Impact Evaluation of National Grid Rhode Island C&I Prescriptive Gas Pre-Rinse Spray Valve Measure

National Grid

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1. EXECUTIVE SUMMARY

1.1 Introduction

This report documents DNV GL's Evaluation of National Grid Rhode Island's Commercial and Industrial Pre-Rinse Spray Valve Measure of the prescriptive gas program. This impact evaluation was performed concurrent with the impact evaluation of the Massachusetts Commercial and Industrial Prescriptive Gas Program which was performed by DNV GL[1] and also focused on evaluation of the prescriptive program pre-rinse spray valve measure. This impact evaluation was completed for National Grid and includes combined National Grid Massachusetts and National Grid Rhode Island site results.

1.1.1 Program Description

The National Grid Rhode Island Prescriptive Gas Program is an existing program that reduces natural gas consumption through offering incentives for natural gas efficiency measures. National Grid includes a variety of gas efficiency measures in the prescriptive program. This evaluation focuses on the Pre-rinse spray valve (PRSV) measure.

National Grid uses a direct installation contractor for the majority of implementation of the PRSV measure. This contractor physically replaces the old valve with a "program approved" new low-flow pre-rinse spray valve at the customer's place of business. Both installation of the new valve and removal of the old valve are done by the contractor. The contractor also removes the old valve from the customer premise and either returns or recycles the old valve based upon the locational specific policy of National Grid. The same manufacture valve model industry recognized "best-in-class" valve has consistently been used as the "program approved" new valve for a period of 2011 to present. The contractor, delivery and implementation methods are identical between the National Grid Rhode Island and Massachusetts programs.

1.1.2 Purpose of Study

The research objectives of this impact evaluation of National Grid Rhode Island's Commercial and Industrial Prescriptive Gas Pre-Rinse Spray Valve Program include updating the following assumptions:

- To provide new deemed savings value recommendations that have been derived from actual field-testing for the pre-rinse spray valve measure for use in the National Grid Rhode Island Technical Resource Manual (TRM). The deemed savings value recommendations will be available for National Grid use for retrospective and future planning purposes.
- To make observations based upon actual pre-post site level monitoring that has been performed on the site level and integrate PRSV user surveys conducted on the site level focusing on PRSV user tendencies and savings. Recommendations on administration or implementation that may help to maximize the measure savings are offered.

1.2 Results, Conclusions and Recommendations

Overall, the pre-rinse spray valve program that is implemented by direct installation contractor is successfully delivering energy and water savings in Rhode Island.

[1] Impact Evaluation of the 2012 Massachusetts C&I Prescriptive Gas Program, Final Report, October 1, 2014, Prepared by DNV GL.

The annual savings associated with the spray valve measure of a sample of 23 National Grid sites monitored in Rhode Island and Massachusetts was calculated as 104 Therms per year . The energy calculation utilized pre and post metering done with in-line water meters measuring the true spray valve flows for both the new and old valves for a full 30 day pre and post monitoring period. The average calculated water savings per spray valve change-out is 5,669 gallons per year. This is the direct fresh water savings only. There is also a similar associated wastewater savings.

Survey responses from interviews conducted with spray valve users and facility owners during the site monitoring were positive for the change-out program as were opinions toward the performance of the new high efficiency valves being utilized in the program. A wide variation of calculated savings stems from dissimilarity in dish/pot washing within the food service population of the commercial sector. The sample frame of this Rhode Island evaluation included healthcare, education, grocery, both full-plate restaurants and fast food restaurants, commercial kitchens and community assembly facilities that was representative of the program population. The calculated energy savings represented a wider range of values than what was reported in other studies that did site monitoring on restaurants only. The relative precision of 48% for the Rhode Island and Massachusetts sample suggests that the adoption of pooled or aggregated average savings values of all monitored sites as advantageous since the delivery and populations are similar for National Grid programs in Rhode Island and Massachusetts.

The combined results of all site monitoring, data analysis, fieldwork and observations of the retired spray valves collected in the evaluation is combined with the results of the onsite survey to lead to a better understanding of pre-rinse spray valves.

The following are conclusions and recommendations for the program, and future evaluations of the program.

Deemed Savings Value Adjustment: The recommendation is to utilize the average calculated annual savings of 114 Therms (per pre-rinse spray valve). This average value reflects 39 total sites involved in site monitoring in Rhode Island and Massachusetts. Precision and confidence associated with the savings value is improved by pooling all site monitoring results for the largest sample. This initial evaluation determined that no discernable differences exist between the two state program implementations or C&I spray valve populations. Additional average calculated values for National Grid sites (Rhode Island only, National Grid only “pooled” are further detailed in Section 6:

results. The average savings/year calculated from site level monitoring conducted in the evaluation more accurately represents the program savings value for a prescriptive program spray valve change out than the corrected deemed savings value of 126 Therms currently being utilized in the 2012/2013 program data. The National Grid Rhode Island TRM has a corrected annual savings value of 126 Therms.

Non Energy Impact Adjustment, Water and Wastewater Savings: The evaluation measured water savings at the site level using in-line water meters for old and new spray valves (pre-post monitoring). The average annual calculated water savings of 39 total site monitored spray valves is 6,410 gallons per spray valve change-out. The same value of 6,410 gallons is identified as the annual wastewater savings.

Spray Valve Measure Lifetime Adjustment: Three factors each contribute to the spray valve measure lifetime increase from five to eight years. First, eight years is the average valve lifetime of 36 survey responses where retired spray valve lifetime was known for certain. Unsure or unknown responses were not counted. Second, forensic inspection of the spray valves taken out of service confirmed that many old valves were in service for a long period and none appeared to conflict with the survey responses. Lastly, the newer higher efficiency low-flow spray valves such as what is being used as the default program valve in Rhode Island are less prone to clogging, have more robust design mechanisms and are expected to have longer service lives than the older vintage valves being replaced by change-out programs occurring now.

Recommendations to Increase Savings: Results showed that a percentage of change-outs (approximately 20%) resulted in small energy savings because of either low spray valve use at a site or old valves already having low flow rates. Solutions to address these "small-savers" in the program population do not seem practical and are further explained:

- No practical method can be recommended to accurately identify low use sites. A free change-out program would quickly become very complex and un-manageable if simple eligibility rules changed to make it selective to certain commercial businesses. Site level monitoring proved that spray valve use remains site specific even between facility types such as healthcare, fast food and full service restaurants where there was a wide variation in savings between the same type of buildings or businesses.
- No practical method exists to stop the easy modification of older spray valve's flow rate. Hundreds of bucket tests performed in this evaluation proved that even if a newer vintage EPACT 2005 Compliant (with flow rate <1.6 GPM) were in place at a customer site and a bucket test was performed to confirm that it's flow rate was less than 1.6 GPM there is no way to stop it from being quickly modified in the future to a higher flow rate. The existing program implementation practice of changing all valves to the high efficiency "tamper-proof" model to assure low flow operation is maintained in the future appears to be prudent administration.

Recommendation for future Market Assessment: National Grid's implementation of the spray valve program utilizing direct installation contractors has availed the change-out of 2-3,000 spray valves per year in the state resulting in substantial gas savings. Currently there are some synergies achieved by common program implementation occurring between two States and multiple program administrators. Further investigation of the state-wide inventory of spray valves and historic program data analysis will provide meaningful planning details for the remaining overall gas savings potential and feasible future strategies for this measure.

Figure 1: Old and New: Pre-Rinse Spray Valve Change-out

2. INTRODUCTION

This report documents DNV GL's Evaluation of National Grid Rhode Island's Commercial and Industrial Pre-Rinse Spray Valve Measure of the prescriptive gas program. This impact evaluation was performed concurrent with the impact evaluation of the Massachusetts Commercial and Industrial Prescriptive Gas Program which was performed by DNV GL[2] and also focused on evaluation of the prescriptive program pre-rinse spray valve measure. This impact evaluation was completed for National Grid and includes combined National Grid Massachusetts and National Grid Rhode Island site results.

2.1 Program Description

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National Grid uses a direct installation contractor for the majority of implementation of the PRSV measure. This contractor physically replaces the old valve with a "program approved" new low-flow pre-rinse spray valve at the customer's place of business. Both installation of the new valve and removal of the old valve are done by the contractor. The contractor also removes the old valve from the customer premise and either returns or recycles the old valve based upon the locational specific policy of National Grid. The same manufacture valve model industry recognized "best-in-class" valve has consistently been used as the "program approved" new valve for a period of 2011 to present. The contractor, delivery and implementation methods are identical between the National Grid Rhode Island and Massachusetts programs.

2.2 Purpose of Study

The research objectives of this impact evaluation of National Grid Rhode Island's Commercial and Industrial Prescriptive Gas Pre-Rinse Spray Valve Program include updating the following assumptions:

- To provide new deemed savings value recommendations that have been derived from actual field-testing for the pre-rinse spray valve measure for use in the National Grid Rhode Island Technical Resource Manual (TRM). The deemed savings value recommendations will be available for National Grid use for retrospective and future planning purposes.
- To make observations based upon actual pre-post site level monitoring that has been performed on the site level and integrate PRSV user surveys conducted on the site level focusing on PRSV user tendencies and savings. Recommendations on administration or implementation that may help to maximize the measure savings are offered.

2.3 Scope of Evaluation

The scope of work of this impact evaluation covers pre-rinse spray valve change-outs that occurred in National Grid service territory in Massachusetts and Rhode Island.

[2] Impact Evaluation of the 2012 Massachusetts C&I Prescriptive Gas Program, Final Report, October 1, 2014, Prepared by DNV GL.

This evaluation incorporates recommendations of National Grid's Rhode Island gas evaluation team that have been made in a series of ongoing meetings during project scoping and field work phases: A summary of important information about this evaluation includes:

- In-depth examination of 2012 program data on the basis of 2012 program year savings and lifetime savings identified that the top measure that was not previously evaluated was the pre-rinse spray valve. This evaluation focuses on identification of energy savings associated with the replacement of an older or standard spray valve with an approved efficient low flow pre-rinse spray valve. The expectation is that the PRSV measure will continue to be one of the gas efficiency measures that results in significant gas program savings particularly in light of the current ongoing aggressive direct install programs.

- Part of the evaluation project scoping effort included a comprehensive review of:

  (a.) what other evaluations have been performed,
  (b.) what methodology was used, and
  (c.) the results and recommendations.

  The existing evaluation work is presented in this Report and was used to guide the recommended evaluation approach.

- Unlike, other studies that were performed outside of Rhode Island and the adjacent New England region, easy access to the replaced spray valves that were taken out of service during the 2012 program year did not exist in Rhode Island. This is a major factor in the choice of the evaluation approach for this measure.

- The valves that were taken out of service during the first quarter of 2014 (January - April 2014) played a critical role in this evaluation. During this time evaluators recruited a sample of sites where new valves had just been installed. Evaluators first installed site monitoring equipment at sample sites which was used to first measure the new valve usage pattern, and then evaluators re-installed the old valve and subsequently measured the usage pattern again providing pre-post spray valve usage data for analysis.

3. 2012 PROGRAM DATA ANALYSIS

This population analysis section provides a discussion of the savings allocation of the 2012 prescriptive gas program in terms of number of projects and savings per measure category. DNV GL worked with the initial tracking data to make sure that measures were categorized accurately, communize measure descriptions and to provide some qualitative review of the program data.

3.1 Tracking System Data Summary

The population frame for this impact evaluation is the set of prescriptive gas projects rebated in 2012 through both the prescriptive and direct install subprograms, as included in the tracking system data provided by the Program Administrator (PA) in Rhode Island. DNV GL consolidated the PA records into 4045 unique projects and measure categories. Table 1 shows the distribution of the consolidated tracking system numbers of projects and annual savings in Therms, for the Prescriptive Program categories. A total of 3,850 projects in the Prescriptive Program were analysed with the Direct Install Program projects included. The measure with the highest savings is the pre-rinse spray valve and is highlighted in yellow in Table 1. The four measures that are considered “traditional HVAC” measures are highlighted in gray to identify their comparative rank by measure savings.

