AUTOMATIC SETBACK THERMOSTATS: MEASURE PERSISTENCE AND CUSTOMER BEHAVIOR

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Summary

This report presents findings from a telephone survey of 100 customers living in gas-heated premises where programmable clock thermostats were installed free-of-charge by Connecticut Natural Gas Corporation (CNG). The survey focused on long-term measure persistence and customer behavior over time. These topics have rarely been researched even though assumptions regarding long-term effects play a crucial role when financial benefits are estimated for conservation investments. The survey was conducted by RPM Systems, Inc. (RPM) as one part of a PUC-mandated evaluation of CNG conservation programs.

Two groups of customers were surveyed in the fall of 1996, both living in private sector housing: 60 now living in premises where clock and programmable thermostats were installed in 1990-1991 after an RCS audit, and 40 customers now living in premises that received programmable thermostats in 1994-6 during a CNG service call. Twenty percent of the thermostats installed 5-6 years ago had been replaced, typically with a manual-adjustment model.

As shown in Figure 1, 21% of all 100 current occupants maintain a constant temperature, 34% set back their temperature manually, and 36% set back temperatures automatically. Comparing the groups using manual vs. automatic setbacks, there were no statistically significant differences in the number of set-backs, the average setback amount (5°F), or the time required for homes to heat up after a setback.

Other findings from this survey include:

- Customers whose homes heat up slowly are less likely than others to set back their thermostat.
- Most customer-installed replacement thermostats are manual models.
- Customer transience rates average 4.4% per year. Very few new occupants use the automatic feature of the set-back thermostat they found on the wall when they moved in.
- 33% of customers complain that the clock thermostat directions were too complicated.
- In the most favorable circumstances (customers interested in conservation, receiving a dependable model thermostat, still living at the address where it was installed) only 51% of customers used the automatic setback feature five to six years after installation.

These results suggest that programmable thermostat measure persistence calculations should incorporate:

- A long-term annual utilization loss rate of about 6%, incorporating the interactive factors of equipment loss and customer transience (4.4%/year).
- A more rapid loss of utilization in the first year or two following installation.

Interviewers did not reach customers who moved out of premises after thermostat installation. It is conceivable that there is an education effect which these customers carry with them to their new home. They might, for example, be more likely to install or use a clock thermostat in their new dwelling based on their successful use of the thermostat installed by CNG in their former dwelling.

Survey results also have important implications for program design. The effectiveness of clock thermostats is entirely dependent upon customer behavior. Customers must desire a lower temperature. They must understand how to use thermostat features and how to replace batteries

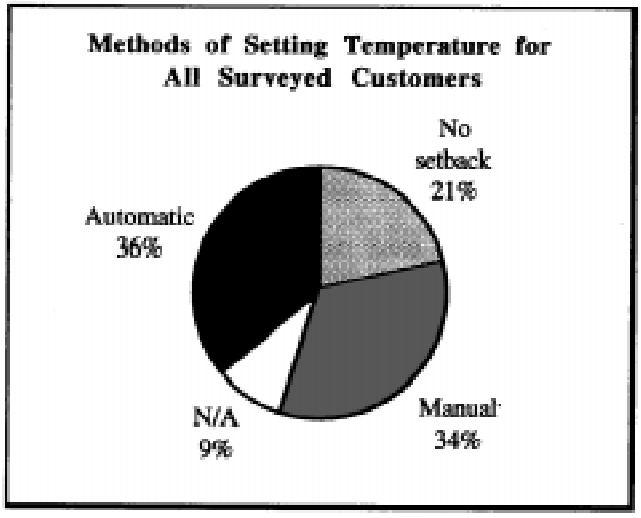

Figure 1

or reprogram the thermostat after a power failure. Thus long-term use of automatic setback thermostats can be maximized by:

- selecting highly motivated and capable customers to receive thermostats;
- installing dependable, low-maintenance, easily-understood models; and
- delivering to customers excellent training in their use and maintenance.

The detailed report that follows has four sections. The first describes methodology; the second describes the 1990-91 cohort, its selection, and its results. The third section similarly describes the 1994-96 cohort. The fourth section covers other topics of interest.

