ENERGY EFFICIENCY AND RENEWABLE ENERGY RESOURCE DEVELOPMENT POTENTIAL IN NEW YORK STATE

Final Report

VOLUME THREE:

ENERGY EFFICIENCY TECHNICAL REPORT

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AUGUST 2003

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SECTION 4: INDUSTRIAL EFFICIENCY ANALYSIS

Section 1:
OVERVIEW OF APPROACH

This study analyzed the energy-efficiency potential in the residential, commercial, and industrial sectors in 2007, 2012, and 2022. This overview summarizes the methodology used to assess energy-efficiency potential in all three sectors, focusing on the following common areas of analysis:

- Technology characterization
- Market segmentation
- Technical and economic potential analysis
- Achievable potential analysis for meeting New York's greenhouse-gas (GHG) reduction targets and the State's currently planned initiatives (CPI)

Following this overview (Section 1), this report presents the analysis and results for the residential, commercial, and industrial sectors.

TECHNOLOGY CHARACTERIZATION

Each sector's potential analysis quantified savings from a wide range of efficiency technologies. The study analyzed both technologies that are commercially available now and emerging technologies considered likely to become available over the study horizon. The study characterized the performance of individual efficiency technologies or grouped sets of technologies in terms of their electricity savings and their expected lifetime. Each sector's analysis estimated electricity savings for each technology or technology set during the energy and demand costing periods associated with NYSERDA's time-differentiated avoided costs. This study also tailored technology characterizations for the market segments discussed below.

Residential and commercial technology characterizations for this study were identified in conjunction with two Vermont studies on the potential of energy efficiency.[1] Pooling resources afforded this study the opportunity to develop savings profiles for all residential and commercial end uses using hourly load shapes licensed from Regional Economic Research Inc. (RER). It also allowed for the development of efficiency technology characterizations for a large number of building types in the commercial sector. The residential and commercial technology characterizations also addressed interactions between technologies (such as between cooling efficiency improvements and lighting efficiency improvements that reduce cooling load).[2]

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1 The Vermont statewide efficiency potential analysis was "Electric and Economic Impacts of Maximum Achievable Statewide Efficiency Savings," Public Review Draft, prepared by Optimal Energy for the Vermont Department of Public Service, January 2003. The other Vermont analysis was "Assessment of Economically Deliverable Transmission Capacity from Targeted Energy-Efficiency Investments in the Inner and Metro-Area and Northwest and Northwest/Central Load Zones," January 2003.

2 This report uses the terms "efficiency technology" and "efficiency measure" interchangeably.

MARKET SEGMENTATION

The study examines energy-efficiency potential arising in three basic types of market events: new construction; natural turnover of existing energy-using products, equipment, and facilities; and discretionary retrofit. The residential, commercial, and industrial sector analyses all treat the first two types of efficiency market opportunities, which constitute the classic "lost-opportunity" resources. These situations present short-lived opportunities to make efficiency choices offering significant, long-lived savings at relatively low incremental cost compared to the overall costs of building new homes, buildings, or facilities, or purchasing new products or equipment.

Efficiency retrofit opportunities are discretionary in the sense that they can be made at any time, i.e., unrelated to the construction, equipment, and product market cycles. Retrofits consist of two distinct types of technology investments: application of supplemental measures (e.g., installation of a variable speed drive) or early replacement of operational equipment (e.g., removal of existing inefficient lighting and replacement with new high-efficiency equipment). Both the residential and the commercial analyses examined efficiency potential in all three efficiency market segments. The industrial analysis, however, was confined to the two lost-opportunity markets, i.e., new construction and natural equipment turnover, because industrial customers can rarely be induced to undertake efficiency investments outside their normal product and investment cycles.

Each sector segmented its markets differently for assessing efficiency potential. The residential analysis segmented markets by building type (single- vs. multi-family) and according to new construction, retail, and retrofit. The commercial analysis distinguished between new and existing buildings and between 12 building types. The industrial analysis examined 22 industries judged to represent the vast majority of New York's industrial electricity conservation base.

Due to differences in market structure and data availability, each sector's analysis of statewide and zonal estimates of savings potential employed a different approach to estimating the size of underlying population for each market segment examined. All three approaches share NYSERDA's long-range statewide and zonal electricity forecasts. Also common to the three sectors was the need to supplement NYSERDA's forecasts with additional public or private data to disaggregate statewide or zonal electricity usage according to their respective market segmentation schemes, which are discussed in the sections that follow this overview. The zonal technical potential estimates were developed by applying technology characterizations developed at the statewide to the estimates of eligible zonal market population developed by each sector. In general, the quality of underlying data used to create zonal market segmentation was necessarily lower than that used for segmenting statewide efficiency markets in each sector. Consequently, the reliability of the statewide potential estimates is superior to that associated with the zonal potential analysis.

TECHNICAL AND ECONOMIC POTENTIAL

Unlike renewable energy resources, some level of energy-efficiency is implicit in the current and expected electricity use by each sector. All electricity demand is derived from its application to a variety of end uses, which vary enormously between and within the residential, commercial, and industrial sectors. Efficiency technologies reduce the electric intensity of these end uses. Each sector's potential analysis reflects the efficiency levels built into the underlying end-use energy intensities in statewide and zonal forecasts of sectoral electricity consumption. The analysis handles the end-use efficiency built into sectoral electricity forecasts by characterizing each efficiency technology in terms of changes to baseline, end-use energy intensities and deviations from base-case technology market penetrations. The analysis did not consider any changes in economic activity resulting from implementation of efficiency measures.

The economic potential for energy-efficiency resources developed cost estimates for efficiency technologies. In new construction and equipment replacement market segments, costs were estimated on an incremental basis compared to baseline efficiency levels. In the case of early-retirement retrofit efficiency technologies analyzed in the residential and commercial sectors, the economic potential analysis reflected two important but often-overlooked timing elements:

- The first timing element concerns the reduction in expected savings from early retirement measures once the original equipment would have been replaced during the normal replacement cycle. At that point, the baseline shifts from the energy-intensity of the original equipment to that of the new equipment that would have been installed anyway.
- The second timing element has to do with the estimate of incremental costs for early-retirement investments. By interrupting the natural replacement cycle, early retirement permanently postpones the future replacement cycle. The economic potential analysis of energy-efficiency resources explicitly accounts for both the baseline shift and the equipment replacement deferral credit associated with early-retirement efficiency retrofits.

ACHIEVABLE POTENTIAL

Estimates of achievable efficiency potential in each sector involved estimates of achievable market penetration rates and program administration cost "adders" to the efficiency technology costs estimated for the economic potential. The study analyzed two types of achievable efficiency potential: electric energy savings that could be achieved with market intervention strategies designed to increase market penetration of energy-efficiency technologies as part of a least-cost contribution towards the State's greenhouse gas reduction targets; and savings expected to result from currently planned initiatives.

As was true for efficiency technology characterizations, the analysis of potential achievable residential and commercial efficiency contributions toward New York's greenhouse-gas reduction targets capitalized on the two Vermont studies of economically achievable efficiency potential. The Vermont analyses estimated the market effects and program costs of highly aggressive market-intervention strategies designed conceptually to maximize efficiency technology penetration in the residential, commercial, and industrial sectors. This study adapted the Vermont studies' efficiency technology market-penetration rates assuming that roughly similar kinds of market-intervention strategies would be required to realize enough savings to meet New York's greenhouse-gas emission goals. Section 5.4 of the efficiency Technical Appendix (Volume 5) provides a conceptual discussion of the aggressive market-intervention strategies needed to achieve the market-penetration rates in the three sectors. This study also referred to the Vermont studies to develop the administrative cost adders to determine achievable technology costs.

For the industrial sector, data obtained from long-standing NYSERDA programs, data obtained from the Industrial Assessment Centers database, and the 1997 Mid-Atlantic energy-efficiency study conducted by the American Council for an Energy Efficient Economy (ACEEE) were used to estimate the achievable savings potential. A further discussion of the methodology is discussed in Section 4.

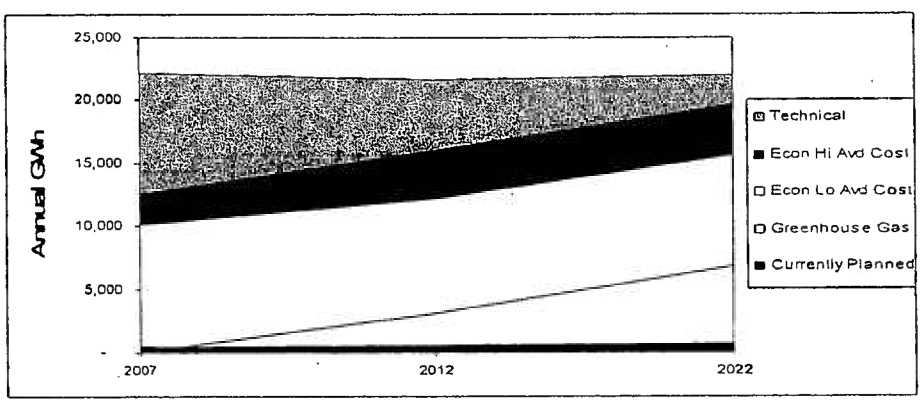
For estimates of the expected achievements from currently planned initiatives, the efficiency analysis in the three sectors relied heavily on information from NYSERDA concerning actual results to date and historical and projected initiative costs. For the most part the cost-effectiveness analysis of expected achievements relied on technology cost estimates developed for the economic potential analysis. In all three sectors the analysis projected continued market effects after the expiration of current initiative plans.

Section 2:
RESIDENTIAL EFFICIENCY ANALYSIS

SUMMARY OF RESULTS

As Figure 3.2.1 graphically demonstrates, the savings potential from residential efficiency measures is substantial. From a theoretical "technical" perspective, the potential is on the order of 22,000 GWh per year in each of the three years analyzed -- 2007, 2012, and 2022. The portion of technical potential that is economic (i.e., cost-effective) grows from between 46% and 57% in 2007, to between 70% and 88% in 2022, depending on the avoided costs used. Achievable residential efficiency contributes 3,105 GWh of annual savings in 2012 and 6,818 GWh of annual savings in 2022 to the least-cost efficiency and renewable-energy solution to meeting a greenhouse-gas emission reduction goal for the electric utility industry. That represents approximately 15.6% and 32.9% respectively of the total industry goals for those years. Currently planned initiatives are projected to provide 0.5 thousand GWh of savings in 2007, with savings growing gradually to 0.7 thousand GWh in 2022.

Figure 3.2.1 Summary of Residential Efficiency Savings Potential in New York



OVERVIEW OF APPROACH

The residential sector analysis is built "from the ground up." The first fundamental building block was a current end-use disaggregation of electricity use. It included both the percentage of households with each end use and the average kWh consumption for each household with each end use. This disaggregation was adjusted in future years to reflect expected changes in saturation of different appliances (e.g., increasing use of central air conditioning and computers) as well as expected increases in the efficiency of the stock of certain appliances (e.g., refrigerators). Together with forecasts of new construction (for which separate disaggregations were developed), it was calibrated until it was consistent with a forecast of residential consumption that NYSERDA is using.

The second step was to characterize the markets for residential efficiency measures. We analyzed three kinds of efficiency markets:

- **"New construction"** -- in which a builder and/or his/her home buyer face choices between standard products or practices and more efficient alternatives;
- **"Retail"** -- in which consumers are already making purchasing decisions, typically to replace existing products that have failed, and face choices between standard new products and efficient alternatives; and
- **"Retrofit"** -- in which consumers can potentially be convinced to either: 1) replace an inefficient product that is still functioning and that they were not otherwise planning to replace yet (often referred to as "early retirement"), or 2) add a product (e.g., insulation or waterbed pad) or service (e.g., duct sealing) to improve efficiency.

The size of the new-construction markets for each different efficiency measure was a function of both assumptions about the number of new homes built each year and the forecasted saturations of different end uses within those homes. The size of the retail markets for most efficiency measures was generally assumed to be a function of estimated existing end-use saturations and equipment turnover rates. Turnover rates were assumed to be a function of assumed life of a piece of equipment (e.g., if the life of a central air conditioner is 15 years, then 1/15th -- or 6.7% -- of existing central air conditioners were assumed to be replaced each year). The size of retrofit markets is a function of the number of existing homes and saturations of relevant end uses.

The third step was to identify and characterize a wide variety of efficiency technologies in terms of their typical per-unit savings, costs, peak demand savings, and lifespan. All told, more than 50 different measures, measure bundles, or measure categories were analyzed. After considering both different tiers of efficiency and different applications of the measures (e.g., to different building types, different markets, and different usage bins), the study ultimately assessed nearly 400 permutations of those measures. In all cases, assumptions about per-unit measure savings were consistent with the calibrated end-use disaggregations. Where appropriate, per-unit savings and costs were also adjusted over time to reflect changes in baselines. For example, the advent of new minimum-efficiency standards for clothes washers in 2004 and 2007 reduces savings potential for washers with a specific Modified Energy Factor beginning in those years. Similarly, as the stock of existing refrigerators gradually turns over and is replaced by new models manufactured under increasingly stringent federal efficiency standards, the savings potential for early retirement of the average refrigerator is expected to decline. Also, as the equipment gains acceptance in the market and production volumes grow, the study projects that incremental costs of emerging technologies, such as heat-pump water heaters, will decline over time.

The fourth step in the analysis was to estimate baseline market penetrations for each efficiency measure (i.e., the frequency with which each measure would be purchased and installed absent any market interventions).

The fifth step was to estimate measure penetration rates for each of the scenarios analyzed. For the technical potential scenario, it was assumed that 100% of all eligible measures would be installed. Similarly, for the economic potential scenario, it was assumed that 100% of all cost-effective measures would be installed. For the greenhouse gas (GHG) scenario, we estimated the portion of the market that could be "moved" to different efficiency levels through aggressive market interventions. To reflect differences in current market acceptance, the nature of existing barriers to measure adoption, the difficulty in "ramping up" efficiency initiatives, and other factors, that potential was assumed to be different at different points in time for different measures. For the currently planned initiatives (CPI) scenario, we forecast the future effects of expected new codes and standards (state and federal); we also extrapolated from recent experience to forecast future efficiency measure penetrations under efficiency programs. The CPI scenario was limited to the effects of NYSERDA, LIPA and NYPA residential programs projected to be in place through 2006, 2004 and 2003, respectively. [3] We estimated the effects in those years as well as market effects that would persist after the programs were terminated. In all scenarios, market penetrations of competing (i.e., mutually exclusive) measures were adjusted to ensure that savings were not "double-counted."

Finally, in the cases of the GHG and CPI scenarios, we estimated administrative costs (defined broadly to include administration, marketing, training, evaluation, and any other non-incentive costs) that would be associated with the initiatives necessary to achieve the measure penetration rates projected. For the greenhouse gas scenario, the adders were estimated for groups of measures within different markets based largely on the experience of leading aggressive programs in the region. For most measures they were assumed to be between 20% and 50% of incremental measure costs. For the CPI scenario, we calculated the net present value of non-incentive costs estimated for the portfolio of currently implemented New York residential efficiency programs. Our estimates were based -- to the extent possible -- on NYSERDA and LIPA program budget information.

Savings potential in each year, for each scenario, was then calculated by multiplying per-unit savings for each measure by the size of the annual market, and again by the difference between achievable market shares and baseline market shares. Efficiency-measure costs were calculated in the same way, except that the administrative cost adders were multiplied by measure costs to generate a larger societal cost figure for the GHG and CPI scenarios.

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3 Although we were charged with analyzing NYPA programs through 2004, the only residential program NYPA currently operates – bulk purchase of efficient refrigerators to replace old, inefficient models in pubic housing – was projected by NYPA to conclude at the end of 2003.

END USE DISAGGREGATION

The study heavily on data from the U.S. Energy Information Administrations' 1997 Residential Energy Consumption Survey (RECS) to develop end-use disaggregations for New York. RECS provides statistically valid data for the country as a whole, for each region of the country and for each of the four largest states. Since New York is one of the four largest states, we had access to a substantial volume of state-specific data regarding residential energy use. This is particularly true for data on saturations of various end uses. New York-specific data on average consumption by end use are not quite as extensive, though still available for most of the larger end uses. We relied on such New York-specific data whenever possible. For end uses that are weather-sensitive (i.e., heating and cooling), we weather-normalized the 1997 data. For several end uses, neither New York nor regional data were available (e.g., for total lighting consumption). In those cases we used national RECS estimates. In a couple of cases (i.e., furnace fans and auxiliary kWh for boilers), we used RECS data for New York for end-use saturations, but our own estimates (based on the Gas Appliance Manufacturers' Association directory) of average per-unit kWh consumption. Finally, a "residual factor" was developed to represent small end uses not specifically addressed in our analysis and to help calibrate total average consumption so that it was consistent with residential sales data and/or sales forecasts. Table 2, Average New York Residential Consumption by End Use – 1997, shows the weather-normalized disaggregation we developed for the average residential household in 1997.

Table 3.2.1 Average New York Residential Consumption by End Use -- 1997

End Use	Homes w/ End Use	Avg No of Units	Avg kWh	Wtd Avg kWh	Source Notes
Space Heating					
Primary	5.5%	1.00	4103	226	2
Secondary	13.7%	1.00	585	80	2
Furnace fan	33.8%	1.00	901	305	5
Other Auxiliary (boiler)	54.4%	1.00	300	163	5
Space Cooling					
Central A/C	17.8%	1.00	823	146	2
Heat Pump	1.4%	1.00	823	11	2
Room A/C	44.1%	1.63	306	220	2
Water Heating	14.7%	1.00	2696	396	1
Refrigeration					
Primary	100.0%	1.12	871	975	1
Freezer	20.6%	1.00	1013	209	3
Lighting	100.0%	1.00	940	940	3
Range/Oven	35.3%	1.00	451	159	3
Clothes Washing					
Washer	66.2%	1.00	108	71	3
Dryer	54.4%	1.00	1090	593	3
Dishwasher	45.6%	1.00	410	187	3
Other/Misc					
TVs	100.0%	2.04	144	295	3
VCRs	86.8%	1.39	70	84	3
Hot Tub	2.9%	1.00	2300	68	4
Waterbed	5.9%	1.00	1286	76	4
Pool Pump	8.8%	1.00	792	70	
Well Pump	10.3%	1.00	83	9	
Aquarium (heated)	4.4%	1.00	548	24	3
Microwave	76.5%	1.00	135	103	3
Stereo	69.1%	1.00	71	49	3
Computers	31.6%	1.14	262	95	3
Laser Printer	12.9%	1.00	250	32	3
Fax	7.5%	1.00	216	16	3
Copier	3.7%	1.00	25	1	3
Ceiling Fans	50.0%	1.65	50	41	4
Cordless phone	60.6%	1.00	26	16	3
Answering Machine	60.0%	1.00	35	21	3
Residual	100.0%	1.00	262	262	6
TOTAL KWH				5,943	

Source Notes:
1 RECS 1997 - New York data
2 RECS 1997 - New York data weather-normalized
3 RECS 1997 - New York data for saturation, RECS 1997 national data for per unit kWh
4 RECS 1997 - national data for saturation and per unit kWh
5 RECS 1997 - New York data for saturation, VEIC estimate for per unit kWh
6 Used to calibrate totals to be consistent w/weather-normalized experience

The study further disaggregated existing residential consumption into consumption for single-family homes and consumption for multi-family homes. Two sets of assumptions were used to do this: (1) RECS 1997 for New York regarding the fraction of existing homes that were represented by each of those two categories (i.e., 59% single family, 41% multi-family); and (2) RECS regional data for the Northeast (regarding both differences in appliance saturations and differences in kWh consumption by house type). These disaggregations were then adjusted for future years to reflect expected changes in saturation of different appliances (e.g., increasing use of central air conditioning and computers) and expected changes in per-unit consumption for different appliances (e.g., declining consumption for refrigerators as newer, more efficient models replaced older, inefficient ones). Together with forecasts of new construction (for which separate disaggregations were developed) and changes to the residual factors, these changes over time were used to calibrate our estimates of residential consumption to NYSERDA's forecast of residential consumption. Additional tables showing the disaggregation between single-family and multi-family homes, as well as for different years in our analysis period, are provided in Technical Appendix Table 5.1.2.2 through Table 5.1.2.4. Tables showing similar disaggregations for new construction are provided in Table 5.1.2.5 through Table 5.1.2.6.

MARKETS FOR EFFICIENCY MEASURES

As noted earlier, residential-efficiency potential exists in three distinct markets:

- "**New construction**" -- in which a builder and/or his/her home-buyer face choices between standard products or practices and more efficient alternatives;
- "**Retail**" -- in which consumers are already making purchasing decisions, typically to replace existing products that have failed, and face choices between standard new products and efficient alternatives; and
- "**Retrofit**" -- in which consumers can potentially be convinced to either: (1) replace an inefficient product that is still functioning and that they otherwise were not planning to replace yet (often referred to as "early retirement"), or (2) add a product (e.g., insulation or waterbed pad) or service (e.g., duct sealing) to improve efficiency.

Promoting efficiency investments in the first two of these market types requires influencing decisions that are planned, even if only very shortly before the market action – i.e., a builder is going to construct a new home. However, there is a question as to how efficient his/her construction practices will be. When a homeowner decides to buy a new refrigerator, there is question as to whether it will be an Energy Star®-rated refrigerator or a standard efficiency model. Intervention in these markets has one major advantage: They offer the opportunity to "get it right from the start." Further, since some sort of market action is already contemplated, all the intervention needs to accomplish is convincing the market actor (e.g., the builder or homeowner) to pay the *incremental cost* of upgrading to greater efficiency. The difficulty in addressing these markets is that the decisions you are trying to influence are very time-sensitive. Once a new home is built or a new refrigerator is purchased, it often is a difficult and expensive investment to change.

The retrofit market is fundamentally different from the new-construction and retail markets: It requires convincing an existing homeowner to make an efficiency investment at a time when they are *not* already planning to spend any money (e.g., replacing an existing, inefficient refrigerator that is still working or adding insulation to the attic). The advantage of working in this market is that there is no time sensitivity. Attic insulation can be added this week, next month or next year without affecting its ability to cost-effectively provide long-term savings. As noted, however, the disadvantage is that it is more a difficult and expensive to make such investments "after the fact."

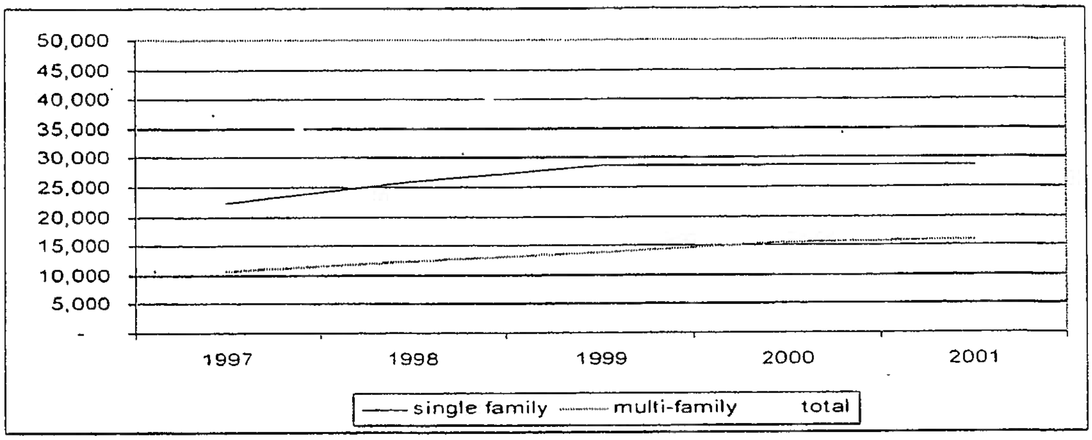
What follows is a brief discussion of the methodology used to estimate the size of the markets for different efficiency measures. Resulting assumptions can be found for each measure in Technical Appendix 5.1, Residential Efficiency.

Statewide New Construction Market

The study took two factors into account when estimating the size of the new construction market: (1) historical data on permits for new homes; and (2) the need to reconcile our estimates of savings potential with NYSERDA's forecast (and the fact that forecasts of housing starts are an important factor in projected future sales growth).

As Figure 3.2.2 illustrates, between 1997 and 2001 the number of permits issued annually for construction of new housing units in New York grew from about 33,000 to 45,000. Most of the growth was in the first few years of that period. Although they accounted for only one-third of permits in 1997, multi-family units accounted for roughly half of the growth over the 1997-2001 period -- and essentially all of it over the past couple of years. All told, even after the growth of the new construction market in recent years, housing permit requests in 2001 represented only about 0.6% of the total existing housing stock.

Figure 3.2.2 New York Housing Permits by Building Type -- 1997 through 2001



The residential forecast to which the study was calibrated suggested that residential demand would grow by nearly 1% per year through 2010 and by about 0.8% per year over the following decade or so. Given the study's projections of how consumption in existing homes would change over that period (e.g., forecasts of increasing saturations of some appliances and decreasing consumption from several appliances), it was necessary to assume that the number of new homes built in New York would continue to grow, particularly between 2003 and 2010. Specifically, the study assumed that the number of housing units would grow initially by about 3.4% per year (5% for multi-family and 2.5% for single family), for a total increase of about 51,000 housing units in the year 2005, with the growth rate then gradually declining to 0.6% (0.9% for multi-family and 0.3% for single family), for a total annual increase of about 69,000 housing units in the year 2022. All told, the study projected that approximately 1.2 million new homes would be added over the next 20 years.

Once estimates of housing starts were complete, the study estimated the number of electric end uses available for efficiency upgrades in each home to develop an estimate of the total size of the new-construction market. For most key end uses -- including central air conditioning, heat pumps, and electric water heating -- saturation assumptions were developed through analysis of data on New York residential new-construction practices.[4] For others the study relied on professional judgment, informed by extensive involvement in a number of regional new-construction efficiency programs on the part of the authors. For example, the study assumed that average lighting consumption in new homes was greater than in existing homes, both because new homes tend to be larger and because they tend to have many more recessed cans. Saturation assumptions for new construction can be found in the Technical Appendix 5.1, Residential Efficiency.

Statewide Retail Markets

For most retail measures, the study estimated the size of the market by multiplying the number of homes by the saturation of an appliance in those homes and dividing the product by the assumed life of the measure. For example, given our assumptions of 4.3 million existing single-family homes, 83% saturation of clothes washers in those homes and a 15-year life for a clothes washer, we estimate that approximately 237,000 clothes washers are sold for installation in existing single-family homes each year.

There were a few exceptions to this rule. For several technologies it is reasonable to expect saturations in existing homes to grow over time. Central air conditioners are a good example. Recent HVAC market studies on Long Island and in New Jersey, for example, suggest that as much as half of all sales of new central air conditioners for existing homes are first-time installations rather than replacements for older units.[5] For these measures, the study calculated the turnover rate for existing appliances as described above, but added estimates of first-time installations to annual turnover to estimate the size of the existing home market.

Note that appliances that are often installed in new homes by a builder (e.g., refrigerators and dishwashers) had a separate new-construction measure characterization and market estimate. Appliances that are typically brought into a new home rather than purchased anew (e.g., television and home office products) had just one measure characterization and market estimate. In those cases, the size of the retail market was estimated as the sum of projected equipment turnover in existing homes, any first-time sales to existing homes, and the product of the number of new homes and new home saturations.

Statewide Retrofit Markets

The retrofit market was initially estimated as a function of two variables: (1) the number of existing homes; and (2) the saturation of different end uses in those homes. For example, we estimated that there were approximately 4.3 million single-family homes in 2003 and that 5.9% of them have a waterbed. This led to the assumption that there were about 250,000 waterbeds in single-family homes that were candidates for replacement with standard mattresses.

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4 Science Applications International Corporation (SAIC), "Analysis of Alternative Residential Energy Code Standards for New York State," September 1998.

5 Opinion Dynamics Corporation, "Efficient Central Air Conditioning and Heat Pumps: Baseline Study for LIPA/Keyspan," January 2002; Xenergy Inc., "New Jersey Residential HVAC Baseline Study," prepared for the New Jersey Residential HVAC Working Group, November 16, 2001.

Adjustments for Competing Measures

A number of the technologies analyzed in the study are mutually exclusive. For example, a light fixture with an incandescent bulb can be replaced either with a hard-wired fluorescent fixture (one efficiency measure) or have its bulb replaced with a compact fluorescent (CFL) bulb (another efficiency measure). Similarly, some efficiency measures can be installed through different market channels. Particularly important is the potential overlap between the retail markets and retrofit markets. For example, as more CFLs are sold through retail stores, the potential for retrofit installation of CFLs is reduced -- and vice versa. Thus, to make sure that we did not double-count savings from such competing measures, the study constrained the size of markets for several measures. In general, the study gave priority to the measures that were most cost-effective. This, in turn, generally meant that the study allowed as much retail sales of a product as was feasible under each scenario analyzed while limiting retrofit markets to the portion of savings potential not captured by retail sales. In the case of lighting, it also meant constraining fixture markets, since CFLs capture the same savings potential less expensively.

Zonal Markets

The assessment of markets for efficiency measures in each zone started with estimates of the number of existing residential single-family and residential multi-family households in each zone. These estimates were developed by analyzing county-level Census data and estimating the percentage of each county that fell into each zone. Table 3.2.2 presents the number of households estimated for each zone in the year 2000.[6] Note that the five zones we analyzed account for approximately 70% of all single-family households, 89% of all multi-family households and 78% of total households in the state. Although 41% of households statewide were multi-family, that figure was heavily influenced by Zone J (New York City), where more than 70% of all households are multi-family (none of the other zones analyzed had more than 20% multi-family).

