Evaluation of Energy Savings in Varying Economic Conditions

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ABSTRACT

An impact evaluation of a 2007-2008 industrial efficiency program occurred during the recent financial crisis. The industrial sector is sensitive to economic changes and entire production lines were idled in response to the declining business climate. These different operating conditions affected both the baseline and replacement equipment's operation and efficiency. As measure level savings are assessed over a lifetime of several years, the impact of unusual economic activity on savings may be magnified. The evaluation recognized the importance of disaggregating the effects of these factors on savings and developed two methods that accounted for variations in operating conditions attributed to external economic activity.

The first method utilized a difference in differences approach to disaggregate savings. Project level savings were calculated for both current and *full production* operating schedules; the difference of which distinguished savings attributed to the economic downturn. Full-production adjusted operating schedules were derived from a comprehensive review of historic production logs relative to current operating schedules. This review discounted production schedule changes associated with demand driven capacity requirements. Savings were calculated by modeling the performance of retrofit and replacement equipment during periods of "normal" production activity.

The second method mitigated variability caused by economic conditions by averaging end-use level savings over a three year period. The 2008 program savings were based on observed operating conditions during the economic turndown, but the influence of the economy on program performance is normalized by accounting for prior year program savings.

Study overview

The Energy Trust of Oregon (Energy Trust) provides incentives to customers of investor-owned utilities (IOUs) in Oregon that install qualifying energy efficient equipment and upgrades. Navigant Consulting performed Impact Evaluations of the Energy Trust Production Efficiency Program (PEP) for the 2007 and 2008 program cycles. Qualifying measures offered through the PEP include efficient lighting, motors, air compressors and process equipment.

Electric demand within Oregon's industrial sector fell sharply during the recent recession. Site level capacity requirements and production schedules were adjusted downwards to reflect this change in the market climate. In response to these changes, both the capacity and efficiency of equipment installed through the PEP differed significantly from the assumptions used to estimate *ex ante* project savings.

The forest products industry is a case in point. The recession was responsible for a number of factors affecting demand for forest products, and these recessionary effects overlie long-term trends. Paper production represents a large portion of the forest products industry. The long-term decline in printed document circulation has exposed excess capacity in pulp and paper mills and many of those mills in Energy Trust's service territory have been shuttered or operate at reduced capacity. The effects of the recession compound the long-term decline in paper production. Similarly, the collapse of the housing market resulted in fewer homes being built and less timber milled for construction. Finally, the decline in consumer spending also manifests in the forests products industry. For example, the demand for cardboard packaging, a staple product of this industry, parallels the reduction in demand for those

consumer products requiring packaging. Other industries have faced similar affects on production and operations.

In evaluating the 2007 Production Efficiency Program (PEP), Navigant Consulting[1] identified the number of site closures and project decommissionings in the analysis sample, but did not systematically account for the differences in the production levels' pre- and post-installation estimates as this was not within the scope of the study. This phenomenon was especially prevalent in the wood products industries, which make up much of the industrial base in rural Oregon, but was also the case with other industries. During the 2008 PEP evaluation, Navigant and Energy Trust agreed to estimate savings under the conditions observed during the recession and under more typical economic conditions. Where the production differences significantly influenced project savings, Navigant compared the two savings estimates and reported both within the evaluation.

Adjusting for output

During the timeframe of the evaluations, a number of projects had been permanently removed, but others were only temporarily shut down or reduced in operation. The evaluation research took place during 2008 and 2009 and included projects installed in both 2007 and 2008. Most projects had been in operation between one and two years at the time of the evaluation research. While impact evaluations provide a more accurate assessment of the long term savings of energy efficiency projects than *ex-ante* estimates, they still provide only a snapshot in time of system performance and operating conditions. Since many efficiency measures and opportunities in the industrial sector have expected useful lives (EULs) in excess of 10 years, it is expected that individual installations will have varying annual savings over the equipment lifetime. With the recent downturn many businesses experienced temporarily idled production areas, but still planned on recovering this excess capacity when business conditions improved. Conversely, once a site or process was completely shut down (e.g.: sold or reconfigured), savings were deemed irrecoverable.

