Do Your Homework!
Designing an Effective Industrial Efficiency Program around What's *Really* Going on in the Marketplace

John McMurry, Vermont Energy Investment Corporation (Efficiency Vermont)

ABSTRACT

Creating effective efficiency initiatives for industrial facilities and processes cannot take place without market research that aligns prospective initiatives with product development peaks, consumer appetite, and acceptance by regulators. All effective commercial and industrial efficiency program models have these as their basic tenets. But what do the details look like? What if an efficiency program is trying to fulfill a market transformation strategy for a single, durable, and sustainable family of technologies? And what it those technologies have been engineered to achieve a high degree of energy savings—especially in a market constrained by external conditions no one can control? And how did an efficiency utility overcome a decade of regulatory friction that revolved around these uncontrollable external conditions?

This paper presents a case study that discusses—and shows the data for—the strategic breakdown of regulatory, technological, and customer barriers that allowed the roll-out of an unprecedented program that permeated the snow making market with high-efficiency snow guns. In Vermont alone, ski areas saved over $2 million in annual energy costs. The ambitious initiative also had subsidiary effects in the rest of the Northeast's ski areas, swiftly transforming the snow gun market there, and setting a precedent for the rest of the winter recreation market in the United States. This paper explores the history, the challenges, the quantitative and qualitative solutions, and their data-driven impacts on market transformation in the snowmaking industry.

Introduction

Snowmaking is an energy-intensive, compressed-air industrial process, and a necessary process for assuring a strong tourist season at the nation's 430 ski areas. It is therefore a critically important business investment, requiring well-informed decision making. In regions where energy efficiency is regulated, claiming accurate energy savings from snowmaking efficiency measures has been a perennial struggle, because it has been difficult to prove with sufficient accuracy the extent to which and how operators use efficient snowmaking systems—even with new generations of progressively more efficient equipment.

The basis for the predicted energy savings is relatively sound, since new technologies unquestionably use less compressed air than their replacements. However, the variables that affect these savings are difficult to quantify and thus very difficult for regulators to accept. Temperature, precipitation, humidity, timing, operations, and equipment infrastructure changes all significantly affect snowmaking energy use. Together, each factor can swing energy savings by an order of magnitude, per installation project. In one case, an Efficiency Vermont team saw a 24% difference in energy savings in one project in which the only factor that changed was monthly operations. That is, all factors—including the most controllable one, how operators choose to use the equipment—can significantly affect how much the equipment is in use.

The Technology

Efficient snow guns can now reduce ski area compressed-air needs by 95%, depending on the baseline. This impressive result is due to well-engineered designs that provide precise air and water flows that optimize mixing ratios. Low-energy snow guns take efficiency a step further and use compressed air only to create a nucleate, a small ice particle that becomes a "seed" for a snowflake. Pressurized water—a different technology—then forces the nucleate away from the snow gun while atomized water clings to its circumference and freezes, creating a snowflake.

Prior to this low-energy option, older snow gun technologies (top left and bottom right of Figure 1) were typically extruded cast aluminum bulbs. These bulbs contained compressed air that frothed the water, forcing it to exit through drilled holes in the mixing chamber. This older technology typically produced good-quality snow, but it relied heavily on the power of compressed air. Understandably, this snowmaking method created high energy costs.

ASC Sunday River

Snow Logic Tripod

HKD SV-14

K2000

Figure 1. Various types of snow gun technologies in use.

Performance in the Marketplace

As with most new technologies, particularly in industrial settings, efficient snow guns were slow to be adopted. Early efficient models had difficulty creating snow in warm temperatures, thus limiting their use on many ski area trails. They also required significantly more maintenance. They used nozzles, gaskets, and O-rings that could not be as easily maintained under ice-up conditions as could internal-mix snow guns like the bulb-style technologies that might be hammered or heated with a torch—a typical routine field maintenance approach on internal-mix snow guns. Early efficient snow guns were also much more likely to freeze, necessitating more maintenance. Due to their design, more efficient technologies were more susceptible to environmental changes. A gust or other change in wind conditions could drive nucleates back into the face of the snow gun, preventing snowflakes from forming and being projected into the air. If the water could not attach either to the nucleates or escape from the snow gun into the air, water would then freeze in the gun, and all subsequent water would collect in place, creating a beard of ice on the snow gun. If left unmonitored, the water chamber could freeze solid and create hazardous water line freezing back to the main line.