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[6] The zonal analysis started with these estimates. However, it ultimately was necessary for the study to reconcile against zonal forecasts of residential consumption (which were developed based on very limited data). Such zonal reconciliations were made difficult by the absence of any consistently available data regarding zonal end use saturations and/or end use consumption patterns. Thus, the reconciliation against the forecasts was accomplished by applying adjustment factors for each zone to total savings estimated for the zones using Census-based household estimates, statewide end use saturations, and statewide average end-use consumption estimates (except for heating and cooling). The adjustment factors used were as follows: 89.3% for Zone A, 87.6% for Zone F, 105.7% for Zone G, 77.3% for Zone J, and 105.6% for Zone K. All zonal results shown in this report incorporate those adjustment factors.

Table 3.2.2 New York Households by Building Type and Zone in 2000

Zone	Description	Single Family	Multi-Family	Total
Zone A	Far west, including Buffalo	520,140	110,343	630,482
Zone F	Capitol region, including Albany	355,621	84,858	440,480
Zone G	Hudson Valley	351,649	87,990	439,639
Zone J	New York City	871,599	2,212,835	3,084,434
Zone K	Long Island	794,543	104,252	898,795
Statewide Total		**4,138,956**	**2,918,044**	**7,057,000**

Once zonal household estimates were developed, the size of retail markets and retrofit markets were estimated in the same manner as for New York State as a whole. County-level data on new construction activity were not available. Thus, the study allocated statewide estimates of the number of new single-family and new multi-family units built each year to each zone based on its share of existing single-family and multi-family households.

EFFICIENCY TECHNOLOGY CHARACTERIZATION

Measures Analyzed

The study analyzed more than 50 different efficiency measures, measure bundles, and/or measure categories, addressing virtually all residential end uses. Most of the measures are both widely available today and currently promoted by efficiency programs in numerous states. However, given the 20-year time horizon for the analysis, the study also included several measures that are commercially available but not widely promoted through efficiency programs (e.g., efficient furnace fans and heat-pump water heaters). We also included several measures that are not quite commercially available but could be fairly soon (e.g., power supply improvements in a number of products).

Most measures were analyzed separately for single-family and multi-family building applications, in part to capture the effects of different levels of savings and costs. In many cases, they also were analyzed separately for different markets (i.e., new construction, retail and retrofit). This enabled us to capture the effect of different savings, the duration of savings, and costs in different markets -- particularly differences between retrofit and non-retrofit applications. For example, a new Energy Star® refrigerator provides modest savings at modest cost for nearly 20 years if it is an upgrade at the time of a new purchase (retail or new construction). The same refrigerator will provide much greater savings at much greater cost -- though for a shorter time period -- if purchased as a replacement for an older, existing unit that a household would continue to use absent some sort of efficiency program.

In many cases, the study also separately analyzed the incremental savings and costs associated with different efficiency tiers for a measure category (e.g., SEER 13, 14, 15 and 16 for central air conditioners) in order to enable a more refined assessment of the efficiency potential that was cost-effective.

Similarly, the study also analyzed different efficiency "bins" for some measures, also to enable a more refined assessment of cost-effective potential. For example, for all fluorescent lighting measures the study separately examined the potential to displace incandescent or torchiere applications that had one of four usage patterns: (1) less than one hour per day; (2) 1.5 hours per day; (3) 2.5 hours per day; or (4) greater than 3 hours per day. This binning was done by first estimating the number of each type of fixtures in use in the average home (we assumed it was approximately 22), as well as the number of lamps in the average fixture (assumed to be approximately 1.7, for a grand total of 38 lamps).[7] The study then used light logger data from the Lawrence Berkeley National Laboratory on the fraction of lamps and lighting kWh that can be attributed to different usage levels to allocate our estimate of New York lighting consumption and replacement opportunities to each of the four bins used.[8]

The net effect of these various refinements was to turn a little more than 50 measures into nearly 400 efficiency measure permutations analyzed. Table 3.2.2 summarizes the measures analyzed, as well as the different efficiency tiers and or usage bins applied to each measure.

<u>Statewide Measure Costs, Savings and Other Characteristics</u>

The study used a variety of different sources to characterize the per-unit costs, savings, life, and other key characteristics of the efficiency measures analyzed. Chief among them were the U.S. Environmental Protection Agency's Energy Star® program (particularly for incremental costs and savings associated with home office equipment, electronics, humidifiers, and other products); various demand-side management (DSM) program evaluations conducted throughout the Northeast; information provided by NYSERDA; and our own judgment based on both extensive experience in promoting and/or directly installing many of the

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7 The Natural Resources Defense Council (NRDC) (Volume 1, p. 4) cites Lawrence Berkeley Laboratory research suggesting the average home has 20 to 30 light fixtures and 35 to 50 individual light bulbs (Calwell, Chris et al., *Lighting the Way to Energy Savings: How Can We Transform Residential Lighting Markets?*, an NRDC Report, December 1999). The same report suggests that both the number of fixtures and average lighting consumption are twice as great in single-family homes as in multi-family homes (Volume 2, p. 26). Since New York has a larger fraction of multi-family homes (41%) than the country as a whole (20%), our estimates of fixtures and lamps are on the lower end of the ranges for the average home.

measures through DSM programs in Vermont and review of similar programs in other states. Savings assumptions were first developed as statewide averages. Technical Appendix Table 5.1.3.0.1 shows all key statewide assumptions for all measures analyzed.

Table 3.2.3 Residential Efficiency Measures Analyzed for New York Potential Study

END USE	MEASURE	EFFICIENCY TIERS
Heating	Efficient furnace fans	
	Programmable thermostats	
	Energy Star windows	
	Storm Windows	
	Blower door-guided air sealing	
	Attic insulation	
	Wall insulation	
	Foundation insulation	
	Replace electric baseboard w/mini-split Heat Pump	
	Improve controls on auxiliary heating	
	Heat recovery ventilator	
	Improve distribution system to eliminate secondary electric heat	
Cooling/Heat Pump	upgrade to efficient central air conditioner	4: SEER 13 (Energy Star), 14, 15, and 16
	upgrade to efficient air source heat pump	4: SEER 13 (Energy Star), 14, 15, and 16
	upgrade to Ground Source Heat Pump (EER 18)	
	proper sizing of new central A/C or heat pump	
	refrigerant charge and airflow correction	
	duct sealing	
	duct insulation	
	upgrade to efficient room A/C	4: EER 10.7 (Energy Star), 11.5, 12.5 and 13.5
	upgrade to Energy Star dehumidifier	
	Reduce humidity by addressing moisture sources	2: Remove or reduce
	New construction shell/HVAC	3: 86 (Energy Star), 88 and 90 point HERS scores
Water Heating	Upgrade to heat pump water heater	
	Upgrade to efficient well pump	
	GFX heat exchanger	
	Hot water conservation measure package	
	Desuperheater off ground source heat pump	
Refrigeration	Upgrade to efficient refrigerator	2: Energy Star and 1 kWh/yr
	Remove 2nd refrigerator/freezer	
Lighting	compact fluorescent light bulbs	
	flourescent light fixtures - indoor	
	flourescent torchiere light fixtures	
	flourescent fixtures - outdoor	
	outdoor light controls (e.g. motion sensors)	
	LED nightlights	
	ceiling fans w/flourescent lights	
	Multi-family common area T8s w/specular reflectors	
	Multi-family common area lighting motion sensors	
	Multi-family LED exit signs	
Clothes Washing	Upgrade to efficient washer (avg MEF of 1.7)	
Dishwashing	Upgrade to Energy Star dishwasher	
TV	Upgrade to efficient TV	3: Energy Star, further standby reduction, power supply improvemt
	Upgrade to efficient VCR/DVD	3: Energy Star, further standby reduction, power supply improvemt
Pools	Upgrade to efficient pool pump motor (if >1 HP)	
	Pool pump timer	
Miscellaneous	Upgrade to efficient computer monitor	2: improve power supply and upgrade to LCD
	Upgrade to efficient computer CPU	
	Upgrade to efficient laser printer	2: Energy Star and further power supply improvement
	Upgrade to efficient fax machine	2: Energy Star and further power supply improvement
	Upgrade to Energy Star exhaust fan	
	Power supply improvements to various products	
	Waterbed mattress pad	
	Replace waterbed with standard mattress	

8 The data suggest that 53.2% of all lamps are used less than an hour per day and that those lamps account for only 9.9% of all household lighting energy use. The data also suggest that 18.6% of lamps are used between one and two hours per day, accounting for 13.9% of lighting energy use; 9.5% are used between two and three hours per day, accounting for 12.2% of lighting energy use; and 18.9% are used three hours per day or more, accounting for 64% of lighting energy use (Lawrence Berkeley National Laboratory Lighting Market Sourcebook data cited by Ecos Consulting, Benya Lighting Design and Rising Sun Enterprises in presentation titled "Research Summary of Northwest Energy Efficiency Alliance Residential New Construction Program" at the American Council for an Energy Efficient Economy/Consortium for Energy Efficiency National Symposium on Market Transformation, March 25-26, 2002).

Zonal Adjustments to Statewide Measure Characterizations

For most measures, assumptions regarding efficiency-measure savings, costs, lives, and other attributes were assumed to be the same in all regions of New York State. However, for several heating and cooling measures, the study adjusted statewide savings assumptions when analyzing potential in individual zones. In such cases, adjustments typically were based on differences between statewide averages and zonal heating and/or cooling degree-days.

BASELINE PENETRATION RATES

Baseline market penetrations -- the portion of the market that would buy or install the efficiency measure absent any new efficiency programs -- were developed from several sources. For virtually all retail Energy Star® measures -- including light fixtures, torchieres, home office equipment, audio-visual equipment, and appliances -- baseline market shares were based on estimates provided by the U.S. Environmental Protection Agency for the years 2002, 2005, and 2010. The study extrapolated from those values to develop estimates for other years in our analysis period.

There were a few exceptions to this rule. For example, the study assumed that the current market share for Star® windows was 35% based on a recent study of the Northeast.[9] That percentage was assumed to increase at a rate of 1% per year. For CFLs, we developed a baseline penetration that was based on national data from Regional Economic Research (RER) for California utilities. RER estimated that the average market share for CFLs in all states other than California in 2002 was about 1.5%.[10] The study adjusted that value down to 0.5% for the baseline for 2003 (and increased by 0.1 percentage points per year) to account for the fact that even outside of California, sales of CFLs are likely to be heavily influenced by selected regional DSM programs. A recent evaluation, for example, suggests that CFL sales in 2001 in Vermont -- where there was an aggressive program promoting them -- were slightly higher on a per-household basis than in California, but about 50 times greater than 2001 sales in comparable stores in Maine, where there has not been an active program for several years.[11] The study also assumed that sales of SEER 13 central air conditioners, absent any market interventions such as LIPA's current rebate program, would be about half as high in New York (i.e., about 2%) as in the rest of the country (about 4 to 5%) in 2003. This is because New York has much smaller cooling loads compared to Florida, Texas, California, and other states that dominate central air conditioner sales and, therefore, fewer benefits to consumers. That rate was increased by approximately 0.5 percentage points per year.

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9 Quantec, "Baseline Characterization of the Residential Market for Energy Star Windows in the Northeast," prepared for Northeast Energy Efficiency Partnerships Inc., October 2002.

10 Regional Economic Research, "Residential Market Share Tracking Project Report," 2002, Volume 1, p. 1.

11 Xenergy Inc., "Draft Final Report of the Phase 1 Evaluation of Efficiency Vermont's (EVT's) Efficient Products Program (EPP)," prepared for the Vermont Department of Public Service, December 2002.

For most other retail and new-construction measures there are few if any good data available on baseline market shares. Thus, assumptions regarding baseline market penetrations were based on professional judgment, informed by the authors' experience working on DSM programs that address comparable efficiency markets, particularly in the Northeast.

For retrofit measures, the study assumed that baseline penetrations were 0% across the board. For early-retirement measures (i.e., replacing an existing operational room air conditioner before the customer otherwise would have), it is 0% by definition. For the other category of retrofit measures -- i.e., the addition of a product (e.g., insulation or waterbed pad) or service (e.g., duct sealing) -- the study adjusted the size of the market to account for homes that already had installed such measures. Thus, baseline penetrations are also, by definition (at least for some period of time), 0%.

The full set of baseline market share assumptions used for all scenarios analyzed can be found in the Technical Appendix 5.1, Residential Efficiency.

ANALYSIS OF TECHNICAL AND ECONOMIC POTENTIAL

With the completion of all the assumptions and estimates discussed above, the assessments of technical and economic potential were largely computational tasks.

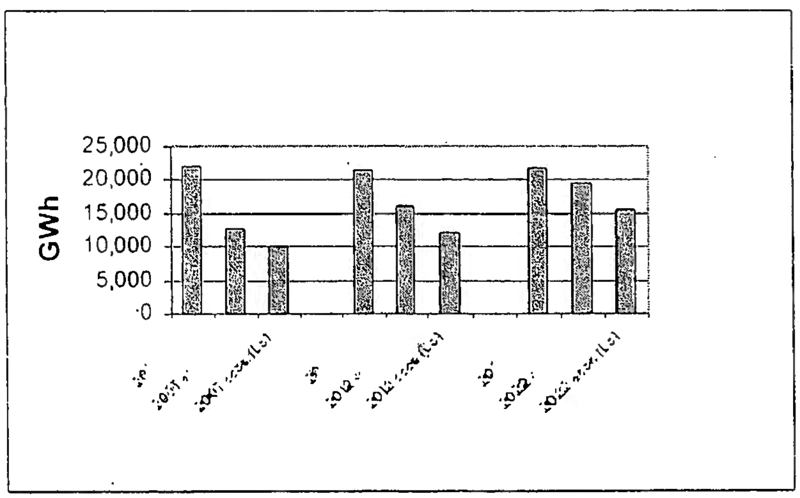
Overview

As Table 3.2.4 illustrates, the analysis suggests that residential efficiency improvements could technically eliminate a little more than 22,000 GWh of statewide annual energy use in New York. A significant portion of that statewide potential is cost-effective. The percentage that is cost-effective varies depending on two key factors: (1) the avoided costs used; and (2) the year in question. Use of the highest zonal avoided costs increase estimates of the fraction of savings that is cost-effective by about 20% (relative to the lowest zonal avoided costs). Economic potential in 2022 is approximately 1.5 times as great as economic potential in 2007. These trends are shown graphically for the state in Figure 3.2.3.

Table 3.2.4 Technical and Economic Residential Energy Savings Potential (GWh) by Load Zone

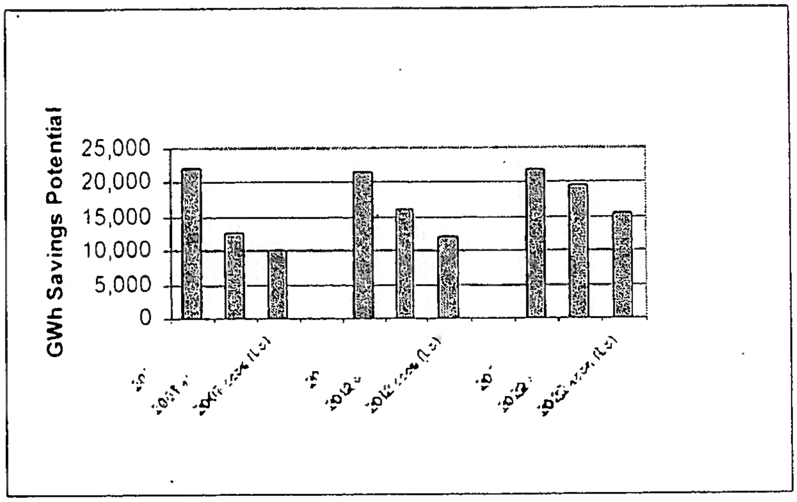
	Statewide High Avoided Costs	Statewide Low Avoided Costs	Zone A	Zone F	Zone G	Zone J	Zone K
Sales Forecast 2007	48,553	N/A	4,372	2,969	3,566	13,638	7,580
Sales Forecast 2012	50,306	N/A	4,530	3,077	3,695	14,131	7,854
Sales Forecast 2022	54,749	N/A	4,930	3,348	4,021	15,379	8,547
Tech Potential 2007	22,236	N/A	1,816	1,279	1,516	7,037	3,209
Tech Potential 2012	21,642	N/A	1,743	1,235	1,461	6,935	3,096
Tech Potential 2022	21,964	N/A	1,772	1,266	1,493	6,972	3,191
Econ Potential 2007	12,593	10,124	679	560	593	3,774	1,751
Econ Potential 2012	15,982	12,205	754	698	831	4,532	2,332
Econ Potential 2022	19,660	15,610	1,279	892	1,270	6,224	2,950
Econ as % of Tech 2007	56.6%	45.5%	37.4%	43.8%	39.1%	53.6%	54.6%
Econ as % of Tech 2012	73.8%	56.4%	43.3%	56.5%	56.9%	65.4%	75.3%
Econ as % of Tech 2022	89.5%	71.1%	72.2%	70.5%	85.1%	89.3%	92.4%

Figure 3.2.3 Technical and Economic Residential Energy Savings Potential (GWh) Statewide



Results at the zonal level show trends similar to the statewide results. The percentage of technical potential that is economic varies somewhat from zone to zone. As one would expect, the variation is consistent with variations avoided costs. For example, as Figure 3.2.4 illustrates, the percent of technical potential that is economic in 2012 is lowest in Zone A -- the zone with the lowest avoided costs -- and highest in Zone K -- the zone with the highest avoided costs.

Figure 3.2.4 Percent of Technical Energy Savings Potential (GWh) That is Economic by Zone in 2012

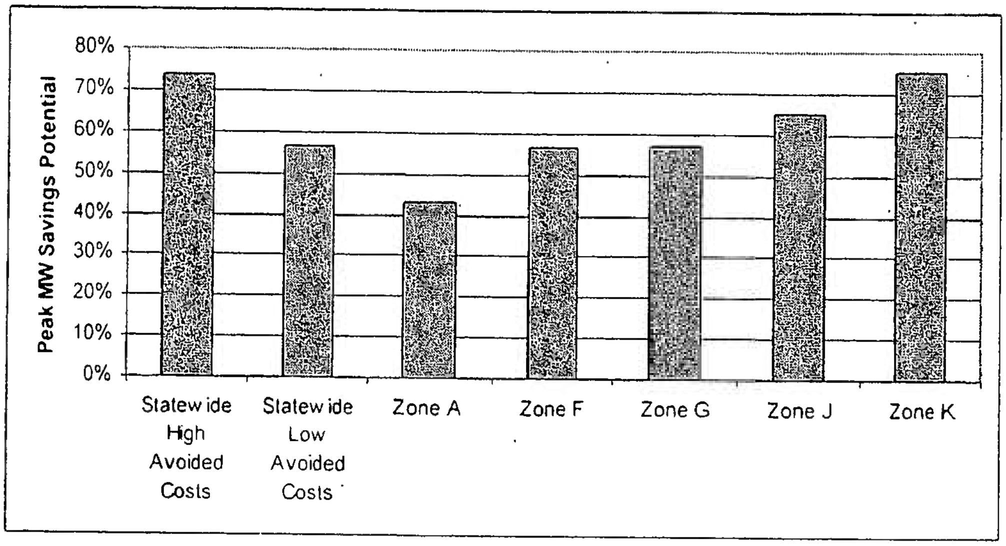


As Table 3.2.5 shows, the analysis also suggests that residential efficiency improvements could technically provide 5,000 to 6,000 MW (depending on the year) of coincident summer peak-demand savings. A significant portion of that peak-demand savings potential is cost-effective. However, that portion is smaller (in percentage terms) than the portion of energy savings that is cost-effective. Assessment of the portion of technical peak-demand savings potential that is cost-effective also appears to be a little more sensitive to the choice of avoided cost, with about two-thirds more savings being cost-effective under higher avoided costs. These trends are also shown graphically for the state in Figure 3.2.5.

Table 3.2.5 Technical and Economic Residential Peak Savings Potential (MW) by Load Zone

	Statewide High Avoided Costs	Statewide Low Avoided Costs	Zone A	Zone F	Zone G	Zone J	Zone K
Tech Potential 2007	5,011	N/A	368	317	361	1,973	942
Tech Potential 2012	5,255	N/A	382	335	380	2,084	1,004
Tech Potential 2022	6,067	N/A	439	393	443	2,390	1,195
Econ Potential 2007	2,433	1,475	103	91	100	1,051	485
Econ Potential 2012	3,267	1,981	128	123	141	1,637	696
Econ Potential 2022	4,480	2,646	192	166	201	2,217	980
Econ as % of Tech 2007	48.6%	29.4%	27.9%	28.5%	27.6%	53.3%	51.5%
Econ as % of Tech 2012	62.2%	37.7%	33.4%	36.7%	37.1%	78.6%	69.3%
Econ as % of Tech 2022	73.8%	43.6%	43.8%	42.2%	45.4%	92.8%	82.0%

Figure 3.2.5 Technical and Economic Residential Peak Savings Potential (MW) Statewide



Analysis of Technical Potential Results

Technical potential appears to remain relatively constant over time due to several counter-balancing factors. Two factors tend to reduce savings potential over time: (1) opportunities for efficiency improvements shrink in size as older, inefficient equipment is replaced by newer, more efficient equipment (most standard efficiency new appliances are still more efficient than older models); and (2) market shares for products we consider efficient today are likely to grow even without market interventions.[12] These factors appear to be offset by two others: (1) new construction increases the number of homes from which efficiency savings can be acquired; and (2) increasing saturations of some end uses in existing homes (e.g., central air conditioning, dishwashers, computers, and other home office equipment) somewhat increase savings opportunities in existing homes. Note that although the analysis included some emerging technologies, it is impossible to fully anticipate the range of new efficiency improvements that will be available in the market in 10 years, let alone in 20 years. In that regard, the study's estimates for 2022 are likely to be somewhat conservative.

As Table 3.2.6 shows, the amount of technical savings potential available from each of the three major markets that we analyzed -- new construction, retail, and retrofit -- differs and changes over time. Potential in the new-construction and retail markets grows over time; potential in retrofit markets declines significantly. In new construction, this is the result of a growing number of new (i.e., post-2002) homes. The growth in retail potential is directly related to the shrinking potential from the retrofit market. As more

[12] Such growth would likely be very gradual. However, over a 20-year time horizon, even gradual growth erodes some potential for capturing efficiency potential through market interventions.

and more equipment gets replaced through a natural turnover cycle, there is more "retail" potential and less potential available from early-retirement retrofits.

Table 3.2.6 New York Residential Technical Potential by Market

Market	2007			2012			2022		
	Annual GWh	Summer Peak MW	Winter Peak MW	Annual GWh	Summer Peak MW	Winter Peak MW	Annual GWh	Summer Peak MW	Winter Peak MW
Retail	6,570	1,647	1,110	11,155	3,064	1,939	16,538	4,741	3,036
Retrofit	15,128	3,234	2,811	9,358	1,909	1,837	3,142	696	627
RNC	538	129	137	1,130	282	289	2,284	630	598
Grand Total	22,236	5,011	4,058	21,642	5,255	4,065	21,964	6,067	4,262

Table 3.2.7 shows a breakdown of statewide technical potential by end use. Lighting provides the largest technical energy savings potential -- about one-third of the total in each year. Five other end uses -- heating, cooling, hot water, refrigeration, and miscellaneous -- each provide between 9% and 13% of technical savings potential in 2007 and 2012, and between 7% and 15% of technical energy savings potential in 2022. There is gradual but significant growth in technical energy-savings potential from cooling and heating over the 20 years. In contrast, the energy-savings potential from refrigeration declines significantly between 2007 and 2022 as older refrigerators are replaced by new models for which "standard efficiency" is still a substantial improvement over older units.

While one might have expected the same trend for cooling, it does not happen for two reasons. First, the difference between the efficiency of an old central air conditioner and a new standard model is relatively small, particularly compared to the difference for refrigerators. Second, because we have assumed that saturations of central air conditioning will continue to grow over time, the cumulative savings potential also grows. No other end use provides more than 5% of the total technical energy savings potential in any year.

Table 3.2.7 also shows that cooling-efficiency measures dominate the technical summer peak-demand savings potential. Cooling accounts for 65% of such potential in 2007. That fraction growns to 69% in 2012 and 75% in 2022. No other end use accounts for more than 7% in any year.

Table 3.2.7 New York Residential Technical Potential by End Use

	2007			2012			2022		
End Use	Annual GWh	Summer Peak MW	Winter Peak MW	Annual GWh	Summer Peak MW	Winter Peak MW	Annual GWh	Summer Peak MW	Winter Peak MW
Clotheswasher	1,091	165	204	993	150	186	851	128	159
Cooling	1,964	3,253	-	2,197	3,649	-	2,721	4,542	-
Dishwasher	298	33	48	267	29	43	196	22	32
Heat pump	472	123	215	479	124	218	531	138	242
Hot Water	1,973	254	334	2,129	274	360	2,282	294	386
Lighting	7,160	358	1,028	7,460	373	1,071	7,459	373	1,073
Miscellaneous	2,645	295	305	2,231	249	257	2,221	248	256
Pool/Hot Tub Pump	162	26	30	120	19	22	79	13	15
Refrigerator	2,815	359	311	2,019	258	223	1,510	193	167
Space Heating	2,643	12	1,437	2,863	13	1,557	3,349	15	1,822
TV/VCR/DVD	1,012	134	146	884	117	127	765	101	110
Grand Total	22,236	5,011	4,058	21,642	5,255	4,065	21,964	6,067	4,262

Analysis of Economic Potential

The increase over time in the fraction of sales that could be cost-effectively offset by efficiency investments was expected. It is largely due to the fact that the fraction of potential available from retail and new-construction markets -- where it is cheapest -- grows over time (as more and more older equipment turns over naturally). This point is illustrated in Tables 3.2.8 and 3.2.9.

Table 3.2.8 New York Residential Economic Potential by Market (High Avoided Costs)

	2007			2012			2022		
Market	Annual GWh	Summer Peak MW	Winter Peak MW	Annual GWh	Summer Peak MW	Winter Peak MW	Annual GWh	Summer Peak MW	Winter Peak MW
Retail	6,141	1,286	1,075	10,456	2,426	1,856	15,260	3,715	2,866
Retrofit	6,016	1,089	949	4,619	720	762	2,533	516	485
RNC	436	58	119	907	121	252	1,866	249	531
Grand Total	12,593	2,433	2,144	15,982	3,267	2,870	19,660	4,480	3,883

Table 3.2.9 New York Residential Economic Potential by Market (Low Avoided Costs)

	2007			2012			2022		
Market	Annual GWh	Summer Peak MW	Winter Peak MW	Annual GWh	Summer Peak MW	Winter Peak MW	Annual GWh	Summer Peak MW	Winter Peak MW
Retail	6,412	767	1,141	7,673	1,236	1,491	11,976	1,923	2,445
Retrofit	3,288	652	420	3,649	627	491	1,847	481	246
RNC	423	56	118	883	118	249	1,787	242	521
Grand Total	10,124	1,475	1,678	12,205	1,981	2,231	15,610	2,646	3,212

As Tables 3.2.10 and 3.2.11 show, lighting dominates economic energy-savings potential even more than technical potential. It accounts for more than half of all cost-effective energy-savings potential in 2007 and nearly 40% of cost-effective savings in 2022 under high-avoided costs. Its dominance is even greater under low avoided costs, accounting for more than 60% of all cost-effective energy savings potential in 2007 and nearly 45% in 2022. Space heating is the only other end use that accounts for more than 10% of savings potential in any year under either high or low avoided costs. Although it provides only 7% to 9% of cost-effective potential in 2007, that fraction grows to between 16% and 17% in 2022 -- largely due to savings potential from efficient furnace fans.

