Tennessee Public Utility Commission

502 Deaderick Street, 4th Floor
Nashville, Tennessee 37243

September 19, 2017

Mr. David Jones, Chairman
c/o Sharla Dillon – Docket Room
Tennessee Public Utility Commission
502 Deaderick Street, 4th Floor
Nashville, TN 37243

Re: Staff Report – Docket No. 09-00183, Petition of Chattanooga Gas Company For Approval of Its Rates and Charges, Modification Of Its Rate Design and Revised Tariff.

Dear Chairman Jones:

This filing represent Staff's Report as discussed in the August 9, 2013 Order Entering Amended Procedural Schedule. Staff's Report is presented as the testimony of Jerry Kettles. The Report was prepared in consultation with Lisa Cooper, Michelle Ramsey and Monica Smith-Ashford, who were designated as parties to this proceeding.

Sincerely,

Jerry Kettles

Jerry Kettles
Director, Economic Analysis
Tennessee Public Utility Commission

BEFORE THE

TENNESSEE PUBLIC UTILITY COMMISSION

TESTIMONY

OF

JERRY KETTLES

IN RE:

PETITION OF CHATTANOOGA GAS COMPANY

FOR APPROVAL OF ITS RATES AND CHARGES,

MODIFICATION OF ITS RATE DESIGN, AND

REVISED TARIFF

DOCKET NO. 09-000183

September 19, 2017

Q: **Please state your name, position and business address.**

A: My name is Jerry Kettles. I am the Director of Economic Analysis for the Tennessee Public Utility Commission (TPUC). My business address is 502 Deaderick Street, Fourth Floor, Nashville, TN 37243.

Q: **Please provide a summary of your educational background and professional experience.**

A: I have a B.A. in Mathematics from Berea College, Berea KY. I engaged in graduate studies in Economics at the University of Tennessee, Knoxville. I have over 17 years of experience with utility regulation in the natural gas, telecommunications, electricity, water and waste water industries.

Q: **What is the purpose of your testimony in this proceeding?**

A: The purpose of my testimony is to provide Staff's report concerning Chattanooga Gas Company's (CGC) energy conservation programs initiated subsequent to its last general rate case. As part of this report, I summarize the report prepared by National Regulatory Research Institute (NRRI) researcher Tom Stanton. The NRRI Report is provided as Exhibit 1 to my testimony. I also discuss recommended evaluation procedures for programmable thermostat and public education energy conservation programs. As part of the Staff report, I performed a statistical analysis of CGC's programmable thermostat program. I discuss the methodology and results of the analysis. I conclude with a discussion of how current and expected natural gas market conditions compare to market conditions when the TPUC established the energy conservation program discussed herein.

Q: **Please explain why NRRI produced the report.**

A: The agency issued an Order on CGC's last general rate case on November 8, 2010. The Order directed "Staff to work with the National Regulatory Research Institute ("NRRI") to establish a set of measures sufficient to evaluate the Programmable Thermostat and Education and Outreach components." (Order at 62)

Q: Describe the programs authorized by the Authority.

A: CGC proposed several programs as part of a multi-faceted energy conservation plan it called energySMART. The Authority adopted two portions of the energySMART plan - the programmable thermostat program and a limited education and outreach program. (Order at 61)

Q: **Why is it necessary to evaluate programs?**

A: As noted in the Order, Tenn. Code Ann. §65-4-126 requires that the agency "approve energy efficiency programs that are: 1) cost effective; 2) measurable; and 3) verifiable in sustaining or enhancing incentives for consumers to use energy more efficiently." (Order at 61) The statute referenced in the Order originated in legislation passed by the General Assembly in 2009 that required energy efficiency programs to be measurable and verifiable. The legislation was codified as Tennessee Code Annotated Section 65-4-126 and reads "The general assembly declares that the policy of this state is that the Tennessee regulatory authority will seek to implement, in appropriate proceedings for each electric and gas utility, with respect to which the authority has rate making authority, a general policy that ensures that utility financial incentives are aligned with helping their customers use energy more efficiently and that provides timely cost recovery and a timely earnings opportunity for utilities associated with cost-effective measurable and verifiable efficiency savings, in a way that sustains or enhances utility customers' incentives to use energy more efficiently."

Q: **Please summarize NRRI's general statements about evaluating energy efficiency programs.**

A: First, NRRI notes that it is best if evaluation techniques and protocols are incorporated at the beginning of energy efficiency (EE) programming, when measures and program delivery mechanisms are selected." (NRRI Report at p. 1) In this case, the TRA chose to develop measures to evaluate EE programs during and after the term of the programs. Secondly, when measuring the effectiveness of EE programs, measures should be developed to evaluate (1) the process of how the utility administers the EE program and (2) the outcomes of the EE program. NRRI notes "process evaluation investigates how efficiently and effectively the utility acts in implementing the approved measures. The major focus is on program administration costs, both in total and per participating customer." (NRRI Report at p. 7) Outcomes measurement is an effort "to quantify the energy savings associated with the measures and determine whether and to what extent the program benefits exceed costs." (NRRI Report at p. 7)

Q: Which benefit-cost tests are commonly used to evaluate energy efficiency programs?

A: The benefit-cost tests set out in the California Standard Practice Manual (Standard Practice Manual) are frequently used to evaluate energy efficiency programs. The tests in the Standard Practice Manual were utilized by CGC when it proposed its energySMART program.

The benefit-cost tests set out in the Standard Practice Manual include the Program Administrator test, the Participant test, the Ratepayer Impact test, the Total Resource Cost test, and the Societal Cost test. The primary benefit of energy conservation programs is savings from the avoidance of using fuel. The primary costs of an energy conservation program are associated with program administration, program financial incentives and utility revenues lost from conservation. A chart comparing the benefit-cost tests described in the Standard Practice Manual can be found as Exhibit 2.

Q: Why should the administration of energy efficiency programs be reviewed on the basis of benefit-cost tests?

A: As discussed above, state law requires that EE programs be cost-effective. The use of benefit-cost measures provides useful information in evaluating if an EE program is cost effective.

Q: What analytic tools, in addition to benefit-cost tests, should be used in evaluating energy efficiency programs?

A: When possible, statistical methods that allow differentiation between outcomes of program participants and non-participants should be utilized to test whether observed program outcomes are attributable to the EE program under examination.

Q: Why should the outcomes of energy efficiency programs be subjected to statistical analysis?

A: As discussed above, state law requires that EE programs should have outcomes that are measurable and verifiable in sustaining or enhancing incentives for consumers to use energy more efficiently. Statistical analysis of program outcomes is an approach that allows for measurement of program outcomes and provides evidence to help evaluate whether an EE program produces verifiable conservation.

Q: **If the TPUC considers energy efficiency programs that include the distribution of programmable thermostats, how do you recommend the programmable thermostat program should be evaluated?**

A: Based upon NRRI's guidance, program evaluation should consider both the process of administering and the outcomes of the programmable thermostat program energy efficiency program. With respect to the thermostat program, the NRRI Report notes "… it makes sense to use the standard benefit-cost tests, to the extent practical, to compare actual program benefits and costs to the assumptions used when designing the program." (NRRI Report at p. 10) The benefit-cost tests described in the Standard Practice Manual incorporate information associated with program outcomes, like savings from using less primary fuel, and metrics related to the process of administering the EE program, like program administration costs.

To the extent possible, statistical tests should be used to determine that observed benefits flow from the programmable thermostat program instead of other factors.

Q: Has CGC performed benefit-cost tests for the programmable thermostat program?

A: Yes. CGC provided a summary of the benefit-cost measures of the programmable thermostat program in a filing made on May 30, 2014. CGC's summary is Exhibit 3 to this testimony.

Q: Describe the data CGC provided to facilitate statistical evaluation of the programmable thermostat program?

A: Yes. CGC provided data for two groups of consumers; those that received programmable thermostats (Participants) and a control group of consumers who did not receive a programmable thermostat from CGC (Non-Participants). For each group of consumers, the Participant and Non-Participants, weather normalized consumption for the months spanning April 2009 through March 2010 and April 2011 through March 2012 was provided.

Q: What measure should be used to make a statistical comparison of program efficacy?

