A FIELD COMPARISON OF PERFORMANCE BASED ENERGY EFFICIENT AND CONVENTIONALLY CONSTRUCTED HOMES IN SOUTH TEXAS

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ABSTRACT

The Residential Good ¢ents Program is a program designed to reduce energy use and electrical demand of residences. It was introduced to residential developers and contractors in the Spring of 1983 in the Central Power and Light service area. The program, originally developed at Gulf Power Co., is an energy efficiency designation and implied the inclusion of some or all of ten recommended construction features. Central Power and Light Company's criteria for qualification as a "Good ¢ents Home" requires: 1) proper sizing of the air conditioning equipment through a calculated heat-gain of not more than 12,000 Btu's per 1000 square foot of conditioned space and, 2) the total energy requirement for heating, cooling, and water heating be approximately 50 percent less than a conventionally built home.

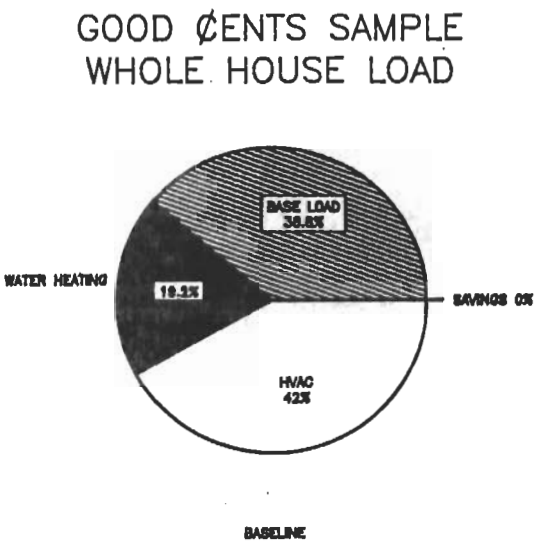
The load data gathered for this study included whole-house HVAC Compressor, HVAC Air handler heating and water heater KWH by a 15 minute interval. The data was gathered using multi-channel magnetic tape recorder, remote sensors and power line carrier end use equipment. All loads presented in this study are on an hourly basis unless otherwise noted. Both energy use and demand are compared for the Good ¢ents and conventional built homes.

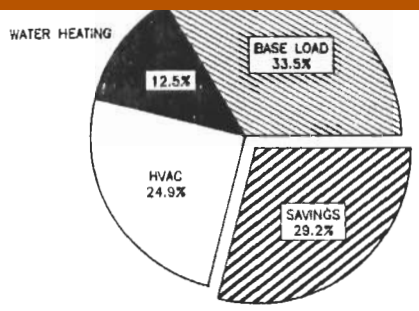
Central Power and Light Company's Good ¢ents Program was designed and implemented to promote increased efficiency in the electrical operating characteristics of new residential homes being constructed for todays market while improving the comfort levels experienced by the customer. To measure the effectiveness of this program, a sample was drawn from the available homes in 1983. A comparison sample was selected from non-Good ¢ents homes to act as a control group.

End use metering was installed to monitor energy consumption on the whole house, HVAC compressor, HVAC air handler heating, and water heaters. Also monitored was the inside and outside temperatures and in most cases a refrigerator/freezer.

Analysis of the available demographics data showed that the good cents home tended to be a larger home. The sample selected averaged 1869 sq. ft. for the good cents and 1613 sq. ft. for the control group.

The coincident demands of the two customer groups, as summarized in Table 1, indicates the program's ability to significantly reduce a customer's demand requirements at the time of the system peak. This demand reduction occurred in 10 of the 12 months in the study and was 2.52 KW and 3.34 KW at the systems summer and winter peaks respectively.



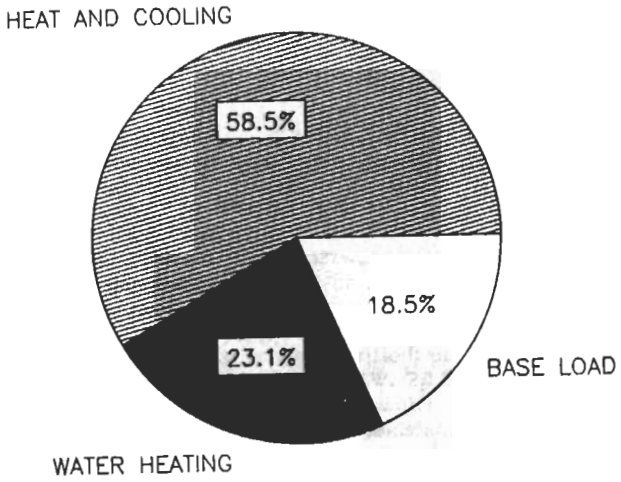


The same trend appears in the maximum diversified demand and the non-coincident maximum demands.

The KWH consumption of the two customer groups (table 2) shows that the good cents construction features reduced the sample's annual energy requirement by 7,146 KWH, representing a 29.2 percent reduction in billed energy. On a per square footage basis this represents a 38.9 percent reduction in required whole house energy. The energy used in heating and cooling was reduced by 65.8 percent and 40.7 percent respectively. The good

cents customer's annual consumption also reflected a savings of 1650 KWH for water heating; thus, the combined energy savings for heating, cooling and water heating were 43.7 percent over the energy required by by the control group.

SOURCE OF GOOD ¢ENTS KWH SAVINGS



SAMPLE DESIGN

The first problem encountered in designing a sample for the Good ¢ents Program was the scarcity of completed units from which to draw the sample. It was determined at the time that a random selection would exclude company districts in which construction activity was slow or newly constructed homes were still unoccupied. Therefore, 16 homes for which monitoring equipment was available would be selected proportionately from each of the six company districts based on the number of customers in the district.

The same procedure was used to select 12 customers for the control group.

