ENERGY AND ECONOMIC SAVINGS FROM NATIONAL APPLIANCE EFFICIENCY STANDARDS

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This analysis examines the energy and economic savings that can be expected from the national minimum efficiency standards for appliances signed into law by President Reagan in March, 1987 [1]. These standards represent a compromise agreed to by appliance manufacturers and conservation advocates. The proposed standards levels are listed in Appendix A. The savings are calculated on a product-by-product basis using a consistent methodology, as explained below.

I. Methodology

A. General

The analysis covers the following products included in the national appliance standards bill: refrigerators (R/F), freezers (FR), room air conditioners (RAC), central air conditioners and heat pumps (CAC and HP), electric water heaters (EWH), gas water heaters (GWH), gas furnaces and boilers (GF), and gas ranges (GR). Direct heating equipment (space heaters), dishwashers, clothes washers, and swimming pool heaters are included in the bill but not in this analysis because savings for these products are difficult to estimate and are unlikely to be as large as for the other products.

The analysis considers the energy use, first cost, and operating cost of products sold between 1986 and 2000. National product sales

are projected year-by-year along with the anticipated energy use of typical models produced under a "marketplace scenario" (i.e., without national standards) and a "standards scenario". Improvements in efficiency in the marketplace scenario are based on estimates provided by industry associations where available. Specific assumptions are explained below for each type of product.

Product sales are projected by first taking the average number of shipments during 1981-1985. This value is considered the normalized shipment level for 1983. It is increased on an annual basis using the estimated rate of increase of the housing stock during 1983-2000, 1.33% per year [3]. The sales projections are included in the tables of results.

The analysis includes the energy and dollar savings over the lifetime of products affected by standards sold by the year 2000. The economic analysis is done in terms of constant 1985 dollars using a 5% real discount rate for equipment and energy costs in the future. The extra first cost for more energy-efficient models is estimated based on a constant cost increase per unit of energy savings. This value is derived from other studies as described below for each product. Average residential energy prices in 1985 -- $0.078/kWh for electricity and $6.06/MBtu for natural gas -- are used [2]. Also, it is assuming that prices remain level in constant dollars; i.e., prices do not rise faster (or slower) than inflation.

B. Refrigerators and Freezers

In the marketplace case, projections by AHAM of the average electricity consumption of new models produced in 1987, 1990, and 1996

are used [4]. During 1996-2000, the same rate of decrease in new product UEC as during 1990-96 (1.6%/yr for R/Fs, 1.7%/yr for FRs) is assumed.

According to AHAM, the shipment-weighted maximum electricity use is 976 kWh/yr under the 1990 R/F standard and is 671 kWh/yr under the FR standard. Of course, there will be some distribution of shipments whose average electricity use is below these ceilings. It is assumed that the marketplace average is 7.5% below the ceilings the year that the standard goes into effect. This assumption is based on discussions with AHAM [4] and experience in California when state refrigerator and freezer standards became effective there [5].

It is highly likely that the 1990 R/F and FR standards will be upgraded through a DOE rulemaking given the provisions in the proposed standards bill. This is necessary in order to avoid having California (and possibly other states) adopt the 1992 California R/F and FR standards effective in 1993. It is uncertain what the exact outcome will be -- no doubt conservation advocates will be arguing for a major strengthening while manufacturers will attempt to limit the increase in stringency. In this analysis, it is assumed that the 1992 California standard levels are adopted as national standards effective in 1995. This assumption is conservative to the extent that R/F and FR standards could be revised as early as 1993.

During the period 1996-2000, the same rate of decrease in new product UEC is assumed in the standards case as in the marketplace case. Other assumptions include a 19 year lifetime for R/Fs and 21 year lifetime for FRs [6], and peak-to-average load factors of 1.17

for R/Fs and 1.15 for FRs [7].

The extra first cost for reducing the electricity consumption of R/Fs and FRs is derived from the standards analysis conducted by the California Energy Commission [8]. In the efficiency ranges of interest, the increase in first cost is assumed to be $0.26 per kWh/yr of savings for R/Fs and $0.17 per kWh/yr of saviings for FRs (in 1985 $).

C. Water Heaters

The water heater UEC values are based on a constant hot water demand of 43 gal/day for an average household (2.7 persons) [9]. It is assumed that the shipment-weighted energy factor (EF) ratings in 1984 were 0.494 for GWHs and 0.836 for EWHs. These estimates were made by Lawrence Berkeley Laboratory based on limited shipment data [10]. The EF ratings are corrected to account for the different water consumption levels in the test procedure and in a typical household.

In the marketplace case, it is assumed that the moderate increases in new product efficiency experienced during 1978-1984 continue in the future. The rates of increase are 0.4%/yr for GWHs and 0.6%/yr for EWHs.

In the standards case, it is assumed that the average new model is 5% more efficient than the minimum level the year that standards go into effect (1990). The relatively low margin in this case is due to the narrow range of efficiencies now offered in excess of the standards levels. After the standards become effective, the same rates of efficiency improvement as in the marketplace case are assumed.

The extra first cost for increasing the efficiency of water heaters is derived from the engineering analysis sponsored by DOE when it considered standards during the early 1980s [6]. In the range of interest, increasing the efficiency of EWHs is assumed to cost $3.70 per unit of EF or $0.09 per kWh/yr of savings and increasing the efficiency of GWHs is assumed to cost $2.70 per unit of EF or $6.56 per MBtu/yr of savings. Other key assumptions for water heaters are a 13 year lifetime [6] and peak-to-average load factor of 1.08 [7].

D. Room Air Conditioners

The proposed 1990 RAC standards vary according to the capacity of the RAC unit (see Appendix A). According to AHAM, the shipment-weighted average standard level is an EER of 8.6 [4]. This is 15% greater than the shipment-weighted EER in 1984. With an average capacity of 10,200 Btu/hr and an average usage level of 750 hrs/yr [4], an 8.6 EER corresponds to 896 kWh/yr of electricity consumption.

