Appendix A: Efficiency & Industry Sectors Strategy Analysis

INTRODUCTION

The efficiency and industry sector analysis estimates several energy consumption scenarios and their costs and benefits to evaluate energy efficiency and fuel switching potential for the three major fuels (electricity, natural gas, and oil) used in Connecticut between 2012 and 2050.

This Appendix describes the approach to calculating sector energy consumption scenarios, the approach to identifying their costs and benefits, the main assumptions underpinning the analysis, and the key outputs of the analysis.

PROJECTING BUILDINGS AND INDUSTRY ENERGY CONSUMPTION

The analysis projects efficiency and industry sector energy consumption from 2012 to 2050 for electricity, natural gas, and oil in the following four scenarios:

- No efficiency programs—no efficiency program funding or associated energy savings;
- Base efficiency—current levels of efficiency funding and energy savings;
- Expanded efficiency—increased efficiency funding to capture all cost-effective energy savings; and
- Fuel switching—Expanded efficiency plus converting all oil use to natural gas and electric heat pumps.

"NO EFFICIENCY PROGRAMS" AND "BASE EFFICIENCY" ENERGY FORECAST

Electricity

To define electricity consumption in "no efficiency programs" and "base efficiency" scenarios, the analysis took two steps (Figure A-1): (1) Define the total electricity consumption from 2012–2050 and (2) Split the total electricity consumption by sector.

(1) Define the total electricity consumption from 2012–2050: The Connecticut 2012 Integrated Resource Plan (IRP) provides projections for No efficiency programs and Base efficiency electricity consumption for Connecticut through 2022.[1] Brattle Group, the author of the IRP, projected this consumption past the 2022 IRP time horizon to 2050 for the purpose of the Draft Strategy.

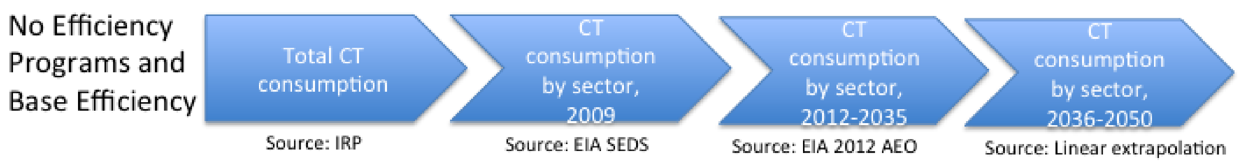
(2) Split the total electricity consumption by sector: The combined electricity projections for both No efficiency programs and Base efficiency scenarios are broken down into projections for the energy

[1] Connecticut Department of Energy and Environmental Protection, "2012 Integrated Resource Plan for Connecticut." Available at http://www.ct.gov/deep/cwp/view.asp?a=4120&q=486946.

efficiency sector (residential and commercial buildings) and the industrial sector using data from the U.S. Energy Information Administration (U.S. EIA) State Energy Data System (SEDS) for Connecticut and data from 2012 U.S. EIA Annual Energy Outlook (AEO) forecasts for New England.[2] The SEDS data provides the electricity consumption for each sector (residential, commercial and industrial) in the year 2009. The share of electricity sales per sector from SEDS applied to the total electricity consumption data from the IRP determines the 2009 electricity consumption per sector in the No efficiency programs and Base efficiency scenarios. Since the relative share of electricity consumption between efficiency and industrial sectors is expected to change over time, sector growth rates are needed to create a more accurate split of electricity consumption between sectors for 2012–2050.

The sector growth rates used were from the U.S. EIA 2012 AEO forecast for the New England Region, which runs from 2009–2035.[3] The annual growth rate in each sector's electricity consumption from 2009 to 2035 is applied to Connecticut's 2009 electricity consumption to develop sector-level electricity consumption from 2012–2035. Sector electricity consumption from 2036–2050 is linearly extrapolated from the 2012–2035 sector compound annual growth rates.

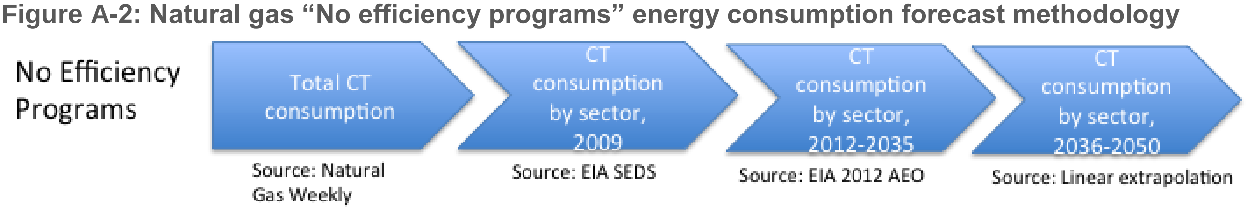
Figure A-1: Electric "No efficiency programs" and "Base efficiency" energy consumption forecast methodology



Natural Gas

Since there is not a Connecticut projection for natural gas use like there is for electricity, projections for both No efficiency programs and Base efficiency scenarios had to be developed. To develop the No efficiency programs scenario, the 2009 Connecticut consumption from U.S. EIA Natural Gas Weekly is used and split into sectors using 2009 U.S. EIA SEDS sector consumption.[4] It is projected to 2050 using the same process detailed in the electricity section above (Figure A-2).