Process Improvements

During 2007, one project had an exceptionally large scope of *ex ante* savings. This project increased the production capacity of a recycled paper process by upgrading the de-ink line. The plant had the ability to produce paper from both virgin pulp, using thermomechanical pulp (TMP) lines, and recycled paper, using a de-ink production line. De-ink production uses significantly less energy than TMP, and shifting production in its favor can substantially reduce power use at the facility. Since the facility has submetering of energy use for each line and keeps detailed production records, the energy use of lines was easily normalized to production. The project plan included shutting down one of their TMP lines completely and using de-ink processes to substitute for the TMP capacity.

Figure 1 shows the production of paper at the facility. All values have been normalized to baseline total production or energy use to protect customer confidentiality. Prior to the project, the facility produced an average of 39.9% TMP and 60.1% de-ink pulp per day. The original project plan assumed that de-ink pulp production would increase to 67.7% of baseline production after the upgrade. De-ink production varied both before and after the project. Before the upgrade, this variation was partly due to capacity limitations at the recycling center and partly due to limitations in the de-ink production line. The project encompassed removing both of those limitations, although the de-ink production line upgrade provided the energy savings.

[1] Navigant consulting acquired Summit Blue Consulting in December 2009. The 2007 PEP evaluation was prepared by the same team working as Summit Blue Consulting at the time.

