

## **8.0 Attainment Demonstration and Weight-of-Evidence**

As described in Section 4.1.1, all of Connecticut is classified by the EPA as moderate nonattainment for the 8-hour ozone NAAQS. EPA requires that states with moderate (and above) ozone nonattainment areas prepare and adopt SIP revisions demonstrating attainment of the 8-hour ozone standard using photochemical grid modeling and weight-of-evidence (WOE) analyses. States with moderate nonattainment areas are required to attain the 8-hour ozone NAAQS by June 15, 2010. Because the June 15, 2010 deadline occurs in the middle of the 2010 ozone season, Connecticut and other states with moderate nonattainment areas must demonstrate NAAQS compliance for the preceding ozone season of 2009.

Sections 8.1 through 8.4 of this document describe the procedures, inputs and results of the regional photochemical grid modeling exercise. Section 8.5 describes various WOE analyses used as supplements to the modeling results to determine the likelihood of attaining the 8-hour NAAQS in both the Greater Connecticut nonattainment area and the Southwest Connecticut portion of the NY/NJ/CT nonattainment area.

CTDEP's primary conclusions based on the results of the photochemical modeling and WOE analyses are:

- 1) There is a high level of probability that the Greater Connecticut area will achieve attainment of the 8-hour ozone NAAQS by the end of the 2009 ozone season; and
- 2) A credible case can be made that Southwest Connecticut will attain by the end of the 2009 ozone season. The probability of attainment increases as additional emission reductions occur in each subsequent year, such that attainment by 2012 is highly probable.

## **8.1 Background and Objective of the Photochemical Modeling**

The objective of the photochemical modeling study is to enable the CTDEP to analyze the efficacy of various control strategies, and to demonstrate that the measures adopted as part of the SIP will result in attainment of the 8-hour ozone standard by the June 15, 2010 deadline for moderate nonattainment areas. The modeling exercise predicts future year 2009 and 2012 air quality conditions based on the worst observed ozone episodes in the base year 2002 and demonstrates the effectiveness of new control measures in reducing air pollution.

The photochemical modeling was performed as part of a regional partnership under the auspices of the Ozone Transport Commission (OTC), a multi-state ozone planning organization created under the CAA to assist EPA and the states from Virginia to Maine, the Ozone Transport Region (OTR), with the development and implementation of regional solutions to the ground-level ozone problem in the Northeast and Mid-Atlantic regions. The OTC Air Directors served as the Oversight Committee for the modeling process, providing overall direction for all aspects of the modeling and control strategy development. Day-to-day management and coordination of modeling activities was provided by the OTC Modeling Committee, with the following workgroups established to accomplish assigned tasks. The various committees and workgroups were comprised of state air quality agency staff members (including CTDEP representatives),

with support provided by OTC and the staff of the Mid-Atlantic Regional Air Management Association (MARAMA).

### **Photochemical Modeling Workgroup**

The Photochemical Modeling Workgroup was responsible for preparing the modeling assessment, collecting and processing model input data, setting up all model input files, performing model runs and interpreting and documenting the results of the modeling analyses. The Workgroup also prepared and submitted all OTC SIP quality modeling system documentation to the Oversight Committee.

### **Meteorological Modeling Workgroup**

The Meteorological Modeling Workgroup was responsible for preparing and assessing meteorological fields for the OTR Modeling Domain. This Workgroup also worked with the Photochemical Modeling Workgroup to prepare all meteorological input files for the OTC SIP quality modeling system.

### **Emission Inventory Development Workgroup**

The Emission Inventory Development Workgroup was responsible for obtaining and developing guidance for preparing 2002 and 2009 state emission inventories for all states in the OTR. MARAMA and the Mid-Atlantic/Northeast Visibility Union (MANE-VU) organizations provided funding for contractors and worked with OTR states to help prepare state-of-the-art 2002 emission files, 2009 and 2012 CAA emission files and 2009 and 2012 Control Strategy emission files for the states in the OTR Modeling Domain. The Oversight Committee was responsible for obtaining emission inventories for non-OTR states in the OTR Modeling Domain.

### **Control Strategy Development Workgroup**

The Control Strategy Development Workgroup was responsible for evaluating control strategies and recommending to the Oversight Committee a suite of measures for attaining the ozone NAAQS in the OTR. Control strategy evaluation and selection was coordinated with the OTC Stationary/Area Source committee and the OTC Mobile Source Committee.

#### **8.1.1 Conceptual Description**

EPA recommends that a conceptual description of the area's ozone problem be developed prior to the initiation of any air quality modeling study. A "conceptual description" is a qualitative way of characterizing the nature of an area's nonattainment problem. Within the conceptual description of a particular modeling exercise, it is recommended that the specific meteorological parameters that influence air quality be identified and qualitatively ranked in importance.

A conceptual description of the ozone air quality problem in the OTR was prepared by the Northeast States for Coordinated Air Use Management (NESCAUM)<sup>1</sup> and is reproduced in Appendix 2A. A summary of key findings of the conceptual model was provided earlier in Section 2.0.

### **8.1.2 Regional Modeling Protocol**

All aspects of the modeling effort were conducted in accordance with the modeling protocol developed by the OTC Modeling Committee (see Appendix 8A). The lead agency for coordinating and performing modeling runs for the OTC was the New York State Department of Environmental Conservation (NYSDEC). Modeling centers for the OTC included the NYSDEC, the University of Maryland at College Park (UMD), NESCAUM, the New Jersey Department of Environmental Protection (NJDEP) and the Virginia Department of Environmental Quality (VADEQ). Although NYSDEC was the lead agency for coordinating modeling runs, member states of the OTC, through participation on the OTC Modeling Committee and associated workgroups, managed the modeling project jointly.

## **8.2 Modeling Platform and Configuration**

The following discussion provides an overview of the air quality, meteorological, and emission modeling systems used for the analysis, as well as a description of model configuration and quality assurance procedures. Much of this discussion is based on modeling documentation prepared by NYSDEC<sup>2</sup> for the OTC states and boilerplate OTR summaries included as part of the Washington, D.C. draft ozone SIP.<sup>3</sup>

### **8.2.1 Episode Selection**

Since it would be impractical to model every violation day, EPA has traditionally recommended targeting a select group of episode days for ozone attainment demonstrations. Such episode days should be (1) meteorologically representative of typical high ozone exceedance days in the domain, and (2) so severe that any control strategies predicted to attain the ozone NAAQS for that episode day would also result in attainment for all other exceedance days.

While EPA's suggested approach is perhaps feasible for isolated urban areas, such an approach is impractical in this case given the spatial extent of the regional ozone problem in the Northeast and the resulting size of the modeling domain. Also, selection of episodes from different years would require the generation of multiple meteorological fields and emissions databases, which would be an extremely difficult proposition given the modeling domain.

Recent experience has shown that model performance evaluations and the response to emissions controls need to include consideration of modeling results from longer time periods, in particular

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<sup>1</sup> *The Nature of the Ozone Air Quality Problem in the Ozone Transport Region: A Conceptual Description* (NESCAUM, October 2006).

<sup>2</sup> Modeling documentation prepared by NYSDEC is housed at: [http://www.otcair.org/projects\\_details.asp?FID=101&fview=modeling](http://www.otcair.org/projects_details.asp?FID=101&fview=modeling).

<sup>3</sup> The draft Washington D.C. ozone SIP is located at: <http://sharepoint.mwcog.org/airquality/default.aspx>.

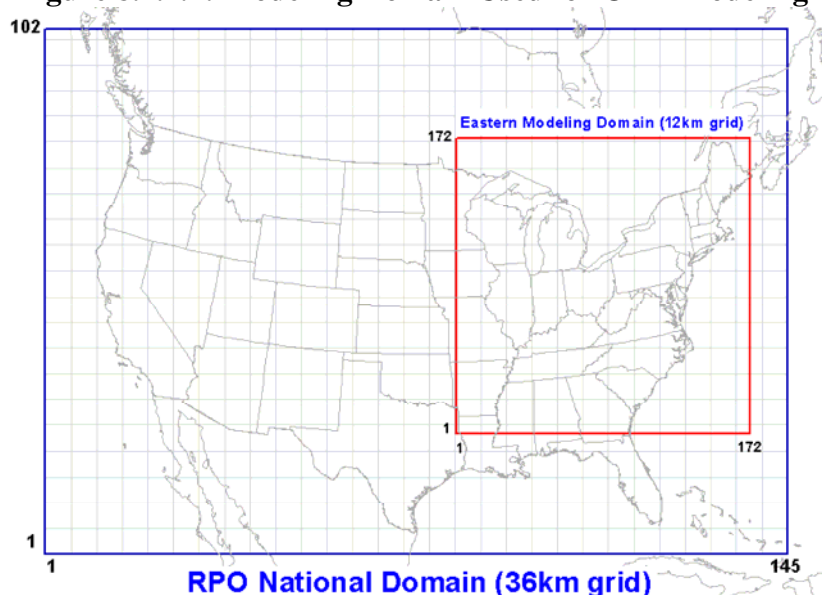
full synoptic cycles or even full ozone seasons. The 2002 ozone season had a significant number of exceedance days spread over numerous ozone episodes. As a result, the OTC Modeling Committee decided to investigate the appropriateness of modeling the entire 5-month 2002 ozone season with the OTC SIP Quality Modeling System. Results of that investigation, documented in a contractor report included as Appendix 8B,<sup>4</sup> demonstrate that 2002 episode days are (1) meteorologically representative of typical high ozone exceedance days in the domain, and (2) so severe that control strategies predicted to attain the ozone NAAQS for those episode days would likely also result in attainment for all other exceedance days. The total number of days examined for the complete ozone season far exceeds EPA recommendations and provides for better assessment of the simulated pollutant fields.

## 8.2.2 Modeling Domain

In defining the modeling domain, the following parameters should all be considered: location of local urban areas; the downwind extent of elevated ozone levels; the location of large emission sources; the availability of meteorological and air quality data; and available computer resources. In addition to the nonattainment areas of concern, the modeling domain should encompass enough of the surrounding area such that major upwind sources fall within the domain and emissions produced in the nonattainment areas remain within the domain throughout the day.

The areal extent of the OTR modeling domain (see Figure 8.2.2.1) is identical to the national grid adopted by the regional haze Regional Planning Organizations (RPOs), with a more refined “eastern modeling domain” focused on the eastern US and southeastern Canada. The placement of the eastern modeling domain was selected such that the northeastern areas of Maine are included. Based upon the existing computer resources, the southern and western boundaries of the imbedded region were limited to the area shown in Figure 8.2.2.1.

**Figure 8.2.2.1: Modeling Domain Used for OTR Modeling**



<sup>4</sup> “Determination of Representativeness of 2002 Ozone Season for Ozone Transport Region SIP Modeling,” ENVIRON, prepared for OTC, June 2005. (Report is contained in Appendix 8B.)

### **8.2.3 Horizontal Grid Size**

As shown in Figure 8.2.1.1, the larger RPO national domain utilized a coarse grid with a 36-km horizontal grid resolution. The imbedded eastern modeling domain used a grid resolution of 12 km, resulting in 172 grids in both the east-west and north-south directions. More detailed descriptions regarding grid configurations are provided in Appendix 8C.

### **8.2.4 Vertical Resolution**

The vertical structure of the air quality model is primarily defined by the vertical grid used in the meteorological modeling, which used a terrain-following coordinate system defined by pressure to create a total of 29 layers. The layer-averaging scheme adopted for the air quality modeling is designed to reduce the computational cost of the simulations, resulting in incorporation of 22 layers in the vertical, of which the lower 16 layers (approximately 3 km) coincide with those of the meteorological model. Layer averaging has a relatively minor effect on the model performance metrics when compared to ambient monitoring data. Appendix 8C contains the vertical layer definitions for the meteorological and air quality modeling domains.

### **8.2.5 Initial and Boundary Conditions**

The objective of a photochemical grid model is to estimate the air quality given a set of meteorological and emissions conditions. When initializing a modeling simulation, the exact concentration fields are unknown in every grid cell for the start time. Therefore, photochemical grid models are typically started with clean conditions within the domain and allowed to stabilize before the period of interest is simulated. In practice this is accomplished by starting the model several days prior to the period of interest. For this application, the air quality modeling for 2002 began May 1, with the first 15 days assumed to be ramp-up days not used for performance evaluation or prediction purposes.

The winds move pollutants into, out of, and within the domain. The model handles the movement of pollutants within the domain and out of the domain. An estimate of the quantity of pollutants moving into the domain is needed. These are called boundary conditions. To estimate the boundary conditions for the modeling study, three-hourly boundary conditions for the outer 36-km domain were derived from an annual model run performed by researchers at Harvard University using the GEOS-Chem global chemistry transport model. The influence of boundary conditions was minimized by the 15-day ramp-up period, which is sufficient to establish pollutant levels that are encountered in the beginning of the ozone episode.

