ComEd Energy Efficiency Program

SMART VALVE DEMONSTRATION FINAL REPORT

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Prepared By
Slipstream

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Legal Notice

The ComEd Energy Efficiency Program is funded in compliance with state law.

1.0 EXECUTIVE SUMMARY

Background and Objective

HVAC energy accounts for approximately half (53 percent) of the energy use in commercial buildings in ComEd service territory. [1]A significant portion (43 percent) of this energy is associated with either chilled water (CHW) and hot water (HW) systems and their associated air distributions systems. Even with properly designed, operated, and maintained conventional valves, Low Delta-T Syndrome (LDTS) still occurs frequently and significantly decreases system performance due to load changes, water pressure imbalance, the impact of air economizers, and coil effectiveness degradation as systems age.

“Smart” pressure independent control valves (PICV) have the potential to significantly improve the energy performance of these intensive energy uses in commercial buildings. Smart valves are defined here as pressure-independent control valves with on-board electronics that can accurately and stably control air handling unit (AHU) supply air temperature (SAT) via superior variable flow control. These valves can also connect with additional sensors and be linked to a cloud-based software platform to form a system, providing real-time intelligence, optimization, energy analytics, and fault detection capabilities.

The primary ways in which these smart valves save energy are:

1. Increasing ΔT decreases water flow rate, reducing pumping energy.
2. Tuning ΔT and water flow rate leads to more precise leaving air temperature at the AHU’s coil. This generally reduces overcooling (and sometimes overheating), saving chiller or boiler energy
3. In CHW systems, increasing ΔT sends higher temperature water back to the chiller; chillers operate more efficiently with warmer return water.

The objective of this pilot is to demonstrate the energy savings performance and usability of smart valves as an HVAC retrofit measure in ComEd’s service territory. This project will enable ComEd to better understand the energy savings potential of smart valves, allowing them to consider incorporating the technology into their energy efficiency portfolio. In addition we are addressing barriers to increased customer adoption by documenting best practices in designing, installing, and commissioning these systems. Finally, we are engaging stakeholders to develop recommendations for including smart valves in ComEd program offerings.

Savings Sensitivity

The goal of the savings sensitivity analysis was to identify the applications that had the most (and least) energy savings from a smart valve retrofit. This will allow a program to

[1] CBECS, https://www.eia.gov/consumption/commercial/

target the best candidates for smart valve retrofits. We used data from our characterization, building energy codes, and input from chilled water plant experts to define a range of applications. We then modeled energy savings from a smart valve retrofit within each application using eQuest.

We estimate potential energy savings as between 12 percent and 21 percent of chiller and CHW pump energy, or between 0.2 and 1.5 kWh saved per square foot. The energy savings are highest in facilities with longer hours of CHW system operation. This includes both facilities that operate more hours per week, and those that need CHW for a larger portion of the year.

Healthcare and laboratory buildings are the best examples of these building types, but a small portion of office and education buildings may also meet these characteristics. A typical office building has relatively low overall energy savings due to its relatively low annual CHW usage intensity.

The above characterizations apply to buildings with relatively modern, efficient CHW plants. There are other cases where smart valve savings are more significant. Energy savings are higher in:

- older, existing facilities with less efficient water-cooled chillers
- facilities that have relatively inefficient air-cooled chillers
- facilities with older, inefficient CHW pumps; especially those with Primary/Secondary pumping arrangements
- variable speed CHW systems.

Within a given building type, the simple payback trends reflect the energy savings trends. On average, the education/laboratory simple payback was 3.9 years with incentives. It increased to 5.1 years without incentives. The hospital and inpatient healthcare buildings had simple paybacks of 5.2 and 10.7 years, respectively. The longer simple payback for the inpatient healthcare model was mainly driven by its lower cooling energy intensity since the costs per square foot for both were the same. Despite having a relatively low cost per square foot, the office model had the longest payback of 14.3 years. This was also driven by its low cooling intensity and resulting savings. On average, our modeling showed that ComEd's current Custom offering incentive of $0.12/kWh reduces the payback period by roughly one year.

