DOCKET NO. F-2014/2015 – Connecticut Siting Council Review of the Ten-Year Forecast of Connecticut Electric Loads and Resources

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Draft Report

November 12, 2015

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INTRODUCTION

Connecticut's electric system provides service to approximately 3.6 million residents and approximately 78 thousand businesses. The system's infrastructure includes 108 generating units whose electrical energy is dispatched onto the regional supply network—over 1,800 circuit-miles of high-voltage conductors that form the transmission grid and more than 130 substations that direct electricity to individual users via the distribution system.

This network of electric connections must be highly reliable, given its importance not only for our State, but for our region. In current global circumstances, with volatile fuel prices, new energy technologies and climate change concerns, reliability is a special challenge. Daily operations of the grid, including both power flows and transactions within the wholesale market for electricity, are managed by the Independent System Operator for New England. ISO New England Inc. (ISO-NE) is a private, not-for-profit corporation, governed by an independent board of directors and overseen by the Federal Energy Regulatory Commission (FERC). Reliability standards set or approved by FERC are carried out through ISO-NE by its member companies. This centralized regional authority for management helps to ensure that the system functions reliably and efficiently. ISO-NE also directs annual forward planning for both electric transmission and generation needs in our region. Members choose to participate in this regional planning process in one of the following sectors: generators, suppliers, alternative resources (including renewable resources), transmission owners, publicly-owned utilities, and end users. Nonetheless, since each state regulates the power facilities in-state only, and affects future electric reliability by establishing energy policies for in-state businesses and citizens, the prudent state must carefully review forecasts of anticipated electric supply and demand within its own borders.

Since 1972, the Connecticut General Assembly has mandated the Connecticut Siting Council (Council) to review of the forecasts of our State's electricity needs and resources. Specifically, since the passage of Public Act (PA) 01-144 in 2001, the requirement is to review a ten-year forecast of needs and resources. As is to be expected, the utility companies themselves provide these forecasts/projections. Most of Connecticut's electric system data is used in common by all the State and regional planners and is supplied by Connecticut generators and by our State's two largest transmission and distribution companies, The Connecticut Light and Power Company d/b/a Eversource Energy (Eversource) and The United Illuminating Company (UI), as well as by municipal electric distribution companies, the Connecticut Municipal Electric Energy Cooperative (CMEEC) and Wallingford Electric Division (WED)[1]. These data have been developed for their own internal planning. Other planning groups model these data to emphasize fuel characteristics, cost issues, efficiency, and so forth. As more and more forecasting has been undertaken by different parties to make sure, in different ways, that the electric system will remain reliable, the more the Council has tried, in its annual forecast review, to emphasize openness, to clarify differences in approach, and to assess consistency.

Pursuant to PA 11-80 and PA 13-298, the Department of Energy and Environmental Protection (DEEP) is mandated to create an Integrated Resource Plan (IRP). Its most important features, to be discussed below in more detail, are its coordinated approach to procuring electricity and its emphasis on energy reliability and efficiency.

Furthermore, in accordance with PA 11-80 and PA 13-298, DEEP is also mandated to create a Comprehensive Energy Strategy (CES). The CES, while taking into account the findings of the IRP, lays out a coordinated approach to address our collective energy, economic, and environmental challenges while aiming towards a cheaper, cleaner, and more reliable energy future.

In contrast to the IRP, which establishes policy, and the CES, which not only addresses policy and strategy but covers multiple types of energy, the Council's report is limited strictly to forecasting and focuses on electricity, as required by statute.

ELECTRIC DEMAND

Load and Load Forecasting

The principal term for describing electric load is "demand," which can be thought of as the rate at which electrical energy is consumed. (This is not to be confused with "energy", which is the total work done over a given period of time by the electricity and will be discussed later.) The most familiar unit of load or demand is a "Watt." On a household scale, a kilowatt (kW) is used, a unit of 1,000 Watts. However, since utility companies serve loads on a much larger scale, forecasts typically use the unit of a megawatt (MW), or one million watts[2]. Very large utility-level loads can sometimes be expressed in gigawatts (GW). One GW is equal to one billion watts or 1,000 MW.

Loads increase with any increase in the number of electrical devices being used at the same time. Demand also depends on the size of the electrical loads or how much work is being performed by those devices. Generally, the higher the electrical loads, the more the stress on the electrical infrastructure. Higher loads result in more generators having to run, and run at higher output levels. Transmission lines must carry more current to transformers located at the various substations. The transformers in turn must carry more electrical load, and supply it to the distribution feeders, which must carry more current to supply the end users. In order to maintain reliability and predict when infrastructure must be added, upgraded, and replaced to serve customers adequately, utilities must have a meaningful and reasonably accurate estimate or projection of future loads. The process of calculating future loads is called "load forecasting."

Load forecasting by the Connecticut utilities is broken down by each company's respective service area. UI serves 17 municipalities in the New Haven area near the coast from Fairfield to North Branford and north to Hamden. The Connecticut Municipal Electric Energy Cooperative (CMEEC) collectively serves the majority of the municipal utilities in Connecticut, namely, the City of Norwalk's Third Taxing District Electrical Department; Groton Utilities; Jewett City Department of Public Utilities; Norwich Public Utilities; and South Norwalk Electric & Water. Bozrah Power & Light Company (Bozrah) and the Mohegan Tribal Utility Authority (MTUA) are also full-requirement wholesale customers of CMEEC[3]. Wallingford Electric Division (WED) serves the Town of Wallingford, as a municipal utility. The largest transmission/distribution company by size and service area is The Connecticut Light and Power Company d/b/a Eversource Energy (Eversource).

Eversource serves all of the remaining municipalities in Connecticut. Collectively, at any given time, the sum of Eversource, UI, CMEEC[4], and WED loads is approximately equal to the Connecticut load. The Council is mandated by statute to review these utility forecasts for the Connecticut load.

In addition to producing its regional forecast, ISO-NE prepares individual forecasts for each of the New England states, including Connecticut. The Council acknowledges the importance of this forecast by reviewing it in parallel with the sum of the Eversource, UI, CMEEC, and WED forecasts, even though the statute does not specifically require the Council to do so.

By statute, the Connecticut utilities must provide ten-year forecasts of loads and resources to the Council by March 1 of each year. The ISO-NE forecasts also include projections for ten years based on their planning horizon. In a ten-year forecast, peak loads and electrical energy consumption are predicted for the calendar year that the forecast report is issued and for nine additional years into the future. Thus, a 2015 ten-year forecast does not predict peak loads and energy usage through 2025, but rather 2024. The 2015 utility and ISO-NE forecast reports will be subjects of the Council's report here, as they are the most up-to-date available at this time.

Peak Load Forecasting

Load forecasting focuses primarily on peak load, that is, the highest hourly load experienced during the year. Peak load is more important than typical or average load because the peak represents a clearly-defined worst-case stress on the electric system. Connecticut experiences its peak load during a hot, humid summer day. This is because air conditioning generally creates one of the largest components of demand for power.

While winter months in Connecticut do have periods of significant loads, winter peaks are generally lower than summer peaks because much of the energy for heating is supplied directly by fossil fuels consumed on the customer's premises, not by electricity[5]. While natural gas, propane, or oil heating systems do typically require electricity for blowers/fans, control systems, pumps, etc., this electrical load is generally smaller than the load from air conditioning, which runs entirely on electricity[6]. Conversely, areas such as the Canadian province of Québec, where electric heating is common in winter and there is less demand for air conditioning in summer, can experience peak loads in winter.

While a detailed discussion of peak loads would have to include additional factors such as customer usage, demographics, conservation efforts, economic conditions, and others, the most important factor is weather—specifically the temperature and humidity. Higher temperatures result in more frequent use of air conditioning, and the units work harder, consuming more electricity. Also, higher humidity can exacerbate the situation, as it can make the temperature feel hotter than it actually is (raising what is sometimes called the "heat index") and further encourage air conditioning use.

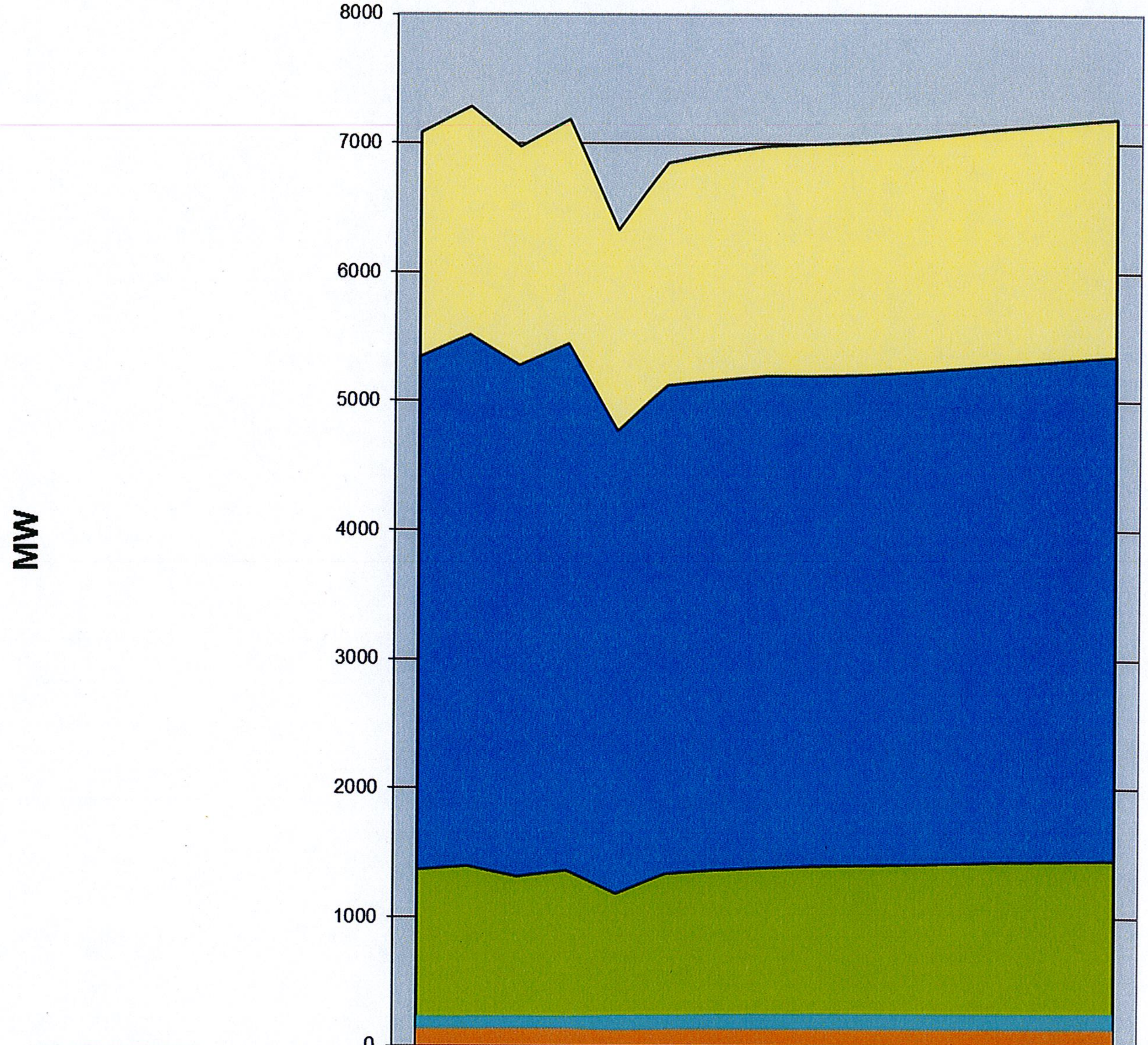
The duration of a "heat wave" is another factor. While some customers may tolerate an unusually warm day or two with little or no air conditioning use, extended periods of hot weather can lead to those customers (who initially may be reluctant to run air conditioning) to turn on their air conditioning units. Thus, daily peak loads can sometimes rise during a heat wave even if the daily high temperatures remain more or less uniform.

In order to account for weather effects as accurately as possible (for financial planning purposes, not infrastructure planning), the Connecticut transmission/distribution companies provide a forecast based on "normal weather", or assumed temperatures consistent with approximately the past 30 years of meteorological data. This is also referred to as the "50/50" forecast, which means that, in a given year, the probability of the projected peak load being exceeded is 50 percent, while the probability that the actual peak load would be less than predicted is also 50 percent. Another way of considering this 50/50 forecast would be to say that it has the probability of being exceeded, on average, once every two years.

Normal Weather (50/50) Peak Load Forecast

In its normal weather (50/50) forecast, Eversource predicted a peak load of 5,127 MW for its service area during 2015. This load is expected to grow during the forecast period at a compound annual growth rate (CAGR) of 0.48 percent, reaching 5,353 MW in 2024. UI predicted, in its normal weather (50/50) forecast, a peak load of 1,341 MW for its service area during 2015. This load is expected to grow during the forecast period at a CAGR of 0.83 percent, reaching 1,445 MW in 2024. CMEEC predicted, in its normal weather (50/50) forecast, a peak load of 251 MW for its service area during 2015. This load is expected to grow during the forecast period at a CAGR of 0.56 percent, reaching 264 MW in 2024. Finally, WED predicted a peak load of 133 MW for its service area during 2015. This load is expected to grow at a relatively flat CAGR of 0.08 percent, reaching 134 MW in 2024. All the State utilities' 50/50 summer peak loads are depicted in Figure 1a.

Figure 1a: Utility Adjusted Historical & 50/50 Peak Load Forecast in MW



Years	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
CT Utilities Historical & 50/50 Forecast Peak w/C&LM & DG	7085	7286	6975	7188	6329	6852	6925	6982	6999	7015	7046	7085	7128	7163	7196
Eversource Historical & 50/50 Forecast Peak	5345	5516	5280	5448	4772	5127	5165	5201	5202	5210	5234	5263	5293	5323	5353
UI Historical & 50/50 Forecast Peak	1369	1398	1317	1365	1186	1341	1370	1388	1402	1409	1416	1426	1438	1442	1445
CMEEC Historical & 50/50 Forecast Peak	236	238	241	238	248	251	257	259	261	262	262	262	263	264	264
WED Historical & 50/50 Forecast Peak	135	134	137	137	123	133	133	134	134	134	134	134	134	134	134

Megawatts

The sum of the utilities' forecasts resulted in a projected statewide peak load of 6,852 MW during 2015. This load is expected to grow at a CAGR of 0.55 percent and reach 7,196 MW by year 2024. The statewide CAGR is a weighted average of the individual utilities' CAGRs.

While Eversource has the largest service area in Connecticut, and its customers are the dominant source of load in the State, the statewide CAGR of 0.55 percent is larger than Eversource's (i.e. 0.48 percent) and coincidentally very close to that of CMEEC (i.e. 0.56 percent). This is due to the effect of UI's higher CAGR (i.e. 0.83 percent) and its service area having the second-largest peak loads of the Connecticut utilities, which in turn raises the statewide CAGR. While WED has the lowest CAGR of the Connecticut utilities, its effect on the statewide CAGR is very small because it has the lowest peak loads as compared with the other utilities. (See Figure 1a.)

However, the Council cautions that the sum of individual utilities' forecasts can only approximate the total Connecticut peak load. Because temperatures and customer usage patterns vary across the State, the individual utilities do not necessarily experience their peaks on the same hour and/or same day. Indeed, adding the four utilities' forecasts may slightly overstate the peak load in the State (i.e. be a conservative analysis), but the error is generally considered small.

In its 50/50 forecast for Connecticut, ISO-NE predicted a peak load of 7,450 MW during 2015. This peak load is expected to grow at a CAGR of 1.05 percent and reach 8,185 MW by year 2024. Note that the ISO-NE 50/50 forecast exceeds the sum of the utilities' forecasts each year by an average of 820 MW or about 10.4 percent. This is due to a difference in the way conservation and load management (C&LM) and distributed generation (DG) are treated, but has no material difference in facility planning. (These topics will be discussed in later sections.) Generally, ISO-NE considers C&LM and DG to be capacity resources (i.e. sources similar to generation) while the Connecticut utilities consider them to be reductions in load. Thus, the forecasts differ by approximately the sum of the C&LM and DG effects. Because of this difference, the ISO-NE forecast numbers appear higher and the utilities numbers appear lower. See ISO-NE and the State utilities' forecasts in Figure 1b.

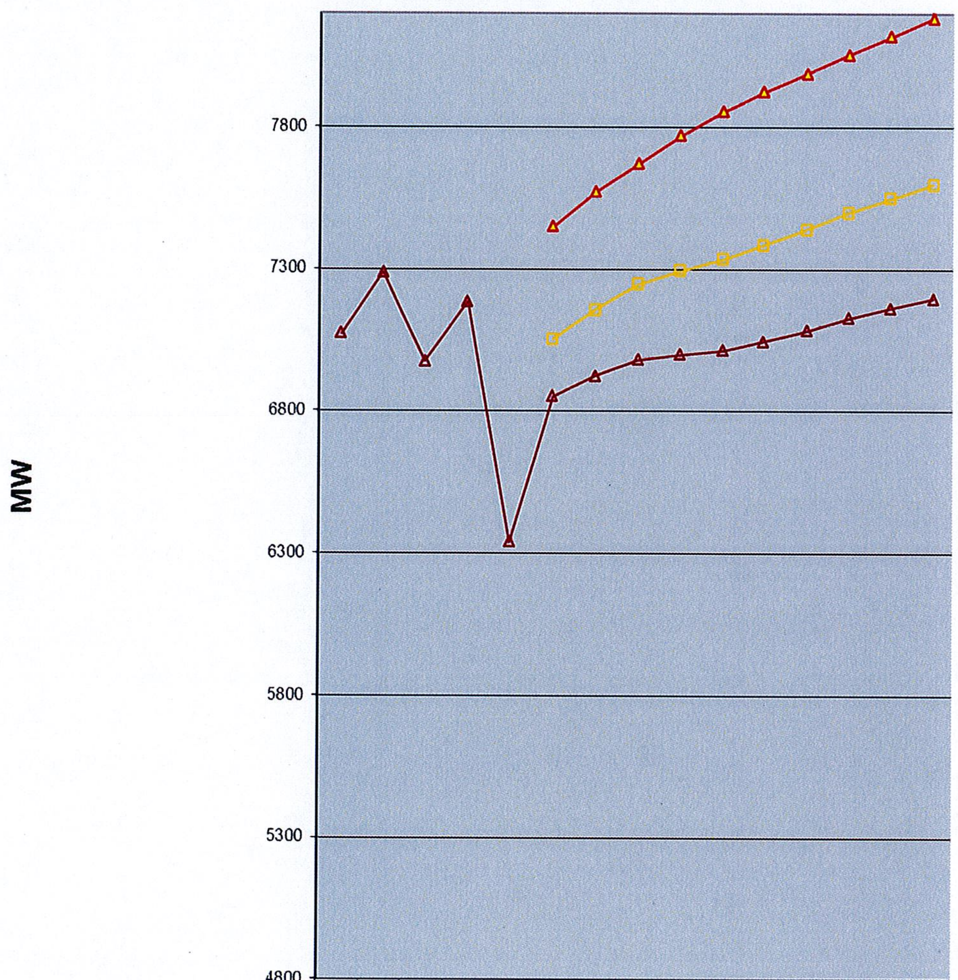
There are two methods to roughly adjust for this difference and provide more of an "apples to apples" comparison. In the first method, the total amount of C&LM and DG is added back to the utilities forecast, which already has been reduced for them. This cancels out the C&LM and DG effects, removing them from the utilities forecast, and making it comparable to the forecast of ISO-NE. The second method, following a similar logic, subtracts the effects of C&LM and DG from the ISO-NE forecast, which includes them, and thus makes it roughly comparable to the forecasts of UI and CL&P. The Council will use the first method of adjustment in this report.

