Canadian Manufacturers & Exporters

Best Practices Report

Energy Pathfinder Research Initiative

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Prepared by **ICF Canada** and **ADM Engineering** for:
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1 Introduction

This report discusses a series of best practices for process energy management that were developed as part of the Energy Pathfinder Research Initiative. The goal of this project was to explore, define, and quantify low cost opportunities to improve, control, or optimize specific end uses and energy intensive processes for selected industries within Ontario's industrial and manufacturing sector.

The project focused on ***the identification of unoptimized processes, rather than inefficient equipment*** and aimed to improve process efficiency by controlling overhead loads, aligning operation with production drivers, and mitigating non-production drivers. In this respect, the study aims to produce energy savings in two manners:

- Base load reduction through optimization of electricity and gas use (reducing waste energy)
- Peak load reduction through load shifting strategies (reducing cost of energy)

This component of the Energy Pathfinder Research Initiative involved deep dive energy analyses of five facilities. Each facility was carefully chosen to represent a distinct segment of Ontario's industrial and manufacturing sector. As part of the project, each facility was equipped with a suite of sub-meters to monitor the energy consumption of specific end use equipment. Exhibit 1 presents the five segments targeted by the study and summarizes the number of best practices identified for each end use.

Exhibit 1 Number of Best Practices by End Use in each Target Segment

TARGET SEGMENT	END USE						
	COMPRESSED AIR	PROCESS HEATING	PROCESS COOLING	MACHINE DRIVES	HVAC	LIGHTING	IM MACHINE OPERATION
Bakeries	5	3	2	2	3	3	-
Machining	5	-	-	1	6	3	-
Meat Processing	4	1	2	1	2	3	-
Metal Fabrication	4	1	1	1	6	3	-
Plastic Injection Moulding	5	-	-	-	6	3	3

The remainder of this report is divided into five sections, with each section dedicated to one of the five target segments. While each section describes the best practices identified for a specific target segment, it should be noted that several common misaligned drivers may be observed in any of these manufacturing segments (). These common misaligned drivers include:

- Process equipment not aligned to production flow
- Indoor lighting not aligned to occupancy
- Outdoor lighting not aligned to darkness
- Ceiling fan use not aligned to heating/cooling season
- Compressed air systems not aligned to plant operation

Common opportunities are repeated between manufacturing segments, as each section of this report is intended to be a stand-alone reference document.

2 Bakeries

Commercial bakeries produce a variety of baked goods, including bagels, biscuits, breads, and buns. Although the end products vary from one bakery to the next, most bakeries share a common production process that includes a combination of mixing, portioning, forming, proofing, baking, cooling, and packaging. The production process begins when large mixers blend the ingredients to form the dough. After a few minutes of vigorous mixing, the dough is cut into portions and sent along a conveyer system where it is further shaped as it passes through a series of molders. Next, the individual portions enter the proofing ovens, which serve to warm and soften the dough as it rises. Once formed, the product passes through a large baking oven. The baked goods are then slowly cooled by the room air as they are transported to the packaging station by a long series of conveyers.

The baking process results in a buildup of heat in the operating area that needs to be removed by the building's HVAC system. Because bakeries must adhere to food health and safety regulations, low-cost free flowing ventilation strategies such as opening windows and doors cannot be used. Instead, mechanical ventilation systems must be used to filter and temper any fresh make-up air that is brought into the operating area. If the oven burner air is taken directly from the operating area, the majority of the facility, in effect, becomes a direct part of the air distribution system, which can lead to a number of inefficiencies.

2.1 Process Heating

Ovens

Ovens are one of the largest energy consumers at bakeries and often offer one of the greatest opportunities for energy saving.

Driver Alignment **Align oven gas consumption to product flow**

Baking ovens are set to achieve a specific moisture content in the final product, and rely on a tightly controlled baking temperature to achieve the best product. Therefore, most bakeries will maintain the desired oven temperature, even during interruptions in production. For short interruptions, fuel input should be reduced to the minimum amount required to maintain the desired oven temperature. For longer interruptions in production, fuel input should be reduced to zero.
Estimated conservation potential: 30 minutes per day or 2% of oven gas consumption

Baseload Reduction **Recover stack heat with an economizer**

For bakeries, the exhaust of moisture and heat from the ovens is the largest release of energy into the environment. An economizer should be used to recover the energy from the oven's exhaust. The recovered heat can be used to preheat the gas burner air or to temper fresh make-up air during the winter.
Estimated conservation potential: 30 - 60% of oven gas energy consumption

Steam Boiler

The steam boiler is used for humidifying the dough during proofing and heating water for cleaning purposes.

Baseload Reduction **Boiler right sizing**

The steam boiler should be sized to the actual needs of the bakery to avoid inefficiencies. An oversized boiler will cycle on and off repeatedly, which lowers its overall efficiency since the boiler's large thermal mass will cool down between each cycle.
Estimated conservation potential: 3 - 5% of boiler gas consumption

2.2 Process Cooling

In a bakery, the yeast must be maintained at a specific temperature to maintain the desired growth rate of the culture. The yeast tank temperature is maintained by circulating coolant through a jacket to remove the excess heat that is produced by the yeast reaction.

Baseload Reduction **Manage waste heat from process cooling**

During the summer, the chiller should exhaust its waste heat outside the building to reduce the building's cooling load. During the winter, the chiller should exhaust its waste heat inside the building to reduce the building's heating load.

