Pressurized Irrigation Dealing with Water and Energy Efficiencies

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• Introduction

• Highlights
  ▪ Automation on operation, control and management
  ▪ Irrigation efficiency
  ▪ Water saving

• Challenges
  ▪ Design, management and operation of collective pressurized irrigation water networks to improve the energy and water efficiencies
INTRODUCTION

SURFACE IRRIGATION METHODS

High Water Use
Low Energy Consumption
Low level of Technology
PRESSURIZED IRRIGATION METHODS

Less Water Use
High Energy Consumption
High Level of Technology
Automation on operation, control and management

Technology development

- Pumps, filters...
- frequency speed drives
- Electrical-hydraulic valves
- Flow meters
- Pressure transducers
- Remote controllers
HIGHLIGHTS

Automation on operation, control and management

Collective pressurized water networks

Management of irrigation networks

- On demand irrigation
- In turns irrigation

Irrigators file water orders at their Water Users Associations
Andalucian Irrigation Systems

<table>
<thead>
<tr>
<th>Irrigation Method</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>72.5</td>
</tr>
<tr>
<td>Sprinkler</td>
<td>85</td>
</tr>
<tr>
<td>Drip</td>
<td>92.5</td>
</tr>
</tbody>
</table>

Modernization of irrigation systems

Open-channel systems change to Pressurized pipe systems
Objectives for transforming traditional irrigation systems

- Water savings: competitiveness for different water uses, environmental sustainability
- Increase water productivity
- Increase agriculture competitiveness
Spain

- Area: 2 000 000 ha
- Cost: 7 400 M €
  (80 % paid by Public Administrations)
- Water savings: 1 132 hm³/year

Water used for irrigation:
- 80 % before modernization
- 65 % after modernization

(Source: MARM, 2002; MARM, 2006)
### HIGHLIGHTS

**PRESSURIZED IRRIGATION IN THE WORLD**

<table>
<thead>
<tr>
<th>Country</th>
<th>Total irrigated area (Mha)</th>
<th>Sprinkler (ha)</th>
<th>Micro irrigation (ha)</th>
<th>Total sprinkler and micro irrigation (ha)</th>
<th>Percentage of total irrigated area</th>
<th>Year of reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>USA</strong></td>
<td>21.6</td>
<td>10 900 000</td>
<td>1 200 000</td>
<td>12 100 000</td>
<td>56</td>
<td>2003</td>
</tr>
<tr>
<td>Russia</td>
<td>4.5</td>
<td>3 500 000</td>
<td>20 000</td>
<td>3 520 000</td>
<td>78.2</td>
<td>2008</td>
</tr>
<tr>
<td>China</td>
<td>55.9</td>
<td>2 634 000</td>
<td>371 000</td>
<td>3 005 000</td>
<td>5.4</td>
<td>2005</td>
</tr>
<tr>
<td>India</td>
<td>56.8</td>
<td>1 634 997</td>
<td>864 000</td>
<td>2 498 997</td>
<td>4.4</td>
<td>2007</td>
</tr>
<tr>
<td><strong>Spain</strong></td>
<td>3.36</td>
<td>715 102</td>
<td>1 502 327</td>
<td>2 217 429</td>
<td>66.9</td>
<td>2007</td>
</tr>
<tr>
<td>Brazil</td>
<td>3.5</td>
<td>1 570 000</td>
<td>340 000</td>
<td>1 910 000</td>
<td>54.58</td>
<td>2004</td>
</tr>
<tr>
<td>France</td>
<td>1.575</td>
<td>1 379 800</td>
<td>103 300</td>
<td>1 483 699</td>
<td>94.2</td>
<td>2000</td>
</tr>
<tr>
<td>Italy</td>
<td>2.535</td>
<td>1 047 680</td>
<td>365 700</td>
<td>1 413 380</td>
<td>55.8</td>
<td>2000</td>
</tr>
<tr>
<td>South Africa</td>
<td>1.6</td>
<td>848 000</td>
<td>296 000</td>
<td>1 144 000</td>
<td>71.5</td>
<td>2004</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>1.17</td>
<td>716 000</td>
<td>198 000</td>
<td>914 000</td>
<td>78.1</td>
<td>2004</td>
</tr>
<tr>
<td>Australia</td>
<td>2.384</td>
<td>524 480</td>
<td>190 720</td>
<td>715 200</td>
<td>30</td>
<td>2000</td>
</tr>
<tr>
<td>Canada</td>
<td>0.87</td>
<td>683 029</td>
<td>6 034</td>
<td>689 063</td>
<td>79.2</td>
<td>2004</td>
</tr>
<tr>
<td>Mexico</td>
<td>6.2</td>
<td>400 000</td>
<td>200 000</td>
<td>600 000</td>
<td>9.7</td>
<td>1999</td>
</tr>
</tbody>
</table>
HIGHLIGHTS

EXPERIENCES IN WATER USER ASSOCIATIONS FROM THE EBRO BASIN (SPAIN)

Why this variability?

