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ORIGINAL RESEARCH PAPER

Developing water supply system in Szőgye

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ABSTRACT

The deteriorative processes occurring in the environment, the growth of population, the water demand of industry and agriculture, point out day after day the increasing role of water management. The economical use of drinking-water consumption as well as the cost reduction is becoming more and more important. In this research, the measure of a water supplier of Győr was examined in terms of implementing the purposes above.

KEYWORDS

drinking-water, smart city, energy saving, water management, water pump, water supply systems

1. INTRODUCTION

Nowadays, energy saving is becoming more and more important as a result of world growing population. Energy saving solutions include modernizing technology in new and old systems while reducing energy consumption.

Water pumps play an important role in water management. Purified water is delivered from service reservoirs, wells to various water supply systems by means of a pump. The water supplier is constantly improving its water pump fleet. Its aim is to use modern water pumps, which are reliable, economical from the aspect of water delivery, as well [1–3].

In order to ensure the safe and economical operation of the pumps, the evolution of the pump parameters during operation must be examined. The paper indicates an energy efficiency examination of pumps with synchronous and asynchronous motor.

2. WATER PUMP REPLACEMENT IN THE WATER SUPPLIER OF SZŐGYE

2.1. The venue of the measuring process

In recent years, the water supplier has purchased water well pumps equipped with permanent magnet motors for water wells with significant daily operating time (20–24 operating hours per day). This decision was based on a comparative measurement performed at the Waterworks of Szőgye. The paper discusses this comparative measurement of pumps. Figure 1 shows the waterworks of Szőgye.

Drilling was carried out next to two wells that lied on the same aquifer. In one of the wells a synchronous (Well 4), while in the other well (Well 15) an asynchronous well pump was installed. As a result, it was possible to compare the operating characteristics of the synchronous and asynchronous well pumps. Table 1 contains the water well pump data.

2.2. Presenting measurement method and measurement results

The measure data are displayed at local works, plant engineering, and central dispatche computers on permanent duty. Starting and stopping of pumps can be controlled from the

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Fig. 1. The waterworks of Szőgye
(*Source*: Author)

monitoring computer. The Programmable Logic Controllers (PLCs) operating central data collection points control and collect measurement data. The data of water flow rate, electricity consume and the specific electricity consumption required for the comparative measurement. The measuring instruments used during the measurement:

- Pulse water meter (Zenner) are used to measure the water produced in wells 4 and 15 at the waterworks;
- Power meter is used to measure electrical power during water supply system operation. (Schneider Power Meter Series PM9).

Figure 2 shows the change of average water flow rate.

Main parameters of pumps selection: water flow rate, pressure, pressure drop, spread, power, speed, net positive suction head, efficiency. Volume flow is the volume of liquid flowing through a given cross section per unit time [4]. Figure 2 shows that the water flow rate of the Well 4 pump is better than Well 15.

Figures 3 and 4 show the nominal water flow rate and the measured value.

Despite that the nominal water flow rate of Well 15 pump is higher, the measured water flow rate of Well 15 pump is lower than Well 4. These data support the fact that the measured data may in some cases different from the values given in the catalog.

The measured values may differ from the actual value of the physical quantity to be measured. Figure 5 shows the measurement error when measuring volume flow.

Positive deviation is observed for Well 4 and a negative deviation for Well 15. Maximum deviation for Well 15 is −31.25%, for Well 4 is +12.61%.

The main task of pump design and production is to make this efficiency as high as possible. The overall efficiency is made up of different sub-efficiencies. The volumetric efficiency is used to evaluate the pumping mechanism.

The factors that could be lowering the efficiency below nominal (optimal) levels [5]:

- Hydraulic losses of the pumps:
  - fluid friction;
  - circulatory flow;
  - shock and eddy losses;
  - transient phenomenon;
- Non-hydraulic losses of the pumps:
  - worn valves, seats, liners, piston rings, or plungers;
  - cavitation caused by corrosion;
  - loose belts, valve covers, cylinder heads, or bolts in the pump inlet manifold.

Figure 6 shows the volumetric efficiency of pumps.

