Independent Assessment of Conservation and Energy Efficiency Potential for Connecticut and the Southwest Connecticut Region

FINAL REPORT

For the Connecticut ECMB

April 2004

Prepared for the

Energy Conservation Management Board

by:

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and

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This final report provides valuable and up-to-date energy efficiency potential information for decision-makers in Connecticut, and it will also be useful to energy efficiency program designers and implementers in other States who need a template for their own energy efficiency potential studies.

Richard F. Spellman, Vice President
GDS Associates, Inc.
April 5, 2004

1.0 EXECUTIVE SUMMARY

This study estimates the maximum achievable cost effective potential for electric energy and peak demand savings from energy-efficiency measures[1] in the geographic region of Connecticut served by United Illuminating and Connecticut Light and Power Company.[2] Energy-efficiency opportunities typically are physical, long-lasting changes to buildings and equipment that result in decreased energy use while maintaining the same or improved levels of energy service. The study shows that there is significant savings potential in Connecticut for implementation of additional and long-lasting energy-efficiency measures. Capturing the maximum achievable cost effective potential for energy efficiency in Connecticut would reduce peak demand by 13% (908 MW) and electric energy use by 13% (4,466 GWh) by 2012, resulting in zero growth in electric load from 2003 through 2012. Load reductions from load management and load response measures, which were not analyzed in this study, would be in addition to the energy efficiency savings.

1.1 Study Scope

The objective of the study was to estimate the maximum achievable cost effective potential for energy conservation and energy efficiency resources over the ten-year period from 2003 through 2012 in three geographic areas:

- Connecticut statewide[3]
- The 52 towns in the constrained area of Southwest Connecticut, and
- The 16 critical constrained area towns in Southwest Connecticut (the Norwalk-Stamford area).

The definitions used in this study for energy efficiency potential estimates are the following:

- **Technical potential** is defined in this study as the complete penetration of all measures analyzed in applications where they were deemed technically feasible from an engineering perspective.

- **Maximum achievable potential** is defined as the maximum penetration of an efficient measure that would be adopted given unlimited funding, and by determining the maximum market penetration that can be achieved with a concerted, sustained campaign involving highly aggressive programs and market intervention. The term "maximum" refers to

[1] This report estimates the potential for energy efficiency and conservation only. It does not estimate the potential of other resources.
[2] It is important to note that peak load for the geographic area served by the Connecticut Municipal Electric Energy Cooperative (CMEEC) has not been included in this study, nor does this study estimate the energy efficiency potential in the CMEEC service area.
[3] "Statewide" in this study refers to the combination of the CL&P and UI service territories.

efficiency measure penetration, and means that the GDS Team has based our estimates of efficiency potential on the maximum realistic penetration that can be achieved by 2012. The term "maximum" does not apply to other factors used in developing these estimates, such as measures energy savings or measure lives.

- **Maximum achievable cost effective potential** is defined as the potential for maximum penetration of energy efficient measures that are cost effective according to the Total Resource Cost test, and would be adopted given unlimited funding, and by determining the maximum market penetration that can be achieved with a concerted, sustained campaign involving highly aggressive programs and market interventions.[4]

The main outputs of this study are summary data tables and graphs reporting the total cumulative maximum achievable cost effective potential for energy efficiency over the ten-year period, and the annual incremental achievable potential and cumulative potential, by year, for 2003 through 2012. Appendix G of the final report also provides estimates of the remaining resource potential available after 2012.

This study makes use of over 200 existing studies conducted throughout the US on the potential savings and penetration of energy efficiency measures. These other existing studies provided an extensive foundation for estimates of energy savings potential in existing residential, commercial and industrial facilities. Energy savings potential for almost 300 efficiency measures were assessed during the course of this project. This study does not estimate the potential of other resources.

1.2 Key Findings

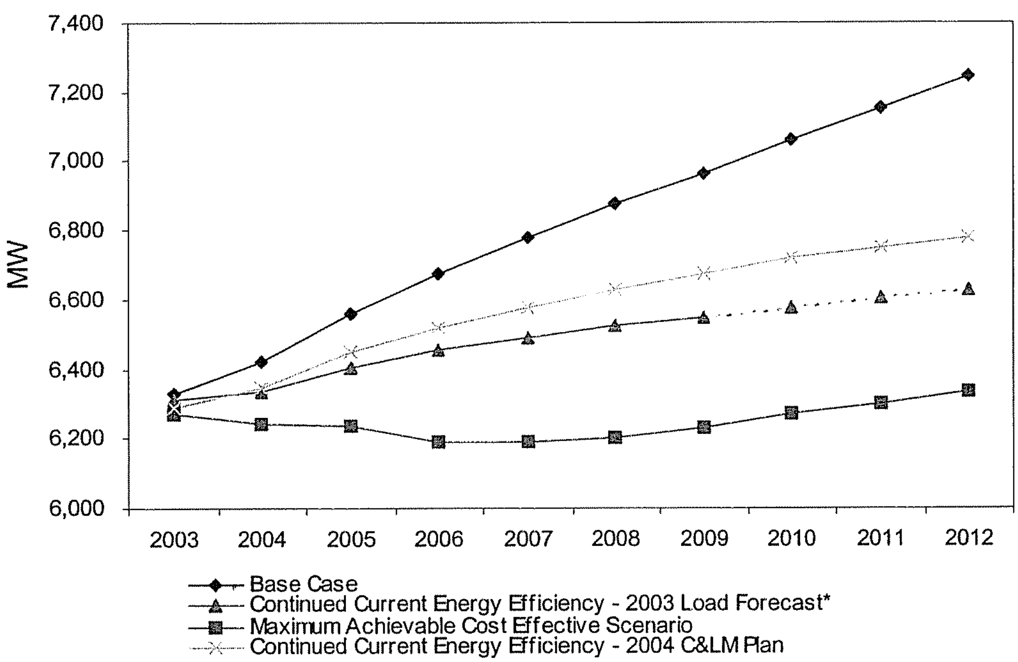
If all energy efficiency measures analyzed in this study were implemented immediately where technically feasible, we estimate that overall peak demand savings would be 1,748 megawatts (MW) on a statewide basis (a **24%** reduction in the projected 2012 peak load of 7,243 MW). The peak load in 2012 for the CL&P and UI service areas without energy efficiency programs is 7,243 MW. If all measures that are cost effective were implemented, and consumer acceptance trends and the timing of equipment replacements in the market are factored in, the maximum achievable cost effective potential peak demand savings amount to 908 MW in 2012 (a **13%** reduction in the projected 2012 peak

[4] This is the definition of "maximum achievable potential" provided on page 2 of the ECMB's RFP for this study. The term "maximum" refers to efficiency measure penetration, and means that the GDS Team has based our estimates of efficiency potential on the maximum realistic penetration that can be achieved by 2012. The term "maximum" does not apply to other factors used in developing these estimates, such as measures energy savings or measure lives.

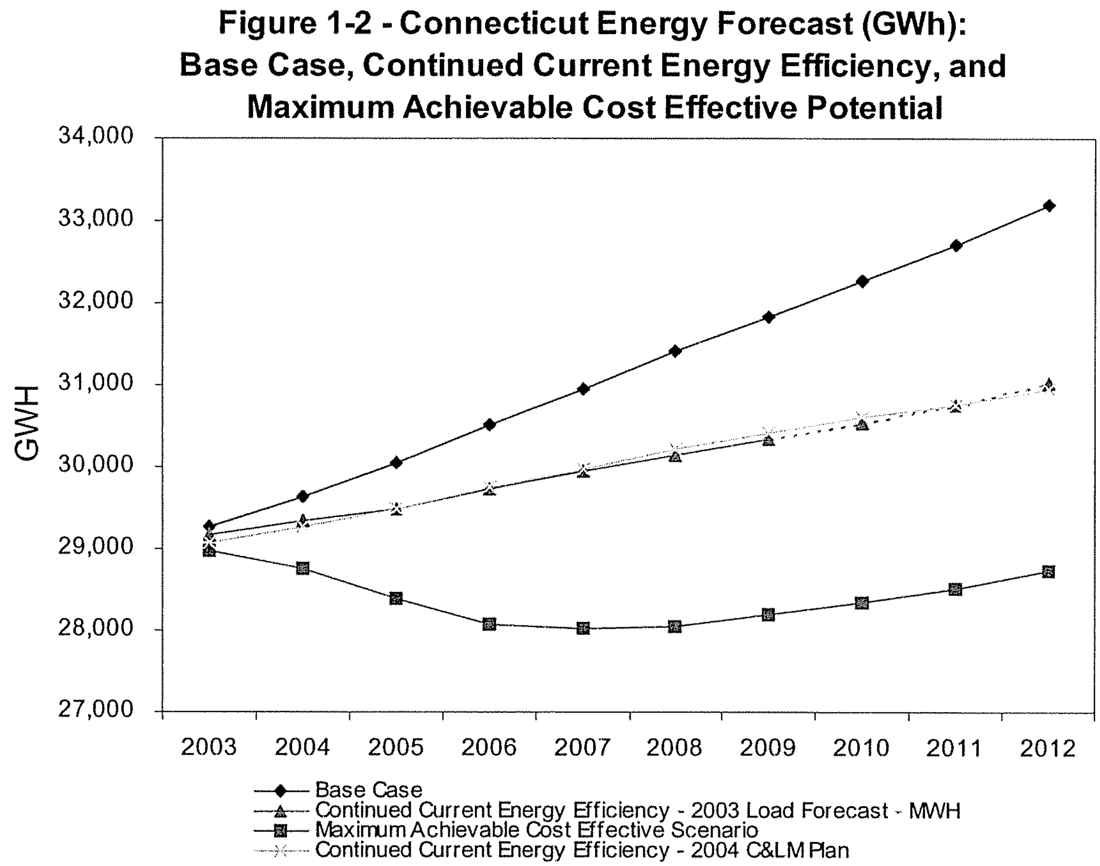
load for the regions of Connecticut served by CL&P and UI). It is important to note that this 908 MW potential reduction in the projected 2012 peak load for these regions of the State does not include impacts of any load management or load response programs.

Figure 1-1 below compares (1) a peak load (MW) forecast for the State of Connecticut (CL&P and UI service areas only) assuming complete implementation of the maximum achievable cost effective potential scenario for energy efficiency, to (2) a "Base Case" scenario (the Base Case is the load forecast for the State of Connecticut that includes naturally occurring energy efficiency, but no "Public Benefits" funded conservation and load management programs), to (3) Connecticut's continued current level of energy efficiency efforts as stated in the utilities' 2003 load forecasts (equivalent to annual energy efficiency program funding of $72.5 million) and to (4) Connecticut's continued current level of energy efficiency efforts as stated in the utilities' 2004 C&LM Plans. Figure 1-2 provides a similar comparison for energy (GWh) forecasts for the State.

Figure 1-1 Connecticut Summer Peak Load Forecast (MW): Base Case, Continued Current Energy Efficiency, and Maximum Achievable Cost Effective Potential



*For the "Continued Energy Efficiency" scenario from the 2003 Load Forecast, values for the CL&P service territory for years 2009 to 2012 are estimates based on the average of prior year values.



*For the "Continued Energy Efficiency" scenario from the 2003 Load Forecast, values for the CL&P service territory for years 2009 to 2012 are estimates based on the average of prior year values.

Table 1-1 below provides a comparison of the estimates of the MW and GWh savings, percent savings and load growth by geographic region of the State for maximum achievable cost effective potential savings and technical potential savings.

Table 1-1 Load Reductions (MW) and Energy Savings (GWh), % Savings, and Load Growth by Region

Reductions in Summer Peak Load (MW)

Region		Base Case (No C&LM)		Achievable Cost-Effective Potential			Technical Potential		
	Year	Load (MW)	Load Growth	Savings (MW)	% of Load in Year	Load Growth	Savings (MW)	% of Load in Year	Load Growth
Statewide	2007	6,776	1.7%	588	8.7%	-0.3%	1,160	17.1%	-2.5%
	2012	7,243	1.5%	908	12.5%	0.1%	1,748	24.1%	-1.4%
SWCT (52 Towns)	2007	3,872	2.2%	342	8.8%	0.1%	674	17.4%	-2.1%
	2012	4,209	1.9%	527	12.5%	0.5%	1,016	24.1%	-1.0%
Norwalk-Stamford	2007	1,378	2.2%	122	8.8%	0.1%	241	17.4%	-2.1%
	2012	1,502	1.9%	188	12.5%	0.6%	363	24.1%	-0.9%

Energy Savings (GWh)

Region		Base Case (No C&LM)		Achievable Cost-Effective Potential			Technical Potential		
	Year	Load (GWh)	Load Growth	Savings (GWh)	% of Load in Year	Load Growth	Savings (GWh)	% of Load in Year	Load Growth
Statewide	2007	30,961	1.4%	2,946	9.5%	-0.8%	5,339	17.2%	-2.9%
	2012	33,205	1.4%	4,466	13.4%	-0.1%	8,021	24.2%	-1.5%
SWCT (52 Towns)	2007	18,283	1.8%	1,762	9.6%	-0.5%	3,193	17.5%	-2.5%
	2012	19,856	1.7%	2,670	13.4%	0.2%	4,796	24.2%	-1.2%
Norwalk-Stamford	2007	6,402	1.8%	618	9.7%	-0.5%	1,121	17.5%	-2.5%
	2012	6,971	1.8%	938	13.4%	0.3%	1,684	24.2%	-1.1%

1.3 Future Program Investment Scenarios

Achieving the maximum achievable cost effective energy efficiency savings by 2012 requires programmatic support. Programmatic support includes financial incentives to customers, marketing, administration, planning, and program evaluation activities provided to ensure the delivery of energy efficiency products and services to consumers. CL&P and UI spent $66 million on electric energy efficiency programs in 2002.[5] The 2004 C&LM Plan, filed in November 2003, estimated that CL&P and UI would spend about $46 million on energy efficiency programs (including allocated administration and other program costs) in 2004.[6] The reduction in energy efficiency funding from 2002 is due to the State of Connecticut reallocating C&LM funding to assist with deficit reduction.

As shown in Figure 1-1 and Table 1-1, the statewide maximum achievable cost effective peak demand savings is 908 MW (13%) in 2012. Using two methods, it is estimated that approximately $82 million to $148 million annually (in 2003 dollars) in total energy efficiency program costs would need to be invested over the next decade to achieve these savings.[7] This funding level for energy efficiency programs would be about 177% to 322% of the funding level in the 2004 C&LM Plan, and 124% to 224% of 2002 energy efficiency expenditures. With implementation of the maximum achievable cost-effective energy efficiency potential, we estimate that growth in statewide peak demand could be cut from about 1.5% per year to zero. The Total Resource Costs to achieve the maximum achievable cost effective savings are provided in Section 1.4 below.

GDS estimates that Connecticut utility costs for program planning, administration, marketing, reporting and evaluation ("other program costs") will be 25% of efficiency measure incremental costs in the maximum achievable energy efficiency scenario. For further information on this estimate, see the discussion in Section 3.5, the uncertainty analysis in Section 3.8, and Appendix H.

1.4 Present Value of Savings and Costs (in millions of 2003 $)

The results of this study demonstrate that energy-efficiency resources can play a significantly expanded role in Connecticut's electricity resource mix over the next

[5] Total Conservation and Load Management spending in 2002 was $87 million, with $66 million for energy efficiency, $9 million for load management and other programs, and $12 million for state facilities (a direct legislative allocation to the Department of Public Works).

[6] The total C&LM budget in 2004 is $90 million, with $49.9 million allocated to C&LM programs administered by the electric utilities, $12 million allocated to the State General Fund (PA 03-2), and $28.1 million allocated for securitization. Of the $49.9 million for C&LM programs, $46 million is budgeted for energy efficiency programs.

[7] See the analysis in Section 3.5 and Appendix I.

decade. Table 1-2 below shows the present value[8] of benefits and costs associated with implementing the maximum achievable potential energy savings in the State of Connecticut. The net present savings to citizens of the State for statewide implementation of programs are almost **$1.8 billion.**

[8] The term "present value" refers to a mathematical technique used to convert a future stream of dollars into their equivalent value in today's dollars.

Table 1-2 - Sector Level Benefit/Cost Ratios For All Measures with a Benefit/Cost Ratio of Greater than 1.0 Using the Total Resource Cost Test

State of Connecticut

	Total Resource Benefits, Costs, and Net Benefits			
	Present Value Benefit	Present Value Cost	PV of Net Benefits	Benefit-Cost Ratio
Commercial Sector	$1,411,460,062	$358,414,779	$1,053,045,283	3.94
Residential Sector	$1,062,432,855	$390,141,582	$672,291,273	2.72
Industrial Sector	$341,431,615	$79,413,671	$262,017,944	4.30
All Sectors	$2,815,324,532	$827,970,032	$1,987,354,500	3.40
O&M Benefits (incl. avoided inc. bulb purchases)		$(80,156,204)		
Other Program Costs (25%)*		$206,992,508		
All Sectors	$2,815,324,532	$954,806,336	$1,780,361,992	2.95

*Other program costs estimated as 25% of total incremental measure costs, net of O&M benefits.
Values shown include effects of Supply Curve "Stacking" and were calculated using version 9 of the "NSTAR" model, with CL&P avoided cost estimates.

Southwest Connecticut (SWCT)

	Total Resource Benefits, Costs, and Net Benefits			
	Present Value Benefit	Present Value Cost	PV of Net Benefits	Benefit-Cost Ratio
Commercial Sector	$844,015,610	$214,322,514	$629,693,096	3.94
Residential Sector	$635,306,615	$233,294,299	$402,012,316	2.72
Industrial Sector	$204,167,033	$47,487,265	$156,679,768	4.30
All Sectors	$1,683,489,257	$495,104,077	$1,188,385,180	3.40
O&M Benefits (incl. avoided inc. bulb purchases)		$(47,931,280)		
Other Program Costs (25%)*		$123,776,019		
All Sectors	$1,683,489,257	$570,948,816	$1,064,609,161	2.95

*Other program costs estimated as 25% of total incremental measure costs, net of O&M benefits.
Values shown include effects of Supply Curve "Stacking" and were calculated using version 9 of the "NSTAR" model, with CL&P avoided cost estimates.

SWCT/CT Ratio *59.8% (Based on GWh Sales from Table A-26)*

Norwalk / Stamford Region of Connecticut

	Total Resource Benefits, Costs, and Net Benefits			
	Present Value Benefit	Present Value Cost	PV of Net Benefits	Benefit-Cost Ratio
Commercial Sector	$296,339,205	$75,249,987	$221,089,219	3.94
Residential Sector	$223,060,160	$81,911,100	$141,149,060	2.72
Industrial Sector	$71,684,333	$16,673,078	$55,011,255	4.30
All Sectors	$591,083,699	$173,834,165	$417,249,534	3.40
O&M Benefits (incl. avoided inc. bulb purchases)		$(16,828,975)		
Other Program Costs (25%)*		$43,458,541		
All Sectors	$591,083,699	$200,463,731	$373,790,993	2.95

*Other program costs estimated as 25% of total incremental measure costs, net of O&M benefits.
Values shown include effects of Supply Curve "Stacking" and were calculated using version 9 of the "NSTAR" model, with CL&P avoided cost estimates.

Norwalk/Stamford *21.0% (Based on GWh Sales from Table A-29)*

Table 1-2 also provides the Total Resource Cost (TRC) Test benefit/cost ratio for the overall maximum achievable cost effective portfolio of energy efficiency measures, and the benefit/cost ratio by major market sector. The Total Resource Cost (TRC) Test is a standard benefit-cost test used by many of the public utilities commissions in the US and other organizations to compare the value of the avoided energy production and power plant construction to the costs of energy-efficiency measures and program activities necessary to deliver them. The value of both energy savings and peak demand reductions are incorporated into the TRC test.

1.5 Definition of the Total Resource Cost Test

The Total Resource Cost Test measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs.[9]

The test is applicable to conservation, load management, and fuel substitution programs. For fuel substitution programs, the test measures the net effect of the impacts from the fuel not chosen versus the impacts from the fuel that is chosen as a result of the program. TRC test results for fuel substitution programs should be viewed as a measure of the economic efficiency implications of the total energy supply system (gas and electric).

Benefits and Costs: The TRC test represents the combination of the effects of a program on both the customers participating and those not participating in a program. In a sense, it is the summation of the benefit and cost terms in the Participant and the Ratepayer Impact Measure tests, where the revenue (bill) change and the incentive terms intuitively cancel (except for the differences in net and gross savings).

The benefits calculated in the Total Resource Cost Test are the avoided supply costs, the reduction in transmission, distribution, generation, and capacity costs valued at marginal cost for the periods when there is a load reduction. The avoided supply costs should be calculated using net program savings, savings net of changes in energy use that would have happened in the absence of the program. For fuel substitution programs, benefits include the avoided device costs and avoided supply costs for the energy, using equipment not chosen by the program participant. This study does not include the benefits that could be realized from reducing hourly market clearing prices, reducing risk, increasing energy security and improving electric grid stability. While not the focus of this

[9] California Public Utilities Commission, California Standard Practice Manual, Economic Analysis of Demand-Side Management Programs and Projects, October 2001, page 18. A variant on the TRC test is the Societal Test. The Societal Test differs from the TRC test in that it includes the effects of externalities (e.g., environmental, national security), excludes tax credit benefits, and uses a different (societal) discount rate.

study, others have documented these benefits, particularly reducing the market-clearing price.

The costs in this test are the program costs paid by the utility and the participants plus the increase in supply costs for the periods in which load is increased. Thus all equipment costs, installation, operation and maintenance, cost of removal (less salvage value), and administration costs, no matter who pays for them, are included in this test. Any tax credits are considered a reduction to costs in this test.

1.6 Sources of Maximum Achievable Efficiency Potential

Table 1-3 provides information on the sources of the maximum achievable energy efficiency potential from early replacement, retrofit and replace-on-burnout markets. The majority (55%) of the statewide savings of 908 MW in 2012 come from retrofit measures (499 MW). The second largest contributor to savings is from replace-on-burnout measures (339 MW). Early replacement measures provide the remaining 69 MW of savings by 2012.

1.7 TRC Cost per kWh Saved Information

Table 1-4 provides a summary of the TRC cost per lifetime kWh and kW saved for the maximum achievable energy efficiency portfolio of measures. These cost data include participant costs and utility costs. The overall cost of the maximum achievable energy efficiency portfolio of measures is $.0137 per lifetime kWh saved (in 2004 dollars).

