

Energy Savings in Blast Chillers using *EnviroStart* Motor Energy Controllers

Macrae Foods Limited - Fraserburgh

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MACRAE®

George Grant PhD CEng

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Background

The Fraserburgh Smokehouse of Macrae Foods Ltd has been smoking fish for over 50 years. Various species of fish are smoked at this site, including: Salmon, Trout, Mackerel, Herring, Haddock, Cod and Shellfish. There is a range of different kilns that accommodate hot, cold and traditional smoking. Once the fish is smoked it is either packed ready for sending out to the retailers or is it used to create a wide variety of different recipes in Macrae's delicatessen.

In common with many UK businesses, energy costs represent one of the most significant overheads incurred by Macrae Foods and there is a recognised need to reduce consumption. Coupled with this, the company is keen to present a responsible environmental stance and recognises the beneficial impact of such an outlook with its own clients and ultimately, the buying public.

A large part of the energy load for Macrae Foods comes from refrigeration and air-conditioning equipment; it is a fact that such equipment does not run under full load continuously and hence there is a potential to save energy through the introduction of intelligent motor control hardware such as the *Envirostart* Motor Energy Control (MEC) units manufactured by EMS (European) Ltd and distributed by Optimal Energies Ltd. As a result of an energy audit conducted on 23rd May 2007 at the Fraserburgh site, potential savings levels of between 8 ~ 17% had been predicted, depending on the application.

Following the issue of the energy audit results, Macrae Foods commissioned Optimal Energies to install a trial MEC unit on a representative item of plant within the Fraserburgh site, in order to obtain 'before vs. after' energy consumption data to demonstrate the effectiveness of the MEC units. Assuming a satisfactory outcome of the trial, it was the intention of Macrae Foods to roll-out the complete installation of all the MEC units recommended in the initial 2007 energy survey.

The following sections describe how the trial installation was carried out and include survey measurements that demonstrate the effectiveness of a three-phase MEC unit in controlling and saving energy on a 45 kW blast chiller unit.

2

How motor energy controls work

AC induction motors run at a fixed speed determined by the number of poles in the motor, and the frequency of the electricity supply. AC motors only run at maximum efficiency and effectiveness when they are running at the plated rating of the motor.

Once the motor starts to run below its maximum plated rating it starts to waste energy and the lower the load measured against plated rating the more inefficient and ineffective the motor becomes, this is usually displayed by the generation of heat and vibration within the motor.

The graph below shows current consumption of the motor with and without energy savings.

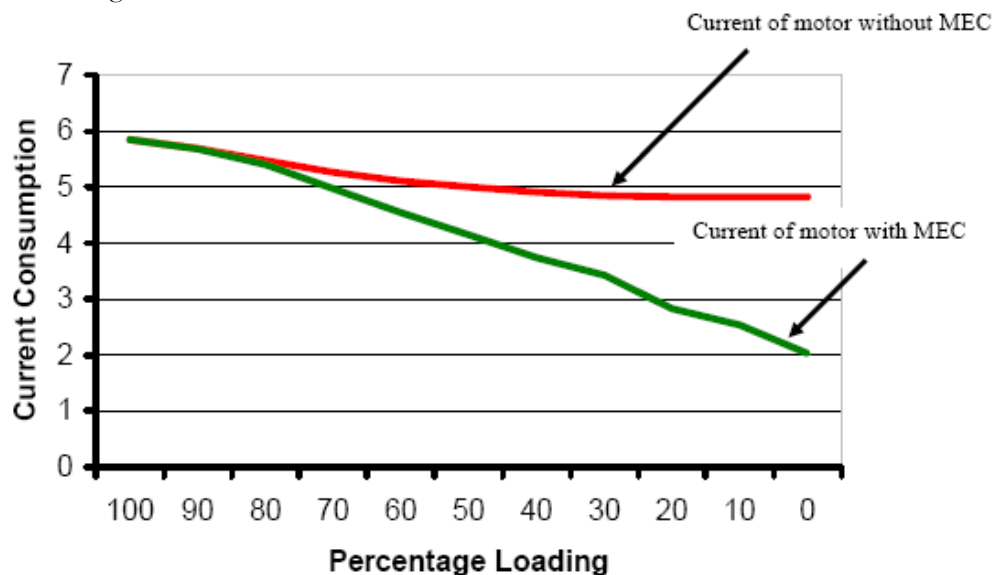
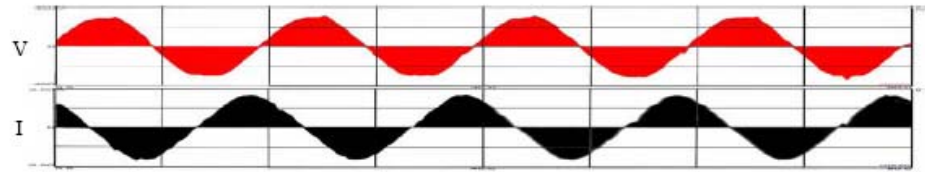