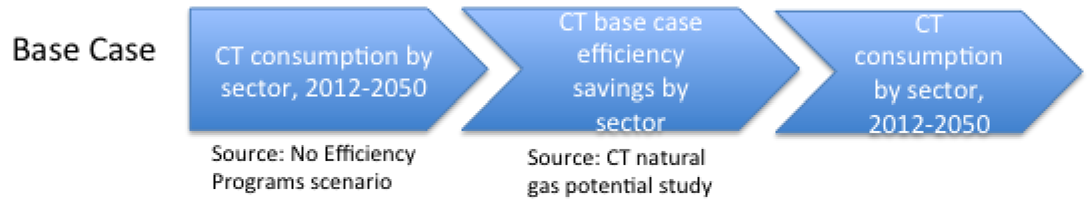
Figure A-2: Natural gas "No efficiency programs" energy consumption forecast methodology



[2] U.S. Energy Information Administration State Energy Data System, "2012 Annual Energy Outlook." Available at http://www.eia.gov/forecasts/aeo/
[3] Ibid.
[4] U.S. Energy Information Administration, "Natural Gas Weekly Update." Available at http://www.eia.gov/naturalgas/weekly/

To develop the Base efficiency scenario, the efficiency potential of current efficiency programs, as identified in the Connecticut natural gas potential study, is subtracted from the No efficiency programs scenario energy consumption forecast.[5] The current efficiency programs potential savings is 0.29% of the No efficiency programs scenario annual natural gas consumption for the commercial and industrial sectors.[6] This percentage is applied to all years of the forecast, assuming that savings beyond the ten-year forecast provided in the potential study will be achieved at the same rate. The natural gas potential study does not cover the residential sector. The model therefore assumes that the residential efficiency potential of current efficiency programs, as a percentage of sales, is identical to the commercial and industrial sectors.

Figure A-3: Natural gas "Base efficiency" energy consumption forecast methodology



Oil

Just like natural gas, Connecticut does not have a long-term projection for oil consumption in the industrial, residential, and commercial sectors. The same approach that is discussed above for natural gas is used to create the oil projection. The main difference being that consumption of motor gasoline and industrial feed stocks is excluded from the U.S. EIA SEDS data since the buildings and industrial model analyzed efficiency and fuel switching opportunities for buildings and processes but not transportation. All residential sector oil consumption is assumed to be for heating and is included in the model inputs.

There is currently no consistent oil efficiency program funding in Connecticut so the Base efficiency scenario oil forecast is the same as the No efficiency programs scenario.

"EXPANDED EFFICIENCY" ENERGY FORECAST

The Expanded efficiency scenario models the capture of all cost-effective efficiency potential for each fuel. The Connecticut electricity and natural gas potential studies are used to define the cost-effective potential. However, the natural gas potential study did not define the potential in residential buildings and there is no state-level oil potential study. To accommodate these data gaps the Connecticut studies were

[5] KEMA, "Connecticut Natural Gas Commercial and Industrial Energy-Efficiency Potential Study." Available at http://ctsavesenergy.org/files/CTNGPotential090508FINAL
[6] KEMA, "Connecticut Natural Gas Commercial and Industrial Energy-Efficiency Potential Study." Available at http://ctsavesenergy.org/files/CTNGPotential090508FINAL, Pages 1–6.

supplemented with a recent Massachusetts residential natural gas potential study and a Vermont oil potential study.[7,8]

The sections below provide additional detail on the cost-effective efficiency potential for each fuel.

Electricity

The Connecticut electricity potential study calculates each sector's ten-year cumulative "program achievable potential" efficiency savings, which defines all cost-effective energy efficiency for the Expanded efficiency scenario.[9] The ten-year cumulative efficiency potential (6,616 GWh for all sectors) is divided equally into each year to determine an annual average efficiency potential for each sector (residential, commercial, industrial). For each year beyond the ten-year efficiency potential study forecast, the efficiency potential is held constant as a percent of the No efficiency programs scenario electricity consumption. This assumes that technology development will replenish the energy savings potential at the same pace it is captured.

For example, the Connecticut electricity potential study determined that the ten-year cumulative efficiency potential for industry is 910 GWh. That cumulative savings divided into each year results in an annual electricity savings potential of 91 GWh for each year between 2012 and 2022. That 91 GWh is 2.3% of the No efficiency programs scenario industrial electricity consumption of 3,965 GWh. The electricity savings potential from 2022–2050 is therefore 2.3% of consumption each year.

This analysis determined that the all cost-effective levels for electricity sales reductions per year are; 1.8% for residential, 2.7% for commercial, and 2.3% for industry. It is important to remember that these percentages are the potential reductions from the No Efficiency programs scenario

To reach the all cost-effective levels in this analysis for all three sectors, a program budget would need to be set at $206 million, assuming a contribution level of 48% from program participants.