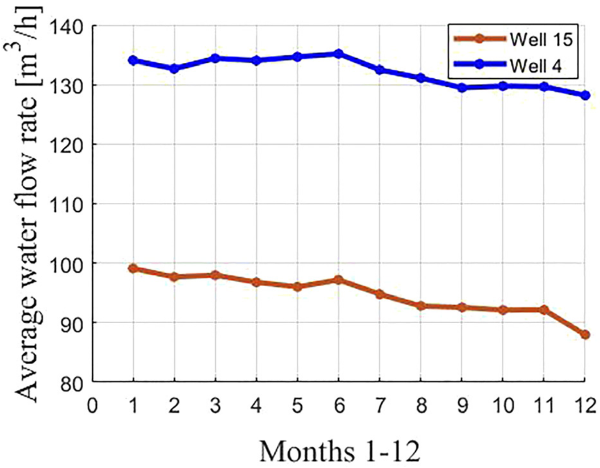

Fig. 2. The change of average water flow rate
(*Source*: Author)

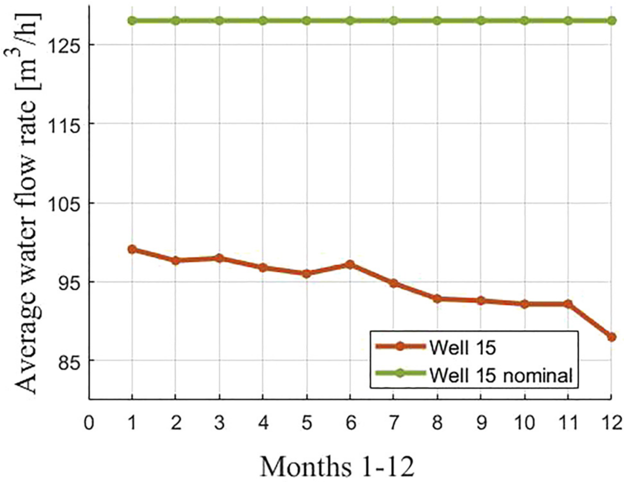

Fig. 3. The change of average water flow rate at the Well 15 pump
(*Source*: Author)

Table 1. Water well pump data

Model	Well 4	Well 15
Delivery height	45 m	45 m
Nominal electrical capacity	22 kW (synchronous motor)	242 kW (asynchronous motor)
Nominal water flow rate	120 m^3 h^{-1}	128 m^3 h^{-1}

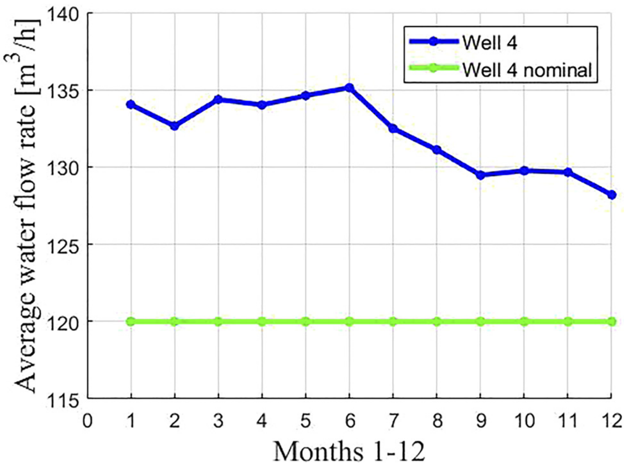

Fig. 4. The change of average water flow rate at the Well 4 pump (*Source*: Author)

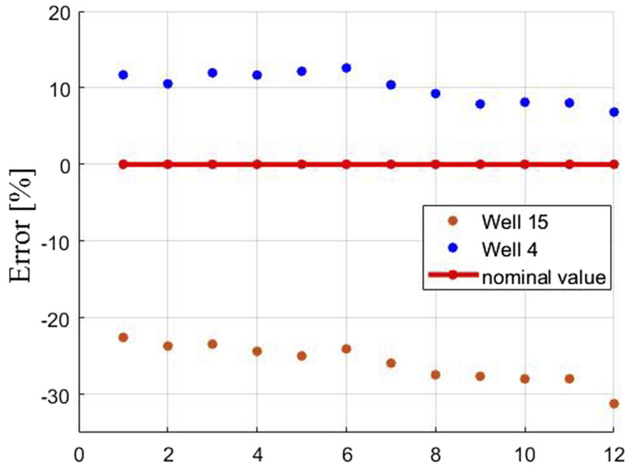

Fig. 5. The measurement error (*Source*: Author)

