

**Monitoring and Targeting of Energy
for the Ontario Food Industry**

A Pilot Project

prepared for

Alliance of Ontario Food Processors

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EXECUTIVE SUMMARY

Food processors in Ontario face global competition and continuously rising production costs. Energy costs are a large part of that mix. Reducing those costs, through effective demand management, is a key success factor for food processors long term viability and growth.

The Alliance of Ontario Food Processors (AOFPP) partnered with the Ontario Power Authority (OPA) as well as with the Ontario Ministry of Food and Rural Affairs (OMAFRA) to study the opportunity to conserve energy, one of the most important costs of production.

The M&T Pilot Project was designed to determine the implementability of a monitoring and targeting program for the food industry. Monitoring and Targeting, and the development of an Energy Management Plan to support and manage the results, has long been considered important for true understanding of how energy is used within an operation. Dynamic monitoring allows for immediate response to control energy cost based on consumption or other parameters that exceed Key Performance Indicators (KPI).

One of the objectives of the Pilot Project was to determine the practicality of implementing an M&T system in a number of different food processing operations. In the execution of the Pilot, it became clear that there are a number of challenges to convince companies to implement an M&T system. There are some valuable lessons learned from the Pilot that need to be communicated to improve the success of future projects.

Overall, interest in the opportunity was disappointingly low. It was very difficult to get companies engaged with the concept of M&T to the point of getting meetings to explain the opportunity and to offer a proposal. For those that did accept a meeting and proposal, the sales process was very long and challenging. Many possible clients did not fully understand the M&T concept when they asked for the proposal, which resulted in not accepting the program.

Based on the completion of the project, there are a number of lessons that can be shared:

- Convincing companies to participate in M&T is a slow process. The easiest are companies with Monitoring and Targeting experience. Some of the larger companies have corporate directives on metering and targeting.
- Smaller companies are clearly focused on immediate cost savings, and are not interested in longer term energy monitoring. Energy audits and energy retrofits provide a more immediate payback.
- Each situation is very different with little generic application of metering and targeting. The M & T application depends on the objectives and goals of each plant, as well as on budgets, manpower, and their specific situation.
- Many companies look at Monitoring and Targeting as comprehensive metering of many parameters in the plant without a strategic plan or objective on how to use the data. Not all facilities link the information from an M&T program to an overall Energy Management Plan.

- Monitoring and targeting appears best suited to larger companies, especially those with automated processes or high volume production. Real time feedback on energy use can provide some significant savings but the company must be large enough with a significant energy bill to make it worthwhile. With automated processes, energy data can be linked to other controls to achieve optimization objectives.
- Monitoring and Targeting must be clearly linked to other aspects of the operation. Other operational parameters such as quality, reliability, maintenance, and production increase must be linked.
- Corporate management systems must integrate energy management reporting, require performance monitoring, and accountability. Currently many of the directives are only energy conservation targets and objectives.
- Monitoring and Targeting must be clearly linked to productivity, food safety, quality assurance or other important aspects of overall operations to get maximum attention and priority.

1.0 INTRODUCTION

Food processors in Ontario face global competition and continuously rising production costs. Energy costs are a large part of that mix. Reducing those costs, through effective demand management, is a key success factor for food processors long-term viability and growth.

The Alliance of Ontario Food Processors (AOFP) partnered with the Ontario Power Authority (OPA) as well as with the Ontario Ministry of Food and Rural Affairs (OMAFRA) to study the opportunity to conserve energy, one of the most important costs of production.

The AOFP, OPA, and OMAFRA seek to implement a measured approach to embedding the culture of energy and resource conservation in the food processing industry. The first step is to launch a pilot project linking energy management training and the installation of utility metering and management systems to track consumption and to record real savings in energy and resource conservation.

The AOFP embarked on this pilot project to demonstrate the benefits of real time monitoring of energy use in the food processing industry. Monitoring and Targeting (M&T) principles include the development of energy conservation objectives as well as the installation of meters to measure improvements in energy use.

While many food processors have begun looking at energy and water consumption reductions as a way to reduce costs, this trend has been slow largely due to management's daily focus on production and distribution issues.

2.0 DESCRIPTION OF THE PROJECT

2.1 Energy Tracking Pilot Study for Food Processors

The Alliance of Ontario Food Processors (AOFPP) represents companies in the food processing industry, providing support, information and education, and advocacy to provide strength to the industry. The industry generates over \$32 billion in shipments annually and employs more than 100,000 people in 3,000 establishments ranging from small family-owned businesses to large multi-national companies. The AOFPP partnered with the Ontario Power Authority (OPA) as well as the Ontario Ministry of Food and Rural Affairs (OMAFRA) to study the opportunity to conserve energy, one of the most important costs of production.

The AOFPP embarked on this pilot project to demonstrate the benefits of real time monitoring of energy use in the food processing industry. Monitoring and Targeting (M&T) principles include the development of energy conservation objectives as well as the installation of meters and sub-meters to measure improvements in energy use. The project included identifying 5 participants, implementing an M&T program including the installation of sub-meters, and installation of software to record and manage the data.

The AOFPP, OPA, and OMAFRA seek to implement a measured approach to embedding the culture of energy and resource conservation in the food processing industry. The first step is to launch a pilot project linking energy management training and the installation of utility metering and management systems to track consumption and to record real savings in energy and resource conservation.

