



# **Variable Speed Drives:** Reducing energy costs in horticulture

**Brochure**



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Variable Speed Drives:  
Reducing energy costs  
in horticulture



Very diverse in its activities, covering plants for food and non-food crops, horticulture is the science, technology and business of intensive plant cultivation for human use – from a garden to the activities of a multinational corporation.

Sector overview in South Africa

- The horticultural sector is an important generator of employment, exports and Growth Domestic Product.
- Horticultural value chains are undergoing a process of rapid transformation in South Africa. European supermarkets have long been an important destination for South African fruit and source produce through coordinated value chains with stringent requirements, which have driven both improvements in crop quality and increases in costs for growers.
  - The expansion of South African supermarkets and trade in sub-Saharan Africa, Asia and the Middle East are providing new channels for fruit and vegetables. These markets require standards that are generally less stringent than European supermarkets but are, nonetheless, paying comparable prices.
  - South African growers now have a wider range of buyers; European supermarkets can no longer be assured of automatic availability of quality produce.

Production overview – fruit and vegetables (2011 to 2012)

| Crop             | Tons      |
|------------------|-----------|
| Potatoes         | 2 215 000 |
| Grapes           | 1 839 030 |
| Oranges          | 1 496 171 |
| Apples           | 790 636   |
| Onions           | 625 000   |
| Tomatoes         | 540 000   |
| Grapefruit       | 415 572   |
| Green mealies    | 347 000   |
| Pears            | 346 642   |
| Lemons and limes | 260 385   |

| Crop                                   | Tons    |
|----------------------------------------|---------|
| Pumpkins                               | 244 000 |
| Bananas                                | 222 294 |
| Peaches                                | 190 531 |
| Carrots                                | 177 000 |
| Cabbages                               | 142 000 |
| Pineapples                             | 108 697 |
| Watermelons and melons                 | 93 277  |
| Avocados                               | 87 895  |
| Apricots                               | 66 762  |
| Beetroot                               | 66 000  |
| Mangos                                 | 65 439  |
| Plums                                  | 60 925  |
| Sweet potatoes                         | 58 000  |
| Dried fruit (vine fruit)               | 37 907  |
| Naartjies                              | 28 855  |
| Green beans                            | 25 000  |
| Guavas                                 | 23 699  |
| Cauliflower                            | 15 000  |
| Green peas                             | 8 000   |
| Papayas                                | 7 755   |
| Dried fruit (tree fruit)               | 5 602   |
| Strawberries                           | 5 543   |
| Other berries (excluding strawberries) | 3 914   |
| Prunes                                 | 3 426   |
| Litchis                                | 1 951   |
| Figs                                   | 1 925   |
| Granadillas                            | 484     |
| Cherries                               | 388     |
| Quinces                                | 208     |

### Quick facts

- South Africa is the world's ninth largest producer of wine – over 300 million vines are being cultivated on over 110 000 ha of land (843 800 000 gross litres were produced in 2011/12).
- South Africa is the world's 10th largest producer of sunflower seed.
- South Africa is the world's 13th largest sugar producer.
- The deciduous fruit industry's export earnings account for about 12% of South Africa's total earnings from agricultural exports.
- Potatoes make up about 40% of South African vegetable farmers' gross income, with tomatoes, onions, green mealies and sweetcorn contributing about 38%.

### Cutting costs in the horticultural sector

Because of the growing consciousness of the enormous challenges of feeding the world's expanding population in future, the concepts "farm to the fork" and "farm for the future" are extremely important. Both concepts place the emphasis on the sustainable use of natural resources to produce tasty and nourishing products with the least amount of waste and at the lowest possible cost.<sup>1</sup>

By improving the energy efficiency of electric motors that drive pumps and irrigation and ventilation systems, Variable Speed Drives (VSDs) can play a significant role in lowering energy use and reducing operating costs in the horticultural sector – Variable Speed Drives are extremely versatile and potentially the most underutilised solution when optimising the energy efficiency of a wide range of equipment.

## 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%.

### 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.



## Using VSDs in irrigation systems

The electric motors that drive pumps on irrigation systems are extremely energy intensive, making irrigation one of the largest end uses of electricity in the horticultural sector.

Motors on irrigation systems often use more electricity than needed because they are designed to cope with maximum loads that rarely or never occur. This means that they run at full speed regardless of the actual output required. This wastes electricity.

Installing a VSD will regulate the speed and rotational force - or torque output - of the motor to match actual demand so that it doesn't work faster than it needs to.

Centrifugal pumps on irrigation systems are variable-torque applications, which offer the highest potential to save power. Reducing the speed of the pump by a small amount will result in a massive reduction in the amount of energy used because pumps are governed by the Affinity Law of Power  $\propto$  (Speed)<sup>3</sup>. Slowing down a pump from 100% to 80% can reduce motor energy use by up to 50%.