Savings Extrapolation

We also estimated the magnitude of energy impact that smart valves could have across ComEd service territory. We estimate a total smart valve technical potential of approximately 90 million kWh. The sectors with the highest potential savings are Inpatient Healthcare and Education. This analysis indicated a per-site savings of approximately 230,000 kWh in hospitals and education/labs buildings. Assuming 5 projects per year, smart valve projects in ComEd territory could save approximately 1.1

million kWh per year or 5.7 million kWh over five years. The measure life is expected to be 15 years.

Hospital Retrofit

We evaluated a smart valve retrofit at a 516,000 square foot hospital located in Rockford, IL. Its total annual electricity consumption is approximately 18 million kWh at $0.035/kWh. The central plant is relatively new, having been retrofit in the summer of 2019. It includes 3 water-cooled chillers totaling 2,750 tons. The CHW pumping arrangement is primary-secondary. It includes 5 primary pumps and 3 secondary pumps. Note that the secondary distribution systems serve 2 wings of the hospital. Only one wing, representing approximately 40% of the cooling load, was retrofit with smart valves. The retrofit wing contains 16 cooling coils serving a variety of spaces and loads including surgery suites, cafeteria, imaging equipment, labs, exam and patient rooms. There is also a server room and basement electrical room. Of these cooling coils, twelve were retrofit with smart valves (i.e. Surge valves). Two were retrofit with pressure-independent valves (i.e. DeltaP valves) due to their smaller size not justifying the full smart valve functionality. There are 13 tertiary pumps that are located at the AHUs. Prior to the retrofit, these constant speed pumps ensured flow through the cooling coils. After the retrofit, many of these pumps were no longer needed, or their operating hours were greatly reduced.

Our analysis found approximately 16 percent chiller plant energy savings, or 566,000 kWh per year.

	Energy Savings (kWh)	Percent Savings
Chillers	234,427	9%
Primary Pumps	93,167	30%
Secondary Pumps	170,672	52%
Tertiary Pumps	67,834	93%
Total	***566,099***	***16%***

Note that chillers had the lowest percent savings, but the highest total savings. This is due to their relatively large power compared to the pumps. The tertiary pump energy percent savings was relatively high, as the smart valves nearly eliminated the need for them. Chiller and secondary pump savings comprise the majority of the savings with a smaller portion coming from primary and tertiary pumps

Lessons Learned

Throughout the project, we engaged with all stakeholders and discussed project progress and lessons learned. We specifically interviewed hospital staff, installation contractors, ComEd outreach staff, and manufacturer representatives for more in-depth insight.

- First cost is a barrier, but a strong financial case may be made.
- Projects benefit from an internal champion to develop.
- Frequent communication between the manufacturer and the contractor needs to occur to clarify scope and improve budget estimates.
- Preliminary data collection, including a site walk through, is beneficial before the final pitch.
- Contractor familiarity or training are important.
- Healthcare operations cannot be interrupted, but this can be overcome.
- Involve IT staff as early as possible to enable network connectivity.
- Utilize the BAS service contractor early and in all aspects of the project
- Train operators early. The manufacturer provides technical support in operations.

Program Implementation

Portfolio Opportunities

The Custom program represents the primary pathway for addressing smart valve retrofit opportunities. The custom calculation methodology described in the Custom Calculation section identifies variables that have the greatest impact on estimated energy savings. These include:

- Peak cooling load
- Equivalent full load hours
- Efficiency of chiller and CHW pumps
- CHW pump design flow
- CHW pump total design head

We investigated the feasibility of developing a prescriptive incentive offering for smart valves. A prescriptive approach would be challenging due to the high degree of variability in site-specific factors that impact energy savings.

Smart valve technology could support ongoing system optimization opportunities through program offerings like monitoring-based commissioning (MBCx). The data generated by smart valves could be incorporated into monitoring software to track and improve chilled water system performance over time.

The Strategic Energy Management (SEM) program is another ComEd offering that could play a role in educating customers about smart valve opportunities. While the SEM program mainly targets operations and maintenance opportunities, it is also a pathway for informing customers about Standard and Custom incentive offerings that can support capital projects.

