Energy Efficiency Portfolio of the Future

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ABSTRACT

Faced with increasingly stringent goals for reducing future natural gas consumption, as well as the maturity of many traditional energy efficiency measures, the Southern California Gas Company (SoCalGas®), in cooperation with Navigant Consulting Inc., (NCI) has expanded its efforts to accelerate the commercial acceptance of emerging energy efficient technologies. Distinct from R&D, this effort focuses on advancing technologies across the chasm between R&D and market acceptance, in order to accelerate market adoption and consequent energy savings. New technologies or business practices are required, but they must be sufficiently mature to be broadly implemented within a few years in order to make a significant impact on gas usage. This effort is referred to as SoCalGas' "Portfolio of the Future" (POF).

The POF program consists of several tasks, beginning with a screening of approximately 500 potential efficiency measures with respect to metrics such as stage of commercialization, cost effectiveness, energy savings potential, market and technical risk, and criticality of SoCalGas' involvement. Eventually, fourteen top-tier measures were identified, of which six are currently the subjects of demonstration projects, field evaluations, market assessments, or business strategy development. For the other top tier measures, strategies for accelerating market adoption are being considered. The goal is to ready some of these technologies for inclusion in SoCalGas' 2009 – 2011 efficiency programs. The following paper provides an overview of the POF project, explains the screening process, identifies the top tier measures, and describes the status of the pilot and demonstration projects.

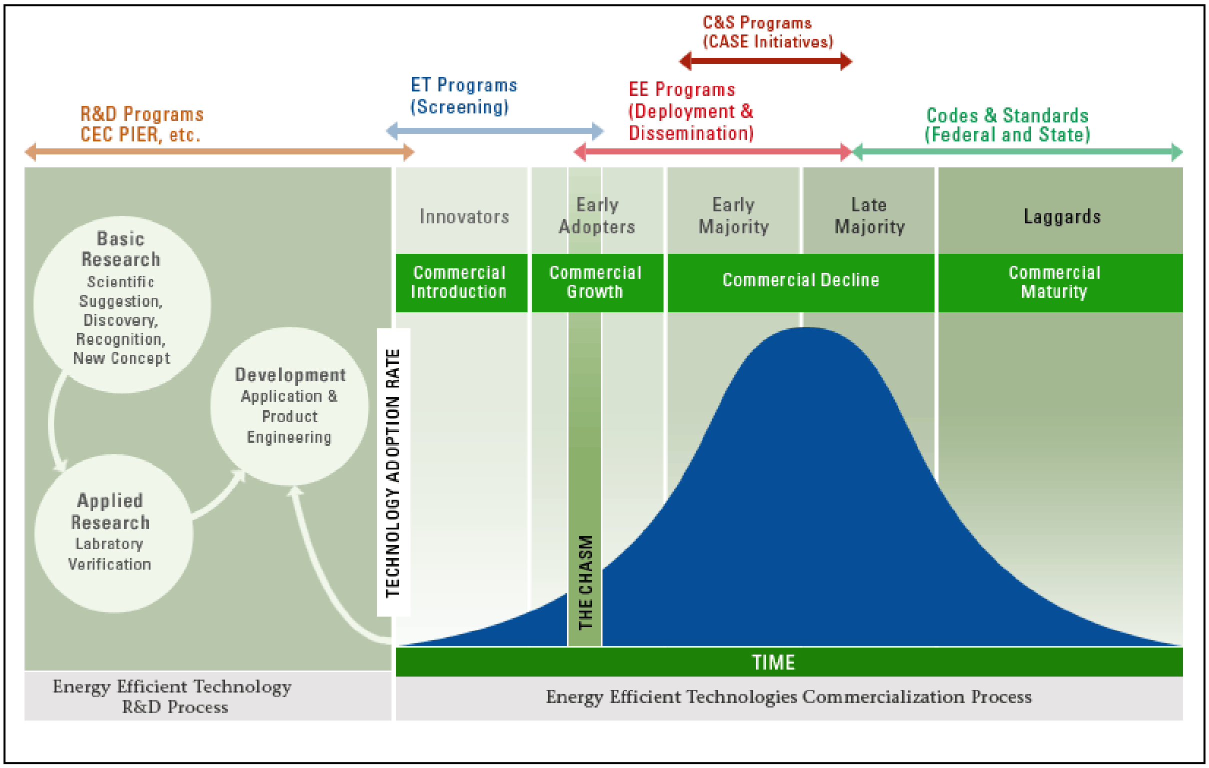
Introduction

SoCalGas, like many utilities, faces a major challenge in meeting aggressive energy efficiency goals. In California, these needs are driven in part by legislation such as California Assembly Bill 32 (AB 32). AB 32, the California Global Warming Solutions Act of 2006, requires the state to reduce carbon emissions to 1990 levels by the year 2020.