Table 1: 2012 Prescriptive Gas Project Program Year Savings by Measure Category

Program Year - **2012 Prescriptive Gas Projects and Savings by Measure Category**					
Prescriptive Measure	Number of Projects	Percent of Projects	Number of Units Installed	Annual Savings by Measure, Therms	Percent of Total Program Savings
Hot Water - Pre-Rinse Spray Valve	2356	61%	3,937	1,322,832	67.5%
HVAC - Boiler	519	13%	557	386,586	19.7%
Hot Water - Water Heaters	343	9%	377	73,127	3.7%
Food Service - Commercial Fryer	33	1%	35	45,210	2.3%
HVAC - Infrared Heater	44	1%	53	33,690	1.7%
Food Service - Commercial Ovens	73	2%	76	27,502	1.4%
HVAC - Thermostats	310	8%	310	23,866	1.2%
HVAC - Furnaces	120	3%	120	20,100	1.0%
Hot Water - Steam Traps	1	0%	41	10,537	0.5%
HVAC - Boiler Reset Controls	27	1%	27	9,585	0.5%
HVAC - Combo Water Heater/Boiler	19	0%	19	4,674	0.2%
Food Service - Commercial Steamer	2	0%	2	2,122	0.1%
HVAC - Condensing Unit Heater	2	0%	2	818	0.0%
Food Service - Commercial Griddle	1	0%	1	185	0.0%
HVAC/Hot Water - Pipe Insulation	0	0%	-	-	0.0%
Hot Water - Faucet Aerator	0	0%	-	-	0.0%
Hot Water - Low-Flow Shower Heads	0	0%	-	-	0.0%
Total	3850		5,557	1,960,834	100.0%

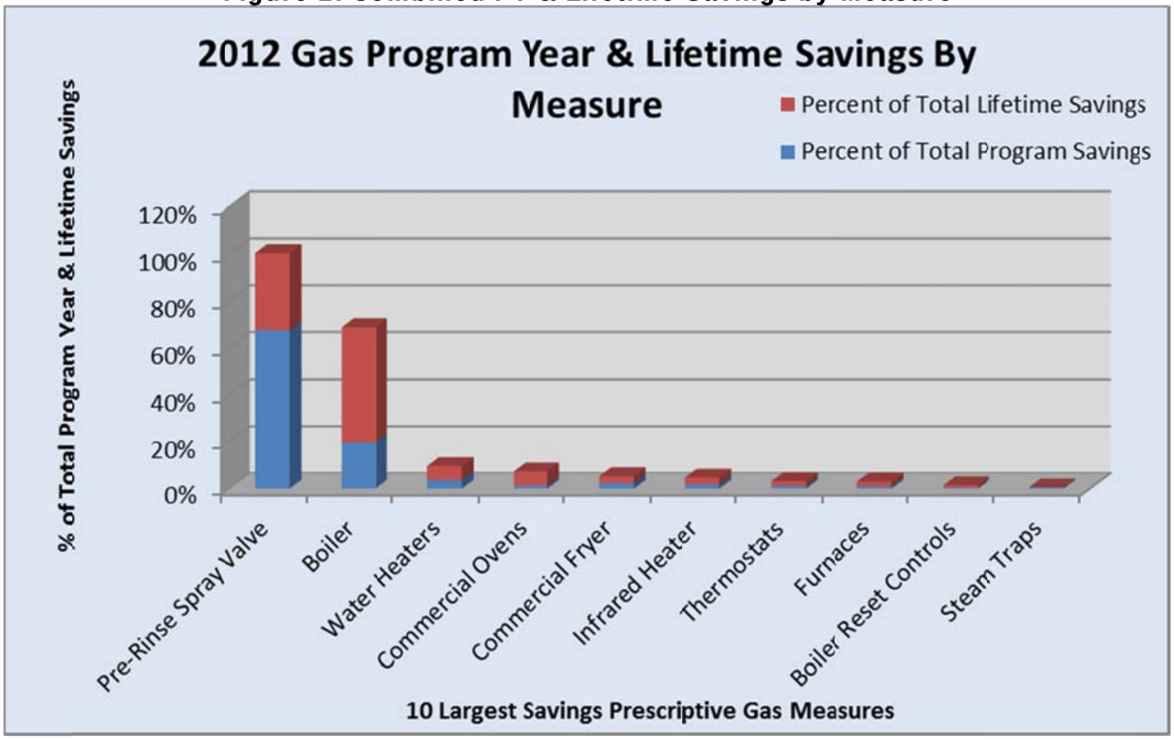
In addition to the program year savings, the Rhode Island gas evaluation team considers lifetime savings as an additional criterion for ongoing evaluation focus. Table 2 provides the rank, percent of annual savings, measure lifetime, lifetime savings, percent of total lifetime savings and further details if the measure was previously evaluated. The table is sorted with the highest lifetime savings from top to bottom. Pre-rinse spray valve measure is highlighted in yellow and is second to the boiler measure in terms of total lifetime savings. From a historical trending standpoint, similar to program year 2012, the energy efficient spray valve measure was the top measure for program annual savings in 2011 accounting for 35% of the total annual program savings. This measure was the eighth largest measure in PY 2010 and accounted for just over 1% of the program savings.

Table 2: Lifetime Savings by Measure

Lifetime Savings - **2012 Prescriptive Gas Projects and Savings by Measure Category**					
Measure Category	Annual Savings by Measure, Therms	Percent of Total Program Year Savings	Measure Lifetime, Years	Lifetime Savings	Percent of Lifetime Savings
HVAC - Boiler	386,586	19.7%	25	9,664,650	49%
Hot Water - Pre-Rinse Spray Valve	1,322,832	67.5%	5	6,614,160	33%
Hot Water - Water Heaters	73,127	3.7%	13,15,20	1,096,905	6%
Food Service - Commercial Ovens	27,502	1.4%	12	330,024	6%
HVAC - Infrared Heater	33,690	1.7%	17	572,730	3%
Food Service - Commercial Fryer	45,210	2.3%	12	542,520	3%
HVAC - Furnaces	20,100	1.0%	18	361,800	2%
HVAC - Thermostats	23,866	1.2%	15	357,990	2%
HVAC - Boiler Reset Controls	9,585	0.5%	15	143,775	1%
HVAC - Combo Water Heater/Boiler	4,674	0.2%	20	93,480	0%
Hot Water - Steam Traps	10,537	0.5%	3	31,611	0%
Food Service - Commercial Steamer	2,122	0.1%	12	25,464	0%
HVAC - Condensing Unit Heater	818	0.0%	18	14,724	0%
Food Service - Commercial Griddle	185	0.0%	12	2,220	0%
HVAC/Hot Water - Pipe Insulation	-	0.0%	15	-	0%
Hot Water - Faucet Aerator	-	0.0%	10	-	0%
Hot Water - Low-Flow Shower Heads	-	0.0%	10	-	0%
Total	1,960,834	100%		19,852,053	100%

During the scoping process, the Rhode Island gas evaluation team considered lifetime savings in combination with program year savings as yet other criteria for evaluation focus. Figure 2 shows a graphical representation of program year 2012 percent of total savings combined with percent of total savings utilizing a one-to-one weighting factor which illustrates the dominance of the two top measures, boilers and pre-rinse spray valves and the contribution of both lifetime and program year savings. During planning meetings involving National Grid and DNV GL a determination was reached that the Pre-Rinse Spray Valve measure should be the focus of the current program evaluation.

Figure 2: Combined PY & Lifetime Savings by Measure



3.2 Rhode Island TRM PRSV Measure Detail

The current National Grid Rhode Island Technical Resource Manual[3] (TRM) describes the Pre-Rinse Spray Valve (PRSV) measure as retrofitting existing standard spray nozzles in locations where service water is supplied by a natural gas fired hot water heater with new low flow pre-rinse spray nozzles with an average flow rate of 1.6 GPM or less. The TRM classification of the measure is for gas savings through hot water efficiency. A detailed savings algorithm is not specified. The deemed savings value is identified as "Average annual savings of 33.6 MMBTU per unit" in the documented Manual but the corrected value of 126 MMBTU per unit is utilized in program administration and exists in program data. The baseline efficiency case is a non-descript standard efficiency spray valve. The high efficiency case or "eligible" unit for retrofitting is a low flow pre-rinse spray valve with an average flow rate of 1.6 GPM (gallons per minute). The measure life is five years. This report was for the Regional Municipality of Waterloo, ON (Canada)[4]. Table 3 summarizes the current TRM values for the pre-rinse spray valve measure.

The National Grid 2010 Program year TRM (Report Version) uses a 33.6 MMBTU average annual savings per unit value which is incorporated by reference of "*EM&V Report for the CUWCC Pre-Rinse Spray Head Distribution Program*" This report was prepared for the California Urban Water Conservation Council; Page 20, savings of 0.92 Therms per day multiplied by 365 days per year to yield 335.8 Therms[5]. The citation for measure life in the 2010 TRM plan is "*Pre-Rinse Spray Valve Pilot Study – Final Report*"; January 2005, by

[3] Rhode Island Technical Resource Manual for Estimating Savings from Energy Efficiency Measures, Plan Version (October 2012) and the Rhode Island Technical Resource Manual 2012 Report-Version contain the same information for this measure.

[4] Waterloo Pre-Rinse Spray Valve Pilot Study, Final Report; Veritec Consulting Inc., January 2005.

[5] 2004-5 Pre-Rinse Spray Valve Installation Program (Phase II), SBW Consulting Inc., Feb. 2007.

Veritec Consulting Inc.[6] which remains as the citation for measure life in the 2012, and current Plans. The cited reference for the non-energy impact of C&I water savings of 62,305 gallons/unit is the same Veritec Consulting 2005 Report[7]. More detailed information on the four existing PRSV evaluation studies is presented next in Section 4.1.

Table 3: TRM Values and Assumptions

Rhode Island NGRID	Technical Reference Manual PRSV Values
Deemed Savings	Average annual savings of 33.6 MMBTU per unit Average annual savings of 12.6 MMBTU per unit
High efficiency case	Low flow pre-rinse spray valve with an average flow rate of 1.6 GPM
Baseline efficiency case	Standard spray valve
Measure lifetime	Five years

[6] Ibid – (Waterloo Study)
[7] Ibid

4. EVALUATION APPROACH

4.1 Existing Spray Valve Evaluation Work

A component of the project scoping for the pre-rinse spray valve was the review of the existing pre-rinse spray valves evaluations and reports, which was presented and discussed during recent Rhode Island gas evaluation team meetings. This review included four recent studies that evaluated energy and water savings resulting from pre-rinse spray valve installation programs. The studies were presented in summarized form in Table 4 and are further summarized and compared.

Table 4: Existing PRSV Evaluations

Low-Flow Pre-Rinse Spray Valve - Existing Evaluation Summary (Cited Report)
2002-03 Pre-Rinse Spray Valve Installation Program (Phase 1), SBW Consulting, Inc. June. 2004 (CUWCC I)
➢ First phase of California Urban Water Conservation Council (CUWCC) program evaluation
➢ Program Installed 17,000 efficient valves throught California, 336/252 Therms/yr. energy savings
➢ Included pre- and post- flow measurement of less than 20 sites. Site monitoring of restaraunts only
2004-05 Pre-Rinse Spray Valve Installation Program (Phase 2), SBW Consulting, Inc. Feb. 2007 (CUWCC II)
➢ 195 site inspections, 19 pre/post metered 1.11 gpm flow reduction, 5 yr. measure life (CPUC)
➢ User tendency effect was 33% increase in post-installed duration of use.
➢ Separated grocery & non-grocery, non-grocery = 45 Therms/yr. grocery = 5 Therms/yr.
➢ More rigorous evaluation used in Phase 2 yielded drastically lower savings than Phase 1.
➢ Turbine meter was inserted for a month to measure new valve, then old valve was reinserted.
➢ Metering Errors encountered when pulsing (on-off) use occurred.
2005 SmartRinse Program Evaluation, Quantec LLC, April 2006 -non CUWCC area **(SmartRinse)**
➢ SmartRinse (direct install program) Installation verification revealed problems with 1 of 11 contractors.
➢ 4,237 units installed 2005, at 2,961 customer sites (1.4 units/site)
➢ Survey was used to recruit, Sample of 15 sites pre-post flow measurement… old valve was re-installed.
➢ Only restaurants were metered, pre-post data for 10 sites, savings of 85 Therms per year
Waterloo Pre-Rinse Spray Valve Pilot Study Final Report, Veritec Consulting Inc., Jan. 2005 (Waterloo)
➢ Regional Municipality of Waterloo (Ontario)… This was a water conservation project
➢ Water savings: Spray valve programs is three times (3X's) greater than toilet programs.
➢ 5 Year life of the spray valve (program assumption) (MA TRM reference for measure life)
➢ User tendency effect was 19% increase in post-installed duration of use.
➢ Utilized a flow switch/pressure logger instead of a positive displacement meter
➢ 126 Therms per valve per year (based on sample of 10 sites)

During project scoping meetings in early December 2013 discussions occurred regarding the three west coast pre-rinse spray valve evaluations and one evaluation conducted in the Waterloo region of Ontario. The most comprehensive evaluation report "Impact and Process Evaluation Report" for California Urban Water Conservation Council (CUWCC) was actually two reports since the evaluation was conducted in phases (CUWCC I & CUWCC II)[8] based on the first 2002-03 program year and then the second 2004-05 program year. The population of valves replaced in these two phases approaches 40,000 units. Table 5 provides additional comparative details of the existing studies and the methods that each study utilized. The details

[8] Ibid

and results of each of the studies were used to provide insight to the most practical way to proceed with the Rhode Island evaluation.

Table 5: Summary of PRSV Evaluation Methods & TESTING

Summary of Studies				
	SmartRinse	**Waterloo**	**CUWCC(I)**	**CUWCC(II)**
Evaluation Report Date	2006	2005	2004	2007
Sample Size	15	10	19	29
Sample Period	28 days	?	35 days	35 days
Population	Restaurants/ institutions	Restaurants	Restaurants	Restaurants/ grocery
Flow Measurement	Turbine on mixed flow of old and new valves	Duration switch and pressure on mixed flow of old and new valves	New valve hot and cold metered, also average mixed flow from spot readings	New and old valve hot and cold metered, also average mixed flow from spot readings
Temp. Measurement	T (mix) and T(cold) spot measurement on visit	Assumes 50% hot/50% cold	T(hot), T(cold), T(mix) (spot measured)	T(hot), T(cold), and T(mix) (spot measured)
Pressure Measurement	No	Supply	Supply	Supply
Avg. Water Savings (gal/yr/valve)	13,052	23,617	17,410	6388
Avg. Energy Savings (therm/yr/valve)	85	126	252	28

4.2 Discussion and Recommendations from the Existing Studies

Each of the four reviewed studies (CUWCC has a Phase I and Phase II) used different methods to compare the water and energy use of the old valve to the water and energy use of the efficient valve. Some measured pre- and post- installation cases, while others measured only the post-installation case and estimated the pre-installation case. Each measured quantity of water and water temperature at some location, and some measured time of use. Most used spot measurements of flow rate and temperature to determine energy savings.

It is important to note that the three evaluations that were previously done had a slightly different focus than what is planned in Rhode Island. The three evaluations in California were each fundamentally driven by drought conditions which elevated the need and public awareness for water conservation. The large spray valve replacement programs in California were direct installation programs offering end users free high efficiency valves coupled with free installation that is similar to the Rhode Island Direct Installed Program without the state-wide drought conditions. The programs in California effectively changed-out over 10,000 to 20,000 units each year. The studies were conducted for purposes of program review with an emphasis on installation verification since many independent installation contractors were involved in the program. The one non-West Coast study which was done for the Regional Municipality of Waterloo in an area between Toronto, Ontario and Detroit, Michigan was not motivated by regional drought issues. This was a pilot study commissioned to attempt to prove future water conservation program viability. The authors of the Waterloo report relayed that while the study's results were favorable there has been no wide-scale program implementation like the West Coast free-valve-change-out as a result of the pilot study.