Sample Distribution
By District

District	Good ¢ents	Standard Construction
Valley	3	2
Gulf Coast	3	2
Mid Coast	3	2
Corpus Christi	3	2
Winter Garden	2	2
Laredo	2	2
Total	16	12

KW Demand
12 Month Ending May, 1985
Avg. Per Customer

	Jun84	Jul84	Aug84	Sep84	Oct84	Nov84	Dec84	Jan85	Feb85	Mar85	Apr85	May85	12 Mo. Avg.
Coincident Peak KW													
Standard Construction	5.72	5.30	5.15	2.90	2.96	2.68	8.85	8.67	8.47	2.07	1.45	4.99	4.93
Good Cents	3.01	2.83	2.63	2.43	2.68	3.02	5.15	5.33	5.78	1.67	2.57	2.74	3.32
Difference	2.71	2.47	2.52	0.47	0.28	-0.34	3.70	3.34	2.69	0.40	-1.12	2.25	1.61
Max. Group KW													
Standard Construction	5.90	6.28	8.26	6.57	5.11	7.11	8.85	9.73	9.68	4.87	5.27	6.13	6.98
Good Cents	3.95	4.53	4.09	3.73	3.80	3.78	4.81	6.06	6.50	4.39	3.93	3.69	4.44
Difference	1.95	1.75	4.17	2.84	1.31	3.33	4.04	3.67	3.18	0.48	1.34	2.44	2.54
Individual Max. KW(60)													
Standard Construction	10.85	10.73	12.88	11.14	9.33	11.41	11.20	14.94	13.88	10.61	9.35	9.72	11.34
Good Cents	8.62	8.44	8.86	8.68	9.08	8.74	8.64	12.79	11.71	9.27	8.62	8.85	9.36
Difference	2.23	2.29	4.02	2.46	0.25	2.67	2.56	2.15	2.17	1.34	0.73	0.87	1.98

TABLE 1

KWH Consumption
12 Months Ending May, 1985
Avg. Per Customer

	Jun84	Jul84	Aug84	Sep84	Oct84	Nov84	Dec84	Jan85	Feb85	Mar85	Apr85	May85	
Standard Construction													
Whole House	2309.3	2499.0	2482.1	1989.6	1764.0	1591.1	1763.6	2870.0	2226.0	1566.2	1407.1	1995.8	24463.8
HVAC - Compressor	901.0	1269.9	1237.1	748.3	521.5	173.2	143.7	135.9	102.5	140.3	224.6	642.2	6240.2
HVAC - Air Handler	129.5	156.8	192.6	90.6	79.9	232.7	298.1	1532.3	1040.4	141.9	43.2	94.5	4032.5
Water Heating	290.8	308.9	326.6	306.9	354.9	377.2	435.3	544.7	462.6	488.5	408.1	383.4	4687.9
Base Load Per Customer	988.0	763.4	725.8	843.8	807.7	808.0	886.5	657.1	620.5	795.5	731.2	875.7	9503.2
Good Cents Construction													
Whole House	1583.7	1687.6	1731.4	1373.9	1385.6	1117.3	1192.1	1776.7	1488.8	1245.7	1286.5	1448.5	17317.8
HVAC - Compressor	516.7	703.8	774.0	489.7	340.7	150.1	162.1	364.4	278.4	152.4	269.6	476.9	4678.8
HVAC - Air Handler	124.3	135.0	173.9	141.8	91.3	68.3	50.6	247.5	173.8	47.9	67.6	95.3	1417.3
Water Heating	132.1	213.7	168.5	153.9	205.2	301.8	306.4	358.6	342.1	339.7	287.8	228.2	3038.0
Base Load Per Customer	810.6	635.1	615.0	588.5	748.4	597.1	673.0	806.2	694.5	705.7	661.5	648.1	8183.7

TABLE 2

GOOD CENTS
KWH CONSUMPTION BILLED
12 MONTHS ENDING MAY, 1985

CUST ID *******	MAY85 *****	APR85 *****	MAR85 *****	FEB85 *****	JAN85 *****	DEC84 *****	NOV84 *****	OCT84 *****	SEP84 *****	AUG84 *****	JUL84 *****	JUN84 *****	12 MOS. E 5/85 ******
1J111	1890	1958	2026	1657	1953	1844	1592	1410	1654	1628	1829	1707	21148
1J112	2217	1868	1912	2239	2865	2017	1912	1935	2584	2290	2460	2090	26389
1J113	1018	1023	1439	1528	994	1001	1077	1471	1373	1651	1305	1198	15078
1J215	2636	2099	2266	2716	1949	2503	2423	2257	3271	3090	2812	2237	30259
1J216	1072	1913	2467	1561	1230	1460	1670	2095	1818	2027	1431	1286	20030
1J317	1079	1138	1593	1689	951	1406	1467	1627	1521	1507	1387	1266	16631
1J318	1758	1232	1006	2051	1654	1320	1090	1411	1828	1744	1826	1574	18494
1J319	1767	1469	2094	1982	1411	1307	1540	2082	2102	2610	2238	1794	22396
1J520	920	516	875	1277	1000	951	745	648	1402	1311	1876	1091	12612
1J521	784	903	719	1295	1032	809	888	1010	1079	1082	870	1046	11517
1J522	678	529	674	1186	815	606	975	1295	1369	1007	1009	624	10767
1J623	988	970	1344	1723	1183	1152	1108	1293	1525	1766	2129	736	15917
1J624	1102	1108	893	1412	1561	1124	773	816	1200	1063	1295	1035	13382
1J725	738	595	937	1005	834	671	721	1042	1002	1129	1000	972	10646
AVG/CUS	1332	1237	1446	1666	1388	1298	1284	1457	1695	1708	1676	1333	17519

