vehicles should give priority to such vehicles that operate in these communities.

Traditionally, LMI households spend a far greater share of income on transportation services than wealthier households do, with some LMI households devoting more than 15 percent of their total income. For many such households, vehicle ownership is simply not viable due to financial constraints or ease-of-use concerns, or it holds less appeal because public transit or alternative travel modes are more financially accessible.

Expanding access to zero-emission vehicles (ZEVs) in LMI communities: Expanding access to ZEVs in LMI communities will require intentional policies such as:

- actively promoting rebates for used ZEVs (available in early 2021);
- requiring car-share and ride share companies to establish ZEV fleet percentage goals that align with the state's goals and providing rebates for ZEVs purchased by such companies;
- allowing state and municipal ZEV fleets to be managed by a car-share company that can rent them to local residents on weekends and evenings; and
- exploring the potential for electric utilities to own and operate public charging infrastructure in rural and underserved communities where private investment is falling short (with the Public Utilities Regulatory Authority providing oversight of any impacts on ratepayers).

Prioritizing investments in active transportation and transit: Active transportation (walking and biking) and high-quality transit systems that enable users to get where they are going safely and efficiently are particularly important in municipalities with low-income and diverse communities. Such communities typically have much lower rates of car ownership than residents of suburban and rural towns. Investment of funds from alternative funding mechanisms—e.g. Transportation and Climate Initiative or a vehicle miles traveled (VMT) tax—should prioritize measures that address these equity concerns and positively impact EJ communities.

Vulnerable user safety: It is difficult to promote increased active transportation in a state where the incidence of pedestrian fatalities is rising and where none of the four cities with high zero-car ownership household levels (Hartford, New Haven, Bridgeport, and Waterbury) have connected, cross-city bike route networks. People are less inclined to walk and ride when personal safety concerns are significant.

Creating an equitable and inclusive clean transportation system will require harmonizing automobile ownership-based solutions with inclusive ZEV ridesharing, community bicycle access, e-bike and e-scooter incentives, and public transit initiatives that, when implemented together, offer LMI households a range of reliable options to get to destinations safely, efficiently, and affordably, while helping to reduce GHG emissions and driving down air pollution in LMI and EJ communities. It also will be important to understand and account for urban-rural differences when crafting such policies.

Adaptation and resilience overview

To strengthen the resilience, reduce the vulnerabilities, and mitigate the environmental impacts of the transportation sector, Connecticut must reduce emissions, implement more sustainable land use practices, and create a more equitable and accessible multi-modal transportation system. Reducing

suburban and rural car-centric sprawl will improve the sector's overall resilience. Town centers, employment centers, and urban areas that are well-served by transit while also being safely walkable and bikeable are both more resilient and have lower emissions than an overwhelmingly car-centric system. A state that has more sustainable transportation options, including transit and active transportation, is more resilient to future economic and climate change challenges. Reducing emissions today reduces the probability of devastating storms and other climate impacts in the future, and therefore has long-term resiliency benefits.

Sustainable funding for transportation electrification and infrastructure: Both a multi-state cap-and-invest program, such as TCI, and a mileage-based user fee would generate funds that the state should intentionally invest in ways that strengthen the resilience of the transportation system and enable cleaner travel options. The cornerstone of TCI is support for the transformation of our state's transportation system with increased electrification, transit ridership, and active transportation while encouraging development in-fill and transit-oriented development. These investments will help upgrade the state's aging transportation infrastructure with a clearer view of likely climate change impacts, such as sea level rise and more frequent extreme storms.

Implementation of a multi-modal transportation network: Prioritizing multi-modal access to destinations and jobs, while reducing the priority of inefficient, low-occupancy vehicle travel in town centers, urban areas, and around high frequency transit hubs and transit corridors will improve the resiliency of the state's transportation system and the communities it serves. The state should promote and invest in initiatives that encourage active transportation, complete gaps in regional and statewide transportation networks, and increase and expand service on our rail and transit lines. Such investments should be coupled with complementary land-use policies that will create urban and suburban communities that promote shorter trips, reduce automobile trips, and ultimately reduce the rate of VMT growth and car ownership.

Investment in a full range of electric vehicles (EVs): Connecticut should more intentionally integrate small electric vehicles, including ultra-compact EV cars, e-bikes, and e-scooters, into its EV planning. Charging for these smaller EVs can be served by the existing electrical infrastructure or more resilient microgrids, especially in urban areas where it may be more difficult to install public fast-charging facilities. To take full advantage of e-bikes and e-scooters, cities and town centers must be designed with connected, safe bike routes.

Telecommuting: The COVID-19 pandemic demonstrated many state agencies were less resilient than businesses that had already implemented work arrangements that allowed for, and in some cases encouraged, telecommuting. Beyond the opportunity for reduced driving and emissions, increased rates of telecommuting for state employees and other workers provides better operational resiliency during extreme weather events and pandemics. The pandemic disrupted the narrative that state employees could not telecommute at rates seen in the private sector, and it is imperative that we consider what other false limitations are holding Connecticut back from meeting our combined mitigation and adaptation priorities.

Maintain increasing fuel economy and low- and zero-emission standards

Improving fuel economy of internal combustion engines (ICE) is an essential part of GHG reduction in the transportation sector. Vehicle emissions account for the bulk of the state's transportation emissions and disproportionately affect LMI communities due to the density of traffic in or near these areas.[4] High-efficiency ICEs encourage more driving, so complementary measures (e.g. a transition to ZEVs) are needed to reduce overall GHG emissions.[5]

Strategy – Maintain adherence to Corporate Average Fuel Economy (CAFE) and GHG emission standards mid-term review 2016 final determination [PRIORITY]

Strategy – Maintain adherence to California low-emissions and zero-emission vehicle requirements [PRIORITY]

Progress to date – Progress on both of these recommendations has been hindered by concerted federal action. In August 2018, EPA and NHTSA issued a proposed rule, The Safer Affordable Fuel-Efficient Vehicles Rule for Model Years 2021 to 2026 Passenger Cars and Light Trucks (SAFE Vehicles Rule), seeking to significantly weaken the GHG emission and CAFE standards and revoke the CAA waiver that permits California to set tailpipe emissions standards more stringent than the federal standards.[6] Connecticut joined 23 states and Puerto Rico in signing the Nation's Clean Car Promise in opposition to the proposed rule.[7] Connecticut also joined a coalition of 26 jurisdictions that filed a complaint on September 26, 2019, challenging the Trump Administration's intention to preempt California's authority to regulate motor vehicle GHG emissions and issue ZEV standards.[8]

The 2018 GC3 report neglected to provide any recommendations regarding emissions standards for medium- and heavy-duty vehicles.

Enhancement – Establish emissions standards for medium- and heavy-duty vehicles, including school buses. [PRIORITY]

State legislation introduced in 2020 (S.B. 10) incorporated a provision to authorize Connecticut to adopt California's emissions standards for these vehicles. Diesel vehicle exhaust from trucks and buses contribute to higher levels of air pollution and particulate matter (PM2.5) in urban areas and low-

[4] [INSERT REFERENCE(S)]
[5] Appendix 2 presents a summary of Connecticut state policies and statutes related to transportation emissions.
[6] Section 209 of the Clean Air Act (CAA) permits California to seek a waiver of the preemptive effect of the CAA, which otherwise prohibits states from enacting emission standards for new motor vehicles stricter than federal standards. Under the CAA, California may request a waiver to set emissions standards more stringent than the federal government. If approved, other states may then adopt California's standards.
[7] The Nation's Clean Car Promise. United States Climate Alliance. July 9, 2019.
[8] California v. Chao, No. 1:19-cv-02826 (D.D.C. filed Sept. 20, 2020). The coalition includes 23 states, the District of Columbia, and the cities of Los Angeles and New York. Connecticut is among the coalition states that have adopted California's GHG and ZEV standards. These states comprise more than 35 percent of the domestic LDV market in the United States.

income communities, which are often communities of color. In recent years, the state has taken concrete steps to reduce emissions from this segment of the fleet with support from federal programs and Volkswagen Settlement money, as well as commitments to ZEVs constituting 30 percent of the state's transit buses and 30 percent of medium- and heavy-duty truck sales by 2030. Establishing statewide emissions standards would complement the shift to ZEVs by requiring trucks still operating on fossil fuels to use the most effective exhaust-control technology and/or alternative fuels.

Increase light-duty ZEV penetration rate to at least 20 percent by 2030

According to the Northeast States for Coordinated Air Use Management analysis in GC3's 2018 report, achieving the 2030 interim economy-wide GHG emissions reduction target will require 500,000 ZEVs (roughly 20 percent of the total light-duty fleet) to be registered in Connecticut by that date. With only about 12,000 ZEVs currently registered in the state, reaching this goal will require substantial and coordinated action.[9] Because many households do not own cars or may not be able to afford a ZEV, intentional policies are required to provide more equitable access to a full range of ZEVs. ZEVs require little maintenance, but they will increase electricity demand. ZEV penetration will be enhanced as these vehicles purchase costs decline, their ranges increase, and charging times decrease. Incentives such as Connecticut Hydrogen and Electric Automobile Purchase Rebate (CHEAPR) must be expanded and sustained until targets are met. Finally, as the proportion of ZEVs increases, motor fuels tax proceeds will continue to decline, and the state will need to identify alternative sources of transportation funding, such as road user fees.

Equity and environmental justice – Reducing motor vehicle air pollution in urban and LMI communities will be an equity and environmental justice benefit of higher ZEV purchases, as these communities are disproportionately impacted. The respiratory issues associated with long-term air pollution exposure have been amplified by disproportionate COVID-19 fatality rates. Electric cars, and cars in general, are not in the budget of many households[10]. LMI households that do not have a car often use taxis, rental vehicles, rideshare, and car share services. Electrifying private fleet vehicles has an equity benefit, especially in cities with low car-ownership rates. The CHEAPR program needs to expand to include rebates that increase EV adoption rates for private fleet vehicles that operate in such communities. Establishing new rebate programs to encourage purchases of electric motorcycles, bicycles and scooters would also have an equity benefit for LMI communities.

Strategy – Implement price signals to incentivize EV adoption and reduce electric system impacts [PRIORITY]

[9] In April 2020, CT DEEP released the *Electric Vehicle Roadmap for Connecticut: A Policy Framework to Accelerate Electric Vehicle Adoption*.

[10] Appendix 3 provides an affordability analysis of a used EV for a median-income household in Hartford.

The CHEAPR program supporting zero-emission electric vehicles and fuel cell vehicles is allocated $3 million per year through 2025 from revenue generated by the state's vehicle GHG emissions reduction registration fee set in the 2019 legislative budget, Section 94 of PA 19-117.[11] The 2019 legislation established a new CHEAPR governing board, with designated membership, and prompted DEEP to pursue rebates for used EVs and an additional rebate for LMI buyers. The program changes are expected in late 2020 to early 2021; and until then rebates have been continued at 2019 levels. CHEAPR Board members have recommended increasing the funding level for EV rebates to improve the effectiveness of the program, in part through updated legislation that would utilize the full $8 million projected from the GHG emissions-reduction registration fee, and a proposal for a gas guzzler tax on non-commercial low-gas-mileage personal vehicles not currently covered by the federal gas guzzler program.

CT DEEP has a detailed website with program statistics, and the EV Club of CT has performed detailed program analysis. Between the CHEAPR program's initiation in 2015 and July 31, 2020, a total of 6,049 rebates were issued: 3,193 for plug-in hybrids and 2,866 for battery electric vehicles.[12] The state's goal for light-duty ZEVs by 2030 was set at 20 percent of the fleet in the 2018 GC3 report. Connecticut is also party to a multi-state zero-emission vehicle memorandum of understanding (ZEV MOU),[13] under which Connecticut has committed to an ambitious goal of putting 125,000 to 150,000 EVs on the road by 2025, equivalent to 5-6 percent of the total number of Connecticut light-duty vehicles on the road.

Through 2019, ZEVS constituted only 0.5 percent of Connecticut's light-duty fleet.[14] In order to reach the 2025 and 2030 goals, the annual rate of ZEV sales must increase significantly, year after year. As noted in a recent analysis of 2020 EV rebates[15], the CHEAPR program needs to be adjusted both to spend the allotted $3 million in annual funds and to increase the number of ZEVs purchased. Post-pandemic EV rebate levels should be adjusted upward and expanded to additional markets. Rebate popularity and levels can be evaluated and adjusted as necessary to avoid overspending the program budget as the economy recovers.

ZEV rebates should be expanded to include e-motorcycles, e-scooters, and e-bicycles.[16] [17] These smaller ZEVs have much lower lifecycle emissions due to their much smaller batteries and lower vehicle weight. A transportation system with a higher percentage of e-micromobility vehicles and fewer cars would improve the state's progress toward its emissions-reduction goals. Small ZEVs also provide an equity benefit, as the purchase price and maintenance costs are much lower than a car.

Strategy – **Expand EV charging network to ensure consumer confidence and reduce range anxiety**

[11] Total proceeds from the fee were estimated to be $8 million per year (Source is two OLR Reports here and here).
[12] CT CHEAPR Program Statistics, updated periodically.
[13] Zero-Emission Vehicle Memorandum of Understanding.
[14] CT By The Numbers, May 4th, 2020, "On the Road Again? State Issues Electric Vehicle Roadmap"
[15] CHEAPR Rebates Continue at Slow Pace – May 2020 Update
[16] In New England, declining car sales prompt call for electric bike rebates
[17] Letters in support of e-bike rebates presented at the 7/17/2020 CT CHEAPR meeting

As of July 2020, there are 393 alternative fueling stations, which includes biodiesel (B20 and above), compressed natural gas, electric, ethanol (E85), hydrogen, liquefied natural gas, and propane.[18] Across the state there are 376 publicly accessible EV charging stations – Level 2 and DC Fast Charge – with a total of 965 charging outlets. In addition, there are 51 private Level 2 charging stations with 85 total charging outlets in Connecticut.[19]

PURA is currently reviewing proposals submitted in response to a Request for Program Design Proposals to realize a comprehensive, portfolio approach to enable and optimize deployment of EV supply equipment (EVSE) and associated distribution-system infrastructure necessary to meet the state's transportation electrification goals.[20]

To ensure consumer confidence, the number of public charging stations needs to be increased dramatically both along our highway corridors and throughout our municipalities. A recent report found that regions with the highest adoption rates have two to six times greater than average charging infrastructure and tend to have 275 charging stations per million people – which is more than twice the statewide average. [21] State and local governments could take a number of steps to enable and expand deployment of EVSE, including:

a. Revise zoning regulations and building codes to require a minimum number of ZEV parking spaces for new construction in both multi-unit dwellings and commercial properties and to require all new residential construction to be EV-ready.[22]

b. Provide incentives to property owners of existing multi-unit dwellings and to homeowners associations to add charging stations.

c. Require municipalities to develop EV-adoption plans that include: educational programs for business owners, commercial property owners and residents; overnight charging opportunities for people without garages; and dedicated ZEV parking with EV charging at municipal offices.

[18] U.S. Department of Energy, Alternative Fuels Data Center, Electric Vehicle Charging Station Locations (https://afdc.energy.gov/fuels/electricity_locations.html#/analyze?country=US&region=US-CT, accessed on 7/29/2020) provides a list of charging stations with detailed parameters for each one.
[19] Level 2 charging requires the installation of charging equipment using 240 volts of power. It can deliver 12-25 miles of vehicle range per hour, depending on the type and charging capability of an EV. DCFC is currently the quickest charging solution for EVs, charging some EVs to 80% in 20-30 minutes. It can deliver a charge of 100 or more miles of vehicle range per hour.
[20] After it reviews all timely submitted proposals, PURA stated it intends to create and issue one straw proposal and request written comments from stakeholders. Notice of Release of Final Requests for Program Design and Proposals. May 6, 2020.
[21] The International Council on Clean Transportation: "Expanding The Electric Vehicle Market In U.S. Cities" (https://theicct.org/publications/expanding-electric-vehicle-market-us-cities)
[22] An EV-ready structure is designed and built with the infrastructure necessary to accommodate an EV.

d. Alternative Fuel Corridor[23] signage needs to be posted on the Federal Highway Administration's Designated Corridors in Connecticut to let drivers know about available charging and to encourage additional charging stations.

Strategy – Develop a State fleet transportation Lead by Example program that sets annual emissions-reduction targets and enables increasing adoption of zero-emission vehicles.

Progress to date – Executive Order 1, signed by Governor Ned Lamont on April 24, 2019, directs state agencies to "Lead by Example" by setting targets and policies for the state vehicle fleet to achieve near-term and 2030 GHG emissions reductions, and creates the Clean and Efficient Transportation Impact Team to help inform recommendations. An interagency team is charged with developing EV and infrastructure deployment plans in all executive agencies, and these plans are to be incorporated into the GreenerGov Handbook. As of April 2020, the state's fleet of more than 3,500 vehicles includes only 17 hybrids and 5 electric vehicles. Under the current Department of Administrative Services (DAS) procurement plan, the State will increase its purchases of EVs each year, starting with 5 percent of purchases in 2020 and increasing by 5 percent each year in order to meet the goal of having EVs account for 50 percent of new purchases in 2030.

DAS and the interagency team should actively seek opportunities to reduce the overall number of vehicles in the fleet. Actions designed to increase state employees' use of transit and active transportation, as outlined elsewhere in these recommendations, should be considered in developing a coordinated strategy to reduce reliance on agency fleet vehicles.

Plans for increasing the number of ZEVs in the State's light-duty vehicle fleet should incorporate criteria that prioritize replacement of fleet vehicles that operate in LMI and EJ communities. As the state pursues this shift toward ZEVs, agencies must find ways to continue meeting accessibility needs, since ZEVs are often smaller and more difficult for people with mobility impairment to use – as either passengers or drivers.

Across the strategies laid out in 2018 for light-duty ZEVs, a number of gaps and challenges stand out:

- annual targets/benchmarks for passenger/light-duty vehicles;
- look beyond the state fleet to require municipal EV-readiness plans and encourage electrification of municipal fleets;
- expand ZEV targets for medium and heavy duty vehicles to school buses and trucks;
- establish new sources of funding for EV rebate programs;

[23] https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/all_corridors/

- expand/strengthen the market for the full-range of electric vehicles;
- incentivize electrification of "long haul" fleets; and
- provide education for green hydrogen that supports medium- and heavy-duty trucks.

These are addressed by the following recommended new strategies.

New strategy – Establish specific ZEV targets that align with the ZEV MOU and the 20 percent by 2030 target

Under the ZEV MOU, Connecticut has committed to deploying 125,000 to 150,000 ZEVs by 2025. And the goal GC3 recommended in 2018 – 20 percent EVs in the statewide fleet of passenger and light-duty vehicles in 2030 – would be roughly 500,000 vehicles. As of Jan. 1, 2020, Connecticut had registered a mere 11,677 EVs, so a major escalation of efforts to increase the penetration of EVs in the Connecticut vehicle market is required. We propose establishing a timeline of annual targets that can help assess whether the state is on track to meet its long-term commitment. Appendix 4 presents a series of proposed annual targets in a chart and graph.

New strategy – Expand the Lead By Example approach to encourage electrification of municipal fleets

Each municipality should be required to develop an EV Readiness Plan that maps out how it will transition to a zero-emission fleet by 2050. As part of that plan, a fleet inventory should be completed and municipalities should work with CT Clean Cities Coordinators to help them identify how to start the transition. Municipalities should be encouraged to participate in educational programs that lead them through the process of electrification. Town/city leadership should encourage and incentivize town employees to successfully create and implement EV transition plans. Municipalities should also seek opportunities to work with the utilities on potential "vehicle-to-grid" projects. Partnerships with manufacturers and multi-municipality purchases could reduce costs.