A: The metric to compare Participants and Non-Participants is average savings per month. Also, comparing the average total annual heating-season savings between the Participant and Non-Participant groups will provide evidence to evaluate program efficacy. To measures savings, I calculate the average difference in weather-normalized monthly usage for each corresponding heating-season month between the time periods April 2009 through March 2010 and April 2011 through March 2012 for the Participants and Non-Participants. For the Participants, I assume the difference in usage between April 2011 through March 2012 and April 2009 through March 2010 results from CGC's programmable thermostat program participation. A statistical difference in average monthly savings between program Participants and Non-Participants supports a conclusion that the programmable thermostat program encourages energy conservation.

Q: What statistical test should be used to test if the programmable thermostat program encourages energy conservation?

A: To determine if the average savings are different between Participants and Non-Participants, I use Welch's t-test (Welch test) for each corresponding month and total savings. The test statistic calculated to implement the Welch test is given by:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

The subscripts, 1 and 2, denote the different populations under investigation. $\bar{X}_1$ and $\bar{X}_2$ represent the respective sample means. The expressions s_1^2 and s_2^2 represent the variances of the two populations. The expressions n_1 and n_2 represent the sample sizes for the populations under examination. The Welch test is a flexible test that allows population variances to vary and for populations to have different sizes. The test statistic t is calculated to test the null hypothesis H_0: $\bar{X}_1$- $\bar{X}_2$ = 0, that the sample means are not different. The alternative hypothesis is that the means are not equal.

Q: How did you perform the statistical analysis?

A: To perform the statistical analysis, I use R version 3.2.3 statistical software.

Q: After reviewing the customer usage data, did you identify characteristics of the data that are likely to unduly influence the results of the statistical analysis?

A: Yes. The April 2009 through March 2010 consumption data for Participants has a large number of missing observations. The number of missing observations in the April 2011 through March 2012 Participant consumption data are negligible. The missing observations influence the calculation of total year over year savings in the Participant sample. By comparison, the Non-Participant consumption data has almost no missing observation and thus, lacks a comparable distortion in the calculation of total savings. I also discovered that the data had several observations that had extremely large savings or increases in usage.

Q: Did you take steps to correct the consumption data?

A: Yes. I noticed that the majority, but not all, of the missing observations were in the non-heating season months of June, July and August. Since June, July and August have no or minimal heating degree days, a programmable thermostat will have a negligible impact on usage in these summer months. As such, I removed the months of June, July and August from the analysis. Next, I removed any premise included in a sample that did not complete data for April 2009 through March 2010 and April 2011 through March 2012. I then filtered the data to eliminate customers that had very large changes (+/-400 therms) in total annual savings. Such levels of saving are sufficiently large to not be attributable the installation of a programmable thermostat and were more likely attributable to the addition of a natural gas load (natural gas furnace) or the elimination of a natural gas load (replacement of natural gas water heater with another product). I also excluded observations that had monthly savings that exceeded +/-100 therms, as such are unlikely attributable to installation of a programmable thermostat. To maintain comparability between Participant and Non-Participant data, the same changes were performed on the Non-Participant consumption data.

Q: Discuss the results of your analysis.

A: The results of my analysis can be found in Exhibit 4. I calculate that program participants had total savings in excess of 24 therms compared to over 14 therms for consumers that did not receive a programmable thermostat from CGC. The difference in total savings between program Participants and Non-Participants is statistically significant. Individual months with differences in saving that are statistically significant at the 5% level are shaded in Exhibit 4. The decision to place emphasis on results that are statistically significant at the 5% level does not imply that useful information concerning program evaluation cannot be inferred from the other statistical results. Rather, the 5% standard is simply commonly used in the research community. Below I discuss recent research that cautions against focusing on statistical results that are only considered if they meet an arbitrary level of statistical significance.

Generally, the statistical results support that programmable thermostat program participants had greater energy savings during the sample period. The statistical results are particularly strong for total savings and for the months of December and January. For some months in the sample period, there was no statistical difference in savings between the thermostat program participant and control group. I attribute this to the factors that influence consumption but are unobservable or not included in the program evaluation data. Overall, the statistical analysis supports that programmable thermostats are conducive to conservation but the poor statistical results for several months suggest a degree of uncertainty concerning their effectiveness.

Q: When interpreting statistical results for future energy conservation programs, should the TPUC require a specific criteria for statistical significance?

A: No. The American Statistical Association released a statement on the use of "bright-line" tests of statistical significance through the specification p-values. The statement advises "Practices that reduce data analysis or scientific inference to mechanical 'bright-line' rules (such as "$p < 0.05$") for justifying scientific claims or conclusions can lead to erroneous beliefs and poor decision-making."[1]

Q: **Discuss the NRRI Report's observations on programmable thermostat programs.**

A: The NRRI report summarizes research that illustrates that the benefits of programmable thermostat programs are seldom fully realized because consumers have difficulty properly operating the programmable thermostat devices. (NRRI Report at pp. A1- A3) The NRRI Report further notes that "such complexities and the difficulties associated with verifying energy savings resulting from programmable thermostats caused the U.S. DOE and EPA Energy Star program to cease certifying programmable thermostats in 2009. Subsequently, many energy efficiency programs stopped including programmable thermostats as a measure qualifying for ratepayer or taxpayer funded incentives …" (NRRI Report at p. A2)

Q: **Discuss the relationship between the findings of your analysis and the NRRI Report's observations on programmable thermostat programs.**

A: The results of the statistical analysis are consistent with the observation that potential savings may not be fully realized because consumers may have difficulty operating the

[1] Ronald L. Wasserstein & Nicole A. Lazar (2016): The ASA's statement on p-values: context, process, and purpose, The American Statistician, DOI:10.1080/00031305.2016.1154108

programmable thermostat. If savings among program participants are attenuated by suboptimal use of programmable thermostats, statistically it is more difficult to distinguish the amount of savings between program participants and the control group.

Q: Discuss any additional factors that may have influenced the results of the statistical analysis.

A: It is my understanding that the programmable thermostat program distributed thermostats to eligible customers that requested a thermostat. It is also my understanding that the program did not include follow-up monitoring to ensure that the thermostat was installed. Such monitoring would have increased the cost of program operation. Also, since thermostats were distributed by request there is the possibility that the statistical results are influenced by selection bias. It is likely that the consumers that are most interested in conservation are the ones that opted into the programmable thermostat program. To the extent that such consumers already conserve energy through manual control of the thermostat – a possibility discussed in the NRRI Report (p. A1) – the measurement of savings would be biased. Only randomization of the distribution of thermostats or collection of data on program participants sufficient to allow for statistical control would cure the results of selection bias. Such steps would also increase the expense of administering the program.

Q: Did the data provided by CGC allow the measurement of all program benefits?

A: No. Programmable thermostats would also provide benefits, if used properly, with respect to electrical consumption for home cooling. No data on electricity consumption was available for analysis.

Q: How many programmable thermostats were distributed by CGC?

A: In filing made by CGC on May 30, 2014, CGC indicated that "the demand for the programmable thermostats continued to exceed the Company's expectation." (p. 3) CGC indicated that it distributed 8,198 programmable thermostats from September 2010 through May 2013 and that "as of May 31, 2013, approximately 15% of eligible customers had requested programmable thermostats." (p. 6)

Q: Please summarize NRRI's general statements about CGC's outreach and education programs.

A: NRRI notes that "CGC's outreach and education measure aimed to change behaviors associated with both purchasing and operating natural gas appliances. The associated behavior changes would be towards purchasing higher efficiency equipment and towards operating and maintaining existing or new equipment most efficiently, specifically to achieve natural gas conservation." (NRRI Report at pp. 9-10)

Q: If the TPUC considers energy efficiency programs that include an education and outreach component, how do you recommend the education and outreach component program should be evaluated?

A: Similar to the evaluation of the programmable thermostat program, the education and outreach program should be evaluated using the benefit-cost tests described in the Standard Practice Manual.

Measuring outcomes, primarily avoided natural gas use, is more difficult for education and outreach programs as it is difficult to gauge the dissemination of program messaging.

In some instances, outcome measures of education programs may not directly result in energy conservation or may do so at a level that is not detectable absent very targeted, and likely costly, data collection and analysis. For education focused programs, more useful metrics may involve gauging the effectiveness of program materials and success in spreading program messaging.

To the extent possible, statistical tests, should be used but should be tailored to the program outcome be it avoided fuel usage or dissemination of program messaging.

Q: Can you provide context on the price of gas prior to the 09-00183 rate hearing and currently?