The high level goal of this pilot project is to provide a framework and strategy for other food processors to follow, where tangible conservation and savings results are achieved. The real success of this project is measured on the ability to broadly communicate the successful results and to have participants convinced that there is significant value to continue the Monitoring and Targeting program over the long term. The pilot, then, would enable these facilities to practice M & T on a voluntary basis, offering the opportunity for AOFPP, OPA, and OMAFRA to monitor their progress and success during and after the lifetime of the pilot.

2.2 Project Objectives:

The objectives of this pilot project are:

- Determine the best technology & software alternatives for installation at the food processors' sites.
- Identify where to place sub-meters within the plant, to maximize return on investment for monitoring energy/water use with then purpose of effecting efficiencies.
- Help embed energy & water use efficiency into the corporate culture of the site, and look broadly at how best to replicate that culture shift at other food processors.

- Position the M&T system approach with product costing models & benefits, to readily allow replication to the sector as a whole.

2.3 Benefits for Participants:

From the Food Processors' perspective, benefits for the individual firms include:

- Save on plant operating costs, by reducing energy and water use.
- Tap into practical and professional energy engineering expertise.
- Leverage co-funding for project management, auditing, metering, tracking & training.
- Have sub-meters and software installed at significantly reduced prices.
- Create and understand the facility's energy consumption baseline by process area.
- Lower wastewater treatment and discharge costs or surcharges.
- Calculate and reduce total greenhouse gas emissions.

2.4 Building a Culture of Conservation

Energy and water costs are a significant percentage of production costs for most sectors in the food processing industry. Whether it is meat or vegetable processing, bakeries or dairy etc., the cost of energy and water continues to increase, representing an even greater percentage of the cost of the product. Conservation activities can have a significant impact on cost reduction and more efficient manufacturing, helping to make Ontario industry more than competitive.

In addition, conservation activities can have a significant impact on the sustainability of the energy and water resources. With the energy supply at risk of not meeting the demand, and the increasing costs to deliver potable water, energy and environmental sustainability is a priority for Ontario and industry and an important benefit of conservation.

The first step to building a culture of conservation is to monitor and track energy and water use to establish a baseline and to evaluate savings opportunities against that baseline. Understanding the use of these resources, and how they break down in processes, allows management to better identify specific conservation projects, engineer a solution, and track payback on capital. With this metering, corporate management can set targets for energy and water reduction, then monitor the progress to the resource conservation targets. Training with this system and approach is required to ensure food processing operations can use the information, and management can take the information and make decisions.

2.5 Approach to Metering the Software Installation

The key to success of the project is the appropriate design and installation of the metering equipment and tracking software. The design and installation of a complete Utility Management System, then, includes;

- Choice of metering equipment including size vs. flow, primary or secondary standard, calibration requirements, ease of installation;
- Installation requirements including regulatory compliance (esp. with natural gas), accessible locations, confined space entry (i.e. sewer manholes, under equipment etc.), licensed installers (electricians, gas pipefitters), and ensuring all safety standards are followed;
- Data logging and interface between meter and software location including choice of analog or digital signal, wireless or hardwired transmission of data, data reading and integration with the software;
- Integration of the software product with the metering data including language and/or programming interface requirements that will allow the software to read the data;
- Training on how to operate the system as well as how to use the data that are obtained.

2.6 Training

Training is a key component to the project goals of building a culture of conservation and energy demand management in Ontario's food industry. One of the objectives of the project is to help the food processors participating in the pilot gain a broader understanding of how M&T systems can be embedded into their corporate culture and how they should manage the benefits.

2.7 Energy Assessments

Energy Assessments were performed at the participating food processors to identify the optimal sub-metering locations, appropriate targets for resource reduction that are estimated to be available, and the approximate cost of the technology systems. The best location for the sub-meters in terms of separating a food process, a specific piece of equipment, or a section of the plant was determined.

3.0 PROJECT RESULTS

3.1 Targeted Marketing Campaign

The Pilot Project started as a marketing program. The participant companies were not identified in advance. It was suggested that, with the external incentives, participants would quickly volunteer to participate in the M&T program. Altech, with the help of the Alliance of Ontario Food Processors, would solicit members of the association and select a short list of the number who would apply.

The first step was to send a notice to all members to ask for interest. A small number of companies asked for further information. Altech was able to visit and identify how M&T could be applied to these companies. Several proposals were presented and a significant amount of follow up was required to review and tailor the approach.

The low interest from the association members was not expected and was disappointing. Based on the number of solicitations that resulted, Altech launched a broader marketing program to all its food industry clients. As well, Mr. Phil Dick of the Ontario Ministry of Agriculture and Rural Affairs (OMAFRA) solicited potential clients and offered a number of leads. Finally, Altech developed a broadly based marketing campaign to generally solicit clients to participate in the program. The sales campaign included direct mail and telephone follow up.

Overall, interest in the opportunity was disappointingly low. It was very difficult to get companies engaged with the concept of M&T to the point of getting meetings to explain the opportunity and to offer a proposal. For those that did accept a meeting and proposal, the sales process was very long, challenging, and not satisfying. Many possible clients did not fully understand the M&T concept when they asked for the proposal, which resulted in not accepting the program.

There were two challenges in the sales activity. First, getting the first meeting and the initial interest was difficult. For those who accepted the meeting, the proposal and sales process was long and arduous. In some regard it was based on a misconception on how M&T would help them immediately.