New strategy – Establish statewide goals for zero-emission medium- and heavy duty trucks and for school transportation [PRIORITY]

In July 2020, Connecticut joined 14 states and the District of Columbia in announcing a joint MOU, committing to work collaboratively to accelerate the market for zero-emission medium- and heavy-duty vehicles, including large pickup trucks and vans, delivery trucks, box trucks, school and transit buses, and

long-haul delivery trucks (big-rigs).[24] The goal is to ensure that 100 percent of sales of new medium- and heavy-duty vehicle are zero-emission vehicles by 2050, with an interim target of 30 percent zero-emission vehicle sales by 2030. While much of the focus is on electric vehicles, "green hydrogen" offers another alternative to be explored. Green hydrogen is derived from electrolysis using electricity from renewable sources to separate hydrogen from oxygen in water, and it can be used in fuel-cell-powered vehicles that have zero emissions.[25]

CT should build on this new MOU by establishing a statewide goal of electrifying 50 percent of school buses and other school vehicles by 2030. Meeting this goal by prioritizing large urban districts will enhance the equity benefits of this recommendation. The City of Hartford has already incorporated a goal of electrifying 100 percent of its school vehicles by 2035 in its Plan of Conservation and Development.[26] Several Connecticut cities are ranked as U.S. asthma capitals; these include Hartford and New Haven, at #13 and #11, respectively. Electrifying school buses, especially in urban areas, would have a significant environmental justice a co-benefit to reducing greenhouse gas emissions. To achieve an ambitious goal for zero-emission school transportation, school district fleet managers and/or operations and finance directors should be mandated to review their contracts with service providers and establish a plan for transitioning to electric school buses, working with the utilities and taking advantage of grants where possible.[27]

Similarly, municipal fleet managers should establish plans for transitioning waste hauling and other public works vehicles to zero-emission technology, which could involve renegotiating contracts with private service providers.

New strategy – **Establish new sources of funding for EV rebate programs**

Two approaches should be adopted:

- All proceeds from the state's GHG emissions-reduction vehicle registration fee should be allocated to CHEAPR.
- A gas-guzzler fee on new vehicles sold in Connecticut, perhaps in conjunction with other states in the ZEV MOU, should be dedicated to the CHEAPR rebate budget and to related charging infrastructure projects across the state.

[24] Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Memorandum of Understanding
[25] See information on green hydrogen-powered vehicles in *CT 2020 H2 Roadmap* (https://www.ccat.us/wp-content/uploads/2020/05/2020-CT_H2_Fuel_Cell_Dev_Plan_w-Cover-PDF-1-8-20.pdf) and The Hydrogen Council Roadmap (https://hydrogencouncil.com/wp-content/uploads/2020/01/Path-to-Hydrogen-Competitiveness_Full-Study-1.pdf).
[26] Hartford City Plan, City of Hartford, Planning and Zoning Commission, adopted May 12, 2020, p. 20.
[27] Live Green and the CT Southwestern Area Clean Cities Coalition have developed a variety of resources for towns pursuing electrification of school transportation, including: the Municipal EV Readiness Toolkit 12-Month Program and the Electric School Bus Bootcamp.

Equity and environmental justice – Large, low-efficiency new SUVs, trucks, and vans make their way to middle- and lower-income households. Having low-efficiency and high-emissions vehicles concentrated in low-income communities while plug-in hybrids and BEVs increase in middle and higher income communities is its own equity and disproportionate pollution exposure concern. It would be important from an equity standpoint to apply a gas-guzzler fee to new vehicle sales but not used vehicle sales. To remove aging gas guzzlers from the fleet, there is a model "cash-for-clunkers" program in California that helps low-income owners of low-efficiency fossil fueled vehicles trade them in for plug-in hybrids, BEVs or receive a credit for transit, an e-bike, or a bike share membership.[28] The gas-guzzler fee should not be applied to Americans With Disabilities Act-modified vehicles, at least until cost-competitive ZEV vehicles are reasonably well established in that vehicle class.

New strategy – Expand/strengthen the market for the full-range of electric vehicles

Four approaches should be adopted:

- remove the legal barrier to direct sales of EVs in Connecticut[29];
- accelerate plans to offer CHEAPR rebates on used EVs and seek other ways to make used EVs more available;
- establish ZEV rebates for e-motorcycles, e-scooters, and e-bicycles; and
- establish mandatory training for dealerships on ZEVs and buyer incentives.

Equity and environmental justice – Applying ZEV targets and rebates with a primary focus on battery electric cars is inherently inequitable and puts zero investment into clean and cost-effective mobility for low-income, zero-car, and car-light households.

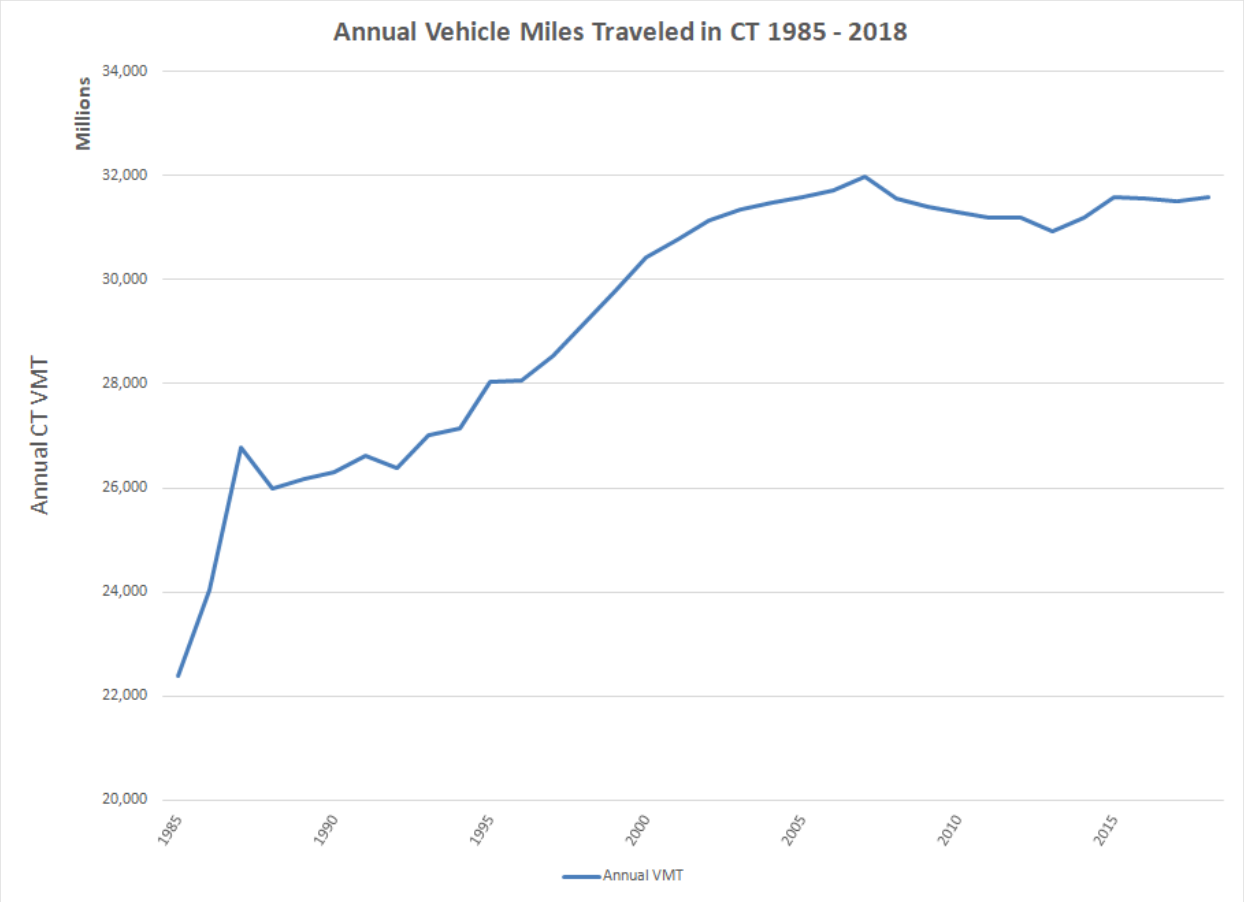
Advance initiatives that eliminate VMT growth by 2030

Substantially reducing GHG emissions in the transportation sector will be achieved in part by replacing ICE vehicles with ZEVs in all vehicle categories, by increasing fuel efficiency, and by increasing use of alternative fuels in vehicles that continue to operate on fossil fuels as the transition proceeds. Reducing VMT is equally important, especially in passenger vehicles. Reducing the need for travel in personal vehicles (which are expensive to own, insure, and operate) by incentivizing housing and business clusters around transit nodes is one strategy. Another is implementing a mileage-based user fee that

[28] Appendix 5 provides information about California's gas guzzler/cash-for-clunkers program: Clean Cars 4 All - https://ww3.arb.ca.gov/msprog/lct/vehiclescrap.htm

[29] Legislation introduced in the Connecticut General Assembly in recent years would remove this barrier; see e.g. https://www.cga.ct.gov/2019/TOB/h/pdf/2019HB-07142-R00-HB.PDF

would fund infrastructure maintenance and improvement (e.g., more bike lanes and transit options, better-maintained bridges and harbors). The decline in motor fuel tax revenue will continue, making it essential to identify alternative funding sources. Eliminating free municipal and corporate parking and providing reduced- or no-fare transit passes would help free up valuable acreage, reducing VMT and improving the health of urban communities.



Strategy – **Implement Transit-Oriented Development projects and adopt state policies and local zoning regulations that support walkable, mixed-use, and sustainable urban and suburban development in areas served by transit [PRIORITY]**

Progress to date – Across the state, Connecticut continues to make substantial progress in reducing VMT through Transit Oriented Development (TOD). The State's draft *Conservation & Development Policies: The Plan for Connecticut 2018–2023* consists of a series of growth-management principles that all state agencies must consider when carrying out specified actions with state and federal funding. These principles include a series of policies that have been used to advocate for, and implement, TOD and reduce the rate of VMT growth. The Department of Transportation's 2018–2050 Long Range

Transportation Plan identifies a series of goals, objectives, and policy recommendations to reduce VMT and GHGs by promoting and incentivizing TOD.

Implementation of TOD at the local and regional levels is funded through a series of grant programs. Through the Responsible Growth and Transit-Oriented Development Program, the State has granted 47 awards totaling more than $27M, primarily to municipalities and regional councils of government. Other funding sources include the Connecticut TOD Fund, the Community Connectivity Program, the Local Transportation Capital Improvement Program, and the Brownfield Remediation & Revitalization Program, all of which have provided funding for projects along the state's major transportation corridors.

At the local level, some municipalities have adopted TOD zoning ordinances that aim to enhance surrounding and existing neighborhoods, preserve historic character, revitalize the retail community, provide a range of transit opportunities, and promote mixed-use development that increases employment and the local tax base. These initiatives that encourage active transportation and eliminate gaps in the regional and statewide trail networks, along with increasing and expanding service on our rail and transit lines, are critical to ensuring smart growth, which will lead to reduction in VMT and GHG emissions. Such improvements, coupled with complementary land-use policies, can create urban and suburban communities that promote shorter trips, reduce automobile trips, and ultimately reduce the rate of VMT growth.[30]

Strategy – Encourage, incentivize, and support alternative modes and active transportation that reduce single-occupant vehicle driving [PRIORITY]

Progress to date – CT*rides* helps commuters find the best way to get to work or school and offers information and resources for multi-modal travel options throughout Connecticut. Responding to needs during the Covid-19 pandemic, CT*rides* developed a series of webinars on telecommuting. In May 2018, CT*rides* was working with 259 businesses and institutions across Connecticut. By May 2020, that number had increased to 315.

Many groups and organizations across the state encourage Complete Streets[31] and increased mult-imodal and active transportation mode share.[32] The Transport Hartford Academy, which was formed in 2017 as a program of the Center for Latino Progress, has facilitated an active online discussion group, walk/bike audits, public meetings and workshops, and ongoing action teams. The group's third annual Northeast Multimodal and Transit Summit is planned for November 2020.

[30] Appendix 6 provides additional information on Transportation Demand Management (TDM) as an approach to VMT reduction.

[31] *Complete Streets* is a transportation policy and design approach for communities to help "ensure streets are safe for people of all ages and abilities, balance the needs of different modes, and support local land uses, economies, cultures, and natural environments." https://smartgrowthamerica.org/program/national-complete-streets-coalition/

[32] Connecticut Bicycle and Pedestrian Advocacy Groups

Connecticut's Complete Streets law (Conn. Gen. Stat. §13-153f) requires pedestrians, cyclists, and transit users to be routinely considered in the planning, designing, construction, and operation of all roads. In 2018, Complete Streets policies were in place in ten municipalities; in May 2020,[33] they were in place in twelve and being developed in several more. Connecticut has ten Bicycle Friendly Communities and one Walk Friendly Community.

The City of Hartford initiated a prototype program to provide dockless bike share city wide in mid-2018. The program had no financial support from the city, state, or sponsors and was discontinued.[34] In July 2020, Bridgeport initiated an e-scooter pilot project.

New Haven implemented a docked bike share program in early 2018, but the program recently was discontinued due to a shortfall in advertising revenue. At this point New Haven is working on a permit system for operators interested in bike or e-scooter share operating within the city. Lack of consistent operating and maintenance budgets for urban bike-share systems has been a stumbling block in Connecticut's two recent attempts. Much smaller bike share systems that are sponsored by institutions continue to operate.[35] To incentivize alternatives to driving, bike share/e-scooter share, programs could be sponsored in part with revenue from the CT Green Bank or TCI.

To increase walking and biking mode share, Connecticut needs to reverse a steady climb in annual pedestrian fatalities.[36] In 2019 the state passed a modification of the Vulnerable User Bill, imposing enhanced penalties for reckless drivers who cause significant injury to a person walking or biking.[37] Unlike the prior version of the bill, this updated bill has been implemented at least a dozen times since adoption. A multifaceted road-safety bill[38] was proposed in 2020 but derailed when the legislature went into recess due to the COVID-19 pandemic.

[33] Complete Streets policies nationwide, Smart Growth America

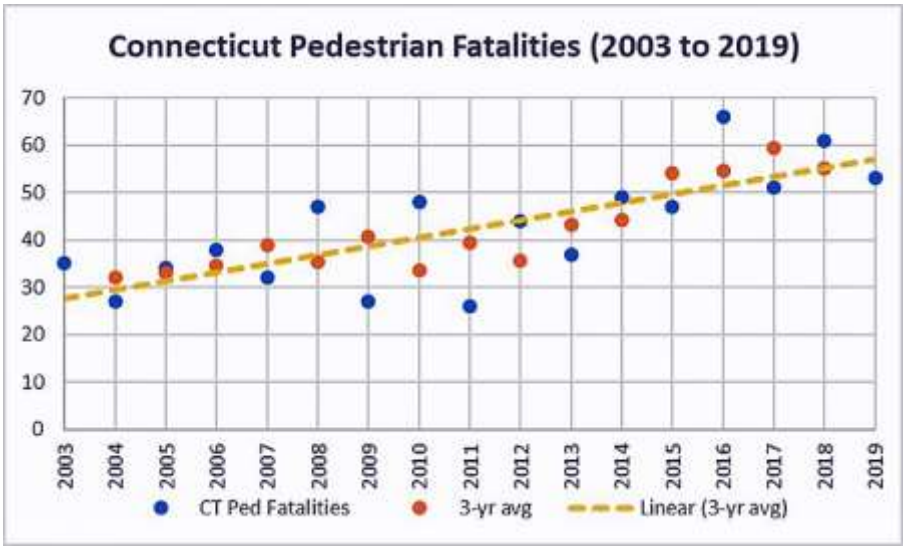
[34] A Fleeting Lime Affair, Real Hartford, February 2019 - "If you do not see Lime bikes out in Hartford this Spring, there are a few reasons why…"

[35] Examples of micro bike share in Connecticut - Simbury Free Bike, Bike New Britain, Art Bikes, and Mystic Community Bikes

[36] State On Pace For 84 Pedestrian Deaths; 2 Safety Bills Stalled in 2019

[37] Vulnerable User Law Change, Included in the 2019 E-Scooter Bill, Public Act No. 19-162

[38] 2020 Raised H.B. No. 5324 - An Act Concerning Pedestrian Safety At Crosswalks, Speed Limits In Municipalities, Fines And Charges For Certain Violations And The Greenways Commemorative Account.



Pedestrian fatalities trending upward, 2003–2019. Source data: UConn Crash Data Repository

Active transportation is particularly important in cities with low-income and diverse communities that have much lower rates of car ownership than suburban and rural towns.[39] One obvious shortfall in 2020 is the lack of cross-city, connected, and safe bicycle routes. One of the biggest incentives for increasing bicycle use is a network of safe, family-friendly bicycle routes that connect residents to destinations within a 2- to 3-mile radius. Investment in safe, connected bicycle infrastructure has good public support. In the 2019 CT's Transportation Future Survey, 91 percent of respondents preferred "expanding/improving sidewalks and bike lanes to provide safe alternatives to driving" as a way to reduce GHG emissions from the transportation sector.

Urban areas and town centers with more developed and well-maintained sidewalks, curb ramps, and connected bicycle routes and multi-use trails reduce Americans With Disabilities Act (ADA) violations that hinder safe and convenient mobility for low-income residents who use wheelchairs, walkers, and adaptive bicycles. Cities and town centers that increase priority for active transportation should be intentional about providing exceptions and design allowances for ADA vehicle access and parking. For example, an urban street closed to private motor vehicle traffic can still allow ADA vehicle access (along with allowances for delivery vehicles).

A number of gaps and challenges are apparent:

- legislative prohibition on exploring mileage-based user fee (MBUF);
- lack of transit benefit for state employees as an alternative to free parking;
- TOD programs need to be augmented by disincentives to sprawl;
- state and regional long-range plans need to address VMT; and

[39] Vehicle Ownership in U.S. Cities Data and Map (2016, from American Community Survey Census Data).

- COVID-19 recovery plans need to explicitly include goals for revitalizing transit and transit ridership.

The following new strategies are recommended to address these.

New strategy – Remove the legislative barrier to exploration of a mileage-based user fee

In setting a price for carbon in the transportation sector, a mileage-based user fee (MBUF) and an emissions trading system (ETS) such as the Transportation and Climate Initiative (TCI) are not mutually exclusive. An MBUF is paid directly by transportation infrastructure users, and the revenue it produces exclusively supports infrastructure maintenance and improvement, while TCI sets a declining cap on carbon emission from burning fossil fuels in cars and trucks. TCI requires large gasoline and diesel fuel suppliers to hold allowances for the pollution produced from the combustion of the fuel they sell to consumers. In this case, there is pass-through and fossil fuel users will see an increase in gasoline and diesel prices while fuel suppliers absorb part of the cost increase. The Connecticut legislature must allow DOT, Department of Revenue Services, and other agencies (e.g., Department of Economic and Community Development) to work with the Eastern Transportation Coalition to implement interstate trials of an MBUF by repealing PA 17-174. (See Appendix 7 for a detailed discussion of MBUF.)

New strategy – Transit benefit, parking cash-out, and telecommuting for state employees [PRIORITY]

The State of Connecticut is the largest employer in the state, and many state employees are guaranteed free parking as part of their union contracts. One outcome is increased traffic congestion and emissions in urban areas, most notably Hartford, which has a high concentration of state agency offices. Another outcome is significant loss of urban real estate to provide sufficient parking spaces for state employees. Creating a transit benefit alternative would allow state employees to choose a transit pass[40] and a parking "cash-out." Such a program could be expanded to municipal employees over time. When combined with an intentional expansion of telework (drawing upon the recent experience during the COVID-19 pandemic), these programs could yield a significant reduction in VMT and GHG emissions from government operations.

Equity and environmental justice – Free parking policies without a comparable transit alternative for government workers neglect the needs of workers who do not own a vehicle and exacerbate pollution in Hartford and other urban centers with a high density of State agency offices. Parking subsidies increase single-occupancy car commuting, and motor vehicle polluting exhaust is more heavily concentrated in low-income neighborhoods and communities of color.

[40] Appendix 8 provides additional information about how such a transit benefit could be modeled on the successful transit pass program for students at Connecticut state colleges and universities.

New strategy – **Implement State and Regional Policies designed to reduce VMT [PRIORITY]**

A suite of approaches is recommended:

- strategy in long-range state and regional transportation plans to reduce vehicle miles traveled and rural sprawl;
- disincentivizing sprawl to inhibit land uses that increase VMT; and
- inclusion of goals for revitalizing transit and transit ridership (a critical strategy for reducing VMT) in COVID-19 recovery plans.