### **8.2.6 Meteorological Model Selection and Configuration**

The Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Meteorological Model (MM5) was selected to produce meteorological data fields for the modeling analysis. MM5 is a non-hydrostatic, prognostic meteorological model routinely used for urban-scale and regional-scale photochemical regulatory modeling studies. Based on model validation and sensitivity testing, the MM5 configurations provided in Appendix 8D were

selected. Results of the NYSDEC's detailed performance evaluation of the MM5 modeling used in conjunction with the OTC platform are provided in Appendices 8E and 8F.

### **8.2.7 Emissions Inventory and Model Selection and Configuration**

Significant regional coordination was required to assemble the emission inventories needed to produce the emission data fields required for the modeling analysis. Recognizing the need for developing multi-pollutant inventories across many states to support both ozone and fine-particulate SIP modeling requirements, the Northeast and Mid-Atlantic states agreed to combine efforts under the MANE-VU RPO umbrella to compile base year and future year emission estimates for all required pollutants into a common format. The states were joined in the inventory development effort by MARAMA, OTC and NESCAUM.

Modeling inventories for the MANE-VU region were prepared, with the assistance of contractors, for the 2002 base year and the projection years of 2009 and 2012. The base year inventory was compiled using 2002 inventory estimates provided by the states. Projection year inventories account for any expected changes in economic activity as well the implementation of control strategies occurring after 2002. Inventories for adjacent areas outside the MANE-VU region were obtained from the corresponding RPOs. Detailed descriptions of the inventories are provided in Appendices 8G, 8H and 8I.

The Sparse Matrix Operator Kernel Emissions (SMOKE, Version 2.1) Emissions Processing System was used for pollutant speciation and for allocating annual county-level emissions from the regional inventory to grid cells on an hourly basis. Detailed descriptions of SMOKE processing are included in Appendices 8J and 8K.

### **8.2.8 Air Quality Model Selection and Configuration**

EPA's Models-3/Community Multi-scale Air Quality (CMAQ) modeling system was selected for the attainment demonstration primarily because it is a "one-atmosphere" photochemical grid model capable of addressing ozone at regional scale. EPA considers CMAQ to be one of the preferred models for regulatory modeling applications, citing the model in its ozone modeling guidance.<sup>5</sup> The CMAQ configuration is provided in Appendix 8L.

### **8.2.9 Quality Assurance**

All air quality, emissions, and meteorological data were reviewed to ensure completeness, accuracy, and consistency before proceeding with modeling. Any errors, missing data or inconsistencies were addressed using appropriate methods that are consistent with standard practices. All modeling was benchmarked at each of the OTC modeling centers through the duplication of a set of standard modeling results.

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<sup>5</sup> Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM<sub>2.5</sub>, and Regional Haze; EPA OAQPS; EPA-454/B-07-002; April 2007; See: <http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf>. Hereinafter referred to as EPA Guidance (2007).

Quality assurance activities were carried out for the various emissions, meteorological, and photochemical modeling components of the modeling study. Emissions inventories obtained from the RPOs were examined to check for errors in the emissions estimates. When such errors were discovered, the problems in the input data files were corrected.

The MM5 meteorological and CMAQ air quality model inputs and outputs were plotted and examined to ensure accurate representation of the observed data in the model-ready fields, and temporal and spatial consistency and reasonableness. Both MM5 and CMAQ underwent operational and scientific evaluations in order to facilitate the quality assurance review of the meteorological and air quality modeling procedures.

### **8.3 Model Performance Evaluation**

There are many aspects of model performance. This section will focus primarily on the methods and techniques recommended by EPA for evaluating the performance of the air quality model. It should be noted that the other parts of the modeling process, the emissions and meteorology, underwent a similar evaluation. As mentioned in Section 8.2.6, the NYSDEC conducted an evaluation of the MM5 meteorological model (see Appendices 8E and 8F). The remainder of this section focuses on the air quality model evaluation.

The first step in the modeling process is to verify the model's performance in terms of its ability to predict the ozone in the right locations and at the right levels. To do this, model predictions for the base year simulation are compared to the ambient data observed in the historical episode. This verification is a combination of statistical and graphical evaluations. If the model appears to be producing ozone in the right locations for the right reasons, then the model can be used as a predictive tool to evaluate various control strategies and their effects on ozone. The purpose of the model performance evaluation is to assess how accurately the model predicts ozone levels observed in the historical episode.

The results of the model performance evaluation were evaluated prior to commencing modeling in support of the attainment demonstration. The performance of CMAQ was evaluated using both operational and diagnostic methods. Operational evaluation refers to the model's ability to replicate observed concentrations of ozone and/or precursors (surface and aloft), whereas diagnostic evaluation assesses the model's accuracy with respect to characterizing the sensitivity of ozone to changes in emissions (i.e., relative response factors).

The NYSDEC, Division of Air Resources, conducted a performance evaluation of the 2002 base case CMAQ simulation (May 15-September 30) on behalf of the OTC member States. Appendix 8M provides comprehensive operational and diagnostic evaluation results. Highlights of this evaluation are provided in the following sub-sections.

#### **8.3.1 Diagnostic and Operational Evaluation**

The issue of model performance goals for ozone is an area of ongoing research and debate. To evaluate model performance, EPA recommends that several statistical metrics be developed for air quality modeling. Two of the common metrics that are most often used to assess

performance are the mean normalized gross error and the mean normalized bias. The mean normalized gross error (MNGE) parameter provides an overall assessment of model performance and can be interpreted as precision. The mean normalized bias parameter (MNB) measures a model's ability to reproduce observed spatial and temporal patterns and can be interpreted as accuracy. EPA suggests the following criteria: an MNB of  $< \pm 15\%$ , and an MNGE of  $< 35\%$  above a threshold of 40-60 ppb. These results are presented in Table 8.3.1.1 below for the local nonattainment areas and in Tables 8.3.1.2 and 8.3.1.3 on a monitor-by-monitor basis averaged over all days for the 40 ppb and 60 ppb thresholds, respectively. Figure 8.3.1.1 shows the location of the monitors.

**Table 8.3.1.1 Southwest CT and Greater CT Statistics for 8-hour Ozone**

<b>Location</b>	<b>Ozone Cutoff Threshold (ppb)</b>	<b>Mean Normalized Gross Error (MNGE) (%)</b>	<b>Mean Normalized Bias (MNB) (%)</b>
SW CT Portion of NY/NJ/CT Area	60	13.52	2.46
Greater CT Area	60	19.13	14.2

**Table 8.3.1.2 Individual Site Statistics for 8-hour Ozone Using 40 ppb Cutoff**

<b>Monitor AIRS-ID</b>	<b>Ozone Cutoff Threshold (ppb)</b>	<b>Site Name</b>	<b>County</b>	<b>Area</b>	<b>MNGE (%)</b>	<b>MNB (%)</b>
0900100171	40	Greenwich	Fairfield	NY/NJ/CT	13.94	3.75
0900111231	40	Danbury	Fairfield	NY/NJ/CT	15.35	-2.77
0900130071	40	Stratford	Fairfield	NY/NJ/CT	15.8	-0.03
0900190031	40	Westport	Fairfield	NY/NJ/CT	14.67	2.28
0900700071	40	Middletown	Middlesex	NY/NJ/CT	13.31	2.28
0900930021	40	Madison	New Haven	NY/NJ/CT	15.37	5.25
0900990051	40	Hamden	New Haven	NY/NJ/CT	15.99	-0.67
0900310031	40	East Hartford	Hartford	Greater CT	13.36	2.59
0900500051	40	Cornwall	Litchfield	Greater CT	17.75	-12.6
0901100081	40	Groton	New London	Greater CT	31.94	29.51
0901310011	40	Stafford	Tolland	Greater CT	12.53	-4.67





The base year performance evaluation indicates that CMAQ model meets EPA's suggested criteria for the 40 ppb threshold at all Connecticut sites except Groton, where the MNB exceeds +/- 15% (+29.1%). EPA's suggested criteria for the 60ppb threshold are met at all Connecticut sites except Groton and Cornwall, where the MNB exceeds +/- 15% (+28.1% and -17.7%, respectively).

The following statistics for the OTC domain have also been provided in Appendix 8M:

1. Archive file containing time series of 8-hour average observed and predicted ozone organized by state;
2. Observed and predicted composite diurnal variations of selected species, including but not limited to ozone at State and Local Air Monitoring System and National Air Monitoring System (SLAMS/NAMS) sites, ozone at Clean Air Status and Trends Network (CASTNet) and other sites, VOC species such as ethene, isoprene, formaldehyde and gas phase compounds such as CO, NO and NO<sub>2</sub>;
3. Statistical evaluation of daily maximum 8-hour ozone at SLAMS/NAMS sites and CASTNet/other sites. Statistics are computed using two different thresholds for observed daily maximum ozone - 40 and 60 ppb. Statistics are computed by date (all sites on a given day) and by site (one site over all days);
4. Statistical evaluation of daily maximum 8-hour ozone at SLAMS/NAMS sites that fall within nonattainment counties. Statistics are computed by nonattainment area.
5. Statistical evaluation of daily average CO, NO, NO<sub>2</sub>, and SO<sub>2</sub> at SLAMS/NAMS and other sites. Statistics are computed by date and by site);
6. Statistical evaluation of daily average ethene, isoprene, and formaldehyde at SLAMS/NAMS and other sites (statistics are computed by date and by site);
7. Plots of composite time series for daily max 8-hour ozone, root mean square error and mean bias for illustrative purposes; and
8. Tile plots of daily 8-hour maximum predicted ozone across the modeling domain compared with actual observations.

### **8.3.2 Summary of Model Performance**

CMAQ was employed to simulate ozone concentrations for the 2002 season (May 15 through September 30). A comparison of the temporal and spatial distributions of ozone and its precursors was conducted for the study domain with additional focus placed on performance in the NY/NJ/CT and Greater Connecticut areas.

The CMAQ model performance for surface ozone is quite good overall, with low bias and error. Model performance is generally consistent from day to day. The results for the 2002 ozone season show that the modeling system tends to over-predict minimum concentrations and slightly under-predict peak concentrations. The over-prediction of minimum concentrations is not of great regulatory concern since attainment tests are based on the application of relative response factors to daily peak concentrations. However, prediction of minimum concentrations is still important to appropriately model regional transport and nighttime ozone removal processes in order to accurately estimate peak concentrations.

The model performance for the Southwest Connecticut portion of the NY/NJ/CT area and the Greater Connecticut area averaged over all stations and all days meet the guidelines suggested by EPA. The criteria for acceptable model performance are met on most individual days as well.

No significant differences in model performance for ozone and its precursors were encountered across the OTC. While there are some differences across sub-regions, there is nothing to suggest a tendency for the model to respond in a systematically different manner between regions. Examination of the statistical metrics by sub-region confirms the absence of significant performance problems arising in one area but not in another, building confidence that the CMAQ modeling system is operating consistently across the full OTC domain.

Overall, the modeling system does a good job of appropriately estimating 8-hour average surface ozone throughout the OTR and in the Southwest Connecticut and Greater Connecticut areas. This confidence in the modeling results allows for the modeling system to be used to support the development of emissions control scenarios to meet the 8-hour ozone NAAQS.

As stated previously, the model performance for the 2002 ozone season meets all EPA guidelines, demonstrating that the modeling platform is appropriate for modeling emissions controls scenarios for the 8-hour ozone SIP. However, it must be remembered that CMAQ has been evaluated by using measures that reflect its ability to represent average conditions instead of its ability to respond to changes in emissions. Thus, it is likely that although CMAQ has met the traditional performance measures set out in the EPA guidance, it may actually under-predict the magnitude of ozone changes due to various control measures being modeled. This means that future year modeling results should be viewed not in the traditional sense as being exact, but should be seen as an upper limit to anticipated ozone levels. This observation will be explored more fully as part of the weight-of-evidence discussion in Section 8.5.

#### **8.4 Attainment Demonstration Modeling** *(Note: The Hearing Report contains material that is supplemental to the information in Section 8.4.)*

The CMAQ modeling analyzes the potential for the Greater Connecticut area and the Southwest Connecticut portion of the NY/NJ/CT area to achieve attainment of the 8-hour ozone standard. The attainment demonstration is based on both the CMAQ modeling results and a number of additional weight-of-evidence analyses (provided in Section 8.5) that support the attainment modeling results. Details of the CMAQ modeling are provided in the following sub-sections.

##### **8.4.1 Modeling Inventories**

As described in Section 8.2.1, CMAQ modeling runs were completed for the 2002 baseline year and 2009 and 2012 projection years using inventories developed as part of cooperative effort by the MANE-VU states to support ozone, PM<sub>2.5</sub> and regional haze planning activities. Modeling results presented in this document are based on projected emissions representing the OTC's "beyond-on-the-way" (BOTW) control scenario, which is comprised of the suite of measures each state indicated were likely to be adopted as of the commencement of modeling runs in late 2006. A full description of the inventories is provided in Appendices 8G, 8H and 8I.