In SoCalGas' case, there are several particularly daunting challenges. The natural gas savings targets set for it by the California Public Utilities Commission (CPUC) are extremely aggressive. Many technologies that have provided energy savings in the past are now quite mature, so many customers for whom energy savings measures are attractive have already adopted them. The newly instituted earnings-based incentive mechanism for California utilities strongly encourages the utilities to focus on cost effectiveness in their choice of measures. Finally, Southern California's temperate climate makes energy efficient space heating measures, which can save a great deal of gas and are highly cost effective in many other regions, difficult to justify to customers. For these reasons, it is apparent that new technologies, strategies, and business models are necessary to meet the company's energy savings commitments.

The Portfolio of the Future (POF) project was undertaken by SoCalGas in order to identify and accelerate the commercialization of emerging technologies that can significantly improve natural gas energy efficiency. Residential, commercial, and industrial technologies are included. The term technologies is broadly defined to include (1) hardware and software, (2) tools and techniques (e.g. design guides and codified practices), and (3) business models. As shown graphically in Figure 1 from the California Emerging Technology Coordinating Council (ETCC), while there is considerable support for R&D related to energy efficient technologies, many technical successes never make the leap to achieve significant market impacts. The gap between the laboratory and the market is often the most challenging element of the product commercialization pathway. The POF program is designed to move technologies across this "Chasm" and build market adoption so that substantial energy savings can be achieved.

Figure 1. Technology Commercialization Path for Energy Efficient Technologies



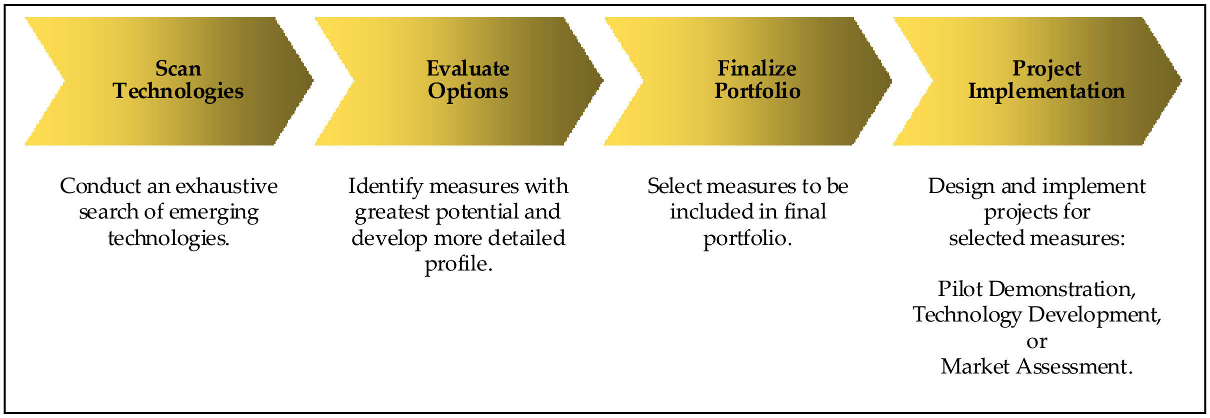
Source: California Emerging Technology Coordinating Council (ETCC).   http://www.etcc-ca.com/about/et_innovation.php

The following paper explains the process used for identifying and screening technologies in order to build the portfolio, identifies the highest priority measures that resulted from the screening process, and describes the pilot projects undertaken to accelerate market adoption of the highest priority measures.

Evaluation Process

As shown in Figure 2, the POF program is based on a four step process consisting of identifying technologies, evaluating options, finalizing the portfolio, and implementing pilot projects.

