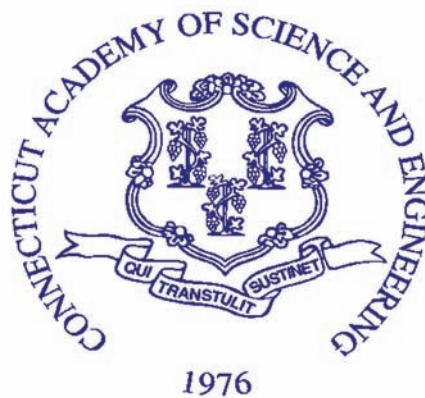


ENERGY ALTERNATIVES AND CONSERVATION

DECEMBER, 2006

A REPORT BY

THE CONNECTICUT
ACADEMY OF SCIENCE
AND ENGINEERING



FOR

THE CONNECTICUT GENERAL ASSEMBLY
COMMERCE COMMITTEE
ENERGY AND TECHNOLOGY COMMITTEE
ENVIRONMENT COMMITTEE

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OF SCIENCE AND ENGINEERING**

ORIGIN OF INQUIRY: CONNECTICUT GENERAL ASSEMBLY
 COMMERCE COMMITTEE
 ENERGY AND TECHNOLOGY COMMITTEE
 ENVIRONMENT COMMITTEE

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This study was initiated at the request of the Commerce Committee, Energy and Technology Committee, and the Environment Committee of the Connecticut General Assembly on May 1, 2006. The project was conducted by an Academy Study Committee with the support of David Pines, PhD, Project Study Manager and Tom Filburn, PhD, Study Consultant. The content of this report lies within the province of the Academy's Energy Production, Use and Conservation Technical Board. The report has been reviewed by Academy Members A. George Foyt, PhD and John P. Cagnetta, PhD. Martha Sherman, the Academy's managing editor, edited the report. The report is hereby released with the approval of the Academy Council.

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EXECUTIVE SUMMARY

STUDY OBJECTIVE

The Commerce, Energy and Technology, and Environmental Committees of the Connecticut General Assembly asked the Connecticut Academy of Science and Engineering (CASE) to conduct an assessment of energy alternatives and conservation actions which have the potential to reduce reliance on oil and fossil fuels over the next ten years; which are applicable to Connecticut; and which would spur innovation, diversity and consumer choice. To conduct this assessment, CASE assembled a Study Committee of both in-state and national experts on energy efficiency, conservation, and alternative energy.

The study was conducted in the following three phases:

1. The historical trend of energy consumption in the state, fuel mix diversity, and sector energy demand was reviewed. Also, the effectiveness of existing energy efficiency and conservation programs and the extent to which the state is already using renewable and non-fossil fuel resources were analyzed.
2. Programs and initiatives that other states and countries have used to reduce their consumption of fossil fuels were identified and considered.
3. The Study Committee then selected those conservation and energy efficiency measures that were deemed to be the most significant in reducing the state's dependence on fossil fuels. These formed the basis for a comprehensive strategy for reducing Connecticut's reliance on fossil fuels both in the short and long term.

BACKGROUND

The state's total energy consumption increased approximately 80% from 1960 to 2004, with electric power (37%) and transportation (32%) currently being the largest energy-consuming sectors. About 80% of Connecticut's energy in 2004 came from fossil fuels. The primary non-fossil fuel source was nuclear power, with much smaller contributions of 0.5% from hydroelectric and 2% from biomass, primarily from direct combustion of municipal solid waste. Compared to the state's total energy consumption, there was no significant contribution from solar or wind power. The requirement that gasoline contain 10% ethanol by volume is expected to decrease the state's dependence on fossil fuels by up to 3%, depending on the source of the ethanol.

The state's annual per capita energy consumption has been relatively constant since the late 1980s at 250 million BTUs (75 MWh). That figure is

- significantly lower than the US consumption rate of 340 million BTUs (100 MWh).
- higher than the consumption rate of 225 million BTUs (65 MWh) for New York and California. It is also interesting to note that California has been able to reduce its annual

per capita energy consumption from 290 million BTUs (85 MWh) in the late 1970s to the current consumption of 225 million BTUs (65 MWh).

- higher than the annual per capita energy consumption of United Kingdom, France, and Germany, which was about 175 million BTUs (50 MWh) in 2004.

Similarly, Connecticut's annual per capita electricity consumption of 9,000 kWh is lower than the US average of 12,000 kWh, but higher than New York's and California's annual per capita electricity consumption of 7,200 kWh.

A variety of conservation programs are currently being implemented through a number of state government departments and non-profit organizations. One of the most effective is the Connecticut Energy Efficiency Fund (CEEF), which is funded by a small charge on consumers' electric bills. A review of CEEF's 2005 programs by the Energy Conservation Management Board (ECMB) estimated that the annual and projected lifetime savings of the installed energy efficiency measures was 318 million kWh and 4.4 billion kWh, respectively. This is equivalent to a lifetime savings of \$550 million, assuming an average price of \$0.125 per kWh, compared to the \$65 million cost to operate these programs. In comparison, the natural gas conservation program is relatively small; there is no similar program for conservation of heating oil.

To promote renewable energy, the Connecticut General Assembly passed a law in 1998 creating a Renewable Energy Investment Fund, currently named the Connecticut Clean Energy Fund (CCEF). The CCEF is charged with promoting the development and commercialization of clean energy technologies and is funded through a surcharge on electric ratepayers' utilities bills. The other effort to raise public awareness of clean energy is a program adopted by the Department of Public Utility Control (DPUC) and promoted by SmartPower that provides electric ratepayers the option to purchase 50% or 100% of their electricity from clean energy sources.

SUMMARY OF FINDINGS AND SUGGESTIONS

The Study Committee suggests that many of the state's existing programs be expanded and new initiatives be implemented to meet the goal of reducing Connecticut's dependence on fossil fuels. Aggressive efforts are required to increase the market penetration of energy efficiency technologies, and long-term investments are needed to develop renewable and non-fossil fuel energy sources. Both energy efficiency and non-fossil fuel sources are essential, but their time frame (short-term versus long-term) and financial commitment are quite different. Many of this study's suggested conservation and energy efficiency initiatives and programs use existing technologies and have benefits that can be obtained immediately. Furthermore, the resources invested in energy efficiency incentives and education/outreach are more than offset by a reduction in energy expenditures by the state's citizens and businesses, and savings in infrastructure costs, such as transmission lines and new power generating facilities.

In contrast, the technology for most of the renewable and non-fossil fuel alternative energy supply sources needs to be developed. Therefore, it should not be expected that initial investments will be cost effective, but rather they are suggested as part of an overall plan with a goal of helping to increase the competitiveness of these non-fossil fuel alternatives.

Energy Efficiency and Conservation

Review of annual per capita total energy consumption and electric consumption indicates that an increased investment in energy efficiency and conservation can lead to significant energy consumption reductions. Connecticut should be able to reduce its per capita energy consumption to that achieved by New York and California (e.g., 10% total energy consumption and 20% electrical consumption), with a goal of having per capita energy consumption similar to that of the United Kingdom, France, and Germany (e.g., 30% reduction). These conclusions are supported by an independent assessment of Connecticut's conservation and efficiency potential that was prepared for the ECMB by GDS Associates in June, 2004. This study found that Connecticut has a maximum achievable cost-effective potential for energy efficiency of 12% by 2012 at a cost of less than \$0.05/kWh based on 2003 energy consumption. It was estimated that the annual investment required to achieve these savings is between \$82 million and \$148 million, with an estimated net present savings of \$1.78 billion.

Many of the energy efficiency measures suggested by the Study Committee have very short payback periods of less than five years, and are sound investments that will have the added benefit of strengthening Connecticut's economy. These initiatives are

- **Combined Heat and Power (CHP):** Increase outreach to promote the market penetration of CHP systems. It is estimated that there is the potential to replace 1,670 MW of power plant generating capacity with new CHP systems. Very good incentives are currently available for distributed generation, but should be tailored to CHP systems that have efficiencies of up to 85% when a system uses natural gas as its fuel source. Programs such as "Distributed Generation\$" sponsored by DPUC and the Connecticut Department of Environmental Protection (DEP) should be expanded to include electric and heating load assessments for businesses that have potential CHP applications.
- **CEEF:** Restore funding of the CEEF to at least \$90 million with consideration given to increasing it to \$148 million. The state should adopt the principle that energy resource needs will first be met through all available energy efficiency and demand reduction resources that are cost effective, reliable, and feasible. The 2004 independent assessment performed for the ECMB should be updated periodically to reflect current market conditions for the energy efficiency measures that meet these criteria. Also, the ECMB should oversee expanded natural gas and heating oil conservation programs that are funded by users of these energy sources.
- **Compact Fluorescent Light Bulbs:** Aggressively market compact fluorescent light bulbs because of their significantly higher efficiency as compared to incandescent light bulbs and the very attractive cost of conserved electricity of less than \$0.03/kWh. In addition to the currently available incentives, a fee should be added to the sale of incandescent light bulbs at the wholesale level when a compact fluorescent light bulb has comparable lighting characteristics. Consider developing and implementing a statewide fund raiser for all schools in Connecticut to sell compact fluorescent light bulbs. The program would have an education component. Students would benefit from the educational effort and from funds raised, which could be used to support student activity programs. Establish a statewide sales target, such as 1 million light bulbs.

- **Advanced Metering – Three-Tier Electricity Rate Structure:** Switch from a one-tier electric rate to the use of advanced metering with time-variant rates within the next five years. Electric rates should reflect the actual cost of generating electricity. A revenue neutral, three-tier rate structure which includes a peak daily rate, reduced off-peak rate, and a surcharge on the peak daily rate during peak electricity demand is suggested. The expected direct benefits are lower peak demand and more efficient use of generating facilities and the electric grid.
- **Fuel-Efficient Car Purchase Incentives:** Provide consumer incentives for the purchase of fuel-efficient cars by modifying both the initial sales tax and the subsequent property tax via a Fuel Efficiency Adjustment (FEA) based on the formula $FEA = \$(100 - 4 \times \text{MPG})$. The formula should be modified in subsequent years to make it cost neutral to the state. Also, the Study Committee suggests eliminating all sales tax on the purchase of hybrid cars and applying a property tax only to the gasoline portion of the car. To further promote fuel efficiency, incentives should be provided for having properly inflated tires, which can increase gasoline efficiency by up to 7%. This program could be implemented as part of the state's emissions testing program. Car owners would receive 5% off the cost of the emissions test if their tires are properly inflated, and would pay 10% extra if they are not.
- **Lead by Example Program:** Expand the "Lead by Example" program with the goal of having all schools and state buildings achieve an average benchmark of 50 based on EPA's Energy Star Portfolio Manager rating system (a scale of 1-100) within five years. This investment is estimated to save \$46 million annually based on 2006 energy costs.
- **Green Building Initiative:** Adopt a program similar to California's Green Building Initiative with a goal of reducing energy in privately owned commercial buildings by 20% over the next 15 years, using 2006 as the benchmark.
- **Energy Use Reduction Incentive Program:** Adopt an incentive program to encourage residents to take the initiative to reduce their own energy consumption. A model for this program is California's 20/20 program, through which residents receive an additional 20% reduction in their electric bills if they reduce their summer electrical consumption by more than 20%.

The Study Committee also supports investment in energy efficiency and conservation measures that have a longer time frame. They are

- **Focused Mass Transit Initiatives:** Continue to invest in mass transit in regions of the state where population and employment density makes this a viable alternative. The Study Committee supports initiatives in the area of "smart growth" and livable communities passed by the 2005 Connecticut General Assembly, including Public Act 05-205. Also, legislation adopted in 2006 provides for two significant mass transit projects: the development of the New Britain to Hartford busway and a New Haven-Springfield, MA commuter rail service. Even though the investment in mass transit will be significant, the success of these initiatives will have the greatest impact in reducing the consumption of energy in the transportation sector.

- **Education Effort Expansion:** Include “Energy Transfer and Transformation” and “Science and Technology in Society” themes in the Connecticut Core Science Curriculum and add a course to the curriculum at the high school level that is devoted to the thermodynamics of energy, energy conversion and energy economics. Mastery of these fundamental concepts will give high school students the background to understand the need for alternative energy and conservation initiatives, to be responsible energy users, and to encourage tomorrow’s leaders to further develop these initiatives.
- **Public Awareness Campaign:** Over time, education of the state’s K-12 students will have a significantly greater impact on conservation and energy efficiency. It is also critical to educate the general public about these topics on a continuing basis through a mass media marketing campaign. The campaign should emphasize the importance of reducing overall and peak energy consumption, and provide information on incentives available to both residents and businesses to meet the state’s energy reduction goals. Several initiatives to increase public awareness and conservation among the public, especially during peak load periods, should be considered, including
 - o development of a Real-Time Energy Report for use on television and by other media as a part of daily weather reports
 - o establishment of a voluntary E-Mail and Cell Phone Energy Alert System to inform the public of the need in real-time to reduce energy use
- **State Oversight and Accountability:** To more effectively promote conservation and energy efficiency, task one organization with monitoring the progress of state programs and activities aimed at achieving the annual targets that are needed to reach the state’s long-term goals. This will enable Connecticut’s policy makers to annually assess the funding and effectiveness of individual programs and to quickly develop new strategies to meet the long-term milestones. In addition, this organization should be responsible for providing Connecticut citizens and businesses with comprehensive information about all of the state’s energy programs in a variety of formats, such as the web, print and mass media.

ALTERNATIVE AND RENEWABLE ENERGY - FOSSIL FUELS

The state also should consider investing in efforts to increase the use of non-fossil fuels. The technology for most of these alternative energy supplies needs to be further supported and developed. Therefore, it should not be expected that initial investments will be cost effective, but rather they are suggested as part of an overall plan with a goal of helping to increase the competitiveness of these non-fossil fuel alternatives compared to traditional fossil fuels. The most plentiful source for renewable energy within Connecticut is biomass, which can be used as a fuel for generating electricity or transformed into a liquid fuel such as biodiesel or ethanol. The initiatives supported by the Study Committee are

- **Biomass:** Maximize the state’s electricity generation from biomass. Currently, a 37.5 MW power plant that utilizes a biomass gasification technology is expected to be built in Plainfield, CT. This power plant is expected to use 1,000 tons/day of biomass material, including construction and demolition (C&D) waste, trimmings from tree and brush

CONCLUDING REMARKS

The state's energy efficiency and conservation programs are achieving reductions in energy consumption as shown by its lower per capita energy consumption as compared to that for the United States. However, the state can achieve even greater reductions by aggressively implementing the suggestions provided by the Study Committee. At a minimum, the state should establish a goal to reduce the state's per capita energy consumption to that of California and New York. Looking toward the future, the state should consider adopting a more ambitious goal of achieving a per capita energy consumption that meets that of the most energy-efficient countries in the world, such as the United Kingdom, France, and Germany. The state should also actively pursue opportunities for the use of non-fossil fuel alternative energy sources such as biomass, low-head hydroelectric, solar, and local wind farms for electricity generation. Also, biodiesel should be promoted as an alternative liquid fuel with the potential of producing biodiesel fuel either from state-grown crops or from vegetable oil imported from other northeastern states. Additionally, the state should actively monitor the progress made in commercializing the production of cellulosic ethanol. Finally, alternatives to traditional heating and cooling such as combined heat and power systems, solar thermal and geothermal heat pump systems should be promoted.

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I. INTRODUCTION

The Commerce, Energy and Technology, and Environmental Committees of the Connecticut General Assembly asked the Connecticut Academy of Science and Engineering (CASE) to conduct an assessment of energy alternatives and conservation actions which have the potential to reduce reliance on oil and fossil fuels over the next ten years; which are applicable to Connecticut; and which would spur innovation, diversity and consumer choice. This assessment includes but is not limited to

- providing an analysis of the state of emerging energy alternatives and renewable fuels and their applicability for use in Connecticut, including technologies that can help to reduce greenhouse gases and electricity congestion
- assessing technological opportunities for supporting energy independence for current and future motorized transportation, such as the potential for developing biofuel crops and building biofuel refineries and production facilities in Connecticut
- identifying new ideas to promote energy conservation, such as the consumption of biofuel/ ethanol fuels and use of electric vehicles, based on a best practices survey of what other states and countries doing

The report is divided into three sections. The first section of the report reviews the historical trend of energy consumption in the state and the fuel mix diversity to meet that demand, and the energy requirements of each sector (residential, commercial, industrial, transportation, and electrical) from 1960-2004. The effectiveness of the existing conservation and efficiency programs is presented, followed by a summary of the current renewable and non-fossil fuel energy resources.

The second section of the report provides a listing of suggestions that the CASE Study Committee has determined will provide the most significant opportunity for reducing the reliance on fossil fuels over the next ten years. Included in each suggestion is an estimate of the total potential energy savings where data are available, case studies, and a suggested methodology or procedure for increasing market penetration for each suggestion.

The third section of the report provides an analysis of non-fossil fuels and identifies which of these potentially would have the most impact on reducing Connecticut's dependence on fossil fuels.

A summary of the Study Committee's findings is given in the last section of the report. The individual energy efficiency and conservation programs and alternative energy initiatives are brought together in a comprehensive plan to reduce Connecticut's dependence on fossil fuels.

II. ASSESSMENT OF CONNECTICUT'S ENERGY USAGE, CONSERVATION PROGRAMS, AND RENEWABLE ENERGY PROJECTS

This section of the report summarizes the historical trend in energy consumption since 1960 and the effectiveness of current conservation and efficiency programs, and reviews the state's existing renewable and non-fossil fuel energy resources.

ENERGY CONSUMPTION

The total energy consumption for the state of Connecticut in 2004 is estimated to be 877 trillion BTUs, not including the net interstate flow of electricity. Energy consumption has increased by almost 80% since 1960, when it was estimated to be about 500 trillion BTUs. The trend of increasing energy demand from 1960–2004 is shown in Figure 1. While more recent data are not available, the \$8 billion Connecticut energy users paid in 2001 for energy is significantly higher today due to the recent sharp increase in energy costs (2006 Connecticut Energy Plan). As for electric energy consumption, the 2006 Connecticut Siting Council (CSC) report, "Review of the Ten Year Forecast of Connecticut Electric Loads and Resources," estimates that the annual compounded growth rate will be 1.26%.

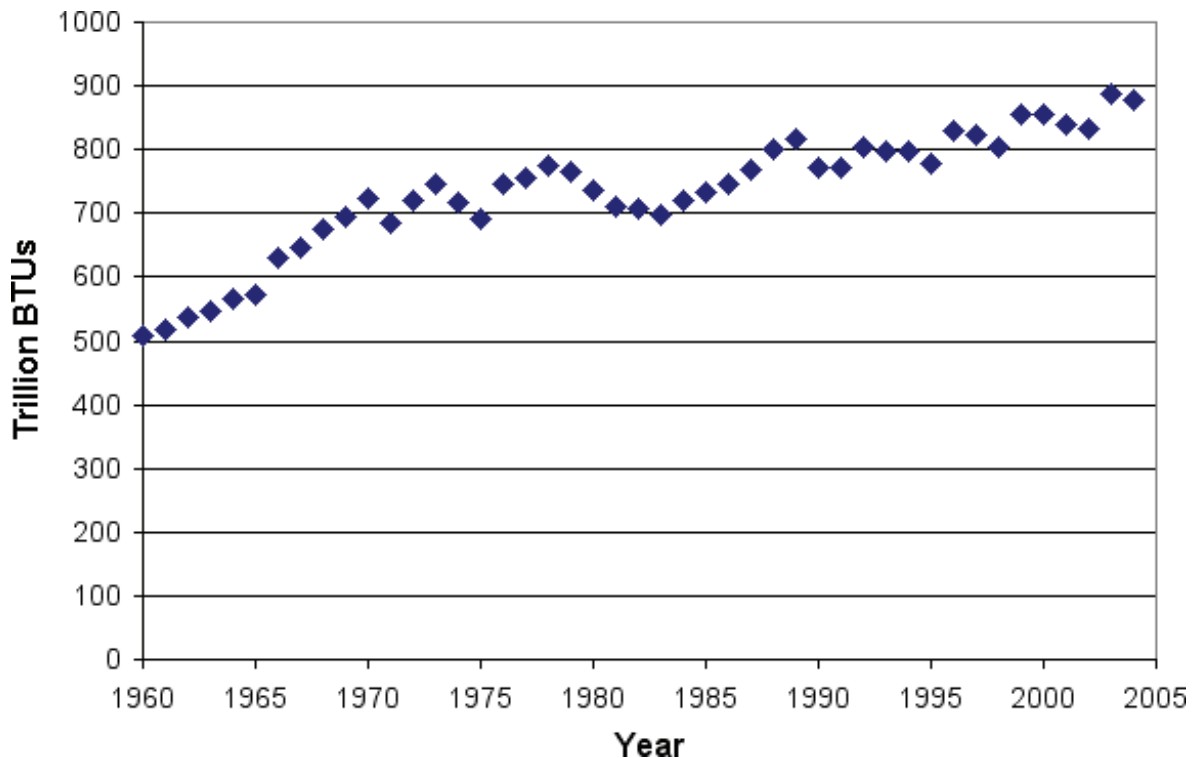


FIGURE 1: CONNECTICUT TOTAL ENERGY CONSUMPTION (1960–2003 DATA FROM ENERGY INFORMATION ADMINISTRATION (EIA), *STATE ENERGY DATA 2003: CONSUMPTION, TABLE 7*; 2004 DATA ESTIMATED BASED ON VARIOUS EIA SOURCES)

The distribution of the energy used for residential, commercial, industrial, transportation, and electric power is shown in Figure 2. In 2004, generation of electricity accounted for the largest share, about 37% of the state's total energy consumption. Transportation was the next most significant sector, accounting for about 32% of the state's energy requirements. Of the total energy consumed, about 80% was derived from the burning of fossil fuels, primarily petroleum products and natural gas. The fuel diversity mix for 2004 is shown in Figure 3.