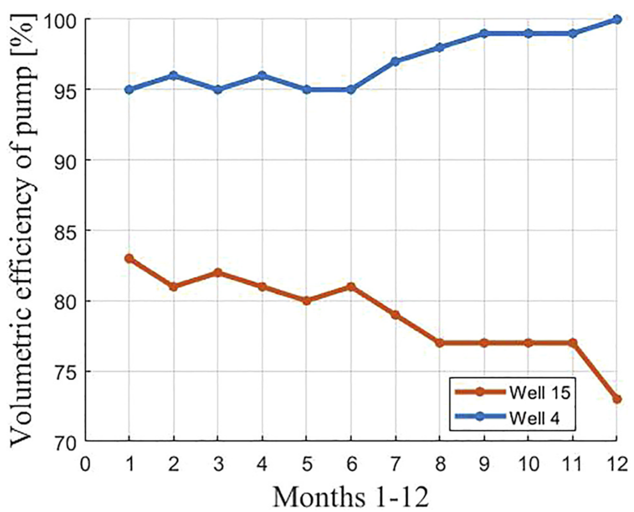

Fig. 6. The volumetric efficiency of pumps (*Source*: Author)

The results indicate that the Well 4 pump has better volumetric efficiency.

The Well 15 pump had an investigation into the transient phenomenon. The applied measuring instrument the TRAREC® measuring instrument. Two measuring instruments were used during the measurement due to synchronous measurement. 1 h method was applied. The number of occurrences of transient was evaluated during an hour [6–9].

Table 2 shows the TRAREC® calibration data of measuring instrument.

Press level software was used for evaluation. Figure 7 shows the measurements made by measuring instruments. Mwc (meter of water column) is unit of measure in hungarian mvo (vízoszlop méter).

Figure 7 shows a diagram of transients generated during operation of the asynchronous pump of Well 15. the maximum, minimum and absolute values of the pressure change can be read from the diagram [10].

The pressure peak can be estimated from the Allievi-Zsukovszkij equation. More accurate results can be obtained by the method of characteristics [11]:

$$\frac{\partial p}{\partial t} = \rho \cdot v \cdot \frac{\partial v_1}{\partial t}. \tag{1}$$

Maximum pressure increases due to water shock:

$$\Delta p = \rho \cdot v \cdot \Delta v_1, \tag{2}$$

where v is the propagation speed; Δv_1 is the change in fluid velocity; t is the closing time.

In water utility networks transient pressures occur during operation under certain conditions. transient phenomenon can cause noise, vibration and fracture of a pipe or connecting pipe fittings. the measurement data show that the phenomenon of trazies can be observed in the system. This measurement also supports the importance of pump replacement.

An energy efficiency examination was also performed by replacing the pump. It is very important to save as much energy as possible.

There are several reasons:

- direct saving in costs;
- improvement of our environment.

Figure 8 shows the change of electricity consumed.

The electricity consumed of Well 4 is lower than of Well 15. Figures 9 and 10 show the measure value of electricity consumed and the nominal value.

Figure 9 shows the change of the electricity consumed is above the nominal value.

Figure 10 shows the change of the electricity consumed is under the nominal value. The development of energy values is more even and closer to the nominal value. This measurement confirms that it is advisable to replace the pump. Figure 11 shows the measurement error when measuring electricity consumed.

Maximum deviation for Well 15 is 14.35%, for Well 4 is 7%. In the case of Well 15, there is an accidental error. In the

Table 2. TRAREC® calibration data of measuring instrument

Name	LL1-12078	LL1-12078
Pressure range	211 meter of water column (mwc)	211 (mwc)
Calibration	0.861114	0.864657
Sea level	0.00 m	0.00 m
Frequence of measurement	256 Hz	256 Hz
Frequence of data collection	1 s	1 s