3.2 Companies Solicited for the M & T Pilots Study

Based on the efforts of Altech, AOFP, and OMAFRA, the project team was able to negotiate with 11 companies to participate in the pilot program. The companies include;

Carriere Foods – Tecumseh
Heinz Canada – Leamington
Grand River Foods – Cambridge
Halenda Meats – Oshawa
Sleeman Breweries – Guelph
Weston Bakeries – Kitchener
Neilson Dairy – Georgetown

Kellogg Canada – London
Cambridge Fine Foods – Cambridge
Frito Lay Canada – Cambridge
Maidstone Bakeries – Brantford

A number of proposals, sometimes as many as four, were given to each of these companies to help develop the best program for them. Each proposal was customize for their needs. Aggressive follow up occurred. Follow up with a number of the companies above continued for 8 month to 1 year. In the end three companies agreed to proceed. Halenda Meats, Weston Bakeries, and Kellogg agreed to move forward, although the sales cycle was long. For Halenda the cycle was about 3 month but for Weston’s and Kellogg the cycle was longer than 1 year.

3.3 Results

3.3.1 Halenda Meats, Oshawa

Introduction

Halenda’s Fine Foods Ltd. (Halenda’s) is a manufacturer of meat products and deli meats, located at 915 Nelson, Oshawa, Ontario. Halenda’s has production lines capable of processing raw meat, poultry, fish, sausage, hot dog, breads, etc. Production runs 7-10 hours per day, five days per week. Electricity is used at Halenda’s to operate refrigeration units (including freezers, coolers, containers), smokehouses, condensers, lighting, and HVAC units. Natural gas is used for the steam boiler, kettle cooker, comfort heating furnace and hot water heater.

Process operations are energy intensive and the energy loads are not clearly defined. Halenda’s wished to obtain a better understanding of its electrical and natural gas consumption. One of the main objectives at the plant was to develop a baseline energy usage profile and improve the efficiency of energy consumption.

Objectives

The objectives identified jointly by Halenda’s and Altech for the project are summarised as follows;

- Conduct an energy assessment investigating aspects of electrical and natural gas use;
- Breakdown and profile energy consumption by major equipment components;
- Develop a plant wide energy baseline and provide the software tools (E2 Action) for continued tracking and monitoring by plant staff;
- Complete an engineering and financial analysis of conservation opportunities identified through the assessment including an estimate of payback;

Results

The main process equipment includes Freezers, Coolers, Chopper & Dumper, Deep Fryer, Cube Machine, Grinder & Dumper, Ovens, Kettle Cooker, Smokehouses, Tumblers, Rollstock, and Vacuum Pack.

The following actions to improve energy efficiency, obtain savings, or prevent a negative impact on production were recommended:

- Improve the power factor by installing power factor improvement capacitors.
- Improve the load factor by eliminating peaks in power consumption.
- Purchase premium efficiency motors during motor retrofit.
- Install new evaporative condensers to reduce compressor horsepower in order to lower the condensing temperature.
- Clean and de-scale the condensers.
- Install variable frequency drives (VFD) on compressors.
- Use natural gas rather than electricity as energy for the deep fryer.
- Use steam for smokehouse cleaning.
- Install a window for the wall-mounted exhaust fan in the cooking area.
- Install automated doors between different temperature zones.
- Inspect and repair/install insulation and/or sealing materials for the walls and doors.
- Develop demand profiles for both of the production facility and the warehouse.
- Educate young operators on energy saving issues.

If all the energy conservation options are implemented, the reduction in greenhouse gas emissions is estimated to be approximately 22 tonnes CO₂ / year.

Halenda was left with the E2 Action software to continue to monitor and track energy consumption. Altech conducted a training session on the Energy Management Program and how to use the E2 Action software as part of the system.

3.3.2 Kellogg Canada, London

Introduction

Kellogg Canada's London plant is a major manufacturer of cereal. The plant produces more than 30 brands of breakfast cereal for all of Canada and exports approximately 30 percent of the plant's production to the United States. Approximately 750,000 cartons of cereal are produced every day at the plant.

Kellogg's London plant is a very large energy user. Kellogg's is interested in energy conservation and reducing the overall cost of energy in terms of production. However, there is no way to measure consumption and break it down or assign it to specific production units.

Powerhouse operations account for most of the energy used in production. The Powerhouse generates and delivers steam, compressed air, and chilled water. Powerhouse operators are interested in energy conservation and have made some progress with energy efficiency. However, to further encourage energy efficiency in production, the Powerhouse needs to measure and meter the utilities going to the separate production units and make them aware of what they are consuming. From there, an awareness of energy consumption and a culture of energy conservation can be built.

Electricity is metered into the site through 2 mains, each of which has an interval meter. Kellogg's has access to the metered data through London Hydro's website. This information is not available in real time.

Natural gas is metered into the site by a main outside the Powerhouse. The main splits into feed lines to the Powerhouse, North Building, South Building, and Building #26. The gas that feeds the Powerhouse is almost exclusively used for the generation of steam, which is then circulated to operations for production use. For the natural gas lines that go directly to operations, it is assumed that some of the gas is used for comfort heat and some for production but the ratio is unknown.

Objectives

The objectives of the project with Kellogg's, then, are summarized as:

- Determine the overall energy baseline for the facility based on the utility invoices.
- Profile operations at the Powerhouse and determine location for sub meters to measure utility use by production unit.
- Evaluate meter technology and choose the right meters for Kellogg's.
- Evaluate data collection and management options.
- Automate data collection and storage for the electrical and gas gate meters.