Estimated conservation potential: 300% of refrigerant compressor motor load in heat energy *(assumes 3 COP system)*

Driver Alignment **Align chiller compressor load to coolant temperature**

The temperature of the circulating water/glycol mixture should be maintained by matching the motor load of the compressor to the cooling requirements of the system with a variable speed drive.

Estimated conservation potential: 20 - 30% electricity consumption of refrigerant compressor motor

2.3 Machine Drives

Machine drives are mainly used in bakeries to control dough mixers, as well as the various conveyors that move the product from forming to proofing, through the ovens, and on to packaging.

Driver Alignment **Align conveyor load to production flow**

During interruptions in production, the conveyers are often left running because they are considered to be a small or insignificant loads. While it is true that the load produced by each individual conveyor motor is small, the aggregate load of all the conveyor motors is large. Therefore, the conveyor system should be turned off during production interruptions.

Estimated conservation potential: 1 hour per day or 4% of total conveyor electricity consumption

Baseload Reduction **Use variable speed drives for intermittent loads**

The dough is made in batches and the load on the dough mixers varies significantly from the introduction of the liquid ingredients to the addition of the dry flour mix. If the dough mixer were to use a fixed speed motor, it would remain idle for a significant portion of production hours. Since idle motors typically consume 30% of full load power, a variable speed drive should be used to efficiently follow the load of the dough mixers.

Estimated conservation potential: 5 - 10% of motor full load rating

2.4 HVAC

Oven Ventilation

Bakeries often draw oven burner air directly from the operating space, a practice that leads to increased energy costs from excessive ventilation and tempering of building air.

Driver Alignment **Enable process control through process isolation**

If ovens draw burner air from the operating area, the building's HVAC system must compensate by supplying the space with fresh make-up air. Instead, the HVAC system should include separate outside air intakes for the oven and building space, thereby allowing the building to manage space heating and cooling separately from the air intake needs of the oven.

Estimated conservation potential: 1% of HVAC electricity consumption. Little impact on HVAC fan HP. This is a best practice that facilitates the heat recovery mentioned previously in process heating.

Ceiling Fans

Ceiling fans can be used to strategically eliminate naturally occurring air stratification and improve employee comfort. The volume of air in the building requiring heating or cooling is changed significantly through mixing and destratification.

Driver Alignment **Align ceiling fan use to season**

Air stratification strategies vary from winter to summer. During the winter, large ceiling fans should be used to move hot air from the ceiling to the floor. This strategy reduces the winter space heating load by reducing the amount of overheating at roof level in order to maintain a comfortable temperature at floor level. During the summer, an opposite strategy should be employed wherein air stratification is encouraged by turning off the large ceiling fans. This strategy reduces the summer cooling load by allowing the warm air to be exhausted from the building at the ceiling level.
Estimated conservation potential: 5 - 10% of heating/cooling cost

Baseload Reduction **Reduce volume of air movement for comfort cooling**

Large ceiling fans should not be used for comfort cooling (evaporative cooling through air movement) because moving the building's entire air volume requires more fan energy and can cause heat to be moved from the ceiling to the floor. Instead, comfort cooling should be accomplished using local fans at the operator stations.
Estimated conservation potential: 10 - 50% of ceiling fan capacity

2.5 Lighting

The operating areas of commercial bakeries typically employ high ceiling lighting fixtures to provide an evenly distributed illumination of the work plane so that employees can effectively monitor the various baking processes.

Baseload Reduction **Use efficient lighting**

The baking process adds excess heat to the operating space year-round. During the summer, inefficient indoor lighting exacerbates this problem by releasing additional heat to the space through the inefficient conversion of electricity to light. LEDs are generally considered to be the most efficient and cost-effective lighting technology available on the market today, and should therefore be used throughout the bakery. In addition to lowering lighting costs, LEDs will minimize the lighting system's contribution of heat to the operating areas, leading to lower cooling costs during the summer.
Estimated conservation potential: 50 - 60% of lighting load

Driver Alignment **Align lighting to occupancy**

Occupancy should be the first consideration for whether or not lights are turned on inside buildings. Lights can be controlled by various methods including standard operating procedures, timers fixed to work schedules, or occupancy detection technologies.
Estimated conservation potential: 10 - 90% of space lighting electricity consumption

Driver Alignment **Align outside lighting to darkness**

If outside lighting is not controlled automatically, it can represent a significant overhead load. Outside lighting should always be controlled by photo sensors.
Estimated conservation potential: 40 - 60% of outside lighting electricity consumption

2.6 Compressed Air

Air compressors are used to supply a header system that in turn supplies air for various end uses such as pneumatic cylinders, packaging equipment, and instrumentation.