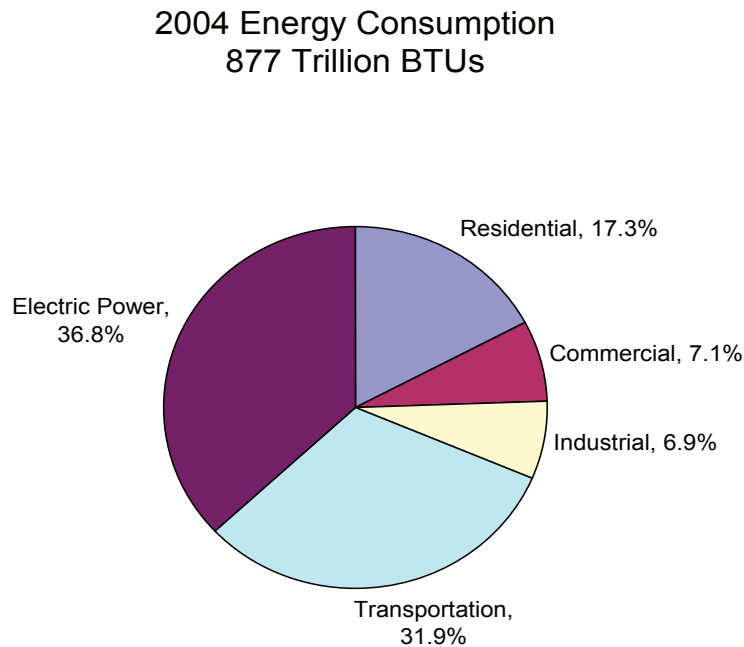


FIGURE 2: 2004 ENERGY CONSUMPTION BY SECTOR
(DATA COMPILED FROM 2004 EIA ELECTRICITY GENERATION, PETROLEUM, AND
NATURAL GAS ANNUAL REPORTS)

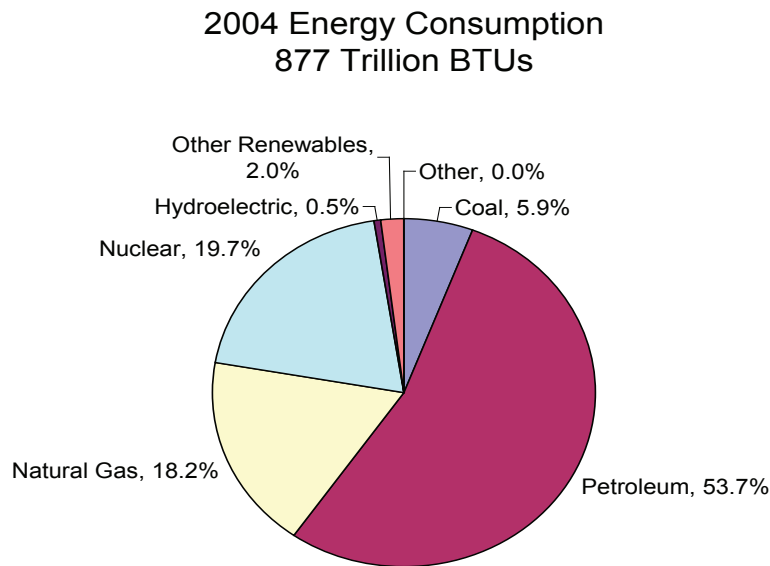


FIGURE 3: 2004 ENERGY FUEL MIX
(DATA COMPILED FROM 2004 EIA ELECTRICITY GENERATION, PETROLEUM, AND
NATURAL GAS ANNUAL REPORTS)

Connecticut's dependence on fossil fuel since 1960 has ranged from a low of 70% between 1985 and 1995 to almost 100% in the 1960s (see Figure 4). The reduction in reliance on fossil fuels was primarily a result of increased nuclear electric power generation. The other trends that have occurred are a steady increase in natural gas consumption and a reduction on the dependence of petroleum products since the mid 1970s. The trends for coal, natural gas, petroleum, nuclear, and net interstate flow of electricity are shown in Figure 5.

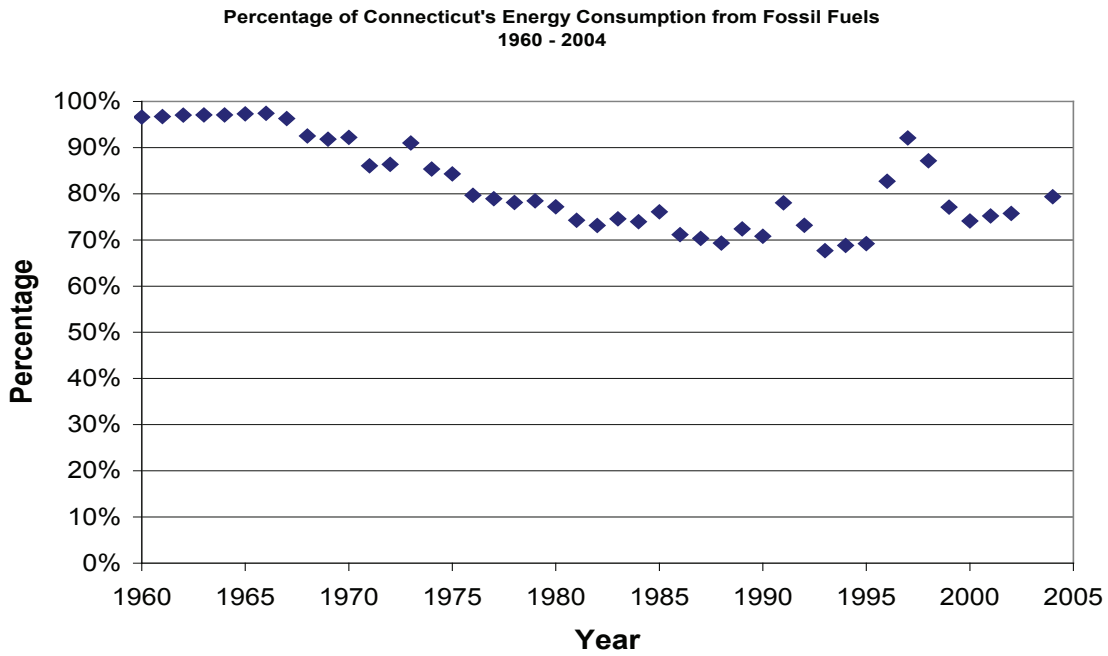


FIGURE 4: PERCENTAGE OF CONNECTICUT'S ENERGY CONSUMPTION FROM FOSSIL FUELS, 1960-2004

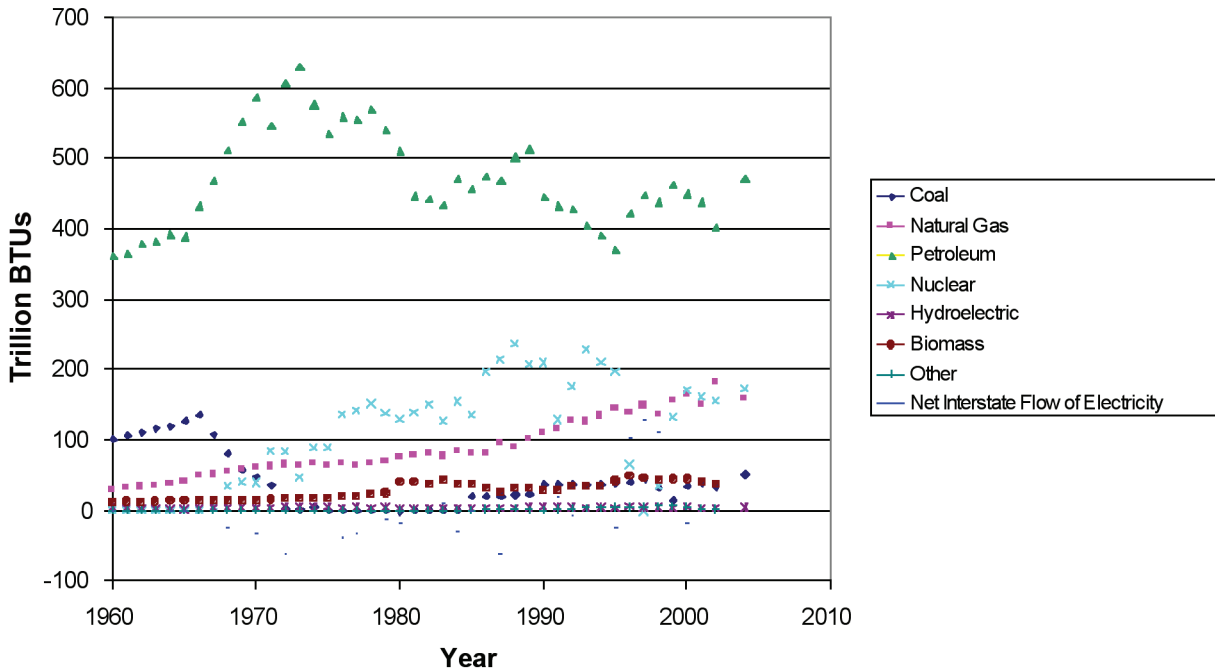


FIGURE 5: CONNECTICUT'S FUEL MIX CONSUMPTION (COAL, NATURAL GAS, PETROLEUM, NUCLEAR, AND INTERSTATE FLOW OF ELECTRICITY), 1960-2004

Based on East Coast imports of petroleum (http://tonto.eia.doe.gov/dnav/pet/pet_move_impcp_a2_r10_ep00_ip0_mbb1_m.htm), the sources for petroleum used in Connecticut in 2005 were 65.6% from non-OPEC countries and the remaining 34.4% from OPEC countries, with 20% of the OPEC share coming from Persian gulf countries. The average price for crude oil in January 2005 was \$38.80 and increased to \$52.60 by December 2005. It is estimated that for 2005, the cost of importing petroleum products for use in the state based on the monthly average cost per barrel of petroleum was \$3.13 billion. It is expected that the amount of money leaving Connecticut for the importation of petroleum products will be even higher in 2006, with the average price per barrel of petroleum having increased on the spot market to \$65.60 by May 2006.

There has been a steady increase on the reliance on natural gas from 29.4 trillion BTUs in 1960 to 159.7 trillion BTUs in 2004. Since 2001, natural gas has been relied on more as a fuel source for electricity generation (see Figure 6). For example, the dependence on natural gas for generating electricity has increased from 13.4% in 2001 to 24.8% in 2004.

32.6 TW-h Total Electric Energy Generation, 2004

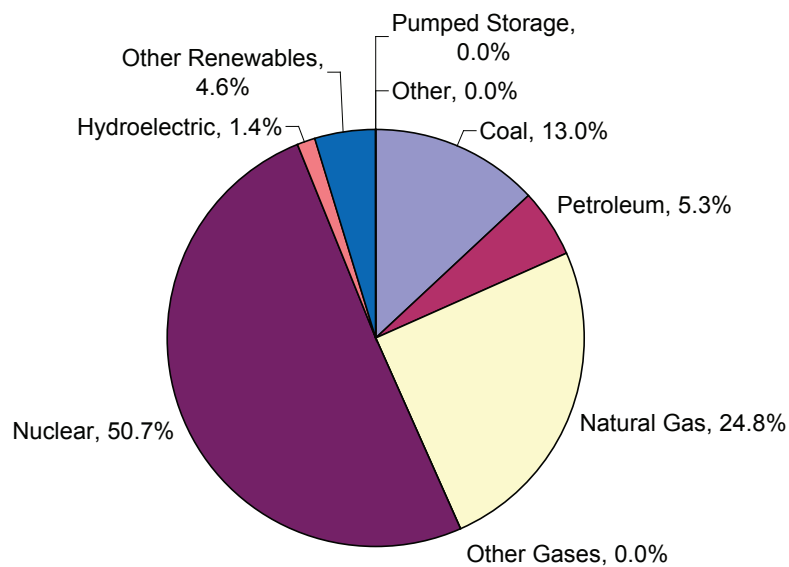


FIGURE 6: ELECTRIC POWER INDUSTRY GENERATION BY PRIMARY ENERGY SOURCE IN 2004

ASSESSMENT OF CONSERVATION PROGRAMS

Conservation and Efficiency Programs

The following is a short summary of selected conservation and efficiency programs currently in place in Connecticut.

- **Connecticut Energy Efficiency Fund (CEEF)**

The CEEF was created to address Connecticut's increasing electric energy needs and is funded by a small charge on customers' electric bills. One of the missions of the CEEF is to help homeowners and renters, small and large businesses, and state and local governments use energy more efficiently. The planning and implementation of the CEEF is overseen by the Energy Conservation Management Board (ECMB). Appendix A lists the 2006 Connecticut Energy Efficiency Fund's residential, commercial and industrial programs; an assessment of CEEF's programs in 2005 by the ECMB is given later in this chapter.

- **Natural Gas Conservation Programs**

Connecticut's current natural gas conservation programs are relatively small compared to those of other New England states, and cover only residential customers. The programs are delivered by natural gas companies, and their planning and implementation are also overseen by the ECMB. The current programs are

- o **Low Income Weatherization and Heating System Replacement:** This program is restricted to owner-occupied buildings with one to four residential units that meet income guidelines. The customers must use the natural gas for heat. The conservation measures, installed at no cost for those who qualify, include insulation and air sealing measures. Inefficient heating systems may be replaced at a cost of up to \$3,640.
- o **General Weatherization Program:** This program is available without regard to income. It is operated jointly with the electric utilities' Residential Heating and Cooling Program. The contractor conducts blower door and duct leakage tests and performs air sealing and duct sealing as appropriate. Insulation needs are assessed and utility rebates are available. Domestic hot water saving measures are installed where appropriate. In addition, electric efficiency opportunities are identified and incentives made available pursuant to the electric program.
- o **Energy Conservation Loan Program:** This loan program provides financial assistance in the form of below-market interest rates to eligible building owners for residential energy efficiency improvements. The loans can be used for the purchase and installation of setback thermostats, caulking, weather stripping, conversion of electric heating systems if house was constructed before 1980, heating system improvements/replacements, insulation, low-flow shower heads, solar installations, storm windows and doors, thermal windows and doors, wood stoves, and other items that will reduce energy bills. This program is administered by the Connecticut Housing Investment Fund under the Connecticut Department of Economic and Community Development.
- o **Residential Conservation Services Program (home energy audits):** This program provides residential heating customers the opportunity to have a professional energy consultant conduct a home energy audit at an affordable cost. The cost is \$85 for non-hardship customers and is free for hardship customers. The audit is conducted by a certified home energy rater and

includes a review of the dwelling energy consumption patterns, air infiltration characteristics, and other variables affecting energy usage.

- **Farms to Schools Program: Reducing “Food Miles”**

The goals of this program are to reduce vehicle miles driven for food shipments, promote good nutrition, and support local farmers. As of June 2006, 51 school districts and 40 farms participate in the program.

- **ISO-NE (Independent System Operator–New England)**

Voluntary Electricity Conservation Program: In June 2006, ISO-NE launched a campaign to teach and encourage energy conservation. One aspect of their Take Charge New England campaign messages will be the broadcast of information about energy conservation on radio. This effort will complement ISO-NE's request for voluntary conservation during times of high electricity demand.

- **State Government “Leading by Example” (Executive Order 32)**

The State of Connecticut has recognized the need to reduce energy consumption and greenhouse gas emissions in order to provide an example for the state's citizens. These measures include promoting clean energy, conservation, and efficiency. Several steps have already been taken.

Clean Energy

1. A Solar Photovoltaic (PV) system is installed at a Connecticut Department of Transportation's (ConnDOT) maintenance garage in Hartford.
2. A 25 kW fuel cell is installed at the Connecticut Department of Environmental Protection's (DEP) Dinosaur State Park in Rocky Hill.
3. DEP has agreed to purchase a 100% clean energy option through the grid.
4. State employees are encouraged to purchase clean energy for their homes.

Conservation and Efficiency

1. New state buildings, including ones on the campuses of the University of Connecticut, Eastern Connecticut State University, Western Connecticut State University, and Southern Connecticut State University, have been designed to meet Leadership in Energy and Environmental (LEED) standards.
2. Governor Rell directed the Department of Public Utility Control (dPUC), Office of Consumer Counsel (OCC) and the ECMB to prepare a report on opportunities to reduce electric consumption at state facilities. The report, “Energy Efficiency Opportunities in State Facilities,” was completed in February 2005 and the Governor asked all agencies to reduce energy use by 10% in 2006.

3. The Office of Policy and Management (OPM) Energy roundtable assists state agencies achieve conservation and efficiency measures.
4. Energy use at state agencies (DEP, Department of Administrative Services, DPUC, OPM, Department of Revenue Services, and Connecticut Innovations) will be benchmarked.
5. Videoconferencing will be encouraged in an effort to reduce vehicle miles traveled.
6. The state purchased 125 new hybrid-gasoline-electric vehicles in May 2005 toward the goal of operating a more fuel-efficient state motor vehicle fleet.

- **NuRide: 2,000,000 Mile Rideshare Connecticut Challenge**

NuRide is a ride network that encourages people to share rides through reward incentives. The program allows people to become members and share rides with any other members by simply searching for someone with the same commute. The goal of NuRide is to reduce traffic congestion and air pollution. As part of its marketing campaign, NuRide informs people that 78% of cars on the road are occupied by a solo driver and that vehicles generate 50% of urban air pollution.

- **DPUC / DEP Distributed Generation Incentives Pilot Program**

DPUC, with the cooperation of DEP, hired the Connecticut Economic Resource Center (CERC) to promote incentives for distributed generation—focusing initially only on Southwestern Connecticut/Fairfield County—through a multi-phased program:

- o Connecticut Light and Power (CL&P) and United Illuminating (UI) provided CERC with a targeted list of customers that consume more than 100 kW. CERC crafted and distributed a letter, signed by the commissioners of both DPUC and DEP, which was sent to approximately 300 Connecticut companies.
- o The second phase of the program was to create and distribute a creative brochure that highlighted the incentives DEP and DPUC offered companies that embarked on a distributed generation project. The brochures were mailed to the same 300 companies to establish continuity and to keep the message in front of the key target audience.
- o The third phase of the program featured a telemarketing program. All 300 facility managers on the targeted list were personally called, asked about their level of interest in a distributed generation project, and invited to attend a special Energy Forum event.
- o The last phase of the pilot program was to host a conference that was held in Fairfield County on October 5, 2006. More than 200 attendees participated in the event, which featured nine guest speakers and 17 exhibitors.

From the start of the program, 46 companies with a combined total of 151 MW of power have applied to participate in the distributed generation program through DPUC.

- **Northeast Energy Efficiency Partnerships, Inc**

n ortheast Energy Eff iciency Partnerships (n EEP) is a nonprof t organization that promotes energy eff iciency in homes, buildings and industry. The organization promotes energy eff iciency by increasing markets for energy-eff icient products, encouraging energy-eff icient practices, and educating the public. The n ortheast r esidential Energy Star Production initiative is an example of a NEEP-coordinated program. This program's mission is to create markets for energy-eff icient appliances and lighting.

Connecticut Energy Efficiency Fund

The CEEF's 2005 programs were reviewed by the ECMB in their annual report. It was found that these programs provided an annual savings of approximately 318 million kWh, which equates to an annual savings of approximately \$40 million assuming an average price of \$0.125 per kWh. Over the lifetime of the installed energy-eff iciency measures, the projected savings are 4.4 billion kWh. This is equivalent to an estimated savings of \$550 million, assuming an average price of \$0.125 per kWh. The cost of operating these programs to achieve these savings was \$65 million, which is about 12% of the projected lifetime savings. There were a total of 366,000 instances of participation in the programs, with the commercial sector being the most signif cant benef ciary. About \$42 million was invested in large commercial and industrial retrof ts. For example, an independent grocery store in Bridgeport installed new f uorescent lighting, a new computerized control system for refrigeration, and other retrof ts at a cost of \$31,950. The owner received a cash incentive of \$12,210 from CEEF. The remaining net cost to the owner of \$19,740 was f nanced by a 28-month loan. This retrof t reduced the store's annual electricity consumption by 17% (101,750 kWh) for a savings of \$10,890 per year providing a simple payback period of less than two years.

The residential sector realized an estimated 106 million kWh of energy savings through CEEF programs (see Appendix A for list of CEEF residential incentives for energy eff iciency and conservation measures). For example, low- and moderate-income individuals were identif ed as targets for weatherization services under Public Act 05-2 *An Act Concerning Heating Assistance*. This program provided assistance to approximately 18,000 utility customers, with a projected lifetime energy savings of 144 million kWh and a benef t-to-cost ratio of approximately 3.

The ECMB is concerned that the effectiveness of the CEEF will be hindered in 2006 because of a 33% budget reduction. This budget reduction is the result of a 2003 legislative mandate that directed CEEF funds to be used to reduce the state's budget def cit. The ECMB concluded that there is a critical need for effective energy eff iciency and load management programs, and that these programs are a critical part of Connecticut's energy infrastructure. A reduction in the CEEF budget will result in a signif cant reduction in the level of programs that result in energy savings.

Independent Assessment of Conservation and Energy Efficiency Potential for Connecticut and the Southwest Connecticut Region (GDS Associates, 2004)

An independent assessment of Connecticut's conservation and energy eff iciency potential was prepared for the ECMB by GDS Associates in June 2004. This study estimated the potential energy savings from eff iciency measures that are cost effective. Cost effectiveness is determined

by equipment costs, installation, operation and maintenance, cost of removal, administration cost, and cost reduction from tax credits. The key finding from this study is that energy-efficient lighting can have a potentially large impact on energy consumption and demand.

In the residential sector, it was estimated that the maximum achievable, cost-effective potential energy savings is 14%, based on 2003 energy consumption. The most significant source of cost-effective savings is more energy-efficient lighting, where 57% of energy consumption savings and 35% of demand savings can be achieved. Other significant sources of potential savings include improved space and water heating systems. Also, water heating pipe wrap—which can reduce water heating energy use by 48%—was found to be the least expensive conservation measure.

In the commercial sector, office buildings are the source of the highest maximum achievable, cost-effective potential energy savings. As with the residential sector, lighting provides 47% of potential energy savings and 39% of potential demand savings. Cooling also represents a large portion of potential demand savings. The report encourages more efficient lighting, namely Super T-8 to reduce energy used for lighting by 50%. Other factors that may also have a significant impact include more efficient cooling, refrigeration, and ventilation, which can reduce overall electricity consumption by 13-30%. Turning off desktop computers at night was found to be the lowest-cost energy conservation measure. In 2004, the commercial sector was estimated to have a maximum achievable cost-effective potential of 14% based on 2003 energy consumption.