Powerhouse records and utility bills were used to characterize energy consumption and develop a baseline of monthly natural gas and steam use. The project team also profiled electrical energy. The baseline describes the plant's electrical power consumption (kWh), demand (kW), load factor, power factor as well as natural gas and steam use, and combined total energy use. Energy use can be normalized by a rational unit of production, which may be used for the ongoing tracking and benchmarking of energy use. Altech's *E2 Action* spreadsheet tool, specifically developed for this type of analysis, includes the ability to normalize data for Heating and Cooling Degree days and other analysis.

Results

Electricity Consumption

Monthly consumption of electricity at the Kellogg's London plant ranges from 4.4 million kWh to 6.2 million kWh. There is little correlation between electricity consumption and weather (as referenced to cooling degree-days). There is also a poor correlation between electricity consumption and production.

Natural Gas Consumption

Natural gas consumption for Kellogg's London plant typically ranges from about 800,000 m³ for a summer month to 1,500,000 m³ for a winter month. There is little correlation between natural gas consumption and production.

Powerhouse

The Powerhouse is the generator of steam, compressed air, and chilled water for the manufacturing facility. There are no flow meters on these outputs from the Powerhouse so there is no way of knowing how much each production area is using. Natural gas is metered into the boilers, which are the natural gas consumers in the Powerhouse. Electricity for the air compressors or the chillers is not metered into the Powerhouse.

Natural Gas

The natural gas consumption by the Powerhouse ranges from 48% to 75% of the plant total, depending on the time of year. The yearly average is 63%. The Powerhouse natural gas consumption is for steam production of the two boilers. ABB Swirl flow meters meter the natural gas feed to the boilers. ABB Vortex flow meters meter the steam output from the boilers.

Steam

Steam is generated in two Babcock and Wilcox Type FM Boilers. There are natural gas meters on the feed to the boilers, and steam meters on the output. The two output steam lines combine in a distribution header with take-offs to buildings: #26 (6" line), South (6" line), North (6" line), Inventory Control Centre (3" line), and the Powerhouse (3" line). None of the take-offs from the steam header are metered.

The boilers are rated at 50,000 lbs/hr steam at 150 psi. The gas input ratings are 65,300,000 BTU/hr and 63,800,000 BTU/hr respectively. From September to May usually both boilers are running.

Compressed Air

Compressed air is generated in the Powerhouse by four Atlas Copco 400 HP (1500 CFM) compressors and the air is distributed to Building #26 (3" line), North Building (4" line), and South Building (6" line). The pressure is between 100 to 110 psi.

Chilled Water

Chilled water for space cooling and process cooling is produced in two Carrier Evergreen Centrifugal Chillers, each of 550 ton, 350 kW with Variable Frequency Drive.

Selection of Meters and Data

The main focus of the work is on metering the steam and compressed air to the three main users, namely, the North Building, South Building, and Building #26. The concept is to have accurate measurements of steam and compressed air to these production areas so that measurements can be made for each production area and costs assigned to them. A baseline will then be created to allow each production unit to monitor energy consumption and look within their process to determine energy conservation opportunities. Energy savings can be explored and implemented and their success monitored by comparison to the baseline.

Meter Selection

The type of flow meters selected for these applications (both gas and compressed air) are Vortex flow meters and Swirl flow meters. The principle behind Vortex flow meters is that when a flowing fluid meets an obstruction, pressure variations are created in the fluid, which cause eddies to shed at the obstruction. Eddies are formed in the fluid at a geometrically defined obstruction whose frequency is measured by a sensor. The flow rate of the fluid is determined precisely from this frequency measurement. The Swirl flow meter has a flow conditioner feature for applications where there are not sufficient upstream and/or downstream straight sections. Typically the Vortex flow meter requires a straight length of 15 diameters upstream and 5 diameters downstream. The Swirl flow meter typically requires a straight length of 3 diameters upstream and 1 downstream. The accuracy of the meters are within 1% of the flow rate.

Although there are several manufacturers of Vortex flow meters, ABB was selected as the supplier because they are the only manufacturer of the Swirl flow meter and because Kellogg's already has ABB Vortex flow meters in the Powerhouse on the steam output lines from the boilers. Swirl flow meters are also on the natural gas lines to the boilers. The steam lines require 300 psi meters. The compressed air lines require 150 psi meters.

Data Logger

For data recording and storage, an SM2000 Videographic Recorder from ABB was selected. It provides 12 recording channels and up to 12 universal analog inputs. The inputs can be viewed in a variety of display formats such as chart, bar graph, digital indicator, and process summary. Historical logs are provided for recording alarms, operator and system events, and totalizer values.

The SM2000 has an internal memory capacity of 8Mb Flash providing storage of up to 2.9 million samples. There are two options for retrieving the data to a computer:

1. Media card (manual to card reader).
2. Ethernet card connection.

For this application the ethernet is the preferred option so that the data is accessed from a remote location and downloaded into the data analysis software program.

Description of System Design

After review and final selection of the meter and data management system, Altech presented the following approach to Kellogg's for input and approval.

Steam Line Flow meters

Each of the steam lines from the steam header is 6" diameter. There are sufficient straight sections on each that a Vortex flow meter can be used. Three 6" ABB Vortex meters will be installed by a certified contractor on the lines leading to the North building, South building, and Building #26. The flow meters will send a 4 to 20 mA signal to the data logger.

