Emerging Technologies for PG&E's Industrial Sector
Accelerating the Deployment of Energy Efficient Innovations

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ABSTRACT

The Emerging Technologies Program is in charge of detecting, assessing, and introducing new energy efficient solutions to PG&E's customers. In the challenging context of the 2006-2008 mandates of the Californian utilities, it focuses its activity on the commercialization of proven technologies in order to rapidly obtain substantial savings in its territory. Current examples from its portfolio illustrate how this approach works for different applications and different industrial segments.

Introduction

With rapidly increasing concerns about global warming and energy prices, governments have increasingly developed different initiatives to improve the energy efficiency of utility customers.

Leading this trend was the California's Energy Action Plan (CEC & CPUC 2005) which put energy efficiency as the number one priority to help accommodate state-wide new development as well meet its aggressive goals in green house gas reduction. Similarly, various White Certificate mechanisms were introduced in Europe since 2005.

These initiatives were set up to quickly and broadly implement economically effective energy solutions. Incentives were provided to offset the investment costs of energy efficient solutions so that industrial companies could see a quick return on their investment while maintaining the quality of their products and their profitability.

In California, the four investor-owned utilities were mandated to implement the plan's objectives for the 2006-2008 period which set forth the most ambitious efficiency goals in their history.

In response to this new challenge, the Emerging Technologies Program at Pacific Gas and Electric Company (PG&E) was structured around five principles:

- focus on the latter stage of the innovation process, in particular, the market adoption phase,
- select technologies and solutions that help PG&E achieve its customer-focused goals and maximize potential savings in its markets,
- integrate new technologies into PG&E's service offerings through a cross-functional process,
- mitigate risks using a portfolio approach that includes projects with different objectives, timelines, and risks, and
- develop alliances and partnerships with a broad range of companies and organizations along the innovation process for emerging technologies.

We discuss and illustrate the initial results with examples from the past two years of operation in PG&E's Industrial portfolio.

Focusing on Market Adoption

Energy Efficiency and Demand Response were recognized by the California Energy Action Plan (CEC & CPUC 2005) as an energy resource similar to generation and the procurement of electricity and gas. They are also considered the preferred option in the energy mix for the State, before renewable energy, distributed generation and finally clean and efficient fossil-fired generation.

PG&E, for its part, must generate 3 TeraWattHours (TWh) and 48 Million Therms (MMTherms) of annual savings along with 613 MegaWatts (MW) of demand reduction by the year 2008. These savings goals are equivalent to five percent of its 2006 electricity delivery and two percent of its 2006 gas delivery (PG&E delivered 65 TWh of electricity and 269 Million Cubic Feet (Mcf) of gas in 2006).

Table 1: PG&E Saving Goals for the 2006-2008 Period

	2006	**2007**	**2008**	**TOTAL**
MW	132	223	258	613
Annual GWh	677	1,125	1,261	3,063
Annual MMTherms	10	18	20	48

The cost-effectiveness of each efficiency improvement is measured by two parameters:

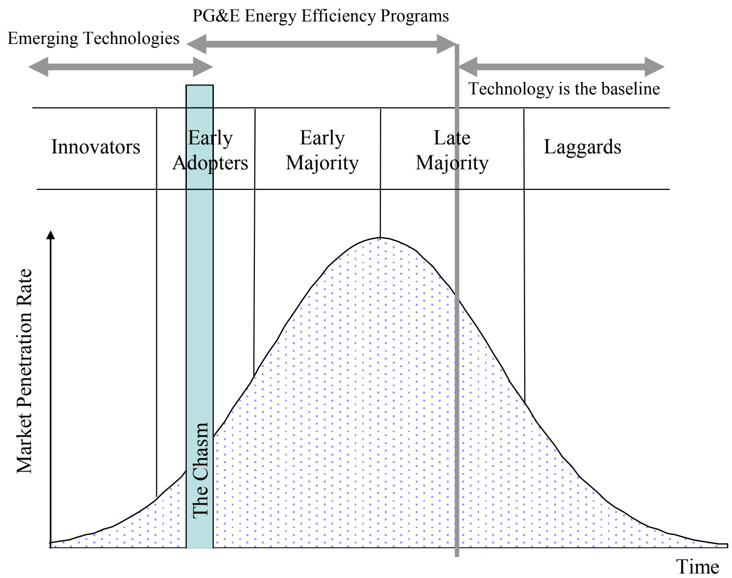
- The TRC (Total Resource Cost) represents the ratio between the value of the savings at the 2005 energy price and the overall investment made by the customer and the utility to implement it.
- The PAC (Program Administration Cost) represents the ratio between the value of the savings at the 2005 energy price and the administration cost including the incentives.

