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An analysis of energetic cost for an irrigation network in France

AN ANALYSIS OF ENERGETIC COST FOR AN IRRIGATION NETWORK IN FRANCE

ANALYSE DU COUT ENERGETIQUE D'UN RESEAU D'IRRIGATION EN FRANCE

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ABSTRACT

This work is dedicated to energetic cost analysis for an irrigation networks in France, namely, the canal of Carpentras in southeast. The goal is to bring new solutions for this very important financial aspect. To do so, two main factors are considered and analyzed based on the specific aspects of the network and on the available data during the last decade.

RÉSUMÉ

Ce travail est dédié à l'analyse du coût énergétique pour réseau d'irrigation en France, à savoir, le canal de Carpentras dans le sud-est. L'objectif est d'apporter de nouvelles solutions pour aspect financier assez important. Pour ce faire, deux facteurs principaux sont considérés et analysés en se basant sur des aspects spécifiques du réseau et sur les données disponibles de la dernière décennie.

Keywords: Pressurized irrigation network; Pumping station; Energetic cost;

1. Introduction

The water management of pressurized irrigation network becomes challenging issue due to continuous expansion of irrigated area, fluctuating weather conditions and changes on irrigation practices. Moreover, the numbers of the irrigation pumping stations are constantly increasing to satisfy the evolution of the demand. As a direct consequence, the energy bill is in constant increasing. Hence, the subject has attracted the interest of several authors. However, it should be noted that the analysis of energetic cost of the irrigation network is related to its geographic localization, the energetic policy of the country considered, the kinds of the users, etc.

This work is a contribution to the problem of energetic cost analysis for irrigation networks. The objective is to study the evolution of the cost for identifying the main causes of its increasing in order to seek relevant solutions for its control.

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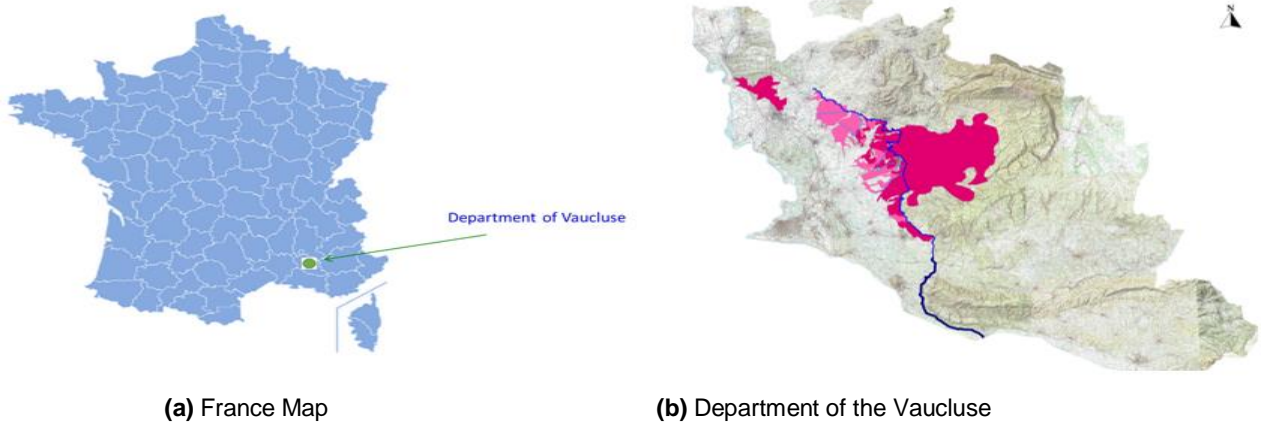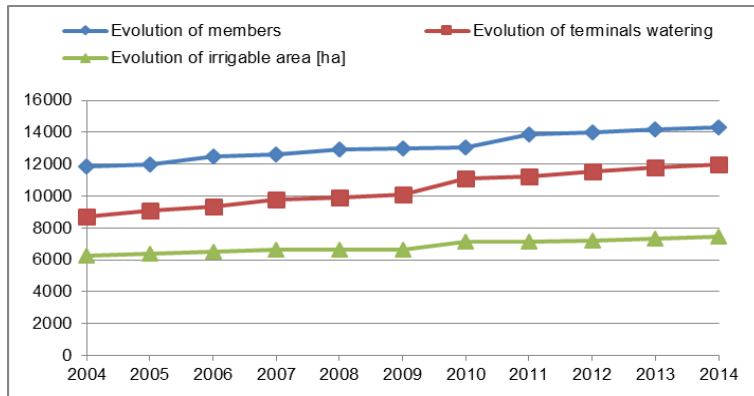
(a) France Map

(b) Department of the Vaucluse

Figure 1. The considered area

Figure 2. Evolution of the demand

More precisely, this study concerns the irrigation network of Carpentras. This network is located in the south east of France (see Figure. 1) and is with Mediterranean climatic conditions. The network is composed by more than 1000 km of piping, 34 stations and 24 storage tanks. It is used by more than 14, 000 customers for irrigating of more than 12, 000 hectares. Figure 2 depicts the evolution of the number of customers. Figure 1-(b) and Figure 2 show the geographical location of the area concerned (see the red surface) and its evolution during the last decade, respectively. A simple analysis of the curves in Figure 2, shows the constant increasing of the demand.