Figure 2. POF Process



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The screening process began by identifying approximately 500 measures, drawn from various sources such as the American Council for an Energy Efficient Economy (ACEEE), the U.S. Department of Energy (DOE), New York State Energy Research & Development Authority (NYSERDA), and the California Energy Commission (CEC), as well as discussions with manufacturers, utilities, energy efficiency contractors, industry experts, and other stakeholders. From the initial list, many were screened out quickly for reasons such as:

- Inappropriate for an energy efficiency program
- Still in the R&D stage
- Already widely commercialized
- Has limited market application or low baseline gas consumption in SoCalGas' territory
- Offers very low energy efficiency improvement potential in SoCalGas' territory
- Not cost effective in SoCalGas' territory (i.e. long payback period, >~10 years)
- Already a SoCalGas energy efficiency activity

At this point, approximately 46 measures remained, and detailed profiles of these measures were prepared. Eight parameters, with appropriate weighting factors, were then used to score each measure. Both the weighting factors and the scoring were somewhat subjective, as precise data was either unavailable or could not be assembled without major analysis efforts, which would be unrealistic for such a large data set. Nevertheless, the team of SoCalGas and NCI were comfortable that the scoring process broadly represented the potential for the energy efficiency measures selected. As shown in Figure 3, key parameters included: technical savings potential, cumulative market potential (2009-2011), the number of potential customers, market risk, technical risk, criticality of SoCalGas' involvement, non-energy benefits, and simple payback period. The qualitative evaluation parameters require additional guidance to ensure accurate and consistent scoring, as illustrated in Figure 4.

Each of the 46 measures was evaluated independently and subjectively to capture all its strengths and weaknesses. The scoring process included the following steps:

1. Identify a promising measure
2. Develop a profile of the measure
3. Assign a score for each evaluation parameter

4. Calculate the weighted total score
5. Compare measure to peers
6. Facilitate subjective conversation about measure strengths and weaknesses
7. Assign a "final grade"
   - 4-5 Recommend for further consideration
   - 3 Monitor for future developments
   - 1-2 Remove from consideration

Figure 3. Energy Efficiency Measure Scoring Criteria

	Parameter	Wt	1	2	3	4	5
1	Technical Savings Potential (annual)	10%	< 25 MTh	25-50 MTh	50-100 MTh	100-200 MTh	> 200 MTh
2	Cumulative Market Potential (2009-11)	20%	< 0.5 MTh	0.5-1.0 MTh	1.0-2.5 MTh	2.5-5.0 MTh	> 5.0 MTh
3	Potential Customers	5%	Limited < 1k Customers	1k – 10k Customers	10k – 100k Customers	100k – 1M Customers	Mass Market > 1M Customers
4	Market Risk	15%	High	High – Medium	Medium	Medium – Low	Low
5	Technical Risk	15%	High	High – Medium	Medium	Medium – Low	Low
6	Criticality of SCG Involvement	15%	Not Essential	Not Important	Limited Impact	Very Important	Essential
7	Non-energy Benefits	10%	None	Limited	Various	Significant	Extensive
8	Simple Payback Period	10%	> 10 years	10.0 – 7.0 years	7.0 – 4.0 years	4.0 – 2.0 years	< 2.0 years

Figure 4. Qualitative Evaluation Parameters

Parameter	1	2	3	4	5
Market Risk	• Requires new business model • Start-up, or small manufacturer • Requires significant changes to infrastructure • Requires training of contractors • Consumer acceptance barriers exist				• Trained contractors • Established Business Models (distributors, sales channels) • Already in U.S. Market • Manufacturer committed to commercialization
Technical Risk	• Product prototype demonstrated in first field tests	• Low volume manufacturer • Limited long term field experience	• New product introduction with a credible path to broad commercial application	• Proven technology in different application or different region	• Proven technology in target application
Criticality of SCG Involvement	• Private sector will be successful without SCG involvement	• SCG is unlikely to be critical to adoption	• SCG is likely to accelerate adoption	• SCG is very important in accelerating adoption	• SCG required to stimulate market • No other efforts in SCG service area
Non-energy Benefits	• Few or none non-energy benefits	• Some modest non-energy benefit likely	• Significant benefits expected, but difficult to quantify, not as well understood	• 1 or 2 quantified, well-documented	• Extensive, quantifiable, well-documented non-energy benefits

It should be noted that the "final grade" was not simply equal to the total score, but rather included some additional subjective prioritization, considering factors such as the time and budgetary limitations of the program, as well as key market sector priorities for SoCalGas. Fourteen "top tier" measures emerged from this process, but due to resource and time limitations, as well as other factors such as the scale of the projects, the feasibility of a pilot program, or the fit with SoCalGas' existing portfolio, only some of these could be pursued further.

Portfolio Evaluation Tool

As part of this process, we created a customized spreadsheet tool to facilitate portfolio analysis. This tool enables us to visualize the portfolio in many ways to assess issues such as portfolio risk (market or technology), economic feasibility, or energy savings potential and to make appropriate adjustments to the portfolio, for example to improve balance. Some examples of the outputs from this tool are illustrated in Figures 5-7.