Natural Gas

The Connecticut natural gas potential study for the commercial and industrial sectors calculates each sector's ten-year cumulative "program achievable potential" savings[10], which defines all cost-effective energy efficiency for the Expanded efficiency scenario.[11] The ten-year cumulative efficiency potential is divided equally into each year to determine an annual average efficiency potential for each sector. For each year beyond the ten-year efficiency potential study forecast, the efficiency potential across commercial buildings and industry is held constant as 1.8% percent of the No efficiency programs

[7] GDS Associates, "Natural Gas Energy Efficiency Potential in Massachusetts." Available at http://www.ma-eeac.org/docs/PAcites/GDS_Report.pdf.
[8] GDS Associates, "Vermont Energy Efficiency Potential Study for Oil, Propane, Kerosene and Wood Fuels." Available at http://publicservice.vermont.gov/pub/other/allfuelstudyfinalreport.pdf.
[9] KEMA, *Electric Efficiency Study*.
[10] 5,953,454 Dth for Commercial, 1,359,303 Dth for Industry
[11] KEMA, "Connecticut Natural Gas Commercial and Industrial Energy-Efficiency Potential Study." Available at http://ctsavesenergy.org/files/CTNGPotential090508FINAL

scenario natural gas consumption. This assumes that technology development will replenish the energy savings potential at the same pace it is captured.

For example, the Connecticut natural gas potential study determined that the ten-year cumulative efficiency potential for commercial is 5,953,454 Dth. That cumulative savings divided into each year results in an annual natural gas savings potential of 595,345 Dth for each year between 2012 and 2022. That 595,345 Dth is 2.0% of the No efficiency programs scenario industrial natural gas consumption of 29,452,160 Dth. The commercial natural gas savings potential from 2022–2050 is therefore 2.0% of consumption each year.

Connecticut does not have a recent natural gas efficiency potential forecast for the residential sector, so a recent Massachusetts residential efficiency potential study is used to estimate Connecticut's residential natural gas savings potential.[12] This study was chosen because Massachusetts' type and vintage of housing stock and applications for natural gas use is similar to Connecticut's. Furthermore, the available efficiency technologies, their cost, and the cost of natural gas will largely be the same across the New England region, meaning that the assumptions underpinning the Massachusetts study will apply to Connecticut. . Using the Massachusetts analysis, a potential savings of 2.6% natural gas savings was identified for Connecticut's the residential sector. This estimate for all cost-effective residential savings is multiplied by Connecticut's annual residential natural gas consumption in the No efficiency programs scenario to determine the natural gas savings potential in each year to 2050.

This analysis determined that the all cost-effective savings levels for natural gas sales are; 2.6% for residential, 2.0% for commercial, and 1.1% for industry.

To reach the all cost-effective levels in this analysis for all three sectors, a program budget would need to be set at $75 million, assuming a contribution level of 48% from program participants.

Oil

There are currently no existing oil efficiency potential studies for Connecticut, so a recent Vermont oil efficiency potential study is used.[13] This study was chosen because Vermont's type and vintage of building stock and applications for oil use are likely similar to Connecticut's. Moreover, the available efficiency technologies, their cost, and the cost of oil will largely be the same across the New England region, meaning that the assumptions underpinning the Vermont study will apply to Connecticut. However, the 2007 study used fuel price forecasts starting at $7–12 per MMBTU, depending on the type of petroleum, which are much lower than those seen in 2012. As a result, fewer efficiency measures were cost-effective than would be found today, making the potential savings modeled conservative.

[12] GDS Associates, "Natural Gas Energy Efficiency Potential in Massachusetts." Available at http://www.ma-eeac.org/docs/PAcites/GDS_Report.pdf.
[13] GDS Associates, "Vermont Energy Efficiency Potential Study for Oil, Propane, Kerosene and Wood Fuels." Available at http://publicservice.vermont.gov/pub/other/allfuelstudyfinalreport.pdf.

The Vermont oil efficiency potential is converted to a percent of sales for each sector[14]. That percent is multiplied by the Connecticut annual oil consumption by sector in the No efficiency programs scenario to determine the oil savings potential in each year to 2050. This analysis determined that Connecticut's all cost effective levels for oil sales reductions would be; 1.0% for residential, 2.4% for commercial, 1.0% for industrial.

Given these reduction goals, a program budget would need to be set at $46 million, assuming a 48% contribution level from program participants.

ASSESSING THE IMPACTS OF FUEL SWITCHING

An additional model scenario analyzes the impact of a fuel switching strategy. This scenario is based on selecting the most cost effective available heating options and scaling investment in these options from 2012–2050.

Identifying Cost Effective Heating Options

The levelized capital and operating costs (per million BTU of heat delivered) are calculated to evaluate the costs of different heating options. The analysis compared oil furnaces to natural gas furnaces, ground source and air source heat pumps, electric resistance heating, and biodiesel-fueled oil furnaces. The equipment capital costs, lifetime, and efficiency assumptions used are from the technology forecasts in the U.S. EIA's AEO.[15] The added capital cost of natural gas distribution expansion to serve new natural gas customers comes from the Connecticut Department of Economic and Community Development (DECD).[16] The operating cost of each heating systems is based upon the U.S. EIA AEO reference case fuel prices forecast by sector for New England.

