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An Evaluation of the *Good Cents*? Program in College Station, Texas

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This study is an evaluation of an energy-efficiency program sponsored by College Station, Texas, called the *Good Cents*? Program. The *Good Cents* Program is designed to encourage builders to build more energy-efficient homes. One difficulty with evaluating this type of program is that energy use not related to outdoor air temperature introduces a large amount of unexplained variability into total energy use. This study uses a statistical method that separates energy related to outdoor temperature from energy not related to outdoor temperature. Three-parameter models have proven to be very useful in modeling residential energy use. This study uses parameter estimates of three-parameter models to compare a treatment group of *Good Cents* houses to a control group of non-*Good Cents* houses. Parameters used are cooling slope, heating slope, and Normalized Annual Consumption (NAC).

Key Words: Energy, Good Cents? Program, Residential, and Statistics

Background

Utility companies are in the process of shifting emphasis from the production of energy to a more comprehensive strategy of managing energy resources. Utility companies are encouraging their customers to be more energy efficient. It may appear to be counterintuitive for a supplier to advocate efficient use of the product it sells (in this case, electricity). This is partly due to the monopoly status enjoyed by many utility companies. In return for this status, utility commissions require electricity providers to install and maintain the infrastructure to cope with extreme power demands. This means that under average conditions the utility's infrastructure is not operating at full capacity. This does not optimize the industry's potential for making profits. Moreover, the construction of new power plants has become exorbitantly expensive. Utility companies are interested in reducing the rate of demand—not total consumption. This is consistent with the original vision of Thomas Edison. As the inventor of both the generating plant and the light bulb, he understood the importance of efficient generation and conversion. Today, many utility companies are once again taking interest in the efficient conversion of energy to specific uses and are considering a more comprehensive approach to their business activities. This comprehensive strategy is called Integrated Resource Planning (IRP).

Integrated Resource Planning involves both the supply and demand of energy resources. The supply side of the energy business has reached a state of great efficiency. On the other hand, the demand side of the energy business remains relatively inefficient. It is ironic that the word utility implies the practical use of energy rather than the production of energy. But utilities are changing their concept of what services they can and should provide. Encouraged by increased demand

and the increasing cost of production, utility companies are beginning to address the second half of Edison’s vision? the efficient and profitable use of energy.

Strategies that encourage more efficient utilization of energy are called Demand Side Management (DSM). The popularity of DSM is growing. Utilities are projecting expenditures of $23 billion on DSM programs by the year 2000 (Southerland, 1994). DSM programs may be classified into two types-energy-efficiency programs and market transformation programs. Residential energy efficiency programs offer a variety of services to individual customers, such as energy audits, weatherization, rebates, or low-interest loans. Market-transformation programs differ from energy-efficiency programs in that they attempt to influence an entire industry rather than individual customers. A good example is the EPA Energy Star program that allows participating companies to identify their computer equipment with the program logo. Another good example is the Good Cents Program, which offers rebates to homebuilders for each new house that meets program criteria.

The Good Cents Program was developed by the electric utility industry (Homebuyer’s Guide). Although national in scope, it is adopted locally. Each local utility company has a good deal of autonomy in establishing program criteria and how the program is administered. The Good Cents Program of College Station, Texas has adopted both descriptive and performance criteria. Typical descriptive criteria are minimum insulation requirements, double-glazed windows, minimum equipment efficiency, and maximum equipment capacity; performance criteria consist of a blower-door test and estimated heat gain.

The federal government, many public utility commissions, and conservationists are supporting Integrated Resource Planning and Demand Side Management in an effort to make conservation programs competitive with energy supply alternatives. However, some people question the means that are currently being used to evaluate the true costs of energy-efficiency programs (Jaskow & Marron, 1993). Jaskow and Marron claim that savings estimates for many utility programs have not been subject to rigorous, empirical examination in real, representative settings.

