Variable Speed Drives: Reducing energy costs in the sugar industry
In recent years it has become clear that for the industry to remain competitive and sustainable, pioneering technologies will be required to create much needed change. This can be achieved by:

- Radically reducing production costs by using novel processing technologies and strategies, which include process optimisation and improving energy efficiency to reduce the “loss” of potential value; and
- Incorporating a strategy of diversification and beneficiation by creating new revenue streams through the adoption of an integrated biorefinery approach.

Sector overview in South Africa

A strategic goal of the sugar industry is to maintain global competitiveness by being a low cost producer. For coal-burning factories, the cost of energy impacts significantly on production, making it a strong incentive to reduce energy consumption.

The potential for increased cogeneration from bagasse¹ is an attractive opportunity to partially reduce reliance on coal-generated electricity. This scenario rests on the assumption that co-generation of heat and power will become a strategic commercial issue for the sugar industry in the future.

- The traditional scheme of energy supply in a sugar mill is to burn bagasse to produce enough steam and electrical power for its own consumption.

Quick facts

Sugar is a 100% natural sweetener of plant origin and an extremely efficient converter of sunlight and CO₂ - its composition: sugars (14%), fibre (16%) and water (70%).

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¹ Bagasse: The fibrous matter that remains after sugarcane stalks are crushed to extract juice.
On average 19 million tons of sugarcane are produced annually in mill-supply areas, extending from northern Pondoland in the Eastern Cape to KwaZulu-Natal and the Mpumalanga Lowveld.

14 sugar mills are located in Mpumalanga and KwaZulu-Natal provinces:
- Malelane
- Komati
- Dalton
- Eston
- Noordsberg
- Umzimkulu
- Sezela
- Maidstone
- Gledhow
- Darnall
- Amatikulu
- Felixton
- Umfolozi
- Pongola

The South African sugar industry generates an estimated annual income of R8 billion, which constitutes R 5.1 billion in value of sugarcane production.

Direct employment in the sugar industry is estimated at 79 000, which represent a significant percentage of the total agricultural workforce in South Africa. Indirect employment is estimated at 350 000.

About one million people, more than 2% of South Africa’s population, depend on the sugar industry for a living.

There are approximately 29 130 registered cane growers - 1 383 large-scale growers (inclusive of 323 black emerging farmers) produce 83.3% of total sugarcane production.

Milling companies with their own sugar estates produce 7.94% of the crop.

According to independent surveys of the production costs of more than 100 global sugar industries, the South African sugar industry consistently ranks amongst the top 15.

Its excellent export infrastructure, world-renowned agricultural and industrial research platforms and efficient industry organisation are key drivers of excellence.

However, despite its comparative production efficiencies, the South African sugar industry finds it difficult at times to export profitably to the world market, as the global sugar price is severely eroded by subsidy-induced overproduction in some major sugar-producing countries.

Access to the major markets for raw and refined sugar is, furthermore, restricted by high tariffs and preferential trade arrangements in the form of tariff rate quotas.

These same global market distortions also threaten the maintenance of a profitable and sustainable sugar price on the domestic market.

Based on these considerations government support includes intervention in the following three areas:
- Tariff protection against disruptively low world sugar prices;
- Provision for the establishment of equitable export obligations for millers and growers; and
- The Sugar Cooperation Agreement between the members of the Southern African Development Community.
The global sugar industry has seen a fundamental shift as increasing quantities of sugarcane are directed at renewable electricity generation and ethanol production as an effective carbon dioxide (CO₂) mitigation strategy. The need to create jobs and the current electricity constraints in South Africa, together with the carbon mitigation drive, will continue to maintain the focus on the development of renewable energy.²

Energy efficient technology interventions in the sugar industry

Remaining sustainable into the future and improving its global competitiveness are two of the most strategic goals of the sugar industry in South Africa.

Technology interventions, like utilising low voltage Variable Speed Drives (VSDs) to optimize the energy efficiency of pumps, fans, conveyors and centrifuges, can contribute to improving the industry’s competitiveness by saving energy, improving process control and lowering maintenance costs.

