FINAL

CAPE LIGHT COMPACT

RESOURCE ASSESSMENT

Strategic Options in
Electric Supply and Demand
for Cape Cod and Martha's Vineyard
2005-2015

Prepared for the Cape Light Compact
by Ridley & Associates, Inc.
with Synapse Energy Economics, Resource Insight, Inc. and Distributed Utility Associates

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The *Resource Assessment* was designed and managed for the Cape Light Compact by Ridley & Associates, Inc. which also conducted research and analysis.

The five technical studies were prepared by three groups of industry analysts: Synapse Energy Economics, Inc. prepared *Energy Efficiency Potential on Cape Cod and Martha's Vineyard: Long-Term Forecasts and Scenarios.* Resource Insight, Inc. prepared *Peak-Shaving/Demand Response Analysis: Load-Shifting by Residential Customers* and also prepared *Costs and Environmental Effects of Wind Turbines and Natural Gas Generation.* Distributed Utility Associates prepared *End-User Distributed Generation Applications in the Cape Light Compact Communities* and also prepared *Utility Distributed Generation Applications in the Cape Light Compact Communities.*

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The Cape Light Compact is an organization of all 21 towns and two counties on Cape Cod and Martha's Vineyard. The Compact's general mission is to protect and advance the interests of consumers and member communities in an emerging competitive market for energy supply. The Compact currently operates a Pilot Project for competitive supply for 50,000 electric customers; operates the regional energy efficiency program; and has a deep interest in facilitating development of distributed generation and "clean and green" energy supply.

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1.0 Introduction

1.1 Purpose of the Resource Assessment

The *Resource Assessment* has been prepared to provide perspective and technical information on strategic electric supply and demand options for the 21 communities on Cape Cod and Martha's Vineyard. It places renewable energy resources and clean generating technologies in a broad context. It is intended to offer a basis for development of policies and planning for near-term and long-term production and usage of electricity in the region. The five studies it contains present evaluations of the potential for energy efficiency, distributed generation, peak-shaving, and production cost estimates for wind and natural gas-fired plants through 2015.

The *Resource Assessment* is one of four documents prepared concerning the region's electric energy future. Together with a *Regulatory Assessment* which focuses on local zoning and permitting barriers, the *Resource Assessment* serves as a technical source document for a *Regional Options Study* issued for public review and comment in a second stage of evaluation of electric supply and conservation opportunities. A third stage document, an *Energy Plan* for Cape Cod and Martha's Vineyard communities, is based on public comments on the *Regional Options Study*. The *Energy Plan* offers a policy framework for the region. It is a "living document" to be updated as technologies, markets, and policies evolve over time.

1.2 Scope and Methodology

The *Resource Assessment* outlines a starting point for technical examination of energy policy and planning for the region. The five studies it contains focus on strategic electric supply and demand options for Cape Cod and Martha's Vineyard communities for three target years: 2005, 2010, and 2015. It also contains profile information for the Cape and Vineyard electric supply and consumption. And it includes a brief discussion of electric system infrastructure; retail, wholesale and green power supply markets; and resources in the region that may affect implementation of options. This background is intended to provide a general context for the studies.

The five studies utilize common baseline data from the New England Power Pool, NSTAR Electric, the Massachusetts Division of Energy Resources and industry sources. This information is applied to the specific costs, conditions and electric usage profiles of the Cape and Vineyard communities. The analyses examine all Cape and Vineyard communities combined, as well as the Cape and Vineyard as separate areas with specific distinctions in growth rates, fuel costs, and opportunities for technology installation.

Only "clean" generating technologies utilizing renewable resources, natural gas or propane fuel and currently in the market or entering the market are considered in the study. These technologies include: microturbines, fuel cells, reciprocating engines, photovoltaic systems, wind turbines, and combined cycle plants. Not included at this time are generating technologies for wave power, tidal power, ocean thermal energy, or energy storage technologies which may offer meaningful alternatives in the future. Similarly, the study does not evaluate options for undergrounding of the distribution system, or superconductors for transmission at this time. The study does not include assumptions concerning the viability of specific generating projects.

The studies evaluate the benefits and costs for energy conservation, renewable and distributed energy development for the region. They include estimates production costs and environmental impacts of new utility scale power plants in the New England region, and estimates of reductions in emissions from utilization of these options. The results provide data and information for consideration of alternatives to investment in generating plants and the transmission and distribution system serving Cape and Vineyard communities.

Ridley & Associates designed the project, provided project management, conducted related research and analysis, and prepared the *Resource Assessment* with the oversight of the Cape Light Compact Distributed Resources Committee. The five studies within the *Resource Assessment* were prepared by electric industry analysts from three consulting firms utilizing standard industry practices for information and data gathering and analysis. Their results are based on industry experience and costs of other programs and projects.

Synapse Energy Economics, Inc. conducted analysis for the Energy Efficiency study (*Energy Efficiency Potential on Cape Cod and Martha's Vineyard: Long-Term Forecasts and Scenarios*). Synapse utilized current energy efficiency experience and planning for the region to evaluate four cases for possible expansion of these programs for both the Cape and Vineyard.

Resource Insight, Inc. (RII) conducted analysis for Peak-Shaving for residential customers (*Peak-Shaving/Demand Response Analysis: Load-Shifting by Residential Customers*). For this analysis RII surveyed similar programs, estimated average customer response, evaluated differences in peak and off-peak rates, and projected customer and aggregate load impacts. RII also conducted the research and analysis for the Wind/Natural Gas study (*Costs and Environmental Effects of Wind Turbines and Natural Gas Generation.* The methodology included a survey of costs for newly installed plants and estimation of production costs. It also briefly reviewed environmental impacts related to siting and energy production by wind and natural gas fired generating units.

Distributed Utility Associates (DUA) conducted two Distributed Generation studies. DUA examined the potential cost-effective end-user market penetration of distributed generation for both Martha's Vineyard and the Cape (*End-User Distributed Generation Applications in the Cape Light Compact Communities*). In a second study, DUA examined utility application of distributed generation to augment or offset costs of the transmission and distribution system (*Utility Distributed Generation Applications in the Cape Light Compact Communities*).

Each of the five studies can be read as stand-alone documents. However, the studies offer greater value when considered as integral parts of a whole picture concerning strategic options for electricity supply and demand for the region. Within this larger perspective, the sum is greater than the parts in outlining opportunities to develop implementation targets for the Cape and Vineyard.

1.3 Resource Assessment Overview

The *Resource Assessment* shows substantial opportunities for development of strategic options for electric supply and demand for the entire study period of 2005 to 2015. For demand-side options there is a potential for one-third of the projected Cape and Vineyard power supply to be met by cost-effective distributed generation and energy efficiency by 2015. For supply-side options that may be undertaken by competitive suppliers, additional potential for the region arises with the installation of new wind-powered and natural gas-fired utility scale generating facilities, if appropriate sites are available. At an optimum level, all of the region's needs could be met by combining utility-scale development with customer demand-side energy efficiency and distributed generation. All of the options would reduce emissions below those projected for the New England Power Pool.[1]

Various scenarios can be constructed to outline the potential for customer demand-side options and utility-scale supply-side options. However, such scenarios need to be considered for illustrative purposes only. Target levels of development for any option or technology will be constrained by the characteristics and preferences of the region's electric customers, transmission and distribution infrastructure, fuel availability and cost, market conditions, site availability, and policy evolution. (See *Regional Options Study* for option illustrations.)

Section 2 outlines electric supply profile data for the Cape and Vineyard communities. It notes the historic and anticipated electric usage growth on the Cape and Martha's Vineyard. It also notes that the rate of growth and resulting stresses on the supply system for the Cape and Vineyard will require greater supply resources and on-going investment in expansion and maintenance of the transmission and distribution system. This section includes several graphs delineating growth and annual electric usage and demand on the Cape and the Vineyard.

Section 3 describes the current electric supply infrastructure on the Cape and Vineyard and the transport system for natural gas. This section includes a map of the transmission and distribution system and location of substations.

Section 4 reviews the "base case" and existing local supply resources, and new options for research and development. It notes both "demand side" options that can be undertaken by consumers and their communities, and "supply side" options undertaken through power supply purchases and utility-scale development.

Section 5 describes the retail and wholesale electric supply markets. It notes that in addition to local conditions, changes in federal and state law, the evolution of the competitive market system, and rules for ISO New England which coordinates markets and use of the regional electric grid will influence costs and options for Cape and Vineyard consumers.

[1] The only exception is a single landfill gas facility prior to 2010.

Section 6 is a summary of the main points of the *Resource Assessment*. In general, the *Resource Assessment* indicates while reliance on the New England regional central generating units (and power imports from Canada and New York) could remain the core supply for the Cape and Vineyard through 2015, substantial opportunities exist to promote economic savings, renewable energy supply, reduction in emissions, and greater system reliability through the development of local strategic electric supply and demand options. The ability to implement such options will be affected by infrastructure constraints as well as changes in policy and market evolution.

A Glossary includes terms commonly used in the *Resource Assessment*.

The Appendix contains each of the five technical studies.

2.0 Cape Cod/Martha's Vineyard Electric Supply Data

2.1 Historical Electric Supply Data

According to NSTAR Electric data, at the end of 2002 there were 194,928 metered electric customers being served in the 21 towns on the Cape and Martha's Vineyard. Of these, 87 percent are residential, 12 percent are commercial or industrial, 1 percent is municipal. The number of customers has increased by an average of 1.1 percent annually since 1998. The number of Vineyard customers has increased by 6.8 percent and the number of Cape customers by about 4.1 percent. (See Figure 2A)

During the same period, electric usage has increased at the rate of 3.5 percent per year from 1,663,123 megawatt hours in 1998 to 1,911,914 megawatt hours in 2002. Residential, commercial and municipal customer usages have each grown by approximately the same percentage. In 2002, residential customers consumed 53.9 percent of the total kilowatt hours, commercial and industrial customers consumed 40.6 percent and municipal customers consumed 5.5 percent. (See Figures 2B, 2C and 2D)

The summer non-coincident peak demand for the region has increased 2 percent per year from 2000 to 2002 (394 megawatts to 410 megawatts). While the winter peak for the region has declined by 4 percent per year (376 megawatts to 343 megawatts) according to NSTAR Electric data. (See Figure 2E)