Using this model, PG&E sells energy savings as it would sell any other product. Its revenues are rated in avoided GWh, MW and Million Therms. A mechanism to reward its shareholders on its results compared to these goals is under development (Kushler, York & Witte 2006).

In California, this mechanism is not in conflict with the main business of the utilities (distribution of electricity and gas) since they do not generate profit on the commodity itself - the quantity of gas and electricity sold - but on the performance of their operations (Eto, Stoft & Belden 1994).

In addition, the savings are calculated by comparison to a baseline defined as the state of the art or the efficiency mandated by the established codes and standards. Since the state of the art or regulations change, the base line is a moving target that motivates utilities to introduce new solutions for their customers. Figure 1 represents the typical adoption curve of a new technology and the window of opportunity for the utilities to claim energy savings.

Figure 1: Emerging Technology Program in the Process of Market Adoption



ET brings new technologies over the "chasm" between early adopters and large-scale deployment

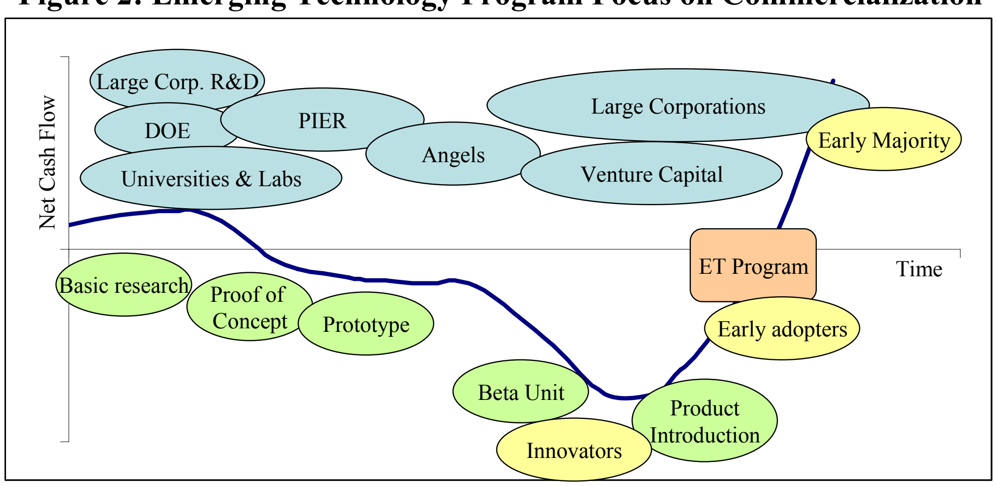
At this point solutions are in the baseline. They do not contribute any more to PG&E's efficiency goals.

Emerging technologies, in this context, faces three challenges to contribute to the success of PG&E's energy efficiency efforts:

- To rapidly introduce new solutions in the 2006-2008 time frame,
- To introduce market innovations that can generate enough savings to justify replacement of older solutions,
- To control its budget to ensure it can meet the economical performance parameters.

To meet these challenges it focuses on the market adoption phase of the innovation development process (see Figure 2).

Figure 2: Emerging Technology Program Focus on Commercialization



For this reason, the team looks for already proven technologies that are backed by organizations with strong customer support systems that can adequately serve their customers. We do not participate in the product development phase but get very much involved in the commercialization phase by packaging the technology with incentives, education and support to accelerate and to facilitate the adoption of the technology by PG&E customers.