Baseload Reduction **Eliminate unnecessary overhead loads**

The unpredictable use of air from moment to moment results in variable flow of air in the system. If a fixed speed drive is used for the compressor, an overhead load is created since the compressor will idle on and off to meet the needs of the air systems. Instead of idling on and off, motors with variable speed drives can be shut down when compressed air demands are low due to their comparatively low in-rush currents. Therefore, a variable speed drive should be used to eliminate idling loads by more efficiently following the load profile of the compressed air system.
Estimated conservation potential: 10 - 30% of motor load

Driver Alignment **Align air compression to plant operation**

If the plant is not running then the compressor system should be shut down. This practice can be implemented by introducing new standard operating procedures or through system interlocks.
Estimated conservation potential: 1 day per week or 5 - 14% of compressor motor electricity consumption

Baseload Reduction **Reduce overhead load from over compression**

A review of all the devices connected to the compressed air system will determine the maximum pressure required by the system. The system pressure should be set to the maximum pressure that is required and not any higher.
Estimated conservation potential: 10% of compressor motor electricity consumption

Baseload Reduction **Reduce overhead load from misapplication**

Compressed air is often used for applications that can be executed with more energy efficient equipment such as low-power blower fans. Commercial bakeries should use blower fans in place of compressed air for applications such as drying pans, conveyor gap transfer assistance, and crumb blow-off.
Estimated conservation potential: 10 - 30% of portion of compressed air motor load replaced

Baseload Reduction **Reduce overhead load from equipment design**

Air intake for air compressors should be taken from the coldest source available. Generally, this would be from outside the building on the north or east side. This air will be the densest source and will require the least amount of energy to compress to operating pressure.
Estimated conservation potential: 5 - 20% of compressor motor load (seasonal influence)

3 Meat Processing

Primary meat processing most commonly involves the slaughter and dressing of beef, pork, lamb, or veal. Some primary meat processors may also act as secondary meat processors by preparing the meat into prime cuts for distribution to retailers. Primary meat processing starts early in the day and is a batch process. The daily cycle is split into two shifts because the abattoir needs to be disinfected after each batch of meat is processed. Typically, an 8 hour meat processing shift is followed by a 16 hour cleaning and disinfecting shift. During the meat processing shift, live animals enter the building in the abattoir where they are slaughtered and dressed. Each carcass is then cleaned with hot water and sterilized with steam. The carcasses must be cooled and dried before secondary processing into prime cuts. This task is accomplished by placing the carcasses on a slow moving conveyor that moves through a refrigerated warehouse. The cooling process can take up to two days because of the poor thermal conductivity of meat. The slow cooling process also allows the meat to tenderize before it is cut into smaller pieces for packaging and distribution. After the daily processing shift is completed, the entire processing area is cleaned and sterilized to ensure the next batch of carcasses can be processed safely.

The main energy end uses at a meat processing plant are refrigeration and water heating. Operations with simultaneous heating and cooling requirements are often energy inefficient, but also offer opportunities to reduce heating costs through waste heat recovery.

3.1 Process Heating

Large quantities of hot water and steam throughout the day to clean and disinfect the carcasses, tools, and machinery.

Baseload Reduction **Recover heat from refrigeration compressors and condensers**
Waste heat from the refrigeration compressors and condensers should be used to preheat fresh make-up water for the hot water heaters and/or steam boilers.
Estimated conservation potential: 10 - 30% of water heating load

3.2 Process Cooling

The introduction of a huge mass of warm carcasses to the refrigerated warehouse requires a refrigeration response that represents the largest electrical energy process.

Baseload Reduction **Use variable speed drives to eliminate the overhead load**
The refrigeration load of the warehouse varies substantially throughout the day and year as conditions change due to batch loading and seasonal weather variations. The refrigerant compressors should therefore employ variable speed drives to eliminate the overhead load associated with idling. Additionally, the variable speed drives should be paired with an automated master controller to coordinate the staging of multiple refrigerant compressors.
Estimated conservation potential: 10 - 30% of refrigeration compressor load

Load Shifting **Employ load shifting to reduce peak refrigeration consumption**
Because meat processing plants typically experience their largest refrigeration load early in the morning, the large thermal mass of the refrigerated warehouse should be pre-cooled overnight to reduce the daytime peak. This load shifting strategy also benefits from the fact that the refrigeration system can operate more efficiently overnight, when outdoor temperatures are lower.
Estimated conservation potential: $14.00 charge reduction per kW of monthly shifted demand

3.3 Machine Drives

High pressure pumps are needed to carry out cleaning and disinfecting tasks.

Driver Alignment **Align pump to header pressure driver**

Water demand for cleaning and disinfecting varies throughout the day due to the cyclical nature of batch processing. The pump motor should be controlled by a variable speed drive in order to vary the pump capacity through a wide range of flow requirements. The controller can maintain a high pressure in the header while varying the flow capacity to meet demand.
Estimated conservation potential: 10 - 30% of pump motor electricity consumption

3.4 HVAC

Abattoir

Most meat processing facilities do not air condition the operating areas of the plant. Instead, employee comfort relies on moving fresh air through the building to remove the heat and humidity produced by the processing equipment and carcasses.

Baseload Reduction **Reduce building heating load through heat exchange**

During the winter, fresh make-up air should be pre-heated by passing through an air to air heat exchanger with the warm exhaust air.
Estimated conservation potential: 30 - 60% of heating load

Refrigerated Warehouse

The cold storage warehouse is separated from the non-refrigerated area by insulated panels, vapour barriers, and doors. The warehouse requires ventilation to provide fresh air to the workers while simultaneously removing the exhaust produced by fork trucks.

Baseload Reduction **Reduce cooling load through heat exchange**

Fresh air exchange is necessary year round to dry the carcasses as they cool. During the summer, a heat exchanger should be used to cool the incoming fresh air with the air being exhausted from the refrigerated warehouse.
Estimated conservation potential: 30 - 60% of air cooling load

3.5 Lighting

Lighting generally makes up a small portion of energy costs for a meat processing plant, and is primarily required in the abattoir which is constantly occupied by either the processing crew or the cleaning crew.