Figure 1: Measured consumption of 0.5 kW single-phase motor

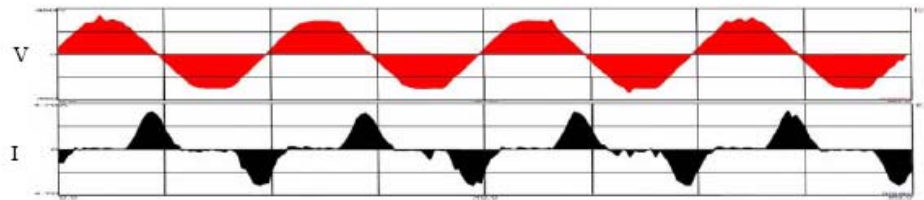
EnviroStart saves energy by sensing when the motor is running off full load by looking at Pf, the phase angle between voltage and current.

The lower the load, the wider the phase angle between voltage and current. *EnviroStart* uses this “positioning” to constantly balance reduction in the supplied voltage to the motor to reduce current consumption thereby reducing the breadth of the phase angle and improving the Pf. This careful “dynamic” adjustment causes the power supplied to the motor to always be in balance with the torque demand of the motor load thereby creating real kW savings within the system without detriment to the motor or reducing the capability of the load itself.

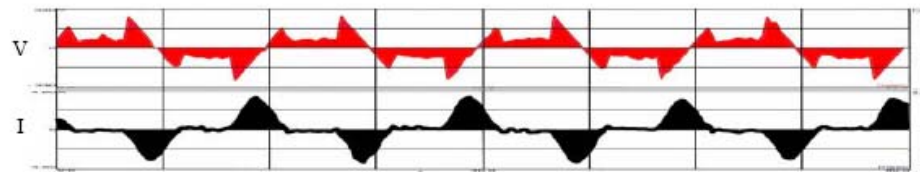
The graphs below show the current and voltage waveforms both with and without energy savings.



Input Voltage and Current – With Energy Savings Disabled



Input Voltage and Current – With Energy Savings Enabled



MEC Output Voltage and Current – With Energy Savings Enabled

Figure 2: Current & voltage waveforms on single-phase motor

Customers of the electricity supply firms pay for kW, which is the integral of the area of the input voltage waveform multiplied by the integral of the area of the current waveform multiplied by the Pf.

As can be seen from Figure 2 above, the areas under both the voltage and current profiles are reduced when the *EnviroStart* unit is in energy saving mode.

On varying load systems such as compressors (both air and refrigeration), injection moulding machines etc, *EnviroStart* will supply the motor sufficient power to ensure the motor maintains the torque required for the job, this is achieved within 5 μ s of any load change. To maintain this response time *EnviroStart* systems operate at 12MHz for single phase and 48MHz for three phase *EnviroStart* units.