The introduction of the electrodialysis process in the wine production is an example of this approach. The electrodialysis process was initiated by Gallo wineries in the mid-eighties but the company did not have the capacity to develop the technology beyond a prototype phase. A French university, the Institute National de la Recherche Agronomique rejuvenated the idea in the early nineties. The university's contribution included work to assure that the process has no impact on the wine quality and with obtaining the requested industry certifications in Europe and in the United States.

A company named Eurodia was formed to commercialize the technology for different applications. During the product development process, a large Japanese chemical company that manufactures the membranes, which is a core technology of this process, acquired Eurodia. Eurodia created a subsidiary in the USA and a distributor (WineSecrets) introduced the product to the California markets. California Energy Commission's Public Interest Energy Research program supported the first demonstrations in California in 2004 (Dahlberg & DiManno 2004).

Recognizing the potential energy savings for its customers, PG&E took the lead to validate an easy to use calculation model at two customers' sites and to integrate this solution into PG&E's incentive programs. Two machines have been acquired in its territory in the first quarter of 2007 and PG&E expects a broader deployment in the upcoming years.

Insert 1: Electrodialysis for Wine Stabilization

Stabilization is the final step in wine making. It eliminates the tartaric acid which crystallizes at low temperature when combining with calcium and potassium. Cooling the wine down to 28^{o} F or less for up to several weeks traditionally completes this step. In addition to the inconvenience of a batch process, low temperature stabilization is a huge energy hog. It may represent up to 25% of the overall electricity needed per gallon of wine.

Electrodialysis reduces the electricity consumption by up to 90%, representing a potential annual saving of 52 GWh in PG&E's territory, the equivalent of 7,700 homes and 4,000 cars (28,000 Tons of CO_2).

Iced wine tanks during low temperature stabilization

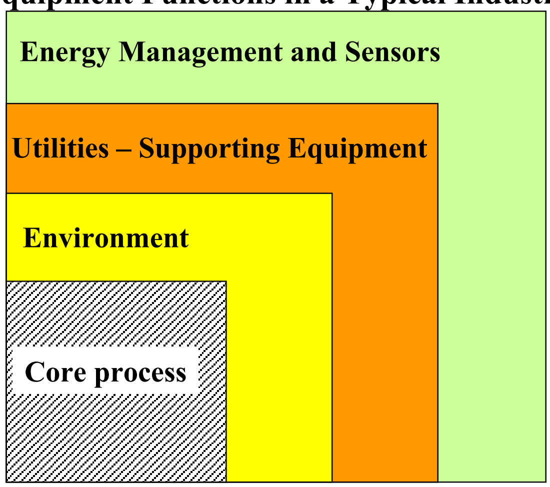
Voice of the Customer and Market Potential Are Key in our Selection Process

When we detect a new technology or solution, we systematically evaluate its potential in PG&E's territory. We focus on the largest segments where a broad deployment can make a difference.

The business case for PG&E customers is also assessed by comparing the investment cost for the solution along with the estimated savings. Only solutions offering substantial savings and a short payback, typically shorter than three years, can make the cut and get the attention of industrial customers.

Acceptance and integration by PG&E customers is a prime factor of selection as well. The preferred target for PG&E's efforts is the supporting equipment of a facility: steam and hot water production and distribution, refrigeration processes, compressed air, electricity supply, etc. (see Figure 3)

Figure 3: Equipment Functions in a Typical Industrial Facility



PG&E generally avoids technologies and solutions that focus on the core processes, for three main reasons:

- Introducing new technologies requires a level of expertise that we cannot have on each specific process,
- It may impact the quality and the cost of our customers' products, and
- It generally determines the competitive advantage of our customers. It would then be difficult to broadly deploy the solution in our territory.

The environment and monitoring segments of technologies and solutions are also less attractive than providing supporting equipment since the environment applications are mainly driven by regulations and the monitoring equipment would not directly deliver savings.

The combined heat pump solution – chiller technology offered by the Thermosorber - illustrates a technology that is an ideal match for this approach (Erickson 2006). First, it is a concept that can save on large volumes of gas usage for two large sectors in PG&E's territory - hospitals and the food industry. We estimate that 5 Million Therms can be saved each year in the hospital sector alone.