Connecticut's Statewide Long-Range Transportation Plan, 2018-2050 includes several mentions of the importance of reducing greenhouse gas emissions – but does not include a specific target. Transportation strategies at both the state and regional levels should adopt and conform to the state's GHG emissions reduction mandates and set an aggressive yet achievable goal: reducing VMT 5 percent below a 2019 baseline by 2030. This goal would complement the state's transit-oriented development and walkable community goals, rather than work against them. Policies to reduce rural sprawl will also be critical to protecting the state's forests (see recommendations from the Forests sub-group of the Working and Natural Lands Working Group).

The General Assembly should place a moratorium or steep fee on conversion of suburban and rural green space, farms, and woodland into sprawling housing, office parks, and industrial buildings. In the October 2019 CT's Transportation Future statewide survey, 65 percent of respondents supported this. The moratorium or steep fee would not apply to in-fill development in cities and town centers and within one mile of a high-frequency bus transit or rail stop. Additionally, environmental-impact studies for large developments should be required by policy or legislation to include an analysis of VMT impact, with a VMT increase designated as a negative finding contrary to the state's GHG emissions-reduction goals.

The COVID-19 pandemic has resulted in a dramatic reduction in transit ridership, causing serious budget shortfalls and endangering the long-term stability of the state's transit systems. Transit employees have continued to keep buses and trains operating despite significant risk to their own health, and public transit has been a critical resource for essential workers commuting to their jobs. Maintaining vital public transit infrastructure and operations is not only essential for achieving the state's GHG emissions-reduction goals, it is among the highest priority measures for ensuring equity in the state's transportation system. Post-pandemic economic recovery plans must feature measures to revitalize the state's transit systems, including the possibility of continuing the fare-free policies implemented during the pandemic. Appendix 9 provides information on evaluating fare-free transit policies.

Develop sustainable funding for transportation electrification and transit infrastructure

Currently the primary funding sources for transportation infrastructure maintenance are federal and state motor fuel taxes on each gallon of fuel sold. However, revenue from these taxes has been declining for several years, as ICE vehicles' fuel efficiency has improved and hybrids and ZEVs have increased their share of the passenger vehicle market. The state needs to consider the potential of alternative funding sources, such as tolls, road usage fees, and an emissions trading system such as the one proposed by TCI. Unlike fuel taxes, these alternatives are inherently stable and can provide co-benefits that aid planners and motorists.

Strategy – Implement a multi-state cap-and-invest program that: sets a limit on transportation sector emissions and reinvests program proceeds in measures that reduce emissions; provides benefits to citizens, especially LMI communities; protects existing transportation funding; generates sufficient additional funding to support transportation infrastructure and operation; and mitigates costs to consumers. *[PRIORITY]*

Progress to date – In 2010, a group of Northeast and Mid-Atlantic states, including the District of Columbia, signed a Declaration of Intent to create the Transportation and Climate Initiative (TCI) – a regional transportation approach to help states build the clean energy economy of the future. In 2018, those states agreed to work together to "design a regional low-carbon transportation policy proposal that would cap and reduce carbon emissions from the combustion of transportation fuels through a cap-and-invest program or other pricing mechanism."[41]

As of May 2020, that coalition of states has drafted and received plentiful feedback[42] on a Draft Memorandum of Understanding outlining the process, targets, and regulated fuels – gasoline and diesel. The next step in the process is for the participating states to reconfirm their participation and sign the Memorandum of Understanding in the Fall of 2020, and continue with enabling legislation in 2021, keeping the initiative on track for implementation in 2022.

In Connecticut and across the participating states, support for TCI's proposed multi-state cap-and-invest program has been robust, especially when directly paired with the investments that cap-and-invest auction revenues would support:

- 65 percent of CT residents surveyed by MassINC supported "...a multi-state policy to cap carbon pollution from transportation and invest in transportation improvements." Support went up to 69% after those surveyed were informed of the sustainable transportation investments that could be funded.

[41] Transportation and Climate Initiative Regional Policy Design Process Website
[42] Regional Proposal for Clean Transportation Reaches Milestone, Draft MOU and Feedback

- The CT's Transportation Future Survey in October 2019 showed 82 percent support for TCI.
- 85 percent of small town and rural Connecticut voters surveyed by The Nature Conservancy in 2019 "support the creation of a state clean transportation fund."
- As of February 2020 over 95 percent of comments that Connecticut residents have submitted to an online TCI comment portal had been supportive of the initiative.[43]

Enhancement – **Continue and expand surveys, public meetings, and public engagement on this proposal throughout 2020 and into 2021, including intentional outreach to rural communities and low-income communities.**

Equity and environmental justice – Climate change mitigation policies that ignore "hot spots" of air pollution have the potential to exacerbate inequities. Residents living near power plants or highways often continue to experience poor air quality and public health burdens even after an overall reduction of air pollution. Acknowledging the historic and existing inequities in our transportation systems and housing, and the role that policy making played in creating those systems, are key to understanding how current policy design and implementation can reconcile inequities rather than perpetuate them.

It is imperative to design the TCI cap-and-invest program so that it reduces GHG emissions while improving air quality, increases access and mobility, creates quality jobs at living wages, alleviates economic burdens, and improves resilient infrastructure while targeting the program's benefits to underserved and overburdened communities. A coalition of organizations submitted a joint equity and environmental justice letter that includes detailed recommendations for the states participating in the TCI.[44]

Strategy – **Implement transportation user fees – market mechanisms to reduce traffic congestion and improve efficiency of travel for all drivers.**

Progress to date – After much debate and multiple iterations during 2019 and 2020, the Connecticut General Assembly did not vote on proposed legislation to implement tolling on interstate highways in the state. It seems unlikely that another proposal for roadway user fees will be put forward again in the near future. However, user fees, particularly with congestion pricing mechanisms, could have a positive equity impact by reducing emissions in urban corridors. Attention would be needed, however, to prevent the potential negative impact on low-income households by incorporating targeted pricing or rebate policies.

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[43] March 2020, Smart Cities Dive - Transportation & Climate Initiative sees 'overwhelming support' of cap-and-invest plan

[44] It should be noted that some climate justice organizations have critiqued the market-based approach of TCI and continue to express concern that targeted allocation of generated funds will not adequately address the need for a comprehensive "just transition" in the transportation sector. See, for example: https://climatejusticealliance.org/climate-justice-equity-principles-transportation-climate-initiative/.

The legislative prohibition on exploring mileage-based user fee has been discussed above and is explore further in Appendix 7.

New recommendation – Explore strategies to reduce total number of vehicles on the road

An important GHG reduction strategy is to simply reduce the number of vehicles on the road. As car-share, bike-share, and transit systems improve, and as housing and commercial establishments arise around transit hubs, people will rely less on a personal motor vehicle. The pandemic has demonstrated the feasibility of widespread use of telecommuting.

New strategy – Explore car-share options for municipal and state fleets as a complement to electrification

Expanding car-share options in urban areas and town centers near transit-oriented development is a mechanism for reducing individual car ownership and overall vehicle miles traveled. The business case for car sharing may not currently support that expansion, but a large municipality, State of Connecticut, or corporate entity could approach car-share companies about the opportunity to operate fleet vehicles as dual purpose with resident-rentable car-share (ZipCar-type model) on evenings and weekends.

Car-share and -rental companies already manage some fleet vehicles. It should be possible to alter this business model to allow public use of the car-share fleet vehicles on evenings, weekends, and holidays when vehicles are not dedicated to fleet use. CTrides has pointed to examples of private-combined-with-public-use car-share models in other cities and states.[45]

Equity and environmental justice – Four cities in Connecticut have a high percentage of zero-car households. Expanded car-share programs would provide additional mobility options for those households, reducing the need for individual car ownership. If the fleets were comprised of EVs, that would allow those work trips and personal trips to be EV-powered while redressing the problem of EVs being available primarily to middle- and upper-income households. Hartford and some other cities currently do not have customer density high enough to allow car-share companies to expand their services; but expansion might be possible if the cars did double duty as municipal or State fleet vehicles.

New recommendation – Reduce emissions from freight transportation

[45] [INSERT REFERENCE]

GHG emissions from freight transportation has not received specific attention from the GC3. Nationally, freight transportation accounts for 9 percent of total GHG emissions and trucking is responsible for 60 percent of freight emissions.[46] The recommendations for statewide emissions standards for medium- and heavy-duty vehicles and electrification of those vehicles outlined earlier in this chapter will have an impact on freight emissions.[47] The multi-state Transportation and Climate Initiative, which will raise the costs of transporting freight with fossil fuels, will help to shape freight companies' investments in their vehicle fleets. However, other measures focused specifically on freight also should be considered.

The CT Statewide Freight Plan (Nov 2017) provides no assessment of or goal to reduce GHG emissions. The strategies outlined below provide a few high-level recommendations to address emissions when the plan is updated in 2021/2022.

Equity and environmental justice – As with other measures outlined in this report to reduce emissions from medium- and heavy duty trucks, reducing freight emissions will have a positive equity impact in communities disproportionately impacted by emissions from diesel vehicles and from traffic congestion in general. Efforts to reduce the volume of waste transported in and out of Hartford will have particular impact on neighborhoods surrounding the waste incinerator and transfer station. At the same time, it is important to recognize that the trucking industry employs a significant number of low-wage workers, and any measures that cause a shift in the types of freight jobs will need to address the need for skills training and other just-transition measures to ensure that these workers find well-paid jobs in the clean transportation economy.

New strategy – Address GHG emissions in state-level freight planning

The next revision of the Statewide Freight Plan should include an assessment of GHG emissions from the movement of freight in and through Connecticut. The plan also should identify measures for reducing emissions, including regional cooperation with surrounding states. Such proposals can draw upon best practices in cities, regions, and countries around the world that have tackled this problem.

New strategy – Seek opportunities to shift freight from trucks to rail and ports

Connecticut, historically built around rail corridors, can shift more freight to rail. Modernizing our ports presents the opportunity to shift freight, particularly goods bound for New York City, from the I-95 corridor to marine transport. Removing interstate freight from our highways could not only reduce emissions from freight transportation[48] but reduce traffic congestion and thereby reduce emissions from other vehicles.

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[46] Assessment of Potential Reduction in Greenhouse Gas Emissions in Freight Transportation, 2007

[47] With the expansion of direct-to-consumer delivery, for example, ZEV fleet programs for the United States Postal Service, United Parcel Service, FedEx, and Amazon could have a significant impact.

[48] "*...a shift from truck to rail modes can reduce GHG emissions per ton-mile by 85 percent, even when truck transport at the start and end of the trip are considered.*" Assessment of Potential Reduction in Greenhouse Gas (GHG) Emissions in Freight Transportation, 2007

New strategy – **Expand waste reduction and recycling programs**

With the Hartford Materials Innovation and Recycling Authority (MIRA) trash incinerator planning to shut down in the next year due to lack of funding for upgrading the facility, there is an immediate need for waste stream freight reduction. Without a plan for waste stream tonnage reduction, the state will increase emissions due to trucking waste out of state rather than incinerating the waste in Hartford. MIRA operates the Connecticut Solid Waste System (CSWS) as "a hub-and-spoke system that serves the needs of approximately 70 municipalities located throughout the State." Increasing composting, increasing recycling, increasing supplier responsibility for product lifecycle, and reducing wasteful packaging are all ways to address this need.

Appendices

Appendix 1: Members of the Transportation team

Chair	
John Humphries	CT Roundtable on Climate and Jobs
Working Group	
Patrick Carleton	Metropolitan Council of Governments
Tony Cherolis	Transport Hartford Academy at the Center for Latino Progress
Daphne Dixon	Live Green & CT Southwestern Area Clean Cities Coalition
David Elder	CT Department of Transportation
Gannon Long	Operation Fuel
Stanley McMillen	UConn
Jon Slifka	CT Department Of Rehabilitation Services
Other Stakeholders	
Sahar Amjad	Transport Hartford Academy/UConn
Aziz Dehkan	CT Roundtable on Climate and Jobs
Jayden Dickens	Transport Hartford Academy
David Gable	Hocon Gas
Lee Grannis	New Haven Clean Cities Coalition
T. Michael Morrissey	Alternative Fuels Coalition of Connecticut
Craig Peters	Capitol Clean Cities of Connecticut
Chris Phelps	Environment Connecticut
DEEP support staff	
Brian Basso	Intern
Spencer Kinyon	Intern
Dino Pascua	Bureau of Energy & Technology Policy

Appendix 2

Connecticut State Policies and Statutes Related to Transportation Emissions

In addition to adopting California's light-duty vehicle GHG emissions standards, Connecticut has demonstrated its strong commitment toward advancing the deployment of ZEVs on it roadways through the adoption of legislative/regulatory mandates and multi-state initiatives, the development of an EV roadmap, and other actions, including:

Pursuant to Public Act 04-84, *An Act Concerning Clean Cars*, codified at Conn. Gen. Stat. § 22a-174g, Connecticut committed to implement by regulation California's new motor vehicle emissions standards, including the Greenhouse Gas Tailpipe Standards and the Zero Emission Vehicle (ZEV) Program, and to amend its regulations in accordance with changes in those standards. [See Conn. Agencies Regs. §22a-174-36b and §22a-147-36c.]

Under Section 5 of Public Act 16-135, *An Act Concerning Electric and Fuel Cell Electric Vehicles*, Eversource Energy (Eversource) and The United Illuminating Company (UI), the electric distribution companies (EDCs) in Connecticut, are required to integrate EV charging load projections into their distribution planning, based on the number of EVs registered in Connecticut and any projected EV sales trends, and to publish on their websites annual reports explaining how EV charging load projections factor into their distribution system planning. Furthermore, Public Act 16-135 requires DEEP, in its Integrated Resources Plan (IRP), to "analyze the potential for electric vehicles . . . to provide energy storage and other services to the electric grid and identify strategies to ensure that the grid is prepared to support increased electric vehicle charging, based on projections of sales of electric vehicles." DEEP issued a draft of the next iteration of its IRP in August 2020 for public comment.

Public Act 18-82, *An Act Concerning Climate Change Planning and Resiliency*, sec. 7, codified at Conn. Gen. Stat. § 22a-200a, requires reducing GHG emissions from the transportation sector to achieve Connecticut's economy-wide targets of at least 45 percent below 2001 levels by 2030, and Public Act 08-98, *An Act Concerning Global Warming Solutions*, sec. 2, codified at Conn. Gen. Stat. § 22a-200a, requires a reduction of GHG emissions of 80 percent below 2001 levels by 2050.

Section 93 of Public Act 19-117, *An Act Concerning* the *State Budget for the Biennium Ending June 30, 2021, and Making Appropriations Therefore, and Provisions Related to Revenue and Other Items to Implement the State Budget*, provides that on and after January 1, 2030, at least 50 percent of all cars and light-duty trucks and 30 percent of all buses purchased or leased by the state shall be zero-emission vehicles.

Connecticut has signed onto two ZEV MOUs. In October 2013, Connecticut and seven other states entered into the multi-state ZEV MOU for light-duty ZEVs. Now endorsed by 10 states and under consideration by several more, the ZEV MOU commits its signatories to deploying 3.3 million light-duty ZEVs on the road by 2025. Connecticut's share of that deployment is equivalent to 125,000 to 150,000 ZEVs. In support of these efforts, the Multi-State ZEV Task Force released its *Multi-State ZEV Action Plan 2018-2021* to propel rapid adoption of light-duty ZEVs over the next several years. In July 2020, Connecticut joined 14 other states and the District of Columbia in signing an MOU to work collaboratively to advance and accelerate the

market for medium- and heavy-duty EVs (MHD ZEV MOU). Under the MHD ZEV MOU, signatory states will work toward ensuring that 100% of all new medium- and heavy-duty vehicle sales be ZEVs by 2050, with an interim target of 30% ZEV sales by 2030.

In 2015, Connecticut launched the pilot Connecticut Hydrogen and Electric Automobile Purchase Rebate (CHEAPR) Program, a first of its kind rebate program for EVs. In June 2019, Public Act 19-117 recommitted to the CHEAPR program and allocated $15 million dollars over the next five years for additional rebates. Analysis done by DEEP anticipates these rebates will provide funding for the purchase of 10,000 to 14,000 more EVs in the next five years.

In April 2020, DEEP released the Electric Vehicle Roadmap for Connecticut: A Policy Framework to Accelerate Electric Vehicle Adoption (EV Roadmap). The EV Roadmap represents a comprehensive strategy for accelerating the deployment of electric vehicles (EVs) through policies and regulatory tools addressing transportation equity, purchasing incentives, consumer education, charging infrastructure expansion, consumer protection, integration of EVs into the electric grid, utility investment, and utility rate design.

Appendix 3

Used EV Affordability Analysis

Comments on access and equity for the CHEAPR Program's proposed rebate:

- Overall – The CHEAPR EV Rebate Program, even with proposed LMI rebate levels, will not reach low-income households or even the median income household in the City of Hartford. The EV rebate program is structurally inequitable.
- City Hartford's median household income is $34,338. The table below is based on the annual cost of ownership for the lowest-priced EV found advertised online in early July 2020.*
- The lowest cost used EV's found in an online search were Nissan Leafs. Even at the low end of $8,000 to $12,5000 (with a $2,000 LMI EV credit), such Evs are outside the budget of a median-income Hartford household, chewing up 17.4% of the household's income. The LMI credit should be called a MI ("moderate income") credit.
- The reason the sector team's report proposed establishing a rebate program for e-bicycles was partly due to the structural inequity in the current program, even with an enhanced LMI rebate. Fossil-fueled motor vehicle replacement with e-bicycles would have the biggest benefit inn CT cities where inequitable long-term exposure to motor vehicle air pollution is the most severe.

Example - Used 2012 Nissan Leaf, total cost of ownership		
Purchase price = $6,000 after $2,000 LMI used EV Rebate		
Assuming 10k miles driven / yr	**Cost per year**	**Assumptions**
Full year financing	$1,812	9.5% rate, used car loan term 48 months
Maintenance	$660	6.6 cents / mile (AAA)
Registration and licensing	$123	From CT DMV estimate
Taxes	$360	Hartford has a 45 mill rate for motor vehicles
Insurance	$2,664	06106 Hartford zip code avg, 30 y/o male (CT avg is $1,771)
Electricity/charging	$365	3.65 cents / mile (AAA)
Total cost of car ownership	**$5,984**	

Hartford median household income	$34,338	City wide
% of Household Income	17.4%	
Recommended % for transportation	15.0%	

Hartford Census Tract 5003, Median Household Income (Frog Hollow)	$23,368	(source)
% of Household Income	25.6%	
Recommended % for transportation	15.0%	

[contributed by Anthony Cherolis, CHEAPR Board Member and Transport Hartford Coordinator]

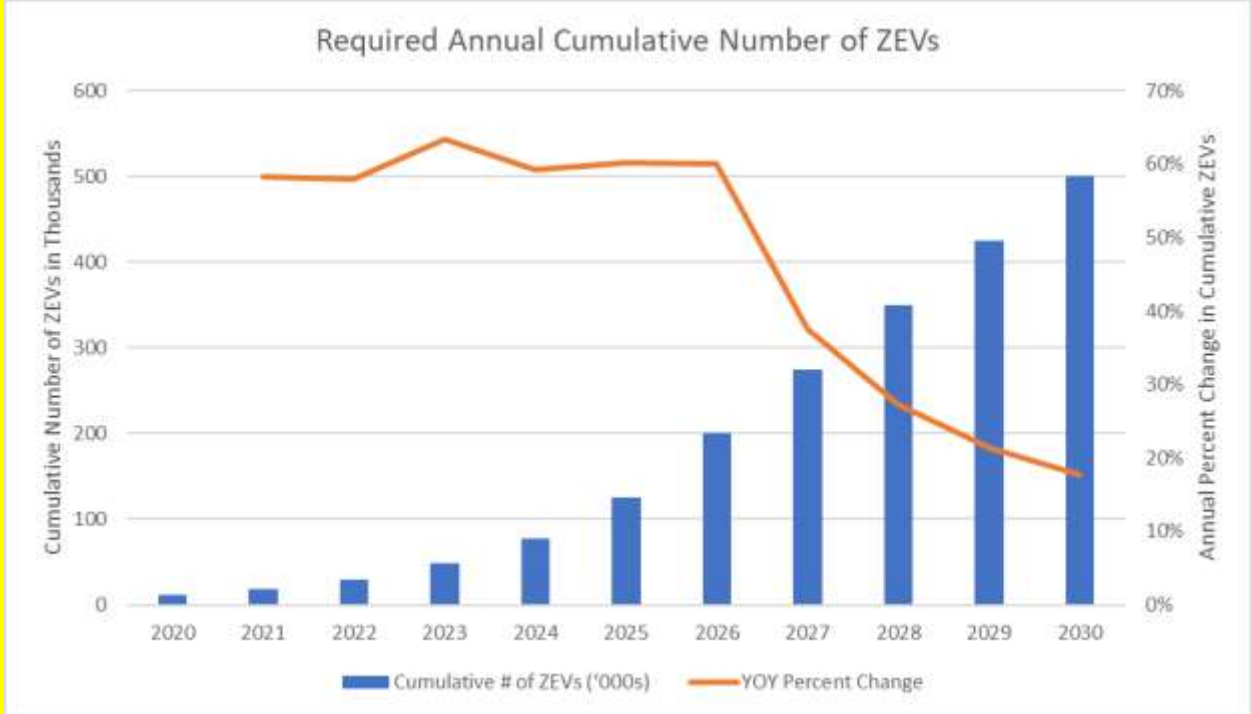
Appendix 4: Proposed Annual Targets for Light-Duty ZEV Penetration Rate

Pursuant to the ZEV MOU, Connecticut has committed to deploying the equivalent of 125,000 to 150,000 ZEVs by 2025. According to Northeast States Coordinated Air Use Management analysis in the 2018 GC3 report, achieving the 2030 interim GHG reduction target will require 500,000 ZEVs (roughly 20% of the total light-duty fleet) to be registered in Connecticut by that date. Connecticut had 11,677 EVs registered in-state, as of Jan. 1, 2020.