The study recognizes that the industrial sector is difficult to assess because of its heterogeneous nature. However, significant potential energy savings were discovered in HVAC systems, pumps, energy-efficient lighting, motors, and air compressors. The study breaks down a variety of measures for various industries. Some significant measures include optimization of air compressor systems, fan control systems, and HVAC management systems. The maximum achievable cost-effective potential for the industrial sector was estimated to be 13%. However, individual industries must be separately analyzed to truly understand potential energy savings.

The study also projected that Connecticut has a maximum achievable cost-effective potential for energy efficiency of 12% by 2012 at a cost of less than \$0.05/kWh. The supply curve showing the percent reduction as a function of cost is shown in Figure 7. To achieve the maximum achievable potential, it is estimated that investment in energy-efficiency programs would have to be approximately \$82 million to \$148 million annually (in 2003 dollars). It is estimated that this investment will provide the residents of Connecticut with a net present savings of \$1.78 billion. This estimated 12% reduction in electricity over the ten-year time frame of this study would not actually reduce the state's electrical consumption, but would essentially lead to zero growth in electrical demand based on the CSC's 2006 forecast for an annual compounded electrical consumption growth rate of 1.26%.

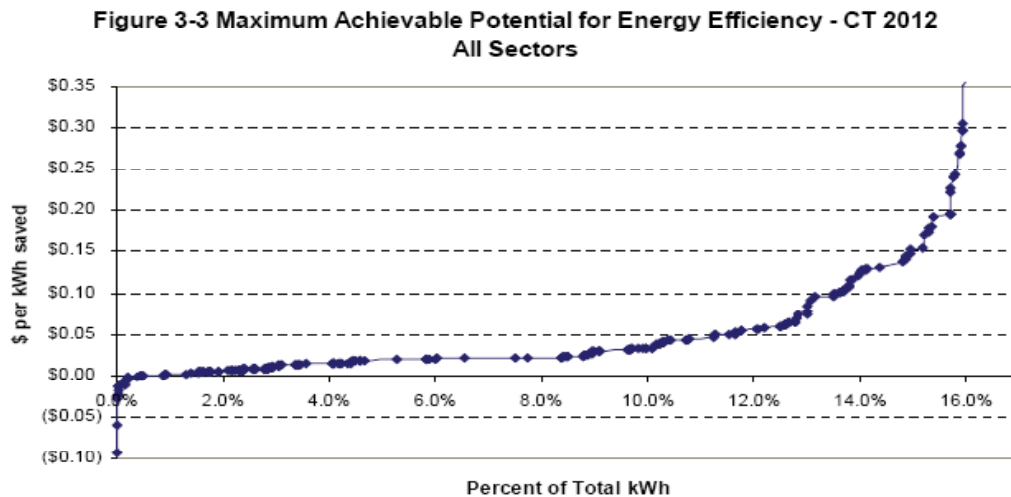


FIGURE 7: MAXIMUM ACHIEVABLE POTENTIAL FOR ENERGY EFFICIENCY BY 2012
 (FROM GDS ASSOCIATES CONSERVATION AND ENERGY EFFICIENCY REPORT TO ECMB, JUNE 2004
 FIGURE COURTESY OF GDS ASSOCIATES)

Assessment of Connecticut's Efficiency Programs Based on Total Energy and Electrical Consumption on a Per Capita Basis

Per capita energy usage is one tool that can be used to assess the effectiveness of past and present conservation programs. This measure can disaggregate meaningfully demographic trends, as well as clarifying the trade-offs and opportunities that exist for more supply versus efficiency and demand-side changes. Figure 8 shows the per capita energy consumption for Connecticut compared to the United States, California, New York, France, Germany, and the United Kingdom for the period from 1960–2004. Connecticut's per capita energy consumption of 250 million BTUs/year is significantly less than the overall per capita consumption of 350 million BTUs/year for the United States. This difference is likely due to many factors, including more effective conservation programs, shorter driving distances due to the small size and dense population of the state, and the presence of less energy-intensive industry than in other states. However, Connecticut's per capita energy consumption is about 10% greater than New York and California. There are likely numerous factors unrelated to conservation that contribute to lower per capita energy consumption in New York and California, but the difference still presents a potential opportunity for Connecticut to reduce its per capita energy consumption without affecting quality of life. Furthermore, Connecticut's per capita energy consumption is about 40% higher than that of France, Germany, and the United Kingdom.

Since 1960, Connecticut, New York, California, and the United States as a whole have had many similar trends in per capita energy consumption.

- In all cases, the per capita energy consumption increased from 1960–1973.
- The energy crisis spurred a reduction in per capita consumption for about two years before consumption started to increase again.

- In the late 1970s, per capita energy usage decreased again due to the rising cost of energy, a decrease which lasted for about five years.
- Connecticut then mirrored the change in the rest of the country, with an increase in per capita energy consumption until about 1990, at which time consumption was equivalent to late 1970s usage levels.
- The per capita consumption remained relatively constant from 1990-2004.
- The most dramatic difference has been the per capita energy consumption in California. The state has not only maintained the lower per capita energy consumption level reached in 1981, but has slowly reduced its per capita energy consumption to a level that is about the same as that in 1960. This provides further evidence that aggressive conservation programs like the ones that have been implemented in California can reduce per capita energy consumption.

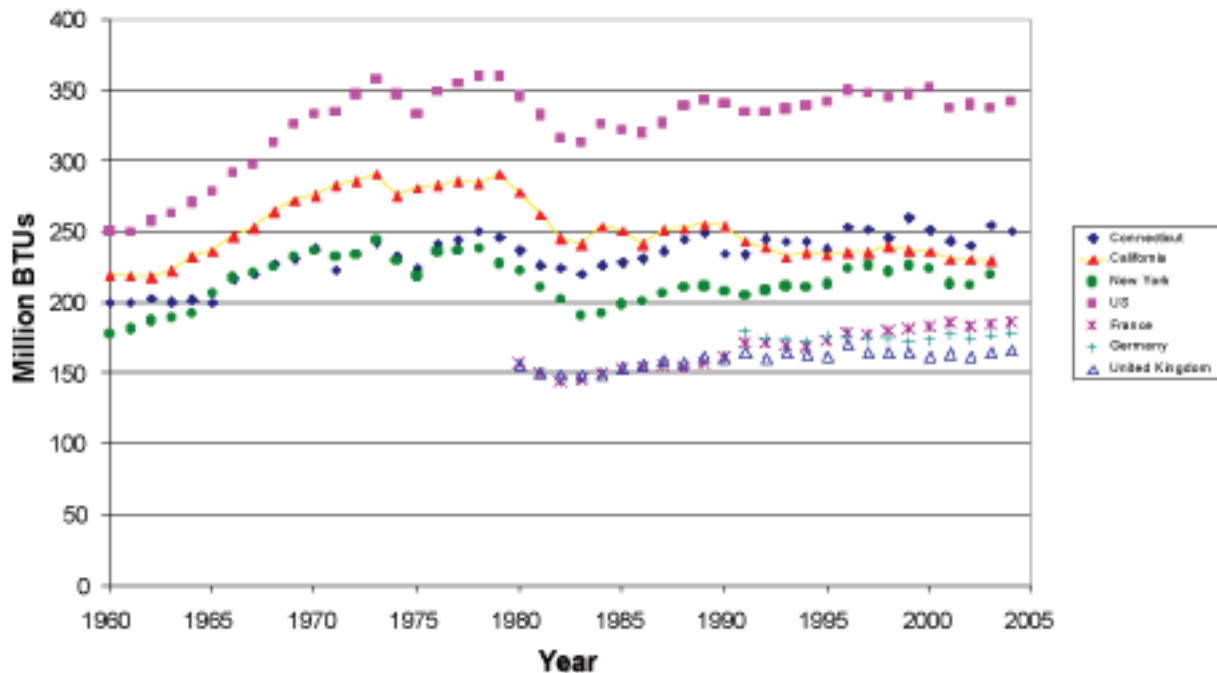


FIGURE 8: CONNECTICUT, CALIFORNIA, NEW YORK, UNITED STATES, FRANCE, GERMANY, AND UNITED KINGDOM PER CAPITA ENERGY CONSUMPTION FROM 1960–2004

Through the electrical ratepayers' surcharge, the CEEF has implemented numerous programs to help businesses and residents reduce their electrical energy usage by providing incentives for the purchase of energy-efficient products. The effectiveness of these programs in reducing the per capita electrical energy consumption is shown in Figure 9. Connecticut has reduced the rate at which its per capita electrical consumption is increasing compared to that of the United States as a whole. However, Connecticut's per capita consumption in 2004 is still about 1,800 kWh/year greater than that of New York (7,500 kWh/year) and 2,100 kWh/year greater than that of California (7,200 kWh/year). Thus, it is reasonable to expect that Connecticut could reduce its per capita consumption by at least 20%.

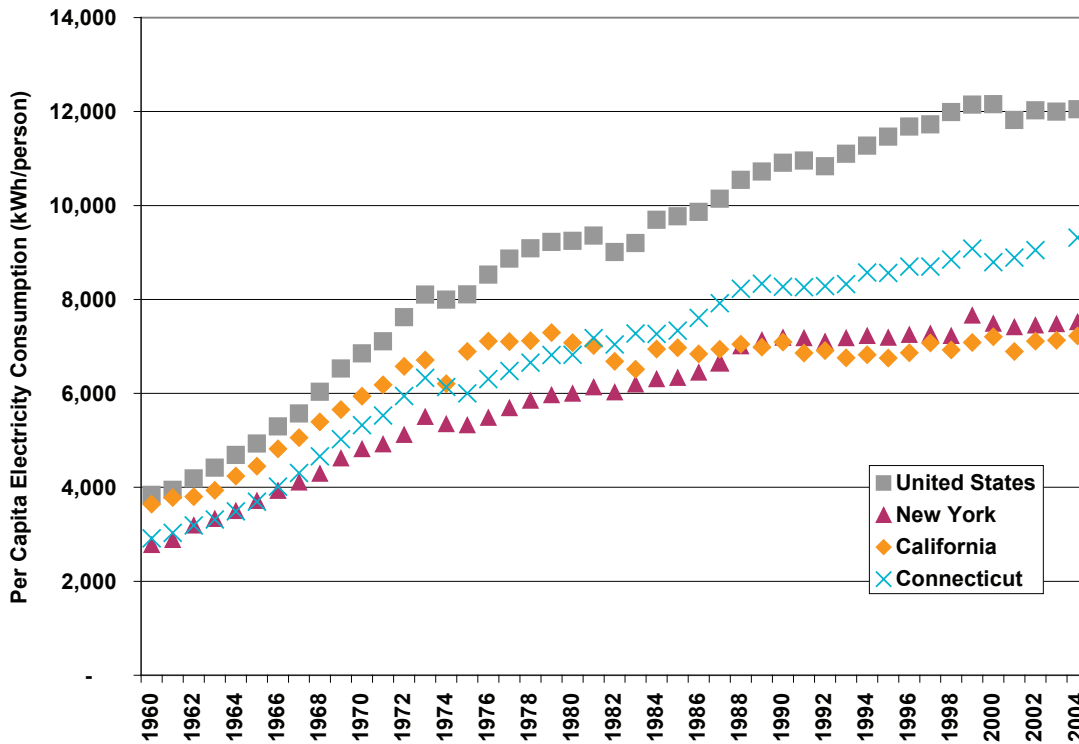


FIGURE 9: PER CAPITA ELECTRICITY CONSUMPTION FROM 1960–2004

RENEWABLE AND NON-FOSSIL FUEL SOURCES

Connecticut does not have any indigenous fossil fuel resources. However, Connecticut can rely on some renewable energy sources to reduce its dependence on traditional fossil fuels. Reducing the state's reliance on fossil fuels should result in air quality improvements and a decrease in production of greenhouse gases. A summary of the non-fossil fuel sources presently being used in electricity production within the state is contained in Table 1. This table shows that nuclear power is by far the dominant non-fossil fuel energy source within the state. While hydroelectric is listed as the second largest source, no new major hydro installations are expected within the state or the United States.

Non-Fossil Fuel Source	Power (MW)
Nuclear	2,037
Hydroelectric	148
Biomass	187 (Includes 159 MW from refuse)
Solar PV	0.7
Wind	0

TABLE 1: NON-FOSSIL FUEL ELECTRICITY GENERATION SOURCES

Connecticut Clean Energy Fund (CCEF)

In 1998 the Connecticut General Assembly passed a law creating a Renewable Energy Investment Fund, currently named the Connecticut Clean Energy Fund (CCEF) and the Conservation and Load Management Fund, now known as the Connecticut Energy Efficiency Fund. CCEF was charged with promoting the development and commercialization of clean energy technologies and stimulating the growth of markets for electricity from clean energy sources. The law directed that money for the CCEF come from a surcharge on electric ratepayers' utility bills and that Connecticut Innovations administer the activities and investments of CCEF.

The types of renewable energy that CCEF can invest in are defined by state statute as being solar energy, wind, ocean thermal energy, wave or tidal energy, fuel cells, landfill gas, hydrogen production and hydrogen conversion technologies, low emission advanced biomass conversion technologies, usable electricity from combined heat and power systems with waste heat recovery systems, thermal storage systems and other energy resources and emerging technologies which have significant potential for commercialization and which do not involve the combustion of coal, petroleum or petroleum products, municipal solid waste or nuclear fission. Table 2 contains a summary of projects that have received at least partial funding and others that are being considered for funding by CCEF.

Technology	Completed Projects		Approved Projects / In Process		Pending Projects	
	Number	Size (kW)	Number	Size (kW)	Number	Size (kW)
PV Commercial	12	302	12	792	0	0
PV Residential	96	404	84	393	0	0
Fuel Cell Commercial	6	1,300	0	0	1	10,000
Fuel Cell Demonstration	5	62	2	27	0	0
Biomass	0	0	1	288	2	60,000
Other	0	0	1	35	0	0
TOTAL	119	2,068	100	1,535	3	70,000

TABLE 2: SUMMARY OF CCEF PROJECTS (AS OF 12/18/06)

SmartPower's 20% by 2010 Campaign

This program was adopted by the DPUC and is promoted by SmartPower. SmartPower, funded by the Clean Energy States Alliance, is a non-profit marketing campaign with the goal of raising public awareness of clean energy. Through SmartPower, towns and cities can commit to the

20% by 2010 Clean Energy Campaign. Connecticut businesses and residents are encouraged to choose clean energy options from their electrical utilities—CI &P or UI. Consumers can choose to purchase 50% or 100% clean energy, which result in rate increases of \$0.0055/kWh or \$0.011/kWh, respectively. When consumers sign up, they earn points for their communities—a half point for the 50% clean energy option and one point for the 100% clean energy option. Depending on the percentage of residential and business customers who select a clean energy option, communities can qualify for a clean energy Solar PV System.

According to the May 2006 monthly market progress report prepared by Nexus Market Research, Inc., 25 municipalities have committed to the SmartPower 20% by 2010 Clean Energy Campaign, and 11 of the 25 have met the standards for becoming a Connecticut Clean Energy Community. West Hartford and New Haven are the two communities with the highest number of signup points (462.5 and 494.5 points, respectively). This can be attributed to the competition between the two cities, which recently ended on Earth Day, April 22, 2006. Not only do these cities have the highest number of signups, but their totals far surpass all other communities, with the third highest total being only 186 points.

As of May 2006, participation in this program resulted in a total of 7,253.5 signup points, creating environmental benefits through the use of clean energy fuel sources. Based on this level of participation, the estimated annual emission reductions credited to the SmartPower program is 2,720 tons of CO₂; the projected amounts of avoided conventional fuels would be 333 tons of coal, or 386 barrels of oil, or 22,288 millions of cubic feet (mcf) of gas.

Ethanol

Ethanol is added to gasoline to increase the octane rating and to add oxygen to the fuel mixture, which results in a reduction in carbon monoxide formation for the purpose of improving air quality. Ethanol has replaced the use of MTBE for this purpose, due to environmental concerns regarding the possible MTBE pollution of drinking water supplies. In Connecticut, ethanol blends in gasoline typically operate at 10% by volume to achieve desired oxygenation levels. Additional information regarding the use of ethanol is included in Chapter IV.

III. STUDY COMMITTEE SUGGESTIONS FOR ENERGY EFFICIENCY AND CONSERVATION

Both the ECMB Annual Reports and the Independent Assessment of Conservation and Energy Efficiency report (see page 11) found that an aggressive approach to funding conservation programs can achieve significant reductions in total energy use and peak electrical demand. Furthermore, aggressive conservation programs should be able to reduce Connecticut's annual per capita total energy consumption from 250 million BTUs to 225 million BTUs, and electrical per capita electrical consumption from 9,000 kWh to 7,000 kWh, which are both similar to the demand in New York and California. To achieve this, it is suggested that

- Both broad-based policy initiatives and outreach/ education programs are needed, as well as targeted marketing efforts to make sure that businesses and households are aware of state and federal incentives that make energy efficiency and conservation measures financially attractive.
- State policy concerning energy investments should adopt the principle of the California loading order, which specifies that the state will first meet its resource needs "through all available energy efficiency and demand reduction resources that are cost effective, reliable, and feasible." (Chapter 366, California Statutes of 2005).
- A single state agency should track the progress of state programs and activities aimed at energy efficiency and hold them accountable for meeting specific reductions in per capita energy consumption. The payback would be considerable and significant considering that Connecticut residents paid \$8 billion in 2001 on energy.

The specific measures suggested by the Study Committee are listed below in general order of importance, but it should be noted that it will be necessary for many conservation programs to succeed if there is to be a significant reduction in energy consumption. Following is a description of each initiative, an estimate of the potential energy savings if data are available, and a suggested method for implementing the program or policy. A table summarizing these measures is provided in Appendix B.

COMBINED HEAT AND POWER (CHP)

CHP systems are designed so that the waste heat that would otherwise be rejected to the environment is used beneficially for heating, chilling water, or steam. For commercial, industrial, and institutional applications where the heat load (or cooling load) matches the electrical load requirements, CHP system efficiencies can approach 85%. This compares to an efficiency of about 45%, depending on heat and electrical load, for separate electrical and heating systems. The technology is well advanced, reliable, and turn-key systems are readily available.

For many applications, the most cost-effective CHP system is designed to assist the user in providing base load electrical requirements. Therefore, in addition to being more efficient than separate heating and electrical systems, CHP systems also reduce the demand on the electrical

grid, which is especially important for southwestern Connecticut. In addition, CHP systems also improve the reliability of the grid by decentralizing the generation of electricity.

n numerous case studies have shown the benefits of installing CHP systems. Examples can be found at the US CHP Association (<http://www.uschpa.org>) and the Northeast CHP Application Center located at University of Massachusetts, Amherst (www.northeastchp.org). Two examples of CHP applications in Connecticut are at Bristol-Myers Squibb in Wallingford, CT (4.7 MW), and at Wooster Manor (60 kW), operated by the Housing Authority of the City of Danbury. The Bristol-Myers Squibb application was installed in 1998 and had a five-year simple payback. The heat recovery applications are for both manufacturing processes, and building heating and cooling. The system's overall efficiency is 72%. For Wooster Manor, the system provides 60-70% of total building electric load, 100% of the domestic hot water needs, and 50% of the building's total space heating needs. It is estimated that the system is 30-40% more efficient than separate heat and electric systems and the project has reduced Wooster Manor's annual energy expense by \$40,000.

In 2004, a study by the Connecticut Institute for Sustainable Energy (ISE), entitled "Distributed generation Market Potential: 2004 Update/ CT and SW CT," found that the CHP potential in Connecticut is 1,670MW (980MW of Commercial/Institutional and 690MW of Industrial). Even though actual cost-effective CHP capacity will be less than the market potential because the market potential considers all commercial, industrial, and institutional users with greater than 100kW electrical loads, it does show that there is great potential for significantly increasing the energy efficiency of Connecticut's businesses and institutions. Furthermore, there is currently only minimal market penetration of CHP systems. In the study, it was estimated that the CHP market penetration in 2004 was less than 1% for applications smaller than 20 MW and approximately 5% for applications greater than 20 MW.

The range of possible applications for CHP systems includes hospitals, nursing homes, grocery stores, restaurants, schools and universities, and data centers. The economic incentives available at the present time are very good, which should give many businesses and institutions a very competitive return on investment with a short payback period. The CHP financial incentives are:

- \$450/kW base load generation including CHP (SW CT project receives an additional \$50/kw if online prior to 4/30/08)
 - Renewable Energy Projects may receive greater grants through programs offered by CCEF (\$470/kW for fuel cell system applications)
- Low Interest Loans (1% lower than a customer's applicable rate for projects greater than 50 kW)
- Gas Discount: Gas distribution charges waived and gas rates reduced
- Backup Rates: Electricity rates for power used when base load customer-side generators are out of service will be reduced by eliminating backup rates and eliminating demand ratchets for these projects
- Renewable Energy Credits are awarded to Class I, II, and III fuel sources that can then be sold to electric suppliers

At the present time, potential investors do not know enough about the technology to confidently invest, even though there are very good incentives available. The pilot program for southwestern Connecticut sponsored by DPUC and DEP called “Distributed Generation Incentive\$” has helped to alleviate this shortcoming (see page 10). In addition to informing businesses about the incentives, there is a need to provide potential businesses interested in CHP with electric and heating load analysis. Also, a site assessment on the technical feasibility is necessary due to the one-of-a-kind customized installations and variability of each building’s design. One aspect of the technical feasibility that must be addressed is the initial design of the heating/ cooling system. For example, if the building was designed with distributed rooftop units, which is common practice today, then CHP cannot be easily integrated. If the outcome of the audit is favorable, then businesses/ institutions can work directly with a building management consultant or CHP vendor for the purchase and installation of a CHP system.

If programs to increase CHP market penetration are successful, it is suggested that the above incentives (i.e., Customer-Side Distributed Resources) be more selective by funding only those projects that provide a significant increase in energy efficiency (e.g., greater than 40%) resulting in a combined benefit of reducing the demand on the electrical grid and the state’s dependence on fossil fuels.