Compressed Air Line Flow meters

The size of the compressed air lines to the three buildings varies. It is a 6" line to the South building, a 4" line to the North building, and a 3" line to Building #26. There are sufficient straight runs on the 4" and 3" lines for Vortex flow meters to be used. The 6" line requires a Swirl flow meter because of insufficient straight runs.

Data Logger

The data logger is to be installed on the panel by the control room. The flow meter outputs, 3 from the steam lines and 3 from the compressed air lines, will be wired into an ABB SM2000 videographic data logger. The SM2000 comes equipped with an ethernet connection. The data logger, then, will be connected to the network by wiring the ethernet connection to the operator panel across the aisle. The data will then be automatically transferred from the logger to the network where it can be stored. This will allow remote access to all the stored data.

Data Management Software

The data from the SM2000 will be downloaded into an analysis program from ABB called DataManager. DataManager is a Microsoft Excel add-in designed to enable the analysis and validation on a PC of the data archives generated by the SM2000 recorder. It automatically formats the selected data file into 'time', 'date', and 'process value' columns. It checks the data's validation by matching the file against its encrypted digital signature.

In addition, Altech proposes to develop an extended software package that will allow management and evaluation of the data including comparison to targets, alerts, and alarms that are based on Key Performance Indicators (KPI). DataManager is a 'storage' file where Altech will extract the data and rearrange it to perform calculations and comparisons to help interpret the information in real time, to help make decisions or troubleshoot issues. The extended software will also provide for short, medium, and long term trending, which will be important for tracking improvements and for reporting to management.

Implementation of an M & T Program

Altech developed, in consultation with Kellogg's, a strategy for a Monitoring and Targeting Program that will become the first step in helping Kellogg's investigate, evaluate, and implement energy saving opportunities. The first step includes equipping the Powerhouse with sub meters to allocate energy consumption by processing divisions. In addition, real time monitoring and data management allows Powerhouse staff to monitor energy consumption and respond to alerts, identify troubleshooting situations, and to develop integrated reports on improvements in energy efficiency.

With the Powerhouse able to monitor and evaluate energy usage, production departments can be made more aware of their consumption and will more accountable for energy conservation and cost savings. This, then, becomes the basis for an Energy Management Program.

Next Steps

Altech has assembled a complete M&T system including meters, data logger, and software for data management. The next step is to install the system. The installation includes coordination/supervision of meter installation, installation and hook up of the data loggers, and development and loading of the software. Once all the pieces are installed, the system is commissioned by ensuring the data is collected and transferred correctly and stored correctly on the data files.

Another part of the project is to convert the Utility gas meter (gate meter) to a pulse meter to allow it to send an input signal to the SM2000 Videographic Recorder. In this way the meter will be able to be automatically read on a real time basis and the data recorded and stored. Natural gas pulse data will be received by installation of a 5-30 VDC dry contact voltage supply in the Union Gas cabinet. A pulse based on corrected flow will be received for every 1000 cubic ft. directly from the meter.

With this metering system in place Kellogg's will then be able to target for electricity and natural gas savings downstream from the Powerhouse at the point of use.

3.3.3 Weston Bakeries, Kitchener

Introduction

Weston Bakeries Kitchener is a manufacturer of baked products, making premium bread and buns. The non-weather related natural gas consumption is 84% to the baking ovens and 16% to the boilers. The main natural gas energy consumers are the baking ovens, each of which has a number of zones, and each zone with multiple natural gas burners. Although the temperature of each zone is monitored and controlled, this does not always ensure good baking as the temperature is of the air space, not the product.

Weston's plan for energy reduction is to reduce the amount of wastage by not cooking twice because the first bake is out of specification. The concept is to correlate the gas flow to each baking zone to proper baking and generate a joules per kilogram for each recipe. When the energy per kilogram of properly baked product is known, any deviation from this will be rapidly detected and responded to. Long-term drift from the baseline could be a predictor of a maintenance requirement or oven overhaul.

Project Objectives

The overall project objective is to establish a correlation between properly baked products and natural gas consumption, and with this information establish limits for alarms and maintenance. The project is in two phases, first to select the appropriate flow meters and recording equipment, and second, to install the equipment, collect the data, and develop a model of energy consumption per mass of quality baked product. With an oven upgrade project about 18 months

in the future, the objective is to understand the base load energy requirement for the oven by product and to generate a production/gas consumption predictor model.

Phase 1 Objectives

- Plan the location and installation of a prescribed number of sub-meters at the oven based on company/corporate objectives;
- Determine software to read and record meters;
- Provide detailed cost requirements for Phase 2.

Phase 2 Objectives - Monitoring and Tracking Program

- Install the meters;
- Collect the data;
- Correlate the data to baking quality.

Bread Baking Oven

The bread oven consists of 6 baking zones. Each zone contains between 10 and 14 burners, each burner capable of 70,000 BTU/hr maximum. The natural gas is fed into each burner via a venturi mixer where the airflow draws in natural gas, which is at zero pressure. Each zone has a thermocouple that is tied into an Omron controller. The controller operates a valve that regulates the airflow to the venturi, increased airflow to draw in more natural gas.

For each zone there is a gas line that comes off a main header on top of the oven. The gas lines are 1-1/2" diameter and come off the main header, across the top of the oven, and down the side of the oven to the burner manifold. There is 6 inches of straight pipe run on the horizontal at the top of the oven. There is about 12 inches of straight run after the 90° bend down the side of the oven before pipe is behind the protective cowling. Due to the space limitation behind the cowling the flow meters have to be installed in the vertical section behind the cowling, after the 90° bend.

