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HYDRAULIC IRRIGATION INSTALLATION DIAGNOSIS: KNOWING OF THE SYSTEM TO IMPROVE IT

DIAGNOSTIC DES INSTALLATIONS D'IRRIGATION : CONNAITRE LE SYSTEME POUR L'AMELIORER

Sophie GENDRE[1]; Cyril DEJEAN[2]; Jacques GEORGES[3];Jean-Marc DEUMIER[4]

ABSTRACT

The cost of electricity has increased steadily over the past decade. One of the most demanding items in agriculturefor electricity is irrigation. The objective of the study conducted from 2012 to 2014 summarized in this document was to build an energy diagnosis of irrigation installation to offer solutions to farmers to reduce their energy consumption and thus reduce energy bill. In order to build this diagnosis, nine installations equipped with mobile gun were followed during the three years of the project. One of the installations was equipped by pressure sensors to study pressure loss variations during an irrigation campaign. This study has led to simple indicators definition to characterize irrigation installations in terms of energy and to a diagnosis method to help farmers who want to reduce their electrical consumption.

RÉSUMÉ

Le prix de l'électricité n'a cessé d'augmenter ces dix dernières années. L'un des postes agricoles les plus gourmands en électricité est l'irrigation. L'objectif de l'étude menée de 2012 à 2014 résumée dans ce documentétait de construire un diagnostic énergétique des installations d'irrigation afin de proposer des solutions pour réduire leurs consommations énergétiques et ainsi diminuer la facture pour les irrigants. Afin de construire ce diagnostic, neuf suivis sur des installations équipées par des enrouleurs ont été menés durant les trois années du projet. Un suivi a été mené à l'aide de capteurs de pression relevant en continu des données sur l'installation d'irrigation afin d'étudier les variations de perte de charge sur une installation en fonctionnement. Cette étude a permis d'aboutir à la définition d'indicateurs simples de caractérisation des installations d'irrigation en terme énergétique et de construire une méthode de diagnostic des installations à mettre en place chez les irrigants désireux de trouver des solutions pour réduire leurs consommations électriques.

Keywords:diagnosis, pressure loss, measurement set up, irrigation, energy consumption

[1]*ARVALIS – Institut du végétal, 6 chemin de la côte vieille 31450 Baziège – France - s.gendre@arvalisinstitutduvegetal.fr*
[2]*IRSTEA – UMR G-eau, 361 rue Jean-François Breton, BP 5095 34196 Montpellier Cedex 05 – France - cyril.dejean@irstea.fr*
[3]*Chambre d'Agriculture de Haute Garonne, 28 route d'Eaunes, 31605 Muret – France – jacques.georges@haute-garonne.chambagri.fr*
[4]*jm.deumier@orange.fr*

1. Study context

Between 2004 and 2013 in France, electricity costs raised ofaround 12% each year (the electricity price has double in France in ten years). This increase has an important impact on energy bill for farmers who chose to irrigate their lands. Regarding this fact, a project to develop a method to diagnose energy consumption of irrigation installations for farmers has begun in 2012. This study was lead as part of a CASDAR ("*Compted'AffectationSpécial pour le DéveloppementAgricoleet Rural"* = *Special Allocation Account for Agricultural and Rural Development*) project on Energy and Farming called EDEN. Regarding irrigation work package, the objective was to develop a method to diagnose energy consumption of irrigation installations for farmers and to define indicators as reference to well describe it. This diagnosis is a global approach with agronomical, economical and energetics parts. Indeed, first energy economy in irrigation is the water you don't use. Our work was limited to farm irrigation net equipment. We mainly studied sprinkling irrigation. In this paper, we only present work on mobile gun (hose-reel) and the energetics part of the diagnosis but we also worked on sprinkler irrigation and center pivot.

2. Methodology

The study was lead during three years (2012-2014) on nine (9)mobile gun (hose-reel) installations located on the south-west of France (Haute-Garonne). On one of these installations, measurement chain was set up. Others installations were followed with occasional measurements during the season.

