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# Water Consumption Management and its role on Energy Saving, Case study of Tehran, Iran

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**ABSTRACT:**Due to shortage of precipitation and the spatial and periodical disparity of rainfalls, Iran is counted among the arid and semi-arid countries of the world, and therefore the water utilities have put the control of consumption and efficient use of water high on their priorities. Water consumption management is considered as a field of energy management, and the impacts of effective measure related to water consumption pattern and its optimization on reducing demands are quite clear. Therefore one of the main objectives of consumption management policies is to optimize energy and reducing the costs of energy needed to supply potable water from production sources. To have a relative estimate of the amount of energy reduced as a consequence of consumption management the outcomes of a case study undertaken in a region of Tehran were used. In this study, the application of consumption management measures yielded in a 19% reduction in water consumption. This amount of reduction limits requirements from production sources such as wells and treatment plants and its direct impact is to reduce the required energy and the costs of water supply.

**Key words:** Cost reduction, Energy saving, Water consumption management

## INTRODUCTION

The role of water in health, hygiene and social welfare is known to all, and it is up to humans as rational creatures to do the outmost to preserve their lives (Nasrabadi *et al.,* 2009; Nasrabadi *et al.,* 2010; Mondejar-Jimenez *et al.,* 2011; Tabesh *et al.,* 2011; Pamer *et al.,* 2011; Pirani and Secondi, 2011; Nasrabadi *et al.,* 2011; Ghaderi *et al.,* 2012; Mobarak-Qamsari *et al.,* 2012; Hatamoto *et al.,* 2012; Arshad and Hashim, 2012; Adl *et al.,* 2012). All the planning potentials and efforts must be concentrated on target-oriented activities. An important strategy in this context would be to create equilibrium and to enhance the consumption management activities in the natural cycle. Several researchers have worked on enhancement of such management activities (Sakuringwa, 2007; Papadakis *et al.,* 2000; Papadakis *et al.,* 2007; Hoque *et al.,* 2006; Mossalanejad, 2011; Ataei *et al.,* 2011). The water consumption management is considered as a branch of energy management (Blum *et al.,* 1990). The impacts of appropriate measures related to consumption pattern and its influence on reducing energy requirement is quite clear. Therefore in addition to optimization of potable water consumption, an important objective of water consumption management is to optimize energy and reduce its costs during the supply of potable water from production sources, such as wells and treatment plants. Therefore the impact of consumption control on energy management in water industry terminates in considerable reduction in required energy and its costs. Lots of studies have been run regarding optimization of energy consumption in water and wastewater industry (Islam, 1995; Maria and Tsoutsos, 2004; Palmer and Burtraw, 2005; Tsagarakis, 2007; Tsagarakis and Papadogiannis, 2006; Xiaohua *et al.,* 2007) as well as the water consumption management all around the world (Fytianos, and Christophoridis, 2004; Magadza, 2003; Papadakis, 2000).

## MATERIALS & METHODS

The important question to be raised on consumption management and consequently on energy management is to estimate the real per capita consumption at its different components during the day, the reduction of this consumption by application of management measures and consequently the reduction in the energy needed to produce and supply

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water required in the city. To answer the above question one needs a comprehensive study involving a number of water consumers, to be able to measure the amount of reduction. Through a study conducted on consumers in Tehran it was determined that over 70% of the consumers are households. For the purpose of this study, a residential complex that allowed the installation of separate meter in each unit to measure hot and cold water consumption was selected. The complex consisted of 4 blocks of 30 units each, where people of different cultures, education and revenue level and other backgrounds lived. In this context a number of questionnaires were prepared and distributed among the residents, asking them about their pattern of consumption. The next stage involved the installation of auxiliary cold and hot water meters throughout the complex as well as auxiliary meters preferably separate from those for hot and cold waters in one of the blocks (these were installed in kitchen, bathroom, wash basins, toilets, washing machines, flush tanks, AC, etc, and for all faucets). Then separate forms were made for each consumption component and given to a NGO group (composed of young residents of the complex) for reading. In the next stage by placing valves in some units and consumption reducing equipment in the other 25, the effects of the equipment were studied for the next thirty days. The readings were undertaken either by residents or trained personnel once a day and the total of internal consumptions were compared with the meter fixed outside each unit. This plan permitted measuring the daily hot and cold water consumption of each person, which could be considered as a model for the entire city of Tehran. Moreover the effects of reducing equipment in improving the consumption of residents were determined. By appropriate planning and taking technical and cultural measures, it will be possible to identify the volume of water consumed in Tehran within an acceptable confidence interval. In this plan an average of 15 meters were installed in each residential unit and a 30-day reading of the faucets was carried out at current situation.

