

## Reducing motor drive energy costs

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### The Challenge

Did you know that electric motor drive systems use over half the total power consumed by New Zealand industry and up to 95% of all electricity in some large processing plants?

Because motor drives are large consumers of energy they are an important target for energy and cost savings. A recent study indicates it is

possible to save 20% of the energy consumed by motor drives in New Zealand. This would be worth \$115 million per annum at current electricity prices.

Savings on individual motor drives will vary, but savings of up to 70% are common. For you to achieve a portion of these energy savings you

must take a systems approach. All parts of the motor drive system, particularly the driven load and the process, must be examined for opportunities to save energy costs. In larger plants this systems approach may require you to make it a team effort involving management, process and engineering staff.

### A systems approach to motor drives

Attempts to improve the efficiency of electric motor drives have traditionally tended to focus on the motor itself, and perhaps its controller. This focus may stem from a feeling that the motor is the end user of the energy supplied. In fact, the motor is just another energy conversion device in the chain of energy conversion from the prime mover in the power station. It converts the electrical energy back to mechanical energy to be used by the driven load. The end use is in fact the pumped water, ventilated space or chipped wood at the end of the energy chain.

Too narrow a focus may mean that larger, cost-effective energy savings are being overlooked. A recent study by the Office of Industrial Technologies of the US

Department of Energy (DOE) estimates that only 20% of potential energy savings are associated with improvements in the efficiency of motors and the electrical supply system. To capture the other 80% of potential energy savings it is necessary that a systems approach be taken, with all parts of the motor drive system, including the driven load and process, being considered.

Your motor drive system can be broken into a series of four inter-related component parts:

- **Facility Power Supply System** to deliver electrical power from your power company to the motor drive control system;

- **Motor/Controller Subsystem** comprising a device or devices to control the motor, and the motor itself;
- **Mechanical Subsystem** comprising a drive train to link the motor to the driven load, and the driven load itself;
- the **process** itself, be that circulation of air, pumping of water, or whatever.

## Measures to improve efficiency

### Electrical distribution correction

Measures available to you to improve power quality and reduce electrical losses are:

- Maintain voltage levels as close to the motor nameplate as possible, with a maximum suggested deviation of 5%. (At 5% under voltage, copper losses are increased 10%)
- Minimise phase imbalance within a tolerance of 1%. (3.5% deviation of one phase voltage from average phase voltages increases motor temperature rise by 14% and reduces performance)
- Maintain a high power factor to reduce distribution system losses.
- Avoid excessive harmonic content.
- Use oversize distribution cables in new installations to reduce copper losses. (Using one cable size larger can show paybacks of about one year)

### Motor efficiency improvement

The traditional approach. Measures available to you to improve motor efficiency:

- Specify enhanced efficiency motors in new or burn-out situations. (Approach your power company regarding ECNZ's Motor Selector software)
- Replace reduced efficiency rewind induction motors.
- Control motor drive temperatures.

### Better system matching

Measures available to you include:

- Use an on/off control system using timers, PLCs and so on to provide motor power only when required. (Simple, but amazingly effective in some cases)
- Install a variable speed controller where demand varies, allowing a better match of motor and mechanical

subsystem to process requirements. (This may involve replacing a damper, control valve or other inefficient device)

- Size motors to avoid inefficient low load operation. Motors should run at 65% to 100% full load. (A New Zealand survey found that 50% of motors run at less than 65% load)

### Driven load and process optimisation

Measures that you can take to optimise the process and its operation are:

- Change or reconfigure the process or application so that less input power is required. Look at duct or pipe sizes. Can the process be improved? Does the process require this much energy?
- Downsize oversized pumps, fans, compressors or other driven loads.
- Install more efficient mechanical subsystems. Is your coupling, gearbox, fan or pump efficient?



## Relative size opportunities

The DOE study went on to quantify the average energy saving potential of the opportunities identified.

### The multiplying of downstream efficiency improvements

Consider each measure to improve motor drive efficiency, starting with the process. Process efficiency improvements are always the most effective because energy saved at the end of the drive train is multiplied by the energy efficiencies of all components of the system.

## Opportunities by driven load types

Driven loads are often divided into those with similar characteristics.

**Fans, pumps and blowers** make up the largest driven load class and account for about 55% of motor drive energy. All move fluids so their energy requirements can vary as the cube of speed. Running a pump at half speed uses as little as one-eighth of the power. So, if a fluid is pumped at half the rate for twice the time, the same volume is transported for 25% of the energy. And this is before we consider whether we really have to pump or blow this volume at all!

Further, efficiency differences between different fans, pumps and blowers can be an order of 10 greater than that between different motors.

**Materials handling and processing** account for 40% of motor drive energy, including 10% used by the timber processing industry for refining pulp used in paper and particle board. Efficiency improvements can be large but tend to be process specific, and result from industry-focused research.

**Compressors** account for only 5% of motor energy. Efficiencies vary markedly, especially at low loads. For instance compressors that use interstage coolers can be considerably more efficient than older types. Opportunities also exist for heat recovery, so improving the overall energy efficiency.

## Maintenance

A monitoring and preventive maintenance programme can maximise the reliability and efficiency of your motor drives. Perform periodic checks of motor noise, vibration, temperature, and winding resistance. Check belt tension and lubricate motor components correctly. Maintain motor records including function, technical specifications, typical running currents and voltages, no-load current, repairs carried out, and so on.

## Team approach

The most effective motor drive efficiency programmes have involved a multi-disciplinary team. You will need a team approach in a plant or organisation any size. Where the same staff members are responsible for two or more of the major areas of responsibility, they can play a dual role.

Any substantial improvements in motor drive energy efficiency requires capital investment, which means that management must be represented on the team. In fact the most successful motor drive efficiency programmes have been those that have been initiated by management.

Because the largest energy efficiency improvements involve either the process or matching the motor drive to the process, it is also essential that staff responsible for the process are involved.

Engineering staff on their own can only take the process as a "given" with the consequence that they can only look at the two smallest areas of opportunity identified above. They can be much more effective when they are part of the energy efficiency team. It is most important to appoint an articulate and motivated programme leader who has a good knowledge of your process or industry.

## Audit your motor drives

The first job the team must tackle is to record the details of all motor drives and decide which of the measures to apply. It can be an instructive first step to calculate the annual running cost of each drive and compare it to the value it adds to the product. You may be in for some surprises.

## Implementation

After the team has studied the motor drives in your plant and made recommendations, the task of retrofitting the efficiency measures begins. This may involve such practical tasks as checking whether existing motors are suitable for variable frequency operation, specifying variable frequency controllers that will not cause excessive harmonic effects, assessing process control requirements, and so on. Specialist advice may be required to address some of these issues.

## Key procedures

- Obtain a commitment from management, process and engineering supervisors. Select a programme team from these disciplines and appoint a motivated leader.
- Take a systems approach to motor drive energy savings.
- Start with the process when looking for savings.
- Consider all opportunities for energy saving and optimise your motor drive system.
- Where necessary get specialised consultant advice during the investigation of opportunities.
- Put a monitoring and preventive maintenance programme in place for your motor drives.
- Measure the energy savings and promote the benefits.



Emprove is a service provided by the Energy Efficiency and Conservation Authority (EECA). EECA is a Crown entity working to improve New Zealanders' energy choices.

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