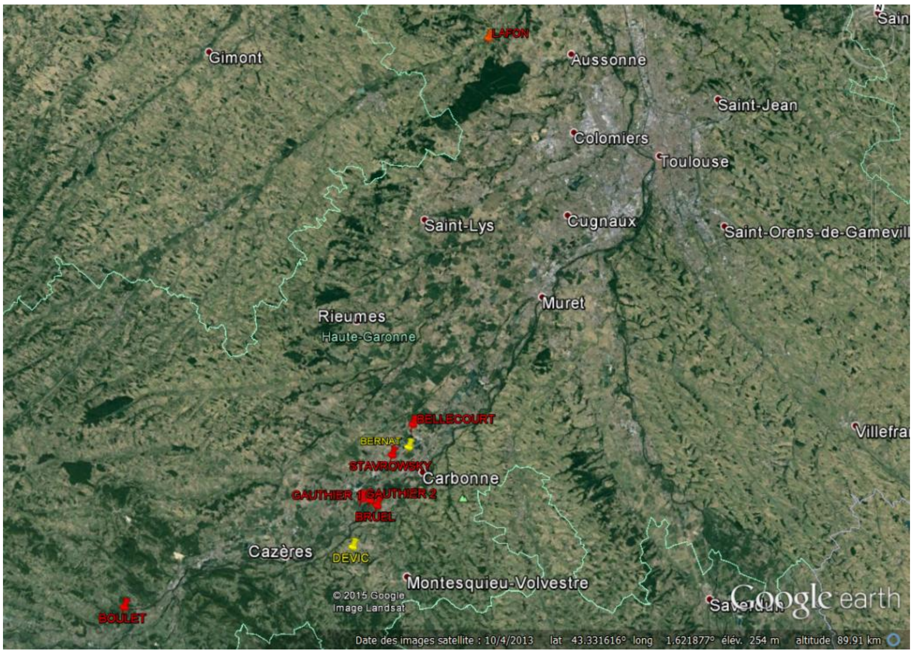

Figure 1: Location of followed farms during the project

2.1 Measurement chain

The mobile gun installation (hose-reel) followed during three (3) years was used to irrigate 14 ha of grain maize. Farmer was pumping in an aquifer layer at few meters from the surface through a well.The first work was to get the description of the irrigation equipment from the pumping station to the nozzle of the hose-reel. Identifying the pipes inner size and material with their length and change in diameter, elbow, to have the ability to build an hydraulic model. The objective of this monitoring was to know pressure losses evolution at a short time step (5 minutes) during irrigation season to see effect of the hose-reel position and change during the gun removal at a position and alsoto identify eventual representative periods to supply an energetic diagnosis.

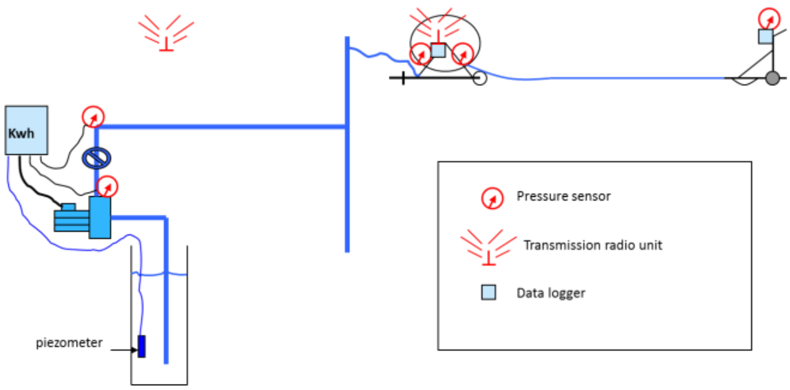

Figure 2: measurement chain on mobile gun

In order to finely understand pressure loss in an irrigation system in operation, a measurement chain was set up on this installation. Five (5) pressure sensors, one (1) transmission radio and one (1) data logger Red Lion equipped the mobile gun as shown on figure 2. The different sensors used are shown on figure 3.