The Problem

A direct and logical method to evaluate the effectiveness of the Good Cents Program would be to compare the total energy used by a treatment group of houses with the total energy used by a control group of houses. The treatment group would consist of houses approved by the Program; the control group would consist of houses not approved by the Program. If the total energy used by the treatment group is significantly less than the total energy used by the control group, this should indicate that the Program is indeed effective. There is only one problem with this method-miscellaneous energy use.

Miscellaneous energy use is energy that is not related to outdoor air temperature. This category of energy use is highly correlated to occupant behavior. The efficiency of the house, on the other hand, is highly correlated to the materials and workmanship of the structure and the efficiency of the heating and cooling equipment. The efficiency of the house is the target of the *Good Cents*

Program. Research has shown that miscellaneous energy use can constitute from 20 to 80 percent of the total electricity consumption for a typical modern house (Goldstein, Schneider & Clarke, 1985; Meier, Rainer & Greenburg, 1992; and Pettersen, 1994). Therefore, in order to effectively compare the energy efficiency of two experimental groups, it is necessary to separate out energy use that is related to outdoor air temperature from total energy use. Otherwise, miscellaneous energy use will mask or overwhelm any difference that is due to the energy efficiency of the houses.

The Study

This is an *Ex Post Facto* correlation study. The study was designed to take advantage of available data. Two types of data that are readily available are daily temperature readings and monthly billing statements. Daily temperature readings are available from the local weather station, and monthly billing statements are available from the local utility company. Houses included in the study were selected by a two-step process. In order to qualify for the study, houses had to be detached single-family and must have been built after 1989, the onset of the *Good Cents* Program. The population of the treatment group included every house approved by the Program. The population of the control group included every house issued a building permit from 1990 to 1993 with the houses approved by the Program removed. All houses in the study are cooled with electricity and heated with natural gas. A random sample of 100 houses was selected from the population of each group using a random number table. The final selection of houses was based on the following criteria: All houses must have had the same residents for the study period, and they must have had a minimum of twelve consecutive months of utility data. The final number of houses for each group is 71. Color photographs were taken of every house in the study. These were used to visually compare houses between the treatment group and the control group. Floor area, land value, value of improvements, and total value for each house were collected from the county tax appraiser. These statistics were used to compare the two experimental groups.

In order to separate energy use related to air temperature from energy use not related to outdoor air temperature, spline regression is used to construct three-parameter models for both cooling and heating. The three parameters are cooling or heating slope, base load, and change point. When using three-parameter models, the slope of the base load is assumed to be zero. The cooling and heating models are defined by the following equations:

$$\text{KWhday} = \text{alpha } 1 + \text{beta } 1 * \max(\text{Tavg} - \text{Tcool}, 0) \quad (1)$$
$$\text{Gasday} = \text{alpha } 2 + \text{beta } 2 * \min(\text{Tavg} - \text{Theat}, 0) \quad (2)$$

Where kWh = estimated electric energy used per day, gasday = estimated gas energy used per day, alpha 1 = cooling intercept, alpha 2 = heating intercept, beta 1 = cooling slope, beta 2 = heating slope, Tavg = average billing period temperature, Tcool = cooling change point, and Theat = heating change point.

The cooling or heating slope is a ratio of energy consumption per day to the average billing period temperature. This is sometimes called the cooling or heating efficiency. These two variables are used to compare the thermal efficiency of houses in the two experimental groups. A more sophisticated variable of efficiency is Normalized Annual Consumption (NAC). This is determined by multiplying the cooling or heating slope times an average or "normalized" monthly temperature for an extended period - in this case, thirty years. Normalized Annual Consumption is especially valuable in retrofit studies when it is necessary to adjust for the weather. Research has shown that NAC is a robust and reliable indicator of energy efficiency (Fels, 1986; Stram & Fels, 1986).