BASELINE
KWH CONSUMPTION BILLED
12 MONTHS ENDING MAY, 1985

CUST ID *******	MAY85 *****	APR85 *****	MAR85 *****	FEB85 *****	JAN85 *****	DEC84 *****	NOV84 *****	OCT84 *****	SEP84 *****	AUG84 *****	JUL84 *****	JUN84 *****	12 MOS. E 5/85 ******
1J151	1054	1200	2002	2405	1240	1114	1136	1656	1772	2583	1866	1788	19816
1J152	2631	1900	2379	2578	2554	2560	2462	2371	2884	2300	2831	3371	30821
1J253	1654	1620	3175	4204	2085	1928	2328	2630	2839	3386	3033	2831	31713
1J254	2162	1798	1932	2038	2360	2078	1779	2234	2421	2776	2725	3042	27345
1J355	770	996	3039	3036	1439	1019	1250	1871	1904	2220	1829	1265	20638
1J356	2147	2529	3730	4068	2531	2411	2324	2803	3477	3521	2850	2595	34986
1J557	1572	1196	1062	1800	1885	1170	1393	1451	2136	1904	2658	1916	20143
1J558	1336	1252	1709	2812	1573	2693	1355	1659	2537	2248	2483	2316	23973
1J659	851	543	1153	2703	1314	1334	1189	1315	1692	1144	1156	1215	15609
1J660	1003	1143	1929	2418	1519	1539	1361	2048	1729	2459	1938	1941	21027
1J761	1898	1668	1956	3239	2119	1749	2029	2376	2873	2547	2767	2416	27637
1J762	1416	1730	1893	2855	2059	1822	1342	1387	2407	2118	1586	1473	22088
AVG/CUS	1541	1465	2163	2846	1890	1785	1662	1983	2389	2434	2310	2181	24650

TABLE 3

STUDY RESULTS

The average whole house billed energy use for the 12 months ending May 1985 was 17,519 KWH versus 17,318 KWH recorded by the test equipment. This is 29.2 percent less than the 24,464 KWH for the baseline group without adjustment for the difference in square footage of conditioned space.

The lowest individual annual usage billed was 10,646 KWH and the highest was 30,259 KWH (Table 3.) This represents a range of 39.2 percent below and 72.7 percent above the group average of 17,519 KWH. Table 2 contains the average use by calendar month and average use by major end-use category.

The maximum diversified demand for the group averaged 6.5 KW and occurred at 9:00 a.m. on February 2, 1985. The weighted system average temperature was 33°F on that day. The baseline group peaked at 10:00 a.m. on January 20, 1985 with an average of 9.73 KW. The system weighted average temperature on that day was 33.6°F. The difference between the average maximum demands is 3.23 KW or 33 percent below that of the baseline group.

The average individual (non-diversified) peak demand for the good cents homes was 12.79 KW, 2.15 KW less than the average for the baseline group which occurred in the same month. This peak demand yields an annual group coincidence factor of 38.2 percent for the good cents customer and 51.3 percent for the control group.

Analysis of the relationship between study's energy and demands yields an annual load factor for the good cents group of 30.8 percent and 28.7 percent for the control group. The average individual load factors are 15.5 percent for good cents and 18.7 percent for the control group indicating that while the Good ¢ents Program reduces KWH more than the individual's maximum demand, it also produces increased diversity among the Good ¢ents customers.

The maximum one-hour demand for the system during the study period occured on August 20, 1984 at 4:00 p.m. The whole house demand of the good cents sample was 2.63 KW versus 5.15 KW for the control group, a difference of 2.52 KW. These coincident peak demands yield load factors of 75.2 percent for the good cents sample and 54.2 percent for the control group.

HVAC RESULTS

The average HVAC energy used for the test period was 6,096 KWH or 35.2 percent of the total consumption. This is 4,178 KWH or 40.7 percent less than the 10,274 KWH by the control group. Approximately 4820 KWH of the HVAC total was used for cooling and the remaining 1276 KWH or 20.9 percent was used for heating. Table 2 shows the monthly energy consumption by the HVAC system.

The average HVAC demand at the time of the system peak was 2.01 KW or 76 percent of the total contribution to system peak for the good cents sample. The control group's HVAC contributed 3.40 KW or 66 percent of the total. This reflects a reduction of 1.39 KW in HVAC demand or 41 percent. The Good ¢ents HVAC Compressor non-diversified demand averaged 2.59 KW for a diversity factor of 68 percent at the time of system peak and the control group non-diversified demand was 3.82 KW for a diversity factor of 81 percent.

At the time of the Systems winter peak, January 21, 1985 at 8:00 a.m., the good cents customer's HVAC System contributed 3.06 KW compared to 5.93 KW for the control group, a reduction of 48 percent.

The average good cents customer's HVAC non-diversified demand for January 1985 was 8.72 KW versus 10.51 KW for the control group. This represents 68 percent and 70 percent of the winter maximum demand for the good cents and control group respectively.

ANNUAL ENERGY CONSUMPTION

As A Percent of Whole House

(Average per customer)