Table 3.2.10 New York Residential Economic Potential by End Use (High Avoided Costs)

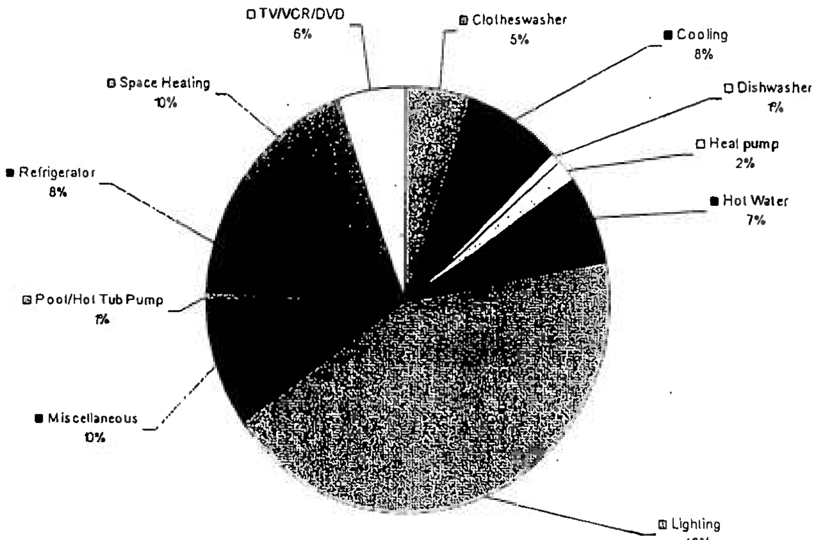
	2007			2012			2022		
End Use	Annual GWh	Summer Peak MW	Winter Peak MW	Annual GWh	Summer Peak MW	Winter Peak MW	Annual GWh	Summer Peak MW	Winter Peak MW
Clotheswasher	467	70	87	789	119	148	851	128	159
Cooling	917	1,541	-	1,250	2,104	-	1,832	3,104	-
Dishwasher	79	9	13	152	17	25	196	22	32
Heat pump	206	54	93	262	69	119	359	94	163
Hot Water	594	76	100	1,064	136	179	1,843	237	311
Lighting	6,265	313	900	6,934	347	997	7,289	365	1,050
Miscellaneous	1,266	141	146	1,519	170	175	1,887	211	218
Pool/Hot Tub Pump	121	19	23	100	16	19	79	13	15
Refrigerator	1,135	145	125	1,301	166	144	1,510	193	167
Space Heating	1,093	5	591	1,727	8	937	3,049	14	1,658
TV/VCR/DVD	451	59	65	884	117	127	765	101	110
Grand Total	12,593	2,433	2,144	15,982	3,267	2,870	19,660	4,480	3,883

Table 3.2.11 New York Residential Economic Potential by End Use (Low Avoided Costs)

	2007			2012			2022		
End Use	Annual GWh	Summer Peak MW	Winter Peak MW	Annual GWh	Summer Peak MW	Winter Peak MW	Annual GWh	Summer Peak MW	Winter Peak MW
Clotheswasher	467	70	87	789	119	148	851	128	159
Cooling	487	801	-	677	1,124	-	955	1,596	-
Dishwasher	79	9	13	152	17	25	196	22	32
Heat pump	107	28	48	201	53	91	267	70	121
Hot Water	167	22	28	182	23	31	491	64	84
Lighting	6,201	310	893	6,197	310	893	6,885	345	995
Miscellaneous	893	100	103	1,130	126	130	1,498	167	173
Pool/Hot Tub Pump	7	1	1	13	2	2	20	3	4
Refrigerator	684	87	76	900	115	99	1,258	161	139
Space Heating	699	3	381	1,318	6	718	2,608	12	1,422
TV/VCR/DVD	332	44	48	647	85	93	581	77	84
Grand Total	10,124	1,475	1,678	12,205	1,981	2,231	15,610	2,646	3,212

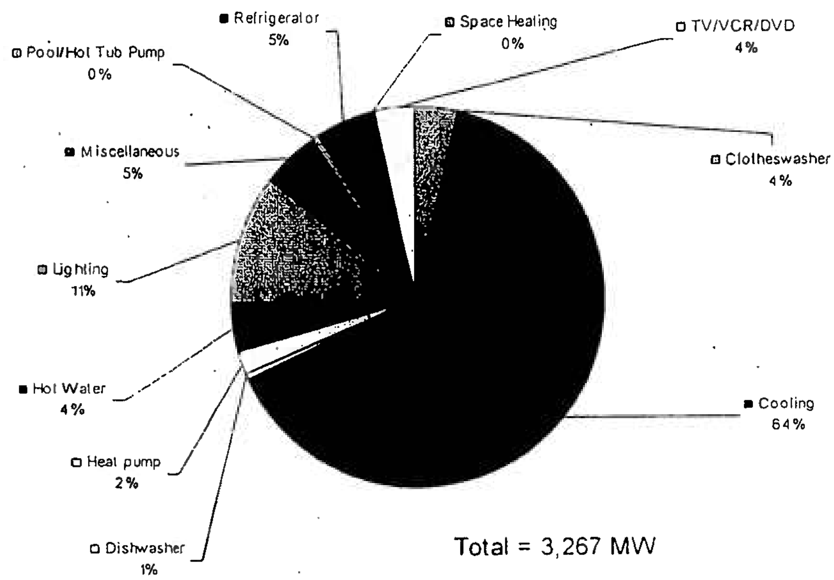
Figure 3.2.6 illustrates the distribution of energy savings potential under one scenario (i.e., 2012, under high avoided costs).

Figure 3.2.6 New York Residential Economic Energy Savings Potential (GWh) in 2012 (High Avoided Costs)



As with technical potential, cooling dominates cost-effective summer peak-demand savings potential. Cooling accounts for about two-thirds of such potential under high avoided costs and 55% to 60% of it under low avoided costs. Lighting is a distant second in contribution to cost-effective summer peak-demand savings potential, providing 8% to 13% of it under high avoided costs and 13% to 21% of it under low avoided costs (the higher of those ranges applies to the earlier years). No other end use accounts for more than 7% cost-effective summer peak-demand savings potential in any year under either set of avoided costs. Figure 3.2.7 graphically shows the distribution of summer peak-demand potential under one scenario (i.e., 2012, under high avoided costs).

Figure 3.2.7 **New York Residential Economic Summer Peak Demand Savings Potential (MW) in 2012 (High Avoided Costs)**



The difference between high and low avoided costs appears to have the greatest impact on the cost-effectiveness of cooling and water heating (particularly heat-pump water heater) measures, particularly in 2022. Some 37% to 61% of the difference in total cost-effective energy savings potential under high and low avoided costs is attributable to those two end uses. 82% to 91% of the difference in total cost-effective

ANALYSIS OF GREENHOUSE GAS EMISSION REDUCTION SCENARIO

Our analysis of the GHG emission-reduction scenario required two additional sets of assumptions: (1) "achievable" penetration rates for efficiency measures over time; and (2) administrative cost "adders." Policies and program strategies for achieving additional contributions toward greenhouse gas markets are included in Technical Appendix Table 5.1.5.

Achievable Penetration Rates

Achievable penetration rates were estimated separately for each market and often for different measures within those markets. Estimates were based on our best judgment -- informed by program experience with similar markets -- of what the most aggressive efficiency programs could achieve. We assumed that such programs would provide incentives of up to 100% of the incremental measure cost for those measures for which high cost currently appears to be a barrier to consumer purchases. This excludes a variety of measures -- such as Energy Star® electronics, Energy Star® home office equipment, and Energy Star® dehumidifiers -- which appear to cost very little if any more than standard products. For all markets we also assumed there would be reasonably aggressive marketing, trade-ally outreach and training, and other efforts necessary to "move the market."

Table 3.2.12 shows the penetration assumptions we used for nine retail measures that collectively account for roughly half of the savings potential achievable in retail markets. As the table makes clear, we assumed different penetration patterns for different measures. The variations are driven by a variety of factors, including the current availability of the product, current market shares, and the relative importance of incremental cost as a barrier (this is the easiest barrier to overcome if one can spend the money).

Table 3.2.12 Achievable Penetration Rates for Key Residential Measures

End Use	Measure	2003	2007	2012	2022
Lighting	Indoor Fluorescent Fixtures	5%	10%	15%	20%
Lighting	Fluorescent Torchieres	15%	30%	50%	80%
Lighting	Energy Star Ceiling Fans	15%	50%	75%	90%
Cooling	Central A/C - SEER 13	20%	50%	75%	90%
Cooling	Central A/C - charge/airflow correction	20%	50%	75%	90%
Refrig	Energy Star Refrigerator	30%	70%	90%	95%
Washing	Efficient Clothes Washer (MEF 1.7)	50%	70%	80%	80%
Heating	Efficient Furnace Fan	10%	25%	40%	50%
Water Heating	Heat Pump Water Heater	0%	5%	20%	80%

For example, we assumed that efficient washer penetration rates could start at 50% (about 15% above leading programs today) and reach 80% within 10 years. The reason for substantial penetration is the anticipation that the rebate would be substantial -- several times larger than any currently offered in the market -- and that incremental cost is by far the most important barrier today to purchase of efficient washers. In contrast, for fluorescent indoor light fixtures we assumed that it was possible to achieve a 5% penetration rate in 2003 and 20% by 2022. The penetration rates are much lower than for washers because we believe that availability of and customer access to aesthetically appealing products in a wide variety of styles and applications -- not price -- is the most important barrier in this market. Note that while we assumed that heat-pump water heaters would have the lowest initial penetration rate in 2003 -- near 0% because the product is not yet ready for substantial sales volumes -- we assumed that its penetration rate would increase substantially over the second decade of our analysis period if substantial rebates were offered and the industry had the time to ramp up production to meet demand.

The one important retail measure absent from Table 3.2.12 is the compact fluorescent (CFL). We did not include it in the table because the concept of market share is tricky if penetration rates ever reach substantial levels, as we assume they could. This is because, unlike most other measures, CFLs have a different (i.e., much longer) life than the incandescent products they replace. As a result, the more CFLs are sold, the smaller the future market for light bulbs becomes. Thus, what really matters is the fraction of sockets in the average home that would be using CFLs as a result of making retail purchases (note that this does not include those sockets using CFLs as a result of retrofit installations). For the GHG scenario we assumed that fraction would grow from a couple of percent today to 5% by 2007 and 20% by 2022.

Penetration rates for most new-construction measures (i.e., light fixtures and appliances) were assumed to be the same as for retail markets. The one exception is Energy Star® standards for building shell and HVAC equipment (i.e., new Energy Star® homes). For that measure bundle, we assumed it would be possible to achieve a penetration rate of 10% in 2003, with the rate growing to 30% in 2007, 50% in 2012 and 75% by 2022.

In the retrofit market we assumed that 70% of all homes would be visited and treated over the 20-year analysis period (starting at 0.3% in 2003 and reaching 8.5% by 2007, 32% by 2012 and 70% by 2022). That is comparable to rates that have been realized in small service territories, such as the Washington Electric Cooperative's in Vermont; however, it would require an enormous build-up of service delivery capability in New York State. Of the homes visited, we assumed that it would be possible to install 75% of most applicable efficiency measures if offered free of charge to consumers. The only exceptions to this rule were a handful of measures (e.g., removal of second refrigerators, replacement of waterbeds with standard mattresses, installation of GFX heat-exchange pipes) for which we believe there are important barriers other than cost. For such measures, we assumed penetration rates of 25% to 50% depending on the measure.

Administrative Cost Adders

Table 3.2.13 summarizes the administrative cost adders we developed for different measure groupings (by incremental cost) within each market. In general, these adders were developed by examining leading programs in the region, comparing their non-incentive budgets to their incentive budgets, and adjusting those ratios to account for: (1) differences between incentives and incremental measure costs; (2) expected differences between program participation and market changes (i.e., accounting for spillover); and (3) likely reductions in non-incentive-to-measure cost ratios resulting from increasing market shares, greater efficiencies, etc.

Table 3.2.13 Residential Administrative Cost Adders for Greenhouse Gas Scenario

Measure Cost	New Construction	Retail	Retrofit
<$5	n.a.	100%	33%
$5 to $99	20%	20%	33%
$100 to$1000	20%	20%	33%
>$1000	50%	20%	33%

Note that these administrative cost adders are necessarily very approximate. More precise numbers would require development of detailed budgets for each market and submarket targeted. Such an undertaking was beyond the scope of this study.

Greenhouse Gas Scenario Results

This study analyzed the least-cost mix of renewable supply and energy-efficiency measures needed to meet an emission-reduction requirement for the electric utility industry. NYSERDA estimated that requirement to be equal to a marginal reduction on baseline electricity production of nearly 20,000 GWh in 2012 and a little more than 27,000 GWh in 2022. Our analysis suggests that the least-cost path to meeting those targets includes all renewable and energy-efficiency measures that have a net cost of less than approximately $0.0276 per kWh in 2012 and $0.0264 per kWh in 2022 (what one might call least-cost greenhouse gas thresholds).[13] We estimate that 3,105 GWh of residential efficiency savings can be achieved at costs less than the 2012 least-cost threshold; 6,818 GWh of residential efficiency savings can be achieved at costs less than the 2022 least-cost threshold. Of the 2,654 total measures in 2012, 126 residential measures meet the least-cost threshold. In 2022, there are 125 residential measures, out of 2,609 total measures, meeting the least-cost threshold.

Complete, integrated results for our analysis of the Greenhouse Gas Scenario can be found in Volumes 1 and 2 of this report.

ANALYSIS OF CURRENTLY PLANNED INITIATIVES

The Expected Achievements Under Currently Planned Initiatives Scenario (CPI Scenario) estimates the likely residential sector impacts over the next 20 years from five items:

- Currently planned NYSERDA Energy $mart initiatives through 2006
- Currently planned LIPA Clean Energy initiatives through 2004
- Currently planned New York Power Authority (NYPA) initiatives through 2004 [14]
- Expected enhancements to existing or new federal and state appliance efficiency standards through 2022
- Expected enhancements to the energy components of the New York State Building Code through 2022
-

NYSERDA, LIPA, and NYPA Residential Programs

Table 3.2.14 summarizes the existing NYSERDA, LIPA, and NYPA residential efficiency programs that we analyzed for this scenario. We built up our analysis of these initiatives from the measure level. When we had access to New York-specific market-share data for 2002 (e.g., for Energy Star® appliances), we extrapolated from those data to estimate the effects of appliance programs on future program years. For those markets for which we did not have market-share data, we used either estimates of future program

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13 See Volumes 1 and/or 2 for discussion of how net costs were calculated.

14 Although we were charged with analyzing NYPA programs through 2004, the only residential program NYPA currently operates – bulk purchase of efficient refrigerators to replace old inefficient models in pubic housing – was projected by NYPA to conclude at the end of 2003.

participation (e.g., for LIPA and NYPA) or extrapolations from data on recent program participation (i.e., for NYSERDA) to estimate future program impacts.

Table 3.2.14 Current New York Residential Efficiency Programs Analyzed

Program Administrator	Program Name	Program Summary	Years Analyzed	Estimated Annual Spending ($ millions)
NYSERDA	Energy Star Lighting & Appliances	Marketing to consumers and sales support to retailers to promote sales of Energy Star lighting & appliances and other products	2003 to 2006	$5.8
NYSERDA	Keep Cool	Bounty for turn-in of old inefficient room A/Cs and purchase of new Energy Star models to replace them	2003 to 2006	$11.7
NYSERDA	Energy Star Homes	Technical and financial assistance to builders of homes that meet the Energy Star standard	2003 to 2006	$2.7
NYSERDA	Home Performance w/Energy Star	Build infrastructure of contractors capable of providing "whole house" efficiency assessments through training, certification, incentives for diagnostic equipment and consumer financing	2003 to 2006	$2.3
NYSERDA	Low Income Direct Install	Direct installation of efficiency measures in low income households	2003 to 2006	$18.4
NYSERDA	Low Income Assisted Housing	Incentives to incorporate efficiency into the design, selection and installation of equipment in publicly assisted housing	2003 to 2006	$1.3
NYSERDA	Loan Fund	Provides loans for efficiency investments by building owners	2003 to 2006	$1.5
NYSERDA	Comprehensive Energy Management	Loan end use meters to consumers to identify opportunities for energy savings	2003 to 2006	$0.8
LIPA	Residential Energy Affordability Partnership	Direct installation of efficiency measures in low income households	2003 to 2004	$2.6
LIPA	HVAC	Rebates for new central A/Cs and heat pumps that are properly sized and installed	2003 to 2004	$4.0
LIPA	Lighting & Appliances	Rebates and marketing to consumers and sales support to retailers to promote sales of Energy Star lighting & appliances	2003 to 2004	$3.3
NYPA	Public Housing	Replace old refrigerators in NYC Housing Authority buildings with new efficient models	2003	$10.0

Sources:
NYSERDA Keep Cool and Energy Star Homes spending estimates from conversation w/Jennifer Ellefson, Feb. 2003; others from New York Energy Smart Program Evaluation and Status Report, Report to the System Benefits Charge Advisory Group, Initial 3-Year Program, January 2002 (assumed to remain unchanged absent better
LIPA spending estimates from LIPA 2003 budgets.
NYPA spending estimated from December 2002 revisions to State Energy Plan, adjusting for number of units (I.e. 25,000) still to be installed. End date of 2003 from NYPA website.

For several retail markets, we made very rough adjustments to projected participation levels to account for spillover that evaluations in relevant markets in the region suggest is taking place. For example, recent analyses of the Vermont CFL and washer markets and the New Jersey central air conditioner market, where there are rebate programs in place very similar to those on Long Island, suggest spillover rates may be on the order of 50% to 100%.[15] In all cases, savings were estimated using our per-unit savings assumptions.

As noted above, analysis of this scenario was limited to programs by NYSERDA from 2003 to 2006 and initiatives by LIPA and NYPA from 2003 to 2004, which was the focus of our work. However, we did assume that some of the programs operated during those years -- particularly those the long-term market transformation orientations -- would have lingering effects on the market afterward.[16] To capture such effects, we simply assumed that a fixed percentage of the results realized in the last year of a program would continue into future years. Table 3.2.15 presents the factors we used.

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15 A draft evaluation of Efficiency Vermont's Efficient Products Program suggested that 37% of all Energy Star® clothes washer sales in the Vermont in the first 10 months of 2002 occurred outside of the program – i.e., without a rebate (Xenergy Inc., "Draft Final Report of the Phase 1 Evaluation of Efficiency Vermont's [EVT's] Efficient Products Program [EPP]," prepared for the Vermont Department of Public Service, December 2002). That translates to a spillover rate of 59% (0.37 divided by 0.63). The same study suggested that 35% to 50% of all CFL sales occurred outside of the program. That translates to a spillover rate of 54% to 100%. The New Jersey HVAC baseline study suggested that, for the period from 1998 to 2000, 28% of the roughly 100,000 central air conditioners and heat pumps sold each year to existing homes in the state were SEER 13 or greater (Xenergy Inc. New Jersey Residential HVAC Baseline Study, prepared for the New Jersey Residential HVAC Working Group, November 16, 2001). However, over the same period utility rebates for SEER 13 or better equipment were only about half as large. This suggests a spillover rate of 100%.

16 Examples of such programs include those that significantly increase consumer awareness and interest in Energy Star (as demonstrated by significant short-term increases in market share) -- such as LIPA's lighting, appliance and HVAC programs and NYSERDA's Keep Cool room A/C program -- and those that use training and/or certification to increase capabilities and/or consumer recognition of contractors -- such as NYSERDA's Home Performance for Energy Star® program and LIPA's HVAC program.

Table 3.2.15 **Annual Residential DSM Program Effects Projected to Continue After Program's End**

End Use	Market	NYSERDA	LIPA	NYPA
Lighting	Retail/RNC	5%	15%	0%
Refrigeration	Retail/RNC	25%	25%	0%
TV	Retail/RNC	0%	0%	0%
Water Heating	Retail/RNC	0%	0%	0%
Cooling - Room A/C	Retail/RNC	15%	15%	0%
Cooling Central A/C	Retail/RNC	0%	25%	0%
Dishwashing	Retail/RNC	0%	0%	0%
Clothes Washing	Retail/RNC	0%	15%	0%
Pools	Retail/RNC	0%	0%	0%
Heat Pumps	Retail/RNC	0%	25%	0%
Heating	Retail/RNC	0%	0%	0%
Miscellaneous	Retail/RNC	0%	0%	0%
Lighting	Retrofit	0%	0%	0%
Refrigeration	Retrofit	0%	0%	0%
TV	Retrofit	0%	0%	0%
Water Heating	Retrofit	0%	0%	0%
Cooling	Retrofit	20%	0%	0%
Dishwashing	Retrofit	0%	0%	0%
Clothes Washing	Retrofit	0%	0%	0%
Pools	Retrofit	0%	0%	0%
Heat Pumps	Retrofit	20%	0%	0%
Heating	Retrofit	35%	0%	0%
Miscellaneous	Retrofit	0%	0%	0%

Notes:
1 All retrofit effects a result of market transformation by Home Performance program
2 Retail/RNC effects assumed to be a function of both severity of market barriers, degree to which program addressed all barriers and degree to which program moved the market.

Appliance Standards and Building Codes

Table 3.2.16 summarizes the appliance standards and building code changes that we incorporated into our analysis. Assumptions regarding the five appliance standards that we analyzed, including their assumed start dates, were based on a draft analysis conducted by the American Council for an Energy Efficient Economy (ACEEE). Because both the start date and the final passage of standards as currently envisioned are uncertain, we applied a 50% probability factor to impacts from 2003 to 2010 and a 67% probability factor for post-2010 impacts.

With building codes, we assumed that the new standard would be approximately halfway between the current code and the performance of an Energy Star® home. We also assumed that there would be a 90% compliance rate with the new code.

Table 3.2.16 New Residential Codes and Standards Assumed for CPI Scenario

Product	Assumed Standard	Anticipated Start Date
Ceiling Fans	Current Energy Star standard	2005
External Power Supplies	75-85% efficient in active mode; max 0.75 W standby	2005
Torchiere Lamps	Max of 190 W	2005
Furnace Fans	ECM motor or equivalent	2010
Dishwashers	Current Energy Star standard	2010
New Homes	Half way to current Energy Star standard	2013

Administration Costs for CPI Scenario

The last part of the analysis for this scenario was estimating "administration" costs (defined broadly to include all non-incentive costs, including marketing, training, sales, management, etc.) associated with the current initiatives. We assumed that new codes and standards would not impose any new or incremental administration costs. However, such costs were estimated for DSM programs. This was done separately for each program analyzed. In the case of LIPA's programs, the estimates were based on budget breakdowns that we have from our work on those programs. For NYSERDA's programs we relied on information provided by NYSERDA as well as information in several NYSERDA documents. Since several of NYSERDA's programs are expected to generate substantial fossil fuel savings as well as electricity savings, we developed rough adjustment factors to allocate only a portion of the program costs to electric savings. For the one NYPA residential program, we simply assumed that 12.5% of the cost was for items other than incentives. The assumptions we used are summarized in the Table 3.2.17.

Table 3.2.17 Estimated Non-Incentive Portions of Current New York Residential Efficiency Program Budgets

Program Administrator	Program Name	Estimated Total Annual Spending ($ millions)	Estimated Non-Incentive Portion of Spending ($millions)	Allocation of Spending to Electric Savings	Net Non-Incentive Spending ($millions)			
					2003	2004	2005	2006
NYSERDA	E-Star Lites & Appliances	$5.8	$5.8	90%	$5.2	$5.2	$5.2	$5.2
NYSERDA	Keep Cool	$11.7	$7.9	100%	$7.9	$2.7	$2.7	$2.7
NYSERDA	Energy Star Homes	$2.7	$1.0	10%	$0.1	$0.1	$0.1	$0.1
NYSERDA	Home Performance	$2.3	$1.4	10%	$0.1	$0.1	$0.1	$0.1
NYSERDA	Low Income DI	$18.4	$2.17	100%	$2.2	$2.2	$2.2	$2.2
NYSERDA	Low Income Assist Housing	$1.3	$0.3	100%	$0.3	$0.3	$0.3	$0.3
NYSERDA	Loan Fund	$1.5	$0.1	10%	$0.0	$0.0	$0.0	$0.0
NYSERDA	Comprehensive Energy Mngmt	$0.8	$0.2	100%	$0.2	$0.2	$0.2	$0.2
LIPA	Res Energy Affordability	$2.6	$1.2	100%	$1.2	$1.2	$0.0	$0.0
LIPA	HVAC	$4.0	$1.1	100%	$1.1	$1.1	$0.0	$0.0
LIPA	Lighting & Appliances	$3.3	$1.5	90%	$1.3	$1.3	$0.0	$0.0
NYPA	Public Housing	$10.0	$1.3	100%	$1.3	$0.0	$0.0	$0.0
Annual Totals					$ 20.8	$ 14.4	$ 10.7	$ 10.7
NPV of 4-Year Totals					$ 49.4			

Sources:
- NYSERDA Keep Cool and Energy Star Homes spending estimates, as well as share of Home Performance spending on non-incentives, from conversations w/Jennifer Ellefson, Feb. 2003; others from New York Energy Smart Program Evaluation and Status Report, Report to the System Benefits Charge Advisory Group, Initial 3-Year Program, January 2002 (assumed to remain unchanged absent better information).
- LIPA spending estimates from LIPA 2003 budgets.
- NYPA spending estimated from December 2002 revisions to State Energy Plan, adjusting for number of units (i.e. 25,000) still to be installed. End date of 2003 from NYPA website. Assumption that 12.5% of budget is non-incentive is VEIC's.
- Estimated fraction of spending allocated to electric savings are VEIC's based on our knowledge of how the programs work and the kind of savings they are likely to generate.

Residential CPI Results

Table 3.2.18 summarizes our estimates of savings from currently planned initiatives targeting the residential sector.

Table 3.2.18 Residential CPI Savings Estimates

Year	Annual MWh	Summer Peak MW	Winter Peak MW
2007	501,033	134	65
2012	581,332	114	82
2022	748,059	146	106

Table 3.2.19 summarizes our assessment of the cost-effectiveness of these initiatives, taken as a whole. As the table makes clear, the initiatives are very cost-effective under both the high and low zonal avoided costs provided to us by NYSERDA.

Table 3.2.19 Residential CPI Cost-Effectiveness

Scenario	Total Resource Benefits (NPV in 2003 $)	Total Resource Costs (NPV in 2003 $)	Total Resource Net Benefits (NPV in 2003 $)	Benefit-Cost Ratio
High Avoided Costs	$ 605,792,833	$ 179,664,373	$ 426,128,461	3.37
Low Avoided Costs	$ 359,336,965	$ 179,664,373	$ 179,672,592	2.00

Complete, integrated results for the CPI Scenario can be found in Volumes 1 and 2 of this report.

Section 3:
COMMERCIAL EFFICIENCY ANALYSIS

SUMMARY OF RESULTS

As Figure 3.3.1, Summary of Commercial Efficiency Savings Potential in New York, illustrates, the savings potential from commercial efficiency measures is substantial. From a theoretical "technical" perspective, the potential is on the order of 32.4 thousand GWh per year by 2007, growing to approximately 38,000 GWh per year by 2012 and then remaining fairly flat from 2012 to 2022. The vast majority of statewide technical potential is economic (i.e., cost-effective) based on NYSERDA avoided costs. The portion of technical potential that is economic grows from between 85% and 93% in 2007 to between 86% and 96% in 2022 (depending on the avoided costs used). Achievable commercial efficiency contributes about 12.5 thousand GWh of annual savings in 2012 and 12.8 thousand GWh of annual savings in 2022 to the least-cost efficiency and renewable-energy solution to meeting a greenhouse-gas (GHG) emission reduction goal for the electric utility industry.[17] That represents approximately 62% in 2012 and 40% in 2022 of the total electric industry GHG emission reduction goal for those years. Currently planned initiatives are projected to provide 1.1 thousand GWh of savings in 2007, with savings growing gradually to 2.8 thousand GWh in 2012, and then climbing more rapidly to 8.6 thousand GWh in 2022. The climb in later years is a result of substantial expected savings accruing from improvements to state and federal codes and standards.

Figure 3.3.1 Summary of Commercial Efficiency Savings Potential in New York

[17] These data are based on the greenhouse gas analysis using the low avoided costs. Note that the Greenhouse Gas analysis is only done for 2012 and 2022; therefore, the graph shows it starting at zero in 2007.

OVERVIEW OF APPROACH

The commercial-sector analysis focuses on four different markets, which represent distinct opportunities for savings: new construction; renovation; natural equipment replacement and remodeling; and discretionary retrofit. The first three markets reflect time-dependent opportunities for efficiency and are driven by natural market events ("market-driven"). The retrofit market reflects discretionary investments to retire equipment or systems before the end of their useful life (or add supplemental measures that wouldn't otherwise exist) primarily for purposes of increased efficiency. We estimated savings for 87 efficiency technologies or bundles of technology separately for nine building types in these four separate markets. For each combination of technology, building type and market (which resulted in 2,163 individual measures), separate measure costs, performance characteristics, and annual penetrations were estimated for baseline, technical, economic, and two achievable scenarios (currently planned initiatives and greenhouse gas).

The commercial analysis uses a combination of "top-down" and "bottom-up" approaches. Electric sales were broken down into component parts applicable to different technologies ("top-down"), while individual technology performance and cost characteristics by building type were developed and applied to the applicable electric loads ("bottom-up"). The process began with the total NYSERDA New York commercial electric-sales forecast (see Table 1.14 in Volume 1). We disaggregated the statewide forecast into each control-area load zone. For those load zones analyzed, we further broke out the forecasts by building type and major end use for each year of the analysis period (see Table 3.3.1[18]). These disaggregated loads were then further defined in terms of the portion feasibly applicable to each technology in each year for each market. We then multiplied the energy-savings potential for each measure (as a percent of baseline measure load) by the existing or expected load attributable to that measure for each building type to arrive at first-year measure potential. Finally, we applied base-case and achievable scenario penetrations to each measure over time to capture annual impacts for each of the 2,163 measures. The following is an overview of this process and the major factors, assumptions and data sources used.

Commercial Sector Potential Simplified Central Equation

We applied various technology factors to the forecasted new or existing building-type/end-use sales by year to derive the maximum achievable potential for each of the 2,163 separate measures for each of 20 years (2003 to 2022.) The basic method for developing kWh savings by measure is summarized by the following simplified central equation. The product of these factors provides measure-level kWh savings by year. Technical Appendix Table 5.2.1.2, Commercial Technology Analysis Example, provides a sample calculation for a T8 fixture measure.

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18 Table 3.3.1 shows the statewide disaggregated 2003 electricity sales forecast. For disaggregated electricity sales forecasts for individual zones, see Tables 5.2.2.2.1 – 5.2.2.2.6.

Annual Measure Scenario Potential	=	New or Existing Building End Use KWh Sales Per Year	X	Applicability Factor	X	Feasibility Factor	X	Turnover Factor (Existing Market-Driven only)	X	Savings Factor	X	Annual Net Penetration (Achievable - Base Case)

where:

- **Applicability Factor** is the fraction of the end-use level sales for each building type attributable to equipment that could be replaced by the high-efficiency measure (e.g., for a packaged air conditioner, it is the portion of cooling load consumed by packaged systems).
- **Feasibility Factor** is the fraction of the applicable end use that is technically feasible for conversion to the high-efficiency technology. Numbers less than 100% reflect engineering or other technical barriers that would preclude adoption of the measure. (e.g., cold-temperature applications might preclude certain lighting technologies).
- **Turnover Factor** is the portion of existing equipment that will be naturally replaced each year due to failure, remodeling, or renovation. This applies only to the renovation and replacement/remodel markets.
- **Savings Fraction** is the percent savings (as compared to either existing stock or new baseline equipment for retrofit and market-driven markets, respectively) of the high-efficiency technology.
- **Annual Net Penetration** is the difference between the base-case measure penetrations underlying the zonal and statewide forecasts and the measure penetrations assumed for each scenario.