The body of evaluation, monitoring and verification work that has been done on pre-rinse spray valves points to the fact that since operation may vary between the old and new valves, the only accurate way to compare pre- and post-valve installation is to meter both cases. Similarly, based on the studies presented and reviewed, it is necessary to measure water temperature and flow to get an accurate measurement of the energy savings realized when using the new valve. Each of the studies also identifies that restaurants make up a large component of the population and present a challenge to any evaluation involving site monitoring since restaurant owners and operators do not generally respond well to participation in field testing programs or follow-on evaluation activities because of the attention they must dedicate to their business. This Work Plan focuses on a specialized site recruiting strategy that seems like a practical approach given the challenges associated with the need to do site monitoring in the restaurant and food service sector that is often focused on business and less open to distractions than other types of businesses.

4.3 Initial Sample Strategy Design

The evaluation of pre-rinse spray valves utilizing a pre-post monitoring approach requires that sample projects would be selected as applications are received in order to acquire a selection of valves that were taken out of service in the early 2014 winter/spring months. Since the finalized 2013 program data was not available during the 2013 summer time period when the Work Plan for this evaluation was developed the exact population of projects was not known in advance. For this reason a conventional stratified sample design was not pursued. An alternative approach using a representative simple random sample selection size based on analysis of the 2012 program data coupled with the knowledge that no significant changes have occurred in installation practices and program implementation between the 2012 and current 2013/2014 program years. The project timeline allows for the finalized 2013 and preliminary 2014 program pre-rinse spray valve installation totals to be compared to the 2012 program data to confirm final validation of sample size.

Table 6Table 6 provides more details of the total of all 2012 program year PRSV projects, including the total valves replaced that can be extracted from the further analysis of the 2012 Program data.

Table 6: 2012 Program Year PRSV Installations

Program	Number of Customer Sites	Program Total of PRSV's Installed	Range of PRSV's at site	Average number of PRSV's at site
2012 Prescriptive Direct Install Program	2356	3937	1 to 17	1.44

It was anticipated that the practicality of an end use customer for which a large percentage of the population would be restaurants agreeing to wait for a one-month monitoring period before a new valve is installed is less likely than a restaurant agreeing to monitoring with the new valve first, then followed by a second monitoring period re-using the old valve. It was determined that the sample selection by recruitment process would be followed in the sequence as shown in Table 7.

Table 7: Sample Selection by Recruitment Sequence

	Sample Selection by Recruitment Process Sequence
A.	***Old valves will be retained from new installations by others (for example: The direct intaller will aquire all replacement valves for the period from February 2014 - April 2014). Old valves will be tagged and cataloged.***
B.	***The evaluator will recruit from the population of sites where old valves have been retained and cataloged. This requires participation of the direct installer. Ongoing coordination meetings are planned.***
C.	***Willingness of the customers to a monitoring period of old valve re-use will determine if post-pre monitoring can be done.***
1	***"First option"(post-pre monitoring) : Evaluator recruiting will attempt post-pre monitoring from each site.***
2	***"Second option" (hybrid approach) : Evaluator recruiting will offer a second option of monitoring with the new valve only and spot measurements with the old valve as a second option to sites that do not agree to "First option".***

Thus, the evaluation as originally designed employed a nested sample with the size determined by the ongoing site recruitment of the current year installation population where replaced valves were retained by the direct installer. Preliminary sample design employing sample selection by site using a ± 20% relative precision within the 80% confidence interval of the population of 2012 Program Data where 3,937 PRSV replacements occurred is shown in Table 8 where the number of 2014 installations is expected to exceed 3000 valves. Since Rhode Island and the Northeast region in general had no evaluation precedent for spray valves an error ratio value assumption of 0.7 was used based on the West Coast evaluations. The initial sample design targets a sample of site monitoring for 20 valves.

Table 9 presents sample design incorporating possible variations that were anticipated from the recruiting success of pre-post monitoring versus hybrid monitoring and the requirement for attempting to maintain a minimum number of grocery sites to not limit the possible desire for stratification of grocery and non-grocery applications.

Table 8: Initial Sample Design from 2012 Program Data Population

ClassCD	*Class*	*SectorCd*	*Sector*	*# Accounts (Sites)*	*Total Valves Installed*	*Anticipated Valve Installations*	*Error Ratio*	*Sample Number of Spray Valves*	*Expected Relative Precision*
1	Prescriptive Gas	1	Spray Valve	2356	3937	3000	0.7	20	< 20%

Table 9: Initial Sample Design Incorporated Nested Loop & Stratification

Preliminary Sample Design		*Incorporating Nested Loop (Pre-Post/Hybrid)*	*& Stratification (grocery/non-grocery)*	
Number of Actual RI Post-Pre Monitored Sites	*Number of Incorporated NGRID Valve Sites*	*Number of "Hybrid" Monitored Sites (monitored with new valve and spot tested with old valve)*	*Total Sites Involved in Field Monitoring*	Targeted Number of Grocery Sites
5	15	0	20	4
5	13	3	21	4
5	11	6	22	4
5	9	9	23	5
5	7	12	24	5
5	5	15	25	5

Table 9 also captures the synergy of the National Grid pre-rinse spray valve evaluation occurring in adjacent states where site monitoring data from Rhode Island sites can be aggregated with additional National Grid site monitoring data that may be available and incorporated in the analysis for more robust sample representation. The target of 20 replaced valve locations that should be metered for one month after efficient PRSV installation and for one month, using the old valve was identified in the initial sample design. It was recognized that the practicality of having to first establish the sample population by accumulating the removed valves and then successfully recruit a site to a post-pre monitoring or a hybrid monitoring scheme would ultimately be the overriding factors to establish the exact size of sample for evaluation. Recruiting success did govern the size and composition of monitored sites.

4.4 Final Sample

Contrary to concerns in the project planning phase, all National Grid Rhode Island and Massachusetts sites recruited for site monitoring agreed to full pre-post metering scenarios so the “hybrid” monitoring scenario was not employed. Site monitoring was done for 24 spray valves producing results for 23 valves in the National Grid sample frame. Monitoring at one site was not completed in order to minimize customer apprehensions that developed from the monitoring equipment.

5. PRSV M&V METHODOLOGY

This section identifies the details of the on-site monitoring that was employed.

5.1 Temperature Measurement

In the reviewed literature, temperature was measured by either:

- Spot measurement of hot, cold, and/or mixed streams, or
- None measured, assumed hot and cold water temperatures and mix percentage

How temperature was measured: A wide variety of piping configurations were encountered in the spray valve sample monitoring sites. This is believed to be the case in the population also. There was definitely not a standardized plumbing scheme proving that spray valves are installed in a variety of ways. For this reason different users of the PRSV's can control mixed water temperature with hot and cold valves. Therefore, spot measurement is not the most accurate way to approximate average usage temperature, unless the sample size of spot measurements is high and the measurements are taken to represent each user and task. To improve the accuracy of the study, temperature gauge/logger equipment was utilized for the entire duration of the monitoring period.

Where temperature was measured: The temperature of the mixed stream was measured and recorded, rather than that of the hot and/or hot and cold streams during each of three site visits. Some other studies measured hot and cold-water temperature, while others measured mixed temperature. For most installations done in the Northeast the temperature of water is controlled by a hot and cold-water faucet or mixing valve. Typically, there is a sink and spigot downstream of these faucets and upstream of the PRSV. So, the temperature of water through the PRSV may not be accurately estimated by the temperature of the hot and cold streams only, since the mixture may not be consistently 50% hot and 50% cold. At each site the hot/cold mixing ratio that was being utilized was recorded. The majority of sites used 100% hot water consistently but this was not the case for all sites. If spot measurements are utilized, inaccuracy of gas savings will be introduced if the hot and cold mixing valves are re-adjusted after the spot test. Ease of adjustment and user access of the temperature mixing valves varied from site to site. It was believed that a benefit of temperature logging done with a time-of-use data logger during the pre- and post- site monitoring period would add value towards the duration of use analysis in addition to being able to utilize the real-time temperature values for analysis rather than an average value. At most sites the analysis of temperature time-of-use logger data provided less than desirable analytic value because long periods of spray valve inactivity caused temperature values to converge at the value of thermal equilibrium of room temperature. Energy savings calculations used the site specific hot water set point (hottest temperature) and the average annual cold water inlet temperature.

5.2 Flow Measurement

In the reviewed literature, flow was measured in three different ways:

- Duration and pressure logger used to estimate flow from a flow/pressure curve,
- Flow of hot line and flow of cold line, and
- Flow of mixed stream

How spray valve flow was measured: The duration and pressure logger, used with a flow/pressure curve, requires that a flow/pressure curve be generated in a laboratory setting. In addition, accuracy degraded at high pressures. One study found flow meters to be inaccurate with pulsed flows, but CUWCC Phase II found the flow meters they used to be reasonably accurate.

This evaluation used flow meters similar to those used by CUWCC Phase II Study. All the studies that used flow meters used those that record total flow (gallons) over a sampling period, not loggers that report flow rate (gallons per minute) on a regular timed interval. Three different water metering equipment configurations were investigated during a 2013 bench testing phase. A major factor in this decision is the wiring that would stretch between the meter and the data-logger when a pulse capable flow meter is coupled to a time-of-use-data-logger. Wiring was permissible at some sites and not permissible at other sites. The advantage of the use of a time-of-use data logger is that it would avail field data that could be further analysed to understand duration of use.

The results of bench testing that was performed prior to actual customer site monitoring prompted the decision to utilize an in-line flow meter that has pulse capabilities that was paired with an on/off state logger with a wired connection for every site where the wired connection did not present a problem. In addition to the raw data that results from the metered pulse and data logger combination a manual totalized flow meter index reading ("manual meter read") was manually recorded at the end of each pre- and post- monitoring period during each field visit. A spot check "bucket test" was performed twice during each site visit with old and new spray valves in addition to before and after the water meter is installed or removed to determine if the metering assembly creates any change in the spray valve flow rate during the pre- and post- monitoring periods.

Where flow was measured: Since the study measured mixed water temperature, the desired water flow location was the stationary part of the gooseneck that feeds the PRSV. This was done for all sites consistently. An alternative of measuring the hot water temperature and flow only was not done, but as discussed above, this would include any water used in the sink, not just the water supplying the PRSV and lead to inaccurate energy and water use.

5.3 Duration of Use

Duration of use is not required to determine energy savings or water savings. Both values can be determined without duration of use data, and a comparison between old (baseline) and new (efficient) valves used to generate average savings per valve per year. Yet the change in the duration of use between high-efficiency spray valves and that standard spray valve remains as an elemental focus of the evaluation in order to better identify "user tendencies". More bluntly stated: the additional time a low flow spray valve is kept on compared to a standard high flow spray valve is a key factor in both energy and water savings. The important question is how best to measure or calculate it directly.

Survey instruments used in the existing studies suggest that time of use is often overestimated by customers. Based on the results of bench test evaluation an in-line totalizing water meter with an index that can be manually read and an internal Reed Switch for communication of on/off cycles that is wired to a change-of-state data logger was the best option. This meter was favored and offered the option of wiring a data-logger if the wired connection was permissible based on the individual site conditions. If duration of open valve use is not measured with an associated wired data logger, an estimate of daily time of use can be back-calculated using total flow (gallons) and an average flow rate through the PRSV based on spot measurements.

5.4 Pressure Measurement

Pressure measurements were done on a spot testing basis at every opportunity during the site monitoring process. Based on the recommendation to use an in-line water metering device to directly measure the water flow through the spray valve the need for pressure measurement is less critical than metering approaches in other studies where pressure is used to calculate flow rate. Since pressure, flow, and the valve specifications are related hydro dynamically the pressure data will be used to confirm the direct measured flow meter values. The pressure measurements should be done both when the valve is open and closed for reporting purposes to verify both the static and dynamic changes to pressure with the original and low flow spray valves.

5.5 Monitoring Period

Of the existing studies that reported a monitoring duration, all are approximately one month. Considering all of the published work available, a range of potential time of use was identified as 0.08 – 0.75 hours per day (5 – 45 minutes per day) at each site. Using this range and the error analysis associated with the totalizing water meters and temperature data logger combinations, a high-use site would generate statistically valuable field data with a shorter than one-month monitoring period but a low-use site would be problematic if shorter monitoring periods were employed. The existing studies reviewed appeared to balance this dynamic effectively with a month-long monitoring period for both the old and the new valve. The longer the monitoring period, the lesser the effect of a weekly fluctuation in business or a single event (food service function, weather, cultural, etc.) having an effect on the results. At the conclusion of the site monitoring field work the minimum one month standard period was adhered to for all sites for both new and old valve monitoring periods. Site monitoring details are provided in Table 10.

Table 10: Old and New Valve Monitoring Periods

Pre/Post Monitoring Period		
	New Valve, Days	Old Valve, Days
Total all sites	922	833
Average	40	36
Minimum	32	31
Maximum	48	64

5.6 Pre-Post Monitoring Period Spray Valve Use Normalization

Since the pre-post evaluation approach is recommended because it provides the best analytic method for capturing the user tendency effects associated with the differences between standard spray valves and high-efficiency spray valves, it makes sense to attempt to protect against biases that may be introduced during the pre and post installation monitoring periods. It is common for restaurants or food service facilities to experience "events" (holiday parties, wedding receptions, etc.) that occur in one month and not the next month which may introduce bias in the form of a different amount of spray valve usage between the pre and post monitoring periods. For this reason, the evaluation included an attempt to normalize the amount of washing that is done during the two monitoring periods. Possible methods of site-level normalization are shown in Table 11. The specific method used in the final analysis was chosen for each site based on what was the best method given the site specific conditions. The site report details the method chosen.