Identifying Opportunities

Given that smart valve energy savings and project economics are highly site-specific, an effective targeting strategy should guide marketing and outreach efforts. As described in the Modeling Results section, the best candidates for smart valves are cooling-intensive facilities that are more likely to run CHW systems year-round. Higher opportunity market segments include healthcare and higher education with labs. Per the Modeling Results section, the shortest paybacks were found in education/laboratory and hospitals.

Other characteristics that may be found in higher-opportunity sites include:

- Buildings that will be constructing (or recently completing) additions and therefore have capacity constraints on their existing chilled water system.
- Buildings anticipating need for chiller replacement in near future.
- Sophisticated facilities staff that can analyze data and optimize controls.
- Owner-operated facilities that are willing to tolerate higher paybacks for longer-term efficiency gains.

Multiple factors impact the magnitude of energy savings from a smart valve retrofit. This is particularly true for older CHW plants with a long history of changes and additions. For energy efficiency program representatives looking to identify candidate sites, the best indicator of energy savings opportunity is a low operating CHW ΔT, which is indicative of LDTS. This occurs when operating CHW ΔT is well below the design parameter.

- Other factors indicating higher electricity savings opportunity:
- Older, existing facilities with less efficient water-cooled chillers
- Facilities that have relatively inefficient air-cooled chillers
- Facilities with older, inefficient CHW pumps; especially those with Primary/Secondary pumping arrangements
- Variable speed CHW systems
- Minimal CHW temperature resets
- The absence of a water side economizer or absorption chiller

Customer Engagement

As we observed during the demonstration site recruitment process, smart valve retrofits typically require a lengthy sales process and multiple discussions with the customer. A typical sales process is at least six months but can be even longer for public sector customers due to more complex procurement processes.

The ultimate decision to pursue a project will come from a financial decision maker. However, getting the project green-lit will benefit from having champions at multiple levels. The chief facility engineer or someone with granular knowledge about the operation of the CHW system will be critical to the process. It is also helpful to involve IT staff in the early stages due to the cloud connectivity and the ethernet connection at each valve.

Failure to engage IT staff early in the scoping process can derail a project, as discussed in the Lessons Learned section of this report.

Payback on smart valve projects may be longer than 3-4 years, which is beyond the acceptable threshold for some types of owners (e.g., CRE) but potentially doable for others (e.g., healthcare, higher education, public sector). Due to the high cost differential between smart valves and comparable standard products, it could be more effective to position smart valves as a controls retrofit rather than a valve retrofit so that the financial case is comparable to other kinds of products that offer an advanced level of optimization and control. The manufacturers we interviewed emphasized that controllability and system optimization are the major selling points for smart valves. Customers will also want to know how this technology can streamline building operations, including quicker diagnosis of chiller plant issues by having additional data and performance insights in one place. Customers will likely be interested in how the system can integrate with other building control systems and EMS.

Measurement and Verification

Under the current ComEd program design, a Custom project with incentives over $25k is subject to M&V to measure savings impacts. Custom project M&V will likely be required for most smart valve projects. The highest priority data for evaluating the electricity savings of a smart valve retrofit are:

- Chiller electric power (kW)
- Chilled water pump power (kW)
- Outdoor air enthalpy (Btu/lb)

The frequency of this data should be at most hourly, and should span a wide range of outdoor conditions for both the pre- and post-retrofit periods. We recommend capturing several cold, mild and hot/humid days. This likely entails a pre- and post-retrofit monitoring periods of 4 to 6 months each.

Chiller and chilled water pump power may be sanity checked against nameplate horsepower data. Outliers should be identified and eliminated.

We found that outdoor air enthalpy was the best proxy for cooling load, although drybulb or wetbulb temperature may be substituted if enthalpy is not readily calculatable.

Regressions should account for weekday versus weekend occupancy, and low vs high enthalpy conditions. Low enthalpy conditions are often characterized by near constant power consumption, while high enthalpy conditions have increasing power with increasing enthalpy.