Figure 2. Unexpelled water creates ice build-up and reduces the efficacy of early energy-efficient snow guns. *Source:* VEIC 2014.

Even with these problems, ski areas recognized that the potential for energy savings—and thus for cost savings from lower energy use—was substantial. But because maintenance costs increased from use of this equipment, ski areas were reluctant to embrace efficient snow guns. Ski area operators could not justify the business case for investing in this equipment, because of the risk of lost revenue from delaying the opening of terrain early in the season. Consequently, business as usual—using the older technologies to produce snow—was essentially the cost of doing business.

It was no secret in the industry that early adopters of the technology were not seeing their financial return on these investments. Even when these products were working as advertised, ski areas did not notice any savings in their monthly bills. Because ski areas typically purchase small quantities of new snow guns to try them out, any energy savings accruing from the new equipment can easily be hidden by uncontrollable external factors, the largest and most variable of which is weather. The invisible (or buried) savings led to distrust of vendors' and / or manufacturers' energy efficiency claims. Such perceptions led to easy conclusions that the new

technologies were of little benefit to ski area business. Thus, as newer technologies entered the market, they faced widespread resistance among ski area operators.

The EM&V Factor: Quantifying Energy Efficiency in Well-Regulated Efficiency Programs

A regulator's ability to assure consumers that energy savings from an efficiency program are verifiable rests with good data. Good data in turn, are a function of testable conditions with well-understood factors. Snowmaking traditionally has eluded both the ability to obtain good data and to test equipment use under assumed conditions.

Weather, temperature, line leaks, and operations practices all have significant effects on energy savings, and each variable can change—each season. The volatile external conditions make energy savings predictions difficult. Thus, regulators and efficiency programs seek qualitative inputs to determine how ski areas will use the equipment. In Vermont, which has many prominent ski areas, the nation's longest-running statewide efficiency program, and very experienced regulators, savings verification on the several generations of efficiency snowmaking equipment has been challenging. For the past 15 years, the Vermont Public Service Department and the Efficiency Vermont administrator, the Vermont Energy Investment Corporation (VEIC), have had distinct differences of opinion about energy savings from snowmaking equipment. The Department's subcontracted savings verification analysts found it difficult to agree with VEIC on predicted and claimed savings from these technologies.

Both VEIC and the Department sought clarity to better determine energy savings, and thus agreed to ask the ski areas fixed questions that could shed light on how ski areas would use the installed snowmaking equipment. The questions made sense to Efficiency Vermont and the Department. They were, after all, about energy use and predicting energy savings. The questions made less sense to ski area operators, however, whose everyday concerns ranged across field conditions, snow depth, and other non-energy factors such as lift operations. Not having access to the kind of data that interested Efficiency Vermont and its regulators, ski area operators could provide VEIC only with their best guesses, and guesses that were often vastly different from reality.

Another regulatory problem plaguing the accurate evaluation of new snowmaking equipment was knowing which new-equipment purchases were replacements of older inefficient technologies, and which were new purchases to help increase flow capacity by covering more terrain or by being sited on new trails, for example. This is a persistent challenge for regulators of many industrial efficiency programs: agreeing on how to normalize energy savings. Another round of questions targeted this determination for snowmaking, but it didn't achieve the intended results.

Asking the Wrong Question, Getting an Ineffective Answer

For instance, if a snow gun flow rate is, on average, lower than its more efficient replacement, that replacement snow gun could be classified as having higher capacity, and the installation of new efficient equipment would fit the category of a "market opportunity." It has also been argued that due to global warming, all efficient snow gun purchases should be considered market opportunities, since they now operate well in warmer temperatures.