TABLE 1-3 INDEPENDENT ASSESSMENT OF CONSERVATION AND ENERGY EFFICIENCY POTENTIAL FOR CONNECTICUT AND THE SOUTHWEST CONNECTICUT REGION
FOR MEASURES WITH A TRC BENEFIT COST RATIO OF GREATER THAN 1.0
October 14, 2003

Added Detail Based on Table 1-1

Region	Year	Maximum Achievable Cost-Effective Potential Savings (MW)			
		Commercial	Residential	Industrial	All Sectors
Statewide	2007	387	140	61	588
	2012	575	240	93	908
Early Replacements	2007	69	0	0	69
	2012	69	0	0	69
Retrofit Measures	2007	229	69	52	350
	2012	327	99	74	499
Replace-On-Burnout (Cycle) Measures	2007	90	71	9	170
	2012	179	141	19	339
SWCT (52 Towns)	2007	225	81	36	342
	2012	334	139	54	527
Early Replacements	2007	40	0	0	40
	2012	40	0	0	40
Retrofit Measures	2007	133	40	30	203
	2012	190	57	43	290
Replace-On-Burnout (Cycle) Measures	2007	52	41	5	99
	2012	104	82	11	197
Norwalk-Stamford	2007	80	29	13	122
	2012	119	50	19	188
Early Replacements	2007	14	0	0	14
	2012	14	0	0	14
Retrofit Measures	2007	47	14	11	73
	2012	68	20	15	104
Replace-On-Burnout (Cycle) Measures	2007	19	15	2	35
	2012	37	29	4	70

Added Detail Based on Table 1-1

Region	Year	Maximum Achievable Cost-Effective Potential Savings (GWh)			
		Commercial	Residential	Industrial	All Sectors
Statewide	2007	1,405	1,057	484	2,946
	2012	2,088	1,655	723	4,466
Early Replacements	2007	242	0	0	242
	2012	242	0	0	242
Retrofit Measures	2007	839	805	427	2,072
	2012	1,199	1,150	611	2,960
Replace-On-Burnout (Cycle) Measures	2007	324	252	56	632
	2012	647	504	112	1,264
SWCT (52 Towns)	2007	840	632	289	1,762
	2012	1,249	989	432	2,670
Early Replacements	2007	145	0	0	145
	2012	145	0	0	145
Retrofit Measures	2007	502	482	256	1,239
	2012	717	688	365	1,770
Replace-On-Burnout (Cycle) Measures	2007	194	151	34	378
	2012	387	302	67	756
Norwalk-Stamford	2007	295	222	102	618
	2012	438	347	152	938
Early Replacements	2007	51	0	0	51
	2012	51	0	0	51
Retrofit Measures	2007	176	169	90	435
	2012	252	242	128	622
Replace-On-Burnout (Cycle) Measures	2007	68	53	12	133
	2012	136	106	24	265

TABLE 1-4 INDEPENDENT ASSESSMENT OF CONSERVATION AND ENERGY EFFICIENCY POTENTIAL FOR CONNECTICUT AND THE SOUTHWEST CONNECTICUT REGION
FOR MEASURES WITH A TRC BENEFIT COST RATIO OF GREATER THAN 1.0
October 14, 2003

State of Connecticut - Cost Per Lifetime Savings Values

	Benefit-Cost Ratio	Levelized Cost Per Lifetime kWh Saved	Levelized Cost Per Lifetime kW Saved	Cost Per $ Unit of Benefits
Commercial Sector	3.97	$0.0136	$47.33	$0.25
Residential Sector	3.11	$0.0106	$79.76	$0.32
Industrial Sector	6.65	$0.0070	$54.51	$0.15
All Sectors	3.76	$0.0114	$58.77	$0.27
All Sectors (Including Other Programs Costs*)	3.14	$0.0137	$70.52	$0.32

*Other program costs estimated as 20% of total incremental measure costs.

2.0 INTRODUCTION

This section of the report presents the original objectives of the study, an overview of the efficiency measures examined, the organization of this report, and information on how the findings of this report can be used.

2.1 Objective of this study

The objective of this study is to estimate the maximum achievable cost effective potential for energy conservation and energy efficiency resources over the ten-year period from 2003 through 2012 in three geographic areas:

- Connecticut statewide
- The 52 towns in the constrained area of Southwest Connecticut, and
- The 16 critical constrained area towns in Southwest Connecticut (the Norwalk-Stamford area).

For purposes of this study, the maximum achievable technical potential is defined as the maximum penetration of energy efficiency measures that would be adopted given unlimited funding, and assuming a concerted, sustained campaign involving highly aggressive programs and market interventions.[10]

The main outputs of this study are summary data tables and graphs reporting the total cumulative maximum achievable cost effective potential over the ten-year period, and the annual incremental achievable potential and cumulative potential, by year, for 2003 through 2012. Appendix G of this final report also provides estimates of the remaining resource potential available after 2012 for energy efficiency investments assumed to be made prior to 2013.

The achievable potential information provided in this study can be used to develop and revise the State's energy efficiency policies, to plan and implement programs, to allocate program budgets and resources, and to target energy conservation and energy efficiency efforts more accurately to those market segments with the largest cost-effective achievable potential.

2.2 Energy Efficiency Measures Examined

This study examined the maximum achievable energy efficiency potential for over 270 energy efficiency measures across the residential, commercial and industrial sectors. A list of energy efficiency measures to be included in this study was developed by starting with the list of measures included in other recent technical and achievable potential studies that have been conducted in New England, New York, Wisconsin, California and the Southwest. The members of the Connecticut

[10] This is the definition of "maximum achievable potential" provided on page 2 of the ECMB's RFP for this study.

Energy Conservation Management Board (ECMB) then reviewed this measure list, and several other efficiency measures were added to the list to be assessed in this project. Table 2-1 below shows the number of efficiency measures included in this study by sector.

Table 2-1 – Efficiency Measures Included In Study by Sector

Sector	Number of Efficiency Measures In Study
Residential	68
Commercial	104
Industrial	106
Total	278

Table 2-2 below shows the number of resource materials used in developing the major inputs for this study.

Table 2-2 - Data Sources for CT Potential Study

Load Forecasts	12
Residential Sector Data Sources	35
Commercial/Industrial Sector Data Sources	21
Recent Technical Potential Studies	11
Connecticut Saturation Studies	4
State, Regional, and National Studies	15
Electronic Files Supplied by UI	17
Electronic Files Supplied by CL&P	38
Industry References	43
Other Data Sources	4
Total Data Sources	200

2.3 Organization of the Report

This report is organized into six sections as follows:

- Section 1 – Executive Summary
- Section 2 – Introduction
- Section 3 – Key Findings
- Section 4 – Methodology
- Section 5 – Load Forecasts for the State of Connecticut
- Section 6 – Sector Specific Maximum Achievable Potential in Connecticut

2.4 How This Report Can Be Used

The findings in this report can be used as a foundation for the planning and implementation of energy efficiency programs in the State of Connecticut for the next decade. Listed below are five examples of how the findings and data in this report can be useful to decision-makers and legislators.

- The report identifies the amount of energy efficiency potential that remains in the State of Connecticut and pinpoints markets and cost effective efficiency measures that can provide the most savings at the lowest cost.

- The report will be useful to legislators so they can understand the return on investment they can achieve for every "public benefits" dollar invested in energy efficiency in Connecticut.

- The data in the report for the costs, energy savings and environmental benefits of energy efficiency measures are very useful for making decisions on which programs should be done first, which energy efficiency technologies offer the most savings, which technologies are most cost effective, and how the environment can benefit from aggressive programs.

- The reports provide the well-documented evidence of the large magnitude of net present value savings to the State available from energy efficiency over the next decade – almost 2 billion dollars.

- The report provides useful comparisons to similar studies in other States to show legislators and key decision-makers that the remaining efficiency potential in the State is a huge and valuable resource, waiting to be tapped.

This study finds that substantial cost effective energy efficiency potential (over 900 MW by 2012) remains to be tapped in the State of Connecticut. This study does not seek to answer the larger resource-planning question of exactly how much energy efficiency ought to be purchased as part of an overall portfolio of electric resources for the State. This study, however, is a critical source of information for policy-makers and decision-makers in Connecticut who are participating in funding decisions for existing and future energy efficiency programs in the State funded with public benefits dollars.

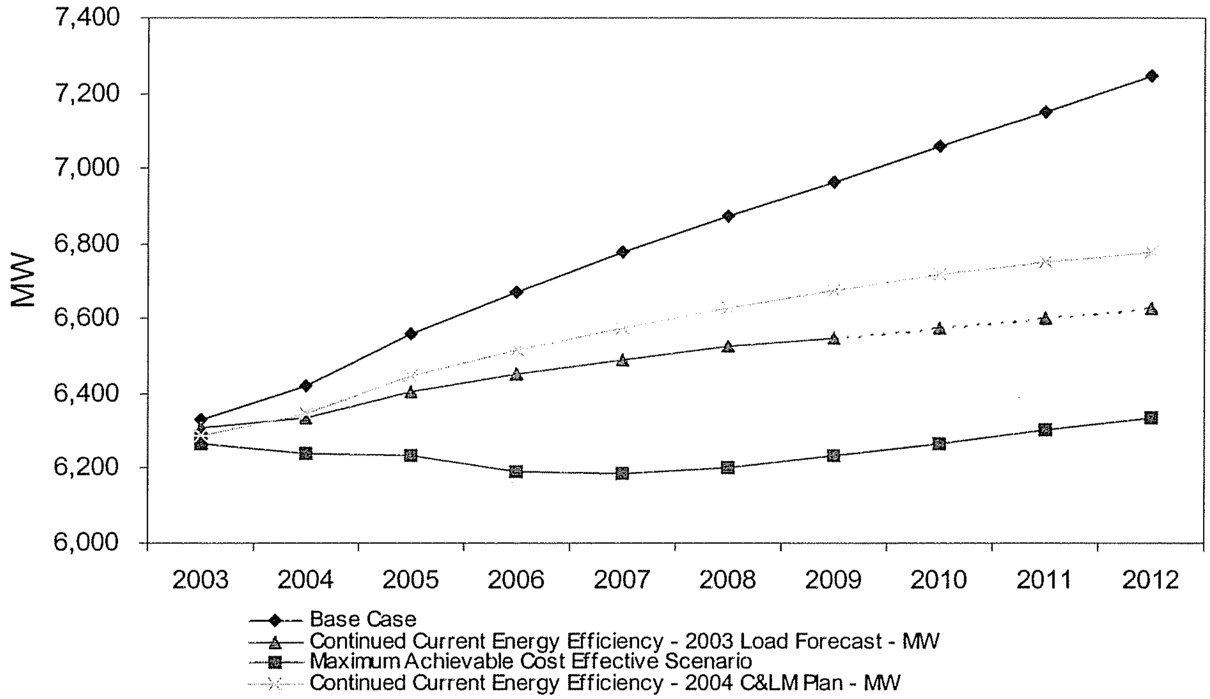
3.0 Key Findings

This section presents the statewide maximum achievable cost effective potential findings first, followed by the findings for the two southwest Connecticut sub-areas.

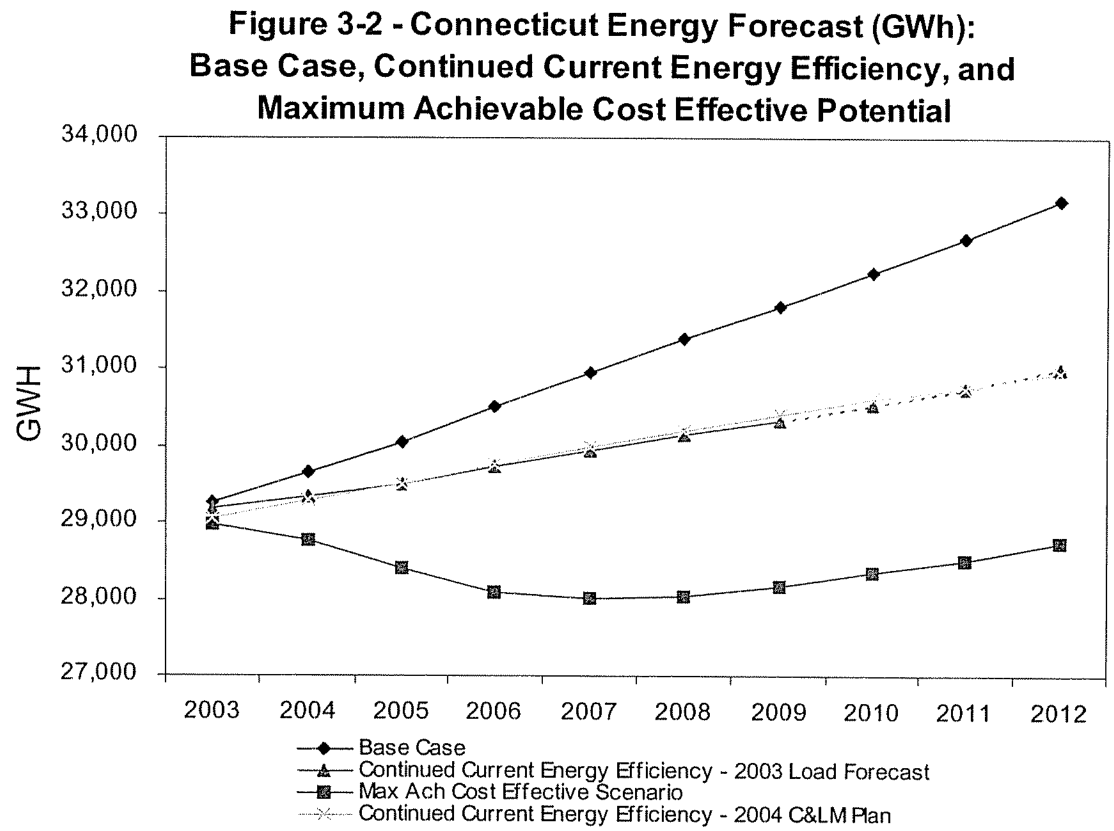
3.1 Key Findings – Statewide

There is a large potential for energy efficiency in the State of Connecticut. Figure 3-1 below compares (1) a peak load (MW) forecast for the State of Connecticut (CL&P and UI service areas only) assuming complete implementation of the maximum achievable cost effective potential scenario for energy efficiency, to (2) a "Base Case" scenario (the Base Case is the load forecast for the State of Connecticut that includes naturally occurring energy efficiency, but no "Public Benefits" funded conservation and load management programs), to (3) Connecticut's continued current level of energy efficiency efforts as stated in the utilities' 2003 load forecasts (equivalent to annual energy efficiency program funding of $72.5 million) and to (4) Connecticut's continued current level of energy efficiency efforts as stated in the utilities' 2004 C&LM Plans. The "Base Case" load forecast for the State of Connecticut is based upon the June 2003 load forecasts provided by CL&P and UI. The GDS/Quantum Team did not produce an independent "Base Case" load forecast. Figure 3-2 on the next page provides a similar comparison for GWh load forecasts (energy) for the State. A more detailed description of the basis for these electric load forecasts is provided in Section 5 of this report.

Figure 3-1 Connecticut Summer Peak Load Forecast (MW): Base Case, Continued Current Energy Efficiency, and Maximum Achievable Cost Effective Potential



*For the "Continued Energy Efficiency" scenario, values for the CL&P service territory for years 2009 to 2012 are estimates based on the average of prior year values.



*For the "Continued Energy Efficiency" scenario, values for the CL&P service territory for years 2009 to 2012 are estimates based on the average of prior year values.

The MW and GWh savings graphs shown in Figures 3-1 and 3-2 are slightly different in terms of overall shape. It is important to note that there are differences in the way that specific energy efficiency measures affect reductions in peak demand and energy sales. For example, in the residential sector, compact fluorescent lighting accounts for approximately 9% of the peak demand reductions for all sectors but over 21% of the energy savings. This variation occurs to some extent for all measures in all sectors and causes the overall shape of the MW and GWh graphs to be slightly different in terms of overall shape.

The key statewide findings of this study are the following:

- Capturing the maximum achievable **cost effective** potential for energy efficiency in the State would reduce peak demand by **908 MW** by 2012, or 13 percent from the base case. This strategy would reduce the average annual electric peak demand growth rate for the State from 1.5 percent per year in the Base Case Scenario to a 0.10 percent per year in the maximum achievable cost effective potential scenario with aggressive energy efficiency programs.
- There is sufficient achievable cost-effective[11] potential to reduce total electricity sales in Connecticut by 13.4 percent by 2012 (4,466 GWh/yr).
- Capturing the maximum achievable cost effective potential of energy efficiency statewide can save consumers and businesses $1.78 billion (in net present value savings) over the next decade, or about $1,228 for each of the 1.45 million households in the service areas of Connecticut Light and Power Company and United Illuminating.
- Such a strategy can reduce power plant SOX, NOX and CO2 emissions for the State from the Base Case by 13.4 percent by the year 2012.

The maximum achievable potential supply curve for the State of Connecticut for all sectors (residential, commercial and industrial) is shown below in Figure 3-3.

[11] For this estimate, cost-effectiveness is determined based on the avoided costs, discount rate and inflation rate used to plan 2003 programs in CT.

Figure 3-3 Maximum Achievable Potential for Energy Efficiency - CT 2012
All Sectors

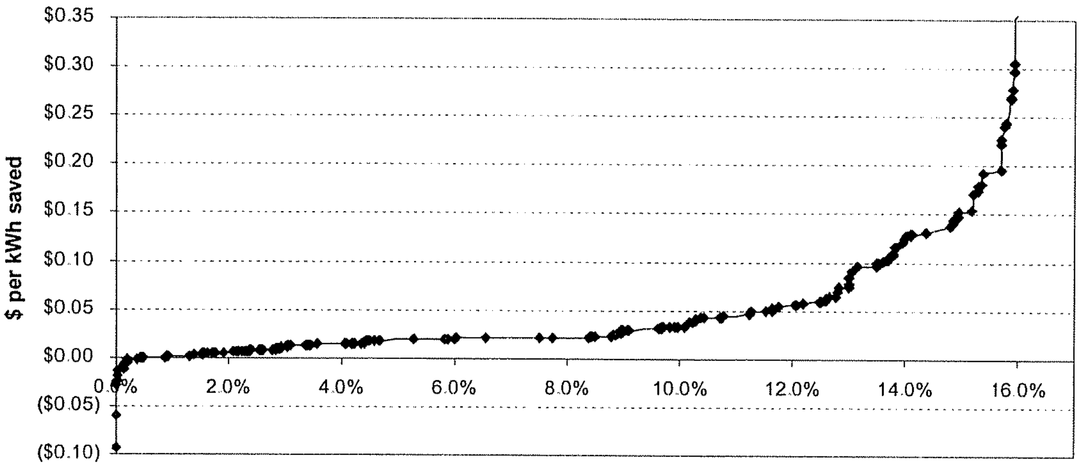


Table 3-1 shows the year-by-year maximum achievable **cost effective** potential savings for electric energy (GWh) and demand (MW) for the State, and the percent of base case electricity sales and peak load that can be saved each year. Table 3-1 shows that by the year 2012, **13.4** percent of Statewide electricity sales can be saved, and **12.5** percent of summer peak load. It is important to note that the majority of the peak load savings potential (63.4%) is from the commercial sector. Section 5 of this report provides additional detailed information on energy savings and peak load savings potential for 2003 and 2012, and detailed information on the costs and benefits of the maximum achievable potential for the State of Connecticut.