During three years, we collect pressure data every 5 minutes on the device on each pressure sensor. This way, we could follow on a whole irrigation campaign pressure in each part of the installation.

Figure 3: equipment used on measurement chain

Then, with the help of hydraulic model, we calculated theoretical pressure losses and we compared it with data.

2.2 Non monitored experimental system

At the same time as measurement chain, we followed nine (9) installations with only occasional measures in terms of flow and pressure. We collect hydraulic, energetic, agronomic and economic information to size our future diagnosis in terms of time and farmer interest and to develop simple indicators to describe and situate the installation in comparison with other installations.

3. Results

3.1 Measurement chain knowledge

The Monitored installation allowed us to well represent pressure losses. Figure 4 shows the steps where electrical power is lost for the installation we monitored.

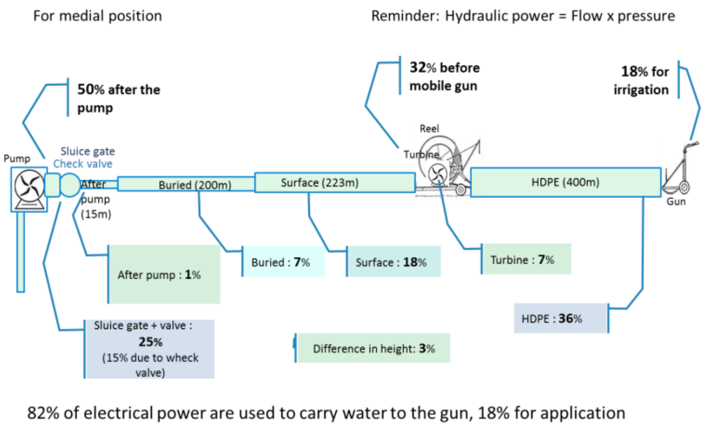

Figure 4: energy loss distribution on the mobile gun installation

A big pressure loss is due to check valve in this installation. It means farmer, due to oversized pump, partially close check valve. This pressure loss can be avoided with a better adapted pump.

This monitored experimental system showed us small variations of pressure loss during irrigation period for a position. It allowed us to define minimal one-time measurements to do for non-monitored experimental system. We define three required measures: flow on the medial position, pressure after the pump and pressure at the gun. With these three (3) measures, we consider having a good start to estimate energy loss in a system.

3.2 Definition of simple indicators

One (1) main indicator was chosen to describe energetics consumption installation, kWh/m^3, calculated by three (3) different ways:

1) kWh/m^3 “meter”: calculated with flowmeter-readings

2) kWh/m^3 “flow measure”: calculated using ultrasonic flow measure made during irrigation season

3) kWh/m^3 “optimized”: calculated with a system without any pressure loss in the sluice gate at the water pump exit. Indeed, the study showed that main energy consumption on irrigation installations was located on sluice gate

Installation	kWh/m^3 "meter"	kWh/m3 "flow measure"	Difference between "meter" and "flow measure"	%	kWh/m3 "optimized"	Difference between "meter" and "optimized"	%
1	0.40	0.38	0.02	5.9%	0.28	0.12	***30.5%***
2	0.61	0.63	-0.01	-2.2%	0.64	-0.03	NA
3	0.49	0.39	0.10	***21.3%***	0.35	0.14	***28.6%***
4	0.62	0.43	0.19	***30.9%***	0.36	0.26	***41.6%***
5	0.62	0.59	0.03	4.2%	0.54	0.08	12.7%
6	0.49	0.47	0.02	4.2%	0.41	0.08	***15.9%***

Figure 5: Results coming from non-monitored experimental system

All indicators are compared to the reference, kWh/m^3. kWh/m^3 “flow measure” is calculated to estimate energetics consumption in sluice gate and to see how energetics losses are distributed among the irrigation net. Figure 5 shows results and comparison between these three (3) indicators on our mobile gun panel.