**RESULTS & DISCUSSION**

In the third phase, after completion of the second 30-day readings, all meters were removed and the internal installations were returned to their original state.By applying the technical measures of consumption management a 19% drop in consumption was observed in block 3 (Fig. 1). No special action was taken in blocks 1, 2 and 4, which were considered as blank samples.

Therefore the expansion and implementation of this plan in a large city such as Tehran would not only reduce the per capita consumption, but would also lead to a reduction in the energy needed to supply this per capita water. This is a great step towards considerable savings at national level, given the current high costs of energy needed for operation and supply of water from wells and treatment plants in big cities. The water production sources and the required energy and costs in the year 2006-2007 in Tehran are shown in Table 1.

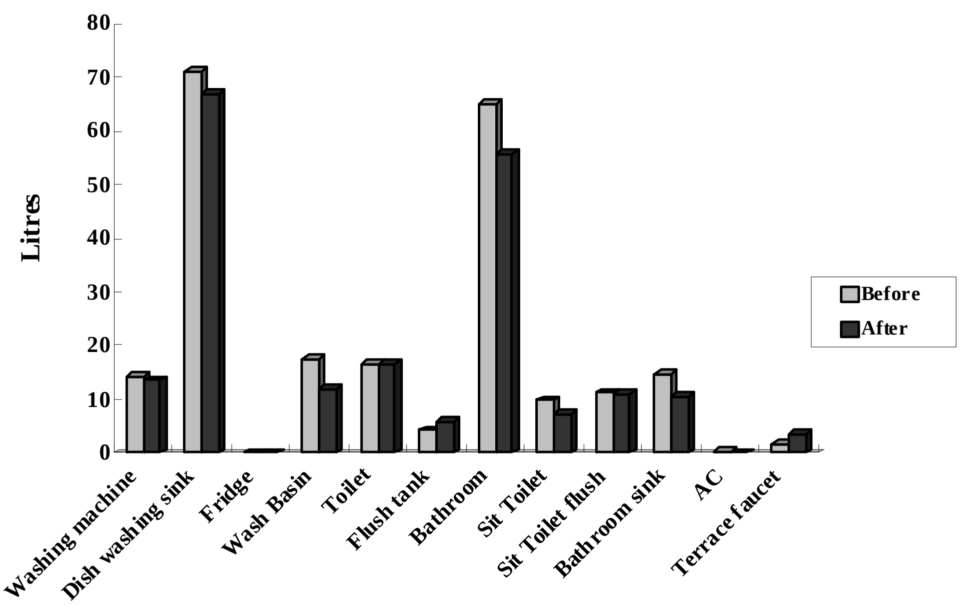


**Fig. 1. Comparison of per capita consumption before and after installation of consumption reducing equipment**

**Table 1. The required energy and costs of water production and distribution in Tehran**

| Data | | Drinking water supply | |
|---|---|---|---|
| | | Well and Pumping systems | Water treatment plants |
| No. of Power connections | | 401 | 4 |
| Energy consumption (KWh) | Normal | 106,341,243 | 11,221,100 |
| | Peak load | 26,862,423 | 3,426,350 |
| | Low load | 14,144,380 | 3,644,000 |
| Volume of water production($m^3$/year) | | 276,170,155 | 709,266,800 |
| Power Consumption (KWh) | | 159,210,696 | 18,291,450 |
| Energy costs (US $) | | 13,995,349 | 1,232,329 |

As shown in Table 1, in the year 2006-2007, 159,210,696 KWh of energy was needed to produce 276,170,155 $m^3$ of water from groundwater resources in Tehran, while around 18,291,450 KWh of power was needed to produce 709,266,800 $m^3$ of water from the 4 existing treatment plants. Therefore an investment of around US$ 1,522,767 is was needed to produce around 2.7 million cubic meters of water per day in Tehran. It is obvious that the application of water consumption management strategies and its optimization, which lead to lesser need for water production, will have a direct impact on the amount of savings and a reduction of energy required to produce and supply water, and subsequently on the costs of energy supply.

If we assume that there is a direct relation between the 19% drop in water consumption and the reduced energy needs, the application of water consumption management measures would lead to approximately 0.513 million $m^3$ of savings in Tehran on the water produced from existing wells and treatment plants. Consequently the water production requirements would drop to 2.187 million $m^3$ per day. Considering that 0.76 million $m^3$ per day of water needed by Tehran is produced from well and the rest 1.94 million $m^3$ from treatment plants, the 0.513 million $m^3$ per day reduction caused from consumption management strategies would allow a considerable number of wells to be taken out of the production and distribution circuit. This would in turn lead to a great energy saving as well as reduction in the costs of pumps, installations, and their operation and maintenance. The energy needed in the process of water production and distribution from wells is equivalent to 159,210,696 KWh, having an approximate cost of US$ 1,400,000. The 19% drop in water consumption would save energy needed to produce and distribute water from wells up to 30,250,032.24 KWh, with an approximate cost of US$ 260,000 (Figs 2 and 3). If this amount of energy and costs savings in extended to a national level, in addition to a considerable and direct impact on national economy, it would lead to a significant preservation of natural water resources in the country, particularly the groundwater resources, and in this way the need for investment to produce energy is greatly diminished and we can resolve the problem of water shortage and scarcity of renewable resources. The amount of energy consumption and costs of electricity in water production and distribution process from wells before and after application of consumption management policies are shown in Table 2. Moreover the number of existing wastewater treatment plants in Tehran, and their energy requirements and related costs are shown in Table 3.