The analysis showed that several cost effective options exist to replace oil. Using the most cost effective technologies, a fuel switching scenario is developed that replaces all oil use by 2050 with natural gas (the most cost-effective option) and electrically powered ground source heat pumps (the next most cost-effective option). Switching to natural gas requires extending the natural gas distribution system, so data from the State's natural gas local distribution companies is used to define the number of customers that were within a reasonable distance of natural gas and could be considered cost effective for switching. It is not feasible or cost-effective to extend the natural gas distribution system to all oil customers, and since ground source heat pumps are still less costly than oil, the remainder of oil use is replaced with it. The adoption of these two technologies is scaled up using customer penetration levels discussed below to show total fuel switching from 2012–2050.

Scaling Investment in Cost Effective Heating Options

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[15] Navigant Consulting, "EIA-Technology Forecast Updates-Residential and Commercial Building Technologies." Available at http://wpui.wisc.edu/news/EIA%20Posts/EIA%20Reference%20Case%2009-2007%20Second%20Edition%20Final.pdf

[16] Connecticut Department of Economic and Community Development, "The Economic Impact of Expanding Natural Gas Use in Connecticut." By Stanley McMillen and Nandika Prakash. Hartford, CT, 2011.

The model is currently constructed to apply a top-down fuel switching percentage equally across all years of the forecast (Table A-1). Pre-defined percentages of switching oil to natural gas replicate the natural gas expansion proposal currently being considered and will cause the model to stop switching from oil to natural gas after 2022, the end year of the natural gas proposal. The model is constructed to switch the remaining oil consumption after the natural gas expansion to electricity (in the form of ground source heat pumps) so that oil consumption for heating is reduced to zero in 2050. If the fuel switching in any year reduces oil use to zero in a sector, the model will not attempt to switch fuel in the remaining years of the forecast, so oil use cannot go negative.

Table A-1: Fuel switching scenario inputs

	Natural Gas		Ground Source Heat Pumps (Electricity)	
	Annual fuel switched	End date for switching	Annual fuel switched	End date for switching
Residential	2.5%	2022	1.0%	2050
Commercial	7.5%		0.0%	
Industrial	4.7%		1.2%	

The model is constructed to calculate fuel switching changes before calculating efficiency savings in each year. This structure accounts for the fact that a switch away from oil will reduce potential oil efficiency savings in future years while at the same time increase the electricity and natural gas efficiency potential. Because the total resource cost of efficiency is calculated on a dollar per MMBTU saved basis, shifts in the potential between natural gas and oil will also shift the efficiency budgets for each fuel (raising natural gas budgets at the expense of oil).

The fuel switching calculation itself also takes into account the varying efficiencies of the different heating technologies. The model assumes an existing oil furnace efficiency of 80% across all sectors. When converting oil to natural gas for instance, the model calculates the heating work performed by the existing furnace (80% of the total fuel use), and then calculates how much natural gas would be needed to provide that same work through a new 93% efficient gas furnace. Similarly the model uses an average coefficient of performance (COP) of 4.2 for ground source heat pumps when converting from oil to electricity.[17]

For example, if a residential customer uses 100 million BTUs per year of oil to heat their home, then their 80% efficient oil furnace is delivering 80 million BTUs of heat. To provide that same 80 million BTUs of

[17] Navigant Consulting, "EIA-Technology Forecast Updates-Residential and Commercial Building Technologies." Available at http://wpui.wisc.edu/news/EIA%20Posts/EIA%20Reference%20Case%2009-2007%20Second%20Edition%20Final.pdf

heat, a 93% efficient natural gas furnace would need 86 million BTUs of natural gas while a ground source electric heat pump with a COP of 4.2 would need 19 million BTUs of electricity per year.

IDENTIFYING THE COSTS AND BENEFITS

Capital costs and energy cost savings benefits are calculated for the Expanded efficiency and Fuel switching scenarios in each sector for each fuel type. The Draft Strategy calculates all costs and benefits in real 2012 dollars and uses a 5% real discount rate for taking future years back to a 2012 present value. The Draft Strategy uses a 5% discount rate to reflect the public-private relationship of many of the investment choices in the State of Connecticut. For cost-benefit analysis, the federal Office of Management and Budget (OMB) recommends using discount rates of 7% for private investment and 3% for public investment with social benefits,[18] and the 5% discount rate is an appropriate midpoint. Past Connecticut efficiency potential studies have also used around a 5% discount to account for a combination of utility and customer discount rates.

CAPITAL COSTS

Expanded Efficiency

The capital costs for the Expanded efficiency scenario for electricity are sourced from the 2012 IRP for Connecticut.[19] The IRP tabulates total participant and program costs for the Expanded efficiency scenario from 2012–2022. The total sector capital costs were divided by the total sector potential electricity savings over this time period to calculate a capital cost in dollars per million BTU of energy saved in each sector. That dollar per million BTU of energy saved value is then multiplied by the annual electricity savings to calculate the capital cost for efficiency in each year of the forecast.