Two actions that would be helpful for increasing CHP market penetration include

- quantifying the technical and economic impact of CHP on the transmission and distribution system
- determining the impact of CHP on natural gas delivery system (Connecticut Institute of Sustainable Energy, 2004)

With the potential of up to about 20% peak load reduction based on the 2006 peak load, a significant penetration of CHP systems has the possibility of saving electrical ratepayers money that otherwise would be required for upgrading the transmission and distribution system.

Since many CHP systems use natural gas, it is suggested that a study be conducted that addresses the concern of having the state overly dependent on natural gas for electric generation and heating. Data from 2004 indicate that 18.2% of the state’s total energy needs and 24.8% of the electrical power generation comes from burning natural gas.

The Use of Fuel Cell Systems for CHP

With high efficiency, virtually zero emissions, and 24/7 generation capability, fuel cells represent the cleanest means of generating continuous on-site electrical power of any available technology. Compared to conventional generation where the grid supplies electricity, on-site CHP cogeneration provided by fuel cells offers significant efficiency advantages similar to gas turbine CHP systems.

A large percentage of fuel cell installations in the near future are expected to be cogeneration applications in facilities such as hospitals, hotels, and others where there is a demand not just for power but also for heat. Worldwide, there are approximately 400 stationary fuel cell installations in operation. These systems are primarily provided by three major fuel cell

companies: Fuel Cell Energy and UTC Power, which are located in Connecticut, and Fuji Electric. The estimated total fuel cell power installed is 75 MW. In Connecticut, there are about 20 installations with a total generating capacity of about 4.0 MW.

Two states that have implemented significant incentive programs are California and Connecticut.

- California's "Self-generation Incentives" program offers as much as \$4,500/kW for fuel cells operating on renewable fuels such as anaerobic digester gas.
- Connecticut's "On-Site renewable" program offers as much as \$4,700/kW for fuel cells operating on natural gas.

Since fuel cells can deliver high-efficiency and high-quality electric power while at the same time minimizing the pollution and emissions when compared with the electric grid and other on-site distributed generation technologies, the Study Committee suggests that the state consider expanding its existing "On-Site renewable" incentive program to increase the number of fuel cell units used for CHP applications. Incentives can gradually be eliminated as market penetration increases and capital costs become significantly lower than current costs.

INCREASED INVESTMENT AND EXPANSION OF CONNECTICUT ENERGY EFFICIENCY FUND PROGRAM

The Study Committee suggests two proposals for increasing the effectiveness of the CEEF.

- Investment in energy-efficient programs should be increased to a minimum of \$90 million, but further investment should be considered if it can be shown that these investments will result in a net present savings to Connecticut residents. This action makes fiscal sense considering that \$65 million invested in conservation programs resulted in an estimated \$550 million savings in electrical energy costs in 2005. By increasing investment into energy efficiency and conservation programs even further, one could expect even greater energy savings. For example, an assessment performed by GDS Associates in June 2004, entitled "Independent Assessment of Conservation and Energy Efficiency Potential for Connecticut and the Southwest Connecticut region," estimated that a net present savings of \$1.78 billion could be achieved over a ten-year time frame with annual investments conservation and energy efficiency investments of \$82-\$148 million (in 2003 dollars).
- Because of the success of the CEEF program in providing net present savings, it is also suggested that a heating oil conservation program should be created which would be overseen by the ECMB, and that funding for the natural gas program should be expanded. These programs should be funded by a surcharge on oil and natural gas purchases. As with the electricity program, the ECMB should ensure that there is a net present savings for the investments that are made in natural gas and oil conservation.

There are several different methods for determining if conservation and energy efficiency programs are cost effective. The assessment performed by GDS Associates, previously referenced, used a benefit-cost ratio technique that found that 12% of Connecticut's electricity

consumption could be reduced at a cost of less than \$0.05/ kWh (see Figure 7). An alternative method that may be easier for ratepayers to understand is Cost of Conserved Energy (CCE). The CCE is a value that can be directly compared to the cost of generating electricity, so that it clearly indicates which measures are most cost effective. The CCE is:

$$\text{CCE} = \text{Annualized Investment (\$/year)} / \text{Conserved Energy (kWh/year)}$$

An example of this type of analysis is shown in Figure 10 for California, where 16% of the state's baseline electricity usage could be reduced at less than \$0.045/ kWh. The important aspect of the California study is the determination of the CCE for various residential and conservation measures, which should be about the same for Connecticut. For example, commercial lighting has a negative cost of conserved electricity. This means that it actually costs less to purchase energy-efficient compact fluorescent light bulbs compared to incandescent light bulbs over the lifetime of the longer-lasting compact fluorescent lights. For residential lighting, the CCE is about \$0.0275/ kWh. While the financial savings are not as great as those realized by investment in commercial lighting, it is less than it costs to generate a kWh of electricity. By using this type of analysis, Connecticut ratepayers can clearly identify whether an energy efficiency measure is more or less expensive than increasing electric generation capacity and transmission.

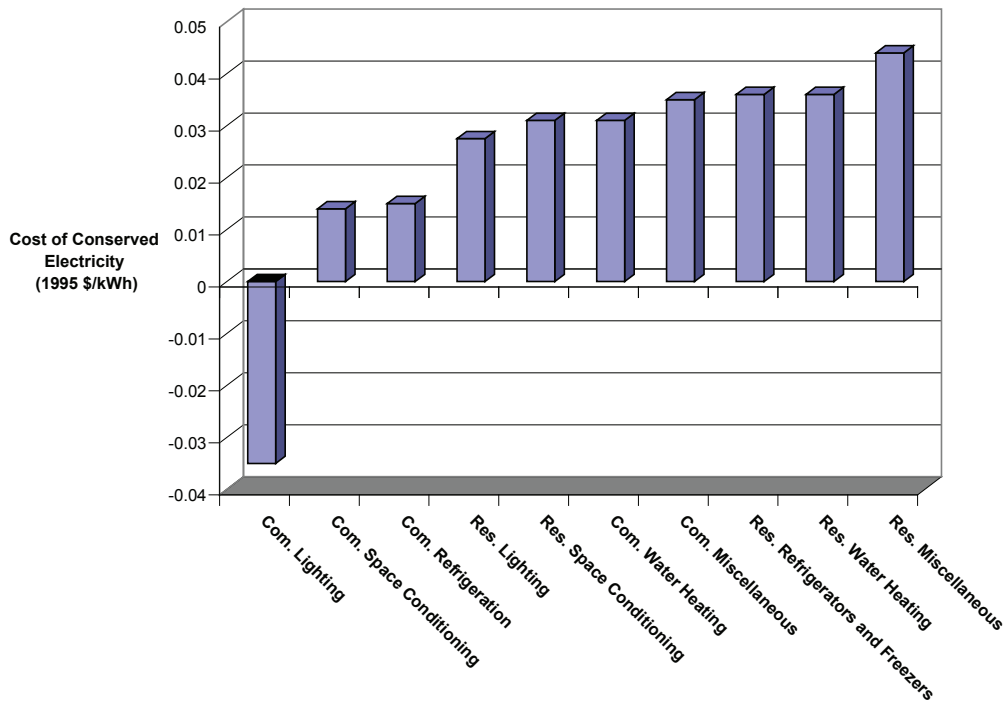


FIGURE 10: COST OF CONSERVED ENERGY (ASSUMES 7% DISCOUNT RATE)

The Study Committee's second suggestion is to invest in the conservation of natural gas and oil programs in the same way that Connecticut already invests in electrical efficiency. Programs such as insulation and weatherization, replacement of electric heating systems, and heating system

improvements should be available to all natural gas and oil users. In addition, the state should invest in alternatives that do not use fossil fuels for both space heating and hot water heating. Specifics about alternatives, such as solar hot water and geothermal, are discussed on page 33

COMPACT FLUORESCENT LIGHTING INITIATIVE

The low cost of conserved electricity for lighting ($-\$0.035 / \text{kWh}$ for commercial and $\$0.03 / \text{kWh}$ for residential) and the ease of implementation (it is not necessary to change light fixtures when using compact fluorescent light bulbs as replacements for incandescent light bulbs) makes the use of compact fluorescent light bulbs a prime candidate as a source for energy savings. An independent assessment of the cost-effective conservation and efficiency potential for Connecticut estimated that the impact would be about a 7% decrease in both residential and commercial electrical energy consumption. The cost-effective residential and commercial reduction in peak demand was estimated to be 4% and 6%, respectively (Independent Assessment of Conservation and Energy Efficiency Potential for Connecticut and the Southwest Connecticut Region, 2004).

Therefore, it is suggested that incentives for purchasing compact fluorescent light bulbs should be increased and that a surcharge be placed on the purchase of incandescent light bulbs if a comparable compact fluorescent replacement is available. Just as the incentives for compact fluorescent light bulbs are provided at the wholesale level, the surcharge on the incandescent light bulbs should be paid to the state when the retailer purchases these bulbs from a supplier. This surcharge would then be used to help fund the additional incentives that are offered for purchasing the compact fluorescent light bulbs. The aggressive nature of this suggestion is because the change in consumer lifestyle is minimal while the financial benefits and reduction of Connecticut's dependence on fossil fuels will be significant. It is hoped that this change in behavior will begin a process ultimately resulting in the phaseout of the use and sale of incandescent light bulbs. The conversion from incandescent to fluorescent light bulbs will also provide the additional advantage of reducing the cooling load during the summer, which will further reduce the peak electrical demand.

In an effort to encourage the conversion from incandescent to fluorescent lighting, an incentive program could be developed that would serve as a fund raiser for schools. Today, many schools have students sell candy, wrapping paper, and magazines as fund raisers to support student activities. A similar program can be put in place for the sale of fluorescent light bulbs. This would have the benefit of allowing schools to raise funds to support programs, as well as serving as a learning experience for students, who would be engaged in encouraging the replacement of incandescent light bulbs.

ADVANCED METERING WITH TIME-VARIANT RATES

Critical peak pricing or other time-variant rate designs, when added to an advanced metering infrastructure, will provide customers with an opportunity to reduce their energy bills through efficiency, peak reduction, and peak shifting actions. Currently, only customers that have electrical power demand of more than 350 kW are charged based on a time-variant rate. For residential customers, there is no economic incentive to change electrical consumption patterns, because the rate per kWh is independent of whether the electricity is used during peak periods, such as hot summer afternoons, or at low-demand periods, such as at night.

However, the cost of building and maintaining the electrical transmission and distribution infrastructure to meet peak demand is significant. Furthermore, additional electricity generated to meet the peak demand is most expensive, and is produced at power plants that are the least efficient. For example, the electrical load, as a function of hours per year and the cost of the peak load, is presented in Figure 11. For about 100 hours or 1% of the year, the cost of electricity increases significantly. In 2005, the average cost was \$0.0799/kWh, but increased to \$0.1782/kWh when the peak exceeded 6,300 MW. This occurred for 134 hours, or about 1.5% of the time. The maximum cost was \$0.866/kWh, which is more than ten times the average cost for generating electricity. Advanced metering, along with time-variant rates, address this inefficient and costly consumption of electricity directly by having users pay the actual cost of providing them with electricity during the peak consumption periods. It is suggested that advanced metering technologies coupled with time-variant rates will be a very effective way to change consumer behavior and to flatten out the load curve. It is estimated that the upgrade of residential electrical meters to provide advanced metering capability is about \$200/meter.

The Study Committee suggests adopting a three-tier, time-variant rate structure. An example of how that might be implemented is shown below.

- Peak Daily Rates from noon–8:00 pm
- Off-Peak reduced rates from 8:00 pm–noon
- Surcharge on Peak Daily Rate During Peak Electricity Demand

The specific times for peak and off-peak rates should be based on an analysis of daily electricity demand, with the goal of keeping on the flat part of the Connecticut Price duration curve (see Figure 11). Also, the rate structure should be determined so that the switch to time-variant rates is revenue neutral. The surcharge on the daily peak would occur during those times, such as hot summer days, when electricity demand is stressing the capacity of the electric grid. In this case, a 24-hour notice should be provided via various media channels, such as television, radio, print media, and personalized voluntary e-mail and cell phone alerts, that these higher rates would be in effect during the following day's peak hours. Along with stating that higher rates would be in effect, the notices should educate ratepayers as to why the cost of generating electricity is significantly higher during peak usage times, and should offer various ways to reduce electricity consumption while still maintaining comfortable living conditions.

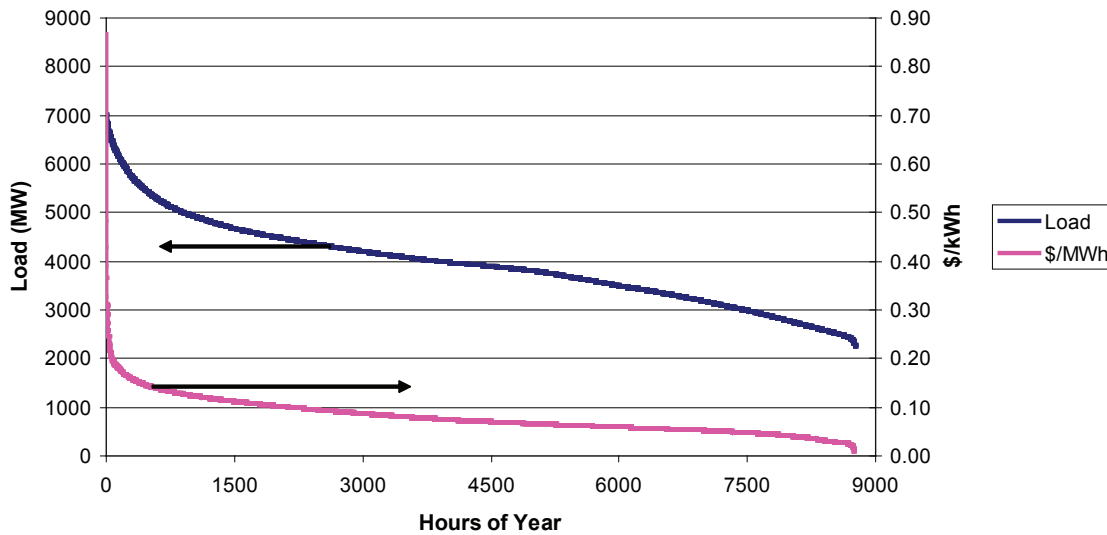


FIGURE 11: 2005 CT LOAD DURATION AND PRICE DURATION CURVE

INCENTIVES FOR INCREASING AUTOMOBILE FUEL EFFICIENCY

The Study Committee suggests that significant changes in sales and property taxes associated with the purchase and ownership of automobiles be considered to encourage the purchase of fuel-efficient cars and hybrid electric vehicles (HEVs). Connecticut has encouraged the purchase of some HEVs by eliminating the sales tax on those that get at least 40 MPG (<http://www.ct.gov/drs/cwp/view.asp?Q=284656&A=1436>). By excluding a majority of hybrids and providing no property tax incentives, the state inadvertently discourages the purchase of all hybrids, including those that get 40 MPG or better. This is due to the fact that because hybrids are more expensive than their comparable gas-powered variants by roughly one-third, savings on sales tax are adversely compensated by increased property taxes during the life of the car. It is suggested that:

- Connecticut encourage the development of HEV technology by eliminating the sales tax on all HEVs registered in Connecticut.
- HEV property taxes be calculated based on two-thirds of the vehicle's depreciated value to compensate for the additional cost of purchasing and maintaining hybrid electric vehicles (e.g., new batteries, motors and kinetic converters).
- Fuel efficiency be included in calculations of the sales tax and the property tax on automobiles and trucks by introducing a Fuel Efficiency Adjustment (FEA). The initial FEA will be a modest adjustment based on the EPA average MPG estimate:

$$\text{FEA} = \$(100 - 4 * \text{MPG})$$

The MPG value in the equation will be calculated as the average of the city and highway EPA MPG estimates. Thus, a car that gets 12 MPG would generate an additional fee of

\$52, a car that gets 20 MPG would generate an additional fee of \$20 and a car that gets 40 MPG would generate a rebate of \$80. The above formula is neutral (FEA=0) at 25 MPG. The worst-case FEA is \$100 and the approximate best-case subsidy is about \$100 (MPG=50). (The FEA would not be relevant to new hybrid purchases if the sales tax on such vehicles is waived as proposed.) The FEA can be modified each year to be cost neutral to the state based on data provided by the Connecticut Department of Motor Vehicles (DMV). Based on the limited data provided to the Study Committee by DMV, it is anticipated that the above formula will return sufficient funds to the state to fully cover the loss of sales tax on new hybrid car purchases. This calculation assumes that the FEA will not be used for motorcycles or specialty vehicles such as golf carts.

The above proposals are cost neutral, or very nearly cost neutral, to the state and will encourage conservation through improved fuel efficiency and improved air quality via reduced emissions. Cost neutrality in subsequent years can be achieved via manipulation of the FEA equation.

Additionally, the Study Committee suggests that an incentive for having properly inflated tires should be considered because up to 7% greater gasoline efficiency can be achieved with properly inflated tires. To achieve these savings, a three-year public information program should be initiated that would be followed by a mandatory “fee-bate” program. Vehicles that are inspected under the state’s biennial vehicle emissions program will receive 5% off the cost of the test if their tires are properly inflated (e.g., within 3% of correct value), and will pay 10% extra if their tires are more than 5% from the correct tire inflation value. The Study Committee also suggests that automobile manufacturers be asked to include pressure tire monitoring as standard equipment so that drivers are alerted when tires are under or over inflated.

EDUCATION

The Connecticut Core Science Curriculum Framework that was adopted in October 2004 is organized around eleven conceptual themes. The theme most relevant to conservation and alternative energy is “Energy Transfer and Transformations – What is the role of energy in our world?” This theme is divided into the following five topics:

- Electricity and Magnetism – Grade 4
- Sound and Light – Grade 5
- Energy and Work – Grade 7
- Energy Conservation and Transformation – Grade 9
- Electrical Forces – Grade 9

These core concepts are then re-emphasized and applied under the theme “Science and Technology in Society – How do science and technology affect the quality of our lives?” Specifically, the topics related to energy are:

- Batteries, Bulbs and Magnets – Grade 4
- Energy and Power Technologies – Grade 9

For example, the Study Committee supports the Expected Performances listed under the Energy and Power Technologies topic of study:

1. Explain how heat is used to generate electricity
2. Describe the availability, current uses and environmental issues related to the use of fossil and nuclear fuels to produce electricity
3. Describe the availability, current uses and environmental issues related to the use of hydrogen fuel cells, wind, and solar energy to produce electricity

A key, but often overlooked, part of any energy policy initiative is public education. After the catastrophic explosion and fire at the Soviet Union's Chernobyl nuclear Power Plant in 1986, many European governments abandoned their existing and future plans for electric power plants using nuclear fuel. However, France steadfastly stuck to theirs, so that today, two decades after Chernobyl, 80% of French electricity is still nuclear generated. A year after Chernobyl, a French government official was asked why the French people hadn't followed the rest of Europe in abandoning nuclear plants. He replied: "Twenty years of public education on nuclear power."

It is therefore suggested that the subject of thermodynamics, which deals with the study of energy and energy conversion, be required for all Connecticut high school students. The subject of energy is covered in present day high school sciences courses, but what is suggested here is a course devoted solely to the thermodynamics of energy, energy conversion, and energy economics.

It is suggested that this be a required one-semester course for all high school students, during either their junior or senior year. The course would include the following concepts: the conservation of mass for systems and control volumes; the various forms of energy and power, with extensive problem solving dealing with the many energy unit systems used by modern society; the First Law of Thermodynamics, also called the Conservation of Energy, for systems and control volumes; the Second Law of Thermodynamics, covered in enough detail to alert a student to be wary of proposed energy conversion schemes that may violate this basic law; how and where electric power is generated and distributed in Connecticut; and the basics of energy economics and energy costs.

In summary, thermodynamics is the study of energy, and energy is the basis of all life. The public has a need for a basic understanding of energy and energy policies in order to make informed choices in our modern, democratic society. The suggested required course will help fill that need.

Additionally, the CEEF has for several years funded an eeSmarts program which develops curriculum materials and provides teacher training workshops aimed at promoting an energy efficiency ethic in K-8 schools. For the last two years, a similar program funded by the CEEF and aimed at high schools has been developed by the ISE. The Study Committee supports these efforts and their integration into the Science Curriculum Framework.

PUBLIC AWARENESS CAMPAIGN

The weather report on Tv /radio has a great influence on people's behavior. This especially occurs during the winter, when there is a possibility of a snow storm; in the summer, when it is predicted to be very hot and heat advisories are issued; and when rain/ thunderstorms are predicted. It is expected that the public's attitudes, behaviors, and actions could be impacted by including a "Real-Time Energy Report" on TV and radio, as well as in print form in newspapers as part of the weather report, especially during critical peak power usage times. In addition, such a report should periodically be presented at other times to maintain the public's awareness about energy use and conservation. The report would be designed to

- Identify the state's current real-time energy demand, along with how the demand has changed over the course of the day, and in the case of TV, the real-time change between the beginning and end of the news broadcast.
- Emphasize the importance of reducing peak demand (see previous section on the high cost of providing electricity for those peak demand periods) and provide dollar estimates of the money leaving the state/ country because of our dependence on fossil fuels.
- Provide tips on conservation measures, promote community and business rivalries to reduce energy consumption, and give visibility to communities and businesses that have implemented energy saving changes and/ or are using renewable resources.

The data required for the production of the "Real-Time Energy Report" would be made available through ISO-NE. It is envisioned that report could be commercially produced and marketed for purchase in a readily available format for broadcast or print purposes, or developed through a state-funded project with free access to the information by the media.

Additionally, it is suggested that a Real-Time Energy E-Mail and Cell Phone Alert System should be developed to notify the public of the need to reduce energy consumption during peak power periods that require energy conservation to maintain the integrity and reliability of the electric grid system. Currently in Connecticut, it is possible to sign up for voluntary real-time traffic alerts and weather alerts from a variety of agencies and media providers. Real-time information provided in a timely manner to the public has the potential for immediate and dramatic reductions in demand during peak power periods.

The Real-Time Energy Report should be part of a mass media campaign to educate residents on the importance of energy efficiency and conservation. For example, California's "you're your Power" campaign estimated that volunteer conservation savings accounted for almost one-half of the 12.3% reduction in peak power demand.