A: The price of natural gas has been generally in decline since 2008. A graph of monthly city gate natural gas prices for the time period of October 1983 through May 2017 prepared by the Department of Energy's Energy Information Administration is provided as Exhibit 5. In July 2008, city gate prices spiked to $12.48 per MCF. When CGC initiated the 09-00183 rate case in November of 2009, city gate prices had fallen to $6.34 per MCF. In April 2016, city gate prices hit a 15-year low of $3.22 per MCF. As of May 2017, city gate pricing sits at $4.38 per MCF.

Q: Describe the relationship between the current price of natural gas and program benefits that can be realized from an energy efficiency program.

A: The primary consumer benefit from an energy conservation program is savings from avoided fuel consumption. As the price of the underlying commodity decreases, the benefits that flow from a program decrease.

Q: Does this conclude your testimony?

A: Yes.

Exhibit 1

NRRI Study

Evaluating Chattanooga Gas Company's 2012-13 Energy Efficiency Programs and Ideas for Evaluating Future Energy Efficiency Programs in Tennessee

Tom Stanton

Principal Researcher – Energy & Environment

Report No. 16-09

December 2016

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National Regulatory Research Institute

About NRRI

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Mission Statement

To serve state utility regulators by producing and disseminating relevant, high-quality research that provides the analytical framework and practical tools necessary to improve their public interest decision-making. In all its activities, NRRI embodies the following values: relevance, excellence, objectivity, creativity, independence, fiscal prudence, ethics, timeliness and continuous improvement.

Board of Directors

Acknowledgments

Soon after this project began in early 2013, a workgroup was formed to help guide this project. The group was comprised of staff from AGL Resources (the corporate parent company representing Chattanooga Gas Company), Tennessee Regulatory Authority, and National Regulatory Research Institute. I thank all of the participants for their efforts to bring this project to completion. In addition to myself, the workgroup participants included:

Dr. Rajnish Barua, NRRI Executive Director;

Lisa Cooper, Tennessee Regulatory Authority;

Rishi Garg, Esq., (former) NRRI General Counsel & Principal Researcher;

Archie Hickerson, AGL Resources;

Emily Hickey, AGL Resources;

Jerry Kettles, Tennessee Regulatory Authority;

Andy McIntosh, AGL Resources; and,

Monica Smith-Ashford, Tennessee Regulatory Authority.

Over time, workgroup membership changed somewhat to reflect changes in employment. Former NRRI Research Associate Daniel Phelan participated in some meetings. Marci Shields, from AGL Resources, replaced Emily Hickey.

All of those individuals participated in discussions that helped to shape this research. Mr. Kettles, particularly, served as communications liaison to the others and provided continuing assistance.

I wish to thank all of those workgroup participants. I also thank some friends who are energy program evaluators and provided insights and advice as the project proceeded. They include ACEEE researcher Patti Witte and research fellow Martin Kushler, Ph.D., plus evaluations director for mid-Michigan consulting firm Public Sector Consultants, Jill Steiner.

Any errors or omissions are my responsibility.

Tom Stanton, Principal Researcher, Energy and Environment
National Regulatory Research Institute

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Executive Summary

Chattanooga Gas Company (CGC), a subsidiary of Southern Company, delivered an energy efficiency program for its Tennessee residential customers from 2011 through 2013. The program included two measures: (1) providing programmable, automatic set-back thermostats to requesting customers, free of charge; and (2) a related Community Outreach and Customer Education effort. The Tennessee Regulatory Authority (TRA), in its November 8, 2010 Order in Docket No. 09-00183, approved the CGC efficiency program. That Order also specified that TRA and CGC would consult with the National Regulatory Research Institute (NRRI) about the program evaluation.

NRRI and CGC initiated a contract for work on April 1, 2013. NRRI agreed to assist TRA with two tasks: (1) establishing evaluation metrics and completing an evaluation for a 2012-13 CGC energy efficiency program; and also (2) providing general guidance about evaluating any future energy efficiency programs. This document is the NRRI final work product for those two tasks. This document is organized into five major parts: (1) Part I provides an introduction to the project and the two tasks; (2) Part II describes the CGC 2012-13 program and measures to be evaluated; (3) Part III presents ideas about evaluating that particular program; (4) Part IV presents general concepts about evaluating any future TRA regulated energy efficiency programs; and (5) Part V is a brief conclusion. In addition, an Appendix presents an annotated review of literature regarding energy program evaluations, particularly including several references about the specific challenges associated with public utility energy efficiency (EE) programs, like the 2012-13 CGC offering, that include incentives for programmable set-back thermostats. As that Appendix shows, evaluations have identified several important concerns and two major results were: (1) the U.S. Department of Energy and Environmental Protection Agency stopped certifying programmable thermostats in 2009; and, (2) many EE programs subsequently discontinued incentives for programmable thermostats.

The CGC 2012-13 program succeeded in notifying customers and delivering the set-back thermostats: almost twice as many customers as initially projected asked for and received the thermostats, reaching approximately 16% of CGC's eligible customers. However, extensive efforts would have been needed to determine the associated energy savings and compare them to the expected savings CGC modeled prior to initiating the program. Now, after the fact, it such efforts would be impractical. NRRI's recommendation to TRA is to direct CGC to complete a simple process evaluation, based on the data that is already accessible.

Going forward, it is best if evaluation techniques and protocols are incorporated at the beginning of EE programming, when measures and program delivery mechanisms are selected. That way, provisions can be made for collecting and analyzing the relevant data and the evaluation activity can proceed in concert with program delivery.

I. Introduction

Chattanooga Gas Company (CGC), a subsidiary of Southern Company, delivered an energy efficiency program for its Tennessee residential customers from 2011 through 2013. The program included two measures: (1) providing programmable, automatic set-back thermostats to requesting customers, free of charge; and (2) a related Community Outreach and Customer Education effort.

In its November 8, 2010 Order in Docket No. 09-00183, the Tennessee Regulatory Authority (TRA) approved CGC spending on the program and specified that the National Regulatory Research Institute (NRRI) would consult with TRA and CGC about the program evaluation. The TRA Order (pp. 58-62) stated:

> CGC commits to promote energy conservation through its energySMART programs, consisting of the Community Outreach and Customer Education Program and additional energy conservation initiatives including the Programmable Thermostat Program, the Low-Income Home Weatherization Program, and programs aimed at encouraging consumers to install high-efficiency gas water heaters and furnaces.
>
> With regard to the Community Outreach and Customer Education Program, the Company planned to utilize several methods of communication to reach consumers including newspapers, magazines, radio, television, billboards, digital media, direct mail and bill inserts.
>
> Also, the Company proposes to develop literature to distribute directly to consumers by means of its own field service representatives, along with heating, ventilating, and air conditioning (HVAC) contractors and plumbers. CGC also planned to explore establishing collaborative relationships with retailers of natural gas appliances, with the possibility of holding homeowner clinics. By utilizing this program, the Company asserted that a consumer could save up to $280 annually. …
>
> CGC proposed to provide residential consumers with a free programmable thermostat so that consumers can automatically reduce the thermostat temperature setting when no one is home or when it is not necessary to maintain a high home temperature, thereby reducing natural gas usage. The Company estimated that homeowners could save an average of $180 annually by properly setting programmable thermostats.
>
> The Company utilized… standard cost/benefit analysis tests for evaluating its energySMART Program… .
>
> Tenn. Code Ann. §65-4-126 requires that TRA approve energy efficiency programs that are: (1) cost-effective; (2) measurable; and (3) verifiable in sustaining or enhancing incentives for consumers to use energy more efficiently. … [T]he panel voted to adopt… the Programmable Thermostat measure and a more limited Education and Outreach component than proposed by the Company. Regarding the latter, the panel voted unanimously to approve only half of the proposed funding, $150,000, for CGC's proposed Education and Outreach program. The panel noted that with the shareholder

> money pledged, the first three years of the energySMART Program will cost ratepayers a total of $275,000, or $91,666 annually over three years. The panel found that the two programs in the amounts outlined above fit the cost-effective standard of the statute. …
>
> [T]he panel directed TRA Staff to work with the National Regulatory Research Institute ("NRRI") to establish a set of measures sufficient to evaluate the Programmable Thermostat and Education and Outreach components. …
>
> [T]he panel voted unanimously that the Company be required to file annual reports… detailing the costs incurred with the programmable Thermostat Program and a detailed accounting of all money spent on its Education and Outreach Programs, as well as, the program evaluation created by the TRA Staff.