The adjusted Connecticut utilities forecast has a projected load for 2015 of 7,054 MW. This is expected to grow at a CAGR of 0.83 percent, reaching 7,599 MW by 2024. This adjusted utilities 50/50 forecast CAGR of 0.83 is closer to ISO-NE's CAGR of 1.05 percent than the unadjusted statewide peak load forecast CAGR of 0.55 percent. This also suggests that

C&LM and DG effects, while not eliminating peak load growth, have the effect of slowing down load growth and reducing the statewide peak load CAGR for the forecast period.

Finally, the adjusted utilities 50/50 forecast and the ISO-NE forecast only vary by an annual average of 503 MW or 6.38 percent per year, which is reasonable agreement. See Figure 1b for the comparison of the Connecticut utilities and ISO-NE 50/50 forecasts.

Figure 1b: 50/50 Forecasts in MW



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
ISO-NE 50/50 CT Forecast Peak						7450	7570	7670	7770	7855	7925	7990	8055	8120	8185
CT Utilities Historical & 50/50 Forecast Peak w/o C&LM & DG						7054	7157	7247	7295	7335	7384	7440	7499	7549	7599
CT Utilities Historical & 50/50 Forecast Peak w/C&LM & DG	7073	7289	6975	7185	6341	6852	6925	6982	6999	7015	7046	7085	7128	7163	7196

Megawatts

Hot Weather (90/10) Peak Forecast

The more significant forecast to be discussed in this review is the 90/10 forecast produced by ISO-NE. It is separate from the normal weather (50/50) forecasts offered by ISO-NE and the Connecticut utilities. However, it is the one used by both ISO-NE and by the Connecticut utilities for utility infrastructure planning, including both transmission and generation.

A 90/10 forecast is a plausible worst-case hot weather scenario. It means there is only a 10 percent chance that the projected peak load would be exceeded in a given year, while the odds are 90 percent that it would not be exceeded in a given year. Put another way, the forecast would be exceeded, on average, only once every ten years. While this projection is quite conservative, it is reasonable for facility planning because of the potentially severe disruptive consequences of inadequate facilities: brownouts, blackouts, damage to equipment, and other failures.

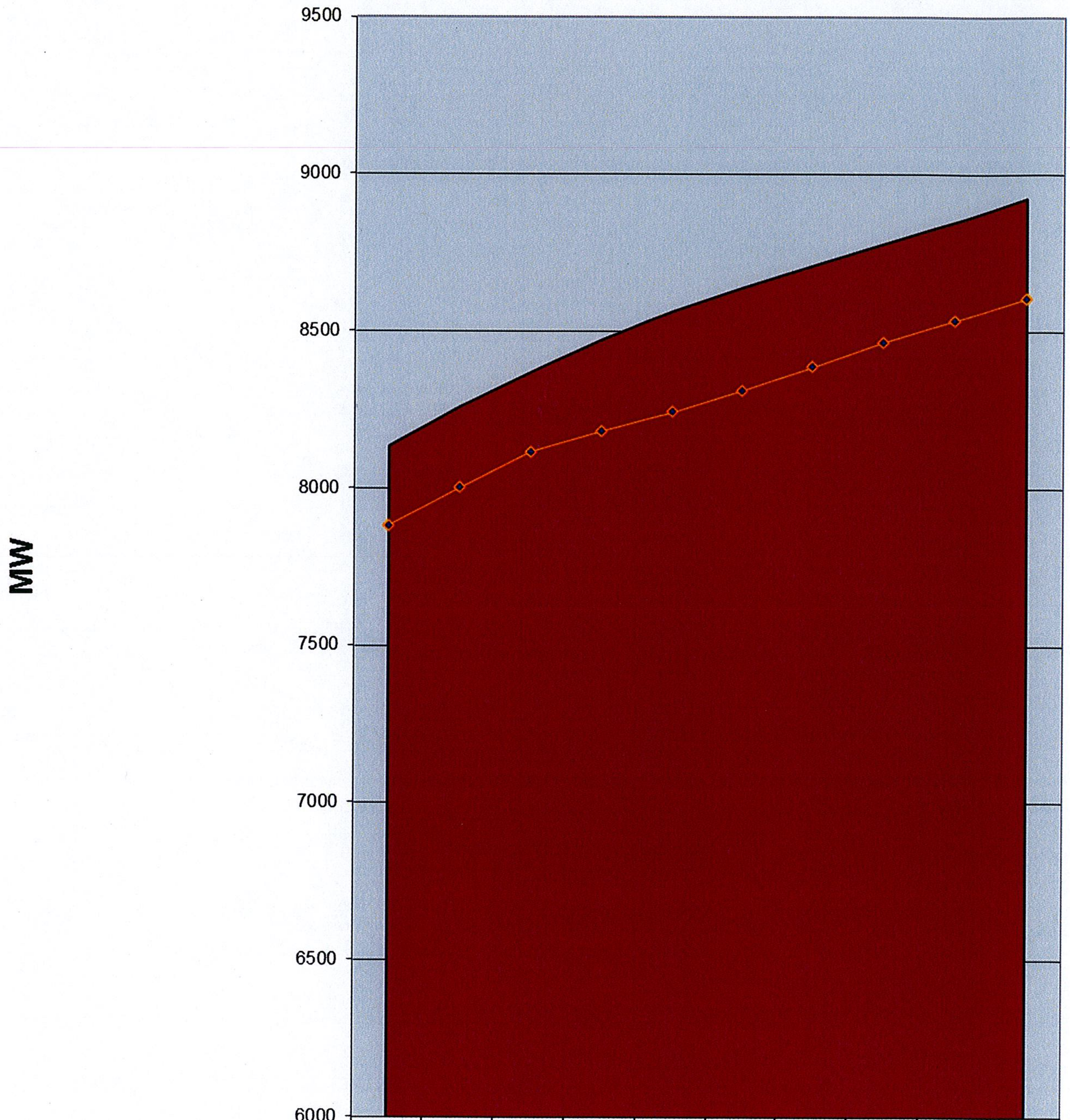
Utility planners must be conservative in estimating risk because they cannot afford the alternative. Just as bank planners should ensure the health of the financial system by maintaining sufficient collateral to meet worst-case liquidity risks, so load forecasters must ensure the reliability of the electric system by maintaining adequate facilities to meet peak loads in worst-case weather conditions. While over-forecasting can have economic penalties due to excessive and/or unnecessary expenditures on infrastructure, the consequences of under-forecasting can be much more serious. Accordingly, the Council will base its analysis in this review on the ISO-NE 90/10 forecast.

Specifically, the ISO-NE 90/10 forecast has a projected (worst-case) peak load for Connecticut of 8,135 MW in 2015. This extreme weather load is expected to grow at a CAGR of 1.04 percent and reach 8,925 MW by 2024.

The Connecticut utilities also have extreme weather forecasts, which are approximately the same as 90/10 forecasts. For the extreme weather forecasts, it is also necessary to adjust for C&LM and DG to properly compare the utility projections to ISO-NE's projections. Specifically, the sum of the utilities' extreme weather forecasts[7] adjusted by removing the effects of C&LM and DG is 7,882 MW for 2015. This would grow at a CAGR of 0.98 percent to reach 8,606 MW in 2024.

These adjusted utility extreme weather forecasts only differ from the ISO-NE 90/10 forecast by an annual average of 297 MW, or about 3.46 percent, which is very good agreement. Both CAGRs are approximately equal at about one percent, which is good agreement. See Figure 1c for the extreme weather forecasts.

Figure 1c: Extreme Weather and 90/10 Forecasts in MW



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
ISO-NE 90/10 CT Forecast Peak	8135	8260	8370	8475	8565	8640	8710	8780	8850	8925
CT Utilities Extreme w/o C&LM & DG	7882	8003	8116	8183	8243	8313	8388	8466	8536	8606

Megawatts

Past Accuracy of Peak Load Forecasts

Ten years ago, the Council received the 2005 ten-year forecast reports from the Connecticut electric utilities. These reports projected annual peak loads for 2005 through 2014. The Council has compared the 2005 forecast projections from Eversource, UI, and CMEEC[8] to the weather-normalized historical peak loads provided by the utilities[9] for 2003 through 2012 in order to determine the percent errors for each utility service area and the State for each of those years. See Table 1 for this comparison.

Note that, since the comparison involves ten years' worth of data with a different percent error per year, the percent errors were averaged over ten years to determine the average accuracy of these forecasts. The average percent error was based on the magnitudes or absolute values of the errors. Otherwise, when a sum is taken to compute the average, a positive error one year (or forecast that was too high) would cancel out a negative error another year (or forecast that was too low) and distort the results by making the average error much lower (i.e. closer to zero). For example, if a ten-year forecast is 5 percent too high for the first half of the forecast period and 5 percent too low for the second half of the forecast period, then these errors would cancel out when an average is taken, and the average error over 10 years would be zero. That would be misleading. However, if the magnitudes of the errors were used, the average error would be plus or minus 5 percent. Accordingly, in this report, the Council has taken the average of the error magnitudes.

Also, to prevent distorted results in the comparison, it is very important to use weather-normalized past (historical) data, not actual historical data. (This only works for 50/50 forecasts because the 50/50 forecast is based on "normal" weather.) The reason this is done is to remove the effects of weather. Otherwise, an accurate forecast could appear to be more "wrong" simply because of an unusual (and unforeseen) weather pattern in a given year. On the other hand, a less accurate forecast could appear to be more "right" by fortunate coincidence if a warmer or cooler than normal weather pattern happened to compensate for a forecast that was too high or low, respectively.

Table 1

Years	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Avg. % Error
CT Utilities Weather Normalized Historical Loads	7042	6860	6957	7001	6595	6622	7018	6751	6879	6575	
CT Utilities 2005 Forecast Loads	6757	6842	6950	7026	7113	7217	7323	7451	7575	7559	
Eversource Weather Normalized Historical Loads	5277	5084	5209	5184	4935	4994	5279	5039	5202	5002	
Eversource 2005 50/50 Forecast	5116	5181	5274	5338	5412	5494	5590	5709	5822	5933	
UI Weather Normalized Historical Loads	1405	1430	1365	1440	1272	1244	1324	1315	1277	1310	
UI 2005 50/50 Forecast	1284	1297	1305	1313	1321	1329	1337	1345	1353	1362	
CMEEC Weather Normalized Historical Loads	360	346	383	377	388	384	415	397	400	263	
CMEEC 2005 50/50 Forecast	357	364	371	375	380	394	396	397	400	264	
% Error for State 50/50 Forecast	-4.05	-0.26	-0.10	0.36	7.85	8.99	4.35	10.37	10.12	14.97	6.14
% Error for Eversource 50/50 Forecast	-3.05	1.91	1.25	2.97	9.67	10.01	5.89	13.30	11.92	18.61	7.86
% Error for UI 50/50 Forecast	-8.61	-9.30	-4.40	-8.82	3.85	6.83	0.98	2.28	5.95	3.97	5.50
% Error for CMEEC 50/50 Forecast	-0.8	5.2	-3.1	-0.5	-2.1	2.6	-4.6	0.00	0.00	0.4	1.93

As noted in Table 1, Eversource's average percent error for the ten-year (2005 through 2015) forecast period is 7.86 percent. UI's average percent error is 5.50 percent. CMEEC's is 1.93 percent. This results in a weighted average state-wide forecast error of 6.14 percent. (As already noted, the state-wide average is weighted more towards Eversource because they serve the largest load.)

In the Council's Interim Forecast Report dated December 27, 2012, the Council reported that the statewide 2002 forecast had an average accuracy of plus or minus 5.16 percent. In the Council's Final (Docket No. F-2012/2013) Report dated December 12, 2013, the statewide 2003 forecast had an average accuracy of plus or minus 3.15 percent. The average accuracy will vary from (Council) report to report (and may go up or down) because even one additional year of forecast data can significantly affect the results.

Overall, an average forecast accuracy (for the 2005 forecast reports) to approximately plus or minus 6.14 percent is reasonable. The utilities continue to refine their forecasts, so future forecast accuracy is expected to improve in the long term.

ELECTRIC ENERGY CONSUMPTION

Forecasting Electric Energy Consumption

Energy consumption is the product of the average load and time. As an analogy, load (or rate of energy consumption) can be thought of as the gallons per minute running out of a water faucet to fill a sink, while energy consumption can be thought of as the total number of gallons of water that accumulate in the sink, or average gallons per minute multiplied by the number of minutes.

Energy consumption is also the total work done by the electricity over time. A smaller load operating for a longer period of time could consume as much energy as larger load operating for a smaller amount of time[10].

Energy consumption is represented in units of load multiplied by time or Watt-hours. On a household scale and for most electric sales, a unit of kilowatt-hours is used (kWh, or one thousand watt-hours). A household or business electric meter essentially records the sum of the energy in kilowatt-hours of all loads that have operated on the premises during the billing period[11].

On a larger statewide scale, the units used are megawatt-hours (MWh, or one million watt-hours), or gigawatt-hours (GWh, or one billion watt-hours). While load (demand) is measured as an instantaneous snapshot of time (usually recorded hourly by utilities) and can go up or down, annual energy consumption acts like a "running total" that starts at zero at the beginning of the calendar year and increases all during the year, reaching a final annual total at year-end. Also, unlike annual peak loads, every season in Connecticut affects the total annual energy consumption, including winter.

The transmission/distribution utilities maintain records of total energy consumption in their service area. This total is generally the sum of the customers' consumption, the utilities' internal consumption, and losses in the system. The sum of the utilities' energy consumption approximates the electric energy consumption in Connecticut.

Eversource predicts a total electrical energy consumption in its service area of 23,201 GWh for calendar year 2015. The calculated CAGR is -0.21 percent. This means annual energy consumption in Eversource's service territory is forecast to decrease over time and reach 22,757 GWh by 2024.

UI predicts a total electrical energy consumption in its service area of 5,598 GWh for 2015. UI's projections result in a CAGR of -0.20 percent. That is, UI's annual electric energy consumption is expected to decrease over the forecast period to reach 5,498 GWh by 2024.

CMEEC predicts a total electrical energy consumption in its service area of 1,355 GWh for 2015. This number is expected to grow at a relatively flat CAGR of 0.08 percent, reaching 1,365 GWh by 2024.

WED's forward-looking or projected electrical energy consumption is not available in this proceeding. However, the energy data for the past five years has been provided as required by statute. Over the last five years, WED's annual electrical energy consumption has been in the range of 614 to 624 GWh. Thus, an annual average of 618.6 or about 619 GWh has been assumed. Given the relatively flat or even declining CAGRs for the other utility service areas and WED's small size relative to the statewide total, the error is expected to be small relative to the statewide total energy consumption calculations.

Taken together, these data result in a projected statewide electrical energy consumption of approximately 30,733 GWh for 2015. This number is expected to decrease due to a (weighted) CAGR of -0.19 percent and reach approximately 30,239 GWh by 2024.

Just as ISO-NE forecasts electric load for Connecticut, it also forecasts the State's energy consumption. Specifically, ISO-NE predicts electric energy consumption in Connecticut to be 34,430 GWh in 2015. This number is expected to grow at a CAGR of 0.98 percent and reach 37,580 GWh by 2024. Figure 2 depicts the energy consumption requirement forecasts.

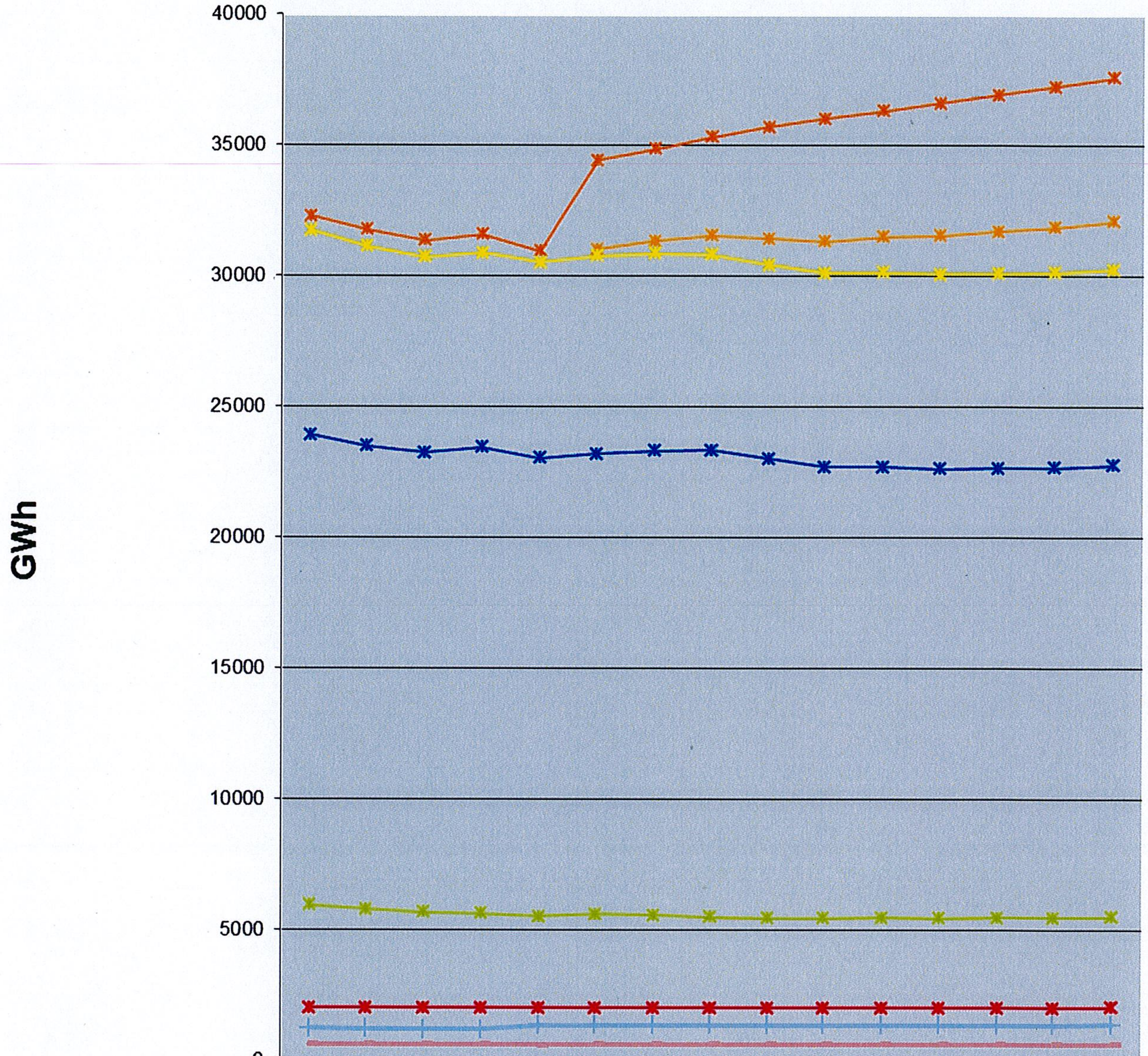
Figure 2 also includes two curves showing Connecticut both with and without C&LM and DG. Similar to the 50/50 peak load forecasts, the curve for Connecticut adjusted by removing C&LM and DG is closer to the ISO-NE curve because of different approaches to C&LM and DG in the modeling done by ISO-NE and the Connecticut utilities.

Accordingly, for 2015, the adjusted Connecticut utilities annual energy consumption forecast total is 31,014 GWh. This is expected to grow at a CAGR of 0.38 percent to reach approximately 32,094 GWh by 2024.

On the surface, the statewide energy consumption CAGR of -0.19 percent (taking into account C&LM and DG effects) might seem inconsistent compared with the +0.55 percent CAGR of peak electric load in the State (also taking into account C&LM and DG).

Furthermore, when the effects of C&LM and DG are removed, the Connecticut utilities annual energy consumption CAGR becomes positive. The only explanation is that C&LM and DG are predicted to eliminate (and even reduce) the average increases in electric energy consumption. While not eliminating the peak load growth, C&LM and DG help to mitigate peak load increases, as will be discussed in the Conservation and Load Management and Distributed Generation section.