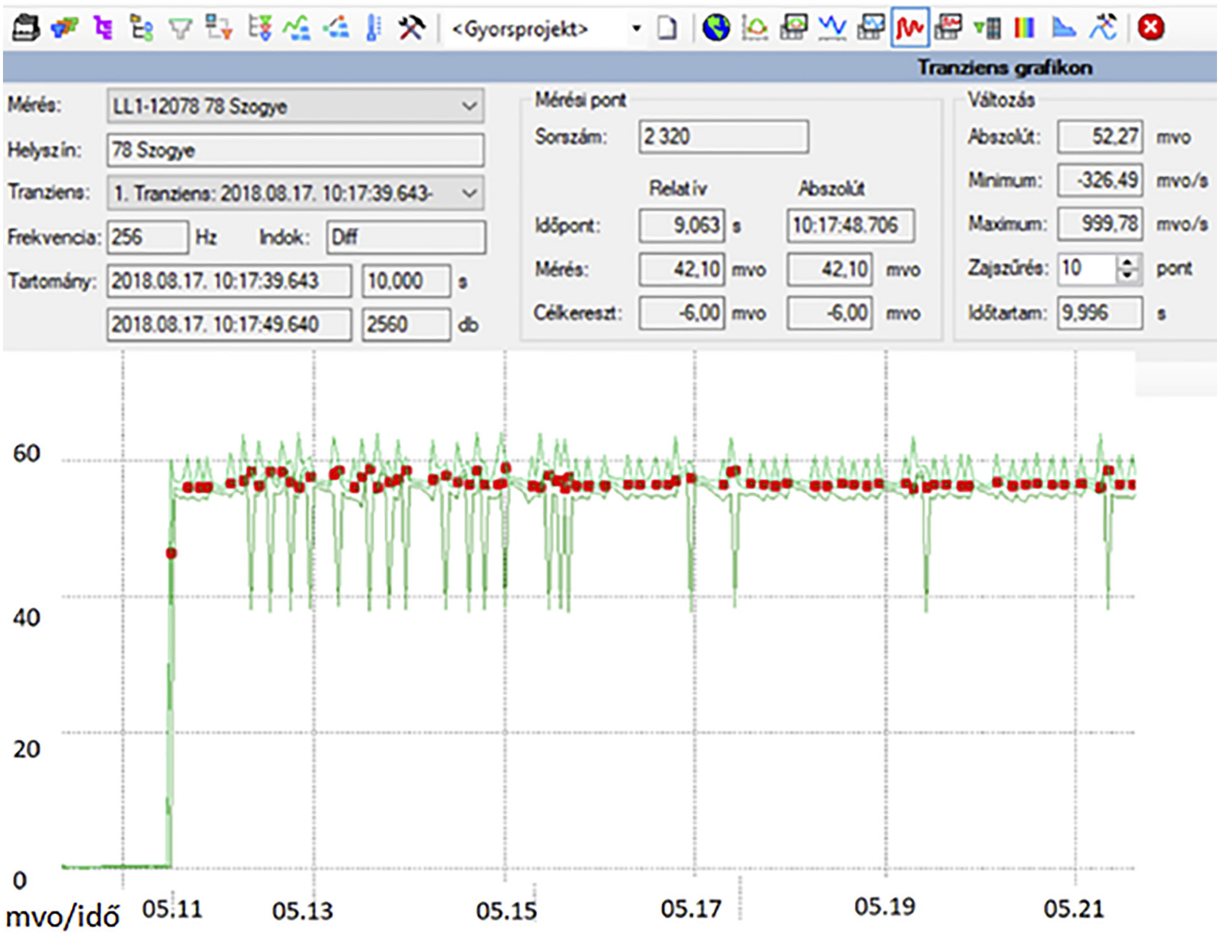

Fig. 7. The transient phenomenon
(*Source*: Author)

following, the specific energy consumption of the pumps is shown, which shows how much energy the particular pumps actually consume. The results of the calculations show how many kW are used by the pump to transport 1 m^3 of water. Figure 12 shows the change of the specific electricity consumption [12, 13].

The electricity consumed and the specific electricity of Well 4 pump is lower than Well 15 pump. Pumps require a lot of energy, as a result, costs increase, it follows that low energy consumption is an important consideration when selecting a pump. The technical data related to the operation of the two pumps were examined. This data helps to determine which pump is more efficient. As a result of the measurement, the nominal and real technical data of the two pumps can be compared.

Figure 13 shows the relationship of the electricity consumed and water flow rate.

Figure 14 shows the relationship of the specific electricity consumption and cost of electricity.

If the obtained measured results are converted into an electricity fee of HUF 35 kWh^{-1}, the costs of transporting 1 m^3 of water will be as it is shown in Fig. 14.

The unit cost of electricity at the Waterworks of Szőgye is 35.00 HUF kWh^{-1}. Well 4's electricity savings compared to the well pump 15 is 8,654 kW, equals to 302,890 HUF. Due to the different manufacturer, type, and construction of the

