Achievable Cost-Effective Natural Gas Savings in the United States Due to Adoption of Aggressive Energy Efficiency Policies and Programs

June 22, 2006

Prepared and Submitted by:

GDS Associates, Inc.
Engineers and Consultants

Preface

The Natural Resources Defense Council (NRDC) retained GDS Associates, Inc., to prepare this report on the potential for saving natural gas in the United States over the next five decades. GDS is a multi-service engineering and management consulting firm, headquartered in Marietta Georgia, with offices in Auburn, Alabama; Austin, Texas; Manchester, New Hampshire; Madison, Wisconsin; and Manchester Maine. Since its inception in 1986, GDS has enjoyed considerable growth and now employs a staff of over 100. GDS consultants include nuclear, electrical, mechanical, civil and industrial engineers, as well as financial analysts, lawyers, accountants and certified energy managers.

GDS offers an array of engineering and management consulting services and specializes in energy, telecommunications, water and utility planning issues. The firm has completed numerous renewable energy, bio-energy, and energy efficiency research, design, implementation and evaluation projects for electric and natural gas utilities, commercial and organizations, nonprofit organizations, and government agencies. GDS has completed more than 20 research reports on the technical and economic potential for electric and natural gas energy efficiency programs for various regions of the United States.

GDS is a corporate sponsor of the American Council for an Energy Efficient Economy (ACEEE) Summer Study on Building Energy Efficiency and is a corporate sponsor of the Association of Energy Services Professionals (AESP).

Table of Contents

1.0 Executive Summary

This report presents estimates of the achievable potential for natural gas savings in the United States if aggressive policies and programs were implemented now to capture cost effective and untapped energy savings, which can save natural gas. Given the higher retail prices for natural gas and concerns about over reliance of the United States on fossil fuels, it is imperative that policymakers at the national and state levels examine additional energy efficiency programs and standards as a least cost way to meet the growing energy needs of U.S. consumers. This report concludes that the United States could save more than 234 trillion cubic feet (TCF) of natural gas over the next 50 years with aggressive and bold energy efficiency policies and programs.

This report examines the potential for future savings of natural gas from two sources; (1) direct savings from installation of high efficiency natural gas equipment in homes and businesses in the United States, such as natural gas furnaces that are 90 percent to 95 percent efficient, and (2) indirect savings from installation of high efficiency electrical equipment in homes and businesses (such as high efficiency compact fluorescent lighting and energy efficient home appliances) that will reduce the need for electricity generated from power plants fueled with natural gas. Section 5 of this report describes the high efficiency natural gas and electrical equipment that can deliver these large savings of natural gas.[1]

If aggressive policies and programs were implemented today to capture the cost effective savings potential for natural gas, GDS estimates that after 10 years of programs, consumers could save almost 2.8 TCF annually of natural gas. These savings can amount to over 14.5 TCF in the United States by the year 2015. In 2055, after 50 years of program implementation, consumers can save more than 234 TCF. Table 1-1 below summarizes the findings of this analysis for each decade. Potential annual savings of natural gas in the United States are provided in a more detailed chart in section 4.0.

Table 1-1: Summary of Potential Cumulative Natural Gas Savings from Adoption of New Efficiency Standards and Efficiency Measures by Decade
Prepared by NRDC with Technical Assistance from GDS Associates, Inc. - June 16, 2006

Decade	Cumulative Natural Gas Savings (mmbtu)	Cumulative Electric Savings with Losses (TWh)	Cumulative US Natural Gas Savings TCF
2006-2015	8,489,847,320.17	2,783.28	14.53
2016-2025	24,672,550,471.38	7,417.81	40.72
2026-2035	32,192,310,551.54	9,515.74	52.77
2036-2045	35,221,171,392.34	11,280.24	59.69
2046-2055	38,343,517,224.64	13,048.90	66.72
Total	138,919,396,960.07	44,045.96	234.44

The natural gas savings potential estimates presented in this report are very conservative. While GDS has included many of the most cost effective natural gas energy efficiency policies and programs in this analysis, GDS only included technologies that are commercially available. GDS has not included potential natural gas savings from emerging natural gas energy efficiency technologies or potential savings due to technological change. It is clear that over the 50 year horizon examined in this report, it is a certainty that new energy efficiency technologies will be invented and commercialized. Savings from such technological advancements are not reflected in this report. In addition, GDS has only reflected the energy savings from moving from the current baseline for energy efficient equipment available in the market to higher efficiency equipment. GDS has not counted the energy savings due to replacement of older, less efficient equipment (below the current baseline) up to the current baseline. If GDS had included potential savings due to technological change and due to replacements of old equipment below the current efficiency baseline, the potential savings estimates for natural gas over the next five decades would be much higher than the 234 TCF presented in this report.

The remainder of this report provides the following information:

- data on natural gas consumption trends in the United States
- results of other natural gas savings technical potential studies
- potential natural gas savings in the United States resulting from new energy efficiency programs and policies
- documentation of the underlying data for energy efficiency measures examined in this analysis
- conclusions

2.0. Natural Gas Consumption in the United States

Total consumption of natural gas in the United States was approximately 22 trillion cubic feet (TCF) in calendar year 2005. Figure 2-1 illustrates the trend in total natural gas consumption in the United States from 1990 to 2005.[2] As this figure shows, the mid-1990s are marked with a steady increase in natural gas consumption. After 1997, consumption of natural gas declines slightly before peaking in the year 2000. Consumption of natural gas declined in 2003, 2004 and 2005 from the level recorded in 2002.

Figure 2-2 provides a breakdown of total natural gas consumed in 2004 by sector (residential, commercial, industrial and other). As this figure shows, the industrial sector uses the most natural gas (32 percent of total consumption), followed by the residential sector (23 percent of the total), and the commercial sector (14 percent of the total). The “other” sector consumes 31 percent of the total natural gas sold in the United States.

Figure 2-1: Total Annual Natural Gas Consumption in the US - 1990 to 2005

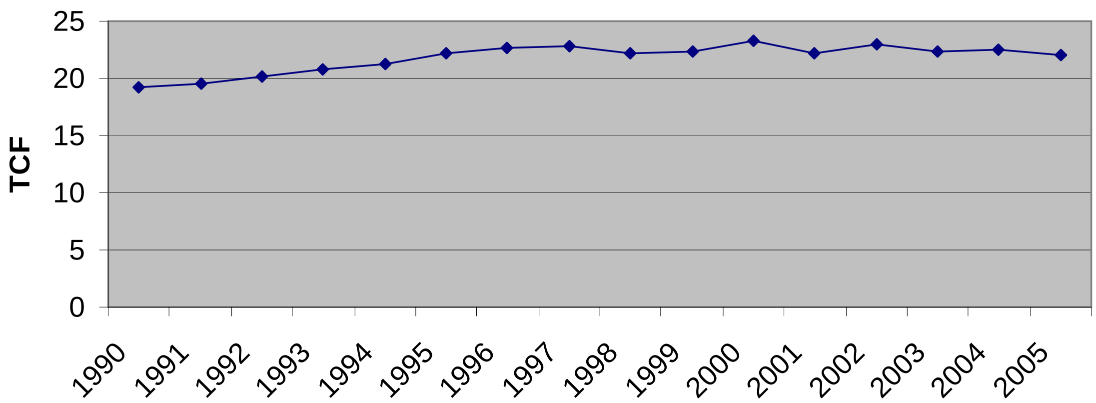
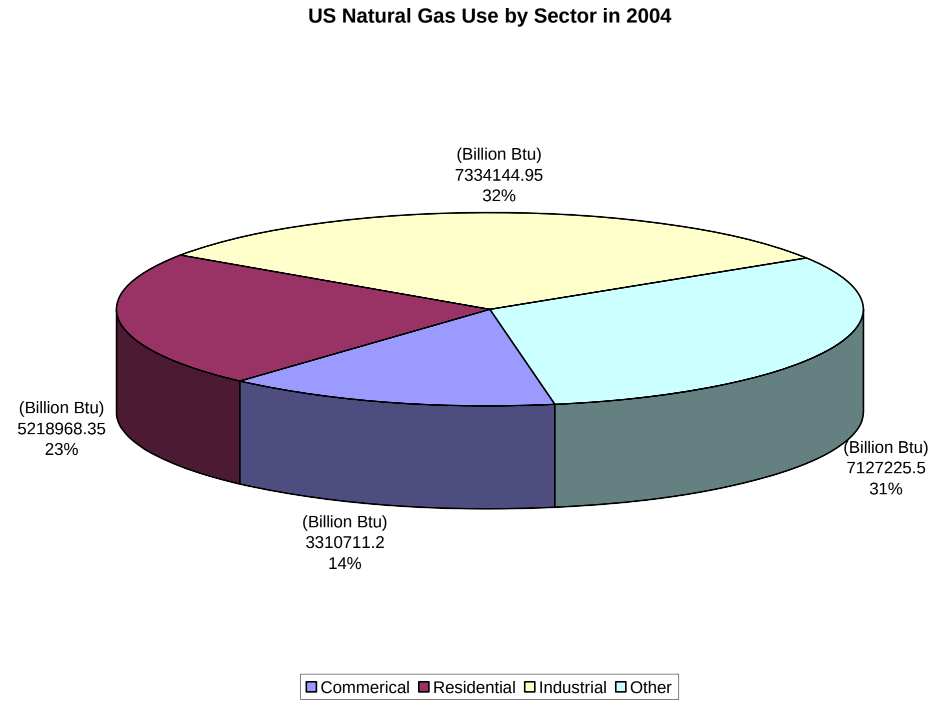


Figure 2-2



3.0 Results of Other Natural Gas Energy Savings Potential Studies

Several organizations have conducted studies to determine the potential for decreasing the total amount of natural gas that Americans use. Table 3-1 below shows the results of six such studies. In these studies, estimates of achievable savings potential range from 9 percent to 20 percent of total annual natural gas consumption in the United States. On average, these reports find that the United States could potentially decrease its annual natural gas consumption by almost 14 percent by the year 2020 through legislation, building and appliance efficiency standards, promotion of high efficiency equipment, and other methods.

