Portfolio of the Future:

Recirculation Pump Time Clock Field Testing Report

Prepared for:
Southern California Gas Company

Submitted by:
Navigant Consulting, Inc.
77 South Bedford St
Suite 400
Burlington, MA 01803

781-270-8300
navigant.com

April 2017

TABLE OF CONTENTS

FIGURES & TABLES

Figures:

Tables:

DISCLAIMER

This report was prepared by Navigant Consulting, Inc. (Navigant) for Southern California Gas Company. The work presented in this report represents Navigant's professional judgment based on the information available at the time this report was prepared. Navigant is not responsible for the reader's use of, or reliance upon, the report, nor any decisions based on the report. NAVIGANT MAKES NO REPRESENTATIONS OR WARRANTIES, EXPRESSED OR IMPLIED. Readers of the report are advised that they assume all liabilities incurred by them, or third parties, as a result of their reliance on the report, or the data, information, findings and opinions contained in the report

1. BACKGROUND

This report documents the results of field testing a recirculation pump time clock (RPTC) for SoCalGas as part of their Portfolio of the Future Program (PoF). The PoF is a non-resource energy efficiency program that is "designed to identify…emerging technologies that can improve energy efficiency and reduce reliance on natural gas supplies in the Southern California market at a quick pace."[1]

The objective of this field test was to gather field data on the RPTC that is required to draft a technical work paper on this technology. SoCalGas will use this work paper to inform SoCalGas energy efficiency program(s) that may consider incorporating the RPTC (and similar products) into their portfolio and to document the achievable savings for the California Public Utilities Commission (CPUC).

The field testing consisted of installation of a RPTC at a customer site in [redacted], CA – a seven-story 150,000 ft.^{2} office space with a set of men's and women's bathrooms on each floor and a fitness center with eight showers on the first floor.

Energized Solutions installed and implemented the RPTC. Navigant conducted the data collection, monitoring, and evaluation of the RPTC performance.

1.1 Recirculation Pump Time Clock

Recirculation pumps are often used to circulate hot water in commercial buildings or apartment complexes in order to provide hot water instantly or shortly after demand. In typical one-way plumbing without a recirculation pump, water is simply piped from the water heater through the pipes to the tap. Once the tap is shut off, the water remaining in the pipes cools and results in a wait for hot water the next time the tap is opened. By adding a circulator pump and constantly circulating a small amount of hot water through the pipes from the water heater to the farthest fixture and back to the heater, the water in the pipes is always hot, and no water is wasted during the wait. While a recirculation pump saves water, it uses energy by continuously operating the pump.

While most of these pumps mount near the hot water heater and have no adjustable temperature capabilities, a significant reduction in energy can be achieved by using a thermostatically controlled circulation pump mounted at the last fixture on the loop. For recirculation pumps without a temperature adjustment capability, a simple plug-in time clock will achieve the same effect. The demonstrated technology is a time clock used to turn off the hot water recirculation pump at times when the building is unoccupied.

In the absence of a time clock, a hot water recirculation pump will heat water continuously throughout the day and night. This time clock saves gas by turning off the recirculation pump and not heating water when water is not in demand. This measure is ideal for buildings with set occupancy schedules, such as offices, schools, and gyms.

[1] PoF summary from www.socalgas.com/for-your-business/energy-efficiency-programs/portfolio.shtml

1.1.1 Savings Value Proposition

RPTCs reduce heat loss from recirculation loops by shutting the system off during schedules periods. Therefore, RPTC technology is best implemented in buildings that have regularly scheduled times of no occupancy, such as office buildings, schools, commercial gyms (that are not operated 24 hours), restaurants, and outpatient health care facilities. Site-level gas savings are a function of the following parameters: pipe characteristics such length, size, material, and insulation; hours of vacancy; domestic hot water (DHW) set-points; room temperature set-points; water heater efficiency; and recirculation flow rate. Site-level gas savings can vary significantly based on these parameters.

1.1.2 Technical Operating Information

The RPTC system consists of a time clock installed on a DHW recirculation pump that is programmed with occupancy schedules. Once properly installed, the RPTC system will continue to operate without customer intervention. An example of a RPTC is shown in Figure 1-1.