Many of these determinations were based on basic common sense, rather than hard facts, and were often incorrect. However, when ski areas decided to purchase new equipment, vendor

marketing would always tout that these investments would allow earlier seasonal openings from the increased capacity to make snow in warmer temperatures. These appeared to be clear market opportunities; however, the data did not support these statements.

How the Regulators and the Efficiency Program Approached the Verification Challenges

The Vermont Public Service Department and VEIC each arrived at differing savings analyses and verification of the savings claims for snowmaking equipment. Verification realization rates were, in fact, highly varied, as shown in the lack of a trending pattern in Figure 3. Together, the 9-year history reflects uncertainty and an inability to build on previous years' verification methods.

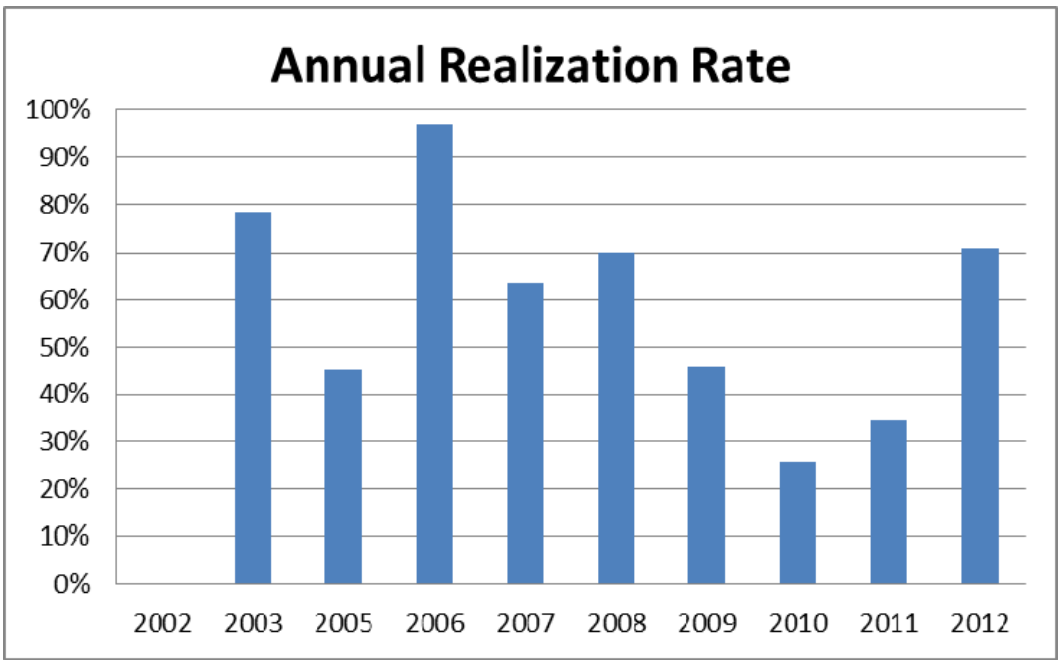

Figure 3. Annual realization of snowgun savings post-verification in Vermont. *Source*: VEIC 2015.

These challenges were exacerbated by the fact that across a 5-year period beginning in 2008, the snow gun market was evolving swiftly. Manufacturers re-engineered their snow guns, designing them to remediate many of the problems that plagued earlier models. Their performance in the field in warmer temperatures, for example, began to rival the performance of internal-mix snow guns. Strategic valves simplified operations and nozzles could be configured to adapt to the particular terrain and broad weather conditions of each ski area. Nevertheless, savings verification analysts had a difficult time in accepting the savings claims of these improving technologies during that period, as shown in Figure 3.