- irrigation systems? (flexibility, capability)
- Irrigators?
- (training, commitment)
**Water and energy in Andalucian irrigation systems (year 2008)**

<table>
<thead>
<tr>
<th>Irrigation method</th>
<th>Average water use (m³/ha)</th>
<th>Energy consumption (kW h/ m³)</th>
<th>Energy consumption (kW h/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>5500</td>
<td>0.06</td>
<td>328</td>
</tr>
<tr>
<td>Sprinkler</td>
<td>5000</td>
<td>0.34</td>
<td>1723</td>
</tr>
<tr>
<td>Drip</td>
<td>2500</td>
<td>0.51</td>
<td>1264</td>
</tr>
</tbody>
</table>

Source: Corominas 2009.
### CHANGING ENERGY PRICE SCENARIO

#### SPAIN

<table>
<thead>
<tr>
<th>IRRIGATION METHOD</th>
<th>Before 2009</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ha</td>
<td>%</td>
<td>ha</td>
</tr>
<tr>
<td>Surface</td>
<td>1,973,336</td>
<td>59</td>
<td>1,064,248</td>
</tr>
<tr>
<td>Sprinkler</td>
<td>802,712</td>
<td>24</td>
<td>765,440</td>
</tr>
<tr>
<td>Drip</td>
<td>568,588</td>
<td>17</td>
<td>1,591,616</td>
</tr>
<tr>
<td>Total</td>
<td>3,344,636</td>
<td>100</td>
<td>3,421,304</td>
</tr>
</tbody>
</table>

Source: PNR 2001, irrigated areas and crop yield survey.

Reduction of 14,000 ha
High energy consumption > 600 GWh/year
High power requirement > 500 MW/year

Since 2006, the electrical tariffs have increased:
✓ 455 % the power term
✓ 70 % the energy term
Evolution of Spanish farmers revenue (1190-2009)

Source: Anuario Estadística, MMARM.
WHAT'S UP WITH ENERGY?

HIGHLIGHTS

CONSUMPTION OF ENERGY IN SPAIN

70 % from May to September
30 % from January-April and October to December

Source: Iberdrolal Generación SAU.
Electrical tariffs are different during the day, they are grouped on: peak, medium, low.

The power requirements hired at the electrical company is high.

The cost of the power term is paid all year long although only pumping is concentrated in five months.
Regional Energy Agencies develop AUDITS (http://www.idae.es/index.php/mod.pags/mem.detalle/relcategoria.1034/id.93/relmenu.55) for the improvement of the energy efficiency in irrigated areas.

**HIGHLIGHTS**

Energy Efficiency regards with the reduction in energy consumption while Economical Efficiency regards with the lowest energy cost for the same energy consumption.

Energy Efficiency might improve by enhancing the design, operation and management of the irrigation systems network.

Economical Efficiency might improve by enhancing the terms of the contract with the electrical supplier.
HIGHLIGHTS

Energy audits in Water Users Associations (WUA) in Spain:

- Assess the energy efficiency in WUA (adequacy in the design of the pumping system components and their management)
- Give a grade to the WUE assessing its energy efficiency
- Propose measures to reduce the energy consumption and, therefore, the operation cost
Develop criteria for a proper design, operation and regulation of pumps in pumping station taking into consideration energy efficiency.
Proper operation, regulation and maintenance of hydraulic valves

Source: Sánchez (2012).
Optimal operation of collective irrigation water networks

• Several user friendly computer models analyzing hydraulic networks: most commonly used for irrigation networks are: EPANET (Rossman, 2001), COPAM (Lamaddalena), and Sagardoy, 2000), and GESTAR (Aliod et al., 1997).

• The calibrated hydraulic model can be used to provide information about the hydraulic behaviour of the network for each possible loading condition (scenario), and can be a useful tool for solving network management problems.
Water orders allocated and executed for optimizing water productivity and energy cost: genetic algorithms, dynamic calculation

Optimum sectoring depending on the network topology and monthly water demand. Number and arrangement of operating sectors would be different during the irrigation season according to water demand variability.

- Accurate estimation of crop water demands and irrigation practices

The analysis and control of critical points improve network operation by saving energy
Optimize the Design, operation and management of irrigation systems in plot

- high effect on the performance of the irrigation systems in plot of the pressure variations at hydrant level (Daccache et al. (2010)).
CHALLENGES

**Dynamic simulation**

- Simulation of different global (cropping patterns, irrigation operation,…) strategies performance on energy balance in irrigated districts.
- Determination of key factors for improving energy balance.

Source: Sánchez et al. 2012.
CHALLENGES

MANAGEMENT OF PRESSURIZED IRRIGATION NETWORKS

Determine the energy efficiency of pumping stations (Methodology developed by Abadía et al. 2008)

Fix the power term in the contract with the electrical supplier attending the real demanding irrigation requirements
Use of renewable energy sources:
- solar panels
- windmills
Thank you very much for your attention