Figure 5. Visual Analysis of Portfolio Savings Potential

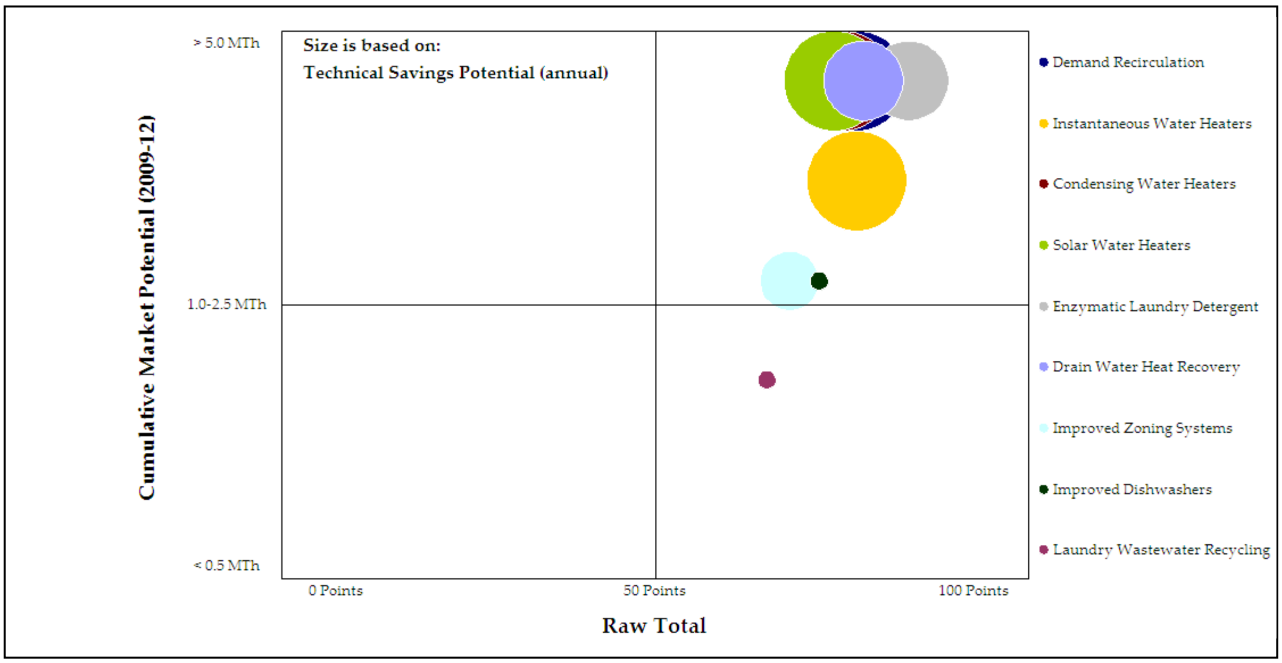


Figure 6. Visual Analysis of Portfolio Risk (Combined Technical x Market)