Secondly, it is pure supporting equipment used to provide two commodities: hot and chilled water. It can be installed seamlessly in any process; in particular the acceptance by the hospital certification board OSHPOD is not an issue. Third, thanks to its high efficiency, the investment cost may be rapidly recovered for applications where concurrent needs of hot and chilled water fit within its specifications.

Insert 2: Thermosorber for Hospitals

Hospitals simultaneously use large amounts of hot and chilled water. The two commodities are traditionally generated by two separate systems: a gas boiler and an electric or an absorption chiller.

The Thermosorber combines the two processes to save as much as 40% of gas and 90% of electricity usage by utilizing the heat rejected in the chiller process to heat the water up to 140^{o}F.

The Thermosorber is based on a standard water-ammonia absorption cycle with heat recuperation at the condenser and at the absorber.

We estimated a potential annual saving in PG&E's territory of 5.3 MMTherm and 22 GWh representing 10,000 homes and 5,000 cars (39,000 Tons of CO_2)

A 100 Ton chiller – 3.2 MMBTU/hr water heater unit.

Source: Energy Concepts Company LLC

Integrating New Technology in a Service Through a Cross-Functional Process

To be successfully adopted, a new technology must also have support services during implementation. That is why PG&E integrates new solutions at customer sites in a package that includes incentives, education and training, and engineering support and calculation methods. This compelling solution is built through a cross-functional process recently established at PG&E, named *Customers Love Innovative Products* (CLIP).

In that process, PG&E's customer account managers and communication and training staff are involved early to identify road blocks, discuss opportunities and work on strategies to implement the solutions. Sometimes, CPUC rules must be adapted to cover new technologies. To address this constraint, PG&E's regulatory issues experts propose and negotiate new rules to ensure that new solutions will be fully supported and that the savings claimed by the customer and PG&E can be recognized and rewarded.

A new service being introduced by PG&E for airflow management improvement in DataCenters is an example of this cross-functional approach. Based on the positive results of an Emerging Technologies project assessment (Tschudi & Fok 2007), a tool kit has been developed to assist DataCenter managers in assessing the current air-flow management performance of their facilities. It will provide them methods to identify possible actions, implementation measures, and a means to measure the resulting gain in energy efficiency.

Insert 3: Air-Flow Management in Data Centers

In a typical hot-and-cold aisle Data Center configuration, racks of servers are lined up in aisles with their fronts facing each other. Fans (Computer Room Air Handlers or CRAH) push cool air from a chiller up through an under-floor plenum. The server fans pull the cool air from the plenum through perforated floor tiles in the cold aisles. After cooling the servers, the air is released at a higher temperature into the hot aisles where it returns to the cooling units.

In this configuration substantial mixing may occur between the cold and hot air. In fact, about 30% of the cold air emitted by chillers is wasted due to unbalanced air mix, leading to the following problems:

- Temperatures vary widely in the cold aisles, which creates cold and hot spots: servers near the floor tend to overcool while servers in the upper tend to overheat.

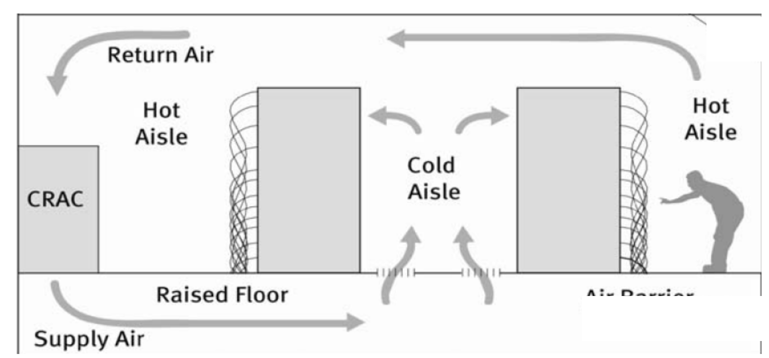
- Excessive CRAH fan airflow leads to a higher electricity bill.