Reducing a pump or fan speed by 20% can reduce energy consumption by more than 50%

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 a pump or a fan - where variable loads are required. 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%.

2. Tongaat Hulett Sugar. www.huletts.co.za
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.

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 increase in speed requires a lot more power.

VSDs deliver accurate control and less mechanical wear, reducing maintenance and extending the life expectancy of systems.
Many applications in the industry are suited for operation with a LV-VSD instead of conventional driving methods, such as:

- Cane carrier drives;
- Feeder table drives;
- Milling plant drives;
- Raw juice pumps;
- Sulphited juice pumps;
- Molasses pumps;
- Injection pumps;
- Cooling tower pumps; and
- Sugar curing and chemical dosing pumps.

Pump applications
The sugar industry, in particular, uses pumps for transferring liquor with a:

- Controlled flow rate;
- Controlled pressure; and
- Controlled level in the vessel.

Besides the transfer of liquor, pumps are also used in power generation to feed water to boilers. Using VSDs for such applications contributes to a high savings potential, making it the most economical and efficient method to drive pumps.

Conveyor applications
VSDs can be used to control the speed and torque of belt conveyors, resulting in easy management and very precise control.
Induced Draft and Forced Draft fan applications
Sugar mills use boilers to generate high-pressure steam for electrical power generation and low pressure steam for heat exchangers.

Since the steam consumption varies depending on demand, the boiler has to accommodate the variation by controlling fuel and air. Achieving this with improved performance and remarkable energy savings requires VSDs for the control of Induced Draft (ID) and Forced Draft (FD) fans in the boiler area.

Centrifuge applications
VSDs can also be applied for batch centrifugal speed control, which is the heart of sugar refining.

Think of a VSD as a “design compensator” that closes the gap between the design and the energy demand of your system, thereby achieving optimal efficiency.

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.
• Allow for dynamic braking to decelerate loads in a quick and controlled manner.
• Help to improve 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 the supplied kVA.
• 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.

Some VSDs can regenerate power - there are options where the rectifier stage is similar to the inverter stage, making it possible to return energy recovered during the electrical braking of the load to the electricity supply.

• 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 whilst 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 for your plant.
• 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 systems and processes.
• Once installed, VSDs must be correctly programmed to deliver the intended energy savings - setting incorrect parameters will result 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.
• Ventilation and/or air gaps must be provided (according to manufacturers’ 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.

• Full energy saving gains will be achieved when harmonic filter protections 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.

• 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 you have a power factor correction capacitor installed, remove it before installing a VSD.

• Always choose purpose-designed VSD cables and ensure that the correct cable length is installed. Electrical energy flowing in these cables contains frequencies as high as 30 megahertz. If this radio frequency energy is not contained in the cable, it can radiate out to interfere with the proper operation of nearby electronic equipment, less-than-robust Ethernet systems, simple instrumentation wires and even circuits that have nothing to do with the VSD system itself.

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 for sufficient ventilation.
• Earthing is critical: both the motor and the drive must be earthed according to installation guidelines

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.
Eskom’s national Advisory Service can help to locate VSD suppliers. The team can also advise sugar mills on:

• Reducing energy usage;
• Doing walk-through energy use 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; and
• 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, ask for a specific advisor to contact you or email an enquiry to AdvisoryService@eskom.co.za

Credits:

• Fanie Steyn, technical paper - Energy savings on motor-driven systems (Johannesburg, South Africa, 2012)
• Sugar Milling Research Institute NPC. Enabling Programme for bio-energy (Step-bio). www.smri.org
• Department: Science and Technology. www.dst.gov.za
• http://citeseerx.ist.psu.edu
• https://en.wikipedia.org/wiki/Bagasse
• South African Sugar Association. www.sasa.org.za
• Tongaat Hulett Sugar. www.huletts.co.za
• www.carbontrust.com
• Belden technical Support. Belden Inc. www.belden.com