Industrial Re-commissioning:

Not Just a Building Tune-up

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Industrial re-commissioning programs can help all sizes of industrial customers save energy and money. Through low-cost improvements to common industrial energy systems such as compressed air, pumping, process cooling, and refrigeration, customers can often save 10-20 percent of the energy consumption of the systems targeted. Industrial re-commissioning programs complement demand-side management incentive programs for capital projects (equipment upgrades), and also complement strategic energy management (SEM) programs, which provide more in-depth training and typically target larger customers.

BEYOND BUILDING SYSTEMS

Re-commissioning, or retro-commissioning, is a systematic process to improve an existing building's performance to save energy and possibly also increase comfort.[1] Many utilities offer building re-commissioning programs to their commercial customers. These programs generally consist of performing a free or subsidized study to identify low-cost, building tune-up measures for commercial buildings, generally focused on the HVAC systems. Some programs also offer incentives for measures implemented (even though they are generally low-cost measures).

Similar to re-commissioning for buildings, industrial re-commissioning programs generally involve a study of the facility or of the relevant energy systems, with incentives provided for implementing the measures identified. However, for industrial customers, building HVAC systems generally account for only a small percentage of the facility's total energy consumption. (Exceptions to this include laboratories, data centers, or operations with clean rooms.) The best targets for industrial re-commissioning are energy-using systems that require some attention to efficiently modulate the system output for different levels of demand. Compressed air, refrigeration, process cooling, and pumping systems are the most common targets. Commonwealth Edison's program focuses exclusively on industrial compressed air, process cooling, and refrigeration systems. Rocky

[1] Sometimes people make the distinction that re-commissioning is a tune-up process for buildings (or industrial systems) that have had an initial commissioning after the building was constructed; and for buildings (or systems) that have *not* had an initial commissioning, retro-commissioning is the proper term to use for a tune-up process. But in practice, re-commissioning and retro-commissioning programs are essentially the same, so we make no distinction between these two terms for this report.

Mountain Power's program has had success working with municipal drinking water and wastewater treatment facilities. A list of common low-cost measures identified through re-commissioning programs is provided in Table 1 below.

Both re-commissioning and strategic energy management (SEM) programs measure savings from operations and maintenance (O&M) measures. However, SEM programs typically have longer engagement periods, such as two or three years, in which to measure savings from the training and coaching efforts. And a key difference is that one of the main goals of SEM is to influence the customers' motivation and abilities to achieve energy savings over a longer-term period, which some SEM experts refer to as "teaching the customer how to fish." Industrial re-commissioning programs have the simpler, more targeted goal of helping customers find and implement a set of low-cost energy-saving measures. In other words, re-commissioning is basically a short-term project, while SEM involves a longer-term program (like safety or quality) in which the customer continues to improve its approach to managing energy.

Table 1 | Common Low-Cost Measures

System	Common Measures
Compressed air	Fix leaks, adjust system pressure, adjust sequencing of compressors
Refrigeration	Lower condensing pressure, reduce defrosts, cycle evaporator fans
Pumping	Trim impellers, throttle pumps providing excess flow/pressure, operate the most efficient pump
Wastewater treatment	Turn off equipment when not needed, clean probes and diffusers, monitor loading and turn off or adjust processes when not needed

Program Examples

Six U.S. utilities with industrial re-commissioning programs are highlighted below in Table 2. All these programs include a free study and incentives to help customers implement the measures identified. In addition to varying incentive rates (as shown below), one key difference is the method for measuring energy savings. Other differences are that three of the programs help customers identify capital measures within the targeted energy systems in addition to the low-cost measures. And two programs provide incentives for energy information systems (EIS), including hardware and software, to help customers continue to adjust operating practices to maintain or enhance the energy savings achieved during the initial implementation period.

Table 2 |Highlights of Six Industrial Re-Commissioning Programs

Utility/Program[2]	Measurement of Energy Savings	Incentives[3]	Assistance Provided
Commonwealth Edison (ComEd) *Industrial Systems Optimization*	Bottom-up; Estimates based on specific measures	$.07/kWh, up to 100% of customer's implementation costs	Studies of three types of systems to identify capital and low-cost measures.
Pacific Gas & Electric (PG&E) *Retro-commissioning*	Bottom-up; Estimates based on specific measures	$0.08/kWh, $1/therm and $100/on-peak kW, up to 50% of the customer's total implementation costs	Study to identify no- and low-cost opportunities
Wisconsin Focus on Energy (FOE) *Retro-commissioning*	Bottom-up; Estimates based on specific measures	Up to $0.08/kWh, $0.50/therm; total not to exceed 100% of customer's total implementation costs	Study to identify no- and low-cost opportunities
Bonneville Power Administration (BPA) *Track and Tune*	Top-down analysis	$.075/kWh of energy saved, up to 70% of project costs; up to $50,000 for installing an energy information system[4]	Study to identify low-cost opportunities, suggestions and incentives for energy information system. Audit report also identifies capital measures for referral to other incentive programs.
Puget Sound Energy (PSE) *Industrial Systems Optimization*	Top-down analysis	$.05/kWh, $0.80/therm for energy saved, up to 70% of the total cost of energy saving measures installed plus cost of new energy information system	Study to identify no- and low-cost opportunities, and report analyzing the plant's energy use by equipment type. Audit report also identifies capital measures for referral to other incentive programs, and suggestions and incentives for energy information system.
Rocky Mountain Power (RMP) *Industrial Re-commissioning*	Top-down analysis	$.02/kWh of energy saved	Study to identify no- and low-cost opportunities