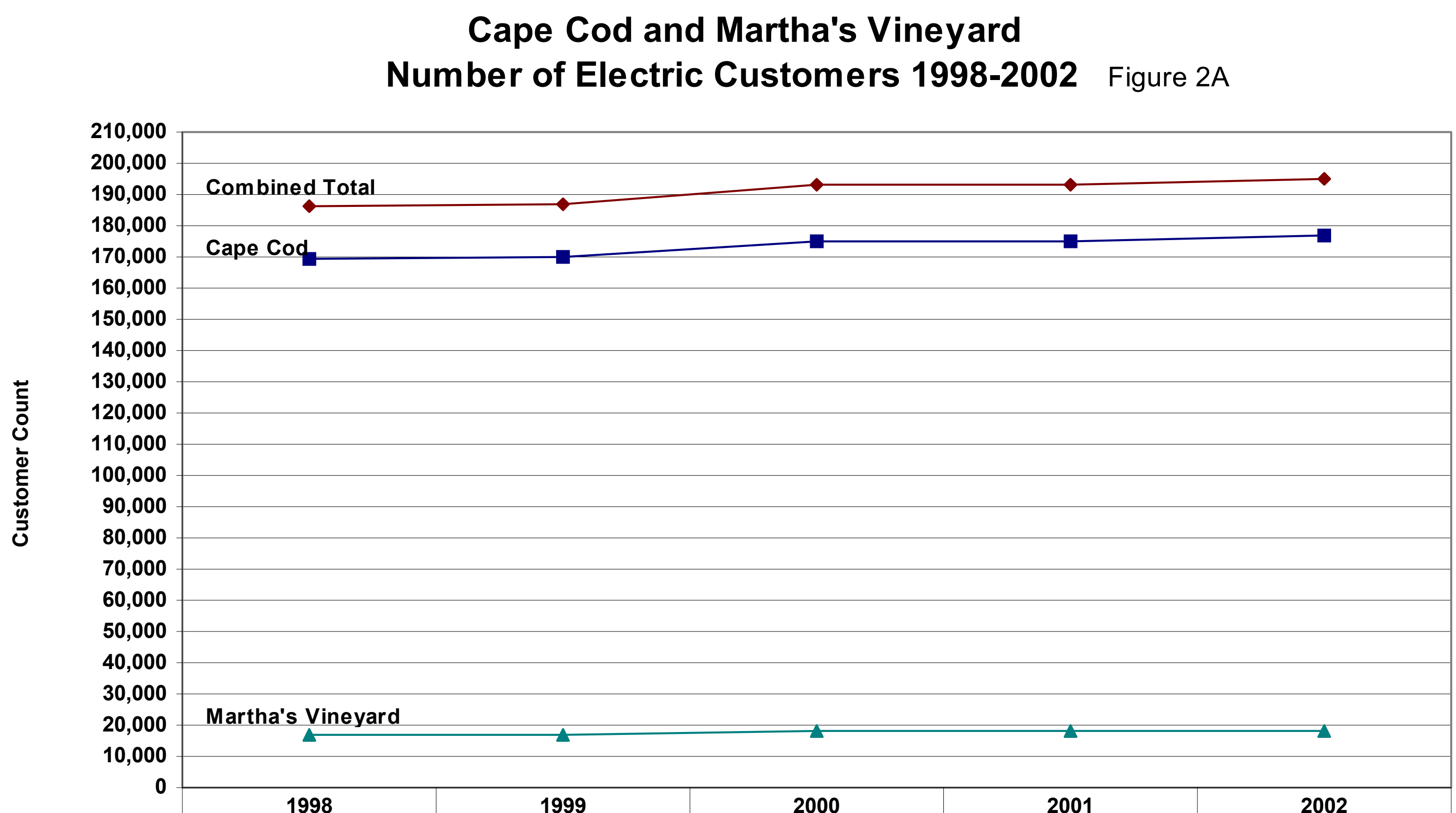
2.2 Electric Supply Forecast Data

Forecast growth for the Cape and Vineyard currently being utilized by NSTAR anticipates summer peak demand growth of 3 percent per year through 2005 and 2 percent after that time. If this level of growth were sustained it would increase summer peak demand for the region from 493.9 megawatts in 2005 to 596.8 megawatts in 2015. The Vineyard demand would grow from 45.9 megawatts in 2005 to 50.7 megawatts in 2015 and the Cape demand would grow from 448 megawatts in 2005 to 546.1 megawatts in 2015. (See Figure 2F)

Assuming a similar growth rate for electric usage, the total kilowatt hours consumed on the Cape and Vineyard would increase from 2,062,237 megawatt hours in 2005 to 2,494,119 megawatt hours in 2015.[2] (See Figure 2G)

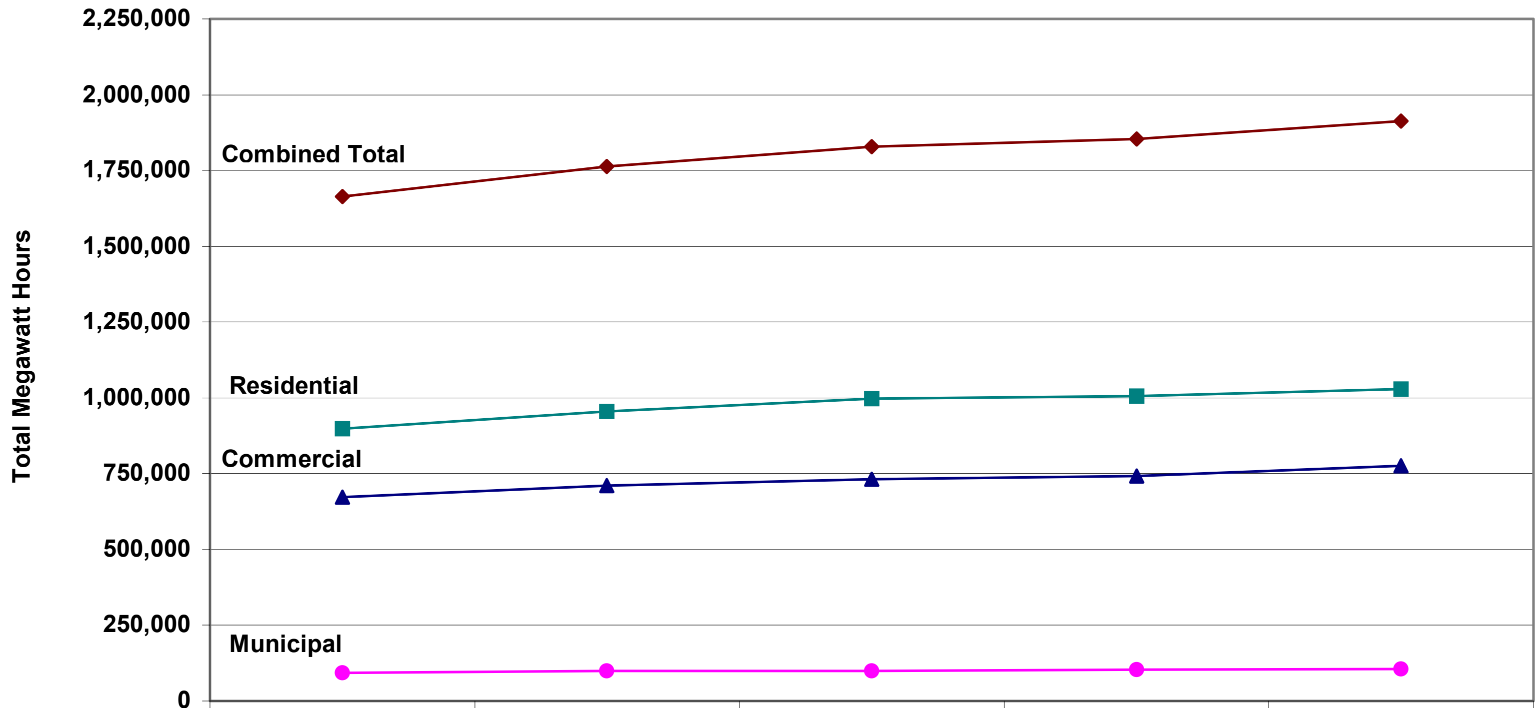
This increased electric usage and demand will require greater supply resources and on-going investment in expansion and maintenance of the transmission and distribution system. The methods and technologies utilized for reducing or meeting future demand will determine consumer costs and emissions levels.

[2] Electric use and demand forecasting is an imperfect science, and forecasts must be periodically updated to reflect changing conditions and trends. These figures represent the best estimate at this time.



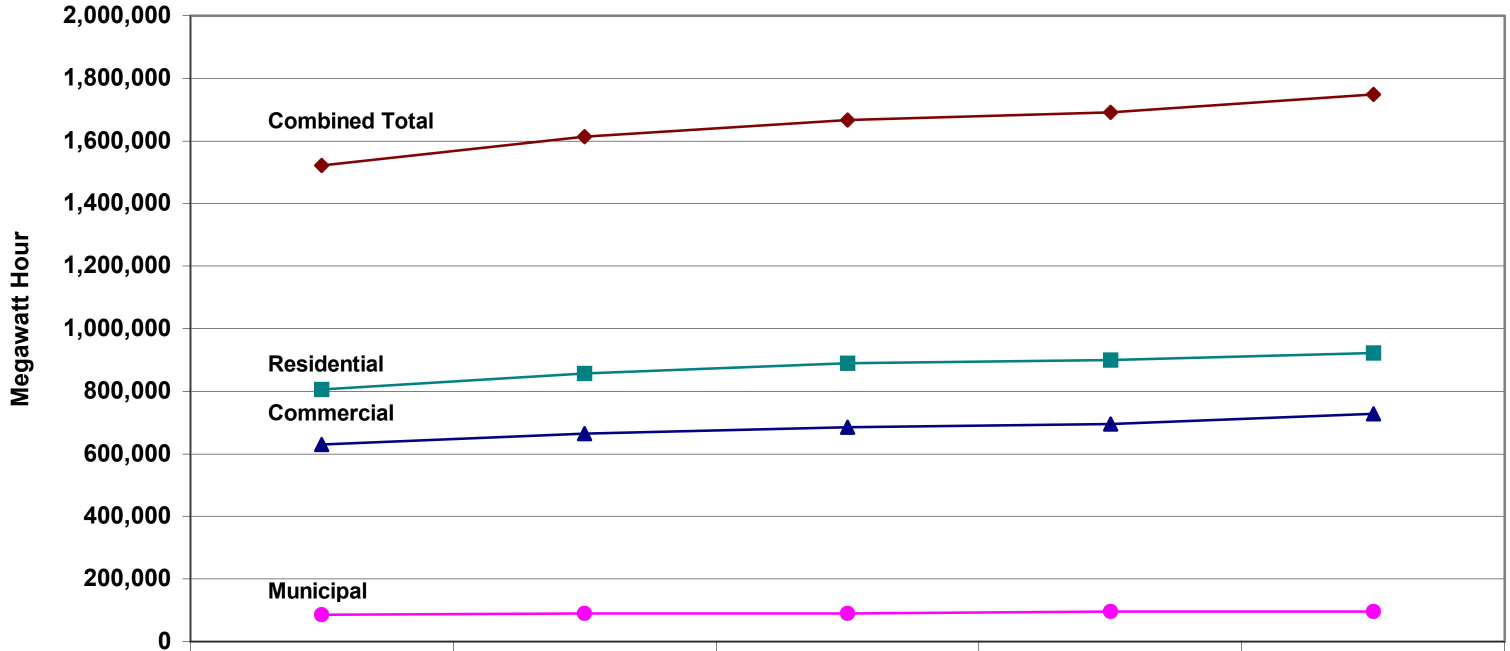
	1998	1999	2000	2001	2002
Combined Total	186,413	187,134	192,885	193,061	194,928
Cape Cod	169,482	170,026	175,042	175,146	176,750
Martha's Vineyard	16,931	17,108	17,844	17,915	18,178

Cape Cod And Martha's Vineyard
Annual Electric Usage By Customer Type 1998-2002 Figure 2B



	1998	1999	2000	2001	2002
Combined Total	1,663,123	1,763,901	1,827,431	1,852,904	1,911,914
Residential	897,777	954,795	997,731	1,005,664	1,030,076
Commercial	672,641	710,570	731,555	742,902	776,273
Municipal	92,706	98,536	98,145	104,338	105,565

