

Latest solutions in optimizing electrical energy consumption in water supply systems

Water losses in the water supply system

Soluții de ultimă oră în optimizarea consumului de energie electrică în sistemele de alimentare cu apă

Pierderile de apă ale sistemului de alimentare cu apă

Dragoș – Vasile Ille¹, Coita Flaviu-Glad¹, George – Lucian Ionescu²

¹University of Oradea, PhD student, Energy Engineering Field
4 Delavrancea Str., Oradea, Bihor, Romania

E-mail: illedragos@yahoo.com, gladflaviu@gmail.com

² University of Oradea, 4 Delavrancea Str., Oradea, Bihor, Romania

E-mail: lucian.ionescu1985@yahoo.com

DOI: 10.37789/rjce.2026.17.1.9

Abstract. *The main source of energy loss within water supply systems is found within the loss of water from within said systems. Understanding the reasons for these losses and taking the proper steps in curtailing their occurrence while also reinforcing the reliability of the systems will ensure not only the optimal operational regime for the system but also increase the energy economy.*

Key words: water losses, water supply systems, energy consumption

1. Introduction

Water losses in water supply systems are the most common phenomena that lead to large energy losses.

Water losses in water supply systems of populated centers and industries, i.e. water that does not bring in revenue (Non Revenue Water) is understood as the amount of water that leaves the installations without a specific use, due to leaks in pipe joints, the operation of reservoir overflows, etc. and must represent a percentage as small as possible of the total volume of water distributed [6], [8], [16], [17].

Upon a deeper analysis of the phenomenon of water losses, it is found that these losses are divided into three categories:

A) Technological water loss, referring to the water used to ensure the proper functioning of the water treatment process.

According to IWA (International Water Association) this is a loss of water because it does not bring in income. However, this loss of water should not be quantified as water that does not bring in income, due to the fact that if a treatment plant is not maintained in proper operating condition, we will have nothing to sell, so we will have no income. However, there is also a component of this water that can be perceived as a loss of water, namely, the part of the technological consumption used independently of the water strictly necessary for the maintenance of the plant.

For example, if the operator washes the filter with $4 \text{ l/s}\cdot\text{m}^2$ in a time interval of 20 minutes instead of 15 minutes as would be necessary, although normally, the filter can be washed with $2 \text{ l/s}\cdot\text{m}^2$, then the difference between the actual consumption required and the actual consumption used constitutes a loss of water. In addition, the tank is washed until the resulting water at the spillway is clear, or washing could be stopped when the resulting water has a turbidity equivalent to the decanted water.

By proceeding in this way, washing water can be saved, thus reducing the loss of technological water. This additional water consumption is considered a real loss, as is the water for discharging the sludge when it is very diluted. In the end, it can be concluded that water loss is only the amount of water used irrationally in the station.

B) Physical loss of water that occurs through leaks in pipes, basins, overflows, hydrants, etc. located on the water circuit between the point of capture and the consumer.

These constitute effective water losses and can be divided into two categories:

- technically admissible loss – refers to the "losses" (consumptions) of water necessary to ensure the technological process. The logical question would be: who and how establishes the limit from which the costs are exaggerated, given that the amount of water required for the technological process is related to local conditions and especially to the real cost of water;

- real water loss in addition to the technically admissible loss; is in fact the true water loss; this depends on many elements that will be detailed below.

C) Water waste is considered to be the loss of water at the user, a loss of water that also produces income; it is metered water (carrying fictitious lost water) or not (but accepted and sold at a flat rate) but water that is actually a real loss of water.

If the garden is irrigated with tap water, even if it is paid for, this is lost water considering that it is used for a completely different purpose than the one for which it was intended; this forces the entire system to introduce more water into the locality, therefore, to increase the pressure in the pipes, inevitably leading to a greater real loss from group B. Although it is metered water, it still falls into the category of water loss.