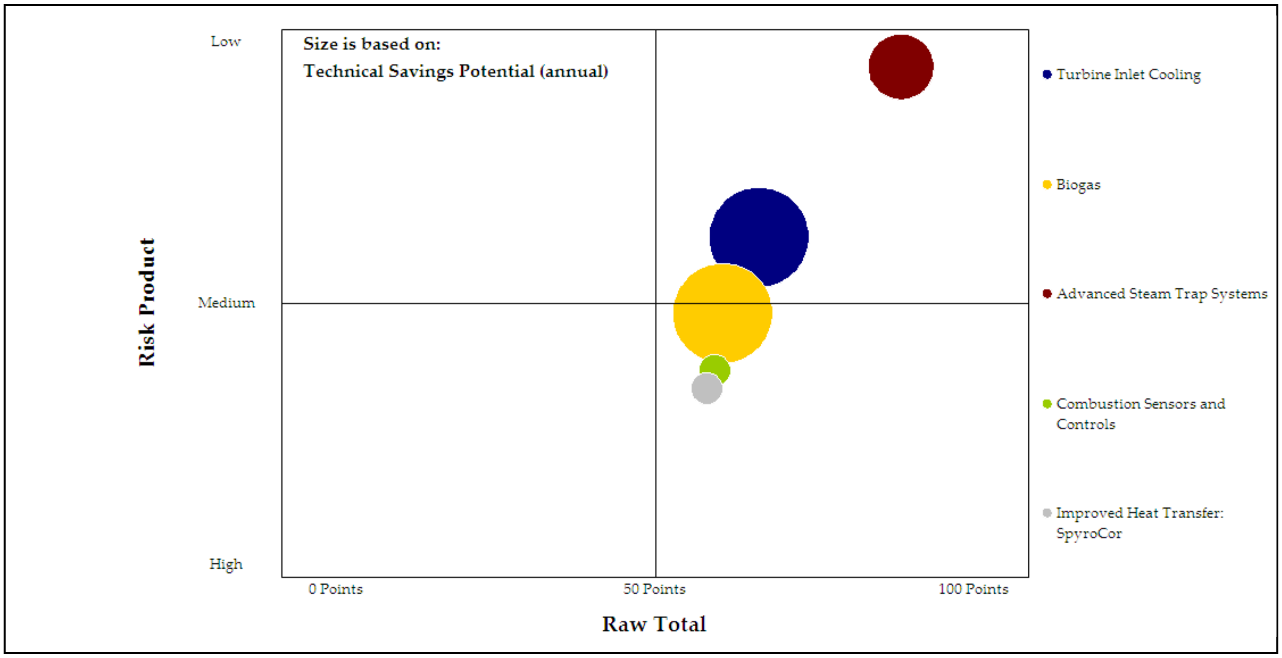
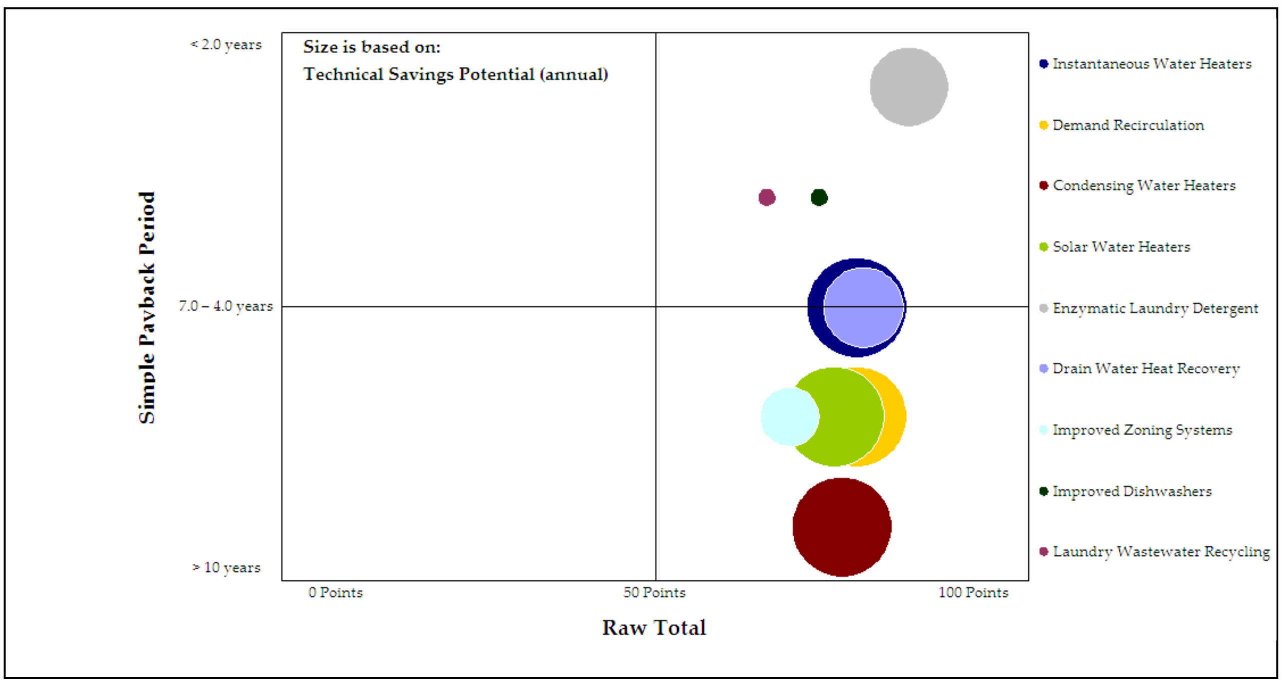


Figure 7. Visual Analysis of Portfolio Economic Feasibility



Pilot Projects

Among the top tier measures, six were selected for pilot programs or market and technology assessments, and one is under consideration. These measures and the corresponding market or technical savings potential estimates are shown in Table 1. The five measures currently being piloted or subject to market studies are described in further detail below.

