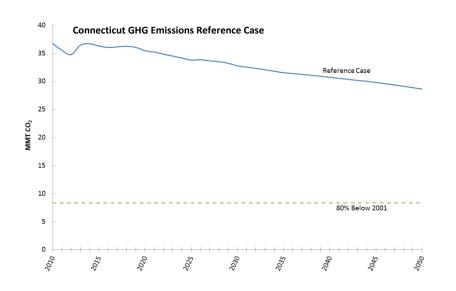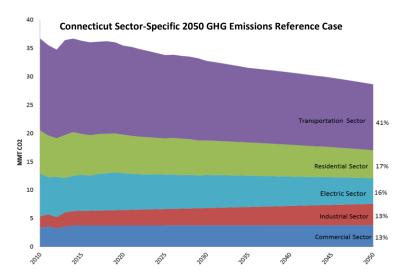# Governor's Council on Climate Change
www.ct.gov/deep/GC3

Developing a GHG Reference Case for Connecticut

The first step in developing a climate strategy is building a Connecticut-specific reference case to provide a basis for examination of potential GHG mitigation technologies and measures. Utilizing projection data from the Energy Information Administration and factors expected to shape Connecticut's future energy consumption, Northeast States for Coordinated Air Use Management (NESCAUM), GC3's technical consulting group, developed a reference case projection of future emissions through 2050 (figures below). Sector specific projections out to 2050 suggest that the transportation sector will make up 41 percent of future emissions, with the residential and electricity sectors following at 17 and 16 percent, respectively.

Connecticut GHG Emissions Reference Case

Connecticut Sector-Specific 2050 GHG Emissions Reference Case

Greenhouse Gas Emissions Reference Case Inputs and Assumptions

The below table is a summary of informational resources used to develop the Connecticut greenhouse gas emissions reference case in the Long-range Energy Alternatives Planning (LEAP) framework. The reference case incorporates historical and projected energy use data from publicly available resources to create a greenhouse gas (GHG) baseline from which future GHG mitigation scenarios in Connecticut can be evaluated.

Governor's Council on Climate Change (GC3)
www.ct.gov/deep/GC3

Energy use data for individual technologies and end uses form the basis of the reference case, and these individual technologies and end uses collectively comprise the main aggregated transportation, electric power, residential, commercial, and industrial sectors.

Assumptions included in the reference case	Description
The LEAP reference case projection includes existing federal, regional, and state regulatory requirements expected to shape future energy use in Connecticut.	Examples of rules included in the reference case are federal energy efficiency standards, state renewable portfolio standards (RPS), and the revised power plant GHG emissions cap under the Regional Greenhouse Gas Initiative (RGGI).
TRANSPORTATION SECTOR The transportation sector within the LEAP reference case is based on emissions estimated using the Motor Vehicle Emissions Simulator (MOVES2014a) emissions model. MOVES2014a is the latest version of MOVES. It incorporates significant improvements in calculating onroad and nonroad equipment emissions.	MOVES is the EPA-accepted mobile source emissions model for state air quality planning and emissions inventory development under the Clean Air Act. The MOVES runs for the LEAP reference case use input data specific to Connecticut for projecting state vehicle miles travelled (VMT), energy consumption, and emissions out to 2050 by vehicle type for all key vehicle classes (e.g., passenger cars, passenger trucks, long haul trucks, refuse trucks, etc.). The vehicle emission estimates from MOVES include vehicles meeting the latest federal fuel efficiency (CAFE) standards and low sulfur gasoline requirements ("Tier 3").
ELECTRIC POWER SECTOR The electric power sector in the LEAP reference case is based on the state's consumption of electricity, which can be supplied by power plants inside and outside of Connecticut. For this reason, the LEAP approach is to characterize the generation mix for the overall ISO-NE region out to 2050.	The generation mix depends upon a number of key variables, such as capacity in megawatts by fuel type, operating efficiency, availability factor, capital cost, and operations and maintenance costs. Capacity data are based on the ISO-NE Capacity, Energy, Loads, and Transmission (CELT) 2016 report. Operating characteristics and economic data are based on the input assumptions for power plants used in the U.S. Energy Information Administration's Annual Energy Outlook (AEO) 2015 projections. For state EE programs not in AEO 2015, we use load demand projections from ISO-NE and cost data from Energize CT, which provides evaluation reports from CT utilities on energy savings from their energy efficiency programs:

	http://www.energizect.com/connecticut-energy-efficiency-board/evaluation-reports.
RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL SECTORS The residential, commercial and industrial sectors in the LEAP reference case are developed using detailed model outputs from AEO 2015 to project energy consumption and emissions for specific end-use technologies out to 2040. AEO 2015 assumptions are given at the links below: NEMS Residential Demand Module NEMS Commercial Demand Module NEMS Industrial Demand Module	The LEAP reference case continues the projection to 2050 as a straight-line extrapolation based on the average annual growth rate from 2030 to 2040. Specific examples of end-use technologies are natural gas furnaces in commercial space heating applications and distillate oil boilers for residential space and water heating applications.