Table 3-1[3]

National US Natural Gas Technical Potential Studies and Conclusions					
	Title of Study	Sponsoring Organization	Date of Publication	Potential Natural Gas Savings in the US	Estimated Achievement Year
1	The Technical, Economic and Achievable Potential for Energy-Efficiency in the U.S. –A Meta-Analysis of Recent Studies	ACEEE	2004	40% (T) 21% (E) 9%(A)	Over any 20 year period
2	America's Energy Straitjacket	ACEEE	Apr 2006	20% (A)	2020
3	Energy Efficiency Resource Standards: Experience and Recommendations	ACEEE	Feb 2006	10% (A)	2020
4	A Choice of Two Paths: Energy Savings from Pending Federal Energy Legislation	ACEEE	Apr 2005	12.6% (A)	2020
5	Reducing Pollutant Emissions through Greater Energy Efficiency	ACEEE	2001	20% (A)	2020
6	A Responsible Energy Plan for America	NRDC	Apr 2005	10% (A)	2015

4.0 Potential for Natural Gas Savings in the United States

Working with NRDC staff, GDS developed estimates of the potential for natural gas savings from a range of new energy efficiency programs, energy efficiency policies, and new efficiency standards for buildings and equipment. This detailed analysis is unique in that it considers natural gas savings due to installation of high efficiency natural gas equipment, and it also considers natural gas savings from implementation of electric energy efficiency programs and policies that will result in less need for electric generation that is fueled by natural gas.

To develop these estimates of natural gas savings, GDS used a detailed computer model developed by GDS to assess the cost effectiveness and energy savings potential of new energy efficiency programs and policies at the local, state or national levels of implementation. This GDS computer model can assess the cost effectiveness of energy efficiency, load management and demand response measures or programs. The GDS computer model is user-friendly, well-documented, has been accepted by regulatory agencies, and provides the following benefit/cost ratio calculations:

- Total Resource Cost Test
- Utility Cost Test
- Participant Test
- Rate Impact Measure Test
- Societal Test

The model is comprehensive and uses the following types of data as input:

- Costs, useful lives and energy savings of electric and natural gas energy efficiency, load management or demand response measures
- Load shape impacts of electric or natural gas energy efficiency measures
- Avoided costs of electricity for generation, transmission and distribution
- Avoided costs of natural gas and other fuels
- Avoided water costs for efficiency measures that also save water (such as high efficiency clothes washers)
- Projected or actual measure or program penetration assuming no program
- Projected or actual measure or program penetration with a program

- Participant costs
- Energy efficiency organization or utility costs (including rebates or financial incentives) relating to program implementation
- Non-energy benefits of measures or programs
- Electric line losses
- Discount rate
- Inflation rate

The model provides calculations of five benefit/cost ratios as well as year-by-year and cumulative energy savings (broken down by fuel type), dollar costs and dollar benefits. The model also calculates environmental benefits relating to reduced emissions of green house gases, and non-energy benefits such as water savings. The GDS computer model will allow NRDC staff the flexibility to vary assumptions in the analysis to reflect uncertainty, changing market circumstance, statutory change or other factors that influence assessment of reasonably available potential through the efficiency utility. The GDS model will also allow flexibility for NRDC staff to incorporate changes to reflect real world circumstances and a dynamic environment. The GDS tool exists in a single Microsoft Excel file, and includes several linked worksheets that present clearly documented inputs and outputs.

If aggressive policies and programs were implemented today to capture the cost effective savings potential for natural gas, GDS estimates that after only one year of programs, consumers could save more than 0.2 TCF of natural gas. In 10 years' time, those savings can increase to more than 2.7 TCF of natural gas savings annually by the end of 2015. A 50-year program of adopting new efficiency standards and programs can result in a total cumulative savings of over 234 TCF of natural gas over the next five decades. Table 4-1 below summarizes the annual findings of this analysis.

Table 4-1: Summary of Potential Annual Natural Gas Savings from Adoption of New Efficiency Standards and Efficiency Measures Prepared by NRDC with Technical Assistance from GDS Associates, Inc. - June 16, 2006			
Year	Cumulative Annual Natural Gas Savings (mmbtu)	Cumulative Annual Electric Savings with Losses (TWh)	Cumulative Annual US Natural Gas Savings TCF
2006	134,008,796.24	31.2298	0.2007
2007	286,124,612.85	81.8283	0.4628
2008	440,353,619.74	134.2047	0.7309
2009	596,938,510.89	188.3851	1.0054
2010	756,121,996.52	244.3957	1.2866
2011	918,146,754.94	302.2626	1.5747
2012	1,083,255,446.36	362.0119	1.8700
2013	1,251,690,726.69	422.6603	2.1707
2014	1,423,695,240.72	478.4687	2.4638
2015	1,599,511,615.23	537.8319	2.7687
2016	1,775,634,232.20	597.0047	3.0735
2017	1,951,503,252.29	655.6012	3.3767
2018	2,127,766,224.74	683.8331	3.6116
2019	2,273,733,305.37	709.9787	3.8124
2020	2,419,021,995.71	734.5056	4.0089
2021	2,563,634,250.10	760.4168	4.2079
2022	2,707,572,040.73	783.1685	4.3991
2023	2,850,837,295.69	807.4277	4.5930
2024	2,950,029,750.37	830.3387	4.7411
2025	3,052,818,124.19	855.5328	4.8979
2026	3,086,380,656.38	873.2696	4.9705
2027	3,115,916,657.28	889.4030	5.0357
2028	3,145,437,374.70	908.2227	5.1069
2029	3,174,946,957.42	926.2649	5.1763
2030	3,204,461,029.45	942.3212	5.2413
2031	3,233,979,510.03	959.9619	5.3098
2032	3,263,502,324.77	977.6047	5.3784
2033	3,293,029,396.05	995.2496	5.4469
2034	3,322,560,646.49	1,012.8966	5.5155
2035	3,352,095,998.97	1,030.5456	5.5840
2036	3,382,192,471.60	1,048.1966	5.6532
2037	3,412,698,052.74	1,067.3199	5.7260
2038	3,443,227,763.99	1,083.3751	5.7919
2039	3,473,925,032.93	1,101.0477	5.8617
2040	3,504,666,537.88	1,118.7223	5.9315
2041	3,535,452,203.18	1,136.3990	6.0013
2042	3,566,071,527.36	1,154.0628	6.0710
2043	3,600,740,310.36	1,172.0116	6.1452
2044	3,635,640,685.87	1,189.9756	6.2197
2045	3,666,556,806.42	1,209.1273	6.2930
2046	3,697,432,928.25	1,225.2012	6.3593
2047	3,727,796,121.95	1,242.8776	6.4288
2048	3,758,183,148.91	1,260.5560	6.4982
2049	3,788,593,933.78	1,278.2363	6.5677
2050	3,819,028,401.44	1,295.9187	6.6373
2051	3,849,486,476.98	1,313.6031	6.7068
2052	3,879,968,085.76	1,331.2895	6.7764
2053	3,910,473,153.37	1,350.4480	6.8493
2054	3,941,001,605.62	1,366.5383	6.9153
2055	3,971,553,368.57	1,384.2310	6.9850
Total	138,919,396,960.07	44,045.96	234.44

5.0 Energy Efficiency Programs Considered in This Analysis of Potential Natural Gas Savings

GDS considered the following energy efficiency programs in this analysis:

- High efficiency ENERGY STAR® Homes
- Retrofitting of existing commercial buildings with high efficiency equipment
- High efficiency water heating systems
- High efficiency HVAC systems and heat pumps
- High efficiency natural gas furnaces
- Solar water heating systems
- High efficiency residential lighting
- ENERGY STAR® clothes washers
- ENERGY STAR® refrigerators
- ENERGY STAR® diswashers
- Retrofits of existing homes

Table 5-2 on the next page summarizes the costs, useful lives and energy savings assumptions for the energy efficiency measures considered in this analysis. Table 5-3 on the following page shows the average number of program participants in each decade of the program. It is important to note that participation for the commercial sector is shown in units of square footage, not numbers of commercial buildings. Table 5-4 provides the sources for these assumptions.

Table 5-2: BASIS FOR ENERGY SAVINGS AND COSTS FOR MEASURES

	Measure	kWh Savings	mmbtu Savings	Per	Useful Life	Incremental Cost	% Already Energy Efficient
1	New Homes (30% Savings)	699.00	16.98	Home	18	$ 1,000.00	0.00%
2	New Homes w/ Electric Heat (30% Savings)	1663.50	-	Home	18	$ 1,000.00	0.00%
3	New Homes (50% Savings)	1165.00	28.30	Home	18	$ 5,100.00	0.00%
4	New Homes with Electric Heat (50% Savings)	2772.50	-	Home	18	$ 5,100.00	0.00%
5	Existing Homes	859.60	13.52	Home	20	$ 1,000.00	0.00%
6	Commercial Buildings - New	8.00	-	Sq. Foot	12	$ 3.00	0.00%
7	Commercial Buildings - Existing	4.00	-	Sq. Foot	12	$ 1.00	0.00%
8	Air Conditioning	396.16	-	A/C	14	$ 750.00	0.00%
9	Water Heating (Electric)	362.00	-	Water Heater	13	$ 90.00	0.00%
10	Water Heating (Gas)	-	6.88	Water Heater	13	$ 250.00	0.00%
11	Solar Energy Systems (Electric)	1665.00	-	Solar Heat System	20	$ 5,000.00	0.00%
12	Solar Energy Systems (Natural Gas)	-	11.48	Solar Heat System	20	$5,000.00	0.00%
13	Compact Fluor. Lighting	489.00	-	home	7.6	$ 5.00	10.00%
14	Clothes Washers (Electric) Tier 1	102.00	-	Washer/ Dryer	11	$ 51.00	10.55%
15	Clothes Washers (Electric) Tier 2	192.00	-	Washer/ Dryer	11	$ 58.00	
16	Clothes Washers (Gas) Tier 1	74.50	0.12	Washer/ Dryer	11	$ 51.00	10.55%
17	Clothes Washers (Gas) Tier 2	141.20	0.18	Washer/ Dryer	11	$ 58.00	
18	Energy Star Refrigerators (Tier 1)	85.65	-	Refrigerator	13	$ 30.00	19.19%
19	Energy Star Refrigerators (Tier 2)	114.20	-	Refrigerator	13	$ 500.00	
20	Dishwashers (Tier 1)	58.00	-	Dishwasher	10	$ 50.00	0.00%
21	Dishwashers (Tier 2)	88.00	-	Dishwasher	10	$ -	
22	Heat Pump	464.32	-	Heat Pump	18	$ 1,000.00	0.00%
23	Natural Gas Furnaces (Tier 1)	-	7.30	Gas Furnace	18	$ 373.00	0.00%
24	Natural Gas Furnaces (Tier 2)	600.00	29.80	Gas Furnace	18	$ 1,800.00	0.00%