[2] The first three programs shown use the "bottom-up" approach to measure energy savings, and the last three use the "top-down" method. These are described in the next section.

[3] All incentives are for first-year savings, except as noted for BPA.

[4] BPA's incentives are actually slightly more complicated than what is shown in the table. For the energy savings incentive, BPA will provide $.075/kWh for first-year savings, up to 70% of the customer's implementation costs, or it will provide $.025/kWh for energy savings (based on savings relative to the modeled baseline consumption). The customer can choose either option for both years of the engagement (noting that the first option only applies if the customer implements additional measures in year 2). Some customers earn a greater incentive amount by opting for the lower incentive rate, since there is no cap. For the EIS, BPA will pay incentives of up to $0.0025/kWh of annual energy consumption within the project boundary, up to a maximum of $50,000.

Customer Engagement, Study and Implementation Process

After recruiting the customer to engage in the program, some programs ask the customer to sign an agreement to implement some or most of the measures identified. For example, for PG&E, the customer must agree to implement all measures with a payback period of one year or less, up to the cost of the re-commissioning study (which is capped at $25,000). For ComEd's program, the customer must agree to repair at least half of all identified compressed air leaks; or for refrigeration or process cooling systems, the customer must agree to spend at least $15,000 implementing measures identified. These types of agreements help ensure that the energy savings achieved will justify the cost of the studies.

The studies typically involve two to three days of the contractor being on-site at the customer's facility. Good contractors have expertise in optimizing the types of systems mentioned above. Average study costs are shown below in Table 4. After the study is performed, most programs provide a list of recommended low-cost measures, along with the amount of incentives to be provided. The customer then implements some or most of the measures, which is followed by some type of verification of the energy savings (explained further in the next section).

Measurement of Energy Savings

PG&E, FOE and ComEd measure energy savings through engineering calculations for each measure identified; this is referred to as the "bottom-up" approach. RMP, PSE and BPA develop a baseline model for the systems targeted, and measure savings by comparing actual energy data during the performance period (after measures are implemented) to the model's predicted energy consumption during that period; this is referred to as the "top-down" approach. PSE's program has helped a variety of customers using the top-down approach. RMP's industrial re-commissioning program has so far mainly focused on municipal water and wastewater treatment facilities, and has been successful in modeling the pumping systems for these facilities to identify opportunities as well as to measure savings.[5]

There can be exceptions to relying on one approach or the other. For example, PG&E will use modeling for compressed air systems to measure energy savings from all the measures implemented. And there can be cases for which RMP and PSE revert to the bottom-up approach because a good model for that operation or facility cannot be developed.

PSE's program mainly uses the top-down approach, and its process typically works as follows. PSE (through its contractor) develops a baseline model for the customer using one year of daily energy consumption and production data. (This could include one or two production variables, and perhaps also weather data.) The contractor then performs a two- or three-day on-site study with the customer and identifies 15-40 low-cost measures for the areas/systems targeted. The contractor also identifies capital projects, but these are referred to other PSE programs for incentives. The customer then implements most of the low-cost measures identified (about 70 percent of the measures on average), typically within four months. After implementation, energy

[5] Jeff Hare, Senior Engineer, Cascade Energy. Personal communication, Nov. 1, 2016.

and other relevant data are gathered for 60 days, and the actual energy consumption is compared to the modeled energy consumption. If the energy savings for the 60-day period is statistically significant, then the savings is extrapolated to 12 months.[6]

There are a few potential advantages of the top-down approach. The first is that it allows the contractor to identify many more measures (up to 40 in some cases). Using the bottom-up approach, typically no more than ten measures are identified, because each one requires an engineering estimate of savings. The top-down approach allows a meter-level estimation of savings, accounting for interactive effects between systems and measures. In addition, with the top-down approach, the customer has the flexibility to implement any of the measures identified without waiting for the utility's approval. With a bottom-up approach, depending on the program, the customer may have to wait several months for the utility's approval before implementing the measures in order to receive the incentives.