Baseload Reduction **Use efficient lighting**

LEDs are generally the most efficient and cost-effective lighting technology currently available on the market. Therefore, LEDs should be used throughout the meat processing plant, and especially in highly occupied areas such as the abattoir. In addition to lowering lighting costs, LEDs will minimize the lighting system’s contribution of heat to the refrigerated warehouse, leading to lower cooling costs.
Estimated conservation potential: 50 - 60% of lighting load

Driver Alignment **Align lighting to occupancy**
Occupancy should be the first consideration for whether or not lights are turned on inside buildings. Lights can be controlled by various methods including standard operating procedures, timers fixed to work schedules, or occupancy detection technologies.
Estimated conservation potential: 10 - 90% of space lighting electricity consumption

Driver Alignment **Align outside lighting to darkness**
Outside lighting is used for safety and security and is mostly found along the periphery of the building as well as in parking lots. If outside lighting is not controlled automatically, it can represent a significant overhead load. Outside lighting should always be controlled by photo sensors.
Estimated conservation potential: 40 - 60% of outside lighting electricity consumption

3.6 Compressed Air

Air compressors are used to supply a header system that in turn supplies air for various end uses such as pneumatic cylinders, packaging equipment, and instrumentation.

Baseload Reduction **Eliminate unnecessary overhead loads**
The unpredictable use of air from moment to moment results in variable flow of air in the system. If a fixed speed drive is used for the compressor, an overhead load is created since the compressor will idle on and off to meet the needs of the air systems. Instead of idling on and off, motors with variable speed drives can be shut down when compressed air demands are low due to their comparatively low in-rush currents. Therefore, a variable speed drive should be used to eliminate idling loads by more efficiently following the load profile of the compressed air system.
Estimated conservation potential: 10 - 30% of motor load

Driver Alignment **Align air compression to plant operation**
If the plant is not running then the compressor system should be shut down. This practice can be implemented by introducing new standard operating procedures or through system interlocks.
Estimated conservation potential: 1 day per week or 5 - 14% of compressor motor electricity consumption

Baseload Reduction **Reduce overhead load from over compression**
A review of all the devices connected to the compressed air system will determine the maximum pressure required by the system. The system pressure should be set to the maximum pressure that is required and not any higher.
Estimated conservation potential: 10% of compressor motor electricity consumption

Baseload Reduction **Reduce overhead load from equipment design**
Air intake for air compressors should be taken from the coldest source available. Generally, this would be from outside the building on the north or east side. This air will be the densest source and will require the least amount of energy to compress to operating pressure.
Estimated conservation potential: 5 - 20% of compressor motor load (seasonal influence)

4 Plastic Injection Moulding

Plastic injection moulding (IM) is a manufacturing process that produces parts by injecting molten plastic into a mould. The process begins when small plastic pellets are fed into the barrel of the injection unit through a hopper. Once inside the barrel, a reciprocating screw serves to mix and heat the pellets as they are transported to the front of the injection unit. The shearing action of the reciprocating screw provides the majority of the heat required to melt the plastic pellets, while supplemental heat is provided by heating bands that envelope the barrel. A plunger forces the molten plastic at the front of the injection unit into the cavity of the mould, where it quickly solidifies thanks to a series of cooling channels just below the surface of the mould. The two halves of the mould are then separated and the finished part is removed. The mould then closes, and the process repeats.

Since daily production numbers depend on a quick turn-around of the mould, each mould undergoes numerous cycles of rapid heating and cooling, which generates a significant amount of waste heat. Rather than being reused, this waste heat is typically removed from the plant by the ventilation system or a cooling tower.

4.1 IM Process Operation

Plastic injection moulding is a unique segment in that process heating, process cooling, and machine drives are all integrated in a single injection moulding machine. Therefore, there is little opportunity to disaggregate heating (mechanical shear heating, thermal addition through barrel heating), hydraulic injection of the melt into the mould, or mould heating and cooling cycles because of the inherent design of the injection moulding machine as a packaged unit.

Load Shifting **Implement a start-up sequence to minimize peak electricity demand**

Injection moulding plants typically employ many injection moulding machines, with each machine responsible for manufacturing a unique part. It is rare, however, for all of these machines to run simultaneously due to scheduled down time for maintenance, mould changes, or lack of orders for certain parts. A start-up sequence should be implemented for the injection moulding machines to ensure that the peak electricity demand is not being caused by starting multiple machines simultaneously. If possible, the down time of machines should be scheduled to coincide with utility peak demand times.

Estimated conservation potential: $14.00 per kW per month, shifted demand, charge reduction

Baseload Reduction **Eliminate overhead load of fan in cooling tower**

Plastic injection moulding operations typically run several machines that dissipate varying amounts of heat. As a result, the cooling load varies throughout the day as the number of operating machines varies. The warm water returning from the process is typically cooled in a wet cooling tower and circulated back into the building for distribution as a coolant. The cooling tower fan should be equipped with a variable speed drive to efficiently follow the variable cooling load.

Estimated conservation potential: 10 - 30% of total fan motor load

Driver Alignment **Bypass idle equipment**

At various times throughout the production day, machines will remain idle while they are serviced or are transitioning to a different mould. Bypass valves should be installed to allow the cooling system to bypass any idle machinery, thereby reducing the cooling load as well as the load on the pumps circulating the coolant.

