Variable Speed Drives:
Reducing energy costs in meat processing plants
Meat processing plants, like all other commercial operations, are under increasing pressure from rising input costs. With energy being a major contributor to operating costs, optimising plants has become a priority across the sector: A 20% cut in energy costs can represent the same approximate bottom line benefit as a 5% increase in sales.

Meat processing operations can cut energy consumption and reduce energy costs by installing Variable Speed Drives (VSDs) on electricity-driven equipment - reducing a pump’s speed by 20% can reduce energy consumption by more than 50%.

Sector overview

The beef supply chain has become increasingly vertically integrated, a development mainly fueled by the feedlot industry where most of the larger feedlots own their own abattoirs, or at least have some commercial interest in certain abattoirs.

In addition, some feedlots have integrated further down the value chain and sell directly to consumers through their own retail outlets. Some abattoirs have also started to integrate vertically towards the wholesale level.

Currently, many wholesalers source live slaughter animals (excluding weaners) directly from farmers or feedlots on a bid and offer basis. They take ownership and slaughter the animals at an abattoir of their choice, whereafter the carcasses are distributed to retailers.

In some instances, the public can also buy carcasses directly from wholesalers.

The abattoir industry has expanded tremendously in number and capacity. South Africa has approximately 495 abattoirs, divided into those that are:

- Linked to the feedlot and wholesale sector or owned by municipalities; and
- Mainly owned by farmers and SMMEs.
Key facts and figures for South Africa (2011):

- The beef industry as a whole employs 500 000 people; 2 125 000 are dependent on the livestock industry for their livelihood.
- Cattle production has increased by 37 000 heads from 13.5 million in 2004 to 13.87 million in 2011.
- Approximately 60% of cattle are owned by commercial farmers and 40% by emerging and communal farmers.
- 80% of cattle are beef and the remaining 20% dairy.
- Beef is produced throughout South Africa.

Production kilograms depend on quality of grazing, supplementary feeding and infrastructure, such as abattoirs and feedlots, and not necessarily on the number of cattle available in specific areas. South Africa’s highly developed transport infrastructure allows for the movement of cattle and calves from one area to another and even from neighbouring countries.

Beef production is shared as follows:
  - Mpumalanga (23%)
  - Free State (19%)
  - Gauteng (14%)
  - KwaZulu Natal (12%)
  - North West (11%)

- South Africa is a beef importer; beef consumption is higher than production -

<table>
<thead>
<tr>
<th>Year</th>
<th>Head of cattle slaughtered</th>
<th>Production kilograms</th>
<th>Consumption kilograms</th>
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<td>2010/11</td>
<td>2 880 000</td>
<td>819 600 000</td>
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Competitiveness in the sector

Meat processing plants must control operating costs, electricity being one of the major expenses, to remain competitive.

Energy is used in all aspects of meat processing. Aside from lighting, steam and water heating systems, motor-driven equipment contribute significantly to energy consumption and, depending on the type and size of a facility, can include:

- Deharing equipment
- Processing equipment
- Refrigeration equipment
- Air compressors
- Boiler pumps
Installing Variable Speed Drives (VSDs) on motor-driven equipment is one of the most effective energy efficiency interventions to reduce electricity consumption and cut energy costs in meat processing operations.

Beyond lower electricity bills and reduced operating costs, companies that invest in energy efficient equipment such as VSDs enjoy additional benefits such as greater reliability, improved productivity and lower maintenance costs.

What is a VSD?

A VSD, also known as a Variable Frequency Drive (VFD) or adjustable speed drive, is a device that can adjust the frequency to regulate and adapt motor speed to match the actual demand required by the system or application it is driving, resulting in a reduction in energy consumption.

VSDs offer a high degree of motor control, accurately varying motor speed according to demand while also adjusting torque – all within the specifications of a particular manufacturer.

A basic VSD can be used for simple applications - such as to control the speed of a pump or a fan according to the required load. It can also be interfaced with a transducer, such as a pressure or flow-rate sensor, and programmed to maintain a particular setting.

More advanced VSDs can be used for precise speed and torque control in complex applications and can be interfaced with a computing system to provide real-time operating data on the status and performance of a motor.

Slowing down a pump from 100 to 80% can reduce motor energy use by up to 50%.
How does a VSD work?

All VSDs work on the same principle: they convert incoming electricity, which is at a fixed frequency and voltage, into variable frequency and voltage.

When a VSD starts a motor, it initially applies low frequency and voltage, typically 2Hz or less, which avoids the high starting current that occurs when a motor is started using a direct-on-line or star-delta starter method. The applied frequency and voltage are increased at a controlled rate to increase the speed of the motor (load) without excessive current being drawn.

Drives adjust the speed of electric motors to match the actual demand of the application, thereby reducing motor energy consumption by 20 to 50%.

How does a VSD save?

VSDs save energy because they prevent motors from using more electricity than required - many motors are oversized to cope with a maximum demand that rarely or never occurs.