Table 11: Methods of Spray Valve Use Normalization

Methods of Spray Valve Use Normalization During Monitoring Periods	
Primary Spray Valve Use Normalization Method:	
1	*Raw data analysis of on/off cycles of spray valve operation from pulse capable meter coupled with time of use data logger.*
Secondary Spray Valve Normalization Methods:	
2	*Automatic dishwashing (or domestic hot water equipment if applicable) on/off cycles or run-time.*
3	*Kitchen lights and kitchen occupancy.*
4	*Water meter readings/billing analysis (water meter "clocked" by evaluators for each monitoring period).*
5	*Variety of restaurant/food service customer volunteered indices collected during interviews during site visits*

Occupancy loggers that provide an indication of when there was active motion within a fifteen foot radius of the spray valve sink location were installed at all locations and proved to be the most used method. Automatic dishwashing equipment monitoring was used in only one case because of a combination of factors: either they did not exist, were not used, were leased or their design did not facilitate data logger installation. Water meter readings were typically not suitably specific to provide an index of food service activity. In a small number of cases the site hosts were able to provide some daily "production index" although seemed less directly connected to spray valve activity than the occupancy data. One case existed where the occupancy data was flawed (tight hallway installation) lighting sensors provided a suitable alternative.

A detailed "On-site Data Acquisition Form" was used for each monitored site to compile specific details and are included in Appendix B and maintained on the RI NGRID Prescriptive Gas PRSV SharePoint site. An eight question pre-rinse spray valve operator/owner survey instrument was administered during the onsite visits with the best available individual at each site. The on-site survey focused on distilling the important perspectives of the spray valve users and owners of the facilities involved in the site monitoring. The survey responses highlight several interesting items that are discussed in Section 1: Results.

5.6.1 Verification

Each initial site visit consisted of installing metering and monitoring equipment in the kitchens of 2014 program participants. In order to successfully recruit the overall 40 sites for site monitoring there was daily contact between the direct installation contractor and the evaluation team. Electronic lists of customer installations were exchanged on a weekly basis during a four month period in early 2014. The recruiting process for site monitoring involved the evaluator calling a customer within a week after the installation of new spray valves to determine if the customer had willingness to participate in site monitoring. A component of the recruiting script was getting customer confirmation of the direct installation reported installations. While the focus of the evaluation was on the savings value, the challenging nature of customer recruiting process and the requirement of close coordination between evaluation team and direct installation contractor provides insight on program verification. Table 12 further illustrates program verification by the evaluation activities.

Table 12: Program Verification

Phone & Field Visit Verification of Program Data	
Item	**Verification**
278 sites contacted by phone by evaluators during site recruiting	**278 customer responses confirming valve change-outs had occurred as reported.**
39 spray valve site visits by evaluators	**39 spray valve change-outs confirmed**

5.6.2 Monitoring

True pre-post site monitoring of current 2013-14 spray valve installations was utilized to fully capture the user tendency effects of spray valve change- outs. A "hybrid" approach to pre-post monitoring utilizing spot measurements with the old valve temporarily re-installed at sites that do not agree to full pre-post monitoring will be adopted. This approach means that the valves that are being taken out of service for new installations play a critical role in this evaluation. Evaluators propose that a sample of sites where new valves are installed will be contacted to participate in the study, which will first measure the new valve usage pattern, and will subsequently re-install the old valve and then re-measure the usage pattern with the old valve in place for purposes of analytic comparison.

Pre-post site monitoring will require three site visits except when a "hybrid" site monitoring is used which will require two site visits. Time-of-use [TOU] loggers that will be installed at the spray valve assembly for direct flow, temperature, pressure measurements in combination with spot tests which be performed twice during each site visit. The sequence of tasks that will be employed at each location during site monitoring is listed as follows:

5.6.3 Site Monitoring- Sequence of Tasks

<u>Initial Site Visit</u> – Installation of water meter and data loggers

1. Measure/record height of spray valve head.
2. Run the spray valve sufficiently to get "hottest" water temperature prior to any spot testing and data recording.
3. First Bucket Test, flow rate, temperature, pressure
4. Install water meter and short-riser length to match original height of spray valve head (tag/catalog any original piping lengths, fitting, etc. for final restoration)

5. Launch water meter data-logger.
6. Install temperature probe, launch temperature time-of-use data logger.
7. Second Bucket Test, flow rate, temperature, pressure (within tolerance of first).
8. Install normalization monitoring – employing multiple methods (if full pre-post site monitoring is being done)
9. Site inspection of water heating equipment, domestic water meter supply,

Second Site Visit – Valve Change-Out

10. Third Bucket Test
11. Remove new spray valve, install old spray valve.
12. Fourth Bucket Test

Third Site Visit – Reinstall new valve, Retrieval of water meter and retrieve data loggers

13. Fifth Bucket Test
14. Remove temperature probe and data logger.
15. Remove water meter/data logger and restore original piping configuration.
16. Remove old spray valve, re-install new spray valve.
17. Retrieve normalization monitoring.
18. Sixth Bucket Test

Key Savings Calculation Inputs

- Quantity of pre-rinse spray valves
- Spray valve nameplate information: Make, model, rated flow rate, vintage if available,
- Food service facility type: (fast food restaurant, full service restaurant, school, healthcare, grocery, hospitality, religious, business cafeteria),
- Water temperature: mixed temperature of spray valve stream, cold water inlet, DHW supply, DHW set-point, DHW set-point test method.
- Spray valve use during each monitoring period.
- Water pressure delivered to spray valve in flowing condition,
- Domestic hot water heating equipment: type, nameplate ratings, operating efficiency.

The installed inline positive displacement water meter will deliver an internal Reed Switch change of state contact-closure pulse signal to the state on/off data logger to record on/off cycles. The state on/off loggers record on and off cycles according to the time stamp in the unit. The time required for filling a calibrated one gallon container with a spray valve stream with associated flowing temperature and pressure conditions constitute a “Bucket Test”. Multiple “Bucket tests” were performed during each of the three site visits to better capture changes that may have occurred between site visits. Bucket tests were performed before and after the installation of site monitoring equipment to determine if the installation of metering, piping and associated fittings introduced any changes in the spray valve flow rates. At no point, during any of the site monitoring did the monitoring equipment appear to introduce any changes in spray valve flow. Monitoring at one site was not completed in order to minimize customer apprehensions that developed from the monitoring equipment.

Bucket test methodology

The evaluation assumes that the original height of the spray valve is set by user preference and will be maintained throughout the monitoring period. Spray valve height measurement/ record height of spray valve head. Is always the first step.

- Run the spray valve sufficiently to get "hottest" water temperature prior to any spot testing and data recording.
- Date, time of day, static water pressure is recorded.
- The time in seconds to completely fill a graduated one gallon container is recorded.
- The dynamic pressure is recorded while the spray valve is "on" or actively filling the one gallon container.
- The temperature using a calibrated high accuracy laboratory style mercury thermometer and a kitchen style digital thermometer is recorded immediately after the gallon container is filled. The recorded temperature should be the highest temperature since the water within the container will decline as it is slowly cooled by air temperature.

The pre-post monitoring period to monitor spray valve operation will be a period of 30-days. Totalized flow during each of the monitoring periods will be manually recorded from the installed water meter index (manual meter reading of the totalized meter index).

The water meter and temperature data loggers will be set to record average temperatures in 10-second increments. Large variations in temperature are expected since the delivery pipes and hoses associated with spray valves exist with no-flow flow for the majority of time and have hot water flow only for short periods of time in most cases.

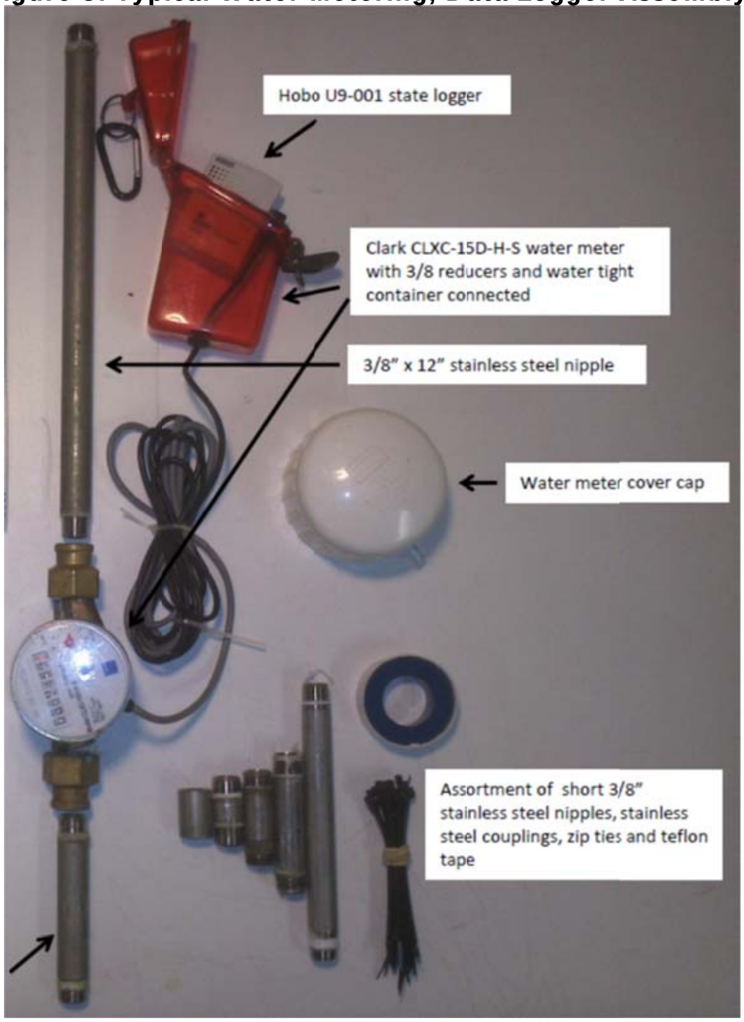
Duration of spray valve use between the high efficiency low-flow spray valve and the replaced standard spray valve will be determined from the on/off cycles from flow meter/data logger and also analytically from on/off cycles of the temperature data. Each site monitoring location will have a combination of spot testing, physical inspection of water heater equipment, interview of food service facility individuals and meter/data logger data acquisition which is shown holistically in Table 13.

Table 13: Site Monitoring Details

Site Monitoring Parameters and Monitoring Methods							
	Real Time Testing			Spot Testing			
Parameter Measured	Real-time During Monitoring Period	Duration	Data Logger, Measurement Device	Multiple Onsite "Bucket Test"	Number of Measurements during "Bucket Test" (Pre-Post/Hybrid)	Data Logger, Measurement Device	Spot test other than "Bucket Test"
Water Temperature, mixed pre-rinse water	✓	30 day old/new valve monitoring periods / 10-second intervals	Temperature probe providing signal to TOU data logger	✓	(6 times during 3 site visits/5 times during 2 site visits)	Digital thermometer, conventional mercury thermometer	Not applicable
Water Temperature, cold inlet	-	-	-	-	each site visit	Infrared or conventional thermometer	✓
Water Temperature, DHW supply	-	-	-	-	each site visit	Infrared, direct measurement with conventional	✓
Water Temperature, Set point	-	-	-	-	each site visit	direct measurement with conventional thermometer, Equipment setting	✓
Water Pressure, flowing	-	-	-	✓	(6 times during 3 site visits/5 times during 2 site visits)	Pressure guage with installed spray valve in flowing condition	-
Flow Measurement	✓	30 day old/new valve monitoring periods / 10-second intervals	Inline water meter providing signal to TOU data Logger plus manual totalized reading at the end of each	✓	(6 times during 3 site visits/5 times during 2 site visits)	Time to fill 1-gallon graduated container	-
DHW Equipment	-	-	-	-	each site visit	type of system, onsite combustion analyzer	✓

Typical site monitoring equipment consisting of inline water meter, wired data logger, piping and protective field enclosures are shown in Figure 3.

Figure 3: Typical Water Metering, Data Logger Assembly[9]



5.6.4 PRSV Calculations and Analysis

The following variables and equations are used to calculate energy and water use before and after efficient PRSV installation:

Equation 1 & 2: Energy & Water Use

AMWU=[MWU (gal)/EMT (days)] x AOD(days)	Eq. 1
*AEU= [(AMWU*Density*SH*(MWT-CWST)] / [TBTU* Efficiency]*	Eq. 2

[9] Photograph courtesy of SBW Consulting, Bellevue, WA, 2013

Table 14: Descriptions and Values of the Variables from Equation 1&2

Variable	Description	Source
AMWU	Annual mixed water use	Eq. 1
MWU	Water Used in Sampling Period (gal)	Flow meter on mixed line
EMT	Elapsed metering time (days)	Recorded
AOD	Annual operating days	Survey or site provided data
AEU	Annual energy use	Calculated from equation (Eq. 10)
Density	Density of water (8.29lb/gallon)	Assumed
SH	Specific heat(1.0 Btu/lb/F)	Assumed
MWT	Average water temp (F) during use over sampling period	Data logged Temperature Probe or Temperature gauge on mixed line, in-use average
CWST	Average cold water supply temp (F)	Data logged temperature Probe or Temperature gauge on inlet piping. Seasonal assumption (35 - 55°F)
TBTU	BTU/Therms ratio (100,000)	Definition
Efficiency	Gas hot water efficiency	Site specific determination

AMWU and AEU for the post-installation case will then be subtracted from those for the pre-installation case to determine annual savings for each location. These will then be used to determine average annual energy savings. While not the primary concern of this evaluation, which focuses on energy, savings this analysis provides direct measurement and calculation of annual water savings, which is also tracked by the Massachusetts program. Similarly the duration of use comparison between old and new spray valves are developed through an analytical basis to compare to the on-site survey responses.