Cape Cod
Annual Electric Usage by Customer Type 1998-2002 Figure 2C

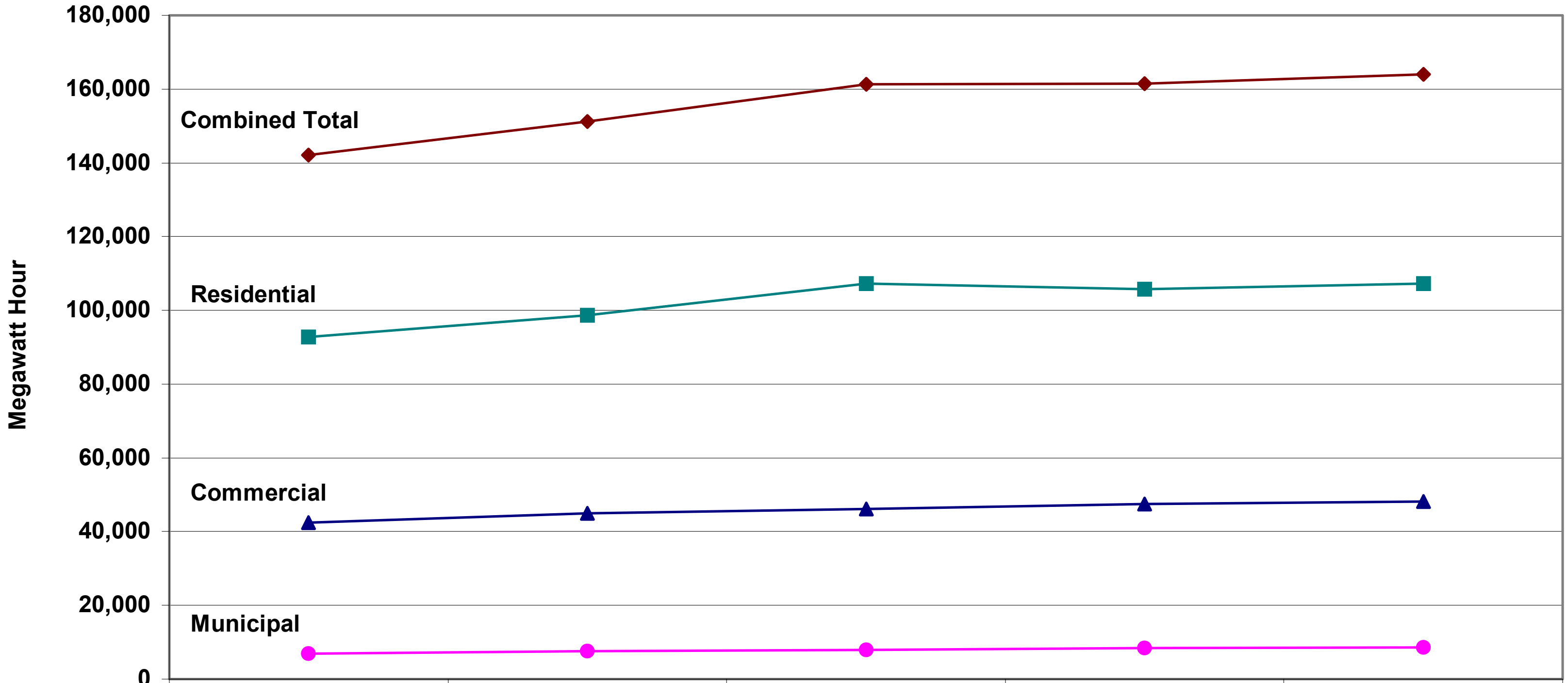


	1998	1999	2000	2001	2002
Combined Total	1,521,025	1,612,672	1,666,116	1,691,431	1,747,875
Residential	805,033	856,183	890,455	899,995	922,829
Commercial	630,249	665,605	685,355	695,439	728,056
Municipal	85,744	90,884	90,305	95,997	96,990

Year

Martha's Vineyard
Annual Electric Usage By Customer Type 1998-2002

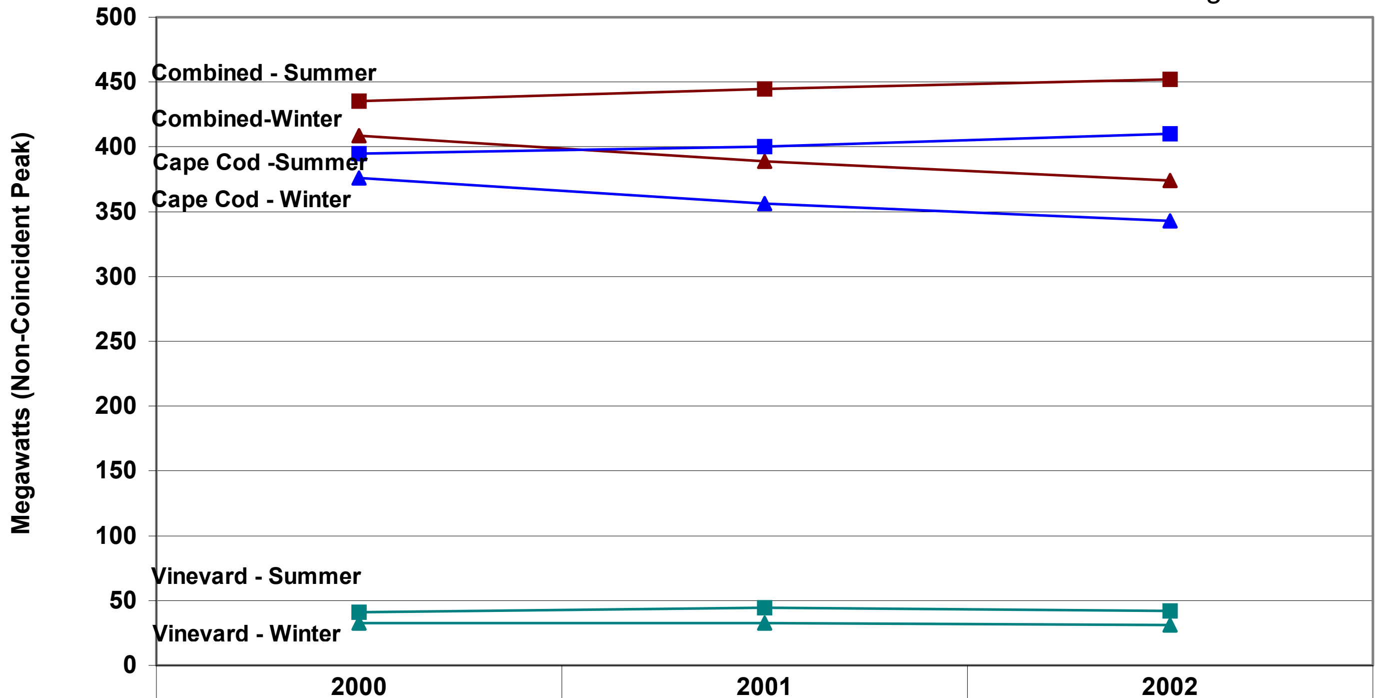
Figure 2D



	1998	1999	2000	2001	2002
Combined Total	142,098	151,229	161,315	161,473	164,039
Residential	92,744	98,612	107,276	105,669	107,247
Commercial	42,392	44,964	46,200	47,463	48,217
Municipal	6,963	7,652	7,840	8,341	8,575

Year

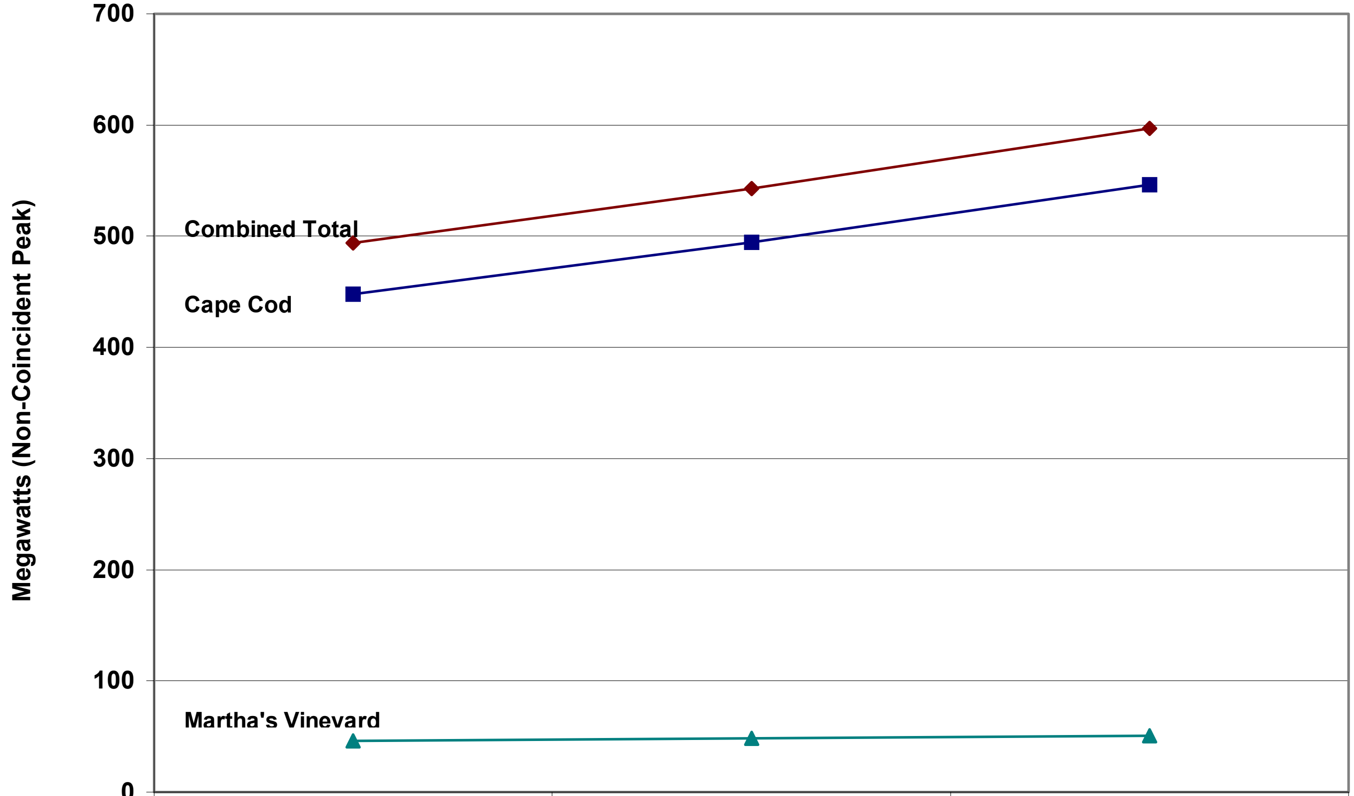
Cape Cod and Martha's Vineyard
Winter and Summer Peak Demand 2000-2002 Figure 2E



	2000	2001	2002
Combined - Winter	408.6	388.8	373.9
Combined - Summer	435.5	444.7	452.0
Cape Cod - Winter	376.0	356.0	343.0
Cape Cod - Summer	394.6	400.4	410.0
Vineyard - Winter	32.6	32.8	30.9
Vineyard - Summer	40.9	44.3	42.0