EXTENDING THE "LEAD BY EXAMPLE" PROGRAM

The Study Committee supports the High Performance Schools Initiative proposed by the Connecticut Green Building Council (January 2006). Energy cost for Connecticut's Public Schools was over \$125 million in the 2004-05 school year and it is estimated that the cost could exceed \$160 million in 2005-06. The Study Committee suggests that all newly constructed

buildings be designed and built to be at least 20% more energy efficient than current Connecticut building code requirements, and should be sited to utilize properly designed solar orientation and day lighting as much as possible. Furthermore, the building should be designed for CHP. In addition, building commissioning should be mandatory prior to occupancy to ensure proper design and operation of the specified equipment and systems. Proper training of maintenance personnel should be provided, along with periodic refresher training courses. One of the major obstacles to building high-performance school buildings is higher costs, but nationwide data suggest that up-front costs of high-performance construction are only 0–2% more than conventional construction. For example, the average premium to achieve LEED Silver status is 2%. This additional cost is offset by typical energy savings of 30% compared to code-built buildings, so that utility savings alone result in cost payback in three to five years.

In conjunction with the Connecticut Green Building Council report, the ISE performed a study assessing the energy efficiency of Connecticut schools (June 2006). As part of this study, ISE benchmarked and surveyed 35% of Connecticut schools. The benchmarking of 199 schools from 13 school districts utilized the EPA Energy Star Portfolio Manager rating system with scale of 1-100. A score of 50 represents average energy performance and a score of 75 or higher indicates top performance and qualifies a school for Energy Star recognition. The average benchmarking score for Connecticut schools was 26, which makes them among the least efficient in the United States. It was estimated that raising the average Connecticut school score to the benchmark of 50 would save \$46 million annually in 2006 energy costs. Additional efficiency improvements to achieve an overall school average score of 75 would save \$69 million annually.

The Study Committee suggests that over the next five years, the state should invest in all public schools and state buildings with the goal of having an average benchmark of 50 by the end of that time frame. The buildings with the shortest payback period—less than five years—should be retrofitted first. A second phase of the program would then address schools with below-average energy consumption that are cost effective to upgrade, but have longer payback periods. The effectiveness of this program should be assessed through annual reports that analyze energy savings compared to the investment in upgrading school buildings. Other potential benefits, such as improved indoor air quality and student performance and reduced absentee rates, should also be documented.

SET STATE GOAL OF 20% FOR REDUCING MILES DRIVEN BY 2025

Transportation accounted for about one-third of Connecticut's energy consumption in 2004. The Study Committee supports initiatives to increase fuel efficiency (see page 26) and to reduce miles driven. It is acknowledged that one of the most difficult challenges is to change people's behavior in order to reduce the number of miles they drive. However, the Study Committee supports a very ambitious goal of reducing the miles driven by 20% by 2025 because of its direct impact on reducing Connecticut's dependence on fossil fuels; the Committee understands that some of these initiatives will likely take longer than the ten-year time frame of this study to take full effect. The existing and new initiatives that the Study Committee supports are

- Legislation adopted in 2006 that provides for two significant mass transit projects: the development of the new Britain to Hartford busway; and a new Haven–Springfield, MA commuter rail service. Improving public transportation and its use will have the largest impact on reducing miles driven.

- Public Act 05-205 that promotes initiatives in the area of “smart growth” and livable communities.
- Promotion of NuRide Program to meet 2 million rideshare challenge.
- Incentives to promote condensed work weeks and telecommuting where possible.
- Promotion of consumption of local products.

PLUG-IN HYBRIDS AND OTHER ALTERNATIVE-POWERED VEHICLES

It is suggested that a program to encourage companies and municipalities to purchase plug-in hybrid vehicles (PHEVs) should be considered. Such a program would provide the advantage of being able to more efficiently use electrical resources by flattening out the demand and reducing reliance on fossil fuels, since PHEVs can be charged during the night, when power plants operate at a low-efficiency state so that they can meet the next day’s peak demand. PHEVs are estimated to cost \$2,000–\$5,000 more than regular vehicles, but will pay for themselves in reduced operation costs (i.e., gasoline costs) in about six years. To promote the commercialization of PHEVs, it is suggested that the state, municipalities, and local governments should consider actively pursuing the purchase of a fleet of PHEVs when they become available on the market. Along with time-variant rates, this would be a very effective measure to use energy resources more efficiently.

In addition to PHEVs, it is also suggested that the state should consider purchasing fuel cell vehicles when they become commercially available. The development of other alternatives to traditional vehicles powered by fossil fuels and internal combustion engines should be monitored and these vehicles should be evaluated if and when they become commercially available.

ENERGY EFFICIENCY IN EXISTING BUILDINGS

It is suggested that a goal of reducing energy use by 20% in privately owned commercial buildings by 2020 should be established. This program would be modeled after California’s Green Building Initiative and would emphasize the use of trigger points to identify when the most likely opportunities exist to effect a significant change in a building’s energy-consuming characteristics. Examples of trigger points include the sale of property; a change in the leasehold on a property; refinancing; replacement of equipment and components installed on the premises; and remodeling, renovation or rehabilitation events.

The Study Committee suggests that the following commercial strategies be implemented to meet the energy savings goal:

- **Benchmarking:** When a commercial building is financed or refinanced, it would be required that the building be benchmarked using the EPA ENERGY STAR system or similar benchmarking system developed by California. Benchmarking will provide energy consumption information in a form that commercial building owners and operators can use to compare their building’s performance to similar buildings. Providing this information will increase the likelihood that energy-inefficient buildings will be upgraded to meet or exceed the benchmark standard. Legislation is suggested to require benchmarking at these trigger points.

- **Retro-Commissioning:** The CEEF should establish a program that promotes and facilitates retro-commissioning of existing commercial buildings. Retro-commissioning systematically investigates the operation of a building's energy consuming equipment to detect, diagnose, and correct faults in the installation and operation of commercial building energy systems. After the building has been retro-commissioned, it is also suggested that building owners be encouraged to have their energy systems checked on a quarterly or annual basis to make sure that the initial energy savings are being maintained. While all building owners should be encouraged to perform retro-commissioning, implementation of the findings will most likely be done at the identified trigger points. Therefore, it is at these times that the greatest savings in energy will likely be accomplished.

INCENTIVES FOR RESIDENTIAL CUSTOMERS TO REDUCE ENERGY USE

The Study Committee suggests that residential customers should receive electric rate reductions for meeting targeted load reductions. This program should be modeled after the 20/20 program that was established by California in March 2001. The key concepts of the 20/20 program are its simplicity and the fact that participation is automatic. The following is a summary of the residential aspect of the 20/20 program that was authorized by the California Public Utilities Commission for the summer of 2005:

- Single-family residential and small commercial customers who reduced their average daily electric usage by an average of 20% from July 1, 2005-October 31, 2005, compared to the same four-month billing period in 2004, received a one-time bill credit equal to 20% of the electric charges billed during the 20/20 season. The earned credit was then applied to customer bills at the end of the 20/20 season.
- Customers do not need to enroll in the program in order to participate.
- Customers must have at least one year of electric billed history at their current residences, must have maintained their account at the same premises since June 30, 2004, and must continue to maintain the same account throughout the 20/20 season.

A Lawrence Berkeley National Laboratory study of the 20/20 program indicated that program was successful based on the number of rebates given, with one-third of residential customers qualifying for a rebate in 2001 and 2002. (The 2001 and 2002 programs were done on a monthly basis and the fraction of residents qualifying was based on receiving rebates in one or more months.) While there are many confounding variables in estimating the cost of conserved energy (i.e., how much of the load reduction can be attributed to the 20/20 program), the study estimated a cost of \$0.09/kWh. While other conservation measures have lower cost of conserved energy, the Study Committee suggests that direct incentives such as the 20/20 program should be included in an overall conservation initiative. It is also believed that the cost of conservation will be less when the rebate is provided on the total summer energy usage, as was done for the 2005 20/20 program, as compared to the monthly rebates that were given during the 2001 and 2002 20/20 programs.

HOT WATER HEATING INITIATIVE

The Study Committee suggests that incentives similar to those provided for distributed generation should be provided for hot water systems that use renewable energy sources and more efficient processes than conventional fossil fuel systems or electricity. Because hot water is a very low-quality form of energy, this is one of the easiest places to reduce the use of fossil fuels and electrical consumption. One of the best renewable energy sources available is solar thermal hot water heating systems. Solar thermal hot water systems are much more efficient than Pv cells and current designs are much more reliable than systems that were built in the 1970s. A complete discussion of thermal solar hot water systems is discussed on page 36.

Geothermal heat pump systems use electricity, but are more efficient than fossil fuels or resistive heating for hot water. These same systems also provide very efficient processes for space heating and air conditioning. The key to a geothermal system is that the heat source for heating and the heat sink for cooling is the ground, which remains at about a constant 50°F. all year round. A more complete discussion about geothermal heat pump systems will be found on page 39.

The other alternative available for hot water heating is combined heat and power systems. These systems are desirable when there is a match between electrical and heating loads. A complete discussion of this technology can be found beginning on page 19.

Because these are proven technologies which generate heat more efficiently than conventional fossil fuel systems or resistive heating, the Study Committee suggests that an innovative program for new construction should be created to promote the purchase and installation of alternative hot water heating systems. Incentives equivalent to those provided for distributed power should be considered so that solar thermal hot water systems, geothermal heat pumps, and CHP are competitive on a life-cycle basis with traditional systems.

IV. RENEWABLE ENERGY AND NON-FOSSIL ENERGY SOURCES

Since Connecticut does not have any indigenous fossil fuel resources, it has a large financial and environmental incentive to use renewable energy. The average costs to produce electricity from a variety of alternative sources that are available to Connecticut are shown in Table 4. Depending on the specific site and environmental issues, these costs may vary. Based on recent increases in the cost of generating electricity from fossil fuels, electricity produced from wind and biomass fuel sources is now cost competitive with that produced from fossil fuels. Unfortunately, the solar electricity production is currently not cost competitive with fossil-fueled electric generation strictly on a dollar/kWh basis. Initiatives and incentives, including sales and income tax incentives and rebates, have been used by the state to foster the adoption of some forms of renewable energy systems.

Energy Source	Cost (\$/kWh)
Wind	\$0.05 - \$0.07
Biomass	\$0.07 - \$0.09
Solar	Greater than \$0.20
Fossil fuels	\$0.07-\$0.12

TABLE 4: COMPARATIVE COST OF RENEWABLE ENERGY SOURCES (2006 DOLLARS)

The following sections include a description of non-fossil fuel sources and an assessment of the potential for these sources to reduce Connecticut's dependence on fossil fuels. The alternatives will address both the need to replace fossil fuel used for generating electricity and liquid fuels used for transportation—gasoline and diesel.

BIOMASS

Biomass is generally defined as any living plant matter as well as organic wastes such as sewage, garbage, wood construction residue and other components from municipal solid waste. Connecticut has investigated using biomass as an energy source for several years, with electricity currently being generated using municipal solid waste—conventional trash—as the primary fuel source at four locations: Hartford, Bridgeport, Wallingford and Preston. These “trash-to-energy” plants presently contribute about 125 MWe to Connecticut's electric grid, while also greatly reducing the volume of solid waste material that needs to be deposited in landfills. Also, power generating units that operate on methane gas from two landfills located in Hartford and New Milford are producing nearly 5MW of electricity.

In addition, other fuels are being examined for their viability as renewable energy sources. A biomass gasification plant has been proposed for Plainfield, in eastern Connecticut, which will use waste wood as the chief fuel source. This 37.5 MWe (net) power plant will utilize as its fuel

source a combination of segregated construction and demolition (C&D) wood waste, along with trimmings from tree and brush removal, and used wood pallets. The plant is expected to burn 1,000 tons/ day of these materials, which are presently shipped to out-of-state landfills. Gasifying the wood allows for better combustion, and generally lower predicted air emissions. The low BTU gas produced in the gasifier will be burned in a traditional furnace to create steam, which will operate in a traditional Rankine cycle. However, this gas is a poor candidate for use as a fuel in gas turbine, combined-cycle power plants, which presently produce electricity with the highest efficiency.

Other biomass opportunities exist in the state, including oversized municipal solid waste, highway C&D waste, and sewage sludge. A study in 2000 (Biomass Strategies for Connecticut, prepared for CCEF by Joel Gordes; July 27, 2000) estimated that over 2,200 tons/ day are available from C&D and land-clearing debris. This estimate indicates that Connecticut can support a second, similarly sized biomass plant operating on the same C&D waste, and producing greater than 35 MWe. The benefit to the state from operating these biomass electric generating plants within the state is two-fold. First, the need to dispose of large quantities of waste material at out-of-state landfills will be eliminated, reducing truck traffic and the transportation fuel required for moving these large quantities of waste material long distances; disposing of these materials from the remaining landfill sites require trucks to travel to New York, Pennsylvania and Ohio. Second, the state will produce a new renewable fuel source for its electric generating system. The Study Committee suggests that an additional study should be conducted to determine if the quantity of waste presently generated and forecasted to be available within the state is adequate to support two biomass power plants.

Beyond these solid materials, large sewage treatment facilities are investigating the use of their solid sludge as a fuel material. Hartford and other large treatment facilities can produce usable electricity from this material, previously consigned to landfills.

SOLAR

The source of most renewable energy, including wind, ocean thermal and biomass, can be traced back to the sun's incident radiation on the earth. Solar energy may be more narrowly defined by the following three modes of use:

- Thermal energy collected actively or passively for space heating
- Thermal energy collected and converted to electricity
- Solar energy directly converted into electricity

The US Department of Energy (DOE) has a variety of programs in place to encourage the use of active and passive solar energy systems. These programs, chiefly centered at the National Renewable Energy Laboratory (NREL), include both engineering and policy support. NREL provides a wealth of information for consumers and system developers, as well providing states with programs like the Million Solar Roof campaign, a program designed to encourage the adoption of solar energy systems of any type.

While both federal and state financial incentives exist for the direct conversion of solar energy into electricity, no incentives exist for the active or passive collection of solar radiation for space heating. The higher overall efficiency resulting from the active collection of solar radiation and its conversion to thermal energy versus photovoltaic cells (PV), which directly convert sunlight into high grade energy—electricity—makes the use of solar thermal collectors attractive. However, the energy crisis of the 1970s saw a large influx of solar thermal systems with a wide range of reliability.

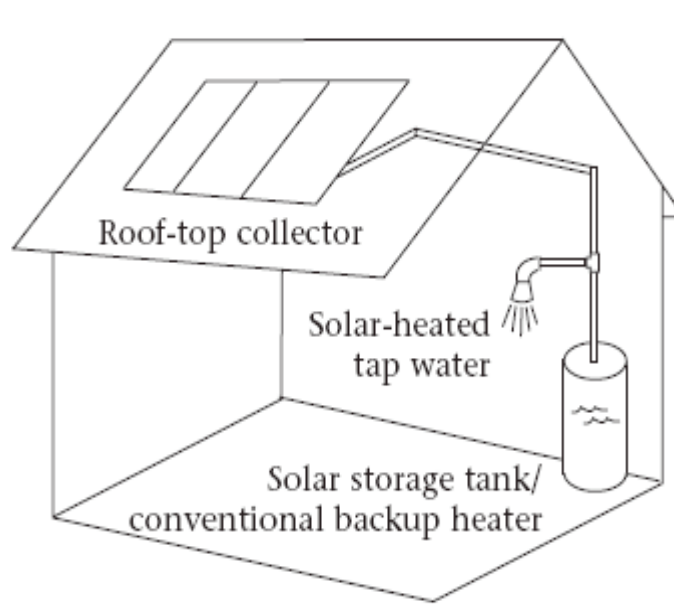


FIGURE 12: TYPICAL ROOFTOP SOLAR THERMAL SYSTEM

(FROM *A CONSUMER'S GUIDE: HEAT YOUR WATER WITH THE SUN*, US DEPARTMENT OF ENERGY, ENERGY EFFICIENCY AND RENEWABLE ENERGY)

Collecting solar radiation via active thermal collectors for low-grade energy, such as for producing hot water, can be a simple but effective process. Connecticut surprisingly receives a significant amount of annual solar radiation, despite its northern latitude location. Figure 13 shows that Connecticut receives between 4-5 kWh of solar radiation per square meter per day. Therefore, with higher efficiencies and lower costs, thermal systems have the potential to produce a significant amount of energy. For instance if only 0.01% of Connecticut's 5,500 square miles of surface were covered with solar thermal collectors, enough heat could be generated to offset approximately 6% of the total electric usage within the state.

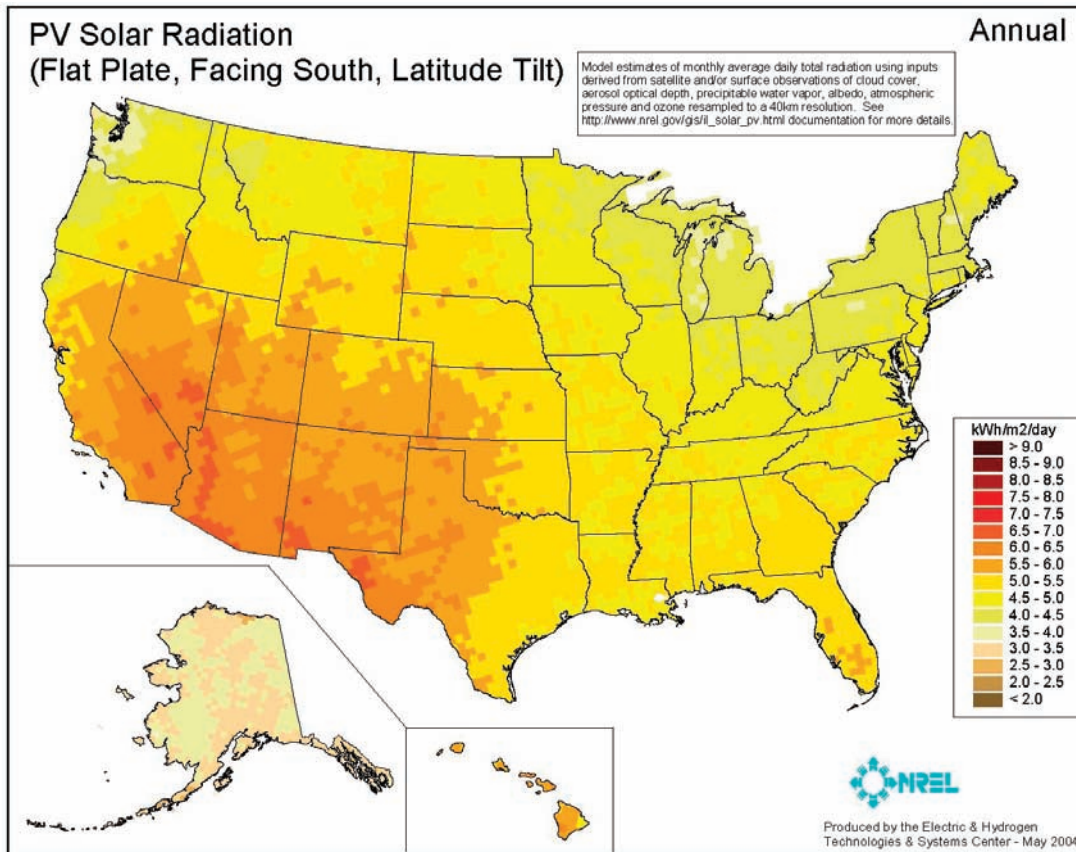


FIGURE 13: AVERAGE ANNUAL SOLAR RADIATION INTENSITY FOR THE UNITED STATES

This is accomplished through the direct conversion of sunlight into DC power, which is generally then inverted for use as AC power on the grid. Worldwide production of PV cells has grown at a very brisk 30% pace. Figures are easily discernible for Connecticut, but fabrication of these systems within the United States has grown at 25% per year for the period from 2000–2003. The reason for the growth in PV systems is their production of high-grade power, producing their highest electric output when most electric systems are operating at maximum demand, in the middle of the daylight hours. However, within Connecticut, the amount of energy produced from the use of PV systems is still small, with only 200 kW of installed capacity in comparison to Connecticut’s peak load during the summer of 2006 of well over 7,000 MW.

Figure 13 and analyses show that the state receives sufficient annual sunlight to provide a significant energy source, but that it is too costly to directly convert this energy into high-grade electric power.

It is suggested that the state develop and institute programs to avoid the poor construction quality and associated reliability concerns that plagued the solar thermal industry in the 1970s.

This can be achieved by

- Requiring mandatory training for installers.
- Identifying systems that meet certain performance and quality standards. These standards presently exist for PV systems, but need to be extended to the solar thermal systems envisioned under this program. Consideration should be given to using programs that are already in place in Florida as a model for the development of a Connecticut program. The Florida state legislature has mandated that a solar thermal system will receive a state tax credit if the system is approved by the Florida Solar Energy Center (FSEC) and is installed by a licensed contractor. Connecticut can use these concepts in developing its program.

Also, the incentives presently in place for PV systems through the CCEF should remain in place. Since solar thermal systems have a higher overall efficiency as compared to PV systems, it is suggested that the state's solar incentive program should be extended to include solar thermal systems.

GEOHERMAL

Geothermal energy is considered the renewable energy source that makes the largest contribution to electricity production from power plants in the United States. Geothermal energy power plants use steam to drive turbines for the direct generation of electricity. The steam is derived either directly from the earth, or by converting energy from water captured from the earth into a process fluid. California leads the nation, with nearly 5% of its total electricity production coming from geothermal power plants.

Some regions of the United States—typically western regions—make use of warm subterranean temperatures in applications other than power plants. These systems, commonly referred to as heat pumps, pump water into underground wells and then use the heated fluid for space heating applications. Other uses have even extended to melting snow from sidewalks by using water that is heated by its passage through underground rock structures.

Figure 14 shows a geothermal resource map for the United States, which indicates that even at a depth of 6 km, the technical limit for drilling, the internal temperature beneath Connecticut only reaches ~ 100°C. Therefore, Connecticut does not have practical access to geothermal energy for the large-scale power plant production of electricity.