	Table 5-3: AVERAGE PROJECTED NUMBER OF PROGRAM PARTICIPANTS					
	Measure	2006-2015	2016-2025	2026-2035	2036-2045	2046-2055
1	New Homes (30% Savings)	307,125	53,550	313,425	82,950	254,100
2	New Homes w/ Electric Heat (30% Savings)	131,625	22,950	134,325	35,550	108,900
3	New Homes (50% Savings)	392,875	1,304,450	1,954,575	2,689,050	3,525,900
4	New Homes with Electric Heat (50% Savings)	168,375	559,050	837,675	1,152,450	1,511,100
5	Existing Homes	5,175,495	5,064,337	4,874,311	4,659,070	4,561,147
6	Commercial Buildings - New	1,764,337,790	2,957,837,790	4,197,837,790	5,437,837,790	6,677,837,790
7	Commercial Buildings - Existing	4,645,586,756	4,645,586,756	4,645,586,756	4,645,586,756	4,645,586,756
8	Air Conditioning	3,553,177	3,430,025	3,309,564	3,317,549	3,141,148
9	Water Heating (Electric)	2,715,443	2,627,084	2,540,973	2,439,475	2,494,591
10	Water Heating (Gas)	3,862,915	3,737,217	3,614,717	3,495,313	3,548,735
11	Solar Energy Systems (Electric)	139,792	41,937	131,639	29,253	126,574
12	Solar Energy Systems (Gas)	198,864	59,659	187,266	41,615	180,060
13	Heat Pumps	1,112,731	1,058,594	1,047,977	1,000,519	980,647
14	Natural Gas Furnaces (Tier 1)	1,822,477	1,733,809	1,716,419	1,640,625	1,606,143
15	Natural Gas Furnaces (Tier 2)	1,034,397	984,071	974,201	930,084	911,611
	Existing Homes Measures					
16	Compact Fluor. Lighting	10,023,465	10,412,747	10,095,074	9,700,323	8,830,129
17	Clothes Washers (Electric) Tier 1	873,843	30,861	0	0	0
18	Clothes Washers (Electric) Tier 2	714,250	1,509,587	1,494,194	1,440,515	1,405,700
19	Clothes Washers (Gas) Tier 1	2,038,966	72,009	0	0	0
20	Clothes Washers (Gas) Tier 2	1,666,584	3,522,369	3,486,453	3,361,203	3,279,966
21	Energy Star Refrigerators (Tier 1)	3,161,019	128,208	0	0	0
22	Energy Star Refrigerators (Tier 2)	2,540,835	5,388,111	5,335,503	5,122,380	5,238,110
23	Dishwashers (Tier 1)	2,024,708	57,296	0	0	0
24	Dishwashers (Tier 2)	1,669,062	3,527,145	3,478,348	3,564,363	3,275,489
	New Homes Measures					
25	Compact Fluor. Lighting	1,040,000	3,400,000	5,760,000	8,120,000	10,520,000
26	Clothes Washers (Electric) Tier 1	131,625	13,050	0	0	0
27	Clothes Washers (Electric) Tier 2	168,375	799,950	1,332,000	1,851,000	2,370,000
28	Clothes Washers (Gas) Tier 1	307,125	30,450	0	0	0
29	Clothes Washers (Gas) Tier 2	392,875	1,866,550	3,108,000	4,319,000	5,530,000
30	Energy Star Refrigerators (Tier 1)	438,750	42,750	0	0	0
31	Energy Star Refrigerators (Tier 2)	561,250	2,347,250	3,900,000	5,410,000	6,880,000
32	Dishwashers (Tier 1)	438,750	46,500	0	0	0
33	Dishwashers (Tier 2)	561,250	2,853,500	4,800,000	6,700,000	8,600,000

Table 5-4: SOURCES FOR ASSUMPTIONS

Measure	kWh Savings	mmbtu Savings	Useful Life	Incremental Cost	% Already Energy Efficient
New Homes (30% Savings)	Florida Solar Energy Center. Annual usage figures originally calculated by Philip Fairey.	Florida Solar Energy Center. Annual usage figures originally calculated by Philip Fairey.	Efficiency Vermont (EVT) 2004 Annual Report. Nov. 2005. pg 49	NRDC 'Snowe Feinstein2006 v1.1.xls' spreadsheet, Table A	Phone call with David Goldstein of NRDC, June 2006
New Homes w/ Electric Heat (30% Savings)	Florida Solar Energy Center. Annual usage figures originally calculated by Philip Fairey.	-	Efficiency Vermont (EVT) 2004 Annual Report. Nov. 2005. pg 49	NRDC 'Snowe Feinstein2006 v1.1.xls' spreadsheet, Table A	Phone call with David Goldstein of NRDC, June 2006
New Homes (50% Savings)	Florida Solar Energy Center. Annual usage figures originally calculated by Philip Fairey.	Florida Solar Energy Center. Annual usage figures originally calculated by Philip Fairey.	Efficiency Vermont (EVT) 2004 Annual Report. Nov. 2005. pg 49	NRDC 'Snowe Feinstein2006 v1.1.xls' spreadsheet, Table A	Phone call with David Goldstein of NRDC, June 2006
New Homes with Electric Heat (50% Savings)	Florida Solar Energy Center. Annual usage figures originally calculated by Philip Fairey.	-	Efficiency Vermont (EVT) 2004 Annual Report. Nov. 2005. pg 49	NRDC 'Snowe Feinstein2006 v1.1.xls' spreadsheet, Table A	Phone call with David Goldstein of NRDC, June 2006
Existing Homes	Florida Solar Energy Center. Annual usage figures originally calculated by Philip Fairey.	Florida Solar Energy Center. Annual usage figures originally calculated by Philip Fairey.	Vermont Electric Energy Efficiency Potential Study. GDS Associates. May 2006. Table A-1.	NRDC 'Snowe Feinstein2006 v1.1.xls' spreadsheet, Table A	Phone call with David Goldstein of NRDC, June 2006
Commercial Buildings - New	NRDC 'Snowe Feinstein2006 v1.1.xls' spreadsheet, Table A	-	Vermont Electric Energy Efficiency Potential Study. GDS Associates. May 2006.	NRDC 'Snowe Feinstein2006 v1.1.xls' spreadsheet, Table A	Phone call with David Goldstein of NRDC, June 2006
Commercial Buildings - Existing	NRDC 'Snowe Feinstein2006 v1.1.xls' spreadsheet, Table A	-	Vermont Electric Energy Efficiency Potential Study. GDS Associates. May 2006.	NRDC 'Snowe Feinstein2006 v1.1.xls' spreadsheet, Table A	Phone call with David Goldstein of NRDC, June 2006
Air Conditioning	Florida Solar Energy Center. Annual usage figures originally calculated by Philip Fairey.	-	Savings Calculator-Central Air Conditioners (.xls), found on the EnergyStar website (www.energystar.gov)	NRDC 'Snowe Feinstein2006 v1.1.xls' spreadsheet, Table A	Phone call with David Goldstein of NRDC, June 2006
Water Heating (Electric)	Table 6-6 in "Consumer Guide to Home Energy Savings" 8th ed. ACEEE. 2003. Page 110.	-	Table 6-6 in "Consumer Guide to Home Energy Savings" 8th ed. ACEEE. 2003. Page 110.	Table 6-6 in "Consumer Guide to Home Energy Savings" 8th ed. ACEEE. 2003. Page 110.	Phone call with David Goldstein of NRDC, June 2006
Water Heating (Gas)	-	GasFacts: A Statistical Record of the Gas Industry with 2004 Data. AGA. Pg. 77.	Table 6-6 in "Consumer Guide to Home Energy Savings" 8th ed. ACEEE. 2003. Page 110.	NRDC 'Snowe Feinstein2006 v1.1.xls' spreadsheet, Table A	Phone call with David Goldstein of NRDC, June 2006

Measure	kWh Savings	mmbtu Savings	Useful Life	Incremental Cost	% Already Energy Efficient
Solar Energy Systems (Electric)	Independent Assessment of Conservation and Energy Efficiency Potential for Connecticut and the Southwest Connecticut Region. GDS. June 2004. App. B.	-	Table 6-6 in "Consumer Guide to Home Energy Savings" 8th ed. ACEEE. 2003.	NRDC 'Snowe Feinstein2006 v1.1.xls' spreadsheet, Table A	Phone call with David Goldstein of NRDC, June 2006
Solar Energy Systems (Gas)	-	GasFacts: A Statistical Record of the Gas Industry with 2004 Data. AGA. Pg. 77.	Table 6-6 in "Consumer Guide to Home Energy Savings" 8th ed. ACEEE. 2003.	NRDC 'Snowe Feinstein2006 v1.1.xls' spreadsheet, Table A	Phone call with David Goldstein of NRDC, June 2006
Compact Fluor. Lighting	Impact Evaluation of the Massachusetts, Rhode Island, & Vermont 2003 Residential Lightings Programs. Nexus Market Research (NMR). Oct. 2004.	-	Impact Evaluation of the Massachusetts, Rhode Island, & Vermont 2003 Residential Lightings Programs. Nexus Market Research (NMR). Oct. 2004.	GDS Calculation	GDS Assumption
Clothes Washers (Electric) Tier 1	Table 5 in "Residential Clothes Washer Initiative Program Description" Revised. CEE. 2002.	-	Savings Calculator-Clothes Washers (.xls), found on the EnergyStar website (www.energystar.gov)	Table 14 in "Residential Clothes Washer Initiative Program Description" Revised. CEE. 2002.	Email with Bill McNary of D&R International. March 2006.
Clothes Washers (Electric) Tier 2	Table 5 in "Residential Clothes Washer Initiative Program Description" Revised. CEE. 2002.	-	Savings Calculator-Clothes Washers (.xls), found on the EnergyStar website (www.energystar.gov)	Table 14 in "Residential Clothes Washer Initiative Program Description" Revised. CEE. 2002.	Email with Bill McNary of D&R International. March 2006.
Clothes Washers (Gas) Tier 1	Table 7 in "Residential Clothes Washer Initiative Program Description" Revised. CEE. 2002.	Table 7 in "Residential Clothes Washer Initiative Program Description" Revised. CEE. 2002.	Savings Calculator-Clothes Washers (.xls), found on the EnergyStar website (www.energystar.gov)	Table 14 in "Residential Clothes Washer Initiative Program Description" Revised. CEE. 2002.	Email with Bill McNary of D&R International. March 2006.
Clothes Washers (Gas) Tier 2	Table 7 in "Residential Clothes Washer Initiative Program Description" Revised. CEE. 2002.	Table 7 in "Residential Clothes Washer Initiative Program Description" Revised. CEE. 2002.	Savings Calculator-Clothes Washers (.xls), found on the EnergyStar website (www.energystar.gov)	Table 14 in "Residential Clothes Washer Initiative Program Description" Revised. CEE. 2002.	Email with Bill McNary of D&R International. March 2006.