In summary, CGC proposed two residential energy efficiency (EE) measures to the TRA involving customer education and free programmable thermostats and weatherization. CGC asserted that bill savings to residential customers who participated in these programs could total $280 annually and $180 annually respectively. CGC relied upon an analysis that used standardized cost-benefit test calculations, to arrive at these projected savings levels and presented their analyses to the TRA. Based upon CGC's presentation, TRA voted to fund only the programmable thermostat measure along with a limited customer education effort. The TRA Order directed TRA staff to work with NRRI to establish a set of measures sufficient to evaluate the Programmable Thermostat and Education and Outreach Program. The Order also directed CGC to file annual reports detailing costs incurred for the program and to complete the program evaluation created by TRA staff with NRRI assistance.

NRRI and CGC initiated a contract for work on April 1, 2013. The scope of work for that contract (Exhibit A: Scope of Work) provided that NRRI would:

(1) assist the Chattanooga Gas Company (CGC) and the Tennessee Regulatory Authority (TRA) Staff in establishing evaluation metrics and completing an evaluation report for the two energy efficiency measures delivered and managed by CGC; and

(2) provide general guidance to TRA regarding evaluation metrics for any future energy efficiency program efforts.

This report is the NRRI work product.

Part II of this report provides summary descriptions of the CGC program and measures to be evaluated. That information is based on communications and data shared by CGC to date. Editing to reflect any additional explanations from CGC could be needed to finalize Part II. Part III presents preliminary ideas about evaluation methods for the particular 2012-13 CGC program.

In addition, an Appendix presents an annotated review of literature regarding energy program evaluations, particularly including several references about the specific challenges associated with public utility energy efficiency (EE) programs, like the 2012-13 CGC offering, that include incentives for programmable set-back thermostats. That review identifies several concerns about programmable thermostat incentives that were raised in several studies from 2000 to 2013. Experience with similar programs elsewhere in the country suggested that energy savings estimates frequently turned out to be overstated. That is generally because customers predisposed to operating programmable thermostats according to recommended energy-saving settings are frequently those who have been diligent about operating manual thermostats in almost the same manner, thus leaving little if any energy savings to be achieved through automatic operations. Other concerns are related to: (a) the complexity of programming the devices; (b) whether household occupancy patterns are predictable and stable enough to encourage energy-saving temperature setback; (c) how much hands-on education and training is necessary for customers to be able to manage programmable thermostats effectively, according to the expected energy saving practices; and (d) how many free-riders participate in utility-sponsored incentive programs. Because of these kinds of difficulties, the U.S. Department of Energy and Environmental Protection Agency EnergyStar program quit certifying programmable thermostats in 2009, and many energy efficiency programs discontinued incentives for programmable thermostats in the last several years. Thus, two major results from such studies were: (1) the U.S. Department of Energy and Environmental Protection Agency stopped certifying programmable thermostats in 2009; and, (2) many EE programs subsequently discontinued incentives for programmable thermostats.

Part III presents a basic plan for evaluating the CGC program.

Part IV of this document presents general concepts about evaluating any future TRA regulated energy efficiency programs. The essence of these ideas is that evaluation techniques and protocols need to be designed at the same time that energy efficiency programs are being designed, when the measures and program delivery mechanisms are selected. That way, provisions can be made for collecting and analyzing the relevant data and the evaluation activity can proceed in concert with program delivery. The experience with the CGC program efforts in 2012-2013 demonstrates why this is so important: In the absence of a pre-planned evaluation methodology, collecting and analyzing the required data after the fact becomes much more difficult and expensive, perhaps even impossible or certainly at least impractical.

Part V presents a brief conclusion.

II. Description of the CGC Program and Measures

In 2012-13, CGC implemented a program comprised of two measures: (1) providing automatic setback thermostats to interested customers, at no direct cost; and, (2) producing and delivering educational messages through a Community Outreach and Customer Education Program that was intended generally to inform customers about basic methods for natural gas conservation and efficiency, and more specifically to familiarize customers with, and thereby encourage interest in, the thermostat give-away measure.

Residential customers could receive a free programmable thermostat, either by completing a request form on CGC's website or by making a request by telephone. Prior to shipping the thermostat, CGC staff reviewed each request to determine that the customer requesting the thermostat was an eligible residential customer. The customer's address and the date the thermostat was issued were recorded, to enable CGC to track the customer's natural gas usage, before and after the Company issued the thermostat. As an initial evaluation plan, CGC proposed to weather-normalize usage information and compare usage of customers receiving the automatic thermostat to usage by a control group, to determine whether and how much the thermostat might impact the use of natural gas.

Based on the experience of affiliates of CGC, the demand for the thermostats had been projected to be approximately 1,500 units annually. The actual demand was much greater. During the first three months following the program's launch, CGC processed 2,162 requests. During the period from September 2010, when the program was initiated, through May 2013, when the program terminated, 8,198 thermostats were provided, reflecting a demand that was approximately twice the level anticipated. During this program, approximately 16% of CGC's eligible customers received free programmable thermostats.

CGC's Community Outreach and Customer Education Program focused on two primary messages: (1) explaining the availability of free programmable thermostats to CGC's residential customers, and (2) conveying that energy conservation – not just natural gas but all energy sources – is better for the environment, and that energy savings translates into lower energy use and therefore lower energy bills. The campaign included the use of bill inserts, on-bill messaging, social media, outdoor billboards, online and print advertisements, and paid radio advertising. In general, the messages addressed the free thermostat program as the primary message and promoted energy conservation as a secondary message: The messages served both a marketing function helping to recruit customers to request a setback thermostat and a more general education function, helping to introduce customers to the idea that energy and dollars can be saved by employing high-efficiency appliances and by following basic guidance about how to best maintain and operate the appliances.

CGC reports that its outreach program leveraged both existing relationships and newly developed partnerships with community non-profits, contractors, builders and GCG company representatives. In particular, CGC made agreements with the Tennessee Aquarium and the Chattanooga Creative Discovery Museum, capitalizing on the considerable credibility of those entities, the audience of each, and the organizations' commitment to environmental and conservation initiatives. Through those partnerships, brochures were available to visitors in the

Aquarium and Museum, which enabled CGC to have its materials delivered to large numbers of stakeholders at low cost. In addition, GCG considered that visitors to the Aquarium and Museum would be a subset of the broader Chattanooga population who would likely be positively predisposed towards energy conservation.

The outreach and education materials promoted the use of more efficient equipment such as on-demand (tankless) and high efficiency water heaters, high-efficiency natural gas furnaces, and low-flow faucet aerators; the potential for reducing energy use by repairing hot water leaks, sealing air leaks using caulking and weather stripping, and adding insulation; cleaning clothes-dryer lint traps; replacing furnace and air conditioning filters, and having heating and air conditioning equipment serviced regularly.

As explained above, the requests for residential programmable thermostats during the 33 months of program activity were nearly double the demand that CGC anticipated. In addition, CGC reports that many of the times when large numbers of customers were requesting their free thermostats coincided directly with CGC's outreach and customer education program efforts, particularly with bill inserts and radio advertising activities. Those observations indicate CGC's outreach methods were successful in supporting customer demand for the free thermostats.

III. General Evaluation Methods for the CGC Program

A. Basic concepts

Both of the CGC measures – programmable setback thermostats and education programs – are examples of conservation efforts that require changes in consumer behavior to achieve the associated energy savings. For a programmable thermostat measure, achieving energy savings requires consumers to install the new thermostat and then operate it in a prescribed manner. The behavior change, in essence, is how the consumer schedules their thermostat settings and setback temperatures. And, in this particular circumstance, the aim of the CGC education measure was both: (1) to make customers aware of their opportunity to request a free programmable thermostat and motivate them to make that request; and (2) more generally to change behaviors associated with both purchasing and operating natural gas appliances by encouraging customers to purchase more efficient appliances and to operate them to achieve maximum efficiency.

There are two general purposes for evaluations of the types of programs CGC has delivered: (1) A process evaluation investigates how efficient and effective the utility is, in delivering the educational information and the thermostats, and (2) An outcomes and impacts evaluation attempts to quantify the energy savings associated with the measures and determine whether and to what extent the program benefits exceed costs. Information from both types of evaluations can also provide useful information to help guide the design of future programs.

Public utility energy program evaluations usually rely on the use of one, or often more than one, standardized benefit-cost tests (California Public Utilities Commission, 2013). Table 1 (on page 12) presents a high-level summary of the benefits and costs included in the five major standardized benefit-cost tests.