Meeting the 2025 commitment in the ZEV MOU will require increasing the number of ZEVs by roughly 60% each year. Assuming that commitment is met, reaching the 2030 target will require adding an average of another 75,000 new ZEVs annually beginning in 2026.

We propose a timeline of annual targets that can help assess whether the state is on track to meet its long-term commitments:

YEAR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cumulative # of ZEVs ('000s)	12	19	30	49	78	125	200	275	350	425	500



Appendix 5: California's Gas Guzzler/Cash-for-Clunkers Incentive Program

A pilot "Cash for Clunkers" program in the California South Coast and San Joaquin Valley air districts includes associated incentives for hybrid, plug-in hybrid, and electric vehicles, with higher incentives for low income participants. Incentives are also based on type car being purchased.

	Hybrid (35+ mpg)	**Plug-in Hybrid**	**Electric Vehicle**
Low income	$7K	$11K	$12K
Moderate income	$5K	$9K	$10K
Above moderate income	$0K	$7K	$8K

The program also provides public transit vouchers or an e-bike as an alternative to the ZEV-car incentive.

- eligible for vouchers for public transit passes, between $2,500 and $4,500, depending on income level
- a voucher up to $7,500, depending on income level, toward the purchase of an e-bike or bikeshare program in exchange for the gas-powered vehicle

[contributed by Anthony Cherolis, Transport Hartford]

Appendix 6

Transportation Demand Management & VMT Reduction

Transportation Demand Management (TDM) consists of a range of congestion management strategies that reduce or modify the demand for transportation, rather than increase the capacity of the transportation system. While the primary goal of TDM is to reduce traffic congestion, the strategies also benefit the environment through reduced Vehicle Miles Traveled (VMTs) and vehicle emissions. Strategies are often aimed at improving transit service, providing robust bicycle and pedestrian amenities; offering telecommuting options and increasing the use of carpools, vanpools and ridesharing. Aside from the multimodal strategies aimed at expanding travel options, other vital TDM strategies include the implementation of land use and smart growth policies that reduce travel distances and VMTs. In Connecticut, most of the state's voluntary TDM programs and initiatives are coordinated through CTrides, a free service of CTDOT. CTrides provides both residents and businesses with information to find the best way to get to work or school and offers information & resources for travel options throughout Connecticut. CTrides also offers carpool & vanpool events, a comprehensive website with information on local and express buses, vanpool providers and information on rail, walk, bike and teleworking options as well as a commuter reward program. In addition, TDM is further supported by the statewide system of park and ride lots, which provides commuters who carpool or utilize a vanpool service with a place to park.

[contributed by Patrick Carleton, MetroCOG]

Appendix 7

Brief Review on the Literature on a Mileage-Based User Fee

by Stanley McMillen, University of Connecticut

It was clear in analyzing the economics of the 2018 Governor's Council on Climate Change GHG reduction strategies that the downward trend in fuel tax revenue would be insufficient to maintain Connecticut's transportation network. Motor fuel tax revenues have declined as passenger vehicles have become more efficient on average due to more stringent CAFE standards and to the uptake of hybrid and battery-powered vehicles. This trend has reduced revenue to the national Highway Trust Fund and the consequences at the state level have been reduced maintenance and less new construction of, for example, bridges to replace century-old structures in Connecticut. State legislatures and Congress have been reluctant to increase fuel taxes as they are (perceived to be) politically unpopular.[49] The 1993 federal excise tax of 18.4 cents per gallon is unchanged and unadjusted for inflation. Therefore, inflation-adjusted fuel tax revenues have declined as fuel efficiency has increased primarily due to the evolving and less unpopular CAFE standard.

As vehicle miles traveled and vehicle weights increase, our highways and bridges, many built in the 1960s, have been maintained in less than optimum condition. The Connecticut Society of Civil Engineers' 2018 report card on the state's infrastructure rates the Connecticut's bridges as C- and its roads as D+.[50] Alternative means of financing needed maintenance and improvement have been debated (tolls and bonding most recently) as the state's Special Transportation Fund is insufficient to meet the needs articulated for example in the Let's Go CT plan.[51]

A mileage-based user fee (MBUF) or vehicle-miles-traveled (VMT) tax is an alternative method of raising revenue to finance transportation infrastructure maintenance and improvement. Tolls collected electronically or at toll stations are another means of providing revenue for road maintenance and improvement. Providing electronic tolls in Connecticut has gained little traction. There is a large literature on MBUF revenue generation, and a pilot program in Oregon has been underway for five years.[52] MBUF fees may be collected in a variety of ways. Users may have an on-board unit (OBU) that connects the vehicle to tracking software that periodically issues a bill or debit on the user's account. Oregon's experience will yield helpful insights for fee collection mechanisms (see page 8 of the RAND report in note 5).

In order to reduce GHGs and provide funding for transportation infrastructure, some sort of fee must be levied on road users. The fuel tax is one method of raising revenue and is insufficient to fund road, rail,

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[49] See for example, Langer et al. (2017), "From gallons to miles: A disaggregate analysis of automobile travel and externality taxes", *Journal of Public Economics*, Issue 152, pp. 34-46 and Sorensen, Paul, Liisa Ecola, and Martin Wachs (2012), "Mileage-Based User Fees for Transportation Funding: A Primer for State and Local Decisionmakers", Santa Monica, CA: RAND Corporation, https://www.rand.org/pubs/tools/TL104.html.

[50] Report Card for Connecticut's Infrastructure – 2018, www.csce.org.

[51] https://portal.ct.gov/DOT/Common-Elements/V4-Template/Lets-Go-CT-Page.

[52] See https://www.fhwa.dot.gov/ipd/tolling_and_pricing/defined/vmt.aspx for several studies.

bridge, harbor and airport maintenance. In addition, fuel tax revenues decline as fuel efficiency increases and increases in tax rates are usually non-starters. People respond to incentives and taxes are in general distortionary, that is, they introduce an inefficiency in the market-based pricing mechanism. The inefficiency is measured as a deadweight loss and both consumer and producer surpluses are reduced. However, taxes that mitigate an externality such as air pollution or health-harming activity (e.g., smoking) do not introduce an inefficiency; rather they move production and consumption toward a social optimum (with reduced consumption and production) that reduces pollution or other externality (such as congestion and noise) to a socially acceptable level. Such taxes attempt to correct a market failure (there is no market for pollution). In the case where we would like to reduce both VMT and transportation related GHG emissions, fuel taxes, tolls and MBUFs perform similar functions in correcting the market failure. In addition, to achieving social goals, transportation taxes and fees are essential to fund infrastructure maintenance and improvement. It is possible that the twin goals designed to achieve necessary maintenance and improvement and reduce GHG emissions, may produce more funds than infrastructure alone requires. The excess needed to reduce GHG emissions could be targeted at providing incentives to increase ZEV deployment, provide an extensive charging infrastructure and public education, expand public transit and bike paths, among other transport-related GHG-reducing strategies.

MBUFs have an advantage that they are inherently more stable than fuel taxes and can be tailored to urban-rural regions, time-of-day travel patterns (reducing congestion) and they can be adjusted for vehicle fuel consumption (see the RAND report in note 1). This flexibility would appeal more to consumers and businesses as clearly one size does not fit all. In addition, a MBUF can be tailored to meet needed regional transportation goals (such as incentivizing housing density around transportation nodes) as well as reducing GHGs.

Oregon's MBUF, OReGO, introduced as a pilot program in 2015, tracks participating drivers' mileage using a GPS-enabled device that plugs into a vehicle diagnostic port. In turn, drivers get a rebate on state gasoline taxes they pay at the pump. Currently, more than 5,000 drivers are taking part in the nation's first statewide road usage charge (RUC) system. The State of Washington is launching a RUC pilot to dovetail with Oregon's program and Idaho is considering a RUC system. The three states will work out the kinks of interstate travel and the complexities of billing.[53]

The I-95 Corridor Coalition has brought east coast decision makers and drivers into the discussion of a MBUF as a potential alternative to the fuel tax. The unique characteristics of the eastern seaboard – such as significant cross-state travel, numerous toll facilities, and several major truck corridors – make it a natural testing ground for the potential challenges of implementing a MBUF system nationally. The Coalition's passenger car pilot studies have been the first in the country to demonstrate MBUF in the context of interstate travel and tolling.[54] Connecticut, Delaware, New Hampshire and Pennsylvania have, as part of the I-95 Corridor Coalition, applied for federal support to test how a MBUF could work across

[53] See http://djcoregon.com/news/2018/03/22/driving-toward-new-transportation-funding/.
[54] See https://www.i95coalitionmbuf.org/.

multiple states. In Connecticut, a MBUF could obviate Connecticut's toll debate and provide significant additional benefits relative to either tolls or fuel taxes (see below). Unfortunately, PA 17-704 stipulates that no public funds can be used to consider a MBUF.[55] This statute must be repealed to allow CONNDOT and other agencies (e.g., DECD) to collaborate with the I-95 Corridor Coalition (see page 19 of the RAND report for an example of such collaboration).

To address the disproportionate effects of GHGs including particulates (PM) on LMI/EJ communities, there are opportunities for using MBUF revenue to address these issues. First, LMI households could receive reduced auto registration and licensing fees. Second, an allocation of the tax could be made to reduce pollution in such neighborhoods by rerouting heavy truck traffic, using electric busses and delivery vehicles for last mile work that would reduce PM and noise pollution. Third, allocate a portion of MBUF revenues to increase public transportation in LMI neighborhoods to provide easier access to jobs and reduce the need for cars. LMI communities tend to be more vulnerable to pollution and congestion (regarded as physical stressors) in part because they don't get the nutrition or health care they need, so some MBUF revenues should be allocated to increasing access to better nutrition and health care. This problem is exacerbated because Hartford has a cap and surcharge property tax system that chased small businesses away in the early 1990s and as a result, residents (mostly LMI households) do not have access to high-quality grocery stores for example and they need to travel to other towns to purchase groceries and sundries. Another opportunity is to allocate a portion of MBUF revenue to more affordable housing and retrofit existing housing with EE building envelope products. LMI communities lack many basic resources that people in more affluent communities ~~t~~ake for granted. In addition, MBUF revenue can be used to expand bike paths and bike lanes, sidewalks and reduce heat islands with tree planting.

There are several methods to monitor vehicle miles traveled. The most effective and potentially the most problematic from a privacy perspective is an on-board unit (OBU) with GPS monitoring. The OBU collects travel data and connects to the vehicle's onboard computer. This monitoring mode also provides several co-benefits including (from the RAND report):

Pay-as-you-drive auto insurance where instead of paying a fixed annual insurance premium, drivers could pay by the mile. Such a system would give those who drive fewer miles the opportunity to save hundreds of dollars on their insurance each year.

Automated parking payment. In-vehicle metering equipment (OBU/GPS) could be configured to allow for automated payment of parking charges, eliminating the need to pay at meters or multispace parking machines. Drivers could pay for the actual time that they occupied the space, with no more need to "leave extra time on the meter." Systems could be designed to generate payment summaries for those who need to report parking fees as a business expense. And cities might forgo issuing parking tickets and instead allow drivers to remain in parking spaces beyond the posted time limit but at a significantly higher rate.

[55] See: https://www.cga.ct.gov/2017/ACT/pa/2017PA-00174-R00SB-000.

Automated toll payment. On toll roads where both cash and electronic payments are accepted, and for users who have not yet acquired an electronic tolling transponder, in-vehicle metering equipment could support automated toll payments, eliminating the need to stop at the tollbooth and have cash in hand.

Location-dependent travel services. The in-vehicle equipment could share many features associated with personal navigation devices, such as real-time routing assistance based on current traffic conditions or identification of nearby points of interest.

Improved safety. The U.S. Research and Innovative Technology Administration's connected vehicle program envisions sophisticated in-vehicle equipment could support numerous potential safety features, such as alerting the driver of school zones, construction zones, hazardous conditions, or traffic incidents; warning the driver of imminent collisions from sudden lane changes or braking vehicles; and allowing the driver to send emergency distress signals.

And finally, an OBU with GPS could offer improved transportation planning and operations. Anonymous, detailed travel data could provide real-time information on traffic conditions throughout the road network to help make local traffic management operations more effective and efficient, and, to better calibrate regional transportation planning models, which in turn could provide a more reliable guide for making system improvements and for economic development professionals to better plan commercial, residential and industrial development. In addition, MBUF revenue could be apportioned by jurisdiction that could disproportionately address LMI community issues.

How do fuel taxes and MBUFs compare? Both raise revenue for transportation infrastructure maintenance and improvement and reduce GHG emissions. Which approach is more efficient, more flexible, more stable, more tailorable and would produce the greatest net benefit to society? Langer et al. (2017) demonstrate with a model calibrated with Ohio residents' driving data that under several scenarios, a MBUF is superior to a tax on motor fuel. The authors' model accounts for differences in rural and urban settings, low- and high-gas mileage vehicles, people who are more sensitive and those who are less sensitive to fuel price changes and those who drive more than others (high or low vehicle utilization). Further, a MBUF is stable because it is independent of fuel prices and vehicle efficiencies.

In their analysis, Langer et al. (2017) include the proposed 40% increase in passenger vehicle mileage proposed in the new CAFE standard (now being contested) as well as a status quo CAFE scenario. The table below shows the results of their simulation that raises $55 billion called for in the 2015 federal transportation spending bill and reduces fuel consumption by 1% (roughly 14.68 MMT CO_{2e} [derived from Table 1-4 in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2014* (published 2016)]).

As fuel economy standards become more stringent, a tax on vehicle miles traveled is more beneficial than a gas tax

Annual net benefits of a gas tax vs. VMT tax assuming fuel economy increases by 40%
(tax rates set to raise at least $55 billion/year for highway spending)

	Gas tax (54.9 cents/gallon)	Differentiated VMT tax (0.575 cent/rural mile; 2.409 cent/urban mile)
Decrease in consumer surplus	- $55.5 billion	- $57.6 billion
Increase in government revenues	+ $55.0 billion	+ $57.0 billion
Decrease in congestion	+ $5.13 billion	+ $6.12 billion
Decrease in CO_2 emissions	+ $0.73 billion	+ $0.69 billion
Decrease in accidents	+ $2.90 billion	+ $3.46 billion
Decrease in local air pollution	+ $0.62 billion	+ $0.75 billion
Net Benefits	**$8.9 billion**	**$10.5 billion**

Source: Authors' calculations. Some columns may not sum precisely due to rounding. BROOKINGS

It should be noted that increasing CAFE standards mitigates efforts to reduce VMT because driving becomes less costly and drivers do more. In fact, part of the reason VMT has been increasing is due to this effect. In addition, fuel taxes are more effective than CAFE standards because a tax incentivizes drivers to both reduce VMT and drive more fuel-efficient vehicles (Langer et al., 2017). A MBUF is similar to an effluent tax proposed by Lawrence J. White in 1982.[56] White's proposal was to inspect vehicles annually and determine VMT and effluent levels (HC, CO, NOx and then, not CO_2). The MBUF analyzed by Langer et al. (2017) is in effect an effluent tax because it is tailorable to vehicles with different fuel efficiencies and it measures VMT. In addition, a MBUF collects revenue from ZEVs that would otherwise pay no fuel tax and thus would shift transportation infrastructure support to fossil-fuel powered vehicles.

RECOMMENDATION

In setting a price for carbon, a MBUF and an emissions trading system (ETS) such as that proposed in the Transportation and Climate Initiative (TCI) are not mutually exclusive. Taxes alter input or output prices by an amount determined theoretically by the elasticities of supply and demand. Taxes therefore are a price constraint. An ETS sets a cap or quantity constraint and the price is determined theoretically by the elasticities of supply and demand. ***In reality, things are more complex, but our recommendation here is to implement both the TCI and a MBUF.*** The logic is that the MBUF is paid by transportation infrastructure users (there is no pass-through) and the revenue supports infrastructure maintenance

[56] White, Lawrence J. (1982). "The Regulation of Air Pollutant Emissions from Motor Vehicles", The American Enterprise Institute for Public Policy Research. (https://www.aei.org/research-products/book/the-regulation-of-air-pollutant-emissions-from-motor-vehicles)

and improvement.[57] The user fee could be structured to fund infrastructure maintenance and improvement exclusively, regardless of fuel consumption. It could in addition be structured to fund mass transit and bike paths among other VMT-reducing strategies. The MBUF can also be varied by time of day and location to relieve congestion, among other benefits described in the RAND report (see note 1). As revenue from a MBUF increases, the state's fuel taxes should be phased out such that when revenue from the MBUF funds required maintenance and improvement, they would be zero. Federal excise tax would still remain and be beyond state control. The Oregon example is a model that we can learn from. Connecticut should aggressively push the I-95 Corridor Coalition model to implement a MBUF model and regional trials.

TCI on the other hand sets a declining cap on carbon emission from burning fossil fuels in the transportation sector that reduces transportation emissions over time.[58] It requires large gasoline and diesel fuel suppliers to hold allowances for the pollution that results from the combustion of the fuels they sell to consumers. In this case, there is pass-through and fossil fuel users will see an increase in gasoline and diesel prices. The pass-through is not 100% and part of the increase in cost to fuel suppliers is absorbed by them (see note 9). In addition, both producers and consumers can alter their choices of what inputs to use in production and what modes of transport to use in 'consuming' transportation (ZEVs, mass transit, carpooling, biking). Proceeds from the sale of allowances can be used to fund programs to increase public transit and make it more effective in connecting LMI communities with jobs and cleaner (electrify busses and trains), build safe places for people to walk and bike, encourage ZEVs, and address disproportionate health and safety issues in LMI communities, among others.

[57] Ganapati et al. (2020). "Energy Cost Pass-Through in US Manufacturing: Estimates and Implications for Carbon Taxes," *American Economic Journal: Applied Economics 2020,* 12(2): 303–342, https://doi.org/10.1257/app.20180474.
[58] See https://www.transportationandclimate.org/.

Appendix 8

Extending Connecticut's U-Pass Program

Through the state's U-Pass program, nearly 15,000 students at state universities and community colleges pay $20 per semester as an "activity fee" (part of their tuition package) and get unlimited free rides on most of the state's public transit systems (both bus and rail).