Commercial and industrial sector capital costs for the Expanded efficiency scenario for natural gas are provided in the Connecticut natural gas potential study, and were inflated to real 2012 dollars.[20] These sector capital costs are divided by the sector potential savings to calculate a capital cost in dollars per million BTU of energy saved. The residential sector is not included in Connecticut's potential study, and the Massachusetts residential efficiency potential study used in its place does not provide capital cost estimates for natural gas efficiency. The residential natural gas efficiency capital costs are assumed to be the same as the commercial and industrial sector on a dollar per million BTU of energy saved basis. To calculate the total annual capital cost, the capital cost per million BTU of energy saved is multiplied by the new efficiency that is implemented in each year of the Expanded efficiency scenario from 2012–2050.

[18] U.S. Office of Management and Budget, *Guidelines and Discount Rates.*
[19] Connecticut Department of Energy and Environmental Protection, “2012 Integrated Resource Plan for Connecticut.” Available at http://www.ct.gov/deep/cwp/view.asp?a=4120&q=486946. Page 37.
[20] KEMA, "Connecticut Natural Gas Commercial and Industrial Energy-Efficiency Potential Study." Available at http://ctsavesenergy.org/files/CTNGPotential090508FINAL. Pages 1–9.

Capital costs for the Expanded efficiency scenario for oil are provided in the Vermont oil efficiency potential study, and were inflated to real 2012 dollars.[21] The sector capital costs are divided by the potential sector oil savings to calculate a capital cost in dollars per million BTU of energy saved in each sector. That dollar per million BTU of energy saved value is then multiplied by the annual oil savings to calculate the capital cost for efficiency in each year of the forecast.

Fuel Switching

The natural gas capital costs for the Fuel switching scenario are based upon the total cost of the proposed natural gas expansion as provided by DECD.[22] The total cost per sector is divided by the proposed volume of new natural gas used to determine a cost per million BTU of natural gas expansion. This cost per million BTU of new natural gas is then multiplied by the annual new natural gas switched to determine annual capital costs.

The Fuel switching scenario capital costs for ground source heat pumps is based upon the U.S. EIA AEO.[23] The equipment capital cost needed to serve the average residential, commercial and industrial heating load is divided by the annual heating load per customer in each sector to determine a capital cost per million BTU of fuel switched. That capital cost per million BTU of fuel switched is multiplied by the annual increase in electricity consumption that comes from switching from oil heat to determine the ground source heat pump capital cost in each year.

Combined Heat and Power (CHP)

The capital cost of a new combined heat and power unit is based upon a typical reciprocating engine system from the U.S. Environmental Protection Agency's (EPA's) CHP technology catalog.[24] The capital costs per kW are multiplied by the annual installed CHP capacity over the forecast period, which is 10,000 kW per year to 2031.

BENEFITS

Expanded Efficiency

The electricity benefits from the Expanded efficiency scenario are based on the cumulative electricity savings in each year. The cumulative electricity savings in each year is multiplied by the projected annual electricity price from the U.S. EIA 2012 AEO New England reference case fuel price forecast for each sector. Cumulative efficiency savings are used because an efficiency measure continues to save with each passing year. For example, total savings in year 5 is the sum of incremental savings from efficiency measures installed in years 1–4. When the efficiency measure reaches the end of its useful life, it is