In the marketplace case, it is assumed that the electricity use of new models declines 1.5%/yr during 1984-90, and 1.0%/yr during 1991-2000. These forecasts were provided by AHAM [4]. In the standards case, it is assumed that the average model sold in 1990 is 7.5% more efficient than the minimum indicated by the standard, the same margin used for refrigerators and freezers. A 1.0%/yr decline in the electricity use of new products is assumed during 1991-2000.

The extra first cost for increasing the efficiency of RACs is derived from the DOE engineering analysis published in 1982 [6]. The cost premium is $63 per unit of EER (in 1985 $), or $0.53 per kWh/yr of savings at the assumed usage level. Also, a 15 year lifetime is

assumed along with a 75% diversification factor for determining coincident peak demand (i.e., aggregate peak demand is equal to 75% of installed RAC wattage).

E. Central Air Conditioners and Heat Pumps

The proposed national standards are an SEER rating of 10.0 for split system CACs and HPs beginning in 1992 and an SEER rating of 9.7 for packaged units beginning in 1993. Since about 85% of shipments are split systems, it is reasonable to assume the effective standard is an SEER of 9.95 as of 1992. For comparison, the shipment-weighted SEER rating for CACs and HPs was 8.75 in 1985 [11].

The electricity consumption of CACs and HPs is calculated assuming an average capacity of 35,000 Btu/hr and an average cooling use of 750 hrs/yr, as indicated by the CAC industry [11, 12]. This corresponds to 3000 kWh/yr of electricity use for cooling at the 1985 SEER level of 8.75. In the marketplace case, it is assumed that the average efficiency of new models rises 1.5%/yr during 1985-90 and 1.0%/yr during 1991-2000. These rates are somewhat lower than those recently experienced (the average rate of increase was 2.0%/yr during 1982-85). Declining rates of efficiency improvement are forecast because of anticipated stability in electricity prices and rising costs for efficiency improvements as SEER advances.

In the standards case, it is assumed that the average efficiency is 10% greater than the minimum the year the standards become effective (i.e., an SEER of 10.95 in 1992). This margin is based on the wide range of efficiencies produced (models with an SEER rating as high as 15.5 are already available) and the popularity of utility

rebate programs that encourage the purchase of highly efficient models. During 1993-2000, the same rate of efficiency increase as in the marketplace case (1.0%/yr) is assumed.

In this analysis, electricity savings resulting from the use of HPs for heating is not accounted for. This underestimates the savings potential from standards because there will be a reduction in electricity consumption for heating as well as cooling. However, the heating efficiency of HPs is not regulated, making it difficult to estimate savings on the heating side.

Regarding the extra first cost associated with increasing the efficiency of CACs and HPs, there is currently a first cost premium of about $320 per unit of SEER for systems of average capacity in the SEER range of 8.5 to 12.0 [13]. This high cost premium is expected to fall when less efficient equipment is eliminated from the marketplace and the market share for highly efficiency equipment expands. Once the CAC and HP standards becomes effective in 1992-93, a first cost premium of $160 per unit of SEER improvement is assumed for a typical CAC or HP.

Other key assumptions include a 12 year lifetime [6] and a 75% diversification factor when estimating peak load.

F. Central Furnaces and Boilers

Based on data collected by GAMA, it is estimated that the average AFUE rating of new furnaces reached about 0.74 in 1985, up 2.1%/yr on the average during 1978-85 [14]. In the marketplace scenario, it is assumed this rate of increase falls to 1.0%/yr during 1986-90 and 0.5%/yr during 1991-2000. These rates are consistent with stable gas

prices and are considered reasonable by GAMA [14].

The furnace and boiler standard, a minimum AFUE rating of 0.78 using the California isolated combustion test, implies that fuel-fired heating systems must be of the power burner or condensing flue gas design. Assuming that two-thirds of gas furnace and boiler shipments have a power burner and one third are condensing in 1992 (the year the standard becomes effective), the average AFUE that year would be about 0.86. This is 10% greater than the minimum level. The same rate of efficiency improvement is assumed during 1993-2000 in both the standards and marketplace cases.

Energy savings due to standards are estimated for gas furnaces and boilers only. Oil-fired equipment is not included because the average AFUE is already 0.78. Thus, a minimum efficiency standard at this level in 1992 will probably not have much impact.

Energy consumption for space heating is determined assuming an average space heating load of 45 MBtu throughout the 1986-2000 time period. This value is based on estimates indicating the national average heating load was 50 MBtu during the early 1980s [9,16], along with the assumption that the thermal integrity of housing gradually improves over time.

Estimating the extra first cost for increasing the efficiency of gas furnaces and boilers is problematic because there is a moderate increase in first cost for the addition of the power burner but a large incremental cost for condensing furnaces [12]. Assuming that two-thirds of shipments under standards feature the power burner and one third are condensing models, the average cost increase is $30.60 per

unit of AFUE improvement based on DOE's cost data updated to 1985 dollars [12]. This corresponds to $43 per MBtu/yr of savings at the assumed heating load.

A 23 year lifetime is also assumed for the gas furnace and boiler analysis.

G. Gas Ranges

The proposed standards include a ban on pilot lights in gas ranges with an electrical connection. About 95% of all ranges produced have an electrical connection [14]. In recent years, 38-41% of all gas ranges produced included pilot lights [14]. This percentage has been falling slowly over time.

Once the pilot light ban becomes effective beginning in 1990, it is assumed that pilot lights are removed from 30% of all shipments. Furthermore, it is assumed that the removal of pilot lights lowers the gas consumption of a typical range from 8.7 MBtu/yr to 4.8 MBtu/yr [6].

The extra first cost for the replacement of pilot lights with electric ignition is based on the retail prices of otherwise identical models listed in the 1985 Sears catalog. This price difference is $40. Thus, pilot light removal reduces gas use at a cost of $10 per MBtu/yr of savings.