The energetic cost is depending on several factors. An analysis in depth of these factors is necessary for bringing solutions in order to reduce the energetic cost. The factors are of different kinds that can be the water lost, the structure of the network, etc. In this work, we focus on two factors; namely, the electricity bill and the ratio between the water pumped and the quantity registered in the terminals of watering. Note that analysis proposed in this work is based on the historical data during the last decade and the specificities of irrigation network considered.

2. Billing of electrical energy

The first part of our analysis concerns the contracts adopted for billing. More precisely, the goal is to investigate the profitability of some contracts taking into account the energetic cost based on the rules of calculations for establishing the final bill and the tariffs applied.

2.1 The billing

In France, there are three main categories of electrical tariff depending on customer energy consumption (Yellow, Blue, and Green). In each category, there are many options to be chosen by the consumer. In this subsection, a description of the billing adopted by the electricity supplier called "Green bill A5 basic" is given. Similar to the other categories, five period are defined: Rush hours (P1), Winter Peak hours (P2), Winter Off-peak hours (P3), Summer Peak hours (P4) and Summer Off-Peak hours (P5). According to the adopted utilization option, the energy cost of these periods change considerably which makes the end consumer very confused when choosing the most suited one. There are 4 types of utilization option: the Very Long utilization (VLU), Long Utilization (LU), Medium Utilization (MU) and Short Utilization (SU). The total cost of the energy bill can be described by:

$$C_{Total} = C_{EA} + C_{FP} + Taxes \qquad (1)$$

where C_{EA} is the cost of active energy, C_{FP} represents the fixed prime cost and $Taxes$ regroups all kind of charges related to French policies in electrical sector.

Let's define E_k^a the active energy of the kth period and C_k^U the cost of energy for the kth period according the utilization option. For instance, C_4^{VLU} is the energy cost for a very long utilization at summer peak hours. Thus, we have

$$C_{EA} = \sum_k E_k^a C_k^U \tag{2}$$

The fixed prime cost depends on the subscribed Power Ps_k for each period of time, the coefficient $Coeff_k^U$ and the cost C_{FP}^U related to the utilization option. It can be calculated by:

$$C_{FP} = C_{FP}^U (Coeff_1^U Ps_1 + Coeff_2^U (Ps_2 - Ps_1) + Coeff_3^U (Ps_3 - Ps_2)$$
$$+ Coeff_4^U (Ps_4 - Ps_3) + Coeff_4^U (Ps_5 - Ps_4)) \tag{3}$$

Through these options, the electricity supplier trends to give more advantageous C_k^U for very long utilization and more advantageous C_{FP}^U for short utilizations.
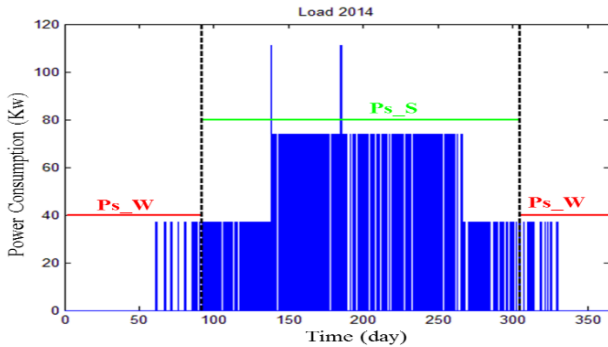
2.2 Tariff analysis