Survey Methodology

CNG furnished lists of premises, most with a phone number. RPM drew a random sample of 1990-91 cohort premises and used all the 1994-96 cohort premises with phone numbers. For each cohort two or more attempts were made at varied times of day to reach each of 100 customers, until the target numbers of 60 and 40 respondents were achieved. Demographic questions were not asked, an omission which makes it difficult to compare the two cohorts.

Given sample sizes of 40, 60, and 100, confidence intervals depend on sample proportion and are shown in Table 1.

Table 1. Confidence Intervals

	Sample proportion is:	
Sample size	25% or 75%	40% or 60%
40	+/- 11.3%	+/- 12.8%
60	+/- 9.2%	+/- 10.4%
100	+/- 7.1%	+/- 8.1%

The 1990-91 Cohort: Selection and Persistence

RPM completed 60 surveys with current occupants of premises that received one or more programmable thermostats from CNG in 1990 or 1991. The 1990 occupants had responded to a mailed offer sent only to customers who had requested an RCS conservation audit that in turn recommended a clock thermostat. RPM believes these customers were more interested in clock thermostats and in conservation than those customers who did not request an energy audit in the late 1980s. Based on its earlier analysis of demographics for audited households, RPM infers that these 1990 cohort customers were, compared to all CNG customers, somewhat younger and more likely to have recently purchased a home. Thus RPM believes they had an above-average ability to manage the technical complexities of maintaining a programmable thermostat.

Results for the 1990-91 Cohort

A total of 89 thermostats were installed in the 60 dwellings surveyed (due to the fact that some dwellings have more than one zone). Major findings are as follows:

- 78% of the 60 customers who received 90-91 thermostats are still at the same address (a 4.4% annual transience rate);
- 82% of the installed thermostats remain in service five years later (if the loss rate is linear it would be 3.5% per year);
- 60% of the CNG-installed thermostats that have been replaced by customers were replaced with a manual model;
- 83% of current occupants now have at least one clock thermostat in their dwelling;
- 15% of occupants have a clock thermostat but maintain a constant temperature;
- 25% of occupants have a clock thermostat but change their temperature manually
- 40% of occupants have a clock thermostat and change their temperature using the automatic setback feature. Their average night setback last winter was 5°F, on average 1.8°F lower than the setbacks they recall using before receiving a CNG thermostat.

Among residents who received thermostats in 1990-91, 28% complain that thermostat directions are too complicated, and 15% do not use the automatic feature because they find it too hard to understand or program. 22% report that their unit does not hold a temperature setting. 7% report that their unit stopped working or gains or loses time.

Transience is associated with less use of automatic setback thermostats:

- 90% of still-resident recipients have a clock thermostat of some kind in their dwelling, compared to 80% of current occupants who moved in after installation;
- 80% of still-resident recipients make a setback of some kind, but only 60% of new occupants turn their thermostats down at all;
- 51% of still-resident recipients use the automatic setback feature. Only one of twelve new occupants uses the automatic feature of a clock thermostat to achieve a set-back.

The 1994-96 Cohort: Selection and Persistence

The 94-96 cohort of customers was selected in a different manner and received programmable thermostat models different from those installed in 1990-91. Comparisons to the earlier cohort should be made with caution, but differences may also be revealing. In this later time period, clock thermostats were offered customers by CNG service personnel during a service visit which the customer requested for another reason. RPM therefore believes the 94-96 cohort had only an average interest in conservation, and they may have had less technical sophistication than the 1990-91 cohort. Some may have accepted the free programmable thermostat with a "why-not/no loss" attitude, thinking that it would not matter whether or not they eventually used it. Certainly they were less pro-active in obtaining the thermostat than the 90-91 group who had initiated two requests for conservation-related services.

During the fall of 1995 customers received a model of thermostat that was discovered to have technical problems. CNG continued the program with a different model and has been replacing defective thermostats as customers report problems.

Results for the 1994-96 Cohort

RPM completed 40 surveys with occupants of premises that received one or more clock thermostats from CNG in 1994-96. A total of 52 thermostats were installed in the 40 dwellings.

- 60% of the installed thermostats remain in service one to two years later. Twenty-one (40%) were replaced at least once. Most were replaced by CNG with another clock thermostat.
- 95% of the 60 customers who received 94-95 thermostats are still at the same address;
- 90% of current occupants now have at least one clock thermostat in their dwelling;
- 8% of occupants have a clock thermostat but maintain a constant temperature;
- 40% of occupants have a clock thermostat but change their temperature manually;
- 33% of occupants have a clock thermostat and change their temperature using the automatic setback feature. Their average night setback last winter was 4.8°F, 0.3°F lower than the settings they recall using before receiving a CNG thermostat.