Table 1. Activities for Highest Priority Measures

Measure	Project Type	2009-2011 Cumulative Market Potential (Mth)	Technical Savings Potential (Mth/year)
Enzymatic Laundry Detergent (Residential)	Market Study/Consumer Test	4.2	
Improved Commercial Dishwashers	Market Study	0.6	
Improved Heat Transfer: Radiant Tube Burner Inserts	Pilot	1.2	
Automatic Steam Trap Monitoring	Pilot	4.2	
Commercial Laundry Technologies	Pilot	8.4	
Combustion Sensors & Controls	Market/Technology Assessment		74-91
Solar Water Heating	Under Evaluation		375

Enzymatic Laundry Detergent

Substituting cold water for warm or hot water in clothes washing is a simple means of reducing natural gas consumption, because the vast majority of homes in California use natural gas for water heating. In fact, 80-85% of the total energy consumed in residential clothes washing is thermal energy used for heating water. Laundry detergents must be specially formulated for cold water washing. In order to effectively remove fabric stains and dirt during cold (~60 °F) water washing, a proprietary combination of enzymes to catalytically remove stains, including amylase for starch and protease for protein, and surfactants for emulsifying and suspending soil particles, is used.

Cold water laundry detergents are available from major consumer goods companies but have a very low market share in the U.S. While some performance limitations exist (e.g. the detergents can not provide disinfection and are unavailable for high efficiency horizontal axis washers), cleaning performance is generally as good as that of standard detergents. Nevertheless, some market barriers remain, including the consumer perception that warm or hot water washing is always superior to cold. Cold water detergents can cost slightly more per wash load (~1-2 ¢) than their standard detergent equivalents, but this cost premium is easily recovered in a few weeks due to the reduction in water heating energy.

Although the technical potential energy savings of cold water clothes washing is clear, actual savings depend on factors such as compliance and persistence. Consumers might purchase a cold water detergent but still wash in warm or hot water, assuming that if it cleans well in cold water, performance will be even better in warm or hot water. If incentives are provided in the form of coupons, persistence is also uncertain. Consumers might purchase and use cold water detergents as long as coupons are provided, but once the incentives are removed, would they revert to their previous behavior? Finally, actual savings depend on how many wash loads are shifted from warm to cold water. Some hot loads would likely remain.

Although coupon redemption rates provide one metric for evaluating the energy savings potential of cold water detergents, they are insufficient to validate compliance, persistence, and actual savings. To address these issues rigorously, an extensive field monitoring study is underway, in cooperation with the leading supplier of cold water detergent, and supported by two other California utilities, San Diego Gas & Electric Company (SDG&E) and Pacific Gas & Electric Company (PG&E). The objectives of the study are to:

1. Determine whether provision of cold water detergent changes mix of cold, warm and hot water wash loads in customer homes.
2. Estimate gas consumption reductions due to observed wash temperature switching.
3. Assess persistence of behavioral change to washing certain/all loads in cold water.
4. Assess impact of ongoing messaging on cold water wash benefits.

The study includes 3 distinct groups: a control group, a treatment group with limited messaging, and a treatment group with expanded messaging. Customers maintain logbooks of clothes washing behavior, and monitoring equipment is installed on a subset of participants to determine the extent to which reported temperature settings reflect actual temperature settings. Participants report their behavior before starting to use cold water detergent and for a two-month period during which detergent is supplied. Follow-up surveys are conducted six weeks and six months after the end of the study to gauge persistence of switching behavior.

Improved Commercial Dishwashers

High efficiency commercial dishwashers are an attractive gas savings measure because dishwashing accounts for 2/3 of all water usage in restaurants, and is one of the largest energy consumers in commercial kitchens. Natural gas consumption attributable to commercial dishwashers in SoCalGas territory is estimated to be approximately 62 Mth/year, over 80% of which is used in restaurants, with the remainder in schools, hotels, food stores, and hospitals.

Commercial dishwashers clean and sanitize dishware using a combination of heat, mechanical scrubbing action, and chemicals. High efficiency commercial dishwashers save energy by reducing the amount of water heating required. There are four types of commercial dishwashers, differentiated by capacity measured in racks/hr:

- **Undercounter –** similar to residential units, but faster cycles and more rugged
- **Door-type –** batch operation, dishware loaded in racks
- **Rack conveyer –** continuous operation, dishware loaded in racks
- **Flight-type –** continuous operation, dishware individually loaded

Each type is also classified by the rinse water temperature:

- **High temperature** (180 °F) **–** sanitizes by heat; water heating, including boost heating, represents 54-79% of machine energy consumption
- **Low temperature** (120 – 140 °F) – chemicals used for sanitization; water heating accounts for up to 95% of machine energy consumption

High efficiency machines maintain cleaning performance by reducing heat losses, improving mechanical soil removal, and/or increasing component efficiencies. By using strategies such as waste air heat recovery, drain heat recovery, re-using rinse water, double-walled insulated construction, high efficiency anti-clogging nozzles, continuous filtering, and efficient boost heaters, water consumption can be reduced from as high as 4 or 5 gallons/rack to less than 0.5 gallons/rack, depending on the type of dishwasher.