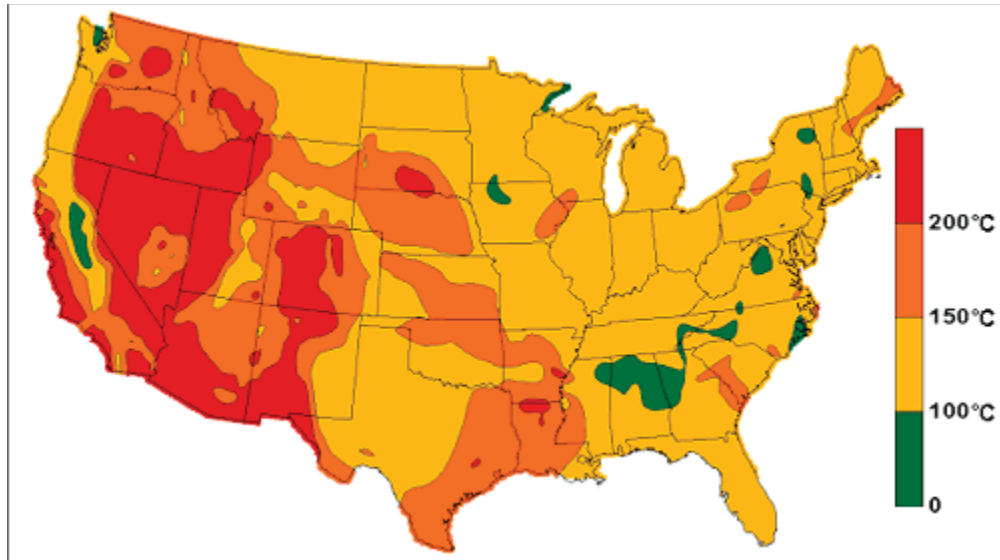


FIGURE 14: US GEOTHERMAL RESOURCE MAP

(FROM THE US DEPARTMENT OF ENERGY, ENERGY EFFICIENCY AND RENEWABLE ENERGY, GEOTHERMAL TECHNOLOGIES PROGRAM)

Ground Source Heat Pumps

A vapor-compression thermal cycle that relies on the outside air as its ultimate heat sink can be operated for space heating. These vapor compression cycles are typically heat pumps, because they provide a building with cooling during the summer months and heating during the winter. Heat pumps are well known mechanical systems that are useful for transferring energy between different thermal reservoirs. However, these systems suffer large drops in efficiency when the outside air temperature drops below 40°F. The temperature of the soil even a modest six feet below grade tends to stay at a constant temperature near 50°F. Therefore, soil can be considered a warm temperature reservoir for heat pumps in Connecticut during all winter months.

The largest disadvantage of heat pump systems comes from the poor thermal conductivity of the soil/rock material that is used as the heat sink. This low thermal conductivity dictates that a large piping system, either horizontal or vertical, will be required to gather the desired heating energy. These large fluid loops require more digging/drilling, adding a significant financial penalty to the capital costs of these systems. An assessment to determine the most cost-effective installation method should be conducted for each installation.

While no detailed technical assessment has been performed, anecdotal data indicate that geothermal can provide a potent heat sink for operation of heat pumps. These systems can operate efficiently during cold New England winters, providing space heating for a large percentage of new residential construction. Heat pumps would seem to be a logical system to consider for space heating and central air conditioning applications.

The benefits for Connecticut will be a reduction in the use of home heating fuel, mostly oil and some natural gas and propane, during winter months. Also, the constant temperature sink available to the heat pump will greatly increase system efficiency compared to a conventional

system that rejects heat to the air during summer months. These large increases in efficiency offer a chance to significantly reduce air conditioning electric loads during summer months.

It is suggested that a detailed economic/technical assessment should be performed to determine the efficiency of using heat pump systems, including the various types of ground source systems in Connecticut.

If the economic assessment indicates a significant benefit—a reduction in the use of fossil fuels—then it is suggested that the state should provide incentives for the purchase and installation of these types of heat pump systems, such as income tax credits, sales tax reduction or elimination, and property tax abatement by removing the capital value of these systems from property assessments.

WIND

Wind energy is one of the fastest growing renewable energy sources in the world. In reality, it is another manifestation of solar energy, for it is the uneven heating of the earth that produces most of the wind around the globe. Wind power systems in New England that are located in Massachusetts, Rhode Island and Vermont presently produce 11 MWe of power.

Wind power as evidenced by Table 4 is one of the most cost-effective methods of producing renewable energy. The technology exists and large installations have been inaugurated at sites around the globe. There are over 10,000 MW of installed wind capacity in the United States, and nearly 60,000 MW installed worldwide. This resource has been and will continue to be relied upon as a source of renewable energy.

Wind power density—the ability to extract energy from the wind at a reasonable level—is very low for most of Connecticut (Figure 15), and does not become significant until average wind speeds reach 12.5 mph.

- There are very few regions in the state that have an average wind speed above 14.3 mph, which is classified as fair by NREL for electricity generation.
- The majority of regions that are classified as marginal, with wind speed above 12.5 mph, are in the northwest sector of the state.
- Coastal regions of the state are predominantly in the fair to marginal classification.
- Large swaths of Long Island Sound have sustained average wind speeds that place these regions in the good category. Although Long Island Sound appears to be the most fertile region of the state for electricity production from wind power, it is expected that proposals to install wind turbines in Long Island Sound would meet with significant public opposition.

Other regions of the northeast such as Maine, Massachusetts, New Hampshire, New York and Vermont have much greater potential than Connecticut for the installation of large-scale wind turbine systems that can generate electricity in the MW scale. The public is most familiar with the proposed Cape Wind farm in Nantucket Sound that would generate over 400 MWe of wind

power. While not within Connecticut, these regional installations would have the capability of reducing New England's reliance on fossil fuel.

It is suggested that:

- Connecticut should investigate ways to collaborate on proposed or future Northeast wind turbine installations.
- The state should consider creating incentives for the purchase and installation of small wind power systems, less than 25 kW, for residential and business use.

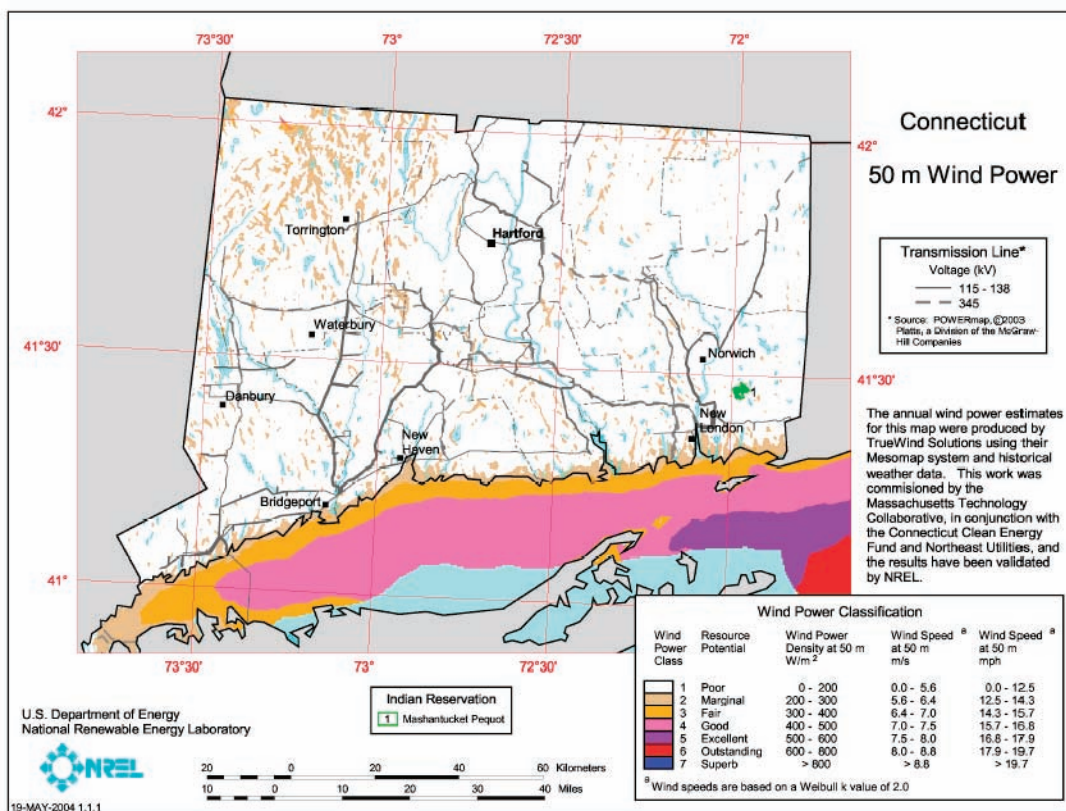


FIGURE 15: AVERAGE WIND SPEED MAP FOR CONNECTICUT

HYDROPOWER

DOE recently completed a study (DOE-Id-11263- January 2006) that looked at the potential for additional hydropower sites in all 50 states. This study examined ways to reduce the environmental impacts of hydropower. The study identified sites that would

- not require a dam across a river
- not require the creation of new reservoirs
- limit access to less than 50% of an existing watercourse flow

Typically these new hydropower installations would rely on a penstock built parallel to existing streams and rivers.

Although Connecticut has the potential for approximately 100 MW available from a variety of hydropower sites including low-head (small elevation change) and low-power (less than 1 MW) installations, the state's topography does not support large-scale hydropower installations, as is available in many western states. However, it may be possible to derive additional electricity generation from the state's water resources.

While the DOE report investigated the technical viability of potential hydropower sites, a detailed economic analysis has not been performed. Therefore, the Study Committee suggests that a detailed economic feasibility analysis be performed to determine the potential for developing those additional Connecticut hydropower sites that were identified within the report.

NUCLEAR

Connecticut has a long history of operating with fission energy nuclear power plants. The *USS Nautilus*, the first nuclear-powered naval ship, was launched from the Electric Boat shipyard in Groton and commissioned in September 1954. The Connecticut Yankee Nuclear Power Plant, located in Haddam Neck, began the first commercial nuclear electric power operation in Connecticut on January 1, 1968, and operated until 1996. The multi-unit Millstone Power station in Waterford began commercial operation in 1970 with the initial start-up of the 670 MWe Unit 1 plant. The second unit, an 880 MWe plant, began commercial operation in 1975, with the third unit, a 1,155 MWe, starting service in 1986. While Connecticut Yankee and Millstone Unit 1 have ceased operation, the state still generates over 2,000 MWe of electric power from the remaining two plants at the Millstone site. These two nuclear plants can provide approximately 30% of the state's overall generating capacity, and because of their low-cost operation and reliable dispatch, they provided over 50% of the state's entire electricity usage during the 2004 calendar year. Both remaining units at Millstone have received operating license extensions (Millstone 2 until 2035, and Millstone 3 until 2045) from the US Nuclear Regulatory Commission.

Nuclear power may offer an opportunity for the state to reduce its dependence on fossil fuels for the generation of electricity. In fact, in the future, a significant increase in baseload electric generation using fission reactors that operate continuously at their generating capacity could provide for

- the charging of PVEHs during off-peak electricity demand periods
- hydrogen production for fuel cell vehicles during off-peak electricity demand periods

Nuclear power plants need as long as a ten-year lead time to complete the nuclear regulatory licensing process, and have long lead times to fabricate system components including the reactor core and steam generating heat exchangers. Nuclear power can provide a large shift in the fuel mix used to provide the state's electricity. However, the lead time required for permitting and construction will push any new nuclear electric generation capacity beyond the ten-year time frame for this report.

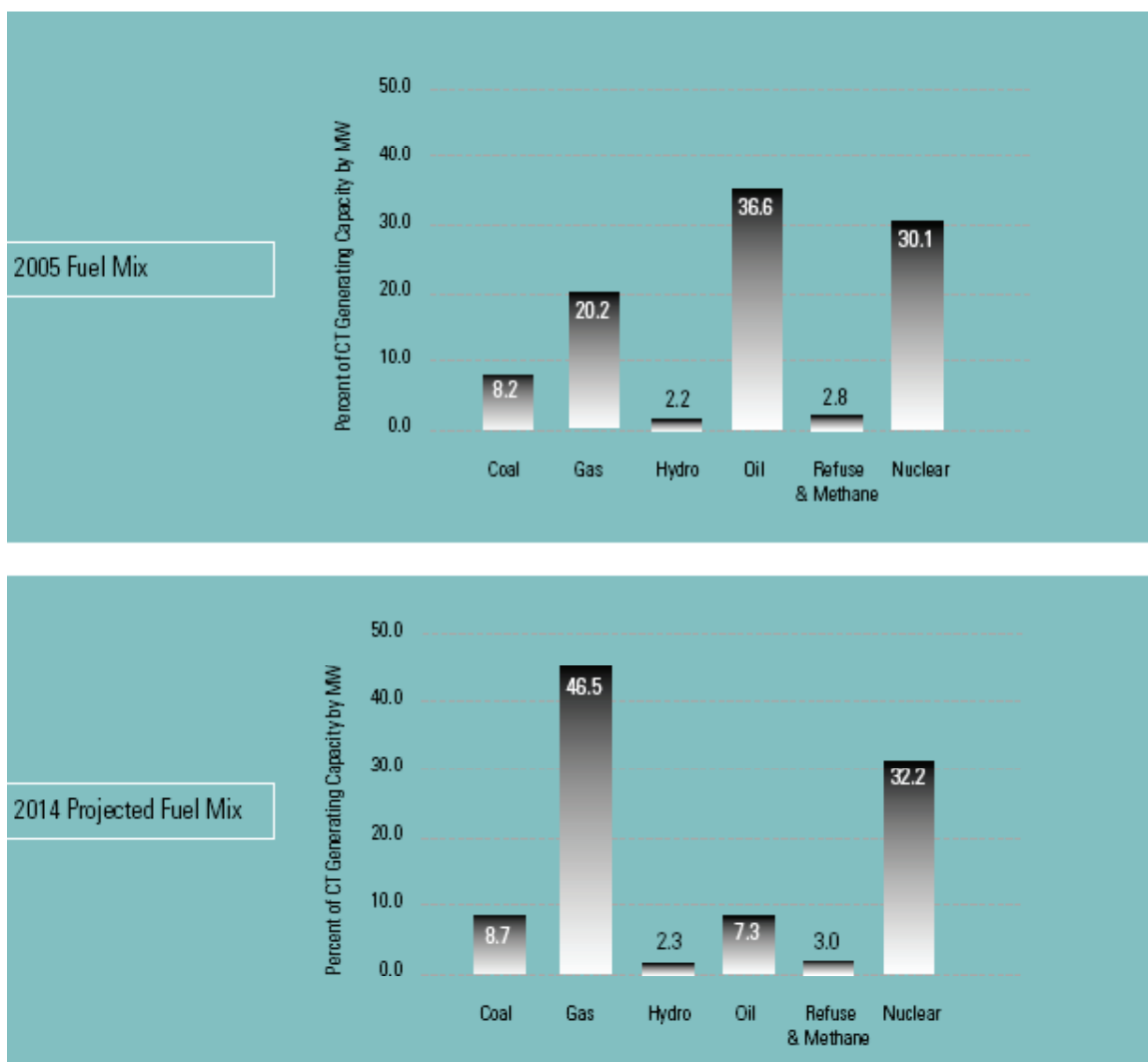


FIGURE 16: CONNECTICUT SITING COUNCIL ELECTRIC GENERATION MIX BY FUEL TYPE
(FROM *REVIEW OF THE TEN YEAR FORECAST OF CONNECTICUT ELECTRIC LOADS AND RESOURCES 2005-2014*, CONNECTICUT SITING COUNCIL, DECEMBER 2005)

Additional market signals beyond the incentives presently being instituted by ISO-NE may be necessary for any entity to invest in nuclear-powered electric generating plants. While the newest generation of nuclear power plant designs contain fewer pumps and valves, and incorporate more passive safety features, their capital costs are much greater than comparably sized fossil fueled plants. Therefore, it is unlikely that any company would commit the large capital investment needed to bring one of these plants to commercial operation in the current regulatory environment. Several utilities have begun the licensing process for new nuclear power plant reactors, but they are regulated utilities in high-growth regions like the southeastern United States. n r g has filed a letter of intent to build two additional nuclear power plants, with a total rated generating capacity of over 2,700MW, at their South Texas Project site located in Bay City, Texas. The preliminary construction cost estimate for this project is over \$5 billion.

Figure 17 shows a simplified schematic for a new Pressurized Water reactor (PWR) AP1000 developed by Westinghouse Electric Company. This 1,000 MWe plant design, like most conventional PWR designs, relies on large concrete structures to protect the public and plant workers from the nuclear fuel, thus adding to the plant's capital cost. This design has been standardized at the 1,000 MWe output level in an effort to achieve economy of scale.

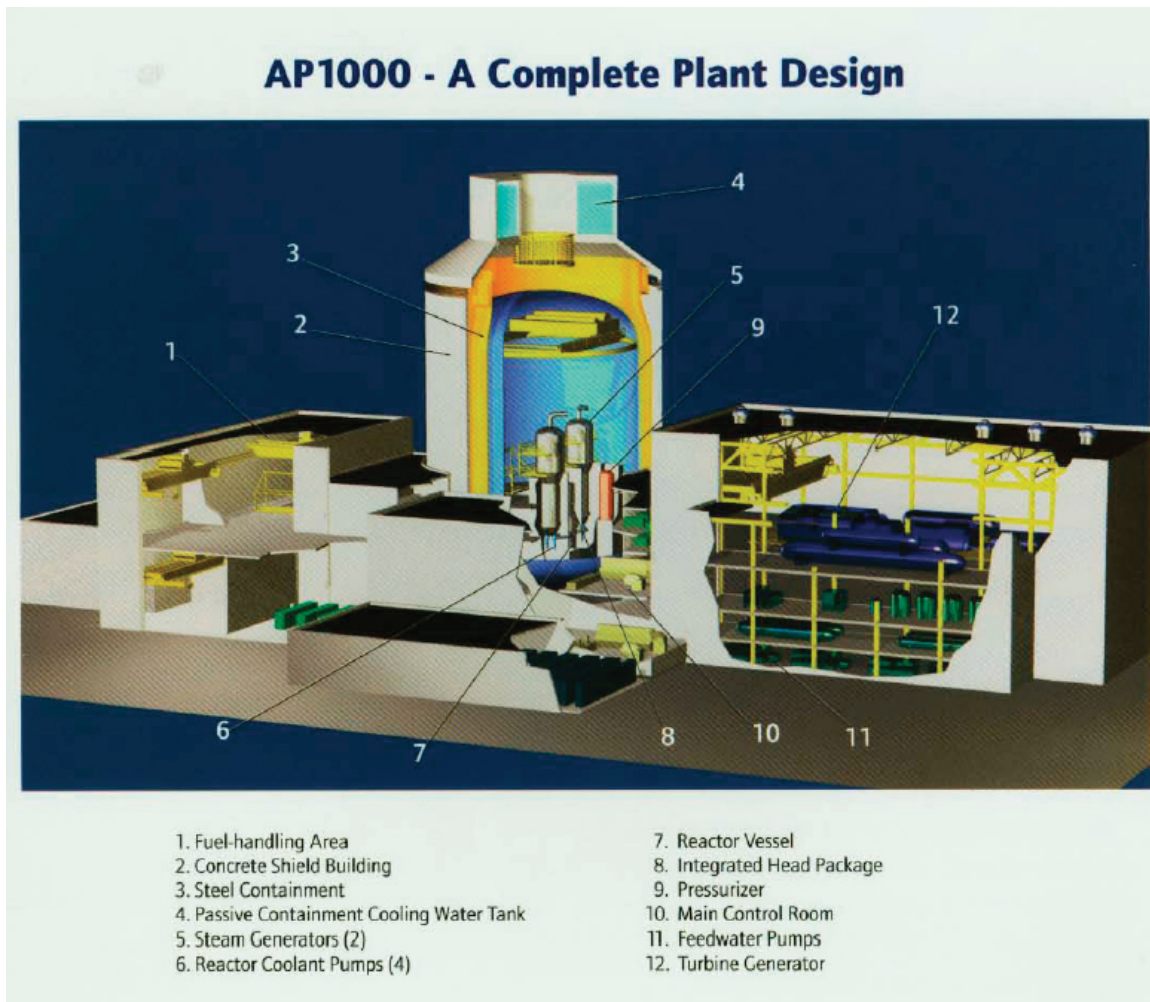


FIGURE 17: WESTINGHOUSE AP1000 STANDARDIZED PWR DESIGN
(COURTESY OF WESTINGHOUSE ELECTRIC COMPANY, LLC)

Alternate modular nuclear reactor models are being designed with smaller electric output. Westinghouse, with the South African electric utility, is presently working on a 200 MWe Pebble Bed Modular reactor. While the size of this reactor fits better into producing grid reliability, it has not been built yet and must be considered at least 15 years away from commercial deployment in the United States.

This assessment of a potential resurgence in nuclear power assumes there will not be any reactor accidents or external events to change the public perception of nuclear power. Even beyond the technical, financial and regulatory hurdles necessary to produce large amounts of electricity using nuclear power, other issues remain. The public's safety against terrorist attack or as a result of a large-scale accident needs to be fully assessed. In addition, the federal

government is many years, and perhaps further litigation, away from completing its long-term spent fuel repository at Yucca Mountain, Nevada, which has been proposed to safely dispose of high-level radioactive waste produced by fission reactors. However, it is worthy to note that France is a world leader in reprocessing spent nuclear fuel and thereby reducing the volume of high-level radioactive waste material requiring long-term storage.

It should be noted that ISO-NE's current operating rules dictate the quantity, location and size of any future nuclear-power electric generating station. The need for redundancy and overall system reliability based on ISO-NE's implementation of Federal Energy Regulatory Commission (FERC) rules will mandate that adequate backup power needs to be available if a single fault removed a power generating station from the grid. For instance, ISO-NE presently operates with the Millstone site as the largest single power source in the area. Therefore, they need to prepare for the loss of the entire ~1,100 MWe generated by Millstone unit 3. This large loss of generation must be replaced by spinning reserves or imported power from other regions. Currently, when fossil-fueled power plants are used as spinning reserves, it is expensive and wasteful to keep them at a hot condition below their most efficient operating condition, simply waiting for a loss of generating capacity.