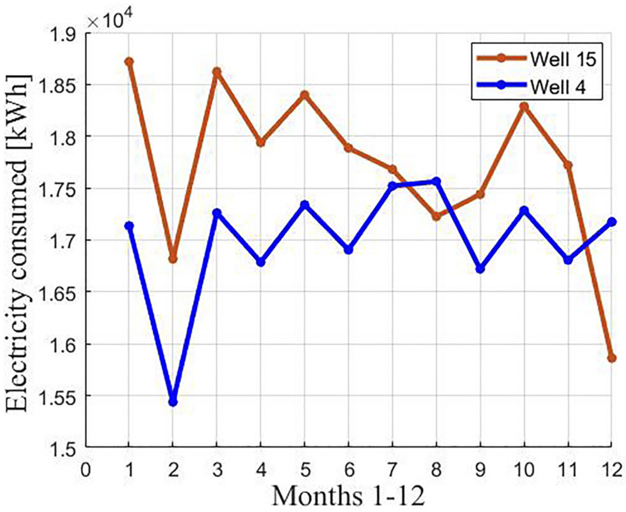

Fig. 8. The change of electricity consumed
(*Source*: Author)

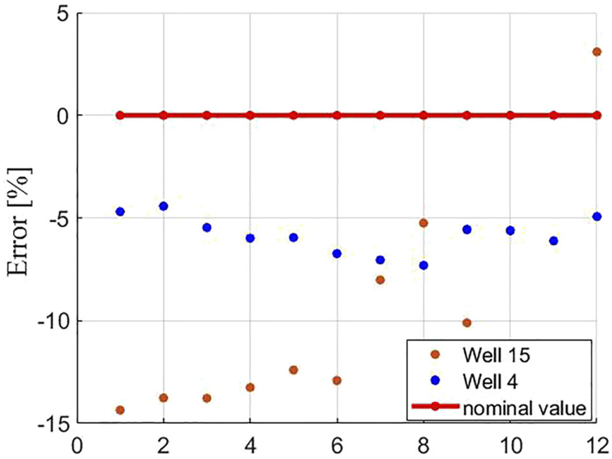

Fig. 11. Measurement error
(*Source*: Author)

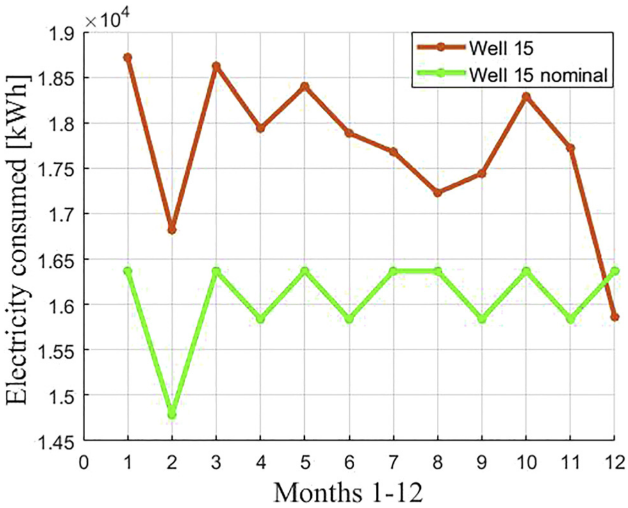

Fig. 9. The change of electricity consumed Well 15
(*Source*: Author)

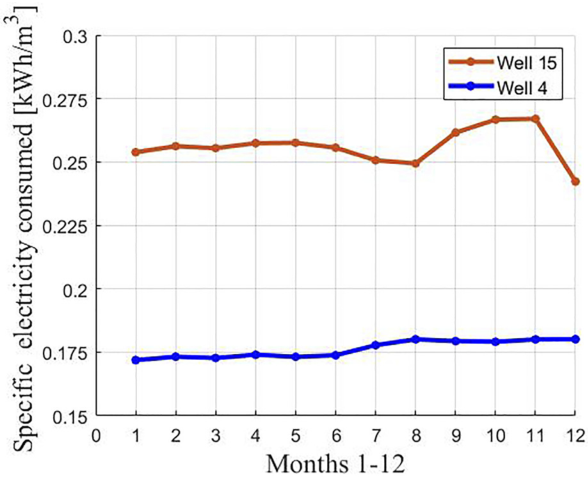

Fig. 12. The change of specific electricity consumption
(*Source*: Author)