When other control methods are used, such as valves, motors run at full speed and the flow of the output is mechanically restricted. This is wasteful, because the motor keeps running at its nominal speed regardless of demand. A pump, for instance, delivers maximum output and the excess is reduced at the valve where the surplus energy is wasted through friction.

A pump or fan running at half speed, consumes only one eighth of the power compared to one running at full speed, which means a small decrease in speed requires a lot less power.
VSDs deliver accurate control and less mechanical wear, reducing maintenance and extending the life expectancy of systems.

**Applying VSDs in meat processing plants**

**Reducing refrigeration costs**

Refrigeration is used to preserve meat products. Refrigeration, therefore, accounts for a large portion of meat processing costs. As such, improving the energy efficiency of refrigeration systems represents huge opportunities for saving energy.

- Screw and reciprocating compressors and evaporative condensers are widely used throughout industrial refrigeration applications, from cold rooms through to blast freezing.

When refrigeration demand is low, compressors are switched off in sequence and restarted when demand increases. Condenser fans use on/off control and vaporator fans are stop-started as required. This on/off operation is extremely energy inefficient as large amounts of power are required to get a fan up to full speed; every time an electric motor is started conventionally it can consume up to 6 times its normal full load. VSDs have a soft starting function to prevent this from occurring.

VSDs are an excellent tool for optimising the energy consumption of conditioned atmosphere and refrigeration processes. Since cold storages and refrigeration plants typically run 24 hours a day, most refrigeration drive applications are candidates for VSDs - any refrigeration system with a wide variation in operating hours or with variable heat loads that are less than the peak load, can benefit from a VSD.
• VSDs can also be installed on screw compressors, chilled water pumps and condenser fans. Appropriately applied in refrigeration systems, VSDs can achieve huge energy savings and help meat processing plants to cut operating costs and remain competitive.

**Taking the load off ventilation systems**
Ventilation and air conditioning are some of the biggest consumers of electricity in meat processing plants. Even in the case of the most energy efficient systems, VSDs can help to further reduce energy usage by closely matching the speed of the motors that drive these systems with actual demand.

• When ventilation and air conditioning systems need to provide less cooling than the maximum load for which they are sized, VSDs allow the equipment to operate at a lower speed, thereby using less power.

There is a broad range of Variable Speed Drives specifically engineered for ventilation and air conditioning applications. These can be integrated into a variety of building management systems (BMS) to improve the flexibility and optimise the efficiency of systems.

• In ventilation and air conditioning systems for large buildings, VSDs on fans save energy by matching the volume of air moved to the system demand.

**Improving the energy efficiency of compressors**
Air compressors are used to run air knives, animal handling apparatus and pneumatic controls for automated machinery in meat processing plants.

The traditional way of controlling a compressor, is by running the motor at full speed and then stopping it when the air has been compressed to the correct pressure. It is then stored at a slightly higher pressure than needed to allow hysteresis¹ in the pressure. This “on-off” method is wasteful, because the motor keeps running at its nominal speed regardless of the requirement. Some compressors are designed with a bypass system to return air from output to input, which is also wasteful.

• A VSD controlled air compressor changes the AC drive to DC to be able to control the speed of the unit, thereby saving energy by not operating at a fixed speed.

**Cutting the cost of pumps**
There is a wide variety of pumps at work in meat processing plants, including:

• Blood and bone pumps;
• Hot wash pumps;
• Effluent pumps;
• Specialised sump pumps for use with hot water or floor waste transfer; and
• Gear pumps for tallow.

VSDs reduce motor speed so that the pump output matches the system requirement at reduced power usage levels - flow will decrease at the same rate as motor speed decreases.

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1. Hysteresis: In a broad sense, hysteresis represents the history dependence of physical systems. If you push on something, it will yield: when you release, does it spring back completely? If it doesn’t, it is exhibiting hysteresis.
Improving conveyor speed control

Conveyors are used to move products and waste materials around meat processing plants and have very specific requirements relating to hygiene, throughput and low temperatures.

Conveyors are inherently constant torque machines and usually operate over a relatively narrow range of speeds near maximum speed. However, extended periods of low speed may be required to accommodate set-up requirements.

In most applications, a VSD can be used to adjust the operating speed of the conveyor:

- Torque does not vary with speed so the amount of power absorbed will be directly proportional to the speed - a 50% speed reduction will result in a 50% reduction in energy used.

VSDs deliver accurate control and less mechanical wear, reducing maintenance and extending the life expectancy of systems.

The advantages of VSDs go beyond improved energy efficiency - they:

- Enable precise control over applications and help to control pressure, flow and temperature;
- Allow for soft starting, which can reduce stress on motors and bearings and, therefore, extend equipment life;
- Enable more frequent starting and help to reduce motor overheating;
- Help to improve the power factor;
- Allow for the rapid adjustment of speed, torque and power to provide better control in high-speed applications;
- Deliver meaningful intelligence on the status and performance of motors when interfaced with computers or wider process control systems;
- Avoid penalties for exceeding supplied kVA; and
- Can run more than one motor at a time if the load on the motors is equal — in fact, up to 6 fans with the same load can be controlled by one VSD.