Figure 2: State and Utility Energy Requirements in GWh



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Years	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
ISO-NE	32296	31755	31364	31589	30952	34430	34860	35300	35690	36005	36300	36600	36920	37250	37580
CT no C&LM and DG						31014	31332	31539	31417	31315	31489	31538	31694	31850	32094
CT w/C&LM and DG	31736	31117	30718	30876	30516	30773	30862	30802	30426	30113	30129	30053	30085	30118	30239
Eversource	23931	23494	23235	23447	23041	23201	23318	23342	23005	22701	22694	22630	22650	22671	22757
UI	5950	5783	5679	5617	5507	5598	5563	5487	5446	5436	5458	5448	5458	5468	5498
CMEEC	1235	1216	1186	1195	1354	1355	1362	1354	1356	1357	1358	1356	1358	1360	1365
WED	620	624	618	617	614	619	619	619	619	619	619	619	619	619	619

Electric Vehicles

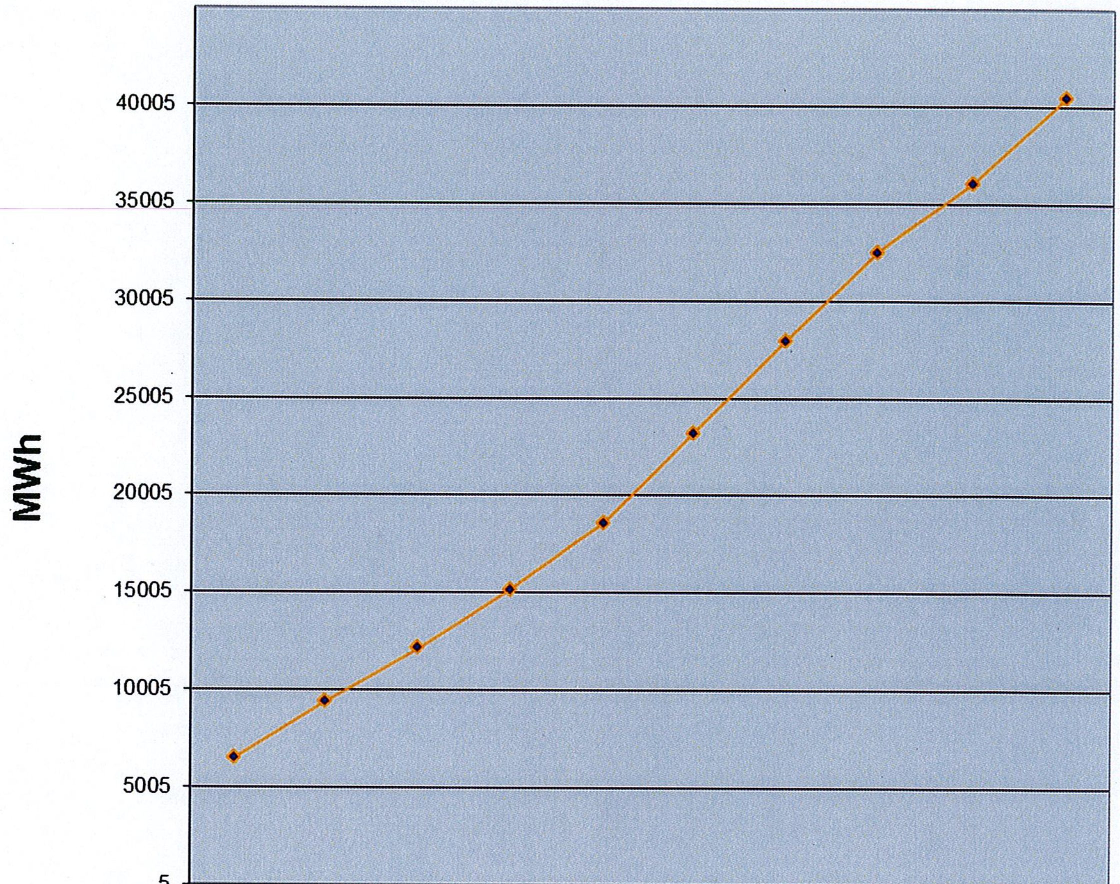
Electric vehicles (EVs) are propelled by an electric motor (or motors) powered by rechargeable battery packs. They have several advantages over internal combustion vehicles such as higher efficiency, lower noise, and zero tailpipe emissions[12]. The tradeoffs are the battery size and weight, cost, and concerns about limited range.

Some vehicles are known as hybrids. Hybrid vehicles have a gasoline engine and an electric motor. For some hybrid vehicles, the motor is only a supplement to the engine. Other hybrid vehicles can operate in electric-(motor)-only mode for a certain distance before the gasoline engine must start in order to charge the batteries. Furthermore, there are also "plug-in hybrids" that can be charged at home. Thus, someone with a plug-in hybrid and a relatively short commute could operate in electric mode during their commute and recharge their vehicle at home at night. They would have many of the benefits of an electric vehicle, but would still have the added range afforded by the gasoline engine if needed.

Of the State's transmission/distribution companies, currently only Eversource expects that EVs would materially affect its forecast. Most charging would be performed at night, so no impact on the peak loads would be expected. But electric vehicles are projected to impact Eversource's energy forecast. Accordingly, Eversource has provided projections for the number of electric vehicles in its service area during the forecast period and the estimated annual energy consumption associated with such vehicles.

Figure 3a shows the projected number of EVs in Eversource's service area during the forecast period. Eversource predicts approximately 2,128 incremental EVs in its service area for 2015. This is expected to grow at a sizeable CAGR of 24.1 percent, reaching 14,842 EVs by 2024. The estimated total annual energy consumption for incremental EVs for 2015 is 6,518 MWh. This is expected to grow at a CAGR of 22.5 percent, reaching 40,509 MWh by 2024. The somewhat lower CAGR for the energy growth versus the number of vehicles is associated with a declining MWh per vehicle. Eversource estimates approximately 3.1 MWh per vehicle for 2015, and this number gradually declines to about 2.7 MWh per vehicle by 2024, likely due to increased efficiency associated with anticipated improvements in technology.

Figure 3a: Eversource's Projected Annual EV Energy



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Eversource's Annual EV Energy	6518	9445	12177	15159	18590	23215	27955	32515	36094	40509

CONSERVATION AND LOAD MANAGEMENT AND DISTRIBUTED GENERATION

Conservation and Load Management (C&LM) and Distributed Generation (DG) are all types of energy efficiency: that is, they are all methods of reducing load on the electric system without compromising essential service to the end user. Conservation means reducing wasted energy; Load Management means turning off non-essential loads during peak periods; and DG means generation that is connected not to transmission, which is regional, but to distribution, which is local.

Of the C&LM and DG components, conservation has the greatest effect on net energy consumption because it is in effect during more hours of the year. Load management tends to have a minimal effect on energy consumption because the savings come during a very limited number of hours. DG has relatively small power outputs currently, so even with greater run time, the effect on net energy consumption is also quite small.

Collectively, these methods can be considered either as a reduction in demand or an increase in supply. As mentioned earlier, the Connecticut utilities consider C&LM and DG a reduction in load, while ISO-NE considers it a supply resource. Either way, the net result is the same: less stress on the electric system, reduced need to construct additional generation and transmission, and greater flexibility to serve loads. C&LM can also have economic benefits, since the marginal cost per kW of energy efficiency can be less than that of new generation, depending on the method employed. DG can have reliability benefits because some DG can be used for backup power.

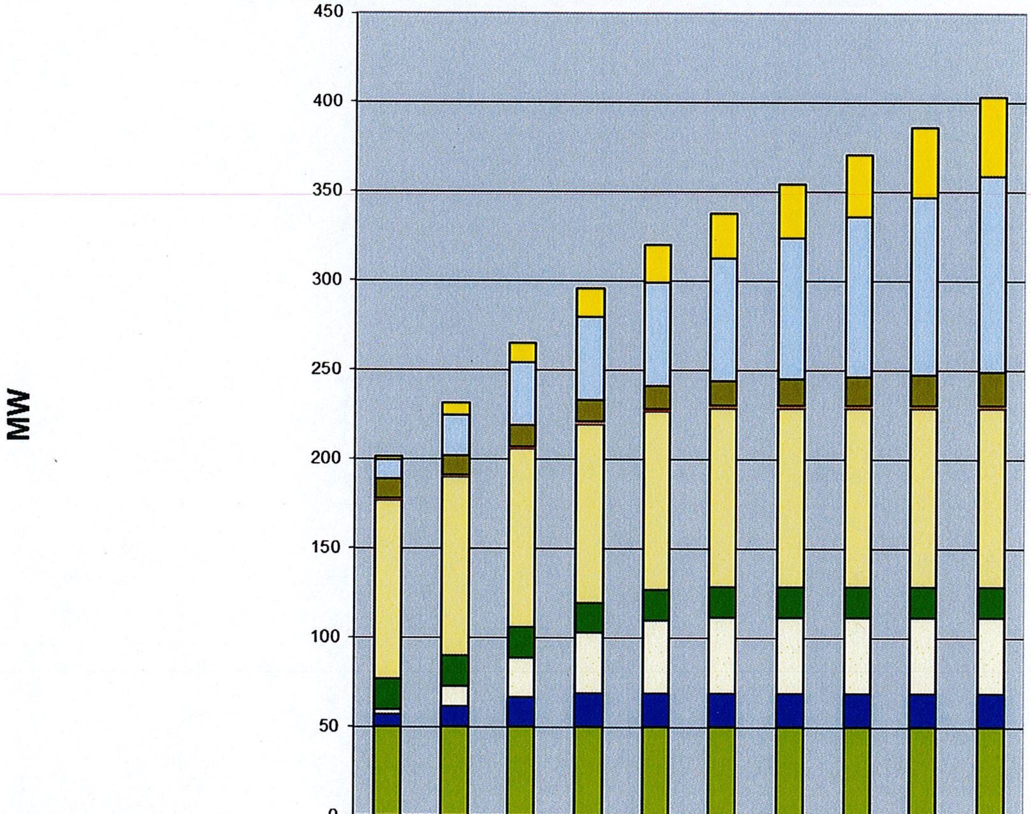
The Connecticut Energy Efficiency Board (EEB), formerly known as the Energy Conservation Management Board, is an appointed group of 15 members representing private and public entities; they serve voluntarily and meet year-round. The original purpose of the EEB was to advise and assist the state's two electric distribution companies, CL&P and UI, in both the development and implementation of Energy Efficiency Fund programs. However, the EEB's oversight was expanded to include the energy efficiency programs of CMEEC (and more recently WED) as well as the State's natural gas utilities: Connecticut Natural Gas, The Southern Connecticut Gas Company, and Eversource Energy (f/k/a Yankee Gas Services Company).[13]

The EEB submits an annual report to the legislature regarding energy efficiency programs in Connecticut. In the EEB report dated March 1, 2015, the EEB notes that the 2014 Connecticut Energy Efficiency Fund programs (for Eversource, UI, CMEEC, and WED) resulted in annual energy savings of 387.8 GWh and lifetime savings of 4,200 GWh. This translates into roughly 1.25 percent of ISO-NE's reported 2014 energy consumption for Connecticut of 30,952 GWh.

Looking at C&LM from a peak load (rather than energy perspective), UI projected a load reduction (excluding DG) of 10.5 MW in 2015. This reduction is expected to increase to 110 MW by 2024. Also, taking Eversource's load management and conservation together, Eversource projected a load reduction (excluding DG) of 102 MW in 2015 due to C&LM (excluding DG and renewable energy credits). This reduction is expected to grow to 144 MW by 2024. Finally, CMEEC reported a projected load reduction (excluding DG) of 28 MW for 2015. This reduction is expected to grow to 36 MW by 2024. From the EEB Report, WED's annual (non-DG) load reduction is on the order of 1.4 MW.

Collectively, these reductions result in a statewide peak load reduction due to C&LM (and excluding DG and renewable energy credits) of 141.9 MW in 2015. The cumulative load reduction is projected to increase annually with a substantial CAGR of 8.32 percent and reach 291.4 MW by 2024, the end of the forecast period. To put this into perspective, the magnitude of the 2024 load reduction is more than the output of the existing 250 MW Wallingford Units #1-#5 facility. See Figure 4.

Figure 4: Load Reductions Due to Conservation, Load Management/Response, and Distributed Generation



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Eversource Conservation	2	7	11	16	21	25	30	35	39	44
UI Conservation	10.5	22.5	34.9	46.7	57.8	68.6	79.3	89.7	99.9	109.9
CMEEC Conservation	11	11	12	12	13	14	15	16	17	19
WED Conservation	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Eversource Load Management	100	100	100	100	100	100	100	100	100	100
UI Load Management	0	0	0	0	0	0	0	0	0	0
CMEEC Load Management	17	17	17	17	17	17	17	17	17	17
WED Load Management	0	0	0	0	0	0	0	0	0	0
Eversource DG and Renewable Energy Credits	3	11	22	34	41	43	43	43	43	43
UI DG	6.8	11.9	16.9	18.9	18.9	18.9	18.9	18.9	18.9	18.9
CMEEC DG	50	50	50	50	50	50	50	50	50	50
WED DG	0	0	0	0	0	0	0	0	0	0

The data in this forecast show that energy efficiency and related programs are an extremely important part of Connecticut's electric energy strategy. Increased efficiency allows the State's electric needs to be met, in part, without incurring the financial costs and the incremental pollution that would be caused by dispatching generation to serve the additional load. Reductions in peak load due to increased efficiency can also impact the schedule of necessary changes to existing utility infrastructure, such as transmission lines and substation equipment (transformers, distribution feeders, etc.) and hence tend to hold down utility costs. Electric energy efficiency also reduces federal congestion charges and the costs of new generation. Currently, Connecticut ranks sixth for energy efficiency in the national rankings put out by the American Council for an Energy-Efficient Economy for 2015. (See annual scorecard at http://aceee.org/research-report/u1509)

Regarding total per capita energy usage, in 2013, according to the United States Department of Energy – Energy Information Administration, Connecticut had one of the lowest amounts of total energy consumed per capita in the U.S. Specifically, Connecticut ranked 46th out of 51 (i.e. 50 states plus District of Columbia) in per capita energy consumption, at 208 million British Thermal Units (BTUs) per person.[14] Wyoming had the highest energy consumption, at 918 million BTUs. The lowest was New York, at 184 million BTUs.

LREC/ZREC Program

As part of Public Act 11-80, the State of Connecticut directed CL&P and UI to launch a program to promote, fund, and expand renewable DG installed behind the utility customer's meter. This program, sometimes referred to as the Low Emissions Renewable Energy Credit/Zero Emissions Renewable Energy Credit (LREC/ZREC) Program, creates a market-driven bidding process for projects to compete to obtain a 15-year revenue stream from the sale of renewable energy credits (RECs) to the electric utilities[15]. The utilities would solicit these projects for up to a six-year period via requests for proposals (RFP).

LREC projects are low emissions projects 2,000 kW (2 MW) or less in size. One example of a low emissions project would be a fuel cell that operates on natural gas. See the Fuel Cell section of this report.

ZREC projects are zero emissions projects. Examples would be solar and wind power. ZREC projects are broken down into two sizes. Medium-sized ZREC projects range in size from 100 kW to 250 kW. Large ZREC programs range in size from 250 kW to 1,000 kW (1 MW).

CL&P and UI jointly issued their first request for proposals (RFP) in May 2012.
A total of 150 bids for medium-sized ZRECs were received in 2012. 60 projects were selected. A total of 162 bids for large-sized ZRECs were received in 2012. 27 projects were selected. The LREC/ZREC Program has led to a significant amount of fuel cell proposals being reviewed and approved by the Council. See later section on Fuel Cells.

CL&P's forecast includes LREC and ZREC projects in both its energy and peak load forecasts. Since LREC/ZREC projects are a form of DG, the Council has included them along with other DG in Figure 4 on page 22. UI's approach is slightly more conservative. UI included the winning LREC/ZREC bidders for the energy forecast; but for the load forecast, UI only included LREC/ZREC DG projects that have filed interconnection applications with UI, and thus are the most likely to go forward.

Distributed Generation Forecast

Eversource forecasts a total of 3 MW of DG for 2015, including renewable energy credits. This is expected to grow at a CAGR of 34.4 percent and reach 43 MW by 2024. UI forecasts 6.8 MW of DG for 2015, which would grow at a CAGR of 12.0 percent, reaching 18.9 MW by 2024. CMEEC forecasts a flat 50 MW of DG for the entire forecast period. This includes 10 MW of approved backup generation for Backus Hospital in the City of

Norwich. See section titled "New Generation." Taking into account these DG forecasts, the statewide total would be 59.8 MW for 2015, which is expected to grow at a CAGR of 7.21 percent and reach 111.9 MW by 2024.

ELECTRIC SUPPLY

While peak loads occur during the summer, the electric system is further challenged by the fact that generation capability is at its lowest during the summer[16]. This is largely due to lower thermodynamic efficiencies of many plants when the outside temperatures are higher. Accordingly, generators report two different power outputs to ISO-NE. They are referred to as Summer and Winter Seasonal Claimed Capabilities, respectively. (See Appendix A.) For instance, Connecticut's September 2015 ISO-NE dispatched generation output (neglecting Lake Road Power Plant) is 7,575 MW in the summer and 7,997 MW during the winter [17].

Even taking into account the most conservative forecast (the ISO-NE 90/10 forecast), the worst-case generating output (the summer output) and neglecting load reducing effects of small DG, the Council anticipates that electric generation supply during the forecast period will be adequate to meet demand. Any deficits prior to the significant Interstate Reliability Project import upgrade and inclusion of Lake Road in Connecticut (to be discussed later) could be made up fairly easily by activating the full range of available generation, maximizing the use of active demand response resources, and devising other such operational strategies.

New and Pending Generation

The largest operational addition to Connecticut's generation resources in recent years is the Kleen Energy facility in Middletown. Kleen is a 620 MW natural gas-fired (with oil pipeline backup) combined-cycle generating facility. The plant was approved by the Council in Docket No. 225. Kleen was later selected by the former Department of Public Utility Control (DPUC) as a project that would significantly reduce federally mandated congestion charges (FMCCs). It went into service on July 12, 2011. Accordingly, the Kleen Energy plant is reflected in the load/resource balance table (Table 4). Other recent additions to Connecticut's electric generation fleet include Waterbury Generation, a 96 MW natural gas-fueled combustion turbine facility. Along with Kleen Energy and Waterside Power (a 69 MW oil-fueled facility in Stamford), the Waterbury Generation project was one of the generating projects selected to reduce FMCCs. This project went into commercial operation in May 2009. This facility is noted in Appendix A.

The Lake Road natural gas-fueled generating facility in Killingly was approved by the Council on December 7, 1998 in Docket No. 189. The plant went into commercial operation in the Spring of 2002. However, while the plant is physically located in Connecticut, electrically, it has been considered a Rhode Island resource and thus not allowed to be counted as a Connecticut resource. However, the Interstate Reliability Transmission Project, according to the 2014 Connecticut Integrated Resource Plan (to be discussed later), would allow Lake Road to be considered a Connecticut resource by 2017. Thus, while the plant has been in-service for over 13 years, effectively, it will soon be a "new" generation resource for Connecticut. The current summer output of the plant is approximately 751 MW. This facility is noted in Appendix A and Table 4.

On June 23, 1999, in Docket No. 192, the Council approved a 512 MW combined cycle electric generating facility in Town of Oxford, Connecticut. Despite several extensions of the Certificate of Environmental Compatibility and Public Need (Certificate), this project was not constructed. However, on November 3, 2014, CPV Towantic, LLC (CPV) submitted to the Council a Petition to Reopen and Modify the June 23, 1999 Certificate based on changed conditions pursuant to C.G.S. §4-181a(b). The updated proposal included plans for a larger 785 MW (nameplate capacity at 59 degrees F or about 740 MW summer capacity) combined cycle electric generating facility. CPV qualified for, bid into, and cleared ISO-NE's Ninth Forward Capacity Auction (FCA #9) which began and ended on February 2, 2015. This auction is for the June 1, 2018 through May 31, 2019 commitment period and counts CPV's plant at 725 MW, which is close to the summer rating of the plant. On May 14, 2015, the Council approved this modified configuration for a 785 MW (nameplate) combined-cycle natural gas-fueled electric generating facility in Oxford. The project is anticipated to be in service for 2018 and is noted in Table 4.

