

# IRRIGATION SECTOR

## Study highlights economic trade-offs in irrigation design

*Water and electricity are precious commodities on farms, given their impact on profitability and food production. Jorisna Bonthuys looks at Water Research Commission (WRC) research that aims to optimise these key assets for those producers who are dependent on irrigation for their livelihoods.*



The recent drought and growing conflict amongst users given water scarcity have put the need for efficient water-use in the agriculture sector firmly in the spotlight again.

To optimise water-use and remain economically sustainable producers are increasingly looking at ways to do more with less water. In future, farmers will need to produce higher yields through beneficial water use, especially given rising input costs and more erratic weather patterns emerging. Water use issues are compounded by the fact that demand outstrips supply in many parts of the country. Besides the growing demand for water for socio-economic growth, other factors, such as ageing water-supply infrastructure and variable rainfall, are adding to emerging water pressures in South Africa.

Between 1991 and 2008 the WRC invested in several research and technology exchange projects to develop models for calculating irrigation costs and testing application in practice, reports Dr Gerhard Backeberg, WRC Executive Manager: Water Utilisation in Agriculture. "With increasing electricity tariffs and changing rate structures, requests were received from representatives of the irrigation industry that norms and standards for irrigation design should be revised. This led to a new research and development project, which ran between 2013 and 2017."

Many farmers are struggling to absorb operating costs caused by rising energy tariffs, reports Prof Bennie Grové from the University of the Free State's Department of Agricultural

Economics. **“In future, rising electricity costs will become a significant part of operating costs on farms,” he points out. “As a result, producers have to focus on the economic trade-off between investment costs and operating expenses when deciding on an irrigation system’s design and management.”**

Prof Grové was involved in research funded by the WRC to optimise the use of water and electricity in the agricultural sector. This is part of efforts to improve on-farm water management through better design and planning. Marcell Venter, who completed her MSc Agric (Agricultural Economics) on this subject, as well as Isobel van der Stoep, from the South African Irrigation Institute, contributed to this technical study.

The researchers focused on three areas to manage rising costs, namely technology (design), farm management and electricity tariff choices. Their work was synthesised in a WRC published report titled, *The optimisation of electricity and water use for sustainable management of irrigation farming systems (WRC Report No. TT 717/17)*. The main aim of this research was to develop a model that would integrate irrigation system design aspects (including pipe diameter selection), electricity tariff choices and water planning to help support more efficient energy management.

Increasingly, farm profitability is coming under pressure due to the cost of pumping irrigation water, says Grové. This is because **higher electricity tariffs create serious problems for many farmers since irrigation depends on electricity to pump water.**

The cost of applying irrigation water on farms must be balanced with expected economic benefits, he notes. **“The old paradigm of applying irrigation water to sustain maximum production will be replaced with the new paradigm where water use is optimised to increase profitability.”**

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#### **Rising input costs**

Previously, Eskom was one of the cheapest electricity suppliers in the world. Many irrigation designers took this situation as a given, Grové points out. This was because they were able to reduce investment costs by decreasing mainline pipe diameters with resulting larger kilowatt requirements.

The average tariff of electricity has, however, increased significantly in the last two decades. From 1998 until 2007 the increase in the average tariff was moving along with the inflation rate. In the year 2008, the tariff increased rapidly to maintain Eskom’s sustainability and to cover expenses associated with the expansion of infrastructure. Indications are that further electricity price hikes are inevitable over the coming years as

South Africa weans itself off its current fossil fuel intensive energy budget. This could have a significant impact on the cash flow, profitability and sustainability of irrigation farmers.

For some producers, the cost of increased electricity tariffs is even higher than for others because they have invested so heavily in outdated and energy-inefficient irrigation systems. Luckily, potential energy savings can be achieved by adopting new technologies (including variable speed drives and high-efficiency motors) while taking cognisance of the trade-offs between investment and operating cost, the report shows. **Says Grové, “The question is not whether irrigation farmers should adopt practices to improve energy and water management. Rather, the problem is how to evaluate the linkages between irrigation management, system design and the choice of electricity tariffs to improve energy and water management. Together these factors will determine the extent of water and energy savings in irrigated agriculture.”**

#### **Consider lifecycle costs**

Currently, the South African Irrigation Institute (SABI) is responsible for local irrigation design norms. These include details about irrigation requirements, system efficiency and even irrigation hours per week. But higher electricity tariffs have now made it necessary to rethink some of these norms given that they are not applicable anymore, the researchers say.

Rethinking these design norms can have a huge impact on local irrigation practices, Grové points out. About 80% of registered irrigation systems in South Africa are pressurised types of irrigation systems (centre pivots, sprinkler, drip and micro sprinkler systems). The majority of these are powered by centrifugal pumps driven by electrical motors. Any practices that will reduce the power demand of such systems will, therefore, have widespread application in the irrigation sector.

A trade-off exists between reducing investment costs and increasing operation costs through higher electricity costs, the researchers say. Following a comprehensive literature review, a conceptual framework was developed of factors influencing the lifecycle costs of alternative electricity management interventions. Emphasis was placed on using lifecycle costing as it incorporates not only the cost of acquiring new technology but also operational costs, maintenance costs and the cost of disposing the product.