Estimating change points is the most difficult procedure in constructing three-parameter models. For this study, a suite of statistical applications called Statistical Analysis System (SAS) was used. Four separate procedures in SAS were used to construct the final models. The four procedures and their output are listed below:

1. Average
   - Calculates the number of days in each billing period
   - Calculates average billing period temperature
   - Plots temperature vs. energy consumption
   - Change points are estimated visually by the researcher
2. Initial Regression
   - Calculates parameter estimates
   - Plots residuals
   - Plots predicted values
3. Iteration
   - Estimates change points more precisely by minimizing the sum of the squared residuals
4. Second Regression
   - Adjusts parameter estimates for new change points
   - Plots residuals
   - Plots predicted values

Results

Figure 1 shows a typical three-parameter model for cooling; Figure 2 shows a typical three-parameter model for heating. The units of the heating model have been converted from cubic feet of gas to kWh so both models can be expressed in consistent units. The cooling or electricity models typically have twenty-three data points; the heating or gas models typically have thirteen data points. Of course, when using least squares regression, more data points provide a more accurate trend line. The R-square value (coefficient of determination) for the model in Figure 1 is 0.92; the R-square value for the model in Figure 2 is 0.51. The R-square values reinforce what is visually obvious: The electric model is a better estimator of energy consumption. The cooling change point is 66? F and the heating change point is 84? F. The cooling change point is the average billing period temperature at which cooling begins, and the heating change point is the average billing period temperature at which heating begins. The cooling change point appears to be reasonable; the heating change point appears to be too high. One reason why the heating change points are consistently too high is that the assumption that the slope of the base load be zero may be incorrect. The gas base load may be slightly related to outdoor air temperature. A comprehensive review of the plots indicated that this might indeed be the case. Water heating is a primary component of gas consumption. Two reasons why gas usage may be seasonally related are that people tend to take more hot showers in the winter, and colder ground temperatures lowers the temperature of water delivered to water heater. A four-parameter model may be more appropriate for the heating data. (See Figure 3.)

An examination of the photographs of the houses revealed no striking or consistent differences between the two groups. The predominate color of the roof shingles is a light gray; a few are light brown. All of the houses have continuous ridge vents. No turbine ventilators can be seen. All have a brick veneer. Trees and landscaping vary considerably between houses but not between groups. There were no significant differences between the mean floor areas or values of the two groups.

Table 1

SAS Parameter Estimates--Treatment Group

Parameter	units	mean	std dev	max	min	median
T-cool	degrees F	67.8	2.8	76.5	56.7	67.7
T-heat	degrees F	79.1	3.9	91.2	72.7	78.7
B1(cooling slope)	kWh/deg F	2.5	0.7	4.3	1.3	2.5
B2(heating slope)	kWh/deg F	-3.0	1.7	-0.5	-12.8	-2.8
Cooling base	kWh	27.6	12.5	63.2	6.4	24.4
Heating base	kWh	20.2	9.1	43.3	1.7	17.4

Table 2

SAS Parameter Estimates—Control Group

Parameter	units	mean	std dev	max	min	median
T-cool	degrees F	68.6	2.7	77.5	63.0	68.6
T-heat	degrees F	78.7	3.7	87.6	62.1	79.1
B1(cooling slope)	kWh/deg F	2.3	0.8	5.1	0.9	2.1
B2(heating slope)	kWh/deg F	-3.2	2.6	-0.2	-21.9	-2.8
Cooling base	kWh	27.7	18.6	152.2	9.2	23.2
Heating base	kWh	15.6	7.6	36.7	3.3	14.0

Table 3

Comparison Tests

Parameter	P-value	Test
T-cool	0.106	t-test
T-heat	0.611	t-test
B1	0.059	MWRST
B2	0.554	MWRST
Cooling base	0.524	MWRST
Heating base	0.002	MWRST

MWRST = Mann-Whitney Rank Sum Test

A simple t-test and the Mann-Whitney Rank Sum Test were used to compare data between the Good Cents houses and the non-Good Cents houses.