Washing hands is another common operation. We can imagine how much water flows when we wash our hands under the water jet in contradiction to the amount normally used. In the same way, the question arises: what happens if the tap is used at a higher water pressure? If we are more responsible with water, we open the tap less and in this way, apparently, the washing time is extended. How significant is this? It should not be. We can imagine how water is used in an apartment on the ground floor

Latest solutions in optimizing electrical energy consumption in water supply systems. Water losses in the water supply system

of a 10-story building and how water is used in a similar apartment on the 10th floor. The risk of water waste is all the greater the higher the pressure at the tap.

Waste can be fought through permanent control of external and internal buildings and installations and by measuring the quantities of water actually consumed, using water meters.

The own needs of the water supply system objects are calculated analytically, based on the following elements:

- The technology used, as well as the components of the treatment plant; the admissible technological losses in the treatment plant should not exceed 6% of the quantity of water produced; in situations where the recirculation of the supernatant from the waters from cleaning the decanters and washing the filters is ensured, the technological losses can be reduced to 3%; for groundwater, the increase must be provided on a case-by-case basis;

- based on an operational plan for cleaning the network sections, the water requirement for periodic cleaning of the distribution network can be established; this depends on the pipe material, water quality and the affinity of the materials to form biofilm; the quantities of water used should not exceed 1...2‰ of the volume of water distributed;

- the water requirement for washing and sanitizing the system tanks; Once or twice a year, each tank in the system's tanks will be emptied, washed and disinfected; the quantities of water required for washing the tanks do not exceed 0.4...0.5% of the annual water volumes consumed.

Technically permissible water losses in the distribution network must be classified as water losses. In distribution networks less than 5 years old, it is estimated that losses will be less than 15% of the volume of water distributed ($K_p^* = 1,15$); these may be the result of improper execution, daily pressure variations or due to defective materials. In the case of existing distribution networks, where renovation and/or expansion works are being carried out, losses can reach values of up to 35% ($K_p = 1.35$). Percentages exceeding 35% as a value of water losses are considered abnormal, in which case appropriate measures must be adopted.

Solutions to reduce water losses exist, but they must be applied with the help of water users and equipment manufacturers. In the following, I will highlight a series of aspects that require reflection and to impose ourselves on finding solutions step by step. In order to quantify the magnitude of the phenomenon and adopt a solution based on certain data, not on assessments, it is necessary to have clear evidence of achievements.

* K_p este un coeficient de majorare a necesarului de apă, pentru a ține seama de pierderile tehnic admisibile în obiectele sistemului de alimentare cu apă ($1,15 \leq K_p \leq 1,35$).

A series of proposals, some of which have already been applied in practice, although not in all countries, are:

- Faucets with smaller diameters;
- The obligation to install flow control valves at the entrance to the internal installation;
- Installing check valves to allow the flow to be regulated in the internal installation (against water losses by maintaining the flow in the area where the meter does not react);
- Pressure control in the general network or in restricted areas;
- Two-speed toilets;
- Variable speed pumps,
- Leak detection equipment,
- Relining technologies, etc.

All of these have repercussions on the functioning of the water supply system, but also on the proper functioning of the sewage system (sewage network, as well as the treatment plant) by reducing the flow of wastewater.

Water supply companies can obtain viable solutions and communicate them to others for efficient use of information. The costs cannot be stopped, but over time, they will contribute to reducing social efforts, while also ensuring a quality service.

2. Detection of water losses in the water supply network

An important economic task is to reduce water losses in its distribution. Through the methods of detection of losses, resources are saved, quality is ensured and costs are reduced.

The strategy of any operator managing water resources in a locality must be a good management of the detection of water losses. To achieve this goal, it is necessary to use specialized personnel or experienced companies.



Fig. 1. – Illustration of water losses

The results obtained through the water loss detection process will be recorded in a breakdown statistics and thus will represent the basis for the systematic renewal of

Latest solutions in optimizing electrical energy consumption in water supply systems. Water losses in the water supply system

the distribution network. It is recommended that the initiation of loss detection and personnel training be done in cooperation with equipment manufacturing companies.