3 Fraserburgh site trial installation

3.1

General

The purpose of the trial installation at Macrae's Fraserburgh site was to obtain 'before vs. after' energy consumption data for a representative three-phase blast chiller unit, in order to prove the MEC concept. The unit selected was designated 'Asset#327: Inside Blast Chiller' and was located in a plant room outside the main food processing areas – see Figure 3 below.

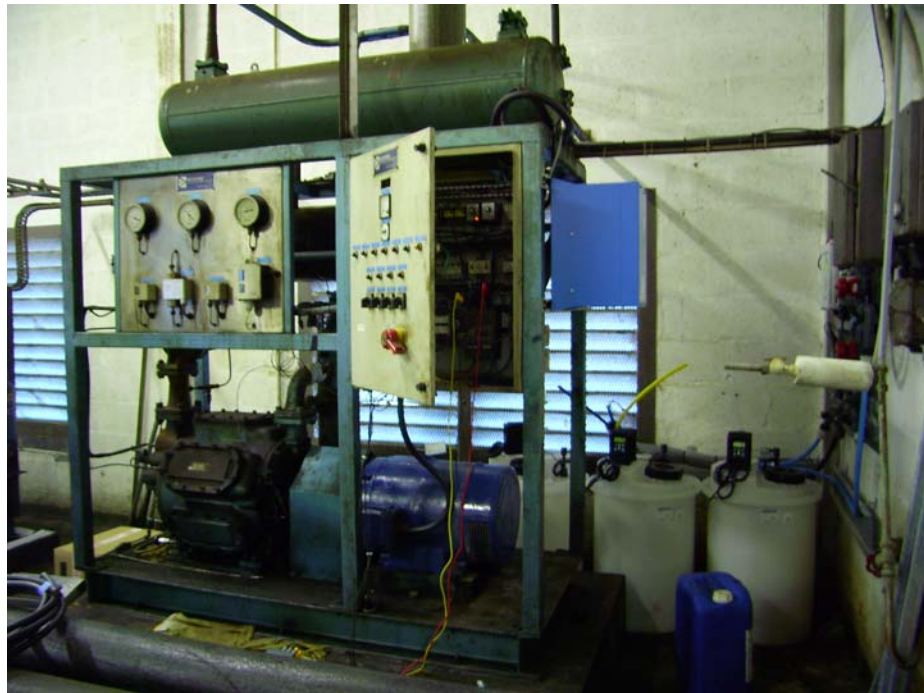


Figure 3: Macrae Foods asset#327 – 'inside blast chiller'

The reciprocating compressor unit is at the lower left of this image and the compressor motor (45 kW) is the blue unit at the lower right hand side. The motor control panel is open above the motor and the *EnviroStart* unit is the blue box mounted on the right hand side of the blast chiller skid assembly.

3.2

EnviroStart MEC installation

For a 45 kW three-phase motor, the recommended standard size of MEC unit is 55 kW; the unit (S/N: TP11672/0608) was installed and commissioned according to the manufacturer's instructions:

<http://www.envirostart.com/documents/EnviroStart%20-%203%20Phase%20MECG6%20Manual%20English%20V2.5%203.8.2007.pdf>



Figure 4: Installation/commissioning of 55 kW MEC unit

Figure 4 above shows the location of the three-phase network analyser (*Circutor*) resting on a cardboard box below the control panel during installation and commissioning of the MEC unit. The *Circutor* analyser has the ability to record the voltage and current for all three supply phases and was used to collect comparative data during commissioning.

3.3

Energy-saving data

Figure 5 below shows the variation in apparent power as measured with the *Circuitor* three-phase network analyser. The graph shows the power profile during a total of five compressor cycles; in all cases, the *EnviroStart* unit was in the motor supply circuit but there were variations in the energy-saving settings:

- Leftmost cycle - energy-saving disabled;
- Second cycle – energy-saving set at ‘40%’;
- Third cycle – energy-saving set at default level (‘25%’);
- Fourth cycle – default setting
- Rightmost cycle – default setting

For the first three cycles, the time delay between successive cycles was 1.5 minutes, however this was extended to 5 minutes for the fourth and fifth cycles to meet the ‘minimum 12 evenly spaced starts per hour’ provision in the MEC technical specification.