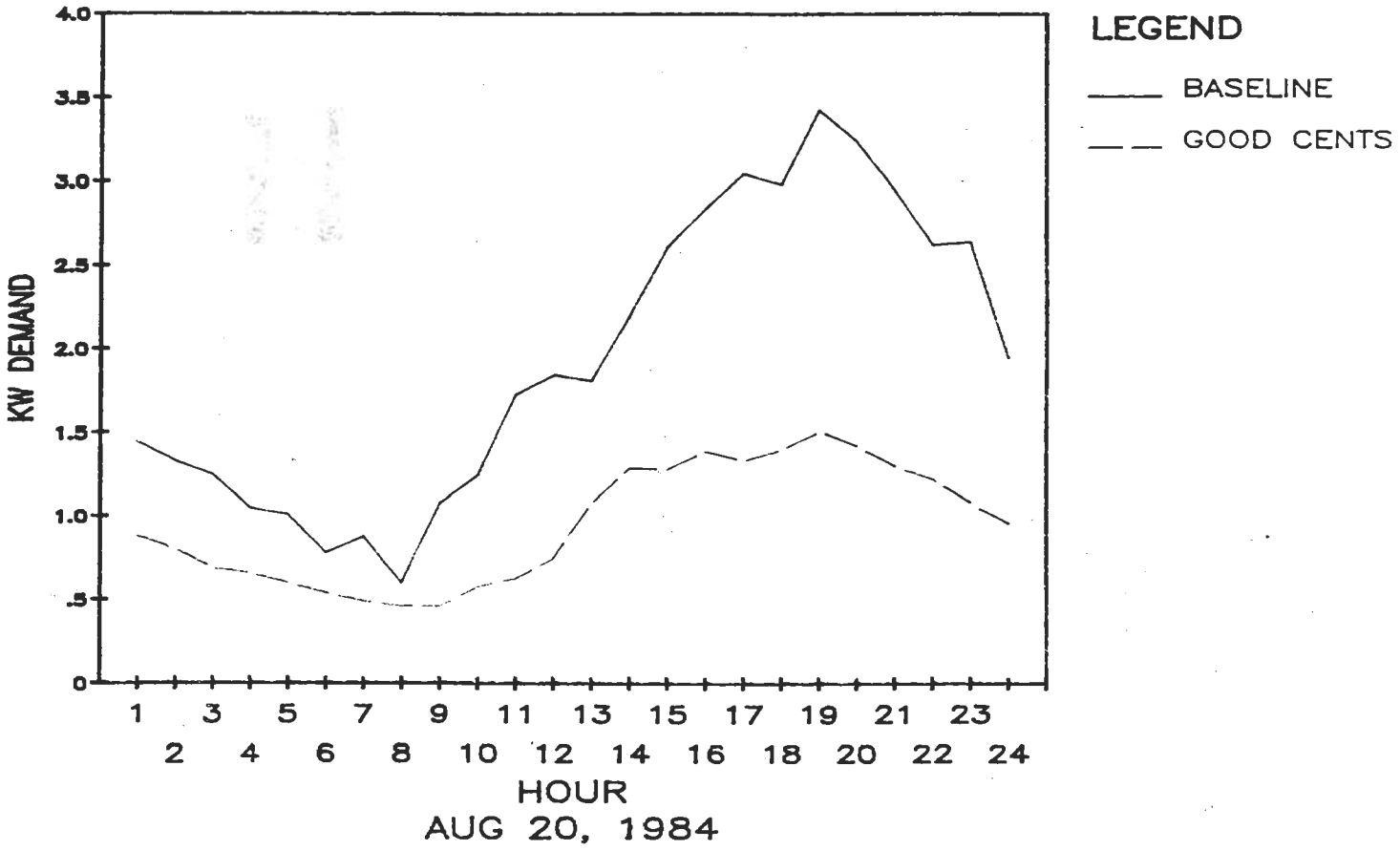
	Good ¢ents	Baseline	Diff. (KWH)	%Reduction over baseline
Whole House	100%	100%	7146	29.2%
HVAC				
Cooling	27.8%	28.7%	2202	31.4%
Heating	7.4%	13.3%	1976	60.7%
Water Heating	17.5%	19.2%	1650	35.2%