Because high efficiency commercial dishwashers save both water and energy, payback periods can be quite attractive. Assuming average savings of 29% for both water and natural gas, payback periods can be less than 2 years. Ancillary benefits include improved indoor air quality due to reductions of steam in kitchens, and consequent reductions in HVAC loads.

A market study was conducted to identify types of equipment in place, usage patterns, market barriers, and non-energy benefits of improved commercial dishwashers. Over 100 sites were interviewed to determine target sectors for promotion of high efficiency dishwashers. Hotels, independent restaurants, and universities were determined to be the best targets. A combination of tailored educational programs (including pilot programs and case studies) and purchase and lease incentives were recommended, depending on the target sector.

Improved Heat Transfer: Radiant Tube Burner Inserts

Gas-fired radiant tube heaters are used in many metal processing applications such as heat treating furnaces. Improving the heat transfer performance of the radiant tube heaters reduces natural gas consumption in the furnaces. SpyroCor™ is a ceramic (silicon carbide) heat transfer device for gas-fired radiant tube heaters that has been developed by Spinworks, LLC. SpyroCor™ is designed to absorb energy that would otherwise be lost from exhaust gases. It is able to absorb energy as a result of its patented twisted "Y" design, which improves heat transfer to the SpyroCor™. It then radiates the energy to the radiant tube wall as a result of its high emissivity (0.95). These characteristics enable the SpyroCor™ to increase the net heat output of the radiant tube and reduce natural gas consumption. The inserts are typically installed as retrofits to existing furnaces.

Many of these inserts have been installed in the Midwest and Mid-Atlantic States, but none had been installed in California. Energy savings vary between approximately 5 and 25%, depending on the existing radiant tube design. For a relatively new furnace with a recuperator, savings may be only 5%, but retrofits to an older furnace may save up to 25%. For our market potential estimates, we used an average of 15% savings. Case studies for several installations have been published that document the performance improvements. **(Spinworks, LLC, 2007)**

The pilot program consists of two elements. The first involves measuring NOx emissions at the supplier's test furnace. NOx emissions are of particular concern in Southern California but the impact of the SpyroCor™ inserts on NOx emissions has not yet been measured, although it is expected to be insignificant. The test furnace will be fired at three rates (300 kBTU/hr, 400 kBTU/hr, and 500 kBTU/hr) and three temperatures (1400 °F, 1600 °F, and 1800 °F) in order to cover about 80% of the radiant tube market operating conditions.

The second element of the pilot program is a demonstration at an industrial heat treating furnace in Southern California. This demonstration will include a measurement of natural gas consumption as well as NOx emissions before and after the installation of the SpyroCor™ inserts, under identical operating conditions. The results of this test, combined with other field data and emissions test data from the supplier's test furnace, will provide the credibility necessary to promote this technology to additional customers in Southern California.

Steam Trap Monitoring Systems

It is estimated that approximately 506 Mth are consumed to produce steam at industrial facilities in the Southern California Gas Company service area, with some additional consumption in hospitals and universities. **(CEC Demand Analysis Office, 2006)** In industrial facilities, the steam is generally used for process heating; in hospitals, it is used for space heating, humidification, and sterilization, and in universities, it is used for space heating and hot water heating. To improve system performance, steam traps are installed to remove condensate and air from the pipes, without releasing steam and wasting the energy embodied in the steam. Steam traps have a typical service life 1-7 years, with shorter service lives for higher pressure traps. **(Environmental Analysis, Inc., 2007)** Steam traps often fail open, which causes steam to leak, thus wasting energy. Without a regular maintenance program, up to 10% of the energy used in a steam system may be wasted **(KEMA, 2006).** Even with inspections every 3-5 years, it is common to find 15%-30% of traps malfunctioning **(DOE EERE Industrial Technologies Program, 2006)**.

