POLICY BRIEF

June 2017
The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

Optimising electricity and water use for sustainable irrigation farming

The dependence of commercial agriculture on electricity as a source of energy to pump water will likely continue in future, even though electricity tariffs are rising. Following requests from industry, the WRC, with its research partners, initiated a research project to develop appropriate management approaches for reducing electricity cost, improve water use productivity and increase profitability of irrigation farming for selected irrigation areas in South Africa. A novel lifecycle conceptual approach and programming model was developed along with guidelines for farmer advisory services and irrigation system designers.

Background

Irrigation farming profitability is increasingly coming under pressure due to the rising cost of pumping irrigation water. The dependence of commercial agriculture on electricity as a source of energy to pump water will likely continue in future, even though electricity tariffs are rising.

This will require irrigators to balance the cost of applying irrigation water with the expected economic benefit from doing so. Thus, the old paradigm with the biological objective of applying irrigation water to sustain maximum production will be replaced with the new paradigm where water use is optimised to increase profitability. Irrigation farmers will need to evaluate different options to manage energy and water use in future.

Significant opportunities exist for irrigation farmers to reduce energy costs through irrigation system design and operating practices to improve profitability. The design of an irrigation system and the operating practice needs to be evaluated in order to reduce energy costs.

The challenge is how to evaluate the interrelated linkages between irrigation management, irrigation system design and choice of electricity tariffs simultaneously to improve energy and water management. Together, these will determine the extent of water and energy savings in irrigated agriculture.

Thus, the WRC, with its research partners, initiated a research project to develop appropriate management approaches for reducing electricity cost, improve water use productivity and increase profitability of irrigation farming for selected irrigation areas in South Africa.

More specifically, the project had the following objectives:

- To review a) design norms and standards for irrigation systems; b) available methods to calculate electricity cost for irrigation; c) changes in electricity tariff structures over the last 10 years; d) current irrigation practice on farms.
- To determine the key decision variables for reducing electricity cost of current and alternative irrigation systems with reference to (among others) planning, design and operation, water use for irrigation, electricity use and electricity rates/tariffs.
- To develop methods and models for actions such as calculating electricity cost, providing decision support for capital investment, operating cost and irrigation water management
- To develop guidelines for farmer advisory services on reducing the impact of electricity cost for sustainable irrigation water use.

Methodology

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 model to calculate the profitability of changes resulting from electricity cost management interventions that embraced the conceptual framework of variables affecting the lifecycle costs. In the process a highly sophisticated non-linear mathematical programming model was developed.

The Soil Water Irrigation Planning and Energy Management (SWIP-E) programming model has the unique characteristic that irrigation pumping hours are determined through a daily soil water budget while simultaneously considering the time-of-use electricity tariff structures and changes in kilowatt requirements resulting from mainline pipe design changes.

Given the sophistication of the model it was decided to validate the model against data for eight specifically designed pivot irrigation systems obtained from an accredited designer. The eight designs were evaluated through the application of the SWIP-E model to determine the impact of electricity tariff choice, irrigation system design capacity and system size on the design of the water distribution network.

In addition to the eight pivot irrigation system designs evaluated, seven other case studies were developed from actual data collected from case study participants. The case studies were used to evaluate the impact of variable speed drives, electricity tariff choice, mainline design changes and management of electricity costs.

Main results

The study considered two electricity tariff structures, namely Ruraflex, a time-of-use tariff for large, rural power users, and Landrate, an electricity tariff for rural customers with a notified maximum demand up to 100 kvA. The results of the project showed that Ruraflex is more profitable than Landrate, irrespective of the centre pivot size and irrigation system delivery capacities.

Further, smaller delivery capacities proved to be the most profitable for all the system sizes and electricity tariff structures investigated, as higher flow rates increased the energy demand. This increase in kiloWatt demand had a greater impact on the energy cost than the decrease in irrigation hours. The conclusion is that careful consideration of the economics is necessary since smaller delivery capacities require much more intensive management, because longer irrigation hours are needed in order to avoid a decrease in crop yield.

The results of the management implications showed that small variation in total irrigation hours between centre pivot sizes was observed for a given irrigation system delivery capacity. Furthermore, the results showed that total irrigation hours were exactly the same between electricity tariff structures. However, variation in total pumping hours between different crops were observed.

Irrigation of maize was mostly in off-peak and standard hours while irrigation of wheat was in off-peak, standard and peak timeslots when considering small irrigation system delivery capacities. The conclusion is that smaller irrigation system delivery capacities require much more intensive management and information to balance the cost of applying water with the possibility of crop yield reductions.

Recommendations

The study provides various recommendations for irrigation system design. Among others, it is recommended that the South African Irrigation Institute (SABI) design norm for the maximum allowable friction losses in main pipelines be reduced from the current 1.5% to 0.7% to ensure that there is a better balance between investment and operating costs. (This new design norm has since been discussed and accepted by SABI as representative of the irrigation industry)

Irrigation designers should apply economic principles when designing irrigation mainline designs since it will increase the overall profitability of the investment compared to applying the friction percentage design norm. It is also recommended that designers should include both the investment costs and an estimate of the operating costs of the irrigation system design in order to allow farmers to make informed decisions.

The SWIP-E model provides a powerful basis for crop water use optimisation for a given irrigation system design. The model may prove invaluable in determining the impact of compulsory licensing of agricultural water use on irrigation farming profitability.

The model could be expanded to include intra-seasonal competing crops, such as maize and groundnuts, which implies that crops will compete for water for water during a growing season.

Lastly, it is recommended that the economic benefit of alternative energy sources, such as wind energy, hydroelectricity and solar panels be investigated.

New knowledge for commercial application

Based on a review of design norms, electricity and water-use costs, a conceptual approach for lifecycle cost analysis of irrigation equipment was developed. The major contribution of this project was the development of methods and a mathematical programming model for electricity cost management.

The Soil Water Irrigation Planning and Energy Management (SWIP-E) programming model has the unique characteristic that irrigation pumping hours are determined through a daily soil water budget while simultaneously considering the time-of-use electricity tariff structure and changes in kilowatt requirements resulting from mainline design changes.

The correctness and validity of the model was tested with data from pivot irrigation methods, based on accredited designs. This was the basis for formulating guides and reduce electricity costs.

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