Cape Cod and Martha's Vineyard Projected Summer Peak Demand 2005-2015

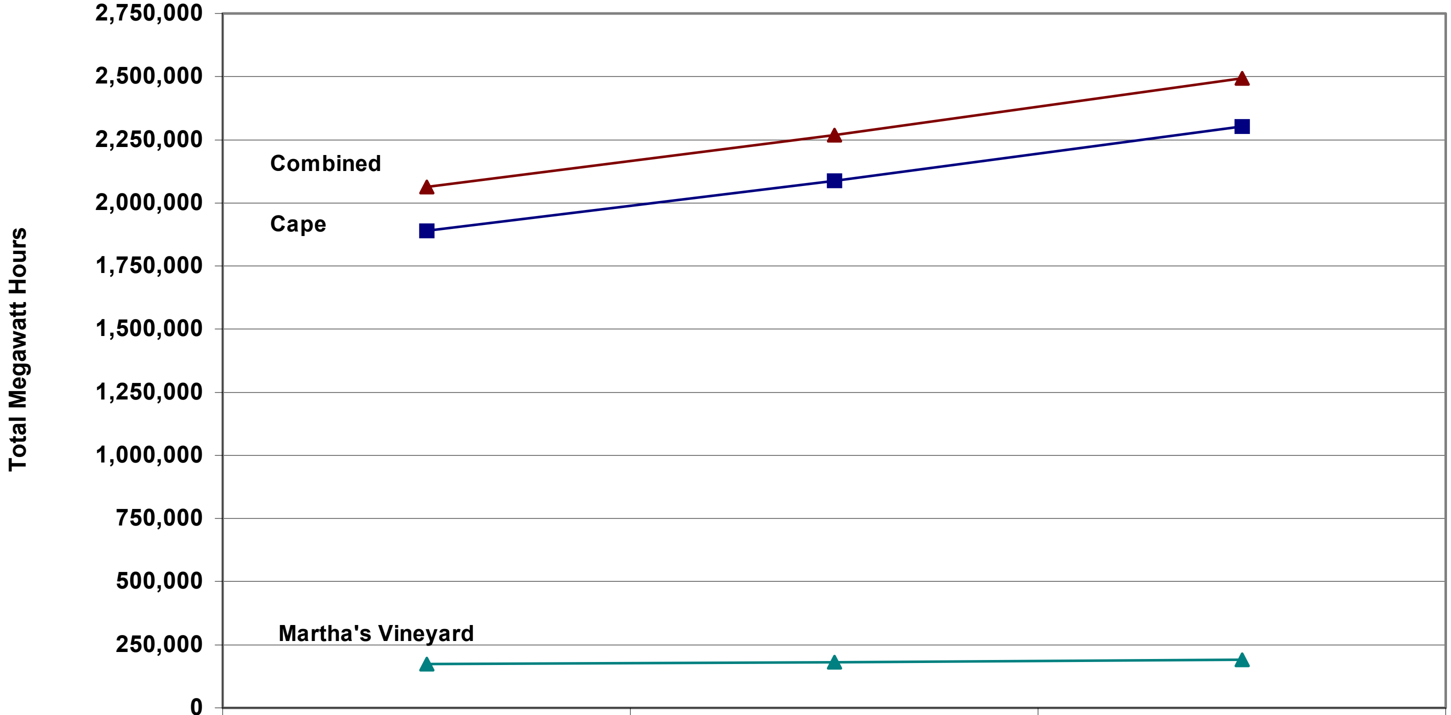
Figure 2F



	Summer 2005	Summer 2010	Summer 2015
Combined Total	493.9	542.8	596.8
Cape Cod	448.0	494.6	546.1
Martha's Vineyard	45.9	48.2	50.7

Cape Cod and Martha's Vineyard Projected Electric Usage 2005-2015

Figure 2G



	2005	2010	2015
Combined Total	2,062,237	2,267,718	2,494,119
Cape Cod	1,889,674	2,086,352	2,303,502
Martha's Vineyard	172,563	181,366	190,617

3.0 Electric and Natural Gas Supply Infrastructure

3.1 Electric Transmission and Distribution System

Meeting future electric supply needs on a reliable basis depends on transmission and distribution infrastructure and may also require availability and accessibility to natural gas fuel. The Cape and Vineyard are served by primarily by power supply from competitive suppliers under contract to NSTAR Electric or the Cape Light Compact. The power is delivered over a transmission and distribution system owned and operated by NSTAR Electric via transmission connections to the mainland and the Canal Electric Generating Plant. This is a system designed to both deliver power to the Cape and to transmit power generated by the Canal Plant to the mainland. Two 345 kilovolt (kV) lines cross the canal, each with the capability of carrying 1,000 megawatts of load. Two 115 kV lines also cross the canal; each are capable of carrying 225 megawatts of load.

The Cape transmission system extending as far as Wellfleet is fed by 115 kV lines. Beyond Wellfleet there are 23.2 kV lines to Truro and Provincetown. This transmission and distribution is structured in a radial system with 13 substations. NSTAR estimates there are 340 miles of 115 kV lines; 4,100 miles of 23 kV lines and 1,100 miles of 4 kV lines supplying customers on 167 circuits.

Martha's Vineyard is supplied by four 23.2 kV underwater transmission lines. Two running from Falmouth to West Chop and two running from Falmouth to Oak Bluffs. Three of the lines have capability of carrying 18 megawatts, one of the lines can carry only 8.5 megawatts. There are no substations on the island; the system operates at 23.2 kV.

For planning purposes, NSTAR estimates 2 percent losses on the transmission system and 8 percent losses on the distribution system for the Cape and Vineyard. Losses for the Outer Cape and the Vineyard would tend to be higher than those for the Mid-Cape and Upper Cape areas.

The adequacy of the system is dependent upon maintenance of existing transmission and distribution facilities, and timely upgrades to meet increased demand. "Hot spots" (problems and demand stresses) for lines and equipment on particular circuits can cause local reliability problems. During the past 10 years the average duration of System Average Interruption Duration Interval (SAIDI) outage has been 127 minutes. This does not include major storm-related outages or other events that result in loss of power for more than 15 percent of the service territory. Periodic storms can cause major power losses for several hours, or a few days.[3] For 2002, NSTAR reported a SAIDI outage period of only 83 minutes. During the past few years, the utility has engaged in an extensive tree-trimming program and other system upgrades While little expansion is

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[3] It is important to note that while storms can have significant consumer impacts, they are viewed as unavoidable events, different from events related to the requirements of normal maintenance and system expansion to meet growth in demand.

anticipated for the Cape transmission and distribution system after 2003, the Vineyard may require an upgrade for its underwater transmission in the 2005 to 2010 timeframe.

Historical expenditures on the transmission and distribution system on the Cape and Vineyard are estimated to be $33 kilowatt-year, which is consistent with national averages for such expenditures.

Utility expenditures on transmission and distribution usually take place to meet system peak demands that occur 100-200 hours per year. Deferral or augmentation of this spending through the use of energy efficiency, peak-shaving and distributed generation can produce savings and increase reliability. Demand-side solutions, such as energy efficiency, peak-shaving and distributed generation should be included in all evaluations of the timing and need for transmission and distribution system expenditures. (See Figure 3A map of the regional transmission system and substations.)

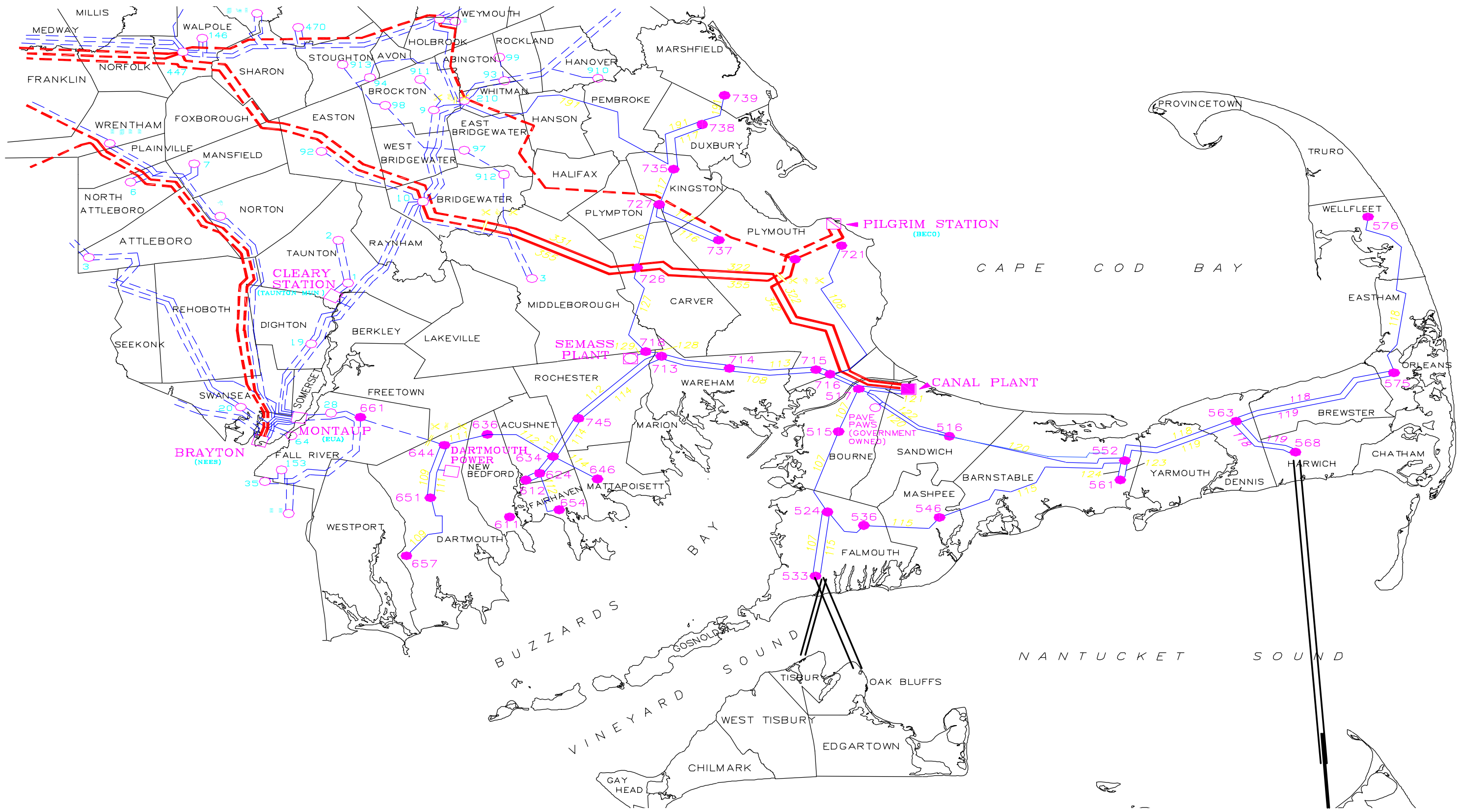
3.2 Natural Gas Fuel Supply

Installation and use of distributed generation could be constrained by availability and pricing of natural gas. The Cape has natural gas access in most communities, although distribution lines commonly do not extend through the entire community. The Vineyard and the Outer Cape beyond South Wellfleet have no natural gas (utilizing propane instead). Natural Gas is supplied to the Cape primarily through the Duke Energy Gas Transmission (DEGT) system and KeySpan Energy. There is also a small Liquefied Natural Gas (LNG) storage tank in South Yarmouth owned and operated by KeySpan. DEGT has access to all of the major supply basins in the U.S. and Canada and access to imported LNG through the Distrigas facility in Everett, Massachusetts. Natural Gas is supplied to the residential and commercial end users on Cape Cod by KeySpan. While the supply access is more than adequate, the delivery system is limited. The interstate transmission and local delivery system is limited to the contractual capacity and design to typically support the residential and commercial space heating loads as well as a portion of the fuel supply for the Canal Electric Generating Plant.

The contractual pipeline delivery capacity is 56,236 MMBtu per day. Under certain conditions, actual deliveries may exceed this quantity. During the approximately 90-day winter peak, all of this capacity is used for residential and commercial heating. However, this does not preclude opportunities for combined-heat-and-power projects that replace existing heating only applications.

During the summer, up to 80 percent of the capacity may be available for distributed generation. Capacity to a specific site for distributed generation requires site-specific analysis. The best areas of deliverability are closer to the Canal and in urbanized areas through the Mid-Cape.

Deliverability of the system can be increased through the addition of a second directionally drilled pipeline under the Cape Cod Canal, and/or the construction of an LNG facility for an area such as Martha's Vineyard. Delivery to specific sites could also require modifications to the distribution system. An LNG facility that could supply 16,000 MMBtu/day would cost in the range of $7 to $8 million including the cost of land and permitting. If properly located, an LNG plant could enhance the overall deliverability of natural gas on Cape Cod or Martha's Vineyard.