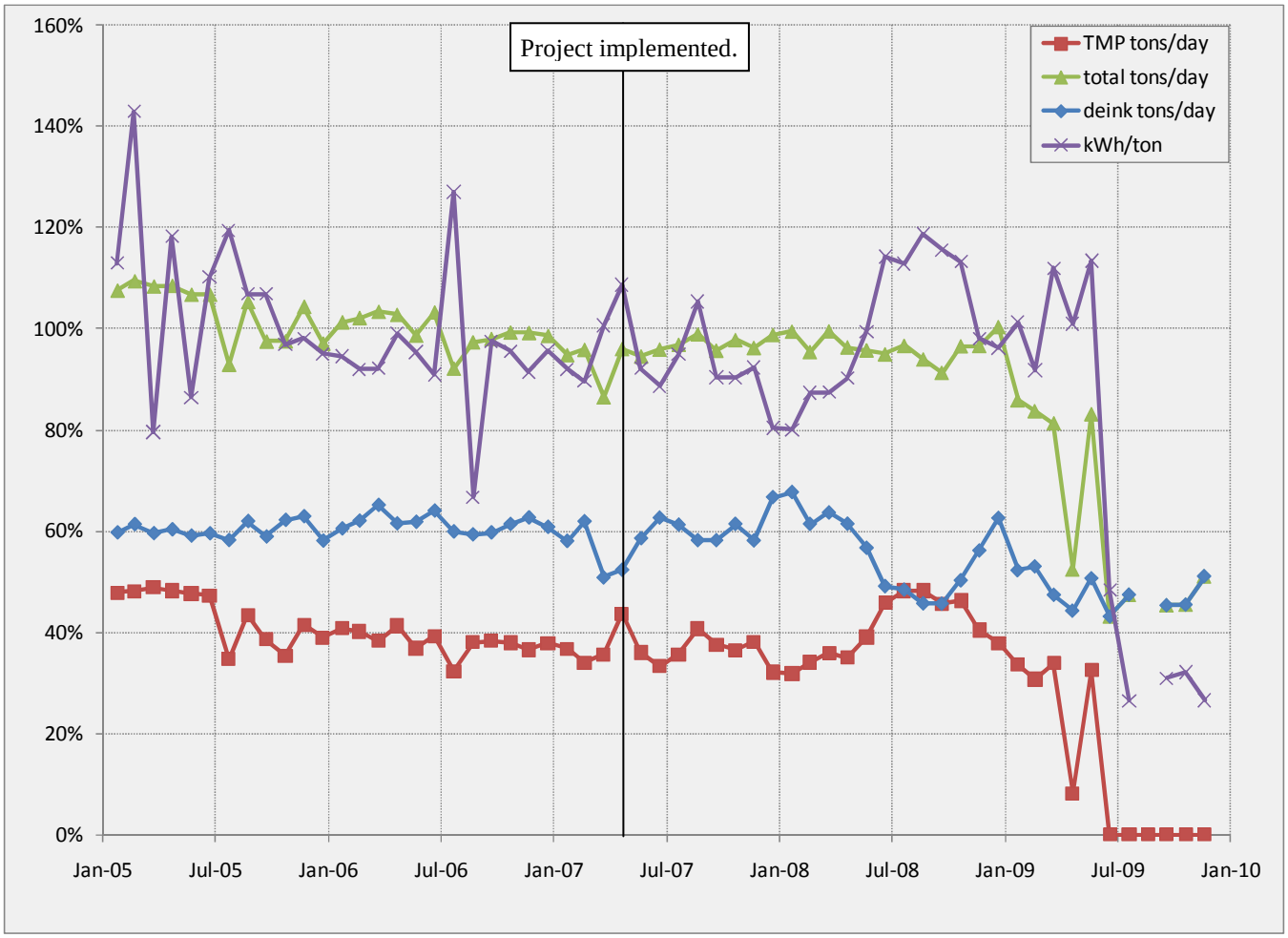

Figure 1. Paper Production[2,3]

Figure 1 shows production since 2005. A gradual decrease in production has been taking place over the long term, as is the case with many wood products in general. Occasional productions peaks were not sustained and do not alter the baseline average production. Table 1 shows the average deink and TMP production 2005 through June 1, 2007, the period used to determine baseline operation without the project. Based on historical data showing a slight decrease in overall production even prior to the downturn, total pulp production of around 95% of the original baseline is expected to resume after the downturn.

[2] source: customer production and submeter records
[3] Production values removed for reasons of customer confidentiality.

Table 1. Pulp production and energy use by process line[4,5]

	Deink		TMP	
Dates	**Pulp Production (% of baseline)**	**Normalized Energy Use**	**Pulp Production (% of baseline)**	**Normalized Energy Use**
2005	60.2%	22.6%	43.2%	224%
2006	61.5%	21.4%	38.2%	214%
2007 (through 6/1)	57.2%	22.7%	36.8%	209%
Baseline average	**60.1%**	**22.0%**	**39.9%**	**217%**
6/07-11/07	59.6%	25.3%	37.6%	204%
12/07-1/08	67.2%	22.4%	32.0%	202%
2/08-12/08	54.5%	26.4%	41.6%	204%
2009	48.9%	29.4%	13.7%	221%
Post-install average	**55.2%**	**26.4%**	**32.8%**	**206%**

The project plan expected that deink production would increase to 67.7% of baseline pulp production, a value only seen briefly at the beginning of 2008. While this does show that the equipment is operating as expected, the data also show that this is not the current production volume. In the two high production months of December 2007 and January 2008, the de-ink process demonstrated its superior energy efficiency and used an average of 22.4% of baseline paper production energy to produce 67.2% of baseline pulp. At the same time the TMP production dropped to 32.0% of total baseline without a significant change in kWh/ton. If these two months were the long term operating conditions, the project would meet or exceed planned energy savings of 22.5% of annual facility electric usage. However, production conditions changed.

Based on more recent production data gathered during the evaluation, it did not appear that the facility would operate at peak de-ink production over the equipment lifetime, particularly because of the economic downturn and the variability of the recycled paper market. Instead, normal production conditions were taken to be the average of post installation data excluding the portion during which TMP line 2 was operating. Under these conditions, de-ink production averaged 60.4% of baseline (essentially the same as the 60.1% before the project) out of a total of 96.8% of total baseline production. This assessment reduced the baseline consumption by approximately 5.5% – a 24% realization rate.

The extreme downturn in production during 2009 resulted in shutdowns of all lines for much of the year. Through November 2009, the facility had operated only 186.5 days, compared to 332 days typically seen in the first eleven months of a *typical* year. As such, the economy adjusted savings were negligible since the original de-ink capacity would easily have been able to support even the heaviest production during the evaluation timeframe.

[4] source: customer production and submeter records

[5] Production percentages are presented as portions of average baseline, so only the baseline totals are 100%. Energy use is presented as a percentage of average baseline use for paper production at the facility and is normalized per ton of paper produced.

In addition to the current low production, the facility ramped up TMP in favor of de-ink production between May and the end of 2008 because of reduced availability, and subsequent higher price, of recycled paper. During the second half of 2008 TMP line 2 was back in use, in contrast to the *ex ante* expectation that it would only be used as backup. Since the paper market is highly volatile, it is to be expected that this could happen in the future as well. Data from installation through January 2009 revealed an average deink production standard of 57.1% of baseline pulp production. TMP production during this period averaged 39.0% of baseline production. Normalizing the baseline for the adjusted operating schedule reduced the total production schedule to 96.2% of the original baseline.[6] These baseline adjustments yielded a loss of efficiency due to the reactivation of TMP line 2 coupled with the increased horsepower on the existing deink.