Measure	kWh Savings	mmbtu Savings	Useful Life	Incremental Cost	% Already Energy Efficient
Energy Star Refrigerators (Tier 1)	Savings Calculator-Residential Refrigerators (.xls), found on the EnergyStar website (www.energystar.gov)	-	Savings Calculator-Residential Refrigerators (.xls), found on the EnergyStar website (www.energystar.gov)	Savings Calculator-Residential Refrigerators (.xls), found on the EnergyStar website (www.energystar.gov)	Email with Bill McNary of D&R International. March 2006.
Energy Star Refrigerators (Tier 2)	Savings Calculator-Residential Refrigerators (.xls), found on the EnergyStar website (www.energystar.gov)	-	Savings Calculator-Residential Refrigerators (.xls), found on the EnergyStar website (www.energystar.gov)	Email with Erica Scroeder of CEE, June 2006	Email with Bill McNary of D&R International. March 2006.
Dishwashers (Tier 1)	Savings Calculator-Dishwashers (.xls), found on the EnergyStar website (www.energystar.gov)	-	Savings Calculator-Dishwashers (.xls), found on the EnergyStar website (www.energystar.gov)	Savings Calculator-Dishwashers (.xls), found on the EnergyStar website (www.energystar.gov)	Phone call with David Goldstein of NRDC, June 2006
Dishwashers (Tier 2)	Savings Calculator-Dishwashers (.xls), found on the EnergyStar website (www.energystar.gov)	-	Savings Calculator-Dishwashers (.xls), found on the EnergyStar website (www.energystar.gov)	GDS Estimate	Phone call with David Goldstein of NRDC, June 2006
Heat Pump	Florida Solar Energy Center. Annual usage figures originally calculated by Philip Fairey.	-	GDS Assumption	NRDC 'Snowe Feinstein2006 v1.1.xls' spreadsheet, Table A	Phone call with David Goldstein of NRDC, June 2006
Natural Gas Furnaces (Tier 1)	-	Nadel, S. et al. Leading the Way: Continued Opportunities for New State Appliance & Equipment Efficiency Standards. ACEEE. March 2006. Pg. 56.	Nadel, S. et al. Leading the Way: Continued Opportunities for New State Appliance & Equipment Efficiency Standards. ACEEE. March 2006. Pg. 56.	Nadel, S. et al. Leading the Way: Continued Opportunities for New State Appliance & Equipment Efficiency Standards. ACEEE. March 2006. Pg. 56.	Phone call with David Goldstein of NRDC, June 2006
Natural Gas Furnaces (Tier 2)	KeySpan Energy Delivery, Massachusetts Regulatory Filing, March 2006.	Savings Calculator-Furnaces (.xls), found on the EnergyStar website (www.energystar.gov)	Nadel, S. et al. Leading the Way: Continued Opportunities for New State Appliance & Equipment Efficiency Standards. ACEEE. March 2006. Pg. 56.	Savings Calculator-Furnaces (.xls), from www.energystar.gov AND KeySpan Energy Delivery, Massachusetts Regulatory Filing, March 2006.	Phone call with David Goldstein of NRDC, June 2006

The remainder of this section describes these efficiency measures in more detail.

5.1 Residential New Construction and ENERGY STAR® Homes

ENERGY STAR® qualified new homes are ones that have been independently verified to be at least 30 percent more energy efficient than homes built to the 1993 national Model Energy Code or 15 percent more efficient than state energy code, whichever is more rigorous. Recently newer standards and a new Home Energy Rating System (HERS) have come into effect. These new guidelines and new HERS rating system must be used to qualify homes for the ENERGY STAR® label that are not enrolled in a state or utility program before December 31, 2005, or permitted before July 1, 2006.

The new system evaluates the energy efficiency of a home compared to a computer-simulated reference house of identical size and shape as the rated home that meets minimum requirements of the 2004 International Energy Conservation Code (IECC). The HERS rating results in a HERS Index score between 0 and 100, with the reference house assigned a score of 100 and a zero energy house assigned a score of 0. Each 1 percent reduction in energy usage (compared to the reference house) results in a one point decrease in the HERS score. Thus, an ENERGY STAR® Qualified Home, required to be approximately 15 percent more energy efficient than 2004 IECC in the south requires a HERS Index of 85; and an ENERGY STAR® Qualified Home, required to be approximately 20 percent more energy efficient than 2004 IECC in the north requires a HERS Index of 80.[4]

Savings are based on heating, cooling, and hot water energy use and typically achieved through a combination of: high performance windows, controlled air infiltration, upgraded heating and conditioning systems, tight duct systems, high efficiency water-heating equipment, and high efficiency building envelope standards. These features contribute to improved home quality and homeowner comfort, and to lower energy demand and reduced air pollution. ENERGY STAR® also encourages the use of energy-efficient lighting and appliances, as well as features designed to improve indoor air quality.

Any single-family or multi-family residential home that is three stories or less in height can qualify to receive the ENERGY STAR® label. This includes traditional site-constructed homes as well as modular, systems-built (e.g., insulated concrete forms, structurally insulated panels), and HUD-code manufactured homes.

Market Barriers

One notable market barrier to the Energy Star® new homes program is that some builders and customers remain confused or unaware regarding program benefits and procedures. Targeted mail and phone call campaigns to municipal officials and builders are some of the efforts that are underway to educate and increase interest in the ENERGY STAR® homes program. Increasing builder awareness of non-energy benefits of energy efficient equipment (including increased comfort and lower equipment maintenance costs) is also important to the success of the program.

ENERGY STAR® Homes - Measure Data

Description – For this analysis, homes that meet Energy Star® standards will use approximately 30 percent less energy for heating and cooling than homes not built to ENERGY STAR® standards. Homes must contain high levels of insulation, efficient heating and hot water equipment, and high quality air sealing measures to meet this rating. Also included in this analysis are new homes meeting increased standards above and beyond typical ENERGY STAR® ratings. These new homes would use approximately 50 percent less energy for heating and cooling than homes not built to ENERGY STAR® standards.

Measure savings – An ENERGY STAR® qualified home saves an average of 30 percent of household energy use per year, according to the ENERGY STAR® Homes web site. In this instance, homes would save 699 kWh and 16.98 mmbtus annually. Homes with electric heat would save 1663.50 kWh per year.[5] Homes meeting additional ENERGY STAR® standards, and using approximately 50 percent less energy than non-qualified homes, would save 1165 kWh and 28.30 mmbtus annually. Homes with electric heating would save 2772.50 per year.[6]

Measure incremental cost – The incremental cost of building a new home to meet the ENERGY STAR® Homes criteria and save approximately 30 percent of annual energy use is approximately $1,000.[7] The incremental cost to build a new home to use approximately 50 percent less energy is $5,100.[8]

Measure useful life – The useful life of an ENERGY STAR® qualified home is 18 years.[9]

5.2 Residential Existing Construction

While new homes can be built with energy efficiency and ENERGY STAR® recommendations in mind, in older existing homes it is usually more difficult to improve energy use. Remodeling is typically just as expensive as it is inconvenient, and many older appliances still operate without the need for replacement by more efficient models.

Despite these drawbacks, improving energy efficiency in existing residential construction can and does happen. Through programs such as the Weatherization Assistance Program and ENERGY STAR's® Home Performance, homeowners can assess their energy usage and find assistance with methods to reduce energy use in their home. Typical methods include appliance replacement, air sealing, HVAC sizing, attic venting, and window improvement.

In this model, savings are based on heating, cooling, and hot water energy use and realized through non-appliance methods such as adding insulation. Although the results of improvement on existing homes tend to be less dramatic than those found in new construction, homeowners can still potentially save significant amounts of energy. Reduced energy use translates to a higher level of comfort for the consumer, both in improved home quality and lower energy bills.

Market Barriers

One notable barrier to improving the energy efficiency of existing homes is the lack of resources and information that homeowners face. In order to complete a significant improvement on a home, a consumer must locate and hire a contractor, as well as live with the inconvenience of the construction itself. Add to this a lack of awareness and a resistance to change, and it shows that existing homes can be a difficult measure to improve upon.

Existing Homes- Measure Data

Description – There may be no specific ENERGY STAR® recognition for improved existing homes, but programs do exist to assist current homeowners in reducing their home's energy usage. By adding insulation and reducing air leaks in the building's shell, the cooling/heating load is reduced. Likewise, sealing the air ducts used by the central air conditioner can greatly boost the efficiency of the entire system.

Measure savings – By completing the methods suggested in the model, it is possible to reduce a home's energy use by 30 percent. This improvement would result in an average 859.6 kWh decrease per year. Homes would also experience an approximate 13.52 mmbtu decrease per year in natural gas use.[10]

Measure incremental cost – The incremental cost of improving an existing home to save approximately 30 percent of annual energy use is approximately $1,000.[11]

Measure useful life – The useful life of an existing residential building is 20 years.[12]

5.3 Commercial Construction

Commercial buildings have the potential to save a lot of energy because they are typically large and affect many people. Many of the same retrofit measures used in residential areas are also available in the commercial sector. However, these measures may be applied differently and with different results.