Metering and Monitoring Equipment Selection

The main focus of Phase 1 was to determine how best to monitor the ovens, identifying the right meters, the number of meters, installation costs, data logging and software packages. The objective of Phase 2 was to install the meters on the bread oven to track its performance and to generate a production/gas consumption predictor model.

Meters

The type of flow meter selected for this application is a thermal mass flow meter with integral flow conditioning. They are very accurate. Fluid Components International's ST75 is accurate to within +/- 2% of reading, +/- 0.5% of full scale. Some natural gas distribution companies are investigating thermal mass flow meters for use as billing meters because of the accuracy and minimal maintenance required. The repeatability is within +/- 0.5% of reading.

Thermal mass flow meters have two sensors. One is a self-heated flow sensor and the other temperature/reference sensor measures the gas temperature. The pair is referred to as the sensing element, and is either installed in a probe as an insertion style, or inserted into a pipe section as an in-line style flow meter. As gas flows by the flow sensor, the gas molecules carry heat away

from the surface, and the sensor cools down as it loses energy. The sensor drive circuit replenishes the lost energy by heating the flow sensor until there is a constant temperature differential above the reference sensor. The electrical power required maintaining a constant temperature differential is directly proportional to the gas mass flow rate and is linear to the output signal of the meter.

Thermal mass flow meters can be used to measure the flow of any industrial gas having a temperature between minus 40°C and plus 110°C and gas pressure up to 500 psig. They do not need correction for variation in pressure or temperature because they measure mass flow directly. The meter's outputs are flow rate, temperature and total flow. They are capable of providing most standard electronic outputs and interfacing with PLC's, existing data systems and various communication protocols. Thermal mass flow meters typically require 10 diameters of straight pipe diameters upstream and 5 diameters downstream to give accurate measurements.

Flow Conditioning

Flow conditioning is required if there is less than 10 diameters of straight pipe upstream and 5 diameters downstream. In the case of the baking oven the flow meters were installed less than 10 diameters from a 90° bend, thus requiring flow conditioning.

Fluid Components International uses VORTAB[®] low pressure loss flow conditioners. VORTAB[®] Flow Conditioners are passive mechanical devices which effectively establish a consistent outlet fluid condition regardless of the fluid's inlet condition. These conditioners use a series of tabs to amplify and accelerate the beneficial boundary layer behaviour of long pipe, fully turbulent flow. The Vortab flow conditioner is able to produce uniform, non-swirling fluid flow within seven pipe diameters with minimal pressure loss.

The upstream three pipe diameters of a Vortab conditioner contains the conditioning tabs. The next four pipe diameters downstream of the tabs are the fluid settling distance. Depending upon the severity of the downstream disturbance, one to five diameters of straight pipe are required after the flow meter outlet.

The VORTAB[®] Flow Conditioner is located three diameters upstream (found to be the optimum distance) of the flow meter installation eliminates gas flow swirl and velocity profile distortions as well as temperature stratification produced by inadequate straight run of pipe. Without flow conditioning the error introduced after one elbow goes from -5% error at 1.5 m/sec to 15% error at 17 m/sec.

Data Logger

For data recording and storage an SM2000 Videographic Recorder from ABB was selected. It provides 12 recording channels and up to 12 universal analog inputs that can be viewed in a variety of display formats: chart, bar chart, digital indicator, and process summary. Historical logs are provided for recording alarms, operator and system events, and totalizer values.

The SM2000 has an internal memory capacity of 8Mb Flash providing storage of up to 2.9 million samples.

There are two options for retrieving the data to a PC, namely;

- Media card (manual to card reader);
- Ethernet card connection.

Data Analysis

The data generated from the meters is logged in the ABB Videographic Recorder. From there is downloaded into a computer and compared with production data such as that determined by the 'M.O.L.E. Profiler' readings - a temperature profiler that is run through the baking oven recording time and temperature. The data is analyzed in an Excel spreadsheet.

ABB's DataManager software is used to import the data from the videographic recorder into an Excel spreadsheet. The range of interest is imported from DataManager into a customized spreadsheet where descriptive statistics are performed on the data.

Data Gathering and Analysis

The objective is to determine the energy per mass for each zone of the baking oven for each recipe. This is done by recording the natural gas consumption per zone and correlating this to bake quantity and quality. It is anticipated that the gas consumption will be a better indicator of baking quality in each zone rather than temperature. This will entail building a database for each product SKU or group of SKU's. The first stage of the program was the installation of the thermal mass flow meters and recording equipment. Data is being collected and correlated to baking quality. These are the comparative stages:

1. The current running state of the oven.
2. The oven will then be tuned to its current best conditions and a new baseline will be established.
3. After the next major overhaul a new baseline will be established which should represent the optimal operating conditions of the oven.
4. Targets/alarms will be developed and set for when the oven gets out of specification. The model should be able to catch bad firing rates, and to be a predictor of required maintenance.

Results

There were immediate benefits from metering the baking oven. When the oven is shut down air is blown through the mixing venturi to remove any residual natural gas. Shutting down the oven shuts the valves on the gas lines to the six zones. Upon shut down it was observed that there was gas flow in three of the six zones, at 10%, 11%, and 26% of full scale (30 m³/hr). Upon shutting off the airflow these values dropped to 0%. The conclusion is that 3 of the 6 natural gas valves leaked, bringing natural gas into the oven while in a non-operating mode (no combustion), creating a potentially very dangerous condition.