Table 4

SAS Normalized Annual Consumption--Treatment Group

Parameter	units	mean	std dev	max	min	median
E-cool	kWh	5,033	1,837	9,621	1,659	5,049
E-base	kWh	10,088	4,570	23,070	2,353	8,906
E-base%	%	66	8	82	44	65
G-heat	kWh	13,288	9,183	74,368	2,484	11,548
G-base	kWh	7,381	3,317	15,816	636	6,361
G-base%	%	37	12	73	14	37
Total	kWh	35,790	14,604	116,130	7,524	33,173

Table 5

SAS Normalized Annual Consumption—Control Group

Parameter	units	mean	std dev	max	min	median
E-cool	kWh	4,279	1,811	9,532	1,250	3,865
E-base	kWh	10,105	6,789	55,599	3,368	8,480
E-base%	%	69	9	89	41	69
G-heat	kWh	13,114	5,772	31,005	1,634	11,806
G-base	kWh	5,700	2,790	13,388	1,212	5,099
G-base%	%	31	12	76	7	30
Total	kWh	33,198	13,033	101,088	15,925	30,303

Table 6

Comparison Tests--Mann-Whitney Rank Sum Test

Parameter	P-value
E-cool	0.004
E-base	0.524
G-heat	0.636
G-base	0.002
Total	0.112

The following results are based on a significance level of 0.05:

- There is no significant difference between the mean cooling slopes (B1, Table 3).
- There is no significant difference between the mean heating slopes (B2, Table 3).
- There is a significant difference between the mean cooling NAC (E-cool, Table 6) However, please note that this statistic is *higher* for the treatment group than for the control group. Since the difference in total NAC is not significant, this may simply be an anomaly. (A non-parametric test is not nearly as sensitive as a parametric test based on normally distributed data.)
- There is no significant difference between the mean heating NAC (G-heat, Table 6). There is no significant difference between the total NAC (Table 6).

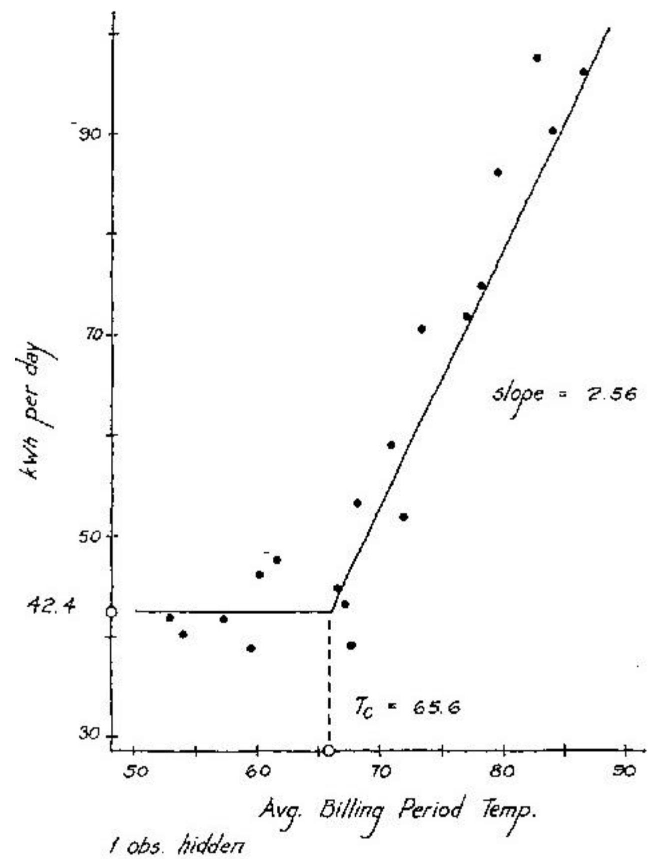

Figure 1: Typical cooling model.