A spreadsheet calculation was used to first identify preliminary savings calculated from spot testing data and then also developed into the final results that used the actual metered flow data that was not available until completion of the final (third) site visit. It should be noted that for purposes of clarity, the nomenclature of “new” valve and “old’ valve is used throughout in the analysis spreadsheet as detailed in Table 15.

Table 15: Spray Valve Spreadsheet Calculations

Energy Saved	**Therms/year**	$\frac{Annual\ Usage\ Savings\ * Water\ Denstity * Water\ Specific\ Heat * (HWT - CWT)}{(TBTU * HWH\ Efficiency)}$
Annual Usage Savings	Gallons/year	GOV-GNV (Gallons Old Valve) - (Gallons New Valve)
Gallons Per year with New valve (GNV)	Gallons/year	Water meter reading with New Valve (visit 2 value-visit 1 value)*365 days/ Monitored days
Gallons Per year with Old valve (GOV)	Gallons/year	(GPMOV *GNV/GPMNV)
GPMOV	Gallons/minute	Gallons per minute (gpm)value for old valve from bucket test 4
GNV	Gallons/monitored days	Value (Gallons)from meter reading (monitored period) for New Valve (visit 3 value- visit 2 value)
GPMNV	Gallons/minute	Gallons per minuite (gpm) value for new valves, averaged from bucket test 1, 2 and 3
Density of Water	lb/gallon	8.29
Specific Heat of Water	Btu/lb/˚F	1
Hot water temperature	˚F	HWT (site specific DHW equipment set point)
Cold water temperature	˚F	CWT (average annual cold water inlet temperature)
TBTU	100,000	BTU to Therm ratio
HWH Efficiency	%	Site specific value from domestic hot water heater equipment rating
Energy Saved	Units Calculation Check	[~~Gallons/year~~*(~~lb~~/~~Gallons/year~~)*(~~Btu~~/~~lb~~/~~˚F~~)*(~~˚F~~)]/[~~Bt~~u/Therms/year] = Therms/year

6. RESULTS

6.1 Energy Savings Values, Water Savings, User Tendencies

Energy savings values were calculated for 23 National Grid spray valves where pre-post site monitoring was conducted on the site level. The results shown in Table 16 illustrate a wide range of savings values that is representative of high and low spray valve activity, a wide variation of old spray valve flow rates and considerable variation in the type of facilities in the Rhode Island program population. Savings Site level preliminary and final results are included in Appendix B - site level results. Additional spray valve results and analysis details are available on the RI NGRID 2012 Prescriptive Gas PRSV SharePoint Site[10] (Smalec, 2013).

The wide variation of calculated annual savings values is represented as a cluster plot in Figure 4. Closer examination of the data suggests the following factors are underlying reasons behind the spray valve energy savings values:

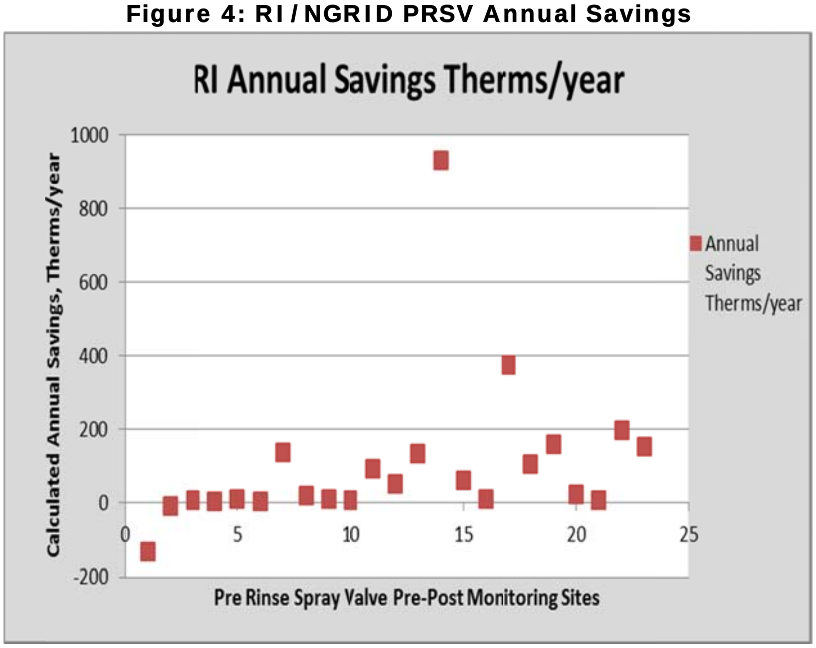
- ***2 clogged old valves resulted in lower flow rates than the new valves and produced negative energy and water savings. More discussion of clogging is presented.***
- ***1 very high use site was a caterer - commercial kitchen application with lots of spray valve use and large annual flow rates. Larger samples validate that high savings values are valid data points rather than outliers or anomalies.***
- ***3 moderately high savings came from high-use applications: two healthcare facilities and one grocery store.***
- ***5 low energy savings sites were a combination of either overall low spray valve use or similar old/new valve flow rates. Similar old/new flow rates are caused by the old valve that was replaced being a newer vintage valve with a relatively low flow rate or being an older vintage valve with a flow rate that was reduced by clogging.***

[10] RI National Grid 2012 Prescriptive Gas PRSV Project – Shared Folder SharePoint Site, DNV GL Energy 2013

Table 16: Calculated Spray Valve Savings (National Grid Sample Frame)

Program Administrator	Site ID (Valve #)	Annual Savings Therms/year
NG MA	DNV 015	-131.01
NG MA	DNV 060	-7.51
NG MA	DNV 061	8.01
NG MA	DNV 066	4.17
NG MA	DNV 068	11.93
NG MA	DNV 073	5.98
NG MA	DNV 076	139.04
NG MA	DNV 076 (Valve 2)	21.48
NG MA	DNV 090	12.32
NG MA	DNV 090 (Valve 2)	7.56
NG MA	DNV 094	94.21
NG MA	DNV 095	51.31
NG MA	DNV 096	133.39
NG MA	DNV 099	931.02
NG MA	DNV 099 (Valve 2)	62.8
NG MA	DNV 104	11.56
NG RI	DNV 196	375.24
NG RI	DNV 197	107.05
NG RI	DNV 198	160.53
NG RI	DNV 198 (Valve 2)	23.96
NG RI	DNV 200	7.94
NG RI	DNV 200 (valve 2)	197.2
NG MA	DNV 222	153.42
23 PRSV's in RI-NGRID Sample Frame		**Average = 104 Therms (103.6)**

Figure 4: RI / NGRID PRSV Annual Savings



All of the RI and National Grid specific factors influencing energy savings are present in the larger adjacent state evaluation involving six combined program administrators' areas. In fact, the evaluation team observed no differences in the implementation, population or any other factor that would suggest there would be a difference in energy or water savings between the two States.

Table 17: Results Statistics (National Grid Sample Frame)

Rhode Island Sample Statistical Results: Precision & Confidence	
Z-Value (80%)	1.28
Student-T value	1.319
Sample Standard Deviation	199.4
Mean	114.2
Upper Confidence Interval	168.9
Lower Confidence Interval	59.5
Standard Error - Sample	41.6
Relative Precision	48.0%
Required sample for 20% Precision	133.0

Of the 23 spray valves involved in site monitoring in the RI National Grid sample frame the average calculated annual savings is 104 Therms

Table 18 shows the pooled results of calculated energy savings and the measured water savings of all 39 monitored sites in both Massachusetts and Rhode Island. The result statistics for all 39 monitored site are presented in Table 18 with respect to the Massachusetts population as if the six Rhode Island monitored sites are considered "proxy" Massachusetts data points.

Table 18: Calculated Energy and Water Savings (all monitored sites)

Program Administrator	Site ID (Valve #)	Annual Savings Therms/year	Annual Water Savings, Gallons
NG MA	DNV 015	-116.576	(7,105)
CG	DNV 035	64.161	3,342
NG MA	DNV 060	-5.922	(572)
NG MA	DNV 061	8.01	394
NG MA	DNV 066	4.168	232
NG MA	DNV 068	11.932	963
NG MA	DNV 073	5.214	303
NG MA	DNV 076	114.038	5,502
NG MA	DNV 076	21.48	1,036
NS	DNV 082	58.806	3,432
NS	DNV 082	13.217	771
NS	DNV 083	151.653	8,262
NG MA	DNV 090	7.503	561
NG MA	DNV 090	7.56	566
NS	DNV 092	37.167	2,544
NG MA	DNV 094	94.21	4,546
NG MA	DNV 095	54.972	2,728
NG MA	DNV 096	108.588	5,801
NG MA	DNV 099	792.162	36,948
NG MA	DNV 099	62.796	4,545
NG MA	DNV 104	4.917	340
NS	DNV 119	88.045	5,310
CG	DNV 136	841.816	46,812
CG	DNV 136	36.545	1,813
CG	DNV 138	4.43	282
CG	DNV 152	50.884	2,599
CG	DNV 152	360.28	18,399
CG	DNV 157	131.147	7,137
NS	DNV 161	232.341	15,048
NS	DNV 167	64.249	4,336
CG	DNV 172	20.221	1,467
CG	DNV 173	94.353	6,292
NG RI	DNV 196	375.238	30,563
NG RI	DNV 197	123.833	6,163
NG RI	DNV 198	153.719	8,952
NG RI	DNV 198	23.957	1,395
NG RI	DNV 200	7.229	349
NG RI	DNV 200	197.203	9,515
NG MA	DNV 222	153.419	8,412
Count = 39 Spray Valves (All Monitored Sites)			
Average Energy Savings = 114.3 Therms			
Average Water Savings = 6,410 gallons			

Table 19: Results Statistics (all 39 monitored sites)

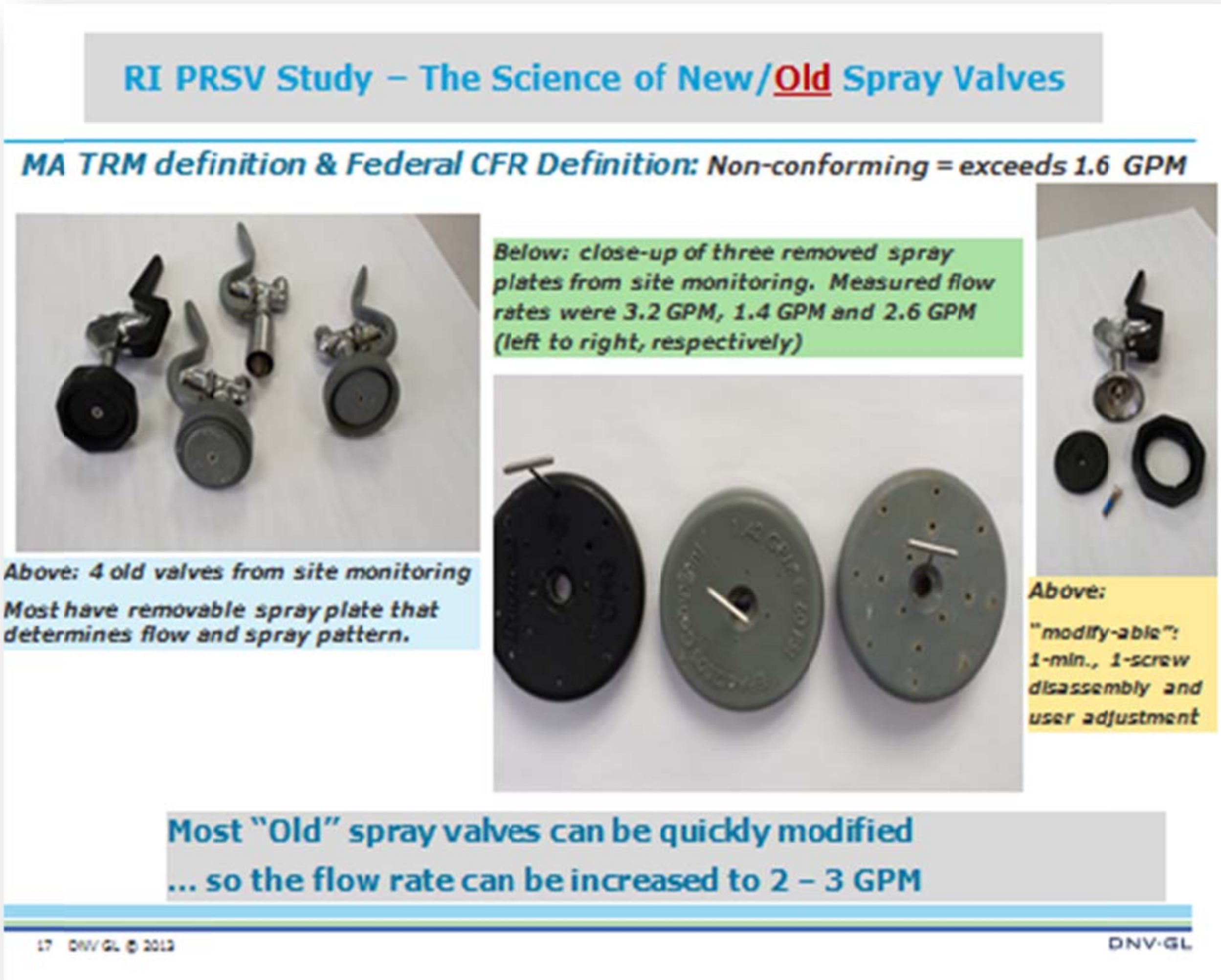
All Monitored Sites Sample Results:	
Average annual savings of 39 calculated pre-post site monitoired spray valves	114 Therms
Existing MA TRM Value	126 Therms
Statistical precision/confidence	
Z-Value (80%)	1.28
Student-T value	1.303
Sample Standard Deviation	190.7
Mean	114.3
Upper Confidence Interval	153.2
Coefficient of Variation	1.67
Lower Confidence Interval	75.4
Standard Error - Sample	38.9
Relative Precision	34.0%
Required sample for 20% Precision	115.0

In all cases the new valve installed by the direct installation contractor as part of the program is the Fisher Manufacturing Inc. Ultra-Spray Model #2949 that has an engineered flow rate of 1.15 GPM at 60 psig. The average of all new spray valves measured via onsite “bucket testing” flow rate was 1.12 GPM. All of the new program default Fisher Ultra-Spray valves were tested by evaluators in relatively brand new condition having been newly installed within a few weeks of the first site visit. The National Grid Rhode Island Fisher Ultra-Spray valve (in middle with blue nozzle) is shown in between two other high efficiency low-flow spray valve models in Figure 5 below.