The Market Characterizations section that follows explains the load-disaggregation approach. The subsequent Overview of Efficiency Measures Analyzed section provides more detail about the measures and markets analyzed and the development of measure-level factors. (Detailed measure descriptions are provided in Technical Appendix 5.2, Commercial Efficiency.) Next, the Base Case Penetrations and Measure Interactions section describes the approach and major assumptions used to develop base-case measure penetrations. The Technical and Economic Potential section provides information about these scenario-specific methods and disaggregated results. The methods and results for the achievable potential scenarios are provided in the Achievable Savings and Costs for Meeting Greenhouse Gas Emission Targets section and the Expected Achievements Under Currently Planned Initiatives section. Technical Appendix 5.2 provides detailed measure-level analysis inputs.

MARKET CHARACTERIZATIONS

Commercial sales follow the U.S. DOE Energy Information Administration's ("EIA") sector definitions. Multi-family buildings are included in the residential sector. The commercial sector includes municipal electric consumption, including street lighting, water, and wastewater-treatment facilities.

Commercial Sales Forecast and Disaggregation

Current and forecast statewide commercial electrical loads constituted the starting point for characterizing the commercial market. Table 1.14 in Volume 1 shows the NYSERDA New York State Commercial Forecast from 2001 through 2021 provided by NYSERDA. NYSERDA developed this forecast based on EIA estimates of Year 2000 New York commercial consumption and EIA's forecasted load growth for the Mid-Atlantic Census region. NYSERDA's commercial forecast estimated average annual growth from 2000 to 2021 of 0.89%. The NYSERDA load forecast accounted for anticipated NYSERDA, LIPA, and NYPA efficiency-initiative impacts after 2002. To develop a base-case forecast that assumed no DSM after 2002, we added back incremental demand savings post-2002 that NYSERDA had assumed.

EIA data is generally consistent with New York utility data in the way it distributes load by sector and accounts for in-state loads. New York Independent Systems Operator ("NY ISO") data, on the other hand, counts generation sold out of state and differs somewhat in designations between sectors. No control-area load-zone data were available except from NY ISO. We therefore calibrated the NY ISO zonal data to the overall statewide EIA data to develop Year 2000 zonal commercial sales estimates. For Zone K (Long Island), no breakout between commercial and industrial loads was available because Long Island Power Authority classifies all commercial and industrial loads under "commercial" in its rate codes. We therefore combined Census data for industrial and agricultural employment, information from the New York State Manufacturer's Directory, and data on total Long Island employment to estimate the commercial share of Long Island's commercial and industrial electrical load.

Once historical sales by zone were developed, we disaggregated it into nine building types[19] using proprietary data from two New York utilities -- one for Zone J (New York City) and the other for all other zones. This data reflected early and mid-1990s data, respectively. To estimate current year building type sales shares, we relied on economic growth data (business-level GDP) by county from Economy.com.[20] No data on changes to energy intensities (kWh/$GDP) of specific business types and geographic areas were available. As a result, we assumed that energy intensities either remain constant or change in similar ways chronologically for each business type and geographic region. As a result, we used the region-specific GDP growth rates to project annual changes to building-type electrical sales shares for each zone. These zonal

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[19] Education, grocery, health, lodging, office, restaurant, retail, warehouse, and other.

temporal changes were then calibrated to the overall NYSERDA statewide commercial forecast to estimate overall zonal and building-type forecasts from 2000 to 2022. Technical Appendix Table 5.2.2.7, Economy.com Commercial Business to Building Mapping, shows the mapping of the Economy.com business types to the nine building types modeled in the analysis.

The NYSERDA forecast was based on Year 2000 EIA data, while the Economy.com data were from after the terrorist attack on New York City in September 2001. When the Year 2000 data were calibrated to the post September 11, 2001 data, New York City showed substantial negative growth rates, forcing all other zonal estimates to show unrealistically high positive growth in early years to compensate for this anomaly. As a result, we levelized the Economy.com business level growth rates over the planning period based on average annual growth rates. This resulted in much more likely zonal estimates over the analysis period.

Based on the EIA forecast of commercial new construction and projected improvements in energy use intensities per square foot for new and existing buildings, we estimate approximately 90% of overall statewide electric load growth results from new construction over the analysis period. In some cases, certain zonal and building-type combinations experienced reduced electric sales over time (e.g., grocery stores in Zones A through F). Because overall business level sales may be decreasing while new construction is still occurring (e.g., big new supermarkets are being built, while existing stores are either going out of business or being replaced by the new ones), we maintained a minimum of 0.25% annual growth for new construction. This results in even greater decreases to existing sales in some isolated cases.

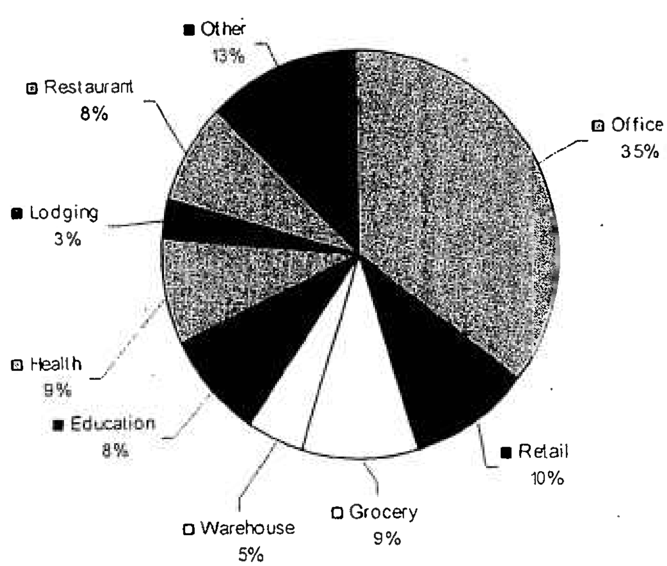
We further disaggregated zonal building-type forecasts into nine separate end uses, using end-use energy intensities (kWh/sq. ft.) by building type supplied by Regional Economic Research ("RER"). Separate end-use energy intensities were applied for down- and up-state zones for each building type based on RER modeling using New York City's Kennedy Airport and Albany weather stations, respectively. Table 3.3.1, Commercial New York Statewide Electricity Sales, shows 2003 estimated statewide existing and new construction sales, respectively. Figure 3.3.2, 2003 Commercial GWh Forecast Disaggregation by Building Type, graphically shows how the 2003 New York commercial electric load is distributed among the nine building types. Existing and new commercial electricity sales for 2003 and future year growth factors for all zones are provided in Technical Appendix Tables 5.2.2.1 through 5.2.2.6.

20 Economy.com data for New York City was used for Zone J and K, Albany data was used in Zone F, Buffalo data for Zone A, and a combination of Albany and Buffalo for Zone G.

Table 3.3.1 Commercial New York Statewide Electricity Sales (GWh)

	1	2	3	4	5	6	7	8	9	
	Office	Retail	Grocery	Warehouse	Education	Health	Lodging	Restaurant	Other	TOTAL
EXISTING END USE SALES FORECAST (GWh), 2003										
1 Indoor Lighting	10,048	1,763	1,374	632	2,456	1,693	620	1,123	1,486	21,195
2 Outdoor Lighting	938	137	166	110	286	114	106	325	198	2,349
3 Cooling	4,322	1,675	582	54	625	1,396	418	683	723	10,477
4 Ventilation	2,425	1,396	271	366	1,018	537	396	407	538	7,342
5 Water Heating	461	346	123	23	337	366	200	759	313	2,927
6 Refrigeration	346	648	3611	1,983	120	188	96	1,791	1,740	10,523
7 Space Heating	1,586	538	132	143	388	280	208	124	277	3,629
8 Office Equipment	2,506	143	57	52	234	117	59	53	140	3,362
9 Miscellaneous	2,123	206	96	94	204	1,264	138	190	3,333	7,647
10 TOTAL	24,726	6,852	6,410	3,447	5,638	5,936	2,239	5,466	8,748	68,451
New Construction Sales in 2003 (GWh)										
1 Indoor Lighting	110	26	23	8	51	46	9	31	16	319
2 Outdoor Lighting	10	2	3	1	5	3	1	9	2	37
3 Cooling	47	25	10	1	13	38	6	19	8	166
4 Ventilation	27	21	4	4	21	14	6	11	6	114
5 Water Heating	5	5	2	0	7	10	3	21	3	56
6 Refrigeration	4	10	60	24	3	5	1	48	19	174
7 Space Heating	17	8	2	2	8	7	3	3	3	53
8 Office Equipment	28	2	1	1	5	3	1	1	2	43
9 Miscellaneous	23	3	2	1	4	34	2	5	4	78
10 TOTAL	271	102	106	42	117	160	31	150	62	1,043
TOTAL EXISTING AND NEW CONSTRUCTION	24,998	6,954	6,516	3,489	5,756	6,096	2,270	5,606	8,811	70,494

Figure 3.3.2 2003 Commercial GWh Forecast Disaggregation by Building Type



Turnover of Market Opportunities

The opportunities for market-driven efficiency investments in existing buildings are driven by the turnover rate of existing equipment. The turnover factor is the portion of existing equipment that will be naturally replaced each year due to failure, remodeling, or renovation. Turnover factors for the replacement/remodel market are based on the lives of the equipment measure. The estimated measure lives reflect both engineering service life and estimated remodel activity. In general, turnover factors are assumed to be 1 divided by the measure life. For example, we assume a measure with a 10-year estimated life will have a turnover rate of 10% (1/10) of the existing stock of equipment each year. Four percent of existing building square footage is assumed to undergo major renovation each year, based on a comparison of NYSERDA new construction and renovation data with the NYSERDA electric growth forecast.[21] Technical Appendix Table 5.2.3.0.2, Commercial Measure Turnover Factors, shows the factors for replacement/remodel measures.

Eligible Stock Adjustments

New measures can be installed in existing buildings either on an early retirement (retrofit) basis, at the time of natural replacement, or at the time of renovation or remodeling. To prevent double counting, the model tracks the eligible stock of equipment over time for each building type and end use based on the assumed measure penetrations for each existing construction market. In this way, activity in one market will lower the opportunities for efficiency in the other markets. For example, if 10% of existing lighting fixtures are retrofitted with high-efficiency models in 2003, then only 90% of the original population of lighting remains eligible for efficiency upgrades in non-retrofit (market-driven) markets during 2004. However, assuming the fixtures had only a five-year measure life, the original 10% of lighting fixtures retrofitted in 2003 would again become eligible for replacement in 2008 (five years after original installation date). Similarly, once a building is renovated or remodeled, the opportunity for retrofit is diminished until the end of the measure lives for those measures installed under the market-driven scenarios. This eligible stock adjustment model is particularly significant for the technical and economic potential analyses, where 100% penetration in one market can eliminate opportunities in other markets for the life of the measure.

OVERVIEW OF EFFICIENCY MEASURES ANALYZED

Eighty-seven technologies or technology bundles covering indoor and outdoor lighting, heating, ventilation, cooling, refrigeration, service water heating, building shell, clothes washing, office equipment, traffic lights, and water and wastewater treatment systems were analyzed. In general, the analysis included those technologies that are commercially available, typically offer cost effective savings and have wide applicability among commercial markets. In some cases, technologies were included only for certain markets, either because they were most feasible and appropriate for those markets (e.g., integrated building design was included only for new construction; retro-commissioning only for retrofit); or because they typically were not cost effective in certain applications (e.g., optimized HVAC distribution was excluded for retrofit). In addition, some technologies apply only to specific building types (e.g., traffic lights apply only to the miscellaneous "building" type). Table 3.3.2, Commercial Technologies and Markets by End Use, shows the list of technologies or technology bundles, along with the markets analyzed for each. Technical Appendix Table 5.2.1.1, Commercial Technology Descriptions, provides a more detailed list of the measures along with descriptions of each high-efficiency and related baseline technology. In some cases, a technology is repeated so that it shows under each applicable end-use category.

21 NYSERDA, Alternate Commercial Energy Code Standards for New York State, prepared by Steven Winter Associates Inc. 1999, P. 42 indicates square footage undergoing renovation each year is approximately five times the rate of new construction. New construction average annual growth rate is approximately 0.8% based on EIA mid-Atlantic forecast of new construction and changes in existing and new energy intensities.

Table 3.3.2 Commercial Technology and Market by End Use

END USE	
Technology	Market Type
NC = New Constructior	RENO = Renovation
RR = Remodel/Replacemen	RET = Retrofit
INTERIOR LIGHTING	
T8 Lamp/Ballast	RET
T8 Fixture	NC/RENO/RR
High Efficiency Fixtures/Design Tier I	NC/RENO/RR/RET
High Efficiency Fixtures/Design Tier II	NC/RENO/RR/RET
Specular Reflector	RET
Compact Fluorescent	NC/RENO/RR/RET
Pulse Start Metal Halide	NC/RENO/RR
High Efficiency Metal Halide	RET
Fluorescent High/Low Bay Fixture	NC/RENO/RR/RET
Occupancy Sensor On/Off Control	NC/RENO/RR/RET
Occupancy Sensor High/Low Control	NC/RENO/RR
Daylight Dimming	NC/RENO/RR
LED Exit Sign	NC/RENO/RR/RET
Electrodeless Technologies (EMERGING TECHNOLOGY)	NC/RENO/RR/RET
White LED Lighting Array (EMERGING TECHNOLOGY)	NC/RENO/RR/RET
OUTDOOR LIGHTING	
LED Traffic Light — RED	NC/RENO/RR/RET
LED Traffic Light — GREEN	NC/RENO/RR/RET
LED Traffic Light — AMBER	NC/RENO/RR/RET
LED Traffic Light — RED ARROW	NC/RENO/RR/RET
LED Traffic Light — GREEN ARROW	NC/RENO/RR/RET
LED Pedestrian Signal Light — Hand/Man	NC/RENO/RR/RET
Pulse Start Metal Halide	NC/RET
Pulse Start Metal Halide vs. Mercury Vapor	RET
Pulse Start Metal Halide vs. Incandescent	RET
Compact Fluorescent	RET
Improved Exterior Lighting Design	NC/RET

COOLING	
High Efficiency Air Conditioning Tier I	NC/RENO/RR/RET
High Efficiency Air Conditioning Tier II	NC/RENO/RR/RET
High Efficiency Air Conditioning Tier III	NC/RENO/RR/RET
High Efficiency Air Conditioning Tier IV (EMERGING TECHNOLOGY)	NC/RENO/RR/RET
High Efficiency Heat Pump Tier I	NC/RENO/RR/RET
High Efficiency Heat Pump Tier II	NC/RENO/RR/RET
High Efficiency Heat Pump Tier III	NC/RENO/RR/RET
High Efficiency Heat Pump Tier IV (EMERGING TECHNOLOGY)	NC/RENO/RR/RET
Water Source Heat Pump	NC/RENO/RR
Ground Source Heat Pump	NC/RENO/RR
High Efficiency Chiller Tier I	NC/RENO/RR/RET
High Efficiency Chiller Tier II (EMERGING TECHNOLOGY)	NC/RENO/RR/RET
Optimized Unitary HVAC Distribution/Control System	NC/RENO
Optimized Chiller Distribution/Control System	NC/RENO
Energy Management System/Control	NC/RENO/RR/RET
Dual Enthalpy Control	NC/RENO/RR/RET
Spot Cooler (EMERGING TECHNOLOGY)	NC/RENO/RR/RET
High Efficiency Stove Hood	NC/RENO/RR/RET
High Performance Glazing Tier I	NC/RENO/RR
High Performance Glazing Tier II (EMERGING TECHNOLOGY)	NC/RENO/RR
SPACE HEATING	
High Efficiency Heat Pump Tier I	NC/RENO/RR/RET
High Efficiency Heat Pump Tier II	NC/RENO/RR/RET
High Efficiency Heat Pump Tier III	NC/RENO/RR/RET
High Efficiency Heat Pump Tier IV (EMERGING TECHNOLOGY)	NC/RENO/RR/RET
Water Source Heat Pump	NC/RENO/RR
Ground Source Heat Pump	NC/RENO/RR
Optimized Unitary HVAC Distribution/Control System	NC/RENO
Optimized Chiller Distribution/Control System	NC/RENO
Energy Management System/Control	NC/RENO/RR/RET
High Efficiency Stove Hood	NC/RENO/RR/RET
High Performance Glazing Tier I	NC/RENO/RR
High Performance Glazing Tier II (EMERGING TECHNOLOGY)	NC/RENO/RR

VENTILATION	
Energy Management System/Control	NC/RENO/RR/RET
Premium Efficiency Motor	NC/RENO/RR/RET
Copper Rotor Motor (EMERGING TECHNOLOGY)	NC/RENO/RR/RET
Variable Frequency Drive	NC/RENO/RR/RET
WATER HEATING	
High Efficiency Tank-Type Water Heater	NC/RENO/RR
Point of Use Water Heater	NC/RENO/RR/RET
Booster Water Heater	RET
Heat Pump Water Heater	NC/RENO/RR/RET
OFFICE EQUIPMENT	
High Efficiency CPU	NC/RR
High Efficiency Computer Display	NC/RR
Low Mass Copier	NC/RR
High Efficiency Fax	NC/RR
High Efficiency Printer	NC/RR
High Efficiency Internal Power Supply	NC/RR
REFRIGERATION	
High Efficiency Vending Machine	NC/RENO/RR
Vending Miser	RET
High Efficiency Refrigeration	NC/RENO/RR/RET
High Efficiency Reach-In	NC/RENO/RR
High Efficiency Ice Maker	NC/RENO/RR
Walk-in Refrigeration Retrofit Package	RET
Heat Pump Water Heater	NC/RENO/RR/RET
WHOLE BUILDING	
Retrocommissioning	RET
Commissioning	NC
Integrated Building Design Tier I	NC
Integrated Building Design Tier II (EMERGING TECHNOLOGY)	NC
High Efficiency Transformer	NC/RENO/RR/RET
MISCELLANEOUS	
High Efficiency Clothes Washer	NC/RENO/RR/RET
Water and Wastewater Optimization	RENO/RR/RET

The number and variety of individual technologies that can be used to improve efficiency in the commercial sector is large and often dependent on site-specific conditions. This is reflected by the fact that many of the leading commercial efficiency initiatives capture the bulk of their savings from "custom" measures. In addition, achieving maximum savings often depends on a marriage of improved technologies and design, making it difficult to separate out the costs and savings attributable to each component. Therefore we included a number of "bundled" technologies to represent best practices. For example, Tier I high-efficiency fixtures and design represents a hypothetical package of lighting improvements. This might include ambient lighting with a combination of high-efficiency direct/indirect fixtures using "Super T8" technology, wall-wash fixtures using T5 technology, selected use of compact fluorescent task lighting, occupancy sensors in private offices, daylighting controls using photocells and continuous dimming, LED exit signs, and state-of-the-art design practices that recognize the different uses in the space and the higher performance and light distribution characteristics of the system components. In the case of these bundled measures, we generally relied on industry literature to estimate likely percentage energy-consumption reductions and typical cost per kWh saved.

Because higher and higher levels of efficiency are typically more costly to realize -- and often more difficult to effectively promote even when eliminating economic barriers -- in some cases the analysis separated measures into two or more efficiency "tiers." This delineation ensured that if some of the higher tier measures were not cost-effective, the analysis did not eliminate all the potential for the technology in the economic potential scenario. All measures that have two or more tiers are treated incrementally. For example, unitary HVAC Tier I in the office sector represents HVAC equipment that is approximately 12% more efficient than baseline new HVAC equipment efficiencies, at a typical cost of $0.51 per annual kWh saved. Office-sector unitary HVAC Tier II equipment is approximately *an additional* 8 % efficiency improvement, at *an additional* annual cost of $0.56/kWh.[22]

In some cases, the highest-level tiers are "emerging technologies" that represent future state-of-the-art technologies that are either not currently commercially available, or are so new and/or costly as to experience virtually no current market share (e.g., Tier III unitary HVAC). There are also distinct technologies that are treated as emerging (e.g., white LED lighting arrays). The emerging technologies capture future improvements in efficiency and/or cost reductions. We assume emerging technologies will not achieve substantial market share until 2012. The preceding Table 3.3.2, Commercial Technology by Market and End Use, indicates emerging technologies.

Development of Measure Factors

Applicability factors represent the share of end-use level sales that are attributable to a particular technology. We drew on a variety of sources to develop applicability factors for each measure by building type. In general, we sought out data on market shares for different types and sizes of technologies, and weighted them based on overall energy consumption or capacity. For example, the applicability factor for packaged unitary HVAC equipment reflects its share of the total estimated cooling tonnage installed, from CBECS 1999 data for the Mid-Atlantic Census region. Where possible, we developed separate applicability factors for each building type. In some cases, we used average data for the total commercial market for all building types. We relied on New York-specific data when available. Alternatively, data from the Northeast or Mid-Atlantic states were used. These data reflect a variety of baseline and market assessment data, including studies done for Long Island Power Authority (LIPA), NYSERDA, proprietary analyses for three

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[22] In this case, Tiers I and II reflect the efficiency tiers for unitary HVAC equipment established by the Consortium for Energy Efficiency.

New York investor-owned utilities, Northeast Energy Efficiency Partnerships (NEEP), New Jersey utilities, Massachusetts utilities, and the Commercial Building Energy Consumption survey (CBECS) developed by EIA. Technical Appendix Table 5.2.0.3, Commercial Measure Applicability Factors, shows all applicability factors.

Feasibility factors are the fraction of the applicable end use technically feasible for conversion to the high-efficiency technology. Feasibility is not reduced for economic or behavioral barriers. Rather, feasibility reflects only technical or physical constraints that would make measure adoption inappropriate (e.g., cold-temperature applications might preclude certain lighting technologies). In most cases, it is feasible to replace baseline technology with an efficient alternative, resulting in a 100% feasibility factor. These data are based on various studies or engineering judgment. Major sources of data include a number of proprietary northeastern U.S. potential studies conducted during the 1990s. (See Technical Appendix Table 5.2.0.4, Commercial Measure Feasibility Factors.)

Measure savings fractions are calculated based on individual measure data and assumptions about existing stock efficiency (for retrofit measures), standard practice for new purchases (for market-driven measures), and high-efficiency options. Measure-savings characteristics were developed using public and private information sources, including NYSERDA, CBECS, California Energy Commission, Efficiency Vermont, American Council for an Energy Efficient Economy (ACEEE), Lawrence Berkeley Laboratory (LBL), New Buildings Institute (NBI), E-Source, Arthur D. Little (ADL), National Fenestration Rating Council (NFRC), various proprietary Northeastern U.S. baseline and market assessment studies, and communications with manufacturers and vendors. See Technical Appendix Table 5.2.0.5, Commercial Market Driven Measure kWh Savings, and Table 5.2.0.6, Commercial Retrofit Measure kWh Savings.

The initial savings for retrofit measures is the difference between the typical existing stock efficiency and the high-efficiency alternative. However, the long-term savings are the difference between the typical baseline efficiency of new equipment and the high-efficiency alternative, which is typically lower. We take this approach because if retrofits were not considered, the existing stock of equipment eventually would get replaced with new baseline efficiency equipment anyway. In most cases, the current baseline efficiency is more efficient than the average existing equipment stock. For example, motors meeting U.S. Energy Policy Act (EPACT) efficiency levels are baseline for new motor purchases. However, the average efficiency of motors existing today in commercial buildings falls short of EPACT levels. We use a *Baseline Adjustment Factor* to adjust the savings downward in future years for retrofit measures. We assume the vintage of all equipment replaced in retrofit markets is roughly half of its estimated measure life. Therefore, the baseline adjustment applies in the year immediately following half of the measure life. Baseline adjustment factors were developed based on the relative baseline efficiencies of new and existing stock equipment, from current and historical technology, baseline and market assessment studies. See Technical Appendix Table 5.2.0.7, Commercial Retrofit Measure Baseline Adjustment Factors.

In addition to the direct measure impacts, a "cooling bonus" and "heating penalty" were calculated for all interior lighting and office equipment measures. These adjustments reflect the effects of reductions in waste heat generated within the building shell as a result of improved efficiency. The cooling bonus increased the kWh savings by 12% and the summer peak kW savings by 28% from reductions in cooling load. The heating penalty resulted in an increased use of fossil fuel for heating of 1,750 Btu per measure kWh saved. These factors were calculated based on an American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) method, taking into consideration New York weather characteristics and load profiles for lighting, cooling and heating, and typical existing HVAC efficiencies.[23]

Load Shapes were used to allocate the annual kWh savings estimates for each measure into rating periods. We used hourly load-shape data to map annual savings to each period, based on NYSERDA's avoided-cost period definitions. Separate hourly load shapes were used for down- and up-state zones and each of the 81 building-type/end-use combinations. In addition, we developed separate load shapes for some measures where the savings do not follow typical end-use load shapes (e.g., control measures). Load shape data is from Regional Economic Research, and reflects building modeling using down- and up-state New York weather data, based on prototypical buildings developed from a national library of approximately 20,000 commercial building audits. Technical Appendix Table 5.2.0.11, Commercial Load Shapes shows the load shapes.

Technical Appendix Table 5.2.8, Commercial Measure kWh-kW Ratios, shows the ratio of kWh savings to diversified kW impacts for each measure, for down- and up-state zones, respectively. Each measure kWh savings was divided by these ratios to produce summer and winter diversified peak-demand savings. These diversified kW impacts were then multiplied by coincident factors (Technical Appendix Table 5.2.10, Commercial Load Shapes, also includes coincident factors) to estimate summer and winter coincident, diversified peak impacts.[24] KWh/kW ratios and coincidence factors were from RER modeling data for down- and up-state New York.

Equipment measure lives were developed from various sources including NYSERDA, DOE, EPA, ACEEE, ASHRAE, Efficiency Vermont, Arthur D. Little, NFRC, and equipment manufacturers. The estimated measure lives reflect both engineering service life and estimated remodel activity. Technical

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23 Rundquist, R., "Calculating lighting and HVAC interactions," ASHRAE Journal, November 1993.

24 Note that coincident factors in many cases are higher than typical because diversity is already included in the kW impacts they are applied to. Typically, "coincident factors" are the product of coincidence and diversity and are applied to undiversified connected load reductions.

Appendix Table 5.2.3.1, Commercial Technology Measure Life and Level of Difficulty, shows the measure lives.

Measure costs for each of the 87 technologies were developed based on a variety of sources, including but not limited to proprietary studies or data from northeastern U.S. utilities, R.S. Means, NEEP, Efficiency Vermont, Grainger and a California Energy Commission database of equipment costs. Measure costs obtained outside the Northeast region were adjusted based on R.S. Means location factors to better reflect New York costs. Separate measure costs were estimated for retrofit and market-driven markets. Retrofit-measure costs include the total equipment and labor cost. Market-driven measure costs reflect the incremental equipment and labor cost of high efficiency (as compared to standard practice).

We generated measure costs per kWh savings ($/kWh) for each building type for each of the 2,163 measures analyzed, based on hours of use and other building-type-specific data. See Technical Appendix Table 5.2.9, Commercial Market-Driven Measure Incremental Cost Per kWh Savings, and Table 5.2.10, Retrofit Measure Incremental Cost Per kWh Savings. Technical Appendix Table 5.2.12, Commercial Technology Characterizations, shows per-unit measure inputs for all cost and performance data.

In addition to measure costs, any incremental effects on operation and maintenance (O&M) costs for each measure were taken into account. O&M cost impacts reflect changes in measure and replacement component lives and costs for both the high- and standard-efficiency options. For example, installation of Light Emitting Diode (LED) traffic signals results in labor and material savings by eliminating incandescent bulb replacements over the life of the measure. O&M baseline and high-efficiency replacement component lives and costs per kWh saved are shown in Technical Appendix Table 5.2.3.0.12, Commercial Technology Characterizations.

Related to O&M costs, we accounted for the time value of permanently deferring the equipment purchase cycle for early-retirement (retrofit) measures. For example, a high-efficiency HVAC unit typically lasts 15 years. If an existing HVAC unit expected to last another 10 years is retrofitted with a new, high-efficiency model, the customer no longer has to purchase a new one in 10 years. Rather, the next HVAC purchase will be in 15 years. Thus, all future HVAC purchases have now been shifted out by five years in perpetuity. This deferment of future HVAC-replacement purchases provides a societal benefit by lowering present-value replacement costs. We recognize this societal value through a "deferral credit." Technical Appendix Table 5.2.3.0.12, Commercial Technology Characterizations, shows the baseline retrofit equipment costs used to calculate the deferral credit. The analysis assumed that the remaining life of all existing equipment to be retrofitted was, on average, equal to one half of the total measure life (i.e., for an HVAC unit with a 15- year life, it was assumed the average existing unit was 7.5 years old and would normally be replaced 7.5 years hence).

To estimate societal cost-effectiveness we also calculated the impacts on fossil fuel and water. Technical Appendix Table 5.2.3.0.12, Commercial Technology Characterizations, show fossil-fuel impacts (MMBTU/kWh saved) for retrofit and market-driven markets, respectively. Water impacts of 376 gallons/kWh saved were counted for clothes washers.

BASE CASE PENETRATIONS AND MEASURE INTERACTIONS

The potential efficiency for any given measure is a function of the size of the market, the measure characteristics and the base-case penetration that would occur absent any market intervention. We separately estimated base-case penetrations for each of the 2,163 measures. The base case represents the existing and forecast measure penetrations that are assumed to underlie the NYSERDA forecast. While there are likely to be changes to federal and state standards and New York energy code updates during the analysis period, the NYSERDA forecast recognizes only current standards and codes. We therefore estimated base-case penetrations based on all past energy-efficiency efforts but assumed no new policy or programmatic initiatives. For retrofit measures, no change in base-case penetrations over time was assumed, since retrofit markets reflect investments purely for efficiency reasons. We separately estimated base-case penetrations for each of the market-driven measures to reflect expectations about likely market adoptions. Technical Appendix Table 5.2.3.1.1, Commercial Market-Driven Measure Base Case Penetrations, and Table 5.2.1.2, Commercial Retrofit Measure Base Case Penetrations, show base-case penetrations for market-driven and retrofit technologies, respectively.