#### 8.4.2 Modeled Attainment Test (MAT)

Consistent with EPA's guidance,<sup>6</sup> CMAQ modeled results were applied in a relative sense, assuming that measured values from the baseline period would decrease in proportion to modeled improvements between the baseline and future projection years. This "modeled attainment test" (MAT) was applied at each monitor using the following equation:

$$(DV_F)_I = (RRF)_I (DV_B)_I \quad \text{(MAT Equation)}$$

Where:

$(DV_B)_I$  = the baseline measured concentration at site I, in ppb

$(RRF)_I$  = the relative response factor determined as the ratio of CMAQ modeled results between the future year and the baseline year, calculated near site I

$(DV_F)_I$  = the estimated future design value for the year of interest, in ppb.

The development of appropriate relative response factors (RRF) and baseline concentrations ( $DV_B$ ) are described below.

#### Development of Relative Response Factors

The RRF used in the MAT Equation is determined by taking the ratio of the mean of the 8-hour daily maximum predictions in the future to the mean of the 8-hour daily maximum predictions with baseline emissions, over all relevant days at each monitor location. Consistent with EPA's recommendations,<sup>7</sup> "relevant days" were determined on a monitor-by-monitor basis using all days in 2002 with a maximum measured 8-hour value of 85 ppb or higher. All monitors in Connecticut recorded more than 10 days during 2002 with 8-hour ozone exceedances, satisfying EPA's criterion for using the 85 ppb threshold.

#### Development of Baseline Concentrations

As indicated by the MAT Equation, the  $DV_B$  at each monitoring site serves as the reality-based "anchor point" for estimating future year projected concentrations. EPA's modeling guidance<sup>8</sup> lists the following attributes that should be reflected in the methodology selected to determine appropriate  $DV_B$  values:

- 1) Should be consistent with the form of the applicable NAAQS;
- 2) Should be easy to calculate;
- 3) Should represent the baseline inventory year;
- 4) Should take into account the year-to-year variability of meteorology; and
- 5) Should take into account the year-to-year variability of emissions.

EPA's guidance also recommends that  $DV_B$  values be determined using the average of the three 8-hour ozone design values that include the baseline inventory year. Accordingly, given a

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<sup>6</sup>EPA Guidance (2007) at page 20.

<sup>7</sup> Ibid. at page 147.

<sup>8</sup> Ibid. at pages 22 and 23.

baseline inventory year of 2002, the years used to calculate the  $DV_B$  would range from 2000-2004. The resulting  $DV_B$  calculation uses the 2000-2002, 2001-2003, and 2002-2004 design value periods, with the year 2002 “weighted” three times, 2001 and 2003 weighted twice each, and 2000 and 2004 weighted once each. EPA concludes that this default method has the desired effect of weighting the projected ozone values towards the middle year of the 5-year period (i.e., the 2002 baseline emissions year) while also taking into account the emissions and meteorological variability that occurs over the full 5-year period.

The guidance also notes that the default weighting procedure emphasizes the importance of the meteorology experienced during the middle years of the 5-year period. As a result, EPA recommends that meteorological data for the five years be evaluated to determine if any extreme conditions have occurred during the period, especially for the middle years that receive extra weighting in the recommended  $DV_B$  methodology.

CTDEP has conducted such an evaluation for the 2000 to 2004 ozone seasons. Figure 8.4.2.1 shows the number of days with maximum temperatures of 90°F or more (90+°F) at Bradley Airport in north-central Connecticut, using EPA’s default 5-year weighting method. The 5-year period ending in 2004 (i.e., with 2002 weighted three times) had the highest weighted number of 90+°F days for any 5-year period over the last 30 years (i.e., 20 days, tied with 2003).

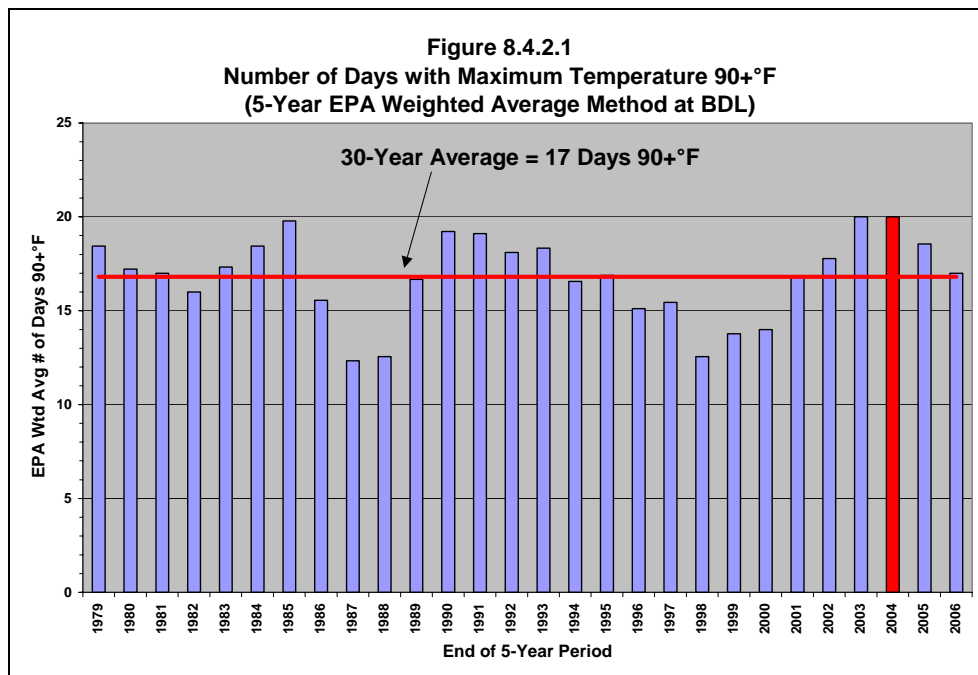
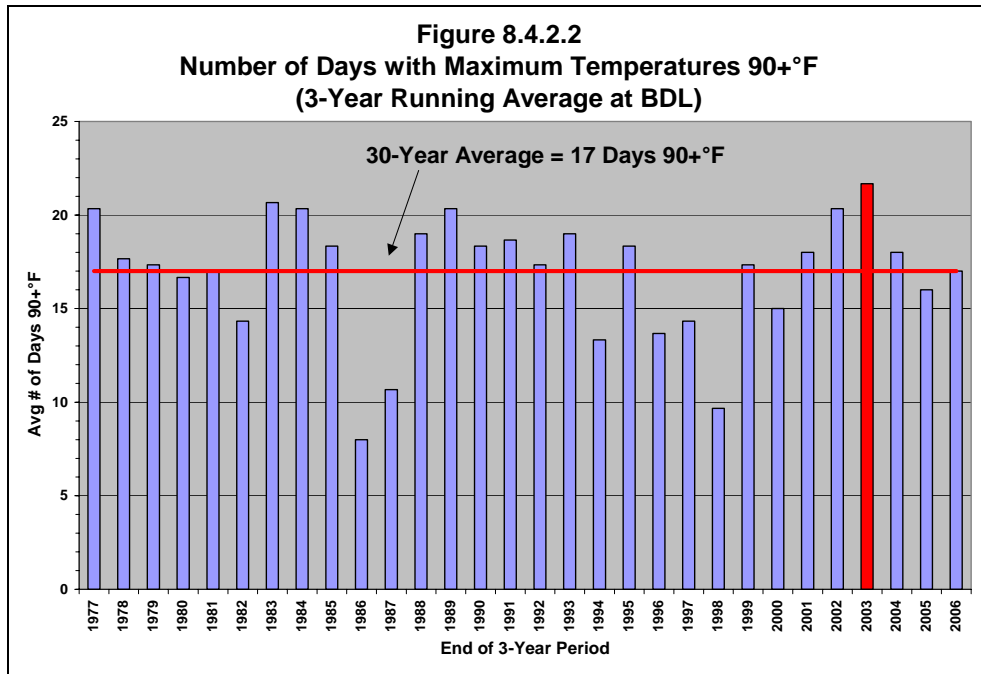
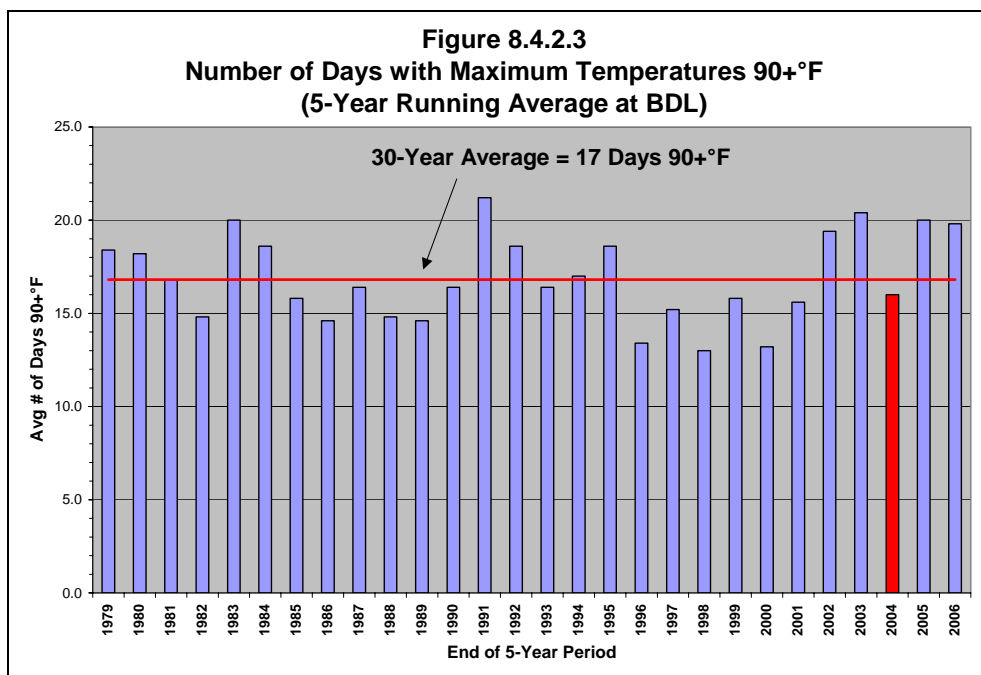


Figure 8.4.2.2 focuses on temperatures for the middle years (i.e., 2001 through 2003) that straddle the 2002 baseline year and which served as the design value period for EPA’s 8-hour ozone nonattainment designations. The 3-year period ending in 2003 experienced the highest average number of days with temperatures of 90°F or higher over the 30-year period (i.e., 22 days, compared to the long-term average of 17 days).



Based on this analysis, CTDEP concludes that EPA’s default DV<sub>B</sub> weighting method should not be used for Connecticut due to the “extreme” meteorological conditions occurring during the middle years of the 5-year period. Instead, CTDEP has determined that a DV<sub>B</sub> method based on a non-weighted 5-year average of ozone concentrations (using 2000 through 2004 4<sup>th</sup>-high ozone values) more appropriately represents summer temperatures in Connecticut. Figure 8.4.2.3 illustrates this point, showing that, when simple 5-year averages of 90+°F days are analyzed, the 5-year period ending in 2004 is very close to the 30-year average of 90+°F days (i.e., 16 days compared to the long-term average of 17 days).



### 8.4.3 Unmonitored Area Analysis

The State of Connecticut's monitoring network, laid over the 12 kilometer CMAQ modeling grid, is depicted in Figure 8.3.1.1. This dense network of monitors covers virtually the entire state when the nine CMAQ modeling grid squares encompassing each of the monitors are considered. Also, the densest portion of the network is along the coastline, where Connecticut's nonattainment issues are the most problematic. Thus, the existing monitoring network is adequate to detect high ozone levels and an analysis of unmonitored areas is unnecessary.

### 8.4.4 Results of the Modeled Attainment Test

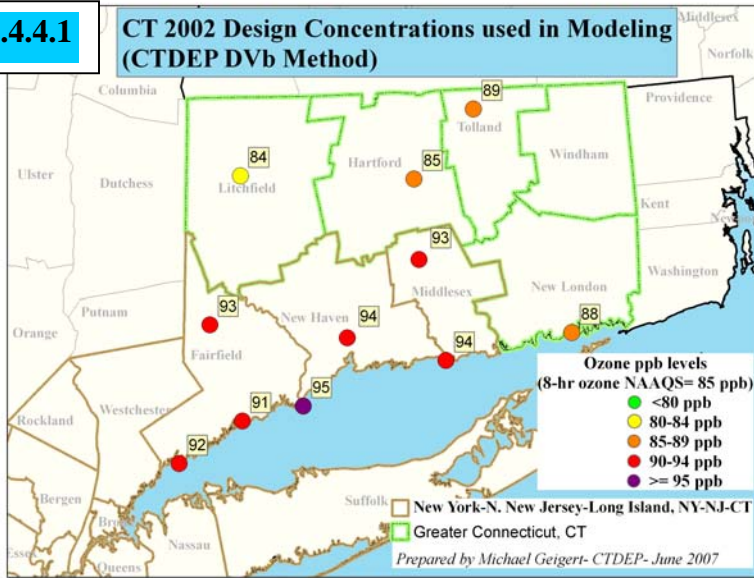
Projected ozone levels in 2009 and 2012 were determined using the MAT Equation, including RRF values developed from the CMAQ BOTW modeling and CTDEP's DV<sub>b</sub> values determined as described above. Results are summarized in Table 8.4.4.1, with the DV<sub>f</sub> values representing the CMAQ projected 8-hour ozone levels, with BOTW controls, in 2009 or 2012. Results are also displayed in Figures 8.4.4.1 through 8.4.4.3, showing the rapid improvement in ozone levels over the period modeled.