Another part of the energetics diagnosis is to place pressure loss on the different parts of the installation. Figure 6 shows the different pressure loss points on an installation. For each installation, pressure lost value comes from Hazen-Williams formula for linear losses:

$$j = 10,68 * (\frac{Q}{C_{wh}})^{1,852} * D^{-4,871}$$

With j = pressure loss in water column meter/meter, Q = flow in m^3/sec., C_{wh} = Hazen-Williams coefficient, D = diameter in meter.

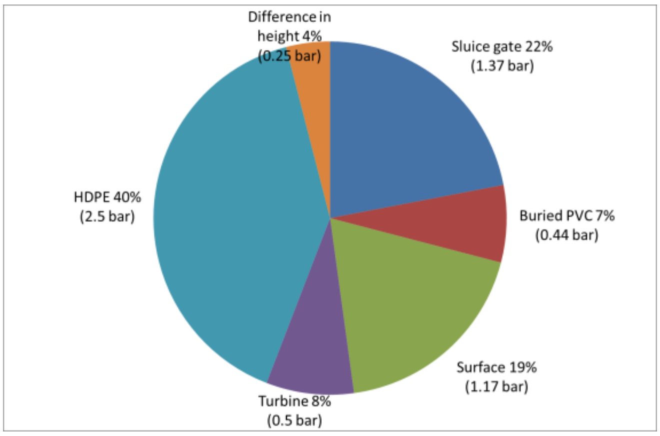

Figure 6: Example of pressure loss in a studied installation

Pressure loss values for singular losses come from an estimate for each "singularity" of the installation (check valve, bends…).

3.3 Comparison between installations

To compare irrigation installation with a panel of other installations, we defined a "constraint" coefficient depending on length between water pump station and irrigation equipment position, difference in meter from water level at pumping station and irrigated field.

Constraint coeff. = length pump/ position in meter pressure loss (average of pressure loss in the pipes for the panel in water meter/meter) + water level difference*

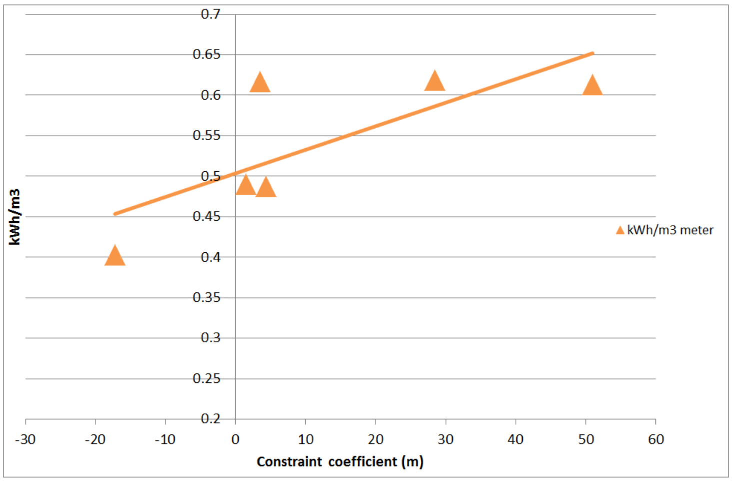

Figure 7: Relation between kWh/m^3 "meter" and constraint coefficient

Indeed, each installation has field constraints which are inherent to the system. This constraint coefficient allows us to compare installation irrigation in reference to field specificity. Figure 7 shows the different values of kWh/m^3 in relation to this constraint coefficient.

4. Conclusion and prospect

This work allowed us to develop a working diagnosis which is going to be tested at the field in 2015. 15 new farm irrigation installations in the south-west of France (Haute-Garonne) will be assess during the irrigation campaign in order to improve and optimize thediagnosis method.

Another contribution of this work is to start acquiring reference for different irrigation equipment on energy and irrigation, beginning building of a database on energy in irrigationthat haven't a lot of references for the moment.

The development at farm level of this diagnosis method will allow supplying the data center for different irrigation installations and improving our global knowledge about energy consumption in irrigation installations.

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