When linked by remote control, VSDs can be used to switch off motors or lower the speed of fan or pump motors to decrease the air or water flow rate during Eskom’s peak hours of demand for electricity.

- A smart VSD with a built-in Programmable Logic Controller (PLC) can do sequence starting and sequence stopping and, therefore, replace a number of devices.

When a motor is started at full voltage without the use of a VSD it could draw up to 400% of its rated current while producing only 50% of its rated torque.
Putting VSDs to work

- Before installing one, make sure that the system to be controlled is efficient and correctly sized for its application; **only opt for a VSD if it is the correct electro-technical solution.**
- VSDs must be correctly installed to operate optimally and achieve the intended energy savings – always select an expert installer who can back up his/her product and who understands the operating profile of your processes.
- Once installed, VSDs must be correctly programmed to deliver the intended energy savings - setting incorrect parameters results in poor control and energy wastage.
- Like all electrical equipment, VSDs are susceptible to damage from humidity and inadequate cooling and need to operate within specified temperature and humidity parameters. (Select the correct IP-rated VSD for your particular environment).
- Ventilation and/or air gaps must be provided (according to the manufacturer’s specifications) to prevent overheating; VSDs should be located near the motor in suitably ventilated enclosures or remotely in a suitably protected area.
- VSDs are dust sensitive; an appropriate dust filter needs to be installed when operating in dusty conditions - filters must be cleaned regularly to avoid overheating. (Select the correct IP-rated VSD for your particular environment).
- Full energy saving gains will be achieved when harmonic filter protection, chokes and components are properly installed and tested.
- Regular maintenance of VSDs – and associated motors – is essential to maintain energy savings. VSDs can become inefficient over time if they aren’t adequately maintained, especially in demanding environments with heavy loads.
- Preventive maintenance is always less expensive than correcting faults and having unanticipated breakdowns - opt for a maintenance contract with a reputable supplier to ensure that VSDs are kept in optimal condition.

Important to know

- Some older motor designs may not have enough electrical insulation in their windings to withstand the high voltages that can occur with VSDs - they must be checked to determine whether they are suitable for VSD controls. It is preferred that VSDs are used with IE2 or IE3 energy efficient motors.
- In some applications, mainly in 90kW motors and higher - or where high switching frequencies are used - there is a risk of stray electrical currents being induced in motors, which can damage bearings.
- VSDs can increase harmonics in the electricity supply, which disturb the sine curve of the alternating current and cause motors to run warmer than what they are designed for, reducing their life expectancy. Harmonics can also decrease the life expectancy of computers and negatively influence the operation and accuracy of electronic measuring devices. The appropriate harmonic filters and chokes must therefore be installed along with the VSD, to filter out the harmonics and protect your equipment.
• Motors operating under VSD control tend to run a little warmer than motors directly connected to the electricity supply; alternative methods of cooling may be required. The threshold for additional cooling will depend on the installation - in some applications motors may be de-rated to ensure adequate cooling. The reason for that is that an electric motor is equipped with a fan to cool it down. If the speed is lowered to below the specifications of the manufacturer, overheating may occur and additional fans or ventilation might be required. (If the motor runs at half the speed forced cooling must be installed to prevent it from overheating.)
• Hermetic and semi-hermetic compressors are not designed to run with a VSD.
• **If you have a power factor correction capacitor installed, remove it before installing a VSD.**

Investing in the correct VSDs for your system or process and regularly maintaining motor drives will save you downtime and money and ensure optimal energy efficiency.

### Safety considerations

• VSDs contain Electrostatic Discharge (ESD) sensitive parts and assemblies.
• Static control precautions are required when installing, testing, servicing or repairing VSDs.
• Component damage may result if ESD procedures are not followed - allow VSD capacitors to discharge for approximately five minutes before starting with work or an inspection.
• The enclosure housing for the VSD must be large enough to allow sufficient ventilation.
• **Earthing is critical: both the motor and the drive must be earthed according to installation guidelines**
Eskom’s Energy Advisors

Eskom’s national Advisory Service can help locate VSD suppliers. The team can also advise meat processing plants on:

- Reducing energy usage
- Doing walk-through energy assessments to identify energy usage patterns, energy needs, areas of energy wastage and energy saving opportunities
- Improving the energy efficiency of operations and electrical systems and processes
- Prioritising maintenance as an important contributor to reducing energy usage
- Finding SANAS approved energy savings Measurement & Verification Authorities.

Advisors also help identify funding opportunities for energy efficiency projects.

Call 08600 37566, leave your name and number and an Eskom Energy Advisor will contact you.

Alternatively, you can ask for a specific advisor to contact you or email an enquiry to AdvisoryService@eskom.co.za.

Visit www.eskom.co.za/idm for more information.

Credits:

- www.carbontrust.com
- Fanie Steyn, technical paper - Energy savings on motor-driven systems (Johannesburg, South Africa, 2012)
- Dowdens Pumping and Water Treatment. www.dowdens.com.au
- www.zuidafrika.nl
- www.ampc.com.au
- www.est-aegis.com
- www.abb.com
- www.advantageengineering.com