Drill, Baby, Drill!
Mining More Energy Savings after Twelve Years of Efficiency Measures

Josh Kelman, Vermont Energy Investment Corporation
Jim Welch, Husky Injection Molding Systems Ltd.

ABSTRACT

Efficiency Vermont, a statewide energy efficiency utility operated by the Vermont Energy Investment Corporation, and Husky Injection Molding Systems Ltd., began working together in 2001 on energy efficiency projects at Husky's manufacturing facility. Husky fabricates injection molding manifolds at its plant in Milton, Vermont, with several dozen large metal cutting machines in a temperature-controlled environment. Initially Husky and Efficiency Vermont addressed traditional efficiency measures on the building and auxiliary processes: lighting, HVAC, and compressed air. The success of these measures led to going deeper into primary processes to find more energy savings. Subsequent measures involved reducing power use to the large metal cutting machines by installing controls for turning off pumps, motors, fans, and compressed air. In addition, Efficiency Vermont and Husky investigated a plant-wide high-pressure cutting fluid system that delivers fluid directly to the cutting heads resulting in a reduction of two-thirds of the original pumping power and saving 1,400 MWh per year. Efficiency Vermont evaluated all measures with energy calculations and pre- and post-metering. Concurrent with ongoing investigations of discrete measures in all these areas, the efficiency utility has implemented a less measure-specific way to evaluate energy savings. Engineers correlated real-time collection of plant power use to proxies for plant activity. This has produced a regression model predicting power use based on level of activity. Results from this model can be compared to actual energy use and plant activity to measure power reduction from behavioral and other measures that do not lend themselves to discrete, project-based measurement.

Introduction

Husky manufactures injection molding manifolds at five facilities on three continents. The company fabricates manifolds, shown in Figure 1, from steel plate stock, involving multiple drilling, cutting, and grinding operations. Custom injection molders use the manifolds in conjunction with multi-cavity injection molds to enable accurate, repeatable cavity filling. Husky's facility in Milton, Vermont, manufactures 5,000 manifolds per year and operates 360 days per year. Forty-eight large metal-cutting machines operate in 210,000 square feet of climate controlled manufacturing floorspace. As in any competitive manufacturing environment, cost cutting projects are ongoing and energy savings projects have become the largest of these.

Efficiency Vermont (EVT) is an efficiency utility chartered by the state of Vermont to lower power usage at a cost that is lower than that to produce it. Historically it has been about ½ the cost. For significant industrial power users, such as Husky, energy consultants work directly with the facilities to develop energy savings projects. Cost and savings are analyzed and projects are funded that meet the customers' economic criteria. Often EVT contributes cash incentives to the project.

Figure1. Manifolds are manufactured from steel plates.

Husky and Efficiency Vermont have completed 36 energy efficiency projects since 2001. The energy and cost savings from these projects are shown in Figure 2, and a list of representative efficiency measures is presented in Table 1. Husky and the efficiency utility began with projects addressing building system and support operations, but over time have found savings within the primary production processes. They have conducted kaizen (continuous improvement) to identify efficiency opportunities. At their biweekly meetings, the two organizations discuss their large list of potential measures. They review significant equipment purchases for efficiency potential, and they review existing equipment and processes to identify further energy savings. The types of efficiency measures installed and under discussion have evolved from building and support measures to primary processing equipment measures, to measures whose savings are corroborated with changes to historical energy use data.