A measures spreadsheet was developed to analyze the data. The data is archived on a memory disk in the videographic recorder. Three years of data can be archived on the 512 MB disk when

the sample rate is set at 10 seconds. The disk is removed and the data is downloaded to a computer using a memory card reader. The software program DataManager is utilized to create a data file of the start and stop time of interest for analysis. This is then copied into the analysis spreadsheet which generates descriptive statistics such as total gas consumption, maximum flow, minimum flow, mean, standard deviation, variance, coefficient of variation, variance to mean ratio, kurtosis, skewness, and energy per kilogram.

4.0 BARRIERS AND LESSONS LEARNED

The M&T Pilot Project was designed to determine the implementability of a monitoring and targeting program for the food industry. Monitoring and Targeting, and the development of an Energy Management Plan to support and manage the results, has long been considered important for true understanding of how energy is used within an operation. Dynamic monitoring allows for immediate response to control energy cost based on consumption or other parameters that exceed Key Performance Indicators (KPI).

One of the objectives of the Pilot Project was to determine the practicality of implementing an M&T system in a number of different food processing operations. In the execution of the Pilot, it became clear that there are a number of challenges to convince companies to implement an M&T system. There are some valuable lessons learned from the Pilot that need to be communicated to improve the success of future projects.

4.1 Potential Applications of M&T

At the beginning of the pilot the M&T system was being offered as a somewhat straight forward application that would include metering incoming energy components on a real time basis and sub meter major energy consuming equipment within production. The application of M&T quickly expanded and diversified as the sales effort expanded to a large number of potential participants. Many potential participants had their own objectives and ideas of how they might like to use and M&T system.

The number of potential applications of M&T expanded and, in many cases, were relatively creative. Facility managers had a good idea of where and how M&T might be more useful for them, based on the characteristics of their production, total energy use, and total cost. Each proposal to potential participants was different and unique to respond to the individual way facilities wanted to use an M&T system.

A summary of some of the potential applications for M&T is presented below.

Specific Products Run on Specific Lines

One application included the installation of a new line where the objective was to determine the most efficient line to run selected products. As a meat processor with a variety of pre-formed products, the production line included forming, cooking, and freezing as one long production line. An additional line was constructed with a number of significant differences in the design to the existing lines and management was interested to understand which products are more efficient to run on the new line.

Based on the size, shape, weight, and throughput of each meat product, the objective of the M&T system was to help decide what products are more efficiently run on each line. An energy sub-metering program will monitor the consumption of gas (mainly for cooking) and electricity (mainly for freezing) to determine the optimal energy consumption by product code.

Real Time Tracking of Energy by Process

Several applications in vegetable processing were identified. Vegetable processing is energy and labour intensive as seasonal crops are brought to vegetable processing plants for processing and freezing. Seasonal vegetables come from the fields in short time windows and must be processed as fast as possible before the next crop comes off the fields. Typically these operations will spend 80 to 90 percent of their energy usage in a 12 to 16 week period in the summer/fall when the crops are harvested.

Processing periods can be chaotic where energy use is not considered. As well, each variety of vegetable has different energy requirements. An M&T system that sub-meters critical process operations can monitor the consumption of energy on a real time basis. Key Performance Indicators can be developed that represent optimum energy consumption for that part of production. These indicators can be 'alarmed' and, with real time monitoring, Powerhouse or Utility staff can monitor situations where energy use exceeds the KPI. When exceedances occur, Utility staff can immediately investigate the situation to determine what may be contributing to the excess use. Upon investigation, immediate action can be taken as appropriate. This close monitoring of energy consumption can have a significant impact. In vegetable processing, when energy costs can exceed \$10 million per year with 90% consumed in a short window, real time energy monitoring can save substantial costs.

Sub-Metering From Powerhouse

In some operations, energy is provided through the Powerhouse to production departments. The Powerhouse is the central source of natural gas, steam, electrical power, compressed gas (electrical consumption), chilled water, and hot water. These utilities are usually delivered to a number of production departments. If the department wants more of a specific utility, they demand more from the Powerhouse rather than look at conservation. The cost of energy is not considered

Sub-metering of utilities from the Powerhouse, we can track the real cost of production in each department. Supervisors and Department Heads can then be held accountable for energy use. With this information reported to them, they can identify energy savings or conservation opportunities and implement a culture of Energy Conservation.

Awareness and Accountability

Clearly metering and sub-metering creates more information to feed back to supervisors and other staff, creating more awareness of energy consumption. This provides opportunities to make supervisors and staff more accountable and helps with the implementation of an Energy Management culture. The M&T system can also be used to support project implementation savings and paybacks by monitoring the actual energy saved after implementation. A baseline can be established and the results of changes monitored and used to evaluate the success of the project.

Optimizing Energy Use and Quality

In one project, the objective was to meter the 6 zones of a commercial baking oven and set the optimum energy required in each zone as it related to tracking the quality of the product and automatically feeding back to adjust energy consumption. Metered data has the ability to be

interfaced with other data and linked to controls to make adjustments, optimizing the energy required for the bake.