Figure 1-1. Recirculation Pump Time Clock

Source: Taco Systems

1.2 Baseline Equipment

The baseline for this measure is a recirculation pump that does not have any controls; and therefore operates continuously year-round unless it is manually shut off.

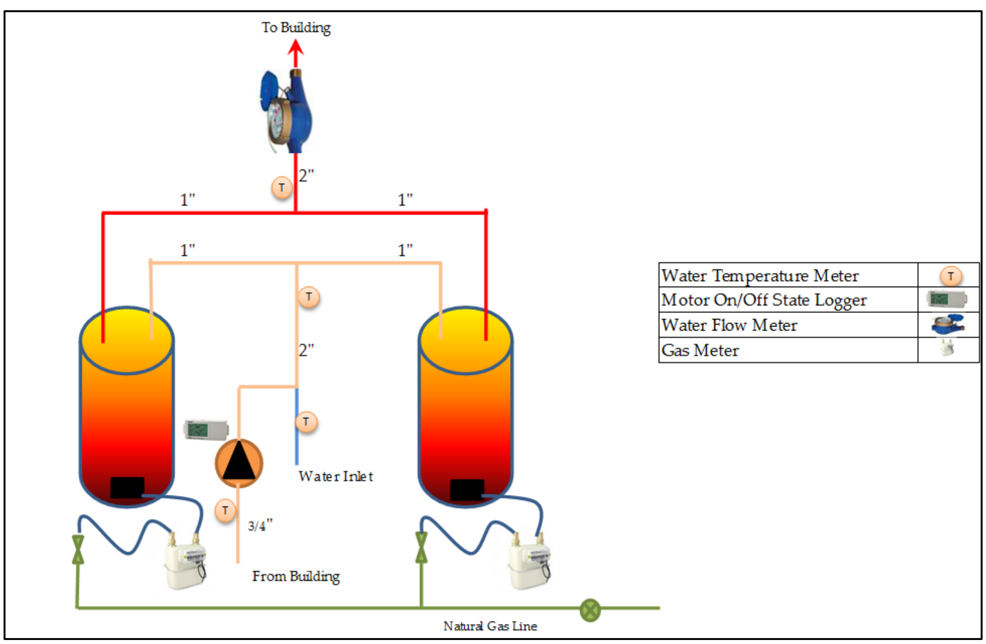
2. PILOT METHODOLOGY

2.1 Methods

The field testing involved installation and monitoring of a RPTC and data loggers at the host site in [redacted], California. The data loggers were installed prior to the installation of the RPTC in order to characterize the baseline system (from December 11, 2013 to March 2, 2014) and remained installed for two months after the installation date in order to characterize the efficient case (from March 3, 2014 to May 2, 2014). Figure 2-1 shows a schematic diagram of the two-tank water heater setup and Navigant's metering implementation. In this figure, the red lines indicate the hot water from the water heater; the green lines indicate the natural gas lines; the blue lines indicate cold water coming into the tanks; and orange lines indicate water within the system. The pipe sizes are indicated in the figure.

Navigant devised a metering plan for determining gas consumption, as shown in Figure 2-1. In order to determine the effectiveness of the time clock at turning the hot water on and off at set times of the day, Navigant placed **temperature sensors** where the hot water enters and leaves the water heaters, as well as at the recirculation loop return point. A **HOBO motor logger** was used at the recirculation pump to collect information about when the motor turns on and off as result of the time clock. Two **gas meters** were installed – one at each hot water heater – to measure the gas savings from the time clock implementation. Navigant did not use a water meter for this site because of their high cost (about $865), invasive installation requirement (cutting pipes), and the fact that quantifying water consumption from installing the time clock was not an objective of the study.

Figure 2-1. System and Metering Plan



Source: Recirculation Time Clock Demonstration Plan (v3) by Navigant

2.2 Site-Level Savings Analysis Methodology

The site-level savings calculated in this analysis are based on data collected from the sensors and meters that were installed per Figure 2-1. The general site-level savings analysis methodology is as follows:

1. Calculate average gas consumption per day for each logged month (i.e. January and February for baseline data, March and April for post-installation data).
2. Extrapolate these particular months' results to a full year based on monthly normalization factors (e.g. incoming water temperature, building schedule, water consumption, etc.).
3. Calculate average gas use per month for the baseline and post-installation cases using both actual logged data and normalization factors.
4. Calculate site-level savings by taking the difference of estimated monthly gas consumption in the baseline case and the post-implementation case.