It is not uncommon for losses greater than 50% to be found, which represents a significant waste of resources and even one of the essential points from an economic point of view for water distribution operators.

Water supply can be organized in the following six stages: capture, pumping, transport, treatment, storage, distribution. In general, each step is equipped with technical equipment, which depends on the availability of energy (pumps, compressors, etc.). In this way, each drop of water can be accounted for both economically and energetically. In locations where water availability is limited, water losses will jeopardize the security of supply, or will generate new costs for the construction of efficient capture facilities.

In locations where water leaks from the supply network, it leads, under low pressure conditions, to infiltration of foreign water, endangering the health of the population. It can be mentioned that in 2008 such conditions led to a devastating cholera epidemic in Harare (Zimbabwe) with numerous deaths.

Water that is introduced into the distribution network but is not metered is considered a loss in the balance sheet. In the event that the metering instruments are missing or lack precision, as well as in the event that the water is used for the benefit of the municipality (network washing, irrigation of green spaces, firefighters, washing roads), it is not metered and falls into the category of apparent losses.

Also in the category of apparent losses are illegal uses of water.

Real losses also occur if water leaks uncontrollably through a crack and the connections between pipes or hydrants as well as the tanks are not tight.

In conclusion, the water distributor has the obligation to maintain only real losses. Apparent water losses must be correctly cataloged from an economic perspective, so that the water supply is not overloaded. Detecting cracks in the network and fixing them is the responsibility of the distributor and must be done with the utmost seriousness.

Knowledge of all equipment and the network as a whole is vital for all maintenance work.

Lately, most distributors recognize the need for this technique, even having switched to mapping water networks in digital form.

A continuous update of the documents is required, in parallel with having a coherent action plan to avoid any failures in time.

There must be as accurate information as possible between the company managers so that the management of changes in the network can be operated on time.

From the design phase of a water plant, the fight against network losses must be taken into account, which is why the design must be entrusted only to qualified engineers. It is of great importance both the correct location of the network, as well as the correct choice of materials to be used, according to the hydraulic and construction conditions.

In addition to the own control service that most companies have, it is imperative to ensure their own site management through their own personnel trained in this direction or by hiring people for this purpose. This way, mistakes during the work can be avoided, which can be repaired more difficult later (collection and provision of evidence, trial, digging again, additional costs).

Both the operation and maintenance of the network and the equipment require a series of maintenance and periodic inspection works for which inspection programs and procedures will be drawn up.

Based on these programs and procedures, the work of the operating personnel will be organized. Periodic inspection of tanks, hydrants and flushing of the network, as well as continuous supervision and inspection of pumping equipment and treatment stations are among the important tasks.

Water leak detection must be done systematically and with great responsibility, thus guaranteeing the formation of a complete picture of the entire network. For this purpose, specially trained personnel must be employed in this direction.

Taking into account the fact that any leak discovered and repaired must be documented, it is necessary to draw up damage statistics, which will allow to establish the vulnerabilities of certain areas of the network in time and thus to avoid losses by drawing up programs for replacing the respective part of the network. Emergencies, such as a cracked pipe, must be immediately identified and remedied, in order to avoid additional damage to streets and other nearby utilities.

According to the IWA (International Water Association), inspections will be carried out regularly at the following intervals:

- annually, in the case of large leaks;
- once every three years, in the case of medium leaks;
- once every six years, in the case of small leaks.

The detailed detection of water losses involves:

- a reduction in water losses due to leaks in raw water pipes, connections or any cracks in the supply pipes;
- a reduction in the costs incurred in paying for damages caused by cracks or even burst pipes;
- ensuring appropriate water quality in accordance with current regulations;
- a reduction in costs by increasing the reliability of the networks;
- a reduction in the costs of maintaining and repairing pipes;
- a reduction in the energy required for the proper functioning of the networks.