HEATING & COOLING LOAD

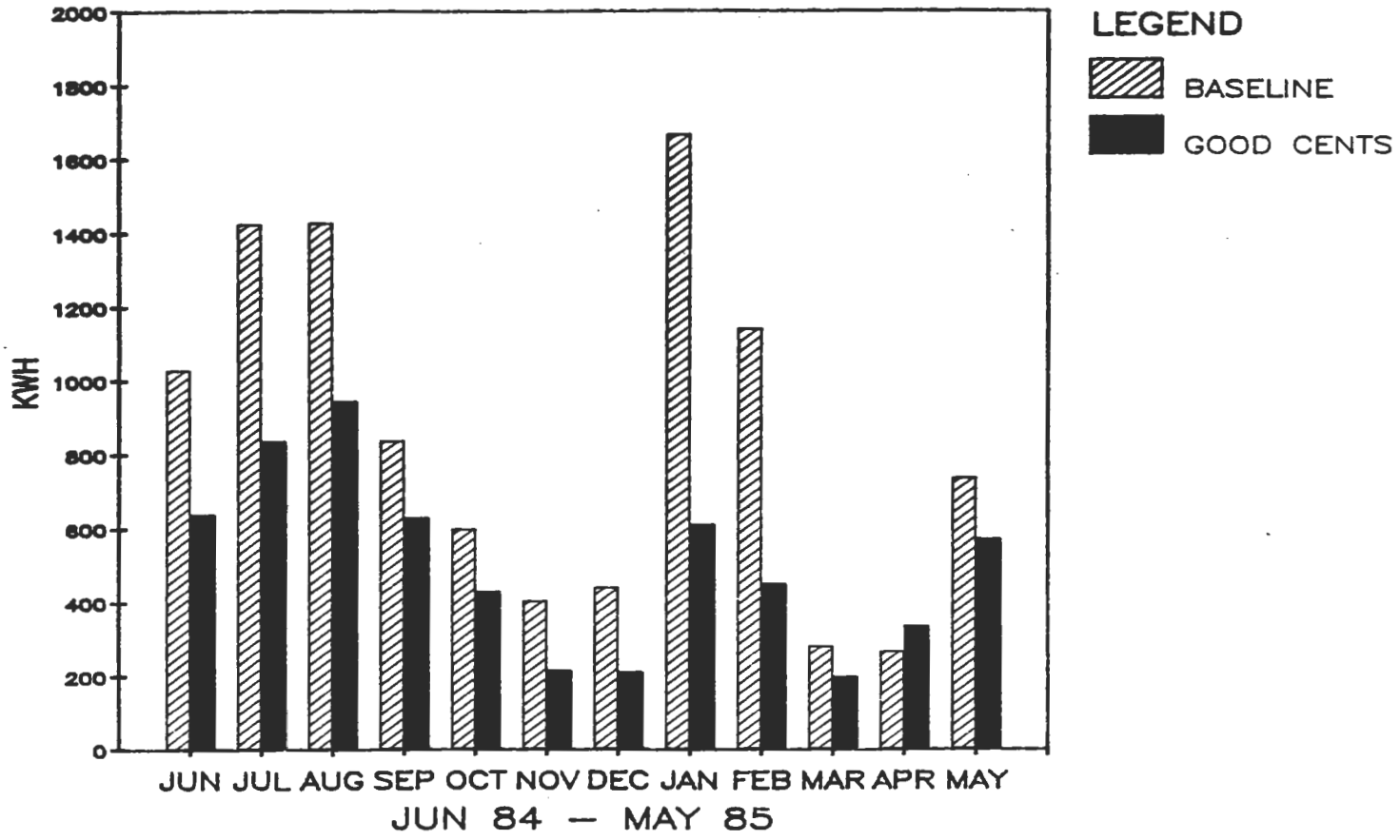
Annual KWH Per Square-Foot

	Good ¢ents	Baseline	Diff. (KWH)	%Reduction over baseline
Whole House	9.27	15.17	5.90	38.9%
HVAC				
Cooling	2.58	4.35	1.77	40.7%
Heating	.69	2.02	1.33	65.8%
Combined	3.27	6.37	3.10	48.7%

HVAC LOAD PROFILE
FOR SYSTEM SUMMER PEAK DAY



COMPARISION OF HVAC KWH CONSUMPTION BY MONTH



WATER HEATING

The energy required for water heating was 3038 KWH for the average good cents customer. This was 1650 KWH less than the 4688 KWH required by the average baseline customer. Water heating KWH expressed as a percentage of total KWH consumption was relatively the same for both groups: 17.5 percent and 19.2 percent for the good cents customer and baseline customer respectively. The difference of 1650 KWH can be primarily attributed to:

1) placement of the water heater closer to the point of use,

2) the inclusion of heat recovery devices on 4 of the good cents customers,

3) the water heater heat pump installed at one location.

These consumption levels are in line with a previous end-use study of electric water heating (Residential Electric Water Heating For the 12 months ending 4/30/84 dated 6/5/84). That study found that 17.6 percent of the customer's annual consumption was for water heating, and averaged 3768 KWH. It is interesting to note, that the average consumption for the good cents and baseline samples was 3800 KWH which is close to the previous study results.

As expected, the non-coincident demands for the baseline sample was equal to the rated element wattage of 4.5 KW, while the good cents sample averaged 3.64 KW.

The contribution to the January 1985 system peak was 1.92 KW for the baseline and .80 for the good cents group. The contribution to the August 20, 1984 System peak was .66 KW for the baseline and .10 KW for the good cents sample yielding an annual load factor based on summer CP demand of 81.08 percent for baseline and in excess of 100 percent for the good cents customer.

CONCLUSION

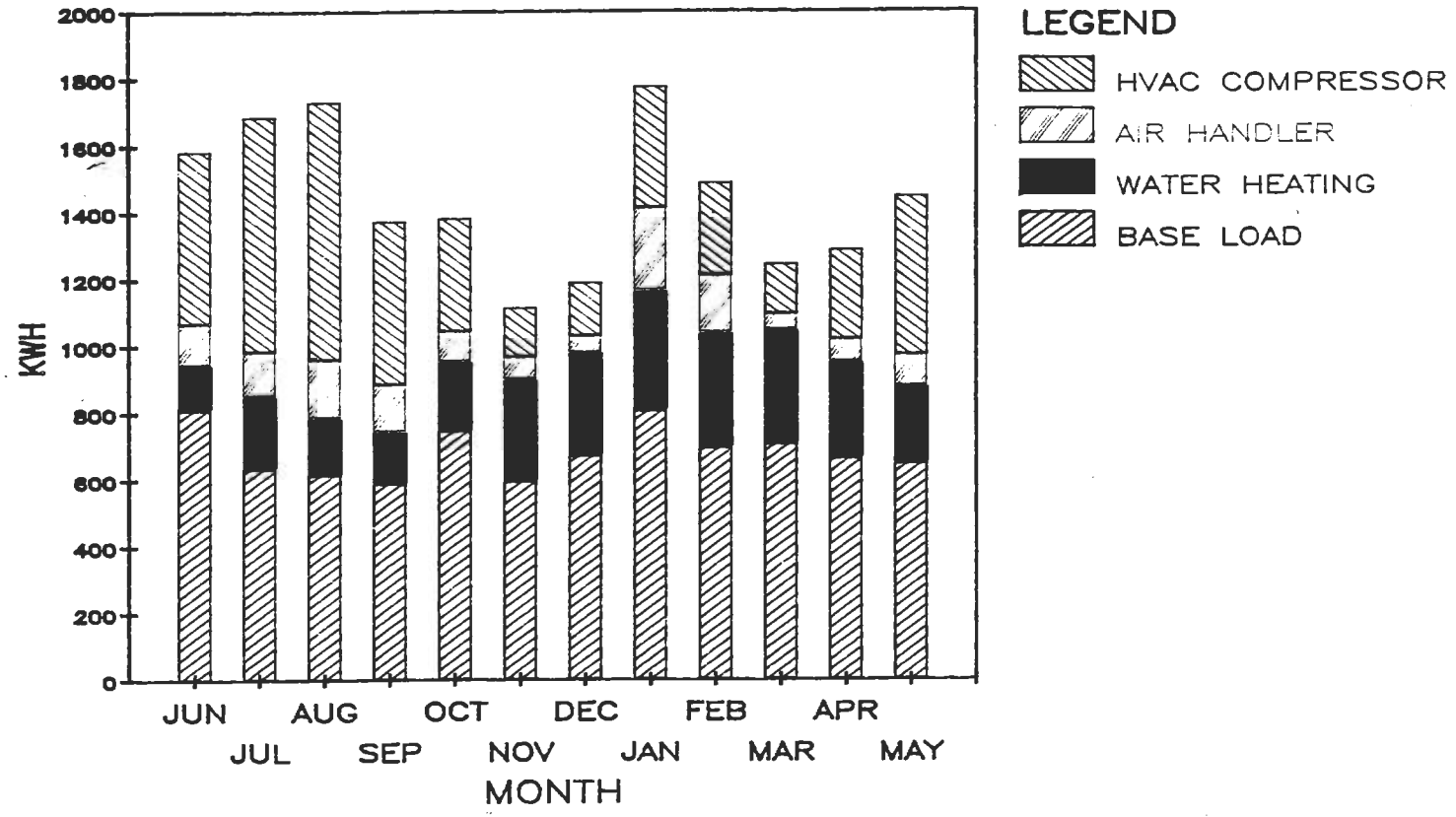
The quality of construction and proper sizing of air conditioning equipment in the good cents home significantly reduced the heating and cooling requirements compared to the conventionally built all electric home. The data shows a 49 percent reduction in total HVAC energy use and a reduction in whole house energy use of 29.2 percent.