There Is No Substitute for Testing in the Field

VEIC began testing in the field in 2008, to verify snow gun flows under many different conditions. The engineers accumulated deep information to precisely determine performance. Armed with good data, VEIC attended the 2012 National Ski Areas Association (NSAA) Eastern Winter Conference and offered on-site snow gun performance testing of all models that were

being demonstrated at that event. This opportunity allowed manufacturers and ski area operators (that is, potential customers) to witness performance in the field. This performance testing, which has continued after that 2012 event, has had a tremendous effect on customers' perceptions. It also created some competition among manufacturers to keep pushing their designs toward better efficiency and higher performance. VEIC helped the market close the gap for manufacturer's inaccurate performance charts.

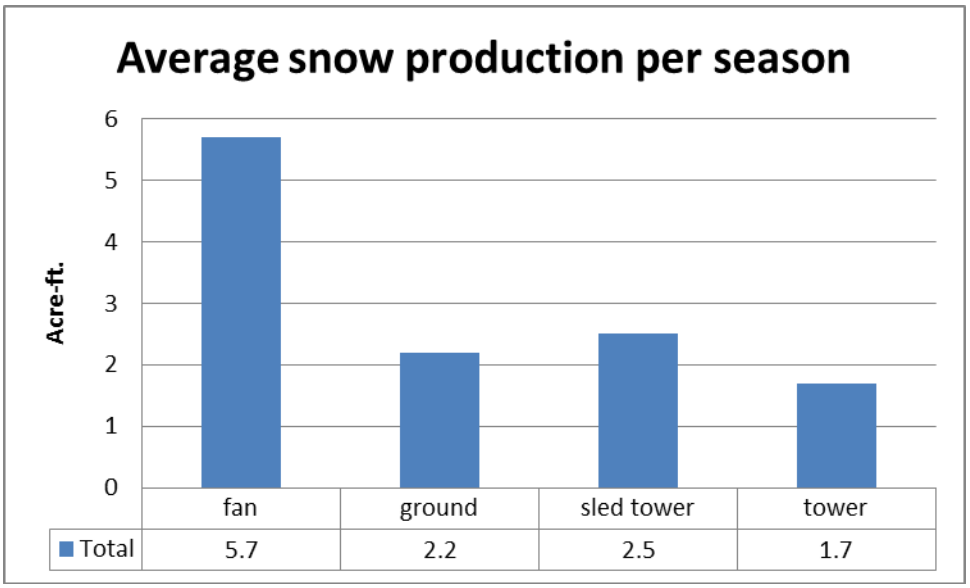

Figure 4. Snowmaking equipment types and their respective production in acre-feet.

Ski area representatives attending the NSAA meetings can now witness how well snow guns perform, back to back, under identical conditions. That is, the external variables are all common to each piece of equipment. This approach has helped the ski area operators more clearly see differences among models, and better inform their purchase decisions. As Figure 4 indicates, operators can clearly see the variations in snow production in acre-feet, per type of snowmaking technology. Further, VEIC has offered site-specific testing for customers who have wanted to test their existing snow guns, comparing them to the equipment they are considering purchasing—on their own territory. VEIC has then provided these operators with a customized energy savings analysis, thereby gaining customer trust in predicted energy and cost savings.

A Better Question Results in Better Estimates of Energy Savings

As Efficiency Vermont's administrator, VEIC identified cost-effective snow gun replacement strategies and helped offset the financial risk to ski area owners by offering incentives for new, site-appropriate, energy-efficient technologies. This strategy enabled ski areas to consider purchases that had previously been perceived as unpalatable because of the rumored risks and upfront costs.

Eyeing the potential for market transformation, VEIC collaborated with the Public Service Department to isolate the most contentious factor in the analysis of snow gun efficiency cost-effectiveness. Looking at seven years of snowmaking projects and the Department's adjustments to those savings, the VEIC – Department team determined that the highest concentration of quantifiable differences were based on snow production. The new and more

accurate question was now: How much snow could each snow gun be expected to make in a typical season? Through this research, VEIC found clear historical trends and proposed that all future snowmaking projects use pre-determined, fixed snow production values (Figure 4). VEIC then refined this metric to account for different snow gun types, and further substantiated the accuracy of the snow production values, using a subset of different data to arrive at similar results.