II. Results

A. Energy Savings

Tables 1-8 contain the energy savings results on a product-by-product basis. The tables include aggregate annual savings from the products sold in any particular year along with the cumulative annual

savings from all products sold between 1986 and the year being considered. Aggregate lifetime savings refer to savings occurring during the lifetime of products sold in a particular year. Cumulative lifetime savings refer to all savings occurring during the lifetime of products sold between 1986 and the year being considered. Reduction in peak demand also is presented on an aggregate basis (i.e., savings from products sold that year) and cumulative basis (i.e., savings from all products sold between 1986 and the year being considered).

The electricity savings results are summarized in Table 17. By 1995, the standards are expected to reduce electricity consumption by 30.4 TWh/yr with peak summer demand reduced by 12,800 MW. By 2000, it is estimated that the standards will reduce electricity consumption by 53.5 TWh/yr and peak summer demand by 22,000 MW. Water heaters account for the largest portion of the electricity savings (39% in 2000) while CACs and HPs account for 56% of the peak demand savings. The anticipated reduction in peak demand in 2000 is equivalent to about 10% of the growth in national peak demand forecast by the utility industry during 1986-2000 [16].

The overall energy savings results (electricity and fuel) are summarized in Table 18. It is estimated that the standards will lower residential energy use by 553 TBtu (trillion Btu) in 1995 and 959 TBtu in 2000. The latter value is equal to about 6% of residential energy consumption at the present time.

Over the lifetime of products sold during 1986-2000, it is estimated that the standards will lower residential energy use by 15

Quads (quadrillion Btu). This is equivalent to over 18 months of energy imports at America's current net import rate. EWHs provide the greatest amount of lifetime energy savings (21% of the total), while R/Fs contribute 20% and GWHs 19% of the total lifetime savings for products sold by 2000.

B. Economic Savings

Tables 9-16 contain the economic savings results on a product-by-product basis. Once again, savings are viewed on both an aggregate annual and cumulative basis. Net savings are the savings in lifetime operating costs minus the estimated extra first cost as a result of imposing the efficiency standards. The benefit-cost ratio is the value of lifetime savings divided by the extra first cost for consumers. All values are expressed in 1985 dollars.

Table 19 summarizes the economic results. With the standards, consumers should realize a reduction in energy costs of $2.6 billion per year by 1995 and $4.0 billion per year by 2000. The net economic savings for consumers over the lifetime of products sold during 1986-2000 is $28.2 billion. This is nearly $300 per household. EWHs provide the most net economic savings (31% of the total), followed by GWHs (22% of the total) and R/Fs (20% of the total).

The overall benefit-cost ratio associated with the standards from the perspective of consumers is 3.0. The benefit-cost ratio is greater than 1.0 for all product types. It ranges from 1.2 for CACs to 8.7 for GWHs. The relatively low benefit-cost ratio for air conditioners is due to the substantial first cost premium associated with increasing the efficiency of this product.

It is also possible to consider the investment in utility plant that can be avoided as a result of the standards. Assuming that half the 22,000 MW of the avoided peak demand would otherwise be provided by peaking gas turbines costing $500/kW on average, half the capacity would be provided by baseload or cycling plants costing $1500/kW on average, and 8% T&D losses, the avoided investment in power generation alone is nearly $24 billion (1985 dollars). In addition, utilities will save on investments in power transmission and distribution facilities.

III. References

1. "National Appliance Energy Conservation Act of 1987", P.L. 100-12, March 17, 1987 (42 USC 6291).

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3. Data Series P-25, #986, U.S. Bureau of Census, Washington, DC, May 1986.

4. Personal communication with Mr. Paul Roman, Association of Home Appliance Manufacturers, Chicago, IL, July 1986.

5. Personal communication with Mr. Michael Messenger, California Energy Commission, Sacramento, CA, 1986.

6. "Consumer Products Efficiency Standards Engineering Analysis Document", DOE/CE-0030, U.S. Dept. of Energy, Washington, DC, March 1982.

7. H.S. Geller, et al., "Residential Conservation Power Plant Study Phase I - Technical Potential", report prepared for Pacific Gas and Electric Co. by the American Council for an Energy-Efficient Economy, Washington, DC, Feb. 1986.

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9. H.S. Geller, "Energy Efficient Appliances", American Council for an Energy-Efficient Economy and Energy Conservation Coalition, Washington, DC, June 1983.

10. Personal communication with Mr. James McMahon, Lawrence Berkeley Laboratory, Berkeley, CA, July 1986.

11. Personal communication from the Air-Conditioning and Refrigeration Institute, Arlington, VA, Aug. 1986.

12. "Supplement to: March 1982 Consumer Products Efficiency Standards Engineering Analysis and Economic Analysis Documents", DOE/CE-0045, U.S. Dept. of Energy, Washington, DC, July 1983.

13. "Staff Report on Proposed Revision of Appliance Efficiency Standards for Central Air Conditioners under 65,000 Btu/hr", P400-84-015, California Energy Commission, Sacramento, CA, Nov. 1984.

14. Personal communication from the Gas Appliance Manufacturers Association, Arlington, VA, July 1986.

15. "Gas Consumption by Residential Appliances", American Gas Association, Arlington, VA, March 2, 1984.

16. "35th Annual Electric Utility Industry Forecast", Electrical World 198 (9), Sept. 1984.

TABLE 1
Appliance Standards Analysis
Refrigerators - Energy Savings

Year	Sales Projec. (1000)	Market Case UEC (kWh/yr)	Stand. Case UEC (kWh/yr)	UEC Savings (kWh/yr)	Agg. Annual Savings (GWh/yr)	Cum. Annual Savings (GWh/yr)	Agg. Lifetime Savings (TWh)	Cum. Lifetime Savings (TWh)	Agg. Peak Savings (MW)	Cum. Peak Savings (MW)
1986	5367	1091	1054	37	199	199	3.77	4	27	27
1987	5438	1068	1014	54	294	492	5.58	9	39	66
1988	5511	1037	976	61	336	828	6.39	16	45	111
1989	5584	1007	939	68	380	1,208	7.21	23	51	161
1990	5658	978	903	75	424	1,632	8.06	31	57	218
1991	5734	962	850	112	642	2,275	12.20	43	86	304
1992	5810	947	800	147	854	3,129	16.23	59	114	418
1993	5887	932	754	178	1048	4,177	19.91	79	140	558
1994	5965	917	710	207	1235	5,411	23.46	103	165	723
1995	6045	902	668	234	1414	6,826	26.87	130	189	912
1996	6125	888	657	231	1415	8,241	26.88	157	189	1101
1997	6207	874	647	227	1409	9,650	26.77	183	188	1289
1998	6289	860	636	224	1409	11,058	26.77	210	188	1477
1999	6373	846	626	220	1402	12,460	26.64	237	187	1664
2000	6457	833	616	217	1401	13,862	26.62	263	187	1851