A similar reduction occurred in the demand requirements with a 33 percent decrease in maximum diversified demand (whole house) and a 49 percent reduction in demand coincident with the company's summer peak.

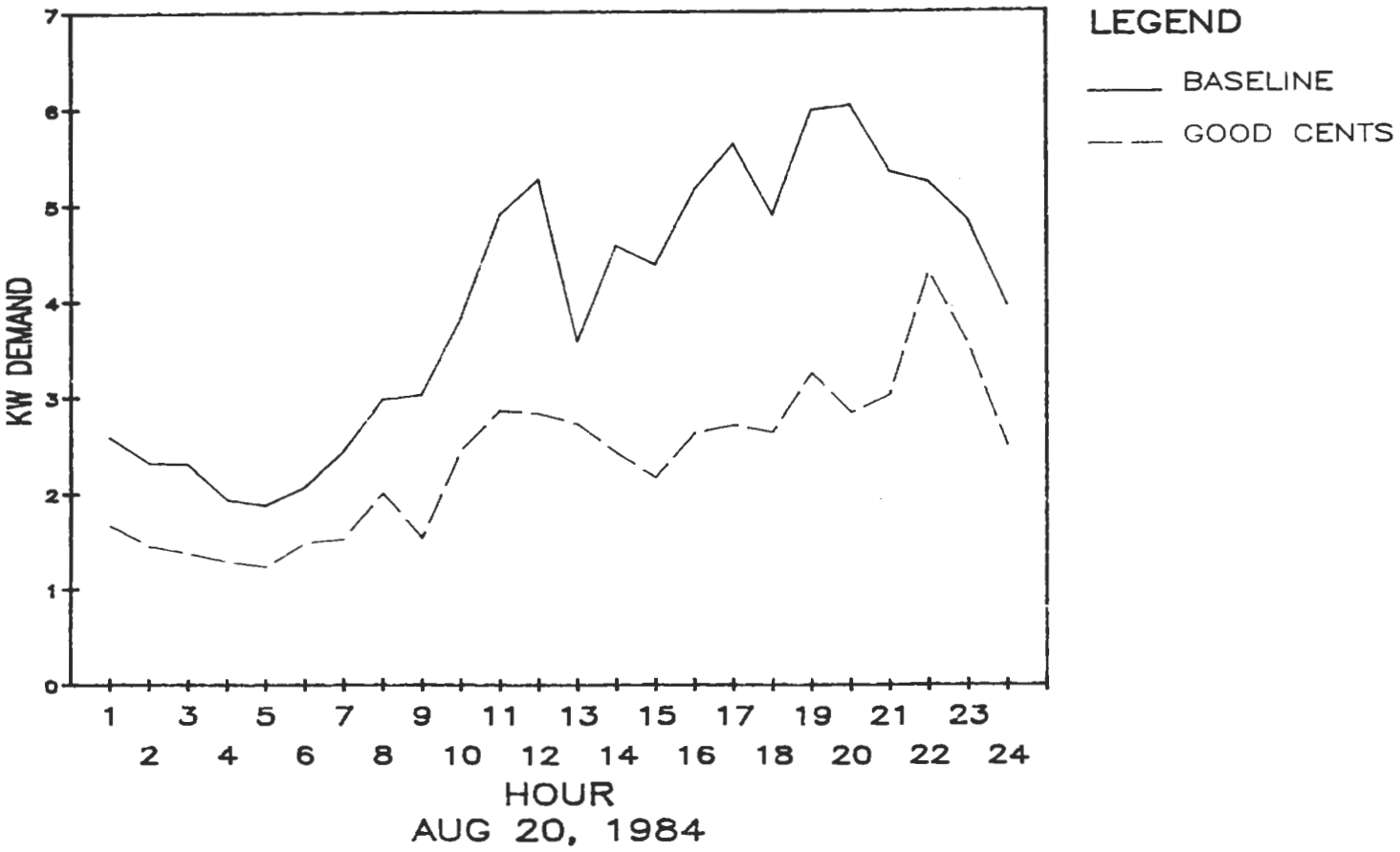
The reduction is both energy and peak demand resulted in a two percent increase in an annual group load factor for the good cents customer from 28.7 percent to 30.4 percent.

Since the start of this study, the program has been well accepted in the market place; and a large number of good cents homes have been or are currently being built. Continued research with a larger sample is planned for the calendar year 1986.