Whether using top-down or bottom-up approaches, most programs use either a three- or five-year measure life for the low-cost measures in evaluating cost-effectiveness of the energy savings achieved (see Table 4 below). With the exception of BPA's and ComEd's, none of these re-commissioning programs have been evaluated yet. However, many SEM programs have had evaluations, and three years is a commonly accepted measure life for O&M measures.[7]

Capital Measures and Low-cost Measures

The focus of industrial re-commissioning programs is to help customers implement low-cost measures. However, three of the programs listed above also use the study process to help customers find capital measures. Both PSE's and BPA's programs list capital project opportunities in their assessment reports, then refer the customer to its custom or prescriptive incentive programs for support in implementing these measures. ComEd's program identifies both low-cost and capital measures, and provides a single, bundled incentive amount for all measures the customer agrees to implement. The bundled incentive approach encourages customers to implement more of the capital measures than they otherwise would in many cases. The energy savings and cost-effectiveness results shown in Tables 3 and 4 below seem to validate the effectiveness of this approach.

Energy Information Systems (EIS)

PSE's and BPA's programs also encourage customers to improve their EIS. These programs provide incentives for additional sub-metering or sensors, and for software to analyze and report the data in a meaningful way. For some customers, improved energy monitoring can improve operating

[6] Sam Skidmore, Energy Management Program Manager, Cascade Energy. Personal communication, Nov. 23, 2016.
[7] Heidi Ochsner-Javanbakht, Senior Associate, Cadmus Group. Personal communication, Oct. 11, 2016. According to CEE's "2016 Industrial SEM Program Summary," there is no clear consensus, but most SEM programs use 3-6 years as the measure life for O&M savings. See https://library.cee1.org/sites/default/files/library/13001/CEE_2016_Industrial_SEM_Program_Summary_Public.pdf, Fig. 7, p. 9.

practices significantly, on an on-going basis. If the data is displayed in a useful way, with appropriate alarms for off-specification or out-of-bounds operations, it helps operators to make adjustments to keep the systems running more efficiently. This is sometimes referred to as "data-driven energy management" or the "Prius effect" (after the Toyota Prius, which displays the instantaneous fuel efficiency/mileage to encourage drivers to adjust their driving habits). On the other hand, it takes management buy-in and operator training to properly take advantage of good EIS.

For BPA's *Track and Tune* program, about 60-70 percent of customers leverage the incentives to install a new or improved EIS.[8] For PSE, only about 20 percent of the *Energy Optimization* program customers take advantage of the EIS incentives.[9]

Incentives for Savings Persistence

Several of the programs provide some type of incentive to encourage customers to maintain the energy savings achieved in the first year. BPA's *Track and Tune* program has a two-year performance period after the initial study; in the second year, customers can earn an incentive of $0.025/kWh for energy savings achieved relative to the base year model, which is a direct incentive for customers to maintain the energy savings achieved in year one.[10] Where appropriate, PG&E encourages customers to install equipment or pay for services to help ensure persistence, and includes these additional measures in the incentives provided. For example, after a boiler tune-up, the customer could pay a contractor to perform an annual adjustment of the excess oxygen level.

Energy Savings and Cost-Effectiveness

Of the six programs listed above, four were able to provide data on energy savings and cost-effectiveness, summarized in Tables 3 and 4 below. PSE's program has been operating since late 2012, with re-commissioning customers achieving average energy savings of nine percent of the facility's total consumption.[11]

Generally these programs have lower costs for the level of energy savings achieved compared to other industrial programs, making them very cost-effective. As shown in Table 4, the levelized cost of energy savings for the four of programs ranges from $.0077 - $.0221/kWh of savings. ComEd's levelized cost is one of the lowest, indicating the potential advantage of its approach of identifying both capital and low-cost measures and providing bundled incentives for all the measures to be implemented.

[8] Todd Amundson, Energy Management Engineer, Energy Smart Industrial, BPA. Personal communication, Dec. 21, 2016.
[9] Skidmore, personal communication Nov. 23, 2016. Part of the reason for this discrepancy is that BPA's program covers a wide range of BPA's member utilities, and many of these require an EIS to be installed in order to measure the savings.
[10] See Footnote 3.
[11] "PSE's Industrial System Optimization Program," a two-page flier available upon request from Cascade Energy.