Market Barriers

Market barriers to improving commercial construction include the high cost and inconvenience of renovation and other measures. The majority of businesses operate for a profit, and office downtime combined with a high initial investment can deter many companies from initiating a change. One solution to this problem is increased program promotion and awareness of benefits.

Commercial Buildings- Measure Data

Description – Because the size and capacity of commercial buildings varies greatly, this model breaks down the savings and cost into per-square-foot increments. A larger building would typically require a larger renovation and consequential higher costs, but, on average, it reaps greater benefits as well.

Measure savings – By applying strict energy efficiency standards to new construction in the commercial sector, businesses can reduce electricity use by about 8.0 kWh per square foot each year.[13] Existing commercial buildings can be renovated to save about 4.0 kWh per square foot each year.[14]

Measure incremental cost – The incremental cost of improving an existing commercial building is approximately $1.00 per square foot. New buildings have a slightly higher initial investment to coordinate with higher potential savings. It costs about $3.00 per square foot to improve energy efficiency in new construction.[15]

Measure useful life – The estimated useful life of a commercial building is 12 years.[16]

5.4 High Efficiency Central Air Conditioners

About one-sixth of all the electricity generated in the United States is used to air condition buildings. Central air conditioners are more efficient than room air conditioners. In addition, they are out of the way, quiet, and convenient to operate. Today's best air conditioners use 30 percent to 50 percent less energy to produce the same amount of cooling as air conditioners made in the mid 1970s. Even if an air conditioner is only 10 years old, one may save 20 percent to 40 percent of cooling energy costs by replacing it with a newer, more efficient model.

The installation of oversized air conditioning units in an effort to avoid problems involving inadequate cooling capacity is common. Oversized units have also been utilized as a method of compensating for potential distribution problems such as uninsulated or leaky ductwork. However, these oversized units also create increased costs and reduced efficiency levels.

A central A/C unit that is too big will cycle on and off much more often spending a greater proportion of time running in an inefficient start-up mode. This results in "blasts" of cold air, reducing efficiency, and increasing stress on components. In addition, moisture removal and interior air mixing are also reduced during short run times.[17] Consequently, oversized air conditioning units can do poor job of lowering the humidity, which is also an important component to comfort. Often, a slightly undersized air conditioner is just as comfortable, if not more, than an oversized air conditioner.

Central air conditioners are rated according to their seasonal energy efficiency ratio (SEER). SEER indicates the relative amount of energy needed to provide a specific cooling output. Many older systems have SEER ratings of 6 or less. New residential central air conditioner standards went into effect in January 2006. Air conditioners manufactured after January 2006 must achieve a Seasonal Energy Efficiency Ratio (SEER) of 13 or higher. SEER 13 is 30 percent more efficient than the current minimum SEER of 10. The standard applies only to appliances manufactured after January 23, 2006. Equipment with a rating less than SEER 13 manufactured before this date may still be sold and installed.

Market Barriers

Among the market barriers in this market are lack of consumer awareness of high efficiency equipment, a high incremental cost and lack of information about this equipment. In addition, lengthy useful life, and high initial product costs largely prevent retrofitting before replacement is necessary.

High Efficiency HVAC - Measure Data

Description – Central air conditioners circulate cool air through a system of supply and return ducts. Supply ducts and registers (i.e., openings in the walls, floors, or ceilings covered by grills) carry cooled air from the air conditioner to the home. This cooled air becomes warmer as it circulates through the home; then it flows back to the central air conditioner through return ducts and registers. This analysis assumed increased efficiency standards would provide 17 percent energy savings annually over current standard equipment

Measure savings – A high efficiency A/C unit would save an average of 396.16 kWh per year.[18]

Measure incremental cost – The comparison between a high efficiency central air conditioning unit and a conventional unit yields about a $750 incremental cost.[19]

Measure useful life – The useful life of a central A/C is 14 years.[20]

5.5 High Efficiency Water Heaters and Solar Water Heaters

The average standard efficiency stand alone electric water heater sold today has an energy factor (EF) of approximately 0.87. Higher efficiency models are available with thicker insulation (up to 3 inches thick) and with heat traps, which limit heat losses through inlet and outlet pipes. These models most commonly have an EF of 0.93. Natural gas water heaters also are sold in higher efficiency models with an EF of approximately .65 compared to less efficient models with an EF around .57. These efficiency values particularly apply to the 50- to 55-gallon size class, which represents a majority of all electric water heater sales. Energy savings with high efficiency water tanks are essentially all in reduced standby losses.

In addition to the traditional stand alone storage tank water heaters, heat pump water heaters are also commercially available. Heat pumps, commonly used for space heating purposes, can also apply the principle of transferring heat from surrounding air and deliver it to water. Some models come as a complete package including tank and back-up resistance heating elements while others work as an accessory to a conventional water heater.

As this unit extracts heat from the surrounding air (indoor, exhaust, or outdoor air), a heat pump water heater delivers about twice the heat for the same electricity costs as a conventional stand alone water heater.[21] In addition, the transfer of heat from neighboring air also serves to cool and dehumidify a space, creating additional benefits during the cooling season, but drawbacks during the heating season. In recent years, the market for heat pump water heating systems has been stagnant due to competition with gas waters heaters enjoying favorable gas prices and the failure of electric rates to rise as fast as initially projected in many areas.[22]

While most water heater systems are stand-alone systems, they can also be integrated with the boiler used to heat the home. There are two styles of integrated systems; Tankless Coil and Indirect. Tankless Coil systems heat water as it is needed just as a demand system, the only difference being that the boiler is used to heat the water. Indirect systems also heat water in the boiler, but the water is then stored in a tank. The advantage of a tankless coil system is the avoided cost of purchasing a separate water heating system. The disadvantage is that during the non-heating season water heating is inefficient since the heating system must operate solely for heating water.

Indirect systems have the added cost of a tank, but since the hot water is stored in an insulated tank, the boiler or furnace does not have to turn on and off as frequently, improving its fuel economy. This increased efficiency generally offsets the cost of a tank. According to ACEEE, when used in combination with new, high efficiency boilers or furnaces, indirect water heaters are generally the least expensive way to provide hot water.[23] Gas, oil, and propane-fired systems are available.

Although ENERGY STAR does not include water heaters in their label program, utilities in the Northwest, for example, have been promoting high efficiency electric water heaters for many years. The typical program pays incentives of $25 to $60 for water heaters with an EF of 0.93 or more. Participation rates of 40 percent to 60 percent of water heater sales have been achieved.

In lieu of replacing a water heater with a more efficient model, there are several alternative measures that can be used to help in the conservation of water and energy loss within the residential sector. The installation of water heater blankets, pipe wrap, low flow shower heads, and faucet aerators are all energy efficient measures that will save energy and money on an existing water heating system. Other techniques for increasing water heater efficiency is the addition of a solar water heating system as well as fuel-switching, or eliminating electric water heating systems for more efficient non-electric systems.

Market Barriers

Among the market barriers in this market are lack of consumer awareness of high efficiency equipment, a long measure useful life, and lack of information about this equipment and the efficiency options.

High Efficiency Water Heaters - Measure Data

Description – Ranging in size from 20 to 80 gallons (75.7 to 302.8 liters), storage water heaters remain the most popular type for residential heating needs in the United States. A storage heater operates by releasing hot water from the top of the tank when the hot water tap is turned on. To replace that hot water, cold water enters the bottom of the tank, ensuring that the tank is always full.[24] This analysis compares the savings realized from increasing the baseline standard efficiency factor of electric and gas storage water heaters to a higher efficiency model.

Measure savings – Energy savings are approximately 362 kWh annually per high efficiency electric water heater installed and 6.88 mmbtus annually for natural gas water heating systems.[25,26]

Measure incremental cost – The incremental cost to consumers of high efficiency electric water heaters is $90.[27] The incremental cost to consumers of high efficiency natural gas water heaters is $250.[28]

Measure useful life – The useful life of an electric water heater is 13 years.[29]

Solar Water Heaters - Measure Data

Description – Solar water heaters are designed to serve as pre-heaters for conventional storage or demand water heaters. As the solar system preheats the water, the extra temperature boost required by the storage or demand water heater is relatively low, and high flow rate can be achieved. Although less common than they were two to three decades ago, solar water heating units are considerably less expensive and more reliable.[30] Solar water heaters can be particularly effective if they are designed for three-season use, with a home’s heating system providing hot water during the winter months.

Measure savings – Solar water heating units save approximately 1665 kWh per year when used with an electric water heater.[31] Solar water heating units that are paired with a natural gas water heater save approximately 11.48 mmbtus per year.[32]

Measure incremental cost – The incremental cost per home to consumers of a solar water heating system is $5000.[33]

Measure useful life – The useful life of a solar water heater is 20 years.[34]

5.6 Residential Lighting - Fluorescent Technologies

Residential fluorescent bulbs and fixtures present a significant opportunity for energy and maintenance savings. On a per lamp basis, compact fluorescent lamps are generally 70 percent more efficient than incandescent lamps and last up to ten times longer. Poor quality, selection, appearance and reliability of residential fluorescent fixtures have in the past contributed to consumer aversion to fluorescent lighting. Additionally, the lack of brand loyalty among consumers coupled with the large number of manufacturers (500, including foreign companies) led to a proliferation of inferior fluorescent fixtures in the 1990's. According to Calwell et al., the existing stock of residential fixtures in 1996 was approximately 15 percent fluorescent and 85 percent incandescent,[35] More recent data shows that approximately 20 percent of existing lighting is fluorescent, suggesting that fluorescent share is increasing, but considerable technical potential for energy savings remains.[36]

In considering possible energy efficiency or market transformation initiatives, the fixture market can and should be separated into two end-use categories: hard-wired and portable units, which differ in both the supply chain and in consumer purchasing patterns. Hard-wired fixtures are most frequently purchased for new construction and major renovations, whereas portable fixtures are most often a retrofit, replacement or remodeling purchase. During recent years, national chain stores such as Home Depot and Lowe's have featured displays of compact fluorescent bulbs and have increased the market share of this technology in homes across the United States.