Through a competent inspection of the pipe networks, possible blockages and damages can be prevented, thus increasing the safety of distribution. The Water Companies are responsible for the annual inspection of the networks, with the obligation to comply with the imposed norms. It is mandatory to use competent and well-trained personnel for such work, and it is also advisable to contract external specialized companies.

Latest solutions in optimizing electrical energy consumption in water supply systems. Water losses in the water supply system

The methods used to detect water losses are:

- flow analysis;
- measurement correlation;
- geophone listening;
- reinforcement verification techniques.

Quantifying water losses through percentage reports can lose their value when the following are not known: the length of the network, the number of consumers or the conditions in which the water distribution takes place.

For illustration, the following simulation example will be given:

A consumption of 1000 m³ of water per day is estimated for a small town.

A loss of 10% is found, equivalent to **100 m³/day**. The respective town is also about to open an industrial park that will consume an additional 1000 m³ of water.

If water losses continue to remain at the value of 100 m³, this quantity will now represent only 5% of the total. The conclusion is that a qualitative characterization of the network status cannot be made only in percentage terms. The recommendation is as follows: the estimated losses will be counted quantitatively per unit of time, in relation to the network length. The calculation of the loss value can be done with the following formula:

$$q_v = \frac{Q_v}{8760} \times L_R \quad (3.1.)$$

where:

q_v – loss value

Q_v – annual loss volume

L_R – network length

8760 – number of operating hours per year

The approximation of the network condition is determined by the specific loss depending on the soil conditions.

For the detection of polymer pipes, it is possible to use a shear probe or a device with a magnetic field transmitter. The proposed methods can be used in the case of detection of leaks in non-metallic pipes. Manufacturers of polymer pipes and pipes can provide more information on drinking water distribution networks.



Fig. 2. – Illustration of how to use metal rods to listen to consumer connections and network fittings

3. Conclusions

Applying polymer coatings to the surface of the pipes – necessarily protected from any sharp stones – will lead to better anti-corrosion protection of the networks. Correct insulation of the connections after installation is mandatory.

The classic principle on which the aforementioned technologies for detecting water leaks are based is based on the fact that water produces noise when it gushes out of a pipe under pressure.

English specialists, 100 years ago, used metal rods with a wooden funnel to listen to consumer connections and fittings on the network (Fig. 3.2.).

Later, in the 1960s, electronic sticks (ground microphones) also known as “electronic ears” appeared. These instruments proved to be useful by amplifying the sound produced by a water leak, thus allowing easier detection. Noise correlators, similar to today's sonic equipment, only appeared in the late 1970s. The evolution of the noise correlator materialized over the next 20 years, moving from the size of a box with appreciable weight and with which it took half a day to locate a water leak, to a small device that can identify a leak in just a few minutes.

A chronological evolution of water loss detection technologies looks like this [15]:

- 1850 – Use of the rod listening method;
- 1880 – Use of water meters;

Latest solutions in optimizing electrical energy consumption in water supply systems. Water losses in the water supply system

- 1920 – transition to helical water meters with paddles;
- 1930 – Implementation of the "step by step" test - zero consumption;
- 1965 – Use of the ground microphone;
- 1978 – Use of noise correlators;
- 1980 – Sectorization;
- 2001 – Use of a combined method – loggers-correlator;
- 2002 – Use of ground penetrating radars - Acoustic loggers;
- 2002 – Digital correlator;
- 2003 – Introduction of advanced detection microphones;
- 2006 – use of leakage indicators.

Due to the exponential development of localities and implicitly of water distribution networks, the need to introduce zonal metering was imposed, which included between 500 and 3,120 connections. As a measure to increase the efficiency of detecting water losses, it is necessary to introduce pressure and flow monitoring points in these areas.

The most modern methods of detecting water losses, which due to their high costs are still quite rarely applied, would be: the isotope method, ground radar, infrared measurement methods, the use of tracer gas, the air pressure method, the air piston press, etc.