**Table 8.4.4.1: CMAQ Modeling Results for Connecticut for 2009 and 2012**

<b>2009</b>				<b>2012</b>			
<b>Monitor</b>	<b>CTDEP DV<sub>b</sub> (ppb)</b>	<b>2009 BOTW RRF</b>	<b>2009 BOTW DV<sub>f</sub> (ppb)</b>	<b>Monitor</b>	<b>CTDEP DV<sub>b</sub> (ppb)</b>	<b>2012 BOTW RRF</b>	<b>2012 BOTW DV<sub>f</sub> (ppb)</b>
<b>Greater CT</b>				<b>Greater CT</b>			
East Hartford	85.0	0.876	74	East Hartford	85.0	0.826	70
Cornwall	83.5	0.870	72	Cornwall	83.5	0.818	68
Groton	87.8	0.879	77	Groton	87.8	0.831	72
Stafford	89.0	0.867	77	Stafford	89.0	0.814	72
<b>Southwest CT</b>				<b>Southwest CT</b>			
Greenwich	91.8	0.913	83	Greenwich	91.8	0.874	80
Danbury	93.2	0.897	83	Danbury	93.2	0.853	79
Stratford	95.4	0.919	87	Stratford	95.4	0.878	83
Westport	91.4	0.909	83	Westport	91.4	0.868	79
Middletown	93.4	0.888	82	Middletown	93.4	0.839	78
Madison	94.4	0.905	85	Madison	94.4	0.853	80
Hamden	93.8	0.912	85	Hamden	93.8	0.874	81

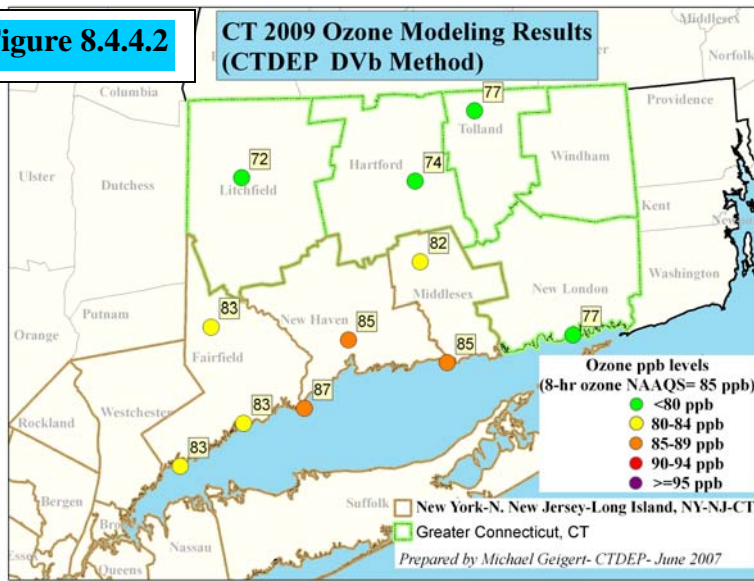
**Figure 8.4.4.1**

**CT 2002 Design Concentrations used in Modeling (CTDEP DVb Method)**



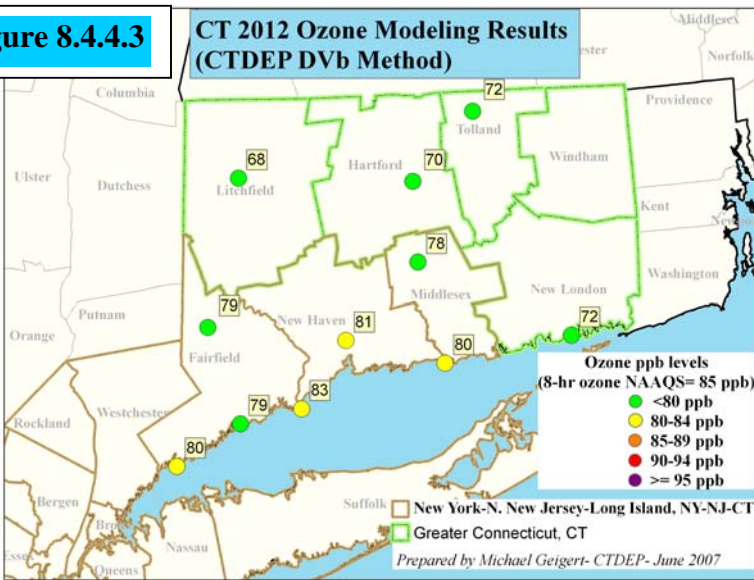
**Figure 8.4.4.2**

**CT 2009 Ozone Modeling Results (CTDEP DVb Method)**



**Figure 8.4.4.3**

**CT 2012 Ozone Modeling Results (CTDEP DVb Method)**





#### **8.4.5 Conclusions for the Greater Connecticut Area**

As displayed in Table 8.4.4.1, all four monitors located in the Greater Connecticut moderate nonattainment are projected by the CMAQ model to reach attainment of the 85 ppb 8-hour ozone NAAQS by 2009. Predicted 2009 ozone design values range from a high of 77 ppb in Groton and Stafford to a low of 72 ppb in Cornwall. All monitors are projected to have design values below the low-end threshold (i.e., 82 ppb) where EPA's modeling guidance recommends the use of supplemental weight of evidence analyses to demonstrate attainment. Therefore, with CMAQ projected concentrations well below both the NAAQS and WOE range, CTDEP concludes that there is a high probability that the Greater Connecticut area will achieve attainment of the 8-hour ozone NAAQS by the end of the 2009 ozone season. Improvements are expected to continue beyond 2009, with the CMAQ model projecting 8-hour ozone levels of 72 ppb or lower in the Greater Connecticut area by 2012.

#### **8.4.6 Conclusions for the Southwest Connecticut Area**

The CMAQ modeling projects that four of the seven monitors located in the Southwest Connecticut portion of the NY/NJ/CT moderate nonattainment area will reach attainment levels by 2009. The model predicts that residual nonattainment will remain in 2009 at three mid-coast monitors: Stratford (87 ppb), Hamden (85 ppb) and Madison (85 ppb). Finally, the CMAQ modeling projects that attainment of the ozone NAAQS will occur throughout all of Southwest Connecticut sometime between 2009 and 2012, with a peak design value of 83 ppb predicted in Stratford in 2012.

All seven Southwest Connecticut monitors are projected by the model to have 2009 design values within the "inconclusive" range (i.e., 82 ppb to 87 ppb) where EPA recommends the use of supplemental weight-of-evidence analysis techniques to better assess the probability of attaining by 2009. Several WOE analyses are presented in the following section. The results of these analyses lead CTDEP to conclude that there is a credible case for attainment throughout all of Southwest Connecticut by the end of the 2009 ozone season.

#### **8.5 Weight-of-Evidence Analysis** *(Note: The Hearing Report contains material that is supplemental to the information in Section 8.5.)*

By definition, models are simplistic approximations of complex phenomena. It is generally recognized that there is significant uncertainty associated with the results of photochemical grid modeling. In addition to the uncertainties associated with the dispersion and chemical response mechanisms built into the air quality model, the required meteorological, baseline and projected emissions, and air quality input data sets also contain their own levels of uncertainty that can affect the performance of the modeling system. These uncertain aspects of the modeling analyses can sometimes prevent definitive assessments of future attainment status especially when projected pollutant levels are at levels close to air quality standards.

Due to these uncertainties, modeling results should not be used in a strictly deterministic fashion to determine "bright-line" compliance by comparing projected air quality levels directly with the ozone NAAQS. Modeling is more appropriately used as a probabilistic tool, along with other

available assessment techniques, to assess the likelihood of complying with the NAAQS by a certain deadline. Of course, a properly performing model which projects air quality in an area to be well above, or well below, the level of the NAAQS may warrant greater consideration among the mix of available other assessments when determining the likelihood of compliance.

EPA addresses the modeling uncertainty issue in its modeling guidance,<sup>9</sup> recommending that WOE analyses be performed to better determine the likelihood of NAAQS compliance when the model attainment test results are “inconclusive”. EPA’s guidance establishes the “inconclusive” range for 8-hour ozone modeling as MAT results between 82 ppb and 87 ppb for the required attainment year. As described above in Section 8.4, 2009 CMAQ MAT results for the Greater Connecticut area are well below this “inconclusive” range, providing a high degree of confidence that Greater Connecticut area will comply with the NAAQS by 2009. CMAQ MAT results for the Southwest Connecticut area fall within the “inconclusive” range, warranting consideration of other evidence to assess the probability of attaining in that area by 2009. Therefore, the focus of the WOE study is on the Southwest Connecticut area.

Several topics are included in the WOE discussion that follows below, including modeling uncertainties, air quality trends, comparison of modeled and monitored ozone levels, additional emission reductions not included in the CMAQ modeling and other important considerations.

### **8.5.1 Modeling Uncertainties Indicate the CMAQ Model May Overpredict 2009 Ozone Levels**

Several contributors to modeling uncertainty may result in overestimation by CMAQ of projected 2009 design values. These include the inadequate incorporation by the modeling system of NO<sub>x</sub> emissions occurring during high electric demand days (HEDD), potential problems with the model’s treatment of aloft transport and difficulties simulating marine boundary layer and sea breeze effects.

#### **8.5.1.1 Modeling Uncertainty Related to HEDD Emissions**

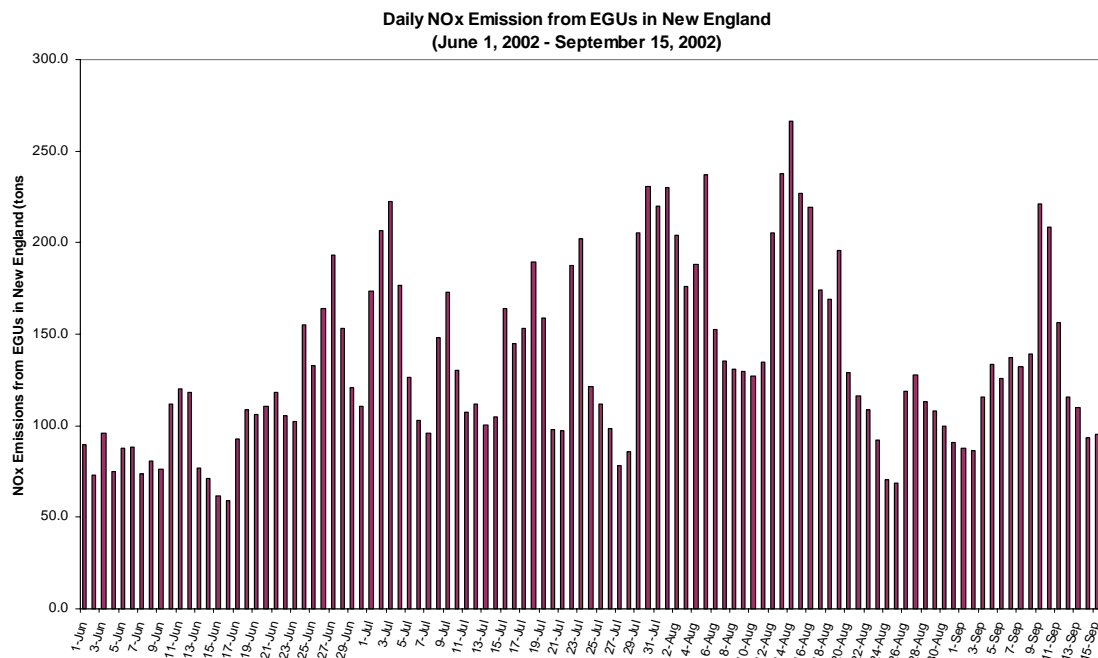
Emissions from the electricity generating source sector vary widely both diurnally and on a day-to-day basis, dependent upon the demand for electricity and the emission characteristics of the mix of electric generating units (EGUs) dispatched to meet changing demand and reserve capacity requirements. The highest level of EGU emissions typically occur on hot summer days, when the demand for air conditioning results in dispatch of load-following and quick-start EGU peaking units, most of which emit NO<sub>x</sub> at much higher rates (per unit of heat input or power output) than base-load units. Unfortunately, these HEDD emissions often occur during the meteorological conditions most conducive to producing the highest levels of ozone. For Connecticut, the most favorable meteorological conditions for ozone production include high temperatures on sunny summer days, with lower level transport winds from the southwest and upper level transport winds from the west, regions rich with emissions from EGUs and other source categories.