When the elapsed years and associated transience are taken into account, the 94-96 cohort shows much lower utilization than the 90-91 cohort: 33% use after one to two years, compared to 40% utilization after five years. RPM suggests three candidate explanations for the lower utilization rate among recent recipients. First, they probably had less interest in conservation than the earlier cohort who had requested conservation audits. Second, some of them received an undependable model. Third, they may have had less patience and ability to deal with programmable devices. They complained of too much complexity with almost twice the frequency of the 90-91 group.

Among occupants of dwellings served in 94-96, 40% complain that thermostat directions are too complicated and 27% do not use the automatic feature because it is too hard to program or understand. 25% report that their unit does not hold a temperature setting. 37% percent report that their unit stopped working or gains or loses time. 27% complain that they must reprogram the unit after a power failure.

Other Topics of Interest

Using the entire sample of 100 respondents, RPM analyzed survey results for other topics of interest.

Thermostat Settings Used

The early evening (i.e., times when people are home and awake) thermostat settings were distributed as shown in Figure 2. Most respondents set their normal temperature from 68° F to 71°F.

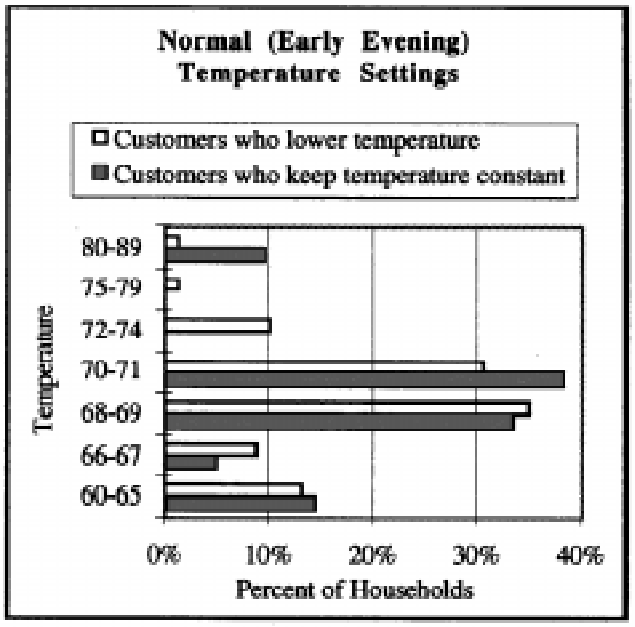

Figure 2

Of all current residents, 61% use a night set-back only, 8% use only a daytime set-back, and 26% use both a night and a workday setback.

RPM calculated the greatest set-back used by each customer, compared these maximum set-back amounts, and found no statistically significant difference between average values for those who set back manually versus those who use the automatic feature. See Figure 3 on the following page.

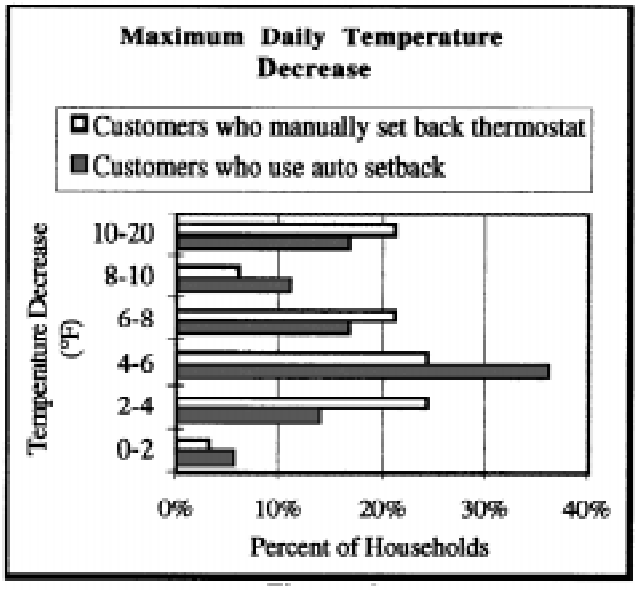

Figure 3

The Effect Of Heating Lag

One third of the surveyed dwellings use a hot air distribution system. Most use water radiators or baseboards, and a few use steam. The survey asked how long it would take for homes to heat up from 60° F to 70°F on a cold winter day. In homes heating up in 30 minutes or less occupants were more likely to use daily thermostat setbacks (84%) compared to occupants in homes that are slower to heat up (66%). However, among customers making a regular set-back, those using automatic setbacks were no more likely than the manual set-back group to have slowly heated houses. This suggests that customer desires and capabilities, and not dwelling conditions, are the dominant factors determining who uses the automatic set-back feature. This is consistent with the large number of reasons customers articulated for not using the automatic feature.