Starting from May 2011, the General Urban Planning Regulation was implemented in our country, approved by Government Decision number 525/2008, which provided in paragraph (2), "The construction and expansion of municipal networks provided for in paragraph (1) letter c), including for their crossing of public roads, shall be carried out in the underground location variant, in compliance with the specific technical regulations in force."

"On the routes of municipal networks located underground, non-destructive identification systems, namely markers, shall be provided for the operative detection of the position of municipal networks in the horizontal and vertical plane, for the purpose of carrying out intervention works on them." (paragraph 7).

A major problem was the accurate location of underground networks due to the large amount of time that had to be allocated for detecting the fault and the additional costs. It was important to note that excavation was no longer necessary to detect the underground water network.

3M systems (www.3M.ro/MarcareSiLocalizare) offer solutions for more accurate location of the municipal network in a relatively short time and at low costs. The localization process is as follows:

1. 3M markers are inserted during the execution or maintenance process of the municipal network in the ground. These markers can be with or without iD. The difference is that iD markers contain a chip inside that stores information, such as: the type of network, its depth, the date of its installation, etc. Writing and reading data was allowed precisely because of the iD function. The only supplier of iD markers on the Romanian market is 3M.

2. To detect the marker and implicitly the water network, the 3M Dynatel TM localization device is passed over the marker, at the surface of the ground.

A detection method used by locators is based on capturing the signal, having a certain frequency, emitted by radio waves, generated by a transmitter.

GPS communication is characteristic of 3M systems and has applicability to GIS maps for cable/locator devices and markers.

The advantages of the 3M solution are: low costs, simple applicability and durability.

References

1. BÎRSAN, E., IGNAT, C. – O modalitate de realizare a controlului reţelelor de distribuţie a apei. Conferinţa de Instalaţii pentru Construcţii, Iaşi, 2008.
2. FELEA, I., IONESCU, GH. C. – Consideraţii privind fiabilitatea previzională a sistemelor de alimentare cu apă a centrelor urbane. Analele Universităţii din Oradea, Fascicula de Energetică, nr. 8, vol.I, 2002.
3. GAVRILAŞ, M., GEORGESCU, G. – Utilizarea algoritmilor genetici pentru determinarea schemei optime de funcţionare a reţelelor de distribuţie urbană. Rev. Energetica, nr. 6B, 2008.
4. IBA, K. – Reactive Power Optimization by Genetic Algorithm, In: IEEE Transactions on Power Systems, Vol. 9, No. 2, May 2006, pp. 685-692.
5. IONESCU, DANIELA-SMARANDA; IONESCU, GH. C. – Similitudinea şi modelarea în hidraulică – A 42-a Conferinţă Naţională de Instalaţii – 17-20 octombrie 2007 – Sinaia, România.
6. IONESCU, G. L. – The optimization of energy consumption in water supply systems – Conferinţa Naţională (cu participare internaţională) „TEHNOLOGII MODERNE PENTRU MILENIUL III” – Analele Universităţii din Oradea – Fascicula Construcţii şi instalaţii hidroedilitare, 2009.
7. IONESCU, GH. C. – Contribuţii la studiul şi optimizarea fiabilităţii instalaţiilor hidraulice din cadrul sistemelor de alimentare cu apă a centrelor urbane – Teză de doctorat, Universitatea din Oradea, martie, 2003.
8. IONESCU, GH. C. – Optimizarea configuraţiei reţelelor de distribuţie urbană a apei prin utilizarea algoritmilor genetici – Conferinţa Naţională (cu participare internaţională) „TEHNOLOGII MODERNE PENTRU MILENIUL III” – Analele Universităţii din Oradea – Fascicula Construcţii şi instalaţii hidroedilitare, 2007.
9. IONESCU, GH. C. – Creşterea siguranţei funcţionării sistemelor de alimentare cu apă – Conferinţa Naţională (cu participare internaţională) „TEHNOLOGII MODERNE PENTRU MILENIUL III” – Analele Universităţii din Oradea – Fascicula Construcţii şi instalaţii hidroedilitare, 2007.
10. IONESCU, GH. C. – Consideration regarding the wastewater biological treatment – Tiszántúli Mezőgazdagsági Tudományos Napok – Környezetvédelmi Szekcio – Debrecen, 28 – 29 octombrie 2011.