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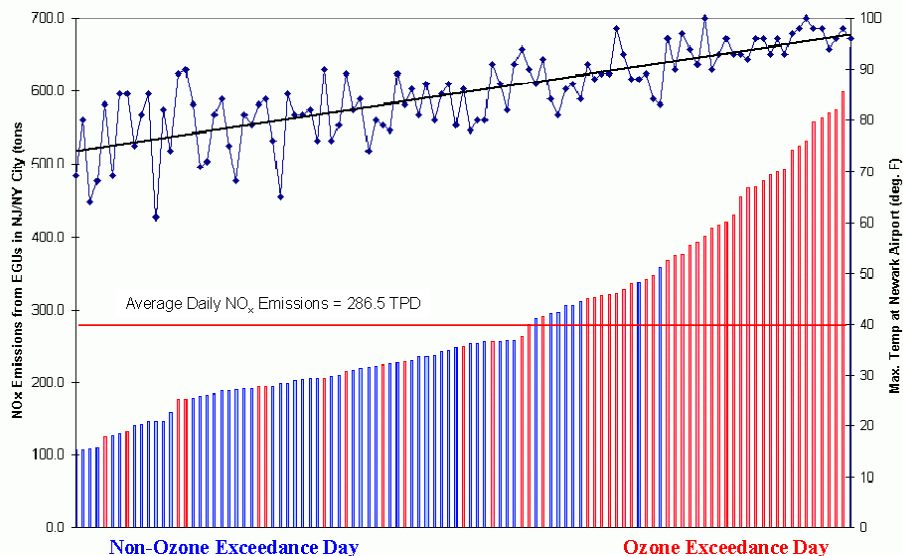
<sup>9</sup> Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM<sub>2.5</sub>, and Regional Haze; EPA OAQPS; EPA-454/B-07-002; April 2007; See page 98 of: <http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf>.

The variability of EGU emission profiles in New England is depicted in Figure 8.5.1.1, which shows that daily EGU NO<sub>x</sub> emissions in New England on high ozone days can be more than twice what they are on low ozone days (e.g., 260 tons on Aug 14, 2002 compared to 130 tons on Aug 8, 2002). In Figure 8.5.1.2, similar variations in emissions are seen upwind from Connecticut in the metropolitan New York City-New Jersey area, with more than double the emissions on high ozone days compared to New England (i.e., maximum 590 tons in the NYC metro area compared to a maximum of 260 tons in New England). These New York City-New Jersey sources impact the key monitors along the southern and western boundaries of Connecticut.

**Figure 8.5.1.1 Daily NO<sub>x</sub> emissions from EGUs in New England**

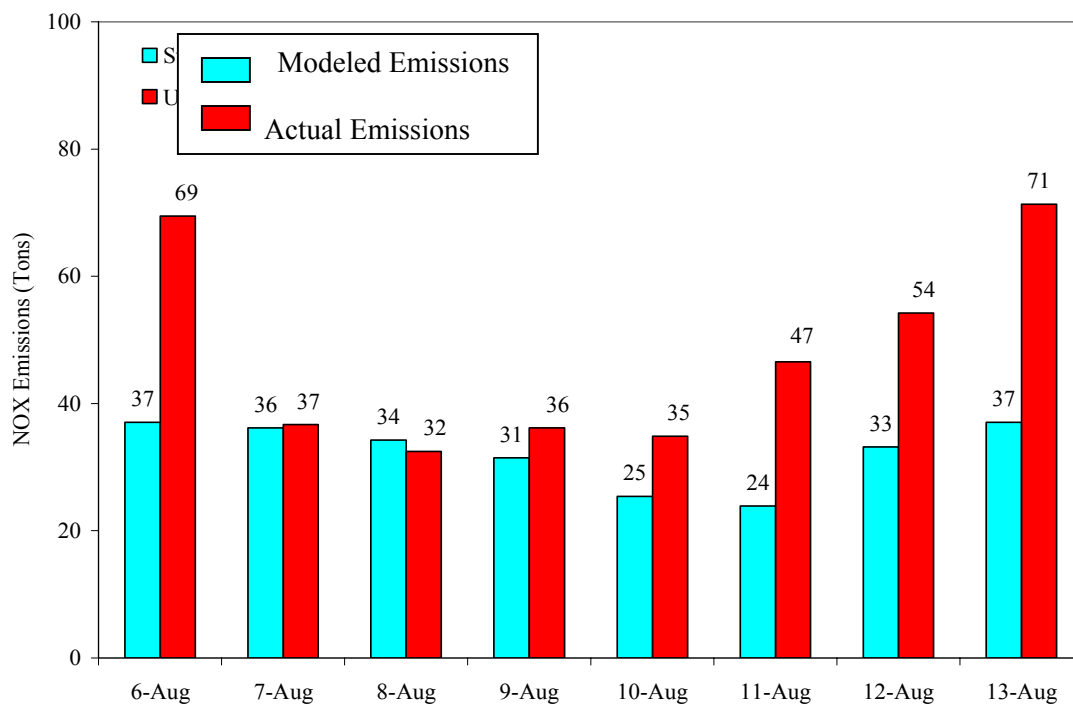


**Figure 8.5.1.2 Daily NO<sub>x</sub> Emissions from EGUs in NJ/NY City (June 1 - September 15, 2002)**



The CMAQ modeling system is not structured to capture the large day-to-day variability that occurs in actual EGU NO<sub>x</sub> emissions. Due to limitations in projecting temporal and spatial distributions of future EGU dispatch, EGUs are simulated by the modeling system using uniform NO<sub>x</sub> hourly profiles that vary only by month of the year and by day of the week, with no distinction made between the highest demand and lowest demand days. The difference between actual and modeled emissions is depicted in the example provided in Figure 8.5.1.3. Modeled emissions for Hudson County, New Jersey follow a day-of-week repeating profile for August 2002. Note that modeled August 6 emissions of 37 tons are repeated one week later, on August 13, in accordance with the day-of-week profile. Meanwhile, actual emissions vary considerably throughout the week depending on electricity demand, with the highest demand days producing NO<sub>x</sub> emissions almost twice those that were modeled. Ozone levels on August 13, 2002 were among the highest that year in Connecticut, with five of the state's eleven monitors measuring 8-hour values in excess of 120 ppb.

**Figure 8.5.1.3 Comparison of Actual and Modeled EGU Emissions for Hudson County, NJ**



This large (i.e., factor of two) underestimate of EGU NO<sub>x</sub> emissions on high demand days has implications for CMAQ modeling results in both the baseline and future year modeling scenarios. Effectively doubling modeled levels of EGU emissions on high demand days (which are often high ozone days) increases the importance of the EGU sector relative to other source categories. As a result, post-2002 controls on the EGU sector, such as the CAIR program and potential HEDD strategies, may result in greater improvements in actual future year ozone levels than the current modeling results indicate.

### **8.5.1.2 Modeling Uncertainty Related to CMAQ's Response to Emission Reductions**

Two recent real-world examples provide an opportunity for assessing the capabilities of the CMAQ modeling system to properly respond to emission changes, especially from elevated EGU emission sources that are known to contribute significantly to ozone transport:

- 2003 Northeast Power Blackout; and
- Implementation of EPA's NO<sub>x</sub> SIP Call.

Detailed descriptions of these events have been developed by the State of Maryland, as presented in that state's ozone SIP.<sup>10</sup> Much of the related analyses are based on aircraft measurements of meteorological and pollutant parameters conducted by the University of Maryland along the eastern seaboard during the 2002 and 2003 ozone seasons (including the 2003 Northeast blackout period), as well as subsequent attempts to simulate each event with the CMAQ model. The summaries provided below are based on the descriptions provided in Maryland's attainment demonstration.

In both of these real-world cases, comparison of actual ozone reductions to CMAQ modeling results reveals that the CMAQ model underpredicted the level of measured ozone improvement associated with reductions in EGU emissions, possibly due to model problems with the simulation of elevated transport. These findings reinforce the possibility that post-2002 EGU reductions from the CAIR program and potential HEDD strategies may result in greater improvements in actual 2009 year ozone levels than indicated by the modeling results described in Section 8.4.5.

#### **2003 Northeast Power Blackout**

Shortly after 4 p.m. eastern daylight time on August 14, 2003, a chain reaction triggered the shutdown of much of the generating capacity in the northeastern U.S. and southeastern Canada. This largest single electricity outage in North American history affected an estimated 50 million people, with 61,800 megawatts (MW) of electrical load lost in parts of Ohio, Michigan, New York, Pennsylvania, New Jersey, Connecticut, Massachusetts, Vermont and the province of Ontario. Many units shut down completely at the start of the blackout, with maximum impact reached a short time later, resulting in 531 units at 263 power plants being shut down. Most of these units remained shut down for 24 hours or more.

Although many ground-based ozone monitoring stations were without electricity, the University of Maryland instrumented aircraft flew that day based on a forecast for high ozone. Airborne measurements were taken over Maryland and Virginia (outside the blackout area) and Pennsylvania (in the center of the area affected by the blackout) on August 15, 2003, 24 hours into the blackout. The data from these flights provided a rare opportunity to test the response of air quality models to a large, sudden drop in emissions.

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<sup>10</sup> "Baltimore Nonattainment Area 8-Hour Ozone State Implementation Plan and Base Year Inventory"; SIP Number: 07-04; June 15, 2007; See: [http://www.mde.state.md.us/Programs/AirPrograms/air\\_planning/index.asp](http://www.mde.state.md.us/Programs/AirPrograms/air_planning/index.asp). In particular, see Appendices G1, G8, G-9, and G-10 of the Maryland SIP.

Airborne measurements collected during the blackout show that ozone was 30 ppb lower throughout the lowest 1.5 km of the atmosphere and 38 ppb lower at ground level on that day, compared to measurements on a meteorologically similar day, August 4, 2002.<sup>11</sup> Comparison to another day (August 3, 2005) that may have been even more similar to the blackout day, especially in regards to transport, found smaller differences in ozone, around 7 ppb. It is important to note that the August 3, 2005 flight occurred after the significant EGU NO<sub>x</sub> reductions from the NO<sub>x</sub> SIP Call were implemented, which likely explains the smaller differences when compared to the blackout measurements.

The only identified CMAQ modeling study of the 2003 blackout event<sup>12</sup> estimated that the blackout resulted in only 2.2 ppb of ozone reduction, far less than the 7 ppb to 38 ppb response determined by either of the above observation-based methods. These comparisons suggest that the model is not appropriately capturing the response in ozone due to changes in power plant emissions.

### **EPA's NO<sub>x</sub> SIP Call**

EPA, in collaboration with researchers from several universities, is performing a CMAQ simulation of 2002 and 2004 summertime air quality to determine the benefits of the NO<sub>x</sub> SIP Call.<sup>13</sup> The NO<sub>x</sub> SIP Call provided a large reduction in NO<sub>x</sub> emissions over a relatively short period of time, providing an opportunity to assess the performance of the CMAQ modeling system.

The final manuscript has not yet been released, but preliminary results indicate that, although observed median 8-hour ozone levels improved by about 18 ppb during the 2002 to 2004 period, the CMAQ model only simulated a change of 8 ppb. If these results are not explained by other factors, they would suggest that the CMAQ model may underpredict changes in ozone, especially from reductions in sources of elevated NO<sub>x</sub> emissions that contribute to transport.

The 2003 Northeast Blackout studies and EPA's NO<sub>x</sub> SIP Call analysis highlight an apparent "stiffness" of the CMAQ model in properly responding to elevated NO<sub>x</sub> reductions. This suggests that the 2009 CMAQ predictions presented in Section 8.4 may be too high, not adequately accounting for the level of ozone improvements that can be expected from control programs such as CAIR. These findings also provide hope that the HEDD reductions being pursued by several Northeast states (including Connecticut) will provide significant additional ozone reductions that have not been reflected in the modeling results.

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<sup>11</sup> Marufu, L. T., B. F. Taubman, B. Bloomer, C. A. Piety, B. G. Doddridge, J. W. Stehr, and R. R. Dickerson; "The 2003 North American electrical blackout: An Accidental Experiment in Atmospheric Chemistry"; *Geophysical Research Letters*; Vol. 33, L22810, doi:10.1029/2006GL027252, 2006..

<sup>12</sup> Hu, Y. M. T. Odman, and A. G. Russell; "Re-examination of the 2003 North American electrical blackout impacts on regional air quality"; *Geophysical Research Letters*, Vol. 33, L22810, doi:10.1029/2006GL027252, 2006.

<sup>13</sup> Gilliland et al; manuscript in preparation, 2007.