Public Act 07-242

Public Act 07-242, An Act Concerning Electricity and Energy Efficiency, included an expedited Council review and approval process to facilitate the siting of certain new power plants. (This section was updated by Public Act 11-80.) The Council is mandated to approve by declaratory ruling:

- the construction of a facility solely for the purpose of generating electricity, other than an electric generating facility that uses nuclear materials or coal as a fuel, at a site where an electric generating facility operated prior to July 1, 2004;
- the construction or location of any fuel cell—unless the Council finds a substantial adverse environmental effect—or of any customer-side distributed resources project or facility or grid-side distributed resources project or facility with a capacity of not more than 65 megawatts, so long as such the project meets the air and water quality standards of the Department of Energy and Environmental Protection;
- the siting of temporary generation solicited by the Public Utilities Regulatory Authority pursuant to section 16-19ss.

Many projects, instead of being submitted to the Council as applications for Certificates of Environmental Compatibility and Public Need, were submitted as petitions for declaratory rulings under this provision. Several distributed resources projects were submitted to the Council over the past few years. Some of these projects are approved and operational. Some are just recently approved, and others are pending review.

On January 24, 2008 (and June 4, 2009, as amended), the Council approved four 50 MW peaking units in Milford. Specifically, in June/July of 2010, Devon Units #15 through 18 in Milford went into commercial operation. These units are natural gas combustion turbines. Per ISO-NE, each unit has a summer rating of approximately 46.9 MW. Combined, they provide nearly 188 MW of available generation for Connecticut and are reflected in Appendix A.

On December 12, 2008, the Council approved four 50 MW peaking units in Middletown. Specifically, in June 2011, Middletown units #12 through #15 went into commercial operation. These units are also natural gas turbines with a summer rating of 46.9 MW each. Combined, they also provide nearly 188 MW of generation for Connecticut and are reflected in Appendix A.

On December 16, 2010, the Council approved three 48.5 MW peaking units in New Haven. Specifically, in May 2012, the New Haven Harbor Units #2 through #4 in New Haven went into commercial operation. These units are also natural gas turbines. Each unit has a summer rating of 43.2 MW. Combined, they provide nearly 130 MW of available generation for Connecticut and are reflected in Appendix A.

On August 31, 2015, the Council received a petition from Wallingford Energy II, LLC for two additional 50 MW (or 100 MW total) combustion turbine units to be installed at the site of five existing 50 MW units in Wallingford. This project cleared FCA #9 for 90 MW (summer). This project is currently pending Council review with a deadline for decision of February 26, 2016. If approved, approximately 100 MW of ISO-NE-dispatched resources would be a significant addition for Connecticut.

In addition to conventional (e.g. natural gas-fueled combustion turbine) generation, many renewable electric energy generating facilities also fit within the framework of the expedited review and approval process via a petition for declaratory ruling because the sizes of such projects are typically under 65 MW. Accordingly, wind and solar (i.e. photovoltaic) projects that have received Council approval and/or are currently under Council review are noted below. Since the renewable electric generating facilities noted are typically connected to distribution and not subject to ISO-NE dispatch, they have not been included in Table 4. This is a conservative approach because DG generally has the effect of "cancelling out" or causing a net reduction in loads on the local distribution system, thus reducing demand.

Wind Renewable Projects

On November 17, 2010, BNE Energy Inc. (BNE), submitted a petition to the Council for a declaratory ruling that no Certificate is required for the construction, maintenance, and operation of a 3.2 MW Wind Renewable Generating facility at 178 New Haven Road in Prospect, Connecticut. The proposed project is referred to as "Wind Prospect." The Wind Prospect project (Petition No. 980) was denied by the Council on May 12, 2011.

On December 6, 2010, BNE submitted a petition to the Council for a declaratory ruling that no Certificate is required for the construction, maintenance, and operation of a 4.8 MW Wind Renewable Generating facility at Flagg Hill Road in Colebrook, Connecticut. The proposed project is referred to as "Wind Colebrook South." The Wind Colebrook South project (Petition No. 983) was approved by the Council on June 2, 2011. On December 12, 2013, the Council approved a modified configuration to include up to three 2.85 MW turbines for a total of 8.55 MW. This modified configuration included General Electric's Low Noise Trailing Edge serrations that are designed to reduce noise levels. BNE installed two 2.85 MW wind turbines at the site (or a total of 5.7 MW), and the Wind Colebrook South facility went into commercial operation in late 2015.

On December 13, 2010, BNE submitted a petition to the Council for a declaratory ruling that no Certificate is required for the construction, operation, and maintenance of a 4.8 MW Wind Renewable Generating facility located on Winsted-Norfolk Road (Route 44) and Rock Hall Road in Colebrook, Connecticut. The project is referred to as "Wind Colebrook North." The Wind Colebrook North project (Petition No. 984) was approved by the Council on June 9, 2011. To date, construction has not begun for this facility.

Solar Renewable Projects

On October 31, 2012, Somers Solar Center, LLC (SSC) submitted a petition to the Council for a declaratory ruling that no Certificate is required for the construction, maintenance, and operation of a 5.0 MW alternating current (AC) solar photovoltaic generating facility at 458 and 488 South Road in Somers, Connecticut. This project (Petition No. 1042) was approved by the Council on March 21, 2013. The project is currently in service.

On December 17, 2012, GRE 314 East Lyme, LLC (GRE) submitted a petition to the Council for a declaratory ruling that no Certificate is required for the construction, maintenance, and operation of a 5.0 MW AC solar photovoltaic generating facility at Grassy Hill Road and Walnut Hill Road in East Lyme, Connecticut. This project (Petition No. 1056) was approved by the Council on May 16, 2013. The project is currently in service.

Other more recent solar projects that have been reviewed and/or approved by the Council are noted below.

Petition No.	Petitioner	Size AC (MW)	Municipality	Status
1104	UI	2.2 MW	Bridgeport	Approved on 11/13/14
1137	Windham Solar, LLC	6.1 MW	Lebanon	Approved on 3/5/15
1150	SolarCity Corp.	3.1 MW	Bozrah	Approved on 5/28/15
1159	Lodestar Energy LLC	2.0 MW	Suffield	Approved on 9/3/15
1178	Fusion Solar Center, LLC	20.0 MW	Sprague	Approved on 9/17/15
1181	SolarCity Corp.	4.93 MW	Norwich	Under Council Review
1192	SolarCity Corp.	2.74 MW	Norwich	Under Council Review
1195	SolarCity Corp.	3.25 MW	Groton	Under Council Review

Generation for Backup Power/Microgrids

Per Section 7 of PA 12-148, a "microgrid" means "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid and that connects and disconnects from such grid to enable it to operate in both grid-connected or island mode."

Pursuant to the same section, DEEP was charged with establishing a microgrid grant and loan program to support local distributed generation for critical facilities. DEEP issued an RFP and, as a result, nine projects in the following municipalities were selected for microgrids: Windham, Bridgeport, Fairfield, Woodbridge, Groton, Hartford, Middletown, and Mansfield (Storrs).

While Norwich Public Utilities (NPU) in Norwich was not selected for an award for a microgrid, NPU went forward with its own proposal. Specifically, on June 28, 2013, the Council received a petition from CMEEC for a declaratory ruling that no Certificate of Environmental Compatibility and Public Need is required for the proposed installation of four 2.49 MW generating units at 4 Matlack Road, Norwich. As part of the microgrid project, in the event of a long-term blackout, the generators would provide back-up power to Backus Hospital as a priority recipient and to other "critical facilities" defined under Section 7 of PA 12-148 as "a hospital, police station, fire station, water treatment plant, sewage treatment plant or commercial area of a municipality." The generators can be utilized to minimize peak demand on the regional power grid. It was approved by the Council on August 8, 2013. This project is currently in service.

Existing Generation

Nuclear Powered Generation

Nuclear plants use nuclear fission (a reaction in which uranium atoms split apart) to produce heat, which in turn generates steam, and the steam pressure operates the turbines that spin the generators. Since no step in the process involves combustion (burning), nuclear plants produce electricity with zero air emissions. Pollutants emitted by fossil-fueled plants are avoided, such as sulfur dioxide (SOx), nitrogen oxides (NOx), mercury, and carbon monoxide. (SOx and NOx contribute to acid rain and smog.) Nuclear plants also do not emit carbon dioxide (CO_2), which is a significant advantage in the effort to curb greenhouse gas emissions. However, issues remain with regard to security, the short and long-term storage of nuclear waste, and the cost of new plants.

Connecticut currently has two operational nuclear electric generating units (Millstone Unit 2 and Unit 3) contributing a total of 2,088 MW of summer capacity, approximately 27.6 percent of the State's peak generating capacity. The Millstone facility is the largest generating facility in Connecticut by power output.

The former Millstone Unit 1 reactor has been decommissioned in place. Dominion Nuclear Connecticut Inc. (Dominion), owner of the Millstone units, has no plans at this time to construct another nuclear power generating unit at the site.

While the number of active nuclear units in Connecticut remains unchanged at two, nuclear power output has gradually increased over time due to modifications that improve the output of the units. Ten years ago, the Council reported in its 2005 Forecast Report that Connecticut had approximately 2,037 MW of nuclear electric generating capacity from the two units. Today, we have 2,088 MW, or a total of 2.50 percent increase over the past ten years.

Dominion submitted license renewal applications to the United States Nuclear Regulatory Commission (NRC) on January 22, 2004. On November 28, 2005, the NRC announced that it had renewed the operating licenses of Unit 2 and Unit 3 for an additional 20 years. With this renewal, the operating license for Unit 2 is extended to July 31, 2035 and the operating license for Unit 3 is extended to November 25, 2045.

Coal Powered Generation

In conventional coal-fired plants, coal is pulverized into a dust and burned to heat steam for operating the turbines. In general, using coal as fuel has the advantages of an abundant domestic supply (US reserves are projected to last approximately 261 years[18]), and an existing rail infrastructure to transport the coal. Despite the advantages of domestic coal, generators sometimes find imported coal more economical to use.

However, burning coal to make electricity causes air pollution. Pollutants emitted include sulfur dioxide, carbon dioxide, and mercury. Coal-fired power plants also have high CO_2 emissions relative to plants using other fuels; thus, they are considered particularly significant contributors to global warming. In addition, fossil-fueled power plants, in general, are facing more stringent standards with regard to CO_2 emissions.

Ten years ago, the Council reported approximately 553 MW of coal-fired generating capacity in Connecticut. This was the sum of AES Thames in Montville at 181 MW and Bridgeport Harbor #3 at 372 MW. AES Thames retired from service in 2011, and Bridgeport Harbor #3 had a power increase of about 11 MW, yielding a total net loss of 170 MW, or a 30.7 percent reduction in coal-fired generation capacity in Connecticut during the past ten years.

Currently, Connecticut's only active coal-fired generation facility is the Bridgeport Harbor #3 facility located in Bridgeport. It has a summer power output of approximately 383 MW, or approximately 5.1 percent of the State's current capacity.

Given the tightening CO_2 emissions standards and higher carbon content than other fossil fuels, no new coal-fired generation is expected in Connecticut at this time. See the sections on the "Regional Greenhouse Gas Initiative" and "Carbon Dioxide Pollution Standard for Power Plants" for more on the legislative and regulatory requirements relative to CO_2 emissions.

Petroleum Powered Generation

Connecticut currently has 29 active oil-fired electric generating facilities contributing 2,109 MW, or 27.8 percent of the State's current peak generating capacity.

The Council notes that oil-fueled peak power output in Connecticut has declined. Ten years ago, the Council reported in its 2005 Forecast Report that Connecticut had approximately 2,477 MW of petroleum-fueled generation capacity. Today, we have 2,109 MW or a total of 14.9 percent decline over the past ten years. This is likely due to the increasing age of the fleet and the loss of Devon 7 (107 MW) and Devon 8 (107 MW). Also, according to ISO-NE's September 2015 Seasonal Claimed Capability Report, Norwalk Harbor #1, 2, and 3, (342 MW), Bridgeport Harbor #2 (130 MW), and John Street Nos. #1, 2, and 3 (6 MW) all have reported seasonal claimed capabilities of zero in the summer. This essentially amounts to losses of active oil-fired generation capacity in Connecticut. However, these reductions were partially offset by the installation of Cos Cob units #13 and #14 (about 38 MW total), CMEEC Norden (6 MW), CMEEC Norwich Wastewater Treatment Facility (2 MW), and the largest of the recent additions: Waterside Power (69 MW).

Additional oil-fired generation is not likely in the near future, due to market volatility and environmental concerns, particularly related to the sulfur content of the oil and also tighter air-emissions standards particularly related CO_2. Oil-fired power plants are significantly affected by CO_2 standards because oil is the second highest carbon fossil fuel (after coal). See the sections on the "Regional Greenhouse Gas Initiative" and "Carbon Dioxide Pollution Standard for Power Plants" for more on the legislative and regulatory requirements relative to CO_2 emissions.

Some of the oil-fired generating facilities in Connecticut are dual-fueled, meaning that they can switch to natural gas if necessary. Currently, four generating units in Connecticut (Middletown #2 and #3; Montville #5; and New Haven Harbor #1), totaling approximately 880 MW, have the ability to change from oil to natural gas. Other facilities, such as the Kleen Energy plant (620 MW), are dual-fueled with natural gas as the primary fuel and oil as the backup or secondary fuel. The Council believes that dual-fuel capability is an important part of diversifying the fuel mix for electric generation, with the benefit of avoiding overdependence on a particular fuel.

Natural Gas Powered Generation

Natural gas-fired electric generating facilities are preferred over those burning coal or oil primarily because of higher efficiency, lower initial cost per MW, and lower air pollution. Natural gas is also the lowest carbon fossil-fuel, which is a significant environmental advantage given tightening CO_2 standards. See the sections on the "Regional Greenhouse Gas Initiative" and "Carbon Dioxide Pollution Standard for Power Plants" for more information on the legislative and regulatory requirements relative to CO_2 emissions.

Some natural gas generating plants, such as Bridgeport Energy, Milford Power, Lake Road, Kleen Energy (and the newly approved Towantic facility) are combined-cycle. Added to the primary cycle, in which gas turbines turn the generators to make electricity, is a second cycle, in which waste heat from the first process is used to generate steam: steam pressure then drives another turbine that generates even more electricity. Thus, a combined-cycle plant is highly efficient, with an efficiency on the order of 60 percent. However, the tradeoffs are higher initial costs and increased space requirements for the extra generating unit.

Natural gas generating facilities also have the advantage of being linked directly to their domestic or North American fuel source via a pipeline. Furthermore, abundant domestic natural gas supplies and lower fuel costs also make natural gas attractive.

Connecticut currently has 25 natural gas-fired generating units (not including Lake Road) contributing a total of 2,716 MW, or 35.8 percent of the State's generating capacity. This includes additions such as Waterbury Generation, Kleen Energy, Middletown #12-15, and Devon #15-18 with summer ratings of 96 MW, 620 MW, 188 MW, and 188 MW, respectively.

Natural gas fueled-generation has been the fastest growing type of electrical generation in Connecticut. Ten years ago, the Council reported in its 2005 Forecast Report that Connecticut had approximately 1,368 MW of natural gas-fueled electric generating capacity (also not including Lake Road). Today, we have 2,716 MW, or a total of 99 percent increase over the past ten years. Overall, natural gas-fired generation is expected to remain a popular choice for new generation as well as repowering older generation, but concerns do exist about possible overreliance on natural gas as a fuel as fuel diversity decreases.

Hydroelectric Power Generation

Hydroelectric generating facilities use a renewable energy source, emit zero air pollutants, and have a long operating life. Also, some hydro units have black start capability.

Connecticut's hydroelectric generation consists of 25 facilities contributing approximately 127 MW, or 1.7 percent of the State's current peak generating capacity.
FirstLight Power Enterprises, Inc. (FirstLight), Connecticut's largest provider of hydroelectric power, owns the following hydroelectric facilities: Bantam, Bulls Bridge, Falls Village, Robertsville, Scotland, Stevenson, Taftville, Tunnel 1-2, Rocky River, and Tunnel 10. Other hydroelectric facilities (over 5 MW) not owned by FirstLight include Derby Dam and Rainbow Dam located in Shelton and Windsor, respectively.

The Council notes that hydroelectric power output in Connecticut has been declining. The 2005 Forecast Report indicated that Connecticut had approximately 148 MW of hydroelectric energy capacity. Today, we have 127 MW, or a total of a 14.2 percent decline over the past ten years. This is likely the result of naturally changing water flows.

The main obstacle to the development of additional hydroelectric generation in Connecticut is a lack of suitable sites.

Solid Waste Power Generation

Solid waste has the advantage of being a renewable, locally supplied fuel and it contributes to Connecticut's fuel diversity. It is not affected by market price volatility, nor supply disruptions—significant advantages over fossil fuels. In addition, the combustion of solid waste reduces the amount of space needed for landfills. Solid waste-fueled facilities are considered Class II renewable resources.

Connecticut currently has approximately 149 MW of solid waste-fueled generation, or approximately 2.0 percent of the State's peak generation capacity. The Exeter generating plant in Sterling (approximately 9.5 MW) which burned tires as fuel is not currently in service. (Accordingly, it is reported as 0 MW in Appendix A.) The remaining active solid waste-fueled generation fleet includes: Bridgeport Wheelabrator; Bristol Resource Recovery Facility (RRF); Lisbon RRF; Preston RRF; Wallingford (Covanta) RRF; and the Connecticut Resource Recovery Agency South Meadows facility. See Table 3.

Table 3

Solid Waste-fueled Generation	**MW**
Bridgeport Wheelabrator	59.07
Bristol Resource Recovery Facility	12.94
Lisbon Resource Recovery Facility	13.33
Preston Resource Recovery Facility	15.86
Wallingford Resource Recovery (Covanta) Facility	5.03
Connecticut Resource Recovery Agency - South Meadows Unit #5	26.14
Connecticut Resource Recovery Agency - South Meadows Unit #6	16.62
Total	148.99

The Council notes that waste-to-energy peak power output in Connecticut has declined. Ten years ago, the Council reported in its 2005 Forecast Report that Connecticut had approximately 184 MW of solid waste-fueled generation capacity. Today, we have 149 MW or a total of 19.0 percent decline over the past ten years. This is likely due to the increasing age of the fleet and the loss of the Exeter facility's generating capacity.

Landfill Gas Power Generation

Connecticut's landfill gas generation consists of three facilities contributing approximately 3.17 MW, or a negligible 0.04 percent of the State's current peak generating capacity. These facilities are located in Hartford, East Windsor, and New Milford and have power outputs of 1.21 MW, 0.78 MW, and 1.18 MW, respectively. Landfill gas (essentially methane), like solid waste, has the advantage of being a locally supplied fuel. In addition, landfill gas-fueled facilities are considered Class I renewable resources.

Ten years ago, in the 2005 Forecast Report, the Council reported 4.97 MW of landfill gas generating capacity. As of today, there is a net reduction of 1.80 MW or a total reduction of 36.2 percent since 2005. The amount of methane gas available at a given landfill site at a given time is variable and depends on many factors. Landfill gas power outputs can vary as conditions and decomposition rates change.

Miscellaneous Distributed Generation

Fuel Cells

Fuel cells have very low emissions compared with other generation technologies. Some fuel cells can offer waste heat for use for domestic heating, hot water, and industrial processes. This can further increase overall efficiency. Fuel cells are also considered Class I renewable resources. Fuel cells have not been included in Table 4 because they are not ISO-NE dispatched. Many of these fuel cells provide base load power to the customer and serve to reduce load on the system. Some do sell excess power to the grid, but it is at the distribution level and thus not under ISO-NE's control.