Latest solutions in optimizing electrical energy consumption in water supply systems. Water losses in the water supply system

11. IONESCU, GH. C., IONESCU, G. L. – Sisteme de Alimentare cu apă. Editura Matrix Rom, București, 2010.
12. IONESCU, GH. C. – Optimizarea fiabilității instalațiilor hidraulice din cadrul sistemelor de alimentare cu apă – Editura Matrix Rom, București, 2004.
13. IONESCU, GH. C.; GLIGOR, E. – Probleme de fiabilitate generală a sistemelor de alimentare cu apă – Conferința Națională (cu participare internațională) „TEHNOLOGII MODERNE PENTRU MILENIUL III” – Analele Universității din Oradea – Fascicula Construcții și instalații hidroedilitare, 2008.
14. IONESCU, GH. C.; IONESCU, DANIELA-SMARANDA – Increasing the efficiency of water supply systems by optimizing the electrical energy consumption - The 19th DAAAM INTERNATIONAL SYMPOSIUM “Intelligent Manufacturing & Automation” 22-25th, October 2008 – Trnava, SLOVAKIA-ISI.
15. IONESCU, GH. C.; IONESCU, DANIELA-SMARANDA – Phisycal and Chemical Techniques for Removing Nitrogen and Phosphorus from Residual Waters – International Symposia Risk Factors for Environment and Food Safety & Natural Resources and Sustainable Development, Faculty of Environmental Protection, Nov. 6-7, Oradea, 2009.
16. IONESCU, GH. C.; IONESCU, DANIELA-SMARANDA – Advanced Water Treatment Technologies – International Symposia Risk Factors for Environment and Food Safety & Natural Resources and Sustainable Development, Faculty of Environmental Protection, Nov. 6-7, Oradea, 2009.
17. IONESCU, GH. C.; GLIGOR, E. – Optimizarea funcționării decantoarelor suspensionale cu ajutorul modelului matematic – Conferința Națională (cu participare internațională) „TEHNOLOGII MODERNE PENTRU MILENIUL III” – Analele Universității din Oradea – Fascicula Construcții și instalații hidroedilitare, 2008.
18. IONESCU, GH. C.; GLIGOR, E. – Probleme de fiabilitate generală a sistemelor de alimentare cu apă – Conferința Națională (cu participare internațională) „TEHNOLOGII MODERNE PENTRU MILENIUL III” – Analele Universității din Oradea – Fascicula Construcții și instalații hidroedilitare, 2008.
19. IONESCU, GH. C., IANCULESCU, O., IONESCU DANIELA. – Fiabilitatea instalațiilor hidraulice. Editura Treira – Oradea, 2012.
20. ROTBERG, R., COTOROBAL, V. – Utilizarea microconvertizoarelor de frecvență la variația turăției pompelor. Conferința de Instalații pentru Construcții, Iași, 2008.
21. SOARE DAVID (Bursașiu Arghir) – Analiza cauzelor de defectare a sistemelor de alimentare cu apă – Lucrare prezentată la a 42-a Conferință Națională de Instalații – 17-20 octombrie 2007 – Sinaia – România.
22. SOARE DAVID (Bursașiu Arghir) – Probleme de fiabilitate generală a sistemelor de alimentare cu apă – Lucrare prezentată la Conferința Națională (cu participare internațională) „TEHNOLOGII MODERNE PENTRU MILENIUL III” – Oradea, 2008
23. SOARE DAVID (Bursașiu Arghir) – Making good use frequency converters for increasing the efficiency of water supply systems – Lucrare prezentată la Conferința Națională (cu participare internațională) „TEHNOLOGII MODERNE PENTRU MILENIUL III” – Oradea, 2011.
24. MĂNESCU, AL. – Manual pentru detectarea și controlul pierderilor de apă în sistemele de alimentare cu apă. ARA/ MUDP II, Bucuresti 2012.
25. MĂNESCU, AL. – Alimentări cu apă – Aplicații. Editura *H*G*A, București, 2010.
26. RÎȘTEIU M. – Elemente de tehnologia informației. Editura Universitas, Petroșani, 2012.
27. RÎȘTEIU M. – Sisteme dinamice asistate de calculator. Editura Universitas, Petroșani, 2001
28. KOVACS TIBERIU, GH. CONSTANTIN IONESCU – Optimization of electrical energy consumption in water supply systems - 19th edition of The National Tehnical-Scientific Conference „Modern Technologies for the 3rd Millenium, April 5-6, 2020, Oradea, România