The standard nuclear power plant designs presently undergoing licensing review by the Nuclear Regulatory Commission (NRC) are large units in the 1,000 MWe range. In addition, the difficulty in the NRC licensing process, public sentiment and security issues all dictate locating nuclear power plants on a few sites. Therefore, building new large, centralized nuclear power plants may exacerbate the reliability issues with which ISO-NE contends.

It is suggested the state begin the process of determining if nuclear energy should play a major role in the state's energy policy while vigorously pursuing the recommendations in this report to reduce the consumption of fossil fuels.

ETHANOL

Ethanol is a clear, colorless liquid that can be produced from fermentation of the starches contained in corn and several other materials (e.g., Brazil uses sugarcane). Ethanol production in the United States has recently increased dramatically due to its use as a gasoline additive, from 2.1 billion gallons in 2002 to 3.4 billion gallons in 2004.

Ethanol is added to gasoline to increase its octane rating and to add oxygen within the fuel mixture, which results in a reduction in carbon monoxide formation, thus improving air quality. It has replaced the use of MTBE for this purpose, due to environmental concerns that MTBE may be polluting drinking water supplies. In Connecticut, ethanol blends in gasoline typically operate at 10% by volume to achieve desired oxygenation levels. However, a higher concentration of ethanol in gasoline, 85% (called E85), can be used to dramatically reduce traditional gasoline consumption.

The benefits from operating with ethanol as part of a gasoline fuel mixture include

- reduction in carbon monoxide and volatile Organic Compound (VOC) emissions.
- no increase in greenhouse gas emissions.

- reduction in reliance on fossil fuels for the transportation sector. The use of ethanol in gasoline results in a 1 for 1 replacement of gasoline, which greatly offsets a minor reduction in fuel economy

There has been significant discussion of the merits of ethanol use as a motor fuel mixture in the United States. The focus of the debate is whether there is a net energy gain or loss from the production and use of ethanol. A recent analysis and survey of published literature by d OE (Hammerschlag) indicates that ethanol returns more energy than is used in its production. This analysis also indicated that future ethanol production from cellulosic material would show a large increase in the energy available from ethanol compared to the energy required for its production.

US ethanol production is currently derived from the starches available in the feedstock, primarily corn. Future ethanol production has the potential to be derived from large amounts of cellulosic material including non-revenue crops, invasive species or wood material widely available in the northeast. Although the production of cellulosic ethanol is technically viable, d OE researchers expect that it will take approximately ten years for it to be produced economically.

Figure 18 shows one of several methods available for producing ethanol from corn starch. The production of ethanol also will allow for the commercial production of other materials like distiller's grain. Distiller's grain can be routinely used for supplements to animal feedstock.

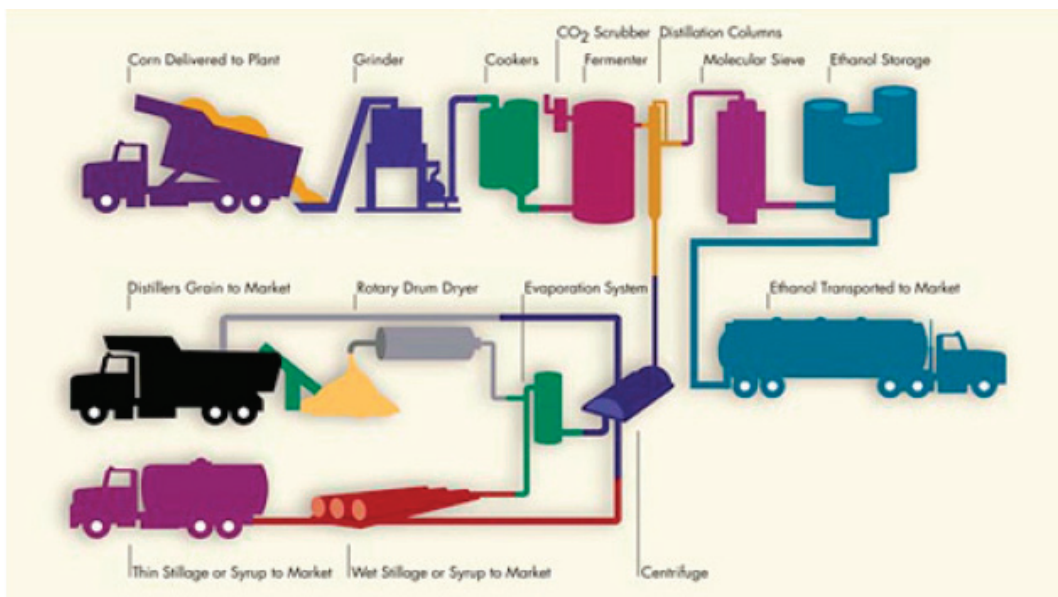


FIGURE 18: DRY MILLING PROCESS FOR ETHANOL PRODUCTION FROM CORN
(COURTESY OF THE RENEWABLE FUELS ASSOCIATION, WASHINGTON, DC)

Currently, the state has in place a \$0.01/gallon excise tax exemption for ethanol and has instituted tax incentives for other alternative fuels, including exempting propane and natural gas from its motor fuels tax. It is suggested that consideration be given to providing these same tax incentives to ethanol and other biofuels to foster their use within the state.

BIODIESEL

Biodiesel is a renewable fuel that can be made from a variety of feedstocks, including virgin vegetable oils, animal fats, and waste vegetable oils and grease, to displace fossil fuel use. The biodiesel manufacturing process converts the oils and fats into a useful fuel via esterification or transesterification, respectively.

Biodiesel has several advantages as a transportation or space heating fuel, including

- It has one of the highest energy balances. Biodiesel can produce useful energy with the lowest input of fossil fuel. As previously mentioned, a variety of feedstocks can be used to produce biodiesel, allowing for fuel diversity.
- When used for transportation purposes, it will produce large reductions in harmful diesel emissions, including particulate emissions, hydrocarbons and carbon monoxide. However, biodiesel nO_x emissions are slightly higher than with traditional diesel fuel.
- The same fuel blend mixture used for ethanol/ gasoline blends can be applied to biodiesel. Most diesel engine day-to-day operations are unaffected by operating on biodiesel blends below 20% biodiesel/ 80% petroleum diesel. Figure 19 shows a biodiesel production process. Also, a typical commercial by-product of the biodiesel production process is glycerin, which may be refined to generate an additional revenue stream.

Biodiesel may be viewed in much the same way as ethanol in that domestic crop production can be used to displace fossil fuel use. In addition, the federal government has enacted a \$1.00/gallon producer tax credit. It is suggested that the state consider providing tax incentives to hasten the introduction and use of biodiesel fuel in Connecticut.

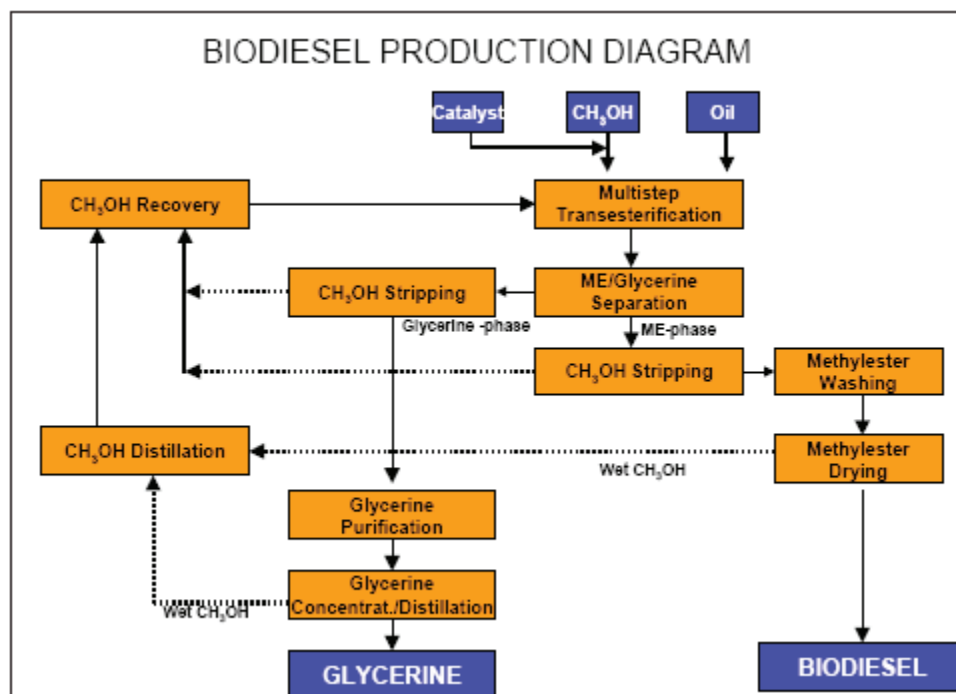


FIGURE 19: BIODIESEL PRODUCTION PROCESS

OTHERS

Other renewable energy sources include tidal power and wave power.

Ocean waves, like wind energy, are a derived form of solar energy. Uneven heating of the earth's surface produces wind, and the wind blowing over long stretches of the oceans produce waves. Ocean waves dissipate very little energy while traveling over the deep ocean. It is only when waves reach water depths of 300 meters or less that the bottom produces drag and thereby disperses their energy.

Tidal power is produced by the daily fluctuation in shoreline water levels caused by the gravitational pull of the moon and the sun. In some locations these daily changes in water level are large enough to produce a significant energy density. Unfortunately, Long Island Sound does not experience these large fluctuations, and the tidal energy density in Long Island Sound is too small to harness practically.

While uneven, the solar flux across the earth only varies between several hundred watts per square meter up to 1,000 watts/m². Wind power densities also vary, but typically range in the hundreds of watts per square meter. Wave densities can reach tens of kilowatts per square meter, one to two orders of magnitude greater than either the wind or solar energy densities.

While the energy density can be very high in ocean waves, the energy density incident upon the Connecticut coastline and Long Island Sound is not adequate for energy production. However, regionally, wave energy may be able to be used effectively to produce electricity by using deepwater buoys along the coastlines of Long Island's south shore, Rhode Island, Massachusetts and Maine, as energy densities in these regions are in the range of 10-25 kW/ m of surface.

RENEWABLE ENERGY HIGHLIGHT SUMMARY

Table 5 on the following page contains a list of renewable energy technologies that have an opportunity to reduce Connecticut's reliance and use of fossil fuels. This table contains suggestions for increasing the rate of adoption for these technologies. Consideration should also be given to conducting a study that assesses the maximum potential of each of these technologies for use in Connecticut.

	Technology	Proposed Action
1	Biomass	Assess the viability of constructing a second biomass power plant
2	Ethanol	State tax incentives
3	Biodiesel	State tax incentives
4	Solar Thermal	Provide CCEF the ability to partially fund; & adopt state tax incentives
5	Solar PV	Continue present CCEF incentives
6	Wind	Align CT with other regional states in New England and NY to support large wind systems
7	Wave & Tidal	Support regional initiatives
8	Hydropower	Assess economic viability of potential CT sites identified in dOE report

TABLE 5: RENEWABLE ENERGY HIGHLIGHT SUMMARY

V. SUMMARY OF FINDINGS AND CONCLUDING REMARKS

Reducing Connecticut's dependence on fossil fuels and per capita energy consumption will require aggressive efforts to increase the market penetration of energy-efficiency technologies and long-term investments in renewable and non-fossil fuel energy sources. Both energy-efficiency and alternative-energy programs will be required, but their time frame (short-term versus long-term) and financial commitment are quite different. Many of this study's suggested conservation and energy-efficiency initiatives and programs use existing technologies and have benefits that can be obtained immediately. Furthermore, the resources invested in energy-efficiency incentives and education/outreach are more than offset by a reduction in energy expenditures by the state's citizens and businesses and savings in infrastructure costs, such as transmission lines and new power generating facilities. Many of these energy-efficiency measures have very short payback periods, less than five years, and are sound investments that will only strengthen Connecticut's economy. The following initiatives are suggested for consideration:

- Funding of the Connecticut Energy Efficiency Fund (CEEF) should be restored to at least \$90 million, with consideration being given to increasing it to \$148 million. The funding of energy efficiency by Connecticut citizens should be viewed as an investment that will save many times this amount and not as a tax with no or very little economic payback. Accordingly, the state should adopt the principle that energy resource needs will first be met through all available energy efficiency and demand reduction resources that are cost effective, reliable, and feasible. The 2004 independent assessment performed for the ECMB should be updated periodically to reflect current market conditions for the energy efficiency measures that meet these criteria.
- Investment should be made in the energy efficiency of schools and state buildings with a goal of having an average benchmark of 50 based on EPA's Energy Star Portfolio Manager rating system within five years. The benchmark of 50 represents just the average energy performance for a building, but this level of energy efficiency compared to existing school building energy performance is estimated to save \$46 million annually based on 2006 energy costs. This extension of the state's "Lead by Example" program should be a major cornerstone of an energy efficiency and conservation program. As with industrial, commercial and residential efficiency programs, the initial investment will be more than offset by reduction in annual energy costs.
- A program similar to California's Green Building Initiative should be adopted, with a goal of reducing energy use in privately owned commercial buildings by 20% over the next 15 years, using 2006 as the benchmark. The emphasis of this program is to identify trigger points such as sale of property or change in leasehold, when it is most likely that significant changes may be made in a building's energy-consuming characteristics. This program should be well integrated into programs supported by CEEF.
- Incentives should be provided to residents who take the initiative to reduce their own energy consumption. This program could be modeled after California's 20/20 program, where residents received an additional 20% reduction in their electric bill if they reduced their summer electrical consumption by more than 20%. This program was very

successful, with one third of residential customers qualifying for the reduction in 2001 and 2002.

While the Study Committee has primarily analyzed these energy efficiency programs on an economic basis and on their potential to reduce Connecticut's dependence on fossil fuels, it should be emphasized that the overall benefits of reduced energy consumption include improved homeland security, lower health care costs, and reduced environmental impact.

The emphasis of the state's existing energy efficiency and conservation programs has been on reducing electrical consumption and peak demand. However, effective energy-efficiency programs should emphasize reducing all forms of energy consumption, including transportation and space heating. One potential problem of looking at individual sectors—electric, transportation, and heating—in isolation is that this practice may lead to imbalances in Connecticut's fuel mix which could adversely impact the state's residents and businesses. The same narrow focus may cause fuels to be used at lower efficiencies than what is achievable. Therefore, the state's over-reliance on natural gas is an immediate concern. For example, the Study Committee strongly supports the state's very attractive incentives for distributed generation. Combined heat and power (CHP) systems provide the attributes of distributed generation with much higher efficiencies, up to 85%, than stand-alone generators. Therefore, when utilizing natural gas for fuel, it is suggested that the state's distributed generation program be tailored to CHP applications.

The state's outreach efforts, as funded by DPUC and DEP, should be continued (e.g., Distributed Generation Incentive Marketing Campaign), with an added component that offers businesses an opportunity to be provided with a no-cost, unbiased electric and heating load analysis and infrastructure assessment. If these marketing and outreach programs are successful and result in a significant increase in market penetration of CHP systems fueled by natural gas, it is suggested that the state annually review and modify its energy policy as necessary to assure that the state maintains a diverse fuel mix.

For reducing natural gas and heating oil consumption, it is suggested that a heating oil conservation program be created which is overseen by the ECMB, and that funding for the existing natural gas program be expanded. Just as the electric efficiency and conservation programs are funded by electrical ratepayers, natural gas and heating oil programs should be funded by users of these energy sources. Also, the state should provide incentives, similar to those in place for distributed generation, to encourage alternatives to traditional oil, gas, and propane-fired hot water heaters and furnaces. These incentives would support the increased market penetration of solar thermal systems and highly efficient geothermal heat pump systems. Also, an aggressive program should be implemented to phase out the use of inefficient electric hot water and space heating systems.

The most challenging area in which to implement significant energy efficiency measures is the transportation sector. Because of its importance in overall energy consumption—32% in 2004—the programs suggested by the Study Committee are vital to meeting the goal of reducing fossil fuel consumption. Programs that can be implemented in the short-term, i.e., less than five years, are

- Fuel Incentive Program
- Tire Efficiency Program
- Car Pooling Initiative
- Telecommuting
- Condensed Work Week
- Plug-In Hybrid Vehicles (PHEVs)

The Study Committee supports new initiatives, such as the fuel incentive and tire efficiency program, that reward behaviors that provide multiple benefits to the state—economic, security, health, and environmental. These two measures will directly reduce energy consumption.

The suggested PHEV initiative is a good example of the need to optimize on overall energy consumption, and not individual sectors. While this initiative will directly reduce the amount of liquid fuels used for transportation purposes, it will increase electrical energy consumption. However, the charging of PHEVs at night will result in more uniform and efficient use of the electric grid and electricity generating facilities. With the use of time-variant electric rates, this type of off-peak electricity consumption can be promoted. As the market for PHEVs grows, the impact on electricity generation versus transportation fuels needs to be analyzed to ensure that this initiative will continue to meet the overall energy objectives of the state.

It is recognized that changing the behavior of businesses and people in ways that result in more car pooling, condensed work weeks, and telecommuting is difficult, but promotional programs and incentives for these activities need to be included in an overall comprehensive energy efficiency and conservation plan.

A single organization should be tasked with monitoring the progress of state programs and activities aimed at achieving the annual targets that are needed to reach the long-term goals established by the state of 10% energy reduction by 2010 (CEAB) or 20% energy reduction by 2020 (Governor Rell's Energy Plan). This will enable Connecticut's policy makers to annually assess the funding and effectiveness of individual programs and to be able to quickly develop new strategies as necessary to meet the long-term goals and milestones.

In a longer-term time frame, it is suggested that Connecticut should continue to invest in mass transit in parts of the state where population and employment density makes this a viable alternative. The Study Committee supports the initiatives in the area of "smart growth" and livable communities passed by the 2005 Connecticut General Assembly, including Public Act 05-205. This Act established growth management principles and issues for consideration in plans of conservation and development. Also, legislation adopted in 2006 provides for two significant mass transit projects: the development of the New Britain to Hartford busway; and a New Haven-Springfield, MA commuter rail service. Both of these projects, when implemented, will have major design components that are focused on "transit-oriented development." Similarly, recently reauthorized federal transportation funding (SAFETEA-LU) contemplates support for transit-oriented design, and more closely integrated land use and transportation planning.

Even though the investment will be significant, the success of mass transit systems will have the largest impact on reducing the consumption of fossil fuels in the transportation sector. Also, investments should be made so that towns

- are knowledgeable of the latest in community design
- understand how zoning changes can promote transit-oriented development and mixed use development (e.g., residential and commercial)

These practices will reduce sprawl, which will have the direct result of reducing miles driven by Connecticut residents.

The support of energy efficiency measures by Connecticut's residents and businesses is the key element in achieving a significant reduction in per capita energy consumption. It is suggested that the most effective long-term method to gain the public's support is through a strong education and mass market media campaign.

- Education Initiative: the Study Committee supports an initiative to enhance the incorporation of energy concepts into the K-12 curriculum. Specifically, all high school students should be required to take a course on basic thermodynamic concepts. By the time students graduate from high school, these fundamental concepts will provide them with a foundation to understand topics such as how electricity is generated from fossil fuels, the efficiency of various energy conversion processes, and issues related to the stability and reliability of the electrical grid. By understanding how power is generated and that heat rejection is a necessary part of the process, students will better appreciate the importance of topics such as reducing peak electrical consumption and why combined heat and power systems can be significantly more efficient than large power plants for electrical generation. Also, students should be aware of the location of the state's largest electrical generation facilities, the fuel mix used to meet the state's energy requirements, and the need for Connecticut to import essentially all of its energy. This will then provide a foundation for understanding the relationship between energy consumption and:
 - o national security
 - o public health
 - o environmental impacts
 - o importance of individual action to ensure the responsible and efficient use of energy
 - o support for the state's energy conservation programs
- General Public Awareness Marketing Campaign: over time, education of the state's K-12 students will have significantly greater impact on conservation and energy efficiency. It is also critical to educate the general public about these topics through a mass media marketing campaign on a continuing basis. The campaign should emphasize the importance of reducing overall and peak energy consumption, and provide information

on incentives available to both residents and businesses to meet the state's energy reduction goals. As with the K-12 education initiative, potential benefits of the public awareness campaign could include improving Connecticut's economy, increasing job creation, enhancing national security, and positive health benefits and environmental impacts. Several initiatives to increase public awareness and conservation, especially during peak load periods, should be considered:

- o develop a Real-Time Energy Report for use on television and by other media as a part of daily weather reports
- o establish a voluntary E-Mail and Cell Phone Energy Alert System to inform the public of the need in real-time to reduce energy use

Another aspect of an effective policy for reducing fossil fuel consumption is for the state to invest in, and encourage the production and use of, non-fossil fuels. However, the technology for most of these alternative energy supplies needs to be developed. Therefore, it should not be expected that initial investments will be cost effective, but rather they are suggested as part of an overall plan with a goal of helping to increase the competitiveness of these non-fossil fuel alternatives compared to traditional fossil fuels.

- The most plentiful source for renewable energy within Connecticut is biomass. At the present time, "trash-to-energy" plants directly combust municipal solid waste to generate about 125 MW of electricity. One other technology beyond simple combustion is the gasification of biomass material. Currently, a 37.5 MW power plant that utilizes a biomass gasification technology is expected to be built in Plainfield, CT. This power plant is expected to use 1,000 tons/day of biomass material, including construction and demolition (C&D) waste, trimmings from tree and brush removal, and used wood pallets. It has been estimated that this plant will use approximately 50% of this type of biomass material that is available in Connecticut. Therefore, it appears that a power plant of similar magnitude may be justified pending further analysis to verify the availability of an adequate supply of biomass material to support the plant's operation. Despite the start-up difficulty in the 288 kW Tallon Lumber gasifier project, the Study Committee supports the investment in biomass power plant projects through CCEF with the goal of maximizing the state's electricity generation from biomass.