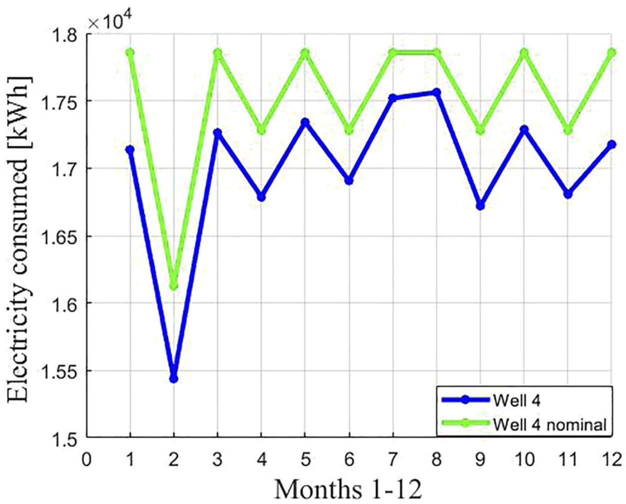

Fig. 10. The change of electricity consumed Well 4
(*Source*: Author)

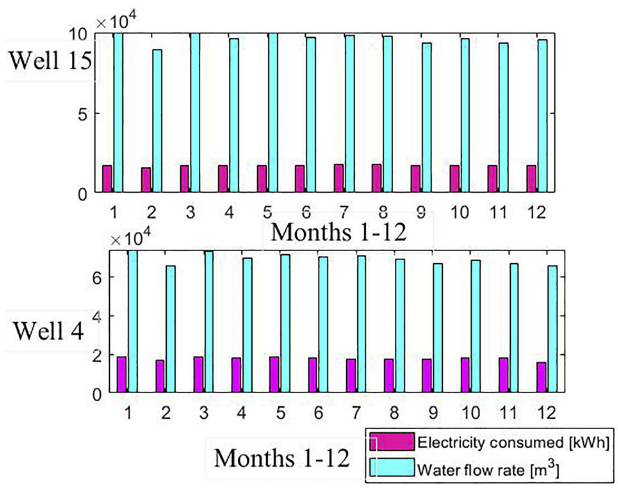

Fig. 13. Relationship of the electricity consumed and water flow rate
(*Source*: Author)

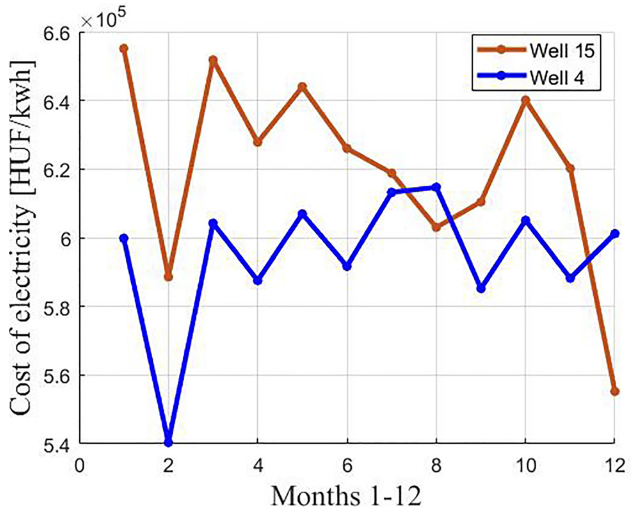

Fig. 14. Relationship of the specific electricity consumption and cost of electricity
(*Source*: Author)

two pumps, it can be seen that the specific electricity consumption of well 4 is also far better than that of Well 15. The data show that the savings of Well 4 compared to Well 15 is 0.080 kWh m^{-3}, 2.80 HUF m^{-3}.

The purchase cost of a Well 4 synchronous pump (Well 4) is 2,589,757 HUF. The purchase cost of a frequency converter is 685,080 HUF. The purchase cost of a conventional Well 15 asynchronous pump (Well 15) is 984,142 HUF. The purchase cost of a frequency converter is 685,080 HUF.

The data above clearly shows the savings in electricity, which is 302,890 HUF over a year. The difference in the purchase cost of the two pumps is 1,605,615 HUF.

In addition, the payback depends on the age of the pump, the nature of the system, the annual operating time, the expected failures.

3. CONCLUSION

The research was conducted at water supplier. In this research, the measures of the water supplier were examined the water pump replacement. The paper concludes that it is advisable to replace Well 15 pumps with a Well 4 pump. Measurement data show that the Well 4 pump has lower energy consumption at higher flow rates. This supports the fact that synchronous motors have better efficiency. Based on the calculation and experience, it has been shown that the investment will pay off in about 5 years. Taking into account an average lifespan of 30 years, savings of approximately 7 million HUF can be expected. It is also important to highlight the fact that the decision should not only be made on the basis of the catalog as the element of the pump is the operation of the system. The catalog shows the guideline values in a well-functioning system. Many places in Hungary, water supply systems are old and this has to take into when selecting a pump.

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