Cape and Vineyard Transmission Map **Figure 3A**

4.0 Electric Generation and Supply Options

4.1 Base Case Option

Purchases from large existing generating plants in the New England Power Pool region delivered by NSTAR Electric, and very limited utilization of local distributed generation essentially provide a "base case" for comparative options to be considered for meeting the region's future supply needs noted on Figures 2F and 2G. However, it is important to note that electricity generated at power plants follows a "physical path" toward the nearest area of demand; while the prices and billing for electricity follows a "contract path" which may be entirely different from the "physical path." In essence, a customer can receive electrons from one generating plant, but the company that sells the electricity may have a contract and base charges for the customer on contracts with any number of plants, or a mix of plants in New England, New York, or Canada. For purposes of efficiency and costs, it may make sense to contract for power from local plants. However, cost competition, transmission constraints, and contract terms are what usually determine the contract path source of supply and ultimate power costs for consumers.[4]

4.2 Local Electric Generation

The Canal Electric Generating Plant in Sandwich is the nearest major generating plant for the Cape and Vineyard. The Canal Plant is owned and operated by Mirant New England LLC. It has two generating units in operation, and a site for a third unit that remains undeveloped. The Canal Plant can deliver up to 1,111.67 megawatts (summer) and 1128 megawatts (winter) to the transmission system. Unit 1 (560 MW) is utilized as a baseload generator and is fueled by residual (No. 6) fuel oil. Unit 2 (560 MW) is utilized as an intermediate generator and has dual fuel capability—either residual fuel oil or natural gas. The Canal Plant has more than enough capacity to supply all power for the Cape and Vineyard (as noted on figure 2F, demand for 2015 for the Cape and Vineyard could reach 596 megawatts under current assumptions).

In addition to the Canal Plant, on Martha's Vineyard there are two small distillate oil fuel generators owned by Mirant. One in Oak Bluffs (installed in 1970) can deliver 8 megawatts (summer) and 8.25 megawatts (winter) to the transmission system. One in West Tisbury (installed in 1975) can deliver 5.5 megawatts (summer and winter) to the transmission system. These units can be utilized for back-up or emergency purposes, but cannot provide full power needs for the island.

[4] Southeast Massachusetts is home to a substantial number of generating plants, estimated to be more than enough to meet regional demand: Plymouth (Pilgrim Nuclear Plant), Rochester (SEMASS Waste-to-Energy Plant), Dartmouth (Dartmouth Power), Somerset (Montaup), Somerset (Brayton Point 1-4) and Sandwich (Canal 1 & 2).

In addition to these utility generating units, there are small customer-owned generators on the Cape and Vineyard targeted to helping meet customer needs. The Cape Cod Community College, for example, operates a 200 kilowatt (kW) fuel cell to help meet its power needs and the Sandwich Public Schools have a 150 kW natural gas co-generation unit. There is also a small number of photovoltaic systems for residences on the Cape and Vineyard. In addition, there are sundry emergency and stand-by gasoline or diesel generators located at hospitals, police and fire stations, and private businesses and residences can provide limited on-site power.

Any electric supply side additions—small-scale customer generation or large utility scale plants—would augment this existing generation. Generally, any addition of energy from a new generating plant, regardless of the fuel source, will tend to reduce regional wholesale market prices. Similarly, energy efficiency, to the extent that it reduces demand, can have the general effect of reducing wholesale market prices.

4.3 Electric Supply Side and Demand Side Options

The options that offer alternatives to the "base case" supply include: energy efficiency, distributed generation, wind and natural-gas fired plants, and competitive power purchases that can incorporate varying amounts of "green power" certificates.

These options consist of both "demand side" options which can be undertaken by consumers and their communities, and "supply side" options for purchase of power or utility-scale development.

4.3.1 Demand-Side Options

Demand-side options that can be undertaken by consumers and their communities are made up of energy efficiency, distributed generation and peak-shaving measures.

4.3.1.1 Energy Efficiency

Energy efficiency presents the most cost-effective option, with an average benefit/cost ratio of $2 saved for every $1 invested. Energy efficiency programs promote the use of improved operational practices and new technology—motors, appliances, lighting, etc.—that offer greater efficiency than devices currently in use. It is the cornerstone of any energy plan. However, its application is limited by funding and the amount of energy use that can be reduced for any individual customer. The Energy Efficiency study examined four scenarios and found:

Figure 4A: Summary of Efficiency Impacts for the Cape & Vineyard Combined: 2015

	Continuation of Existing Programs	Reduce Load Growth in Half	Stabilize CO_2 Emissions	Eliminate New Load Growth
System Benefits Charge ($/MWh)	2.5	5.0	8.9	10.8
Annual Program Cost (mil. nominal $)	$5.9	$11.0	$17.9	$20.7
Cumulative Net Benefits (mil. 2003 PV$)	$77	$149	$252	$297
Annual Energy Savings (GWh)	147.5	284.4	479.7	567.8
Annual Energy Savings (% of load)	6.3%	12.9%	23.8%	29.5%
Capacity Savings (MW)	20.9	38.9	64.3	75.7
Capacity Savings (% of peak)	3.5%	6.5%	10.7%	12.6%
CO_2 Emissions:	---	---	---	---
Reductions (1000 tons/year)	77	148	249	295
Reductions (% relative to BAU)	6.5%	12.5%	21%	25%
Growth (% change relative to 2002)	17%	10%	0%	-6%

* For the base scenario, continuation of the existing Cape Light Compact energy efficiency program will save enough energy to reduce the load in 2015 by 6.3 percent annually (147,500 megawatt hours) with a capacity savings of 3.5 percent (20.9 megawatts) of peak demand. The annual carbon dioxide (CO_2) emissions from generating plants in New England supplying the Cape and Vineyard communities would be reduced by a comparable amount (6.5 percent), but this would still be roughly 17 percent higher than current levels. The investment for this program is $5.9 million annually which results from $2.50 per megawatt hour state-mandated charge on all electric customer bills.

* For the second scenario, reducing the load growth by half, the doubling of investment to $11 million annually would reduce load in 2015 by roughly 12.9 percent annually (284,400 megawatt hours) with a capacity savings of 6.5 percent (38.9 megawatts) of peak demand. The annual CO_2 emissions would be reduced by 12.5 percent, but would still be 10 percent higher than current levels.

* Higher goals for energy savings and emissions reductions can be achieved with increased funding. [See Energy Efficiency Study in Appendix section.]

4.3.1.2 Distributed Generation

Distributed generation installed by customers offers the greatest magnitude of customer opportunity in terms of total impacts with an upper bound of 30 percent of the region's supply by 2015 and an average benefit/cost greater than $1.80 for every $1 invested. Distributed generation (DG) is the term applied to small-scale electric generating technologies located at the customer site, or close to customer sites. These include advanced fossil fuel technologies such as microturbines, reciprocating engines and fuel cells, as well as renewable energy technologies such as photovoltaic cells. There is a general consensus within the electric industry and among policy-makers that distributed generation will play an increasingly important role in power generation.

Figure 4B: DG Market and Technology Results – 2015

Cape Cod

Application	Load in Play MW	Hr/yr	Least-Cost DG Technology	Market MW	Energy MWh	Tech. Cost $/kW-yr	Total Cost $/yr	Net Benefits $/kW-yr	Total Benefits $/yr	NO_X Offset ton/yr	CO_2 Offset ton/yr
Standby Generation	7.7	200	Adv. Fuel Cell	2.4	480	128.2	307,680	18.1	43440	0.19	79.5
Reliability Enhancement	51.0	10	Adv. Fuel Cell	0	0	115.7	0	0	0	0	0
On-Site Energy	95.6	6000	Adv. Fuel Cell	95.6	573,600	480.8	45,964,480	285.5	27,293,800	189.0	93,943
CHP	31.9	6000	Microturbine	31.9	191,400	354.0	11,292,600	658.3	20,999,770	53.2	20,276
Demand Reduction	47.8	600	Adv. Fuel Cell	3.1	1,860	154.5	478,950	6	18,600	0	0
Landfill Gas	1.0	8760	Adv. Fuel Cell	1.0	8,760	224.7	224,700	77	77,000	2.9	1,434
Residential Fuel Cell	2.9	3000	Adv. Fuel Cell	2.9	8,700	358.3	1,039,070	129.5	375550.0	3.000	768.1
Residential PV	1.00	1200	PV	0.51	612	431.0	219,810	56.3	28,713	0.2	320.9
Subtotal:	**238.9**			**137.4**	**785,412**		**59,527,290**		**48,836,873**	**248.4**	**116,822**

Martha's Vineyard

Application	Load in Play MW	Hr/yr	Least-Cost DG Technology	Market MW	Energy MWh	Tech. Cost $/kW-yr	Total Cost $/yr	Net Benefits $/kW-yr	Total Benefits $/yr	NO_X Offset ton/yr	CO_2 Offset ton/yr
Standby Generation	0.5	200	Adv. Fuel Cell	0.1	16	139.7	11,176	12.3	984	0.005	2.5
Reliability Enhancement	3.4	10	Adv. Fuel Cell	0	0	116.2	0	0	0	0	0
On-Site Energy	6.4	6000	Adv. Fuel Cell	0	0	856.3	0	0	0	0.0	0
CHP	2.2	6000	Microturbine	2.2	13,200	578.4	1,272,480	433.9	954,580	4	1,370
Demand Reduction	3.2	600	Adv. Fuel Cell	0	0	189.1	0	0	0	0	0
Landfill Gas	0.0	8760	Adv. Fuel Cell	0	0	224.7	0	0	0	0	0
Residential Fuel Cell	0.33	3000	Adv. Fuel Cell	0.06	180	511.6	30,696	17.4	0	0.0591	15.6
Residential PV	0.43	1200	PV	0.22	264	431.0	94,820	56.3	12,386	0.1	136.4
Subtotal:	**16.5**			**2.6**	**13,660**		**1,409,172**		**967,950**	**4.2**	**1,525**

* In 2015 for Cape Cod, the total upper bound of electric usage subject to cost effective distributed generation is 785,412 megawatt hours out of a projected Cape total of 2,303,502 megawatt hours. Cost and efficiency improvements anticipated by manufacturers for the Advanced Fuel Cell allow this technology to dominate all markets except for combined-heat-and power (CHP) from microturbines and Residential Photovoltaic (PV). Anticipated reduction in the cost of PV allows this technology to capture a share of the residential market (although some commercial application would be likely at this time as well). At this point, markets also emerge in applications for Standby Generation and Demand Reduction. The total technology cost is $59.5 million per year and the resulting net savings is $48.8 million per year. Emissions reductions are 248.4 tons per year for NO_X and 116,821.7 tons per year for CO_2.

* For Martha's Vineyard in 2015, the total amount of electric usage subject to cost effective DG is 13,660 megawatt hours out of a projected total of 190,617 megawatt hours. Microturbines capture the CHP market and the Advanced Fuel Cell moves into markets for Standby Generation and Residential Fuel Cell. PV acquires some Residential (and probably commercial) PV markets. The total estimated technology cost is about $1.4 million per year and the resulting total net savings $967,950 per year. Emissions offsets are 4.2 tons per year for NO_X and 1,524.8 tons per year for CO_2, due in large part to the extremely low emissions from the fuel cells. [See summary of Distributed Generation End User Study in Appendix section.]

4.3.1.3 Peak Shaving

Peak-shaving is the practice of reducing electric usage during peak periods or moving usage from the time of peak demand to off-peak periods during the evening or early morning. This can be achieved through the use of customer-owned generation, timers on appliances, or operational scheduling for start-up of certain equipment or appliances. For individual customers, peak-shaving can reduce demand charges on the monthly electric bill, or if a time-of-use meter is installed, it may result in lower off-peak energy prices. Cumulatively, peak-shaving can reduce peak demand for customers in a region, deferring or offsetting transmission and distribution system costs, improving the aggregated customer load factor and reducing prices paid for bulk power supply.

* The potential for municipal, commercial and industrial customer peak-shaving is examined in the Distributed Generation study where it does not show significant potential as an individual application, but has added value for On-Site Energy or Combined Heat-And-Power applications. (See Utility Distributed Generation Study in Appendix section.)

* A separate Peak-Shaving Study examines the potential for residential customers to utilize peak-shaving technologies and practices to gain individual and cumulative system benefits. Based on a survey of existing programs and analyses of Cape and Vineyard data, peak shaving for residential consumers is shown to lack sufficient benefits under current conditions and costs to programs for central air conditions and heating control functions. (See Peak-Shaving Study in Appendix section.)