In the case of an irrigation system where various sizes of land are irrigated using the same pump, a VSD can be used to adapt the speed according to the respective water and pressure requirements of the various sizes of land, which will prevent the motor from running at full speed and all the excess energy dissipated by the pump's pressure regulator.

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



Your irrigation system could be unnecessarily wasting electricity and pushing up your energy costs if:

- The motor runs at full speed against closed valves when irrigating a number of fields at different times with the same pump.
- The motor runs at full speed when irrigating different sizes of fields with the same pump at different heads.
- You irrigate a number of fields at different times with all the pumps running full speed regardless of the required flow rates.
- You are changing production volumes or restricting the flow of the output by mechanical means, such as valves or chokes.

A VSD improves power factor correction and has a soft starting function. When a VSD is not feasible, soft starters or power factor correction can be considered instead.

## Savings scenarios

A VSD can optimise your irrigation system when one pump delivers water to more than one centre pivot, and:

- The pump is designed to deliver water to all pivots at the same time and has to be throttled when irrigation is needed for fewer centre pivots.
- The pump and motor are over designed and water delivery needs to be throttled.
- An oversized, second-hand pump and motor are used for the application and water delivery needs to be throttled.
- The sizes of the centre pivots are different.
- The distance between the pump station and the centre pivots is not the same.
- The static height of the highest point of irrigated land and the respective pivots is not the same.
- Pipelines between the pump and the respective centre pivots have different friction losses.
- The pressure requirements of the respective centre pivots are different, depending on the type of sprayer package installed.
- The centre pivots are irrigating on sloped topographies.

A VSD can optimise your irrigation system when one pump delivers to only one dedicated centre pivot, and:

- The centre pivot irrigates on a sloped topography.
- The pump and motor are oversized and water delivery needs to be throttled.
- An oversized, second-hand pump and motor are used for the application and water delivery needs to be throttled.

A VSD can optimise your irrigation system when movable pipe systems and micro- and drip-irrigation are used, and:

- Distances between the blocks of land and the pump stations are different, causing a variation in friction loss and power requirements.
- Irrigation blocks are uneven in size and a different number of sprayers or drippers are required.
- Irrigation blocks are on sloped topographies, requiring different pressures and power.
- Pumps and motors are designed to deliver water to the irrigation block that requires the most pressure.
- The pump and motor are oversized and water delivery needs to be throttled.
- A second-hand pump and motor are used for the application and water delivery needs to be throttled.

## Using VSDs in greenhouses

Greenhouses provide a tightly controlled environment to promote crop growth and can be considerably difficult to cool, especially in summer months when solar radiation is highest. Large fans coupled with an evaporative mechanism are commonly used to remove heat and can consume large amounts of electricity.

- Fans are typically sized to ensure that the maximum air flow is high enough to meet the maximum cooling requirement.

Greenhouses' cooling needs can change dramatically throughout the day. During morning and afternoon hours, when outside temperatures are low but the sun is shining, solar gain can still cause the indoor environment to heat up enough that some cooling is required. Exhaust fans that are designed to cool a greenhouse when sunlight and temperatures are at their most extreme are turned on at full power during these mild conditions, run for a short time and then switch off when the set point is reached.

This on / off operation is extremely energy intensive as large amounts of power are required to get the fan up to full speed; the motor can consume several times its normal full load. These high inrush currents not only use large amounts of energy but can also be detrimental to equipment life, creating unnecessary heat and stress each time the fans are turned on.

- The major advantage of using a Variable Speed Drive in a greenhouse is that it allows fan systems that adapt to changes in the outdoor environment.

They can be setup so that the fan speed increases as the indoor temperature gets further away from the set point and slowly reduces as the temperature dictates. During morning and late afternoon hours the sun is still heating up the greenhouse to the point where ventilation is needed. With a VSD installed, the fans will turn on at a low RPM around 20% of full speed. The benefit of this adaptability is lower electricity use and a reduction in energy cost.

Other long-term benefits include:

- Reduced wear and tear on motors.
- Longer motor life expectancy.
- Reduced stress on a greenhouse's electrical system (as a result of there being no inrush current events).
- Better climate and pest control capabilities.

## VSDs can also save water

Water loss in a greenhouse is a function of ventilation speeds. Faster air speeds will increase evaporation and reduce plant boundary layer thickness, thus increasing transpiration.

- Lowering average fan speed and reducing changes in ventilation speed can limit water loss – it allows plants time to respond to changing air speeds, reducing their transpiration rates.



There is a broad range of Variable Speed Drives available specifically engineered for ventilation applications.

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 farm.

- 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.

### 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 your business downtime and money, as well as ensure optimal energy efficiency.**

### Eskom's Energy Advisors

Eskom's national Advisory Service can help to locate VSD suppliers. The team can also advise fruit and vegetable growers 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
- 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 (you can also ask for a specific advisor to contact you).

Alternatively, email an enquiry to [AdvisoryService@eskom.co.za](mailto:AdvisoryService@eskom.co.za)

### Credits:

- [www.carbontrust.com](http://www.carbontrust.com)
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