Assumptions NOT included in the reference case	Description
The reference case projection does not include proposed rules or policies that are not yet adopted as requirements.	Examples of rules and policies not included are state-specific energy efficiency programs that are in the planning stages and EPA's recently proposed heavy-duty vehicle GHG standards. EPA's currently suspended Clean Power Plan rule is also not in the reference case as it was still a proposal at the time the latest energy use data were collected. The revised RGGI cap, however, would likely meet the requirements of the Clean Power Plan, should it be implemented, for Connecticut and the other New England states covered by the ISO-NE grid.
The reference case does not reflect potential long-term contracts for renewables or natural gas that emerge from the PA 15-107 procurement process.	The LEAP modeling tool does not use existing or projected expansion of pipeline capacity as a basis for projecting increased natural gas use. Expanded use of natural gas is incorporated through the AEO 2015 projections. If desired by the GC3, changes in generation sources from potential long-term contracts for renewables or natural gas can be incorporated into mitigation scenarios.

Additional information and presentations relevant to the work of the GC3:

- ➢ GC3 website with meeting notes and presentations www.ct.gov/deep/gc3

- ➢ GC3 Meeting January 22, 2016: Slides and discussion on inputs and on what the reference case includes and omits http://www.ct.gov/deep/lib/deep/climatechange/gc3/(meeting20160122/gc3_meeting_1_22_2016.pdf

- ➢ Analysis, Data, and Metrics (ADM) working group October 14, 2016 Meeting http://www.ct.gov/deep/lib/deep/climatechange/gc3_adm_group/adm_meeting_10_14_2015.pdf

- ➢ GC3 Exploratory Report released March 2016 http://www.ct.gov/deep/lib/deep/climatechange/gc3/gc3_exploratory_report_2016.pdf

Developing the Connecticut Reference Case in LEAP

July 7, 2016

This memorandum describes how the Connecticut reference case is developed in the Long-range Energy Alternatives Planning (LEAP) framework. The reference case incorporates historical and projected energy use data from publicly available resources to create a greenhouse gas (GHG) baseline from which future GHG mitigation scenarios in Connecticut can be evaluated. Energy use data for individual technologies and end uses form the basis of the reference case, and these individual technologies and end uses collectively comprise the main aggregated transportation, electric power, residential, commercial, and industrial sectors.

The LEAP reference case projection includes existing federal, regional, and state regulatory requirements expected to shape future energy use in Connecticut. The projection does not include proposed rules or policies that are not yet adopted as requirements. Examples of rules included in the reference case are federal energy efficiency standards, state renewable portfolio standards (RPS), and the revised power plant GHG emissions cap under the Regional Greenhouse Gas Initiative (RGGI). Examples of rules and policies not included are state-specific energy efficiency programs that are in the planning stages and EPA's recently proposed heavy-duty vehicle GHG standards. EPA's Clean Power Plan rule is also not in the reference case as it was still a proposal at the time the latest energy use data were collected, but the revised RGGI cap is expected to achieve comparable reductions in the electric power sector as under the Clean Power Plan.

The transportation sector within the LEAP reference case is based on emissions estimated using the Motor Vehicle Emissions Simulator (MOVES) emissions model. MOVES is the EPA-accepted mobile source emissions model for state air quality planning and emissions inventory development under the Clean Air Act. The MOVES runs for the LEAP reference case use input data specific to Connecticut for projecting state vehicle miles travelled (VMT), energy consumption, and emissions out to 2050 by vehicle type for all key vehicle classes (e.g., passenger cars, passenger trucks, long haul trucks, refuse trucks, etc.). The vehicle emission estimates from MOVES include vehicles meeting the latest federal fuel efficiency (CAFE) standards and low sulfur gasoline requirements ("Tier 3"). MOVES also includes zero-emission vehicle (ZEV) requirements for those states adopting the ZEV component of the CA LEV program.

The electric power sector in the LEAP reference case is based on the state's consumption of electricity, which can be supplied by power plants inside and outside of Connecticut. For this reason, the LEAP approach is to characterize the generation mix for the overall ISO-NE region out to 2050. The generation mix depends upon a number of key variables, such as capacity in megawatts by fuel type, operating efficiency, availability factor, capital cost, and operations and maintenance costs. Capacity data are based on the ISO-NE Capacity, Energy, Loads, and Transmission (CELT) 2016 report. Operating characteristics and economic data are based on the input assumptions for power plants used in the U.S. Energy Information Administration's Annual Energy Outlook (AEO) 2015 projections.

The residential, commercial and industrial sectors in the LEAP reference case are developed using detailed model outputs from AEO 2015 to project energy consumption and emissions for specific end-use technologies out to 2040. The LEAP reference case continues the projection to 2050 as a straight-line extrapolation based on the average annual growth rate from 2030 to 2040. Specific examples of end-use technologies are natural gas furnaces in commercial space heating applications and distillate oil boilers for residential space and water heating applications.

Once the LEAP reference case is constructed from the underlying energy use information, we compare it to the Connecticut GHG emissions inventory projections using EPA's State Inventory Tool (SIT). This comparison is to verify that the underlying elements of the reference case adequately reproduce historical GHG emissions in Connecticut, as well as to compare how closely the future portion of the reference case tracks the SIT projection. We compare the reference case GHG annual emissions at the total statewide-level and for each underlying aggregated sector (transportation, electric power, residential, commercial, and industrial) as calculated in SIT.