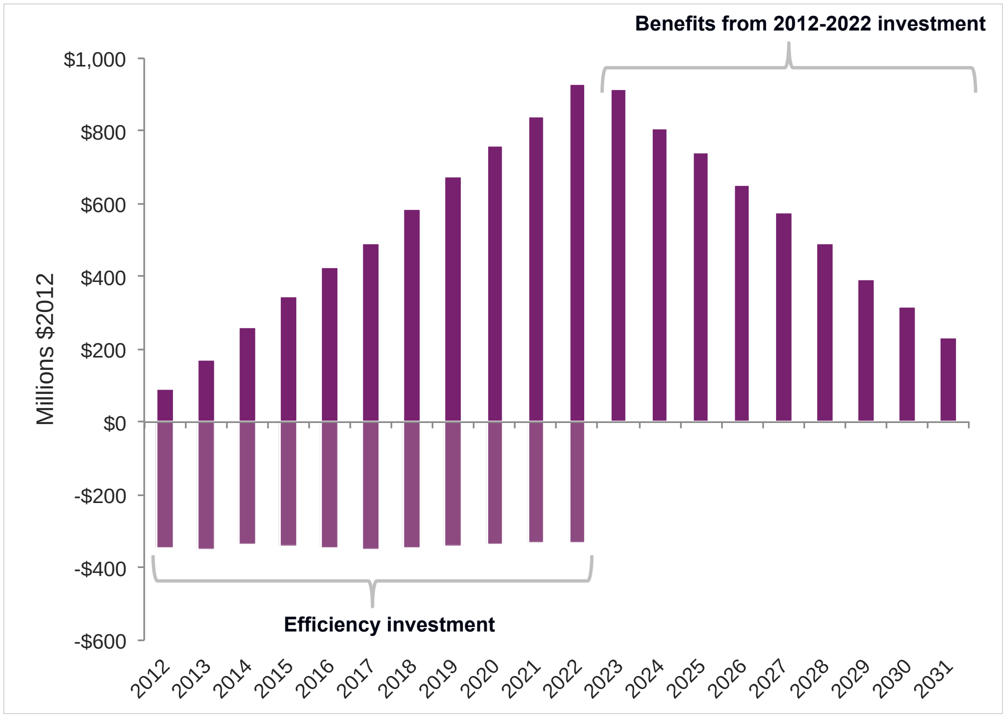
[21] GDS Associates, "Vermont Energy Efficiency Potential Study for Oil, Propane, Kerosene and Wood Fuels." p. 14. Available at http://publicservice.vermont.gov/pub/other/allfuelstudyfinalreport.pdf. Page 14.
[22] Connecticut Department of Economic and Community Development. The Economic Impact of Expanding Natural Gas Use in Connecticut. By Stanley McMillen and Nandika Prakash. Hartford, CT, 2011.
[23] Navigant Consulting, "EIA-Technology Forecast Updates-Residential and Commercial Building Technologies." Available at http://wpui.wisc.edu/news/EIA%20Posts/EIA%20Reference%20Case%2009-2007%20Second%20Edition%20Final.pdf.
[24] Energy and Environmental Analysis, *Introduction to CHP Technologies*.

assumed that it will be replaced either with equipment that performs with similar efficiency or with an incrementally more efficient option. The cost of the like-for-like replacement is not counted as an additional capital cost because it is assumed that codes and standards and/or market forces will make the once efficient technology the baseline or required option. The capital cost and benefits of the subsequent replacement with an incrementally more efficient option is included in the model's calculations of costs and benefits.

For example, if a new 92% efficient residential furnace is installed in 2012, the capital cost in that year is calculated along with the value of the energy savings each year over the twenty year life of the equipment. When that furnace must be replaced in 2032, it is assumed that a 92% efficient furnace is required by code or has become the default choice in the marketplace. If the furnace replacement in 2032 is with a similar 92% efficient unit, the capital costs are not counted in the model. If that furnace replacement in 2032 is with a 95% efficient unit, then the capital costs and the value of the cumulative energy savings would be tallied in the model's cost-benefit analysis.

Because investments in efficiency incur costs only in the first year and provide benefits for each year of the measure life, the model calculates benefits over the lifetime of the investment when determining cumulative benefits for a given time period. This means that when calculating Expanded efficiency scenario electricity cumulative benefits to 2022 for instance, the model calculates the annual cumulative benefits for each year to 2022 and then calculates the cumulative benefits for each year of the remaining life of the measures past 2022 (Figure A-4).

Figure A-4: Annual cash flows for Expanded efficiency scenario electricity investments, 2012 to 2022.



Source: RMI Vision Model Analysis

The methodology used to calculate the natural gas and oil benefits in the Expanded efficiency scenario is to the same as the method used to calculate electricity benefits.

Fuel Switching

The Fuel switching scenario benefits are calculated using the same methodology as the Expanded efficiency scenario (i.e., cumulative fuel savings in each year is multiplied by fuel price in that year). The fuel savings are calculated by taking the value of oil saved minus the cost of additional natural gas and electricity consumption. The benefits are calculated over the 20 year lifetime of a ground source heat pump and natural gas furnace.

Combined Heat and Power (CHP)

The benefits from additional CHP capacity are calculated from the electricity cost savings minus the added natural gas costs needed to run the CHP unit. The electricity cost savings are based upon reduced electricity purchases, equal to the CHP system generation, valued at the current average industrial electricity rate.[25] The model uses values for system operating hours, power to heat ratio, heat rate, and boiler efficiency from EPA's CHP technology catalog.[26]

KEY ASSUMPTIONS

Efficiency potential: the efficiency potential is assumed to remain constant as a percent of sales across the entire forecast period. This assumes that technology development replenishes the efficiency potential at the same rate it is being captured. The Expanded efficiency scenario levels of energy savings result in declining consumption of all fuels. This means that while the efficiency potential as a percent of sales remains constant, the absolute quantity of efficiency potential declines from year to year. It is uncertain if this assumption will hold true as Connecticut, and other states, ramp up to high and sustained levels of efficiency savings. This core assumption should be revisited and re-evaluated in future energy strategies.

Capital costs: the investment cost for efficiency is assumed to remain unchanged across the forecast period on a dollar per million BTU basis. The accuracy of this assumption is impacted by two countervailing forces. As cost-effective efficiency potential is captured, new technologies and approaches will be needed to reload the efficiency potential. It is likely that these new technologies or approaches are more expensive, putting upward pressure on the capital costs of efficiency. At the same time, new programmatic approaches and strategies to capture energy savings, such as behavior modification, will emerge that could offer cost savings. The balance of these two forces will determine if capital costs per million BTU of energy saved increase or decrease in future years.