TABLE 2
Appliance Standards Analysis
Freezers - Energy Savings

Year	Sales Projec. (1000)	Market Case UEC (kWh/yr)	Stand. Case UEC (kWh/yr)	UEC Savings (kWh/yr)	Agg. Annual Savings (GWh/yr)	Cum. Annual Savings (GWh/yr)	Agg. Lifetime Savings (TWh)	Cum. Lifetime Savings (TWh)	Agg. Peak Savings (MW)	Cum. Peak Savings (MW)
1986	1395	771	735	36	50	50	1.05	1	7	7
1987	1414	758	704	54	76	127	1.60	3	10	17
1988	1432	734	675	59	85	211	1.77	4	11	28
1989	1451	710	648	62	90	301	1.89	6	12	40
1990	1471	687	621	66	97	398	2.04	8	13	52
1991	1490	676	588	88	131	529	2.75	11	17	69
1992	1510	664	557	107	162	691	3.39	15	21	91
1993	1530	653	527	126	193	884	4.05	19	25	116
1994	1551	642	499	143	222	1,105	4.66	23	29	145
1995	1571	632	473	159	250	1,355	5.25	28	33	178
1996	1592	621	465	156	248	1,604	5.22	34	33	211
1997	1613	611	457	154	248	1,852	5.22	39	33	243
1998	1635	600	449	151	247	2,099	5.18	44	32	276
1999	1656	590	442	148	245	2,344	5.15	49	32	308
2000	1678	581	434	147	247	2,591	5.18	54	32	340

TABLE 3
Appliance Standards Analysis
Electric Water Heaters - Energy Savings

Year	Sales Projec. (1000)	Market Case UEC (kWh/yr)	Stand. Case UEC (kWh/yr)	UEC Savings (kWh/yr)	Agg. Annual Savings (GWh/yr)	Cum. Annual Savings (GWh/yr)	Agg. Lifetime Savings (TWh)	Cum. Lifetime Savings (TWh)	Agg. Peak Savings (MW)	Cum. Peak Savings (MW)
1986	3173	4312	4212	100	317	317	4	4	39	39
1987	3215	4286	4090	196	630	947	8	12	78	117
1988	3258	4260	3971	289	942	1,889	12	25	116	233
1989	3301	4235	3856	379	1251	3,140	16	41	154	387
1990	3345	4209	3744	465	1556	4,696	20	61	192	579
1991	3390	4184	3722	462	1566	6,262	20	81	193	772
1992	3435	4159	3700	459	1577	7,838	20	102	194	966
1993	3480	4134	3677	457	1591	9,429	21	123	196	1162
1994	3527	4109	3655	454	1601	11,030	21	143	197	1360
1995	3574	4084	3633	451	1612	12,642	21	164	199	1559
1996	3621	4060	3612	448	1622	14,264	21	185	200	1759
1997	3669	4036	3590	446	1637	15,901	21	207	202	1960
1998	3718	4011	3568	443	1647	17,548	21	228	203	2163
1999	3768	3987	3547	440	1658	19,205	22	250	204	2368
2000	3818	3963	3526	437	1668	20,874	22	271	206	2573

TABLE 4
Appliance Standards Analysis
Room Air Conditioners - Energy Savings

Year	Sales Projec. (1000)	Market Case UEC (kWh/yr)	Stand. Case UEC (kWh/yr)	UEC Savings (kWh/yr)	Agg. Annual Savings (GWh/yr)	Cum. Annual Savings (GWh/yr)	Agg. Lifetime Savings (TWh)	Cum. Lifetime Savings (TWh)	Agg. Peak Savings (MW)	Cum. Peak Savings (MW)
1986	2658	1014	969	45	120	120	1.79	2	128	128
1987	2693	999	933	66	178	297	2.67	4	190	317
1988	2729	984	898	86	235	532	3.52	8	250	567
1989	2765	969	865	104	288	820	4.31	12	307	874
1990	2802	954	833	121	339	1,159	5.09	17	362	1,235
1991	2840	944	825	119	338	1,497	5.07	22	360	1,596
1992	2877	935	817	118	340	1,836	5.09	28	362	1,958
1993	2916	926	808	118	344	2,180	5.16	33	367	2,325
1994	2954	916	800	116	343	2,523	5.14	38	365	2,690
1995	2994	907	793	114	341	2,864	5.12	43	364	3,054
1996	3033	898	785	113	343	3,207	5.14	48	365	3,419
1997	3074	889	777	112	344	3,551	5.16	53	367	3,786
1998	3115	880	769	111	346	3,897	5.19	58	369	4,155
1999	3156	871	762	109	344	4,241	5.16	64	367	4,522
2000	3198	862	754	108	345	4,586	5.18	69	368	4,890

TABLE 5
Appliance Standards Analysis
Central Air Conditioners and Heat Pumps
Energy Savings