Tracking Energy Use and Link to Maintenance

Altech also got involved with M&T in terms of tracking energy demand over time and comparing consumption to a standard to determine when equipment requires maintenance. For example, when an oven is overhauled and brought to within the original specifications, a baseline energy consumption is determined. Over time the oven's ability to bake the same quality product will require more energy as the equipment moves out of specification. Monitoring this increase in energy requirement and comparing it to a defined limit will identify the optimum time for maintenance. Without monitoring, the equipment is allowed to deteriorate to the point that a major overhaul is required, costing over \$250,000. With the use of sub-meters, specific zones can be monitored and small deviations in performance can be picked up and maintained for a fraction of the cost as well as longer run times.

4.2 Barriers to Implementation

The implementation of the Pilot Project was a learning process. The project team was not given a list of 'volunteers' but had to market and sell the project to potential participants. Much of the cost to the companies was funded with little financial requirement from the participants. While there was a lot of interest in the program, it was very difficult to get food companies to commit to the program, even with the funding available.

Although the project team did get good initial interest, it was very difficult to get committed companies to sign on. A number of trends and observations started to emerge, which become substantial barriers to any M&T program.

First, there were the usual challenges. Interest was shown, possibly based on the funding available, but the company had no time or resources to deal with the proposal (short staff). This was consistent with most proposals. The proposals and programs were complex because they required significant customization for each opportunity.

From the sales activity it became obvious that the interest in M&T was always from an individual or small group. In most cases it took an individual or 'champion' to start the process, develop the approach to the proposal, and to take the proposal to the decision maker, usually the Plant Manager. The Plant Manager was rarely the champion. Because the process took so long, a number of the initial contacts left, with a changing of personnel in mid-stream. As this person was the champion, there was no one to push to proposal further.

During the sales process it was clear that the potential participant started to recognize that the M&T program would create significant extra work. Although the placement and installation of meters and sub-meters is a project, the long-term commitment to a significant extra effort became obvious. Once this project is completed, the company was responsible for a significant new program that will require resources. Without the complete buy-in from the company, this would be overwhelming for the small group of individuals who are interested. In this regard it could be argued that management commitment from the top is required (as well as the

‘champion’ at the implementation level). While this is true, as a sales activity, the project team could only approach clients or individuals who showed the interest.

Several companies were part of corporations who were pushing energy efficiency and M&T from the top (both US corporations). The reception at these plants was better. However, it still needed the energy champion at each location to push the proposal through. The corporate initiative helped in terms of selling local plant management. However, the proposal was not successful in both situations because the overall budget exceeded local budget authority. Approval would require a more onerous procedure and time delay to get the budget approved corporately.

Finally, the sales cycle is unrealistically long. All sales activities with each potential client was 3 to 6 months with several over one year.

4.3 Lessons Learned

Based on the completion of the project, there are a number of lessons that can be shared. They are itemized as follows.

- Convincing companies to participate in M&T is a slow process. The easiest are companies with Metering and Targeting experience. Some of the larger companies have corporate directives on metering and targeting.
- Smaller companies are clearly focused on immediate cost savings, and are not interested in longer term energy monitoring. Energy audits and energy retrofits provide a more immediate payback.
- Each situation is very different with little generic application of metering and targeting. The M & T application depends on the objectives and goals of each plant, as well as on budgets, manpower, and their specific situation.
- Many companies look at Metering and Targeting as comprehensive metering of many parameters in the plant without a strategic plan or objective on how to use the data. Not all facilities link the information from an M&T program to an overall Energy Management Plan.
- Metering and targeting appears best suited to larger companies, especially those with automated processes or high volume production. Real time feedback on energy use can provide some significant savings but the company must be large enough with a significant energy bill to make it worthwhile. With automated processes, energy data can be linked to other controls to achieve optimization objectives.
- Metering and Targeting must be clearly linked to other aspects of the operation. Other operational parameters such as quality, reliability, maintenance, and production increase must be linked.

- A barrier to Metering and Targeting implementation and operation is that the responsibility for it is shared between too many job functions (ie. production, accounting, maintenance, management etc). It must be streamlined with a clear energy coordinator or champion who can pull everything together as well as have the authority to require changes and/or accountability.
- The budget process rules! Metering and Targeting budgets are usually over plant budgets and need to be approved by corporate.
- Corporate management systems must integrate energy management reporting, require performance monitoring, and accountability. Currently many of the directives are only energy conservation targets and objectives.
- Metering and Targeting must be clearly linked to productivity, food safety, quality assurance or other important aspects of overall operations to get maximum attention and priority.

5.0 CONCLUSIONS

There are significant benefits to be realized from Metering and Targeting, from direct energy savings because of knowledge that the metering provides, to indirect savings from reduction of production wastage. The difficulty in realizing these savings is convincing an organization of the benefits to be realized before there are hard numbers to justify the arguments and payback. Even with valid numbers and acceptable payback there is resistance or apathy due to other competing priorities in operations. It requires an energy champion, with support from a very high level in the organization to implement an M&T system.

Some of the challenges with the M&T system is that it drives a very different way of thinking in terms of energy. It requires that energy management be as an important parameter of production as all other parameters and it must be reported as such. It requires a very demanding, long-term commitment, much different than the commitment for discrete energy conservation projects (which have a start and a stop).

M&T is not effective without an Energy Management Program for long-term success. Some companies monitor sub-meters and collect and report the data but, without a plan or objective on how to use the data, the monitoring will be ineffective and will stop.

It is clear that the M&T system requires a cultural shift in the organization to be effective, in addition to the Energy Management Program. This cultural shift can only be achieved in steps by staging the process and bringing the company along over time. This, again, is part of what needs to be achieved to make the M&T program successful.