4.3.2 Electric Supply-Side Options

Supply-side options include the purchase of power supply and development of utility scale generating facilities. The region's power supply is provided primarily through NSTAR Electric and the Cape Light Compact under contracts with competitive power suppliers. This contracted power supply is produced by plants throughout New England. Replacing this power supply with local power supply can be achieved if there is sufficient cost-effective generating capacity appropriately sited on or near the Cape and Vineyard. It is important to note that the contract path which electricity prices reflect is distinct from the "physical path" of electrons that may be produced locally (such as at the Canal Electric Generating Plant in Sandwich). Plant operations are directed by contract path commitments.

* Competitive power supply contracts can shape the terms and type of power purchased, including the amount of power from renewable resources (see Renewable Energy in section 4.3.3 below).

* The Cape and Vineyard have substantial wind resources. Mapping of wind resources has been conducted by TrueWind Solutions LLC for Connecticut Clean Energy Fund, Massachusetts Technology Collaborative's Renewable Energy Trust, and Northeast Utilities for both onshore and offshore winds. The maps indicate that the most

favorable winds are found offshore, at exposed points along the coast, and on tall hills and mountains of New England. Offshore winds are found to be most favorable, with the best windspeeds for the Cape and Vineyard indicated south and east of Nantucket.

* There is an unused site for an additional generating unit at the Canal Plant in Sandwich that may offer opportunities for development where infrastructure is already in place.

* Utility scale wind turbines and natural gas combined cycle units each offer valuable attributes for power supply; wind can act as a hedge against rising fuel costs; natural gas combined cycle units can provide a steady schedule of energy and offset transmission costs.

* Due to the relative lack of experience and data for offshore wind development, assumptions related to production costs are much softer than assumptions for natural gas fired units for which there is extensive experience. The change in book life for offshore wind from 20 years to 15 years for example can create a 10 percent increase in production costs.

* Utility scale wind generation offers a range of production costs depending on siting and application. Wind production cost estimates include reductions for the federal Production Tax Credit ($11 per megawatt hour) and for a green certificate value ($25 per megawatt hour). For 2005 to 20015, onshore wind farms indicate the lowest level production cost at an average of $25/megawatt hour. Offshore wind farms indicate an average production cost range of $37 to $44/megwatt hour. A "cluster" of seven or more wind turbines indicate an average of $47/megawatt hour. Customer-sited wind turbines indicate and average of $57/megawatt hour for power sold to the grid, and $69/megawatt hour for customer utilized power. (Customer produced and utilized power does not receive the federal Production Tax Credit.) Site acquisition costs could increase production costs.

* Natural gas combined cycle plants for 2005 to 2015 indicate at an average production cost of $42/megawatt hour.

* Wind turbine energy production can displace energy from fossil fuel generating plants, but can only displace a limited amount of the need for fossil fuel capacity due to wind power's intermittent nature.

* Both wind and natural gas combined cycle generation reduce anticipated 2015 emissions from New England region power plants, with wind offsetting marginal emissions of 0.7 lbs/megawatt hour for NOx, 0.5 lbs/megawatt hour for SO_2 and 1,040 lbs./megawatt hour for CO_2; and natural gas combined cycle offsetting average emissions of 0.84 lbs/megawatt hour for NOx, 2.696 lbs./megawatt hour for SO_2 , and 132 lbs/megawatt hour for CO_2. (See Wind/Natural Gas Study in Appendix section.)

4.3.3 Renewable Energy

For strategies targeted to fuel and emissions related concerns, renewable energy can be supplied to the region by both supply-side and demand-side options. All retail suppliers in Massachusetts are required to meet Renewable Portfolio Standards (RPS) utilizing qualified renewable resources starting at 1 percent of supply in 2003 and increasing to 4 percent by 2009, at which time RPS will be reviewed for continuation. In addition to this baseline of supply, consumers can install photovoltaic electric systems or wind turbines, or utility-scale wind facilities may be developed is appropriate sites are available. Photovoltaic systems indicate economic benefits with anticipated cost reductions after 2010. New wind-powered and natural gas-fired generation offer economic opportunities for supply-side options, assuming these units produce at costs below the average regional costs of power supply and can be appropriately sited. However, because renewable energy resources are intermittent, sufficient capacity reserves need to be under contract to assure firm, full requirements power supply.

* Renewable energy for 2015 would be at a low of 4 percent of total usage, if RPS requirements remain frozen at 2009 levels and no purchases above that level are made due to high cost and/or lack of renewable resources in New England

* Increasing RPS purchases if sufficient renewable resources are available, could amount to 10 percent of projected electric usage for 2015 (which could include local as well as non-local resources).

* Anticipated reductions in costs for photovoltaic systems would result in meeting goals of regional developers to have 500 kilowatts of PV installed on the Vineyard and 1,000 kilowatts installed on the Cape by 2015.

* Customer-sited wind facilities (thirty 250 kilowatt turbines) and one utility scale "cluster" (seven 2 megawatt turbines) could provide 2 percent of the Cape's anticipated 2015 power supply, if appropriate sites and economic applications are available.

* As much as 30 percent or more of Cape and Vineyard projected electric usage for 2015 could be supplied if appropriate sites can be developed for utility-scale wind facilities (approximately 246 megawatts).

4.3.4 General Reference

The Appendix section contains the five technical studies that provide technical background and perspective on the potential benefits and costs of current alternatives to the "base case" supply from NSTAR and existing generation. (See the *Regional Options Study* for illustrations of these comparative options and related costs, savings and air emissions.)

4.4 New Options and Research and Development

The five studies examine existing technologies, or those currently emerging in the marketplace. They do not examine a range of technologies now in development that could offer benefits in the long term (or prior to 2015 if there are major advances for particular technologies). These include tidal power, wave energy and ocean thermal energy, new energy storage systems, use of hydrogen fuels and hybrid technologies that include hydrogen production and use, microbiological fuel cells, and superconductors and advanced methods and policies for undergrounding transmission and distribution systems.

Research projects for viable technologies should be supported and should be tracked and evaluated at such times that they offer prospective schedules for market implementation.

5.0 Market Overview

Development of strategic options for energy efficiency, peak-shaving, distributed generation, renewable energy, and other utility-scale generation will be directly affected by the evolution of market policies and pricing. Among the primary factors influencing conditions will be changes in federal law, amendments or regulatory rule changes related to the Electric Utility Restructuring Act of 1997; practices, policies, and pricing of ISO New England regarding wholesale markets and demand response programs; the evolution of "green" pricing and locational market pricing; interconnection policies; and local zoning and regulatory processes.

5.1 Electric Industry Restructuring and Competition

The policy framework for electric industry restructuring and competitive was set in place by the federal Energy Policy Act of 1992; the Massachusetts Legislature's passage in November 1997 of House No. 5117, "An Act Relative to Restructure of the Electric Utility Industry in the Commonwealth, Regulating the Provision of Electricity and Other Services, and Promoting Enhance Consumer Protections Therein"; formation of ISO New England, and the Massachusetts Department of Telecommunications and Energy issuance in February 1998 of its final order in DTE 96-100 and "Rules Governing the Restructuring of the Electric Industry," 220 CMR 11.00.

The purpose of the Massachusetts legislation and rules was to create a transition in the electric industry to introduce competition that would minimize long term costs to consumers while maintaining the safety and reliability of electric services with minimum impact on the environment. Competition was to focus on supply of electricity to consumers at retail. Billing, metering, and other related functions were to remain a monopoly service provided by utilities (although those services could also become subject to competition at some point in time).

In addition, the law and rules included provisions to encourage energy efficiency, the development and use of renewable energy and distributed generation, and on-going studies to examine the effectiveness of operational standards and pricing.

The competitive market opened on March 1, 1998 and has continued to evolve since that time. As the law and rules were applied for asset divestiture and competitive power supply, Cape and Vineyard consumers faced the highest transition costs in the region, and the lowest power prices for suppliers to compete against. Increases in the Standard Offer price for most Cape and Vineyard customers who receive supply from NSTAR (145,000) have gradually moved upward toward market levels. Customers receiving Default Service (those who became customers after March 1, 1998) are served by NSTAR at market rates that have experienced wide price swings. Approximately 50,000 customers on the Cape and Vineyard are currently subject to Default market rates and as an alternative are served at a lower competitive power supply cost through the

Cape Light Compact. A relatively small number of commercial customers on the Cape and Vineyard have independently sought competitive supply. Under current state law, all Standard Offer customers will be placed on Default Service if they have not chosen a competitive supplier when regulated Standard Offer pricing expires on March 1, 2005. This full transition to market rates could have an effect on consumer interest in strategic energy options for the region.

5.2 Wholesale Market

NSTAR and competitive suppliers participate in a wholesale market from which They buy power to resell at retail. The wholesale market receives oversight from ISO New England as well as the Federal Energy Regulatory Commission. It consists of two submarkets: power bought and sold through the New England Power Pool, and power transactions conducted through private "bilateral" contracts with power generators or power traders who buy and resell electricity. Approximately 20 percent of the region's power, usually daily or short term purchases, are conducted through the New England Power Pool in an open transparent market. Approximately 80 percent of the transactions are conducted through bilateral contracts which tend to be longer term and contain terms and prices that are not publicly disclosed.

5.2.1 ISO New England and the New England Power Pool

The New England Power Pool (NEPOOL) was formed in 1971 (from predecessor organizations) as a regional association of electric utilities to coordinate, monitor, and direct the operations of generating plants and transmission in the region. The intent of NEPOOL was to help plan capacity additions and transmission for the region and centrally dispatch wholesale power supplies that offered the greatest economy.

In 1997, with the advent of increased competition at wholesale, the functions of NEPOOL changed and a new regional corporation, ISO New England, was formed to manage NEPOOL operations. Membership in the ISO was expanded to include independent suppliers and end-users. Central dispatch of generating plants was replaced with a market bidding system and "open access" to the transmission grid under an established NEPOOL tariff. The ISO began market operations in April 1999 and currently operates an internet-based market for six electricity products. The bid prices in these markets are viewed as benchmarks in the regional market (for bilateral contracts). The ISO also plans for adequacy of generation and transmission for the region and develops regional policies that have a direct effect on peak-shaving, renewable energy development, distributed generation, energy efficiency, and wholesale power prices. Oversight for the ISO is provided by the Federal Energy Regulatory Commission.

ISO policies regarding: capacity credits for renewable energy facilities; its four demand response programs; transmission tariff pricing; and administration of "green" certificates and emission certificates markets will have a direct impact on strategic supply and demand options.

5.2.2 Bilateral Market

As noted above, approximately 80 percent of the wholesale energy bought and sold in New England is traded privately between two parties in a "bilateral" market. This market is made up of generators, brokers, retail energy suppliers who must be members of NEPOOL, or trade through a NEPOOL member. Contracts in this market must be submitted to NEPOOL to verify the proper amount of reserves and ancillary services (which must be purchased through the NEPOOL market) as well as adequate transmission for the sale.

5.2.3 Green Power Market

A specialized regional market for renewable energy attributes or "green power" certificates has been developed and is administered by the ISO. Qualified generators (in Massachusetts those producing from wind, low-emission advanced biomass units, landfill gas, photovoltaic, ocean thermal/wave/tidal energy, or fuel cells that utilize renewable fuels, developed after December 31, 1997) are eligible to participate in the certificate program. The renewable "attribute" is theoretically separated from the energy produced by the plant and can be sold independently of the sale of energy. Each renewable energy certificate (REC) represents one megawatt hour of production. This provides a premium payment to the generator. Small generators, such as photovoltaic system owners, can aggregate their production to offer REC's and bank production as well. The intent of this program is to recognize the environmental and system benefits from renewable energy and provide incentives for renewable facility development. This market also facilitates the process for retail suppliers to meet Renewable Portfolio Standards (RPS) established by several New England states.