A similar program for state workers (a "G-Pass") could be devised through which all employees contribute a small amount (e.g. a monthly payroll deduction) and get a transit pass. Having such a program would allow some employees to choose to give up their parking space altogether and get a "cash-out" roughly equivalent to the cost of maintaining a parking space. If needed, some portion of the monthly fee and parking savings could be set aside to augment the CT*rides* Emergency Rides Home program for transit riders to ensure that it can meet the needs of state employees.

Some municipalities (e.g. City of Hartford) also provide free parking for employees and could benefit from participation in a G-Pass program. Large and medium sized employers may be interested in a standardized transit pass program for employees, loosely based on the U-Pass model. In 2020, the CT DOT proposed transportation bill included a section that would expand U-Pass to include private colleges and universities, Raised Senate Bill 151. That proposal should go further and allow CT DOT to negotiate those transit pass arrangements with Connecticut businesses and corporations for their employees.

Appendix 9

Evaluating Fare-Free Transit

Fare free transit has been implemented in some cities to increase ridership and reduce transportation system greenhouse gas emissions, by reducing low occupancy motor vehicle trips. Fare free transit also has an accessibility and environmental justice benefit. Transit users are more often low income and in groups that have experienced decades of racial discrimination and reduced opportunity. It is not clear when fare free transit is a recommended course of action, as it could reduce overall funding and reduce quality without some other means of making up for revenue lost from fare box return. There are system benefits such as reduced trip times and improved frequency in a fare-free system, as the system delays from passenger on-bus payment is removed.

It is recommended that CT DOT evaluate other transit systems that have gone to fare free transit[59], consider doing an analysis with recommendations for CT's bus transit systems, and share recommendations with state legislators on the transportation committee, the transportation working group of the Governor's Council on Climate Change, and the state's Office of Policy and Management. Some reduced fare systems are focused on specific groups, like this MBTA Youth Pass program that provides a 50% discount to youth from low-income households.

Near term, CT DOT or CTtransit is operating during the pandemic with a functionally fare free bus transit system, state wide. This would be an ideal time to change transit schedules on several key routes to take up the slack (with no payment delays) and evaluate what route speed an frequency improvements are available. This is a temporary situation during the pandemic, but could provide invaluable system performance benefits that would result from instituting a fare free transit system, or a consistent "off-bus" payment process or payment by honor system (with fare inspectors).

[contributed by Anthony Cherolis, Transport Hartford]

[59] Kansas City is making its bus system fare-free. Will other cities do the same? - Dec 2019, VOX

Appendix 10: Acronyms and Abbreviations

Term	Full Name	Term	Full Name
ADA	Americans with Disabilities Act	**GHG**	Greenhouse Gas (carbon dioxide, methane, water vapor)
AFDC	Alternative Fuels Data Center	**HB**	House Bill
BEV	Battery electric vehicle	**ICE**	Internal Combustion Engine (gasoline, diesel, natural gas, propane, gas turbine)
CAFE	Corporate Average Fuel Economy set by EPA	**LMI**	Low-to-middle income (households)
CHEAPR	Connecticut Hydrogen and Electric Automobile Purchase Rebate	**MBUF**	Mileage-based user fee
COVID-19	Coronavirus Disease 2019	**MIRA**	Materials Innovation and Recycling Authority
CSWS	Connecticut Solid Waste System	**MOU**	Memorandum of Understanding
CT	State of Connecticut	**NESCAUM**	Northeast States Coordinated Air Use Management
DAS	Connecticut Department of Administrative Services	**NHTSA**	National Highway Traffic Safety Administration
DCFC	Direct Current Fast Charger	**PA**	Public Act
DECD	Department of Economic and Community Development (state)	**PM2.5**	Particulate Matter (2.5 micrometers or smaller)
DEEP	Connecticut Department of Energy and Environmental Protection	**POCD**	Plan of Conservation and Development
DOT	Department of Transportation (state)	**RGTOD**	Responsible Growth and Transit-Oriented Development (Program)
DRS	Department of Revenue Services (state)	**SAFE**	Safer Affordable Fuel Efficient Vehicles Rule (emission standards)
EJ	Environmental Justice	**TCI**	Transportation and Climate Initiative

EPA	U. S. Environmental Protection Agency	**TDM**	Transportation Demand Management
ETS	Emissions Trading System (a cap and trade system that limits carbon emission)	**TOD**	Transit-Oriented Development
EV	Electric vehicle (battery-powered, fuel cell-powered, hybrid)	**V2G**	Vehicle to Grid
EVSE	Electric vehicle supply equipment (chargers and related equipment)	**VMT**	Vehicle Miles Traveled
GC3	Governor's Council on Climate Change	**ZEV**	Zero-emission vehicle (a BEV or fuel cell-powered vehicle)

Appendix 11: Preliminary glossary

Term	Definition	Term	Definition
Active Transportation	Self-propelled transportation such as bicycling or walking.	**Mileage-Based User Fee**	An alternative to taxing fuel in order to fund transportation infrastructure based on vehicle usage. Decline in fuel based tax revenue will likely necessitate this revenue model.
Adaptation and Resiliency		**PM2.5**	Particulate Matter that is 2.5 microns in diameter or smaller.
Alternative Fuels	Fuels other than fossil fuels used in vehicular transport.	**Sea Level Rise**	A consequence of climate change, the observed recent change in the median elevation of the sea level.
Distressed, Underserved, or Marginalized Communities		**TCI/Cap-and-Invest**	A model under which carbon emissions are limited and a market is established for trading emission allowances applicable to all sectors. Proceeds from trades are reinvested in the development of renewable energy.
Environmental Justice	Ensuring that no segment of the population should, because of its racial or economic makeup, bear a disproportionate share of the risks and consequences of environmental pollution or be	**Telecommuting**	Work from home through the use of videoconferencing and remote access of business facilities.

	denied equal access to environmental benefits.		
Light-Duty Vehicles		**Transit Oriented Development**	Urban planning strategy that seeks to maximize the destinations available within walking distance of a public transit stop.
Low-Income	Defined as 60% of State Median income for Connecticut for purposes of equitable distribution	**Vehicles Miles Traveled Tax**	Tax paid on vehicle usage at the time of registration rather than on fuel purchases
Low-and Medium-Income (LMI)	Connecticut Green Bank defined low-to-moderate income households as 100% area median income and below	**Volkswagen Settlement**	The $14.7 settlement Volkswagen reached with three federal agencies for excessive diesel emissions in violation of the clean air act
Medium- and Heavy-Duty Vehicles		**Vulnerable User**	

Chapter 3

Cross-sector

Chapter overview	
Equity & environmental justice – Addressed in multiple sections	
Adaptation & resilience overview	
Progress on 2018 recommendations	**Strategies** Enhancements and new strategies recommended
Put a price on carbon	• Implement an economy-wide carbon fee that assesses the carbon content of fossil fuels and sets a price per ton of carbon emitted • Implement an economy-wide cap-and-invest program that sets a limit on carbon emissions and allows the market to determine a price on carbon based on least-cost reduction measures
Expand consumer education and awareness efforts to increase the uptake of zero- and low-carbon technology measures	• Enhance outreach efforts by using social media campaigns, webinars, case studies, testimonials, and customer-engagement platforms ○ Conduct outreach on Climate Action Plan
Pursue an integrated approach to GHG mitigation, adaptation, and resiliency	• Prioritize opportunities for achieving synergies among actions that cut carbon pollution and prepare for the impacts of climate change ○ Proactively address synergies and dis-synergies
New recommendation – Strengthen alignment between state decision making and GHG emissions-reduction goals	• Ensure that regulatory programs and state decision-making take into account their impact on meeting Connecticut's GHG emissions-reduction goals • Ensure that regulatory programs include accounting for health and social cost impacts, including co-benefits of non-CO_2 pollutants • Where appropriate, adopt supplemental lifecycle GHG accounting metrics • Encourage energy-focused partnerships between regional councils of government and their member municipalities, Sustainable CT, and other NGOs to enable and align quantitative measurement of progress in reduction of GHG emissions, using a state-wide standard tool

Introduction

The Cross-Sector recommendations provided in the 2018 GC3 report address issues that impact Connecticut's climate change mitigation efforts broadly, including: carbon-pricing policies; education and outreach activities; and attention to the relationship between mitigation efforts and adaptation/ resiliency efforts. These policies are further explored in this chapter. The chapter also recommends additional policy initiatives: requiring an ongoing greenhouse gas (GHG) emissions-mitigation focus across all state decision-making; expanding GHG inventory practices; and taking a more comprehensive approach to calculating the benefits of reducing GHG emissions.

The Cross-Sector team was chaired by Charles Rothenberger (Save the Sound) and involved eight other Working Group members and 15 other stakeholders representing business, industry, higher education, environmental organizations, social-service organizations, and government agencies.[1] The team held 19 electronic meetings between March and August 2020.

Put a price on carbon

The carbon-pricing recommendation and strategies outlined in 2018, and their implications, are explored below. At the outset, we note that the two strategies identified in 2018 are related and that certain sectors may lend themselves more effectively and readily to a straight carbon-fee approach than a cap-and-invest approach. While an economy-wide approach that covers all sectors under a comprehensive and uniform carbon-pricing policy would be the preferable policy design, establishing such a program has eluded most jurisdictions thus far. However, Connecticut has adopted a carbon pricing mechanism for the electricity sector and is poised to adopt a similar mechanism for the transportation sector.

Equity and environmental justice – Both a straight carbon fees and cap-and-trade systems can either exacerbate or ameliorate impacts on low- and moderate-income communities. Accordingly, it is important to ensure that revenues generated by such a policy are invested largely in programs that reduce the pollution burden on low- and moderate-income communities and address any potential adverse economic impacts of the program.

Adaptation and resilience – Carbon-pricing policies can generate substantial funds to support complementary programmatic and policy priorities, including adaptation and resiliency measures in addition to additional mitigation measures. Identifying opportunities to fund adaptation, resiliency, and mitigation measures that equitably address existing disproportionate burdens and that improve the quality of life in LMI communities should be a priority.

Strategy – Implement an economy-wide carbon fee that assesses the carbon content of fossil fuels and sets a price per ton of carbon emitted

[1] See Appendix 1.

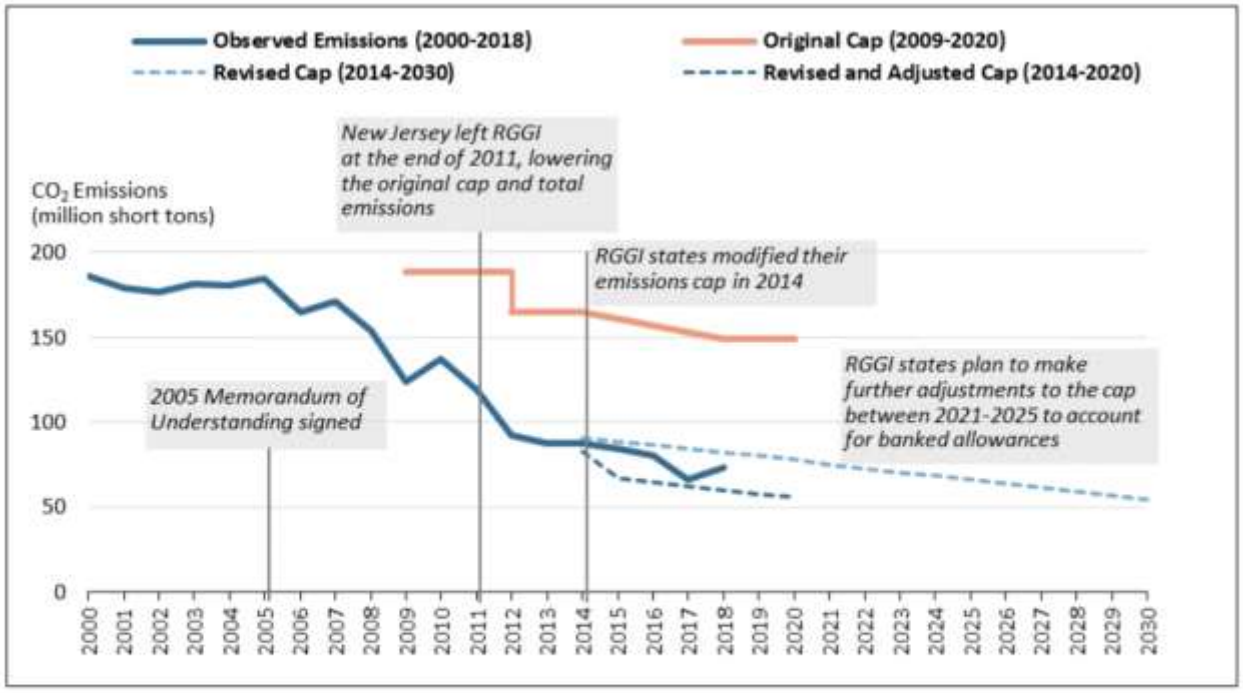
Strategy – **Implement an economy-wide cap-and-invest program that sets a limit on carbon emissions and allows the market to determine a price on carbon based on least-cost reduction measures**

Progress to date – These 2018 recommendations are intended to establish a price for carbon across the state economy. The first would set a price on emitters in the form of a fee (likely calibrated per ton of CO_2 equivalent) that would apply to the transportation, buildings, and electricity-generation sectors. The second would establish explicit limits on emission levels and establish a market for trading emission allowances applicable to all sectors. While Connecticut has no economy-wide carbon fee or carbon emission trading system, it participates with 11 northeastern and southeastern states in the Regional Greenhouse Gas Initiative (RGGI), a cap-and-invest trading system for the electricity sector. Based on the RGGI Model Rule, each RGGI participating state establishes individual CO_2 Budget Trading Programs through its own statutory and regulatory authority. Together, these programs comprise a regional cap and market for emission allowances.[2]

The chart below shows the relationship between historical electricity-sector emissions, the original RGGI cap, and the revised RGGI cap.[3] The revised adjusted cap (the higher dotted line) may not, on its own, sufficiently alter the downward emission's trajectory to achieve Connecticut's 2030 electricity-sector target. The current trading price of around $6/ton of CO_2 is insufficient to reduce emissions enough to reach the reduction target established in Executive Order 46 issued by Governor Malloy, Executive order 3 issued by Governor Lamont, and the 2018 GC3 recommendations. The future trading price under the revised adjusted cap is unknown.

[2] In Connecticut, these regulations and statutes are: R.C.S.A. 22a-174-31: Control of Carbon Dioxide Emissions/CO2 Budget Trading Program (updated consistent with Dec. 2017 program review announcement), R.C.S.A. 22a-174-31a: Greenhouse Gas Emission Offset Projects; and, CGS Section 22a-200c: Implementation of Regional Greenhouse Gas Initiative. Auctioning of Allowances.

[3] Chart is from https://fas.org/sgp/crs/misc/R41836.pdf. This is an updated Congressional Research Services report from July 16, 2019 (see Figure 2 page 7). FAS description of the chart: "Figure 2 illustrates (1) the observed emissions between 2000 and 2018; (2) the original emissions cap (2009-2020); and (3) the revised emissions cap (2014-2030), which includes the 2014-2020 adjustments. As mentioned above, RGGI entities banked a considerable number of emission allowances during the original emissions cap. This allows for the 2015 emissions to be higher than the revised emissions cap, as illustrated in the figure."



Source: Prepared by CRS; observed state emission data (2000-2018) provided by RGGI at http://www.rggi.org and revised emission cap data from RGGI at http://www.rggi.org/design/overview/cap.

Notes: RGGI entities banked a considerable number of emission allowances during the original emissions cap (2009-2013). This allows for the actual emissions to be higher than the revised and adjusted emissions cap.

Motor fuel taxes constitute an implicit price on carbon in the transportation sector and are insufficient to maintain the infrastructure. Connecticut is working with a coalition of states and the District of Columbia to adopt the Transportation and Climate Initiative (TCI), which would establish a cap-and-invest emissions trading system (ETS) for on-road transportation fuel. TCI jurisdictions have been engaged in extensive modeling and anticipate ratification of the program in late 2020.

There is effectively no carbon price in the buildings sector, and existing statutes and executive orders[4], although they provide a partial foundation, are not sufficient to set such a price. Doing so would require legislative action. One partial approach – which we outline below – would be a tax on heating oil inversely proportional to its biodiesel content. Blending biodiesel into heating oil to reduce GHG and particulate emissions is a short-run tactic. Incentivizing heat pump installations and adopting more stringent building codes (proposed elsewhere) to reduce heating and cooling loads are stick-and-carrot tactics that implicitly raise the price of carbon.

As Acadia Center reported in October 2016, "Connecticut's 'Lead by Example' (LBE) energy efficiency program does not appear to be on track to reach its mandatory goal of a 20 [percent] reduction in energy use in state buildings by 2018. The General Assembly established the LBE program in 2011 to

[4] Executive Order 46, issued by Governor Malloy, and Executive Orders 1 and 3, issued by Governor Lamont; and Public Act 08-98; Public Act 18-82; and 18-108, which required the Integrated Resource Plan (IRP) to "consider the creation of a portfolio standard for thermal energy"; and P.A. 19-35, which required the IRP to "include recommendations for the creation of a portfolio standard for thermal energy."

reduce costly energy waste in state buildings, lower the state's significant operating expense for energy use, and make the state a model for energy efficiency and sustainability.

Whatever carbon pricing system may be established in Connecticut, it is an open question what that price should be. There are several estimates regarding the appropriate price level that range from $20/tCO2 to $170/tCO2 (see the social cost of carbon working paper, Appendix 3).

Given that there are two predominant methods to set a carbon price – emissions trading systems and a carbon fee – how would an effective price for carbon manifest in a hybrid system that uses an ETS (e.g., RGGI and TCI) and user fees such as a mileage-based user fee (MBUF) and/or tolls? We must decide what the carbon fee will provide: Will it incentivize investment in renewables such that utilities completely switch to wind and solar? Will it encourage individuals and businesses to switch to ZEVs and heat pumps? And will it motivate individuals, corporations, and governments to determine how to adapt to the effects of global warming? If we decide on a price for carbon, it seems reasonable that the ETS would establish the allowances such that the established carbon price prevailed in each sector in which the ETS was operational and effect the required GHG reduction rate according to the wedge reductions established in GC3's 2018 report. A complementary user fee structure, such as a MBUF or highway tolls, would not function as a direct carbon price, but rather as a funding source for transportation infrastructure that with a complete transition to zero emissions vehicles will still need maintenance and improvement. We assume fuel taxes would disappear over time with infrastructure investments funded in part by these alternative transportation fees.

There is no economy-wide carbon price in the United States. RGGI addresses the electricity sector GHG emissions in 11 states, while the proposed TCI would address the transportation sector in a few states. Recognizing the efficacy of economy-wide carbon fees to reduce GHG emissions, as well as the limitations of sector-specific programs, at least as they have been implemented to date, we recommend that the state explore a uniform economy-wide carbon pricing system.

We also note that within the context of the current pricing programs there is no plan to price GHGs emitted by buildings as they heat and cool directly with fossil fuel or electricity generated in part by fossil fuel. To address that gap, the Buildings-sector chapter proposes to tax heating oil, eliminate natural gas expansion, convert incentives for natural gas conversion to incentives for heat pumps, and adopt building codes that increase building energy efficiency.

Expand consumer education and awareness efforts to increase the uptake of zero- and low-carbon technology measures

Equity and environmental justice – As Connecticut ramps up efforts to reach out to broader constituencies to support action on climate, we must be cognizant that communication needs to be a discussion with communities and stakeholders – not a lecture. Particularly as it relates to LMI communities, we must take the time to ask about local problems and concerns in order to identify what policies will be most meaningful to a particular community. At the same time, we must do a better job of communicating local and immediate benefits that communities could enjoy from the implementation of specific climate policies. At the same time, all outreach efforts should be tailored to the needs of the community with respect to the medium used. Once social distancing requirements are relaxed, it may

be that in some circumstances in-person meetings may be more effective if there are barriers to accessing on-line meeting platforms.