Installing hard-wired fluorescent fixtures reduces the likelihood of reversion to incandescent lamps. Consequently, hard-wired fixtures (indoor and outdoor) that are characterized by energy efficiency, quality and safety present a significant opportunity to reduce energy consumption. Since the point-of-sale for hard-wired fixtures is relatively concentrated (and generally limited to showrooms, contractors and distributors), a fixture initiative can target these markets more effectively than lamp suppliers for which sales locations are more diffuse.

In contrast, portable fixtures represent less of an opportunity for market transformation because the target market is diffuse, and influencing purchasing decisions may take considerably more resources. However, new developments in torchiere lamps provide a unique market transformation opportunity. The 40 million halogen torchieres in American homes, dorms and offices consume up to 600 watts of power each, and often account for 30 percent to 50 percent of lighting retailers' sales.[37] The typical compact fluorescent alternative to halogen torchieres consumes 55 to 100 watts of power, representing an efficiency improvement of 6 times the halogen at full light output. Incandescent torchieres are becoming more popular as well, with consumption rates of 100 to 150 watts. In addition, some non-torchiere portable fixtures that use only compact fluorescent lamps are now available.

Market Barriers – Fluorescent Lighting Technologies

The primary market barriers to the penetration of fluorescent fixtures include product availability, quality of residential grade fixtures, consumer aversion to fluorescent lighting, and the first cost (purchase price) for high quality fixtures and bulbs. For hard-wired fixtures, specifier and commercial grade units are of better quality than residential fixtures. Consequently, making these fixture grades available to homeowners at a reasonable cost is an important market transformation strategy.

Market transformation programs for lighting fixtures exist nationally and regionally. Launched in March of 1997, the ENERGY STAR® Fixture program promotes the adoption of high quality, efficient fixtures through its labeling program. Two regional fixture initiatives sponsored by the Northeast Energy Efficiency Partnerships (NEEP) and the Northwest Energy Efficiency Alliance (NEEA) have recently been adopted and several states also fund their own residential lighting programs. Most of these initiatives coordinate with the ENERGY STAR® program, targeting both hard-wired and portable fixtures, and encourage active retail promotions and consumer education. Similarly, a coalition of California utilities, coordinating with the Northwest, selected the ENERGY STAR® Fixtures specification as the basis of a regional lighting fixture program and plans to offer performance-based incentives to fixture manufacturers, wholesalers, and large and small retailers. In addition to the above market transformation initiatives, another force advancing lighting efficiency is the banning of halogen torchieres by a number of universities due to the fire hazard they pose.[38]

Compact Fluorescent Bulb Measure Data

Description – The purchase price of compact fluorescent bulbs (CFLs) most commonly purchased for residential applications is now in the range of $3 to $5 per bulb. These bulbs can be found in hardware stores as well as in chain stores such as Home Depot and Lowe's. CFL bulbs range in size and shape, and their appearance can be a spiral shaped fluorescent tube, or they can appear as a standard shape such as the R-30 floodlight for use in recessed cans. For this analysis, GDS has assumed each existing and new household included in the program will equip 10 lighting sockets with CFL bulbs.

Measure savings – Energy savings for a CFL are approximately 75 percent as compared to a standard incandescent light bulb (for example, a 19 watt compact fluorescent can replace a 75 watt incandescent bulb). For this report, GDS has calculated an average annual energy savings based on an average wattage difference of 49.6 and 986 hours of annual operation. The average annual kilowatt-hour savings associated with installing CFL bulbs is 48.9 kWh annually.[39]

Measure incremental cost – The incremental purchase price, after calculating the cost of replacement incandescent light bulbs is $.50.[40]

Measure useful life – The useful life of a CFL bulb is approximately 7,500 hours, or 7.6 years.[41]

5.7 High Efficiency Clothes Washers

About 84 percent of clothes washers in the United States are top-loading units that spin on a vertical axis.[42] To wash clothes, the washtub must be filled so that all clothes are covered. In Europe the dominant type of washer is the horizontal axis machine. Horizontal axis machines reduce water use by 50 percent because the washtub is only partially filled. With each rotation of the tub, clothes are dipped in the water at the bottom of the half filled tub. When replacing vertical axis machines that meet the 2006 U.S. energy efficiency standard with H-axis machines, energy use can be reduced by up to 50 percent.[43] Many horizontal axis units are front-loading machines, but some units sold in the US are top loading, consisting of a conventional top loading door with a second door in the rotating metal drum. Additional energy savings can be derived from faster spin speeds. The spin cycle in standard American clothes washers spins clothes at approximately 600 rpm, which reduces the moisture content of the load from 100 percent to approximately 50 to 75 percent (depending on fabric). Typically, this laundry is moved to a dryer, to reduce the moisture content to 2.5 to 5 percent.[44] However, a study by the National Institute of Standards and Technology (NIST) found that to reduce moisture content of a typical laundry load from 70 percent to 40 percent, a spin cycle is approximately 70 times more energy efficient (i.e., requires 1 /70th the energy) than a dryer thermal cycle. For 7 pound loads, increasing the spin speed to 900 rpm reduced dryer energy use by 28 percent to 47 percent depending on the fabric.[45] Many of the new high-efficiency washers that have recently entered the U.S. market have spin speeds significantly higher than conventional U.S. machines. To reduce wrinkling, these machines typically have complex cycles - slow spin, re-balancing, fast spin, and a final slow spin to ventilate the clothes. High spin speeds are also common in Europe, with many machines having spin speeds over 800 rpm, and some machines operating as high as 1500 rpm.

Studies of horizontal-axis clothes washer performance indicate that these products produce substantial energy savings in the field, not just in the laboratory. In 2000, the U.S. Department of Energy and Maytag Appliances conducted field studies in Reading, Massachusetts. This study was done to assess savings in an urban setting experiencing rapid growth in water and sewer rates. The results were 50 percent energy savings and 44 percent water savings.[46]

In addition to saving water and energy, horizontal-axis machines may offer several other advantages. First, customers who own horizontal-axis washers are highly satisfied with their purchases (e.g. 81 percent to 95 percent in a study of the Northwest WashWise program).[47] Second, by eliminating the agitator, these units may create less wear and tear on clothes (however, some manufacturers dispute these claims). Third, they may use less detergent than vertical axis machines. This issue is complex and controversial, and may come down to consumer choices about whether they want better cleaning performance than standard machines (in which case there are unlikely to be detergent savings) or whether current cleaning performance is acceptable (in which case there may be some detergent savings). Finally, they are not as prone to load imbalance problems as some vertical axis machines.[48]

The analysis that follows is based on a high-efficiency machine meeting current ENERGY STAR® qualifications. At these performance levels, washer energy use is reduced by greater than 50 percent relative to the average vertical-axis washer now being sold. In addition, substantial savings on water and sewer bills contribute to the economic benefits of high-efficiency washers. ENERGY STAR® is raising their current standards effective January 2007 from a Modified Energy Factor (MEF) of 1.42 to 1.72. These revised ratings will result in even greater energy savings compared to their standard counterparts.[49]

There are currently many on-going efforts to promote high-efficiency washers. The CEE's Residential Clothes Washer Initiative, launched in 1993, promotes the manufacture and sales of energy-efficient clothes washers. CEE has developed a set of specifications and a qualifying product list to define energy efficiency and works with Initiative participants (utilities and energy organizations) to promote qualifying washers through incentive, educational and promotional programs. There are currently more than 50 participating utilities and energy organizations. Today, hundreds of different high efficiency models are available in leading retail outlets across the country. Every major domestic appliance manufacturer – including Maytag, Frigidaire, Whirlpool and General Electric – has introduced at least one high-efficiency clothes washer to the market. In addition, DOE is sponsoring an ENERGY STAR® marketing and promotion program that awards an ENERGY STAR® label to washers that meet the CEE efficiency thresholds.

Market Barriers

All new washing machines must display EnergyGuide labels to help consumers compare energy efficiency. The EnergyGuide label for clothes washers is based on estimated energy use for 392 loads of laundry per year. This value does not take into account the variations in tub size and other factors. Top loading machines with smaller tubs may have a better rating, but might mean you have to run the machine more often. While high-efficiency washers have many benefits, there may be some limitations. First, most of the current high-efficiency units are front-loading machines. Consumers are used to top-loading machines and it is unclear what proportion of consumers will be averse to front-loaders. Second, some high-efficiency machines have longer cycle times than conventional machines. Third, high-efficiency machines currently sell at a significant cost premium (approximately $300) relative to conventional machines.[50] While prices are likely to come down in the future, the cost increment is likely to be significant (e.g. several knowledgeable industry experts have suggested a long-term incremental cost in mass production of approximately $175).

High Efficiency Clothes Washers - Measure Data

Description – Energy efficient clothes washers can save water, electricity, and natural gas. Natural gas savings and some electricity savings come from water use efficiency, reducing the load for water heating. For this analysis, clothes washer savings have been divided into two different tiers. Tier 1 consists of washers with a MEF of at least 1.42. Tier 2 consists of washers with a MEF of 1.60 or higher. After several years in the program, Tier 1 sales will give way to Tier 2 sales, resulting in higher program savings.

Measure savings – Energy savings for a Tier 1 electric clothes washer are 122 kWh annually, while a Tier 2 electric clothes washer can save 212 kWh.[51] A Tier 1 gas clothes washer can save 74.5 kWh and 0.12 mmbtus of natural gas each year. Energy savings for a Tier 2 gas clothes washer are 141.2 kWh and 0.18 mmbtus annually.[52] All energy efficient washers save approximately 5400 gallons of water each year.[53]

Measure incremental cost – The incremental cost of a Tier 1 clothes washer is approximately $51. Tier 2 clothes washers have an incremental cost of around $58.[54]

Measure useful life – The useful life of a high efficiency clothes washer is 11 years.[55]

5.8 High Efficiency Refrigerators

As of July 1, 2001, new federal minimum efficiency standards went into effect that reduced the average energy use of a new refrigerator to approximately 496 kWh per year. This corresponds to a typical 20 cubic foot unit with a top-mounted freezer and no ice-maker. Very high efficiency refrigerators use a number of technologies to achieve energy savings (more efficient compressors, insulation, door seals, etc.). Additional efficiency improvements, however, are possible beyond this new standard.