The conceptual framework takes cognisance of the irrigation system design process and the three focus areas that should be targeted to manage electricity costs. The design process includes the design of the power supply, water distribution network and the determination of the irrigation water demand and design of the infield irrigation system. Capital investments that influence the kilowatt requirement, management (operation and maintenance) of the irrigation system and choice of electricity tariff was identified as focus areas that should be investigated in order to reduce electricity costs.

The framework emphasises the linkages between irrigation system design and irrigation water and electricity cost management. Specifically, a trade-off exists between reducing



investment costs and increasing operating costs through higher electricity costs.

The next step was to develop a mathematical model to calculate the lifecycle costs of this kind of investment over a period of twenty years. This so-called Soil Water Irrigation Planning and Energy Management (SWIP-E) programming model considers alternative management interventions. Decisions that influence electricity costs included the type of electricity tariff structure used, when irrigation happens throughout the day, the design capacity of the system and other factors like main pipeline size and operation and maintenance.

The model has the unique characteristic that it determines irrigation pumping hours through a daily soil water budget while considering the time-of-use electricity tariff structure. It also considers changes in kilowatt requirements resulting from mainline design changes.

The costing framework was tested on in the Douglas region and in Limpopo, using Eskom's Landrate and Ruraflex tariff structures (both aimed at rural agricultural users). The researchers considered the electricity use of centre pivot sizes of 30 ha and 47,7 ha, as well as static systems like micro irrigation and sprinkler irrigation systems.

Smaller irrigation system delivery capacities proved to be the most profitable for all the systems and electricity tariff structures investigated, as higher flow rates increased the energy demand. The implication of using the current 1,5% norm is that thinner pipe diameters would be used which decrease investment cost but at the same time increase operating cost (electricity costs).

Says Grové, "This means that increasing electricity costs will have a significant effect on the profitability of irrigation systems if thinner pipes are used."

Large pipe diameters reduce friction loss and therefore total pressure with lower kilowatt requirements while increases in flow rate will cause an increase in kilowatt requirements. This increase in kW demand had a greater impact on the energy cost than the decrease in irrigation hours resulting from high system capacities. "Also, electricity tariffs have a significant impact on break-even percentage friction, Grové points out. "Furthermore, the break-even point is much lower than the norm of 1.5%."

The results show that variable electricity costs increase as flow rate increases if the optimal pipe diameter stays the same. "Failure to consider electricity tariffs when designing irrigation mainlines may result in suboptimal designs which will increase electricity costs," he says.

The researchers recommend that the SABI design norm for the maximum allowable friction losses in main pipelines must be reduced from the current 1.5% to 0.7%. This would ensure that there is a better balance between investment and operating costs, Grové indicates. Lowering the norm will also decrease operating costs while increasing the investment costs.

The model provides a basis to evaluate the profitability of new technology such as variable speed drives, energy efficient pumps and motors as well as modification of existing irrigation system designs.

The choice of tariff-structure also has a direct impact on







electricity use and profitability, the research shows. The timing of irrigation is of utmost importance since it has a direct effect on electricity costs and crop yield. Time-of-use electricity tariff structures enable producers to schedule irrigation outside of peak periods to reduce electricity costs.

According to the researchers it is more profitable to use Ruraflex than Landrate, irrespective of the irrigation system size used. Says Grové, "The total annual fixed cost charge for Landrate is consistently higher than the annual fixed cost charge of Ruraflex, and savings can be achieved through careful planning of electricity supply points' sizes and locations."

Making irrigation system investment decisions on investment cost alone is flawed, he believes. "This is because the variable electricity costs may outweigh the capital costs when considering the life cycle of the investment. Investors in irrigation systems should ask their suppliers to provide an estimate of variable electricity costs together with the investment costs."

Management of irrigation systems also remains key to reduce costs while improving efficiency. These systems should, for instance, operate at the correct pressure. Pressures higher than the minimum requirements increase the power demand and thereby increase electricity costs, while those below the design requirements will mean more irrigation.

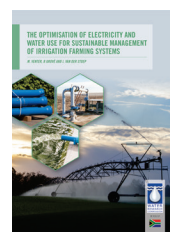
Furthermore, irrigation systems need to be maintained properly to make sure that water is applied at an acceptable uniformity. Lower uniformities necessitates more irrigation to ensure that the whole field receives enough water to maintain high crop yields. More irrigation hours increase electricity costs that again affects farm profitability.

Irrigation designers should also apply economic principles when designing mainline designs, the researchers point out. This will

increase the overall profitability of the investment compared to applying the friction percentage design norm. Using economic principles will also differentiate between electricity tariff structures when designing an irrigation system.

The report shows significant opportunities exist for farmers to reduce electricity cost through irrigation system design, renewable energy resources and adopting new technology, Grové points out. "Careful consideration of the economics is necessary since smaller delivery capacities need much more intensive management because longer irrigation hours are needed to avoid a decrease in crop yield. Designers should include both the investment costs and an estimate of the operating costs of the irrigation system design to allow farmers to make informed decisions. However, cognisance also needs to be taken of the trade-off between investment and operating costs if new technology is adopted."

The SWIP-E model now informs other ongoing research efforts, including a SABI project to rethink the norms applied in irrigation system management across the country.



To access the report, *The optimisation of electricity and water use for sustainable management of irrigation farming systems (WRC Report No. TT 717/17)*, contact Publications at Tel: (012) 761-9300; Email: [orders@wrc.org.za](mailto:orders@wrc.org.za) or Visit: [www.wrg.org.za](http://www.wrg.org.za) to download a free copy of the report.