Adaptation and resilience – The vulnerability of individuals and communities to the impacts of climate change – and hence the need for strong mitigation measures – can be underscored by identifying specific areas/types of potential harm and by highlighting how the costs of protecting vulnerable infrastructure and populations will increase over time unless sufficient mitigation measures are taken.

Strategy – Enhance outreach efforts by using social media campaigns, webinars, case studies, testimonials, and customer-engagement platforms

The COVID-19 pandemic has necessitated a focus on remote work and meetings, and many organizations have taken advantage of these circumstances to expand on-line webinars and educational efforts. As a result, more individuals have gained familiarity (and greater proficiency) with platforms such as ZOOM and Microsoft Teams. DEEP has taken advantage of the opportunity to host broad stakeholder meetings and to move long-standing regular meetings to online platforms. Of particular relevance, DEEP has gone to great lengths to ensure public awareness of and access to the various meetings of the Governor's Council on Climate Change, and its working groups. DEEP also recently posted a series of videos to its website highlighting recent air-quality improvements driven by reduced traffic and other polluting activities.

We recommend that GC3 engage in proactive outreach, particularly to overburdened communities, to highlight on-line resources and engage stakeholders**.**

Enhancement – Conduct outreach on climate action plan

Equity and environmental justice – There is growing concern that programs to promote energy efficiency and rooftop solar primarily serve wealthier residents, to the disadvantage of poor communities that help fund the programs through their energy bills. Disadvantaged communities can have limited concern for climate change, because they face more immediate concerns of poverty, crime, food insecurity, and substandard housing. Outreach efforts will need to connect climate action to the near-term priorities of poor communities and demonstrate measurable improvement in their quality of life.

There is a strong desire to build equity into climate change mitigation efforts to address concerns that past investments have disproportionately served wealthier residents. A key challenge has been engaging hard-to-reach audiences that feel disenfranchised and are often struggling with daily challenges. These households typically have limited time, energy, and interest in climate policy discussions. Designing and implementing an effective communication and outreach strategy will take time and resources.

There is a tendency to underestimate the time and resources required for effective outreach. The Portland, Oregon, Climate Action Through Equity initiative provides an illustrative example. Portland formed an Equity Work Group composed of six community-based organizations supported by grants to lead the process. The initial approach was to present each chapter of the previous climate action plan – e.g., buildings, energy, transportation, etc. – and a worksheet outlining recommended actions in each area. Participants were then asked to identify the equity implications of each action. This approach was not productive. Trying a different tack, the working group introduced each topic and asked participants

to share relevant experiences from their community. Based on the resulting input, climate planners were then tasked with designing actions that would address communities' priority concerns. Although a more productive approach, this required significantly more time than originally planned. The initial schedule assumed a May to October 2013 timeline. The update plan was not adopted until June 2015.[5]

In neighborhoods struggling with substance abuse, crime, abandoned and blighted properties, unhealthy homes, food insecurity, and the many day to day challenges related to poverty, climate change is not a top priority. Linking climate action to solutions that address these near term quality of life issues can help build broader support for action and engage hard to reach constituencies.

We recognize that there is inadequate civic infrastructure[6] to enable meaningful engagement of all residents in collaborative efforts to address their most pressing problems. Civic engagement initiatives have taken two primary forms.[7] Protest campaigns to demand changes to address a specific problem effectively engage a wide and representative range of residents, but they tend to be temporary and disband after the immediate crisis passes. Neighborhood organizations are more formal and permanent and often have established channels with the local government to influence community decisions. However, these are often dominated by the most motivated and confident political actors, and local officials must decide if their recommendations truly represent those of their less-engaged neighbors.

- The GC3 community-engagement effort will necessarily be a multi-year process and be linked to the decision-making processes required to implement the Council's climate action agenda. Public participation should be focused on the selection of criteria important to the community and coordinated with the definition of an environmental justice (EJ) index proposed by the Equity and EJ Working Group.

- These criteria should then be incorporated into any regulatory or agency decision process that requires a cost-benefit analysis to ensure adequate consideration of co-benefits relevant to equity and EJ priorities.

- DEEP should create a staff position to help coordinate a sustained outreach effort with key non-profit and neighborhood organizations to develop an effective communication plan to clearly link climate actions to the quality-of-life issues important to disadvantaged and EJ communities.

- DEEP should partner with the Department of Economic and Community Development to build a civic infrastructure in priority EJ communities to enable residents to more effectively advocate for their interests.

Pursue an integrated approach to GHG mitigation, adaptation, and resiliency

[5] History and key documents of climate planning and action in Portland, https://beta.portland.gov/bps/climate-action/history-and-key-documents-climate-planning-and-action-portland. See also GC3 webinar, "Portland, OR, Equity Work Group," Nov. 16, 2015, https://portal.ct.gov/DEEP/Climate-Change/GC3/Webinars.
[6] Aspen Institute Forum for Community Solutions. 21st Century Civic Infrastructure: Under Construction. https://aspencommunitysolutions.org/21st-century-civic-infastucture-under-construction/.
[7] Leighninger, M. (2006) The Next Form of Democracy. Vanderbilt University Press: Nashville, TN.

Equity and environmental justice – As noted in the discussion regarding the need for equitable investment of revenue from carbon-pricing programs, recognition that the impacts of climate change fall disproportionately on disadvantaged communities should guide Connecticut's approach to determining how and where investments in adaptation and resilience measures ought to be directed. While much attention is, rightfully, focused on the dangers that sea level rise poses to shoreline communities and the state's substantial shoreline transportation infrastructure, it is important to recognize that existing conditions in communities across the state may be exacerbated by climate change. These include existing chronic health issues, substandard living conditions, and a lack of access to essential services. While adaptation and resilience discussions frequently center on the need to protect "hard" assets, there also is need to address "soft assets" related to community resilience at the individual and family level.

Adaptation and resilience – It may be necessary to broaden our working definitions of *adaptation* and *resiliency* in order to adequately identify and capture needed investments in low- and moderate-income communities. While protecting and "future-proofing" infrastructure is an important component of any adaptation and resiliency plan, we need to also consider the individual-level needs of traditionally under-served and overburdened communities, and the challenges that they will face as a result of climate change. Accordingly, additional investments in healthcare, social services, and the rehabilitation of inadequate housing stock should be part of the projected investment portfolio. And there is certainly some overlap among the needed investments in adaptation and mitigation in this area. For instance, transitioning from fossil-fueled transportation and energy generation to electric vehicles and clean renewable energy reduces "climate forcing" emissions, while also contributing to fewer local air pollutants likely to exacerbate asthma and other chronic health conditions. Improving the energy efficiency of our building stock (while also, it is hoped, addressing health and safety issues) means lower energy bills and using less energy to adequately heat and cool the building to handle changing climatic conditions.

Strategy – Prioritize opportunities for achieving synergies among actions that cut carbon pollution and prepare for the impacts of climate change

GC3's 2018 report recommended that Connecticut "prioritize opportunities for achieving synergies among actions that cut carbon pollution and prepare for the impacts of climate change." And Gov. Lamont's Executive Order 3 instructed GC3's Mitigation Progress Working Group to assess progress in "identification of new and emerging mitigation strategies that maximize climate change adaptation and resilience opportunities while ensuring the state is on a sustainable path to meet its [emission] reduction targets."[8]

Progress to date – As part of its process in 2020, the Mitigation Progress Working Group engaged with the Adaptation Planning Working Group and the Science and Technology Working Group for high-level discussions about explicit and implicit interactions between the Council's climate change mitigation efforts and its adaptation and resiliency efforts.

In principal, any climate change mitigation (i.e., emissions-reduction) initiative across the globe serves the interest of climate change adaptation/resiliency by reducing the extent of global warming to which

[8] E.O. 3, signed Sept. 3, 2019, https://portal.ct.gov/-/media/Office-of-the-Governor/Executive-Orders/Lamont-Executive-Orders/Executive-Order-No-3.pdf.

the state, municipalities, businesses, and households must adapt in the long term. The sooner mitigation measures are adopted, and the more effective those measures are, the lower the cost of necessary adaptation measures will be.

However, in developing mitigation recommendations, it is important that policymakers recognize specific ways in which mitigation and adaptation interact – both synergistically and antagonistically – in the short- and medium-term. Doing so will make it possible to:

1. prioritize mitigation options that materially enhance adaptation;

2. when feasible, steer away from mitigation options that run counter to the needs of adaptation;

3. improve awareness of unavoidable tensions between mitigation and adaptation; and

4. establish a framework for coordination between initiatives in the two spheres.

Some mitigation initiatives *directly enhance adaptation.* Some examples:

- *Buildings* – Prioritizing building envelope improvements and expanding access to thermal energy-efficiency measures through innovative financing options for all income levels lessens grid stress, which could make it easier to recover from major storms and other climate shocks.

- *Electricity* – Deploying distributed renewable energy resources reduces GHG emissions and potentially makes communities more climate-resilient by making them less dependent on distant generation resources.

- *Transportation* – Low-emission and zero-emission vehicles require less fuel, which could be a significant benefit when major storms disrupt fuel supplies. They also emit less air pollution, reducing vehicular contributions to smog as climate change exacerbates Connecticut's air quality challenges.

On the other hand, mitigation options also can have *negative impacts on adaptation.* Examples:

- *Buildings* – Curtailing use of natural gas for heating could require expanding the use of deliverable heating fuels, including the use of biodiesel, which could produce a modest increase in emissions of nitrogen oxides, which contribute to smog formation.

- *Electricity* – Adoption of smart-management technologies to optimize flexibility of distributed energy resources could, in the view of some analysts, make the grid more brittle in the face of major storms and other climate shocks.

At the same time, of course, adaptation/resiliency initiatives can also have either productive or counterproductive impacts on climate change mitigation initiatives. A classic example of beneficial synergism is urban tree planting to make a community more resilient by reducing the urban heat island effect and improving air quality. Reducing the urban heat island would simultaneously aid climate change mitigation by reducing summer temperatures and hence energy consumption for air conditioning, and the trees themselves would sequester carbon from the atmosphere and store it.

Conversely, a classic example of antagonism between climate change adaptation and climate change mitigation is a concrete seawall. Erected to protect a community vulnerable to sea level rise, it would undermine the state's progress toward its emissions-reduction goals by requiring vast amounts of cement produced by kilns that emit large quantities of GHGs. A table in Appendix 2 illustrates the variety of relationships between mitigation and adaptation efforts.

Enhancement – **Proactively address synergies and dis-synergies**

As the GC3 develops suites of mitigation and adaptation strategies, it is vitally important that it systematically attend to ways that these strategies interact. Whenever possible, siloed conversations focusing on either mitigation *or* adaptation should be avoided in favor of conversations focusing on a synthesis of mitigation *and* adaptation. And the Council should develop mechanisms to comprehensively assess synergies and dis-synergies across the mitigation/adaptation divide. It should be especially aggressive in identifying and avoiding what has been termed *maladaptation:* climate change adaptation/resiliency efforts that thwart progress toward formal climate change mitigation objectives. Adaptation without effective mitigation is a fool's errand.

New recommendation – Strengthen alignment between state decision making and GHG emissions-reduction goals

New strategy – Ensure that regulatory programs and state decision-making take into account their impact on meeting Connecticut's GHG emissions-reduction goals

We recommend that the Connecticut General Assembly pass legislation requiring that all state action be evaluated for consistency with meeting the GHG emissions-reduction targets set forth in the Global Warming Solutions Act and in PA 18-82.[9]

National and subnational actors are adopting increasingly comprehensive approaches to ensure that they remain on track to fulfill their GHG emissions-reduction obligations. While adoption of comprehensive GHG reduction and reporting requirements is critical to addressing needed emissions reductions, governments are recognizing that comprehensive compliance frameworks also are essential to ensure that discrete actions by agencies do not inadvertently cause states to diverge from the path toward to their formal reduction targets.

For example, New York's landmark Climate Leadership and Community Protection Act (CLCPA) (Assembly Bill A08429) requires all state agencies to evaluate whether their actions are consistent with the state's GHG reduction obligations. If it is determined that an action is not consistent with those obligations, then the agency must explain why the action is necessary and identify additional measures that will be taken to ensure that the state's greenhouse gas reduction goals will be met. Similarly Oregon Executive Order No. 20-04 directs all state agencies to "exercise any and all discretion" to facilitate the state's achievement of its GHG emissions reduction goals, prioritize and expedite any processes and procedures (including rulemaking and agency dockets) that could accelerate GHG

[9] An Act Concerning Connecticut Global Warming Solutions [PA 08-98], Conn. Gen. Stat. Sec. 22a-200a et seq., which established mandatory GHG emissions-reduction targets of 10 percent below 1990 levels by 2020 and 80 percent below 2001 levels by 2050. And PA 18-82, An Act Concerning Climate Change Planning and Resiliency, which established a mandatory GHG emissions-reduction target of 45 percent below 2001 levels by 2030.

reductions, and to consider and integrate climate change impacts and the state's GHG reduction goals into their planning, budgets, investments , and policy making decisions.

In 2019, legislation mirroring many elements of the CLCPA was introduced in Connecticut. (See SB 345, *An Act Concerning A Green New Deal For Connecticut*). The policy recommendations contained in SB 345 should be reintroduced in the 2020 legislative session, and DEEP and other agencies involved in the GC3 should support such legislation.

New strategy – Ensure that regulatory programs include accounting for health and social cost impacts, including co-benefits of non-CO_2 pollutants

As Connecticut ramps up investment in zero-carbon technologies, we must ensure that appropriate metrics are being applied that value the full range of societal benefits these technologies deliver, including environmental and health benefits, in addition to those direct benefits that may be ascribed to the energy system itself, such as improved resilience.

While the focus of this report is on climate change, it is important to recognize that combustion of fossil fuels produces a range of harmful air pollutants damaging to human health and the environment, including carbon monoxide, nitrogen oxides, particulate matter, and unburned hydrocarbons. The public health, environmental, and economic benefits of reducing these non-CO2 pollutants should systematically be accounted in regulatory decision-making.

Efforts to explore the appropriate valuation of clean distributed energy resources has been undertaken jointly by the Public Utility Regulatory Authority and DEEP in Docket No. 19-06-29. Pursuant to that docket, the agencies are evaluating how to assess the relative quantitative and qualitative social benefits. This evaluation should be guided by the recently released National Standard Practice Manual for Distributed Energy Resources, which calls for states to account for health, social, and environmental benefits that align with their formal health, social, and environmental policy objectives. DEEP should similarly require extensive accounting of co-benefits in the utilities' cost-effectiveness testing for energy-efficiency programs under the Conservation and Load Management Plan. Here again the National Standard Practice Manual provides appropriate guidance.

New strategy – Where appropriate, adopt supplemental lifecycle GHG accounting metrics

Connecticut's GHG inventory protocol provides a snapshot of direct emissions occurring within Connecticut in a given year.[10] Climate actions, however, have effects that extend over long time periods and have impacts around the world.

DEEP uses EPA's State Inventory Tool to monitor the state's progress in mitigating climate change.[11] The tool uses top-down estimates for state-level GHG emissions in 11 sectors. Connecticut's inventory focuses on direct emissions within state boundaries for a given year, with the exception of emissions in

[10] See Connecticut Greenhouse Gas Inventory Reports, https://portal.ct.gov/DEEP/Climate-Change/CT-Greenhouse-Gas-Inventory-Reports.
[11] EPA. State Inventory and Projection Tool. https://www.epa.gov/statelocalenergy/state-inventory-and-projection-tool

the electricity-generation sector, for which DEEP employs a consumption-based approach to account for the regional nature of the ISO-New England grid.

While this is an appropriate approach for tracking annual progress, it sometimes is an insufficient basis for planning action. Where the in-state, single-year model might fail to capture significant impacts elsewhere and in the future, it would be appropriate to use lifecycle assessment (LCA) data as a supplement to the inventory data.

LCA considers the full range of environmental impacts, from resource extraction to final disposal, associated with a particular product or activity under consideration. LCA data can help highlight practices that simply shift the environmental burden to a different region or transform it into another environmental impact. For example, when exploring alternatives to fossil fuels, it is important to consider the impacts of the fuel supply chain and health impacts of criteria pollutants associated with burning fossil fuels. Many proposed climate change mitigation strategies, such as converting to renewable power sources or improving building codes to drive energy efficiency involve investment in new materials to reduce operating impacts. Environmental and climate impacts associated with resource extraction and manufacturing processes should be considered to ensure there is a net benefit over a reasonable lifetime. LCA provides a disciplined method to evaluate these distant impacts.

Timing of GHG emissions can be critical, especially in projects to develop biofuels or biomaterials that impose upfront land use change impacts. It is generally agreed that efforts to push out emissions to future years can provide time for technology advancement and help avoid irreversible tipping points. However, it is also generally assumed that climate damages will increase non-linearly with increasing temperatures, making those future emissions much more damaging than current emissions. Methods to adequately model these dynamic effects is a subject of ongoing research.[12]

Connecticut-specific LCA studies would be resource intensive, and DEEP currently does not have the capacity to conduct or fund such studies. However, review of open literature and programs in other states and at the federal level to identify proxy values to support analyses is recommended as a practical approach. For example, natural gas has been promoted as a "bridge" to renewable power. Studies of methane leakage along the supply chain indicate the GHG impact of natural gas is much greater than estimates that consider only the reduced carbon content of natural gas compared to other fossil fuels. A review of several studies concluded a reasonable estimate of upstream emissions was 19.2 kg CO_2e/ MMBtu, compared to 53.1 kg CO_2e/MMBtu for the final combustion of natural gas.[13] These estimates need to be updated to reflect better data on methane emissions, implementation of measures to reduce methane leaks, modified operating procedures to reduce intentional venting, and the increased prevalence of fracking. Some estimates of upstream emissions show significantly higher impacts, 22 to 47 kg CO_2e/ MMBtu.[14]

Connecticut's policies and planning for natural gas distribution and use should account for the lifecycle impacts of methane emissions, as should any proposed fuel taxes. When considering the cost and equity

[12] Sproul, E., Barlow, J., & Quinn, J.C. Time Value of Greenhouse Gas Emissions in Life Cycle Assessment and Techno- Economic Analysis, Environ. Sci. Technol., 2019, 53, 6073-6080, https://doi.org/10.1021/acs.est.9b00514
[13] Worldwatch Institute, Comparing Life- Cycle Greenhouse Gas Emissions from Natural Gas and Coal, 2011, https://www.db.com/cr/en/docs/Natural_Gas_LCA_Update_082511.pdf.
[14] Howarth, R.W., Santoro, R., & Ingraffea, A., Methane and the Greenhouse Gas Footprint of Natural Gas from Shale Formation, Climatic Change, 2011, 106, 679-690. https://www.atkinson.cornell.edu/Assets/ACSF/docs/attachments/Howarth-EtAl-2011.pdf.

implications of electrification, the total CO_2e (carbon dioxide equivalent) of natural gas should be considered. Likewise in consideration of liquid biofuels, the demonstrated lifecycle benefit should factor into the process.

There are two emerging areas where LCA may play an increasingly important role. Waste management is measured based on only the in-state impacts. Much of the benefit of waste reduction or increased recovery of materials fall in other categories of the inventory or outside the state boundaries and hence outside the inventory boundaries. Evaluation of effective waste management should consider a broader range of environmental aspects and the full lifecycle. Land use and land use change associated with forestry management or agricultural practices can have significant effects on GHG emissions. Timing of the emissions is critical and dynamic LCA methods to appropriately account for the effects of various emission profiles are being developed.

DEEP should partner with Connecticut universities to support student teams to research the literature on these topics to monitor ongoing developments and develop a baseline understanding to inform future regulatory actions.

New strategy – Encourage energy-focused partnerships between regional councils of government and their member municipalities, Sustainable CT, and other NGOs to enable and align quantitative measurement of progress in reduction of GHG emissions, using a state-wide standard tool

New ways to measure and report on work that enhances environmental protection and environmental justice at the local level would facilitate the state's ability to measure actual progress in a more granular and timely way.

Cities, counties, states, and countries are using a variety of GHG inventory tools to track and report on emissions. Insights gained from these data sets can inform ever-improving climate policy decisions and speed our progress toward a zero-carbon economy.