There are a few variations of high efficiency refrigerator models. There are top freezer models, side by side models, and bottom freezer models. Top freezer models account for two-thirds of refrigeration sales, the side-by-side models are second in sales volume across the United States, and bottom freezers, although growing in popularity, are still low in sales volume.[56]

Market Barriers

Barriers to improved refrigerator efficiency are several fold, including the useful life of refrigerators of approximately 13 years, limited consumer interest in improved efficiency (due in part to limited understanding of the benefits of high efficiency products), and the fact that many refrigerators are purchased by landlords and builders who care only about purchase price as someone else (home buyers and renters) pay the energy bills. Activities that can address these barriers include improved appliance efficiency labels, increased promotion of the ENERGY STAR® label, and further improvements in federal minimum efficiency standards.

ENERGY STAR® Residential Refrigerators - Measure Data

Description – The refrigerator is the single biggest power consumer in most households.[57] There are a few different models of refrigerators, the top freezer model accounts for almost two-thirds of all refrigerator sales, with side-by-side models coming in second, and bottom freezers being last.[58] In this analysis, refrigerators have been divided into two tiers, with Tier 1 being 15 percent more efficient than standard models, and Tier 2 being 20 percent more efficient than standard models.

Measure savings – A standard refrigerator uses an average of 571 kWh annually. [59] Tier 1 refrigerators save about 15 percent of this electricity, resulting in a savings of 85.65 kWh each year. Tier 2 refrigerators use about 20 percent less energy than a standard model and therefore save approximately 114.2 kWh each year.

Measure incremental cost – The average incremental costs for a Tier 1 refrigerator over a standard model is $30.[60] A Tier 2 refrigerator has an incremental cost of approximately $500 over a standard model.[61]

Measure useful life – The useful life of a refrigerator is 13 years.[62]

5.9 High Efficiency Dishwashers

DOE requires dishwasher manufacturers to meet a minimum energy efficiency standard of 2.17 kWh per cycle, equivalent to an energy factor (EF) of 0.46, for residential standard-capacity dishwashers.[63] About 80 percent of the total energy used by dishwashers goes towards heating the water. So, the best way to improve the efficiency of a dishwasher is to reduce the amount of water needed to clean the dishes. Some dishwashers take advantage of European technology, using a spray system that activates the upper and lower spray arms alternately instead of simultaneously, and thereby reducing water use. A "normal" load for this high efficiency equipment requires 6 gallons of water, instead of 8 to 10 gallons used in competitive models.

To enable consumers to identify dishwashers that are more efficient, DOE has established voluntary energy efficiency targets for dishwashers (as well as other products) under its ENERGY STAR® program. The program promotes the purchase of highly efficient appliances through product labeling, advertising, sales staff training, and promotional activities. Utilities participating in the program share the costs of promoting ENERGY STAR® products in their service territories. Under the ENERGY STAR® program, however, the efficiency targets for dishwashers have been set at an EF of 0.58. Similar to clothes washers, ENERGY STAR® is raising their efficiency requirements on dishwashers effective January 2007 to an EF of .65. These revised standards will further increase the energy savings of efficient models.[64]

To drive the market toward higher-efficiency targets, CEE also developed the Super Efficient Home Appliance (SEHA) Initiative that will add on to the DOE ENERGY STAR® program. Through this initiative, CEE encourages its members to support both the ENERGY STAR® appliance levels as well as higher efficiency tiers established by CEE. Participants in the initiative will work with retailers, providing information, tools, and incentives to increase the sales of products that qualify for CEE's more aggressive tiers. To avoid sending mixed messages to consumers, the distinction between ENERGY STAR® product levels and CEE levels will be transparent to the consumer. DOE is planning to review the ENERGY STAR® qualifying levels for several products including dishwashers; at this time there is a good chance that the qualifying efficiencies will be raised.

Ultimately, however, customer demand for high efficiency products and ancillary benefits of these products (i.e., low noise, better cleaning, etc.) will drive the market. National and regional market transformation initiatives can play a significant role in spurring consumer demand by promoting consumer awareness and knowledge of efficient dishwashers and their benefits. These educational efforts could be incorporated into current energy education efforts.

Educating consumers about the availability of high efficiency dishwashers, and working with retailers to ensure that they are adequately prepared to market high efficiency dishwashers will be key to successful market transformation efforts. Furthermore, actions to increase the availability and market share of high efficiency dishwashers can influence the new standard.

Market Barriers

Barriers to improved dishwasher efficiency are several fold, including the useful life of dishwashers of approximately 10 years, complications of installation, limited consumer interest in improved efficiency (due in part to limited understanding of the benefits of high efficiency products), and the fact that many dishwashers are purchased by landlords and builders who care only about purchase price as someone else (home buyers and renters) pay the energy bills. Activities that can address these barriers include improved appliance efficiency labels, increased promotion of the ENERGY STAR® label, and further improvements in federal minimum efficiency standards.

High Efficiency Dishwashers - Measure Data

Description – In this analysis, dishwashers have been divided into two tiers, with Tier 1 having an EF of at least 0.62, and Tier 2 having an EF of 0.68.

Measure savings – A Tier 1 dishwasher will save approximately 58 kWh annually, while upgrading to a Tier 2 dishwasher can save 88 kWh annual over a standard model.[65]

Measure incremental cost – The average incremental costs for a Tier 1 dishwasher over a standard model is $50.[66] A Tier 2 dishwasher has no incremental cost over a standard model, and in some cases, it may even cost less to buy a Tier 2 dishwasher over a minimally efficient one.[67]

Measure useful life – The useful life of a dishwasher is 10 years.[68]

5.10 High Efficiency Heat Pumps

Science proves that heat naturally moves from warmer areas to cooler areas. However, heat pumps operate by reversing this cycle. In cool seasons, heat pumps extract heat from areas outside the home, such as the ground, and transport it inside to heat air that is circulated around the house. Heat pumps must use energy to reverse the process, but because the energy is primarily being used to move existing heat, rather than create it, heat pumps can be a very efficient form of heating if used in the right climate.

Market Barriers

A major market barrier to heat pumps is public lack of knowledge about the appliance's relative efficiency and operation. Other barriers include the high incremental cost of ENERGY STAR® approved heat pumps and the lack of knowledge of promotional programs and benefits. Activities that can address these barriers include improved appliance efficiency labels, increased promotion of the ENERGY STAR® label and products, and further improvements in federal minimum efficiency standards.

ENERGY STAR® Heat Pump – Measure Data

Description – ENERGY STAR® recognizes heat pumps that have an HSPF rating less than 8.0 with their label. Products must also have a SEER of 14 or less and an Energy Efficiency Ratio of 11 or less. These strict specifications mean that ENERGY STAR® labeled heat pumps are about 20 percent more energy efficient than a standard new model on the market. Since the majority of heat pumps found in homes, however, are not new, the specifications of an ENERGY STAR® model can be up to 50 percent more efficient.[69]

Measure savings – Increasing the energy efficiency ratios of heat pumps as in the model will save about 464.32 kWh each year per heat pump.[70]

Measure incremental cost – The average incremental costs for an ENERGY STAR® heat pump over a standard model is $1,000.[71]

Measure useful life – The useful life of a heat pump is 18 years.[72]

5.11 High Efficiency Furnaces

Natural gas furnaces are used to heat homes and other buildings by burning fuel to heat air directly. This air is then circulated throughout the building via a system of ducts and vents. Less efficient furnaces require more energy to operate because heat can easily escape through un-insulated walls and openings in the heating system. Heating efficiency is measured by comparing the amount of heat output to the amount of energy input. Currently, the efficiency standard set by the Department of Energy is only 78 Annual Fuel Utilization Efficiency (AFUE).[73] However, ENERGY STAR® requires a minimum rating of 90 AFUE.[74] These models allow less opportunity for heat to escape during the heating process, making them about 15 percent more efficient than other models.

A high efficiency natural gas furnace can save additional energy when the central household fan in the HVAC system has an electronically commuted motor (ECM). According to the Energy Star program Web site, if the household furnace fan has an ECM, annual electricity usage related to fan operations can be reduced by 600 kWh annual for space heating and by 150 kwh annually for air conditioning.

Although high efficiency furnaces are available everywhere in the United States most are found in the colder northern areas of the country, where the benefits of heating efficiency are realized sooner than in warmer regions. In 2004, ENERGY STAR®-approved gas furnaces made up 32 percent of national gas furnace sales. In the northern regions of the country, that number was significantly higher.[75] Despite this percentage of sales, furnaces that do not meet the 90 AFUE rating are still prevalent in the market. They are especially common in older homes. Installing high efficiency furnaces in new homes would be particularly cost effective, but replacing older furnaces in existing homes has proven beneficial as well.[76]

Market Barriers

Barriers to improved furnace efficiency include the high cost of retrofit high-efficiency furnaces and the lack of knowledge of promotional programs and benefits. There is also a lack of federal attention to the issue, since the standard of 78 AFUE has not been updated by the government since 1987.[77] Activities that can address these barriers include improved appliance efficiency labels, increased promotion of the ENERGY STAR® label, and further improvements in federal minimum efficiency standards.

ENERGY STAR® Gas Furnace - Measure Data

Description – Furnaces heat air that is then circulated through a system of supply and return ducts. Supply ducts and registers (i.e., openings in the walls, floors, or ceilings covered by grills) carry warm air from the furnace to the home. As this warm air circulates, it becomes cooler; then it flows back to the furnace through return ducts and registers. This analysis compared savings between the current minimum standard (AFUE=78) for operating units and a more efficient commercially available air conditioning unit (AFUE=90) for Tier 1. For Tier 2, the current minimum standard is compared to an even more efficient unit (AFUE =95) combined with an ECM for additional savings.