Competing Technologies

Some of the technologies modeled are mutually exclusive -- that is, one or the other could be installed, but not both. For example, standard metal-halide high-bay fixtures can be replaced with pulse-start metal-halide or fluorescent high-bay fixtures. When two or more measures compete with one another, we first estimated the adoption of the measure offering the highest per-unit savings. The penetration of the next competing measure was then estimated based on the remaining potential, taking into account the applicability, feasibility, and achievable penetration of the first measure. Note that in the Greenhouse Gas (GHG) Scenario, selection of only certain commercial technologies can result in overly conservative estimates of impacts if one has not also selected any competing measures.

Measure Interactions

Individual measure savings are not additive. Because of interactions between measures, the total potential for all measures is less than the sum of individual measure opportunities. For example, installing window film to reduce cooling load will lower the savings opportunities for installing a high-efficiency air conditioner because the air conditioner will not run as long as it otherwise would have. The total potential estimates take into account all the interactions between measures. This approach therefore represents the total savings achievable with maximum measure adoption for each scenario.

We preserved these interaction adjustments for the GHG Scenario to avoid substantially overstating total commercial potential. As a result, selecting only a portion of the commercial GHG measures could result in erroneously low estimates of potential for those measures. This discontinuity occurs because if some measures are eliminated, the potential for remaining measures might increase, depending on their original interactions with the removed measure. Commercial-measure interaction factors for each scenario and zone were developed separately for existing and new-construction technologies, respectively (see Technical Appendix Table 5.2.0.13 through Table 5.2.0.27.)

TECHNICAL AND ECONOMIC POTENTIAL

Overview

Technical and economic potential penetrations assume 100% of remaining opportunities are captured for market-driven markets in each year. For the retrofit market, we assume no penetration until 2007, at which point we assume 100% penetration.[25] As a result, after 2007 no renovation or replacement/remodel opportunities remain until individual measure lives are expired, at which point the analysis assumes 100% of the opportunities under the market-driven scenarios are captured. New-construction opportunities are always available and captured 100% in each year. The savings potential reflects the difference between the technical and economic potential penetrations and the base-case penetrations.

As Figure 3.3.3, Commercial Technical and Economic GWh Savings Potential by Market, illustrates, the commercial efficiency improvements technically couild eliminate 32.4 thousand GWh of New York State's electric load by 2007. This grows to about 38 thousand GWh in 2012 with a slight increase over the next 10 years to 2022. This technical potential is highly economic. Depending on avoided costs and year, between 85% and 96% is economic. Figure 3.3.4, Commercial Technical and Economic MW Savings Potential by Market, shows the technical and economic potential for peak summer demand (MW) reductions over the same period. Technical summer peak demand reductions are about 8.5 GW in 2007, climbing to 10.6 GW by 2012 and 11.1 GW by 2022. Again, the vast majority of the peak technical potential is economic under any avoided-cost scenario. These trends are graphically shown for New York State in Figure 3.3.1.

25 Because the analysis is reporting only selected year outputs, delaying the retrofit penetration until the first reported year (2007) allows us to assume the capture of as much pre-2007 potential at the time of natural replacement as possible, thereby reducing costs associated with its capture and increasing economic potential in 2007.

Figure 3.3.3 Commercial Technical and Economic GWh Savings Potential by Market

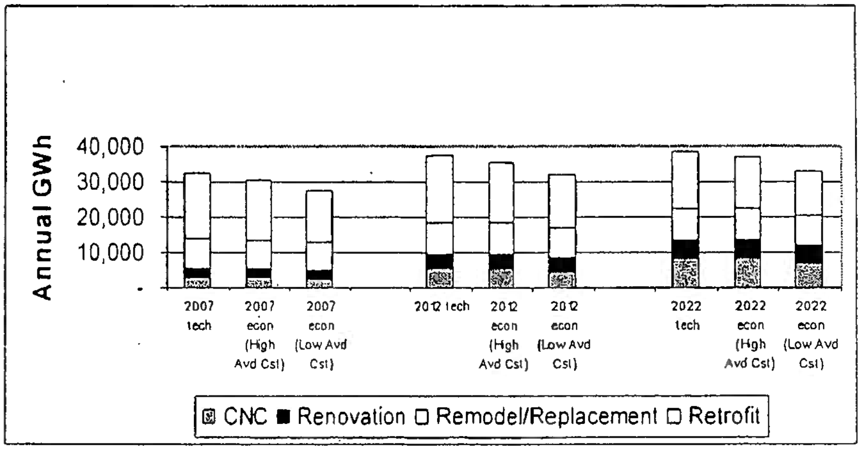
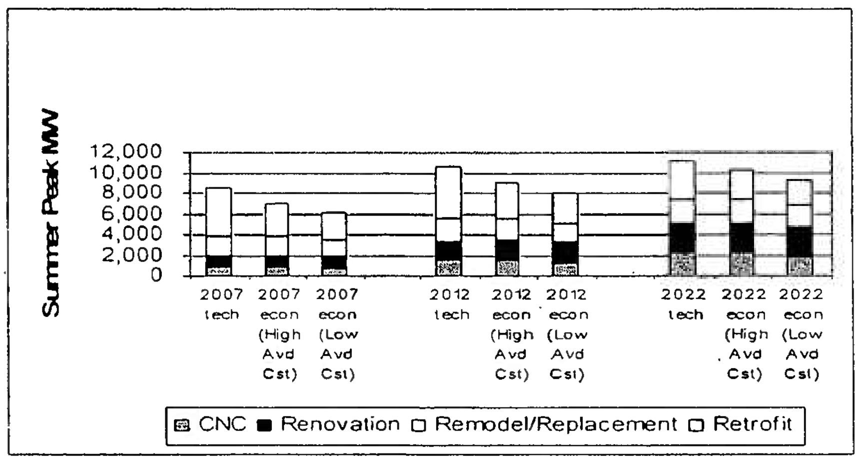


Figure 3.3.4 Commercial Technical and Economic MW Savings Potential by Market



Tables 3.3.3, NYSERDA Commercial Annual GWh Savings Technical and Economic Potential, and 3.3.4, Commercial Annual MW Savings Technical and Economic Potential, illustrate how technical and economic potential varies by load zone for energy and summer peak demand, respectively. Figures 3.3.5, 2012 Commercial Technical and Economic GWh Savings Potential by Zone, and 3.3.6, 2012 Commercial Technical and Economic MW Savings Potential by Zone, show this graphically for 2012. In general, 2007 and 2022 potentials reflect similar relationships. The variation by load zone is a function of three things:

- the actual level of electric load in each zone;
- the mix of building types and end-use characteristics (driven by weather variations) within each zone; and
- the avoided cost zonal variations (economic only).

As a share of total forecast loads, the variation of technical and economic potential by zone is within about ±15%.

Table 3.3.3 NYSERDA Commercial Annual GWh Savings Technical and Economic Potential

	Statewide High Avoided Costs	Statewide Low Avoided Costs	Zone A	Zone F	Zone G	Zone J	Zone K
Tech Potential 2007	32,402	N/A	2,460	1,697	1,760	15,182	4,080
Tech Potential 2012	37,670	N/A	2,857	1,989	2,071	17,601	4,804
Tech Potential 2022	38,282	N/A	2,814	2,029	2,087	18,371	4,844
Econ Potential 2007	30,273	27,490	2,086	1,451	1,485	13,991	3,809
Econ Potential 2012	35,340	32,124	2,444	1,715	1,764	16,275	4,509
Econ Potential 2022	36,847	32,994	2,406	1,743	1,785	17,291	4,656
Econ as % of Tech 2007	93.4%	84.8%	84.8%	85.5%	84.4%	92.2%	93.4%
Econ as % of Tech 2012	93.8%	85.3%	85.5%	86.2%	85.2%	92.5%	93.9%
Econ as % of Tech 2022	96.3%	86.2%	85.5%	85.9%	85.5%	94.1%	96.1%

Table 3.3.4 NYSERDA Commercial Annual Summer Peak MW Savings Technical and Economic Potential

	Statewide High Avoided Costs	Statewide Low Avoided Costs	Zone A	Zone F	Zone G	Zone J	Zone K
Tech Potential 2007	8,564	N/A	588	406	457	4,285	1,060
Tech Potential 2012	10,655	N/A	724	505	575	5,347	1,333
Tech Potential 2022	11,145	N/A	745	536	603	5,668	1,399
Econ Potential 2007	7,021	6,173	430	301	324	3,429	861
Econ Potential 2012	8,988	8,009	551	390	428	4,419	1,119
Econ Potential 2022	10,225	9,266	618	449	498	5,099	1,277
Econ as % of Tech 2007	82.0%	72.1%	73.1%	74.1%	70.9%	80.0%	81.2%
Econ as % of Tech 2012	84.4%	75.2%	76.1%	77.2%	74.4%	82.6%	83.9%
Econ as % of Tech 2022	91.7%	83.1%	83.0%	83.8%	82.6%	90.0%	91.3%

Figure 3.3.5 2012 Commercial Technical and Economic GWh Savings Potential by Zone

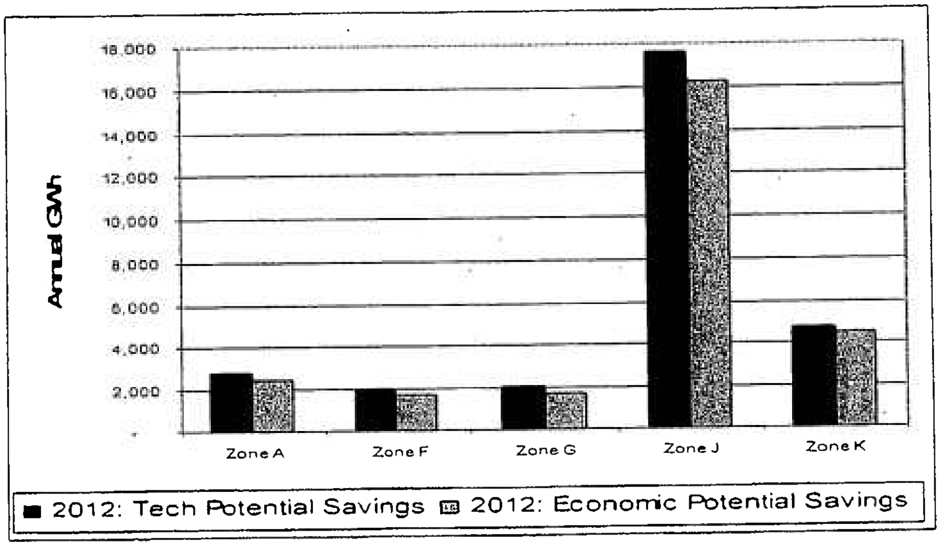
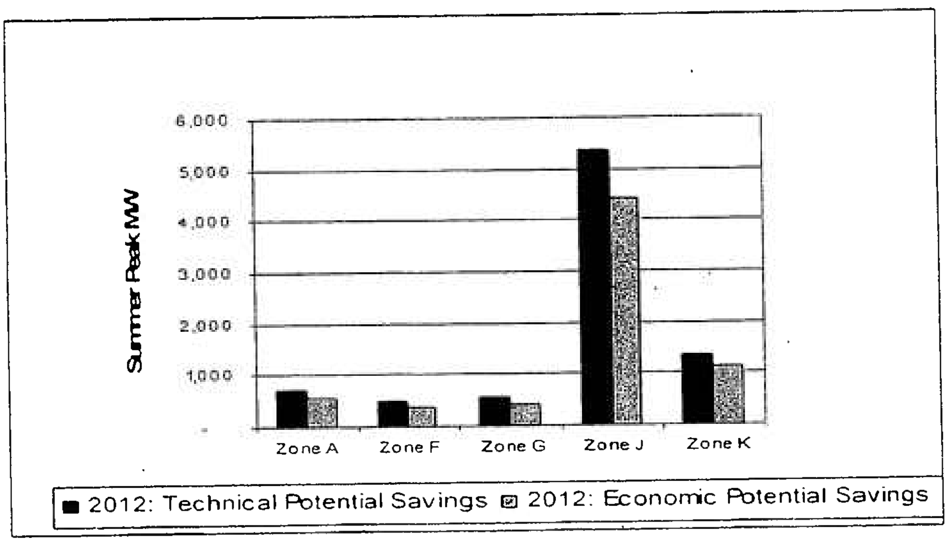


Figure 3.3.6 2012 Commercial Technical and Economic MW Savings Potential by Zone



Technical Potential

The total statewide commercial technical potential in 2007 is 32.4 thousand GWh and 8.6 GW summer peak demand. This grows by 2012 by about to 37.7 thousand GWh and 10.7 GW summer peak demand. This is roughly a 16% increase in energy and 24% for peak demand. By 2022 technical potential is 38.3 thousand GWh and 11.1 GW summer peak demand. This represents modest increases from 2012 of about 2% and 4%, respectively. These trends disguise a number of influences. The large early increases result both from the inclusion of emerging technologies (2012 is the first year of inclusion), as well as continued substantial contributions from new-construction activity, offset somewhat by natural increases in the base-case measure penetrations over time. From 2012 to 2022 no new emerging technologies are added. In addition, while new construction activity continues to provide substantial opportunities each year, the assumptions about natural improvements in efficiency during this decade as markets transform offsets most addition efficiency opportunities. The relatively higher increases over the analysis period in peak demand compared to energy potential is a result of earlier and steeper expected advances in lighting as compared to HVAC markets. The following sections provide greater detail at the market, end-use and building-type level for statewide results. Technical Appendix Table 5.2.4.1 through Table 5.2.4.18 show Commercial Technical Potential Savings by Market, End Use, and Building Type for each zone.

Technical Potential by Market. Table 3.3.5, Commercial Technical Potential Savings by Market, shows how statewide technical potential breaks out by market. This is graphically shown as well in Figures 3.3.3 and 3.3.4 for energy and peak demand, respectively. Retrofit measures offer the major share of potential at 57% in 2007, dropping to a low of 41% in 2022. This result occurs because existing loads are far higher than projected new construction, and under the technical-potential scenario, the analysis assumes 100% of retrofit measures can be captured, thereby eliminating any future opportunities for replacement/remodel and renovation as previously described. New construction offers 10% of the savings potential in 2007, climbing to a high of 22% by 2022. Each year provides a new set of new construction opportunities, thus increasing the share steadily. Renovation grows from 8% to 13%, while replacement/remodel starts at 25% and drops slightly to 24% by 2022. This is a result primarily of early opportunities for replacement/remodel because retrofit is not applied until 2007, and then a growing share shifts to renovation and new construction over time. Proportionately, new construction offers greater opportunities because of opportunities for integrated design -- including choices about siting -- and because some measures are not particularly suited or included for retrofit.

Table 3.3.5 Commercial Technical Potential Savings by Market

Load Zone: New York Statewide

	Annual GWh					
	2007	2012	2022	2007	2012	2022
	Savings			% of total savings		
New construction	3,096	5,491	8,516	9.6%	14.6%	22.2%
Renovation	2,618	3,769	4,886	8.1%	10.0%	12.8%
Remodel/Replacement	8,193	9,390	9,129	25.3%	24.9%	23.8%
Retrofit	18,496	19,020	15,752	57.1%	50.5%	41.1%
Total	**32,402**	**37,670**	**38,282**	**100%**	**100%**	**100%**

	Summer Peak MW					
	2007	2012	2022	2007	2012	2022
	Savings			% of total savings		
New construction	858	1,535	2,263	10.0%	14.4%	20.3%
Renovation	1,068	1,761	2,746	12.5%	16.5%	24.6%
Remodel/Replacement	1,887	2,221	2,359	22.0%	20.8%	21.2%
Retrofit	4,750	5,137	3,777	55.5%	48.2%	33.9%
Total	**8,564**	**10,655**	**11,145**	**100%**	**100%**	**100%**

	Winter Peak MW					
	2007	2012	2022	2007	2012	2022
	Savings			% of total savings		
New construction	366	649	1,021	9.5%	14.5%	21.5%
Renovation	310	439	567	8.0%	9.8%	11.9%
Remodel/Replacement	994	1,150	1,176	25.7%	25.7%	24.8%
Retrofit	2,194	2,236	1,984	56.8%	50.0%	41.8%
Total	**3,864**	**4,473**	**4,748**	**100%**	**100%**	**100%**

<u>**Technical Potential by End Use.**</u> Table 3.3.6, Commercial Technical Potential Savings by Market and End Use, shows statewide technical potential by market and end use. The end-use shares are shown graphically for 2012 in Figures 3.3.7, 2012 Commercial GWh Savings by End Use (Technical Potential with High Avoided Costs), and 3.3.8, 2012 Commercial MW Savings by End Use (Technical Potential with High Avoided Costs) , for energy and summer peak, respectively. For existing buildings, slightly less than half of the energy potential comes from indoor lighting. This reflects the large opportunities that still remain for lighting efficiency, despite the significant strides that efficiency programs have made over the last 15 years in this market. Much of the new opportunities will be captured only through concerted efforts to transform design and control practices and to incorporate advanced technologies. Note that Table 3.3.6 includes the cooling savings associated with high-efficiency lighting from reductions in waste heat. As a result, the total share that actually comes from lighting is approximately 12% lower than indicated. Concomitantly, the reduction in lighting numbers would translate into an addition in the cooling figures. The lighting share of summer peak-demand potential is considerably lower, at about 25% of the total peak potential in each year. This situation is primarily a result of shifts to cooling, which is more highly correlated with summer peaks.

Table 3.3.6 Commercial Technical Potential Savings by Market and End Use

Load Zone: New York Statewide	Annual GWh					
	2007	2012	2022	2007	2012	2022
Commercial Existing Construction End Use	Savings			% of total savings		
Indoor Lighting	14,921	15,457	15,470	50.9%	48.0%	52.0%
Outdoor Lighting	356	356	335	1.2%	1.1%	1.1%
Cooling	4,104	5,504	5,447	14.0%	17.1%	18.3%
Ventilation	2,444	2,623	1,980	8.3%	8.2%	6.7%
Water Heating	618	639	437	2.1%	2.0%	1.5%
Refrigeration	2,735	2,983	1,903	9.3%	9.3%	6.4%
Space Heating	387	505	596	1.3%	1.6%	2.0%
Office Equipment	1,362	1,289	1,027	4.6%	4.0%	3.5%
Miscellaneous	1,041	1,493	1,190	3.6%	4.6%	4.0%
Whole Building	1,338	1,330	1,381	4.6%	4.1%	4.6%
Total Existing Construction End Uses	29,306	32,179	29,787	100%	100%	100%
	Annual GWh					
Commercial New Construction End Use	2007	2012	2022	2007	2012	2022
	Savings			% of total savings		
Indoor Lighting	1,009	1,792	2,588	32.6%	32.6%	30.4%
Outdoor Lighting	32	58	56	1.0%	1.0%	0.7%
Cooling	461	833	980	14.9%	15.2%	11.5%
Ventilation	152	274	277	4.9%	5.0%	3.3%
Water Heating	64	123	141	2.1%	2.2%	1.7%
Refrigeration	190	335	197	6.1%	6.1%	2.3%
Space Heating	40	72	84	1.3%	1.3%	1.0%
Office Equipment	79	57	26	2.6%	1.0%	0.3%
Miscellaneous	0	0	0	0.001%	0.001%	0.0001%
Whole Building	1,069	1,949	4,166	34.5%	35.5%	48.9%
Total New Construction End Uses	3,096	5,491	8,516	100%	100%	100%
Total All Commercial = Existing + New Consuuction	32,402	37,670	38,282	NA		
	Summer Peak MW					
	2007	2012	2022	2007	2012	2022
Commercial Existing Construction End Use	Savings			% of total savings		
Indoor Lighting	3,001.1	3,108.9	3,110.5	38.9%	34.1%	35.0%
Outdoor Lighting	39.8	39.8	35.2	0.5%	0.4%	0.4%
Cooling	3,581.7	4,793.5	4,723.2	46.5%	52.6%	53.2%
Ventilation	73.0	90.9	77.9	0.9%	1.0%	0.9%
Water Heating	109.8	112.9	76.8	1.4%	1.2%	0.9%
Refrigeration	266.3	301.1	252.3	3.5%	3.3%	2.8%
Space Heating	3.3	4.3	5.1	0.04%	0.05%	0.06%
Office Equipment	219.4	207.6	165.0	2.8%	2.3%	1.9%
Miscellaneous	119.0	170.5	135.9	1.545%	1.870%	1.5305%
Whole Building	292.1	290.4	300.1	3.8%	3.2%	3.4%
Total Existing Construction End Uses	7,705.4	9,119.9	8,882.0	100%	100%	100%
	Summer Peak MW					
	2007	2012	2022	2007	2012	2022
Commercial New Construction End Use	Savings			% of total savings		
Indoor Lighting	196.8	347.8	496.2	22.9%	22.7%	21.8%
Outdoor Lighting	0.4	0.7	0.6	0.04%	0.04%	0.03%
Cooling	385.4	700.9	856.9	44.9%	45.7%	37.9%
Ventilation	3.5	6.4	8.3	0.4%	0.4%	0.4%
Water Heating	11.5	22.3	26.4	1.3%	1.5%	1.2%
Refrigeration	25.0	43.8	25.4	2.9%	2.9%	1.1%
Space Heating	0.5	1.0	1.3	0.1%	0.1%	0.1%
Office Equipment	12.5	8.9	3.9	1.5%	0.6%	0.2%
Miscellaneous	0.005	0.005	0.001	0.001%	0.000%	0.0001%
Whole Building	222.6	403.4	844.0	25.9%	26.3%	37.3%
Total New Construction End Uses	858.3	1,535.2	2,263.0	100%	100%	100%
Total All Commercial = Existing + New Construction	8,563.7	10,655.1	11,145.0	NA		
	Winter Peak MW					
	2007	2012	2022	2007	2012	2022
Commercial Existing Construction End Use	Savings			% of total savings		
Indoor Lighting	2,081.9	2,156.6	2,156.5	59.5%	56.4%	57.8%
Outdoor Lighting	58.1	58.1	53.0	1.66%	1.52%	1.42%
Cooling	188.1	253.9	249.4	5.4%	6.6%	6.7%
Ventilation	77.1	96.0	82.4	2.2%	2.5%	2.2%
Water Heating	121.8	125.7	85.7	3.5%	3.3%	2.3%
Refrigeration	239.2	270.5	226.5	6.8%	7.1%	6.1%
Space Heating	295.6	385.5	453.8	8.5%	10.1%	12.2%
Office Equipment	154.1	145.8	116.1	4.4%	3.8%	3.1%
Miscellaneous	119.2	170.6	136.1	3.4%	4.5%	3.7%
Whole Building	162.9	162.0	167.6	4.7%	4.2%	4.5%
Total Existing Construction End Uses	3,498.1	3,824.7	3,727.1	100%	100%	100%
	Winter Peak MW					
	2007	2012	2022	2007	2012	2022
Commercial New Construction End Use	Savings			% of total savings		
Indoor Lighting	139.4	247.9	360.1	38.1%	38.2%	35.3%
Outdoor Lighting	2.9	5.2	5.1	0.78%	0.80%	0.50%
Cooling	19.3	33.6	32.3	5.3%	5.2%	3.2%

The next largest share of existing building savings comes from cooling, at approximately 25% of the total in 2022 when accounting for the benefits from lighting and office equipment waste heat. As with lighting, realizing much of this potential will depend on improved sizing and systems optimization, rather than solely on incremental improvements in the performance of specific major pieces of equipment. To date, most efficiency programs have focused the bulk of their efforts on the latter. In terms of summer peak demand potential, cooling has a much larger share -- approximately 57% in 2007, climbing to 63% in 2022.

The next largest end-use categories are ventilation (8% in 2007 and 2012; 7% in 2022) and refrigeration (9% in 2007 and 2012; 6% in 2022). Approximately 5% of the potential in each of the years is attributable to "whole building" savings. These are multiple end-use measures, such as "integrated building design," "commissioning" and "retrocommissioning," and transformers. Finally, water heating, space heating, office equipment and miscellaneous all account for less than 5% of the total existing building efficiency opportunities.

In new-construction, the breakout by end use is quite similar to that of existing. However, because a much larger portion of opportunities were captured under "whole building" (particularly integrated building design, commissioning and transformers), the fractions allocated to other end uses are correspondingly lower. The bulk of the savings from whole-building measures would accrue to indoor lighting and HVAC in approximately the same proportions as they occur in existing buildings.

Figure 3.3.7 2012 Commercial GWh Savings by End Use (Technical Potential)

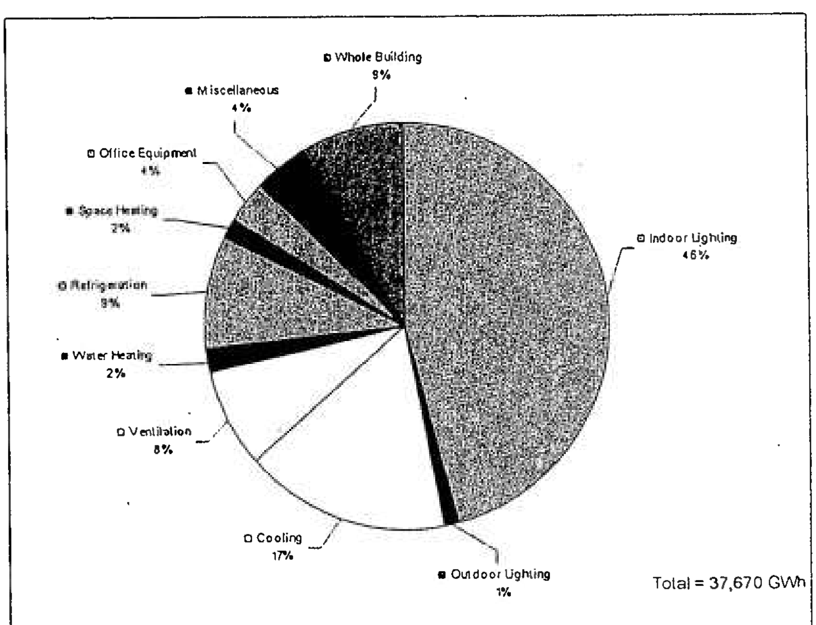
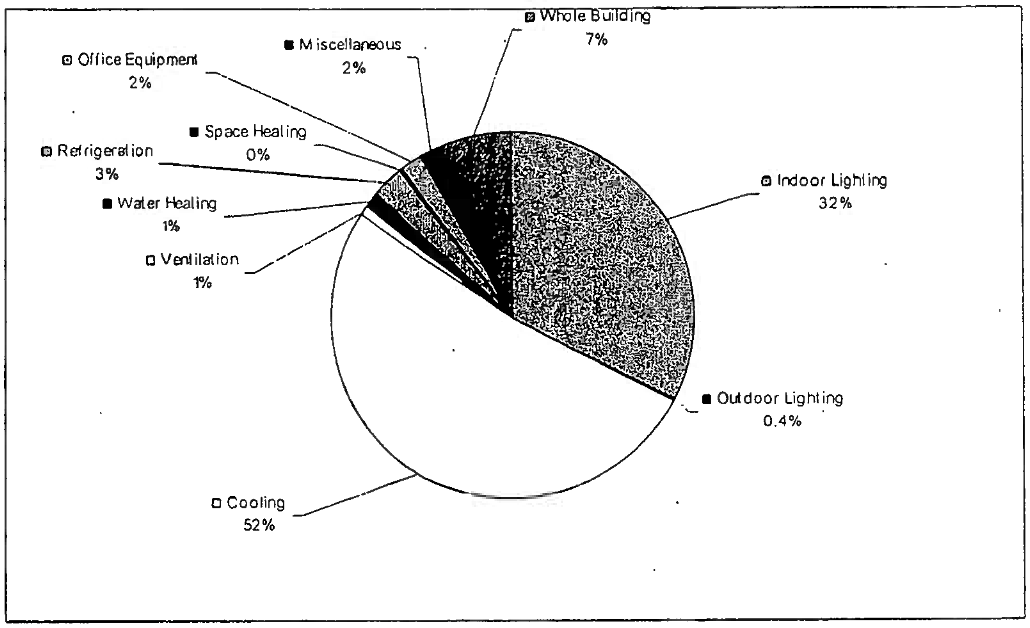


Figure 3.3.8 2012 Commercial MW Savings by End Use (Technical Potential)



Technical Potential by Building Type. Table 3.3.7, Commercial Technical Potential Savings by Building Type, shows statewide technical potential by building type for each year. The building-type shares are shown graphically for 2012 in Figures 3.3.9, 2012 Commercial Summer GWh Savings by Building Type (Technical Potential with High Avoided Costs) , and 3.3.10, 2012 Commercial Summer MW Savings by Building Type (Technical Potential with High Avoided Costs), for energy and summer peak, respectively. By far the greatest commercial opportunities are in the office segment, which accounts for slightly more than one-third of all commercial opportunities in terms of energy and approximately 40% in terms of peak demand. Retail, education, health, restaurant, and "other" all account for roughly 10% of the efficiency potential, closely followed by grocery at about 8%. Finally, warehouse and lodging each account for 3% to 4%.