Recently, technology has become available to automatically and remotely monitor steam traps, immediately alerting plant staff when a trap fails. Facility maintenance teams are often short staffed and unable to inspect steam traps regularly, and many steam traps are located in difficult to access locations. Automatic monitoring allows the maintenance staff to focus their limited resources only on traps that require replacement, thus enhancing productivity, operations and maintenance throughout the facility. It has been estimated that this technology can yield 5% gas savings above and beyond the 10% savings gained with a regular maintenance program **(Lawrence Berkeley National Laboratory, 2001)**. This translates into potential savings of approximately 15.1 Mth annually in SoCalGas service territory, assuming a 50% feasibility factor. The technology is available from several vendors but has rather high capital costs, which has inhibited market adoption to date. Simple payback periods can range from 2-7 years, depending on pressures, current maintenance activities, gas costs and trap failure rates.

Our activities for this measure included a market study to determine the size of the savings opportunity and the barriers to implementation of steam trap monitoring systems, as well as a demonstration of a wireless seam trap monitoring system at a beverage bottling plant in Southern California. The market assessment was completed and enabled us to estimate the size of the market opportunity, as described above. The monitoring system was installed at a customer facility and has been operating trouble-free for several months. Steam trap status can be monitored via a password-protected website. The customer is immediately notified of any faults. The successful installation of this system will provide credibility for promotion of this technology in Southern California.

Commercial Laundry Technologies

On-premise commercial laundries are major gas consumers in Southern California, so we examined several technologies that could yield natural gas savings in these facilities. We estimated that approximately 4.8 billion pounds of laundry are processed annually in our service territory. The primary market segments, in size order, are motels, hotels, nursing homes, and prisons. Water temperatures range from 100 °F – 170 °F.

Beyond the energy usage, it is particularly noteworthy in California that typical commercial laundry operations use a washer/extractor that consumes 2-3 gallons of water per pound of laundry. The water is consumed in a variety of wash and rinse stages during a single laundry cycle. Water is normally discharged from each stage and replaced with fresh water.

Our investigation identified four efficient on-premise commercial laundry technologies:

- Wastewater Recycling: In these systems, which are retrofit to existing machines, water is cleaned and recycled after each stage, rather than being replaced. Natural gas savings of over 50% has been documented, in addition to 80% water savings. Due to the high capital costs, the systems are best suited to large facilities, which process over 5,000 lbs./day, or over 10,000 lbs/day for continuous batch (tunnel) washers (CBWs).
- Cold water detergent: This measure can be used in any type of existing washer. The detergent is formulated for good cleaning performance in cold water, so it eliminates natural gas usage for water heating, though it does not save any water. The major barrier is that the detergent contains phosphates, which are tightly regulated and may eventually be banned in California. Consequently, cold water detergents are not a long term solution. However, warm water detergents are available, and they do not present any environmental concerns. These detergents can reduce gas consumption by 50% compared to hot water washing.
- Advanced Ozone Systems: These systems inject ozone into cold water during the washing process and allow cold water to be used for about 85% of clothing. Wash and drying time are also shortened. The technology is not suitable for heavily soiled items and is available only for new washer/extractors. Natural gas savings as high as 90%, and water savings of up to 45% can be achieved. The technology is most suitable for small to medium size facilities (1,000 – 10,000 lb./day)
- Advanced Tunnel Washers (CBWs): Advanced tunnel washers use much less water than standard tunnel washers and reuse rinse water. They have very high capital costs and are suitable only where continuously high wash volumes are processed (over 10,000 lb./day). Advanced tunnel washers can reduce natural gas consumption by over 60% relative to traditional tunnel washers and over 80% compared to washer/extractors. Water savings of 55 – 80% can also be achieved.

As a result of our market assessment, we were able to estimate the savings potential and key target markets. In addition, we will initiate educational activities with customers and coordinate incentives with the Metropolitan Water District. We will also consider shared savings program options with hospitals and prisons.

Future Plans

The POF program will continue to update its technology portfolio to assess new technologies that are reaching the appropriate stage of development. We are already considering whether to launch new pilot programs or market assessments for several additional industrial heating, drying and water heating technologies.

Conclusions

The process for identifying, screening, and prioritizing emerging energy efficient technologies that was developed in this project could be applied broadly by other electric and gas utilities. Many utilities are facing similar drivers to those of SoCalGas. Their existing energy efficiency program portfolios include many mature technologies which are insufficient to meet their long term energy efficiency goals, so emerging technologies or new business models must be added to their portfolios. Of course, each utility has unique characteristics due to factors such as climate, customer profiles, existing programs, etc. These factors that must be taken into account when developing the screening criteria and weightings, as well as the final decisions regarding top tier measures. It is also worth noting that field testing and pilots are often lengthy and expensive projects, so a POF program requires sufficient resources and time if valuable results are to be achieved.

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