As mentioned the volume of water consumed in Tehran in the year 2006-2007 was equivalent to 2.7 $m^3$ per day. By considering a sewage factor of 0.8, the volume of generated wastewater in Tehran for the same year would be equivalent to 2.16 million $m^3$/day. On the other hand the existing wastewater treatment plants in Tehran have only a small percentage of the population under their coverage. If we assume that 10% of the generated wastewater enters the 6 treatment plants, the required power and the related costs would be 7,826,162 KWh and US$ 56,500, respectively (Table3). Through a 19% reduction in water consumption, the volume of wastewater would also be reduced by 19% to an equivalent of 0.4104 million $m^3$/day, which in turn lead to a reduction in the energy requirements and costs (Figs 4 and 5). Therefore by considering a reduction of 19% the volume of wastewater generated would be 1.75 $m^3$/day, while the energy costs and requirements in the treatment works would be US$ 46,000 and 6,339,191.2 KWh respectively. In this way, once the number of treatment plants increase to cover the entire Tehran population, a 19% reduction in the volume of wastewater generated would mean a considerable reduction in the power costs and requirements.The amount of power consumption and

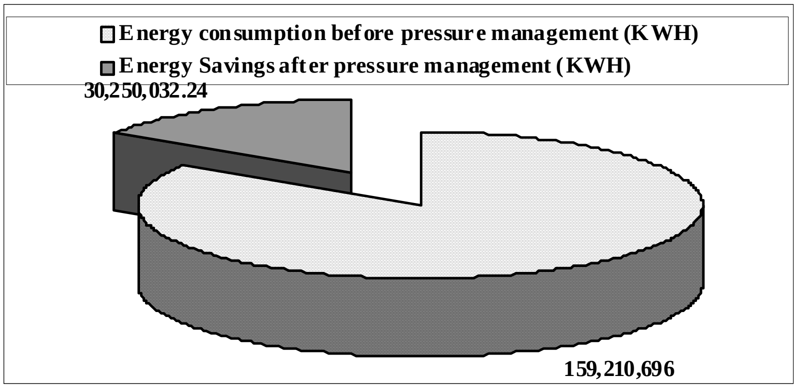


**Fig. 2. The amount of changes in power consumption of well equipment (KWh)**

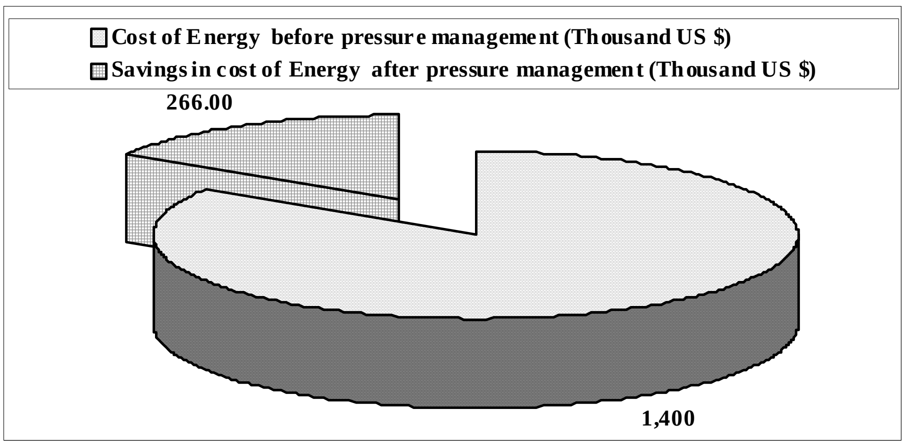


**Fig. 3. The amount of changes in costs of power consumption of well equipment**

**Table 2. Energy consumption and costs involved in the process of water production and distribution from wells before and after consumption management**

| Water consumption pattern | Energy consumption (KWh) | Costs (US dollars) |
|---|---|---|
| Before application of consumption management policies | 150,210,696 | 1,400,000 |
| After application of consumption management policies | 128,960,663.8 | 1,134,000 |