Figure 5: "New" High Efficiency Spray Valves

The average old spray valve measured via the same "bucket testing" method during the second and third site visits was 2.14 GPM making it just less than twice the flow rate of the new valves. A wide variety of old valves were encountered ranging in age, type and manufacturer. At least five different manufacturer brands were identified.

Figure 6: "Old" Spray Valves Replaced by Program



The average low-flow new spray valve duration of "on-time" was only slightly longer than the old valve. However , the difference of time duration is less than 1% (0.68%) longer when expressed as a percentage which is a very slight time duration difference when the average flow rate of old valve is 191% that of the new valves (2.14 GPM vs. 1.12 GPM). The high efficiency spray valves which focus a high pressure water stream are more effective at cleaning using approximately half the water flow in only very slightly longer period of time.

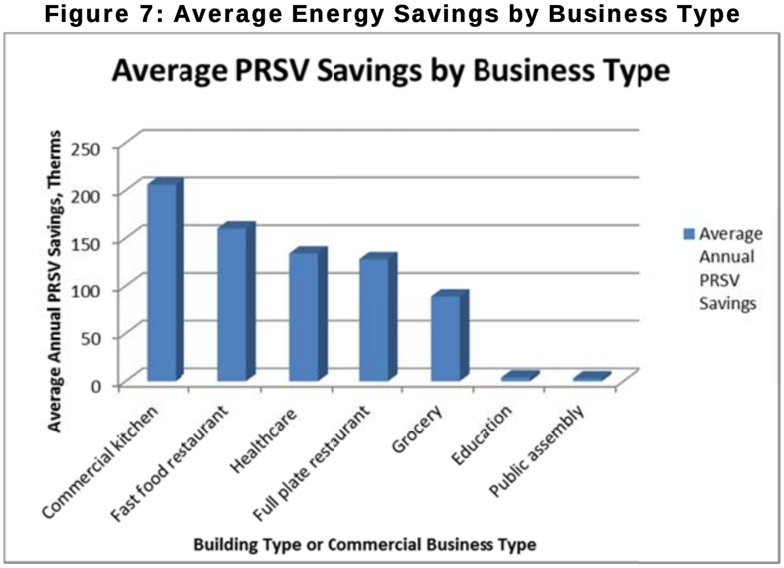
The calculated annual water savings from the 23 National Grid sample frame pre-rinse spray valves involved in site monitoring was 130,390 gallons. The average calculated water savings per spray valve change-out is 5,669 gallons. The average water savings for the "pooled" results of all 39 total site monitored spray valves was 249,983 gallons representing an average of 6,410 gallons per valve change-out. This is the direct fresh water savings only. There is also a similar associated wastewater savings.

During the recruiting process for site monitoring there was ongoing attention to the type of facilities where in-line water meters were being installed. While a perfect match to the 2012 population was limited in that site monitoring had to be done based upon recruiting success working with sites where valve change outs occurred in the first four months of 2014. Table 20 and Figure 7 show the average spray valve energy savings based on the business or building type.

Table 20: Energy Savings By Business Type

Building Type	Average Annual PRSV Savings	Percent of Sample
Commercial kitchen	206	13
Fast food restaurant	160	10
Healthcare	134	21
Full plate restaurant	128	39
Grocery	89	8
Education	4	3
Public assembly	3	8

Figure 7: Average Energy Savings by Business Type



6.2 On-site PRSV Survey Results

An eight question survey instrument was administered to pre-rinse spray valve operators/owners during the onsite visits with the best available individual at each site. The on-site survey focused on distilling the important perspectives of the spray valve users and owners of the facilities involved in the site monitoring to gather more information on pre-rinse spray valve use. The survey responses highlight several interesting items and also helps identify the perspectives of the user. The administration of the survey was attempted at all of 36 sites and resulted in 32 responses.

The majority of sites had only one spray valve versus multiple spray valves. There were two sites that had three and four (respectively) spray valves in the establishment. Review of 2012 Rhode Island Program data showed that for large chain grocery stores the count of spray valves ranged as high as between 8 – 15. Installations at large grocery stores did not occur as frequently during 2014 as 2012 so this type of facility was limited for site monitoring in this evaluation. Spray valve use was found to be almost all for dish and pot cleaning. In a few instances the spray valve was used for food washing in addition to dish washing. There was one instance of a spray valve that was not part of the change-out program which had a very high flow (low pressure) wash nozzle on it that was used exclusively for food washing. **Error! Reference source not found.**, Table 21, Table 22 and Figure 8 provide information on spray valve use and the number of spray valves per site.

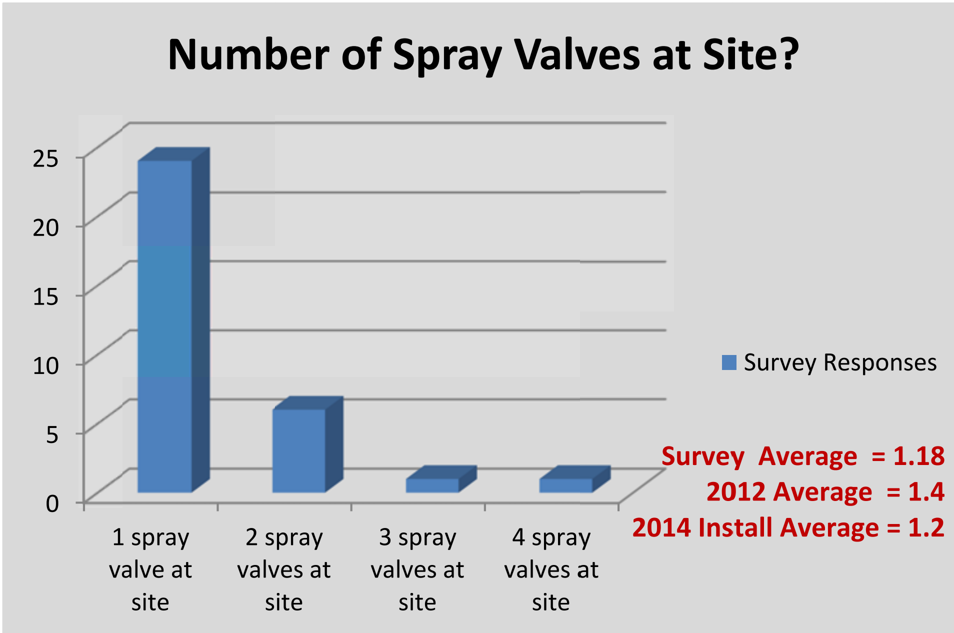
Table 21: Spray Valve Use?

Spray Valve Use?	Sites
(1) dish / pot cleaning	33
(2) edible food washing	0*
(3) both	3
(4) other (cleaning machines)	1
* not preferred for washing	

Table 22: How Many Spray Valves at this Site?

How many spray valves at this site?	Survey Responses
1 spray valve at site	24
2 spray valves at site	6
3 spray valves at site	1
4 spray valves at site	1

Figure 8: Number of Spray Valves at Sites

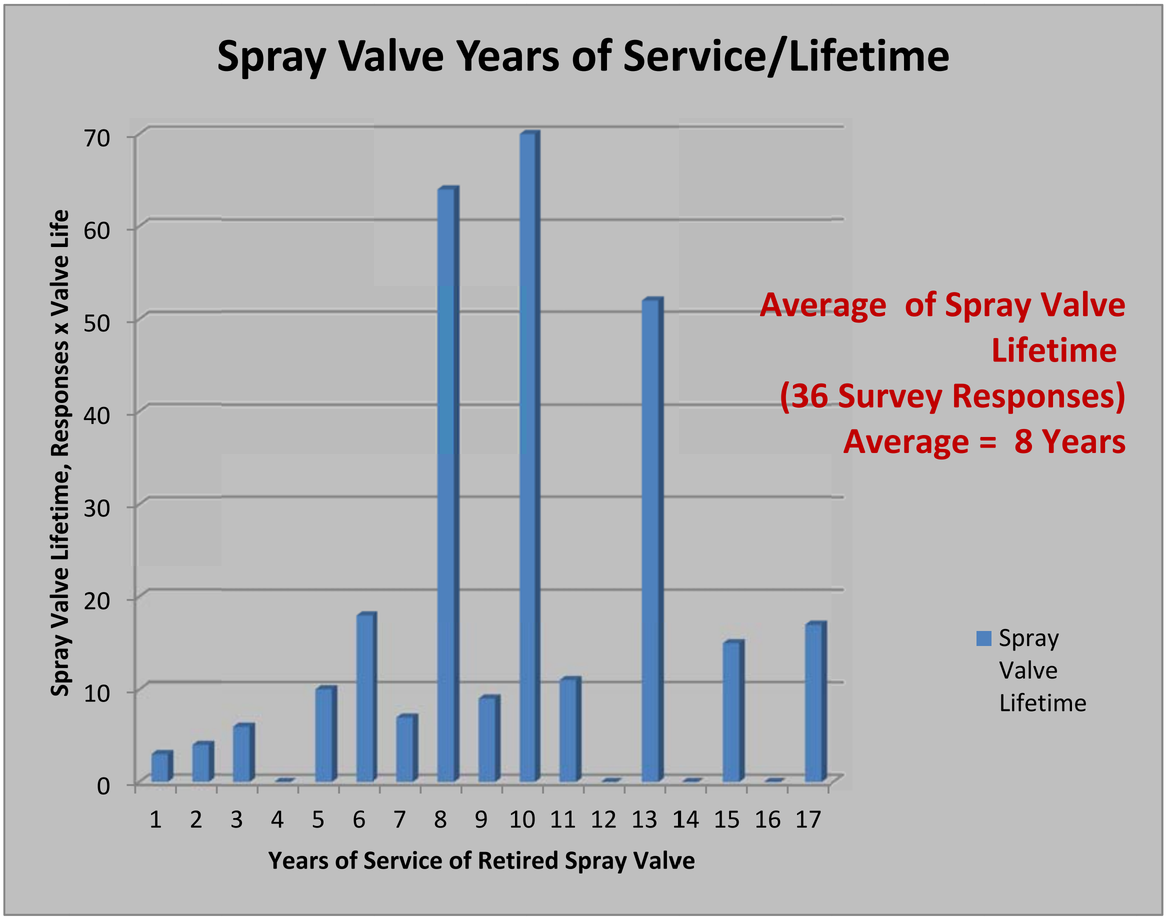


Perhaps the most revealing detail that surfaced during the on-site interviews was the responses to the question about the age of the old spray valves that were taken out of service as a result of the program change-out's that had occurred in early 2014. Responses ranged from less than one to as many as seventeen years. The number of newer vintage valves that were changed-out (replaced) as a part of the program being approximately 10 – 20% appears to align with the analytic results for small saving sites. As a "double-check" the physical inspection of the replaced valve for these specific sites shows that the old valve was a newer vintage valve with a low flow. On the other end of the spectrum for the sites that reported having old valve service life of ten or more years; physical inspection of old valves confirmed that there were some very old valves replaced as a part of the program change-outs. In some cases there were date of manufacture on the old valves but this was specific to certain manufacturers and was not there for the majority of old valves. The date of manufacture observed on some of the old valves has the additional inaccuracy of stocking/inventory time when it is used for the purpose of estimating service life but did serve to generally confirm the survey responses. Table 23 shows survey responses on the number of years that old spray valves were in service. **Error! Reference source not found.** illustrates the range of years of use for old spray valves that were taken out of service and the average lifetime of eight years based on the onsite survey responses. Discussions with spray valve manufacturers suggest validate that this is more information than they can offer and supports that the average life of spray valves in Massachusetts is eight years.

Table 23: Survey Responses - Retired Valve Lifetime

SPRAY VALVE MEASURE LIFETIME How many years was the old spray valve in service?		
Years of Service of Retired Spray Valve	Number of Responses	Spray Valve Lifetime
1	3	3
2	2	4
3	2	6
4	0	0
5	2	10
6	3	18
7	1	7
8	8	64
9	1	9
10	7	70
11	1	11
12	0	0
13	4	52
14	0	0
15	1	15
16	0	0
17	1	17
Unknown	8	0
Total	**44**	**286**
Average Spray Valve Lifetime of 36 Survey Responses		8

Figure 9: Spray Valve Lifetime



Since the site monitoring captured analytics about the number of on/off cycles that occurred for the sample of sites in the evaluation additional investigation is occurring to calculate analytically what the theoretical life before failure calculation using such values of maximum valve cycle life. Research on low flow pre-rinse spray valve life cycle leads to the EPA *Water Sense* certification requirement which is based on ASME A112.18.1/CSA B125.1-2011; Table 3, Life Cycle Test standards. The estimated useful life for new low-flow pre-rinse spray valve is 250,000 cycles[11] and is now required for *EPA Water Sense* certification ratings (EPA, 2013). Using the pooled Massachusetts and Rhode Island totals of all total 39 monitoring sites the total number of monitored on/off cycles was divided by the number of monitoring days to determine an average number of cycles per day. Using this value and the cycle life for new certified valves the theoretical lifetime calculation for new higher efficiency valves is protracted to be twenty five years as identified in Table 23.