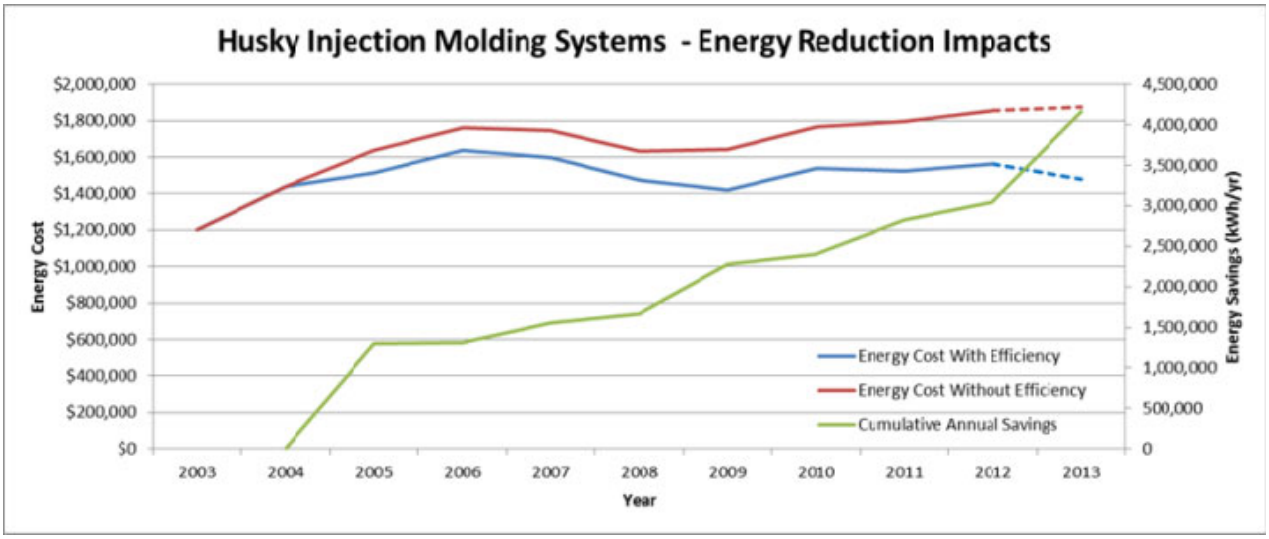

Figure2. Energy reduction impacts from efficiency, compared to likely costs had the efficiency measures not been installed.

Table 1. Summary of significant efficiency measures at Husky

Completion Date	Efficiency Measure
July 2003	Efficient motors
July 2004	Chiller upgrades
July 2004	Lighting upgrades
October 2006	Compressed air system (CAS) upgrades
March 2007	Efficient transformer
September 2007	Server consolidation
November 2007	Office computer upgrades
January 2008	Plant and office lighting
December 2008	Cooling system upgrades
December 2008	CAS leak remediation
April 2009	Chiller pumps
August 2009	Synchronous belts
September 2009	Office thermostat setback
November 2009	Skylight window film
December 2009	Low-wattage high-performance T8 installation
September 2010	Server virtualization
April 2012	Parking lot LED lighting
December 2012	CAS manifold re-piping and leak remediation
May 2013	Cutting fluid pumping use reduction
November 2013	Machine controls
August 2014	Groundwater pumps
September 2014	Air handler VFDs
November 2014	Office HVAC retro-commissioning

First Stage of Measures - Building and Auxiliary Processes

In 2001, when Efficiency Vermont and Husky began working together, the mid-1900s vintage facility did not have an energy efficiency focus and, in fact, did not track energy use. The building itself, of concrete block construction with 6-feet-high windows around much of the perimeter, houses the climate-controlled manufacturing floor (held at 70 degrees F to maintain dimensional tolerances of the steel stock) and an office area. A central chilled-water system provides climate cooling through roof-mounted air handling units. Husky also uses chilled water for process cooling. Heating comes from natural gas burners located in the air handling units. The large metal cutting machines have been served by auxiliary energy consuming processes such as chilled water, compressed air, high-pressure cutting fluid (at 450psi and 1150psi) and machine-specific exhaust fans. Plant ventilation is from the roof-mounted air handlers.

Initial savings came from such measures as high-bay T8 lighting fixtures with occupancy and daylight sensors, compressed air leak remediation, tuning chiller controls and economizers, and upgrading to high efficiency motors. These were tried-and-true measures common in many office and manufacturing facilities. The initial projects led to a search for further opportunities within the auxiliary processes. Lower power-consuming servers were installed. An audit of compressed air systems led to piping and controls measures, no-flow drains, and an in-house ongoing leak detection and remediation program. Husky then installed variable frequency drives (VFDs) on many air handler fans, and initiated a lower power consuming schedule. They also used cutters with higher Rockwell hardness numbers to reduce the time and energy for a given cutting operation. They added VFDs to chiller pumps. Synchronous belts replaced fan belts for air handler fans. Finally, Efficiency Vermont and Husky investigated the cutting fluid system, which delivers high-pressure fluid to the cutting heads during cutting operations. This process, shown in Figure 3, is a closed-loop system that involves collecting, recycling, and filtering the spent fluid. The system provided 450psi and 1150 psi fluid pumped by 12 units totaling 705 nominal HP to each machine. By lowering pressure and reducing waste, power consumption was reduced by two-thirds.

Figure 1. High-pressure metal cutter in operation.