In Massachusetts, the RPS requires 1 percent of retail supply to be from qualified renewable energy generators starting in January 2003. This amount will increase by 0.5 percent each year until it reaches 4 percent in 2009. At that time the RPS will be evaluated for continuation. The first sale of green certificates in July 2002, established prices averaging $25 per megawatt hour. The price has since moved upward to $30 per megawatt hour. The Massachusetts Division of Energy Resources RPS Advisory Group currently anticipates $25 to be the average market price through 2009. However, increased demand for REC's or "green certificates" from consumers wanting more renewable energy in their supply, or due to a scarcity of renewable energy supply could drive prices higher. A few private organizations and businesses currently market "green power" attributes directly to consumers. Utilities in Massachusetts, in addition to their RPS requirements, are also currently planning and introducing programs to sell higher amounts of "green power" to individual consumers.

The Massachusetts Division of Energy Resources currently anticipates a need for 1,089,000 megawatt hours of renewable energy by 2005 and 2,386,000 megawatt hours by 2009 to meet Massachusetts RPS requirements. In 2003, the bulk of renewable energy (approximately 83 percent) for New England RPS programs is expected to come from landfill gas. This landfill gas portion of the renewable mix is expected to decline to 16 percent by 2012, as biomass increases from 16 percent to 29 percent, and as wind rises from 1 percent in 2003 to 22 percent in 2012. Additional wind resources (25 percent of the renewable mix) could be imported from New York and Hydro Quebec in 2012. The potential contribution from fuel cells is expected to be 2 percent of the renewable supply mix by 20012 with photovoltaics and other renewable technologies making very small contributions.

The evolving prices and policies related to RPS and green certificates, and the level of customer demand for additional green power, will have a direct impact on renewable energy development.

5.3 Locational Market Pricing

On March 1, 2003, ISO New England instituted "locational market pricing" which results in a premium for transmission in areas that have insufficient reserves of transmission capacity during peak periods. There are three locational market zones in Massachusetts. The Southeastern Massachusetts zone (SEMA) in which the Cape and Vineyard are located has adequate transmission and supply, thus will not be subject to higher charges for transmission that will apply in the Boston area and southern Connecticut. Over time, additional refinement in transmission zone pricing could pose higher charges for certain areas such as Martha's Vineyard or the Outer Cape. Added charges for transmission increases the value for distributed generation, renewable energy and other local customer-owned generation.

5.4 Retail Market

The retail level of the market is where the impact of policies and pricing regarding wholesale markets, green markets, and locational pricing combine on consumer bills. The retail power cost to consumers, in turn, becomes a determining factor for consumer interest in potential benefits of energy efficiency, distributed generation, renewable energy, and competitive supply purchases. The transition of the regulated retail pricing to market pricing, with the elimination of Standard Offer pricing on March 1, 2005, could have further effects on consumer perception of options.

5.5 Policy Changes

Federal law concerning the electric industry is facing broad revisions. The Massachusetts Utility Restructuring Act of 1997 is also facing anticipated changes. It is also expected that ISO New England will be reorganized and that the regional demand response programs for qualified small generators will be expanded. Policies for interconnection of distributed generation with utility grids are being formulated. These policy changes could cause shifts in the framework for power supply and provide additional incentives or disincentives for consumers considering strategic options. Local policies concerning zoning and permitting can also have a significant impact on the viability of small generation options. (See *Regulatory Assessment* for a sampling of federal and state issues and a focus on local zoning issues.)

6.0 Summary

The demand for electricity and advances in technology to meet that demand or reduce that demand will continue to change over time. Forecast growth for the Cape and Vineyard currently being utilized by NSTAR anticipates summer peak demand growth of 3 percent per year through 2005 and 2 percent after that time. If this level of growth were sustained it would increase summer peak demand for the region from 493.9 megawatts in 2005 to 596.8 megawatts in 2015. The Vineyard demand would grow from 45.9 megawatts in 2005 to 50.7 megawatts in 2015 and the Cape demand would grow from 448 megawatts in 2005 to 546.1 megawatts in 2015. (See Figure 2F)

Assuming a similar growth rate for electric usage, the total kilowatt hours consumed on the Cape and Vineyard would increase from 2,062,237 megawatt hours in 2005 to 2,494,119 megawatt hours in 2015. (See Figure 2G)

This increased electric usage and demand will require greater supply resources and on-going investment for expansion and maintenance of the transmission and distribution system. Electric supply side and demand side options can be utilized to reduce supply and peak demand costs, increase system reliability, and reduce air emissions.

Reliance on the New England regional central generating units (and power imports from Canada and New York) could remain the core supply for the Cape and Vineyard through 2015. However, the *Resource Assessment* shows substantial opportunities for development of strategic options for electric supply and demand for the entire study period of 2005 to 2015. As shown in the technical studies, for demand-side options there is a potential for one-third of the projected Cape and Vineyard power supply to be met by cost-effective distributed generation and energy efficiency by 2015. For supply-side options that may be undertaken by competitive suppliers, additional potential for the region arises with the installation of new wind-powered and natural gas-fired utility scale generating facilities, if appropriate sites are available. At an optimum level, all of the region's needs could be met by combining utility-scale development with customer demand-side energy efficiency and distributed generation. All of the options would reduce emissions below those projected for the New England Power Pool.

The implementation of any option will be affected by infrastructure and fuel cost and availability, the availability of suitable sites, local/state/federal policies, evolution of the wholesale and retail markets, and retail power costs for consumers.

(Please see the *Regional Options Study* for illustrations of the combined options and the five individual studies for technical details on specific technologies or programs.)

GLOSSARY

Aggregator: any entity that seeks to aggregate consumers for delivery of service under specified contract terms. (Also see Municipal Aggregator.)

Ancillary Services: electric supply services for operating reserves; voltage control, regulation and frequency response; scheduling and system control and dispatch; and other power supply necessary to effect a reliable transfer of electrical energy at specified contract terms between a buyer and a seller.

Baseload: the minimum amount of power delivered or demanded over a given period at a constant rate (contrasted with "peak load").

Bilateral Contract: a direct contract between a power producer, or power marketer, and an aggregator or customer end-user.

Biomass: plant and animal matter utilized for fuel purposes. Within the renewable energy industry, biomass usually refers to wood, wood-processing residues, and energy crops used to create electricity, generate heat, or produce liquid transportation fuels (ethanol).

Broker: a retail agent who arranges power transactions but does not take title to the power.

Bulk Power Supply: a term often used interchangeably with "wholesale" power supply bought and sold among suppliers and aggregators (contrasted with "retail" power supply sold to customers).

Capacity: the rated continuous load-carrying ability, expressed in megawatts (MW) or megavolt-amperes (MVA) of generation, transmission, or other electrical equipment.

Central Power Generation: the traditional method of power generation in which power is generated by large power plants and transmitted to distribution systems.

Cogeneration: production of electrical energy and utilization of heat or steam captured from that process and applied as useful energy rather than waste.

Combined Heat and Power (CHP*)*: also known as "cogeneration" and as an application of distributed resources commonly viewed as providing the most rapid direct economic payback.

Competitive Power Supplier: a supplier of wholesale retail energy and capacity, as well as ancillary services, other than the incumbent utility. The *Competitive Power Supplier* may own generation or may buy and resell energy and capacity and has title to the commodity in contrast to a "Broker".

Contract Path: the most direct theoretical transmission ties between two entities. When parties exchange bulk power supplies, the transfer is assumed to take place across the *Contract Path* notwithstanding the fact that power flow in a transmission and distribution network will distribute in accordance with network flow conditions—the "Physical Path." Billing and plant operations follow *Contract Path* requirements but may be constrained by "Physical Path" conditions.

Control and Data Technology: utility service areas are divided into "control areas" for which utilities monitor voltage and power flows and utilize centralized dispatch and transmission equipment to maintain *reliability* and *quality of service*; data technologies are new computer devices that can combine with control technology to monitor power flows and dispatch an array of individual distributed generation units to enhance voltage levels and power flow. Utilities utilize "supervisory control and data acquisition" (SCADA) systems to monitor and obtain data from devices such a circuit breakers and switches.

Default Power Supply: retail electric service provided to customers who became new utility customers after March 1, 1998, or to all customers after the elimination of "Standard Offer Service" set for March 1, 2005 who have not chosen a competitive supplier. Default Power Supply is provided by the utility at market rates for specific periods of time (i.e. six months) at which time the rate changes.

Demand-Side: activities that take place on the customer side of the electric meter that affect customer electric usage, including energy efficiency measures, peak-shaving, and the use of customer sited distributed generation (as contrasted to electric "Supply-Side" activities.

Digital Grid: an "intelligent" transmission and distribution system that utilizes communications equipment to interact with small and large power plants and consumer appliances and equipment; a more comprehensive form of interactive system than might be utilized in a *microgrid,* or *virtual utility* system that may incorporate only generating units and not appliances and equipment consuming power.

Department: the Massachusetts Department of Telecommunications and Energy which has regulatory authority over electric, gas, telephone and other services in Massachusetts.

Distributed Generation (DG): generation of electricity by scalable generating facilities that are located at or near the point of end-use consumption. These facilities can be located on either the customer side of the meter or the utility side of the meter, and may be owned by the individual consumer, the utility, or a third party generator. They are usually connected to the grid, but may be disconnected from the grid as stand-alone systems.

Distributed resources: include distributed generation, energy efficiency, and data and control technology to dispatch distributed generation.

Distribution System: local wires, transformers, substations, and other equipment used to distribute and deliver electricity to the end-use consumer. This is differentiated from the transmission system which carries high-voltage power to the substation.

Electric Distribution Company: a company that owns and operates the transmission and distribution lines necessary to deliver electricity to end -user consumers; also known as local distribution company (LDC).

Electric System Losses: electric energy losses consisting of transmission, transformation, and distribution system losses between supply and delivery points.

Energy (electric): the output of a generator measured in megawatt hours or kilowatt hours; or the usage by a customer, or group of customers measured in megawatt hours or kilowatt hours.

Energy Efficiency (electric): practices and measures undertaken to reduce the consumption of electricity for a specific task or function (i.e. lighting).

Environmental Benefits: benefits resulting from activity such as development of renewable energy systems, that produce energy with less air, water, soil, or other pollution than production of a similar amount of energy produced by conventional fossil fuel sources.

Externalities: benefits or costs created as a by-product of an economic activity that do not accrue only to the parties involved in the activity, such as *environmental benefits* resulting from renewable energy development, or *multiplier effects*. The dollar value of such externalities may or may not be included in cost/benefit analyses

Federal Energy Regulatory Commission (FERC): the federal agency that oversees interstate utility transactions, transmission grids, and policies and markets regarding wholesale electric supply.

Flywheel: a device for storing kinetic energy that can be used to produce electricity using the inertia of a fast-spinning mass. Kinetic energy stored in a flywheel can be retrieved very quickly on command.

Franchise: a grant of right or privilege to occupy or use public streets and ways and facilities located on public streets and ways to deliver service to consumers. Franchises are historically granted by local governments.

Fuel Cell: a technology capable of generating an electrical current by converting the chemical energy of a fuel directly into electrical energy. There are several different types of fuel cells in development. They include:

Molten Carbonate Fuel Cell (MCFC): a type of fuel cell that utilizes molten carbonate electrolytes. This system has the advantage of utilizing carbon monoxide as a fuel, allow mixtures of carbon monoxide and hydrogen, such as those produced in a coal gasifer, to be used as fuel

Phosphoric Acid Fuel Cell (PAFC): a type of fuel cell that employs phosphoric acid electrolytes. It is the most commercially developed type of fuel cell, and can be used in vehicles such as buses and trains.

Proton Exchange Membrane Fuel Cell (PEMFC): a type of fuel cell that operates at relatively low temperatures, has high power density, can vary output quickly to meet shifts in power demand, and is suited for applications such as automobiles.

Solid Oxide Fuel Cell (SOFC): a type of fuel cell that employs solid zirconium dioxide electrolytes. Suitable fuels include hydrogen, carbon monoxide, and methane. Solid oxide fuel cells have the advantage of being relatively insensitive to fuel contaminants such as sulfur and nitrogen compounds that impair the performance of other fuel systems.