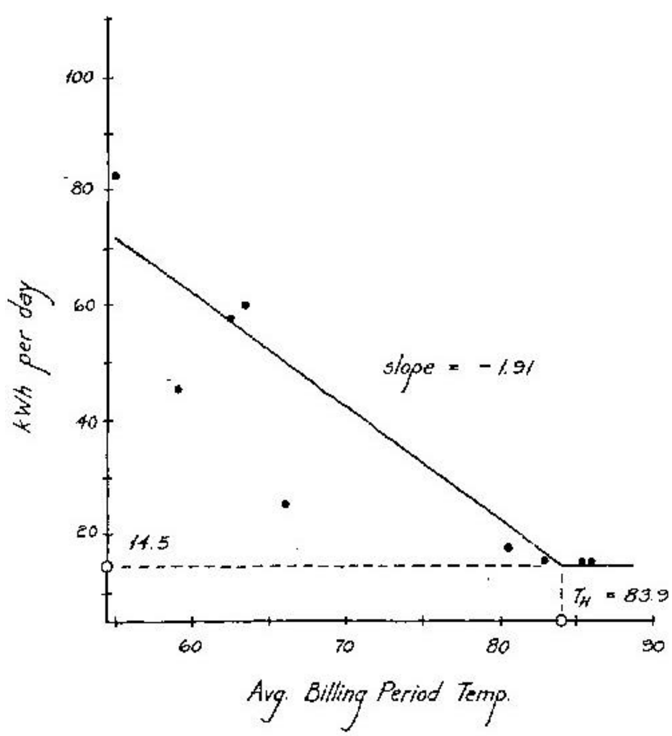

Figure 2: Typical heating model.

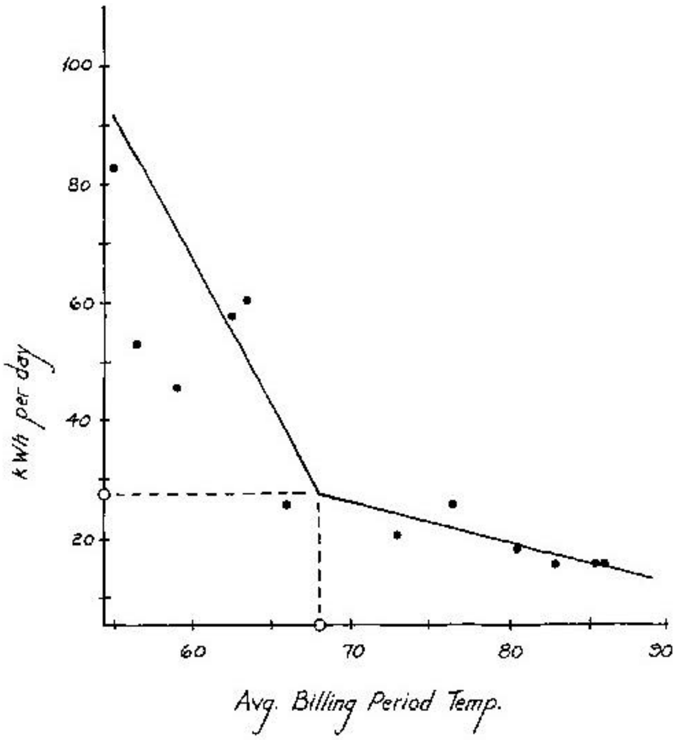

Figure 3: Four-parameter heating model.

Conclusions

Houses constructed between 1990-1993 and approved by the *Good Cents* Program in College Station, Texas, are not more energy efficient than comparable houses not approved by the Program. Houses not approved by the Program include houses that failed inspection and houses that were never submitted for approval. Literature distributed by the *Good Cents* Program nationally, claims that a *Good Cents* home can reduce electric consumption by 28? (Questions and Answers, 1996). Since the literature does not specify the criteria used to calculate the advertised savings, it is not possible to evaluate the stated claims.

Considering the results of this study, it is reasonable to conclude that contemporary builders in College Station are building energy-efficient houses with or without the endorsement of the *Good Cents* Program. In order for the Program to become effective, the qualifying criteria should be made more restrictive. (See Appendix.) Administrative personnel may be reluctant to do so because this may discourage builders from participating in the Program.

Speculative builders are very cost conscious. They probably will not incorporate expensive energy-saving features unless they are confident there is a market for them. It is quite likely that we have arrived at a point of diminishing returns for residential energy-saving features. We can build houses that are more energy-efficient, but will it pay to do so?

References

Fels, M. F. (1986). PRISM: An introduction. *Energy in Buildings*, 9, 5-18.