One example is the internationally recognized ClearPath platform that California and other states are using, along numerous American counties, cities, and towns. ClearPath was developed by the International Council of Local Environmental Initiatives — Local Governments for Sustainability (ICLEI).[15] ICLEI also offers some nationally adopted programs that enhance social equity and environmental justice around climate change mitigation and adaptation. Stamford and New Haven are among the jurisdictions currently poised to begin using ICLEI's solutions-oriented tools.

Municipalities that are interested in conducting GHG inventories should partner with their regional planning organization, and with Sustainable CT, UConn fellows, mentored high school students, and other academics to conduct these inventories, thereby enhancing job training and possibly earning Sustainable CT certification points.

[15] ICLEI has submitted to the Cross-Sector team a quote of an annual $55,000 statewide basic membership fee that would allow any municipality to use the web-based ClearPath tool. Other types of partnerships with this organization would allow Connecticut to benefit from climate action work done by ICLEI USA and its members since 1991. Funding sources for such valuable yet modestly priced partnership options should not be difficult to identify.

DEEP should either encourage municipalities to use a standard GHG inventory tool. Subsequent publication of comparable town-by-town emissions reports on the GC3 website would engender accountability and friendly competition while speeding overall progress.

Appendices	
Appendix 1	Members of the Cross-sector team
Appendix 2	Typology of relationships between climate change mitigation initiatives and climate change adaptation/resiliency initiatives
Appendix 3	Working paper on social cost of carbon
Appendix 4	Acronyms and abbreviations
Appendix 5	Preliminary glossary

Appendix 1

Members of the Cross-sector team	
Chair	
Charles Rothenberger	CT Fund for the Environment
Working Group	
Patrick Carleton	Metropolitan Council of Governments
Tony Cherolis	Transport Hartford Academy at the Center for Latino Progress
Bill Finch	Discovery Museum & Planetarium
Deb Geyer	Stanley Black & Decker
Patrice Gillespie	CT Clean Water Fund / CT Energy Network
Stanley McMillen	UConn
Bernie Pelletier	People's Action for Clean Energy
Tom Swarr	GC3 Equity & Environmental Justice Working Group
Other Stakeholders	
Lynne Bonnett	New Haven Energy Task Force
Sten Caspersson	CT Academy of Science & Engineering
Evan Dantos	Robinson & Cole
Eric Hammerling	Connecticut Forest & Park Association
Lisa Hayden	New England Forestry
Wilhemina Krahn	Metropolitan Council of Governments
Diane Lauricella	CT Green Building Council
Elsa Loehmann	(environmental engineer)
Richard Love	Raytheon
Cary Lynch	Nature Conservancy
Denise Savageau	CT Council on Soil and Water Conservation
Mark Scully	People's Action for Clean Energy
Anji Seth	UConn Geography/GC3 Science & Technology Working Group
Jon Slifka	Department of Aging and Disability Services
David Sutherland	Nature Conservancy
DEEP support staff	
Jeff Howard	Bureau of Energy & Technology Policy
Doris Johnson	Commissioner's Office
Brian Basso	Intern

Appendix 2

Typology of relationships between climate change mitigation initiatives and climate change adaptation/resiliency initiatives

	A1 – Mitigation is directly and immediately synonymous with adaptation Priority: 1	**A2** – Mitigation is adaptation-neutral in short term but supports or obviates adaptation in long term Priority: 2	**A3** – Mitigation undermines adaptation in short term but supports or obviates it in long term Priority: 3	**C** – Adaptation is mitigation-neutral[1] Priority: 4	**E** – Adaptation hinders mitigation[2] Priority: 5
Excessive heat	LEED-certified building standards	Reducing overall levels of consumption	Dense urban form in hot, humid clime (see Pizarro)		Increased use of air conditioning
Drought	Improved efficiency of water use	LEED-EB renovation of existing buildings Using construction materials with low embodied energy	Hydropower (potential conflict with agricultural irrigation)	Local rainwater harvesting and floodwater storage	New conventional reservoirs; importation of water from distant regions
Rising sea levels	Relocating coastal residents inland into LEED platinum urban housing	Reducing personal-vehicle VMT Reducing reliance on air travel Increasing reliance on mass transit and long-distance rail		Relocating coastal residents inland into existing conventional urban housing	Relocating coastal residents inland into new conventional suburban housing
Flooding	Restoration of wetlands				Building concrete dikes and levees
Degradation of urban air quality	Urban tree planting; open space and habitat protection		Use of biodiesel (minor increase in NO_x emissions)	Passive filtering within buildings (e.g. via plants)	Active filtering within buildings via mechanical systems
Increase in incidence or severity of violent storms	Decentralized renewable energy generation; restoration of coastal wetlands			Improved storm warning systems & evacuation planning	Making structures storm-resistant through use of concrete and steel walls

Notes: 1 Most adaptations in column C assume use of renewable energy.

2 Most adaptations in column E assume use of fossil fuels. Some of these would be in column C if carried out with renewable energy.

Source

Howard, Jeff. 2009. Climate change mitigation and adaptation in developed nations: A critical perspective on the adaptation turn in urban climate planning. In *Planning for Climate Change: Strategies for Mitigation and Adaptation*, edited by S. Davoudi, J. Crawford and A. Mehmood. Sterling, VA: Earthscan, pp. 19-32.

Appendix 3

Working Paper on Social Cost of Carbon

Submitted by Stan McMillen

The social cost of carbon is a useful concept as policymakers decide what price they may place on carbon emissions either as a tax or implicitly in an emissions trading system in order to reduce them and address the excess damages from climate warming due to human activity. Fuel taxes, emission permits, regulatory costs such as fuel efficiency standards for motor vehicles as well as building codes establish implicit carbon prices. Complementary mitigation policies such as incentives for switching to zero-emission vehicles from internal combustion engine vehicles, to heat pumps from oil- and gas-fired heating appliances as well as vehicle miles traveled policies act to reduce carbon emissions without setting a carbon price. In addition, carbon capture and sequestration activities reduce accumulated carbon and enhance mitigation practices.

The brief literature review below shows the variety of models and methods for suggesting a social cost of carbon and may not be much help to policymakers. However, there are overlapping ranges where one could reasonably set a price and see what reductions occur over time. Cognizant that one size does not fit all, carbon prices may vary by location and public acceptance. First, some background.

Social and private costs

In producing goods and services, companies and individuals account for their costs of production. Typically, these are accounting costs and include labor (payroll), materials, rent, taxes, insurance and services such as accounting, security, and legal. These costs averaged over the "units" of production are average total costs. The total cost of production is the sum of all costs mentioned above. The marginal cost of production is the cost of producing one additional "unit" (these can be billable hours, number of cars, number of patients treated). This is the private marginal cost of production and companies try to minimize this cost. If the company produces measurable pollution (smoke) or waste material (fly ash, toxic chemical byproducts) and dumps these int*o* the air, water or ground causing health and environmental damage, the company produces an externality that others must pay to manage (increased sickness, reduced fish yields). The company should produce at the higher social marginal cost that accounts for the cost society bears to cope with the externality. This is usually accomplished by taxing the company so that its private marginal cost approaches the social marginal cost (see below). The higher marginal cost of production forces the company to reduce production and resulting pollution to socially acceptable levels. Equivalently, an emissions trading system can be established that sets a quantity limit on pollution emission and auctions permits to 'pollute'. The Regional Greenhouse Gas Initiative of which Connecticut is part with nine other states, is an example of this form of pricing carbon pollution in the electricity sector. In this case, there is a market for carbon pollution, but in most cases, there is no market for the externality (think of the Super Fund sites for which we all bear the cleanup costs: there was no market for the pollution accumulated there). These are cases of market failure that only governments can correct.

Estimating the Social Cost of Carbon

There is a large and growing literature on estimating the social marginal cost of carbon (SCC) that may be defined as the cost in today's dollars of future damages caused by emitting one ton of carbon into the atmosphere today. Equivalently, we can characterize the SCC as the future benefits in today's dollars realized by reducing carbon emissions by one ton today (see below for a more technical definition). There are several mathematical models and techniques used to estimate the SCC and they differ widely in their estimates. The most appealing models account for as many effects of climate warming we know of as well as the behavioral characteristics of people and their leaders. The unknown future (consumption, environmental and ecological damage) is characterized in terms of probabilities. In most cases, the unaccounted for known unknowns are described as avenues of future research (loss of biodiversity, climate induced migration, novel diseases and pests, ocean acidification and loss of salinity). The unknown unknowns await discovery (possible feedback loops that amplify known effects).

Two meta studies illuminate the breadth and diversity of approaches to estimating a SCC. Pei Wang, et al. (2019) provide a meta-analysis of several studies.[16] Their analysis yields global SCC estimates that average \$54.70t/CO_2 for non-peer-reviewed studies and \$30.78t/CO_2 for peer-reviewed studies that are more credible. Tol (2011) looks at nine studies that derive 311 SCC (a marginal cost) estimates from the total cost of carbon and organizes them by discount rate, peer-reviewed, equity accounting, uncertainty handling and vintage.[17] The SCC estimates vary widely depending on the models and the assumptions and parameter calibrations used. The discount rate or pure rate of time preference is a crucial parameter as is the modeling of uncertainty. Unfortunately, Tol's (2011) Table 2 (page 431) does not crosstab his survey. For example, it would be helpful to look at the average SCC from studies that are peer-reviewed, account for equity and uncertainty and are most recent. Nonetheless, Tol's (2011) most appealing average SCC estimates are \$80/MTC (\$21.81/tCO_2)[18] for peer-reviewed studies, \$113/MTC (\$30.81/tCO_2) for studies after 2001, \$168/MTC (\$45.81/tCO_2) for studies accounting for equity and \$177/MTC (\$48.27/tCO_2) for studies incorporating uncertainty. To be complete, Tol (2011) recognizes some SCC estimates that are negative meaning there are short-term benefits to global warming including longer growing seasons in some regions, enhanced plant performance for some plants, year-round navigable arctic seas, newly exposed lands for resource extraction, but that these benefits are likely outweighed by regions with reduced or increased rainfall, higher sea levels, desertification of arable land, more severe and frequent cyclones, among other costs.

Van den Bremer and van der Ploeg (2019) provide a technical definition or characterization of the social cost of carbon.[19] To quote them, "The social cost of carbon (SCC) is the Pigouvian tax that internalizes the expected harm of emitting one ton of carbon to the economy, i.e., the expected present discounted value of all future marginal utility losses resulting from emitting one ton of carbon today, converted from utility into dollars today. The risk-adjusted SCC incorporates uncertainties associated with climate and the economy when calculating this tax." It is helpful to unpack this definition into lay terms. A Pigouvian tax is one that corrects (at least partially) a market failure, where in this case, there is no market for carbon (generally) and therefore no market price associated with emitting carbon into the atmosphere and the consequent damages the emissions cause. Typically, damages are paid or experienced by parties not directly engaged in producing carbon emissions, although ultimately, we all pay for health and environmental damages. A market-correcting tax (directly) or quantity constraint (indirectly) establishes a higher price for carbon that reduces the production and consumption of carbon emissions (GHGs including particulate matter). There is therefore no distortionary effect of the price for carbon established either way. The carbon price forces emitters to internalize the expected discounted future costs of damages estimated as future marginal utility losses measured in dollars.

The rate of discount is another key concept that needs clarification. The idea is how we value the future relative to the present. Because carbon lingers in the atmosphere for a long time, today's emissions cause damages decades in the future. A high discount rate indicates we value the present higher relative to the future while a low discount rate indicates we value the future relatively higher than the present. The baseline rate is the rate of pure time preference that indicates our relative impatience or how much we prefer a dollar today to a dollar tomorrow. The discount rate in the van den Bremer and van der Ploeg (2019) model is the rate of pure time preference adjusted for multiple sources of uncertainty (the size of the carbon stock, the effect of the carbon stock on temperature, the effect of temperature on damages, the growth of the economy and aversion to risk and inequity, among others).

Van der Ploeg (2020) estimates the social discount rate using several models.[20] This is a crucial parameter in estimating the SCC as a low discount rate implies a higher SCC today, while a high discount rate implies a lower SCC today (and a faster growth rate) and the SCC is quite sensitive to the discount rate. And, the discount be not be

[16] Pei Wang, Xiangzheng Deng, Huimin Zhou, and Shangkun Yu (2019). "Estimates of the social cost of carbon: A review based on meta-analysis," *Journal of Cleaner Production*, 209, pp.1494-1507.
[17] Tol, Richard S.J. (2011). "The Social Cost of Carbon," *Annual Review of Resource Economics*, Vol. 3, pp. 419-434, C1-C2, 435-443.
[18] A metric ton of carbon is equivalent to 12/44 tons of CO_2.
[19] van den Bremer, Tan S. and van der Ploeg, Frederick (April 2019). "The risk-adjusted carbon price," CESifo Working Paper No. 7592, Category 10: Energy and Climate Economics.
[20] van der Ploeg, Frederick (July 2020). "Discounting and Climate Policy," CESifo Working Paper No. 8441, Category 10: Energy and Climate Economics.

constant over time. Under certain conditions, the discount rate may increase over time (decades) reducing the SCC. Obviously, if mitigation is successful (including complementary carbon capture), damages from ongoing climate warming are lower in the future and fewer resources need to be dedicated to mitigation and capture. Van der Ploeg's (2020) SCC estimates are in the neighborhood of $\$20/tCO_2$ for the present day and they grow at the discount rate used in their estimation.

The van den Bremer and van der Ploeg (2019) mathematical model generalizes the analysis of the SCC using values for the uncertainties mentioned above (expressed as properties of probability distributions) and their most general formalization estimates a risk-adjusted SCC of $\$40/tCO_2$ (the deterministic or unadjusted for risk SCC estimate is $\$11.50/tCO_2$). This compares with risk-adjusted SCC values estimated by other researchers in a range of $\$18.50/tCO_2$ to $\$165.20/tCO_2$ (unadjusted estimates range from \$14.40 to $\$86.90/tCO_2$).

A U.S. federal Interagency Working Group (IWG) produced widely cited estimates during the Obama Administration. The IWG's central estimate is \$51 per metric ton of carbon dioxide emitted in 2020, rising incrementally to \$85 per metric ton in 2050, at a discount rate of 3 percent (2018 dollars).[21,22] Estimates of SCC have been widely criticized because of the methodological limitations of the underlying economic analyses. A recent critique of the IWG's estimate concludes:

> [D]ecisionmakers should recognize that the [interagency working group's] Social Cost of Carbon is really a lower bound. Many significant climate impacts … are difficult to quantify and so have been omitted from the … estimates. Effects such as increased fire risk, slower economic growth, and large-scale migration are all unaccounted for, despite their potential to cause large economic losses. So, policymakers should account for these omissions by treating the Social Cost of Carbon figures presented within [the interagency] report as underestimates.[23]

That assessment is mild. Deeper evaluation of the limitations of SCC calculations suggests prevailing figures are, at best, "gross underestimates," perhaps by several orders of magnitude.[24] Underscoring this judgment are studies highlighting the deep limitations of the climate models that quantify the damage projections underlying SCC calculations and studies documenting that the climate science community has tended to understate the severity and pace of climate change.[25]

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[21] Ibid. The interagency working group estimated impacts in 2007 dollars. The 2018 figures cited here are from Denis A. Grab et al., "Opportunities for Valuing Climate Impacts in U.S. State Electricity Policy," Institute for Policy Integrity, New York School of Law, 2019, https://policyintegrity.org/files/publications/Valuing_Climate_Impacts.pdf, p. 9.

[22] The Trump administration, in contrast, proposed a value of \$1 to \$7 per ton by disregarding the impacts of U.S. emissions beyond the nation's borders and bumping the discount rate. See Brad Plumer, "Trump Put a Low Cost on Carbon Emissions; Here's Why It Matters," *New York Times*, Aug. 23, 2018, https://www.nytimes.com/2018/08/23/climate/social-cost-carbon.html. In a 2017 executive order, Trump also disbanded the interagency working group. See "Presidential Executive Order on Promoting Energy Independence and Economic Growth," https://www.whitehouse.gov/presidential-actions/presidential-executive-order-promoting-energy-independence-economic-growth/.

[23] Denise A. Grab et al., "Opportunities for valuing climate impacts in U.S. state electricity policy," Institute for Policy Integrity, New York University School of Law, April 2019, https://policyintegrity.org/files/publications/Valuing_Climate_Impacts.pdf, p. 10.

[24] See, e.g., Frances C. Moore and Delavane B. Diaz, "Temperature impacts on economic growth warrant stringent mitigation policy," *Nature Climate Change* 5, 127-131 (2015), https://www.nature.com/articles/nclimate2481. J. Van den Bergh and W. Botzen, "A lower bound to the social cost of CO2 emissions," *Nature Climate Change* 4: 253–258 (2014), https://www.nature.com/articles/nclimate2135 (quoted). Frank Ackerman and Elizabeth A. Stanton, "Climate Risks and Carbon Prices: Revising the Social Cost of Carbon," *Economics: The Open-Access, Open-Assessment E-Journal* 6 (2012-10): 1–25. http://dx.doi.org/10.5018/economics-ejournal.ja.2012-10. Martin L. Weitzman, "On modeling and interpreting the economics of catastrophic climate change," *Review of Economics and Statistics* 91(1): 1-19, 2009, https://www.mitpressjournals.org/doi/pdf/10.1162/rest.91.1.1.

[25] On the limitations of climate models, see, e.g.: Ruth DeFries, et al., "The missing economic risks in assessments of climate change impacts," Earth Institute, Columbia University; Grantham Research Institute on Climate Change and the Environment; Potsdam Institute for Climate Impacts Research, 2019, http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2019/09/The-missing-economic-risks-in-assessments-of-climate-change-impacts-2.pdf. On the broader issue of environmental science understating environmental risk, see: Michael Oppenheimer et al., *Discerning Experts: The Practices of Scientific Assessment for Environmental Policy* (University of Chicago, 2019); and Naomi Oreskes et al., "Scientists Have Been Underestimating the Pace of Climate Change," 2019, https://blogs.scientificamerican.com/observations/scientists-have-been-underestimating-the-pace-of-climate-change/.

The High-Level Commission on Carbon Prices (HLCCP) was established in 2016 to estimate a price for carbon that would induce individuals, corporations and governments to change their behaviors such that a less than 2^{o} C rise in atmospheric temperature by this century's end (the goal of the Paris Agreement) might be met. The Commission did not estimate or evaluate the climate change impacts that would be avoided by reducing carbon emissions.[26] Their summary report says, "Based on industry and policy experience, and the literature reviewed, duly considering the respective strengths and limitations of these information sources, this Commission concludes that the explicit carbon-price level consistent with achieving the Paris temperature target is at least US$40–80/$tCO_2$ by 2020 and US$50–100/tCO2 by 2030, provided a supportive policy environment is in place." The goal here is clear. The means to achieve the goal through specific policies and actions is not. With some form of a carbon price, governments at all levels, corporations and individuals are incentivized to reduce their emissions however they can.

Another approach to estimating a variant of the SCC is to estimate the cost of removing one ton or reducing by one ton the carbon in or emitted to the atmosphere, or the marginal abatement or mitigation cost, using any technology to do so including carbon sequestration. In the analysis of the Avoided Energy Supply Components (AESC) in New England[27], the authors distinguish embedded and non-embedded costs of carbon. Embedded costs include those arising from RGGI and other government-imposed taxes or regulations. These costs represent a partial internalization of the health and environmental damages carbon emissions cause. The difference between these costs and the best estimates of damage represent the non-embedded portion of marginal abatement cost. The AESC study estimates the total environmental cost using expected offshore wind costs at \$68/tCO_2 (this is not the SCC). If we knew the cost of marginal health and environmental damages, they would equal marginal abatement cost, but we don't. This estimate while not including solar, hydro or nuclear sources of electricity is lower that the van den Bremer and van der Ploeg (2019) estimate of \$40/tCO_2 and within the range of estimates of other researchers including the HLCCP SCC estimate.