Table 3 | Energy savings from Four Re-commissioning Programs

Utility / Program	Time Frame	Number of Projects[12]	Total Energy Savings (MWh)	Avg. Energy Savings per year (MWh)
ComEd *Industrial Systems Optimization*	2013-2015	126	80,300 MWh	26,800 MWh
Puget Sound Energy *Retro-commissioning*	2013-2016	39	20,400 MWh	5,100 MWh
Rocky Mountain Power *Industrial Re-commissioning*	2015 - Nov 2016	15	10,340 MWh	5,200 MWh
WI Focus on Energy *Retro-commissioning*	2015-2016	4[13]	8,790 MWh	4,400 MWh

Table 4 | Re-commissioning Program Costs

Utility / Program	Total Program Cost per year	Average Study cost per project	Average Incentive costs per project	Levelized cost of savings[14]	
ComEd *Industrial Systems Optimization*	$2,272,000	~$29,300	$24,800	Assuming 10-yr measure life: $0.0085/kWh	
				3-year measure life	**5-year measure life**
Puget Sound Energy *Retro-commissioning*	$396,600	$24,000	$10,700	$0.0221/kWh	$0.0133/kWh
Rocky Mountain Power *Industrial Re-commissioning*	$198,600	$12,000	$14,500	$0.0128/kWh	$0.0077/kWh
WI Focus on Energy *Retro-commissioning*	$188,800	$43,000	$51,400	$0.0143/kWh	$0.0086/kWh

[12] All the data shown on projects, energy savings, and program costs were obtained through the program contacts provided below in the Resources section.

[13] Focus on Energy's data shown here does not include projects involving customers smaller than 1 MW. Also, the program was not actively marketed, except by one contractor, and was canceled in 2016, but may be offered again in 2017.

[14] The levelized costs shown include the costs of the studies and incentives, but do not include marketing, measurement and verification, and general program management costs, which can amount to as much as 30% of total program costs. ComEd's program includes a blend of capital projects and low-cost measures. ComEd estimates that the average measure life is 12.7 years, but we assumed 10 years to be more conservative. The other programs provide incentives for low-cost measures only. PSE and FOE are allowed to use a measure life of five years; RMP is limited to using a measure life of only three years. Since there is no clear logic to using three vs. five years, we decided to show both for these three programs in order to make the levelized cost comparisons more consistent.

SUMMARY AND RECOMMENDATIONS

Industrial re-commissioning programs provide a valuable service to complement traditional capital incentive programs for all sizes of industrial customers. These programs help customers find and implement low-cost energy-saving measures in a relatively short period of time. For the utility, these programs achieve significant energy savings, are cost-effective, and help keep industrial customers satisfied.

Following are a few recommendations for successfully implementing a new industrial re-commissioning program:

1. Choose contractors with industrial expertise, especially in the targeted industrial energy systems. Most of the programs described above target compressed air, process cooling, refrigeration and pumping systems, but it is also possible to serve a broader variety of industrial systems and operations.

2. It is also helpful for contractors to have expertise in measuring energy savings using the top-down approach as well as using the measure-specific (bottom-up) approach. There are several potential advantages of using the top-down method to estimate energy savings from the low-cost measures (when a good regression model can be developed):
    a. The re-commissioning contractor can suggest a greater number of low-cost measures than using the bottom-up approach.
    b. Customers can implement these measures without obtaining prior approval from the utility.
    c. Using the top-down method, programs can also consider offering the incentive for energy savings over a two-year period, to encourage persistence of the O&M savings, and to encourage customers to continue to look for and implement additional low-cost measures.

3. There are also advantages to ComEd's bundled approach of identifying and providing incentives for low-cost and capital measures at the same time. A disadvantage of this approach is that it lengthens the engagement period, since it typically takes longer for customers to implement capital measures.

4. To help improve the program's cost-effectiveness, we suggest capping the incentives at 70 percent of the customer's total re-commissioning implementation costs. Before offering the re-commissioning study, the customer should agree to implement most of the measures or to spend a minimum amount on implementing the suggested measures, as discussed above.

5. Programs should consider offering incentives and support for EIS, which help customers track and tune their systems on an on-going basis. Although the main focus of industrial re-commissioning programs is to help customers implement low-cost energy-saving measures, providing support for EIS is also one step towards helping customers develop a more strategic approach to energy management.

RESOURCES

Industrial Re-commissioning Program Contacts

Utility & Program	Name & title	Email	Phone
BPA *Track and Tune*	**Todd Amundson** Energy Management Engineer, Energy Smart Industrial, BPA	tamundson@bpa.gov	503-230-5491
	Steve Martin Energy Management Manager, Energy Smart Industrial, Cascade Energy	Steve.martin@energysmartindustrial.com	971-244-8589
ComEd *Industrial Systems Optimization*	**Neal Latham** Sr. Energy Efficiency Program Manager, ComEd	Neal.latham@comed.com	630-437-2415
PG&E *Retro-commissioning*	**Milena Usabiaga** Sr. Project Manager, Nexant, Inc.	musabiaga@nexant.com	415-369-1024
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The Southwest Energy Efficiency Project is a public interest organization dedicated to advancing energy efficiency in Arizona, Colorado, Nevada, New Mexico, Utah and Wyoming. For more information, visit www.swenergy.org.

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