[25] 15 cents per kWh
[26] U.S. Environmental Protection Agency. Combined Heat and Power Partnership, "Catalog of CHP Technologies." Available at http://www.epa.gov/chp/documents/catalog_chptech

<u>Connecticut sector energy consumption growth rates and fuel prices</u>: the New England sector growth rates and fuel prices are assumed to equal to Connecticut's.

<u>Lifetime of efficiency measures and heating equipment remain constant</u>: the average lifetime for efficiency measures and heating equipment is assumed to remain constant over the forecast period. The average lifetime of heating equipment is dependent on the construction and durability of each type of heating equipment, and is assumed to remain fairly constant. The average lifetime of efficiency measures depends on the type and mix of efficiency measures installed in the state. So, for instance, as the portfolio of electric efficiency measures switches away from lighting which has relatively short lifetimes to HVAC which has longer lifetimes, the average lifetime of efficiency measures may rise.

DATA TABLES

ENERGY CONSUMPTION

NO EFFICIENCY PROGRAMS SCENARIO
PRIMARY ENERGY BY FUEL TYPE AND SECTOR

	Trillion BTU	2012	2017	2022	2027	2032	2037	2042	2047	2050
Electricity	**Residential**	131	133	146	154	165	173	181	189	193
	Commercial	138	149	169	183	204	219	239	259	271
	Total Buildings	*269*	*282*	*315*	*338*	*369*	*392*	*419*	*447*	*465*
	Industry	38	43	46	44	42	40	39	39	39
Natural Gas	**Residential**	52	50	50	49	48	46	45	44	43
	Commercial	45	46	47	49	50	52	53	55	56
	Total Buildings	*97*	*97*	*97*	*97*	*98*	*98*	*99*	*99*	*100*
	Industry	27	29	31	31	33	35	37	39	40
Oil	**Residential**	82	75	71	68	65	62	58	54	52
	Commercial	16	15	14	14	14	13	13	13	13
	Total Buildings	*98*	*90*	*85*	*82*	*79*	*75*	*71*	*67*	*65*
	Industry	3	4	4	4	4	4	4	4	4

BASE EFFICIENCY SCENARIO
PRIMARY ENERGY BY FUEL TYPE AND SECTOR

	Trillion BTU	2012	2017	2022	2027	2032	2037	2042	2047	2050
Electricity	**Residential**	131	128	137	141	148	152	156	160	163
	Commercial	138	143	158	168	182	193	206	220	229
	Total Buildings	*269*	*271*	*295*	*308*	*330*	*344*	*362*	*380*	*392*
	Industry	38	41	43	40	38	35	34	33	33

Natural Gas	**Residential**	52	49	48	46	45	43	41	39	38
	Commercial	44	46	46	47	47	48	49	50	51
	Total Buildings	*97*	*95*	*94*	*93*	*92*	*91*	*90*	*89*	*89*
	Industry	26	29	30	30	31	32	34	35	36
Oil	**Residential**	82	75	71	68	65	62	58	54	52
	Commercial	16	15	14	14	14	13	13	13	13
	Total Buildings	*98*	*90*	*85*	*82*	*79*	*75*	*71*	*67*	*65*
	Industry	3	4	4	4	4	4	4	4	4

EXPANDED EFFICIENCY SCENARIO										
PRIMARY ENERGY BY FUEL TYPE AND SECTOR										
	Trillion BTU	**2012**	**2017**	**2022**	**2027**	**2032**	**2037**	**2042**	**2047**	**2050**
Electricity	**Residential**	129	121	123	120	121	118	116	113	112
	Commercial	135	129	133	130	133	130	132	134	135
	Total Buildings	*264*	*250*	*256*	*250*	*254*	*248*	*247*	*247*	*248*
	Industry	38	38	37	31	25	20	18	16	14
Natural Gas	**Residential**	51	42	35	29	25	20	17	14	12
	Commercial	44	41	38	35	33	31	30	29	28
	Total Buildings	*95*	*83*	*72*	*65*	*58*	*52*	*47*	*42*	*40*
	Industry	26	28	28	26	26	27	27	28	28
Oil	**Residential**	81	70	62	55	50	44	38	33	30
	Commercial	15	12	10	9	7	6	5	4	4
	Total Buildings	*97*	*82*	*72*	*64*	*57*	*51*	*44*	*37*	*34*
	Industry	3	3	3	3	3	3	3	3	2