**Table 3. Energy consumption and the related costs in existing wastewater treatment plants of Tehran**

| WWTP | Energy consumption (KWh) | Costs (US dollars) |
|---|---|---|
| Shahrake Ghods | 3,774,800 | 19,068.34 |
| Shahrake Ekbatan | 1,361,000 | 11,071.94 |
| Shahrake Shoush 1 | 456,336 | 7,033.11 |
| Shahrake Shoush 2 | 537,540 | 3,868.99 |
| Zargandeh | 1,072,800 | 9,440.42 |
| Gheitarieh | 486,536 | 2,954.49 |
| Dolat Abad | NA | 1,699.81 |
| Sahebgharanieh 1 | 17,100 | 558.76 |
| Sahebgharanieh 2 | 120,050 | 791.85 |
| Total | 7,826,162 | 56,487.70 |

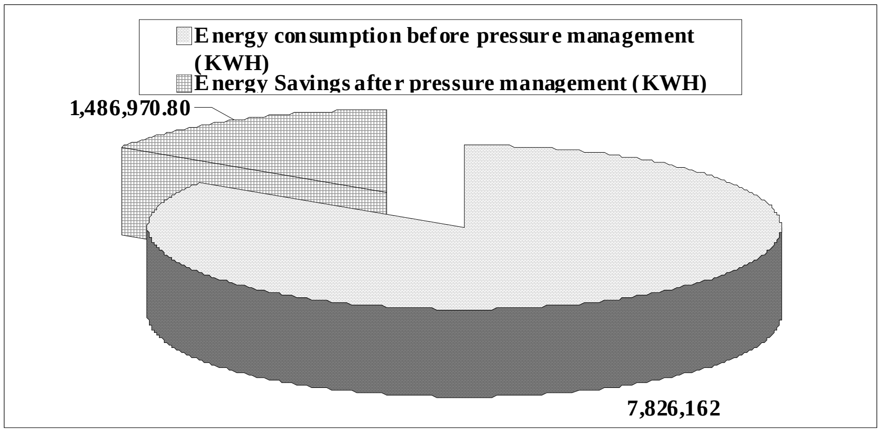


**Fig. 4. The amount of changes in power consumption of Tehran WWTP (KWh)**

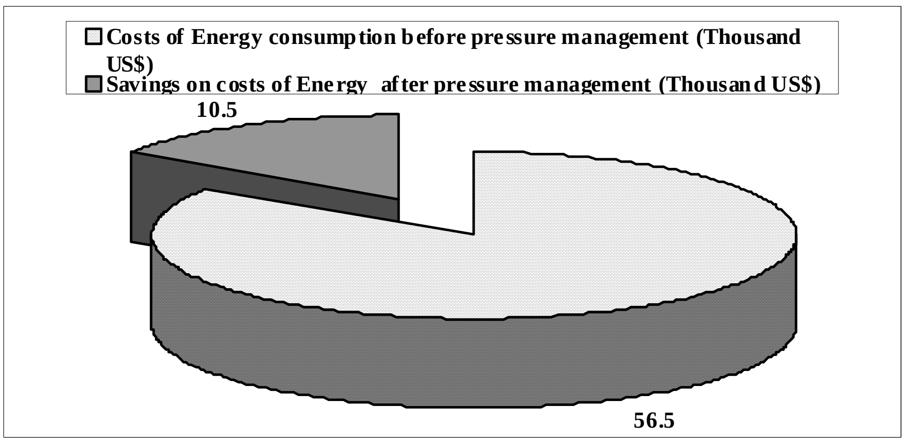


**Fig. 5. The amount of changes in costs of power consumption of Tehran WWTP**

**Table 4. Energy consumption and costs involved in wastewater treatment plants before and after consumption management**

| Water consumption pattern | Energy consumption (KWh) | Costs (US dollars) |
|---|---|---|
| Before application of consumption management policies | 7,826,162 | 56,500 |
| After application of consumption management policies | 633,919.2 | 46,000 |

costs in the Tehran wastewater plants before and after the application of consumption management measures are shown in Table 4.

## CONCLUSION

As a solution for improving the efficiency and savings, water consumption management plays a significant role in energy management and the reduction of energy needed to produce and supply water. The reduction of energy costs is linked directly to the reduction of water consumption. As the level of consumption drops, the need for production is reduced and consequently the costs of energy to produce and supply water are also reduced. In parallel to a reduction in the volume of water consumed, the volume of wastewater generated also drops, as the cost of treating the wastewater generated by about 10% of Tehran population who are under the coverage of the plants, is reduced by 10,500 US dollars. Through application of consumption management policies, and a drop in needs for water production and supply, a considerable number of groundwater resources (wells) can be taken out of circuit. In addition to creating the possibility of preserving resources, this action greatly reduces the energy and the costs of pumping, operation and maintenance of related installations.

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