Fossil Fuels: energy sources formed by the decay of plants and animals over millions of years: coal, oil, and natural gas.

Gas Turbine: an electric generator using natural gas (or another similar gas product) as a fuel source. Gas turbines generally range in size from a few hundred kilowatts to a few hundred megawatts. Also see *microturbine*.

Generation: the process of producing electrical energy from other forms of energy; also the amount of electric energy produced, usually expressed in kilowatt hours (kWh) or megawatt hours (MWh). Gross generation is the electrical output at the terminals of the generator, usually expressed in megawatts (MW). Net generation is gross generation minus the service power requirements of the generating station itself.

Geothermal Energy: heat energy stored in the Earth's crust which can be harnessed to produce electricity or heat water and living spaces.

Good Utility Practice: Any of the practices, methods and acts engaged in or approved by a significant portion of the electric utility industry during the relevant time period, or any of the practices, methods and acts which, in the exercise of reasonable judgment in light of the facts known at the time the decision was made, could have been expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety and expedition. *Good Utility Practice* is not intended to be limited to the optimum practice, method, or act to the exclusion of all others, but rather to be acceptable practices, methods, or acts generally accepted in the region.

Green Building: the use of design and construction methods and materials that are resource efficient and that will not compromise the health of the environments or the associated health and well-being of the buildings occupants, builders, or the general public. Such construction is aimed at maximizing energy efficiency. Also called "environmentally-sound" or "sustainable" building.

Green Power: electricity generated with renewable resources.

Grid: a network of interconnected power lines and associated equipment used to transmit and distribute electricity over a geographic area: also see *Microgrid*.

Harmonics: voltages and currents of frequencies that are multiples of 6- Hertz. Excessive harmonics can cause problems with electronic equipment, especially protection systems, as well as overheating equipment. In some cases high voltage and large currents may be caused by harmonics.

Hydropower: the energy captured from the force of flowing water, which can be harnessed to create electricity or mechanical work.

ISO-New England: The Independent System Operator established July 1, 1997 in accordance with the New England Power Pool Agreement and applicable FERC approvals, which is responsible for managing the bulk power generation and transmission systems in New England.

Interconnection Service Agreement: an agreement between a customer and a utility for that includes the terms for connecting a customer-sited distributed generation facility.

Inverter: an electronic device that converts electricity from DC to AC, used with photovaltaic panels and other technologies that produce DC.

Islanded System: a part of the distribution system that is separated from the rest of the power grid (due to some accidental failure or the system or maintenance). An islanded system, would have distributed generation as its only source of power. Unintentional islanding, due to the failure to isolate generating facilities when the interconnected distribution system is not functioning creates safety hazards for workers and the public.

Isolating Generation: the function of separating a generating facility, such as customer-sited distributed generation from a distribution system to prevent and "islanded system" in situations in which the distribution system is not functioning properly. Customer-sited distributed generation requires systems that will monitor the power from the distribution system and automatically isolate the DG unit when the distribution system is not operating correctly.

Kilowatt: a kilowatt is 1,000 watts of electric power capacity. A watt is the measure of power developed by one ampere of current across a potential of 1 volt. A kilowatt (kW) is used to describe the output of an electric generator at a particular moment—the capacity of that generator. Also see *kilowatt hour, megawatt, and megawatt hour.*

Kilowatt Hour: the measure of electric energy delivered, equal to 1,000 watts of power delivered for one hour. Typically noted on consumer electric bills. See *kilowatt.*

Megawatt: equivalent to 1,000 kilowatts of capacity, noted as (MW) and used to rate the potential output of a generating unit. See *kilowatt.*

Megawatt Hour: 1,000 kilowatt hours, typically used in power sales contracts. See *kilowatt hour.*

Microgrid: a small segment of a grid utilizing distributed generation linked through control and data technologies to supply power to the larger grid, for its own use; a microgrid may consist of as few as 50 small distributed generation facilities.

Microturbine: a very small gas turbine, typically less than 200, kilowatts.

Multiplier Effect: the economic effect of development of energy resources or programs that produce additional jobs and other "ripple" effects as the result of an initial investment. The multiplier effect includes direct effects such as on-site jobs, indirect effects such as off-site jobs providing goods and services, and induced effects which includes economic activity generated by respending of wages.

Municipal Aggregation: a program created by municipal approvals and state approvals to allow customers to join together to negotiate and purchase retail power supply and undertake other related services such as energy efficiency, development of distributed generation, or consumer protection. For communities that adopt municipal aggregation programs and offer power supply, each consumer is notified of the terms of participation in writing and given an opportunity to "opt-out" to receive utility-supplied power, or power from another competitive supplier if one is available.

Municipal Solid Waste: trash or garbage that can be utilized to produce heat or electricity through controlled combustion, or capturing the gases it produces and utilizing the gases as fuel; also known as "waste-to-energy" municipal solid waste is included by some states in a category of renewable energy resources.

New England Power Pool (NEPOOL): a voluntary association of entities that are engaged in the electric power business in New England, including utilities, power marketers, aggregators, brokers, competitive suppliers, generation owners, and end-users. Members operate under the Restated NEPOOL Agreement in the operation of market-based wholesale power operations. NEPOOL operates under the oversight of ISO New England, the regional independent system operator. (See ISO New England)

Net-Metering: a method of metering an end-use consumer's electricity consumption that allows a distributed generation source of 60 kW or less on the customer-side of the meter to run the meter backward when the system is producing more power than the end-user in consuming, thus feeding electricity into the grid and providing an economic credit to the consumer equal to the average monthly market price of generation per kWh, as determined by the Department, in any month during which there was a positive net difference. (See 220 CMR 11.04(7)(c)) This is in contrast to "dual metering" in which two separate meters are used to calculate energy taken from and supplied back to the grid.

Nonrenewable Fuels: fuels that are not naturally replaced as they are utilized; including fossil fuels, nuclear fuels and municipal solid waste.

Off-Peak: the time period when energy demand is not at its highest point, measures on a daily, monthly, or annual basis, and commonly indicated by the lower points on a sine curve. Off-peak power (such as street lighting) is the least-expensive power to supply. Also see *Peak*.

Off-Grid: electric generating units not connected to distribution or transmission lines.

On-Site Generating Facility: a class of customer-owned generating facilities with peak capacity of 60 kW or less. (See 220 CMR 8.02)

Parallel Operation: the utility and the source of distributed generation are operating so that each is capable of serving the same loads at the same time.

Passive Solar: a system in which solar energy is used for the transfer of thermal energy.

Peak: the time period when energy demand is at its highest points; measured on a daily, monthly, or annual basis, and commonly indicated by the upper portion of a sine curve. Peak power is the most expensive power to supply. (Also see *Off-Peak*.)

Peak-Shaving: technology or measures undertaken to reduce power consumption during periods of anticipated *peak*. This may include timers on air-conditioners or electric water heaters, or practices of washing dishes or running commercial or industrial processes during *off-peak* periods.

Photovoltaic Cell (PV): a technology consisting of layers of semiconductor materials and electrical contacts which is capable of converting light into electricity. There are different arrangements and applications for photovoltaic cells:

> Photovoltaic module: an integrated assembly of interconnected photovoltaic cells designed to deliver a selected level of working voltage and current at its output terminals commonly used for small scale applications.
>
> Photovoltaic array: a photovoltaic module or set of modules that may be used in larger applications.

Premium Power: generally refers to power that is utilized for critical and/or sensitive equipment such as computers and medical devices and requires high levels of reliability than that which may be delivered by central power generation. Use of distributed generation technologies may have the purpose of assuring lower risk of blackouts, brownouts or voltage fluctuations than power that may be available from central plant service.

Protection Systems: electronic and/or electromechanical devices that open circuit breakers to avert problems due to short circuits, overloads and other malfunctions which could interrupt electric service and/or damage electric distribution system equipment or jeopardize the safety of distribution system workers.

Quality of Service: the constant flow of electric service including voltage fluctuations, and *reliability* factor; especially important as commercial equipment becomes increasingly sensitive and requires greater attention to control and dispatch, and transmission and distribution power flow operations.

Radial Distribution Circuit: consisting of one primary circuit extending from a single substation or transmission supply point arranged such that the primary circuit serves retail in a particular local area (contrasted to a "Network" Distribution System primarily used in urban areas in which the system collectively feeds retail customers from a number of interconnected points).

Reliability: the constant flow of electric energy through to an end-use consumer minus interruptions in the form of brownouts and blackouts; usually expressed as a percentage of continuous operation on an annual basis.

Renewable Energy Resources: sources of energy that are either continuously resupplied by the sun, water, wind, or geothermal forces

Retail Market: a competitive market under which more than one electric provider can sell to retail customers.

Small Gas Turbine: a high-efficiency power production unit with a capacity usually greater than one *megawatt* that burns a mixture of gas and pressurized air at very high temperatures (3,500 degrees Fahrenheit) and releases hot expanding gases to a series of fixed and rotating power turbine blades.

Solar Thermal: a power system which concentrates the sun's heat energy using reflective mirrors, troughs, dishes, and or power-towers in large applications to activate turbines and generators to create electricity. (This should not be confused with solar thermal systems which utilize collectors to heat water for domestic or commercial purposes.)

Standard Offer Service: retail electric service provided to customers based on tariffed rates approved by the Massachusetts Department of Telecommunications and Energy which may include fuel cost additions from time to time. Standard Offer Service is set to expire March 1, 2005 at which time any customer who has not chose a competitive power supplier will be placed on utility provided Default Power Supply at market rates.

Stiffness (of the distribution system): a measure of how well the distribution system resists change due to loads or other connections. A "stiff" system is the opposite of a "weak" system. The greater the short-circuit MVA, the stiffer the system. The stiffer the system, the less effect distributed generation has on it.

Storage System: a battery, pumped storage, flywheel or other system utilized to store energy that may be utilized to produce electricity when desired.

Supply-Side: activities that take place on the utility side of the meter including merchant-scale power generation, or distributed generation at the substation or feeder level (contrasted to demand-side activities undertaken by the customer).

Synchronous Generator (also synchronous source of power): a source of generation that does not need to be connected to other generation in order to provide consistent voltage and energy to a load.

Tidal Power System: a power system that converts the energy present in tides into electricity by utilizing dams to force water through turbines which are connected to power generators.

Time-of-Use Rates: the pricing of electricity based on the estimated cost of electricity during a particular block of time. Time-of-use rate are usually divided into three or four time blocks per twenty-four hour period (on-peaks, mid-peak, off-peak and sometime super off-peak) and by the seasons of the year (summer and winter).

Transmission System: an interconnected grid of electric transmission lines and associated equipment for moving high -voltage electric energy in bulk between points of generation and delivery to a substation for the *distribution system*.

VAR Support: the requirement for a certain level of reactive volt-amperes in order to provide certain system power factor and/or voltage level.

Virtual Utility: the concept of utilizing distributed generation that may be dispatched to augment power supplied by *central power generation*.

Wave Power: technologies using the rise and fall of ocean swells to generate electric energy.

Wholesale Market: a market system in which a distributor of power, or an aggregator, broker or power marketer has the option to buy from a variety of power producers, and the power producers have the ability to sell to a variety of buyers. The wholesale market in New England consists of both a “Bilateral” contract market (where most power supply is contracted) and short term purchases from the New England Power Pool.

Wind Turbine: a wind generator atop a tower that may be operated in isolation or as part of a group of wind turbines connected to a common electricity grid.

Resource Assessment
<u>APPENDIX</u>

TECHNICAL STUDIES

IMPORTANT NOTE:

The *Resource Assessment* was designed to provide a context for all electric demand and supply-side options. Reading an individual technical study can present limitations. Every electric demand or supply-side option faces varying degrees of challenges and barriers and assumptions made concerning one option can affect other options. Great care should be taken in attempting to evaluate a single option out of context of a total supply mix.

Thus, the information contained in the individual studies should not be for attribution or use without verification with the Cape Light Compact. Contact: Margaret Downey (508) 375-6636.