Table 3.3.7 Commercial Technical Potential Savings by Building Type

Load Zone: New York Statewide

	Annual GWh					
	2007	2012	2022	2007	2012	2022
	Savings			% of total savings		
Office	12,216	13,588	13,292	37.7%	36.1%	34.7%
Retail	3,074	3,664	3,762	9.5%	9.7%	9.8%
Grocery	2,720	3,177	3,124	8.4%	8.4%	8.2%
Warehouse	1,325	1,479	1,228	4.1%	3.9%	3.2%
Education	3,212	3,805	4,691	9.9%	10.1%	12.3%
Health	2,707	3,326	3,658	8.4%	8.8%	9.6%
Lodging	981	1,127	1,094	3.0%	3.0%	2.9%
Restaurant	2,628	3,212	3,679	8.1%	8.5%	9.6%
Other	3,539	4,291	3,755	10.9%	11.4%	9.8%
Total	**32,402**	**37,670**	**38,282**	**100%**	**100%**	**100%**

	Summer Peak MW					
	2007	2012	2022	2007	2012	2022
	Savings			% of total savings		
Office	3,627	4,352	4,272	42.4%	40.8%	38.3%
Retail	1,080	1,422	1,510	12.6%	13.3%	13.5%
Grocery	465	575	618	5.4%	5.4%	5.5%
Warehouse	248	281	266	2.9%	2.6%	2.4%
Education	889	1,148	1,417	10.4%	10.8%	12.7%
Health	642	839	916	7.5%	7.9%	8.2%
Lodging	279	355	353	3.3%	3.3%	3.2%
Restaurant	640	823	986	7.5%	7.7%	8.8%
Other	694	860	807	8.1%	8.1%	7.2%
Total	**8,564**	**10,655**	**11,145**	**100%**	**100%**	**100%**

	Winter Peak MW					
	2007	2012	2022	2007	2012	2022
	Savings			% of total savings		
Office	1,652	1,851	1,880	42.8%	41.4%	39.6%
Retail	280	329	362	7.2%	7.4%	7.6%
Grocery	261	307	330	6.8%	6.9%	6.9%
Warehouse	164	186	176	4.3%	4.2%	3.7%
Education	431	510	646	11.2%	11.4%	13.6%
Health	280	343	386	7.3%	7.7%	8.1%
Lodging	89	101	104	2.3%	2.3%	2.2%
Restaurant	302	361	421	7.8%	8.1%	8.9%
Other	403	485	445	10.4%	10.8%	9.4%
Total	**3,864**	**4,473**	**4,748**	**100%**	**100%**	**100%**

Figure 3.3.9 2012 Commercial Summer GWh Savings by Building Type (Technical Potential)

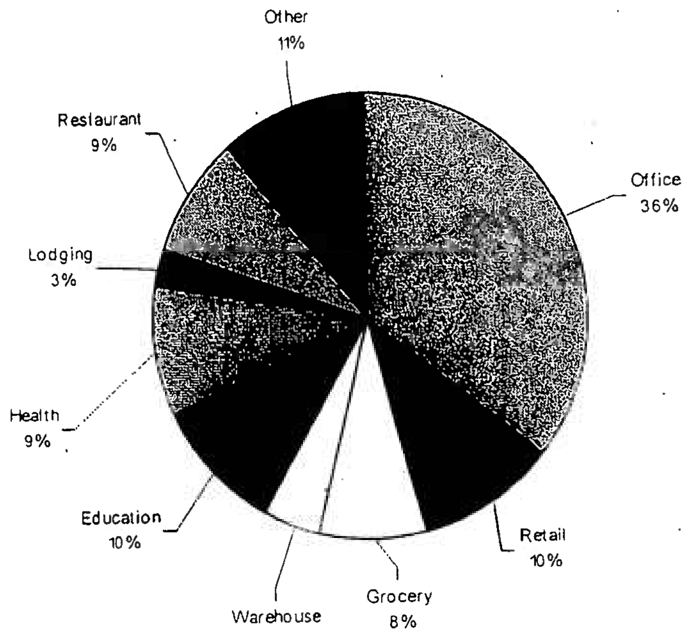
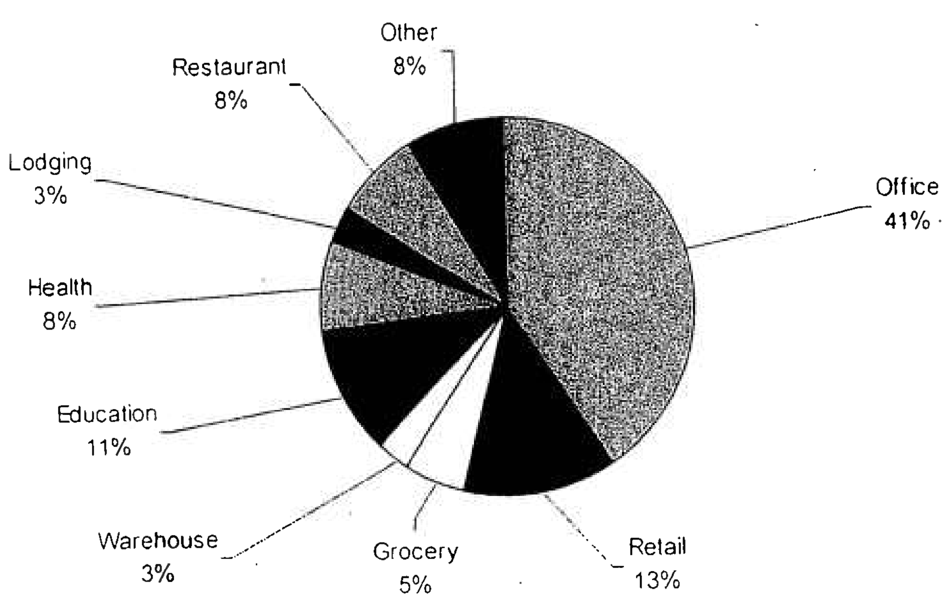


Figure 3.3.10 2012 Commercial Summer MW Savings by Building Type (Technical Potential)



Economic Potential

Economic potential eliminates all technical-potential measures that have negative present-value net benefits (i.e., the benefit-to-cost ratio is less than 1.0). Economic potential was calculated statewide under low and high avoided-cost scenarios, and separately for each analysis zone. The following tables show statewide economic potential for the high avoided-cost scenario only. Technical Appendix Table 5.2.4.19 through Table 5.2.4.39 show commercial economic potential savings by market, end use, and building type for each zone.

The economic-potential results generally mirror those of the technical potential. Because the analysis selected measures that are commonly applicable and typically cost effective, most measures passed the cost-effectiveness screening under the high avoided-costs scenario. The economic potential under high avoided costs ranges from 93% to 96% of technical potential, depending on the year. Under low avoided costs it stays relatively constant at about 85%. (See Volume 1, Tables 1.7, 1.8, and 1.9.)

Economic Potential by Market. Table 3.3.8, Commercial Economic Potential Savings by Market, shows how statewide economic potential with high avoided costs breaks out by market. This is graphically shown for both the high and low avoided costs as well in Figures 3.3.3 and 3.3.4 for energy and peak demand, respectively. As would be expected, these results closely follow technical potential. Retrofit measures offer a slightly lower share of potential (55% in 2007, dropping to a low of 39% in 2022). This result occurs because most of the measures that fail the cost-effectiveness screening are retrofit measures, in which the full costs of new equipment and labor are incurred.

Table 3.3.8 Commercial Economic Potential (High Avoided Costs) Savings by Market

Load Zone: New York Statewide

	Annual GWh					
	2007	2012	2022	2007	2012	2022
	Savings			% of total savings		
New construction	3,003	5,357	8,400	9.9%	15.2%	22.8%
Renovation	2,707	3,946	4,980	8.9%	11.2%	13.5%
Remodel/Replacement	8,033	9,186	8,995	26.5%	26.0%	24.4%
Retrofit	16,529	16,851	14,472	54.6%	47.7%	39.3%
Total	**30,273**	**35,340**	**36,847**	**100%**	**100%**	**100%**

	Summer Peak MW					
	2007	2012	2022	2007	2012	2022
	Savings			% of total savings		
New construction	830	1,492	2,212	11.8%	16.6%	21.6%
Renovation	1,149	1,919	2,833	16.4%	21.3%	27.7%
Remodel/Replacement	1,774	2,101	2,297	25.3%	23.4%	22.5%
Retrofit	3,268	3,477	2,883	46.5%	38.7%	28.2%
Total	**7,021**	**8,988**	**10,225**	**100%**	**100%**	**100%**

	Winter Peak MW					
	2007	2012	2022	2007	2012	2022
	Savings			% of total savings		
New construction	355	633	1,009	9.8%	15.1%	22.3%
Renovation	313	445	567	8.7%	10.6%	12.5%
Remodel/Replacement	981	1,127	1,154	27.2%	26.9%	25.5%
Retrofit	1,952	1,978	1,794	54.2%	47.3%	39.7%
Total	**3,600**	**4,183**	**4,524**	**100%**	**100%**	**100%**

Economic Potential by End Use. Table 3.3.9, Commercial Technical Potential Savings by Market and End Use, shows statewide economic potential with high avoided costs by end use. The end-use shares are shown graphically for 2012 in Figures 3.3.11, 2012 Commercial GWh Savings by End Use (Economic Potential with High Avoided Costs), and 3.3.12, 2012 Commercial MW Savings by End Use (Economic Potential with High Avoided Costs), for energy and summer peak, respectively. Again, the results are very similar to those for the technical-potential scenario. For existing buildings, the share of potential for lighting and refrigeration slightly increases, while heating, ventilation, and cooling (HVAC) potential goes down. In new construction, the end-use results are virtually identical to those of technical potential, as hardly any measures failed the screening.

Table 3.3.9 Commercial Economic Potential (High Avoided Costs) Savings by Market and End Use

Load Zone: New York Statewide	Annual GWh					
	2007	2012	2022	2007	2012	2022
Commercial Existing Construction End Use	Savings			% of total savings		
Indoor Lighting	14,825	15,318	15,405	54.4%	51.1%	54.2%
Outdoor Lighting	356	356	335	1.3%	1.2%	1.2%
Cooling	2,467	3,782	4,555	9.1%	12.6%	16.0%
Ventilation	2,254	2,439	1,781	8.3%	8.1%	6.3%
Water Heating	588	610	408	2.2%	2.0%	1.4%
Refrigeration	2,735	2,983	1,903	10.0%	9.9%	6.7%
Space Heating	200	302	419	0.7%	1.0%	1.5%
Office Equipment	1,362	1,289	1,027	5.0%	4.3%	3.6%
Miscellaneous	1,039	1,492	1,188	3.8%	5.0%	4.2%
Whole Building	1,423	1,414	1,426	5.2%	4.7%	5.0%
Total Existing Construction End Uses	27,270	29,983	28,447	100%	100%	100%

	Annual GWh					
	2007	2012	2022	2007	2012	2022
Commercial New Construction End Use	Savings			% of total savings		
Indoor Lighting	1,004	1,780	2,581	33.4%	33.2%	30.7%
Outdoor Lighting	32	58	56	1.1%	1.1%	0.7%
Cooling	449	809	940	14.9%	15.1%	11.2%
Ventilation	153	274	277	5.1%	5.1%	3.3%
Water Heating	64	123	141	2.1%	2.3%	1.7%
Refrigeration	191	336	198	6.4%	6.3%	2.4%
Space Heating	38	68	80	1.3%	1.3%	0.9%
Office Equipment	79	57	26	2.6%	1.1%	0.3%
Miscellaneous	-	-	-	-	-	-
Whole Building	993	1,851	4,100	33.1%	34.6%	48.8%
Total New Construction End Uses	3,003	5,357	8,400	100%	100%	100%
Total All Commercial = Existing + New Construction	30,273	35,340	36,847	NA		

	Summer Peak MW					
	2007	2012	2022	2007	2012	2022
Commercial Existing Construction End Use	Savings			% of total savings		
Indoor Lighting	2,982	3,081	3,097	48.2%	41.1%	38.7%
Outdoor Lighting	40	40	35	0.6%	0.5%	0.4%
Cooling	2,100	3,211	3,891	33.9%	42.8%	48.6%
Ventilation	47	66	51	0.8%	0.9%	0.6%
Water Heating	105	108	72	1.7%	1.4%	0.9%
Refrigeration	266	301	252	4.3%	4.0%	3.1%
Space Heating	2	3	4	0.03%	0.04%	0.05%
Office Equipment	219	208	165	3.5%	2.8%	2.1%
Miscellaneous	119	170	136	1.9%	2.3%	1.7%
Whole Building	311	309	310	5.0%	4.1%	3.9%
Total Existing Construction End Uses	6,191	7,497	8,013	100%	100%	100%

	Summer Peak MW					
	2007	2012	2022	2007	2012	2022
Commercial New Construction End Use	Savings			% of total savings		
Indoor Lighting	195.7	345.5	495.0	23.6%	23.2%	22.4%
Outdoor Lighting	0.4	0.7	0.6	0.0%	0.0%	0.0%
Cooling	375.1	680.7	820.5	45.2%	45.6%	37.1%
Ventilation	3.6	6.5	8.4	0.4%	0.4%	0.4%
Water Heating	11.5	22.3	26.4	1.4%	1.5%	1.2%
Refrigeration	25.1	44.0	25.4	3.0%	2.9%	1.1%
Space Heating	0.5	0.9	1.2	0.1%	0.1%	0.1%
Office Equipment	12.5	8.9	3.9	1.5%	0.6%	0.2%
Miscellaneous	-	-	-	-	-	-
Whole Building	206.0	382.1	830.3	24.8%	25.6%	37.5%
Total New Construction End Uses	830	1,492	2,212	100%	100%	100%
Total All Commercial = Existing + New Construction	7,021	8,988	10,225	NA		

	Winter Peak MW					
	2007	2012	2022	2007	2012	2022
Commercial Existing Construction End Use	Savings			% of total savings		
Indoor Lighting	2,068.5	2,137.0	2,147.3	63.7%	60.2%	61.1%
Outdoor Lighting	58.1	58.1	53.0	1.79%	1.64%	1.51%
Cooling	119.4	180.8	214.7	3.7%	5.1%	6.1%
Ventilation	49.9	69.5	53.8	1.5%	2.0%	1.5%
Water Heating	116.4	120.3	80.3	3.6%	3.4%	2.3%
Refrigeration	239.2	270.5	226.5	7.4%	7.6%	6.4%
Space Heating	147.9	225.1	314.9	4.6%	6.3%	9.0%
Office Equipment	154.1	145.8	116.1	4.7%	4.1%	3.3%
Miscellaneous	118.8	170.5	135.7	3.7%	4.8%	3.9%

Figure 3.3.11 2012 Commercial GWh Savings by End Use (Economic Potential with High Avoided Costs)

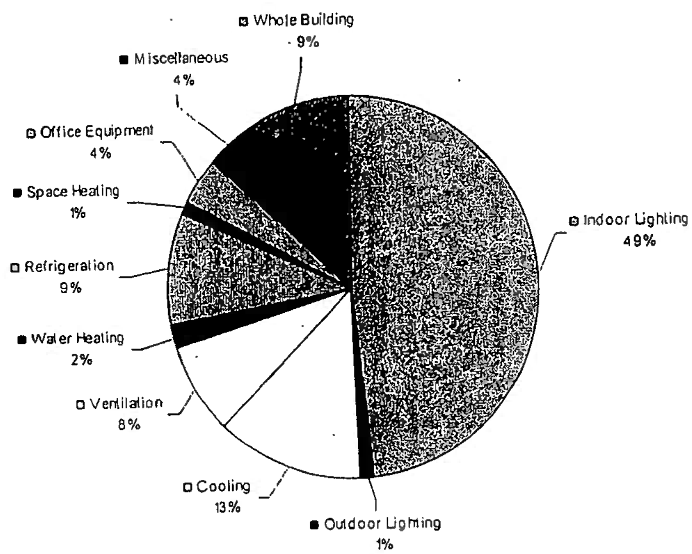
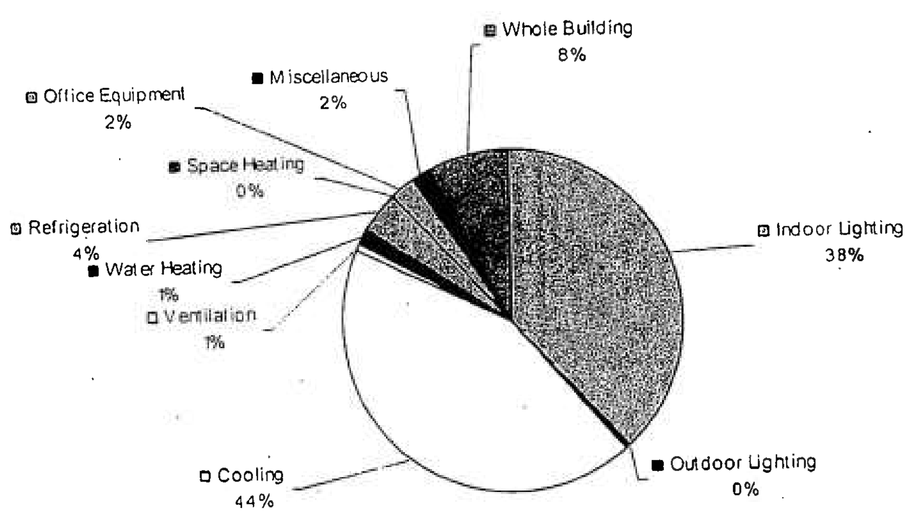


Figure 3.3.12 2012 Commercial MW Savings by End Use (Economic Potential with High Avoided Costs)



Economic Potential by Building Type. Table 3.3.10 Commercial Economic Potential Savings (High Avoided Costs) by Building Type shows statewide economic potential with high avoided costs by building type. The building-type shares are shown graphically for 2012 in Figures 3.3.13, 2012 Commercial GWh Savings by Building Type (Economic Potential with High Avoided Costs), and 3.3.14, 2012 Commercial MW Savings by Building Type (Economic Potential with High Avoided Costs) for energy and summer peak, respectively. The potential goes down among all building segments slightly, with no major shift in the relative allocation of overall potential from the building segment breakout for technical potential. The largest percentage decreases in GWh potential are in lodging and restaurant at 7% and 5%, respectively, in 2022. However, 39% of the total potential decrease in 2022 comes from office -- a result of the large portion of overall efficiency opportunities in the office segment. The smallest percentage decreases come from health and warehouse, at about 0.5% each.

Table 3.3.10 Commercial Economic Potential Savings (High Avoided Costs) by Building Type

Load Zone: New York Statewide

	Annual GWh					
	2007	2012	2022	2007	2012	2022
	Savings			% of total savings		
Office	11,296	12,584	12,733	37.3%	35.6%	34.6%
Retail	2,687	3,242	3,500	8.9%	9.2%	9.5%
Grocery	2,640	3,085	3,087	8.7%	8.7%	8.4%
Warehouse	1,310	1,460	1,222	4.3%	4.1%	3.3%
Education	2,987	3,549	4,477	9.9%	10.0%	12.2%
Health	2,666	3,288	3,640	8.8%	9.3%	9.9%
Lodging	873	1,010	1,022	2.9%	2.9%	2.8%
Restaurant	2,431	2,999	3,505	8.0%	8.5%	9.5%
Other	3,383	4,124	3,661	11.2%	11.7%	9.9%
Total	**30,273**	**35,340**	**36,847**	**100%**	**100%**	**100%**

	Summer Peak MW					
	2007	2012	2022	2007	2012	2022
	Savings			% of total savings		
Office	2,962	3,632	3,915	42.2%	40.4%	38.3%
Retail	772	1,089	1,329	11.0%	12.1%	13.0%
Grocery	419	524	598	6.0%	5.8%	5.8%
Warehouse	242	273	263	3.4%	3.0%	2.6%
Education	690	931	1,269	9.8%	10.4%	12.4%
Health	627	828	913	8.9%	9.2%	8.9%
Lodging	203	274	310	2.9%	3.1%	3.0%
Restaurant	508	681	873	7.2%	7.6%	8.5%
Other	597	755	756	8.5%	8.4%	7.4%
Total	**7,021**	**8,988**	**10,225**	**100%**	**100%**	**100%**

	Winter Peak MW					
	2007	2012	2022	2007	2012	2022
	Savings			% of total savings		
Office	1,494	1,679	1,760	41.5%	40.1%	38.9%
Retail	248	294	330	6.9%	7.0%	7.3%
Grocery	258	303	328	7.2%	7.2%	7.2%
Warehouse	163	184	175	4.5%	4.4%	3.9%
Education	400	473	610	11.1%	11.3%	13.5%
Health	274	336	381	7.6%	8.0%	8.4%
Lodging	78	90	94	2.2%	2.1%	2.1%
Restaurant	296	355	414	8.2%	8.5%	9.2%
Other	389	469	433	10.8%	11.2%	9.6%
Total	**3,600**	**4,183**	**4,524**	**100%**	**100%**	**100%**

Figure 3.3.13 2012 Commercial GWh Savings by Building Type (Economic Potential with High Avoided Costs)

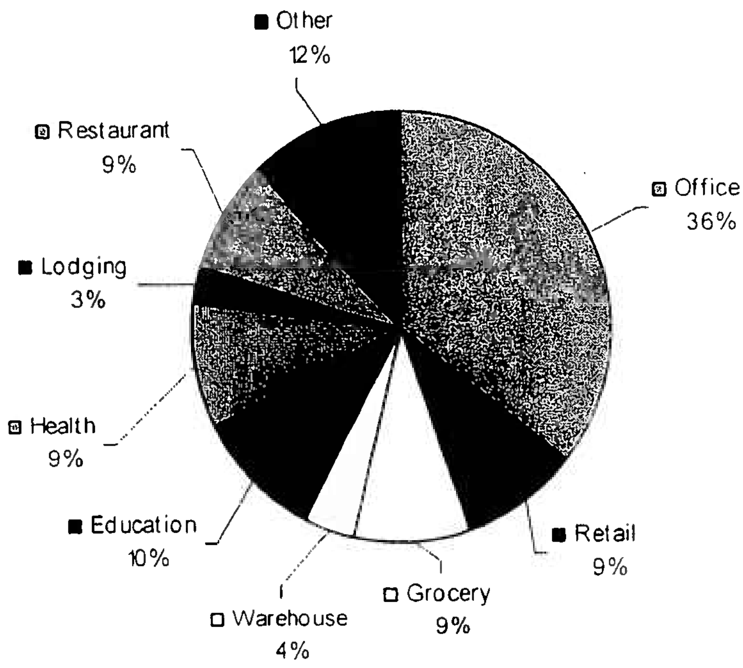
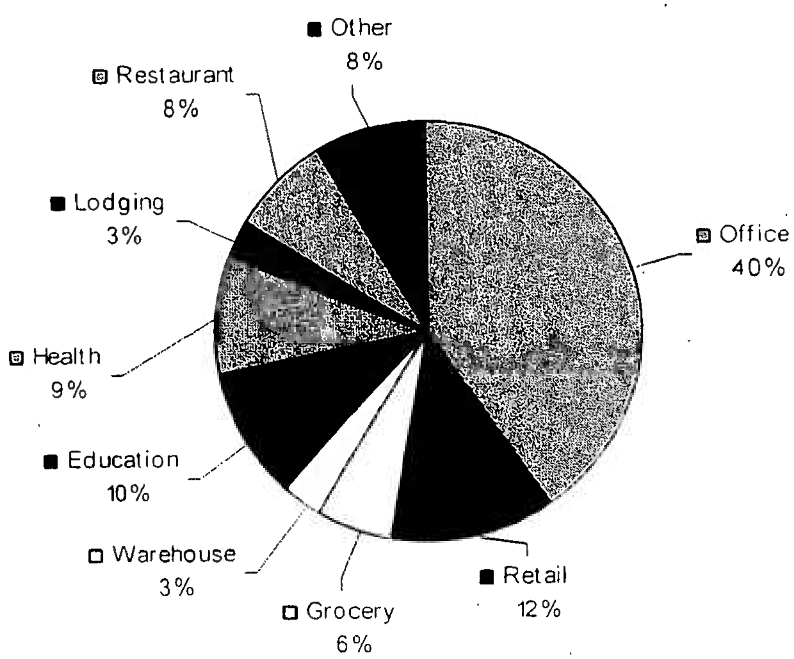


Figure 3.3.14 2012 Commercial MW Savings by Building Type (Economic Potential with High Avoided Costs)



ACHIEVABLE SAVINGS AND COSTS FOR MEETING GREENHOUSE GAS EMISSION TARGETS

The analysis of the GHG emission-reduction scenario required two additional sets of assumptions: (1) "achievable" penetration rates for efficiency measures over time; and (2) administrative cost "adders" to account for non-measure programmatic costs. Policies and program strategies for achieving additional contributions toward greenhouse gas markets are included in Technical Appendix Table 5.2.5.

Achievable Penetration Rates

Nine achievable penetration curves were estimated and applied to measures according to market and ease of adoption. Estimates were based on best judgment – informed by program experience with similar markets and other efficiency potential studies – of what the most aggressive efficiency programs could achieve. We assumed that efficiency programs would provide incentives of 100% of the measure cost (incremental for market-driven; full equipment and labor costs for retrofit) for all measures. For all markets the analysis also assumed there would be aggressive marketing, trade-ally and design-professional outreach and training, technical and design assistance or incentives, and other efforts necessary to "move the market," all at no cost to customers or trade allies.

Three penetration curves were estimated for each market.[26] For each technology, the analysis applied either a low, medium or high penetration curve based on the overall difficulty of capturing measure adoption within that market. Technical Appendix Table 5.2.3.0.1, Commercial Technology Measure Life and Level of Difficulty, lists the level of difficulty for each technology type. The high penetration rates were applied to measures that are traditionally easiest to promote through efficiency programs. These generally are higher-efficiency substitutions of similar equipment components. Examples include one-for-one lighting-fixture retrofits or replacements (e.g., T12 fluorescents replaced with T8 or "Super T8" fixtures), or high-efficiency motors or unitary HVAC equipment. These types of measures typically have the longest history of promotion and success with efficiency programs. Medium curves were used for measures and bundles of measures that are more difficult to promote – those that often require more design and analysis, and result in bundles of technologies that interact to achieve higher system efficiencies. Historically, efficiency programs have not promoted these measures or they have found it harder to obtain high adoption levels even with promotional efforts. However, we assume much greater levels of design assistance and "upstream" outreach training than most programs typically have offered, as well as full elimination of economic barriers -- something rarely done in existing programs. The low penetration curves were used for emerging-market technologies that are not yet typically widely available or cost effective.

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[26] New construction and renovation use the same set of penetration curves.

Note that while the emerging-technology curves don't go above 0% until 2012, for market-driven measures they ramp up to higher penetration levels than the medium-penetration curves by 2022. This is because many of the emerging technologies represent those types of measures that, once widely available, would more likely fall into the "high" measure category – in other words, they do not typically rely heavily on customized analysis and design. Examples include white LED lighting arrays, copper rotor motors, amorphous core transformers, and emerging efficiency levels for HVAC equipment.

As mentioned above, individual base-case penetrations were estimated based on the best available data and projections of likely future market activity given currently existing programs and policies. Because base-case penetrations often are significant for many measures, the achievable penetration percentages are not treated as absolute percentages. Rather, we apply them to the remaining opportunities in each year (e.g., 100% minus the base-case penetration). In some cases base-case penetration rates are 0% by definition (e.g., when the base-case efficiency is defined as the average efficiency). In others, the base case may already be quite high (e.g., when the measure reflects a binary choice such as T12 or T8 fluorescent lighting). For example, T8 fluorescent lighting base-case penetration for offices in the non-retrofit markets is currently 63%.[27]

Table 3.3.11, Maximum Achievable Penetrations for Greenhouse Gas Scenario, shows the measure penetrations for the Greenhouse Gas Scenario. For market-driven measures, we assume that maximum penetrations for the high scenarios will be reached within 10 years, then remain flat. Medium penetrations reach close to maximum levels in 10 years but continue to climb slightly over the next decade as capabilities of designers and contractors continue to transform. We assume emerging technologies will begin to achieve significant market penetration starting in 2012 and will take 10 years to reach maximum levels. In general, emerging technologies exceed the maximum levels of the medium rates by 2022.

The market-driven penetrations reflect incremental percentages of the eligible remaining opportunities that occur in each year. Some of the best historic programs have achieved similar rates. For example, National Grid Transco's Design 2000+ commercial and industrial new-construction program typically reaches 75% to 90% of new buildings built in National Grid's territory in Massachusetts. Buildings with comprehensive measures often perform 40% to 50% better than a typical building.[28] Despite envisioning a more aggressive set of program strategies, we estimate lower ultimate penetration rates for new construction. This is because historically programs are typically not fully comprehensive with each participant.

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27 Based on Long Island Power Authority. *LIPA Commercial and Industrial Baseline Study*, Regional Economic Research. May 2002, Volume 1, page 2-23.

28 Personal communication with Michael McAtteer, Program Manager, November 20, 2002.

The retrofit penetrations are cumulative figures that apply to the full existing stock of systems and equipment. As with market-driven estimates, these reflect maximum levels based on review of similar programs. For example, Citizens Utilities in Vermont offered a small commercial and industrial retrofit program that captured roughly 80% adoption of measures among targeted customers. Other small commercial and industrial programs have achieved similar penetration rates.[29] Again, the analysis assumes somewhat lower ultimate penetrations recognizing that historically programs have not successfully captured all opportunities in each facility.

Table 3.3.11 Maximum Achievable Penetrations for Greenhouse Gas Scenario

		2003	2007	2012	2022
New Construction & Renovation	High	5%	60%	75%	75%
	Medium	2%	30%	45%	50%
	Low	0%	0%	2%	60%
Remodel/ Replacement	High	4%	30%	60%	60%
	Medium	1%	20%	35%	40%
	Low	0%	0%	1%	50%
Retrofit	High	1%	23%	60%	75%
	Medium	0.5%	12%	40%	50%
	Low	0%	0%	2%	50%

NOTES:
Penetrations applied to remaining opportunities (e.g., 100% - basecase)
Retrofit are cumulative penetrations, all others are incremental.