In general, a process evaluation investigates how efficiently and effectively the utility acts in implementing the approved measures. The major focus is on program administration costs, both in total and per participating customer. One important question to review is how the administration costs compare to the estimates used in planning and justifying the program. The evaluation should review the assumptions used to justify the program, and compare those assumptions to the actual program results. Another question to review, when practical, is how reasonable a utility's program administration costs are, compared to other utilities (or possibly even compared to other kinds of non-utility businesses or institutions) that have engaged in similar activities.

Outcomes or impacts evaluations review the effectiveness of energy efficiency programs to determine how actual energy savings compare to the assumptions used in planning and justifying the program. The basic question addressed is whether benefits exceed costs, and by how much.

In this circumstance, TRA needs to consider whether additional time and resources should be expended evaluating this program. CGC already collected and compiled some data on the program, and that data can be used to analyze certain benefits and costs. TRA can readily examine all of CGC's costs associated with the program. But, completing a more thorough program evaluation to more accurately determine the benefits attributable to this program would require more extensive analysis: Additional analysis could be undertaken, but it should be understood that implementing those supplemental techniques would necessitate additional expenditures for data collection and analysis, and the results might still not be conclusive. Specifically, personal interviews would be required with both participating and non-participating customers and with trade partners like natural gas appliance contractors, and perhaps customer site-visits would also be needed to learn more about what percentage of the thermostats remain installed and determine how the thermostats have been operated. As explained in the Appendix, though, quantifying benefits associated with set-back thermostats, if any, has proven difficult in other jurisdictions.

Table 1: Summary of Key Factors Included in Standardized Benefit-Cost Tests

Name of Benefit-Cost Test ⇨ **⇩Benefits & Costs Included⇩**	**Program Administrator (Utility) Cost Test**	**Participant Cost Test**	**Ratepayer Impact Measure Test**	**Total Resource Cost Test**	**Societal Cost Test**
Benefits					
Avoided primary fuel supply	✓		✓	✓	✓
Avoided secondary fuel supply				✓	✓
Primary bill savings (retail)		✓			
Secondary bill savings (retail)		✓			
Other resource savings		✓		✓	✓
Environmental benefits					✓
Other non-energy benefits				Rarely	In theory
Costs					
Program administration	✓		✓	✓	✓
Measure costs					
Program financial incentives	✓		✓	✓	✓
Customer contributions		✓		✓	✓
Utility lost revenues			✓		
Source: California Public Utilities Commission, 2001.					

The TRA November 8, 2010 Order in Docket No. 09-00183 already approved the measures and expenditures, so any cost disallowances would be justifiable only if it would be shown that the Company acted imprudently in implementing the program. From the information reviewed to date, TRA has not made such a determination and there is no indication of such. Therefore, any program evaluation would focus on: (1) the cost-effectiveness of the various outreach mechanisms (described in Part III.B.), and (2) studying available before-and-after usage data for customers receiving the programmable thermostats, compared to a control group of customers who did not receive them, to investigate gas usage patterns and compare the actual results to the assumptions CGC used when designing the program.

As reported in the Appendix, evaluation research for other utilities' use of programmable thermostats as an energy conservation measure raises serious questions about the effectiveness of that particular measure. From the data already available, it appears that CGC's assumptions regarding energy and cost savings were overly optimistic. That subject is reviewed in more detail in Part III.C.

B. Outreach and education program evaluation

For a thorough program evaluation, CGC should provide more detailed documentation of all its outreach activities. That data should include dates, estimated or documented numbers of customers reached, and itemized costs associated with each outreach effort. That data would be used to determine what was done and the relative costs and benefits associated with each outreach mechanism. Depending what data CGC has available, it might also be possible to determine something like success ratios (that is, numbers of customers requesting free thermostats compared to total numbers of customers reached using each outreach mechanism). The comparative analysis of outreach techniques would be at least somewhat helpful for targeting any similar outreach efforts in the future.

CGC should provide a data table that includes the dates (by month, at least, or maybe even by week if that is practical), corresponding to each bill insert mailing and to paid radio advertising, along with any other important outreach events or activities, and how those actions correspond in time to the numbers of requests for programmable thermostats. This data will be used to show the correspondence between the different outreach activities and the subsequent thermostat requests. If the evaluation is later supplemented using personal interview techniques, customers can be asked about their recall of outreach communications and what precipitated their action requesting a thermostat.

Barkenbus (2013, pp. 1692-93) points out some of the evaluation criteria for education programs. Barkenbus notes differences in effectiveness between messages based on their content, which sometimes includes moral persuasion, testimonials from well-known spokespeople, and social marketing techniques. These are among the qualities of persuasive communications campaigns that are regularly evaluated, including the source of the message, the channels used for the communications, the message itself, and the receiver. Researchers typically explore: (a) audience perceptions of the credibility and trustworthiness of the identified source of the message; (b) how cost-effective the selected channels are for reaching the intended target audience; (c) how effective the message is in providing the desired education and producing the desired effects; and (d) how characteristics of the receivers of the message relate to the other three criteria. Depending on TRA's interests, the program evaluation could explore these qualities of the CGC messages, and how effective the communications were in educating the intended audience and achieving the goals CGC intended for the program.

Generally, CGC's outreach and education measure aimed to change behaviors associated with both purchasing and operating natural gas appliances. The associated behavior changes would be towards purchasing higher efficiency equipment and towards operating and maintaining existing or new equipment most efficiently, specifically to achieve natural gas conservation. In addition, a small portion of the content in CGC print materials promotes the use of natural gas as an environmentally preferable and convenient fuel choice. Interview techniques could be used to explore the extent to which participating and non-participating customers have been motivated by the outreach messages to change specific behaviors. That could be accomplished to some extent, using a content analysis of the outreach messages and additional information, if desired, could be obtained through personal interview techniques.

Other programs incorporating programmable thermostats have sometimes included education and training specifically about thermostat operations (see Appendix). In contrast, it is the author's understanding that CGC's program did not provide any specific training about how to set and use the thermostats. That subject could also be explored in future customer interviews, if desired.

C. Thermostat measure evaluation

CGC justified its proposed program expenditures based on its application of the standardized benefit-cost tests, using CGC's estimates of energy savings that would result from consumers operating their set-back thermostats in a preferred manner. TRA is charged with approving energy efficiency programs that are cost-effective, measurable, and verifiable (TRA Order, pp. 59-61). Therefore, it makes sense to use the standard benefit-cost tests, to the extent practical, to compare actual program benefits and costs to the assumptions used when designing the program.

In making its proposal for the gas conservation project, CGC estimated annual natural gas savings of $180 for each participating customer that would "properly" operate their programmable thermostat (TRA Order, p. 60). As a starting point for evaluation, that value would correspond to the "avoided primary fuel supply" benefit, as shown in Table 1. In this particular circumstance, though, the preliminary data CGC has collected and the experiences related in the Appendix both indicate there is scant evidence available to be able to accurately quantify any "avoided primary fuel supply" savings.

"Program financial incentives," as shown in Table 1, corresponds to the cost of the thermostats that were given to the participating customers (including shipping), and "program administration" costs correspond to CGC's spending on the customer outreach and education measure, including costs for printing and disseminating the brochures and the costs associated with production and distribution of all paid advertising and other marketing materials and events. CGC would also have modest administrative costs associated with the data collected and shared with TRA to date.

As shown in Table 1, those are the three elements needed, for completing the program administrator cost test: (1) savings associated with "avoided primary fuel supply"; (2) program administration cost; and (3) program financial incentives. Data comparing customers receiving the programmable thermostats and the control group of customers who did not receive the programmable thermostats would be used to evaluate the actual "avoided primary fuel supply."

CGC has data sets available showing monthly and annual consumption, by premise, for over 3,000 customers who received programmable thermostats and also for a control group of almost 1,500 customers who did not receive programmable thermostats. The CGC data sets include monthly consumption for at least 24 months, along with location-specific heating degree days per month. Depending on the level of TRA interest, CGC could perform statistical analysis to determine how energy use varies: (a) according to each customer's overall energy usage, for example by quintiles representing lowest, low, medium, high, and highest natural gas users; and (b) during time periods with lowest, low, medium, high, and highest monthly heating degree days which reflect weather conditions. However, CGC has already stated, as the literature reviewed in the Appendix might predict, that the data does not show any particular signature reflecting changes in usage by customers who received the free set-back thermostats.[1]

In addition, the CGC data sets also include small numbers of premises with the indication that "furnace conversions" were completed. The author's understanding is that these households previously used another heating fuel, so it would be expected that natural gas usage would increase substantially upon installation of a new gas furnace or converting an existing furnace from fuel oil or propane to natural gas. If TRA confirms that those premises constitute an important sub-set of customers for statistical analysis, then that group's data could be reviewed to help to show how important the furnace conversion households might be to energy savings associated with installation of set-back thermostats. Control group data would have to come from either other households that converted furnaces without getting set-back thermostats, or other households with new furnaces installed.