2.2.1 Gas Consumption Extrapolation and Weather Normalization Methodology

Various factors affect changes in DHW gas consumption in a particular building throughout the year:

- *Incoming water temperature* – in the winter months, water delivered to the site from the city (i.e. mains) is colder and thus requires more gas input to raise the water temperature to the desired delivery temperature.
- *Occupancy* – some building types, such as schools, have drastically different occupancy patterns during the school year versus summer.
- *Behavior* – e.g., tenants may take longer showers in the winter

In order to extrapolate logger gas consumption from one month to an anticipated value in another month at this site, Navigant compared the aforementioned factors in each month to develop normalization factors that adjust gas consumption to capture the effects of that factor on savings.

Navigant interviewed the building manager to better understand how the above factors may affect the gas savings calculation.

3. SITE RESULTS

3.1 Description of Test Site

The field testing consisted of installation of one RPTC at an office building in [redacted], CA. The building is a seven-story 150,000 ft.[2] office space with a set of men's and women's bathrooms on each floor and a fitness center with eight showers on the first floor. The facility's normal hours of operation are 7am to 7pm, Monday through Friday. Pre-installation and post-installation data was collected for the purpose of comparing the actual in-situ use of the RPTC with the data collected before the RPTC was installed. The total pre-installation metering period was 12/11/2013 – 3/2/2014, while the total post-installation metering period was 3/3/2014 – 5/2/2014.

The building's hot water system consists of two 75-gallon natural gas hot water heaters, each with an input capacity of 75,000 BTU/hr. The water heaters are piped in parallel and always operate together. The recirculation pump is 1/6 HP and is controlled via a manual switch that is always set to the "on" position. The baseline control scheme set the recirculation pump to operate at all times, regardless of building occupancy. Now that the RPTC is installed, the recirculation pump is programmed to completely shut off at night for approximately nine hours (from 7pm to 4am) on weekdays and for the entire day on weekends (7pm on Friday until 4am on Monday).

3.2 Data Overview

Baseline (pre-installation) data was collected from December 11, 2013 to March 2, 2014. Navigant identified missing temperature data from December 19, 2013 to January 23, 2014, and missing pulse meter data from February 10, 2014 to February 19, 2014.

Efficient (post-installation) data was collected from March 3, 2014 to May 2, 2014. Navigant did not identify any data quality issues with this dataset.

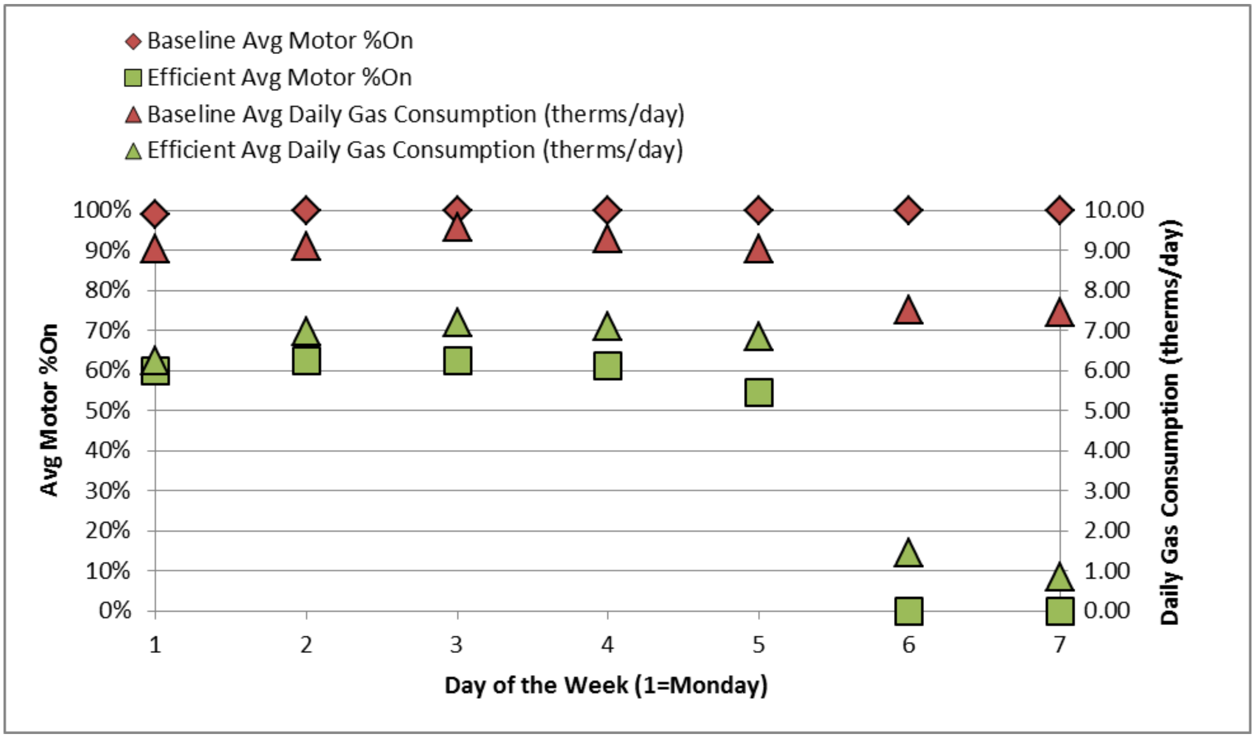
Navigant determined that the incoming mains water temperature meter data showed abnormally high temperatures for most timestamps. Therefore, Navigant used secondary research to estimate the average incoming water temperature in each month.