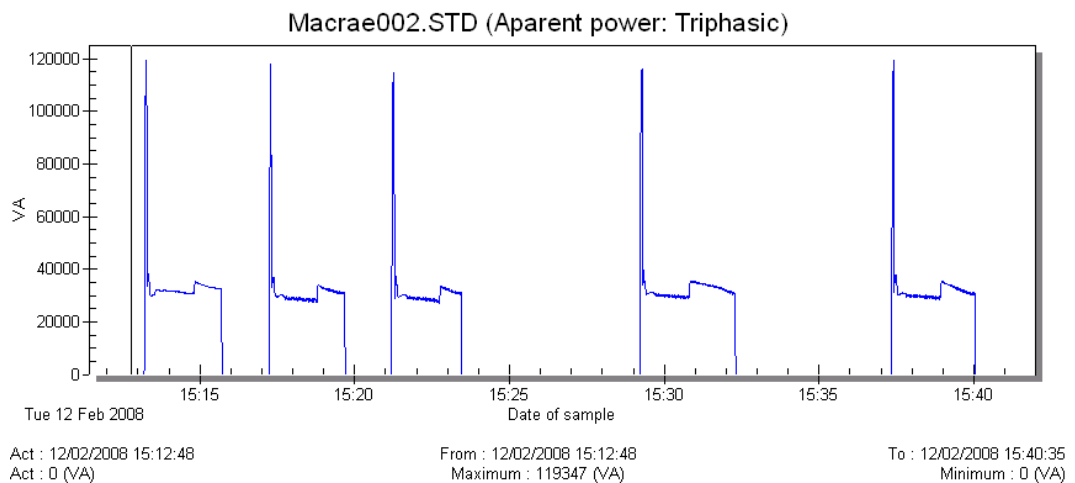
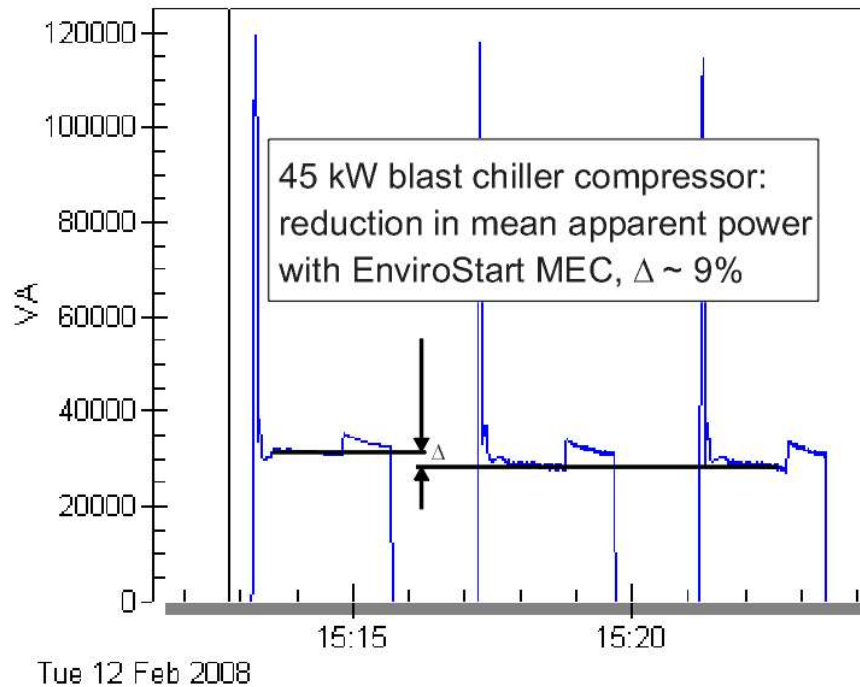


Figure 5: *Circuitor* data for blast chiller apparent power

The levels of savings have been estimated by comparing the apparent power levels in the raw data files and these are summarised in Figure 6 below. The degree of reduction in power consumption is similar in both the second and third cycles when compared with the leftmost profile; both show savings of ~ 9% (e.g. average apparent power decreases from ~ 31.5 kVA to ~ 28.5 kVA) although the data do indicate that the default settings are marginally better.