Table 2

Completed customer surveys	100
Reasons for not using automatic feature	
Need to keep house at same temperature	17
Like to control the heat myself	11
Unit malfunctions	12
Too hard to program, don't understand	20
Moved in post-installation and don't know how	4
Don't remember how and lost directions	1
Impractical due to inconsistent work schedule	2
"Simply don't use", "laziness"	5
Clock ticks loudly	2
Don't trust automatic thermostat	1
Batteries died and weren't replaced	1
Complaints, Problems Reported	88
Directions were too complicated	33
Unit doesn't/didn't hold set temperature	20
Unit malfunctioned or just stopped working	15
Clock gains or loses time	5
Must reprogram after power failure	13
Battery died and didn't know what to do	2

Conclusions

First Year Savings

What do these survey findings imply for estimates of longer-term energy savings for clock thermostats? First, consider engineering estimates of first-year savings. It appears that a priori estimates of first year savings should include at least two factors:

1) The set back effect is *incremental*. Many households change their thermostat setting manually before and after a clock thermostat is installed. Therefore the clock thermostat should not receive full credit for the total estimated setback amount. Instead, an incremental effect should be estimated, assuming the automatic feature results in an increase in the number of hours a lower setting is used, and/or the amount of the setback interval. The survey suggests the typical and average Connecticut setback is 5°F and that the *incremental* setback averages 2° or less. The survey did not address change in the number of hours a setback is used.
2) It seems likely that first year implementation rates are less than 100%. Even among customers interested in conservation (the 1990-91 cohort who had requested an audit), it appears that not all recipients of a free automatic setback thermostat use its automatic feature. Utilization rates are probably lower among those with less interest in conservation. Customer sophistication, technical simplicity, battery replacement requirements, the quality of training and customer transience all impact ease-of-use which in turn affects the utilization factor. Unfortunately, the survey questions did not allow differentiation of respondents who never used their programmable feature from those who used it for a while then stopped. Thus it is difficult to estimate what percent of current non-utilization is due to a less than 100% first year utilization rate, and what percent is due to a decay rate.

Persistence of Savings

To what extent will estimated or observed first year savings persist over time? At least three factors appear to be involved; the knowledge customers gain from the installer, the equipment itself, and customer interest in setbacks. All three factors must be present for automatic setbacks to occur and all three could deteriorate over time. All three appear to decay but the shape of the decay curve cannot be determined from survey results.

If the loss rate were a straight line function, RPM would estimate it at 8% per year. Five to six years after clock or programmable thermostats were installed, only 40% of current occupants use automatic setbacks.

100%	known installation rate
85%	inferred first-year utilization rate
-40%	known current use rate
45%	inferred loss over 5.5 years
8%	linear annual loss rate (dividing by 5.5 years)

Transience (at 4.4%/year) and transience-driven change-outs would account for at least half this inferred 8% annual loss rate. Equipment failure, loss of operating knowledge, and changing preferences would account for the rest.

Transience can be modeled as a straight-line function and is clearly a major cause of lost utilization. Customers leave premises at the rate of 4.4% per year, and they are replaced by new occupants unlikely to use the automatic feature of the clock thermostat. Transience will also lead to equipment change-outs and shifts in occupant preferences. However, knowledge loss, equipment failure and change of preference will also occur even where the same occupant remains where the thermostat was installed. Equipment failures and loss of knowledge are more likely during an initial shake-out period. RPM believes that use falls off rather quickly during the year or two, and that customer-thermostat marriages that survive that period of trial are likely to last for a long period. Thus the long term annual loss rate is probably greater than 4.4% (transience alone) yet less than the 8% linear loss rate projected from survey results for the 1990-91 cohort.