Goldstein, R. J., Schneider, M. E., & Clarke, M. I. (1985). Residential energy use: An analysis of factors affecting gas and electricity use in single-family houses. *ASHRAE Technical Bulletin, 1(3),* 219-236.

Homebuyer's guide. (n.d.) College Station, TX: Energy Conservation Division, City of College Station.

Joskow, P. L., & Marron, D. B. (1993). What does utility-subsidized energy efficiency really cost? *Science, 260*, 281 & 370.

Meier, A., Rainer, L., & Greenberg, S. (1992). Miscellaneous electrical energy use in homes. *Energy, 17*, 509-518.

Questions & Answers. (1996). College Station, TX: Energy Conservation Division, City of College Station.

Stram, D. O. & Fels, M. F. (1986). The applicability of PRISM to electric heating and cooling. *Energy and Buildings, 9,* 101-110.

Sutherland, R. J. (1994). Income distribution effects of electric utility DSM programs. *The Energy Journal, 15*, 103-118.

Appendix
City of College Station
Good Cents Qualifying Criteria

Heat Gain

A heat gain equal to or less than 12 BTU per square foot is required.

Air Infiltration

An air infiltration test will be performed on each Good Cents House during final inspection. The minimum acceptable air change in the Good Cents program is .75 air changes per hour measured at .1 inch of water column using an INFILTEC blower door.

Air Conditioning

All Good Cents homes must have high-efficiency heating and cooling systems. Heat pumps are to have a minimum 10.0 SEER and 3.0 COP as their rating. Back-up electric strip heat shall be no more than 5 kW per ton. Homes with natural gas as a heating fuel are to have the air conditioning with a 10.0 SEER or better rating. The gas furnace will have an 80 AFUE rating or better. The capacity for any air conditioning unit shall not exceed 1 ton per 600 square feet of conditioned floor area.

Insulation

R-13 required in the walls. Insulation to be installed according to manufacturer's specifications including filling the entire stud cavity, cut tightly around junction boxes, and placed behind corners and tees on the exterior walls. All windows in a Good Cents home are to be double-glazed or better. R-30 required in the attic. All attic access doors inside the conditioned area are to be weather-stripped and insulated.

City of College Station
Recommended Energy Efficiency Features

The following features and recommendations are presented as a means to achieve the Good Cents performance standards; they are not requirements, but rather construction features typically found in energy-efficient homes.

Door Insulation

Urethane core doors are recommended. Glass doors should also be double-glazed with a thermal break.

Windows

Exterior shading such as porches or overhangs are recommended. Sun glass is suggested for exposed east and west windows.

Insulation

Experience shows that a house needs a minimum ceiling insulation level of R-30 or greater and R-13 with ½-inch poly sheathing as a minimum in the walls. Cathedral ceilings should be designed to provide proper amount of space for insulation to achieve the R-values specified, as they are generally a source of high BTU heat gain. Sheathing should be placed on entire exterior wall including over bracing when possible.

Attic Ventilation

Continuous ridge and soffit vents are strongly recommended. Ventilation should be calculated at one sq. ft. of net free area for each 100 sq.ft. of horizontal ceiling/attic area. Preferably, half of the ventilation area should be upper and half lower to provide efficient airflow.

Air Infiltration

Sole plates should be sealed. All exterior doors should be weatherstripped. All penetrations in the thermal envelope should be sealed. All sheathing joints should be taped with thermal tape. Windows are to be sealed with expandable foam and taped around the edges to the exterior sheathing.

Roofs

Dark roofs are discouraged as they absorb and transmit a large amount of heat. Lighter color roofs are strongly recommended.

Skylights

Skylights are not recommended due to the emissivity of the glass in relation to its long exposure to solar heat gain.

Water Heaters

Water heaters should be installed with a minimum insulation value of R-11. All exposed hot water pipes should be insulated and the water heater should be centrally located near the highest usage area in the house.

Air Conditioning

While the *Good Cents* requirement for air conditioning sizing is 1 ton per 600 conditioned sq. ft., it is recommended the unit be sized at 1 ton per 750 conditioned sq. ft. The heating and cooling system is suggested to be controlled by programmable thermostats.