### 8.5.1.3 Modeling Uncertainty Related to Sea Breeze Circulations

A sea breeze typically forms along coastlines during afternoons when the land is considerably hotter than the adjacent ocean or bay. The difference in temperature between the land and adjacent water body results in a pressure difference that drives the air circulation. Air flows from the high pressure over the ocean toward the low pressure over land. At night, the opposite may happen as the land cools below the ocean's temperature, and a land breeze blows out to sea. Because the nighttime land and water temperature differences are usually much smaller than in the day, the land breeze is weaker than the sea breeze. Sea breezes typically only penetrate a few kilometers inland because they are driven by temperature contrasts that disappear inland.

The coastal sea breeze can be an important ozone transport mechanism, sweeping ashore pollutants originally transported over the ocean parallel to the coastline. Ozone moving over water is, like ozone aloft, isolated from destructive forces. When ozone gets transported into coastal regions by sea breezes, it can arrive highly concentrated. Conversely, when the offshore air mass contains few pollutants, the sea breeze can draw clean marine air into coastal areas.

Transport over the ocean is commonly observed downwind of the New York City metropolitan area during the summer months due to the city's proximity to the Atlantic Ocean and the Long Island Sound. The relatively cool summertime waters of Long Island Sound limit vertical mixing and deposition of ozone, often resulting in a concentrated ozone plume just offshore that is fueled by upwind emission sources located southwest of Connecticut. On days when a sea breeze forms in the afternoon, the shift in wind can bring high ozone concentrations to Connecticut's coastal monitors. Given the small temporal and spatial scale of sea breeze effects, the CMAQ model is challenged to resolve this feature, thus introducing a significant level of uncertainty to projections at the coastal Connecticut sites. Furthermore, since the emissions contained in the offshore plume do not originate from CT sources, in-state reductions have little effect on coastal concentrations affected by the sea breeze. This further emphasizes the importance of upwind reductions to reach attainment in coastal Connecticut.

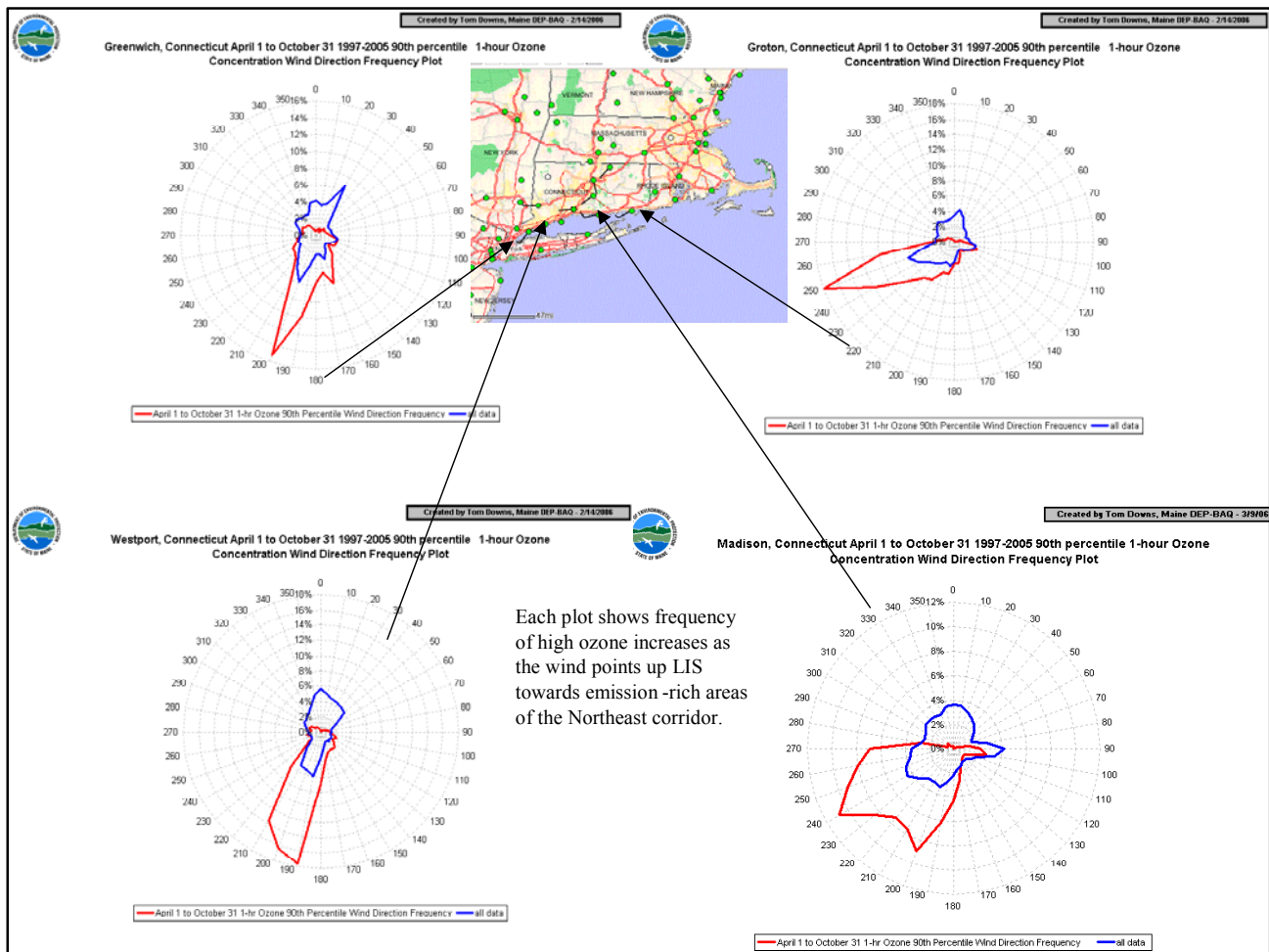
The sea breeze effect along Connecticut's coastline is depicted in the four pollution rose plots presented in Figure 8.5.1.3.1. These pollution roses represent the frequency of wind direction on the highest 10 percentile ozone concentration days from April 1 to October 31 during the years 1997 to 2005.<sup>14</sup> The winds on the highest ozone days point at the New York City metropolitan area at all locations along the Connecticut shoreline. Going along the Connecticut shoreline from the west (i.e. Greenwich) to the east (i.e., Groton), the predominant wind frequency direction (noted in red) shifts increasingly to the west, tracking the upwind location of the New York City metropolitan area.

This analysis suggests that most high ozone events in coastal Connecticut are caused by emissions transported from upwind areas, rather than by in-state emissions. To the extent that any coastal nonattainment issues remain after 2009, additional upwind reductions will be necessary to achieve compliance.

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<sup>14</sup> "The Nature of the Ozone Air Quality Problem in the Ozone Transport Region: A Conceptual Description"; NESCAUM; October 2006; See <http://bronze.nescaum.org/committees/attainment/conceptual/>.

**Figure 8.5.1.3.1 Wind rose plots along Connecticut shoreline for the time period April 1 to October 31 during the years 1997 through 2005**



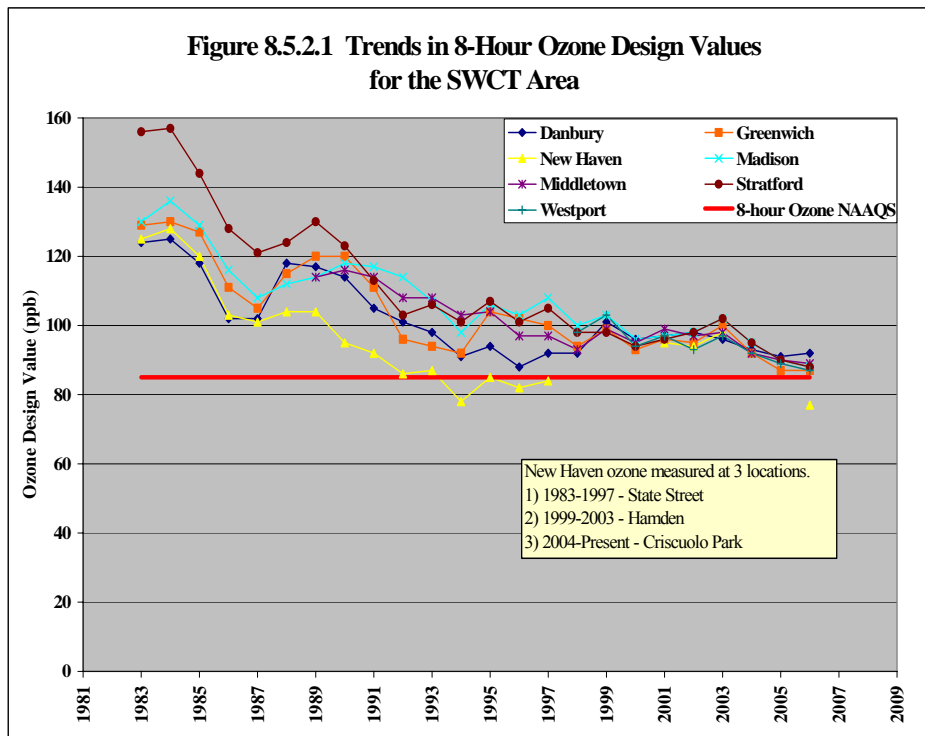
## 8.5.2 Air Quality Trends Indicate the CMAQ Model May Overpredict 2009 Ozone Levels

Emission reduction programs implemented over the last 25 years have resulted in significant decreases in peak ozone levels in Connecticut. The control strategies included in this SIP revision will continue to advance that progress. The following subsections briefly review the progress that has been made to date (see Section 3 for a more complete discussion) and examine how well the CMAQ model captures the progress that has been made since 2002, the baseline year used in the modeling analysis.

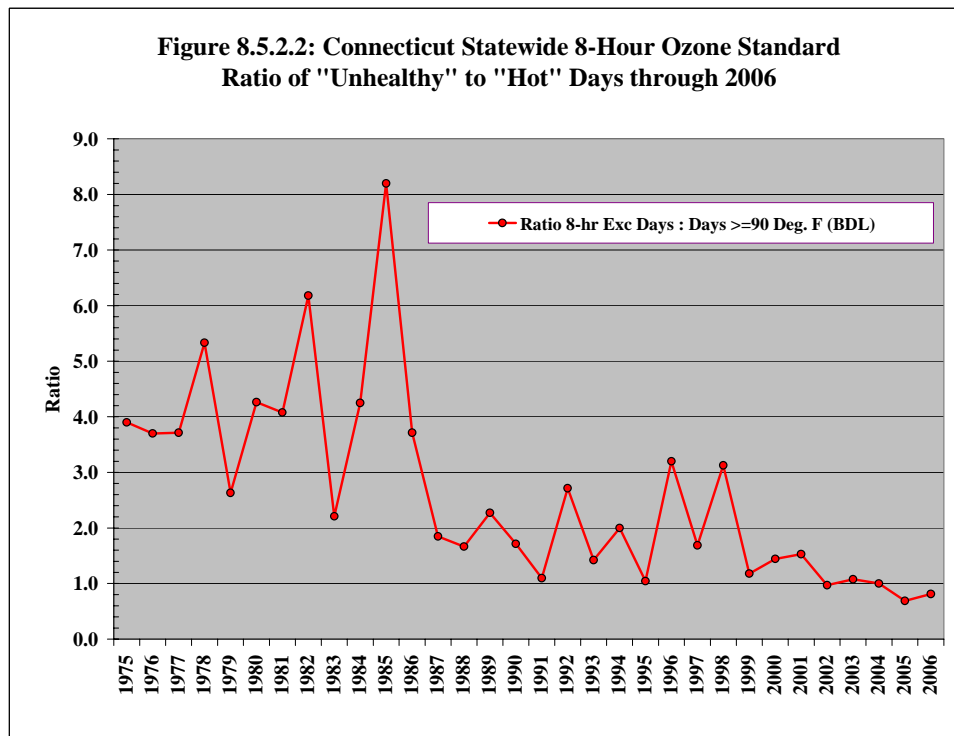
### 8.5.2.1 Air Quality Trends Suggest Southwest Connecticut is on Track for Attainment

As previously described in Section 3, measured levels of ozone and ozone precursor have dramatically decreased in Connecticut over the last 25 years. Figure 8.5.2.1 depicts the substantial reductions in 8-hour ozone design values that have occurred over that period at all monitors in the Southwest Connecticut Area.





The decline in peak ozone levels is apparent even when year-to-year summertime temperature fluctuations are considered. Figure 8.5.2.2 depicts the ratio of ozone exceedance days to the number of days with maximum temperatures of 90°F or more in Connecticut for the period from 1975 through 2006. There were 2.2 to 8 times more exceedance days than hot days during the first ten years of the period (1975 to 1985). Ratios subsequently decreased to levels ranging from one to three exceedance days per each hot day through the 1990s. Most recently, the ratio has declined to one exceedance day or less per hot day since 2002. In 2006, the ratio was 0.81, with 13 exceedance days versus 16 hot days during the ozone season.