The number of petitions for distribution-connected fuel cells that are being filed with the Council has increased significantly. Specifically, the Council approved four projects totaling 1,600 kW or 1.6 MW in 2012. From the beginning of calendar year 2013 through the end of December 2013, the Council has received and approved 18 fuel cell projects totaling 12,080 kW or 12.08 MW. For calendar year 2014, nine fuel cell projects totaling 7.2 MW were received and approved by the Council. For calendar year 2015 (thus far), seven fuel cell projects totaling 6.4 MW have been received and approved. Two other fuel cell projects 500-kW and 63.3 MW (the largest ever submitted to the Council to date) are currently under Council review. The Council strongly supports fuel cells as a very clean, efficient, and reliable source of electricity.

Other Miscellaneous Distributed Generation

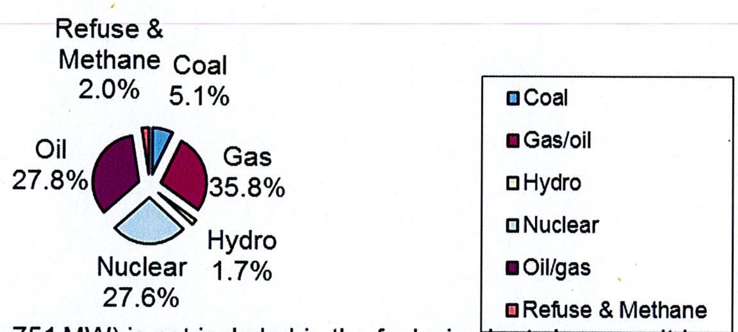
Approximately 134 MW of electricity is generated by 67 independent entities in Connecticut such as schools, businesses, and homes. They range from 5 kW to 32.5 MW in size and are fueled primarily by natural gas, with several others using oil, solid waste, hydro, landfill gas (essentially methane), and propane. For example, a 24.9 MW cogeneration facility was installed at the University of Connecticut. It was put into service in August 2005.

These miscellaneous distributed generators are not credited to the State's capability to meet demand because ISO-NE does not control their dispatch. However, these privately-owned units also serve to reduce the net load on the grid. It is possible some unreported units may be in service in Connecticut, and others may have been removed from service. Therefore, the total amount of miscellaneous small generation capacity is a very rough approximation, and thus, it is not included in Appendix A.

Fuel Mix

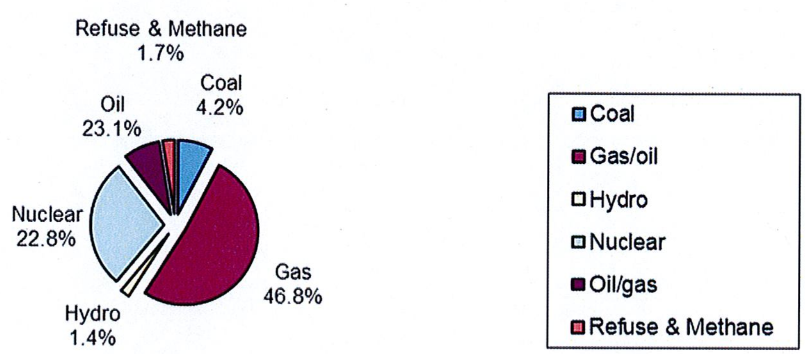
Based on existing generation and future (approved) generation projected in Table 1, the estimated fuel mix (by MW) is provided below for 2015 and also 2024, the end of the forecast period. The retirement assumptions of the 2014 IRP, the inclusion of Lake Road, and the additions of Wallingford and Towantic Oxford natural gas-fueled generation (selected in FCA #9) are included in the 2024 Fuel Mix chart. See Figure 4a and 4b below.

Figure 4a: 2015 Fuel Mix (Capacity)



*Lake Road plant (~751 MW) is not included in the fuel mix charts because it is electrically more a part of Rhode Island than Connecticut.

Figure 4b: 2024 Fuel Mix (Capacity)



Import Capacity

The ability to import electricity plays a significant role in Connecticut's electric supply. It is essential for maximizing reliability and for allowing economic interchange of electric energy. Ten years ago, in the Council's 2005 Forecast Report, the ability of Connecticut to import from its bordering states of New York, Rhode Island, and Massachusetts was estimated at a total of 2,200 to 2,300 MW (or an average of 2,250 MW). That was approximately 30 percent of the ISO-NE 2005 projected 90/10 forecast peak of 7,510 MW.

In 2015, the Connecticut Integrated Resource Plan estimates a Connecticut import capacity of 2,600 MW for 2015 based on the current status of transmission upgrades. This is approximately 32 percent of the ISO-NE project 90/10 forecast peak of 7,510 MW. The import capacity is estimated to remain at 2,600 MW for 2016 and then increase to 2,800 MW for 2017 due to the completion of the Greater Springfield Reliability Project and portions of the Interstate Reliability Project. Connecticut's import capacity is expected to further increase to 2,950 MW in 2018 (or about 35 percent of the ISO-NE 90/10 forecast peak) due to the completion of the Interstate Reliability Project. Then, import capacity would remain flat at 2,950 MW for the remainder of the forecast period (i.e. through 2024).

Demand/Supply Balance

Table 4 contains a tabulation of generation capacity versus peak loads. The ISO-NE 90/10 forecast is applied in this table. Note that peak load here is combined with a reserve requirement. This is an emergency requirement, basically: in case a large generating unit trips off-line, reserves must be available to compensate rapidly for that loss of capacity. The largest reserve requirement is 1,220 MW, which is approximately the current summer output of the State's largest generating unit, Millstone 3.

"Installed capacity derate" takes into account a possible number of power plants off-line for maintenance purposes. Existing generation (less Lake Road) listed in Table 4 is based on the 7,576 MW of total existing generation in Connecticut listed in Appendix A. Appendix A data is from ISO-NE's September 2015 Seasonal Claimed Capability report. Generation projects for Connecticut that have cleared FCA#9 are also listed in Table 4. As indicated, in-service dates for these facilities are estimates and may be subject to change.

The retirement of older generating units is difficult to predict because it is the result of many factors such as market conditions, environmental regulations and the generating companies' business plans. Specifically, Norwalk Harbor (342 MW), Bridgeport Harbor #2 (130 MW), and John Street #3-#5 (6 MW) have retired. These units are already reflected as 0 MW in Appendix A. As such, no adjustments need to be made in Table 4 with respect to retirements noted or projected in the 2014 IRP.

Import capacity into Connecticut is expected to increase as a result transmission upgrades. The additional 200 MW of import capacity beginning in 2017 (relative to 2016) reflects the impact of the Greater Springfield Reliability Project currently under construction, and portions of the planned Interstate Reliability Project. These increases, as reported in the 2014 IRP, have been reflected in Table 4. Beginning in 2018, the Connecticut import limit is expected to further increase to 2,950 MW (and remain flat for the remaining forecast period), due to completion of the remaining portions of the Interstate Reliability Project. The completion of the 345-kV Lake Road to Card Substation line associated with the Interstate Reliability Project is expected to bring the Lake Road units electrically into Connecticut in 2017. Per the 2014 IRP, Lake Road is included in Table 4 beginning in approximately 2017.

Table 4: Connecticut Resources vs. Peak Load

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
90/10 Load	8135	8260	8370	8475	8565	8640	8710	8780	8850	8925
Reserve (Equiv. Millstone 3)	1220	1220	1220	1220	1220	1220	1220	1220	1220	1220
Load + Reserve	9355	9480	9590	9695	9785	9860	9930	10000	10070	10145
Existing Generation w/o Lake Road	7575	7575	7575	7575	7575	7575	7575	7575	7575	7575
Inclusion of Lake Road into CT			751	751	751	751	751	751	751	751
Installed Capacity Derate	813	797	729	716	727	733	737	737	741	744
Available Generation	6762	6778	7597	7610	7599	7593	7589	7589	7585	7582
Normal Import	2600	2600	2800	2950	2950	2950	2950	2950	2950	2950
Energy Efficiency per Fig. 3	25	42	59	76	93	109	126	142	157	174
Total Avail. Resources	9387	9420	10456	10636	10642	10652	10665	10681	10692	10706
Surplus/Deficiency	**32**	**-60**	**866**	**941**	**857**	**792**	**735**	**681**	**622**	**561**
New Generation Projects (per FCA #9)										
Towantic Oxford				725	725	725	725	725	725	725
Wallingford #6&7 (if approved 11/12)				90	90	90	90	90	90	90
Surplus/Deficiency	**32**	**-60**	**866**	**1756**	**1672**	**1607**	**1550**	**1496**	**1437**	**1376**

Market Rules Affecting Supply

Forward Capacity Market (FCM)

Deregulation of the electric system in Connecticut and other New England states was intended to introduce competition into the wholesale market for electric capacity and increase investment in generation while driving prices down. This laudable aim was difficult to achieve, mainly because electricity was and is such a necessity that market rules at the time—as established by FERC and practiced by ISO-NE—imposed penalties suppressing competition on behalf of reliability targets. During a chaotic transition period of about seven years after deregulation, 1998-2005, ISO-NE's authority to enforce reliability brought more control over the increasingly complex and extended electric system into its hands. At the same time, State ratepayers saw prices rise steeply, while diversified generation did not replace traditional resources to the extent expected, and transmission improvements, instead, were proposed and approved by the Council to meet increased load. At length, in 2006 the states reached a settlement with FERC whereby a new electric market in New England was created to satisfy the twin aims of competition and reliability more equally.

This new market, the FCM, starts with ISO-NE's projections of system needs three years in advance, then holds an annual declining auction to purchase generation meeting those needs. The FCM has begun to assure lower pro-rated capacity prices along with reliable supply. It has introduced greater stability to the markets because it: a) assures capacity and price three years ahead; b) establishes rigorous financial tests that generators must pass to qualify for the auction; and c) includes effective rules to enforce auction commitments. Above all, the FCM has succeeded because its rules are more transparent and because it puts traditional generators, renewables, imports and demand response resources more on par. The results of the first nine FCM auction results are listed below in Table 5.

Table 5: FCM Auction Results

	Cleared Generation	Cleared Demand Resources	Cleared Imports	Total Capacity Acquired	Projected Capacity Need	Excess Supply
	MW	MW	MW	MW	MW	MW
2010/11	30,865	2,279	933	34,077	32,305	1772
2011/12	32,207	2,778	2,298	37,283	32,528	4755
2012/13	32,228	2,867	1,900	36,996	31,965	5031
2013/14	32,247	3,261	1,993	37,501	32,127	5374
2014/15	31,439	3,468	2,011	36,918	33,200	3718
2015/16	30,757	3,628	1,924	36,309	33,456	2853
2016/17	31,641	2,748	1,830	36,220	32,968	3252
2017/18	29,435	3,040	1,237	33,702	33,855	(143)
2018/19	30,442	2,803	1,449	34,695	34,189	506
Source: ISO-NE Press Releases dated February 27, 2013; February 28, 2014; and February 4, 2015						

Other ISO-NE Markets

ISO-NE runs other wholesale markets, most notably its day-ahead and real-time energy markets, where generators sell actual MW, as opposed to capacity. The smaller markets in which electricity is sold for specialized purposes need not be discussed here: suffice to say that discussion is ongoing within ISO-NE about possible changes to these markets, too, to promote further competition and investment. For a complete overview of New England's wholesale electricity markets, please see the latest Annual Markets Report: http://www.iso-ne.com/static-assets/documents/2015/05/2014-amr.pdf.

Legislation Affecting Supply

Regional Greenhouse Gas Initiative (RGGI)

The Regional Greenhouse Gas Initiative (RGGI) is the nation's first mandatory, market-based program to reduce emissions CO_2, the principal human-caused greenhouse gas. The states participating in RGGI (CT, DE, MA, MD, ME, NH, NY, RI, and VT) have established a regional cap on CO_2 emissions from the power sector and are requiring power plants 25 MW or greater in size to possess a tradable CO_2 allowance for each ton of CO_2 they emit.

Each state issues the CO_2 allowances to power plants within its own state, based on its independent legal authority. RGGI is composed of these individual CO_2 budget trading programs. RGGI compliance occurs in three-year control periods. At the end of each control period, all regulated power plants must submit the required CO_2 allowances. The first control period began on January 1, 2009, and extended through December 31, 2011.

The second control period began on January 1, 2012, and extends through December 31, 2014. The annual cap for power sector emissions in the region was set at 165 million tons per year through 2014[19].

The auction proceeds for the region through December 5, 2012 exceed $1.1B, of which, $65M is for Connecticut. Overall, 80 percent of the $1.1B is invested in consumer benefit programs, including energy efficiency, renewable energy, direct energy bill assistance, and other greenhouse gas reduction programs.

However, falling natural gas prices (due in large part to new Marcellus gas supplies) have encouraged power plants to switch to burning natural gas wherever feasible. Since natural gas is the lowest carbon fuel of the three fossil fuels (coal, oil, natural gas), power plant CO_2 emissions in this region have plummeted to record low levels. Annual emissions are on the order of 91 million tons, which is about 45 percent below the previous RGGI cap of 165 million tons[20].

Upon further review and analysis, changes were made to RGGI to address this issue. The *Updated Model Rule and Program Review Recommendations Summary* released on February 7, 2013 made changes that will take effect on January 1, 2014. These changes include but are not limited to the following.

- The 2014 regional CO_2 budget (RGGI Cap) will be reduced from 165 million to 91 million tons – a reduction of 45 percent. Starting in 2015, the RGGI Cap will decline 2.5 percent every year until 2020.
- Unsold 2012 and 2013 CO_2 allowances will not be re-offered.
- Regulated entities will be required to hold allowances equal to at least 50 percent of their emissions in each of the first two years of the three-year compliance period, in addition to demonstrating full compliance at the end of each three-year compliance period[21].

Carbon Dioxide Pollution Standard for Power Plants

On August 3, 2015, President Obama and the U.S. Environmental Protection Agency (EPA) announced the "Clean Power Plan" to reduce carbon pollution from power plants to combat climate change[22]. The Clean Air Act, under Section 111(d), creates a partnership between EPA, states, Native American tribes, and U.S. territories with EPA setting a goal and states and Native American tribes choosing how they will meet it. EPA is establishing interim and final carbon dioxide emission performance rates for two subcategories of fossil fuel-fired electric generating units: fossil-fueled electric steam generating units (generally, coal and oil-fired plants) and natural gas-fired combined cycle generating units. To maximize the range of choices available to states in implementing the standards and to utilities in meeting them, EPA is establishing interim and final statewide goals in three forms: a rate-based state goal measured in pounds per MWh; a mass-based goal measured in short tons of CO^2; and a mass-based state goal with a new source complement measured in short tons of CO^2.

States would then develop and implement plans that ensure that the power plants in their state, either individually, together or in combination with other measures, achieve the interim

CO^2 emissions performance rates over the period of 2022 to 2029 and the final CO^2 emissions performance rates, rate-based goals or mass-based goals by 2030[22].

TRANSMISSION SYSTEM

Transmission is often referred to as the "backbone" of the electric system, since it efficiently transports large amounts of electricity over long distances by using high voltage. High voltages are efficient because the greater the voltage, the greater the amount of electricity the lines can carry, and the smaller the amount of electric energy wasted from the lines as heat (as a result of less current).

In Connecticut, electric lines with a line voltage of 69 kilovolts (kV) or more are considered transmission lines. The highest transmission line voltage in Connecticut is 345-kV.

Distribution lines are those below 69-kV. They are the lines that come down our streets to connect (via a transformer) with even lower-voltage lines supplying each residence or business.

Large generating units are typically connected to the 345-kV transmission system because of its high capacity[23]. Older, smaller units are connected to the 115-kV system.

Substations and Switching Stations

A substation is a grouping of electrical equipment that includes switches, circuit breakers, buses, transformers and controls for switching power circuits and transforming electricity from one voltage to another. One common type of substation connects the transmission system to the distribution system. For example, the input might be 115-kV transmission and the output might be 13.8-kV distribution. Another type of substation connects a generator to the grid. Since a generator's output voltage is much less than the transmission voltage, it has to be raised before the power generated can be fed into the grid. Lastly, some substations, called switching stations, simply interconnect transmission lines to others at the same voltage.

As depicted in Appendix C, as many as three new substations are planned for the next three years to address high load areas within the State. Other new substations and/or upgrades to existing substations are also being considered, with the estimated in-service dates to be determined.

Predicting the pace and location of substation development is difficult. Even if predicted load growth overall is low, growth in certain geographical areas can exceed predicted levels due to unplanned population shifts and consequent economic development.

Interstate Connections and Imports

Connections with other systems outside the State are critical to overall reliability and economic efficiency. There are 11 such AC connections or ties: one at 69-kV; one at 138-kV (the underwater set of cables from Norwalk to Long Island); six at 115-kV; and three at 345-kV. In addition, the Cross Sound Cable, a DC tie between New Haven and Long Island, is at 150-kV.

Of these interstate connections, the most prominent are a 345-kV tie with National Grid in Rhode Island; a 345-kV tie with Central Hudson in New York state; and five ties (one 345-kV and four 115-kV) with the Western Massachusetts Electric Company (WMECO).

New England East –West Solution (NEEWS)

In approximately 2004, a working group consisting of National Grid – a utility company that provides service in various parts of New England outside of Connecticut – Northeast Utilities Service Company, and ISO-NE began planning a major tri-state transmission upgrade to improve electricity transfers between Connecticut, Massachusetts, and Rhode Island. Known as NEEWS, the large-scale upgrade is comprised of four separate projects, described below.

The Interstate Reliability Project is the most comprehensive. It consists of a new 345-kV transmission line to tie National Grid's Millbury Substation in central Massachusetts with CL&P's Card Street Substation in Lebanon, thus connecting electric service more efficiently from Massachusetts to eastern Connecticut, via the location of an existing transfer point with Rhode Island. When combined with the three other projects within NEEWS, this one increases the east-west power transfer capability across New England in general and would allow Lake Road to count towards Connecticut's generation capacity. This Connecticut portion of the project was approved by the Council on December 27, 2012. The project is under construction and expected to be in-service approximately late 2015.

The Greater Springfield Reliability Project improves connections between Connecticut and Massachusetts to address particular problems in the Springfield, Massachusetts area. New 345-kV facilities were built to tie WMECO's Ludlow Substation with its Agawam Substation and also to connect Agawam Substation with CL&P's North Bloomfield Substation in Bloomfield. This portion of the project has been built and is in the restoration phase. Also, the 345-kV connections from Manchester Substation to the south to Meekville Junction to the north have been improved. This portion of the project is complete.

The Central Connecticut Reliability Project is intended to increase the reliability of power transfers from eastern Connecticut to western and southwestern Connecticut. A new 345-kV transmission line would connect the North Bloomfield Substation in Bloomfield and the Frost Bridge Substation in Watertown. Associated upgrades to the 115-kV facilities in the area would also be necessary. This project is still under review by the utilities and ISO-NE. To date, no application has been received by the Council.

The Rhode Island Reliability Project principally would affect Rhode Island. New 115-kV and 345-kV facilities would be built to improve Rhode Island's access to the regional 345-kV grid and decrease its dependence on local generation. National Grid would construct the facilities. This transmission project is complete.

Overall, the aggregate of the southern New England transmission reinforcements provided by NEEWS is expected to increase Connecticut's import capacity significantly. See also earlier section on "Import Capacity."

Transmission associated with Renewable Portfolio Standards (RPS)

The requirements that certain percentages of electrical energy for Connecticut come from Class I, Class II, and Class III renewable resources increase annually during the forecast period. See Table 6 below.