Estimated conservation potential: proportional to % flow reduction of circulation pump electricity consumption

4.2 HVAC

Operating Areas

The operating areas of injection moulding plants are usually large open spaces that share a common ventilation system. Although excess heat is generated at each moulding machine as a by-product of the process, the operating areas are generally not air conditioned. Instead, employee comfort relies on moving fresh air through the building to remove the heat produced by the equipment and to dilute any off-gassing from the plastic parts. During the winter, the building heating may be supplemented with spot heating.

Baseload Reduction **Collect contaminants at source**

Gas fumes and exhaust heat from the moulds are generally diluted by a constant stream of fresh air being introduced to the operating area, and are eventually exhausted from the building by the ventilation system. This strategy increases the energy consumed for ventilation, and also leads to higher heating costs during the winter. Instead, contaminants should be removed in a concentrated form by installing local exhaust hoods as close to the source as possible. This strategy will reduce the fresh air make-up requirements of the building, thereby reducing ventilation and space heating energy.
Estimated conservation potential: 10 - 20% reduction of fresh air flow/heating

Driver Alignment **Align ceiling fan use to season**

During the summer, ceiling fans should be turned off to allow temperature stratification in the operating area. Warm air can then be exhausted from the building at ceiling level, while cooler fresh air is added at the operator level to maximize the cooling effect. If necessary, localized fans should be used to provide additional spot cooling of the machine operators.
Estimated conservation potential: 100% of cooling fan motor cost during summer season

Baseload Reduction **Reduce building heating load through heat exchange**

During the winter, fresh make-up air should be pre-heated by the warm exhaust air using an air-to-air heat exchanger. Ceiling fans should be used to push warm air from the ceiling level towards the operators at floor level.
Estimated conservation potential: 30 - 60% of heating load

Conditioned Spaces

Office areas, lunch rooms, and other rooms that are heated during the winter and cooled during the summer are usually separated from the production area's ventilation system. These areas should follow the general best practises of office buildings.

Baseload Reduction **Reduce HVAC energy use through heat exchange**

Fresh air exchange is necessary year round for employee health and comfort. Heat exchangers should be used to temper the incoming fresh air with the building's exhaust air to lower the heating and cooling costs of conditioned spaces.
Estimated conservation potential: 30 - 60% of heating/cooling load

Driver Alignment **Align cooling to occupancy**

Occupancy should drive the need for cooling, and therefore the cooling system should be turned off at night and during weekends or holidays. Cooling can be controlled by various methods but the most common is to implement an occupancy schedule through a programmable controller.
Estimated conservation potential: 30 - 50% of cooling load electricity consumption

Driver Alignment **Align heating to occupancy**

Occupancy should also drive the need for heating, and therefore the heating set-points should be lowered at night and during weekends or holidays. Heating can be controlled by various methods but the most common is to implement an occupancy schedule through a programmable controller. For electrically heated buildings, the heating set-point should be slowly ramped up in the morning before workers arrive to avoid creating a demand peak.

Estimated conservation potential: 5 - 10% of heating load consumption

4.3 Lighting

Lighting generally makes up a small portion of energy costs for plastic injection moulding plants, but standard best practices for lighting should be followed nonetheless.

Baseload Reduction **Use efficient lighting**

LEDs are generally the most efficient and cost-effective lighting technology currently available on the market. Therefore, LEDs should be used throughout the injection moulding plant, and especially in highly occupied areas such as the operating area. In addition to lowering lighting costs, LEDs will minimize the lighting system's contribution of heat to unconditioned spaces such as the operating area, which will increase the comfort of the workers.

Estimated conservation potential: 50 - 60% of lighting load

Driver Alignment **Align lighting to occupancy**

Occupancy should be the first consideration for whether or not lights are turned on inside buildings. Lights can be controlled by various methods including standard operating procedures, timers fixed to work schedules, or occupancy detection technologies.

Estimated conservation potential: 10 - 90% of space lighting electricity consumption

Driver Alignment **Align outside lighting to darkness**

Outside lighting is used for safety and security and is mostly found along the periphery of the building as well as in parking lots. If outside lighting is not controlled automatically, it can represent a significant overhead load. Outside lighting should always be controlled by photo sensors.

Estimated conservation potential: 40 - 60% of outside lighting electricity consumption

4.4 Compressed Air

Air compressors are used in plastic injection moulding plants to supply air for end uses such as part sorting on sub-assembly lines, and for separating finished parts from moulds using ejector pins.

Baseload Reduction **Eliminate unnecessary overhead loads**

The unpredictable use of air from moment to moment results in variable flow of air in the system. If a fixed speed drive is used for the compressor, an overhead load is created since the compressor will idle on and off to meet the needs of the air systems. Instead of idling on and off, motors with variable speed drives can be shut down when compressed air demands are low due to their comparatively low in-rush currents. Therefore, a variable speed drive should be used to eliminate idling loads by more efficiently following the load profile of the compressed air system.

Estimated conservation potential: 10 - 30% of motor load

Driver Alignment **Align air compression to plant operation**

If the plant is not running then the compressor system should be shut down. This practice can be implemented by introducing new standard operating procedures or through system interlocks.

Estimated conservation potential: 1 day per week or 5 - 14% of compressor motor electricity consumption

Baseload Reduction **Reduce overhead load from over compression**

A review of all the devices connected to the compressed air system will determine the maximum pressure required by the system. The system pressure should be set to the maximum pressure that is required and not any higher.