These improvements in ozone levels have resulted from continuing reductions in ozone precursor emissions in Connecticut, throughout the OTR and elsewhere. As is more fully described in Section 4.3, control programs included in Connecticut's RFP demonstration are projected to result in 25% reductions in anthropogenic VOC emissions and 31% reduction in anthropogenic NO<sub>x</sub> emissions between 2002 and 2009, with considerable additional reductions projected through 2012 and beyond.

The dramatic improvement in ozone levels since 1985 in the Northeast is displayed in a series of isopleth maps provided in Appendix 8N. The plots show the progressive reduction in both the magnitude and spatial extent of high ozone levels as the ozone plume has "retreated" towards the southwest due to the success of emission control programs.

Finally, improvements in measured ozone levels suggest that Southwest Connecticut is on-track to achieve the necessary design value of less than 85 ppb to attain the 8-hour NAAQS by the end of the 2009 ozone season. Actual rate-of-progress towards the attainment goal is summarized in Figure 8.5.2.3. EPA used the 2003 design value of 102 ppb, measured at Stratford and Madison, Connecticut to classify the NY/NJ/CT area as moderate nonattainment for the 8-hour ozone NAAQS. Assuming improvements are achieved at an even rate over the 6-year period from 2003 to 2009, ozone levels would need to decline by 3 ppb per year to achieve attainment by 2009. Over the 3-year period from 2003 to 2006, this would require an improvement of 9 ppb, corresponding to a 2006 design value goal of 93 ppb. The highest measured design value in 2006 was 92 ppb, suggesting the Southwest Connecticut area is on-target for attainment in 2009.

**Figure 8.5.2.3 Measured Improvement in Design Values Compared to Rate-of-Progress Needed to be On-Target for 2009 Attainment**

<p>1) <b>Base Year (2003):</b> Design Value = 102 ppb (measured in Stratford and Madison, CT)</p> <p>2) <b>Target Year (2009) Goal:</b> Design Value ≤ 85 ppb</p> <p>3) <b>Desired Rate-of-Progress to Meet Target (assumes even rate):</b> 2009 – 2003 = 6 years 102 ppb - 84 ppb = 18 ppb 18 ppb/6 years = 3 ppb/year</p> <p>4) <b>Goal for 2006:</b> 2006-2003 = 3 years 3 ppb/year x 3 years = 9 ppb (ozone improvement goal) 102 ppb - 9 ppb = 93 ppb (ozone design value goal for 2006)</p> <p>5) <b>Status for 2006:</b> Highest measured design value = 92 ppb (measured in Danbury, CT)</p> <p>6) <b>Conclusion:</b> On-target for attainment in 2009</p>
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### 8.5.2.2 Ozone Improvements Outpace CMAQ Modeled Projections at Key Monitors

As previously described in Section 8.4.3, CMAQ modeling for 2009 projects that only the Stratford, Madison and Hamden monitors in Southwest Connecticut will have design values exceeding the 85 ppb 8-hour ozone NAAQS. Model projections for the other four Southwest Connecticut monitors (and all four Greater Connecticut monitors) are below the level of the NAAQS in 2009.

Measured 2006 design values provide a means to assess how well the CMAQ model is performing relative to actual measured ozone levels. Table 8.5.2.2.1 compares actual measured 2006 design values to 2006 interpolated CMAQ modeling results at the key monitoring sites in Southwest Connecticut. The 2006 modeled values were determined by linearly interpolating between the 2002-era baseline design values (DVb) used as the anchor point in the modeling analysis and the CMAQ-modeled 2009 BOTW results.

**Table 8.5.2.2.1 Comparison of 2006 Actual Design Values to CMAQ Interpolated Results**

Key SWCT Monitors	CTDEP DVb (ppb)	2009 CMAQ BOTW DVf (ppb)	Interpolated 2006 CMAQ DV (ppb)	Actual 2006 DV (ppb)	Are Measured Design Values Ahead or Behind Model Predictions?
Stratford	95.4	87.7	91.0	88	Ahead
Madison	94.4	85.4	89.3	88	Ahead
Hamden	93.8	85.5	89.1	<i>na</i>	<i>na</i>
Danbury	93.2	83.6	87.7	92	Behind

*na* – not applicable (The Hamden monitor was moved to New Haven in 2004. The 2006 design value in New Haven was 77 ppb.)

For the two key monitors at Stratford and Madison, actual 2006 design values are somewhat ahead of the interpolated CMAQ results for 2006. Stratford’s monitored 2006 design value is 88 ppb, while linear interpolation between the 2002 modeling design concentration and the 2009 CMAQ modeling results yields a “modeled” 2006 value of 91 ppb. Similarly, the actual 2006 design value for Madison is 88 ppb, while the interpolated CMAQ results produce a “modeled” 2006 value of 89 ppb. If these differences carry forward to 2009, Stratford’s 2009 modeled value of 87 ppb would translate to a possible 2009 design value of 84 ppb and Madison’s modeled value of 85 ppb would translate to a possible 2009 design value of 84 ppb, both in compliance with the 8-hour ozone NAAQS of 85 ppb. Note that the Hamden ozone monitor was moved to New Haven in 2004, so a similar comparison cannot be made for that site. The 2006 design value at the New Haven site was 77 ppb, in compliance with the ozone NAAQS.

These findings are somewhat consistent with those observed in New Jersey, where all monitored design values in 2006 have already reached CMAQ modeled values for 2009. However, one monitor in Southwest Connecticut, located in Danbury, appears to be significantly behind the design value that might be anticipated by the CMAQ modeling. Danbury's 2006 design value, 92 ppb, is about 4 ppb greater than the interpolated CMAQ value of 88 ppb for 2006, raising doubts that the CMAQ predicted 2009 design value of 83 ppb will actually be realized at that site. It is worth noting that Danbury's measured 2006 design value of 92 ppb is comprised of fourth-high concentrations of 86 ppb in 2004, 104 ppb in 2005, and 87 ppb in 2006. The 104 ppb value from 2005 dominates the three-year design value average. The summer of 2005 experienced 29 days of 90°F or higher temperatures, the 5<sup>th</sup> hottest summer in the last 30 years.

As discussed further in the following subsection, ozone levels have improved to the point that the prospect for attainment in 2009 in Southwest Connecticut is strongly tied to the meteorological conditions that will occur during the summers of 2007, 2008 and 2009.

### **8.5.3 Attainment Levels Have Been Achieved During A Previous Cool Summer**

The occurrence of one or more cool summers would increase the prospects of attaining the ozone standard in Southwest Connecticut by the end of 2009. For example, the 2004 summer experienced only 6 days with maximum temperatures of 90°F or higher (an average summer has 17 days  $\geq$  90°F). As a result, all Connecticut ozone monitors, except for Danbury, recorded 4<sup>th</sup>-high 8-hour ozone levels that were less than the 8-hour ozone NAAQS of 85 ppb. Note that 4<sup>th</sup>-high values are used in the three-year design value calculation to determine NAAQS compliance. The Danbury 4<sup>th</sup>-high value in 2004 was 86 ppb, marginally greater than the standard. Emissions have decreased significantly since the 2004 ozone season, with a 20% reduction in ozone precursors expected between 2004 and 2009. Based on that level of emission reduction, if one or more of the summers of 2007, 2008 and 2009 are similar to, or even slightly warmer than the summer of 2004, compliance with the NAAQS could be achieved.

### **8.5.4 "Clean Data" in 2009 would Qualify SWCT for Clean Air Act Extension Year(s)**

Section 181(a)(5) of the CAA provides a mechanism for states to apply to the EPA administrator for an extension of the attainment deadline:

“Upon application by any State, the Administrator may extend for 1 additional year (hereinafter referred to as the "Extension Year") the date specified in table 1 of paragraph (1) of this subsection if-

- (A) the State has complied with all requirements and commitments pertaining to the area in the applicable implementation plan, and
- (B) no more than 1 exceedance of the national ambient air quality standard level for ozone has occurred in the area in the year preceding the Extension Year.

No more than 2 one-year extensions may be issued under this paragraph for a single nonattainment area.”

The reference to “table 1” points to the classification categories and attainment dates specified by the CAA Amendments of 1990 for the now revoked 1-hour ozone NAAQS. Under the 1-hour NAAQS, compliance in a nonattainment area was determined based on a design value defined as the maximum recorded 4<sup>th</sup>-highest 1-hour concentration recorded at any monitor over the most recent three-year period (i.e., an average of one exceedance per year was allowed at a monitor).

Under the current 8-hour NAAQS, compliance in a nonattainment area is determined based on a design value defined as the average of the 4<sup>th</sup>-highest concentration recorded at a monitor each year over the most recent three-year period. This design value definition allows compliance to be achieved even with three or more exceedances of the 8-hour NAAQS in a given year, provided the three-year average of 4<sup>th</sup>-high values at each monitor is less than 85 ppb.

Section 181(a)(5) of the CAA was written using the definitions of “design value” and “compliance” for the then applicable 1-hour ozone NAAQS and is not as easily interpreted in relation to the changed definitions of those terms for the 8-hour NAAQS. One reasonable interpretation for the 8-hour NAAQS would be that an area is eligible for a one-year extension of the attainment deadline if the maximum measured 4<sup>th</sup>-high concentration in the required attainment year (i.e., in this case, 2009) is less than 85 ppb.

Based on this interpretation, and assuming that the nonattainment area does not have a 2009 design value that fully complies with the NAAQS, Southwest Connecticut would be eligible for a one-year extension of the attainment deadline if the maximum recorded 4<sup>th</sup>-high concentration in 2009 at each monitor in the nonattainment area is less than 85 ppb. Section 181(a)(5) would also allow an additional extension year to achieve attainment, through 2011, if “clean data” were recorded throughout the nonattainment area in 2010.

Section 181(b)(2) also exempts nonattainment areas that receive attainment deadline extensions from the “bump-up” provision of the CAA (emphasis added):

“Reclassification upon failure to attain.- (A) Within 6 months following the applicable attainment date **(including any extension thereof)** for an ozone nonattainment area, the Administrator shall determine, based on the area's design value (as of the attainment date), whether the area attained the standard by that date. Except for any Severe or Extreme area, any area that the Administrator finds has not attained the standard by that date shall be reclassified by operation of law in accordance with table 1 of subsection (a) to the higher of-

- (i) the next higher classification for the area, or
- (ii) the classification applicable to the area's design value as determined at the time of the notice required under subparagraph (B).

No area shall be reclassified as Extreme under clause (ii).”

Based on the above discussion, Southwest Connecticut could reach attainment of the NAAQS in 2011 and still comply with CAA requirements for moderate nonattainment areas.

### **8.5.5 Modeling Does Not Include Several Important Emission Control Strategies**

The CMAQ modeling conducted for the attainment demonstration does not account for several control strategies that are expected to provide additional emission reductions in the 2009 timeframe, thereby increasing the likelihood that ozone levels in 2009 will be lower than the modeled levels reported in Section 8.4. The most important strategies, which are not at this time being proposed for inclusion in the ozone SIP, are summarized in Table 8.5.5.1 with discussion of some of the key Connecticut initiatives provided below.

**Table 8.5.5 Additional Emission Control Strategies Not Included in the CMAQ Modeling**

<b>Strategy</b>	<b>Timing</b>	<b>Comments</b>
High Electric Demand Day Reductions (HEDD)	2009 ozone season	<b>Northeast MOU in place; pursuing this initiative</b>
CT Energy Efficiency, Load Shifting & Clean Energy Programs	Ongoing & Increasing	
CT Energy Bill of 2007 Programs	2008	<b>Plans for peaking generation;</b> <b>Comprehensive plan</b> for procurement of energy resources; <b>Annual Assessment</b> of energy capacity requirements, demand growth, environmental impacts, security and costs
CT \$1 Billion Commitment to Reduce Highway Congestion <ul style="list-style-type: none"> <li>- Regional planning for commuter transport</li> <li>- Encourage port and rail freight use</li> <li>- Expand rail commuter service</li> <li>- Fuel cell study</li> <li>- Telecommuting/flexible employee scheduling</li> </ul>	2008 +	Includes New Haven-Hartford-Springfield MA commuter rail line; other transit; telecommuting
NYC Hybrid Taxi and Energy Efficiency	2007-2012	All hybrid taxi fleet by 2012
OTC Auto Refinishing VOC Content Limits	2012 (anticipated)	Approximately 65% reduction in VOC emissions anticipated from the 2002 baseline for this sector. The requirements are now adopted in some California air quality districts.
EPA National Measures <ul style="list-style-type: none"> <li>- Aerosol Coatings</li> <li>- Consumer Products</li> <li>- Architectural Coatings (AIM)</li> </ul>	2009 2009 2009	Consumer products & AIM included in modeling only for OTR states.
Group II VOC Control Technique Guidelines (CTGs) <ul style="list-style-type: none"> <li>- Flexible package printing</li> <li>- Offset lithographic/letterpress printing</li> <li>- Industrial cleaning solvents</li> </ul>	2009	Rule amendment under development.
Diesel Locomotives & Marine Diesel Engines	2009 starts phase-in	Proposal published March 2007
Small Spark-Ignited Lawn & Garden and Marine Engines	Phase-in starts 2009 Marine & 2011 Nonroad	Proposal published May 2007
NO <sub>x</sub> reductions from minor source asphalt production facilities	2009-2010	State initiative under development

### **8.5.5.1 High Electric Demand Day (HEDD)**

As discussed in Section 8.5.1.1, emissions from the electricity generating source sector can vary widely on a day-to-day basis, depending upon the demand for electricity and the emission characteristics of the mix of electric generating units (EGUs) dispatched to meet changing demand and reserve capacity requirements. The highest levels of EGU emissions typically occur on hot summer days, when the demand for air conditioning results in dispatch of load-following and quick-start EGU peaking units, most of which emit NO<sub>x</sub> at much higher rates (per unit of heat input or power output) than base-load units. Unfortunately, these HEDD emissions often occur during the meteorological conditions most conducive to producing the highest levels of ozone. For Connecticut, the most favorable meteorological conditions for ozone production include high temperatures on sunny summer days, with lower level transport winds from the southwest and upper level transport winds from the west, regions with abundant emissions from EGUs and other source categories.