Taking all of these factors into account, Navigant determined that the long term savings of this project were significantly lower than expected. In particular, the highly variable price of recycled paper severely affects its use in paper production. The facility is expected to continue responding to price pressures by using virgin or recycled pulp. Since TMP line 2 was not de-commissioned, we expect it will be used in the future. We assumed average production levels to estimate savings rather than maximum production, which is not typical. The lower production levels indicated only a 24% realization rate for the project. In addition, the partial use of TMP line 2 reduced the expected realization rate to only 12%.

Air Abatement

In order to comply with new federal maximum achievable control technology (MACT) regulations, a plywood facility upgraded to reduce volatile organic compound (VOC) emissions by adding a regenerative catalytic oxidizer (RCO). Prior to sending emissions to this equipment, small wood particles need to be filtered out of the air stream. The facility could have accomplished this using three older baghouses with 350 HP fans, a blower, and five exhaust fans which they already owned. Instead, the plant installed three new baghouses with 150 HP fans controlled by VFDs and eliminated the the blower and exhaust fans. All of this equipment was operating during measurement and verification for the program evaluation, but the entire plant was on a reduced schedule. Furthermore, the dust collection system was running at 83,696 acfm, significantly higher than the planned 40,000 maximum acfm. The higher flow is necessary to maintain minimum ventilation requirements in the facility. This ventilation level was not anticipated during the project plan.

Navigant considered the airflow increase to be a permanent change to the operation of the facility, which reduced savings regardless of economic conditions. However, reduced operating hours at the plant were a byproduct of the economic downturn, and were expected to be reversed in the long run. The reduced hours resulted in an energy savings realization rate of 72%, but at full production it would be 101%.

Compressed Air

Energy Trust co-funded four projects at one customer's site, comprised of multiple complementary timber products facilities. Navigant determined that three of these projects were located in buildings that had been shut down, sold and were in the process of being dismantled. It is unlikely that any of the efficient equipment installed for these three projects will ever operate or generate future savings.

[6] Navigant assumed that the ratio of deinked to TMP would have remained constant in the base case, giving 485 tons/day of TMP and 730 tons/day of deink pulp.

On the other hand, while the recession caused reduced production for products served by a fourth project, an efficient air compressor, energy savings were greater than anticipated. The part-load efficiency of the variable speed compressors is much better than the single-speed baseline machine. Figure 2 illustrates the different operating modes and relative efficiency of rotary screw compressor with different capacity modulation. When the compressor upgrade was approved, the timber products plant operated two shifts in the region labeled "A" with approximately 10% full load power savings over a baseline machine with slide-valve modulation. The remainder of the time the compressor would operate in region "C" with savings of approximately 50% of full load power. With reduced production, the plant no longer operated in the "A" region but instead saved 25% of full-load power in the "B" region during approximately 1.5 shifts of plant operation and spent more time unloaded (50% of full load savings versus the baseline machine) when there was very little demand for compressed air.