Navigant interviewed the building manager to better understand the effects of building occupancy and other factors that affect the accuracy of extrapolating logger data to a full year. From this interview, Navigant determined that the building was in normal operation and had normal occupancy patterns during both the pre- and post-installation logging period.

3.3 Savings Analysis Results

Navigant performed an initial analysis of the data to visualize the effect of the RPTC on gas usage. This preliminary analysis does not take into consideration changes in weather, which affects the incoming mains water temperature. As shown in Figure 3-1, the RPTC reduces the motor run-time[2] from 100% to about 60% on the weekdays, and from 100% to almost 0% on the weekends. Gas consumption is also reduced by about 2.5 therms/day (i.e. ~25% reduction) and 6.5 therms/day (i.e. ~80% reduction) on weekdays and weekends, respectively.

Figure 3-1. First Look at RPTC Results (Non-Normalized)



Source: Logger data

In the colder months, incoming water to the water heaters is colder, requiring more natural gas to raise that water to the delivery temperature. Therefore, it is necessary to normalize gas consumption based on incoming water temperature in order to accurately compare the baseline and RPTC cases, since data was collected on these cases during different months. Navigant used actual logger data (numbers determined from primary data are shown in ***italicized bold***) along with a "mains normalization factor[3]," to estimate gas consumption in the remaining months, as shown in **Error! Reference source not found.** and **Error! Reference source not found.** below.

[2] Motor run-time is the average percentage of hours per day that the recirculation pump motor runs at full speed, based on the logger data.

[3] Navigant calculated the "mains normalization factor" using expected incoming mains water temperature data. This factor adjusts the measured gas consumption from the baseline months (Jan-Feb) and from the demonstration months (Mar-Apr) to predict gas usage in the remaining months for those cases. Navigant confirmed with the building manager that occupancy or usage patterns are likely consistent throughout the year; therefore, the most likely parameter affecting seasonal DHW gas consumption is the incoming mains water temperature.