Figure 3. electricity consumption during 2014

2.3 The particularity of Canal Carpentras makes difficult to choose the suitable options using classical method based mainly on time function of pumps over one year. The figure 3 shows the electricity consumption for n installation over the last three years. As it can be noticed the energy consumption is more important in the summer period and it is very limited in the other periods. Therefore, taking the time function over one year leads to wrong description of the reality and generally leads to the choice of the short utilization option based on references given by the electricity supplier. These references are more suitable for the classical industrial uses with small power consumption variation over the year and it is not adapted to customer particularities.
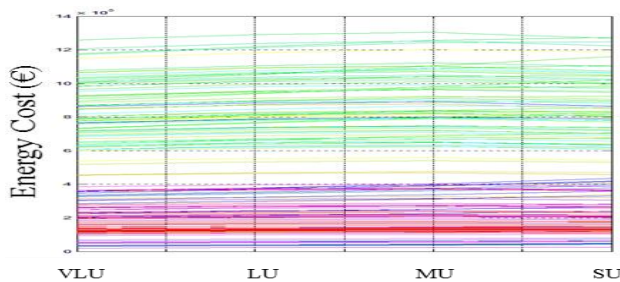

Figure 4. Energy cost C^{SU}>C^{VLU}

In this section, the cost of energy consumption is analysed according to the 4 utilization options. It is done for 10 stations over the last decade. According to this evaluation, the energy cost with "very long utilization" option is more advantageous in 82% of cases and lead to reduced bill. Figure 4 shows the cost evolution of different cases according to the utilization options.
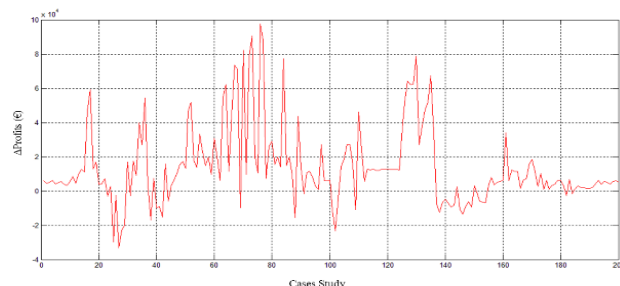

Figure 5. Energy profits with VLU option

Figure 5 highlights these results and gives the energy profit that was possible to be achieved by just changing the utilization option. These results shows that considering an irrigation network as standard user has generated extra-costs that can be converted into benefits by considering its particularities.

3. Water volume analysis
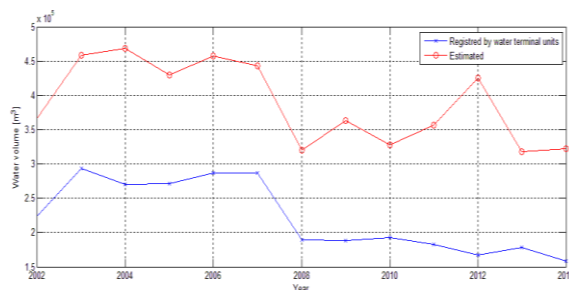
In this subsection we analysis the ratio between the water pumped and the quantity registered in the terminals of watering. The goal is to compare the quantity of the water pumped and the registered one to evaluate the wasted quantity, in the meaning "pumped but not billed". These losses are generally related to the state of canalization and customers with defective terminals.

The estimation of the pumped volume of water V_p, over one year, is based on the flow rate Q, the energy consumption E^a and the rated power P^r of the installation in each station.

Figure 6. Evolution of water volume Registered and estimated

The water volume equation is given by:

$$V_p = \frac{E^a}{P^r} Q \tag{4}$$
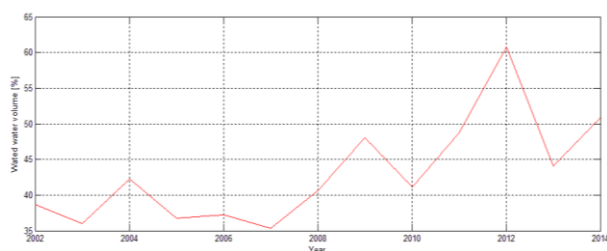
The figure 6 shows the evolution of water demand over the last decade for a main station of the network and highlights the differences between the pumped water volume and the registered one. As it can be noticed from figure 7, the wasted volume of water is increasing each year and reaches 60% of the pumped volume. This study has been extended to other station of the irrigation network considered and the same phenomenon has been noticed.

Figure 7. Wasted water volume

4. Conclusion

In this work we have presented a first analysis on the energetic cost for the network of Carpentras. More precisely, we have considered two main factors that are the bill of electrical energy and the management of water. For a complete analysis, other factors have to be considered. Among these factors, structure of the network and the operating conditions of the pumps are another main cause of the energetic cost increasing. Indeed, the geographic position of each station imposes different operating modes under variable loads. Besides, the efficiency of an irrigation pumping station depends on the operating conditions and ageing of the pumps. This criterion, in spite of its importance, is not monitored and rarely estimated due to the high cost of needed sensors. Work is in progress in order to analysis the efficiency of the machines and the effect of the structure of the network. The goal is to estimate their impact on energy consumed.

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