Table 3-1 Maximum Achievable Cost Effective Potential - Cumulative GWH and MW Savings
State of Connecticut

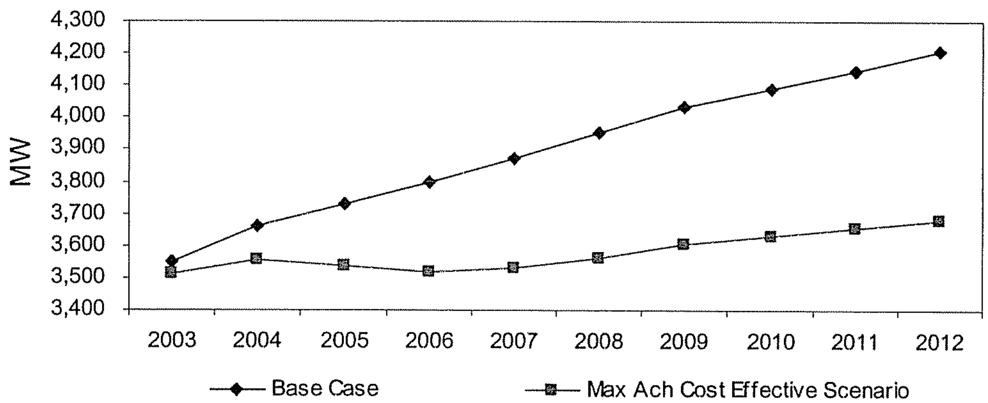
	Residential		Commercial		Industrial		Total Savings		Load Forecast		Net Forecast		Percent Savings	
Year	GWH Savings	MW Savings	GWH Savings	MW Savings	GWH Savings	MW Savings	GWH Savings	MW Savings	GWH	MW	GWH	MW	GWH	MW
2003	107.9	19.0	136.8	37.7	41.8	5.6	286.5	62.3	29,264.9	6,330.5	28,978.5	6,268.2	1.0%	1.0%
2004	330.9	47.9	405.6	111.6	144.6	18.5	881.1	178.1	29,645.7	6,418.5	28,764.6	6,240.4	3.0%	2.8%
2005	611.4	81.8	758.5	208.7	277.9	35.2	1,647.9	325.6	30,040.1	6,560.5	28,392.2	6,234.8	5.5%	5.0%
2006	891.9	115.6	1,135.7	312.6	411.3	51.8	2,438.8	480.1	30,519.2	6,672.1	28,080.3	6,192.1	8.0%	7.2%
2007	1,057.4	139.6	1,405.0	387.4	483.6	61.1	2,945.9	588.0	30,961.2	6,776.2	28,015.3	6,188.1	9.5%	8.7%
2008	1,222.8	163.5	1,589.6	438.0	555.8	70.4	3,368.3	671.9	31,405.4	6,875.3	28,037.1	6,203.4	10.7%	9.8%
2009	1,330.8	182.6	1,714.3	472.3	597.6	75.9	3,642.7	730.8	31,826.2	6,963.7	28,183.6	6,232.9	11.4%	10.5%
2010	1,438.7	201.6	1,839.0	506.6	639.4	81.5	3,917.1	789.7	32,267.4	7,058.4	28,350.4	6,268.6	12.1%	11.2%
2011	1,546.6	220.7	1,963.7	540.9	681.1	87.1	4,191.4	848.6	32,698.0	7,150.2	28,506.6	6,301.6	12.8%	11.9%
2012	1,654.6	239.7	2,088.4	575.1	722.9	92.6	4,465.8	907.5	33,204.7	7,243.4	28,738.9	6,335.8	13.4%	12.5%
Annual Growth									1.4%	1.5%	-0.1%	0.1%		

	Percent of Total Savings							
	Residential		Commercial		Industrial		Total Savings	
Year	GWH Savings	MW Savings	GWH Savings	MW Savings	GWH Savings	MW Savings	GWH Savings	MW Savings
2003	37.7%	30.6%	47.7%	60.5%	14.6%	8.9%	100.0%	100.0%
2004	37.6%	26.9%	46.0%	62.7%	16.4%	10.4%	100.0%	100.0%
2005	37.1%	25.1%	46.0%	64.1%	16.9%	10.8%	100.0%	100.0%
2006	36.6%	24.1%	46.6%	65.1%	16.9%	10.8%	100.0%	100.0%
2007	35.9%	23.7%	47.7%	65.9%	16.4%	10.4%	100.0%	100.0%
2008	36.3%	24.3%	47.2%	65.2%	16.5%	10.5%	100.0%	100.0%
2009	36.5%	25.0%	47.1%	64.6%	16.4%	10.4%	100.0%	100.0%
2010	36.7%	25.5%	46.9%	64.1%	16.3%	10.3%	100.0%	100.0%
2011	36.9%	26.0%	46.8%	63.7%	16.3%	10.3%	100.0%	100.0%
2012	37.0%	26.4%	46.8%	63.4%	16.2%	10.2%	100.0%	100.0%

3.2 Key Findings – Southwest Connecticut (SWCT)

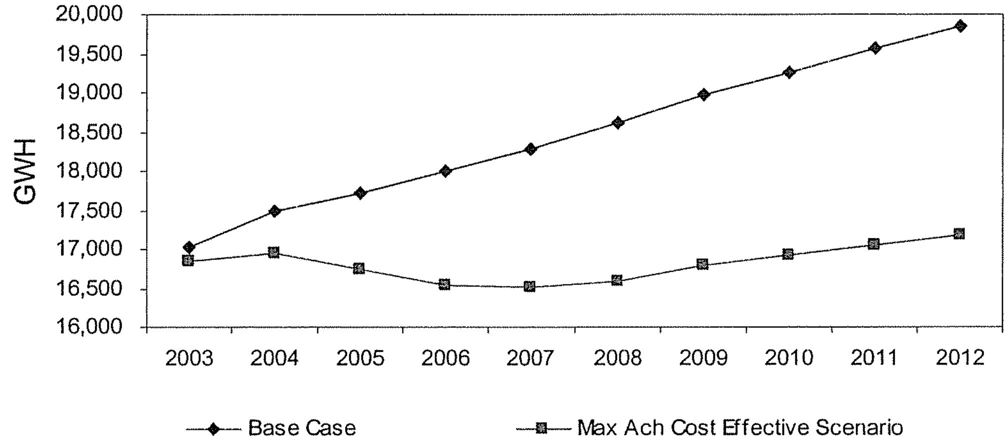
There is also a large maximum achievable cost effective potential for energy efficiency in the Southwest region of the State (SWCT). Figure 3-4 below compares (1) a load forecast for the SWCT region of Connecticut assuming the maximum achievable cost effective potential scenario for energy efficiency to (2) a "Base Case" scenario (the Base Case is a load forecast for Southwest Connecticut that includes naturally occurring energy efficiency, but no "Public Benefits" funded programs). Figure 3-5 on the next page provides a similar comparison for GWh load forecasts (energy) for SWCT. A more detailed description of the basis for these load forecasts is provided in Section 4 of this report. The "Base Case" load forecast for this region is based upon a load forecast obtained from the ISO-New England April 2003 CELT Report.[12] The GDS/'Quantum Team did not produce an independent "Base Case" load forecast for this region of Connecticut. The key findings of this study of this region are the following:

Figure 3-4 Southwest Connecticut Summer Peak Load Forecast (MW): - Base Case and Max Achievable Cost Effective Potential



[12] The GDS/Quantum Team adjusted this load forecast to add back planned conservation and load management savings that ISO-New England staff had incorporated in this load forecast.

Figure 3-5 Southwest Connecticut Energy Forecast (GWh): Base Case and Maximum Achievable Cost Effective Potential



- Capturing the maximum achievable cost effective energy efficiency potential in this region would reduce peak demand by 527 MW by 2012, thereby reducing summer peak demand by 13 percent from the Base Case Scenario.
- There is sufficient achievable cost-effective[13] potential to reduce total annual electricity sales in the SWCT region of Connecticut by 13.4 percent by 2012 (2,670 GWh/yr)
- Capturing the maximum achievable potential of energy efficiency statewide can save electric consumers in this region of Connecticut $1.064 billion in net present value dollars by 2012, or about $1,229 per household.
- Such a strategy can reduce power plant SO_X, NO_X and CO_2 emissions for the SWCT region from the Base Case Scenario by 13.4 percent by the year 2012[14].

Table 3-2 below summarizes the maximum achievable cost effective potential savings for the SWCT Region for the period 2003 to 2012. Section 5 of this report provides additional detailed information on energy savings and peak load savings potential for 2003 and 2012 by geographic region.

[13] For this estimate, cost-effectiveness is determined based on the avoided costs and input values used to plan 2003 programs in CT.

[14] "Emission rates used in this study are based on a December 2002 report titled "NEPOOL Marginal Emission Rate Analysis". The annual average values shown in the report for the year 2001 in Table ES1 are 4.9, 1.7, and 1393.9lb/MWh for SOx, NOx, and C02 (respectively)."

Table 3-2 Maximum Achievable Cost Effective Potential - Cumulative GWH and MW Savings
SWCT Region

	Residential		Commercial		Industrial		Total Savings		Load Forecast		Net Forecast		Percent Savings	
Year	GWH Savings	MW Savings	GWH Savings	MW Savings	GWH Savings	MW Savings	GWH Savings	MW Savings	GWH	MW	GWH	MW	GWH	MW
2003	64.5	11.1	81.8	21.9	25.0	3.2	171.3	36.2	17,028.5	3,549.2	16,857.2	3,513.0	1.0%	1.0%
2004	197.9	27.9	242.5	64.9	86.5	10.8	526.9	103.5	17,479.3	3,657.7	16,952.5	3,554.2	3.0%	2.8%
2005	365.6	47.5	453.6	121.3	166.2	20.4	985.4	189.2	17,718.5	3,725.9	16,733.1	3,536.7	5.6%	5.1%
2006	533.3	67.2	679.1	181.7	245.9	30.1	1,458.4	279.0	18,002.2	3,798.8	16,543.8	3,519.8	8.1%	7.3%
2007	632.3	81.1	840.1	225.1	289.2	35.5	1,761.6	341.7	18,282.8	3,871.7	16,521.2	3,530.0	9.6%	8.8%
2008	731.2	95.0	950.5	254.5	332.4	40.9	2,014.1	390.5	18,611.0	3,951.8	16,596.8	3,561.3	10.8%	9.9%
2009	795.8	106.1	1,025.1	274.5	357.4	44.1	2,178.2	424.7	18,979.7	4,032.1	16,801.5	3,607.4	11.5%	10.5%
2010	860.3	117.2	1,099.7	294.4	382.3	47.4	2,342.3	458.9	19,263.7	4,087.6	16,921.4	3,628.7	12.2%	11.2%
2011	924.9	128.2	1,174.2	314.3	407.3	50.6	2,506.4	493.2	19,557.8	4,147.2	17,051.4	3,654.1	12.8%	11.9%
2012	989.4	139.3	1,248.8	334.2	432.3	53.8	2,670.4	527.4	19,855.5	4,209.4	17,185.1	3,682.0	13.4%	12.5%
Annual Growth									1.7%	1.9%	0.2%	0.5%		

	Percent of Total Savings							
	Residential		Commercial		Industrial		Total Savings	
Year	GWH Savings	MW Savings	GWH Savings	MW Savings	GWH Savings	MW Savings	GWH Savings	MW Savings
2003	37.7%	30.6%	47.7%	60.5%	14.6%	8.9%	100.0%	100.0%
2004	37.6%	26.9%	46.0%	62.7%	16.4%	10.4%	100.0%	100.0%
2005	37.1%	25.1%	46.0%	64.1%	16.9%	10.8%	100.0%	100.0%
2006	36.6%	24.1%	46.6%	65.1%	16.9%	10.8%	100.0%	100.0%
2007	35.9%	23.7%	47.7%	65.9%	16.4%	10.4%	100.0%	100.0%
2008	36.3%	24.3%	47.2%	65.2%	16.5%	10.5%	100.0%	100.0%
2009	36.5%	25.0%	47.1%	64.6%	16.4%	10.4%	100.0%	100.0%
2010	36.7%	25.5%	46.9%	64.1%	16.3%	10.3%	100.0%	100.0%
2011	36.9%	26.0%	46.8%	63.7%	16.3%	10.3%	100.0%	100.0%
2012	37.0%	26.4%	46.8%	63.4%	16.2%	10.2%	100.0%	100.0%

3.3 Key Findings – Norwalk-Stamford Region

There is a large achievable potential for energy efficiency in the Norwalk-Stamford (NOR) region of the State. Figure 3-6 on the next page compares (1) a load forecast for the Norwalk-Stamford region of Connecticut assuming the maximum achievable **cost effective** potential scenario for energy efficiency to (2) a "Base Case" scenario (the Base Case is the load forecast for Norwalk-Stamford Connecticut that includes naturally occurring energy efficiency, but no "Public Benefits" funded programs). Figure 3-7 on the next page provides a similar comparison for GWh load forecasts (energy) for Norwalk-Stamford. The "Base Case" load forecast for this region is based upon a load forecast obtained from the ISO-New England April 2003 CELT Report. The GDS/'Quantum Team did not produce an independent "Base Case" load forecast for this region of Connecticut.

Figure 3-6 Norwalk-Stamford (NOR) Summer Peak Load Forecast (MW): Base Case, Continued Current Energy Efficiency, and Maximum Achievable Cost Effective Potential

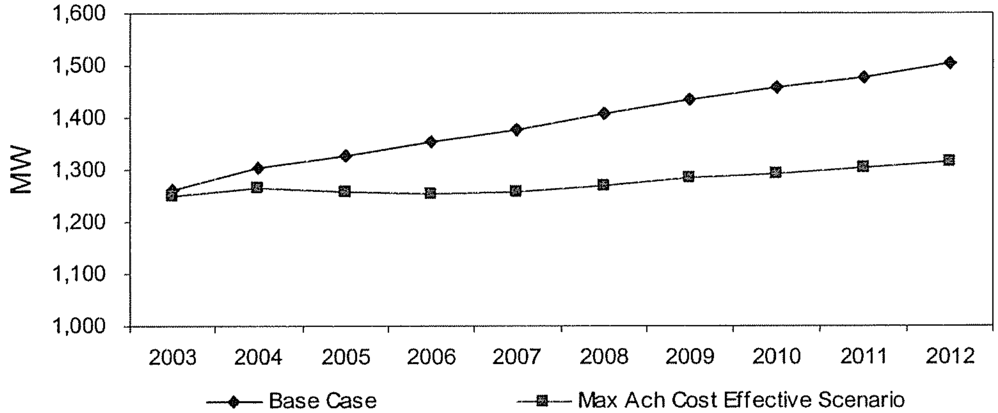


Figure 3-7 Norwalk-Stamford (NOR) Energy Forecast (GWh): Base Case, Continued Current Energy Efficiency, and Maximum Achievable Cost Effective Potential

The key findings of this study of this region are the following:

- Capturing the maximum achievable **cost effective** potential in this region would reduce peak demand by 188 MW by 2012, thereby reducing peak demand for this region by 13 percent from the Base Case load forecast.
- There is sufficient achievable cost-effective[15] potential to reduce total electricity sales in the Norwalk-Stamford region of Connecticut by 12 percent by the end of 2012.
- Capturing the maximum achievable potential of energy efficiency statewide can save consumers and businesses $374 million net in 2003 alone, or about $1,229 per year per household in the region of the State.

[15] For this estimate, cost-effectiveness is determined based on the avoided costs and input values used to plan 2003 programs in CT.

- Such a strategy can reduce power plant SOX, NOX and CO2 emissions for the Norwalk-Stamford region from the Base Case Scenario by 13.4 percent by the year 2012.

Table 3-3 below summarizes the maximum achievable cost effective potential savings for the Norwalk-Stamford region for the period 2003 to 2012. Section 5 of this report provides additional detailed information on energy savings and peak load savings potential for 2003 and 2012 for this region.

Table 3-3 Maximum Achievable Cost Effective Potential - Cumulative GWH and MW Savings
Norwalk-Stamford Region

	Residential		Commercial		Industrial		Total Savings		Load Forecast		Net Forecast		Percent Savings	
Year	GWH Savings	MW Savings	GWH Savings	MW Savings	GWH Savings	MW Savings	GWH Savings	MW Savings	GWH	MW	GWH	MW	GWH	MW
2003	22.7	4.0	28.7	7.8	8.8	1.2	60.1	12.9	5,956.7	1,263.3	5,896.6	1,250.4	1.0%	1.0%
2004	69.5	9.9	85.2	23.1	30.4	3.8	185.0	36.9	6,118.6	1,302.6	5,933.6	1,265.6	3.0%	2.8%
2005	128.4	17.0	159.3	43.3	58.4	7.3	346.0	67.5	6,199.9	1,326.1	5,854.0	1,258.5	5.6%	5.1%
2006	187.3	24.0	238.4	64.8	86.3	10.8	512.0	99.6	6,300.7	1,352.1	5,788.7	1,252.5	8.1%	7.4%
2007	222.0	28.9	295.0	80.3	101.5	12.7	618.5	122.0	6,402.3	1,378.5	5,783.8	1,256.5	9.7%	8.8%
2008	256.7	33.9	333.7	90.8	116.7	14.6	707.2	139.4	6,517.7	1,406.9	5,810.5	1,267.5	10.9%	9.9%
2009	279.4	37.9	359.9	98.0	125.5	15.8	764.8	151.6	6,650.5	1,436.1	5,885.8	1,284.6	11.5%	10.6%
2010	302.1	41.8	386.1	105.1	134.2	16.9	822.4	163.8	6,755.5	1,457.1	5,933.1	1,293.3	12.2%	11.2%
2011	324.7	45.8	412.3	112.2	143.0	18.1	880.0	176.0	6,860.5	1,478.8	5,980.5	1,302.7	12.8%	11.9%
2012	347.4	49.7	438.5	119.3	151.8	19.2	937.6	188.2	6,971.4	1,502.3	6,033.8	1,314.1	13.4%	12.5%
Annual Growth									1.8%	1.9%	0.3%	0.6%		

3.4 Results of Measure Cost Effectiveness Assessment and Metrics Used

The Project Team assessed the cost effectiveness of all energy efficiency measures included in the project's electronic database using the NSTAR cost effectiveness model.[16] The cost effectiveness metrics were calculated for each individual energy efficiency measure (Total Resource Cost Test (TRC), net benefits, the total dollar cost per measure; cost per kWh saved; cost per summer peak kW saved; cost per kW saved per year). Not only did the GDS team calculate the cost of conserved energy for each of the efficiency measures included in this study, but we also calculated the TRC benefit/cost ratio for all measures using up-to-date avoided electric system supply costs provided by CL&P and UI. Table 3-4 below summarizes the number of measures assessed in each sector, and the number having a TRC benefit/cost ratio greater than or equal to 1.0.

Table 3-4 Results of Cost Effectiveness Screening for Statewide Analysis

Sector	Number of Measures Assessed	Number of Measures with TRC Of 1.0 Or Greater (Based on CT Long-Run Avoided Supply Costs)[17]
Residential	68	29
Commercial	104	77
Industrial	106	100
Total	278	206

It is important to note that all measures in the database are included in the maximum achievable potential supply curves, even those measures with a TRC benefit/cost ratio less than 1.0.

3.5 Energy Efficiency Program Costs and Investment Scenarios

Achieving energy efficiency savings requires programmatic support. Programmatic support includes financial incentives to customers, marketing, administration, planning, and program evaluation activities provided to ensure the delivery of energy efficiency products and services to consumers. Electric utilities in Connecticut spent $66 million on energy efficiency programs in 2002.[18] The 2004 C&LM Plan, filed in November 2003, estimated that CL&P and UI would

[16] The NSTAR model is an Excel spreadsheet model that is available in the public domain. It was selected for use in this study because it is a model that is accepted by regulators and utilities in New England.

[17] Equivalent to the avoided costs used to plan 2003 C&LM programs.

[18] Total Conservation and Load Management spending in 2002 was $87 million, with $66 million for energy efficiency, $9 million for load management and other programs, and $12 million for state facilities (a direct legislative allocation to the Department of Public Works).

spend about $46 million on energy efficiency programs (including allocated administration and other energy efficiency program costs) in 2004.[19] The reduction in energy efficiency funding from 2002 is due to the State of Connecticut reallocating C&LM funding to assist with deficit reduction.

As shown in Figure 1-1 and Table 1-1, the statewide maximum achievable cost effective peak demand savings is 908 MW (13%) in 2012. Using two methods, it is estimated that approximately $82 million to $148 million annually (in 2003 dollars) in total energy efficiency program costs would need to be invested over the next decade to achieve these savings. This funding level for energy efficiency programs would be about 177% to 322% of the funding level in the 2004 C&LM Plan, and 124% to 224% of 2002 energy efficiency expenditures.

The first cost estimation method (resulting in the lower value) estimates total energy efficiency program costs based on an analysis of the 2004 C&LM Plan (filed in November 2003), adjustments to percentages and proportions for certain costs due to the larger volume of program activity in the maximum achievable case (which results in fixed costs being a lower percentage of total costs), and the findings of a recent potential study from California.[20] The table below shows total energy efficiency program costs of $817 million (in 2003 dollars) for 2003-2012, or approximately $82 million annually. The table also shows the adjusted cost percentages used in the analysis. See Appendix I for the detailed analysis.

Method 1 Program Cost Estimate (Lower estimate)	**Total Resource Costs to Acquire Maximum Achievable Cost-Effective Energy Efficiency in Connecticut 2003-2012**			
	$, million	**% of UC**	**% of TRC**	**% of IMC**
Total Resource Costs (TRC)	1,034.963			
TR Costs Net of O&M Benefits	954.806			
Utility Costs (UC)	786.572		76.0%	
UC with Other kWh Programs	817.006			
Customer Incentives	579.579	73.7%		70.0%
Customer Costs	248.391		24.0%	30.0%
Incremental Measure Costs (IMC)	827.970			
Other Program Costs	206.993	26.3%	20.0%	25.0%

[19] The total C&LM budget in 2004 is $90 million, with $49.9 million allocated to C&LM programs administered by the electric utilities, $12 million allocated to the State General Fund (PA 03-2), and $28.1 million allocated for securitization. Of the $49.9 million for C&LM programs, $46 million is budgeted for energy efficiency programs.
[20] *California's Secret Energy Surplus*; Energy Foundation/Xenergy. September, 2002.

A level of financial incentives higher than the 2004 incentive level would likely be needed to achieve the maximum achievable potential. In the analysis, we estimate that customer incentives would need to increase compared to the current level of incentives, from about 51% of incremental measure cost in 2004 to 70% on average over the 2003-2012 period. Customer incentives would make up 74% of utility costs, compared to about 60% of utility costs in the 2004 Plan. While this is a significant increase in the level of customer incentives, the resulting savings are cost effective, as shown in Table 1-1.

Other program costs (marketing, administration, planning and evaluation) for capturing the maximum achievable potential would be equivalent to 25% of incremental measure costs. The total utility program costs for energy efficiency would be 79% of the Total Resource Costs shown in Table 1-1 (not accounting for the reduced Total Resource Costs from O&M benefits)

The second cost estimation method (resulting in the higher value in the range) estimates total energy efficiency program costs based on an analysis of the 2004 C&LM Plan, a base cost per kWh of annual savings based on the 2004 plan, and an adjusted cost per kWh of annual savings for the maximum achievable case. The table below shows total energy efficiency program costs of $1.48 billion (in 2003 dollars) for 2003-2012, or approximately $148 million annually. See Appendix I for the detailed analysis.

Method 2 Program Cost Estimate (High estimate) 10 year total	
Cost per kWh (based on 2004 plans)	$0.265
Multiplier (base case to maximum achievable case)	1.25
Adjusted Cost per kWh	$0.33
Cumulative Annual MWH Savings	4465.8
Projected Cost ($000)	**$1,481,748**

3.5.1 Basis for Estimate of Other Program Costs Used in the Study

GDS estimates that Connecticut utility costs for program planning, administration, marketing, reporting and evaluation ("other program costs") are 25% of efficiency measure incremental costs in the maximum achievable energy efficiency scenario. This estimate is based on estimates used in other studies, and on an analysis of the relationship between measure and other program costs for varying levels of program funding. In the recent technical potential study done for the State of California, in the long term, the other program costs for the maximum efficiency case are estimated to be 22.6% of measure incremental costs.[21] At the current level of program funding, which is lower than the funding level necessary to capture the maximum achievable potential, GDS recognizes that these costs may differ from 25% of incremental costs.[22] However, in the long-term (over the next ten years) these non-measure other program costs can reasonably be expected to be approximately 25% of incremental measure costs if Connecticut increases C&LM efforts to capture the maximum achievable potential. Under the maximum achievable case described in this report, there will be economies of scale as fixed program costs are spread over a much larger volume of efficiency measures, and therefore over a larger base of measure incremental costs, thus reducing the overall percentage for program costs as a percent of incremental measure costs.

In the Uncertainty Section of this report, Section 3.8, GDS has examined scenarios where program costs over the long term are 20% and 30% of measure incremental costs. The results of this scenario are provided in Appendix H of this report and show that net present value savings for the State due to implementation of the maximum achievable energy efficiency potential change only slightly if program costs are higher or lower than 25% of measure incremental costs.