Biomass, when in the form of vegetable oils and animal fats, can be converted into biodiesel, which can be used as a liquid fuel. It is suggested that

- A study be performed to determine the location of available farm land where crops such as soybeans, sunflowers, and canola, could be grown. These crops could then be converted to biodiesel using a locally sited, centralized biodiesel plant.
- If the study concludes that enough biodiesel crops could be grown to support a biodiesel production facility, it is suggested that the state consider providing incentives such as the present federal production tax credit to make this a viable homegrown source of biodiesel fuel.
- The production of biodiesel from vegetable oils imported from other states should also be supported. For example, BioPur, located in Bethlehem, CT, constructed a facility to

process five million gallons of biodiesel per year using soybean oil from Delaware and Maryland. The state should consider providing economic and tax incentives for similar types of biodiesel production facilities throughout the state.

Biomass in the form of starches—corn and sugarcane—can be fermented to produce ethanol. At the present time, it is mandated that gasoline sold in Connecticut contain 10% ethanol, because ethanol contains oxygen, which allows for cleaner, more complete combustion of the gasoline. As an additional benefit, the ethanol additive requirement also reduces the state's dependence on fossil fuels. Increased usage and expansion of the ethanol market should provide incentives for market-based development of more efficient fermentation processes, which will help increase the net energy yield and reduce the cost of ethanol. Because of the greater energy yield of biodiesel (3.2 units of fuel product for every unit of fossil fuel energy used in production, manufacture, transportation, and distribution) as compared to corn-based ethanol (0.84-1.65 unit of fuel product), it is suggested that additional farm land resources in Connecticut should be used to grow crops to produce biodiesel, such as soybeans, sunflowers, and canola, instead of corn, for the production of ethanol.

One of the areas that has the most promising potential to make a significant impact on reducing Connecticut's dependence on fossil fuels is the development of an economically viable process to produce ethanol from cellulose material. This process has more promise than producing ethanol from corn because it has a higher energy yield value (4.4-6.6 units of energy for cellulosic ethanol as compared to 0.84-1.65 units for corn-based ethanol and 0.76 units for gasoline) and because non-edible biomass matter can be used as the energy source. The types of crops that could be used as the energy source to produce cellulosic ethanol produce higher yields using fewer resources (e.g., water and fertilizer) than corn. The Department of Energy is funding \$14 million/yr to develop a process to economically produce cellulosic ethanol and has set a goal of displacing 30% of gasoline usage with cellulosic ethanol by 2030. A 2005 joint DOE-USDA study concluded that the United States could theoretically produce over one billion dry tons of biomass each year, enough to generate at least 60 billion gallons of ethanol fuel compared to the 4.5 billion gallons of corn based ethanol that is currently produced. As a result of investment by the federal government, additional investment by the state to make this technology economically competitive cannot be justified at this time. Because of the substantial potential quantity of biomass that could be grown in the state, and the fact that in the foreseeable future there will continue to be a need for a liquid fuel for transportation, the state should appoint an agency/organization to be responsible for following and reporting on the latest developments in cellulosic ethanol to the General Assembly and the Governor. This will enable Connecticut's energy policy to be well aligned to take advantage of a renewable liquid fuel source that can significantly reduce the state's dependence on fossil fuels.

The Study Committee supports further study of the potential of low-head (small elevation) and low-impact hydroelectric power. A recent study by DOE (January 2006, DOE-Id-11263) indicated that Connecticut has the potential to produce approximately 100 MW of new hydropower available from a variety of sites. These sites would not require a dam, but would rely on a penstock built parallel to existing streams and rivers. While the DOE study investigated the technical viability of these installations, no detailed economic or environmental impact study has been performed. Therefore, it is suggested that these assessments be performed on the Connecticut sites identified in the DOE report.

If a primary goal is to reduce the state's dependence on fossil fuels from foreign countries, an alternative that also should be considered is the use of coal. The hurdles that must be overcome include designing a coal gasification process with pollution control equipment that truly makes coal a clean energy source that would be competitive with existing technologies. This includes the development of carbon dioxide removal technologies so that the increased use and dependence on coal does not increase the carbon emissions as compared to emissions from a combined-cycle natural gas power plant.

CONCLUDING REMARKS

The state's energy efficiency and conservation programs are achieving reductions in energy consumption, as shown by the fact that its per capita energy consumption is lower than that of the United States as a whole. However, the state can achieve even greater reductions by aggressively implementing the suggestions provided by the Study Committee. At a minimum, the state should establish to the goal of reducing its per capita energy consumption to that of California and New York. Looking toward the future, the state should consider adopting a more ambitious goal of achieving a per capita energy consumption equivalent to that of the most energy-efficient countries in the world, such as the United Kingdom, France, and Germany. The state should also actively pursue opportunities for the use of non-fossil fuel alternative energy sources such as biomass, low-head hydroelectric, solar, and local wind farms for electricity generation. Also, biodiesel should be promoted as an alternative liquid fuel, with the potential of producing biodiesel fuel either from state-grown crops or from vegetable oil imported from other northeastern states. Additionally, the state should actively monitor the progress made in commercializing the production of cellulosic ethanol. Finally, alternatives to traditional heating and cooling such as combined heat and power systems, solar thermal and geothermal heat pump systems should be promoted.

APPENDIX A CEEFF PROGRAM SUMMARY FOR 2006

CEEFF Program Summary for 2006

Residential Programs			
Programs	Eligibility	Incentive	Program Feature
ENERGY STAR® Retail Products	All residential customers.	Retail incentives, special events and mail order promotions, to encourage customer buying habits of energy-efficient lighting products and clothes washers.	Promotion and education of ENERGY STAR® lighting products and clothes washers to residential customers and retailers.
Appliance Retirement	All residential customers.	Free pickup and rebate for working, inefficient refrigerators and freezers.	Provide proper EPA-compliant disposal of all components in the program. Promotion and education of ENERGY STAR® appliances to residential customers.
Residential New Construction	Residential customers in the process of building a new home.	Incentives for high-efficiency HVAC equipment, lighting products and home performance.	Builder training, home inspections and rebates for energy-saving equipment and measures.
Residential Heating and Cooling	Residential customers with central air conditioning or heat pumps.	Prescriptive incentives for installing energy-efficient central air conditioners and heat pumps; promotion and/or incentives for tune-ups and duct sealing on existing systems.	Promotion of energy-efficient central air conditioners and heat pumps. Contractor training to increase energy-efficient installations and tune-ups.
Energy Audits	Non low-income residential customers using electric, gas or oil heat.	Energy audits available for electric heat customers at no cost and via co-pay for gas and oil heat customers.	On-site home energy audit provides low-cost, unbiased information on lowering energy consumption.
CL&P Weatherization Residential Assistance Partnership, UI Helps	Low-income residents with incomes at or below 60% of the Connecticut state median income.	Full incremental cost of installed conservation measures.	Energy-efficiency measures to address lighting, heating, cooling and water heating. Replacement of qualifying high-energy-use appliances and HVAC equipment may be covered.
Energy Conservation Loan	Owners of single- and multi-family buildings, having an average annual income below the Connecticut Housing Investment Fund (CHIF) established limits.	Low-interest loans for residential energy conservation work.	CHIF administers this loan program. For details, call 800.992.3665 or visit www.chif.org
Community Based	Government, educational groups, economic development organizations, retailers, trade allies and civic organizations.	Financial incentives are provided via an array of conservation programs.	Increases energy-efficiency awareness and participation in conservation programs, transforming communities into active participants through wise resource utilization.
eEsmarts™	Boards of Education, school principals, teachers and parents.	Free K-8 educational materials on energy conservation for Connecticut schoolchildren.	Develops an energy-efficiency ethic among students, encouraging both students and parents to incorporate energy-efficiency practices into their schools and homes.

CALL 1-877-WISE-USE FOR ADDITIONAL INFORMATION

ENERGY EFFICIENCY: INVESTING IN CONNECTICUT'S FUTURE

APPENDIX A (CONTINUED)

Commercial & Industrial (C&I) Programs			
Programs	Eligibility	Incentive	Program Feature
Energy Conscious Blueprint	New Commercial and Industrial (C&I) construction, planned remodeling and major renovations.	Up to 100% of incremental cost.	Equipment, system and design incentives for installation of energy-efficiency measures.
Energy Opportunities	All C&I customers. Express Rebate Services; All C&I customers— Lighting: upgrades only; Motors: up to 200 HP; HVAC: up to 30 tons.	Up to 100% of incremental cost or up to 50% of installed cost. Express Rebate Services: prescriptive rebates paying up to 100% of incremental costs.	Focused studies available for specific projects. Cash incentives for cost-effective energy-efficiency upgrades. Implementation is by the customer. Simple, quick application process.
Operation and Maintenance (O&M) Services	All C&I customers.	Incentives up to 100% of installed cost (See your utility for details).	Energy-saving maintenance procedures and energy-efficiency modifications to existing systems. Focused studies and training are available. (See your utility for details).
Small Business Energy Advantage	All C&I customers, including municipalities, with up to 200 kW (CL&P) or 150 kW (UI) of average peak demand.	Interest-free financing and prescriptive incentives up to 50% of the installed cost for Lighting, HVAC, and Refrigeration measures. Lighting: 50% of installed cost; HVAC: Prescriptive O&M incentives; Refrigeration: 50% of installed cost.	On-site assessment and installation of cost-effective electric energy measures. Interest-free loans for qualified customers for the balance of project costs.
Conservation and Load Management Financing	Small business customers (200 kW (CL&P) or 150 kW (UI)) and municipalities.	Interest-free financing.	Maximum of \$100,000 for implementing cost-effective energy-efficiency projects. (See your utility for details)
Small C&I Conservation Loan (CL&P only)	Commercial customers with average kW demand of 350 kW or less, or industrial customers with less than 100 employees.	Interest-free financing.	Interest-free loan at \$5,000 minimum up to a maximum of \$100,000 per customer for energy-efficient equipment replacements only.
ISO-NE Load Response Program Support	All C&I customers with at least 100 kW of curtailable load.	Incentives are paid for curtailment when requested. Higher payments are available for 30 minutes and two hour demand reduction.	Maintain the ability of existing participants to reduce load during periods of system capacity deficiency.
Demand Reduction (CL&P only)	C&I customers who are capable and willing to control kW demand during peak times through real-time monitoring and control.	Incentives can be up to 50% of installed cost, or up to \$500 per output control point (\$1,000 for SWCT customers).	Incentives for cost-effective projects which provide peak load kW (or kW and kWh) reductions in commercial, industrial and large residential complex applications.
Power Factor Improvement (CL&P only)	CL&P customers who are provided electricity through Rate 58 tariff who have a 12-month average power factor below the approved qualification threshold.	Incentives up to 50% of installed cost to improve power factor to the rate average power factor (0.898 for Rate 58). Absolute cap of \$60/KVAR.	Provide technical and financial incentive support to improve power factor at qualifying facilities.

ENERGY EFFICIENCY: INVESTING IN CONNECTICUT'S FUTURE

APPENDIX B

SUGGESTIONS FOR ENERGY EFFICIENCY AND CONSERVATION

Policy Initiative / Program	Existing or Proposed Program	Benefit	Policy Initiative / Program Summary
Combined Heat and Power (CHP)	<p><u>Existing Programs:</u> Very good incentives available for distributed generation. Small pilot program initiated by DPUC and DEP that educates businesses about distributed generation.</p> <p><u>Proposed Program:</u> Study Committee proposes on-site electrical and heat load assessment be added to education program and that focus of natural gas if red distributed generation be on CHP applications.</p>	Total Energy Reduction	<p>In 2004, CHP potential estimated to be 1,670 MW with market penetration less than 1% for applications smaller than 20 MW and approximately 5% for applications greater than 20MW. Efficiency of CHP systems can approach 85% compared to estimated average efficiency of separate electrical and heating systems of 45%, thus reducing the overall demand for energy. Additional benefit of CHP is that it provides a distributed source of electrical generation, which should reduce Federally Mandated Congestion Charges without the need for costly upgrades in the electrical transmission system and also improve the reliability of the electric grid. This initiative will add an on-site electrical and heat load assessment to current outreach programs that promote the very good incentives available through DPUC. Also, the focus for natural gas fueled projects will be CHP applications because of their higher efficiencies. Program goal is to increase market penetration of CHP systems.</p>
Increased Investment and Expansion of Connecticut Energy Efficiency Fund (CEEF) Programs	Expand Existing Programs	Total Energy Reduction	<p>Restore investment in electric efficiency and conservation programs to at least \$90 million with consideration of increasing it to \$148 million. The state should adopt the principle that energy resource needs will first be met through all available energy efficiency and demand reduction resources that are cost effective, reliable, and feasible. Expand existing natural gas and home heating oil conservation programs that are funded by users of these energy sources.</p>

APPENDIX B (CONTINUED)

Policy Initiative / Program	Existing or Proposed Program	Benefit	Policy Initiative / Program Summary
Compact Fluorescent Lighting Initiative	Expand Existing CEEF Initiative	Electricity Consumption	Compact Fluorescent Lights are up to 75% more efficient than incandescent lights with comparable lighting characteristics for many applications. Incentives for compact fluorescent lights should be continued, but also an additional fee should be added to the purchase price of incandescent lights when comparable compact fluorescent lights are available. Also, phasing out the sale of incandescent lights should be considered. The lower heat load of compact fluorescent lights also has the additional benefit of reduced cooling requirements during summer. Develop and implement statewide fund raiser for all schools in Connecticut to sell compact fluorescent light bulbs. Program would have education component. Students would benefit from educational effort and from funds raised could be used to support student activity programs. Establish statewide target sales target, such as 1 million light bulbs.
Advanced Metering with Time-Variant Rates	Proposed Program	Peak Demand Response	reduction in peak electrical demand and more efficient use of power generating facilities and electrical grid by having consumers electric rates reflect the actual cost of generating electricity during peak and off-peak times. The Study Committee suggests that a three-tier electricity rate structure be fully implemented within five years.
Incentives for Purchasing Fuel Efficient Cars Incentives for Purchasing Hybrid Electric Vehicles Tire Efficiency Program	New initiative for fuel efficient cars and tire efficiency. Expand existing hybrid car sales tax incentive to cover all hybrid electric vehicles	Gasoline Reduction	Provide consumer incentives for the purchase of fuel efficient cars by modifying both the initial sales tax and the subsequent property tax via a Fuel Efficiency Adjustment (FEA) based on the formula $FEA = \$100n - 4 * MPG$. Modify formula in subsequent years to make it cost neutral to state. Approximately one-third of the cost of a new hybrid car is associated with the batteries, electronics and drive systems unique to hybrid technology. It is counterproductive to apply the same sales tax rate on hybrids, as it discourages consumers from investing in this critical technology. It is suggested that the sales tax on the purchase of hybrid cars should be eliminated and that the property tax should only apply to the gasoline related portion of the car by estimating the one-third of the depreciated value that is associated with the hybrid technology. This adjustment is in addition to the FEA (see above). Up to 7% greater gasoline efficiency can be achieved with properly inflated tires. To achieve these savings, a 3-year information program will be followed by a mandatory fleet-based program. Vehicles that are inspected under the state's biennial vehicle emissions program will receive 5% off the test cost if tires are properly inflated (e.g., within 3% of correct value), and will pay 10% extra if they are more than 5% from the correct inflation pressure. The Study Committee also suggests that automobile manufacturers be requested to include pressure tire monitoring as standard equipment so that drivers are alerted when tires are under or over inflated.

APPENDIX B (CONTINUED)

Policy Initiative / Program	Existing or Proposed Program	Benefit	Policy Initiative / Program Summary
Education	Expand Energy Education in Public School Curriculum, with required course on thermodynamics for high school students	Total Energy Reduction	Achieving conservation and energy efficiency goals and ultimately the reduction in our dependence on fossil fuels requires that Connecticut residents understand the importance of this issue. Over the ten-year time frame of this study, educating Connecticut students on all aspects related to energy (e.g., science, engineering, health, economics, and national security) including a high-school level course on Thermodynamics will provide the platform for making these initiatives more successful.
Public Awareness Campaign	Proposed Program	Total Energy Reduction and Peak Demand Response	Key element in a mass marketing campaign to provide broad public education/ outreach that informs residents about the importance of conservation and makes them aware of federal and state incentives. This program should be modeled after California's iFlex Your Power campaign in 2001. It was estimated that 5% of the states 12.3% peak power demand reduction between summer 2000 and summer 2001 was from voluntary conservation savings. Also, consider developing Real-Time Energy Report for media use and voluntary E-Mail and Cell Phone Energy Alert System
Lead by Example Program	Expand Existing Program	Total Energy Reduction	The Study Committee recognizes the importance of the state's iLead by Example program and supports the recommendations in the High Performance Schools Initiative proposed by the Connecticut Green Building Council. These same initiatives should be extended and apply to all state buildings, with the goal of having all schools and state buildings have an average benchmark of 50 based on EPA's Energy Star Portfolio Manager within 5 years.
Set State Goal of 20% for Reducing Miles Driven by 2025	New Programs and Expansion of Existing Programs	Gasoline Consumption	<ul style="list-style-type: none"> • Study Committee supports legislation adopted in 2006 that provides for two significant mass transit projects; the development of the new Britain to Hartford busway; and a new Haven to Springfield, MA commuter rail service. Improving public transportation and increasing its use will have the greatest impact on reducing miles driven. • Study Committee supports Public Act 05-205 that promotes initiatives in the area of smart growth and livable communities • Actively promote NuRide Program to meet the 2 million rideshare challenge • Work with business to promote condensed work weeks and telecommuting where possible • Promote consumption of local products

APPENDIX B (CONTINUED)

Policy Initiative / Program	Existing or Proposed Program	Benefit	Policy Initiative / Program Summary
Plug-In Hybrids (PHEV)	New Initiative	Transportation and Electric Grid Efficiency	More efficiently use electrical resources by flattening out electrical demand. Plug-in hybrid vehicles can be charged during the night when power plants operate at low efficiency state so that they can meet the next day's peak demand. Plug-in hybrid vehicles are estimated to cost \$2,000 - \$5,000 more than regular vehicles, but will pay for themselves in reduced operation costs (i.e., gasoline costs) in about 6 years. To promote the commercialization of PHEVs, the state, municipalities, and local governments should actively pursue the purchase of a fleet of PHEVs when they become available on the market. Along with time variant rates, this would be a very effective measure to use energy resources more efficiently.
Energy Efficiency in Existing Buildings (Existing state buildings and schools would be part of iLead by Example Program)	New Initiative	Total Energy Reduction	A goal of 20% reduction in the energy use of privately-owned commercial buildings over the next 15 years using 2006 as the benchmark. It is suggested that this program be modeled after California's Green Building Initiative. The emphasis of this program is to identify trigger points (e.g., sale of property or change in leasehold) where there are the most likely opportunities to effect a significant change in a building's energy-consuming characteristics.
Incentives for Customers to Reduce Energy Use (e.g., California's 20/20 Program)	New Initiative	Electricity Consumption	Model program similar to California's 20/20 program where customers were provided an additional 20% reduction in electric bill charges if they reduced their summer energy use by 20 percent. One third of California residential customers qualified for the 20/20 program in 2001 and 2002.
Hot Water Heating Initiative	New Initiative	Heating Oil, Natural Gas, Propane Reduction	For new residential construction over a specified selling price and commercial buildings, the state should require that alternatives to electric, natural gas, heating oil, and propane be used as the primary means for hot water. Incentives similar to those for distributed generation should be provided so thermal solar hot water, geothermal, or CHP are competitive on a life cycle basis to traditional hot water systems.

MAJOR STUDIES OF THE ACADEMY

2006

- Improving Winter Highway Maintenance: Case Studies for Connecticut's Consideration
- Information Technology Systems for Use in Incident Management and Work Zones
- Preparing for the Hydrogen Economy: Transportation
- An Evaluation of the Geotechnical Engineering and Limited Environmental Assessment of the Beverly Hills Development, New Haven, CT
- An Analysis of Energy Available from Agricultural Byproducts, Phase 1: Defining the Latent Energy Available

2001

- A Study of **Bus Propulsion** Technologies in Connecticut

2000

- Efficacy of the **Connecticut** Motor Vehicle Emissions Testing Program
- Indoor Air Quality in Connecticut Schools
- Study of Radiation Exposure from the Connecticut Yankee Nuclear Power Plant

2005

- Assessment of a Connecticut Technology Seed Capital Fund/Program
- Demonstration and Evaluation of Hybrid Diesel-Electric Transit Buses
- An Evaluation of Asbestos Exposures in Occupied Spaces

1999

- Evaluation of **MTBE** as a Gasoline Additive
- Strategic Plan for CASE

2004

- Long Island Sound Symposium: A Study of Benthic Habitats
- A Study of Railcar Lavatories and Waste Management Systems

1998

- Radon in **Drinking Water**

1997

- Agricultural **Biotechnology**
- Connecticut Critical Technologies

2003

- An Analysis of Energy Available from Agricultural Byproducts, Phase II: Assessing the Energy Production Processes
- Study Update: Bus Propulsion Technologies Available in Connecticut

1996

- Evaluation of **Critical** Technology Centers
- Advanced Technology Center Evaluation
- Biotechnology in Connecticut

2002

- A Study of Fuel Cell Systems
- Transportation Investment Evaluation Methods and Tools

1994

- Science and **Technology** Policy: Lessons from Six Amer. States

1992

- A State Science and Technology Policy

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CONNECTICUT ACADEMY OF SCIENCE AND ENGINEERING

The Connecticut Academy is a non-profit institution patterned after the National Academy of Sciences to identify and study issues and technological advancements that are or should be of concern to the state of Connecticut. It was founded in 1976 by Special Act of the Connecticut General Assembly.

VISION

The Connecticut Academy will foster an environment in Connecticut where scientific and technological creativity can thrive and contribute to Connecticut becoming a leading place in the country to live, work and produce for all its citizens, who will continue to enjoy economic well-being and a high quality of life.

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The Connecticut Academy will provide expert guidance on science and technology to the people and to the State of Connecticut, and promote its application to human welfare and economic well being.

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- Provide information and advice on science and technology to the government, industry and people of Connecticut.
- Initiate activities that foster science and engineering education of the highest quality, and promote interest in science and engineering on the part of the public, especially young people.
- Provide opportunities for both specialized and interdisciplinary discourse among its own members, members of the broader technical community, and the community at large.

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