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Figure 6: Enlarged view of apparent power data for blast chiller

The level of energy-saving is not affected by the change in the control panel timer setting and savings of $\sim 9\%$ are maintained while the MEC is set in default mode.

According to the original audit sheet compiled in May 2007, the expected savings for a blast chiller of this rating were estimated to be 8%, giving a payback period of 0.94 years assuming a unit cost for electricity of $\pounds 0.057/\text{kWh}$. These estimates are supported by the detailed three-phase apparent power data obtained from the 55 kW *EnviroStart* MEC trial described here.

4

Conclusions

- A trial installation of a 55 kW *EmiroStart* MEC unit has been conducted for Macrae Foods on a blast chiller unit rated at 45 kW;
- Energy-saving levels of ~ 9% have been measured when the MEC is in circuit and set to its default configuration. This result confirms the estimated savings (~ 8%) predicted as a result of the earlier energy audit conducted in May 2007;
- Subject to the approval of this report, Macrae Foods is planning to roll-out an MEC installation programme across the entire Fraserburgh site, in line with the recommendations of the 2007 energy audit conducted by Optimal Energies. It is intended that the installation phase be carried out by Macrae's own electrical technicians, however it is recommended that the commissioning of the units be carried out by Optimal Energies' experienced personnel; this service will be offered free of charge as part of the final contract.

Appendix : Motor Energy Control FAQs

Q. How does the EnviroStart Motor Energy Control, (MEC), work?

A. The MEC is an extended Soft Start with some very smart software which enables it to identify when the motor to which it is attached, is running at less than full power. During these times it is possible to reduce both the voltage and the current supplied to the motor without reducing the motor speed. In effect EnviroStart is always providing sufficient, but not too much, torque, continuously adjusting the power to just the right level, analogous in many ways to the cruise control you may have on your car.

Q. What motors is it possible to fit the EnviroStart Motor Energy Control on?

A. It is possible to fit the MEC to any three phase synchronous AC induction motor, (also known as a squirrel cage motor), and any slip-ring motor, (including motors with DC rotor injection start systems).

The single phase systems can be fitted to any AC Induction motor whether with or without capacitor start and with or without capacitor run systems. It is unimportant how new or old the motor is.

Q. Can EnviroStart Motor Energy Controls and Soft Starts be fitted to High Efficiency motors?

A. The simple answer is yes. EnviroStart systems work just as well with high efficiency motors as they do with lower efficiency or older motor types.

Q. What savings can I expect when I fit an EnviroStart Motor Energy Control?

A. This is a very complex question because there are so many aspects to what creates effective savings. Primarily on three phase systems the thing to examine is how much the motor is loaded; that is how much current is it drawing when measured against the full load current specified for that motor. If the motor is running at greater than 75% loaded on average, then it is unlikely that you will get any reasonable savings levels. Below this 75% level the savings increase steadily to peak at around 20% when the motor is around 40% loaded. (Other factors come in to play here such as the line condition, the age and quality of the motor, the ambient temperature etcetera). We have achieved savings of over 35% on certain applications where everything was favourable to savings and the motor was lightly loaded for a great part of its operational time.

On single phase systems the savings that can be achieved are greater because of the inherent simplicity of the motor structure. Typically savings of between 30 - 40% are achievable on applications such as bottle coolers, refrigeration systems and similar. Again loading is the key measure of the likelihood that the system will be positioned to make energy savings.