[21] Xenergy, Inc., "California's Secret Energy Surplus: The Potential for Energy Efficiency, Final Report", Prepared for the Energy Foundation and the Hewlett Foundation, September 23, 2002.
[22] For example, in the 2004 C&LM Plan, CL&P and UI estimate that other program costs will be about 34 percent of incremental measure costs.

3.6 Highlights of Energy Efficiency Potential Findings

This section of the report presents the highlights of our energy efficiency potential findings. The first finding is that the maximum achievable potential for energy efficiency savings determined in this study are very comparable to the amount of potential savings determined in recent studies completed for other States (such as Vermont, California, Massachusetts and the Southwestern U.S.). Table 3-5 below provides a comparison of the Connecticut saving potential with other recent potential studies.

The remainder of this section describes key findings with respect to the major energy savings opportunities in the residential, commercial and industrial sectors in the State.

Table 3-5 Comparison of Technical and Achievable Potential Savings Percent of Total Energy (GWh) Sales

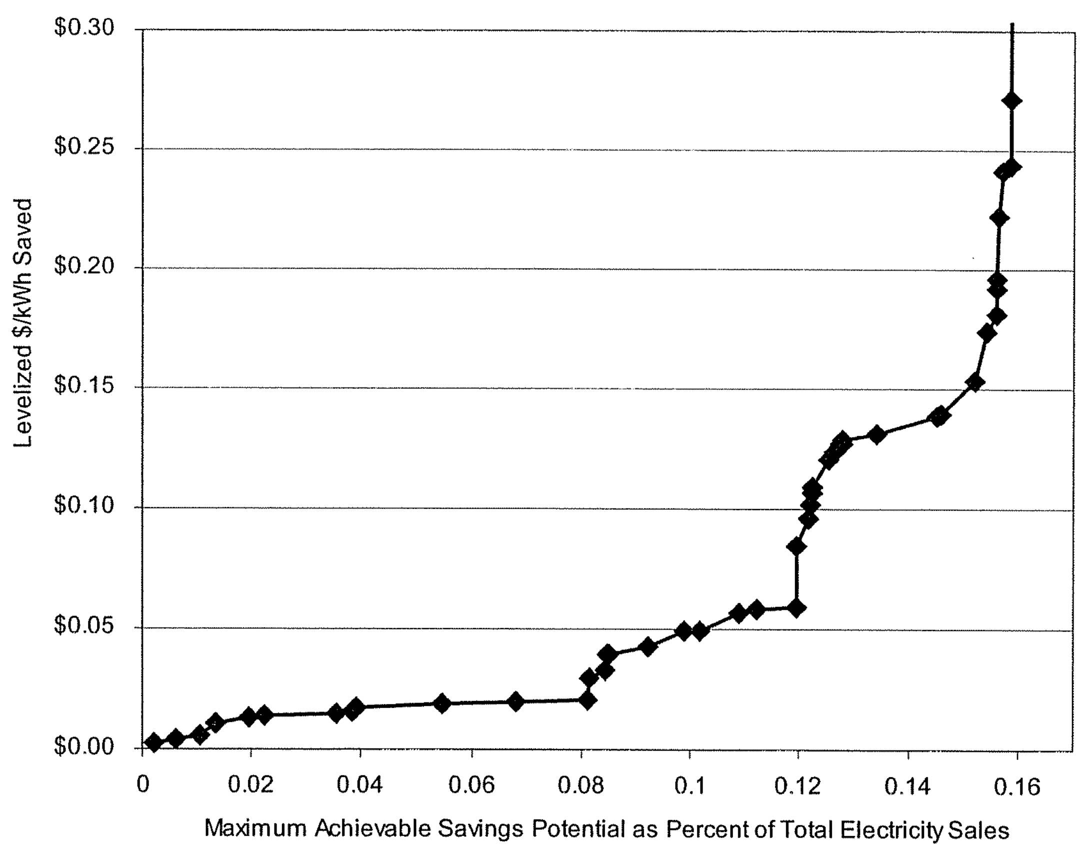
Sector	Connecticut 2012	California 2011[2,3]	Vermont 2012[1,4]	Mass. 2007[1,5]	Southwest 2020[6]
Technical Potential					
Residential	21%	22%			26%[(6)]
Commercial	25%	18%			37%[(6)]
Industrial	20%	15%			33%[(6)]
Total	***24%***	***18%***			***33%***[(6)]
Maximum Achievable Potential					
Residential	17%		30%		
Commercial	17%		32%		
Industrial	15%		32%		
Total	***17%***		***31%***		
Maximum Achievable Cost Effective Potential					
Residential	13%	10%		31%	
Commercial	14%	10%		21%	
Industrial	13%	9%		21%	
Total	***13%***	***10%***		***24%***	

1. Vermont and Massachusetts studies reported commercial and industrial sectors together.
2. "California's Secret Energy Surplus: The Potential For Energy Efficiency – Final Report", Prepared for The Energy Foundation and The Hewlett Foundation, prepared by XENERGY Inc., September 23, 2002. Page 3-3.
3. "CALIFORNIA STATEWIDE RESIDENTIAL SECTOR ENERGY EFFICIENCY POTENTIAL STUDY"; Study ID #SW063; FINAL REPORT VOLUME 1 OF 2; Prepared for Rafael Friedmann, Project Manager Pacific Gas & Electric Company San Francisco, California; Principal Investigator: Fred Coito and Mike Rufo; KEMA-XENERGY Inc. Oakland, California; April 2003; Pages 6-12 and 6-15.
4. "Electric and Economic Impacts of Maximum Achievable Statewide Efficiency Savings; 2003-2012 – Results and Analysis Summary"; Public Review Draft of May 29, 2002; prepared for the Vermont Department of Public Service by Optimal Energy, Inc.; Pages 32 & 33.
5. The Remaining Electric Energy Efficiency Opportunities in Massachusetts; Final Report June 7, 2001; prepared for Program Administrators and Massachusetts Division of Energy Resources by RLW Analytics, Inc. and Shel Feldman Management Consulting; Page iii.
6. Southwest Energy Efficiency Project; "The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest"; Prepared for: Hewlett Foundation Energy Series; prepared by Southwest Energy Efficiency Project; November 2002; Page ES-5. It is important to note that the numbers shown here for SWEEP are for technical cost effective potential.

3.6.1 Residential Sector Potential and Supply Curve

The residential sector maximum achievable potential supply curve for the state of Connecticut is shown in Figure 3-8. In the residential sector for existing homes, the major electricity savings opportunities are in the areas of lighting, electric heat, and electric water heating. For example, use of more energy efficient lamps can save up to 75 percent of the lighting kWh use in a home. We estimate that the payback period for these lighting efficiency measures is typically around 2.7 years on average. Electricity use for water heating can be cut by 48 percent or more through measures that lower hot water use as well as increase the efficiency of water heating. Substantial electricity savings also will occur when older refrigerators and freezers are replaced with new models, and as older home appliances are replaced with Energy Star® labeled models.

Figure 3-8 Maximum Achievable Savings Potential Residential Sector - State of Connecticut



Some initial findings from the residential analysis include the following:

a. Compact fluorescent lamps produce the most significant energy savings potential.
b. The measure with the lowest cost of conserved energy is the water heater pipe wrap (CCE of only $.00226 per kWh saved).
c. CFL and electric water heater measures have the lowest cost of conserved energy values.

3.6.2 Commercial Sector Potential and Supply Curve

Many cost-effective energy savings measures are available today for the commercial sector. For commercial buildings, large energy savings can be achieved through:

- installing more efficient lighting systems
- replacing HVAC equipment with more efficient units and improving the efficiency of existing HVAC systems
- testing and sealing air distribution ducts
- replacing inefficient office equipment with more energy-efficient products

Replacing lighting systems in commercial buildings with more efficient fixtures, lamps, ballasts, and improved controls can save up to 50 percent of lighting energy use. The payback period for Super T-8 lighting retrofits in commercial buildings is typically less than 2 years. Installing more efficient fans, chillers, and packaged air conditioning equipment in commercial buildings can reduce overall electricity consumption by 14-30 percent with a payback of 1.5-7.0 years on the incremental first cost. Energy-efficient office equipment can reduce total electricity consumption by 20 to 50 percent in office buildings at minimal incremental cost.

Following are a few key data points based upon the supply curve developed for the commercial sector in Connecticut

a. Installation of Super T-8 lighting fixtures was found to be the measure with the most potential kWh savings (this includes the early replacement of the estimated 30% of the existing market that has not yet converted to standard T-8 fixtures, as well as the replace on burnout of the existing standard T-8 fixtures)
b. Nighttime shutdown of desktop computers was the measure with the lowest Cost of Conserved Energy (CCE) at $0.0005/kWh
c. The median CCE for this sector is $0.046/kWh[23]

[23] The median value shown is for all measures in the supply curve. The median CCE for the cost effective measures only is $0.0266.

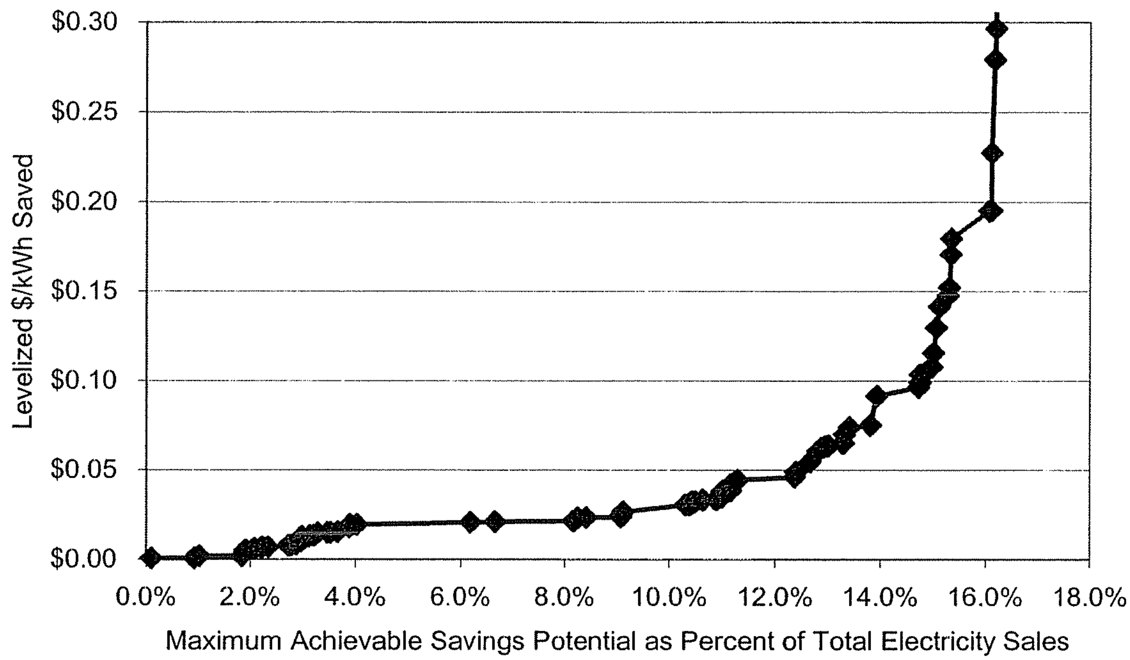
For the commercial sector, supply curves were developed for existing stock and new construction for nine typical building types, as well as for the commercial sector as a whole. Table 3-6 illustrates the technical, maximum achievable and maximum achievable cost effective potential electricity savings for the commercial sector.

Table 3-6 Commercial Sector Potential Electricity Savings

Sector	2012 Technical Potential Savings (GWh)	2012 Maximum Achievable Potential Savings (GWh)	2012 Maximum Achievable Cost Effective Potential Savings (GWh)
Total Commercial Sector	25.3%	17.3%	14.3%

Figure 3-9 illustrates the maximum achievable potential supply curve for the commercial sector for the State of Connecticut. There were 100 measures that were found to be applicable to the commercial sector (including measures that were attributed to both existing stock and new construction), and as shown on the supply curve, more than half of these measures have levelized cost per kWh values of $0.10 or less.

Figure 3-9 Maximum Achievable Savings Potential
Commercial Sector - State of Connecticut



3.6.3 Industrial Sector Potential and Supply Curve

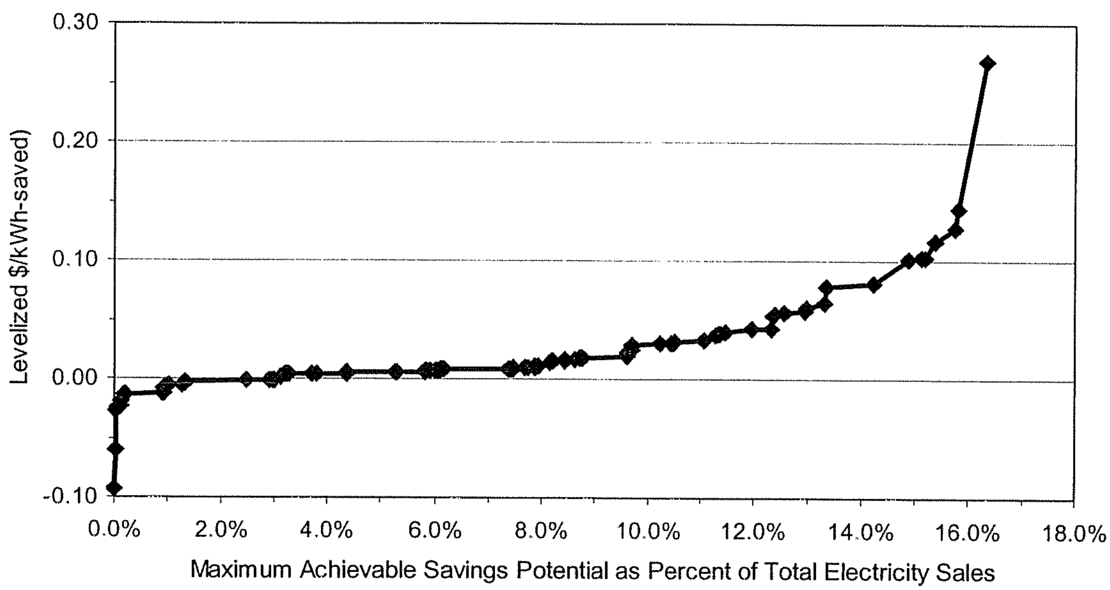
In the industrial sector, motors consume about two-thirds of the electricity used. Energy savings opportunities exist in both the motor, the motor-driven device (e.g., fan, compressor, or pump), and in overall motor system design. These measures include replacing oversized motors, cutting unnecessary flows and friction losses in fluid systems, improving gear ratios, changing fan pulleys or trimming pump impellers, and replacing throttling valves with adjustable speed drives or other speed control devices. In individual plants, electricity use can drop by 5-50 percent depending on the characteristics of the initial system. For example, compressed air systems often present a significant opportunity for cost-effective energy savings through cutting leaks and inappropriate uses, reducing operating pressure, improving maintenance, and installing better controls. The overall potential savings can be up to 60 percent for individual plants.

Following are a few key data points that came out of the supply curve development for the industrial sector.

a. Pump controls in the paper manufacturing industrial sector was found to be the measure with the most potential kWh savings
b. Near Net Shape Casting in the metal manufacturing industry was the measure with the lowest CCE at -$0.09/kWh (the negative value is a result of a large savings due to productivity benefits associated with this measure)
c. The median CCE for the Industrial sector is $0.01/kWh

Figure 3-10 below illustrates the maximum achievable potential supply curve for the industrial sector in Connecticut. This graph includes data from 107 energy efficiency measures that were found to be applicable to the industrial sector.

Figure 3-10 - Maximum Achievable Savings Potential Industrial Sector - State of Connecticut



3.7 Overview of Methodology

A detailed description of the methodology used to develop the estimates of maximum achievable potential is provided in Section 4 of this report. A synopsis of the approach is provided below.

Maximum Achievable Technical Potential: To develop estimates of the achievable potential for energy efficiency for the residential, commercial and industrial sectors in Connecticut and sub areas of the State, this analysis used an existing GDS Associates spreadsheet model[24]; detailed information relating to the current and potential saturation of efficiency measures in the State of Connecticut; and available data on energy efficiency measure incremental costs, energy savings, and useful lives. The maximum achievable technical potential was estimated by determining the maximum penetration of an efficient measure that would be adopted given unlimited funding, and by determining the maximum market penetration that could be achieved with a concerted, sustained campaign involving highly aggressive programs and market intervention.[25] The maximum achievable potential estimates in this study provide a measure of the maximum amount of energy that could be saved if most or every household and business in Connecticut retrofitted their existing standard efficient measures with energy efficient technologies and installed the energy efficient measure in all new construction applications, failed equipment replacement and major renovation applications, regardless of cost or other considerations.

Cost Effective Maximum Achievable Potential: Calculation of the cost effective maximum achievable potential is based on the assumption that energy efficiency measures/bundles will only be included in Statewide efficiency programs when it is cost effective to do so. Once the estimates of the maximum achievable potential had been developed by customer class, the efficiency measures were included in supply curves by sector, and stacked from lowest to highest cost of conserved energy.

A "market driven" scenario assumption is a critical element of the foundation of this study. Essentially, for each sector, it is assumed that existing equipment will be replaced with high efficiency equipment at the time a consumer is shopping for a new appliance or other energy using equipment, or if the consumer is in the process of building or remodeling. Using this assumption, the appropriate cost of

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[24] As required by the ECMB, the GDS Excel spreadsheet model operates on a PC platform using the MS windows operating system, is documented, and can be followed by a technician with expertise.

[25] This is the definition of "maximum achievable potential" provided on page 2 of the ECMB RFP in the last paragraph on that page. The term "maximum" refers to efficiency measure penetration, and means that the GDS Team has based our estimates of efficiency potential on the maximum realistic penetration that can be achieved by 2012. The term "maximum" does not apply to other factors used in developing these estimates, such as measures energy savings or measure lives.

the high efficiency measure is the difference in the marketplace cost of the standard efficiency equipment and the high efficiency equipment. The appropriate energy savings is the difference in the energy use of the standard efficiency equipment and the high efficiency equipment.

For certain energy efficiency measures, the technical potential estimates included in this report "layer" additional retrofit-driven and early retirement-driven savings on top of market-driven energy savings.

3.8 Discussion of Uncertainty

There are two principal classes of uncertainty underlying the results presented in this study. The first area is uncertainty associated with estimates of the *current* characteristics of end-use electricity consumption and energy-efficiency measure data (hereafter, "current market" uncertainty). The second area concerns estimates of the *future* potential for energy efficiency, which is affected by the uncertainty in the first area, as well as additional uncertainty in future energy prices and electric load forecasts, changes in market and energy-efficient measure characteristics over time, and forecasts of customer adoption of measures as a function of energy efficiency program interventions, among other factors (hereafter, "forecast" uncertainty). While there is considerable overlap in the underlying data associated with both types of uncertainty, it is useful to separate these classes of uncertainty for two reasons. First, the study attempts to reduce the effects of the two types of uncertainty through different approaches. Second, although both types of uncertainty could be reduced through further research, the types of research necessary are significantly different across the two classes.

3.8.1 Current Market Uncertainty

With respect to the first class of uncertainty noted above, *current market* uncertainty, readers and users of this study should recognize that estimates of energy efficiency potential involve a process of modeling the substitution of efficient equipment and systems in place of existing energy equipment and systems. As such, this process starts with estimates of current equipment characteristics and energy use by end use and market segment. These data typically are provided as inputs to energy efficiency potential studies and are, in the best of cases, developed from up-to-date and statistically accurate studies that involve detailed collection of technology market shares and comprehensive modeling of end-use consumption and peak demand. When these data are absent, outdated, or inaccurate, the uncertainty in estimates of current equipment shares and associated consumption and peak demand directly impact estimates of energy efficiency potential because energy efficiency potential varies by equipment type and market segment.

The principal sources of data used to develop estimates of current consumption by end use and market segment were the end-use tables associated with CL&P's 1996 forecast. These end-use shares were then applied to both CL&P's and UI's latest (2003) forecasts of consumption at the sector level. Note that the most recent CL&P and UI forecasts did not provide any updated information for this potential study on the end use and market segment shares of energy consumption. In addition, other sources of equipment saturation data were very limited for this study. Residential saturation data was fairly up-to-date for both CL&P and UI; however, no statistically representative, Connecticut-specific sources were available for developing commercial or industrial equipment saturation data. Instead, secondary sources were used for these inputs to the energy efficiency potential estimation process.

Energy efficiency measure data are the second type of data associated with *current market* uncertainty. Examples of energy efficiency measure data include the current incremental costs and savings of efficient measures, the useful lives of those measures, their current market saturation levels, and estimates of the fraction of the market for which efficient equipment and systems could substitute for existing equipment and systems. Fortunately, considerable data on the costs and savings associated with energy efficient measures were available for this study. This is attributable to the considerable number and quality of energy savings measurement and evaluation studies that have been conducted in Connecticut over the past few years, as well as throughout New England and the rest of the United States. Nonetheless, uncertainties exist to varying degrees in estimates of costs and savings by individual technology. In general, new measures (e.g., those on the market for two years or less) have somewhat greater uncertainty in costs and savings than measures that have been on the market for longer periods (e.g., 3 years or more). The most significant uncertainty in the measure-level data is also in the area of measure saturation. Measure-level saturation data typically come from the same types of sources discussed above for baseline equipment consumption and saturation data.