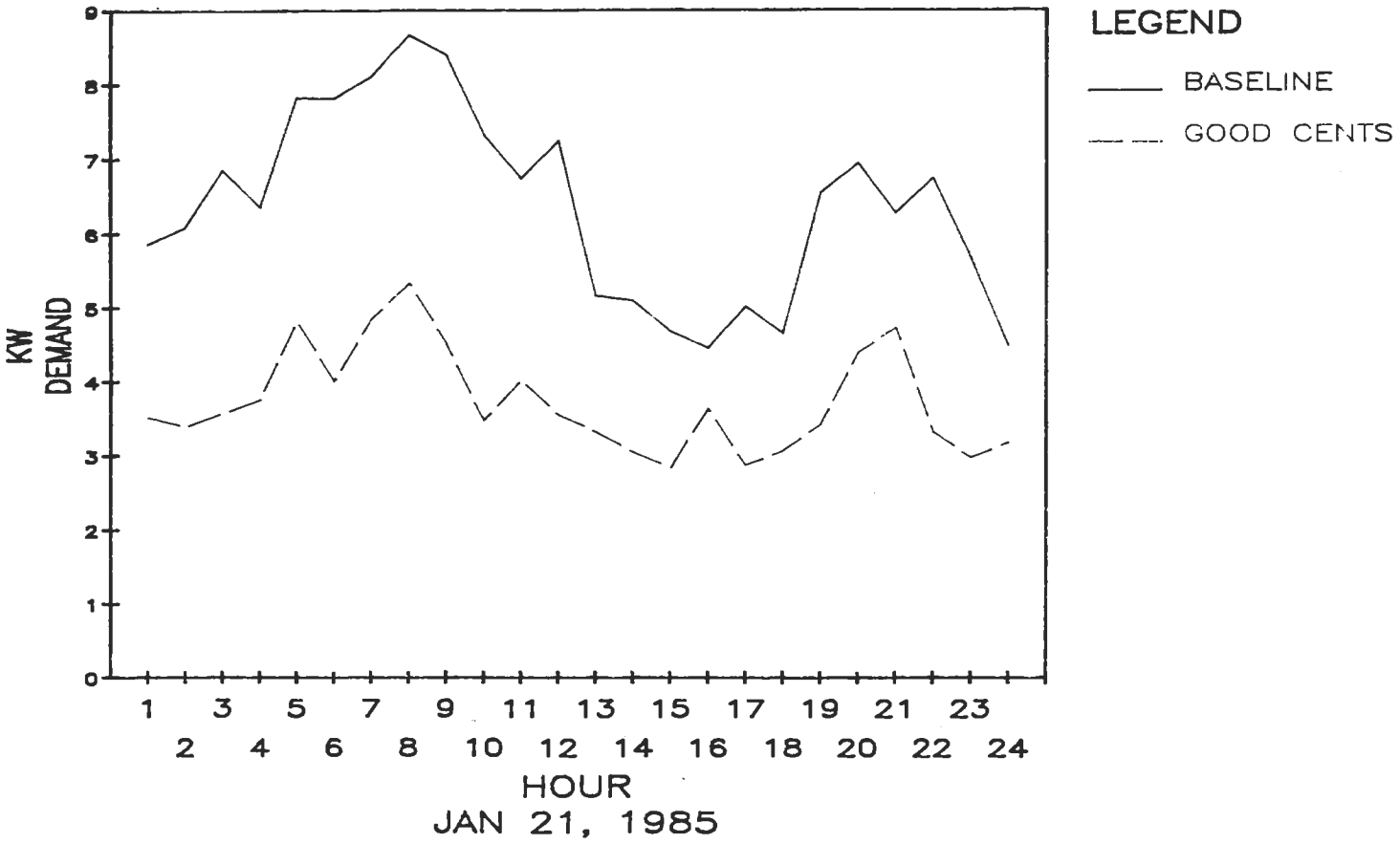
GOOD CENTS CUSTOMER
MONTHLY KWH CONSUMPTION
BY END USE



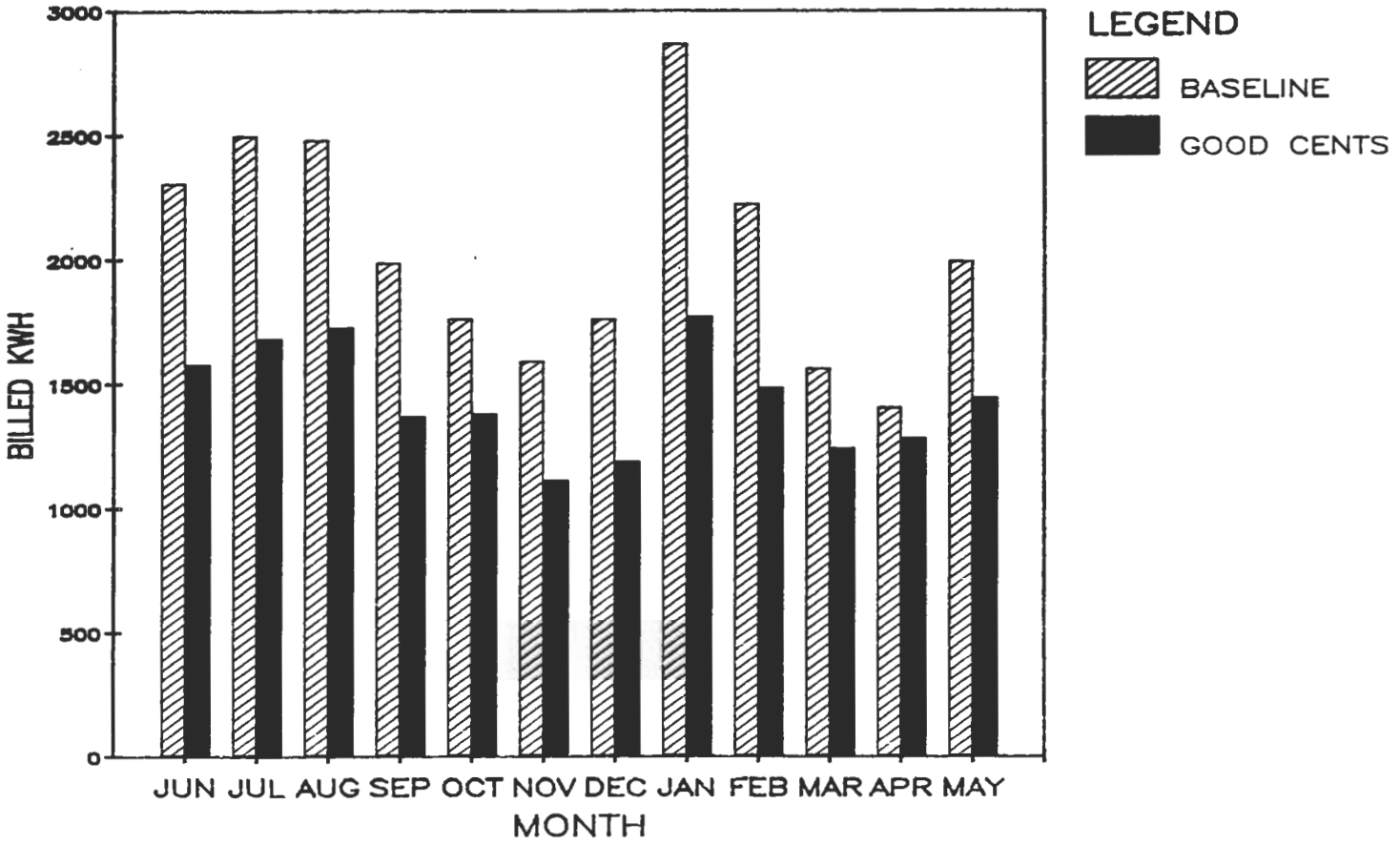
SUMMER SYSTEM PEAK DAY
WHOLE HOUSE LOAD