- Chiller efficiency is reduced because of the use of a cooler supply air.

Different technologies and measures can reduce the mixing allowing energy savings by decreasing the CRAH airflow and raising the supply air temperature.

Monitoring of the temperatures of the return and supply air at the CRAH units is enough to characterize the overall efficiency of the airflow management. This leads to a simple method to assess and reward the improvements implemented in the Data Centers.

Potential annual savings of optimized air-flow management are about 100 GWh representing 15,000 homes and 7,000 cars (50,000 Tons of CO_2)



Typical Hot-and-Cold Aisle Air-flow Configuration in a Data Center

This particular product presents some specific challenges. First, it is not related to a technology but to a group of measures that can be implemented separately or together. The electricity savings result from the combination of measures and cannot be divided and attributed to an individual measure. Some measures involve investments in new equipment that are well supported by existing programs. Others do not require hardware changes but significant re-arrangement of the DataCenter layout and must be rewarded differently. Based on a self-assessment approach, this solution also requires training and the use of monitoring equipment. PG&E's education centers, the Pacific Energy Center in San Francisco and the Energy Training Center in Stockton, will also be involved to provide this service to PG&E's customers.

A Portfolio Approach to Mitigate the Risk and Address Short Term and Long Term Goals

The success of an innovation is never predictable, especially the time it will take to reach the market. Some opportunities may be ready but the market for the product does not respond. Some opportunities may have unexpected issues that may prevent their development for a long time.

To mitigate the risk associated with the timing issues, PG&E manages a portfolio of innovations with different risks, times to market, and potential impacts. The innovations are moved forward in parallel and efforts on projects are adjusted according to the market dynamics. Because of this, some projects may be dropped or put on hold.

Our selection process as described above is flexible enough to consider projects with different potential and risk profile.

Fume-hoods are widely used by various Industries and in Universities. In a recent study, the Lawrence Berkeley Laboratory estimated that there were about 85,000 fume-hoods in California and about 28,000 in PG&E's territory, consuming annually 800 GWh and 59 MMTherms (Mills E. & Sartor D. 2005). Three Emerging Technologies projects have been considered; two of them have been successful and will lead to deployment. The projects have different objectives and different risk profiles.

The first one aims to capture load reduction during the peak periods by a stricter sash closure policy for the small number of hours where demand reduction is critical. It may be deployed as soon as summer 2007 and does not require specific technologies. On the other hand, it has limited impact on the peak demand and no contribution to energy savings.

The second one is based on an automatic sash closing system. It will allow an optimal management of the sash airflow and lead to substantial savings. Its deployment requires the retrofit of existing fume-hoods and will be limited by the customers' acceptance and investment decision process.

The third one consists in a totally new design of the fume-hoods allowing the same or even better safety with much lower airflow. This solution is applicable only to new fume-hoods and currently limited in California by the existing CalOSHA regulation. Its deployment will then require longer time with some regulatory risk exposure.

Insert 4: Fume-Hoods

Fume-Hoods are used in the chemical and biotech industry to prevent potentially hazardous volatile materials from being inhaled by operators. To accomplish this, constant inlet airflow is maintained through the opening of the hood by an exhaust air fan. The extracted air is rejected outside the building with or without treatment.

CalOSHA requires that the face velocity through the opening of the hood be equal or faster than 100 ft/min. This leads, for a typical six-foot long fume-hood, to an airflow of about 1,200 CFM. The estimated energy drained by a fume-hood in California is then larger than the consumption of three houses: 29 MWh/year and 2,100 Therm/year.

Adjustable sashes coupled with variable air volume ventilation and a variable frequency drive on the exhaust fan are recommended to improve the efficiency of laboratories. But closing and opening the sashes may be difficult for the operators carrying equipment and products. The actual savings are then far from optimal.

Improving sash management, installing auto-closure sash systems and improving the aerodynamics of the fume-hood are the three ways to get better results.