To understand participant costs and benefits, as shown in Table 1, it is necessary to understand whether "secondary bill savings" and possibly "other resource savings" might be associated with the installation of programmable thermostats. If the particular thermostats CGC provided were capable of operating both furnaces and air conditioners, then customers with central air conditioning could have operated the thermostats to also capture savings associated with hot-weather cooling, and a thorough program evaluation could determine how much savings. Also, electricity savings results from reductions in the operations of furnace blower motors or boiler pumps. In addition, if customers acted on any of the additional suggestions provided in CGC's educational materials, such as installing low-flow faucet aerators or repairing hot water leaks, or if customers purchased new high-efficiency appliances like clothes washers or dishwashers, then some water savings could also be attributed to the program. Again, TRA should determine whether some interview techniques and perhaps site visits should be employed, to learn from customers how the thermostats are being utilized and what kinds of additional actions customers took in response to the educational messages.

Looking again at Table 1, some estimate should be made of "utility lost revenues," depending on how fuel costs are included in CGC rates and revenue recovery, and on the findings about natural gas usage reductions that can be demonstrated through the review of the available customer usage data, plus any additional data collected through subsequent interviews

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[1] Personal communications with CGC, 4 April 2014, in response to NRRI "Questions about CGC Program Narrative and Spreadsheet Data."

or site visits. Finally, “customer contributions,” that is customer out of pocket investments associated with energy savings, could also be estimated following interviews or site visits.

Depending on TRA’s interest, additional program evaluation could use follow-up interviews with a representative subset of participating customers, guided at least in part by the similar program efforts described in the Appendix, to check on the effectiveness of the educational materials and compare the experiences of CGC customers with customers from other utilities, regarding their use of programmable thermostats.

IV. General Concepts for Evaluating any Future Energy Efficiency Programs

The most important guidance for any future energy efficiency programs is that evaluation techniques should be planned in conjunction with program design. The National Action Plan for Energy Efficiency, a joint project of the U.S. Department of Energy and Environmental Protection Agency, has produced a series of guidebooks to support commissions and utilities in energy efficiency program design, implementation, and evaluation. The evaluation guide (NAPEE 2007) explains the most important linkages between and reasons for fully integrating energy efficiency program design and evaluation planning. The NAPEE guidebook (2007, p. ES-5) explains:

> [E]valuation planning is part of the program planning process so that the evaluation effort can support program implementation, including the alignment of implementation and evaluation budgets and schedules, and can provide evaluation results in a timely manner. … [R]equirements are determined by the program objectives, regulatory mandates (if any), expectations for quality of the evaluation results, intended uses of the evaluation results, and other factors."

Specific linkages that should be thought out as programs are being designed include: (a) what specific benefits will be evaluated; (b) how standard or baseline usage will be determined and measured; and (c) what data will be collected and how will it be analyzed, setting ahead of time the approaches that will be used for calculating savings, and determining in advance which if any environmental or non-energy benefits will be analyzed (NAPEE 2007; Russell, Baatz et al. 2015).

The basic premise is simply a variation of the adage, look before you leap. If the program and evaluation plans are developed in an integrated manner, then it will be clear to all participants and observers what the goals are for the evaluation, and how success will be determined. Such integrated plans can also provide opportunities for mid-course corrections that help achieve the best results with limited expenditures. For example, specific outreach techniques can be ramped up or down and specific efficiency measures can be emphasized, de-emphasized, added or subtracted.

Across the U.S., utility expenditures on energy efficiency are in the range of several billion dollars per year (CEE 2014; EIA 2015). Many utilities are routinely spending as much as one percent or more of total revenues on energy efficiency programs, and those programs are achieving as much as one percent or more in annual sales reductions (Barbose, Goldman et al. 2013; EIA 2015; Gilleo, Nowak et al. 2015). For example, ACEEE (Gilleo, Nowak et al. 2015, p. 12) reports average annual electricity savings equivalent to 0.7 percent of total retail electricity sales in 2014. Barbose, Goldman et al. (2013, p. 9) report:

- 28 states require electric utilities and 21 states require natural gas utilities to develop and implement demand-side energy management plans or multi-year energy efficiency programming budgets;

- 34 states require electric utilities and 17 states natural gas utilities to engage in integrated resource planning;
- 15 states for electric utilities and six of those same states for natural gas utilities have enforceable energy efficiency resource standards that set goals for annual program savings; and,
- Six states have statutory requirements directing both electric and natural gas utilities to “acquire all cost-effective energy efficiency.”

Practically all of these utility programs are the targets of extensive program evaluations, so there is no shortage of readily available information to guide future program designs and no excuse for any utility company not to keep current with plenty of ideas for cost-effective programming. For example, EIA (2014) has compiled and makes available data on energy efficiency programming, drawing from over a hundred annual reports to state commissions, plus an additional more than a hundred impact and process evaluation reports. In addition, ACEEE generates an annual scorecard (e.g., Gilleo, Nowak, et al. 2015), and (ACEEE 2016) produces lists of “exemplary programs” in all major categories: residential, commercial, industrial, low-income, rental properties, etc. Plus, many states use databases that provide savings estimates for dozens of energy efficiency measures. Those savings estimates are subject to continuing review and improvement, as more and more data is collected and used to refine engineering estimates. (See, for example, Davis 2011; EUMMOT 2016; MI-PSC 2016; USEPA 2016.) With such resources readily available, there is no reason why all Tennessee utilities – natural gas, electric, and even water and sewer – should not be able to find ample opportunities for and continuously achieve cost-effective investments in helping customers improve their energy efficiency.

In addition, there two emerging trends in utility efficiency programs that deserve special attention by utility planners. First, much research is currently focusing on behavioral aspects of energy efficiency and the special needs for evaluating programs that rely substantially on behavioral changes. This issue is particularly coming to the fore in response to grid modernization efforts that are providing consumers with much more information about their energy use. (See, for example, Barkenbus 2013; Cappers et al. 2015; Ehrhardt-Martinez at al. 2010; Kerr and Tondro 2012; Moezzi et al. 2009; NARUC 2012; SEE Action 2016a; Todd, Perry et al. 2015.) Second, the field of energy efficiency program evaluation, measurement, and verification (EM&V, or EMV) is also advancing rapidly, particularly as advanced metering infrastructure (AMI) improves the capabilities for collecting from consumers detailed data about energy use. (See, for example, Schiller 2015; SEE Action 2016b and 2016c.)

Furthermore, there has been much progress in recent years about designing utility energy efficiency programs so that they rely less on ratepayer funding and leverage funds from other sources. There are many successful demonstrations about how to accomplish more energy efficiency using less ratepayer funding: Around the country, programs are proving capable of achieving larger energy savings at lower ratepayer costs, often with the participating customers able to obtain such savings on all their utility bills (electric, natural gas, water and sewer), with no money down and monthly payments less than the accumulated monthly savings. (See, for example, Bell et al. 2011; Energy.gov 2016a and 21016b; PACENation 2016.)

V. Conclusion

The CGC program was a modest first effort. As it turns out, the program intent might have been reasonable, but the plan itself turned out to be shortsighted. At this juncture, TRA should consider the purposes to be served by any additional program evaluation. It appears there is little to gain now from revisiting this initial CGC effort. Rather, TRA might better focus resources on future programming, to best ensure that all future programming will be guided by best practices and have the greatest potential for cost-effectiveness and producing benefits for all ratepayers.

Historically, no other utility expenditures of any kind have been evaluated as rigorously as utility ratepayer funded energy efficiency programs. Thus, a wealth of information is readily available about cost effective measures and programs, which TRA and Tennessee utilities can rely on in setting their own specific goals and objectives for future programs.

