Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 186 (2017) 294 – 302

Procedia Engineering

www.elsevier.com/locate/procedia

XVIII International Conference on Water Distribution Systems Analysis, WDSA2016

Strategies to improve the energy efficiency of pressurized water systems

Enrique Cabrera, Elena Gómez*, Vicent Espert, Enrique Cabrera Jr

ITA, Universitat Politècnica de València. Camino de Vera s/n. Edificio 5C
46022 Valencia (España)

Abstract

As time goes by, the need to move water is greater and this water will be pressurized. Layout flexibility, security, quality care, control, lower environmental impact and higher efficiency justify pressurized transport rather than natural gravitational water transport. On the negative side, we find the enormous amount of energy pressurized systems require with the associated negative economic and environmental impacts. Therefore, it is crucial to minimize these impacts and that only can be achieved by improving the energy efficiency of these systems. To achieve that final goal, the first step is to perform an assessment to estimate the margin of improvement from the actual performance of the system to the maximum achievable level of efficiency [1]. The second step is to perform an energy audit in order to identify exactly how the energy is used and where it is lost [2], with the third step being identification of the different actions that can be implemented in practice in a system. The final step is to perform the cost benefit analysis of the selected actions to prioritize execution.

The focus of attention of this paper is on the third step, actions that can be classified in operational actions (do not require investments) and structural actions (require investments).

Peer-review under responsibility of the organizing committee of the XVIII International Conference on Water Distribution Systems

Keywords: Energy audit; water and energy; improve actions; optimal water networks

* Corresponding author. Tel.:+34 963879898; fax: .:+34 963879899
E-mail address: elgosel@ita.upv.es

1877-7058
Peer-review under responsibility of the organizing committee of the XVIII International Conference on Water Distribution Systems
doi:10.1016/j.proeng.2017.03.248

1. Introduction

The need to move water is greater and, except in a few cases, this transport is under pressure. Layout flexibility, security, quality care, better control, lower environmental impact and higher efficiency are just some of the benefits of pressurized transport. On the other hand, the negative aspect of pressurized systems is the enormous amount of energy they require (a cubic meter of water weighs a ton). The transformation process of traditional irrigation to pressurized water transport systems is a clear example of the negative and positive angles. Drip irrigation is much more efficient and is increasingly replacing traditional surface flooding irrigation. As a consequence, the energy expense is growing nonstop. California, the electrical energy linked to water pumps is over 6% of the total [3]. In Europe, this value is around 4%. According to the impact assessment study accompanying the 2009/125/EC Directive [4], the energy demand of water pumps in 2005 was 109 Twh (EU-25), although recent estimations [5] raise those figures considerably (10% of global electrical energy is consumed by pumps, representing 259 TWh per year within the EU). Therefore, assuming that most of this demand is linked to water transport and distribution (urban and agricultural) and that electrical energy demand that same year [6] was of 237,537 ktoe (EU-27) or 210,205 ktoe (EU-15), equivalent to 2766 and 2447 Twh respectively, the percentage of energy linked to water pumping ranges from 3.94% to 4.45%. Considering that agriculture represents 2% of total energy consumption in Europe [7], the energy required for urban use (not treatment) can be assumed to be similar. These are average values as the energy required can vary between countries (e.g., in Spain, -Corominas, 2010 [8]-, agriculture uses 3% of the total energy consumed by the country).

Furthermore, wider environmental studies (e.g., lifecycle analysis of the urban water cycle) indicate that the operational phase, closely linked to water transport (two steps of the urban water cycle, supply and distribution), is the main contribution to Global Warning Effects of the lifecycle [9]. Therefore, from both points of view (economical and environmental), it is crucial to be as efficient as possible. Up to now, energy savings of the pressurized water transport process has been analyzed for specific steps, mainly pumping. For instance, the EU [4], estimates savings at the pumping stage around 20-30%, although commercial estimations [5] go much further: 2/3 of all pumps could save up to 60% energy. And both reports assess these savings only considering the pumping stage. This paper identifies and describes up to eight different strategies to save energy (including the pumping stage) and estimates, supported by practical examples and references, the corresponding energy saving margins. When the selected corrective actions have been implemented, the total energy saving can be 60% or more. Although the main objective of this paper is to describe the different actions that can be taken to improve the energy efficiency of pressurized systems, first a general overview of the whole procedure is presented.

2. Road map description

Maximum energy savings can only be achieved from a global system analysis (assessment) followed by a road map, consisting of different stages. The process must include the concept of topographic energy (linked to the network topography) and simultaneous consideration of shaft and natural energy [1]. As Figure 1 depicts, the method is divided into 6 stages: pre-assessment, diagnosis, audit, cost-benefit analysis, decision-making and final rating of the system's energy efficiency, a procedure that fits very well with the statement "think globally, act locally". In order to save as much energy as possible, all phases go through two columns: the consumed and the topographic energies.

The variables included in the flow chart (listed from top to bottom and from left to right) are: E_{uo}, minimum required energy by users (constant, regardless of whether the system be real or ideal); η_{ai} and η_{ar}, ideal and real performance of the system without recovery (with pumps as turbines, PATs); $\eta_{ar,o}$, target energy efficiency performance of the system without recovery; θ_{ti}, percentage of total topographic energy (ideal case); E_{yr},, recovered energy (from the topographic energy); λ_{wf}, percentage of reducible friction energy related to the supplied energy; λ_{wl}, percentage of reducible energy embedded leaks related to the injected energy; λ_{wo}, percentage of other energy losses related to the supplied energy; λ_{wp}, percentage of reducible energy in pumping related to the supplied energy.

A brief description of the six stages follow:

1. *Assessing initial requirements.* The flow chart (Figure 1) assumes that the useful energy, E_{uo}, is a starting point (E_{uo}, is the result of multiplying the volume demanded by the pressure of service). However, before starting, the