Table 6: Connecticut Renewable Portfolio Standards

Year	Percent Class I	Addt'l Percent Class II or Class I	Percent Class III	Total
2005	1.5	3.0		4.5
2006	2.0	3.0		5.0
2007	3.5	3.0	1.0	7.5
2008	5.0	3.0	2.0	10.0
2009	6.0	3.0	3.0	12.0
2010	7.0	3.0	4.0	14.0
2011	8.0	3.0	4.0	15.0
2012	9.0	3.0	4.0	16.0
2013	10.0	3.0	4.0	17.0
2014	11.0	3.0	4.0	18.0
2015	12.5	3.0	4.0	19.5
2016	14.0	3.0	4.0	21.0
2017	15.5	3.0	4.0	22.5
2018	17.0	3.0	4.0	24.0
2019	19.5	3.0	4.0	26.5
2020	20.0	3.0	4.0	27.0
Source: PURA Website: http://www.ct.gov/pura/cwp/view.asp?a=3354&q=415186				

To achieve these targets, Connecticut will have to utilize imports as well as in-state generation. Six substantial merchant transmission projects have been proposed in recent years that would bring electricity into southern New England or New York generated by renewable sources farther north. Most of these are planned to run partly or wholly along waterways: routes through Lake Champlain and the Hudson River, the upper reaches of the Connecticut River, or the Atlantic. None of them would come directly to Connecticut. One currently under review is the Northern Pass Project, to be discussed in the next section.

The Northern Pass Project

The Northern Pass is a 192-mile long transmission line project that would bring 1,090 MW of clean, low-cost energy from Hydro-Québec's hydroelectric plants in Québec, Canada to

New Hampshire and the rest of New England. A new direct current (DC) transmission line from the Canadian border to Franklin, New Hampshire is planned. A converter terminal in Franklin would convert the DC power to alternating current (AC) power for use in the New England power grid. Northern Pass Transmission LLC announced its updated, preferred route on June 27, 2013 and on July 1, 2013, filed an amended application with DOE for a Presidential Permit to authorize the construction, connection, operation, and maintenance of facilities for the transmission of electricity at an international border. The DOE held four scoping meetings throughout the state between September 23 and 26, 2013. DOE issued its draft Environmental Impact Statement (EIS) on July 21, 2015. A 90-day public comment period began on July 31, 2015 when the EPA published a notice of the draft EIS' availability in the *Federal Register.* The State of New Hampshire's Site Evaluation Committee's review process is expected to commence in fall 2015.

Electric Transmission in Southwest Connecticut

Bethel-Norwalk Project and Middletown-Norwalk Project – Dockets 217 and 272

Lying close to New York and along the coast of Long Island Sound, Southwest Connecticut (SWCT) is the most densely-populated part of the State. Well before the turn of the century, it became evident that the 115-kV lines serving SWCT were reaching the limit of their ability to support the area's current and projected loads reliably and economically. ISO-NE, CL&P, and UI devised a large-scale, long-term plan to supplement the existing 115-kV transmission lines with a new 345-kV "loop" though SWCT that would integrate the area better with the 345-kV system in the rest of the State and New England, and provide electricity more efficiently. Council Docket No. 5 was the first phase of this "macro" upgrade: approved in 1975, it connected New Milford and Danbury.

The second phase of the upgrade plan involved the construction of a 345-kV transmission line from Plumtree Substation in Bethel to the Norwalk Substation in Norwalk. This was the subject of Council Docket No. 217, approved by the Council on July 14, 2003. The line was activated in October 2006.

The third phase of the upgrade plan, by far the largest, completed the loop with a 345-kV transmission line from Middletown to Norwalk Substation. This was Docket No. 272. It was approved by the Council on April 7, 2005. Construction began in 2006. The project went into service in late 2008.

Glenbrook-Norwalk Cable Project – Docket 292

Due to significant economic and population growth in the Norwalk-Stamford area, CL&P proposed to address the associated increase in electric demand with the construction of two 115-kV cables in southwestern Fairfield County. The Council reviewed and approved the plans to construct two new 115-kV underground transmission cables between the Norwalk Substation in Norwalk and the Glenbrook Substation in Stamford. This project was designed to bring the reliability benefits of the new 345-kV transmission loop to the large load center in Stamford. It is currently in service.

While the Bethel-Norwalk, Middletown-Norwalk, and Glenbrook-Norwalk projects relieved transmission congestion in SWCT for the near term, as part of prudent planning, ISO-NE is continually reviewing the New England grid to determine future needs.

Stamford Reliability Cable Project - Docket 435

On January 18, 2013, CL&P submitted an application to the Council, Docket No. 435, for a new 115-kV underground transmission circuit to extend approximately 1.5 miles between CL&P's Glenbrook and South End Substations in Stamford, and for related improvements at both substations. This project is designed to eliminate reliability criteria violations by relieving power flows, and strengthen the 115-kV transmission system serving the Stamford-Greenwich Sub-area, thus ensuring compliance with mandatory national and regional reliability standards. This project would also provide the Stamford-Greenwich Sub-area with a strong electrical connection to the new 345-kV transmission loop through SWCT that was linked to Glenbrook Substation when the Glenbrook-Norwalk Project was completed. See sections on Dockets 217 and 272, 292 above. Finally, the project advances a long-range plan for expanding Connecticut's power grid. Docket 435 was approved by the Council on September 5, 2013. On November 21, 2014, the Stamford Reliability Project was successfully energized and placed in service.

Greenwich Substation and Line Project – Docket 461

On June 26, 2015, Eversource submitted an application to the Council, Docket No. 461, for the construction, maintenance, and operation of a 115-kV bulk substation at 290 Railroad Avenue, in Greenwich, two 115-kV underground transmission circuits extending 2.3 miles between the proposed substation and the existing Cos Cob Substation in Greenwich, and related modifications to existing facilities. The purpose of the proposed project is to provide load relief to the electric distribution supply system in Greenwich by establishing a new bulk power substation near the center of the customer electrical demand to avoid overloads on both distribution lines and transformers. This project is current under Council review.

New Transmission Technologies

Materials and Construction

Within the electric system overall, transmission has been the component slowest to change. In Connecticut, a few innovations have been made, as reported in earlier forecast reviews. Helicopters have been used to install overhead conductors; transmission towers fabricated with new materials are being installed; conductors designed with special-purpose metals and ceramics are being tested elsewhere and could be applied at certain sites in Connecticut; new techniques have been employed for laying cables underground.

Storage

Storage is a hybrid in the electricity sector. Because it can sometimes act as a type of generation (pumped hydro, for instance), and is potentially much cheaper than generation, it is attracting a great deal of basic and engineering research. Building-sized battery "farms" have been developed; storage systems have been devised using cheap electricity at night to make ice that supplies cooling during the day; flywheels have been engineered that take excess electricity from the grid and return it super-efficiently to balance load; compressed-air storage is quite common: the list goes on. Particularly of interest to Connecticut is the form of storage that uses off-peak electricity to charge electric vehicles (EVs): the entire collection of EVs, in this concept, can function as a distributed storage unit. Connecticut is one of the few states to have inaugurated an EV charging station, since Eversource has committed to supporting EVs. See section on Electric Vehicles. Technically, storage is not a transmission technology, but it can be employed in a transmission system to balance electric loads more flexibly and cheaply than conventional methods.

Smart Grid

The technological advances most needed are ones that would improve the working of the grid as a whole. In particular, sweeping improvements are needed in the electronics that control the grid, since, as one expert says "[Today's] switches…operate at a speed that is the equivalent of being 10 days late, relative to the speed of light."[24] A major innovation in control electronics is at hand that will likely change the organization of transmission, even its operating characteristics: this innovation is known as the "Smart Grid."

The Smart Grid is a suite of bundled electronic technologies, some currently available, others only speculative. Many of them apply to electricity distribution, but transmission is importantly involved in the Smart Grid too. Although the Smart Grid can be defined in many different ways, a useful definition here comes from the Energy Security and Independence Act of 2007 (EISA), as reported by ISO-NE: "The goal is to use advanced, information-based technologies to increase power grid efficiency, reliability, and flexibility, and reduce the rate at which electric utility infrastructure needs to be built."[25]

Having anticipated the evolution of the Smart Grid, Connecticut utilities have already taken some steps to implement it. For instance, UI has installed at least four phasor measurement units (PMUs) in its service area, and Eversource has installed at least 13. PMUs are extremely precise devices for monitoring power fluctuations on the grid; by providing early detection and warnings of anomalous events, they can help prevent the spread of local outages to neighboring regions. In addition, CL&P has installed digital fault recorders to identify data that can be used to determine what happened during a disturbance in the system.

The driver of the Smart Grid at its inception was reliability; the driver currently is efficiency; the driver going forward will be flexibility—that is, the need to integrate renewable resources, and storage. Given the scale of the Smart Grid effort, it is difficult to predict how much of an effect it will have on any Connecticut transmission projects during 2015-2024

RESOURCE PLANNING

State of Connecticut Resource Planning

Connecticut Siting Council

The Connecticut Siting Council (Council), formerly known as the Power Facility Evaluation Council, was established in 1971 to approve or deny site applications for power facilities by balancing the need for adequate and reliable public utility services at the lowest reasonable cost to consumers while protecting the environment and ecology of Connecticut. Generally, most power plants over 1 MW, all fuel cells, substations and switching stations (at or above 69 kV), and transmission projects (at or above 69 kV) are under the jurisdiction of the Council.

Beginning in 2002, the Council's review of the Connecticut utility forecasts of electric loads and resources has changed from a twenty-year horizon to a ten-year horizon. The Council also reviews the life cycle costs of electric transmission lines and issues a report every five years. The Council has completed its 2012 review of life-cycle costs of electric transmission lines[26]. The Council also publishes its Best Management Practices for Electric and Magnetic Fields (for electric transmission lines) and updates such report on an annual basis, as necessary[26].

By virtue of its siting authority, the Council accumulates data and maintains records on the physical characteristics, construction costs, adequacy and reliability of power facilities in Connecticut. This material forms the basis for the annual forecast report and the life-cycle report. By extension, it also forms the basis for energy resource planning done by various other state agencies, and for policy decisions. The Council may make recommendations to those other agencies, depending on patterns observed in its data, records, and reports; however, the Council itself is not an energy resource planning agency, nor is it authorized to set policy.

Department of Energy and Environmental Protection (DEEP)

PA 11-80 accomplished a sea-change in energy resource planning and policy-making when it merged the Departments of Environmental Protection and Public Utility Control. The sweeping changes made by PA 11-80 were necessary because, prior to deregulation, energy resource planning had principally been done by the regulated utilities companies themselves, overseen by the Department of Public Utility Control; after de-regulation, the control process became fragmented: no single State agency was responsible for planning and policy, while a proliferation of agency departments and public-private committees or boards carried out various pieces of these tasks. PA 11-80 managed to consolidate the various planning and policy functions within state government along much clearer lines of authority.

Integrated Resource Plan (IRP)

Through a series of energy bills leading up to PA 11-80, the legislature struggled to make the process of energy planning more rational, and in 2007 gave back to the utility companies the job of drafting an annual Integrated Resource Plan (IRP) first due in 2008, which they duly performed for three years. PA 11-80, however, reclaimed that task for the State once more, assigning it to the newly-formed DEEP.

Currently, an IRP is required in every even-number year. It provides an in-depth assessment of the State's energy and capacity resources. Through an analysis of electric supply and demand, which is informed annually by the Council's forecast report, the IRP outlines a plan for securing resources to meet the State's energy needs in a way that will minimize cost and maximize benefits consistent with the State's environmental goals and standards.

On June 14, 2012, DEEP issued the *2012 Integrated Resource Plan for Connecticut* (2012 IRP). In the "Forecast for Future Electricity Supply and Demand" section, the 2012 IRP found that, "Adequate generating resources will likely be available in Connecticut to serve electricity loads reliably through 2022."

On March 17, 2015, DEEP issued the *2014 Integrated Resource Plan for Connecticut* (2014 IRP)[27]. In the "Forecast of Resource Adequacy to Meet Average and Summer Peak Demand" section, the 2014 IRP noted that, "Resources within Connecticut area expected to be sufficient to meet Connecticut's Local Sourcing Requirement as defined by the Transmission Security Analysis criteria through 2024. Within the Connecticut sub-area specifically, no new capacity will be needed beyond existing resources, planned transmission, and energy efficiency will exceed the local requirement beyond the ten-year IRP horizon. Local electric supply should be adequate barring the unexpected loss of approximately 2,000 MW of supply. However, Connecticut reliability and generation prices would be as affected as other states if the entire region had insufficient supply."

Comprehensive Energy Strategy (CES)

Section 51 of PA 11-80 requires that DEEP, in consultation with the CEAB, prepare a CES every three years beginning in 2012. In accordance with the legislation, on February 19, 2013, DEEP issued the final version of its first CES[28]. The next CES report is expected in 2016.

The CES is intended to be the State's main policy document and master plan. Its purpose is to guide the State's regulatory and legislative decisions concerning energy resources and to provide the foundation for better energy choices at every level. It covers all fuels in all sections, with a planning horizon out to 2050. It offers analysis of the State's current energy circumstances and a set of recommendations designed to advance the Governor's agenda of moving Connecticut toward a cheaper, cleaner, and more reliable energy future. Specifically, the CES offers recommendations in five major priority areas: energy efficiency, industrial energy needs, electricity supply (including renewable power), natural gas, and transportation. Of these, the most directly applicable to the Council's work are energy efficiency and electric supply.

Energy efficiency is established by the CES as Connecticut's top policy priority. Fifteen recommendations aim to provide funding for a large range of energy efficiency projects at all levels—state, regional, municipal, and residential—and to ensure building codes or standards foster energy efficiency.

Thirteen recommendations concern energy supply. Many of these overlap with the ones on energy efficiency. Others support strengthening the regional CO_2 cap called for by the RGGI program, emphasize in-state renewable resources with incentives to drive down their costs, and aim to increase electric reliability under emergency conditions through microgrids and other protections called for by the Two Storm Panel.

In general, these two sections of the CES recommendations would continue driving down the capacity needs, consumption and cost of electricity. In terms of siting, the recommendations imply that the Council will likely see applications increasing for smaller, more diversified generation projects using renewable fuels, as well as smaller, more innovative transmission projects emphasizing reliability.

Regional Resource Planning

ISO New England Inc. (ISO-NE) Regional System Plan

ISO-NE is a not-for-profit corporation responsible for the reliable and economical operation of New England's electric power system. It also administers the region's wholesale electricity markets and manages the comprehensive planning of the regional power system. The planning process includes the preparation of an annual Regional System Plan (RSP) for the New England region, which includes the following:

- Forecasts of annual energy use and peak loads (i.e. the demand for electricity) for a 10-year planning horizon and the need for resources (i.e., capacity);

- Information about the amounts, locations, and characteristics of market responses (e.g., generation or demand resources or elective transmission upgrades) that can meet the defined system needs – system-wide and in specific areas; and

- Descriptions of transmission projects for the region that could meet the identified needs, as summarized in an RSP Project List, which includes information on project status and cost estimates and is updated several times each year.

On November 6, 2014, ISO-NE issued its *2014 Regional System Plan* (2014 RSP). In the 2014 RSP, ISO-NE noted that, "Forward Capacity Auction No. 8 (FCA #8) resulted in the first capacity shortage in a primary auction. As recently as fall 2013, a surplus of capacity resources (both new and existing) was considered likely for the auction, but retirements have since been announced. Resources will be procured for the 2017/2018 capacity commitment period if deemed necessary in upcoming annual reconfiguration auctions. The region is expected to require 424 MW in 2019/2020, which would increase to a shortage of 1,155 MW in 2023/2024, accounting for the load and energy-efficiency forecasts and only known retirements. This also assumes all resources will capacity supply obligations for FCA #8 remain in service."

Subsequent to the issuance of the 2014 RSP and FCA #8 results, FCA #9 was held in early 2015. Approximately 1,067 MW of new generation resources cleared the auction, including the following in Connecticut: Towantic Power Plant (~725 MW) and Wallingford Energy (~90 MW). On November 5, 2015, ISO-NE issued its 2015 Regional System Plan (2015 RSP)[29]. In the 2015 RSP, ISO-NE noted that, "Assuming all FCA #9 existing and new resources remain in service in 2018 and beyond, the region would have sufficient resources through 2023, according to RSP15 resource adequacy study results."

CONCLUSION

This Council has considered Connecticut's electric energy future and finds that even taking into account the most conservative prediction, the ISO-NE 90/10 forecast, and conservatively neglecting the effects of non-ISO-NE-dispatched DG, the electric generation supply during 2015-2024 will be adequate to meet demand. Any small deficit early in the forecast prior to the Greater Springfield and Interstate Reliability Projects import upgrades and inclusion of Lake Road in Connecticut could be made up fairly easily by activating the full range of available generation, maximizing the use of active demand response resources, and devising other such operational strategies.

FCA #9 results are very favorable for Connecticut in terms of new generating capacity. Specifically, it includes the Towantic facility in Oxford (approximately 725 MW cleared at auction or 740 MW summer) which was approved by the Council in 2015. FCA #9 also includes the Wallingford #6-#7 facility (approximately 90 MW cleared at auction or about 100 MW nominal). The Wallingford project is currently under Council review.

C&LM and DG (including renewable energy credits) are projected to eliminate Connecticut's increases in energy consumption and reduce the increase in load growth during the forecast period. Specifically, with these measures, annual energy consumption is expected to <u>decrease</u> based on a CAGR of -0.19 percent per year. Without such measures, annual energy consumption in Connecticut would <u>increase</u> at a CAGR of +0.38 percent per year. Such measures also reduce the rate of load growth from a CAGR of +0.83 percent to +0.55 percent per year.

Finally, the Council reviewed the accuracy of past forecasting. Specifically, the 2005 Connecticut utilities' 50/50 load forecasts were compared to the weather-normalized historical data. The utilities' forecasts were, on (weighted) average, accurate to plus or minus 6.14 percent, which is reasonable.

The Council makes the following further observations based on the information presented in this 2015-2024 review.

- Fuel diversity, which is key to Connecticut's policy of energy independence, has been decreasing at the level of power production within the Council's jurisdiction. At the level of DG, however, largely outside the Council's jurisdiction, fuel diversity is markedly increasing, particularly with the recent growth in solar projects in Connecticut.

- Smart Grid improvements offer the potential for significant innovation in transmission, particularly with regard to integrating renewables and storage.

End Notes

1. WED was formerly part of CMEEC. WED separated from CMEEC in 2014.

2. A one MW load, for example, would be the equivalent of simultaneously operating 100,000 compact fluorescent light bulbs of 10 watts each. Put another way, 1 MW could serve between 300 and 1,000 homes, with 500 being a typical number.

3. However, for the purposes of load forecasting, Bozrah and MTUA may be treated as part of CMEEC's "service area."

4. A very small amount of CMEEC load (and thus Connecticut load) is the result of providing service to Fisher's Island, New York via a connection to a substation in Groton, Connecticut. The peak load is on the order of 1 MW and thus considered negligible relative to the Connecticut load.

5. According to the U.S. Department of Energy, roughly 83 percent of Connecticut homes heat with fossil fuels such as heating oil or natural gas or propane. Electric heat is used for about 15 percent of homes in Connecticut. The remaining two percent is "Other" and not listed. See http://apps1.eere.energy.gov/states/residential.cfm/state=CT.

6. There are some natural gas-powered air conditioning systems, but they are much less common than electric air conditioning.

7. An extreme weather forecast is not available for WED. The extreme weather data is estimated from the 50/50 forecast data provided by multiplying by the same ratio (per year) as the sum of the other utilities' 90/10 to 50/50 peak loads. The effects of any errors on the statewide extreme weather forecast total would be very small.

8. CMEEC's 2014 forecast data was properly adjusted to account for the separation of Wallingford from CMEEC. This explains why CMEEC's loads suddenly drop from about 400 MW in 2013 to about 263-264 MW in 2014.

9. During the June 12, 2012 hearing, ISO-NE testified that it does not weather-normalize peak data. Thus, the Council is unable to include the ISO-NE 50/50 forecast in this comparison at this time.