Estimated conservation potential: 10% of compressor motor electricity consumption

Baseload Reduction **Reduce overhead load from misapplication**

Compressed air is often used for applications that can be executed with more energy efficient equipment such as low-power blower fans. Plastic injection moulding plants should use blower fans in place of compressed air for applications such as part sorting on sub-assembly lines.

Estimated conservation potential: 10 - 30% of portion of compressed air motor load replaced

Baseload Reduction **Reduce overhead load from equipment design**

Air intake for air compressors should be taken from the coldest source available. Generally, this would be from outside the building on the north or east side. This air will be the densest source and will require the least amount of energy to compress to operating pressure.

Estimated conservation potential: 5 - 20% of compressor motor load (seasonal influence)

5 Metal Fabrication

Metal fabrication shops involve a variety of internal processes depending on the final product being produced, but generally involve some form of cutting, bending, and assembling. Common metal fabrication processes include forging, forming, cold rolling, punching, bending, stamping, and welding, while some aspects of heat treatment, annealing, and tempering may also be required.

Metal fabrication shops often specialize in manufacturing a single specialized product or may produce a variety of similar products. Each metal fabrication shop has its own suite of process equipment that interacts with the building systems in a unique way. If left unchecked, these interactions between the process equipment and the HVAC system can lead to an inefficient use of energy within the shop.

5.1 Process Heating

Welding, tempering, and annealing processes give off heat that is generally released into the operating area of the shop. Tempering may involve air cooling or water quenching the metal pieces depending on the desired strength and hardness characteristics. Some welding processes also release smoke particles that must be exhausted from the building.

Baseload Reduction **Reduce HVAC load by collecting excess process heat at source**

Waste heat from welding, tempering, and annealing processes is typically absorbed by the building air and is eventually exhausted by the ventilation system. As a result, increased ventilation rates are required to cool the building during the summer. The fabrication shop’s exhaust vents should be located as close as possible to sources of waste heat so that unwanted heat can be removed from the building in a concentrated form.

Estimated conservation potential: 10 - 20% reduction of fresh air flow/heating

5.2 Process Cooling

Cooling water is circulated through the fabrication shop and is used to quench hot metal as part of the welding, tempering, and annealing processes.

Baseload Reduction **Eliminate overhead load of fan in cooling tower**

Most metal fabrication shops receive production orders at irregular intervals, and as a result the cooling load may vary from one day to the next. The warm cooling water returning from the operating area is typically re-cooled by a cooling tower and circulated back into the building for distribution as a coolant. The cooling tower fan should be equipped with a variable speed drive to efficiently follow the variable cooling load.

Estimated conservation potential: 10 - 30% of total fan motor load

5.3 Machine Drives

Metal fabrication shops employ several machines including rolling mills and conveyers.

Driver Alignment **Align machine run times to production**

Machine drives rarely change speeds in multi-step metal fabrication production lines. Once a process is set up to achieve the optimal balance between product quality and throughput, the machines will be set to run continuously at this optimal rate. Machine run times should be optimally scheduled to minimize energy consumption from idling.

Estimated conservation potential: 1 hour per day or 4% of motor electricity consumption

5.4 HVAC

Fabrication Shop

Multi-step fabrication lines typically do not air condition the operating area of the building. Employee comfort relies on moving fresh air through the building to remove heat produced by the processing equipment.

Baseload Reduction **Reduce HVAC load by collecting contaminants at source**

Gas fumes from tempering and annealing are diluted as they mix with air from the shop and are eventually exhausted from the building by the ventilation system. This increases the need for more ventilation in the building. Metal fabrication shops should consider using spot ventilation as close to the source as possible so that contaminants can be removed in a concentrated form, thereby diminishing the requirements for fresh make-up air and thus diminishing both fan and heating energy.
Estimated conservation potential: 10 - 20% reduction of fresh air flow/heating

Driver Alignment **Align ceiling fan use to season**

During the summer, ceiling fans should be turned off to allow temperature stratification in the operating area. Warm air can then be exhausted from the building at ceiling level, while cooler fresh air is added at the operator level to maximize the cooling effect. If necessary, localized fans can be used to provide additional spot cooling of the machinists.
Estimated conservation potential: 100% of cooling fan motor cost during summer season

Baseload Reduction **Reduce wintertime heating load through heat exchange**

During the winter, fresh make-up air should be pre-heated by the warm exhaust air using an air-to-air heat exchanger. Ceiling fans should be used to push warm air from the ceiling level towards the machinists at floor level.
Estimated conservation potential: 30 - 60% of heating load

Air Conditioned Spaces

Office areas, lunch rooms, and other rooms that are heated during the winter and cooled during the summer are usually separated from the production area's ventilation system. These areas should follow the general best practises of office buildings.

Baseload Reduction **Reduce HVAC energy use through heat exchange**

Fresh air exchange is necessary year round for employee health and comfort. Heat exchangers should be used to temper the incoming fresh air with the building's exhaust air to lower the heating and cooling costs of conditioned spaces.
Estimated conservation potential: 30 - 60% of heating/cooling load

Driver Alignment **Align heating to occupancy**

Occupancy should also drive the need for heating, and therefore the heating set-points should be lowered at night and during weekends or holidays. Heating can be controlled by various methods but the most common is to implement an occupancy schedule through a programmable controller. For electrically heated buildings, the heating set-point should be slowly ramped up in the morning before workers arrive to avoid creating a demand peak.
Estimated conservation potential: 5 - 10% of heating load consumption

Driver Alignment **Align cooling to occupancy**

Occupancy should drive the need for cooling, and therefore the cooling system should be turned off at night and during weekends or holidays. Cooling can be controlled by various methods but the most common method is to implement an occupancy schedule through a programmable controller.
Estimated conservation potential: 30 - 50% of cooling load electricity consumption

5.5 Lighting

The building that houses the metal fabrication shop is subjected to sources of waste heat year-round. Lighting adds heat to the building through the inefficient conversion of electricity to light. Winter space heating is more cost-effective through heat pump or gas heating sources than indirectly through lighting losses.