Year	Sales Projec. (1000)	Market Case UEC (kWh/yr)	Stand. Case UEC (kWh/yr)	UEC Savings (kWh/yr)	Agg. Annual Savings (GWh/yr)	Cum. Annual Savings (GWh/yr)	Agg. Lifetime Savings (TWh)	Cum. Lifetime Savings (TWh)	Agg. Peak Savings (MW)	Cum. Peak Savings (MW)
1986	2686	2956	2905	51	137	137	2	2	146	146
1987	2722	2912	2814	98	267	404	3	5	284	430
1988	2758	2869	2725	144	397	801	5	10	423	854
1989	2795	2827	2639	188	525	1,326	6	16	560	1,414
1990	2832	2785	2556	229	648	1,975	8	24	691	2,105
1991	2869	2757	2475	282	809	2,784	10	33	863	2,968
1992	2908	2730	2397	333	968	3,752	12	45	1032	4,001
1993	2946	2703	2373	330	972	4,724	12	57	1037	5,037
1994	2985	2676	2350	326	973	5,698	12	68	1038	6,075
1995	3025	2650	2326	324	980	6,678	12	80	1045	7,120
1996	3065	2624	2303	321	984	7,662	12	92	1049	8,169
1997	3106	2598	2281	317	985	8,646	12	104	1050	9,219
1998	3147	2572	2258	314	988	9,635	12	116	1054	10,273
1999	3189	2546	2236	310	989	10,623	12	127	1054	11,327
2000	3232	2521	2214	307	992	11,616	12	139	1058	12,385

TABLE 6
Appliance Standards Analysis
Gas Furnaces and Boilers - Energy Savings

Year	Sales Projec. (1000)	Market Case UEC (MBtu/yr)	Stand. Case UEC (MBtu/yr)	UEC Savings (MBtu/yr)	Agg. Annual Savings (TBtu/yr)	Cum. Annual Savings (TBtu/yr)	Agg. Lifetime Savings (TBtu)	Cum. Lifetime Savings (Quads)
1986	1821	60.50	59.80	0.70	1.27	1.27	29	0.03
1987	1845	59.90	58.50	1.40	2.58	3.86	59	0.09
1988	1870	59.30	57.20	2.10	3.93	7.78	90	0.18
1989	1895	58.70	56.00	2.70	5.12	12.90	118	0.30
1990	1920	58.10	54.80	3.30	6.34	19.24	146	0.44
1991	1945	57.80	53.60	4.20	8.17	27.41	188	0.63
1992	1971	57.50	52.40	5.10	10.05	37.46	231	0.86
1993	1997	57.20	52.10	5.10	10.19	47.65	234	1.10
1994	2024	56.90	51.80	5.10	10.32	57.97	237	1.33
1995	2051	56.70	51.60	5.10	10.46	68.43	241	1.57
1996	2078	56.40	51.30	5.10	10.60	79.03	244	1.82
1997	2106	56.10	51.10	5.00	10.53	89.56	242	2.06
1998	2134	55.80	50.80	5.00	10.67	100.23	245	2.31
1999	2162	55.50	50.60	4.90	10.59	110.82	244	2.55
2000	2191	55.30	50.30	5.00	10.96	121.78	252	2.80

TABLE 7
Appliance Standards Analysis
Gas Water Heaters - Energy Savings

Year	Sales Projec. (1000)	Market Case UEC (MBtu/yr)	Stand. Case UEC (MBtu/yr)	UEC Savings (MBtu/yr)	Agg. Annual Savings (TBtu/yr)	Cum. Annual Savings (TBtu/yr)	Agg. Lifetime Savings (TBtu)	Cum. Lifetime Savings (Quads)
1986	3288	27.40	26.50	0.90	2.96	2.96	38	0.04
1987	3332	27.30	25.60	1.70	5.66	8.62	74	0.11
1988	3376	27.20	24.60	2.60	8.78	17.40	114	0.23
1989	3421	27.10	23.70	3.40	11.63	29.03	151	0.38
1990	3466	26.90	22.90	4.00	13.87	42.90	180	0.56
1991	3513	26.80	22.80	4.00	14.05	56.95	183	0.74
1992	3559	26.70	22.70	4.00	14.24	71.19	185	0.93
1993	3607	26.60	22.60	4.00	14.43	85.61	188	1.11
1994	3655	26.50	22.50	4.00	14.62	100.23	190	1.30
1995	3703	26.40	22.40	4.00	14.81	115.04	193	1.50
1996	3752	26.30	22.40	3.90	14.63	129.68	190	1.69
1997	3802	26.20	22.30	3.90	14.83	144.51	193	1.88
1998	3853	26.10	22.20	3.90	15.03	159.53	195	2.07
1999	3904	26.00	22.10	3.90	15.23	174.76	198	2.27
2000	3956	25.90	22.00	3.90	15.43	190.19	201	2.47

TABLE 8
Appliance Standards Analysis
Gas Ranges - Energy Savings

Year	Sales Projec. (1000)	Market Case UEC (MBtu/yr)	Stand. Case UEC (MBtu/yr)	UEC Savings (MBtu/yr)	Agg. Annual Savings (TBtu/yr)	Cum. Annual Savings (TBtu/yr)	Agg. Lifetime Savings (TBtu)	Cum. Lifetime Savings (Quads)
1986	1665	6.16	5.00	1.16	1.93	1.93	35	0.03
1987	1687	6.16	5.00	1.16	1.96	3.89	35	0.07
1988	1710	6.16	5.00	1.16	1.98	5.87	36	0.11
1989	1732	6.16	5.00	1.16	2.01	7.88	36	0.14
1990	1755	6.16	5.00	1.16	2.04	9.92	37	0.18
1991	1779	6.16	5.00	1.16	2.06	11.98	37	0.22
1992	1802	6.16	5.00	1.16	2.09	14.07	38	0.25
1993	1826	6.16	5.00	1.16	2.12	16.19	38	0.29
1994	1851	6.16	5.00	1.16	2.15	18.34	39	0.33
1995	1875	6.16	5.00	1.16	2.18	20.51	39	0.37
1996	1900	6.16	5.00	1.16	2.20	22.72	40	0.41
1997	1925	6.16	5.00	1.16	2.23	24.95	40	0.45
1998	1951	6.16	5.00	1.16	2.26	27.21	41	0.49
1999	1977	6.16	5.00	1.16	2.29	29.51	41	0.53
2000	2003	6.16	5.00	1.16	2.32	31.83	42	0.57