More noteworthy from this observation than the actual lifetime value is the overall prediction that new valves that conform to the new high efficiency standards with cycle lifetime standards are expected to function longer than the an older non-conforming valves that was manufactured without the current standard.

[11] EPA. (2013, September 19). *WaterSense Specification for Commercial Pre-Rinse Spray Valves v1.0.* Retrieved September 04, 2014, from EPA: http://www.epa.gov/watersense/docs/prsv-finalspec-091913-final-508.pdf

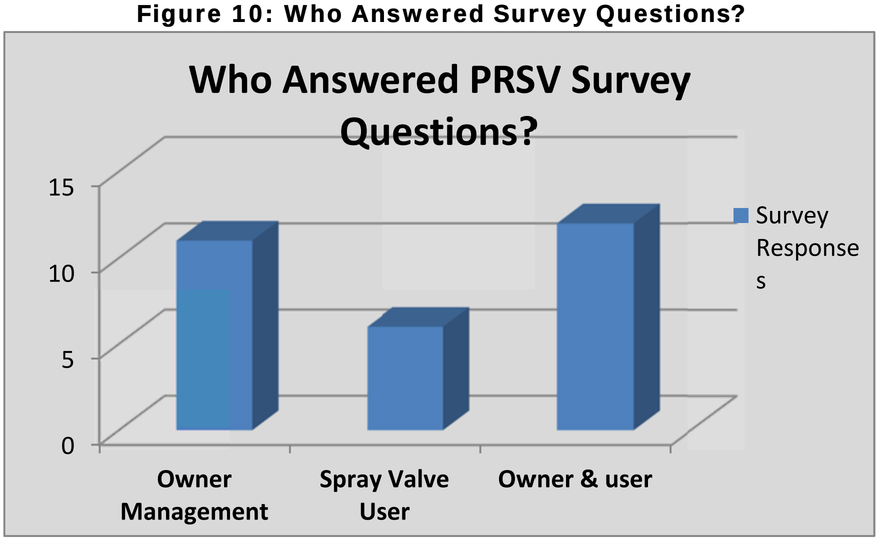
Table 24: Theoretical Lifetime of New Spray Valves Based on Cycles Specifications

Combined All Site Monitoring Results	
Total number of On/Off Cylces	77,317
Total number of Monitoring Days	2,783
Average Number of Cycles/Day	28
Lifetime Cycle Assumption (*Cite)	250,000
Lifetime Calculation Using Average Monitored Cycles/Lifetime Cycle Assumption	25 years

Another important point with regard to spray valve lifetime is that the newer higher efficiency low-flow valves such as what is being used as the default program valve in Rhode Island are less prone to clogging have more robust design mechanisms and are expected to have longer service lives than their older vintage predecessor valves being replaced by change-out programs today.

The on-site surveys was first mentioned to the individual involved with authorizing site monitoring at the site with an emphasis at knowing about the spray valve use. In most cases especially for restaurants and family businesses the facility owner was often the spray valve operator which made the interviewee choice simple. Figure 10 shows the mix of who supplied the survey responses in the survey.

Figure 10: Who Answered Survey Questions?



The remaining survey questions provide insight to the factors that are important to spray valve users and the food service management. The common focus for the majority of responses was on:

- Splashing
- Clogging
- Leaking (refers to spray valve trigger or spray plate leaking)
- Cleaning effectiveness.

The remaining four slides (Figure 11, Figure 12, Figure 13 and Figure 14**Error! Reference source not found.**) summarize survey responses. The majority of responses were appreciative of the Rhode Island spray valve change-out program and liked the performance of the new spray valve, the majority were neutral on the duration of use final question which reinforces the analytically calculated (less than 1%) of time "on" for cleaning tasks when old and new valves were compared.

Figure 11: Use of New Valve?

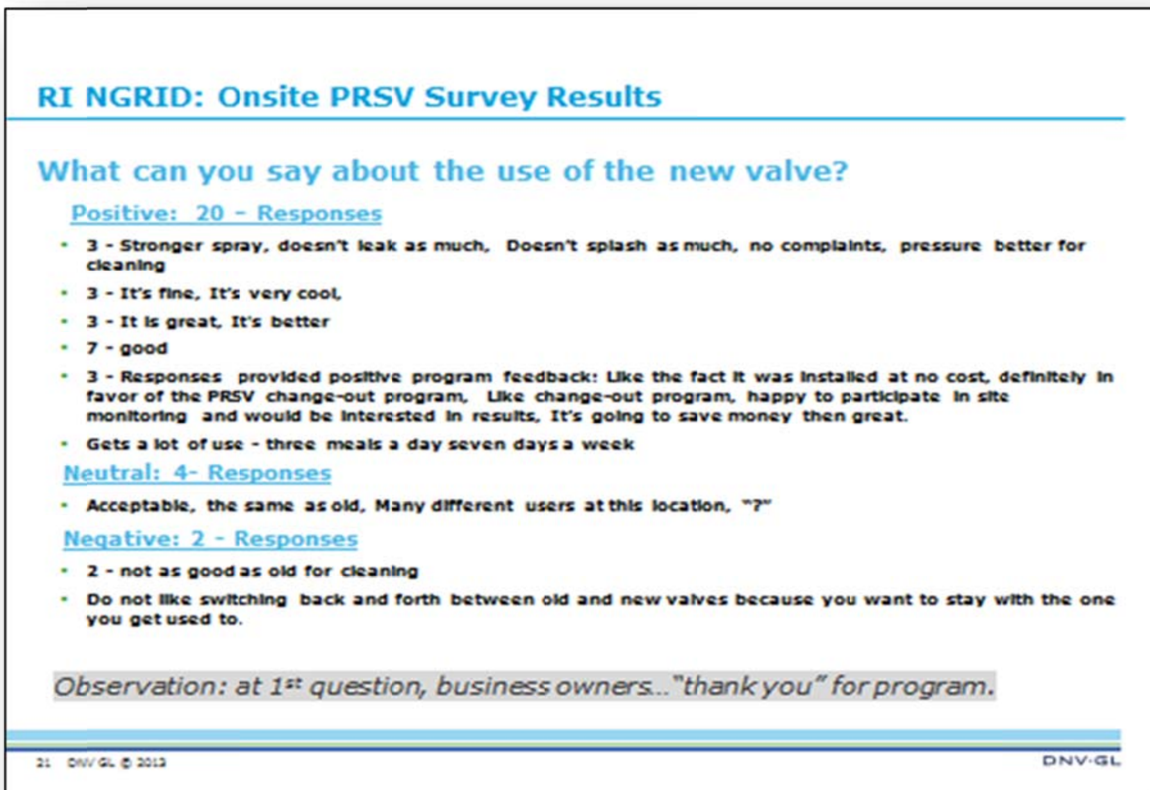


Figure 12: Do You Like the New Valve?

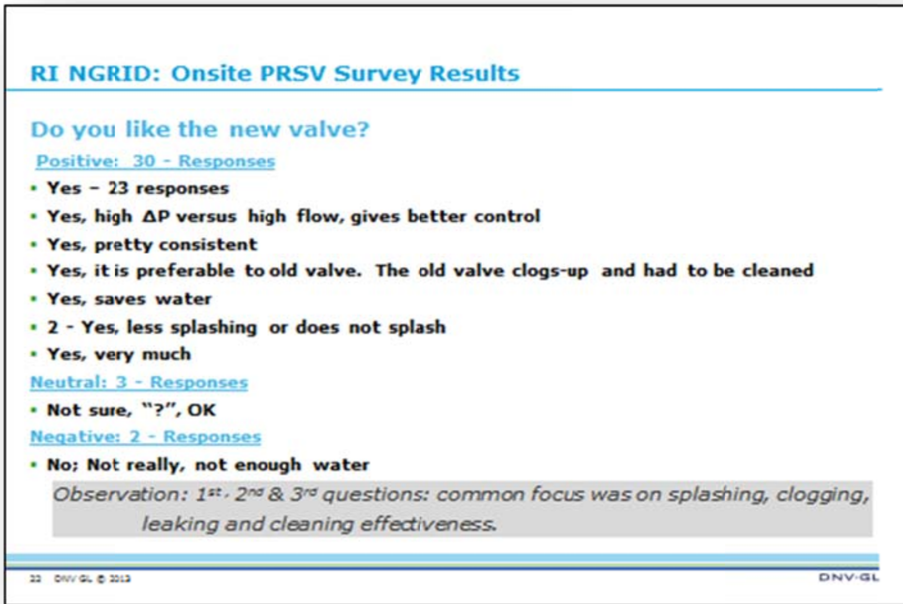


Figure 13: Old vs. New Valve Noticeable Difference?

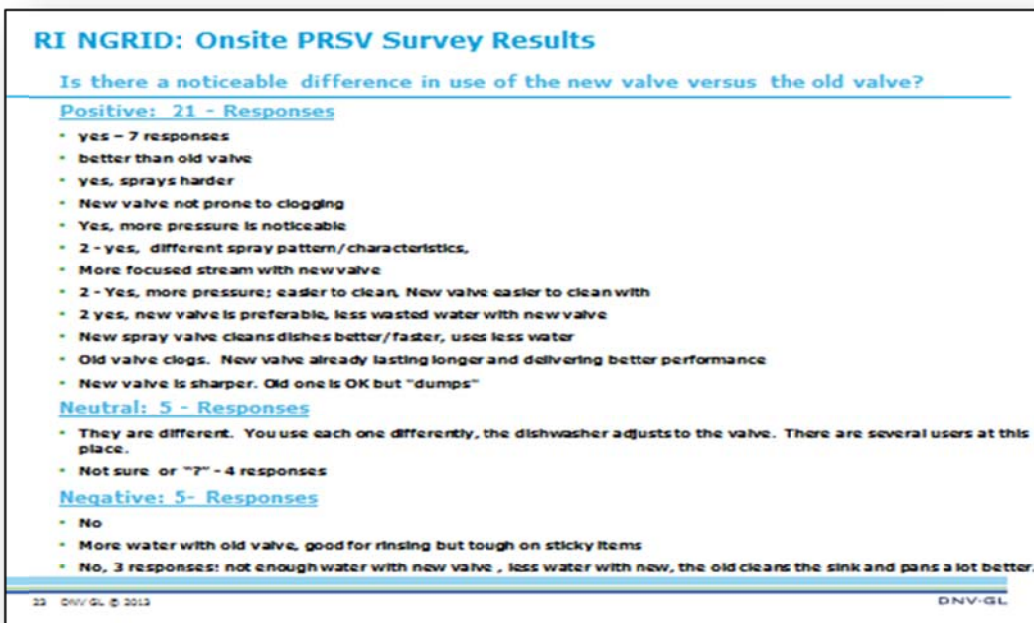
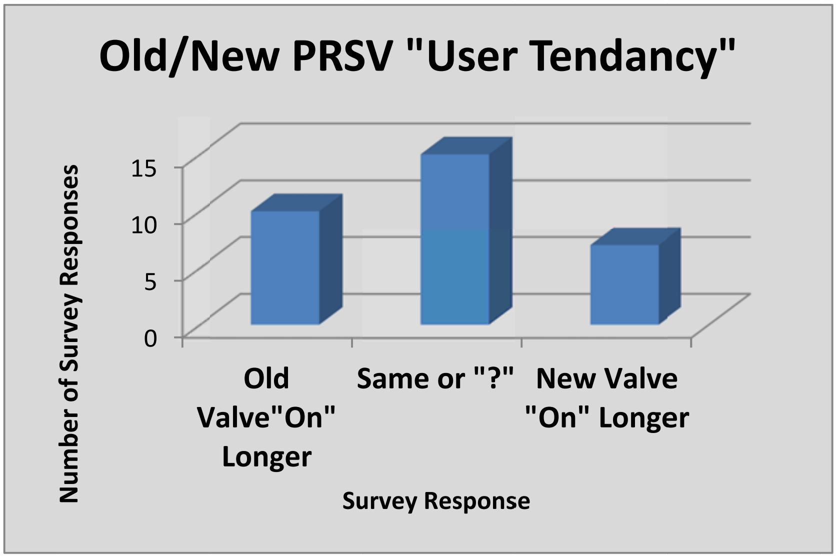


Figure 14: Do You Keep Old / New Valve "On" Longer?



7. CONCLUSIONS AND RECOMMENDATIONS

Overall, the pre-rinse spray valve program that is implemented by direct installation contractor is successfully delivering energy and water savings in Rhode Island.

The savings associated from the spray valve measure of a sample of sites monitored was calculated as 104 Therms per year. The energy calculation utilized pre and post metering done with in-line water meters measuring the true spray valve flows for both the new and old valves for a full 30 day pre and post monitoring period. The average calculated water savings per spray valve change-out is 5,669 gallons. This is the direct fresh water savings only. There is also a similar associated wastewater savings.

Survey responses from interviews conducted with spray valve users and facility owners during the site monitoring were positive for the change-out program as were opinions toward the performance of the new high efficiency valves. A wide variation of calculated savings stems from dissimilarity in dish/pot washing within the food service population of the commercial sector. The sample frame of this Rhode Island evaluation included healthcare, education, grocery, both full-plate restaurants and fast food restaurants, commercial kitchens and community assembly facilities that was representative of the program population. The calculated energy savings represented a wider range of values than what was reported in other studies that did site monitoring on restaurants only. The relative precision of 48% for the RI sample suggests the adoption of aggregated average savings values of all monitored sites since the delivery and populations are similar for National Grid in Rhode Island and Massachusetts.