With snow production values agreed, typical temperatures easily verified, and VEIC's very strong database of field-tested snow gun performance, little disagreement remained between the regulator and the efficiency program administrator about the key metrics associated with predicting energy savings from new snowmaking technologies.

Transforming the Market and the Marketplace

With equipment offering more reliable performance in the field, with improved customer perceptions, and with regulatory progress toward a clear and agreeable verification method, the snowmaking market was ripe for transformation. VEIC was well positioned to roll out an aggressive snow gun incentive initiative. By 2014, VEIC had designed a special initiative that would effectively remove the vast majority of older snow gun technologies and replace them with well-tested, advanced, energy-efficient technologies and practices in the marketplace.

VEIC strived to encourage ski areas to pursue the market's most energy-efficient snow guns appropriate for their conditions. Efficiency Vermont provided aggressive incentives for the snow guns, in line with both their energy savings as well as their perceived risks as being new technologies. The organization based these incentives on air use per season, as shown in Figure 5.

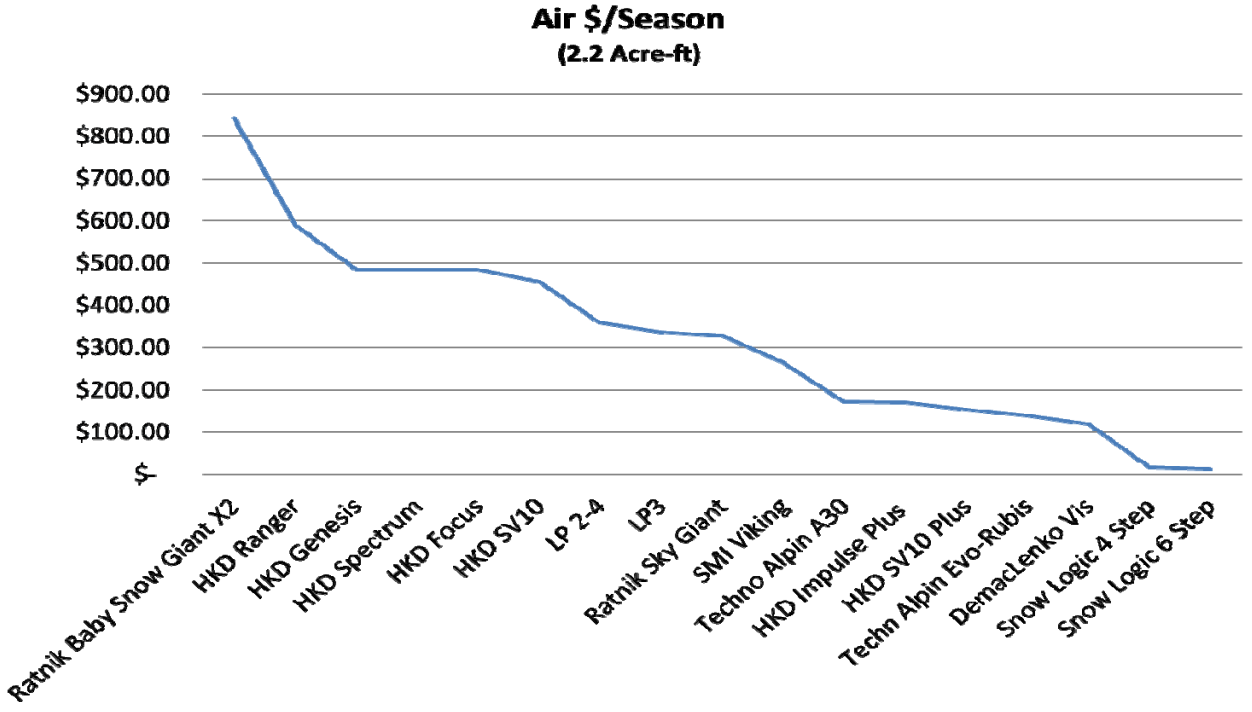

Figure 5. Typical air costs per season using energy efficient snowguns. *Source*: VEIC 2015.