TABLE 9
Appliance Standards Analysis
Refrigerators - Economic Savings

Year	Value Agg. An. Savings (10^6 $)	Value Cum. An. Savings (10^6 $)	Value Lifetime Savings (10^6 $)	Unit Extra First Cost ($)	Agg. Extra First Cost (10^6 $)	Net Agg. Savings (10^6 $)	Net Cum. Savings (10^6 $)	Benefit-Cost Ratio
1986	15	15	178	10	53	125	125	3.37
1987	21	36	251	14	75	177	302	3.37
1988	23	58	274	15	81	193	495	3.37
1989	24	83	295	16	87	207	702	3.37
1990	26	108	314	16	93	220	922	3.37
1991	37	146	452	23	134	318	1240	3.37
1992	47	193	572	29	170	402	1642	3.37
1993	55	249	669	34	199	470	2112	3.37
1994	62	311	751	37	223	528	2640	3.37
1995	68	378	819	40	243	576	3216	3.37
1996	65	443	780	38	232	548	3764	3.37
1997	61	504	740	35	220	520	4285	3.37
1998	58	562	705	33	209	495	4780	3.37
1999	55	618	668	31	198	469	5249	3.37
2000	53	670	636	29	189	447	5696	3.37

TABLE 10
Appliance Standards Analysis
Freezers - Economic Savings

Year	Value Agg. An. Savings (10^6 $)	Value Cum. An. Savings (10^6 $)	Value Lifetime Savings (10^6 $)	Unit Extra First Cost ($)	Agg. Extra First Cost (10^6 $)	Net Agg. Savings (10^6 $)	Net Cum. Savings (10^6 $)	Benefit-Cost Ratio
1986	4	4	48	6	8	40	40	5.88
1987	5	9	69	8	12	57	97	5.88
1988	6	15	73	9	12	61	158	5.88
1989	6	21	74	9	13	61	219	5.88
1990	6	27	76	9	13	63	282	5.88
1991	8	34	98	11	17	81	364	5.88
1992	9	43	115	13	20	95	459	5.88
1993	10	53	130	14	22	108	567	5.88
1994	11	64	143	16	24	119	686	5.88
1995	12	76	153	17	26	127	813	5.88
1996	11	88	145	16	25	121	934	5.88
1997	11	99	138	15	24	115	1048	5.88
1998	10	109	131	14	22	109	1157	5.88
1999	10	118	124	13	21	103	1260	5.88
2000	9	128	119	12	20	99	1358	5.88

TABLE 11
Appliance Standards Analysis
Electric Water Heaters - Economic Savings

Year	Value Agg. An. Savings (10^6 $)	Value Cum. An. Savings (10^6 $)	Value Lifetime Savings (10^6 $)	Unit Extra First Cost ($)	Agg. Extra First Cost (10^6 $)	Net Agg. Savings (10^6 $)	Net Cum. Savings (10^6 $)	Benefit-Cost Ratio
1986	24	24	221	9	27	194	194	8.14
1987	45	68	419	16	51	367	561	8.14
1988	63	132	596	22	73	523	1084	8.14
1989	80	212	754	28	93	661	1745	8.14
1990	95	307	893	33	110	783	2528	8.14
1991	91	398	856	31	105	751	3279	8.14
1992	87	485	821	29	101	720	3999	8.14
1993	84	569	788	28	97	692	4690	8.14
1994	81	650	756	26	93	663	5353	8.14
1995	77	727	725	25	89	636	5989	8.14
1996	74	801	695	24	85	609	6598	8.14
1997	71	872	667	22	82	585	7184	8.14
1998	68	940	640	21	79	561	7745	8.14
1999	65	1006	613	20	75	538	8283	8.14
2000	63	1068	588	19	72	516	8798	8.14

TABLE 12
Appliance Standards Analysis
Room Air Conditioners - Economic Savings

Year	Value Agg. An. Savings (10^6 $)	Value Cum. An. Savings (10^6 $)	Value Lifetime Savings (10^6 $)	Unit Extra First Cost ($)	Agg. Extra First Cost (10^6 $)	Net Agg. Savings (10^6 $)	Net Cum. Savings (10^6 $)	Benefit-Cost Ratio
1986	9	9	92	23	60	32	32	1.53
1987	13	21	131	32	85	45	77	1.53
1988	16	37	164	39	107	57	134	1.53
1989	18	56	192	45	125	66	200	1.53
1990	21	76	215	50	141	74	274	1.53
1991	20	96	204	47	134	71	345	1.53
1992	19	115	195	44	128	67	412	1.53
1993	18	133	189	42	123	65	477	1.53
1994	17	150	179	40	117	62	539	1.53
1995	16	167	170	37	111	59	598	1.53
1996	16	182	162	35	106	56	654	1.53
1997	15	197	155	33	102	54	707	1.53
1998	14	212	148	31	97	51	758	1.53
1999	14	225	141	29	92	49	807	1.53
2000	13	238	135	28	88	46	854	1.53

TABLE 13
Appliance Standards Analysis
Central Air Conditioners and Heat Pumps
Economic Savings

Year	Value Agg. An. Savings (10^6 $)	Value Cum. An. Savings (10^6 $)	Value Lifetime Savings (10^6 $)	Unit Extra First Cost ($)	Agg. Extra First Cost (10^6 $)	Net Agg. Savings (10^6 $)	Net Cum. Savings (10^6 $)	Benefit-Cost Ratio
1986	10	10	90	28	76	14	14	1.19
1987	19	29	167	52	140	27	41	1.19
1988	27	56	237	72	199	38	79	1.19
1989	34	90	299	90	251	48	127	1.19
1990	40	129	351	104	295	56	184	1.19
1991	47	176	417	122	350	67	251	1.19
1992	54	230	476	137	399	76	327	1.19
1993	51	281	455	130	382	73	401	1.19
1994	49	330	434	122	364	70	470	1.19
1995	47	377	416	115	349	67	537	1.19
1996	45	422	398	109	334	64	601	1.19
1997	43	465	379	102	318	61	662	1.19
1998	41	506	362	97	304	58	720	1.19
1999	39	545	345	91	290	55	776	1.19
2000	37	582	330	86	277	53	829	1.19