3.8.2 Forecasting Uncertainty

Turning now to the area of *forecasting* uncertainty, forecasts of energy efficiency savings are also affected by *current market* uncertainty. In any forecasting process, one wants to begin with as accurate an assessment of current conditions as possible; errors in estimates of current conditions are otherwise carried forward and exacerbated. However, even with perfect data on current market conditions, forecasts are subject to their own uncertainties by their very nature. For this study, the key areas of forecast uncertainty are future:

- end use consumption levels and equipment shares (i.e., there is uncertainty in the load forecasts provided by CL&P, UI, and ISO-New England);
- incremental costs and savings for measures on the market today;

- incremental costs and savings for measures not on the market today but likely to be available over the ten-year forecast period (no such measures are included in this study);
- energy efficiency program funding levels;
- customer adoption levels of efficient measures as a function of program intervention types and levels;
- savings associated with continuation of existing CL&P and UI programs; and
- benefit/cost ratios for energy-efficiency measures, which, in addition to uncertainty in future measure costs and savings, are a function of uncertainty in:
    - energy and capacity prices, both retail and wholesale, including those associated with constrained areas, and
    - the value of any environmental externalities
    - the level of the discount rate used in financial analyses of efficiency measures

As noted above, there is also uncertainty with future forecasts for State of Connecticut electricity sales and peak demand. If the future demand for electricity turns out to be higher than currently forecast by CL&P and UI, then there will be more potential for savings from energy efficiency measures. Likewise, if the future demand for electricity is lower than expected, the potential for savings from energy efficiency measures will be lower than the figures provided in this report. This is a particularly relevant issue given the new load forecasts published in mid-June 2003 by CL&P and UI. These new June 2003 forecasts[26], when combined, predict an average annual rate of summer peak load growth for 2003 to 2012 that is higher than the load forecast released just 15 months earlier in March 2002.

Over the period from 1997 to 2002, summer peak load in the State of Connecticut grew at 2.5 percent per year. Table 3-7 below compares the average annual growth rates, GWh sales in 2012, and peak load in 2012 for these 2002 and 2003 load forecasts, and demonstrates the uncertainty involved with load forecasts, and changes that can occur in just a fifteen month period. As one can see, the summer peak load in Connecticut in 2012 is now forecast to be 7,243 MW, **450 MW higher** (or 7%) than the forecast released just 15 months earlier.

[26] To be clear, it is the June 11, 2003 CL&P and UI load forecasts that are used in this study as the basis for the State of Connecticut load forecast.

Table 3-7 – Comparison of Average Annual Compound Growth Rates for the 2002 and 2003 Load Forecasts For the State of Connecticut, Excludes Impacts of Energy Efficiency Programs		
Forecast Indicator	March 2002 Load Forecast for State of Connecticut	June 2003 Load Forecast for State of Connecticut
GWh Sales -- Average Annual Growth Rate (2003 to 2012)	1.6%	1.4%
Summer Peak (MW) – Average Annual Growth Rate (2003 to 2012)	1.3%	1.5%
Total Annual GWh Sales in 2003	29,586 GWH	29,265
Total Annual GWh Sales in 2012	34, 057 GWH	33,205 GWh
Forecast Peak Demand in 2003 (MW)	6,059	6,331
Forecast Peak Demand in 2012 (MW)	6,793	7,243

3.9 Load Forecast Uncertainty

Table 3-8 shows the projected summer peak load forecast for the CL&P and UI service areas in Connecticut and for the SWCT region of the state for the period 2003 to 2012. This table also presents data on the SWCT summer peak load as a percent of the combined CL&P and UI peak loads. The load forecasts shown in Table 3-8 have been adjusted to remove impacts of CL&P and UI energy efficiency programs. It is important to note that peak load for the geographic area served by the Connecticut Municipal Electric Energy Cooperative has not been included in this study, nor does this study estimate the energy efficiency potential in the CMEEC service area.

As directed by the ECMB, GDS used the latest available load forecasts (dated June 11, 2003) from UI and CL&P to develop the load forecast for the State of Connecticut, and GDS used the ISO New England load forecast for the SWCT region of the State. As noted above, there is uncertainty in the load forecasts provided by CL&P, UI, and ISO-New England. SWCT peak load growth for the next decade is forecast to be 1.9% per year in the absence of public benefits funded energy efficiency programs, while statewide peak load growth is projected to be slower, only 1.5% a year. If load growth is higher than these forecasts, there will be additional opportunity for energy efficiency savings beyond those identified in this report, and vice versa.

Table 3-8
SWCT Region Peak Load Forecast as Percent of CL&P/UI Service Area
(Excludes Impacts of Planned Energy Efficiency Programs)

Year	SWCT Region - Summer Peak Load Forecast (MW)	CL&P & UI Combined - Summer Peak Load Forecast (MW)	SWCT Peak Load as % of CL&P & UI Peak Load
2003	3,549	6,331	56.1%
2004	3,658	6,419	57.0%
2005	3,726	6,560	56.8%
2006	3,799	6,672	56.9%
2007	3,872	6,776	57.1%
2008	3,952	6,875	57.5%
2009	4,032	6,964	57.9%
2010	4,088	7,058	57.9%
2011	4,147	7,150	58.0%
2012	4,209	7,243	58.1%
Annual Growth	1.91%	1.51%	

Sources: The peak load forecast for the SWCT region was obtained from ISO-New England. The summer peak load forecast for the State of Connecticut was obtained by summing the peak load forecasts for United Illuminating and Connecticut Light and Power Company.

Table 3-9 below shows the SWCT peak load as a percent of the entire State of Connecticut, where CMEEC loads are included in the denominator of this ratio calculation. When CMEEC loads are included in the denominator of the ratio calculation, the ratio of SWCT peak to the State peak in 2003 is 52.9%, much close to the 48% ratio that existed from 1997 to 2002.

Table 3-9
SWCT Region Peak Load Forecast as Percent of State Peak Load Forecast (Excludes Impacts of Planned Energy Efficiency Programs)

Year	SWCT Region - Summer Peak Load Forecast (MW)	CL&P/UI Service Areas - Summer Peak Load Forecast (MW)	CMEEC Summer Peak Load (assuming Growth of 1.5%/Yr.)	State of CT - Summer Peak Load Forecast (MW) - Including CMEEC	SWCT Peak Load as % of Peak Load for CL&P/UI Service Areas
2003	3,549	6,331	374	6,704	52.9%
2004	3,658	6,419	379	6,798	53.8%
2005	3,726	6,560	385	6,945	53.6%
2006	3,799	6,672	391	7,063	53.8%
2007	3,872	6,776	396	7,173	54.0%
2008	3,952	6,875	402	7,278	54.3%
2009	4,032	6,964	408	7,372	54.7%
2010	4,088	7,058	415	7,473	54.7%
2011	4,147	7,150	421	7,571	54.8%
2012	4,209	7,243	427	7,670	54.9%
Annual Growth	1.91%	1.51%	1.50%	1.51%	

Sources: The peak load forecast for the SWCT region was obtained from ISO-New England.

3.10 Administrative Cost Uncertainty

GDS has also examined scenarios where utility costs for program design, implementation and evaluation over the long term are 20% and 30% of measure incremental costs (in the base case, this percentage is held at 25%). The results of these two scenarios are provided in Appendix H of this report and show that net present value savings for the State due to implementation of the maximum achievable energy efficiency potential change only slightly in these scenarios.

4.0 METHODOLOGY USED TO ASSESS MAXIMUM ACHIEVABLE POTENTIAL

In this section, we give an overview of the approach and method used to complete this technical potential study.

Table 4-1 Roadmap of Approach for Estimating Energy Efficiency Potential in Connecticut	
1	The first step in this study was to estimate technical potential. **Technical potential** is defined in this study as the complete penetration of all measures analyzed in applications where they were deemed technically feasible from an engineering perspective. The total technical potential for energy efficiency for each sector (residential, commercial, and industrial sectors) was developed from estimates of the technical potential of individual energy efficiency measures applicable to each sector (efficient lighting, efficient appliances, weatherization, home insulation, etc.). For each energy efficiency measure included in this study, the GDS Team calculated the electric energy savings that could be captured if 100% of inefficient electric appliances and equipment were replaced instantaneously (where they are deemed to be technically feasible).
2	The second step in this study was to estimate maximum achievable efficiency potential. **Maximum achievable potential** is defined as the maximum penetration of an efficient measure that would be adopted given unlimited funding, and by determining the maximum market penetration that can be achieved with a concerted, sustained campaign involving highly aggressive programs and market intervention. The term "maximum" refers to efficiency measure penetration, and means that the GDS Team has based our estimates of efficiency potential on the maximum realistic penetration that can be achieved by 2012. The GDS Team reviewed maximum penetration forecasts from other recent technical potential studies, actual penetration experience for programs operated by energy efficiency organizations (NEEP, NYSERDA, NEEA, BPA, utilities, etc.), input from the Project Advisory Team and penetration data from other sources (program evaluation reports, market progress reports, etc.) to estimate terminal penetration rates in 2012 for the maximum achievable scenario. Based on a thorough review of all of this information, the GDS Team selected a maximum achievable penetration rate of **80 percent** by 2012 for all sectors.
3	The third step in this study was to estimate the maximum achievable cost effective potential. **The maximum achievable cost effective potential** is defined as the potential for maximum penetration of energy efficient measures that are cost effective according to the Total Resource Cost test, and would be adopted given unlimited funding, and by determining the

	maximum market penetration that can be achieved with a concerted, sustained campaign involving highly aggressive programs and market interventions.[27] To develop the maximum achievable cost effective potential, the GDS Team only retained in the energy efficiency supply curves those measures that were found to be cost effective (according to the Total Resource Cost Test) based on the individual measure cost effective analyses conducted in Task 4 of this Study. Energy efficiency measures that are not cost effective are excluded from the estimate of maximum achievable cost effective energy efficiency potential.

4.1 Overview of Methodology

Energy efficiency measures can be a cost effective alternative to energy supply options such as conventional power plants. The objective of this study was to determine the maximum achievable cost effective potential for energy conservation and energy efficiency resources in Connecticut over the ten-year period from 2003 through 2012 in three geographic areas (Statewide, the 52-town SWCT area, and the 16 town Norwalk-Stamford area). The main output of this study is summary data tables and graphs reporting the achievable potential and cumulative annual potential, by year, for 2003 through 2012. This final report also provides in Appendix F estimates of the remaining resource potential available after 2012 for energy efficiency investments assumed to be made prior to 2013.

The definitions used in this study for energy efficiency potential estimates are the following:

- **Technical potential** is defined in this study as the complete penetration of all measures analyzed in applications where they were deemed technically feasible from an engineering perspective.

- **Maximum achievable potential** is defined as the maximum penetration of an efficient measure that would be adopted given unlimited funding, and by determining the maximum market penetration that can be achieved with a concerted, sustained campaign involving highly aggressive programs and market intervention. The term "maximum" refers to efficiency measure penetration, and means that the GDS Team has based

[27] This is the definition of "maximum achievable potential" provided on page 2 of the ECMB's RFP for this study. The term "maximum" refers to efficiency measure penetration, and means that the GDS Team has based our estimates of efficiency potential on the maximum realistic penetration that can be achieved by 2012. The term "maximum" does not apply to other factors used in developing these estimates, such as measures energy savings or measure lives.

our estimates of efficiency potential on the maximum realistic penetration that can be achieved by 2012. The term "maximum" does not apply to other factors used in developing these estimates, such as measures energy savings or measure lives.

- **Maximum achievable cost effective potential** is defined as the potential for maximum penetration of energy efficient measures that are cost effective according to the Total Resource Cost test, and would be adopted given unlimited funding, and by determining the maximum market penetration that can be achieved with a concerted, sustained campaign involving highly aggressive programs and market intervention.

To develop estimates of the savings potential for energy efficiency for the residential, commercial and industrial sectors in Connecticut and sub areas of the State, this analysis utilized the following models and data:

(1) a GDS Associates energy efficiency potential supply curve spreadsheet model[28]
(2) detailed information relating to the current and potential saturation of energy efficiency measures in the State of Connecticut
(3) available data on energy efficiency measure costs, energy savings, operations and maintenance savings, and useful lives.

The maximum achievable potential was estimated by determining the maximum penetration of an efficient measure that would be adopted given unlimited funding and a concerted, sustained campaign involving highly aggressive programs and market intervention. This estimate provides a measure of the maximum amount of energy that could be saved if most households and businesses in Connecticut replaced their standard efficient equipment with energy efficient technologies over the ten-year forecast period of this study.

The determination of the cost effective maximum achievable potential is based on the assumption that energy efficiency measures/bundles will only be included in statewide efficiency programs when it is cost effective to do so. Users of this report can determine the cost effective maximum achievable potential by using the energy efficiency supply curves produced by this study.

The methodology used in the determination of the potential for electricity efficiency improvement in all sectors follows basically the following steps:

1. Identification of data sources to be used in this study
2. Identification of measures to be included in the assessment

[28] As required by the ECMB, the GDS Excel spreadsheet model operates on a PC platform using the MS windows operating system, is documented, and can be followed by a technician with expertise.

3. Determination of the characteristics of each measure including its incremental cost, energy savings, operations and maintenance savings, useful life, and peak demand impacts
4. Calculation of initial cost-effectiveness screening metrics (e.g., levelized $ per kWh saved and the total resource cost (TRC) benefit cost ratio) and sorting of measures from least-cost to highest cost
5. Collection and analysis of the baseline and forecasted characteristics of the market including equipment saturation levels and consumption and peak demand, by market segment and end use over the forecast period
6. Integration of measure characteristics and baseline data to produce estimates of cumulative costs and savings across all measures (supply curves)
7. Determination of the cumulative technical and maximum achievable potentials using supply curves.
8. Determination of the annual maximum achievable potential over the ten-year forecast period.

A key element in this approach is the use of energy-efficiency supply curves. Supply curves are a common tool in economics. In the 1970s, conservation supply curves were developed by energy analysts as a means of ranking energy conservation investments alongside investments in energy supply in order to assess the least cost approach to meeting energy service needs.

The advantage of using an energy-efficiency supply curve is that it provides a clear, easy-to-understand framework for summarizing a variety of complex information about energy efficiency technologies, their costs, and the potential for energy savings. Properly constructed, an energy-efficiency supply curve avoids the double counting of energy savings across measures by accounting for interactions between measures, is independent of prices, and also provides a simplified framework to compare the costs of efficiency with the costs of energy supply technologies.

This conservation supply curve approach also has certain limitations. In particular, the potential energy savings for a particular sector are dependent on the underlying load forecast for the sector as well as the measures that are listed and/or analyzed at a particular point in time. There may be additional energy efficiency measures or technologies that do not get included in an analysis, or the fraction of the market to which a measure applies may be miss-stated, so savings may be underestimated or overestimated. In addition, the costs of efficiency improvements (initial investment costs plus operation and maintenance costs) does not include all of the transaction costs for acquiring all the appropriate information needed to evaluate and choose an investment and there may be additional investment barriers as well that are not accounted for in the analysis. There are a number of other advantages and limitations of energy-efficiency supply curves (see, for example, Rufo 2003).[29]

The supply curve is typically built up across individual measures that are applied to specific base-case practices or technologies by market segment. Measures are sorted on a least-cost basis and total savings are calculated incrementally with respect to measures that precede them. Supply curves typically, but not always, end up reflecting diminishing returns, i.e., costs increase rapidly and savings decrease significantly at the end of the curve.

The cost dimension of most energy-efficiency supply curves is usually represented in dollars per unit of energy savings. Costs are usually annualized (often referred to as "levelized") in supply curves. For example, energy-efficiency supply curves usually present levelized costs per kWh or kW saved by multiplying the initial investment in an efficient technology or program by the "capital recovery rate" (CRR):

$$CRR = \frac{d}{1-(1+d)^{-n}}$$

where d is the real discount rate and n is the number of years over which the investment is written off (i.e., amortized). Then the annualized cost of the measure is divided by the annual kWh or kW savings of the measure to obtain the levelized cost per unit of energy saved. This is the approach we are using in this Connecticut Energy Efficiency Potential Study. Table 4-2 lists the discount and inflation rates used in this study.[30]

Table 4-2 Assumptions for Discount and Inflation Rates	
Real Discount Rate (RDR)	5.61%
Inflation Rate (Long Term Future)	2.45%
Nominal Discount Rate (NDR)	8.20%

[29] Rufo, Michael, 2003. *Attachment V – Developing Greenhouse Mitigation Supply Curves for In-State Sources, Climate Change Research Development and Demonstration Plan,* prepared for the California Energy Commission, Public Interest Energy Research Program, P500-03-025FAV, April. http://www.energy.ca.gov/pier/reports/500-03-025fs.html

[30] These are the same rates used by CL&P and UI in their 2003 NSTAR planning models. Avoided electric supply costs used in our NSTAR model benefit/cost analyses are the same avoided costs used in the CL&P and UI planning models for planning of 2003 programs in Connecticut.

The levelized costs are calculated as follows:

Levelized Cost per kWh Saved = Initial Cost x CRR/Annual Energy Savings
Levelized Cost per kW Saved = Initial Cost x CRR/Peak Demand Savings

The levelized cost per kWh and kW saved are useful because they allow simple comparison of the characteristics of energy efficiency with the characteristics of energy supply technologies.[31]

It is important to note that in an energy-efficiency supply curve, the measures are sorted by relative cost: from least to most expensive. In addition, the energy consumption of the system being affected by the efficiency measures goes down as each measure is applied. As a result, the savings attributable to each subsequent measure decrease if the measures are interactive. For example, an occupancy sensor measure would save more at less cost per kWh saved if it were applied to a fluorescent fixture with T12 lamps and magnetic ballasts rather than a T8 lamp and electronic ballast combination. If the T8 electronic ballast combination is more cost-effective, however, it would be applied first in the supply curve, reducing the energy savings potential for the occupancy sensor. Thus, in a typical energy-efficiency supply curve, the base-case end-use consumption is reduced with each unit of energy-efficiency that is acquired. Adjustments for measures that interact need to be performed where necessary. The results are then ordered by levelized cost and the individual measure savings summed to produce the energy-efficiency potential for the entire sector.

In the following sections we discuss the sector-specific aspects of the approaches used in the three sectors in more detail.

4.2 Development of Technical Potential Estimates for Energy Efficiency Measures by 2012

The total technical potential for each sector (residential, commercial, and industrial sectors) was developed from estimates of the technical potential of individual energy efficiency measures applicable to each sector (efficient lighting, efficient appliances, weatherization, home insulation, etc.). The general approach used in this study is identical to the approach used in the recent study completed in September 2002 for the State of California.[32]

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[31] It is important to note that the levelized cost per kW saved is a biased indicator of cost-effectiveness because all of the efficiency measure costs are arbitrarily allocated to peak savings. To address this bias, Koomey, et al. (1990) recommend calculation of the conservation load factor (CLF), which allows efficiency measures and supply options to be calculated together on a traditional energy supply screening curve.

[32] "California's Secret Energy Surplus: The Potential For Energy Efficiency – Final Report", Prepared for The Energy Foundation and The Hewlett Foundation, prepared by XENERGY Inc., September 23, 2002.

Core Equation

The core equation used to calculate the energy efficiency technical potential for each individual efficiency measure, by market segment, is shown below in Table 4-3 below (using a residential example):

Table 4-3 – Core Equation

Technical Potential of Efficient Measure	=	Total Number of Residential Households in State of Connecticut	*	Base Case Equipment End Use Intensity (kWh per home)	*	Base Case Factor	*	Remaining Factor	*	Convertible Factor	*	Savings Factor

where:

- **Number of Households** is the number of residential electric customers in the market segment.

- **Base-case equipment EUI** is the electric energy used per customer per year by each base-case technology in each market segment. This is the consumption of the energy-using equipment that the efficient technology replaces or affects. For example, if the efficient measure were a CFL, the base EUI would be the annual kWh per household associated with all equivalent incandescent lamps in the home.

- **Base Case factor** is the fraction of the end use energy that is applicable for the efficient technology in a given market segment. For example, for a residential high-efficiency lighting technology, this would be the fraction of the energy use that is for incandescent lighting.

- **Remaining factor** is the fraction of applicable dwelling units or floor space that has not yet been converted to the efficient measure; that is, one minus the fraction of households or floor space that already have the energy-efficiency measure installed.

- **Convertible factor** is the fraction of the applicable dwelling units (or floor space) that is technically feasible for conversion to the efficient technology from an *engineering* perspective (e.g., it may not be possible to apply water pipe insulation in all homes due to access difficulties).

- **Savings factor** is the percentage reduction in energy consumption resulting from application of the efficient technology.

Technical potential for peak demand reduction is calculated analogously. An example calculation for residential efficient lighting using the core equation is shown in Table 4-4 below for the case of a typical 75-Watt incandescent lamp, which is replaced by a 19-Watt CFL in the residential sector in Connecticut.

Table 4-4 – Sample Calculation Of Technical Potential For Efficient Lighting Savings In The Residential Sector In Connecticut In 2003

Technical Potential of Efficient Measure	=	Total Number of Residential Households in State of Connecticut	*	Base Case Equipment End Use Intensity (kWh/home)	*	Base Case Factor	*	Remaining Factor	*	Convertible Factor	*	Savings Factor
1,634 GWH	=	1,335,698	*	1,942	*	100%	*	84%	*	100%	*	75%

Technical energy-efficiency potential is calculated in two steps. In the first step, all measures are treated *independently*; that is, the savings of each measure are not marginalized or otherwise adjusted for overlap between competing or synergistic measures. By treating measures independently, their relative economics are analyzed without making assumptions about the order or combinations in which they might be implemented in customer buildings. However, the total technical potential across measures cannot be estimated by summing the individual measure potentials directly because some savings would be double-counted. For example, the savings from a measure that reduces heat gain into a building, such as low-e windows, are partially dependent on other measures that affect the efficiency of the system being used to cool the building, such as high-efficiency central air conditioning; the more efficient the central air conditioning unit, the less energy saved from the low-e windows.

4.2.1 Residential New Construction Sector

The supply curve estimates for the maximum achievable potential for the residential new construction sector in Connecticut are based on a technical analysis that GDS recently conducted for the Energy Star® Homes Program in New England. This study provides the incremental costs of the Energy Star® Homes Program, the useful life of measures, and the energy savings per home. This study also provides the baseline energy use for new homes likely to occur in the absence of the program.

4.2.2 Commercial and Industrial Sectors – Top Down Approach

A "top-down" approach was used to develop the technical potential estimates for the commercial and industrial sectors. The main difference from using a bottom-up method is that data is displayed in terms of energy rather than square feet. It is important to note that square-foot based saturation assumptions cannot be applied to energy use values without taking into account differences in energy intensity, (e.g., incandescent fixtures that represent 2 percent of floor space may represent 5 percent of lighting energy because they are several-fold less efficient than the rest of the lighting stock).

In the top-down method, the core equation used to calculate the energy technical potential for each individual efficiency measure, by market segment, is calculated as shown below in Table 4-5.