Baseload Reduction **Use efficient lighting**

LEDs are generally the most efficient and cost-effective lighting technology currently available on the market. Therefore, LEDs should be used throughout the metal fabrication shop, and especially in highly occupied areas such as the operating area. In addition to lowering lighting costs, LEDs will minimize the lighting system's contribution of heat to unconditioned spaces such as the operating area, which will increase the comfort of the workers.
Estimated conservation potential: 50 - 60% of lighting load

Driver Alignment **Align lighting to occupancy**

Occupancy should be the first consideration for whether or not lights are turned on inside buildings. Lights can be controlled by various methods including standard operating procedures, timers fixed to work schedules, or occupancy detection technologies.
Estimated conservation potential: 10 - 90% of space lighting electricity consumption

Driver Alignment **Align outside lighting to darkness**

Outside lighting is used for safety and security and is mostly found along the periphery of the building as well as in parking lots. If outside lighting is not controlled automatically, it can represent a significant overhead load. Outside lighting should always be controlled by photo sensors.
Estimated conservation potential: 40 - 60% of outside lighting electricity consumption

5.6 Compressed Air

Air compressors are primarily used in metal fabrication shops to supply air for end uses such as pneumatic cylinders and various other types of instrumentation.

Driver Alignment **Align air compression to plant operation**

If the plant is not running then the compressor system should be shut down. This practice can be implemented by introducing new standard operating procedures or through system interlocks.
Estimated conservation potential: 1 day per week or 5 - 14% of compressor motor electricity consumption

Baseload Reduction **Reduce overhead load from over compression**

A review of all the devices connected to the compressed air system will determine the maximum pressure required by the system. The system pressure should be set to the maximum pressure that is required and not any higher.
Estimated conservation potential: 10% of compressor motor electricity consumption

Baseload Reduction **Eliminate unnecessary overhead loads**

The unpredictable use of air from moment to moment results in variable flow of air in the system. If a fixed speed drive is used for the compressor, an overhead load is created since the compressor will idle on and off to meet the needs of the air systems. Instead of idling on and off, motors with variable speed drives can be shut down when compressed air demands are low due to their comparatively low in-rush currents. Therefore, a variable speed drive should be used to follow the load profile, thereby eliminating overhead loads caused by idling.

Estimated conservation potential: 10 - 30% of motor load

Baseload Reduction **Reduce overhead load from equipment design**

Air intake for air compressors should be taken from the coldest source available. Generally, this would be from outside the building on the north or east side. This air will be the densest source and will require the least amount of energy to compress to operating pressure.

Estimated conservation potential: 5 - 20% of compressor motor load (seasonal influence)

6 Machining

Machining operations generally use lathes, milling machines, and drill presses to cut a material (usually metal) into a desired final shape and size by a controlled material-removal process. The machining industry is largely automated today with different types of CNC machines performing most material-removal tasks. CNC machines are self-contained programmable machines that are able to execute a variety of machining operations to produce final machined products. The machining process typically involves an operator passing the stock material through a series of CNC machines to achieve the desired final product.

Some machining operations produce a single specialized product, while others produce a variety of similar products. The energy profile of each machine shop is slightly different but in general, machine shops require the building systems to interact with the process systems. Depending on the type of product being manufactured, there may be a need to exhaust fumes, dust, or humidity from the building. These interactions can lead to an inefficient use of energy within the building.

6.1 Process Heating

Process heating is very minimal in machining operations. If heat treating is required before or after the parts are machined, it is likely to take place at a separate facility.

6.2 Process Cooling

Friction between the machining tool and the workpiece can generate an insignificant amount of heat. Original equipment manufacturers (OEMs) design CNC machines that will include an integrated cooling system if necessary. Process energy management opportunities are therefore found in the HVAC system and not in disaggregating an OEM design.

6.3 Machine Drives

CNC machines are a complex bundle of energy consumers that either draw power from one main motor drive or smaller ancillary drives.

Driver Alignment **Align machine running time to production**

Ancillary services such as lubrication pumps, cooling water, hydraulic pumps, and electronic controls run as a collective unit while the CNC machines are operating. These ancillary services should be turned off any time production stops to reduce their contribution to the machine shop's overhead load.
Estimated conservation potential: 1 hour per day or 4% of motor capacity electricity consumption

6.4 HVAC

Machine Shop Ventilation

Most machining operations do not air condition the operating areas of the plant. Employee comfort relies on moving fresh air throughout the building to remove the heat produced by the machinery.