10. For example, a 23-Watt compact fluorescent light bulb consumes electricity at a rate of 23 Watts. If the bulb were on for ten hours, the total energy consumed would be 230 Watt-hours, or 0.23 kWh. A much larger load, for example, a 1,500 Watt electric heater, would only have to run for approximately 9.2 minutes (0.15 hours) to consume 0.23 kWh of energy.

11. For larger accounts, meters also record the instantaneous load or demand.

12. The only emissions are those associated with generating the electricity.

13. Natural gas efficiency and conservation measures are outside the scope of this report.

14. To put this into perspective, it takes about 8.34 BTUs of heat energy to warm one gallon of water by one degree F.

15. See the PURA Decision in Docket No. 11-12-06. http://www.dpuc.state.ct.us/FINALDEC.NSF/2b40c6ef76b67c438525644800692943/1b95b48c34af2ee285257a3a000bca13?OpenDocument

16. Some combustion turbine power plants can partially compensate for this effect by using evaporative coolers to chill the incoming air during summer months. But all else being equal, power outputs are still generally higher during the winter months.

17. In this report, to be conservative, the summer (not winter) power outputs of existing generation will be considered. To also find the winter power outputs, see Appendix A.

18. http://www.eia.gov/energyexplained/index.cfm?page=coal_reserves

19. RGGI Fact Sheet updated 9/28/2012. http://www.rggi.org/docs/Documents/RGGI_Fact_Sheet_2012_09_28.pdf

20. The Connecticut Mirror article "Overhaul is near for Regional Greenhouse Gas Initiative" by Jan Ellen Spiegel and dated December 11, 2012. http://ctmirror.com/story/18431/overhaul-ner-regional-greenhouse-gas-initiative

21. RGGI press release dated September 6, 2013

22. http://www2.epa.gov/cleanpowerplan/fact-sheet-overview-clean-power-plan

23. Since power is directly proportional to voltage, all else being equal, a 345-kV line can carry three times as much power as a 115-kV line. A typical 345-kV line has two conductors per phase, whereas a typical 115-kV line has one, thus turning the three times power-carrying advantage of a 345-kV line to six times.

24. David Wagman, Power Engineering (March 2011, p. 4).

25. ISO-NE, "Overview of the Smart Grid—Policies, Initiatives, and Needs" (February 17, 2009), p. 1

26. http://www.ct.gov/csc/cwp/view.asp?a=895&q=246816.

27. See the 2014 Integrated Resource Plan. http://www.ct.gov/deep/cwp/view.asp?a=4405&q=486946&deepNav_GID=2121%20

28. See the 2013 Comprehensive Energy Strategy for Connecticut. http://www.ct.gov/deep/lib/deep/energy/cep/2013_ces_final.pdf

29. See the 2015 Regional System Plan. http://www.iso-ne.com/system-planning/system-plans-studies/rsp

Glossary

50/50 forecast: A projection of peak electric load assuming normal weather conditions. The 50/50 projected peak load has a 50 percent chance of being exceeded in a given year.

90/10 forecast: A projection of peak electric load assuming extreme (hot) weather conditions. The 90/10 forecast has a 10 percent chance of being exceeded in a given year. This forecast is used for transmission facility planning.

AC (Alternating Current): An electric current that reverses (alternates) its direction of flow periodically. In the United States, this occurs 60 times per second (60 cycles or 60 Hz).

Ampere (amp): A unit measure for the flow (current) of electricity. As load increases, so does the amperage at any given voltage.

Baseload generator: A generator that operates nearly 24/7 regardless of the system load: for example, a nuclear unit.

Blackout: A total disruption of the power system, usually involving a substantial or total loss of load and generation over a large geographical area.

Black start capability: The capability of a power plant to start generating electricity by itself without any outside source of power, for instance, during a general blackout.

British thermal unit (BTU): The amount of energy required to heat or cool one pound of water by one degree Fahrenheit.

C&LM (Conservation and load management): Any measures to reduce electric usage and provide savings. See Conservation. See Demand response.

Cable: A fully insulated conductor, usually installed underground.

CAGR (Compound annual growth rate): The percentage by which a quantity (such as load or energy) increases per year over the forecast period, on average, while taking into account compounding effects. It is analogous to a computed compound interest rate on a bank account based on a beginning balance and final balance several years later (assuming no deposits other than interest and no withdrawals). Since it is nine years from the first year of the forecast period to the last, CAGR = (100%*((Final Value/Initial Value)^(1/9)) – 1).

CELT (Capacity, Energy, Load and Transmission Report): An annual ISO-NE report including data and projections for New England's electric system over the next ten years.

CHP (Combined heat and power): Term used interchangeably with cogeneration. See Cogen.

Circuit: A system of conductors (three conductors or three bundles of conductors) through which electrical energy flows between substations. Circuits can be supported above ground by transmission structures or placed underground.

Circuit breaker: A device designed to open and close a circuit manually and also to open the circuit automatically on a predetermined overload of current.

Class I renewable energy source: "(A) energy derived from solar power, wind power, a fuel cell, methane gas from landfills, ocean thermal power, wave or tidal power, low emission advanced renewable energy conversion technologies, a run-of-the-river hydropower facility provided such facility has a generating capacity of not more than five megawatts, does not cause an appreciable change in the river flow, and began operation after the effective date of this section, or a biomass facility, including, but not limited to, a biomass gasification plant that utilizes land clearing debris, tree stumps or other biomass that regenerates or the use of which will not result in a depletion of resources, provided such biomass is cultivated and harvested in a sustainable manner and the average emission rate for such facility is equal to or less than .075 pounds of nitrogen oxides per million BTU of heat input for the previous calendar quarter except that energy derived from a biomass facility with a capacity of less than five hundred kilowatts that began construction before July 1, 2003, may be considered a Class I renewable energy source, provided such biomass is cultivated and harvested in a sustainable manner, or (B) any electrical generation, including distributed generation, generated from a Class I renewable energy source." (Conn. Gen. Stat. § 16-1(a)(26))

Class II renewable energy source: "Energy derived from a trash-to-energy facility, a biomass facility that began operation before July 1, 1998, provided the average emission rate for such facility is equal to or less than 0.2 pounds of nitrogen oxides per million BTU of heat input for the previous calendar quarter, or a run-of-the-river hydropower facility provided such facility has a generating capacity of not more than five megawatts, does not cause an appreciable change in the riverflow, and began operation prior to the effective date of this section." (Conn. Gen. Stat. § 16-1(a)(27))

Class III renewable energy source: "The electricity output from combined heat and power systems with an operating efficiency level of no less than fifty percent that are part of customer-side distributed resources developed at commercial and industrial facilities in this state on or after January 1, 2006, a waste heat recovery system installed on or after April 1, 2007, that produces electrical or thermal energy by capturing preexisting waste heat or pressure from industrial or commercial processes, or the electricity savings created in this state from conservation and load management programs begun on or after January 1, 2006." (Conn. Gen. Stat. § 16-1(a)(44))

Combined-cycle: A power plant that uses its waste heat from a gas turbine to generate even more electricity for a higher overall efficiency (on the order of 60 percent).

Conductor: A metallic wire, bus bar, rod, tube or cable, usually made of copper or aluminum, that serves as a path for electric flow.

Cogen (Cogeneration plant): A power plant that produces electricity and uses its waste heat for a useful purpose. For example, cogeneration plants heat buildings, provide domestic hot water, or provide heat or steam for industrial processes.

Conservation: The act of using less electricity. Conservation can be achieved by cutting out certain activities that use electricity, or by adopting energy efficiencies.

Customer-side distributed resource: "The generation of electricity from a unit with a rating of not more than sixty-five megawatts on the premises of a retail end user within the transmission and distribution system including, but not limited to, fuel cells, photovoltaic systems or small wind turbines, or a reduction in demand for electricity on the premises of a retail end user in the distribution system through methods of conservation and load management, including, but not limited to, peak reduction systems and demand response systems." (Conn. Gen. Stat. § 16-1(a)(40))

DC (Direct Current): An electric current that flows continuously in one direction as contrasted to an alternating current (AC).

Dual-fuel: The ability of a generator to operate on two different fuels, typically oil and natural gas. Economics, the availability of fuels and environmental (e.g. air emission) restrictions are factors that generating companies consider when deciding which fuel to burn.

Demand: The total amount of electricity required at any given instant by an electric customers. "Demand" can be used interchangeably with the term "load". See Load.

Demand response: The ability to reduce load during peak hours, by turning down/off air conditioning units, industrial equipment, etc. Demand response resources on a scale large enough to affect transmission are typically aggregated through a third party, using automated controls.

Distribution: The part of the electric delivery system that operates at less than 69,000 volts. Generally, the distribution system connects a substation to an end user.

Distributed generation: Generating units (usually on the customer's premises) that connect to the electric distribution system, not to the transmission system. These units are generally smaller than their counterparts.

Energy (electric): The total work done by electricity. Energy is the product of the average load and time. The unit is kilowatt hours (kWh).

Energy efficiency (in the case of an electric generator or of any dynamic process): The actual amount of energy required to accomplish a task, as opposed to a theoretical 100 percent efficiency.

Eversource (The Connecticut Light and Power Company d/b/a Eversource Energy): Eversource is the largest transmission/distribution company in Connecticut.

Feeder: Conductors forming a circuit that are part of the distribution system. See Distribution. See Circuit.

Fuel cell: Fuel cells are devices that produce electricity and heat by combining fuel and oxygen in an electrochemical reaction. A battery is a form of fuel cell. Fuel cells can operate on a variety of fuels, including natural gas, propane, landfill gas, and hydrogen. Unlike traditional generating technologies, fuel cells do not use a combustion process that converts fuel into heat and mechanical energy. Rather, a fuel cell converts chemical energy into heat and electrical energy. This process results in quiet operation, low emissions, and high efficiencies. Nearly all commercially-installed fuel cells operate in a cogeneration mode. See Cogen. In addition, fuel cells provide very reliable electricity and are therefore potentially attractive to customers operating sensitive electronic equipment.

Generator: A device that produces electricity. See Baseload generator, Intermediate generator, and Peaking generator.

Grid: A system of interconnected power lines and generators that is managed so that the generators are dispatched as needed to meet the overall requirements of the customers connected to the grid at various points. "Grid" has the same meaning as "bulk power system."

Grid-side distributed resource: "The generation of electricity from a unit with a rating of not more than sixty-five megawatts that is connected to the transmission or distribution system, which units may include, but are not limited to, units used primarily to generate electricity to meet peak demand." (Conn. Gen. Stat. § 16-1(a)(43))

ISO-NE: (ISO New England): An entity charged by the federal government to oversee the bulk power system and the electric energy market in the New England region.

Intermediate generator: A generator that operates approximately 50 to 60 percent of the time, depending on the system load.

kV (kilovolt): One thousand volts (i.e. 345 kV = 345,000 volts). See Volt.

Line: A series of overhead transmission structures that support one or more circuits; or, in the case of underground construction, a single electric circuit.

Load: Amount of power delivered, as required, at any point or points in the system. Load is created by the aggregate load (demand) of customers' equipment (residential, commercial, and industrial).

Load management: Steps taken to reduce demand for electricity at peak load times or to shift some of the demand to off-peak times. The reduction may be made with reference to peak hours, peak days or peak seasons. Electric peaks are mainly caused by high air-conditioning use, so air-conditioners are the prime targets for load management efforts. Utilities or businesses that provide load management services pay customers to reduce load through a variety of manual or remotely-controlled methods.

Loss or losses: Electric energy that is lost as heat and cannot be used to serve end users. There are losses in both the transmission and the distribution system. Higher voltages help reduce losses.

LREC (Low Emissions Renewable Energy Credit): A Class I Renewable Energy Certificate from a low-emissions project as defined in Section 110 of Public Act 11-80. LREC-qualified projects are Connecticut generation projects that are located behind company customer meters, achieve commercial operation on or after July 1, 2011, and have emissions of no more than 0.07 pounds per megawatt-hour (MWh) of nitrogen oxides, 0.10 pounds per MWh of carbon monoxide, 0.02 pounds per MWh of volatile organic compounds, and one grain per 100 standard cubic feet. To qualify for the LREC/ZREC Program, LREC projects may not be larger than 2,000 kilowatts (kW).

Megawatt (MW): One million Watts. A measure of the rate at which useful work is done by electricity.

Microgrid: A localized grouping of electricity generation, energy storage, and loads that normally operates connected to a traditional centralized grid or macrogrid. This single point of common coupling with the macrogrid can be disconnected. The microgrid can then function autonomously.

Normal weather: Temperatures and humidity consistent with past meteorological data.

Peak load: The highest electric load experienced during a given time period. See Load.

Peaking unit: A generator that can start under short notice (e.g. 10 to 30 minutes). Peaking units typically operate less than 10 percent of the hours in a year.

Phasor measurement unit (PMU): A device that measures electrical waves on the electric grid via synchronized real-time measurements of multiple remote points on the grid. This monitoring improves reliability. PMUs are also called synchrophasors.

REC (Renewable Energy Credit): A certificate representing proof that one megawatt-hour of electricity has been generated from an eligible renewable energy resource. In Connecticut, a REC is an electronic certificate created by the New England Power Pool Generation Information System. RECs can be sold or traded.

Smart meter: An electrical meter that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing purposes.

Substation: Electric facilities that use equipment to switch, control and change voltages for the transmission and distribution of electrical energy.

Switching station: A type of substation where no change in voltage occurs.

Terminal structure: A structure typically within a substation that physically ends a section of transmission line.

Transformer: A device used to change voltage levels to facilitate the efficient transfer of electrical energy from the generating plant to the ultimate customer.

Transmission line: Any electric line operating at 69,000 or more volts.

Transmission tie-line or tie: A transmission line that connects two separate transmission systems. In the context of this report, a tie is a transmission line that crosses state boundaries and connects the transmission systems of two states.

UI (The United Illuminating Company): A transmission/distribution company that serves customers in the New Haven – Bridgeport area and its vicinity.

Voltage or volts: A measure of electric force.

WED (Wallingford Electric Division): A municipal electric distribution company that serves the Town of Wallingford

Wire: See Conductor.

ZREC (Zero Emissions Renewable Energy Credit): A Class I Renewable Energy Certificate from a zero emissions project as defined in Section 107 of Public Act 11-80. ZREC-qualified projects are Connecticut generation projects that are located behind company customer meters, achieve commercial operation on or after July 1, 2011, and emit no pollutants. To qualify for the LREC/ZREC Program, ZREC projects may not be larger than 1,000 kW.

Appendix A
Existing Electric Generation Facilities
as of September 2015

Facility	Owner	Town	Fuel	Summer Rating	Winter Rating	In-Service Date
Aetna Capitol District (CDECCA)	Capitol District Energy Ctr.	Hartford	Gas	50.09	61.33	11/1/1988
Bantam #1	FirstLight Hydro Generating Co.	Litchfield	Hydro (Run of River)	0.00	0.00	1/1/1905
Branford #10	NRG	Branford	Oil (Jet Fuel)	15.84	20.95	1/1/1969
Bridgeport Energy	Bridgeport Energy LLC	Bridgeport	Gas	476.93	519.94	8/1/1998
Bridgeport Harbor #2	PSEG Power, LLC	Bridgeport	Oil	0.00	0.00	8/1/1961
Bridgeport Harbor #3	PSEG Power, LLC	Bridgeport	Coal/Oil	383.43	384.98	8/1/1968
Bridgeport Harbor #4	PSEG Power, LLC	Bridgeport	Oil (Jet Fuel)	17.02	21.92	10/1/1967
Bridgeport (Wheelabrator)	CRRA	Bridgeport	Wood/Refuse	59.07	58.97	4/1/1988
Bristol Refuse	Ogden Martin Systems-CT	Bristol	Refuse	12.94	13.34	5/1/1988
Bulls Bridge #1- #6	FirstLight Hydro Generating Co.	New Milford	Hydro (Pondage)	5.39	4.15	1/1/1903
Colebrook	MDC	Colebrook	Hydro (Pondage)	0.95	0.74	3/1/1988
Cos Cob #10	NRG	Greenwich	Oil (Jet Fuel)	18.93	23.00	9/1/1969
Cos Cob #11	NRG	Greenwich	Oil (Jet Fuel)	18.72	23.00	1/1/1969
Cos Cob #12	NRG	Greenwich	Oil (Jet Fuel)	19.08	23.00	1/1/1969
Cos Cob #13	NRG	Greenwich	Oil (Jet Fuel)	19.05	22.85	5/29/2008
Cos Cob #14	NRG	Greenwich	Oil (Jet Fuel)	19.21	22.60	5/29/2008
Dayville Pond	Summit Hydro Power	Killingly	Hydro (Run of River)	0.00	0.06	3/1/1995
Derby Dam	McCallum Enterprises	Shelton	Hydro (Run of River)	7.05	7.05	3/1/1989
Devon #10	NRG	Milford	Oil (Jet Fuel)	14.41	18.85	4/1/1988
Devon #11	NRG	Milford	Gas	29.30	38.82	10/1/1996
Devon #12	NRG	Milford	Gas	29.23	38.44	10/1/1996
Devon #13	NRG	Milford	Gas	29.97	38.97	10/1/1996
Devon #14	NRG	Milford	Gas	29.70	40.27	10/1/1996
Devon #15	NRG	Milford	Gas/Oil	46.89	49.20	7/12/2010
Devon #16	NRG	Milford	Gas/Oil	46.90	49.20	6/28/2010
Devon #17	NRG	Milford	Gas/Oil	46.90	49.20	6/15/2010
Devon #18	NRG	Milford	Gas/Oil	46.90	49.20	6/9/2010
Dexter #1- #2	Alstom	Windsor Locks	Gas	42.27	43.20	5/1/1990
East Windsor NORCAP LFG	East Windsor NORCAP	East Windsor	Landfill Gas (Methane)	0.78	0.00	5/7/2007
Exeter	Oxford Energy, Inc.	Sterling	Refuse (Tires)	0.00	0.00	12/1/1991
Falls Village	FirstLight Hydro Generating Co.	Canaan	Hydro (Pondage)	3.94	4.48	1/1/1914
Franklin Drive #10	NRG	Torrington	Oil (Jet Fuel)	15.42	20.53	11/1/1968
Goodwin Dam	MDC	Hartland	Hydro (Run of River)	3.00	3.00	2/1/1986
Hartford Landfill	CRRA	Hartford	Landfill Gas (Methane)	1.21	1.03	8/1/1998
John Street #3	CMEEC	Wallingford	Oil (Diesel)	0.00	0.00	9/26/2007
John Street #4	CMEEC	Wallingford	Oil (Diesel)	0.00	0.00	9/26/2007