<u>Greenhouse Gas Scenario Administrative Cost Adders</u>

To estimate non-measure program-related costs, the analysis applied "administrative adders" to the measure costs. For the Greenhouse Gas Scenario, separate administrative adders were developed for each market based on review of a comparable study of maximum achievable potential in Vermont conducted in 2002 (see Table 3.3.12, Administrative Adders for Greenhouse Gas Scenario).[30] The Vermont study developed bottom-up estimates of individual initiative budgets for each market designed to capture the maximum achievable potential. Vermont costs included fully loaded staff, marketing, tracking, technical assistance, monitoring and evaluation (M&E), and measure incentives. Initiative budgets were developed based on the estimated number of participants, review of other initiatives in the Northeast (most prominently Vermont and Massachusetts initiatives, many of which are similar to NYSERDA's Energy \$mart^{sm} Programs) and professional judgment. The administrative adders reflect average levels over 10

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29 See Mosenthal, P. & Wickenden, M., *The Relationship Between Financial Incentives and Measure Adoption in the Small C&I Retrofit Market*, Proceedings of the ACEEE Summer Study, 2000, at: http://www.aceee.org/.

years of program activity.[31] It should be noted that these adders typically are higher than those experienced by many initiatives -- and those used in the Currently Planned Initiative Scenario -- because of the intended goal of attaining maximum achievable penetration. The adders reflect aggressive and expensive marketing, training and technical assistance efforts directed at all market/actor levels.

Table 3.3.12 Administrative Adders for Greenhouse Gas Scenario

New Construction/Renovation	100%
Remodel/Replacement	25%
Retrofit	15%

Administrative adders based on Velco and Maine maximum achievable potential analyses.

<u>Greenhouse Gas Scenario Results</u>

This study analyzed the least-cost mix of renewable supply and energy-efficiency measures that would meet an emission-reduction requirement for the electric utility industry. NYSERDA estimated that requirement to be equal to a marginal reduction on baseline electricity production of nearly 20 thousand GWh in 2012 and a little more than 27 thousand GWh in 2022. Our analysis suggests that the least cost path to meeting those targets includes all renewable and energy efficiency measures that have a net cost of less than approximately $0.028 and $0.015 per kWh in 2012 for the low and high avoided-cost scenarios and $0.026 and $0.010 per kWh in 2022 for the low and high avoided-cost scenarios (what one might call least-cost greenhouse gas thresholds).[32] We estimate that 12.5 thousand GWh of commercial efficiency savings can be achieved at costs less than the 2012 least cost threshold; 12.8 thousand GWh of commercial efficiency savings can be achieved at costs less than the 2022 least-cost threshold. Overall, the commercial sector would contribute significantly more to the efficiency portion of the GHG least-cost path than the other sectors. In 2012 and 2022, the commercial sector represents 77% and 58% of total efficiency contributions respectively. As a share of total efficiency and renewable contributions, the commercial sector would provide 62% and 40% for 2012 and 2022, respectively.

Complete, integrated results for our analysis of the Greenhouse Gas Scenario can be found in Volumes 1 and 2 of this report.

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30 VELCO Northwest Reliability Project: Assessment of Economically Deliverable Transmission Capacity from Targeted Energy-Efficiency Investments in the Inner and Metro-Area and Northwest and Northwest/Central Load Zones, Optimal Energy Inc., January 29, 2003.

31 In actuality, one would expect high adders in the early years, when significant start-up and marketing costs are incurred, but penetration is relatively low, and declining adders over time as penetrations grow.

32 See Volumes 1 and/or 2 for a discussion of how net costs were calculated.

EXPECTED ACHIEVEMENTS UNDER CURRENTLY PLANNED INITIATIVES

The Expected Achievements Under Currently Planned Initiatives Scenario (CPI Scenario) estimates the likely commercial sector impacts of the next 20 years from seven items:

- Currently planned NYSERDA Energy $mart℠ initiatives through 2006;
- Currently planned Long Island Power Authority (LIPA) Clean Energy initiatives through 2004;
- Currently planned New York Power Authority (NYPA) initiatives through 2004;
- New York State Executive Order 111, through 2010;
- New York State Draft Purchasing Standards, through 2022;
- Expected enhancements to existing, or new, federal and state appliance efficiency standards, through 2022; and
- Expected enhancements to the energy components of the New York State Building Code through 2022.

NYSERDA, LIPA, and NYPA Commercial Programs

Table 3.3.13, Current New York Commercial Efficiency Programs Analyzed, summarizes the existing NYSERDA, LIPA, and NYPA commercial efficiency programs analyzed for this scenario. For the NYSERDA and NYPA initiatives, the analysis drew on NYSERDA data on historical program spending and savings, as well as projected future portfolio funding levels, to estimate annual incremental impacts.[33] In addition to direct impacts during program years, we assumed some market effects from NYSERDA's Energy $mart℠ Commercial and Industrial New Construction, Motors, HVAC, and Small Commercial Lighting programs, based on information gleaned in the program evaluation.[34] For each commercial and industrial initiative, we estimated the share of program savings attributable to each sector based on NYSERDA evaluation data.[35] Estimates of annual program impacts and market effects from LIPA's Clean Energy Initiatives came from LIPA's draft 2003 and prior Clean Energy Plans. Commercial and industrial savings were allocated by sector based on LIPA's share of sector electricity sales.

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33 The primary data sources were: NYSERDA, State Energy Plan, June 2002; NYSERDA, Finding Innovative Ways to Improve Tomorrow's Infrastructure Today: A Three-Year Strategic Outlook — 2002-2005; and NYSERDA, New York Energy $mart℠ Program Evaluation and Status Report, January 2002.

34 NYSERDA, *New York Energy $mart℠ Program Evaluation and Status Report*, January 2002 estimates that three times the square footage that participated in this program was affected by market-transformation efforts. The analysis assumes that non-participant square footage realizes 10% of the savings that participant square footage achieves. Therefore, post-program market effects were assumed to be 30% of "in-program" savings for the first five years, dropping to 20% for the next five years, and then ceasing.

35 NYSERDA, New York Energy $mart℠ Program Evaluation and Status Report, January 2002.

Table 3.3.13 Current New York Commercial Efficiency Programs Analyzed

Program Administration	Program Name	Program Summary	Years Analyzed	Portion Attributed to Commercial Sector
NYSERDA	Commercial & Industrial Performance	Fosters growth of the energy services Industry through performance-based incentives to energy efficiency serviceproviders.	2003 to 2006	67%
NYSERDA	New Construction	Provides financial incentives to building owners and technical assistance to building designers in an effort to change standard building design and construction practices.	2003 to 2006	82%
NYSERDA	Smart Equipment Choices	Provides financial incentives for the purchase and installation of cost-effective, high efficiency equipment (i.e., lighting, motors and HVAC)	2003 to 2006	82%
NYSERDA	Technical Assistance (Flex Tech)	Provides cost-sharing of studies by qualified professionals to help end users identify efficiency improvements in their facilities. Services include energy audits, energy operations management, rate analysis and aggregation, and other services.	2003 to 2006	67%
NYSERDA	Premium Efficiency Motors	Designed to induce lasting structural change in the motors market. Offers incentives to participating vendors for the sale of NEMA Premium efficiency motors.	2003 to 2006	33%
NYSERDA	Commercial HVAC	Designed to increase availability, promotion and sale of energy efficient HVAC products and services. Projects promote commissioning and purchase of high efficiency unitary HVAC.	2003 to 2006	100%
NYSERDA	Small Commercial Lighting	Promotes effective, energy efficient lighting in small commercial spaces by offering incentives to contractors and multi-site end users. Also offers contractor training incentives.	2003 to 2006	
NYSERDA	Loan Fund	The Loan Fund offers an interest rate reduction from participating lenders for loans for energy efficiency improvements and renewable technology projects up to $500,000.	2003 to 2006	67%
LIPA	New Construction	Provides financial incentives and technical and design assistance and incentives to building owners for the purchase and installation of energy efficiency systems and equipment. Targets all lost opportunity markets, including new construction, renovation, remodeling and equipment replacement. Includes separate efforts targeted specifically at motors and HVAC.	2003 to 2004	82%
LIPA	Small Commercial Retrofit	Direct installation retrofit program targeted to small commercial customers. Installs all cost-effective identified measures, with the majority of savings coming from lighting and refrigeration.	2004	100%

NYPA	High Efficiency Lighting	Finances installation of efficient lighting, as well as motors, energy management systems, and sensors.	2003-2004	67%
NYPA	Energy Services	Provides audits and efficiency measures, including lighting boilers and motors, to public entities.	2003-2004	100%
NYPA	Electro-technologies	Provides financing, technical services and installation for energy efficient electric technologies such as chillers and water purification.	2003-2004	67%

State and Federal Regulations, Codes and Standards

Executive Order 111 calls for state buildings to decrease their energy use 35% below 1990 levels by the year 2010.[36] We assume this reduction will occur evenly between electrical and other energy sources. We further assume all state buildings are included in the commercial sector.[37] This results in a target 2010 electrical load for all state buildings of 1,330 GWh.[38] New York has already made significant progress in lowering its energy consumption. Estimated 2002 usage was 90% of 1990 levels.[39] This leaves a necessary decrease of 512 GWh over today's consumption levels by 2010. We assume this savings will be captured evenly over each of the remaining years.

The New York draft purchasing standards specify minimum efficiency levels required for specific equipment purchased for use in state buildings.[40] We assume any purchases between now and 2010 would contribute toward the Executive Order 111 savings, and therefore counted no additional savings prior to 2010 from the purchasing standards to avoid double counting. Based on review of the draft standards, the levels specified are likely to be at or below baseline practices post-2010; similarly, as a result, we do not count additional post-2010 impacts.

Savings attributable to enhancements to existing federal and state appliance-efficiency, and the development of new standards, are estimated for 19 technologies as listed in Table 3.3.14, Technologies in Federal and State Standards Analysis. We drew on a draft ACEEE analysis of likely New York impacts and start dates for each standard. Because both the start date and final passage of standards as currently

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36 NYSERDA, Executive Order No. 111: *"Green and Clean" State Buildings and Vehicles Guidelines*, December 2001.

37 Ibid. This document actually shows a very small portion of energy usage from multi-family housing. For simplicity, this usage is included in the commercial-sector analysis.

38 Sixty-five percent of the 1990 electrical consumption for state buildings. *"Green and Clean" State Buildings and Vehicles Guidelines*, p. 55.

39 NYSERDA, *State Energy Plan*, June 2002, pp. 3-25.

40 21 NYCRR Part 506: Purchase of Energy Efficient Products

envisioned are uncertain, we applied a 50% probability factor to impacts from 2003 to 2010 and a 67% probability for post-2010 impacts.

Table 3.3.14 Technologies in Federal and State Standards Analysis

Equipment	Anticipated Start Date
Beverage merchandisers - Tier 1	2005
Beverage merchandisers - Tier 2	2005
Comm'l clothes washers	2005
Comm packaged A/C (over 20 tons)	2005
Comm'l refrigerators & freezers - Tier 1	2005
Comm'l refrigerators & freezers - Tier 2	2005
Dry type transformers	2005
Exit signs	2005
Ice-makers	2005
Traffic signals	2005
Vending machines - Tier 1	2005
Vending machines - Tier 2	2005
Furnace fans	2010
CFLs	2007
Comm'l packaged A/C&HP (<5 tons) - Tier 1	2006
Comm'l packaged A/C&HP (<5 tons) - Tier 2	2006
Comm'l packaged A/C&HP (5-20 tons)	2009
Liquid immersed transformers	2008
Reflector lamps	2010

New York State recently enacted a new building code that reflects substantial improvement in efficiency levels over the prior energy code adopted in 1989. We assume the state will likely adopt substantive enhancements to the current energy code in approximately the same time frame as past updates – i.e., in 2015. We estimate annual impacts starting in 2015 from an improved energy code to be 360 GWh -- the approximate impact of the 2002 energy code as compared to the 1989 version.[41]

Administrative Cost Adders

As with the GHG Scenario, we used administrative cost adders to estimate non-measure program-related costs. For the CPI Scenario, administrative adders were applied only to measure costs from 2003 to 2006 in order to reflect NYSERDA, LIPA, and NYPA initiative costs. We included no non-measure implementation costs for administration or enforcement of the executive order, or for any federal or state codes and standards. Direct data on the portion of New York program budgets was unavailable. We therefore developed administrative adders based on 2003 program-cost plans for similar initiatives offered

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[41] 360 GWh is the midpoint of an estimate range of annual impact from NYSERDA, *State Energy Plan*, June 2002, pp. 3-26.

in Massachusetts.[42] Table 3.3.15, Administrative Adders for Currently Planned Initiative Scenario, shows the administrative adders for the CPI Scenario by market.

Table 3.3.15 Administrative Adders for Currently Planned Initiative Scenario

New Construction/Renovation	25%
Remodel/Replacement	25%
Retrofit	15%

Admin adders based on MA utility program budgets.

Commercial CPI Results

Table 3.3.16, Commercial Achievable Efficiency Savings from Currently Planned Initiatives, shows estimated incremental and cumulative annual impacts for selected years.

Table 3.3.16 Commercial Achievable Efficiency Savings from Currently Planned Initiatives

		2003	2007	2012	2022
Source of Savings	Period of Impacts	Incremental Annual Impacts (GWh meter level)			
LIPA Initiatives	2003-2004, market effects 2005-2009	22.72	2.25	-	-
NYPA Initiatives	2003-2004	43.23	-	-	-
NYSERDA Initiatives	2003-2006, market effects 2007-2015	175.21	20.82	16.66	-
Executive Order 111 + NY Purchasing Standards	2003-2010	0.06	0.06	-	-
NY Building Code Updates	2015-2022	-	-	-	360.00
Federal and State Efficiency standards	2005-2022	-	44.81	361.99	420.10
Total (Incremental Annual GWH)		241.22	67.94	378.65	780.10
		Cumulative Annual Impacts (GWh meter level)			
Total (Cumulative Annual GWh)		241	1,137	2,684	8,384

Very little data are available on how the impacts of the NYSERDA, LIPA, and NYPA initiatives are distributed among customer types, measures, or end uses. Similarly, no data are available by technology for effects from codes and the executive order. We therefore applied penetration rates to the 2,163 individual measures in the same general proportions used for the Greenhouse Gas Scenario. The one exception to this approach is that once Executive Order 111 ends in 2010, all future savings are assumed to be in market-driven markets, as no further initiatives targeting retrofit activity will exist. Table 3.3.17, Commercial CPI Cost-Effectiveness, shows cost-effectiveness results from the CPI Scenario.

42 Administrative adders were developed based on professional judgment, after review of Massachusetts Electric Company 2003 Energy Efficiency Plan budgets and NSTAR 2003 Draft Energy Efficiency Plan budgets.

Table 3.3.17 Commercial CPI Cost-Effectiveness

Scenario	Total Resource Benefits (NPV in 2003 $)	Total Resource Costs (NPV in 2003 $)	Total Resource Net Benefits (NPV in 2003 $)	Benefit-Cost Ratio
High Avoided Costs	$ 5,342,938,511	$ 2,121,966,469	$ 3,220,972,042	2.52
Low Avoided Costs	$ 2,995,546,145	$ 2,121,966,469	$ 873,579,676	1.41

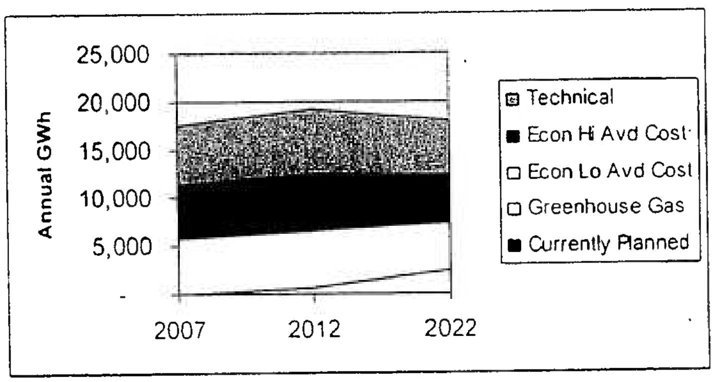
Complete, integrated results for the CPI Scenario can be found in Volumes 1 and 2 of this report.

Section 4:
INDUSTRIAL EFFICIENCY ANALYSIS

SUMMARY OF RESULTS

For the industrial sector, the technical potential peaks in 2012 and then decreases slightly through 2022. This occurs due to the natural rate of capital stock turnover and the autonomous trend toward lower energy-intensive industrial sub-sector mix. The economic potential (both low and high avoided cost) closely mirrors this trend. The avoided costs have no impact on the economic potential of the industrial sector. Table 3.4.1 represents the results obtained from the analysis of industrial energy-efficiency potential.

Figure 3.4.1 Industrial Scenario Savings



OVERVIEW OF APPROACH

The analysis of the potential of electricity savings was accomplished in several steps. The industrial electricity market in New York was characterized, then energy-saving technologies were selected for analysis. The technical, economic, and achievable potential savings for these measures were estimated. The following sections describe the process for estimating the savings potential in New York.

Methodology for Establishing the Baseline for Technical and Economic Potential

The industrial-sector analysis process was performed in three steps:

- Estimation of disaggregated industrial sector base-year (1997) electricity consumption for New York State;
- Estimation of a sector base-case electricity consumption forecast; and
- Calculation of disaggregated electricity savings potential using the screening tool developed by Optimal Energy.

MARKET CHARACTERIZATIONS

Estimation of Base Year Electricity Consumption

The industrial sector is comprised of a diverse group of economic entities spanning agriculture, mining, construction, and manufacturing. Significant diversity exists within most of these industry sub-sectors, with the greatest diversity within manufacturing. The various product categories within manufacturing are classified using the North American Industrial Classification System (NAICS) (Census 1997 and 1999)[43].

Comprehensive, highly disaggregated electricity data for the industrial sector is not available at the state level. To estimate the electricity consumption, this study drew upon a number of resources, all using the same classification system and sample methodology. Fortunately, a conjunction of the various economic censuses for each state allows us to use a common base-year of 1997. The major data sources available for New York State were the1997 Census of Agriculture (USDA 2000) and the 1997 Economic Census Subject Series for Construction, Mining, and Manufacturing (Economic Census). The Census of Agriculture and Census Construction series report electricity purchases by the sub-sector for each state, while the mining and manufacturing series report net electricity consumption. The electricity purchase data were converted to GWh consumption using the SEPER (U.S. Energy Information Agency EIA 2001) prices for commercial electricity for New York State.

Unfortunately, disaggregated state-level electricity consumption data were not reported for the sub-sectors (such as chemical, paper, primary metals industries, etc.). Because of the magnitude and diversity in this manufacturing sub-sector, it is important to disaggregate beyond the sub-sector or industry group level (pharmaceutical products under the chemicals industry, for example). As a result, we used national industry electricity intensities derived from industry group electricity consumption data reported in the *1998 Manufacturing Energy Consumption Survey* (MECS) (EIA 2001) and the value of shipments data reported in the *1998 Annual Survey of Manufacturing* (ASM) (Census 2000). It is assumed that these intensities are relatively constant for this two-year period. These intensities were then applied to the value of shipments data for the manufacturing energy groups (three-digit NAICS) in New York State.

At the sub-group level, national intensities were applied, when available, to estimate electricity consumption. In other cases, manufacturing-group electricity consumption estimates were apportioned to the sub-group based on the share of the group value of shipments. Other sub-sectors have less diversity (e.g., mining) or are significantly smaller (e.g., construction and mining), so less effort was applied to disaggregation. Value of shipments (mining), sales (agriculture), or construction work (construction) were used to characterize these sub-sectors, but no attempt was made to develop estimate disaggregated

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43 The industry sector is comprised of four sub-sectors: manufacturing, mining, agriculture, and construction. Each sub-sector is further broken down into individual industry groups, reflecting the many different definitions of the term "industrial."

electricity consumption. These electricity-consumption estimates were then used to characterize the share of the industrial-sector electricity consumption for each sub-sector and group. To maintain a constant total electricity-consumption basis with the other sector analyses, we used estimates of share of electricity consumption to apportion the electricity-consumption estimates reported in the State Energy Data Report (SEDR) (EIA 2001). While this approach has limitations in that the SEDR uses a different basis than the MECS and Economic Census data, by apportioning the amounts in a data series that spans all three sectors, the sector totals added up to state-level consumption.

Preparation of Baseline Industrial Electricity Forecast

As is the case for state-level energy-consumption data, no state-by-state disaggregated electricity-consumption forecasts are publicly available. Several alternate data sources were used to calculate estimated electricity-consumption growth rates for each state and sub-sector. We made the assumption that electricity consumption will be a function of gross state domestic product (GSP). However, electricity consumption will not grow at the same rate as GSP or the value of shipments, because in general energy intensity (energy consumed per value of output) decreases with time.

Because state-level disaggregated economic-growth projections are not publicly available, data were purchased from Economy.com (Ecomomy.com 2001). Economy.com is a leading provider of economic, financial, and industrial data designed to meet the diverse planning and information needs of business organizations, governments, and professional investors worldwide. The purchased data contained the GSP information for each manufacturing sub-sector in New York State. The data were used to determine an annual rate of growth for the GSP for each individual industry. This growth rate was then applied to the previously obtained 1997 electricity consumption values. These values were calibrated to state-specific projections in the years 2000 and 2010 (NYSERDA 2002).

The 2002 Annual Energy Outlook developed by the Energy Information Administration (EIA 2002) publishes sector-specific national energy-consumption and energy-intensity projections to 2020. The sector-specific national energy-intensity projections were used to calculate an annual energy-intensity growth rate for each manufacturing sub-sector. It was assumed that the rate of energy-intensity growth would be the same in New York State as it is in the national forecasts. Once the economic growth rates and energy-intensity growth rates were obtained, it was possible to calculate an estimated electricity growth rate for each sub-sector. The economic growth rate was applied to the base year electricity consumption value, and the energy-intensity growth rate was used as a damping factor to calculate projected electricity consumption.

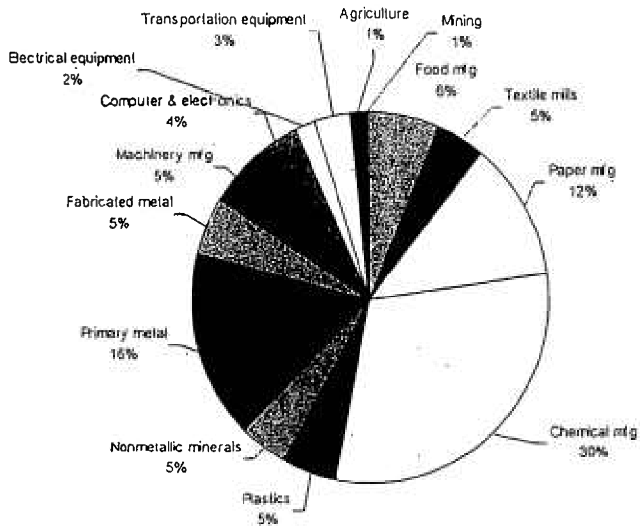
For agriculture, construction, and mining, less effort was applied to the disaggregation. Value of shipments (mining), sales (agriculture), or construction work (construction) were used to characterize these sub-sectors, but no attempt was made to estimate disaggregated electricity consumption. These electricity-consumption estimates were then used to characterize the share of industrial-sector electricity consumption for each sub-sector and group.

The study examined 22 industrial sub-sectors chosen to represent the majority of industrial electricity use in New York State. In order to simplify the analysis and obtain information of the greatest significance to NYSERDA, only sub-sectors with electricity consumption greater than 3% of total New York State industrial consumption were included. The sum of the electricity consumption of these sub-sectors represents over 90% of total New York State industrial electricity consumption. Table 3.4.1, Base-Case Electricity Consumption by Industry, lists consumption for the 22 industrial sub-sectors. Figure 3.4.2, 1997 Electricity Consumption by Industry, shows the percent of consumption by industry.

Table 3.4.1 Base-Case Electricity Consumption by Industry

NAICS Code	Industry Name	(GWh)			
		2003	2007	2012	2022
311	Food Manufacturing	1,319	1,335	1,307	1,263
313	Textile mills	124	934	900	840
322	Paper Manufacturing	2,400	2,354	2,217	1,980
325	Chemical Manufacturing	6,666	6,917	6,991	7,192
3254	Pharmaceutical & medicine Manufacturing	1,955	2,028	2,050	2,109
3259	Other chemical product Manufacturing	2,170	2,252	2,276	2,341
326	Plastics & rubber products Manufacturing	1,019	1,012	969	895
3261	Plastics product Manufacturing	886	880	843	778
327	Nonmetallic mineral product Manufacturing	1,116	1,251	1,393	1,739
3271	Clay product & refractory Manufacturing	179	201	261	325
3272	Glass & glass product Manufacturing	249	279	362	452
3273	Cement & concrete product Manufacturing	337	378	490	612
3279	Other nonmetallic mineral product Manufacturing	351	394	511	638
331	Primary metal Manufacturing	3,759	4,025	4,232	4,710
3313	Alumina & aluminum production & processing	2,951	3,494	3,876	4,314
3314	Nonferrous metal (except aluminum) production & processing	808	531	283	72
332	Fabricated metal product Manufacturing	1,108	1,171	1,210	1,301
333	Machinery Manufacturing	1,377	1,656	2,013	2,995
334	Computer & electronic product Manufacturing	953	1,038	1,116	1,298
336	Transportation equipment Manufacturing	659	637	590	510
11	Agriculture	440	495	553	737
21	Mining	212	224	232	266
	TOTAL	21,151	23,050	23,890	27,191

Figure 3.4.2 1997 Electricity Consumption by Industry



Market Characterization Results

In 1997, the State of New York industrial sector consumed 40,000 GWh of electricity. Manufacturing comprises 94.5% of the industrial load in New York State, with mining comprising much of the remainder at 4.5%. Agriculture comprises 1% of State industrial energy use.

Within the manufacturing sector, chemical manufacturing (NAICS 325) dominates at 25% of the manufacturing electricity use. Primary metals manufacturing (NAICS 331) uses 15% of the manufacturing load, mostly dominated by the sub-category Alumina and Aluminum Production and Processing (NAICS 3313) at 13.8%. Paper manufacturing (NAICS 322) also uses a significant amount -- 11% -- of the electricity used for manufacturing in New York.

While the base-case projection for New York State shows increases in most of the sectors, there is a marked decrease in the oil and gas sector over the duration (see Table 3.4.1, Base-Case Electricity Consumption by Industry). The largest growth is in general manufacturing, while mining's use increase slows toward the end of the duration. Petroleum refining also shows a sharp increase in electricity use in New York. The projection shows that the industries that used very little electricity in New York State (agriculture and construction) will not change their consumption habits.

Of the zones analyzed, Zone A has the largest industrial load with 5,353 GWh; followed by Zones F, G, K, and finally, Zone J with 1,028 GWh. Both usage and largest potentials for savings varied by zone. In Zone A, the largest potential was in agriculture (NAICS 11), transportation equipment manufacturing (NAICS 336), and fabricated metal manufacturing. In Zone F, nonmetallic mineral and paper manufacturing had the largest potential. Zone G had the most potential in chemical manufacturing and computer and electronics. Similarly, Zone K has great potential in computer and electronic manufacturing. Zone J, the lowest electricity user of the zones, has the most potential for savings in textile mills.

OVERVIEW OF EFFICIENCY MEASURES ANALYZED

The first step in our technology assessment was to collect limited information on a broad "universe" of potential technologies. Our key sources of information included the U.S. Department of Energy, Office of Industrial Technologies; the Center for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET); Lawrence Berkeley National Laboratory (LBNL); and American Council for an Energy Efficient Economy (ACEEE) reports; and information from NYSERDA. We did not collect any primary data on technology performance.

Oftentimes, no one source provided all of the information we sought for our assessment (energy use, energy savings compared to average current technology, investment cost, operating cost savings, lifetime, etc.). We therefore made our best effort to combine readily available information along with expert judgment where necessary. To determine the potential for energy savings, our preliminary screening criteria, described in detail below, were first developed.

From these screening criteria we then developed an initial scoring rating -- with a maximum rating of 100 points -- to help select technologies for final screening. We also noted whether a technology had a low market penetration or whether the technology was still emerging. Below we discuss the rating criteria and scoring criteria.

Potential for Energy Savings

We sought to identify technologies that could have a large potential impact in terms of saving energy. These may be technologies that are specific to one process or one industry sector, or so-called "cross-cutting" technologies that are applicable to a variety of sectors. In estimating energy savings, we first identified the specific energy savings of each technology by comparing the energy used by the efficient technology to the energy required by current processes. Our second step was to "scale up" this savings estimate to see how much energy savings -- for industry overall -- this technology would achieve. For the most part, we derived specific energy savings information from the various technology assessment studies noted above.

In scaling up the technology-specific energy savings, we relied on our general knowledge of the various industrial processes to which this technology could be applied. We also took into account structural limitations to the penetration of the technology. Additionally, we recognized that market penetration, in the absence of significant policy support, can take time given the slowness of stock turnover in many industrial facilities.