Q. How long is the warranty of the EnviroStart systems?

A. All EnviroStart units are supplied with a full two year warranty. This does not mean that after this time we will ignore any problems that you have should they arise. We are striving to be the supplier we would like to have supplying us and as such will always respond to a Customers legitimate problems howsoever they are caused.

Q. What is the expected lifetime of the EnviroStart units?

A. All EnviroStart systems are manufactured within the UK to very exacting standards within ISO 9001 qualified facilities. They meet the rigorous standards levelled on them by the various international inspection bodies such as CE and UL and we generally recognise that their lifetime expectancy is around ten years. (The empiric calculations as defined by the IQAB indicate that the MTBF, (Mean Time Between Failure), for our systems, is greater than 100,000 hours, or a little over eleven years).

Q. Does EnviroStart change the motor speed?

A. Not in any way. The EnviroStart Soft Start and Motor Energy Control units are fixed speed controls which do not change the speed of rotation. Rotation speed is determined by the number of poles within the motor and the supply frequency of the current provided to drive the motor. As EnviroStart does not change the frequency of supply and cannot change the number of poles in a motor it is not possible to change the synchronous rotational speed.

Q. How many starts can I allow the system to make per hour?

A. This is a function of the ambient temperature in which the control is operating as well as the size of the motor being started and the load on that motor. The limits are defined on the specification sheets but, because we oversize all of the power components within the EnviroStart units, the number of starts is typically twice that of the competition units.

Q. What is the maximum operating temperature for the EnviroStart units?

A. All EnviroStart's are designed to operate continuously at up to 40DegC without any degradation or de-rating. Above that point there are derating's which have to be applied. For details of these please review the specification sheets associated with the system you are using.

Q. Can the EnviroStart be used in conjunction with a BMS or PLC control system?

A. The Soft Start and Motor Energy Control EnviroStarts have all been designed with ease of operation and application in mind. The control circuits for the "start and stop" function and the "emergency run" function have been designed to allow simple closing of a circuit or alternatively either NPN or PNP, (pull low or pull high), zero-volt drive which will allow any form of PLC to be directly coupled to EnviroStart without interface circuitry of any kind. Additionally we have established a "System Ready" output so that we can feedback ready capability to a PLC control circuit.

Q. Does the EnviroStart radiate or generate harmonic currents?

A. All systems do generate some level of harmonic current. EnviroStart however is designed to minimise the generation of detrimental harmonic currents. Overall the contribution of EnviroStart can be considered to be near zero.

Q. Can EnviroStart be used near other sensitive electronic systems such as PLC controls and BMS systems?

A. Because EnviroStart does not radiate or generate harmonic currents there will be no effect of fitting it close to any other system. Of course with larger motors there will be the effects of induced currents and stray magnetic fields around the feed and supply cabling so normal precautions should be observed in these circumstances.

Q. How environmentally friendly is EnviroStart?

A. EMS (European) are a company dedicated to the reduction of pollution and elimination of waste. The EnviroStart systems have been designed with recyclability in mind so that most of the components within the system are either recyclable or are already using recycled materials. The heatsink and the casing are both made from recycled materials, no toxic components are used in the manufacture and, of course, the Motor Energy Control is designed to save energy which again is environmentally as well as economically friendly.

Q. Can the EnviroStart units be placed outside or in harsh environments?

A. All EnviroStart units meet the expectations of IP43 which means that whilst they will withstand a few drops of rain they will not tolerate a direct shower or a downpour so, if you want to place the units external to a building they should be within another waterproof cabinet which meets the needs of IP55 or greater.

In tropical environments EnviroStart can be provided with full conformal coating to the PCB to meet the needs of very high humidity atmospheres and reduce the possibility of solder bond or component corrosion as a result of high relative humidity.

Optimal Energies Limited

T: +44 (0)788 199 6105

F: +44 (0)1325 520155

E: info@optimal-energies.com

W3: www.optimal-energies.com

Registered Office:

PO Box 15
29 Portland Road
Kilmarnock
Ayrshire
KA1 2BY

Company Registration No. 183625 (Scotland)