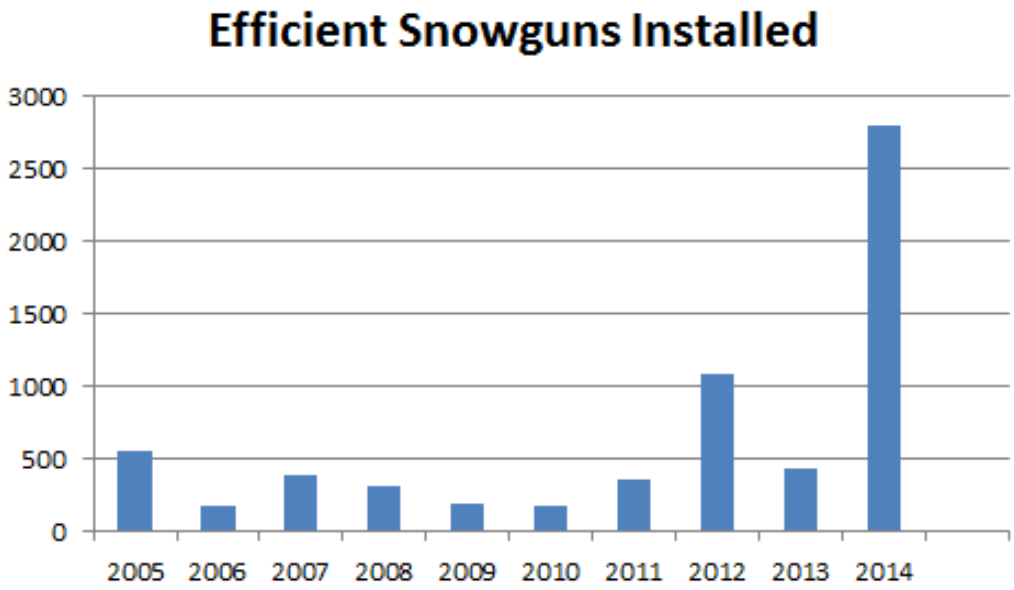

Figure 6. Efficient snow guns installed in Vermont. *Source*: Efficiency Vermont 2015.

Market transformation necessitates the removal of inefficient technologies from field use. Because snow guns have indefinite lives, it was critical that the Efficiency Vermont snow gun initiative remove the technologies it was intended to replace. Aggressive incentives kept this program requirement palatable to ski areas, while also clearly demonstrating to regulators that these projects are essentially retrofits.

Early forecasting predicted 2,000 internal-mix guns could be displaced for a combined savings of 8,000 MWh and over 200,000 gallons of diesel fuel savings. The result of VEIC's 2014 snow gun replacement initiative effectively removed 2,200 inefficient snow guns from operation (Figures 6, 7, and 8). Savings: over 12,000 MWh and over 310,000 gallons of diesel.

Figure 7. Efficient snow guns delivered next to those they replaced. *Source*: Efficiency Vermont 2014.

Figure 8. Delivery of efficient snowguns. *Source*: Efficiency Vermont 2014.

The initiative was widely recognized beyond Vermont borders and brought new snow gun technologies to light. The effect of the initiative rippled across state boundaries, which prompted Efficiency Maine, for example, to take a similar approach, as did NYSERDA, which was investigating a snow gun program of its own.

As the 2014-2015 winter season progressed, newer technologies emerged in response to the market transformation that was occurring in Vermont, and the initiative held its momentum into 2015. Customers are interested in continuing to pursue snow gun replacements, even with incentives significantly less now than those offered in 2014. The initiative had been designed to enable customers to pursue an essential technology that, despite a ragged past, was now sufficiently refined to evolve the market to a state of high efficiency. In short, the program has exceeded expectations and has been extraordinarily influential in the industry as a whole.