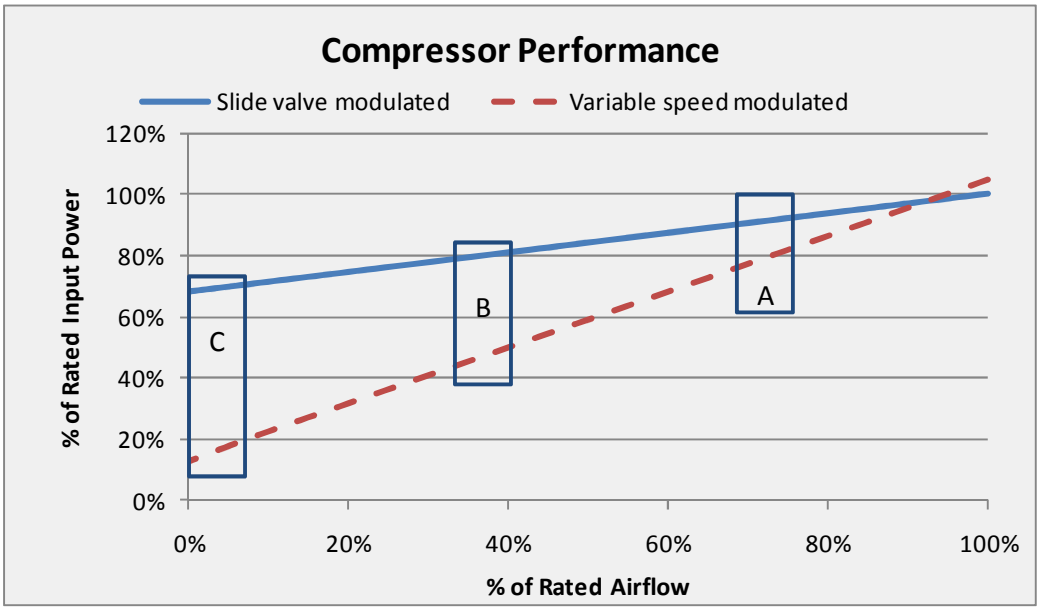

Figure 2. Illustrative Compressor Performance at Key Operating Points

The energy savings realization rate for the one remaining project is 154% at reduced production and an estimated 80% at full production, though the full site realization rate is 23% due to permanent shutdowns.

Variable Speed Fans

A lumber production facility received an incentive for installing a variable frequency drive (VFD) on the drying fan in kiln 12. All of the kilns at the facility vary in production, and have had extended idle time during the recent economic downturn.

According to facility records, kiln 12 ran a total of only 2,318 hours during the year preceding the measurement period, significantly less than the typical 6,430 hours expected in the initial study. As shown in Figure 3, there was a notable down period between October 2008 and April 2009 due to the economic downturn. This resulted in a significant reduction in savings. In addition, the baseline motor loading was significantly below what was estimated in the baseline study, resulting in dramatically decreased savings and a realization rate of only 14%. Under normal economic circumstances, the realization would have been 39% for the kiln fan VFD. These realization rates were calculated based upon production records and fan energy use metered for several weeks during the study.

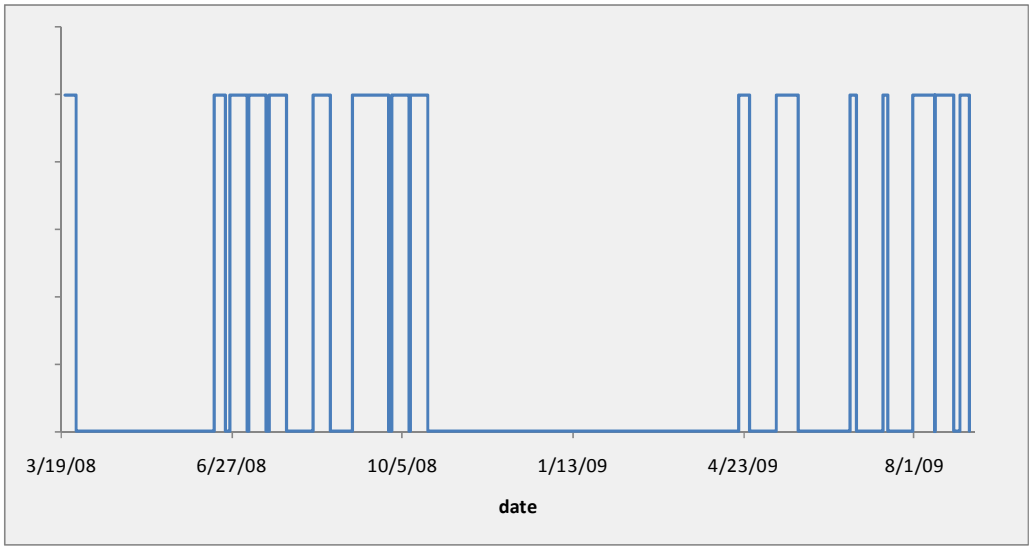

Figure 3. Kiln 12 Operation[7]

Project Comparison

The impact evaluation saw only a minimal difference between full production and recession savings for the 2008 program, decreasing the overall realization rate from 81% to 80%. However, individual projects were significantly affected. Table 2 shows the difference in savings for the projects discussed in this paper.