Thirty-nine distinct measures were analyzed across 22 industrial subsectors for the NYSERDA analysis. The measures include:

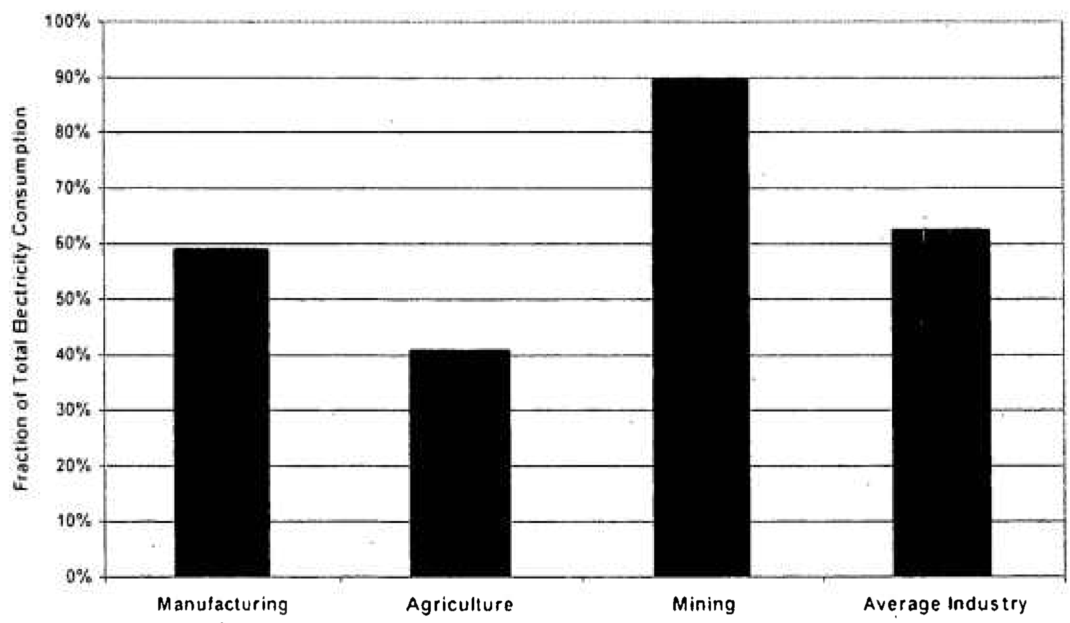
- Sensors and Controls
- Energy Management Systems
- Membrane Technology Wastewater
- Advanced Industrial HVAC
- Energy Information Systems
- Efficient Transformers (Tier 1)
- Efficient Transformers (Tier 2)
- Duct/Pipe Insulation
- Heat Recovery Food Industry - Low Temperature
- Cooling and Storage
- Electric Supply System Improvements
- Microwave Processing
- Radio Frequency (RF) Heating and Drying
- Efficient Lighting Design -- Office
- Efficient Lighting Design -- Manufacturing
- Efficient Lighting Design -- Warehouse
- Efficient Lighting Fixtures and Lamps -- Office
- Efficient Lighting Fixtures and Lamps -- Manufacturing
- Efficient Lighting Fixtures and Lamps -- Warehouse
- Advanced Motor Designs
- Motor Management
- Advanced Lubricants
- Motor System Optimization
- Compressed Air System Management
- Air Compressor Systems Advanced Controls
- Pump Efficiency Improvement
- Fan system Efficiency
- Efficient Cell Retrofit Designs
- Advanced Forming/Near Net Shape Technology
- Liquid membrane Technologies-Chemicals
- Gas Membrane Technologies-Chemicals
- Advanced Cleanroom HVAC (Electronics)
- Advanced Cleanroom HVAC (Pharmaceuticals)
- Membrane Technology -- Food Industry
- Freeze Concentration
- Efficient Refrigeration Systems
- Ultraviolet (UV) Curing
- Electric Infrared (IR) Heating and Drying
- Optimization of Aeration Systems

Industrial Electricity End Uses

In order to determine the electricity savings for any technology, the fraction of the electricity to which the technology is applicable must be determined. Much of the energy consumed by industry is directly involved in processes required to produce various products. Electricity accounts for about one- third of the primary energy used by industries (DOE/EIA 2001b). Electricity is used for many purposes, the most important being to run motors, provide lighting, provide heating, and drive electrochemical processes. While detailed end-use data is available only for each manufacturing sub-sector and group through the MECS survey (DOE/EIA 2001a), motors are estimated to consume almost two-thirds of the industrial electricity (Xenergy 1998). The fraction of total electricity attributed to motors is presented in Figure 3.4.3, Fraction of Industrial Electricity Consumption by Motors. Direct process use, such as heating and electrolysis, appears to be the next most significant use, accounting for 25% of manufacturing electricity consumption, with lighting accounting for about 7% (DOE/EIA 2001a).

Motors are used for diverse applications, from fluid applications (pumps, fans, and air and refrigeration compressors), to materials handling and processing (conveyors, machine tools, and other processing equipment). The distribution of these motor uses varies significantly by industry, with fluid handling (i.e., pumps, fans, blowers, and compressors) being the largest consumer in most of the sector.

Figure 3.4.3 Fraction of Industrial Electricity Consumption by Motors (Source: Xenergy 1998).



While lighting and space conditioning represent a relatively small share of the overall electricity consumption in the industrial sector, they are important in some of the key industries found in the region, such as computers and semiconductors, and the electricity savings potential can be significant. Electrolytic and direct-heating processes are concentrated in particular industries, such as some inorganic chemicals (e.g., NAICS 3251, industrial gasses) and metals production (e.g., NAICS 3313, aluminum production).

The industrial team drew upon various proprietary sources to estimate the share of electricity consumption attributable to 15 end uses in each of the 22 industrial sub-sectors. Information on characterization of end uses by industry sub-sector or group can be found in Technical Appendix 5.3, Industrial Efficiency.

TECHNICAL AND ECONOMIC POTENTIAL

Results

As would be anticipated, the highest energy savings (in terms of total GWh) in all the scenarios lie in some of the most energy-intensive manufacturing industries in New York State. The energy-intensive chemicals industry still holds by far the greatest absolute potential for reduction in electricity demand. For this industry, liquid and gas membrane technologies hold the greatest potential for energy savings, since such a large portion of the chemical industry's energy use is devoted to separations. Cross-cutting measures such as those that improve the efficiency of motor, pump, and fan systems also hold great potential for this industry. Because of its high predicted growth rate in New York State, machinery manufacturing also will have a large absolute electricity savings potential by 2022. Motor and lighting systems will result in large energy savings for this industry as well.

The largest percentage savings versus baseline electricity use can be made in the textile industry. This industry relies heavily on processes such as dying and drying, and great gain can be made by concentrating on more efficient water pumping and water removal (drying) technologies. Other industries that can realize large electricity savings are machinery manufacturing as well as computer and electronics manufacturing. Cross-cutting technologies will have great impact on these industries.

Special Notes About Industrial Sector Results

Compared to the residential and commercial building sectors, the industrial-sector savings potential can seem rather small. There are several reasons for this apparent incongruity. The analysis that was performed in this study was a "bottoms-up" analysis. By this we mean that a finite number of measures was used to estimate savings potential. The overall savings potential for the industrial sector may indeed be slightly larger than what we estimate in this study if all industrial-efficiency technologies are considered. However, we believe that we have chosen a portfolio of measures that represents the vast majority of savings potential.

Some additional reasons for seemingly low savings potentials have to do with the manner in which efficient equipment is purchased and installed at these facilities. The buildings sector has a significant retrofit market for efficiency technologies that is not present in the industrial sector. Equipment "retrofitting" as it is performed in commercial and residential buildings is rarely performed in industry. Equipment is usually changed or replaced at two points during the life of an industrial plant: at the construction of a new plant or process line, or during one of a few regularly scheduled maintenance periods throughout the year.

Equipment therefore is generally installed new or upon failure. Additionally, there is a relatively low capital-turnover rate in industry that does not favor process improvements.

An important consideration to keep in mind when when evaluating the efficiency potential for New York State industry is the fact that the State as a whole has been very successful in encouraging efficiency in industry. Long-standing programs such as NYSERDA's FlexTech Commercial and Industrial Program (FlexTech) have succeeded in significantly reducing the industrial electricity intensity in New York. The State's industrial energy programs are some of the best in the nation, as efficiency opportunities have not been as aggressively pursued in other states. New York's industrial sector also will benefit less from the impact of future building codes, which focus more on the commercial sector.

Technical Potential

Once the baseline electricity consumption and end-use data for each industrial sub-sector was established, it was possible to determine the savings potential of each industrial measure. For each measure and industrial sub-sector, an eligible potential factor, applicability coefficient, and percent savings potential were determined based on consumption in the sub-sector and applicable end use for the technology under consideration. The eligible potential factor is the sum of the total electricity end uses within each sub-sector for which the measure applies. The applicability coefficient is the estimated portion of these end uses for which the measure is applicable. The percent savings potential is the estimated reduction in energy consumption as a result of the measure. To estimate annual electricity consumption savings, the estimated baseline electricity consumption was multiplied by the eligible potential factor, applicability coefficient, and percent savings potential.

It is important to note that the methodology used to estimate the savings potential for the State's industrial sector is a bit different than that used for the commercial and residential buildings sectors. The classic equipment categories of new construction, replacement, and retrofit do not apply in the same way for the industrial sector. As noted, industrial facilities typically install equipment at two points in time: during construction of a new plant or process line, or during a regularly scheduled maintenance period (i.e., equipment generally is replaced on failure or at the end of its useful life). The retrofit market as it applies to the commercial and residential sectors is much more limited for industry. As a result, we determined that only the new and replace-on-failure industrial equipment categories would be included in this analysis. Also, there were no interactive effects among the measures considered for the industrial analysis.

The largest technical savings (in GWh) for the industrial sector are in the chemical industry and in machinery manufacturing, computer and electronics manufacturing, and paper manufacturing. The largest savings potential (by percentage) lies in textile manufacturing, machinery manufacturing, computer and electronics manufacturing, and agriculture.

Statewide technical potential by industry is shown in Table 3.4.2, Statewide Technical Potential by Industry. Technical Appendix 5.3, Industrial Efficiency, includes more detailed tables regarding technical potential.

Figure 3.4.4 Industrial Technical Potential By Industrial Subsector

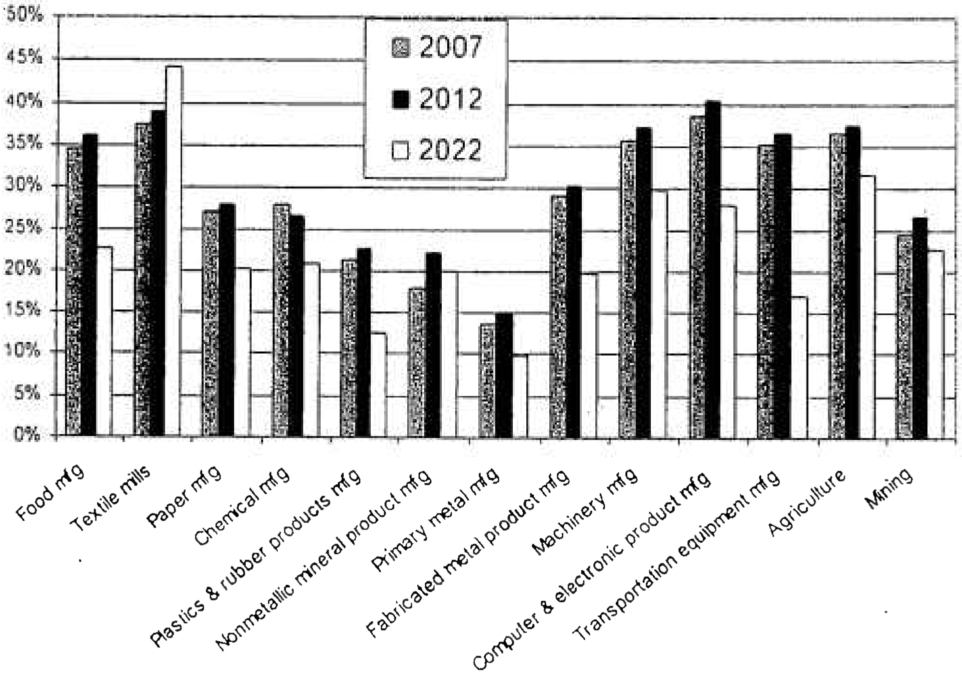


Table 3.4.2 Statewide Technical Potential by Industry

		GWh Measure Savings		
NAICS Code	INDUSTRY	2007	2012	2022
311	Food Manufacturing	461.0	476.2	303.6
313	Textile mills	349.5	352.5	392.3
322	Paper Manufacturing	637.6	623.7	424.1
325	Chemical Manufacturing	1,938.0	1,882.2	1,594.6
3254	Pharmaceutical & medicine Manufacturing	571.8	607.5	476.1
3259	Other chemical product Manufacturing	621.0	656.6	519.6
326	Plastics & rubber products Manufacturing	216.1	221.7	119.8
3261	Plastics product Manufacturing	258.7	260.6	129.4
327	Nonmetallic mineral product Manufacturing	224.4	312.1	369.2
3271	Clay product & refractory Manufacturing	45.0	61.8	62.7
3272	Glass & glass product Manufacturing	48.7	68.1	75.4
3273	Cement & concrete product Manufacturing	68.9	93.8	98.3
3279	Other nonmetallic mineral product Manufacturing	61.9	88.4	94.8
331	Primary metal Manufacturing	549.1	639.9	489.2
3313	Alumina & aluminum production & processing	763.5	922.8	936.2
3314	Nonferrous metal (except aluminum) production & processing	93.6	53.5	(33.3)
332	Fabricated metal product Manufacturing	340.1	369.1	271.9
333	Machinery Manufacturing	591.4	754.6	942.9
334	Computer & electronic product Manufacturing	399.8	454.5	384.1
336	Transportation equipment Manufacturing	223.7	217.2	91.8
11	Agriculture	180.4	209.1	233.2
21	Mining	54.9	62.5	60.1
	TOTAL	6,166.0	6,575.2	5,676.7

Economic Potential

The results of the technical potential analysis were used to obtain the economic potential for New York State. The societal cost-per-measure was determined and applied to the economic potential model developed by Optimal Energy. It is important to note that a large portion of the technical potential was determined to be economically viable. This situation indicates that for the industrial sector, the barriers to efficiency are not simply economic.

As noted, the greatest GWh potential for economic savings lies in the chemical and machinery manufacturing industries. By percentage, textile mills represent the largest area for potential savings. Transportation equipment, agriculture, and mining also potentially hold a large percentage for electricity savings.

The results of the economic potential analysis (based on high avoided costs) are listed in Table 3.4.3, Statewide Economic Potential (High Avoided Costs). Technical Appendix tables 5.3.4.7 through 5.3.4.13 include more detail regarding economic potential.

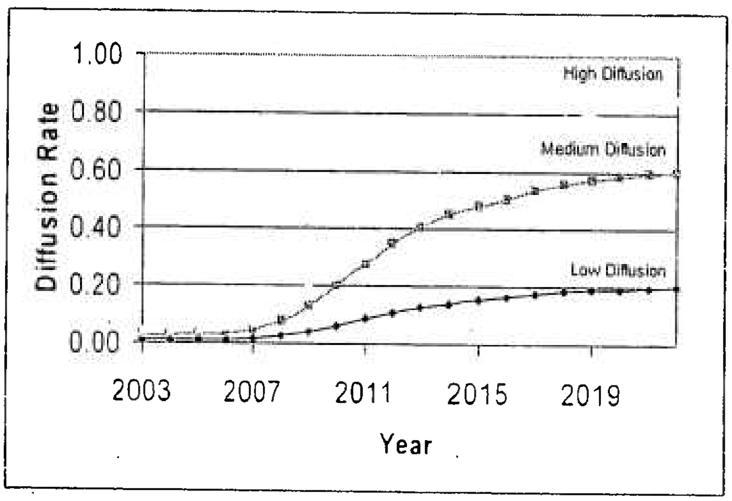
Table 3.4.3 Statewide Economic Potential (High Avoided Costs)

		GWh Measure Savings		
NAICS Code	INDUSTRY	2007	2012	2022
311	Food Manufacturing	421.2	433.9	259.7
313	Textile mills	320.5	320.6	358.9
322	Paper Manufacturing	620.8	605.6	405.9
325	Chemical Manufacturing	1,867.4	1,801.3	1,501.7
3254	Pharmaceutical & medicine Manufacturing	543.1	575.6	440.6
3259	Other chemical product Manufacturing	590.8	623.1	481.9
326	Plastics & rubber products Manufacturing	199.1	203.2	100.7
3261	Plastics product Manufacturing	241.5	242.0	110.3
327	Nonmetallic mineral product Manufacturing	176.8	247.4	269.9
3271	Clay product & refractory Manufacturing	42.3	57.7	56.8
3272	Glass & glass product Manufacturing	45.2	63.0	68.3
3273	Cement & concrete product Manufacturing	67.0	91.0	94.4
3279	Other nonmetallic mineral product Manufacturing	57.2	80.9	83.7
331	Primary metal Manufacturing	525.5	611.7	454.0
3313	Alumina & aluminum production & processing	753.3	910.0	920.4
3314	Nonferrous metal (except aluminum) production & processing	59.7	35.1	6.1
332	Fabricated metal product Manufacturing	301.5	326.0	222.1
333	Machinery Manufacturing	515.3	653.0	778.3
334	Computer & electronic product Manufacturing	343.0	387.5	299.4
336	Transportation equipment Manufacturing	198.0	191.0	67.2
11	Agriculture	175.8	202.8	223.3
21	Mining	53.3	60.8	58.2
	TOTAL	5,718.2	6,045.1	4,999.3

ACHIEVABLE SAVINGS AND COSTS FOR MEETING GREENHOUSE GAS EMISSIONS TARGETS

For the Greenhouse Gas (GHG) Scenario, it became necessary to determine the portion of total savings that would be attributed to each measure and industrial sub-sector. In order to make these determinations for the greenhouse gas emissions targets study, an estimate of realistic technology diffusion (in the absence of programmatic intervention) was made for each measure. Each measure was estimated to have a low, medium, or high rate of natural diffusion into the market. Assignments were made by project staff based on professional judgemnt and a review of penetration rates over time for selected technologies. A list of diffusion rates for the specific technology measures is included below.

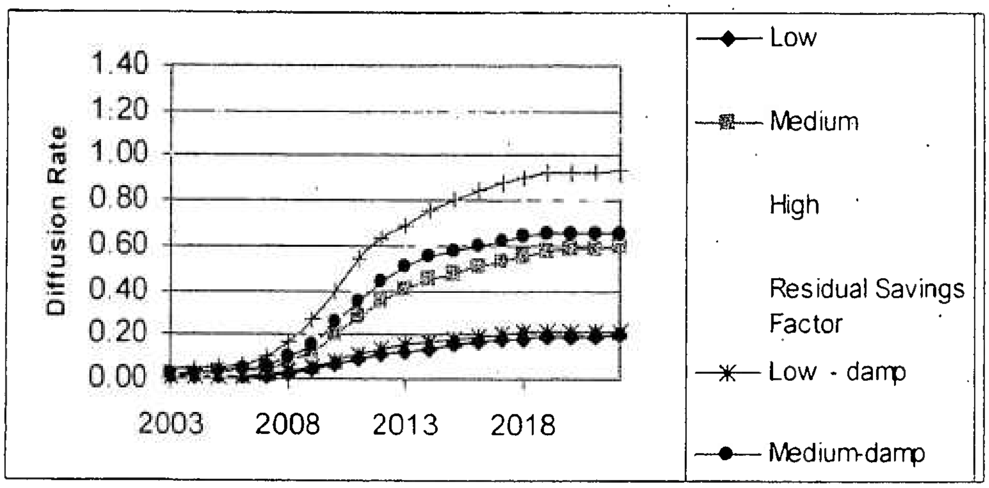
Figure 3.4.5 Estimated Technology Diffusion Rates.



A measure with a low rate of diffusion was estimated to achieve 30% of its technical potential in 2022. Measures with medium and high rates of diffusion were estimated to achieve 60% and 85% of their technical potential in 2022, respectively. The diffusion curves used for the measures are displayed in Figure 3.4.6, Diffusion Curves for Greenhouse Gas Reduction Scenario.

Once these estimates were made, we estimated the impacts the New York programs would have on the measure diffusion. For this study, it was determined that an aggressive greenhouse gas reduction scenario would be in effect. In the GHG-reduction target scenario, relatively aggressive electricity reductions can be achieved. The programmatic interventions that occur under the currently planned initiatives are estimated to continue to affect electricity consumption. It has been estimated that these programs will have residual effects through 2022. Section 4 of the Efficiency Technical Appendix (Volume 5) describes conceptually the kinds of aggressive industrial market-intervention strategies that could help achieve the market-penetration rates needed to reach the State's GHG reduction targets.

Figure 3.4.6 Diffusion Curves for Greenhouse Gas Reduction Scenario



EXPECTED ACHIEVEMENTS UNDER CURRENTLY PLANNED INITIATIVES

The analysis of the results achievable from the Current Planned Initiatives (CPI) Scenario was difficult to assess for the industrial sector because the analysis methodology used was technology-based, and most of the programs in New York State are not technology-specific.

NYSERDA, LIPA, and NYPA have several initiatives under way that serve the industrial sector. These initiatives include:

- Standard Performance Contract
- FlexTech (Commercial and Industrial - C&I)
- Energy $mart[s/m] Loans (C&I)
- Premium Efficiency Motors (C&I)
- New Construction Program (C&I)
- LIPA New Construction (C&I)
- NYPA (C&I)
- Smart Equipment Choices (C&I)
- Compressed Air (C&I)

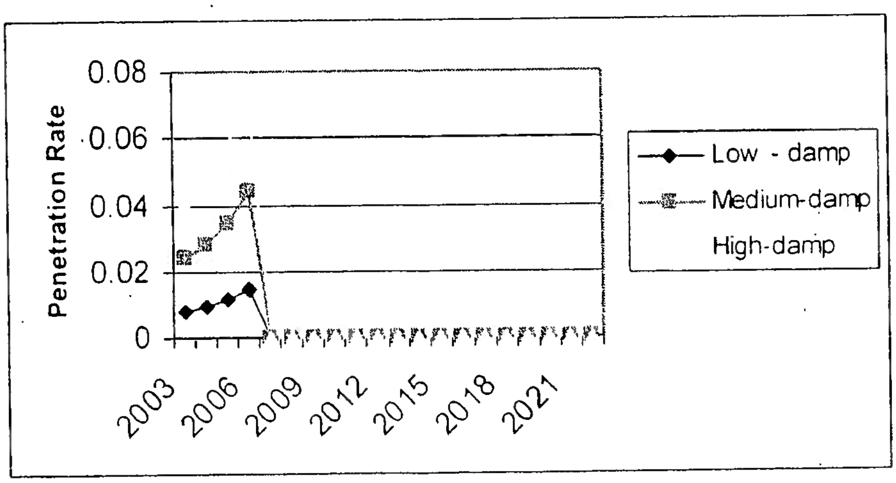
Table 3.4.4, New York Industrial Program Savings, lists the pertinent data for the industrial portion of these energy-efficiency programs. Data were obtained from the *New York EnergySmart Program Evaluation and Status Report*. Better targeting of program services to energy-intensive industries could also result in higher savings.

Table 3.4.4 New York Industrial Program Savings

Program Title	Industrial Portion of Program	Annual Budget ($ Million)	Annual Program Savings (GWh)
Standard Performance Contract	33%	6.05	38.1
Flex Tech	33%	1.03	26.5
Energy Smart Loans	33%	0.65	2.2
Premium Efficiency Motors	67%	0.67	0.9
New Construction	18%	3.36	9.6
LIPA New Construction			4.4
NYPA			11.6
TOTAL			93.3

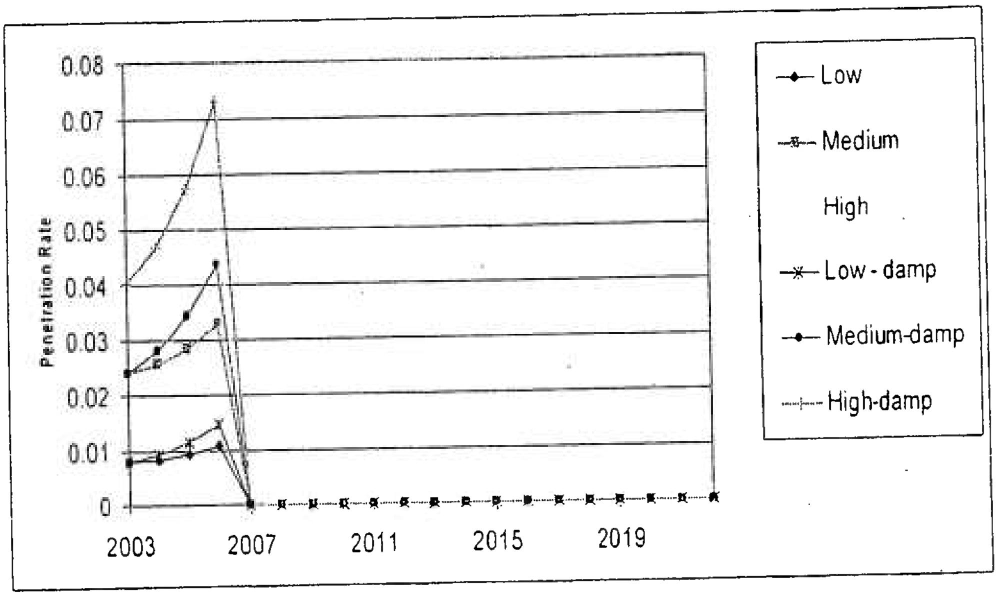
Once the total possible estimated savings were determined for the industrial programs, it became necessary to determine the portion of total savings that would be attributed to each measure and each industrial sub-sector. In order to make these determinations, an estimate of realistic technology diffusion (in the absence of programmatic intervention) was made for each measure. Each measure was estimated to have a low, medium, or high rate of natural diffusion into the market. A measure with a low rate of diffusion was estimated to achieve 15% of its technical potential in 2022. Measures with medium and high rates of diffusion were estimated to achieve 45% and 75% of their technical potential in 2022, respectively. In the CPI Scenario, however, programmatic intervention was assumed to end in 2006. The truncated diffusion curves used for the measures are displayed in Figure 3.4.7, Diffusion Curves for Currently Planned Initiatives.

Figure 3.4.7 Diffusion Curves for Currently Planned Initiatives



Once these estimates were made, an estimate of impacts that New York State programs would have on the measure diffusion was made. For this study, it was determined that New York State programs would be in effect only through 2006. A residual savings factor for how the programs would affect the measure diffusion during and after the program period was created. It was estimated that 10% of the program effects would be maintained at the end of the model period in 2020. Figure 3.4.8, Currently Planned Initiatives --Impacts of Intervention, illustrates the incremental increase in measure diffusion due to the programmatic intervention.

Figure 3.4.8 Currently Planned Initiatives -- Impacts of Intervention



The diffusion rates for each measure were estimated as follows in Table 3.4.5, Estimated Technology Diffusion Rates.

Table 3.4.5 Estimated Technology Diffusion Rates

Measure	Natural Diffusion Rate
Sensors and controls	Medium
Energy Management systems	Low
Membrane technology wastewater	Medium
Advanced Industrial HVAC	Medium
Energy Information Systems	Medium
Efficient Transformers (Tier 1)	Low
Efficient Transformers (Tier 2)	Low
Duct/Pipe Insulation	High
Heat recovery food industry - low temperature	Low
Cooling and storage	Low
Electric supply system improvements	Low
Microwave processing	Low
RF heating and drying	Low
Efficient lighting design -- Office	High
Efficient lighting design -- Manufacturing	Medium
Efficient lighting design -- Warehouse	Medium
Efficient lighting fixtures and lamps -- Office	High
Efficient lighting fixtures and lamps -- Manufacturing	Medium
Efficient lighting fixtures and lamps -- Warehouse	Medium
Advanced motor designs	Low
Motor management	Medium
Advanced lubricants	High
Motor system optimization	Low
Compressed air system management	High
Air Compressor Systems Advanced Controls	High
Pump efficiency improvement	Medium
Fan system efficiency	Medium
Efficient cell retrofit designs	Medium
Advanced forming/near net shape technology	Medium
Liquid membrane technologies-chemicals	Low
Gas membrane technologies-chemicals	Low
Advanced Cleanroom HVAC (Electronics)	Medium
Advanced Cleanroom HVAC (Pharmeceuticals)	Medium
Membrane technology -- food	Low
Freeze concentration	Low
Efficient refrigeration systems	Medium
UV curing	Low
Electric IR heating and drying	Low
Optimization of aeration systems	High

Once these values were assigned to each measure, the energy savings for the program period were calibrated and ramped-up from NYSERDA's estimates of savings in 2002 to our estimates of possible savings in 2006. The estimated savings under New York State's currently planned initiatives are listed in Table 3.4.6, Statewide Savings under Currently Planned Initiatives (High Avoided Costs).

Table 3.4.6 Statewide Savings Under Currently Planned Initiatives (High Avoided Costs)

		GWh Measure Savings		
NAICS Code	**INDUSTRY**	2007	**2012**	**2022**
311	Food Manufacturing	2.6	1.7	0.1
313	Textile mills	0.3	0.2	0.0
322	Paper Manufacturing	3.1	2.6	0.4
325	Chemical Manufacturing	8.1	5.4	0.9
3254	Pharmaceutical & medicine Manufacturing	3.0	2.0	0.3
3259	Other chemical product Manufacturing	3.2	2.1	0.3
326	Plastics & rubber products Manufacturing	1.2	0.7	0.1
3261	Plastics product Manufacturing	1.5	1.0	0.1
327	Nonmetallic mineral product Manufacturing	0.7	0.5	0.1
3271	Clay product & refractory Manufacturing	0.2	0.1	0.0
3272	Glass & glass product Manufacturing	0.2	0.1	0.0
3273	Cement & concrete product Manufacturing	0.3	0.2	0.0
3279	Other nonmetallic mineral product Manufacturing	0.3	0.2	0.0
331	Primary metal Manufacturing	3.0	1.5	0.2
3313	Alumina & aluminum production & processing	4.0	3.2	0.1
3314	Nonferrous metal (except aluminum) production & processing	0.5	0.4	0.1
332	Fabricated metal product Manufacturing	1.8	1.2	0.1
333	Machinery Manufacturing	3.1	2.1	0.2
334	Computer & electronic product Manufacturing	2.5	1.6	0.2
336	Transportation equipment Manufacturing	1.3	0.9	0.1
11	Agriculture	0.9	0.7	0.1
21	Mining	0.2	0.2	0.0
	TOTAL	28.9	19.2	2.7

Under the currently planned initiatives, the largest electricity savings will be achieved by the historically energy-intensive industries such as chemicals and primary metals. The savings will remain high in 2007 through 2012 but will then trail off, as efficient equipment and practices outlive their useful economic lives. In terms of the percentage of electricity used by this sector, the manufacture of food, computer and electronic products, machinery, transportation equipment, and agriculture will have the greatest savings under these programs

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