Baseload Reduction **Reduce wintertime heating load through heat exchange**

During the winter, fresh make-up air should be pre-heated by the warm exhaust air using an air-to-air heat exchanger.
Estimated conservation potential: 30 - 60% of heating load

Baseload Reduction **Reduce HVAC load by collecting contaminants at source**

Some machine shops require painting of the products. Paint particulate and fumes need to be exhausted from the building by ventilation systems, which leads to increased ventilation rates and higher energy costs for heating and cooling. During the summer, plants should consider using louvered openings at floor level to supply make-up air while simultaneously providing employee cooling. During the winter, plants should consider using spot ventilation as close to the source as possible so that contaminants can be removed in a concentrated form, thereby diminishing both fan and heating energy.
Estimated conservation potential: 10 - 20% reduction of fresh air flow/heating

Driver Alignment **Align ceiling fan use to season**

During the summer, ceiling fans should be turned off to promote temperature stratification in the operating area. Warm air can then be exhausted from the building at ceiling level, while cooler make-up air is added at the operator level to maximize the cooling effect. If necessary, localized fans can be used to provide additional spot cooling of employees on the operating floor. During the winter, ceiling fans should be used to push warm air from the ceiling level towards the machinists at floor level.
Estimated conservation potential: 100% of cooling fan motor cost during summer season

Air Conditioned Spaces

Office areas, lunch rooms, and other rooms that are heated during the winter and cooled during the summer are usually separated from the production area's ventilation system. These areas should follow the general best practises of office buildings.

Baseload Reduction **Reduce HVAC energy use through heat exchange**

Fresh air exchange is necessary year round for employee health and comfort. Heat exchangers should be used to temper the incoming fresh air with the building's exhaust air to lower the heating and cooling costs of conditioned spaces.
Estimated conservation potential: 30 - 60% of heating/cooling load

Driver Alignment **Align cooling to occupancy**

Occupancy should drive the need for cooling, and therefore the cooling system should be turned off at night and during weekends or holidays. Cooling can be controlled by various methods but the most common is to implement an occupancy schedule through a programmable controller.
Estimated conservation potential: 30 - 50% of cooling load electricity consumption

Driver Alignment **Align heating to occupancy**

Occupancy should also drive the need for heating, and therefore the heating set-points should be lowered at night and during weekends or holidays. Heating can be controlled by various methods but the most common is to implement an occupancy schedule through a programmable controller. For electrically heated buildings, the heating set-point should be slowly ramped up in the morning before workers arrive to avoid creating a demand peak.
Estimated conservation potential: 5 - 10% of heating load consumption

6.5 Lighting

The building that houses the machine shop is subjected to sources of waste heat year-round. Lighting adds heat to the building through the inefficient conversion of electricity to light. Winter space heating is more cost-effective through heat pump or gas heating sources than indirectly through lighting losses.

Baseload Reduction **Use efficient lighting**

LEDs are generally the most efficient and cost-effective lighting technology currently available on the market. Therefore, LEDs should be used throughout the machine shop, and especially in highly occupied areas such as the operating area. In addition to lowering lighting costs, LEDs will minimize the lighting system's contribution of heat to unconditioned spaces such as the operating area, which will increase the comfort of the workers.
Estimated conservation potential: 50 - 60% of lighting load

Driver Alignment **Align lighting to occupancy**

Occupancy should be the first consideration for whether or not lights are turned on inside buildings. Lights can be controlled by various methods including standard operating procedures, timers fixed to work schedules, or occupancy detection technologies.
Estimated conservation potential: 10 - 90% of space lighting electricity consumption

Driver Alignment **Align outside lighting to darkness**

Outside lighting is used for safety and security and is mostly found along the periphery of the building as well as in parking lots. If outside lighting is not controlled automatically, it can represent a significant overhead load. Outside lighting should always be controlled by photo sensors.
Estimated conservation potential: 40 - 60% of outside lighting electricity consumption

6.6 Compressed Air

Air compressors are used in machine shops to supply air for end uses such as pneumatic controls, part cleaning, and metal chip removal.

Baseload Reduction **Eliminate unnecessary overhead loads**

The unpredictable use of air from moment to moment results in variable flow of air in the system. If a fixed speed drive is used for the compressor, an overhead load is created since the compressor will idle on and off to meet the needs of the air systems. Instead of idling on and off, motors with variable speed drives can be shut down when compressed air demands are low due to their comparatively low in-rush currents. Therefore, a variable speed drive should be used to follow the load profile, thereby eliminating overhead loads caused by idling.
Estimated conservation potential: 10 - 30% of motor load

Driver Alignment **Align air compression to plant operation**

If the plant is not running then the compressor system should be shut down. This practice can be implemented by introducing new standard operating procedures or through system interlocks.
Estimated conservation potential: 1 day per week or 5 - 14% of compressor motor electricity consumption

Baseload Reduction **Reduce overhead load from over compression**

A review of all the devices connected to the compressed air system will determine the maximum pressure required by the system. The system pressure should be set to the maximum pressure that is required and not any higher.
Estimated conservation potential: 0 - 10% of compressor motor electricity consumption

Baseload Reduction **Reduce overhead load from misapplication**

Compressed air is often used for applications that can be executed with more energy efficient equipment such as low-power blower fans. Machine shops should use energy efficient blower fans in place of compressed air for applications such metal chip removal.

Estimated conservation potential: 10 - 30% of portion of compressed air motor load replaced

Baseload Reduction **Reduce overhead load from equipment design**

Air intake for air compressors should be taken from the coldest source available. Generally, this would be from outside the building on the north or east side. This air will be the densest source and will require the least amount of energy to compress to operating pressure.

Estimated conservation potential: 5 - 20% of compressor motor load (seasonal influence)