Table 4-5 – Core Equation – Commercial and Industrial Sectors – Top Down Method

Technical Potential of Efficient Measure	=	Total End Use GWh (by segment)	*	Base Case Factor	*	Remaining Factor	*	Convertible Factor	*	Savings Factor

An example of how the core equation was used in the commercial sector is shown in Table 4-6 for the case of a prototypical four-lamp, T8 fixture with an electronic ballast system, which is replaced by a Super T-8 fixture in the office segment of the CL&P service territory.

Table 4-6
Example of Technical Potential Calculation – Replace a 4-Lamp T-8 32-W EB Fluorescent with Super T-8 Fixture in the Office Segment for Existing Buildings

Technical Potential of Efficient Measure	=	Total End Use GWh (by segment)	*	Base Case Factor	*	Remaining Factor	*	Convertible Factor	*	Savings Factor
130.1 GWH	=	1,747	*	56%	*	95%	*	70%	*	20.0%

(Convertible factor of 70% reflects that 70% of market has already moved to T-8 lighting.)

Total measure costs in the top-down method can be calculated as a function of savings using costs per first-year kWh saved as the basis. For the example above, if the cost of the Super T-8 fixture is $12 and there are 3,000 full-load operation hours, the cost per first-year kWh saved is simply:

$12 divided by [(.12 kW/unit – 0.096 kW/unit) X 3,000 hours] = $0.167/first-year kWh

The total measure cost associated with the technical potential savings of 130.1 GWh can then calculated as:

130,100,000 first-year kWh X $0.167/first-year kWh = $21.7 million

Costs are then adjusted in the supply curve equation to account for reductions in savings that occur through the measure stacking process.

As noted above, a "top down" approach was also used in the Industrial Sector to determine the technical and maximum achievable potential in Connecticut. As with the Commercial Sector, this results in data displayed in terms of energy rather than square feet.

For the Industrial Sector, the core equation is identical to that described previously for the Commercial Sector. Table 4-7 illustrates an example of the core equation for the case of standard 1-5 horsepower motors being replaced by energy efficient motors in buildings within SIC Code 20 – Food.

Table 4-7 Example of Technical Potential Calculation – Replace a Standard Efficiency 1-5 HP Motor with a NEMA Premium Efficient Motor for SIC Code 20 – Food										
Technical Potential of Efficient Measure	=	Total End Use GWh (by segment)	*	Base Case Factor	*	Remaining Factor	*	Convertible Factor	*	Savings Factor
0.239 GWH	=	296.9	*	1.6%	*	87%	*	100%	*	5.7%

(Savings factor is expressed as share of electricity use.)

To determine the level of peak savings, the core equation is analogous with Total End Use kW (by segment) replacing Total End Use kWh (by segment).

A few other items that were unique to the Industrial Sector are discussed below.

Breakdown of electricity use by sector
For the identified sectors on a 2-digit SIC-level (3 digit NAICS), the GDS Team developed a breakdown of electricity use for the major end-uses, using national and regional data. The end-uses include process heating, cooling and refrigeration, motors (pumps, fans, compressors), process use, HVAC, lighting and miscellaneous end-uses (e.g. conveyor belts, internal transport, building support).

Identification of measures for each end-use
For each of the end-uses that apply to several SIC codes (referred to as cross-cutting), the GDS Team identified the energy efficiency measures that may still be applied in the selected industries in Connecticut. This analysis was based on studies available for the nation, Northeastern region and Connecticut, as well as sector studies (see list of sources provided).

To enable analysis within the constraints of this study, individual measures were aggregated using technical and economic criteria. For example, over 20 efficiency measures were identified for compressed air systems. It is impractical to characterize all 20 within the constraints of this study. Aggregating these measures on the basis of technical and economic criteria facilitates their inclusion in the analysis.

Identification of measures for process-specific end-uses (by sector)
For all of the identified sectors, the GDS Team focused on identification of a limited number of process-specific electricity saving measures. We focused on the most important electricity consuming sectors, and included measures for all

sectors. For example, in the plastic processing industry a large part of electricity consumption is used in extruders, for which specific measures can be identified. Similarly, large motors are used to drive a paper machine, and changes in the paper machine can reduce electricity use in the paper industry. Due to the study limitations, this can only be done for the most important electricity consuming processes, and based on already available sector studies (see list of sources provided).

Inclusion of Operation and Maintenance Savings (Non-Energy Benefits)
For many measures, a savings on the O&M of the affected equipment was included in the economic analysis. This O&M savings was estimated on a cost per kWh basis and included in the calculation of the Cost of Conserved Energy (CCE) calculation for each measure. In some cases, this resulted in a measure with a negative CCE. Table 4-8 illustrates the calculation of a negative CCE for the optimization of a compressed air system for SIC Code 20.

Table 4-8
Example of Cost of Conserved Energy Calculation – Optimization of Compressed Air System for SIC Code 20

Measure	O&M Savings ($/kWh)	CCE w/out O&M ($/kWh)	Supply Curve CCE ($/kWh)
Optimization of Compressed Air System	-0.02	0.007	-0.013

4.2.3 Commercial New Construction Sector

For the supply curve estimates for the Commercial Sector, we developed separate supply curve equations for the new construction market segment to capture the cost and savings associated with new construction energy efficiency measures. The supply curve equations are methodologically identical, however, the end-use consumption amounts are different, as are some of the measures.

The GDS Team constructed the commercial Existing and New Construction supply curves for the last year (2012) of the study period. In order to estimate the level of new construction activity in the commercial sector, half of the 22% growth in commercial energy sales (GWh) over the ten-year period from 2003 to 2012 was assumed to be associated with commercial new construction. We believe that this represents a reasonable estimate of commercial new construction activity.

4.3 Development of Maximum Achievable Potential Estimates for Energy Efficiency Measures by the Year 2012

The maximum achievable energy efficiency potential for the State of Connecticut is a subset of the technical potential estimates. **Maximum achievable potential** is defined as the maximum penetration of an efficient measure that would be adopted given unlimited funding, and by determining the maximum market penetration that can be achieved with a concerted, sustained campaign involving highly aggressive programs and market intervention. The term "maximum" refers to efficiency measure penetration, and means that the GDS Team has based our estimates of efficiency potential on the maximum realistic penetration that can be achieved by 2012. The term "maximum" does not apply to other factors used in developing these estimates, such as measures energy savings or measure lives.

The maximum achievable potential estimate for energy efficiency defines the upper limit of savings from market interventions. For each sector, the GDS/Quantum Team developed the initial year (2003) and terminal year (2012) penetration rate that is likely to be achieved for groups of measures (lighting, appliances, heating equipment, etc.) by end use for the "naturally occurring scenario" and the "with aggressive programs and unlimited funding" scenario. The GDS Team reviewed maximum penetration forecasts from other recent technical potential studies, actual penetration experience for programs operated by energy efficiency organizations (NEEP, NYSERDA, NEEA, BPA, utilities, etc.), input from the Project Advisory Team and penetration data from other sources (program evaluation reports, market progress reports, etc.) to estimate terminal penetration rates in 2012 for the maximum achievable scenario. In addition, the GDS Team conducted a survey of nationally recognized energy efficiency experts requesting their estimate of the maximum achievable potential for the State of Connecticut assuming implementation of aggressive programs and unlimited funding. The terminal year (2012) penetration estimates used in this study for Connecticut for all three sectors (residential, commercial, industrial) were based on the information gathered through this process. Based on a thorough review of all of this information, the GDS Team selected a maximum achievable penetration rate of **80 percent** by 2012 for all sectors.

Listed below in Table 4-9 is a summary of the information provided by energy efficiency experts across the U.S. in response to a request from the GDS Team to provide their expert judgment and a response to the following question: "Based on your experience and knowledge, and given the assumptions of implementation of very aggressive energy efficiency programs for the next 10 years in Connecticut and **unlimited funding**, what **maximum** penetration do you believe could be achieved in Connecticut for electric energy efficiency measures by the end of 2012 (ten years from now)?"

Table 4-9 – Expert Input on Maximum Achievable Penetration Rate

#	Efficiency Expert	Maximum Achievable Penetration Estimate Given ECMB Assumptions of Aggressive Programs and Unlimited Funding
1	Dr. Kenneth Keating - BPA	70% of energy efficiency technical potential
2	Fred Gordon-Energy Trust of Oregon	85% of stock for existing markets, on average. For new construction, 85% of turnover of floor space.
3	Raphael Friedman – Pacific Gas and Electric Company	With unlimited funding, you probably could save similar amounts to those shown in the California energy efficiency potential studies. The California Energy Surplus Study used 80% as a maximum penetration rate.
4	Janet Brandt – Wisconsin Energy Conservation Corporation	100% of Connecticut's growth in energy and demand
5	Ernst Worrell - LBL	The maximum penetration rate for energy efficiency measures should be around 80% or slightly more, given aggressive programs and unlimited funding.
6	Tom Eckman – Northwest Power Planning Council (NWPPC)	Historically, the Northwest Power Planning Council has assumed that "on average" 85% of the "cost-effective" and "technically feasible" efficiency potential is achievable over a 20 year planning horizon. The empirical basis for this assumption is the experience in the Hood River Conservation project where Residential Weatherization measures where install free of charge (100% incentives) to participants. In the Hood River project about 90% of the household that were eligible participated and they installed roughly 90% of the technically feasible measures. The project only lasted two years so the NWPPC assumed that after 18 more years they would get most of the rest of the feasible measures installed. Assuming that programs could pay up to the full cost of all but the most expensive measures (since some amount of money must be used for program administration) and still remain cost-effective, the Council believes that a similar fraction of commercial and industrial customers would accept such offers.

		Over the past twenty of more years there were two periods when the Pacific Northwest Utilities and BPA were aggressively pursuing efficiency. During these periods the region "ramped" up efficiency acquisitions from less than 20 average MW to over 130 average MW in three to four years. If utilities and BPA had maintained this level of acquisition over a ten-year period, the region would have achieved about 70% of the technically feasible and cost-effective efficiency potential identified in the Council's Plans covering those same years. I might add that this level was achieved without offering 100% rebates -- the average incentive is probably in the range of 30 to 50% of measure incremental cost.
7	Nick Hall - TecMarket Works	Market research in the area of the diffusion cycle, the adoption path and the steps associated with the decision process leads me to know, without any uncertainty, that we can achieve a 80% to 90% market potential if we are allowed to design and operate a program to do so.
8	Michael Rufo – Quantum Consulting	The California Energy Surplus Study used 80% as a maximum achievable penetration rate for energy efficiency measures. Connecticut should be able to achieve similar maximum penetration of efficiency measures assuming aggressive programs and unlimited funding.

4.3.1 Penetration Rates from Other Efficiency Potential Studies

As noted above, the GDS Team also reviewed maximum penetration rate assumptions used in other recently published energy efficiency potential studies. Table 4-10 on the next page presents the information collected from these other recent studies. Finally, the GDS Team collected information on energy efficiency programs conducted in the Northeast during the past three decades where high penetration has been achieved. Examples of three such programs are listed below:

- Electric water heater insulation programs – A paper presented at the Fourth National DSM Conference[33] by Richard Spellman of GDS found

[33] Spellman, Richard F., "Demand-Side Management Market Penetration: Modeling and Resource Planning Perspectives from Central Maine Power Company", presented at the Fourth National Conference on Utility DSM Programs, April 1989.

that residential electric water heater programs operated in New England by electric utilities had achieved very high penetration rates by 1989.

- Energy efficiency programs targeted at low-income customers of electric utilities in New England have achieved very high penetration rates during the 1980's and 1990's.
- Residential weatherization and insulation programs implemented by electric utilities in New England have achieved high participation rates.

Table 4-10 - Maximum Achievable Penetration of Energy Efficiency Measures by 2012

Data Source	Penetration Rates 2003	Penetration Rates 2012	Notes
Source: The Achievable Potential for Electric Efficiency Savings in Maine			
CFL Saturation	10.0%	55.0%	
Energy Star Refrigerators	30.0%	85.0%	
High Efficiency Freezers	30.0%	85.0%	
High Efficiency Clothes Washers	70.0%	95.0%	
High Efficiency Room Air Conditioner	50.0%	95.0%	
High Efficiency Dishwashers	30.0%	85.0%	
Source: Vermont Department of Public Service - Electric And Economic Impacts of Maximum Achievable Statewide Efficiency Savings			
New Home		95.0%	Percent of homes treated, page 8, savings in 10th year.
Retrofit Measures		70.0%	Percent of homes treated, page 8, savings in 10th year.
Product Sales		75.0%	Percent of homes treated, page 8, savings in 10th year.
Source: California's Secret Energy Surplus: The Potential for Energy Efficiency			
All sectors		80.0%	
Source: The New Mother Lode: The Potential for More Efficient Electricity Use in the Southeast			
New Buildings		80.0%	Analysis was performed over the 2003 - 2020 period
Existing Buildings		100.0%	100% achieved by 2010.

4.3.2 Examples of US Efficiency Programs with High Market Penetration

The GDS Team reviewed data from a recent ACEEE publication[34] on exemplary market transformation (MT) programs. This report provided several examples of MT programs where markets have been transformed or are almost transformed. Examples of such programs that have achieved high penetration and participation in a relatively short period of time are the following:

Table 4-11 – Examples of Markets That Are Highly Transformed	
1	Residential clothes washers
2	Residential appliances
3	Residential central air-conditioning equipment
4	Commercial packaged air conditioning
5	Commercial new construction
6	Exit signs
7	Builder Operator Training
8	Commercial Clothes Washers
9	Traffic Signals
10	Dry-type transformers

4.3.3 Lessons Learned from America's Leading Efficiency Programs

The GDS Team also reviewed program participation and penetration data included in ACEEE's March 2003 report on America's leading energy efficiency programs.[35] The information presented in this recent ACEEE report clearly demonstrates the wide range of high-quality energy efficiency programs that are being offered in various areas of the United States today. A common characteristic of the programs profiled in this ACEEE report is their success in reaching customers with their messages and changing behavior, whether regarding purchasing of new appliances, designing new office buildings, or operating existing buildings.

[34] Nadel, Steven; Thorne, Jennifer; Sachs, Harvey; Prindle, Bill; R Neal Elliott; "Market Transformation: Substantial Progress from a Decade of Work", published by the American Council for an Energy Efficient Economy, April 2003, Report Number A036.
[35] York, Dan; Kushler, Martin; "America's Best: Profiles of America's Leading Energy Efficiency Programs," published by the American Council for an Energy Efficient Economy, March 2003, Report Number U032.

4.3.4 Estimating Maximum Achievable Potential

To estimate the maximum achievable potential for each year of the forecast period, we first separated the forecasts of energy and peak demand in Connecticut into existing and new construction. Existing construction is defined as the entire stock of buildings in place today. New construction is defined as the stock of buildings that is constructed over the 10 years of the forecast period. For new construction, energy-efficiency measures can be implemented when each new building is constructed, thus the rate of availability is a direct function of the rate of new construction. For existing building, determining the annual rate of availability of savings is more complex.

Energy-efficiency potential in the existing stock of buildings can be captured over time through two principal processes: 1) as equipment replacements are made normally in the market when a piece of equipment is at the end of its useful life (we refer to this as the "market-driven" case) and 2) at any time in the life of the equipment or building (which we refer to as the "retrofit" case). Market-driven measures are generally characterized by *incremental* measure costs and savings (e.g., the incremental costs and savings of a high-efficiency versus a standard efficiency air conditioner); whereas retrofit measures are generally characterized by full costs and savings (e.g., the full costs and savings associated with retrofitting ceiling insulation into an existing attic). A specialized retrofit case is often referred to as "early replacement". This refers to a piece of equipment whose replacement is accelerated by several years, as compared to the market-driven assumption, for the purpose of capturing energy and peak demand savings earlier than they would otherwise occur. The actual rates of ramp-in used in this study for each of these types of measures is included in Table 4-1 at the end of this section.

For the market driven measures, it is assumed that existing equipment will be replaced with high efficiency equipment at the time a consumer is shopping for a new appliance or other energy using equipment, or if the consumer is in the process of building or remodeling. Using this assumption, equipment that needs to be replaced (replaced on burnout) in a given year is eligible to be upgraded to high efficiency equipment. For the retrofit measures, savings can theoretically be captured at any time; however, in practice it takes many years to retrofit an entire stock of buildings, even with the most aggressive of efficiency programs.

For certain energy efficiency measures, estimates of potential include both market-driven and early replacement-based savings. Examples of measures that are addressed using both approaches include residential refrigerators, residential air conditioning, commercial chillers and packaged AC units and early replacement of lighting fixtures in commercial buildings. The accelerated replacement of air conditioning measures is particularly relevant to the Southwest Connecticut analysis.

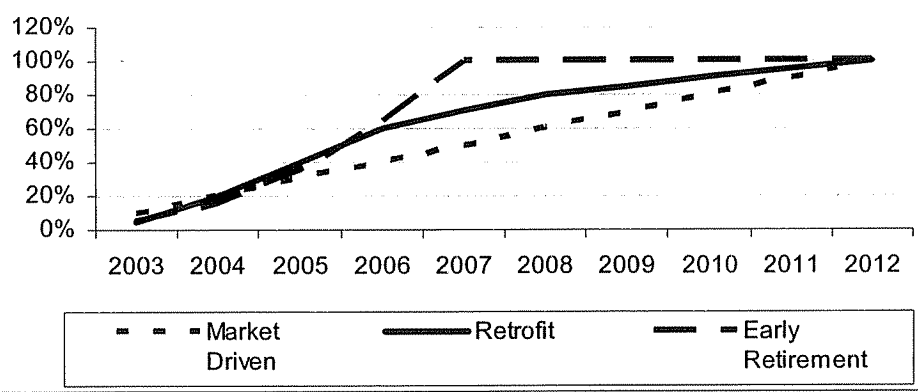
For the "market driven" maximum achievable potential, we calculate the rate at which savings are available as a function of the useful life of each piece of equipment. A simplified form of this function is the inverse of the useful life; thus, if the average life of air conditioners is 20 years, their replacement is estimated to occur in the market-driven case at the rate of 1/20 per year. As noted above, retrofit measures are available for implementation by the entire eligible stock at any time; however, there are practical limits to reaching the entire stock of buildings over a short period of time. In this study, the annual rate of availability of retrofit measures assumes unlimited program funding and a concerted, sustained campaign involving highly aggressive programs and market interventions. For retrofit measures, it was assumed that installations over time would be faster than those done through the market-driven approach. After a short ramp-up period early, it was assumed that retrofit measures would be implemented aggressively in early-to-mid years of the next decade. The GDS team drew on its experience, input from additional national experts, and review of historic program accomplishments (for aggressive programs) over similar time periods (i.e., roughly 10 years) to develop annual rates of availability for the retrofit measures. The annual ramp-in rates that were used in this study for each of the three categories of measures are shown in Table 4-12. For market-driven and retrofit measures, the annual ramp-in rates are applied to the cumulative annual maximum achievable cost effective potential available in the year 2012 to obtain the year-by-year energy savings potential for the period 2003 to 2012. Figure 4-1 graphically illustrates the cumulative ramp-in rates over the ten-year period. By 2012, 100% of the available maximum achievable potential has been ramped-in.

Table 4-12 Annual Ramp-In Rates for Individual Energy Efficiency Measures

Year	Market Driven (1)	Retrofit (1)	Early Retirement
2003	10%	5%	5%
2004	10%	15%	10%
2005	10%	20%	20%
2006	10%	20%	30%
2007	10%	10%	35%
2008	10%	10%	0%
2009	10%	5%	0%
2010	10%	5%	0%
2011	10%	5%	0%
2012	10%	5%	0%

(1) For the market driven and retrofit ramp-in rates, it is important to note that these annual ramp-in rates are applied to the total maximum achievable cost effective potential that is available by 2012. For example, if an efficiency measure has a 20 year useful life, only half of the full technical potential is available by 2012 (ten years from now).

Figure 4-1 Cumulative Ramp-In Rates



4.4 Development of Maximum Achievable Cost Effective Potential Estimates for Energy Efficiency

The maximum achievable cost effective potential is defined as the potential for maximum penetration of energy efficient measures that are cost effective according to the Total Resource Cost test, and would be adopted given unlimited funding, and by determining the maximum market penetration that can be achieved with a concerted, sustained campaign involving highly aggressive programs and market interventions.[36] To develop the maximum achievable cost effective potential, the GDS Team only retained in the energy efficiency supply curves those measures that were found to be cost effective (according to the Total Resource Cost Test) based on the individual measure cost effective analyses conducted in Task 4 of this Study. Energy efficiency measures that are not cost effective are excluded from the estimate of maximum achievable cost effective energy efficiency potential.

4.5 Free-ridership Issues

Free-riders are defined as participants in an energy efficiency program who would have undertaken the energy-efficiency measure or improvement in the absence of a program or in the absence of a monetary incentive. In this energy efficiency potential study, free-riders are addressed through the load forecasts that were used by the GDS Team as the starting point of this technical analysis. The issue of free-ridership was discussed by the GDS Team with CL&P staff, UI staff and the ECMB consultants at the beginning of this study in March and April of 2003. Early on in this study, the GDS Team requested that CL&P and UI provide estimates of naturally occurring energy efficiency (by major market sector) already included in their load forecasts. CL&P and UI responded to the GDS Team that they could not break out from their official load forecasts their estimates of naturally occurring energy efficiency. As a result, the GDS Team did not have any direct and explicit estimates from the utilities of naturally occurring energy efficiency for the period 2003 to 2012.

Fortunately, the utilities (CL&P and UI) were able to provide data that allowed the GDS Team to develop a breakdown of an end use forecast by sector for the State of Connecticut (and sub regions) of electric sales for the period 2003 to 2012 (developed from the CL&P and UI official load forecasts released on June 11, 2003). This base case load forecast for the State ties to the CL&P and UI forecasts, and includes naturally occurring energy efficiency as well as the

[36] This is the definition of "maximum achievable potential" provided on page 2 of the ECMB's RFP for this study. The term "maximum" refers to efficiency measure penetration, and means that the GDS Team has based our estimates of efficiency potential on the maximum realistic penetration that can be achieved by 2012. The term "maximum" does not apply to other factors used in developing these estimates, such as measures energy savings or measure lives.

impacts of the planned energy efficiency (EE) programs. This base case load forecast (including naturally occurring energy efficiency and planned EE programs) for the State of Connecticut is provided in Appendix E of this Report. Once the base case load forecast for the State had been developed and approved by the ECMB, the GDS Team added back to the base case load forecast the impacts of the energy efficiency (EE) programs planned by CL&P and UI. This forecast without EE impacts but with naturally occurring energy efficiency became the starting point in this study for all calculations of energy efficiency potential.