As ACEEE reports, utilities in several jurisdictions have been continuously investing in cost-effective energy efficiency programming for multiple decades, and many utilities are still regularly achieving company-wide savings of one percent or more of total sales, year upon year (York, Witte et al. 2012). Many state legislatures and commissions have regularly set performance based goals for utility efficiency programs, often including establishing minimum targets for the percentage of total revenues utilities will spend on energy efficiency programming. Within the energy efficiency budgets, commissions also frequently establish guidelines for the percentage of total expenditures that will be allocated to program evaluation, typically in the range from only one to three percent for each. CEE (2014, p. 26) shows average utility expenditures in the range of three percent of energy efficiency program budgets, being spent on program research and evaluation, and a bit more than 20% for the total of marketing and program administration, with a bit more than half of all expenditures focused directly on customer rebates and incentives. Those averages provide at least a general framework for consideration, which TRA can use as a foundation to make its decisions.

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Appendix:

Challenges with Deploying Programmable Set-Back Thermostats as a Measure in Ratepayer-Funded Public Utility Energy Efficiency Programs

The underlying theory supporting programmable thermostats as an energy efficiency measure is that each degree (Fahrenheit) of setback for 8 hours is expected to reduce natural gas use for space heating by about 1 percent (Malinick et al., 2012, p. 7-162). This savings estimate is based on two important assumptions, though (BuildingMetrics, Inc., 2011; Haiad et al., 2004; Nextant, 2007; Pigg and Nevius, 2000; RLW, 2007): The first assumption is that customers would have previously maintained their non-programmable thermostats at constant temperature, and the second is that all customers who receive a new programmable thermostat will operate it in automatic, recommended pre-programmed mode, thus achieving the potential savings from temperature setback(s).

Several studies, however, show that at least some consumers who install automatic setback thermostats would have already operated their manual thermostats "diligently" to obtain most of the available energy savings (Malinick et al., 2012, pp. 7-163-164). That is, the same customers inclined to program and operate automatic thermostats for regular temperature setback are also likely to self-adjust manual thermostats to achieve similar results, for example setting temperatures lower when leaving the house empty for extended periods of time and when going to sleep.[2] Barkenbus (2013) reviews data from the Energy Information Administration's Residential Energy Consumption Survey (RECS) (USEIA, 2013), and arrives at four important conclusions:

> (1) "[N]early half of… household energy use is controlled by individuals through their thermostats."
>
> (2) "Thermostat setting constitutes somewhat of a conundrum… . For most people, altering their thermostats over the course of a day requires frequent, repeated, action… . In other words, it must become an engrained habit. It is, of course, not difficult to change the setting on a household, manual, thermostat, but it does require a mindfulness that many do not wish to summon. On the other hand, the habit is not just low-cost, but actually saves the homeowner money without an initial outlay of funds. For those willing to bring mindfulness to the practice of thermostat setting, it is one of the easiest and most significant behavioral responses to climate change amongst all the household options."
>
> (3) "Getting Americans to change their temperature settings in order to save energy is not easy even though it comes with the promise of financial savings. The use of programmable thermostats thus far has proved unsuccessful. … A general number cited

[2] The same basic principles apply when programmable thermostats are used to change air conditioning temperature settings during the summer, cooling season. Air conditioning savings accrues to customer electric, rather than natural gas, bills.

is that fully 90 percent of all installed programmable thermostats are not being used as envisioned by energy experts."

(4) "[P]roper utilization of programmable thermostats is hindered by the complexity of the devices, limited cognitive understanding by the public on how thermostats are designed to work, and a human environment of unpredictable schedules and varying individual comfort levels. Given these features, it is not surprising that energy saving through programmable thermostats has not been a prominent result to date. … [A] certain amount of 'hand-holding' will be required to produce desired energy savings."

Barkenbus's review paints a picture of many variables affecting the energy savings achievable with programmable thermostats. He questions whether demographic differences could translate into important variations in energy savings, for example by: (a) region of the country, because of large variations in heating and cooling loads; (b) occupants' age, education level, income level, and whether occupants are owners or renters; (c) whether household occupancy patterns are more "predictable and stable" or "sporadic and unpredictable"; (d) age of the building, which serves as a rough proxy for air leakage and draftiness; (e) the pre-existing prevalence of programmable thermostats, which reportedly range from a quarter to nearly half of all households; and (f) qualities of the particular thermostats themselves, such as the user interface, ease of use, or complexity of programming or reprogramming settings. And, the quality of training provided to the thermostat users is also thought to be important. Finally, some researchers speculate that reduced and less volatile natural gas prices in the recent past are dampening consumer interest in conservation savings. (Barkenbus, 2013, pp. 1692-94).

Such complexities and the difficulties associated with verifying energy savings resulting from programmable thermostats caused the U.S. DOE and EPA EnergyStar program to cease certifying programmable thermostats in 2009. Subsequently, many energy efficiency programs stopped including programmable thermostats as a measure qualifying for ratepayer or taxpayer funded incentives (Malinick et al., 2012, p. 7-162; Moezzi, Iyer, et al., 2009, pp. 58-60).

Meier et al. (2011) used site-visits and in-person interviews, supplemented with on-line surveys and photos of thermostats that revealed operating settings, and with follow-up laboratory research to explore the usability of residential thermostats, and then designed a measurement protocol and usability scale that might be applied to programmable thermostats. Meier et al. (2011, p. 1892) reviewed literature and found reports of many potential problems in design and challenges in using programmable thermostats. The cited problems, among others, included excess complexity, user confusion, difficulty in changing settings, and a lack of feedback. An earlier report by many of the same authors (Meier et al, 2010) revealed,

Occupants find thermostats cryptic and baffling to operate because manufacturers often rely on obscure, and sometimes even contradictory, terms, symbols, procedures, and icons. It appears that many people are unable to fully exploit even the basic features in today's programmable thermostats, such as setting heating and cooling schedules."

Meier et al. (2011) confirmed these and other issues, using personal interviews and later substantiating their findings using laboratory research. In general, Meier et al. (2011, p. 1891) found “widespread misunderstanding of thermostat operation.” About half of all occupants said they “operated thermostats manually, rather than relying on… programmable features and almost 90% of respondents reported that they rarely or never adjusted the thermostat to set a weekend or weekday program.”

In another review, Dyson et al. (2005) that few programmable thermostats were being used in the most effective way. In fact, they found evidence that:

> customers with programmable thermostats and manual thermostats have similar setpoint behavior for cooling… [AND] customers with programmable thermostats use thermostat setpoints that consume more heating energy than those with manual thermostats (Dyson et al., 2005, p. 243).

These researchers also found high pre-existing market acceptance for programmable thermostats. Similarly, Meier et al. (2011, p. 1892) report that programmable thermostats are installed in “nearly 100% of… new homes.” These factors could imply large numbers of what is called “free-riders,” meaning large numbers of customers who would install programmable thermostats on their own, in the absence of a utility program promoting that option.

In contrast to these several reports about many challenges associated with programmable thermostat delivery programs, Bradshaw et al. (2013) studied low-income energy efficiency programming in a half-dozen states. This research showed wide ranges of savings resulting from the use of programmable thermostats, compared to pre-retrofit conditions, from lows of less than five percent to highs over 15 percent. This project did find programmable thermostats to be cost effective, especially in climates where a predominant energy use is for space heating (as opposed to air cooling). It is noteworthy, however, that the programs reviewed by Bradshaw et al. (2013): (a) targeted low income customers exclusively; (b) proactively installed the thermostats; and perhaps most importantly, (c) trained participating customers about how to set and effectively use the automated thermostat controls. This study also showed much greater energy savings when the programmable thermostats were installed in conjunction with attic insulation and air-sealing measures.

Finally, Barkenbus (2013, p. 1693) describes recent experience from Japan, where a government-supported program encourages temperature changes in commercial and institutional buildings, and those changes, in turn, are influencing residential thermostat operations. In this program, the residential customers have witnessed energy savings achieved through conscientious changes in thermostat settings in their workplaces and in other public buildings, and that experience has been shown to influence energy-saving changes in the customers' residential thermostat settings. Barkenbus notes, “[T]he approach should not be based on calling for sacrifice in pursuit of the common good but rather on the benefits of using energy smarter and enhancing self-image… .”

Exhibit 2

Benefit-Cost Test Comparison Table

Summary of Benefits and Costs Included in Standardized Benefit-Cost Tests

Name of Benefit-Cost Test ⇨ ⇩Benefits & Costs Included⇩	Program Administrator (Utility) Cost Test	Participant Cost Test	Ratepayer Impact Measure Test	Total Resource Cost Test	Societal Cost Test
Benefits					
Avoided primary fuel supply	✓		✓	✓	✓
Avoided secondary fuel supply				✓	✓
Primary bill savings (retail)		✓			
Secondary bill savings (retail)		✓			
Other resource savings		✓		✓	✓
Environmental benefits					✓
Other non-energy benefits				Rarely	In theory
Costs					
Program administration	✓		✓	✓	✓
Measure costs					
Program financial incentives	✓		✓	✓	✓
Customer contributions		✓		✓	✓
Utility lost revenues			✓		
Source: California Public Utilities Commission, 2001.					

