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The Importance of Improving Energy Efficiency in Irrigated Areas

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The improvement of agricultural water management to increase crop productivity, reduce the influence of drought and promoting water conservation is one of the main objectives of current irrigated agriculture. In 2002 the Spanish government implemented a national irrigation and emergency plan to modernize its irrigation infrastructure, aiming to save 3000×10^6 m^3 water per year [1,2]. This has involved investing M€ 7400 to reduce water use across 2 million ha of irrigated land [3] representing about 57% of the total irrigated area in Spain. However, these planned improvements in water efficiency have had important repercussions on other production factors, notably energy consumption.

The Spanish Institution for Diversification and Energy Savings (IDAE) indicates that modernized areas require 2 $kWha^{-1}$ of power [4].The unit energy demand estimated by Diaz et al. [5] was 0.41 $kWh.m^{-3}$ but this value can be much higher where water is diverted from deep aquifers or supplied to steep areas with large differences in elevation from the water source to the point of supply (hydrant). Where water resources are stressed and alternative water resources are used, additional energy of 0.5 $kWh.m^{-3}$ (wastewater treatment) and 3-4 $kWh.m^{-3}$ (desalination) are needed. The increase in power cost in recent years has been more than 200%. Over the last two years, energy tariffs for irrigation in Spain have also increased by 120%. Díaz et al. [6] reported that this increasing dependence on energy is making farmers apply much less water than would be expected to meet theoretical agronomic needs. Actually, in some irrigation districts, water costs after the modernization are up to four times bigger than before the actions.

As energy represents an important percentage of the total water costs (around 40%), nowadays water use in agriculture and energy efficiency cannot be considered independently. Thus, in pressurized systems energy is now becoming a major factor as important as others such as water availability, rainfall or evapotranspiration. Efficient water and energy use take on greater importance in agriculture due to the widespread tendency of reduced water availability and increasing energy costs, which determine the viability of irrigated agriculture in many areas of the world.

Recently, research groups in the field of irrigation engineering have worked on the development of energy saving measures for irrigated areas. Some of the proposed measures are summarized below:

Irrigation networks sectoring: Usually the pressure head at the pumping station is set to supply pressurized water to the highest pressure demanding hydrant while other hydrants receive an excess of pressure that must be removed by hydraulic valves. Network sectoring consists in grouping hydrants with similar energy requirements. Then the network is operated in turns and each sector is enabled a few hours every day only and the pressure head is set according to the worst hydrant (pressure demand) in the sector [7]. Thus, significant energy savings can be achieved when the lower pressure demand hydrants irrigate.

Critical points detection and control: Critical pressure points are those hydrants with special energy requirements, usually caused by their distance from the pumping station and/or their elevation, which determine the minimum pressure head required at the pumping station. Thus, sometimes a few points are responsible for large fractions of the total pressure head at the pumping station. In these cases other strategies such as booster pumps or changes in pipes size, would lead to energy savings usually in the range of 20-30% [8].

Improving the energy efficiency of the pumping system: Usually pumping stations are designed to provide water at the peak demand period. However, as this period takes only 2 or 3 months, and the rest of the year the demanded flows are much lower, and therefore the pump operation point is not the optimum to maximize their Pumping Energy Efficiency (PEE). By installing new smaller pumps, more appropriate for flows demanded during off-peak periods, and using variable speed pumps, it is possible to increase PEE significantly and therefore reduce energy consumption [9].

Irrigation systems at farm level: Theoretically, more efficient irrigation systems and better irrigation scheduling lead to significant simultaneous energy and water savings. Better irrigation scheduling techniques make the application of the right amount of water possible, avoiding excess applications. With more efficient irrigation systems the water is applied in a more efficient way and therefore water losses are reduced. Thus, both measures contribute to reduce both water diversion for irrigation and total energy requirement for pumping. These goals may be achieved thanks to the widespread use of low pressure irrigation application systems. Nowadays, many emitters are designed to work with less than 10 m pressure.

In the coming future, thanks to the great potential of technologies such as solar energy or biomass, renewable energy resources may play an important role in the irrigation water supply. Using renewable resources to power an irrigation network is a mean of decreasing the dependency of food products on the prices of fuel and minimizing the impact of the irrigation system on the environment. But, although some theoretical approaches of the integration of these energy resources have been done in the urban water supply [10], there are not many examples of their use in irrigation at water distribution level.

Compared to urban water supply, the irrigation sector offers more possibilities for this technology. Irrigation is highly concentrated in some months of the year (usually in spring-summer when maximum solar radiation occurs) and this demand is much more flexible. In the irrigation sector, it is possible to organize the irrigation events and apply the water just when energy is available. However, methodologies to fit the irrigation demand in periods of maximum energy availability are not available.

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