Appendix A
Existing Electric Generation Facilities
as of September 2015

Facility	Owner	Town	Fuel	Summer Rating	Winter Rating	In-Service Date
John Street #5	CMEEC	Wallingford	Oil (Diesel)	0.00	0.00	11/1/2007
Kleen Energy	Kleen Energy	Middletown	Gas/Oil	620.00	620.00	7/12/2011
Kimb Rocky River	Kimberly Clark Corporation	New Milford	Gas	13.85	15.80	7/15/2008
Kinneytown A	Kinneytown Hydro Co.	Ansonia	Hydro (Run of River)	0.00	0.00	3/1/1988
Kinneytown B	Kinneytown Hydro Co.	Seymour	Hydro (Run of River)	0.00	0.59	11/1/1986
Lake Road #1	Lake Road Generating Co., L.P.	Killingly	Gas/Oil	245.79	281.42	3/15/2002
Lake Road #2	Lake Road Generating Co., L.P.	Killingly	Gas/Oil	250.66	286.84	3/15/2002
Lake Road #3	Lake Road Generating Co., L.P.	Killingly	Gas/Oil	254.07	289.08	5/22/2002
Lisbon Resource Recovery	Riley Energy Systems	Lisbon	Wood/Refuse	13.33	13.14	1/1/1996
Mechanicsville	Saywatt Hydro Associates	Thompson	Hydro (Run of River)	0.00	0.10	9/1/1995
Middletown #2	NRG	Middletown	Oil/Gas	117.00	120.00	1/1/1958
Middletown #3	NRG	Middletown	Oil/Gas	226.75	244.40	1/1/1964
Middletown #4	NRG	Middletown	Oil	399.92	402.00	6/1/1973
Middletown #10	NRG	Middletown	Oil (Jet Fuel)	15.52	20.02	1/1/1966
Middletown #12	NRG	Middletown	Gas	46.90	49.20	6/24/2011
Middletown #13	NRG	Middletown	Gas	46.90	49.20	6/23/2011
Middletown #14	NRG	Middletown	Gas	46.90	49.20	6/1/2011
Middletown #15	NRG	Middletown	Gas	46.90	49.20	6/1/2011
Milford Power #1	Milford Power Company, LLC	Milford	Gas/Oil	253.61	281.35	2/12/2004
Milford Power #2	Milford Power Company, LLC	Milford	Gas/Oil	253.09	287.44	5/3/2004
Millstone #2	Dominion Nuclear CT, Inc.	Waterford	Nuclear	867.84	875.91	12/1/1975
Millstone #3	Dominion Nuclear CT, Inc.	Waterford	Nuclear	1220.01	1235.00	4/1/1986
Montville #5	NRG	Montville	Oil/Gas	81.00	81.59	1/1/1954
Montville #6	NRG	Montville	Oil	386.05	406.66	7/1/1971
Montville #10 & #11	NRG	Montville	Oil (Diesel)	5.30	5.35	1/1/1967
New Haven Harbor #1	PSEG Power, LLC	New Haven	Oil/Gas	447.12	453.38	8/1/1975
New Haven Harbor #2	PSEG New Haven, LLC	New Haven	Gas/Oil	42.86	48.60	5/30/2012
New Haven Harbor #3	PSEG New Haven, LLC	New Haven	Gas/Oil	42.86	48.60	5/30/2012
New Haven Harbor #4	PSEG New Haven, LLC	New Haven	Gas/Oil	42.86	48.60	5/30/2012
New Milford Landfill	Vermont Electric Power Co.	New Milford	Landfill Gas (Methane)	1.18	1.18	8/1/1991
Norden #1	CMEEC	East Norwalk	Oil	1.79	1.76	2/26/2009
Norden #2	CMEEC	East Norwalk	Oil	1.79	1.77	2/26/2009
Norden #3	CMEEC	East Norwalk	Oil	1.78	1.75	2/26/2009
Norwalk Harbor #1	NRG	Norwalk	Oil	0.00	0.00	1/1/1960
Norwalk Harbor #2	NRG	Norwalk	Oil	0.00	0.00	1/1/1963
Norwalk Harbor #10 (3)	NRG	Norwalk	Oil (Diesel)	0.00	0.00	10/1/1996
Norwich 10th St.	CMEEC	Norwich	Hydro	0.00	0.00	1/1/1966

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Facility	Owner	Town	Fuel	Summer Rating	Winter Rating	In-Service Date
Norwich Jet	CMEEC	Norwich	Oil	15.26	18.80	9/1/1972
Norwich Wasterwater Treatment	CMEEC	Norwich	Oil (Diesel)	2.00	2.00	5/29/2008
Pierce	CMEEC	Wallingford	Gas/Oil	74.09	94.59	10/1/2007
Pinchbeck	William Pinchbeck, Inc.	Guilford	Wood/Refuse	0.00	0.00	7/1/1987
Wallingford Unit #1	PPL EnergyPlus, LLC	Wallingford	Gas	42.94	49.18	12/31/2001
Wallingford Unit #2	PPL EnergyPlus, LLC	Wallingford	Gas	42.26	50.00	2/7/2002
Wallingford Unit #3	PPL EnergyPlus, LLC	Wallingford	Gas	43.68	49.18	12/31/2001
Wallingford Unit #4	PPL EnergyPlus, LLC	Wallingford	Gas	41.59	48.05	1/23/2002
Wallingford Unit #5	PPL EnergyPlus, LLC	Wallingford	Gas	44.43	50.00	2/7/2002
Preston RRF	SCRRF	Preston	Wood/Refuse	15.86	15.93	1/1/1992
Putnam	Putnam Hydropower, Inc.	Putnam	Hydro (Run of River)	0.00	0.31	10/1/1987
Quinebaug	Quinebaug Associates LLC	Killingly	Hydro (Run of River)	0.04	0.66	9/1/1990
Rainbow Dam #1- #2	Farmington River Power Co.	Windsor	Hydro (Run of River)	8.20	8.20	1/1/1980
Robertsville #1- #2	FirstLight Hydro Generating Co.	Colebrook	Hydro (Run of River)	0.00	0.00	1/1/1924
Rocky River	FirstLight Hydro Generating Co.	New Milford	Hydro (Pump Storage)	28.80	28.13	1/1/1928
Sandy Hook Hydro	Rocky Glen Hydro LP	Newtown	Hydro (Run of River)	0.00	0.06	4/1/1989
Scotland #1	FirstLight Hydro Generating Co.	Windham	Hydro (Run of River)	0.00	0.25	1/1/1937
Shepaug #1	FirstLight Hydro Generating Co.	Southbury	Hydro (Reservoir)	41.51	42.52	1/1/1955
South Meadow #5	CRRA	Hartford	Refuse	26.14	16.48	11/1/1987
South Meadow #6	CRRA	Hartford	Refuse	16.62	24.27	11/1/1987
South Meadow #11	CRRA	Hartford	Oil (Jet Fuel)	35.78	46.92	8/1/1970
South Meadow #12	CRRA	Hartford	Oil (Jet Fuel)	37.65	47.82	8/1/1970
South Meadow #13	CRRA	Hartford	Oil (Jet Fuel)	38.32	47.92	8/1/1970
South Meadow #14	CRRA	Hartford	Oil (Jet Fuel)	36.75	46.35	8/1/1970
Stevenson	FirstLight Hydro Generating Co.	Monroe	Hydro (Reservoir)	28.31	28.84	1/1/1919
Taftville #1- #5	FirstLight Hydro Generating Co.	Norwich	Hydro (Run of River)	0.00	0.70	1/1/1906
Torrington Terminal #10	NRG	Torrington	Oil (Jet Fuel)	15.64	20.75	8/1/1967
Toutant	Toutant Hydro Power, Inc.	Putnam	Hydro (Run of River)	0.25	0.40	2/1/1994
Tunnel #1- #2	FirstLight Hydro Generating Co.	Preston	Hydro (Run of River)	0.00	1.02	1/1/1919
Tunnel #10	FirstLight Hydro Generating Co.	Preston	Oil (Jet Fuel)	16.59	21.69	1/1/1969
Wallingford Refuse (Covanta)	CRRA	Wallingford	Refuse/Oil	5.03	2.35	3/1/1989
Waterbury Generation	Waterbury Generation	Waterbury	Gas/Oil	94.90	98.13	5/21/2009
Waterside Power	Waterside Power	Stamford	Oil	69.21	71.56	5/1/2004
Willimantic #1	Willimantic Power Corp.	Willimantic	Hydro (Run of River)	0.00	0.29	6/1/1990
Willimantic #2	Willimantic Power Corp.	Willimantic	Hydro (Run of River)	0.00	0.00	6/1/1990

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Seasonal Claimed Capability of coal fired plants	383.43	384.98
Seasonal Claimed Capability of natural gas fired plants	3466.22	3821.43
Seasonal Claimed Capability of oil fired plants	2108.90	2259.19
Seasonal Claimed Capability of hydroelectric plants	127.44	131.55
Seasonal Claimed Capability of methane fired plants	3.17	2.21
Seasonal Claimed Capability of nuclear plants	2087.85	2110.91
Seasonal Claimed Capability of refuse-fueled plants (inc. wood and tires)	148.99	144.48
Total Seasonal Claimed Capability available for dispatch (less Lake Road)	7575.48	7997.41
Total Seasonal Claimed Capability available for dispatch (with Lake Road)	8326.00	8854.75

***This data is consistent with the September 2015 ISO-NE Seasonal Claimed Capability Report**

Appendix B
Planned Transmission Lines in Connecticut

Planned/Proposed Transmission Projects in Connecticut	Voltage (kV)	Estimated In-Service Date	Length (miles)	Utility	Status
Housatonic River Crossing Project	115	2016	N/A	UI	Proposed
NERC FAC-008 Compliance Program	115	2016	N/A	UI	Planned
Milford Railroad Lines Upgrade Project	115	2016	1.3	UI	Planned
Cos Cob S/S, Greenwich - Greenwich S/S, Greenwich (new transmission)	115	2017	2.4	Eversource	Planned
Cos Cob S/S, Greenwich - Greenwich S/S, Greenwich (new transmission)	115	2017	2.4	Eversource	Planned
Frost Bridge S/S, Watertown - Campville S/S, Harwinton (new transmission)	115	2017	10.4	Eversource	Proposed
Manchester S/S, Manchester - Barbour Hill S/S, South Windsor (reconductor)	115	2017	7.6	Eversource	Proposed
Southington S/S, Southington - Lake Avenue Junction, Bristol (reconductor line section)	115	2017	5.2	Eversource	Proposed
Newington S/S, Newington - Newington Tap, Newington (reconductor line section)	115	2017	0.01	Eversource	Proposed
Newington S/S, Newington - SW Hartford S/S, Hartford (new transmission)	115	2017	4.0	Eversource	Proposed
West Brookfield S/S, Brookfield - West Brookfield Junction, Brookfield (reconductor line section)	115	2017	1.4	Eversource	Proposed
Plumtree S/S, Bethel - Brookfield Junction, Brookfield (new transmission)	115	2017	3.4	Eversource	Proposed
Wilton S/S, Wilton - Norwalk S/S, Norwalk (rebuild line section)	115	2017	1.5	Eversource	Proposed
Wilton S/S, Wilton - Ridgefield Junction, Ridgefield (reconductor line section)	115	2017	5.1	Eversource	Proposed
Peaceable S/S, Redding - Ridgefield Junction, Ridgefield (reconductor line section)	115	2017	0.04	Eversource	Proposed
Bunker Hill S/S, Waterbury - Baldwin Junction, Waterbury (reconductor line section)	115	2017	3.0	Eversource	Proposed
Frost Bridge S/S, Watertown - Campville S/S, Hawinton (line separation)	115	2017	N/A	Eversource	Proposed
Thomaston S/S, Thomaston - Campville S/S, Harwinton (line separation)	115	2017	N/A	Eversource	Proposed
Southington S/S, Southington - Todd S/S, Wolcott (replace line reactors)	115	2017	N/A	Eversource	Proposed
Southington S/S, Southington - Canal S/S, Southington (replace line reactors)	115	2017	N/A	Eversource	Proposed
South Meadow S/S, Hartford - Bloomfield S/S, Bloomfield (loop in and out of Rood Ave. S/S)	115	2017	N/A	Eversource	Proposed
Bloomfield S/S, Bloomfield - South Meadow S/S, Hartford (line separation)	115	2017	N/A	Eversource	Proposed
Bloomfield S/S, Bloomfield - Rood Avenue S/S, Windsor (line separation)	115	2017	N/A	Eversource	Proposed
Bloomfield S/S, Bloomfield - N. Bloomfield S/S, Bloomfield (line separation)	115	2017	N/A	Eversource	Proposed
South Meadow S/S, Hartford - SW Hartford S/S, Hartford (install a series reactor)	115	2017	N/A	Eversource	Proposed
Bloomfield S/S, Bloomfield - N. Bloomfield S/S, Bloomfield (line separation)	115	2017	N/A	Eversource	Proposed
N. Bloomfield S/S, Bloomfield - NW Hartford S/S, Hartford (line separation)	115	2017	N/A	Eversource	Proposed
Branford S/S, Branford - Branford RR S/S, Branford (line separation)	115	2017	N/A	Eversource	Proposed
Branford S/S, Branford - North Haven S/S, North Haven (line separation)	115	2017	N/A	Eversource	Proposed
Middletown S/S, Middletown - Pratt & Whitney S/S, Middletown (line separation)	115	2017	N/A	Eversource	Proposed
Middletown S/S, Middletown - Haddam S/S, Haddam (line separation)	115	2017	N/A	Eversource	Proposed
Beacon Falls S/S, Beacon Falls - Indian Well S/S (UI), Derby (loop in and out of Pootatuck S/S)	115	2017	N/A	Eversource	Proposed
Beacon Falls S/S, Beacon Falls - Devon S/S, Milford (loop in and out of Pootatuck S/S)	115	2017	N/A	Eversource	Proposed
Frost Bridge S/S, Watertown - Baldwin S/S, Waterbury (loop in and out of Bunker Hill S/S)	115	2017	N/A	Eversource	Proposed
Frost Bridge S/S, Watertown - Stevenson S/S, Monroe (loop in and out of Bunker Hill S/S)	115	2017	N/A	Eversource	Proposed
Beseck S/S, Wallingford - East Devon S/S, Milford (line separation)	115	2017	N/A	Eversource	Proposed

Appendix B
Planned Transmission Lines in Connecticut

Southington S/S, Southington - Mix Avenue S/S (UI), Hamden (line separation)	115	2017	N/A	Eversource	Proposed
Southington S/S, Southington - June Street S/S (UI), Woodbridge (line separation)	115	2017	N/A	Eversource	Proposed
Plumtree S/S, Bethel - Stony Hill S/S, Brookfield (line reconfiguration)	115	2017	N/A	Eversource	Proposed
Plumtree S/S, Bethel - Bates Rock S/S, Southbury (line reconfiguration)	115	2017	N/A	Eversource	Proposed
West Brookfield S/S, Brookfield - Stony Hill S/S, Brookfield (line reconfiguration)	115	2017	N/A	Eversource	Proposed
West Brookfield S/S, Brookfield - Shepaug, Southbury (line reconfiguration)	115	2017	N/A	Eversource	Proposed
South Meadow S/S, Hartford - Bloomfield S/S, Bloomfield (rebuild line section)	115	2017	N/A	Eversource	Proposed
Bridgeport-Stratford Railroad Lines Upgrade Project	115	2018	N/A	UI	Proposed
Baird-Housatonic River Railroad Lines Upgrade Project	115	2019	N/A	UI	Proposed
Card S/S, Lebanon - Lake Road S/S, Killingly (new transmission) (1)	345	2015	29.3	Eversource	Under Construction
Lake Road S/S, Killingly - CT/RI Border, Thompson (new transmission) (1)	345	2015	7.6	Eversource	Under Construction
Frost Bridge S/S, Watertown - North Bloomfield S/S, Bloomfield (new transmission) (2)	345	2017	35.4	Eversource	Planned
(1) Related to Interstate Reliability NEEWS Project					
(2) Related to Central Connecticut Reliability NEEWS project					

Appendix C
Planned Substations

Appendix C: Planned Substation and Switching Station Projects	Voltage (kV)	Est. In-Service Date	Utility	Status	Project
Pootatuck S/S, Shelton	115	2015	UI	Under Construction	Install a new substation
Bulls Bridge S/S, New Milford	115	2015	Eversource	Proposed	Replace transformer
Newton S/S, Newtown	115	2015	Eversource	Under Construction	Add a circuit breaker
Montville S/S, Montville	345/115	2015	Eversource	Under Construction	Replace both autotransformers
Sackett S/S, North Haven	115	2015	UI	Planned	Replace control house
Canal S/S, Southington	115	2016	Eversource	Concept	Add a distribution transformer
Tracy S/S, Putnam	115	2016	Eversource	Concept	Add a distribution transformer and a circuit breaker
Hawthorne S/S, Fairfield	115	2016	UI	Proposed	Add capacitor bank(s)
Frost Bridge S/S, Watertown	345/115	2017	Eversource	Planned	Central Connecticut Reliability Project
Greenwich S/S, Greenwich	115	2017	Eversource	Planned	Add a new substation
Beseck S/S, Wallingford	115	2017	Eversource	Planned	Add a second variable shunt reactor
North Bloomfield S/S, Bloomfield	345	2017	Eversource	Planned	Central Connecticut Reliability Project
Barbour Hill S/S, South Windsor	345/115	2017	Eversource	Proposed	Add an autotransformer
Manchester S/S, Manchester	345	2017	Eversource	Proposed	Add a circuit breaker
Campville S/S, Harwinton	115	2017	Eversource	Proposed	Add a circuit breaker
Chippen Hill S/S, Bristol	115	2017	Eversource	Proposed	Upgrade terminal equipment
Southington S/S, Southington	115	2017	Eversource	Proposed	Replace breaker with series reactor and add a new control house
Southington S/S, Southington	345	2017	Eversource	Proposed	Add a circuit breaker
Newington S/S, Newington	115	2017	Eversource	Proposed	Reconfigure substation
Berlin S/S, Berlin	115	2017	Eversource	Proposed	Reconfigure substation and add two breakers
SW Hartford S/S, Hartford	115	2017	Eversource	Proposed	Upgrade terminal equipment
Rood Avenue S/S, Windsor	115	2017	Eversource	Proposed	Reconfigure substation
Bloomfield S/S, Bloomfield	115	2017	Eversource	Proposed	Add a circuit breaker
North Bloomfield S/S, Bloomfield	115	2017	Eversource	Proposed	Add a circuit breaker
Haddam S/S, Haddam	345/115	2017	Eversource	Planned	Add an autotransformer and reconfiguration
Haddam Neck S/S, Haddam	345	2017	Eversource	Proposed	Upgrade terminal equipment
Beseck S/S, Wallingford	345	2017	Eversource	Proposed	Upgrade terminal equipment
Dooley S/S, Middletown	115	2017	Eversource	Proposed	Upgrade terminal equipment
Portland S/S, Portland	115	2017	Eversource	Proposed	Upgrade terminal equipment
Green Hill S/S, Madison	115	2017	Eversource	Proposed	Reconfigure substation and install a capacitor bank
Hopewell S/S, Glastonbury	115	2017	Eversource	Proposed	Install a capacitor bank
Westside S/S, Middletown	115	2017	Eversource	Proposed	Install a capacitor bank
Branford S/S, Branford	115	2017	Eversource	Proposed	Add a series breaker
Newton S/S, Newtown	115	2017	Eversource	Proposed	Upgrade terminal equipment and replace both distribution transformers
Bunker Hill S/S, Waterbury	115	2017	Eversource	Proposed	Rebuild substation
Baldwin S/S, Waterbury	115	2017	Eversource	Proposed	Close circuit breaker
Stony Hill S/S, Brookfield	115	2017	Eversource	Proposed	Add a synchonous condenser and relocate a capacitor bank
West Brookfield S/S, Brookfield	115	2017	Eversource	Proposed	Install two capacitor banks
Freight S/S, Waterbury	115	2017	Eversource	Proposed	Replace two circuit breakers
Plumtree S/S, Bethel	115	2017	Eversource	Proposed	Add a circuit breaker and relocate a capacitor bank
Rocky River S/S, New Milford	115	2017	Eversource	Proposed	Reduce capacitor banks
Oxford S/S, Oxford	115	2017	Eversource	Proposed	Install a capacitor bank
Baird S/S, Stratford	115	2017	UI	Proposed	Rebuild substation
Mix Avenue S/S, Hamden	115	2017	UI	Planned	Modify substation
Ansonia S/S, Ansonia	115	2017	UI	Proposed	Add capacitor bank(s)
Pootatuck S/S, Shelton	115	2017	UI	Proposed	Modify substation
East Devon S/S, Milford	115	2017	Eversource	Planned	Add a series breaker
Cos Cob S/S, Greenwich	115	2017	Eversource	Planned	Add a circuit breaker
Burrville S/S, Torrington	115	2018	Eversource	Concept	Install a new substation
Scitico S/S, Enfield	115	2018	Eversource	Concept	Add a distribution transformer
Old Town S/S, Bridgeport	115	2019	UI	Planned	Rebuild substation