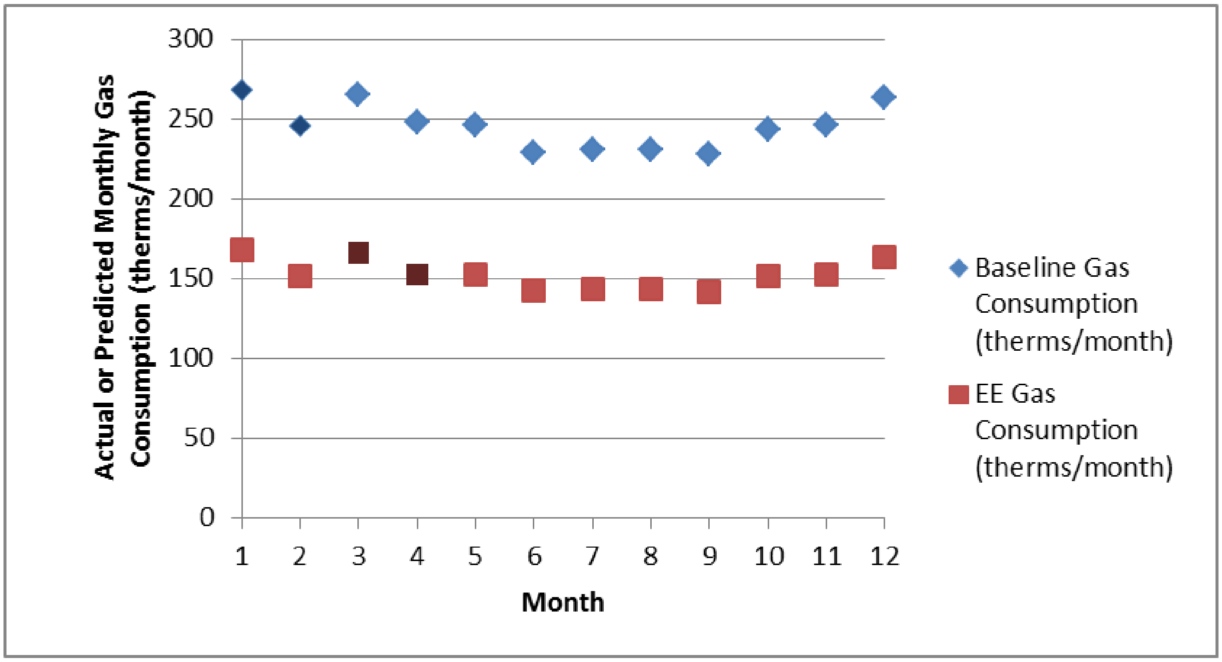
Table 3-1. Summary of Calculations and Resulting Savings of the Host Site

Month	Mains Normalization Factor	Baseline Gas Consumption (therms/month)	EE Gas Consumption (therms/month)	Savings* (therms/month)
1	1.086	***268.2***	167.7	100.5
2	1.086	***245.8***	151.5	94.3
3	1.066	265.2	***166.1***	99.1
4	1.030	248.0	***152.6***	95.4
5	0.989	245.9	152.7	93.3
6	0.951	229.0	142.2	86.9
7	0.928	231.0	143.4	87.6
8	0.927	230.6	143.2	87.5
9	0.946	227.7	141.3	86.3
10	0.980	243.8	151.3	92.5
11	1.021	245.9	152.7	93.3
12	1.059	263.4	163.5	99.9
			Annual Savings (therms/year)	**1,116.5**

Source: Navigant analysis of logger data
**Based on a heat rate[4] of 1,027 btu/cf*

[4] California 2013 data from http://www.eia.gov/dnav/ng/ng_cons_heat_a_epg0_vgth_btucf_a.htm

Figure 3-2. Actual or Predicted Monthly Gas Consumption of Baseline and EE Configurations at the Host Site



Source: Navigant Analysis
Bolded data points from actual logger data; remaining data points from extrapolation (see Section Data Overview*3.2*

3.4 Site Challenges and Issues

Energized Solutions identified the following observations and challenges once the project was completed:

- Some baseline logger data was missing
    - Lost temperature data from 12/19/2013 – 1/23/2014
    - Lost pulse meter data from 2/10/2014 – 2/19/2014
- The hot water system shutdown for sensor installation had to be conducted during nonbusiness hours so as to not disturb the occupants.
- The controller operated as planned during the entire controlled period.
- The facility did not receive any customer comments or complaints related to the hot water service during the controller operation test period.
- The facility was happy with the controller and requested to keep and operate it beyond the demonstration.

3.5 Conclusions

The RPTC saved approximately 1,100 therms of natural gas annually at the host site building based on the logger data analysis. Energized Solutions encountered minimal issues with the installation and implementation of the RPTC, and Navigant's analysis of the logger data indicated that the RPTC operated as expected. Navigant recommends that SoCalGas consider incorporating the RPTC (and similar products) into their portfolio with a provision that the technology is installed in buildings with set occupancy schedules, such as offices, schools, and gyms.