In summary, free-riders are accounted for through the load forecasts used in this study for the State, the SWCT region, and the NOR-STAM region. These load forecasts do include naturally occurring energy efficiency. Once the base case load forecasts for each region were developed by GDS and approved by the ECMB, the GDS Team applied a number of factors to these load forecasts to determine potential energy efficiency savings by end use by sector by region. Because naturally occurring energy savings are already reflected in the load forecasts used in this study, these savings were not available to be saved again through the GDS energy efficiency supply curve analysis. GDS used this process to ensure that there could be no "double-counting" of energy efficiency savings.

4.6 Adjustments to Lifetime Savings for Early Retirement Measures

For early retirement energy efficiency measures, it was assumed that the measure would be replaced five years prior to reaching the end of its expected lifetime. Therefore, for the first five years, the savings associated with the measure reflects the large savings that result from replacing an old, relatively inefficient measure with a new energy-efficient model. For the remaining life of the measure, 12 years in the refrigerator example, the energy savings associated with the measure reflects the incremental savings associated with installing an energy-efficient model rather than a new standard-efficient model. While there are more substantial savings available in the first five years, continued savings at a lower level are captured for the remainder of the measure lifetime.

For the commercial sector, there were three measures that were modeled with this early retirement scenario. These three measures are Super T-8 lighting, packaged air conditioning and chillers. There were no industrial measures modeled as early retirement. For the residential sector, early retirement measures included Energy Star® refrigerators, Energy Star® freezers, and central air conditioners.

5.0 FORECAST OF ELECTRIC ENERGY AND PEAK DEMAND FOR THE STATE OF CONNECTICUT

This section of the report provides a summary of the electric energy and peak load forecasts used in this study for the State of Connecticut and two sub-regions of the State. More detailed information on the load forecasts obtained from Connecticut Light and Power Company, United Illuminating and ISO-New England are provided in the appendices to this report, along with detailed information on residential sales by end use, and commercial and industrial sales by industry classification.

5.1 Historical Electric Peak Demand (MW) – New England and Connecticut

Peak electric demand in New England grew from 20,569 MW in the summer of 1997 to a level of 25,516 MW in the summer of 2002, an increase of 24 percent over this five-year period (this is equivalent to an average annual rate of growth of 4.4 percent per year). Over the same time period, peak demand growth in Connecticut (including service areas of CL&P, UI and CMEEC) averaged 2.5 percent growth per year. The historical peak demand data for the period 1997 to 2002, provided in Table 5-1 below, was obtained from ISO New England and is not weather-normalized. Connecticut includes the Southwest Connecticut region (SWCT), and SWCT includes the Norwalk-Stamford area (NOR). The actual summer peak demand for 2002 for New England of 25,516 MW was obtained from the ISO-New England 4/1/2003 CELT Report, Section 1 Summaries Table, footnote 7. The summer 2002 peak demand for New England occurred on August 14, 2002 at 1500 hours (2 to 3 PM).

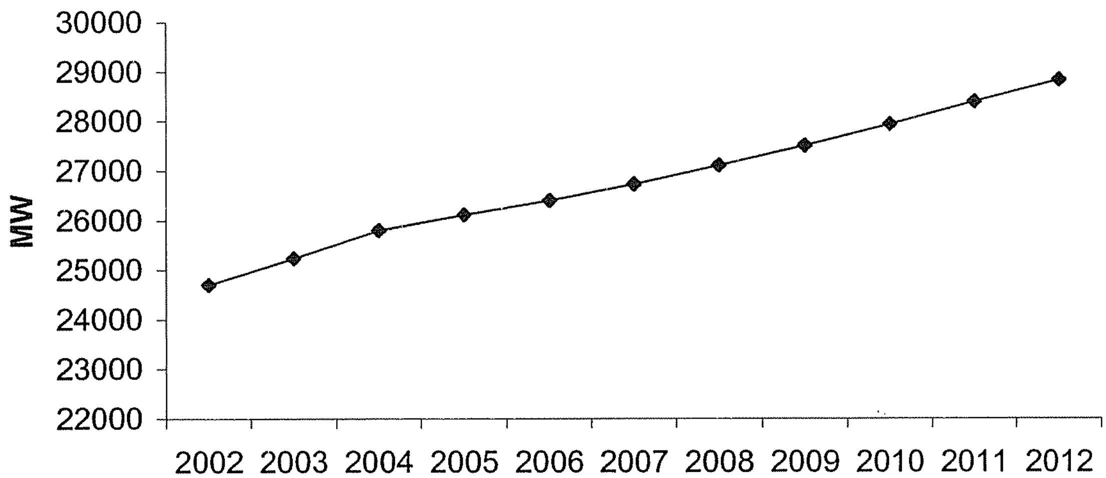
Table 5-1 - Historical Peak Demand (MW) – New England and Connecticut

Year	NEPOOL[1]	Connecticut	SWCT	Norwalk-Stamford	SWCT as % of State
1997	20,569	6,019	2,858	1,043	47.48%
1998	21,406	5,836	2,777	1,029	47.58%
1999	22,544	6,345	3,125	1,142	49.25%
2000	21,736	5,900	2,841	1,018	48.15%
2001	24,967	6,799	3,247	1,188	47.76%
2002	25,516	6,805	3,285	NA	48.27%
Avg. Ann. Growth	4.40%	2.50%	2.80%	3.30%	48.08%

5.2 Demand Forecast for New England

The most recent ISO-New England forecast of peak demand is contained in the **2003 CELT Report**, issued April 1, 2003.[37] This 2003 CELT Report was posted to the ISO New England web site on April 23, 2003. As shown in Figure 5-1, assuming normal summer weather patterns, New England's "adjusted" summer peak demand is expected to grow by 1.6% annually, from 24,699 MW in 2002 to 28,824 MW by 2012.[38] Protracted heat and humidity in the summer of 2002 resulted in a record summer peak of 25,516 MW for NEPOOL, significantly above the forecast value of 24,200 MW for the summer peak for 2002. The fact that actual peak demands can exceed normal weather forecast values must be taken into account when conducting planning studies. Peak demand in the SWCT area is not forecast separately by ISO-NE, but is estimated as a percentage of total New England peak demand.

Figure 5-1 - New England Summer Peak Load Forecast



5.3 Peak Demand Forecast for State of Connecticut

For purposes of the ECMB's Connecticut Technical Potential Study, the ECMB directed the GDS/Quantum team to use the latest available load forecasts from Connecticut Light and Power (CL&P) and United Illuminating (UI) to develop a

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[37] Peak load (also referred to as demand or peak demand) is typically measured in MW and is a key factor in transmission and generation reliability. Load or energy consumption is typically measured in MWh and is not a key reliability factor

[38] NEPOOL peak load forecast takes into account DSM, customer self-generation, weather normalization, and other adjustments. The forecast peak demand figures for 2002 and 2012 were obtained from the April 1, 2003 CELT Report, Section 1-Summaries Table.

load forecast for the State of Connecticut.[39] As of September 1, 2003, the latest available load forecasts for the CL&P and UI service areas were published on June 11, 2003. For CL&P, this forecast is presented in a document titled "CL&P, 2003 Forecast of Loads and Resources for 2003 to 2012, June 11, 2003." The latest available load forecast for United Illuminating is presented in a document titled "The United Illuminating, Report to the Connecticut Siting Council, June 11, 2003." The GDS Team applied the actual 2002 market segment shares for the UI service area to the forecast of Total kWh sales for the UI service area to obtain a forecast of sales by class of customer for the UI service area (because the June 2003 UI load forecast did not provide a forecast of kWh sales by major market segment). Then the CL&P and UI forecasts of the impacts of planned energy efficiency programs were added to the June 11, 2003 CL&P and UI load forecasts to obtain base case forecasts that exclude the impacts of planned energy efficiency programs. To obtain the State of Connecticut load forecast to use in this study, the June 11, 2003 CL&P and UI load forecasts were added together. The resulting State of Connecticut load forecast used in this study is shown in Tables 5-2 and 5-3 below.

[39] The CMEEC service area is not included in this study.

Table 5-2 - June 2003 State of Connecticut Load Forecast (Sum of CL&P and UI June 2003 Load Forecasts - 2003 to 2012) (Excludes Impacts of Planned Energy Efficiency Programs)						
Year	Residential GWH	Commercial GWH	Industrial GWH	Other GWH	Total GWH	Summer Peak (MW)
2003	12,123	12,155	4,650	337	29,265	6,331
2004	12,262	12,360	4,682	342	29,646	6,419
2005	12,344	12,633	4,722	341	30,040	6,560
2006	12,462	12,932	4,782	343	30,519	6,672
2007	12,571	13,214	4,833	343	30,961	6,776
2008	12,672	13,497	4,893	344	31,405	6,875
2009	12,773	13,764	4,943	346	31,826	6,964
2010	12,883	14,039	4,998	348	32,267	7,058
2011	12,996	14,301	5,053	348	32,698	7,150
2012	13,142	14,591	5,121	351	33,205	7,243
Annual Growth	0.90%	2.05%	1.08%	0.43%	1.41%	1.51%

Sources: The United Illuminating, Report to the Connecticut Siting Council, June 11, 2003 and CL&P, 2003 Forecast of Loads and Resources for 2003 to 2012, June 11, 2003. The figures in this table exclude the impacts of planned energy efficiency and load

Table 5-3 - June 2003 State of Connecticut Load Forecast Forecast Market Shares for Energy (GWH) Forecast Based on Sum of CL&P and UI June 2003 Load Forecasts - 2003 to 2012 Excludes Impacts of Planned Energy Efficiency Programs						
Year	Residential GWH	Commercial GWH	Industrial GWH	Other GWH	Total GWH	
2003	41.42%	41.53%	15.89%	1.15%	100.00%	
2004	41.36%	41.69%	15.79%	1.15%	100.00%	
2005	41.09%	42.05%	15.72%	1.14%	100.00%	
2006	40.83%	42.37%	15.67%	1.12%	100.00%	
2007	40.60%	42.68%	15.61%	1.11%	100.00%	
2008	40.35%	42.98%	15.58%	1.09%	100.00%	
2009	40.13%	43.25%	15.53%	1.09%	100.00%	
2010	39.93%	43.51%	15.49%	1.08%	100.00%	
2011	39.74%	43.74%	15.45%	1.07%	100.00%	
2012	39.58%	43.94%	15.42%	1.06%	100.00%	

Source: The above market share percentages are based on data provided by CL&P and UI, and exclude the impacts of planned energy efficiency and load management programs.

5.4 Load Forecasts for Southwest Connecticut and Norwalk-Stamford Regions

The geographic scope of SWCT based on a regional or political boundary consists of the following 52 towns and municipalities:

> **SWCT**—Bridgeport, Darien, Easton, Fairfield, Greenwich, New Canaan, Norwalk, Redding, Ridgefield, Stamford, Weston, Westport, Wilton, Ansonia, Branford, Beacon Falls, Bethany, Bethel, Bridgewater, Brookfield, Cheshire, Danbury, Derby, East Haven, Hamden, Meriden, Middlebury, Milford, Monroe, Naugatuck, New Fairfield, New Milford, New Haven, Newtown, North Branford, North Haven, Orange, Oxford, Prospect, Roxbury, Seymour, Shelton, Sherman, Southbury, Stratford, Trumbull, Wallingford, Waterbury, Watertown, West Haven, Woodbridge, and Woodbury.

After reviewing forecasts of peak demand in Connecticut and SWCT from 2002 forward that had been prepared by ISO-NE and Connecticut's electric distribution companies, the Connecticut Department of Public Utility Control (DPUC) announced its own estimate "that the peak demand in SWCT will range between 3,000 MW and 3,500 MW in 2002 and will grow at approximately 1.75% thereafter."[40] July 3, 2002, the day the DPUC published this conclusion, was the 2002 peak load day for Southwest Connecticut. The load experienced was 3,285 MW, approximately the same as the 3,300 MW that the DPUC used for its "reference case" in the Summer Shortage Report.[41] The peak load forecasts for the SWCT and NOR regions for this study were obtained from ISO New England from the April 1, 2003 CELT Report. The load forecasts published in the CELT report for these two regions include the impacts of CL&P and UI energy efficiency and load management programs.

The map in Figure 5-2, taken from the Transmission Expansion Advisory Committee (TEAC) 13 presentation, graphically illustrates the load densities in SWCT. Heavy electric loads are concentrated around Stamford, Norwalk, and the corridor between Bridgeport and New Haven. Tables 5-4 and 5-5 (following) show the ISO New England's latest reference case electric peak load forecast for the SWCT region and for the Norwalk-Stamford region. The GDS/Quantum Team adjusted these load forecasts (by adding back in the planned C&LM impacts) to arrive at a "base case" for each of these regions.

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[40] DPUC Docket No. 02-04-12 - DPUC Investigation into Possible Shortages of Electricity in Southwest Connecticut During Summer Periods of Peak Demand (July 3, 2002) ("Summer Shortage Report"), p. 8.
[41] Summer Shortage Report, p. 3.

Figure 5-2 - Load Densities - Southwestern Connecticut

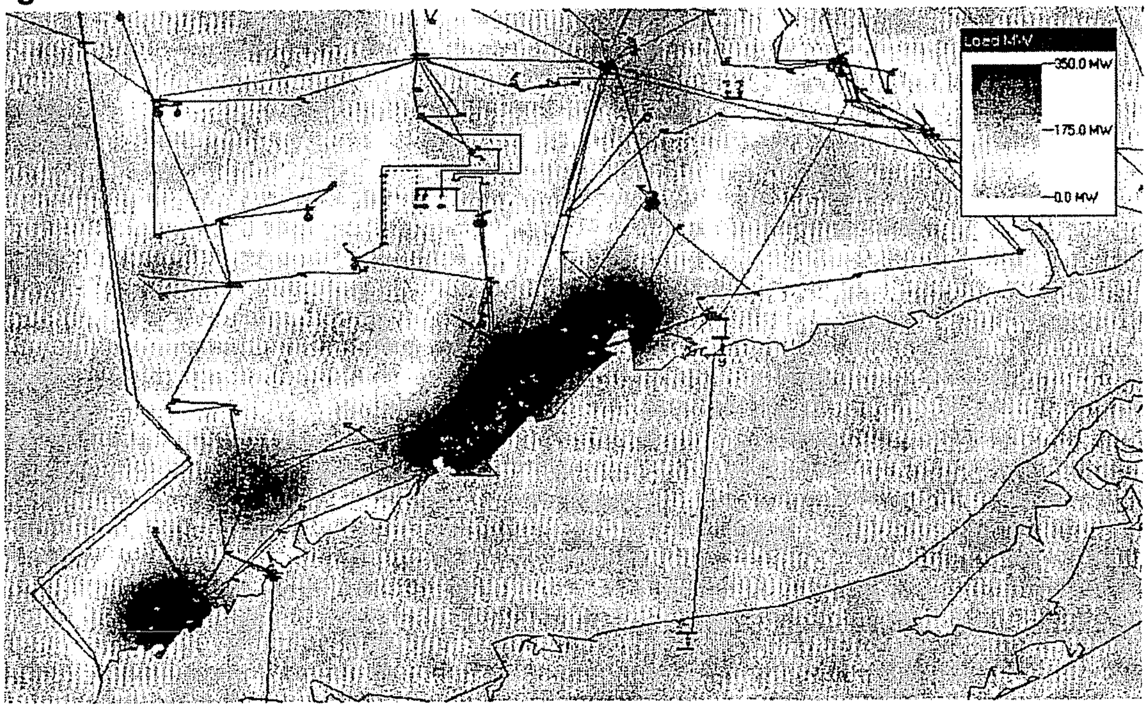


Table 5-4 - Energy and Peak Load Forecast for SWCT (Including Norwalk Stamford - Excluding C& LM)

Reference Case - SWCT - Excluding C&LM			
Year	Total GWH Sales	Summer Peak (MW)	Winter Peak (MW)
2003	17,028.5	3,549	2,907
2004	17,479.3	3,658	2,970
2005	17,718.5	3,726	3,043
2006	18,002.2	3,799	3,111
2007	18,282.8	3,872	3,182
2008	18,611.0	3,952	3,271
2009	18,979.7	4,032	3,347
2010	19,263.7	4,088	3,412
2011	19,557.8	4,147	3,481
2012	19,855.5	4,209	3,548
Average Annual Growth Rate	1.7%	1.9%	2.2%

Table 5-5 - Energy and Peak Load Forecast for NORWALK STAMFORD REGION (Excluding C& LM)

Year	Total GWH Sales	Summer Peak (MW)	Winter Peak (MW)
2003	5,956.7	1,263	987
2004	6,118.6	1,303	997
2005	6,199.9	1,326	1,011
2006	6,300.7	1,352	1,022
2007	6,402.3	1,378	1,033
2008	6,517.7	1,407	1,060
2009	6,650.5	1,436	1,082
2010	6,755.5	1,457	1,099
2011	6,860.5	1,479	1,119
2012	6,971.4	1,502	1,137
Average Annual Growth Rate	1.8%	1.9%	1.6%

5.5 Ratio of SWCT Peak Load to Peak Load for the State of Connecticut

5.5.1 SWCT Load as a Percent of the State Peak Load

Based on the data in Table 5-1 above, the summer peak load in the SWCT region of Connecticut has been about 48 percent of the summer peak load for the entire State of Connecticut for the period 1997 to 2002. By the year 2012, this ratio is expected to increase to 58 percent based on the most recent electricity demand forecasts for the SWCT region and the State as a whole. The major reason that the ratio of SWCT summer peak load to the State peak load increases to 58% by 2012 is due to the fact that CL&P and UI are forecasting lower peak load growth for the State than ISO New England is forecasting for the SWCT and NOR regions of the State. This trend is consistent with recent historical peak growth experience, where the summer peak load for the SWCT region grew at an average annual rate of 2.8% versus 2.5% for the entire State during the period from 1997 to 2002.

5.5.2 SWCT Peak Load as a Percent of CL&P and UI Peak Load

The forecasted peak MW demand values for SWCT and Norwalk/Stamford as shown in Tables 5-4 and 5-5 were developed by the NE ISO because the utilities (CL&P and UI) did not develop forecasts for these regions. It is important to note that the ECMB directed GDS to use the latest available load forecasts (dated June 11, 2003) from UI and CL&P in developing the load forecast for the State of Connecticut, and the ECMB directed GDS to use the ISO New England load forecasts for the SWCT and NOR regions. Finally, the projected maximum achievable cost effective peak load savings for the State of Connecticut, SWCT, and Norwalk/Stamford reflect a 12.5% peak load estimated reduction for each region by 2012.

The major reason that the ratio of SWCT summer peak load to the CL&P/UI serve area peak load increases to 58% by 2012 is due to the fact that CL&P and UI are forecasting lower peak load growth for the State than ISO New England is forecasting for the SWCT and NOR regions of the State. This trend is consistent with recent historical peak growth experience, where the summer peak load for the SWCT region grew at an average annual rate of 2.8% versus 2.5% for the entire State during the period from 1997 to 2002.

5.6 The Southwest Connecticut Load Pocket – Special Situation

Load pockets (congested areas) are regions or sub-regions that are dependent upon transmission capacity to import power to serve their demand. Deficient load pockets require the operation of more expensive local generation (also referred to as out-of-merit) to meet load requirements because less expensive generation outside the load pocket cannot be transported to serve local load. The additional costs to run these generators in a load pocket out-of-merit order are paid by customers in the form of congestion charges called "uplift." Under current NEPOOL regulations (which are in the process of being changed), uplift charges are socialized among all customers in New England. If the transmission constraints are severe enough and loads cannot be met via transmission imports and local generation capability, voltage reductions and power outages may ensue.

SWCT, including the Norwalk-Stamford sub-area (NOR), is designated as a Deficient Load Pocket and is of particular concern to ISO-NE, FERC and the ECMB given the severity of the transmission constraint, the amount of load potentially at risk, and the siting complexities associated with expanding the transmission system to ensure grid security.

Geographically, SWCT is defined as the 52 municipalities within the southwest quadrant of the state, extending as far north as New Milford, east to Meriden, and south to Branford. The NORWALK-STAMFORD sub-area consists of 16 towns and cities and it is separate from SWCT (39 cities and towns).

A 2001 ISO-New England study of the regional transmission expansion plan (RTEP 2001) focused particular attention on SWCT and NOR, and contained the following primary conclusions:

- SWCT, particularly the NOR sub-area, will have severe reliability problems beginning in 2004 if the largest single generation source in the area, the Milford combined cycle plant, is unavailable.
- Even with Milford available, SWCT and especially the NOR sub-area will have reliability problems in later years if other generation (Bridgeport Energy and Bridgeport Harbor) or other transmission resources become unavailable.
- Significant transmission congestion occurs between Maine (locked-in generation in Maine) and Boston (load pocket), SEMA-RI (locked-in generation) and Boston. Congestion in Boston and SWCT costs ratepayers between $125-$600 million annually.[23] Almost two-thirds of this cost was due to congestion in SWCT and the NOR sub-area.[24]

The main recommendation in RTEP01 was "to pursue, on a priority basis, short-term transmission system upgrades to address the SWCT reliability concerns."

The RTEP02 Report provided a status report on the RTEP01 recommendations and updated the RTEP01 findings. The most urgent system reliability need identified in RTEP02 was in SWCT and NOR. "Without widespread transmission infrastructure upgrades, studies demonstrate widespread violations of transmission planning criteria. As a result, without such upgrades, it is doubtful that the existing system could reliably support projected loads in the long term. ISO-NE has determined that the existing transmission system configuration cannot provide for significant generation expansion or even the simultaneous operation of existing generation at full load." Other findings were as follows:

- Short-term transmission upgrades (upgraded breakers, installed capacitor banks, reconductored lines), as well as emergency and load response measures, improved reliability in SWCT for the summer 2002.[42]
- ISO-NE found that the most effective long-term strategy to reduce congestion costs was to improve import limits, i.e., extend a 345 kV loop from Plumtree into NOR (Phase I) and to Beseck Junction (Phase II).
- Projected congestion costs in New England under an SMD environment will be mostly due to constraints in SWCT and NOR, and could range from $50-$300 million in 2003.[25]

[42] The ECMB has noted that load reductions from conservation and energy efficiency measures also have improved reliability in SWCT.