While not specifically quantified in the modeling process, Connecticut worked with the Ozone Transport Commission (OTC) to design a high electric demand day strategy, which, when implemented throughout the OTC and aggressively targeted to the inner core, would achieve real air quality benefits.<sup>15</sup> Due to the high cost of electricity at peak demand times and the need to assure reliability of supply, Connecticut's energy planning and air quality planning are inextricably linked and being coordinated. Preliminary estimates indicate that current demand side reduction efforts have a 7 ton-per-day (tpd) NO<sub>x</sub> reduction benefit on peak days,<sup>16</sup> and the State commitment to reduce peak demand will achieve a very significant further NO<sub>x</sub> reduction benefit on peak days.

### **8.5.5.2 Reducing Peak Demand**

The current approaches to NO<sub>x</sub> control are not designed to effectively address short-term (e.g., hourly or daily) spikes in NO<sub>x</sub> emissions on high electric demand days. However, Connecticut has demonstrated that energy policies can be designed to significantly reduce peak electric demand and its resulting emissions.

In September of 2006, Governor M. Jodi Rell addressed the peak demand issue in her "Energy Vision" for the state,<sup>17</sup> setting a goal of achieving a 20% reduction in electric-peak consumption by 2020. Then, in June of 2007, she signed into law Public Act 07-242, An Act Concerning Electricity and Energy Efficiency (Energy Act),<sup>18</sup> which includes three significant peak reduction measures. On the supply side, the Energy Act calls for mandatory decoupling of utility revenue from the sales of each electric and gas company in the next rate proceeding, thereby

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<sup>15</sup> "Memorandum of Understanding Among the States of the Ozone Transport Commission Concerning the Incorporation of High Electrical Demand Day Emission Reduction Strategies into Ozone Attainment State Implementation Planning" March 2, 2007 and attached hereto as Appendix 8O.

<sup>16</sup> "Avoided Nitrogen Oxide Emissions from Energy Efficiency on High Electric Demand Days in Connecticut: A preliminary Analysis", Resource Systems Group Inc. – March 2007, reproduced in Appendix 8P.

<sup>17</sup> "Connecticut's Energy Vision for a Cleaner, Greener State," September 18, 2006, available at <http://www.ct.gov/governorrell/lib/governorrell/ctenergyvisionsept19.pdf>.

<sup>18</sup> Public Act 07-242, available at <http://www.cga.ct.gov/2007/ACT/PA/2007PA-00242-R00HB-07432-PA.htm>.

ending the incentive for electric utilities to sell more energy to increase profits. On the demand side, the Energy Act calls for the development of plans to implement time-of-use pricing with appropriate metering and network support (“smart meters”) to provide incentives for consumers to reduce electricity use at times of peak demand. The act will also reduce peak demand by providing rebates for the replacement of inefficient home air conditioning units with units that meet the federal Energy Star standard.

### **8.5.5.3 Energy Efficiency Measures**

The State’s efforts to promote Energy Efficiency (EE) as the “resource of first choice” have earned national recognition as Connecticut was named as one of the most energy efficient states in the country.<sup>19</sup> When Governor Rell signed the Energy Act on June 4, 2007, she was building on existing exemplary demand reduction programs in effect in Connecticut. In addition to those mentioned above, several specific provisions of the Energy Act, when fully implemented, will result in additional emission reductions, which can be applied toward attainment. Some of these provisions include:

- The mandatory assessment of energy efficiency and other clean energy resources, such as renewable energy, by Connecticut’s two major load serving entities – United Illuminating and Connecticut Light and Power;
- A requirement that energy capacity needs must first be met through all available energy efficiency and demand-side resources that are cost effective, reliable and feasible;
- The mandatory assessment of how best to eliminate or stabilize growth in electric demand;
- The mandatory incorporation of the impact of current and projected environmental standards, including the ozone standard;
- All state building projects over \$5 million must meet Leadership in Environmental Design Silver (LEEDS Silver) standards or better;
- The creation of the first home heating oil conservation and efficiency program;
- The adoption of appliance efficiency standards for nine additional products; and
- The continued ramp-up of renewable energy portfolio requirements under which 20% of Connecticut’s energy shall be derived from renewable resources by the year 2020.

Even without the legislative driver to reduce energy costs, per capita energy use in Connecticut, which has been constant at 250 million BTUs (75 MWh), is significantly lower than the average US consumption rate of 340 million BTUs (100 MWh). Only California and New York City have lower per capita consumption figures of 225 million BTUs (65 MWh).<sup>20</sup> This low rate was achieved by Connecticut’s commitment to demand-side management.

In Connecticut, the Energy Conservation Management Board (ECMB) advises and assists Connecticut’s electric distribution companies in the development and implementation of comprehensive and cost-effective energy conservation and market transformation plans. The

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<sup>19</sup> “The State Energy Efficiency Score Card”, American Council for an Energy-Efficient Economy Report - Number E075, June 2007.

<sup>20</sup> The Connecticut Academy of Science and Engineering, “Energy Alternatives and Conservation,” December 2006.



ECMB utilizes the Connecticut Energy Efficiency Fund (CEEF) to provide financial support to homeowners and renters, small and large businesses, and state and local governments, for more efficient energy use. Measures include reducing lighting loads, installing more efficient air conditioning and cooling systems, improving insulation and replacing older motors and pumps with state-of-the-art high efficiency units.

Additional support for demand-side management is provided by ISO-New England's new Forward Capacity Market (FCM) Rules. Market Rule 1, and the new FWC rules, which take effect in 2010, will value EE and demand-side resources the same as traditional generation.<sup>21</sup>

EE measures have a lasting 'cumulative' effect on electric demand. The savings in the installation year of an EE measure continue for the duration of its known measured life, usually 15 years. Therefore, efficiency savings installed one year can be added to the measures included in all of the preceding years within its measured life. ECMB projected that \$4 in future savings was generated from every \$1 spent by CEEF in 2006, making for significant annual and cumulative totals. This concept is clearly shown in Table 8.5.5.3 below using data from the ECMB annual reports 2003 through 2006.<sup>22</sup> The increased ECMB funding from the Energy Act, in conjunction with the ISO-NE FCM Rules should further increase NO<sub>x</sub> reductions in 2007.

**Table 8.5.5.3: Energy Savings and Emissions Reductions from CEEF Projects, 2003-2006**

<b>YEAR</b>	<b>Energy Saved in Thousands MWh</b>	<b>CUMULATIVE ENERGY SAVED Thousands MWh</b>	<b>NO<sub>x</sub> reduced (Tons)</b>	<b>Lifetime NO<sub>x</sub> Reduced from annual projects (Tons)</b>
<b>2003</b>	<b>130.7</b>	<b>130.7</b>	<b>73</b>	<b>1151</b>
<b>2004</b>	<b>291</b>	<b>421.7</b>	<b>112</b>	<b>1548</b>
<b>2005</b>	<b>318</b>	<b>739.7</b>	<b>123</b>	<b>1702</b>
<b>2006</b>	<b>328</b>	<b>1067.7</b>	<b>89</b>	<b>1243</b>
<b>TOTALS</b>	<b>1067.7</b>	<b>1067.7</b>	<b>397</b>	<b>5644</b>

Although an assessment of reductions from EE measures is difficult to accomplish with a high-degree of precision, CTDEP with assistance from Resource Systems Group, Environmental Resources Trust (ERT) and DJ Consulting, LLC, developed a methodology designed to estimate NO<sub>x</sub> emission reductions on HEDDs resulting from EE and distributed resource measures.<sup>23</sup> CTDEP plans to further develop inputs to assess the effectiveness of this methodology in the belief that it will be an important tool moving forward.

The adoption of Connecticut's newest energy legislation, in addition to EE measures already in effect, demonstrates a firm commitment to EE by the State. While it is not yet possible to determine EE-associated emission reductions with the precision necessary for full federal approval and for SIP credit towards attainment of the 8-hour ozone NAAQS, this information and the future direction of Connecticut's energy efficiency programs convey a compelling

<sup>21</sup> ISO-NE, Market Rule 1 and FWC Rules available at: <http://www.iso-ne.com/index.html>.

<sup>22</sup> ECMB Annual Reports can be found at: <http://www.ctsavesenergy.com/ecmb/documents.php?section=16>. The ECMB 2006 Annual Report, March 2007 is reproduced in Appendix 8Q.

<sup>23</sup> The full report is reproduced in Appendix 8P.

argument that Connecticut's EE programs are doing much to limit the growth of electricity demand and the otherwise high NO<sub>x</sub> emissions associated with such growth.

The efforts Connecticut has made to reduce peak demand and encourage EE provide further weight-of-evidence that Connecticut could attain the 8-hour ozone NAAQS by 2009.

### **8.5.6 Conclusions Based on Modeling and Weight of Evidence Analyses**

CMAQ modeling performed by the OTC states and weight-of-evidence (WOE) analyses conducted by CTDEP indicate the following for the Greater Connecticut moderate ozone nonattainment area:

- The CMAQ model projects that the 8-hour ozone NAAQS of 85 ppb will be achieved in the Greater Connecticut area by the June 2010 attainment deadline (as determined based on ozone levels at the end of the previous full ozone season, 2009).
- Projected ozone levels throughout Greater Connecticut in 2009 are also less than the lower WOE boundary of 82 ppb, providing a high degree of confidence that the area will reach attainment by the end of the 2009 ozone season.

The CMAQ modeling and WOE analyses indicate the following for the Southwest Connecticut portion of the NY/NJ/CT moderate ozone nonattainment area:

- The CMAQ model projects that four of the seven monitors in Southwest Connecticut will achieve 2009 design values lower than the 85 ppb 8-hour NAAQS. CMAQ projects residual nonattainment at the other three Southwest Connecticut monitoring sites, with design values at all seven sites within the WOE bounds of 82 to 87 ppb.
- Several forms of WOE analyses were conducted for Southwest Connecticut. Findings are listed below.
  - CMAQ modeling uncertainties regarding EGU HEDD emissions, EGU control strategy effectiveness, elevated transport, and sea breeze effects suggest that CMAQ predictions of 2009 ozone levels may be overestimated and that any residual nonattainment at coastal sites will require additional upwind reductions to achieve attainment.
  - Improvements in actual measured ozone levels over the last several years have outpaced CMAQ model predictions in northeastern states, including key monitors in Southwest Connecticut. These improvements suggest that measured design values in 2009 may be less than predicted by the CMAQ model and may be low enough to achieve attainment by 2009.
  - In 2004, Connecticut experienced a cool summer with 4<sup>th</sup>-high ozone levels at (85 ppb in Danbury) or below (all other Connecticut monitors) the 8-hour ozone NAAQS. With significant emission reductions occurring between 2002 and 2009, a similar, or even slightly warmer summer, could produce ozone levels in Southwest Connecticut that meet the NAAQS.

- Section 181(a)(5) of the CAA provides a mechanism for up to two, one-year extensions of the June 2010 attainment deadline for moderate areas. Therefore, if “clean data” are recorded throughout the nonattainment area in 2009, Southwest Connecticut could be eligible for a CAA extension of the moderate nonattainment area attainment deadline to as late as the end of the 2011 ozone season.
- Significant emission control programs not included in the CMAQ modeling should provide additional improvements in ozone levels. These include HEDD emission reductions strategies being pursued by Connecticut and other northeastern states, expanding energy efficiency programs, recent large financial commitments to mass transit and other efforts to reduce vehicle traffic and emissions, and EPA national efforts to further reduce VOC and NO<sub>x</sub> emissions from a number of stationary and mobile source categories.

In conclusion, the results of the CMAQ modeling and WOE analyses suggest a high degree of confidence that the Greater Connecticut area will attain the 8-hour ozone NAAQS by 2009. In addition, a very credible case can be made for attainment of the NAAQS throughout Southwest Connecticut by 2009, with a greater level of confidence in each subsequent year, such that attainment is highly likely by the end of the 2012 ozone season.