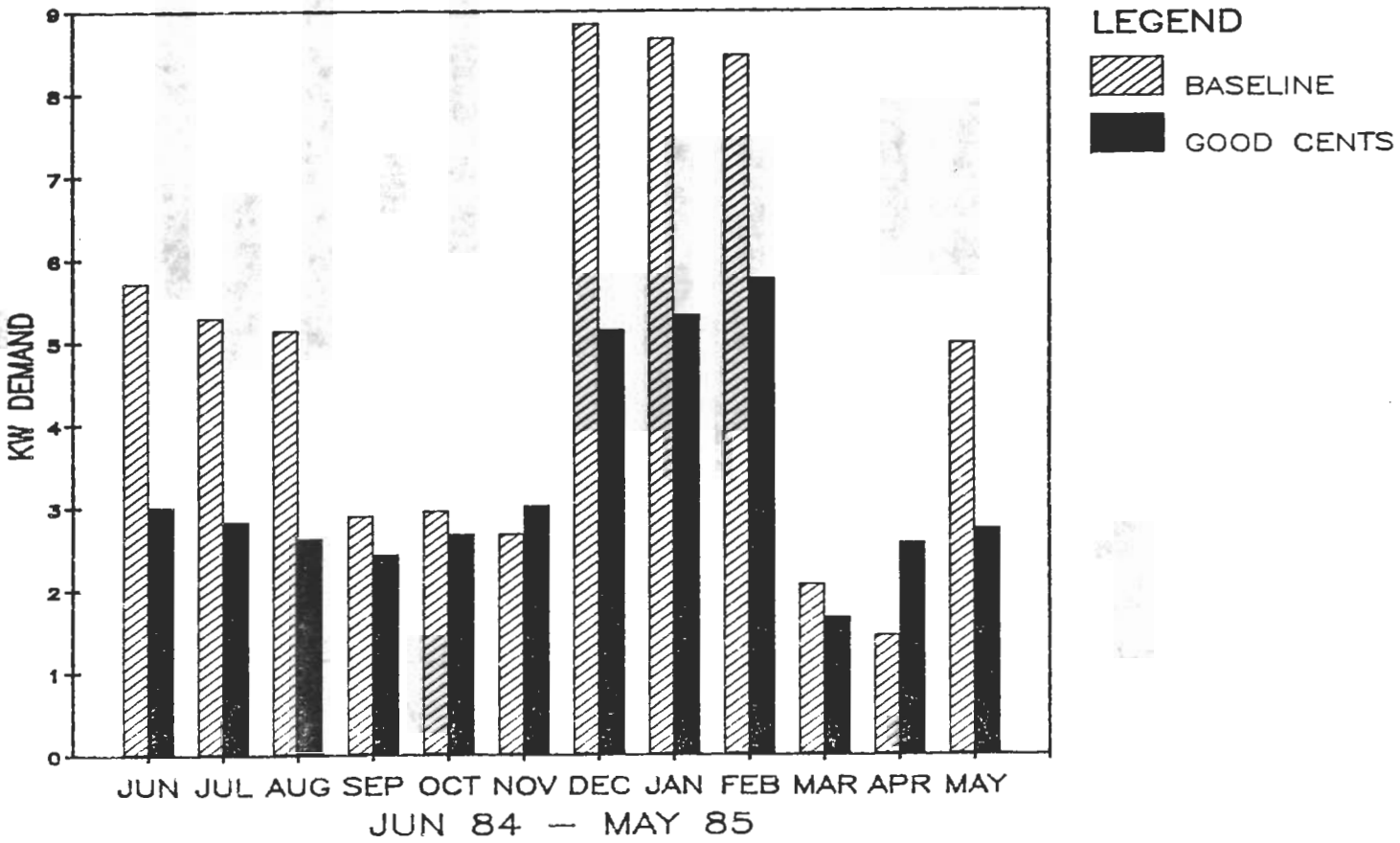
WINTER SYSTEM PEAK DAY
WHOLE HOUSE LOAD



MONTHLY KWH CONSUMPTION
AVG / CUSTOMER



MONTHLY COINCIDENT DEMANDS
AVG / CUSTOMER



MONTHLY MAXIMUM DEMANDS
AVG / CUSTOMER