Another example of a global SCC estimate uses an asset-based approach considering CO_2 in the atmosphere as an asset with negative returns. Kent, Litterman and Wagner (2019) construct a model (EZ-Climate) that regards future states of nature (the economy, the environment, knowledge, technology) as characterized by probabilities.[28] In addition, they characterize human behavior with preferences in which aversion to changes in consumption are independent of the states of nature and time (van der Ploeg [2020] uses this characterization as well). Investments over time to reduce carbon emissions (as a hedge) pay off gradually so that consumption can increase as damages decline. Kent et al. (2019) use a decision tree as is common in financial modeling to show how the decisions that people make at points in time as they learn the effects of their mitigation investments and the new state of nature affect the SCC. As they learn and choose a certain path along which technology grows and mitigation costs decrease, they estimate a new and (usually) lower SCC. This process continues until (at year 2400) carbon in the atmosphere is at a level at which consumption can be maintained at a constant and acceptable growth rate. Kent et al. (2019) note that waiting to mitigate has severe negative growth effects.

Kent et al. (2019) find as all modelers do that their results depend crucially on parameter estimates (discount rate, risk aversion, climate damages) and they estimate a range of SCCs from \$60/tCO2 to \$180/tCO2 in 2015 (their base year). Carbon prices rise for the first 10 to 15 years by about 10% and then decline after 2030 to a range close to the 2015 range by 2050. After 2050 carbon prices decline steadily as technology grows and carbon in the atmosphere approaches an acceptable level. Their results stand in contrast to most SCC estimates that rise over time; however, declining SCCs seem to be quite reasonable given that our knowledge and mitigation technology will grow and reduce costs, while we learn more about earth's climate dynamics and the states of nature that materialize in the future.

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[26] High-Level Commission on Carbon Prices. 2017. Report of the High-Level Commission on Carbon Prices. Washington, DC: World Bank. License: Creative Commons Attribution CC BY 3.0 IGO. Available at: https://www.carbonpricingleadership.org/report-of-the-highlevel-commission-on-carbon-prices

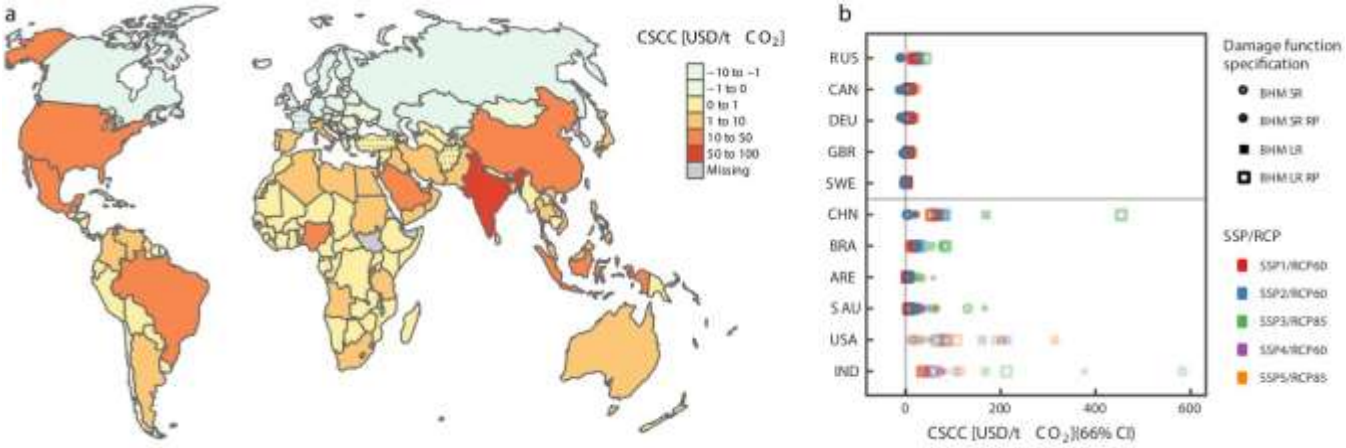
[27] https://www.synapse-energy.com/sites/default/files/AESC-2018-17-080-Oct-ReRelease.pdf.

[28] Kent, Daniel D., Litterman, Robert B. and Wagner, Gernot (2019). "Declining CO2 price paths," Proceedings of the National Academy of Sciences (PNAS), vol. 116, no. 42, 20886–20891. The article and supplementary material are available at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1817444116/-/DCSupplemental.

Kaufman et al. (2020) provide a final example for a social cost of carbon.[29] Aware of the array of models, methods and SCC estimates, Kaufman et al. describe an alternate near-term to net zero (NT2NZ) approach, estimating CO_2 prices needed in the near term (the next decade) for consistency with a net-zero CO_2 emissions target. Their approach dovetails with the emissions-target-focused approach that frames climate policy discussions around the world including the GC3 aggregate CO_2 reductions of 45% by 2030 and by 80% by 2050 below 2001 levels. This approach avoids uncertainties in estimates of climate damages and long-term decarbonization costs, offers transparency about sensitivities such as discount rates, aversion to risk and environmental damage and enables the consideration of CO_2 prices alongside a portfolio of policies. Kaufman et al. estimate illustrative NT2NZ CO_2 prices for the United States; for a 2050 net-zero CO_2 emission target, prices are $34 to $64 per metric ton in 2025 and $77 to $124 in 2030. These results are most influenced by assumptions about complementary policies described above and oil prices.

Regional Social Cost of Carbon

The SCC estimates above are global, while emitters concentrate in relatively rich countries and countries most affected by global warming are relatively poor. Ricke et al. (2018, 2019) show the variation in SCC by country.[30] Using a variety of socio-economic models (shared socio-economic pathways [SSPs]), emission profiles (representative concentration pathways [RCPs]), and a damage model (called BHM for the authors who developed it), Ricke et al. (2018) estimate country-level SCCs (CSCCs) illustrated in their figure 2. The left panel of this figure shows the geographic distribution of median estimates of the CSCCs computed for their reference case of scenario SSP2/RCP6.0, BHM-SR (short run) and a growth-adjusted discount rate. The right panel shows CSCCs for alternative scenarios and damage function specification combinations for the five smallest and six largest CSCCs in the reference case (blue open circles). Note: RUS, Russia; CAN, Canada; DEU, Germany, GBR, Great Britain; SWE, Sweden; CHN, China; BRA, Brazil; ARE, United Arab Emirates; SAU, Saudi Arabia; USA, United States; IND, India.



Evidence for the Efficacy of Carbon Pricing

Best et al. (2020) provide an econometric analysis of carbon pricing on emission levels and growth rates.[31] Their figure 1 below provides evidence for the effect of carbon pricing or the lack thereof in 137 countries. Their econometric analysis provides empirical support for the contention that carbon pricing helps to reduce emissions below levels that would otherwise be observed. Countries with a carbon price have on average had annual CO_2

[29] Kaufman, N., Barron, A.R., Krawczyk, W. *et al.* (2020). "A near-term to net zero alternative to the social cost of carbon for setting carbon prices," *Nat. Climate Change,* https://doi.org/10.1038/s41558-020-0880-3.

[30] Ricke, K., Drouet, L., Caldeira, K., & Tavoni, M. (2018). Country-level social cost of carbon. Nature Climate Change, 8(10), 895–900. https://doi.org/10.1038/s41558-018-0282-y. An author correction to this article was published in the same journal on March 25, 2019 on page 567.

[31] Best, R., Burke, Paul J. and Jotzo, F. (2020). "Carbon Pricing Efficacy: Cross-Country Evidence," *Environmental and Resource Economics*, 77**,** 69–94. https://doi.org/10.1007/s10640-020-00436-x.

emissions growth rates that are about 2 percentage points lower than countries without a carbon price, all else equal (that is, controlling for other influences on emissions). Further, an increase in carbon price of one euro ($1.19) per metric ton (1.1 US ton) of CO_2 is on average associated with a reduction in the subsequent annual growth rate in emissions from fossil fuel combustion of approximately 0.3 percentage points, all else equal.

Carbon Pricing Efficacy: Cross-Country Evidence

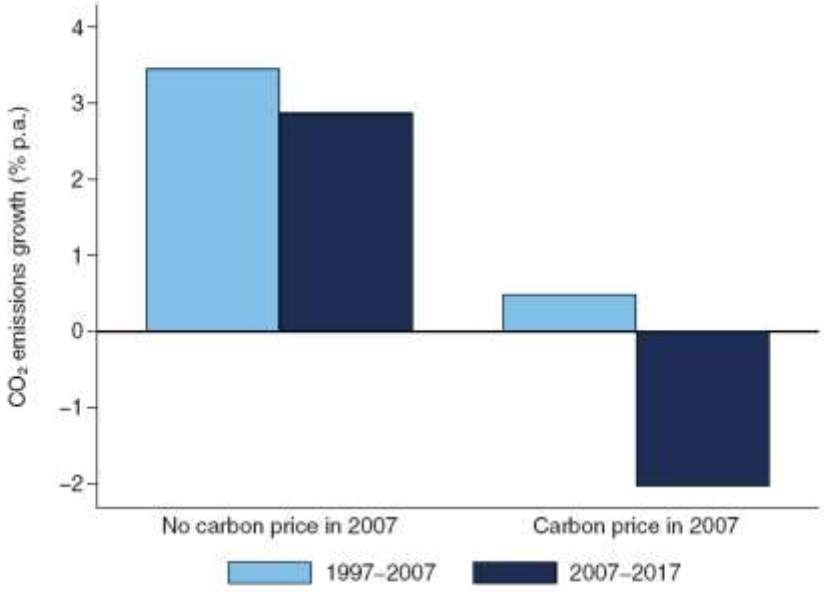


Fig. 1 Average annual CO_2 emissions growth rate, %. Emissions are from fuel combustion. The columns on the left show the annual average for countries without a carbon price in 2007. The columns on the right show the annual average for countries with a carbon price in 2007. 137 countries for which data are available for both 1997–2007 and 2007–2017 are included. Of these, 30 countries had carbon prices in 2007. The association is similar when using an earlier reference year (see the Online Appendix; Figure A.1). Data: International Energy Agency (2019); World Bank and Ecofys (2018)

Implementation of the SCC

Given that there are two predominant methods to set a carbon price (emissions trading systems and a carbon tax), how does a price for carbon manifest in a hybrid system in which uses an ETS (e.g., RGGI and TCI) and road user fees such as a vehicle miles traveled (VMT) tax and/or tolls? We must decide what the carbon fee will provide: will it raise the price of fossil fuel such that utilities completely switch to wind and solar, will it cause individuals and businesses to switch to ZEVs and heat pumps, and, will it cause individuals, corporations and governments to adapt to the effects of global warming? If we decide on a price for carbon, it seems reasonable that the ETS would establish the allowances such that the implied carbon price prevailed in each sector in which the ETS was operational and effect the required GHG reduction rate. A user fee such as a VMT tax or tolls would not function as a carbon price, but rather as a funding source for transportation infrastructure that with a complete transition to ZEVs still needs continuous maintenance and improvement. We assume fossil fuel taxes would disappear over time, while the price of fossil fuel still consumed would increase because an ETS such as TCI would do so.

It is an open question whether the estimated carbon prices above would achieve the GHG reductions in the timeframe envisioned in Governor Malloy's Executive Order 46, that is, a reduction of GHGs of 80% below 2001 statewide levels by 2050. The price of carbon however established should cause behavioral change (in consumption and production) such that the state's carbon reduction goal is met. This means providing regulatory and pecuniary incentives that move households and businesses to purchase ZEVs (and the necessary charging

infrastructure) and heat pumps and improve building envelope efficiency to the extent necessary to meet the target. Further, and most important, the price of carbon should cause a transition to a zero-carbon electricity grid.

The SCC and Equity and Environmental Justice

Carbon pollution has significantly different damage impacts within and among countries (tropical countries more affected, poor countries more affected, and poor people within countries more affected), which make the SCC assessment crucially depend on ethical considerations and aggregation methods. In addition, non-market impacts (loss of lives or health impacts[32]) and an extension to a broader range of pollutants and impacts (aerosol/ozone precursors, products of incomplete combustion) fall more broadly on relatively poor people wherever they live.[33]

If the price of carbon and revenues generated are too low or are implemented years from now, investment in climate mitigation may be insufficient to avoid significant damages and not cause the needed behavioral changes. Disadvantaged communities tend to be at greater risk to climate change and will suffer disproportionately.

The key equity concerns[34] associated with pricing carbon & climate action in general are:

- Pricing carbon is perceived as regressive even though wealthier household spend more in absolute terms, low-income households spend a greater percentage on energy.
- Trading carbon permits can contribute to pollution hotspots – older facilities tend to be more expensive to upgrade and find it more cost effective to buy permits. The legacy facilities tend to locate in poorer communities of color.
- Fair allocation of the climate investments to provide real benefits to disadvantaged, or environmental justice (EJ) communities, including reducing all harmful pollution, and increasing the supply of affordable and healthy housing, good jobs, and community infrastructure.

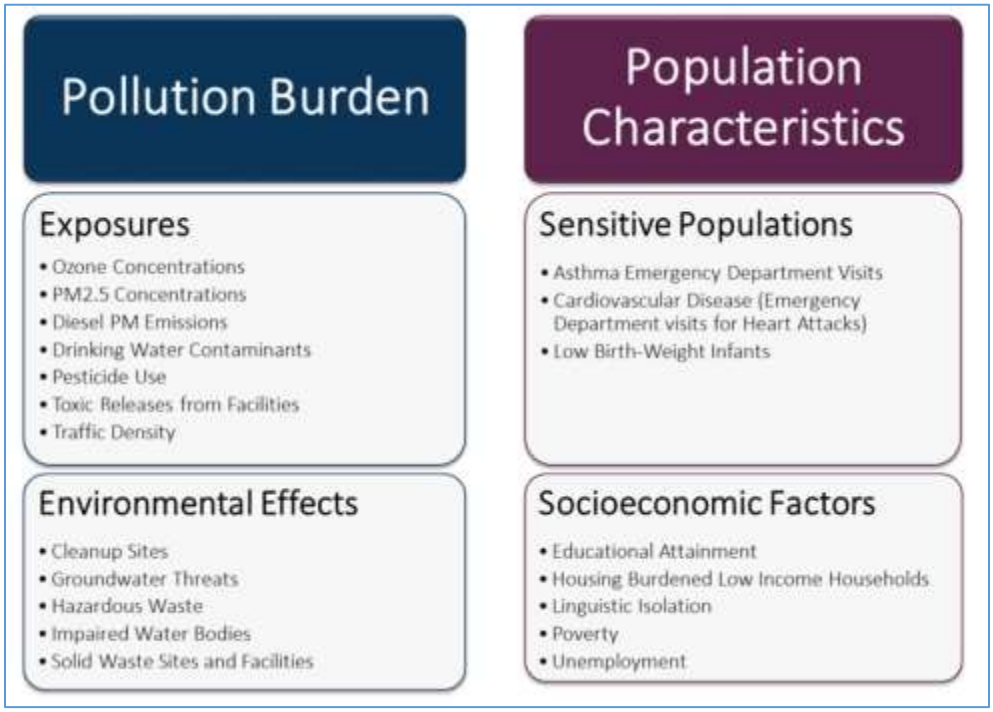
Equity considerations must be addressed by how any carbon revenues are subsequently invested. We recommend that co-benefits be included in addition to the SCC in procedures used to prioritize investments. The health benefits alone from reduced pollutants – CO_2, SOx, NOx, particulates – by reducing combustion of fossil fuels have been shown to equal or exceed the cost of climate mitigation investments in clean energy.[35] Further, these benefits are particularly significant for the legacy facilities in EJ communities.

The recommendation to use co-benefits to ensure that the needs of disadvantaged communities are addressed raises two fundamental questions:

1. What is a fair and transparent method to identify and rank the needs / priority of disadvantaged communities?
2. Which co-benefits should be included and how to measure and monetize them?

CT has an environmental justice law that defines EJ communities as “a census block group…for which thirty percent or more of the population consists of low income persons who…have an income below two hundred percent of the federal poverty level” or is a distressed municipality as defined in CT General Statutes section 32-9p. In brief, the criteria relate to “areas of high unemployment and poverty, aging housing stock and low or declining rates of growth in job creation, population and per capita income.” These definitions do not lend themselves to easy assessment of the benefits of climate action.

[32] Levy, J. I., Woo, M. K., Penn, S. L., Omary, M., Tambouret, Y., Kim, C. S., & Arunachalam, S. (2016). ‘Carbon reductions and health co-benefits from US residential energy efficiency measures,” *Environmental Research Letters*, *11*(3), 034017.
[33] Shindell, D. T. (2015). “The social cost of atmospheric release,” *Climatic Change*, *130*(2), 313-326.
[34] Equitable & Just National Climate Platform, https://ajustclimate.org
[35] Nemet, G.F. et al (2010). “Implications of incorporating air quality co-benefits into climate change policymaking,” Environ. Res. Lett. ***5*** 014007 (9pp) https://iopscience.iop.org/article/10.1088/1748-9326/5/1/014007/pdf



A recent study[36] recommended an approach used in California. While the CA cap and trade system seems a bit more heavy-handed than would be politically feasible in CT, it could serve as a model for a more pragmatic solution. CA developed a CalEnviroScreen 3.0[37] rating system to prioritize the needs of communities. The framework is shown in the figure. This framework could be used to facilitate an outreach effort with communities to identify their needs and serve as an objective measure of the benefits of climate action.

CT should develop a short list of the criteria to be used to measure progress in providing tangible benefits that improve the quality of life in disadvantaged communities. CA has developed methodologies[38] for measuring co-benefits that could provide a starting point for developing CT-specific measures. These same criteria should be quantified in terms of $benefits per tCO_{2e} avoided and factored into processes used to prioritize climate action investments. This will help ensure investments to provide climate benefits, which are long-term, globally dispersed and are fairly balanced while addressing legacy pollution, which is near-term and local.

[36] Breslow, M. & Wincele, R. (2020) Cap- and- trade in California: Health and Climate Benefits Greatly Outweigh Costs Climate X-Change. https://climate-xchange.org/2020/03/16/cap-and-trade-in-california-health-and-climate-benefits-greatly-outweigh-costs/
[37] CalEnviroScreen 3.0, January, 2017. https://oehha.ca.gov/media/downloads/calenviroscreen/report/ces3report.pdf
[38] California Air Resources Board, CCI Co-benefit Assessment Methodologies, https://ww2.arb.ca.gov/resources/documents/cci-methodologies

Appendix 4: Acronyms and abbreviations

Term	Full Name	Term	Full Name
BTU	British Thermal Unit	**GHG**	Greenhouse Gas
CLCPA	Climate Leadership and Community Protection Act	**ICEI**	International Council of Local Environmental Initiatives
CO_2	Carbon Dioxide	**LBE**	Lead by Example
CO_2e	Carbon Dioxide Equivalent	**LMI**	Low-to-middle income (households)
COVID-19	Coronavirus Disease 2019	**LCA**	Lifecycle Assessment
DEEP	Connecticut Department of Energy and Environmental Protection	**MBUF**	Mileage Based User Fee
EJ	Environmental Justice	**NGO**	Non-Governmental Organization
EO	Executive Order	**PA**	Public Act
ETS	Emissions Trading System	**RGGI**	Regional Greenhouse Gas Initiative
FAS	Federation of American Scientists	**TCI**	Transportation and Climate Initiative
GC3	Governor's Council on Climate Change	**UConn**	University of Connecticut

Appendix 5: Preliminary glossary

Term	Definition	Term	Definition
Cap-and-Invest	A model under which carbon emissions are limited and a market is established for trading emission allowances applicable to all sectors. Proceeds from trades are reinvested in the development of renewable energy.	**Lead by Example Energy Efficiency Program**	Advances efficient energy management at state government facilities by driving initiatives that save energy and operational costs while reducing Connecticut's carbon footprint.
Cap-and-Trade	A model that puts a price on carbon emissions by capping the allowed sector wide emissions and allows polluters to trade carbon emission credits on the open market	**Transportation and Climate Initiative**	Regional compact between CT, the District of Columbia, and eight other states to develop a policy that accelerates the transition to a low-carbon transportation future and delivers a better, cleaner, and more resilient transportation system.
Integrated Resource Plan	An Integrated Resource Plan (IRP) is comprised of an assessment of the future electric needs and a plan to meet those future needs. Statute requires the IRP to be updated every two years.		