Table 2. Savings Comparison

Project	Ex Ante Savings kWh	Status	Ex Post Savings kWh (full production)	Ex Post Savings kWh (recession)
Deink production upgrade[8]	22.5%	Idled	5.5%	0
Air abatement	1,980,943	Reduced hours	1,993,569	1,431,280
Kiln fan VFD	80,462	Variable operation	31,648	11,409
Lighting upgrades	275,654	Plant closed	0	0
Process Improvements	3,281,320	Plant closed	0	0
Compressed Air Upgrades	585,077	Operational	468,200	906,000
Motor Replacement	3,486	Plant closed	0	0

[7] source: customer production records
[8] Paper production savings values are presented as a percentage of facility baseline energy use in order to preserve customer confidentiality.

Navigant and Energy Trust applied the adjusted realization rates to projects based on the expected long term conditions for each location. In the case of only short term economic effects, longer term data were used for the realization rate estimates. For locations with longer term impacts, but with the eventual expectation of a return to full production, the average of the full production and recession savings were applied. For sites with permanent changes to production, the current evaluated savings were used to determine the realization rate.

Averaging over multiple years

Navigant and Energy Trust recognize that economic volatility occurs periodically, and it is no more valid to choose an upcycle than a downcycle when evaluating savings. As seen with the paper production, annual values vary significantly over time. While developing a theoretical baseline to calculate project level realization rates under normal operating conditions offset the impact of the economic malaise on program performance, Navigant and Energy Trust sought additional perspective for comparative purposes. One method designed to accomplish this objective involved aggregating program performance, by industry type, over the past three program years. This effectively normalized program performance while still accounting for the GFC's effect on the 2008 Program cycle. Table 3 shows a comparison of realization rates by measure type. The table results show an average of all evaluated projects in the program, not just those discussed in detail here. Energy Trust used these average realization rates to calculate *ex-post* savings at sites which did not receive site visits during the impact evaluation.

Table 3. Program Realization Rates for Select Measure Types

Measure Category	2006	2007	2008	Overall
Air Abatement	108%	89%	87%	99%
Compressed Air	135%	91%	106%	116%
HVAC	92%	0%	58%	69%
Lighting upgrades	91%	117%	88%	101%
Process Improvements	92%	50%	63%	65%
Pumping	72%	41%	56%	61%
Refrigeration	93%	NA	73%	86%

As shown in Table 3 the realization rates for the same type of project can vary significantly year-to-year. By averaging evaluated projects over three years, the effects of economic cycles on realization rates can be reduced. The results of this effort complemented the theoretical baseline approach and Navigant was confident that the results of these two evaluation strategies represented a fair compromise when assessing the Production Efficiency Program's effectiveness.

Discussion and Conclusions

Out of necessity, the merits of energy efficiency projects must judged by the best information available, which is usually current operations. Likewise, evaluations use the best available information to measure and verify savings at the time of the evaluation. Frequently operations during measurement and verification are different than when the measure was planned and/or installed. When energy efficiency measures are climate dependent the process for weather normalization is well-established,

whether by simulation, typical meteorological year data or degree days. When other factors affect operations, such as industrial production levels discussed here, the normalization process is less clear.

- What constitutes normal operations over a span of 3 years that includes pre-installation data and post installation data used in evaluations?
- What forecasts should be used for future production? Site management might have information for projected operations.
- Is there only a concern when savings is unexpectedly lower due to economic downturns or should evaluators consider the effects of a boom economy for the long-term savings of a project?
- What is the threshold we should use to claim that the economy is decreasing or increasing the energy impact of a measure?

In our examples we mostly witnessed decreased savings due to the recession of 2007-2009. Our examples are also all industrial applications, where we expect that economic effects will be greatest as production levels continually adjusts to demand. Navigant Consulting takes the position that we ought to account for economic factors when those factors are pervasive and can be documented, but that adjustments should be transparent and follow commonsense without being overly complex.

Documentation of production levels is key, no matter the direction of production changes. To this end, Navigant advocates that projects with high savings risk, due to factors not readily predictable (non-weather or annual-cyclical), ought to have supporting data to show historic and projected production in the application and implementation phase. These data can be confirmed and updated during measurement and verification to get the best estimate of project savings for program evaluation.