The combined results of all site monitoring, data analysis, fieldwork and observations of the retired spray valves collected in the evaluation can be combined with the results of the onsite survey to lead to a better understanding of pre-rinse spray valves:

The following are some conclusions and recommendations for the program, and future evaluations of the program.

8. DEEMED SAVINGS VALUE ADJUSTMENT: THE RECOMMENDATION IS TO UTILIZE THE AVERAGE CALCULATED ANNUAL SAVINGS OF 114 THERMS (PER PRE-RINSE SPRAY VALVE). THIS AVERAGE VALUE REFLECTS 39 TOTAL SITES INVOLVED IN SITE MONITORING IN RHODE ISLAND AND MASSACHUSETTS. PRECISION AND CONFIDENCE ASSOCIATED WITH THE SAVINGS VALUE IS IMPROVED BY POOLING ALL SITE MONITORING RESULTS FOR THE LARGEST SAMPLE. THIS INITIAL EVALUATION DETERMINED THAT NO DISCERNABLE DIFFERENCES EXIST BETWEEN THE TWO STATE PROGRAM IMPLEMENTATIONS OR C&I SPRAY VALVE POPULATIONS THAT WOULD MAKE THE POOLING NOT DESIRABLE. ADDITIONAL AVERAGE CALCULATED VALUES FOR NATIONAL GRID SITES (RHODE ISLAND ONLY, NATIONAL GRID ONLY "POOLED" ARE FURTHER DETAILED IN SECTION 6:

results. The average savings/year calculated from site level monitoring conducted in the evaluation more accurately represents the program savings value for a prescriptive program spray valve change out than the corrected deemed savings value of 126 Therms currently being utilized in the 2012/2013 program data (or the existing TRM value of 336 Therms as documented).

Non Energy Impact Adjustment, Water and Wastewater Savings: The evaluation measured water savings at the site level using in-line water meters for old and new spray valves (pre-post monitoring). The average annual calculated water savings of 39 total site monitored spray valves is 6,410 gallons per spray valve change-out. The same value of 6,410 gallons is identified as the annual wastewater savings.

Spray Valve Measure Lifetime Adjustment: Three factors each contribute to the spray valve measure lifetime increase from five to eight years. First, eight years represents the average valve lifetime of 36 survey responses where retired spray valve lifetime was known. Unsure or unknown responses were not counted. Second, forensic inspection of the spray valves taken out of service confirmed that many old valves were in service for many years. Lastly, the newer higher efficiency low-flow valves such as what is being used as the default program valve in Rhode Island are less prone to clogging have more robust design mechanisms and are expected to have longer service lives than their older vintage predecessor valves being replaced by change-out programs occurring now.

Valve Clogging: The water chemistry in the Northeast region makes spray valve clogging common. Spray valve users relayed that they periodically replace or clean valves due to clogging. Negative savings was measured at two sites because the old valve was clogged to the point that it had a lower flow rate than the new valve. Survey responses confirmed that valves would be cleaned or replaced when spray valves clogged.

Program Verification: Each site visit that occurred offered site level verification of spray valve change-out program reporting. The evaluators recruiting efforts for site monitoring involved phone calls to hundreds of customers that provided more verification of program reporting was accurate.

Recommendations to Increase Savings: Results showed that a percentage of change-outs (~20%) resulted in small energy savings because of either low spray valve use at a site or old valves already having low flow rates. Solutions to address the small-savers in the program population do not seem practical and are further explained:

- No practical method can be recommended to accurately identify low use sites. A free change-out program would quickly become very complex and un-manageable if simple eligibility rules changed to make it selective to certain commercial businesses. Spray valve use remains site specific even between facility types such as healthcare, fast food and full service restaurants.
- No practical method exists to stop the easy modification of older spray valve's flow rate. Hundreds of bucket tests performed in this evaluation proved that even if a newer vintage EPACT 2005 Compliant (with flow rate <1.6 GPM) were in place at a customer site and a bucket test was performed to confirm that it's flow rate was less than 1.6 GPM there is no way to stop it from being quickly modified in the future to a higher flow rate. The existing program implementation practice of changing all valves to the high efficiency "tamper-proof" model to assure low flow operation is maintained in the future appears to be prudent administration.

Recommendation for future Market Assessment: National Grid's implementation of the spray valve program utilizing direct installation contractors has availed the change-out of 2-3,000 spray valves per year in the state resulting in substantial gas savings. Currently there are some synergies achieved by common program implementation occurring between two States and multiple program administrators. Further investigation of the state-wide inventory of spray valves and historic program data analysis will provide meaningful planning details for the remaining overall gas savings potential and feasible future strategies for this measure. The assessment can provide greater detail specific to the franchise area of a specific program administrator.

9. APPENDIX A – ON-SITE PRSV SURVEY RESPONSES

This section presents a listing of the onsite PRSV survey responses that was administered at each of the site monitoring locations to the best available individual. Two "no responses" were received from Sites: 196 and 197 and are not listed.

Site: DNV_198	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	2
How many years was the old spray valve in service?	2 year, 6 years
Who answered these questions? Owner/management or spray valve user.	management
What can you say about the use of the new valve?	Like
Do you like the new valve?	
Is there a noticeable difference in use of the new valve versus the old valve?	
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	New valve, slightly longer

Site: DNV_200	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	3
How many spray valves at this site?	4
How many years was the old spray valve in service?	8
Who answered these questions? Owner/management or spray valve user.	Owner & user
What can you say about the use of the new valve?	
Do you like the new valve?	
Is there a noticeable difference in use of the new valve versus the old valve?	
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	New valve, slightly longer

Site: DNV_015	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	1
How many years was the old spray valve in service?	5 years
Who answered these questions? Owner/management or spray valve user.	Owner/Management
What can you say about the use of the new valve?	Pretty consistent
Do you like the new valve?	Yes
Is there a noticeable difference in use of the new valve versus the old valve?	Better than old valve
Do you think you keep the old or new valve “on” longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	Old valve much longer

Site: DNV_060	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	1
How many years was the old spray valve in service?	7 years
Who answered these questions? Owner/management or spray valve user.	Owner/Management and PRSV Operator
What can you say about the use of the new valve?	New valve is acceptable
Do you like the new valve?	Yes, it is preferable to old valve. The old valve clogs-up and had to be cleaned
Is there a noticeable difference in use of the new valve versus the old valve?	New valve not prone to clogging
Do you think you keep the old or new valve “on” longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	Old valve much longer

Site: DNV_061	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	1
How many years was the old spray valve in service?	10 years
Who answered these questions? Owner/management or spray valve user.	PRSV Operator
What can you say about the use of the new valve?	Doesn't splash as much
Do you like the new valve?	Yes
Is there a noticeable difference in use of the new valve versus the old valve?	Yes
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	New valve on shorter; Old valve slightly longer

Site: DNV_066	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	1
How many years was the old spray valve in service?	11 years
Who answered these questions? Owner/management or spray valve user.	Owner/Management
What can you say about the use of the new valve?	I think it's good, I don't really wash dishes but I haven't heard any complaints
Do you like the new valve?	Yes, saves water
Is there a noticeable difference in use of the new valve versus the old valve?	Can't say
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	I would guess the same but I don't know.

Site: DNV_068	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1 4 (cleaning machines)
How many spray valves at this site?	1
How many years was the old spray valve in service?	Less than one year
Who answered these questions? Owner/management or spray valve user.	PSRV Operator
What can you say about the use of the new valve?	Haven't used it enough
Do you like the new valve?	Yes, but I haven't used it enough
Is there a noticeable difference in use of the new valve versus the old valve?	Can't tell yet
Do you think you keep the old or new valve “on” longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	Don't know.

Site: DNV_073	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	1
How many years was the old spray valve in service?	Less than one year (6 months)
Who answered these questions? Owner/management or spray valve user.	Owner/Management
What can you say about the use of the new valve?	The pressure is good
Do you like the new valve?	Not really, not enough water
Is there a noticeable difference in use of the new valve versus the old valve?	Yes, not enough water
Do you think you keep the old or new valve “on” longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	New valve longer

Site: DNV_076	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	2
How many years was the old spray valve in service?	10 years
Who answered these questions? Owner/management or spray valve user.	Owner/Management
What can you say about the use of the new valve?	It's fine
Do you like the new valve?	Yes
Is there a noticeable difference in use of the new valve versus the old valve?	Yes
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	Same. New/old the same

Site: DNV_090	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	2
How many years was the old spray valve in service?	13 years
Who answered these questions? Owner/management or spray valve user.	Management
What can you say about the use of the new valve?	Not as strong as old
Do you like the new valve?	No
Is there a noticeable difference in use of the new valve versus the old valve?	Yes, the old cleans the sink and pans a lot better.
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	Have to use the new for a long period of time to do the same amount of cleaning. New valve much longer

Site: DNV_094	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	1
How many years was the old spray valve in service?	
Who answered these questions? Owner/management or spray valve user.	PRSV Operator
What can you say about the use of the new valve?	It's good
Do you like the new valve?	Yeah
Is there a noticeable difference in use of the new valve versus the old valve?	Pressure and flow is noticeable
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	About the same. New/Old the same

Site: DNV_095	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	1
How many years was the old spray valve in service?	Language barrier
Who answered these questions? Owner/management or spray valve user.	
What can you say about the use of the new valve?	Language barrier
Do you like the new valve?	Yes
Is there a noticeable difference in use of the new valve versus the old valve?	Yes (language barrier)
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	Language barrier. New/Old the same

Site: DNV_096	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	1
How many years was the old spray valve in service?	10 years
Who answered these questions? Owner/management or spray valve user.	Owner/Management
What can you say about the use of the new valve?	It's fine
Do you like the new valve?	Yes
Is there a noticeable difference in use of the new valve versus the old valve?	Don't use it that much, not sure
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	About the same. New valve slightly longer

Site: DNV_099	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	2
How many years was the old spray valve in service?	13 years
Who answered these questions? Owner/management or spray valve user.	PRSV Operator
What can you say about the use of the new valve?	It's good
Do you like the new valve?	Yes, doesn't splash
Is there a noticeable difference in use of the new valve versus the old valve?	Yes
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	About the same. Old valve slightly longer

Site: DNV_104	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	
How many years was the old spray valve in service?	1 year
Who answered these questions? Owner/management or spray valve user.	Owner/Management
What can you say about the use of the new valve?	OK/Fine
Do you like the new valve?	Yes
Is there a noticeable difference in use of the new valve versus the old valve?	No
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	Same use. Old valve slightly longer

Date: DNV_196	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	1
How many years was the old spray valve in service?	9 years
Who answered these questions? Owner/management or spray valve user.	Owner/Management PRSV Operator
What can you say about the use of the new valve?	Gets a lot of use - three meals a day seven days a week
Do you like the new valve?	Yes
Is there a noticeable difference in use of the new valve versus the old valve?	New valve uses less water
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	New spray valve cleans dishes better/faster. Old valve slightly longer

Site: DNV_197	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	1
How many years was the old spray valve in service?	15 years
Who answered these questions? Owner/management or spray valve user.	Owner/Management PRSV Operator
What can you say about the use of the new valve?	It's good
Do you like the new valve?	Yes
Is there a noticeable difference in use of the new valve versus the old valve?	Yes, more pressure
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	Same amount. New/Old the same

Site: DNV_198	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	2
How many years was the old spray valve in service?	2 years; 6 years
Who answered these questions? Owner/management or spray valve user.	Owner/Management
What can you say about the use of the new valve?	Like change-out program, happy to participate in site monitoring and would be interested in results
Do you like the new valve?	Yes, like the new valve
Is there a noticeable difference in use of the new valve versus the old valve?	Old valve clogs. New valve already lasting longer and delivering better performance
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	Belief is that new valve saving water/ New valve slightly longer

Site: DNV_200	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	3
How many spray valves at this site?	4
How many years was the old spray valve in service?	8 years
Who answered these questions? Owner/management or spray valve user.	Owner/Management
What can you say about the use of the new valve?	It's going to save money, great
Do you like the new valve?	It's ok
Is there a noticeable difference in use of the new valve versus the old valve?	Not as much water with new
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	New valve slightly longer

Site: DNV_222	
Question(s)	**Response(s)**
Spray valve use? (1) dish/pot cleaning (2) edible food washing (3) both (4) other	1
How many spray valves at this site?	1
How many years was the old spray valve in service?	6 years
Who answered these questions? Owner/management or spray valve user.	PRSV Operator
What can you say about the use of the new valve?	It's better
Do you like the new valve?	Yes
Is there a noticeable difference in use of the new valve versus the old valve?	New valve is sharper. Old one is OK but "dumps"
Do you think you keep the old or new valve "on" longer for the same task… can you estimate the difference of time or use per task? Any comments? Old valve slightly longer Old valve much longer New/Old the same New valve slightly longer New valve much longer Do not know	About the same. New/Old the same

10. APPENDIX B - SITE LEVEL RESULTS

RI National Grid 2012 Prescriptive Gas PRSV Evaluation – SharePoint Site

https://meet.dnv.com/sites/National_Grid_RI_CI/RISprayValve/Forms/AllItems.aspx?RootFolder=%2Fsites%2FNational%5FGrid%5FRI%5FCI%2FRISprayValve%2FShared%20Documents&FolderCTID=0x012000008D30A19C517AB418469AC69A5F65D3E&View={AF2A77F4-0E8C-46A0-9E99-A50D8E973BB7}

11. APPENDIX C - SITE SUMMARIES

RI National Grid 2012 Prescriptive Gas PRSV Evaluation – SharePoint Site

https://meet.dnv.com/sites/National_Grid_RI_CI/RISprayValve/Forms/AllItems.aspx?RootFolder=%2Fsites%2FNational%5FGrid%5FRI%5FCI%2FRISprayValve%2FShared%20Documents&FolderCTID=0x01200008D30A19C517AB418469AC69A5F65D3E&View={AF2A77F4-0E8C-46A0-9E99-A50D8E973BB7}

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.