Second Stage of Measures - Primary Processes

The large cutting machines have work tables exceeding 40 square feet and footprints exceeding 200 square feet. Husky machines the steel to tight tolerances and, in addition to carrying out the specific cutting, the operations involve auxiliary power consuming pumps, compressed air, dryers, fans, mechanical feeds, chip augurs, chilled water, cutting fluid, and chillers. Typically, actual machining takes place approximately two-thirds of the time the machines are in operation. The auxiliary processes are often not needed except during the actual machining. However, as received from the manufacturers, these processes often operate constantly. Further, Husky has a practice of idling machines, rather than shutting them off, to avoid start-up software problems. Both Husky and Efficiency Vermont have work under way to determine which auxiliary processes can be reduced or even eliminated. To date, they have reduced compressed air and exhaust fan use, turned off compressed air dryers (system-wide compressed air dryers make them redundant), and reduced cutting fluid pressure. They are currently investigating the part-specific software programming that defines each machining movement, to call for pump, chiller, and mechanical feed operations only when needed. Future work will address finding the least energy-consuming cutting operation for common machining tasks. Further, the reduction of compressed air, chiller, and cutting fluid use has eliminated additional equipment purchases for these processes to support ongoing facility expansion.

In addition to machining operations, injection manifolds require direct labor to install bolts, wire tubing, and pipe fittings. Husky has historically used compressed air hand tools to install bolts to the plates. Metering and compressed air audit data has shown that these tools consume up to 5.5 kW while operating. Switching to cordless electric tools has reduced energy use by more than 75 percent. In addition, the compressed air tools require 100 psi to operate to Husky's tolerances. Their replacement may enable a plant-wide pressure reduction, once all tools are replaced as planned.

Third Stage of Measures – CEI

Efficiency measures to date have been quantified chiefly through measure-specific analysis and pre- and post-metering. There is a desire at Husky to increase employee involvement to achieve additional savings due to actions from the employees. The company believes that daily awareness of energy efficiency by all employees can produce savings beyond what has been identified to date. To achieve these reductions means are needed both to inform employees and to measure the effect of their involvement.

One key to this effort is sub-metering. Work is under way to both use the existing infrastructure and add metering capabilities to show energy use in selected plant sectors and individual machines. A real-time display of energy use for all employees will be placed in a common area where quality and safety data are already displayed. Energy use will be broken down by operating unit and compared to historical use. This information, and planned employee engagement classes, will create an environment for plant-wide awareness of energy waste. It is expected that both discrete projects and day-to-day decisions will result in a reduction in energy use.

Measuring the potential savings from this employee engagement effort requires data analysis beyond the measure-specific data analysis to date. Husky and Efficiency Vermont will look at plant-wide use, as well as sector-by-sector use, finding ways to measure savings.

Efficiency Vermont has begun a Continuous Energy Improvement (CEI) initiative for customers such as Husky. At Husky, CEI will be used to generate regression analysis of historical energy use and plant activity. This relationship uses labor hours as a proxy for plant level of activity. Regression analysis has shown that labor hours and outdoor temperature accurately predict power use. That relationship can help predict future use by applying the regression formula to actual labor hours. The predicted use will be compared to actual use with any reduction being assumed to result from the employee engagement activity.

Future Plans

Husky recognizes the value of a continuous effort to reduce plant energy use. Efficiency Vermont will continue to work with Husky in reviewing capital purchases for efficiency opportunities. They will continue to evaluate large cutting machine auxiliary process energy inputs. In addition there will be more effort in programming cutter paths that use the most efficient ways to machine steel. Sub-metering infrastructure will be installed to collect data on the use of all large machining centers. This data will help identify performance degradation and the energy content of discrete machining tasks. This information could yield ways to perform a given machining task with less energy input. An analysis is under way to evaluate the use of geothermal groundwater to reduce or eliminate plant chiller compressors. The two organizations will also use CEI to capture savings from ongoing employee engagement activities.

Conclusion

The history of energy savings at Husky shows how a partnership between customer and efficiency utility evolves as the investigation of opportunities moves deeper into the customer's primary processes. Initially, there is a reticence to change anything about these processes and only well-known auxiliary process, climate control and building envelope projects are undertaken. Over time, as familiarity with the facility deepens for the efficiency utility energy consultant and confidence in the value of energy efficiency grows for the customer, resistance to look at primary processes is overcome. Husky's savings of over $400,000 to date has given prominence to these projects at high levels in the company. The reluctance to make any changes to complex equipment which hold tight tolerances is understandable. But by starting in small increments, such as idling with E Stop and turning off redundant in-machine compressed air dryers, energy is reduced without quality and productivity impacts. By understanding the process more, deeper savings become possible. Finally, a continuous energy improvement plan is put in place with sub-metering and employee engagement so that energy usage is constantly monitored, changes in usage are addressed right away and new opportunities can present themselves in the data.