FUEL SWITCHING SCENARIO
PRIMARY ENERGY BY FUEL TYPE AND SECTOR

	Trillion BTU	2012	2017	2022	2027	2032	2037	2042	2047	2050
Electricity	**Residential**	129	121	123	120	121	118	116	113	112
	Commercial	135	129	133	130	133	130	132	134	135
	Total Buildings	*264*	*250*	*256*	*250*	*254*	*248*	*247*	*247*	*248*
	Industry	38	38	37	31	26	21	18	16	15
Natural Gas	**Residential**	51	50	50	43	36	31	26	22	19
	Commercial	44	45	45	42	40	37	35	33	32
	Total Buildings	*95*	*96*	*95*	*85*	*76*	*68*	*61*	*55*	*52*
	Industry	26	28	29	28	28	28	28	29	29
Oil	**Residential**	81	61	44	39	34	29	24	19	17
	Commercial	15	7	1	0	0	0	0	0	0
	Total Buildings	*97*	*68*	*45*	*39*	*34*	*29*	*24*	*19*	*17*
	Industry	3	2	1	1	1	0	0	0	0

ANNUAL COSTS AND BENEFITS

EXPANDED EFFICIENCY SCENARIO

TOTAL RESOURCE CAPITAL COST - EFFICIENCY

	Million $2012	2012	2017	2022	2027	2032	2037	2042	2047	2050
Electricity	**Residential**	$135	$137	$129	$134	$133	$132	$129	$126	$124
	Commercial	$212	$215	$202	$222	$223	$223	$224	$227	$229
	Total Buildings	*$347*	*$353*	*$331*	*$357*	*$355*	*$354*	*$353*	*$353*	*$353*
	Industry	$55	$56	$53	$46	$38	$30	$27	$23	$21
Natural Gas	**Residential**	$76	$76	$76	$45	$38	$31	$26	$21	$19
	Commercial	$51	$51	$51	$40	$38	$36	$34	$33	$32
	Total Buildings	*$127*	*$127*	*$127*	*$85*	*$76*	*$67*	*$60*	*$54*	*$51*
	Industry	$17	$17	$17	$17	$17	$17	$17	$17	$18
Oil	**Residential**	$77	$77	$77	$53	$48	$42	$37	$32	$29

	Commercial	$13	$13	$13	$7	$6	$5	$4	$4	$3
	Total Buildings	*$89*	*$89*	*$89*	*$60*	*$54*	*$48*	*$41*	*$35*	*$32*
	Industry	$0	$0	$0	$0	$0	$0	$0	$0	$0

FUEL SWITCHING SCENARIO

TOTAL RESOURCE CAPITAL COST - FUEL SWITCHING

	Million $2012	**2012**	**2017**	**2022**	**2027**	**2032**	**2037**	**2042**	**2047**	**2050**
Electricity	**Residential**	$-	$166	$157	$150	$143	$136	$128	$120	$116
	Commercial	$-	$-	$-	$-	$-	$-	$-	$-	$-
	Total Buildings	*$-*	*$166*	*$157*	*$150*	*$143*	*$136*	*$128*	*$120*	*$116*
	Industry	$-	$6	$6	$6	$5	$5	$6	$6	$6
Natural Gas	**Residential**	$-	$317	$300	$-	$-	$-	$-	$-	$-
	Commercial	$-	$194	$189	$-	$-	$-	$-	$-	$-
	Total Buildings	*$-*	*$510*	*$489*	*$-*	*$-*	*$-*	*$-*	*$-*	*$-*
	Industry	$-	$5	$5	$-	$-	$-	$-	$-	$-

PRESENT VALUE CUMULATIVE COSTS/BENEFITS

EXPANDED EFFICIENCY SCENARIO

2022 CUMULATIVE PRESENT VALUE COSTS/BENEFITS

	Million $2012	**Investment**	**Gross Savings**	**Net Savings**
Electricity	**Buildings**	$2,850	$6,346	$3,496
	Industry	$455	$695	$241
Natural Gas	**Buildings**	$1,057	$2,964	$1,907
	Industry	$139	$216	$77

Oil	**Buildings**	$741	$3,548	$2,806
	Industry	$2	$93	$91

FUEL SWITCHING SCENARIO 2022 CUMULATIVE PRESENT VALUE COSTS/BENEFITS				
	Million $2012	**Investment**	**Gross Savings**	**Net Savings**
Electricity	**Buildings**	$1,221	$1,598	$376
	Industry	$40	$55	$14
Natural Gas	**Buildings**	$3,767	$5,503	$1,736
	Industry	$36	$326	$289

EXPANDED EFFICIENCY SCENARIO 2050 CUMULATIVE PRESENT VALUE COSTS/BENEFITS				
	Million $2012	**Investment**	**Gross Savings**	**Net Savings**
Electricity	**Buildings**	$5,951	$23,612	$17,661
	Industry	$782	$2,359	$1,577
Natural Gas	**Buildings**	$1,707	$8,610	$6,903
	Industry	$286	$835	$549
Oil	**Buildings**	$1,196	$9,929	$8,734
	Industry	$5	$299	$294

FUEL SWITCHING SCENARIO 2050 CUMULATIVE PRESENT VALUE COSTS/BENEFITS				
	Million $2012	**Investment**	**Gross**	**Net Savings**

			Savings	
Electricity	**Buildings**	$2,448	$4,338	$1,890
	Industry	$88	$182	$93
Natural Gas	**Buildings**	$3,767	$7,374	$3,607
	Industry	$36	$445	$409