TABLE 14
Appliance Standards Analysis
Gas Furnaces and Boilers - Economic Savings

Year	Value Agg. An. Savings (10^6 $)	Value Cum. An. Savings (10^6 $)	Value Lifetime Savings (10^6 $)	Unit Extra First Cost ($)	Agg. Extra First Cost (10^6 $)	Net Agg. Savings (10^6 $)	Net Cum. Savings (10^6 $)	Benefit-Cost Ratio
1986	7	7	99	29	52	47	47	1.90
1987	14	22	192	55	101	91	138	1.90
1988	21	42	277	78	146	131	269	1.90
1989	26	68	344	96	181	163	432	1.90
1990	30	98	406	111	213	192	625	1.90
1991	37	135	498	135	262	236	861	1.90
1992	43	178	584	156	307	277	1138	1.90
1993	42	220	564	148	296	267	1405	1.90
1994	40	260	544	141	286	258	1663	1.90
1995	39	299	525	135	276	249	1912	1.90
1996	38	337	507	128	266	240	2152	1.90
1997	36	372	479	120	252	227	2379	1.90
1998	34	406	463	114	243	219	2598	1.90
1999	32	439	437	106	230	207	2806	1.90
2000	32	471	431	103	227	204	3010	1.90

TABLE 15
Appliance Standards Analysis
Gas Water Heaters - Economic Savings

Year	Value Agg. An. Savings (10^6 $)	Value Cum. An. Savings (10^6 $)	Value Lifetime Savings (10^6 $)	Unit Extra First Cost ($)	Agg. Extra First Cost (10^6 $)	Net Agg. Savings (10^6 $)	Net Cum. Savings (10^6 $)	Benefit-Cost Ratio
1986	17	17	160	6	18	142	142	8.67
1987	31	48	292	10	34	259	401	8.67
1988	46	94	431	15	50	382	782	8.67
1989	58	152	545	18	63	482	1264	8.67
1990	66	218	618	21	71	547	1811	8.67
1991	64	282	597	20	69	528	2339	8.67
1992	61	343	576	19	66	509	2848	8.67
1993	59	402	556	18	64	492	3340	8.67
1994	57	459	536	17	62	474	3814	8.67
1995	55	514	517	16	60	458	4272	8.67
1996	52	566	487	15	56	431	4703	8.67
1997	50	616	470	14	54	416	5118	8.67
1998	48	664	453	14	52	401	5520	8.67
1999	47	711	438	13	50	387	5907	8.67
2000	45	756	422	12	49	374	6280	8.67

TABLE 16
Appliance Standards Analysis
Gas Ranges - Economic Savings

Year	Value Agg. An. Savings (10^6 $)	Value Cum. An. Savings (10^6 $)	Value Lifetime Savings (10^6 $)	Unit Extra First Cost ($)	Agg. Extra First Cost (10^6 $)	Net Agg. Savings (10^6 $)	Net Cum. Savings (10^6 $)	Benefit-Cost Ratio
1986	11	11	130	11	18	112	112	7.09
1987	11	22	126	11	18	108	220	7.09
1988	10	32	121	10	17	104	324	7.09
1989	10	42	117	10	17	101	425	7.09
1990	10	52	113	9	16	97	522	7.09
1991	9	61	109	9	15	94	616	7.09
1992	9	70	105	8	15	90	707	7.09
1993	9	79	102	8	14	87	794	7.09
1994	8	87	98	7	14	84	878	7.09
1995	8	95	95	7	13	81	960	7.09
1996	8	103	91	7	13	78	1038	7.09
1997	8	111	88	6	12	76	1114	7.09
1998	7	118	85	6	12	73	1187	7.09
1999	7	125	82	6	12	71	1257	7.09
2000	7	132	79	6	11	68	1325	7.09

TABLE 17
Appliance Standards Analysis
Electricity Savings Summary

Product	Savings by 1995 Annual (TWh/yr)	Lifetime (TWh)	Peak (MW)	Savings by 2000 Annual (TWh/yr)	Lifetime (TWh)	Peak (MW)
Refrig	6.83	130	912	13.86	263	1,851
Freezer	1.36	28	178	2.59	54	340
Wat. Ht.	12.64	164	1,559	20.87	271	2,573
Room AC	2.86	43	3,054	4.59	69	4,890
Cent. AC	6.68	80	7,120	11.62	139	12,385
TOTAL	30.37	445	12,823	53.53	796	22,039

TABLE 18
Appliance Standards Analysis
Energy Savings Summary

	Savings by 1995		Savings by 2000	
Product	Annual (TBtu/yr)	Lifetime (Quads)	Annual (TBtu/yr)	Lifetime (Quads)
Refrig	78.55	1.50	159.39	3.02
Freezer	15.64	0.32	29.79	0.62
El. WH	145.36	1.89	240.01	3.12
Room AC	32.89	0.49	52.79	0.79
Cent. AC	76.82	0.92	133.63	1.60
Furnace	68.43	1.57	121.78	2.80
Gas WH	115.04	1.50	190.19	2.47
Gas range	20.51	0.37	31.83	0.57
TOTAL	553.24	8.56	959.40	14.99

TABLE 19
Appliance Standards Analysis
Economic Savings Summary

Product	Savings by 1995 Annual Operation ($10^6 $)	Savings by 1995 Net Lifetime ($10^6 $)	Savings by 1995 Benefit-Cost Ratio	Savings by 2000 Annual Operation ($10^6 $)	Savings by 2000 Net Lifetime ($10^6 $)	Savings by 2000 Benefit-Cost Ratio
Refrig	378	3,216	3.37	670	5,696	3.37
Freezer	76	813	5.88	128	1,358	5.88
El. WH	727	5,989	8.14	1,068	8,798	8.14
Room AC	167	598	1.53	238	854	1.53
Cent. AC	377	537	1.19	582	829	1.19
Furnace	299	1,912	1.90	471	3,010	1.90
Gas WH	514	4,272	8.67	756	6,280	8.67
Gas range	95	960	7.09	132	1,325	7.09
TOTAL	2,633	18,297	2.69	4,045	28,150	3.01