6.0 SECTOR SPECIFIC ENERGY EFFICIENCY POTENTIAL IN THE STATE OF CONNECTICUT

In this section we present estimates of the maximum achievable cost-effective electric energy-efficiency potential by sector (residential, commercial and industrial sectors) in the State of Connecticut and two sub-regions of the State. We begin by presenting estimates of technical potential and then discuss our estimates of the maximum achievable cost-effective potential. Definitions of the different types of potentials and our base case load forecast scenario are provided in Section 4 (Methodology) and Section 5 (Load Forecasts) of this report. We analyzed potential for almost 300 unique energy efficiency measures across numerous market segments in the residential, commercial and industrial sectors.

Table 6-1 illustrates the benefit cost ratio for each sector in the Statewide scenario based upon the total resource cost test.

Table 6-1 - Sector Level Benefit/Cost Ratios For All Measures with a Benefit/Cost Ratio of Greater than 1.0 Using the Total Resource Cost Test

State of Connecticut

	Total Resource Benefits, Costs, and Net Benefits			
	Present Value Benefit	Present Value Cost	PV of Net Benefits	Benefit-Cost Ratio
Commercial Sector	$1,411,460,062	$358,414,779	$1,053,045,283	3.94
Residential Sector	$1,062,432,855	$390,141,582	$672,291,273	2.72
Industrial Sector	$341,431,615	$79,413,671	$262,017,944	4.30
All Sectors	$2,815,324,532	$827,970,032	$1,987,354,500	3.40
O&M Benefits (incl. avoided inc. bulb purchases)		$(80,156,204)		
Other Program Costs (25%)*		$206,992,508		
All Sectors	$2,815,324,532	$954,806,336	$1,780,361,992	2.95

**Other program costs estimated as 25% of total incremental measure costs, net of O&M benefits.*
Values shown include effects of Supply Curve "Stacking" and were calculated using version 9 of the "NSTAR" model, with CL&P avoided cost estimates.

Southwest Connecticut (SWCT)

	Total Resource Benefits, Costs, and Net Benefits			
	Present Value Benefit	Present Value Cost	PV of Net Benefits	Benefit-Cost Ratio
Commercial Sector	$844,015,610	$214,322,514	$629,693,096	3.94
Residential Sector	$635,306,615	$233,294,299	$402,012,316	2.72
Industrial Sector	$204,167,033	$47,487,265	$156,679,768	4.30
All Sectors	$1,683,489,257	$495,104,077	$1,188,385,180	3.40
O&M Benefits (incl. avoided inc. bulb purchases)		$(47,931,280)		
Other Program Costs (25%)*		$123,776,019		
All Sectors	$1,683,489,257	$570,948,816	$1,064,609,161	2.95

**Other program costs estimated as 25% of total incremental measure costs, net of O&M benefits.*
Values shown include effects of Supply Curve "Stacking" and were calculated using version 9 of the "NSTAR" model, with CL&P avoided cost estimates.

SWCT/CT Ratio ***59.8% (Based on GWh Sales from Table A-26)***

Norwalk / Stamford Region of Connecticut

	Total Resource Benefits, Costs, and Net Benefits			
	Present Value Benefit	Present Value Cost	PV of Net Benefits	Benefit-Cost Ratio
Commercial Sector	$296,339,205	$75,249,987	$221,089,219	3.94
Residential Sector	$223,060,160	$81,911,100	$141,149,060	2.72
Industrial Sector	$71,684,333	$16,673,078	$55,011,255	4.30
All Sectors	$591,083,699	$173,834,165	$417,249,534	3.40
O&M Benefits (incl. avoided inc. bulb purchases)		$(16,828,975)		
Other Program Costs (25%)*		$43,458,541		
All Sectors	$591,083,699	$200,463,731	$373,790,993	2.95

**Other program costs estimated as 25% of total incremental measure costs, net of O&M benefits.*
Values shown include effects of Supply Curve "Stacking" and were calculated using version 9 of the "NSTAR" model, with CL&P avoided cost estimates.

Norwalk/Stamford ***21.0% (Based on GWh Sales from Table A-29)***

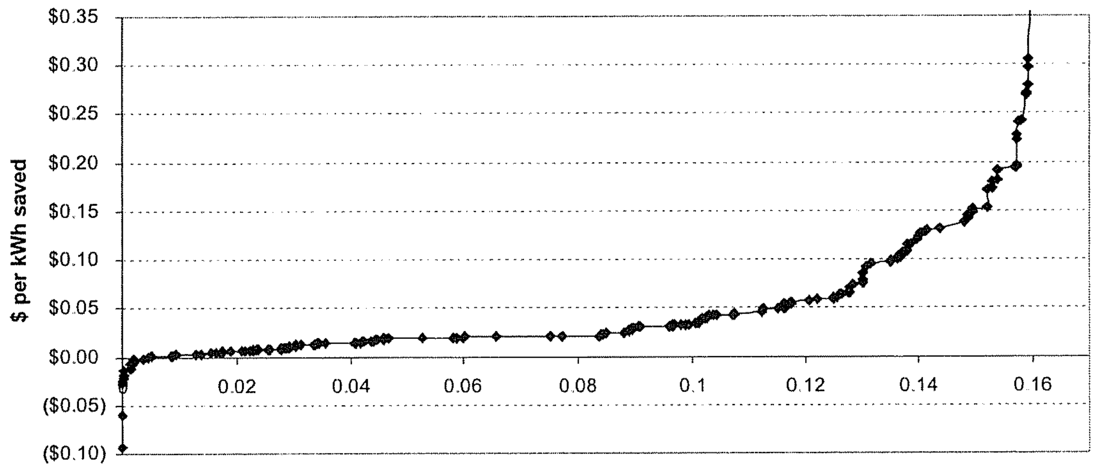
6.1 Technical and Economic Potential

Figures 1-1 and 1-2 in Section 1 of this report present the overall estimates of total maximum cost effective achievable potential for peak demand and electrical energy in the State of Connecticut. **Technical potential** represents the sum of all savings achieved if all measures analyzed in this study were implemented in applications where they are deemed applicable and physically feasible. **Maximum Achievable Cost-Effective potential** is based on efficiency measures that are cost-effective based on the total resource cost (TRC) test, a benefit-cost test that compares the present value of electric energy and capacity savings to the costs of energy-efficiency measures and program activities necessary to deliver them. If all measures analyzed in this study were implemented where technically feasible, we estimate that overall technical potential demand savings would be roughly 1,748 MW in 2012, about 24.0 percent of projected total peak demand in that year. If all measures that pass the TRC test were implemented, economic potential savings would be 908 MW, about 13 percent of total base case demand in 2012.

Technical energy savings potential is estimated to be roughly 8,021 GWh, or 24 percent of total State of Connecticut electric energy usage projected in 2012. Maximum achievable cost-effective energy savings are estimated at 4,466 GWh, about 13 percent of base usage.

A useful way to illustrate the amount of energy-efficiency savings available for a given cost is to construct an energy-efficiency supply curve. As discussed in Section 4, a supply curve typically consists of two axes—one that captures the cost per unit of saving electricity (e.g., levelized $/kWh saved) and the other that shows the percent of total electric load in a region that could be achieved at each level of cost. In the supply-curve development process, measures are sorted on a least-cost basis, and total savings are calculated incrementally with respect to measures that precede them. The costs of the measures are levelized over the life of the savings achieved. The overall energy-efficiency technical potential supply curve constructed for the State of Connecticut is shown in Figure 6-1.

Figure 6-1 Maximum Achievable Potential for Energy Efficiency - CT 2012
All Sectors



The maximum achievable potential supply curve is shown in terms of savings as a percentage of total energy consumption for the state in the year 2012. The curve shows that roughly 12 percent of projected electric sales for the State in 2012 can be obtained from measures with levelized costs below 5 cents per kWh saved, totaling approximately 3,866 GWh per year of savings. Approximately 4,319 GWh per year of savings are available from measures with levelized costs below 8 cents per kWh saved. Savings potentials and levelized costs for the individual measures that comprise the overall supply curve are provided in the Appendices of this report. End use and measure savings are discussed later in this section.

6.2 Energy Savings Potential By Market Sector in Connecticut

This section of the report describes the maximum achievable cost effective potential by market sector and describes the electric end uses and efficiency measures having the greatest savings potential.

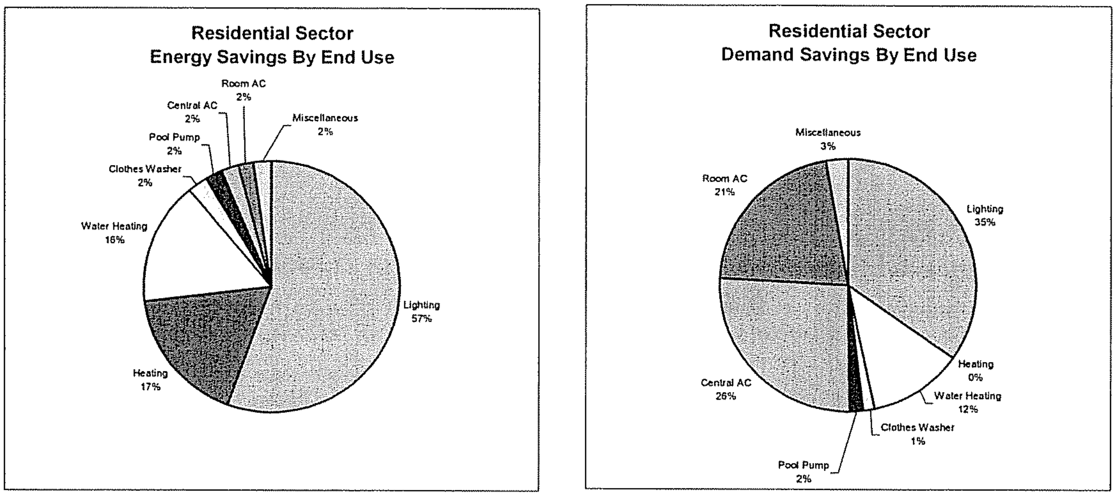
6.2.1 Residential Sector

In the residential sector, lighting energy efficiency accounts for the majority of maximum achievable cost effective energy savings potential, while central air conditioning measures account for the majority of potential peak demand savings. This follows somewhat from these end uses share of current energy and peak demand. Lighting savings are represented by one key measure: CFLs. The contribution of this measure to total residential economic energy savings potential is large because per-unit CFL savings are very high (generally, 70 to 75 percent savings per incandescent lamp replaced).

Figure 6-2 below shows the distribution of the maximum achievable cost effective potential for energy and peak demand savings by residential end use. With respect to peak demand opportunities, the residential measures with the most significant peak demand reduction potential are:

- Lighting - CLF
- Central Air Conditioner
- Room Air Conditioners (SEER 10.3)
- Electric Water Heater Measures

Figure 6-2 Distribution of Residential Sector Maximum Achievable Cost Effective Potential Savings by End Use



6.3.2 Commercial Sector

For the commercial sector, interior lighting still represents the largest end-use savings potential in absolute terms for both energy and peak demand, despite the significant adoption of high-efficiency lighting throughout the 1990's. The distribution of commercial sector savings by end use is shown in Figure 6-3.

As expected, cooling potential represents a significant portion of the total peak demand savings potential. Refrigeration energy savings potential is roughly equal to that of cooling but is significantly less important in terms of peak demand potential. In terms of energy savings, the Super T8 lamp/electronic ballast (SuperT8/EB) combination holds the largest potential, even though we estimate that current saturation levels of standard T-8's are well over 50 percent. Refrigeration compressor and motor upgrades, occupancy sensors for lighting, office equipment power management, and hard-wired CFL fixtures round out the measures that represent the largest opportunities for energy savings.

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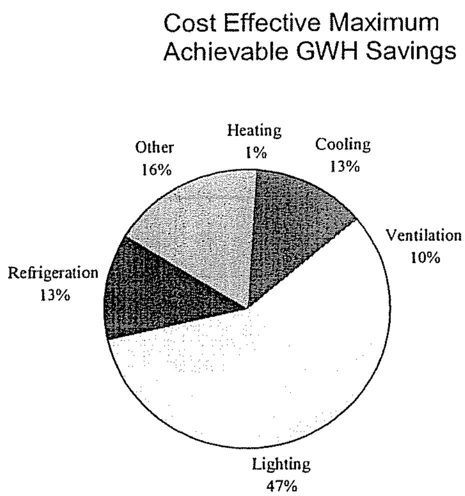
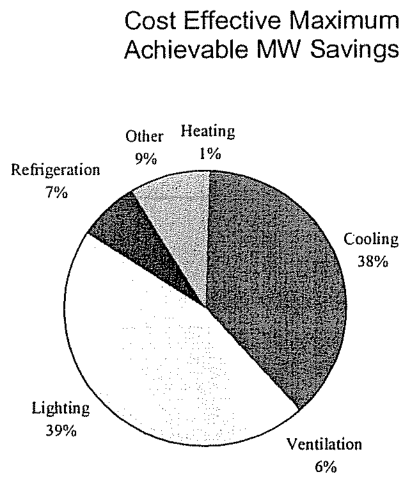
With respect to peak demand savings, comparative enthalpy economizers represent the largest demand savings opportunity, followed by the Super T8/EB combination. Cooling measures become more significant in terms of peak impacts with high-efficiency chillers and packaged units, as well as chiller tune-ups making up a large share of total potential demand savings. Occupancy sensors and Super T8/EB also represent a significant percent of total demand savings potential, as they did with respect to energy savings. These measures, when combined, represent approximately 45% of demand reduction potential.

Figure 6-3 Distribution of Commercial Sector Maximum Achievable Potential Savings by End Use





For the commercial sector, supply curves were developed for existing stock and new construction for nine typical building types, as well as for the commercial sector as a whole. Table 6-2 illustrates the cumulative technical potential electricity savings for the commercial sector, broken down by building type.

Table 6-2 – Commercial Sector Technical and Maximum Achievable Cost Effective Potential Electricity Savings by Building Type

		Technical Potential Savings		Maximum Achievable Cost Effective Savings	
Building Type	Total kWh Sales by Building Type as % of Total Commercial Sales	2012 Savings (GWh)	Savings as % of Total Sales	2012 Savings (GWh)	Savings as % of Total Sales
Office	37.80%	1,620	11.06%	789	5.4%
Retail	12.90%	566	3.86%	269	1.8%
Restaurant	5.70%	155	1.06%	119	0.8%
Food Stores	7.40%	308	2.10%	155	1.1%
Warehouse	3.90%	120	0.82%	81	0.6%
Education	10.40%	332	2.27%	217	1.5%
Health	7.60%	266	1.82%	159	1.1%
Lodging	2.30%	58	0.40%	48	0.3%
Miscellaneous	12.00%	277	1.89%	251	1.7%
Total Commercial Sector	100.00%	3,703	25.28%	2,088	14.3%

Note: The total Maximum Achievable Cost Effective Savings has been allocated to the various building types by kWh Sales by Building Type as % of Total Commercial Sales.

6.3.3 Industrial Sector

The industrial sector is very heterogeneous, being composed of numerous types of manufacturing, production, and assembly plants for thousands of different products. The contribution of potential industrial sector savings by end use is shown in Table 6-3. The percentage mix of end-use savings is similar for both energy and peak demand. This is because the industrial sector has the highest load factor of all customer classes. Motor and process applications account for the majority of potential savings, followed by lighting, compressed air, and space cooling. These savings follow somewhat proportionally from the distribution of base consumption in the sector; however, lighting savings are higher as a proportion of base consumption as compared with other end uses.

Although there is an identified need for more research to understand better the industrial sector savings potential in Connecticut, there were several recent sources available to help us with the initial estimates for this study. Key among these sources is a series of industry-specific efficiency potential studies conducted by Lawrence Berkeley National Laboratory (Martin, et al., 1999 – 2000b and Worrell, et al., 1999) and several recent studies conducted by XENERGY (XENERGY 2001d, 2000a, and 1998b). Furthermore, we use recent studies from the U.S. and other industrialized countries to identify available technologies and potential savings. Details on industrial savings opportunities can be found in these references. Examples of key measures include variable-speed drive motor and pump applications, proper motor and pump sizing, redesign of pumping systems to reduce unnecessary flow restrictions, improved operations and maintenance, reducing compressed air system leaks, and optimizing compressed air storage configurations. Lighting and space cooling savings measures are similar to those in the commercial sector. In addition, there are hundreds of measures specific to individual industrial process applications. In this analysis we focused on the main energy consuming processes in each industry to identify process-specific measures. For example, in the pulp and paper industry in Connecticut, drives for paper machines are one of the largest electricity consumers in this industry, while pulping energy use is far less important.

We estimate the maximum achievable potential by 2012 at 834 GWh or 16% of total estimated consumption. The maximum achievable cost effective potential is estimated at 723 GWh. The maximum achievable potential reduction in peak load demand is estimated at 100.4 MW, while the maximum achievable cost effective reduction in the 2012 load is estimated at 92.6 MW.

The largest savings are found in cross-cutting applications. The applications with the largest potential savings are HVAC/Building (26% of potential savings), pumps (19%), lighting (14%), motors (including adjustable speed drives; 12%), and compressed air (12%). The process-specific applications contribute 11% to the potential savings.

Table 6-3 Connecticut-Measures - Industry - Summary

Measure: No.	Measure	Achievable MWh 2012	Achievable kW 2012
CROSS-CUTTING MEASURES			
1	Replace 1-5 HP motor	3,078	542
2	ASD (1-5 hp)	3,600	63
3	Motor practices-1 (1-5 HP)	2,980	524
4	Replace 6-100 HP motor	10,019	1,763
5	ASD (6-100 hp)	26,778	471
6	Motor practices-1 (6-100 HP)	11,081	1,950
7	Replace 100+ HP motor	9,034	1,590
8	ASD (100+ hp)	44,480	783
9	Motor practices-1 (100+ HP)	11,504	2,024
21	Compressed Air-O&M	48,178	8,773
22	Compressed Air - Controls	11,471	2,089
23	Compressed Air - System Optimization	36,467	6,963
24	Compressed Air- Sizing	13,128	2,507
31	Pumps - O&M	22,627	4,071
32	Pumps - Controls	59,396	10,686
33	Pumps - System Optimization	56,002	10,075
34	Pumps - Sizing	22,627	4,071
41	Fans - O&M	3,322	610
42	Fans - Controls	24,913	4,573
43	Fans - System Optimization	9,965	915
44	Fans- Improve components	3,322	610
51	Replace by T8	26,565	3,353
52	Metal Halides/Fluorescent	8,893	1,122
53	Switch-off/O&M	7,438	2
54	Controls/sensors	20,456	2,019
55	Electronic Ballasts	29,754	3,756
61	HVAC Management System	27,247	1,425
62	Cooling System Improvements	18,330	958
63	Duct/Pipe Insulation/leakage	29,724	1,554
64	Cooling Circ. Pumps - VSD	28,733	150
65	DX Tune Up/ Advanced Diagnostics	34,678	1,813
66	DX Packaged System, EER=10.9, 10 tons	13,623	712
67	Window film	12,880	674
68	Programmable Thermostat	12,385	6
69	Chiller O&M/tune-up	19,816	1,036
70	Setback temperatures (wkd/off duty)	29,724	4
81	Replace V-belts	31	6
91	Energy Star Transformers	6,605	1,227

Table 6-3 Connecticut-Measures - Industry - Summary

Continued

No.	Measure	Achievable MWh 2012	Achievable kW 2012
PROCESS-SPECIFIC MEASURES			
201	Efficient Refrigeration - Operations	1,545	233
202	Optimization Refrigaration	2,368	357
203	Bakery - Process	3,134	473
204	Bakery - Process (Mixing) - O&M	619	93
221	Drying (UV/IR)	170	25
222	Membranes for wastewater	36	9
223	O&M/scheduling spinning machines	1,195	292
241	Air conveying systems	507	36
242	Replace V-Belts	374	100
243	Optimize drying process	377	101
244	Drives - EE motor	249	67
245	Heat Pumps - Drying	136	36
261	Gap Forming papermachine	1,133	168
262	High Consistency forming	1,090	161
263	Optimization control PM	3,585	530
264	High efficiency motors	2,445	362
271	Efficient practices printing press	2,790	530
272	Efficient Printing press (fewer cylinders)	2,232	424
273	Light cylinders	1,116	212
274	Efficient drives	586	111
281	Clean Room - Controls	1,240	223
282	Clean Room - New Designs	1,488	268
283	Process Controls (batch + site)	3,949	711
284	Process Drives - ASD	336	60
301	O&M - Extruders/Injection Molding	4,699	639
302	Extruders/injection Molding-multipump	5,639	766
303	Direct drive Extruders	2,350	319
304	Injection Molding - Impulse Cooling	2,467	335
305	Injection Molding - Direct drive	2,350	319
321	Efficient grinding	775	198
322	High-efficiency motors	194	49
323	Process control	185	47
324	Top-heating (glass)	107	27
325	Autoclave optimization	115	29
331	Process Control	2,978	597
332	Efficient drives - rolling	2,309	463
333	Efficient electric melting	889	178
334	Intelligent extruder (DOE)	20	4
335	Near Net Shape Casting	237	48
341	Optimization (painting) process	4,301	931
342	Scheduling	1,290	56
343	Curing ovens	2,859	619
344	Machinery	1,882	407
345	New transformers welding	3,980	862

Table 6-7 Connecticut-Measures - Industry - Summary

Continued

No.	Measure	Achievable MWh 2012	Achievable kW 2012
PROCESS-SPECIFIC MEASURES			
351	Optimization Process	1,869	296
352	Scheduling	561	18
353	Curing ovens	667	106
354	Machinery	584	92
355	New transformers welding	169	27
361	Scheduling	157	32
362	Curing ovens	1,100	224
363	Machinery	114	23
364	Efficient processes (welding, etc.)	1,535	312
365	Clean rooms - Controls	783	159
371	Optimization (painting) process	1,958	401
372	Scheduling	418	17
373	Curing ovens	1,756	360
374	Machinery	753	154
375	New transformers welding	2,775	569
381	Optimization (painting) process	633	105
382	Scheduling	190	6
383	Curing ovens	399	66
384	Machinery	277	46
385	New transformers welding	352	59
391	Drives - ASD	32	7
392	Scheduling	165	36
393	Process Heating	344	76
394	Efficient Machinery	120	26
395	Process control	1,405	309
	Total	852,297	101,473