Potential annual savings are about 140 GWh and 10 MMTherms representing 20,000 homes and 17,000 cars (120,000 Tons of CO_2)

High efficiency fume-hood
Source: Lawrence Berkeley Laboratory

Alliances and Partnerships to Increase its Outreach in the Detection As Well As in the Deployment Phase

The Emerging Technologies team at PG&E has focused its activity on a very specific stage of the innovation process: Market Adoption. De facto, partnering with other organizations becomes natural. Alliances provide upstream insights on new technologies, which will emerge in the near future. Alliances also help in the deployment phase by offering access to larger markets and better visibility for the new solutions.

In exchange, PG&E offers faster market access for the technologies to enter the commercialization phase sooner. PG&E brings insights about energy saving potential, up-coming opportunities, and it also offers access to its network of partners.

PG&E is currently structuring its long-term alliances with six categories of partners:

- Universities and research organizations,
- Venture Capital and finance,
- Consulting firms,
- Technology providers,
- Customers, and
- Utilities.

In addition, ad-hoc alliances are structured for specific projects to get more impact and involve larger markets.

The Power Supplies for Servers project completed in early 2007 is an example of such a project alliance. The challenge was to create a labeling, similar to 80 plus labeling for stand-alone computers, that differentiated severs equipped with efficient power supplies in order to influence the large OEM suppliers.

The server market has become a commodity market driven by the price and dominated by the four largest manufacturers - HP, Dell, IBM and Sun. And, efficient power supplies are not selection criteria for customers even if they would substantially impact their operation costs over the long run. Given these parameters, introducing a new more expensive technology (even marginally) is challenging. In addition PG&E's territory would not be a large enough market for worldwide leader companies.

By teaming with Natural Resources Canada (NRCan), Energy Trust of Oregon, Bonneville Power Administration, PacifiCorp, Snohomish PUD, Southern California Edison and Northwest Energy Efficiency Alliance, we more than quadrupled our outreach while sharing costs.

Insert 5: Efficient Power Supplies for Servers

A power supply function is to convert the 120V or 230V AC current provided to the rack of servers into a 12V DC current. High reliability requirements leading to redundant power supplies and values of the out-put voltage differentiate servers from desktop computers.

Power supplies may represent up to 30% of the heat dissipated by a server. They are generally cooled by their own fans, which also take a part of the available energy and generate more heat.

Increasing their efficiency is then a key factor in reducing the energy consumption of Data Centers. A recent study, published by the Lawrence Berkeley Laboratory and Advanced Micro Devices (Koomey 2007), stated that about 45 TWh of electricity are used in the USA for Data Centers. Assuming that 15% of this energy is lost in power supplies, this represents the equivalent of about two 400 MW power plants running full time.

New technologies are available to cut 30% of this loss but they struggle to penetrate this market because of the lack of awareness and lack of interest from the customers and the OEM companies.

We expect that developing a label based on a broadly accepted test method may lead to savings of about 20 GWh annually for the 250,000 new servers purchased each year by companies in PG&E's territory or the equivalent of 3,000 homes and 1,400 cars (10,000 Tons of CO_2).

Conclusion

As shown by the examples listed here, there are numerous opportunities for energy savings in the Industrial sector of California. At the same time, there are many new solutions that exist or are emerging. The challenge - for facility mangers, technology providers and utilities, as well as government organizations - is to find a way to accelerate the deployment of these new technologies.

Recognizing this quandary, the Emerging Technologies team at PG&E positioned itself at the transition between product development and commercialization. It knows that an energy efficiency investment is not easy for its customers. It understands that time is a constraint, that the financial justification must be clear and strong and that the impact on operation should be positive with limited risks. PG&E addresses these customer concerns and believes that it can bring high value to the industry sector in its territory by screening new technologies, assessing their energy efficiency, and packaging them to streamline the acquisition process.

The Emerging Technologies program is beginning to have a significant impact on PG&E's overall energy efficiency results. In 2006, solutions validated through the Emerging Technologies program enabled savings of 11.69 MWs and 12.4 GWh, and the contributions can potentially reach more than 20% of PG&E's savings goals by 2008.

For our team, the time is now: we would like to encourage all interested organizations to become a partner to introduce new technologies for energy efficiency and demand response.

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