APPENDIX A

REFRIGERATOR AND FREEZER ENERGY CONSERVATION STANDARDS
Effective January 1, 1990

	Energy Standards Equations	For Example Adjusted Volume	kwh/yr
(A) Refrigerators and Refrigerator-Freezers with manual defrost	16.3 AV + 316	12.8	525
(B) Refrigerator-Freezers - partial automatic defrost	21.8 AV + 429	15.2	760
(C) Refrigerator-Freezers - automatic defrost with:			
(i) Top mounted freezer without ice	23.5 AV + 471	20.4	950
(ii) Side mounted freezer without ice	27.7 AV + 488	24.8	1175
(iii) Bottom mounted freezer without ice	27.7 AV + 488	24.8	1175
(iv) Top mounted freezer with through the door ice service	26.4 AV + 535	25.8	1216
(v) Side mounted freezer with through the door ice	30.9 AV + 547	28.4	1425
(D) Upright Freezers with:			
(i) Manual defrost	10.9 AV + 422	26.9	715
(ii) Automatic defrost	16.0 AV + 623	29.8	1100
(E) Chest Freezers and all other freezers	14.8 AV + 223	23.8	575

"AV" is the adjusted volume as defined in the test procedure under Section 323. These standards do not apply to refrigerator-freezers with total refrigerated volume exceeding 39 cubic feet or freezers with total refrigerated volume exceeding 30 cubic feet.

The average energy use for all refrigerators is 976 kwh/yr and for freezers is 671 kwh/yr.

ROOM AIR CONDITIONER STANDARDS
Effective January 1, 1990

Product Class	EER
Without Reverse Cycle and With Louvered Sides	
Less than 6,000 Btu	8.0
6,000 to 7,999 Btu	8.5
8,000 to 13,999 Btu	9.0
14,000 to 19,999 Btu	8.8
20,000 Btu+	8.2
Without Reverse Cycle and Without Louvered Sides	
Less than 6,000 Btu	8.0
6,000 to 7,999 Btu	8.5
8,000 to 13,999 Btu	8.5
14,000 to 19,999 Btu	8.5
20,000 Btu +	8.2
With Reverse Cycle and With Louvered Sides	8.5
With Reverse Cycle, Without Louvered Sides	8.0
AVERAGE: EER	8.6

Earliest date for revised federal standards or state regulation which is granted waivers. -- January 1, 1995.

CENTRAL AIR CONDITIONER AND CENTRAL AIR CONDITIONING HEAT PUMP STANDARDS

Split Systems:	10.0 SEER - Effective January 1, 1992
Single Package Systems:	9.7 SEER - Effective January 1, 1993

Earliest date for revised federal standards or state standards which are granted waiver -- January 1, 1999.

WATER HEATER STANDARDS

Effective January 1, 1990

Gas:	.62 - (.0019) Rated Storage Volume
Oil:	.59 - (.0019) Rated Storage Volume
Electric:	.95 - (.00132) Rated Storage Volume

Earliest date for revised federal standard or state standard which is granted waiver -- January 1, 1995

FURNACE STANDARDS

Effective January 1, 1992, furnaces shall have an AFUE of not less than 78%, except for gas steam boilers which shall have an AFUE of not less than 75% Earliest date for revision or state standards which receive waivers -- January 1, 2002.

Effective January 1, 1990, mobile home furnaces shall have an AFUE of not less than 75%. Earliest date for revision or state standards which receive waivers -- January 1, 1995. The standard for furnaces under 45,000 Btu/hr is to be determined by DOE, within the range of 71-78% AFUE.

DISHWASHER STANDARD

Effective January 1, 1988 dishwashers shall be equipped with an option to dry without heat. Earliest date for revision or state standards which receive waivers -- January 1, 1993.

CLOTHES WASHER STANDARD

Effective January 1, 1988 all rinse cycles shall include unheated water but may have a heated water rinse option. Earliest date for revision or state standards which receive waivers -- January 1, 1993.

CLOTHES DRYER STANDARD

Effective January 1, 1988 clothes dryers shall not be equipped with a constant burning pilot. Earliest date for revision or state standards which receive waivers -- January 1, 1993.

DIRECT HEATING EQUIPMENT STANDARDS

Effective January 1, 1990, efficiencies of gas direct heating equipment shall not be less than the following:

Wall	
Fan Type	
Up to 42,000 Btu/hour	73% AFUE
Over 42,000 Btu/hour	74% AFUE
Gravity Type	
Up to 10,000 Btu/hour	59% AFUE
Over 10,000 Btu/hour up to 12,000 Btu/hour	60% AFUE
Over 12,000 Btu/hour up to 15,000 Btu/hour	61% AFUE
Over 15,000 Btu/hour up to 19,000 Btu/hour	62% AFUE
Over 19,000 Btu/hour up to 27,000 Btu/hour	63% AFUE
Over 27,000 Btu/hour up to 46,000 Btu/hour	64% AFUE
Over 46,000 Btu/hour	65% AFUE
Floor	
Up to 37,000 Btu/hour	56% AFUE
Over 37,000 Btu/hour	57% AFUE
Room	
Up to 18,000 Btu/hour	57% AFUE
Over 18,000 Btu/hour up to 20,000 Btu/hour	58% AFUE
Over 20,000 Btu/hour up to 27,000 Btu/hour	63% AFUE
Over 27,000 Btu/hour up to 46,000 Btu/hour	64% AFUE
Over 46,000 Btu/hour	65% AFUE

Earliest date for revision or state standards which receive waivers -- January 1, 1995.

KITCHEN RANGE AND OVEN STANDARD

Effective January 1, 1990, gas kitchen ranges and ovens having an electrical supply cord shall not be equipped with a constant burning pilot. Earliest possible date for revision or state standards which receive waivers -- January 1, 1995.

POOL HEATERS

Effective January 1, 1990, the thermal efficiency of pool heaters shall not be less than 78%. Earliest date for revision or state standards which receive waivers -- January 1, 1995.