Excerpted from NRRI Report at p. 7.

Exhibit 3

CGC Benefit-Cost Calculation

Chattanooga Gas Company

energySMART Free Thermostat Program

Cost Benefit Analysis Summary

Assumptions

Discount Rate		7.41%
Inflation Rate		2.46%
Measure Life		15 Years
Program Years		4 Years
Cost to the Participant	$	35
Non-Company Rebate	$	0
Annual Energy Savings in Therms		-17.9
Cost to the Utility per Participant	$	18.81
Overhead per Participant	$	8.95
Total Number of Participants (3 + Years)		7,906
Total Program Cost (3 + Years)	$	227,621

PARTICIPANTS TEST

Benefits:		
Bill Reductions, Primary Fuel (AC)	$	514,357
Incentives	$	142,966
Bill Reductions, Alternate Fuel (AC)	$	0
Avoided Cost, Alternate Fuel Equipment	$	0
Total Benefits	$	657,323
Costs:		
Participant Costs	$	266,088
Bill Increases, Primary Fuel (AC)	$	5,603
Bill Increases, Alternate Fuel (AC)	$	0
Total Costs	$	271,690
Net Benefit	$	385,633
Benefit/Cost Ratio		2.42

TOTAL RESOURCE COST TEST

Benefits:		
Avoided Cost, Primary Fuel Utility (MC)	$	440,698
Avoided Cost, Alternate Fuel (MC)	$	0
Avoided Cost, Alternate Fuel Equipment	$	0
Total Benefits	$	440,698
Costs:		
Utility Cost	$	64,889
Participant Costs	$	266,088
Primary Utility Increased Cost (MC)	$	4,914
Alternate Utility Increased Cost (MC)	$	0
Total Costs	$	335,890
Net Benefit	$	104,808
Benefit/Cost Ratio		1.31

RATE IMPACT MEASURE TEST

Benefits:		
Avoided Cost, Primary Utility (MC)	$	440,698
Revenue Gains, Primary Utility (AC)	$	5,603
Avoided Cost, Alternate Fuel (MC)	$	0
Revenue Gains, Alternate Utility (AC)	$	0
Total Benefits	$	446,301
Costs:		
Primary Utility Increased Cost (MC)	$	4,914
Alternate Utility Increased Cost (MC)	$	0
Revenue Loss, Primary Utility (AC)	$	587,327
Utility Cost	$	64,889
Incentives	$	142,966
Revenue Loss, Alternate Utility (AC)	$	0
Total Costs	$	800,095
Net Benefit	$	(353,795)
Benefit/Cost Ratio		0.56

MC = Calculation Based on Utility Marginal Cost
AC = Calculation Based on Utility Average Cost

PROGRAM ADMINISTRATOR TEST

Benefits:		
Avoided Cost, Primary Fuel Utility (MC)	$	440,698
Avoided Cost, Alternate Fuel Utility (MC)	$	0
Total Benefits	$	440,698
Costs:		
Incentives	$	142,966
Primary Utility Increased Cost (MC)	$	4,914
Primary Utility Cost	$	64,889
Alternate Utility Increased Cost (MC)	$	0
Alternate Utility Cost	$	0
Total Costs	$	212,769
Net Benefit	$	227,930
Benefit/Cost Ratio		2.07

MC = Calculation Based on Utility Marginal Cost
AC = Calculation Based on Utility Average Cost

Exhbit 4

Results of Statistical Analysis of CGC Programmable Thermostat Program

Summary of Statistical Analysis

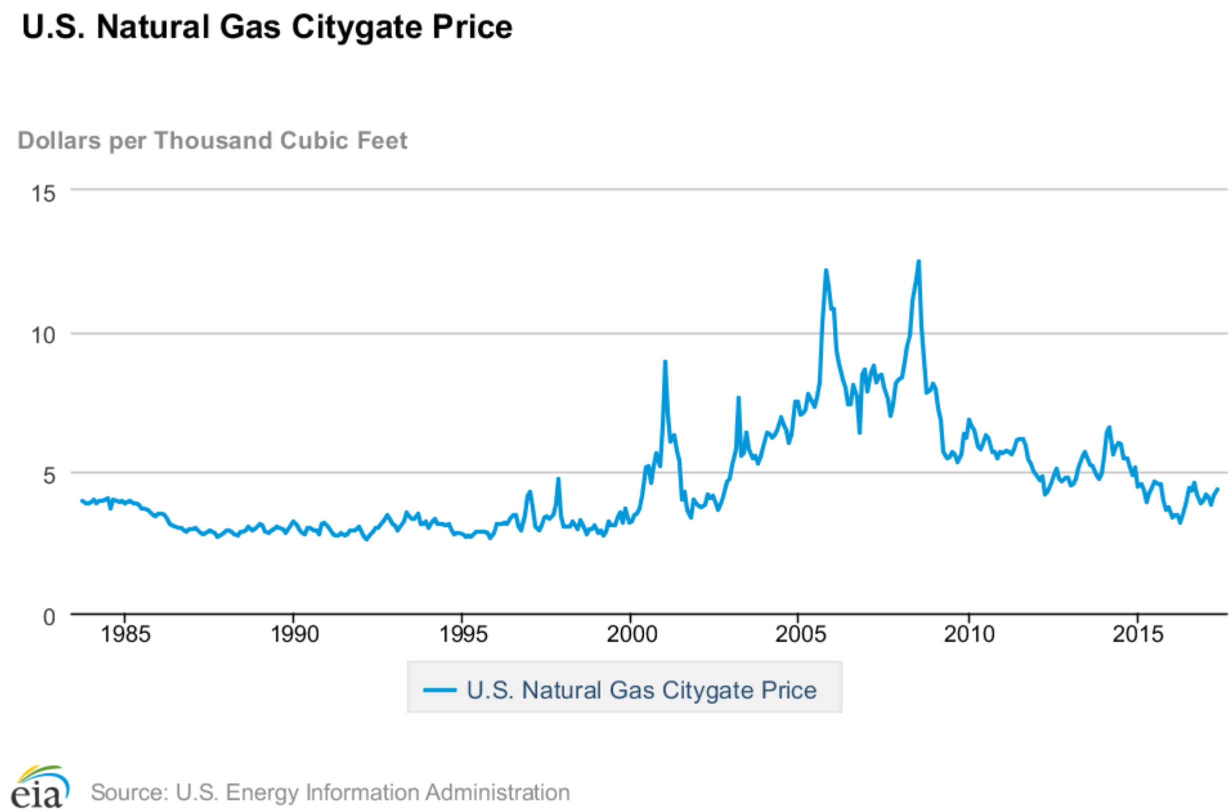
Month	t statistic	p-value	95% confidence interval		Average Usage Change Particpants	Average Usage Change Non-Participant
April	-2.2889	0.02215	-1.5574098	-0.01202566	0.100119	0.9389522
May	0.89896	0.3687	-0.2893976	0.7794328	-2.930124	-3.176041
September	-0.13057	0.8961	-0.6822413	0.5970553	1.470107	1.5127
October	0.074562	0.9406	-1.289799	1.391769	4.072061	4.021075
November	-1.6296	0.1033	-2.5601296	0.2361599	-0.7862452	0.3757396
December	-4.002	0.00006436	-5.202521	-1.78097	1.682091	5.173837
January	-4.5022	0.000006999	-5.681499	-2.234071	-13.770256	-9.812471
February	-0.26443	0.7915	-1.596142	1.216796	-10.58743	-10.39775
March	-1.4878	0.1369	-2.2934489	0.3146227	-3.755781	-2.766368
Total	-2.952	0.003182	-17.267888	-3.484163	-24.50636	-14.13033

Negative usage change represents conservation

(shaded) Statistically significant at 5% level

Exhibit 5

Citygate Natural Gas Prices



Graph generated using U.S. Energy Information Agency data interface found at: https://www.eia.gov/dnav/ng/hist/n3050us3m.htm.

Data graphed are monthly observations on city gate natural gas price for October 1983 through May 2017. Underlying data available for download at the link above.