Measure savings – Increasing the minimum AFUE to 90 for a condensing natural gas furnace, as in Tier 1, would result in an estimated 7.3 mmbtu of gas saved each year for one furnace.[78] Replacing the minimum AFUE with a Tier 2 unit would save an estimated 29.8 mmbtu of natural gas[79] and approximately 600 kWh annually for each furnace.[80]

Measure incremental cost – The average incremental costs for a Tier 1 ENERGY STAR® furnace over a standard model is $373.[81] The incremental cost for a Tier 2 furnace is $1800.[82]

Measure useful life – The useful life of a furnace is 18 years.[83]

6.0 Conclusions

This report has presented estimates of the achievable potential for natural gas savings in the United States if aggressive policies and programs were implemented now to capture cost effective and untapped energy savings, which can save natural gas. Given the higher retail prices for natural gas and concerns about over reliance of the United States on fossil fuels, it is imperative that policymakers at the national and state levels examine additional energy efficiency programs and standards as a least cost way to meet the growing energy needs of U.S. consumers. This report concludes that the United States could save more than 234 trillion cubic feet (TCF) of natural gas over the next 50 years with aggressive and bold energy efficiency policies and programs. These savings of more than 234 TCF are almost three times higher than the volume of natural gas that is projected to be available from off-shore drilling for natural gas off the Atlantic coast of the United States.

This report examines the potential for future savings of natural gas from two sources; (1) direct savings from installation of high efficiency natural gas equipment in homes and businesses in the United States, such as natural gas furnaces that are 90 percent to 95 percent efficient, and (2) indirect savings from installation of high efficiency electrical equipment in homes and businesses (such as high efficiency compact fluorescent lighting and energy efficient home appliances) that will reduce the need for electricity generated from power plants fueled with natural gas. Section 5 of this report described the high efficiency natural gas and electrical equipment that can deliver these large savings of natural gas.

If aggressive policies and programs were implemented today to capture the cost effective savings potential for natural gas, GDS estimates that after 10 years of programs, consumers could save almost 2.8 TCF annually of natural gas. These savings can amount to more than 14.5 TCF in the United States by the year 2015. In 2055, after 50 years of program implementation, consumers could save more than 234 TCF.

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[1] It is interesting to note that page 6 of the executive summary of the September 2003 National Petroleum Council Report concludes that "greater energy efficiency and conservation are vital near-term and long-term mechanisms for moderating price levels and reducing volatility."
[2] Information was obtained from the Energy Information Administration's Web site at www.eia.doe.gov. Values for 1994-2004 were provided in the EIA's "Energy Consumption by Source, 1949-2004" table.
[3] In the Potential Savings column, (T) refers to technical potential, (E) refers to economic potential, and (A) refers to achievable potential. When conclusions are not clear, potential classification is assigned based on best assumption.
[4] "September 2005 Update: EPA Releases Final New Guidelines for ENERGY STAR Qualified Homes." (www.energystar.gov)
[5] Florida Solar Energy Center
[6] Florida Solar Energy Center
[7] NRDC 2006
[8] NRDC 2006
[9] Efficiency Vermont 2004 Annual Report. Nov. 2005. pg 49
[10] Florida Solar Energy Center
[11] NRDC 2006
[12] "Vermont Electric Energy Efficiency Potential Study," prepared for the Vermont Department of Public Service by GDS Associates. May 10, 2006. Table A-1
[13] NRDC 2006
[14] NRDC 2006
[15] NRDC 2006
[16] "Vermont Electric Energy Efficiency Potential Study," prepared for the Vermont Department of Public Service by GDS Associates. May 10, 2006. Table A-1
[17] "How Contractors Really Size Air Conditioning Systems," presented at the 1996 ACEEE Summer Study on Energy Efficiency in Buildings. American Council for an Energy-Efficient Economy. Washington, D.C.
[18] Florida Solar Energy Center
[19] NRDC 2006

[20] Savings Calculator-Central Air Conditioners (.xls), found on the EnergyStar Web site (www.energystar.gov)
[21] "Heat Pump Water Heaters-Residential" Energy Efficiency Factsheet, Washington State University Energy Program. Accessed April 2006. (www.energy.wsu.edu)
[22] "Heat Pump Water Heaters-Residential" Energy Efficiency Factsheet, Washington State University Energy Program. Accessed April 2006. (www.energy.wsu.edu)
[23] "Consumer Guide to Home Energy Savings," 8th edition. ACEEEE. pg. 100
[24] U.S. Department of Energy Web site http://www.eren.doe.gov/erec/factsheets/watheath.html
[25] "Consumer Guide to Home Energy Savings" 8th ed. ACEEE. 2003. Page 101.
[26] GasFacts: A Statistical Record of the Gas Industry with 2004 Data. AGA. Pg. 77.
[27] Table 6-6 in "Consumer Guide to Home Energy Savings" 8th ed. ACEEE. 2003.
[28] NRDC 2006
[29] Table 6-6 in "Consumer Guide to Home Energy Savings" 8th ed. ACEEE. 2003.
[30] "Consumer Guide to Home Energy Savings" 8th ed. ACEEE. 2003. Page 101.
[31] GDS 2004 App. B
[32] Gas Facts: A Statistical Record of the Gas Industry with 2004 Data. AGA. Pg. 77.
[33] NRDC 2006
[34] Table 6-6 in "Consumer Guide to Home Energy Savings" 8th ed. ACEEE. 2003.
[35] Calwell, Chris, Chris Granda, Charlie Stephens and My Ton. 1996. *Energy Efficient Residential Luminaires: Technologies and Strategies for Market Transformation*. Final Report. Submitted to the U.S.E.P.A., Office of Air and Radiation, Energy Star Programs, under grant #CX824685. San Francisco, CA: Natural Resources Defense Council.
[36] "Energy Efficiency Lighting In the Residential Market." Brad Kates and Steve Bonnano. Powerpoint Presentation, April 2005.
[37] Calwell, Chris, Chris Granda, Charlie Stephens and My Ton. 1996. *Energy Efficient Residential Luminaires: Technologies and Strategies for Market Transformation*. Final Report. Submitted to the U.S.E.P.A., Office of Air and Radiation, Energy Star Programs, under grant #CX824685. San Francisco, CA: Natural Resources Defense Council
[38] Chris Calwell, "Big Lamp on Campus: An Energy and Environmental Curriculum Module for Colleges Concerned about Halogen Lamp Use," submitted by Ecos Consulting to the US Environmental Protection Agency, Office of Air and Radiation, Energy Star Programs, under Grant # CX820578-01-0 to the Natural Resources Defense Council, April 15, 1997.
[39] Impact Evaluation of the Massachusetts, Rhode Island, & Vermont 2003 Residential Lightings Programs. Nexus Market Research (NMR). Oct. 2004.
[40] GDS calculation
[41] Impact Evaluation of the Massachusetts, Rhode Island, & Vermont 2003 Residential Lightings Programs. Nexus Market Research (NMR). Oct. 2004.
[42] "Phase 2 Evaluation of the Efficiency Vermont Residential Programs." KEMA, Inc. Dec.2005. pg 3-20.
[43] Partnership for Advancing Technology in Housing. March 10, 2006. (www.toolbase.org/techinv/)
[44] An Evaluation of Assigning Credit/Debit to the Energy Factor of Clothes Washers Based On Water Extraction Performance." NBSIR 81-2309. 1981.
[45] ibid
[46] E Source Technology Atlas Series, Residential Appliances, section 6.2, "Study Finds Conservation Benefits in Switching to High-Efficiency Appliances," Maytag press release (October 2000), www.newstream.com
[47] "Coming Clean About Resource Efficient Clothes Washers: An Initial WashWise Program and Market Progress Report." Pacific Energy Associates. January 1998.
[48] Lebot, B. et al. "Horizontal Access Domestic Clothes Washers: An Alternative Technology That Can Reduce Residential Energy and Water Use." Proceedings from the ACEEE's 1990 Summer Study on Energy Efficiency in Buildings. 1990. 1.148-1.155.
[49] Energy Star Program Requirements for Clothes Washers, found on the EnergyStar Web site (www.energystar.gov)
[50] Savings Calculator-Clothes Washers (.xls), found on the EnergyStar Web site (www.energystar.gov).
[51] Table 5 in "Residential Clothes Washer Initiative Program Description" Revised. CEE. 2002.

[52] Table 7 in “Residential Clothes Washer Initiative Program Description” Revised. CEE. 2002.
[53] GDS Assumption – Utah Report
[54] Table 14 in “Residential Clothes Washer Initiative Program Description” Revised. CEE. 2002.
[55] Savings Calculator-Clothes Washers (.xls), found on the EnergyStar Web site (www.energystar.gov).
[56] “Refrigerators: Buying Advice”, (www.consumerreports.org)
[57] Energy Star Web site. http://www.energystar.gov/products/refrigerators/
[58] www.consumerreports.org
[59] Savings Calculator-Residential Refrigerators (.xls), found on the EnergyStar Web site (www.energystar.gov)
[60] ibid
[61] Email from Erica Schroeder of CEE, June, 2006, and Savings Calculator-Residential Refrigerators (.xls), found on the EnergyStar Web site (www.energystar.gov)
[62] Calculator-Residential Refrigerators (.xls), found on the EnergyStar Web site (www.energystar.gov)
[63] Energy Star Program Requirements for Dishwashers, found on the EnergyStar Web site (www.energystar.gov)
[64] Energy Star Program Requirements for Dishwashers, found on the EnergyStar Web site (www.energystar.gov)
[65] Savings Calculator-Dishwashers (.xls), found on the EnergyStar Web site (www.energystar.gov)
[66] ibid
[67] GDS Estimate
[68] Calculator-Dishwashers (.xls), found on the EnergyStar Web site (www.energystar.gov)
[69] EnergyStar.gov
[70] NRDC 2006
[71] ibid.
[72] GDS assumption
[73] Energy Efficiency and Renewable Energy Web site: http://www.eere.energy.doe.gov/
[74] Energy Star Web site. http://www.energystar.gov/
[75] Leading the Way: Continued Opportunities for New State Appliance & Equipment Efficiency Standards. ACEEE. March 2006.
[76] ibid.
[77] ibid.
[78] Ibid.
[79] Savings Calculator-Furnaces (.xls), found on the EnergyStar Web site (www.energystar.gov)
[80] KeySpan Energy Delivery, Massachusetts Regulatory Filing, March 2006.
[81] Leading the Way: Continued Opportunities for New State Appliance & Equipment Efficiency Standards. ACEEE. March 2006.
[82] Savings Calculator-Furnaces (.xls), from www.energystar.gov AND KeySpan Energy Delivery, Massachusetts Regulatory Filing, March 2006.
[83] Leading the Way: Continued Opportunities for New State Appliance & Equipment Efficiency Standards. ACEEE. March 2006.