<http://www.arhiconoradea.ro/Conferinta/HOME.htm>

ISBN 978-88-7587-724-8 Published: 2020 ISI PROCEEDINGS

29. SZABO STEFAN, KOVACS TIBERIU, IONESCU GEORGE – LUCIAN, CZISZTER K. ISTVAN – ANDRAS, IONESCU DANIELA – SMARANDA, SĂRĂCUTĂ-ARDELEAN ANDREI-FLORIN - Comparative studies and research on optimizing electric consumption of water supply systems - JOURNAL OF APPLIED ENGINEERING SCIENCES, VOL. 12(25)1-2022 B+ by the same C.N.C.S.I.S. Our journal is accepted in five International Databases (IDB), (WOS) Web of Science (see: <http://mjl.clarivate.com/cgi-bin/jrnlst/jlresults.cgi?PC=MASTER&Full=Journal%20of%20Applied%20Engineering%20Sciences>)
 30. CZISZTER K. ISTVAN – ANDRAS, IONESCU GHEORGHE – CONSTANTIN, SĂRĂCUTĂ-ARDELEAN ANDREI-FLORIN, SZABO STEFAN, KOVACS TIBERIU, IONESCU GEORGE – LUCIAN - Comparative studies and research on energy optimization of non-residential buildings - JOURNAL OF APPLIED ENGINEERING SCIENCES, VOL. 12(25)1-2022 B+ by the same C.N.C.S.I.S. Our journal is accepted in five International Databases (IDB), (WOS) Web of Science (see: <http://mjl.clarivate.com/cgi-bin/jrnlst/jlresults.cgi?PC=MASTER&Full=Journal%20of%20Applied%20Engineering%20Sciences>)
 31. DEPARTMENT OF ENERGY U.S, U.S. ENVIRONMENTAL PROTECTION AGENCY- Roof product list, list current as of January 2, 2009, http://www.energystar.gov/ia/products/prod_lists/roofs_prod_list.pdf, March 2021, 18:15
 32. EIA - International Energy Outlook 2010, Report #:DOE/EIA-0484 (2010). <http://www.eia.doe.gov/oiaf/ieo/world.html>, Vizualizat 2020/07/25, 16:45
 33. EUROPEAN PARLIAMENT - Tackling climate change. http://europa.eu/legislation_summaries/environment/tackling_climate_change/index_en.htm, vizualizat 2020/07/10, 11:00
 34. EUROPEAN PARLIAMENT - Energy efficiency: energy performance of buildings, http://europa.eu/legislation_summaries/energy/energy_efficiency/127042_en.htm, vizulizat 2020/07/10, 12:30
 35. EUROPEAN PARLIAMENT - EU energy in figures 2010. http://ec.europa.eu/energy/publications/doc/statistics/part_2_energy_pocket_book_2010.pdf, vizualizat 2020/11/09, 12:00
 36. EUROPEAN PARLIAMENT - The EU climate and energy package. http://ec.europa.eu/environment/climat/climate_action.htm, vizualizat 2020/10/07, 19:00
 37. EUROPEAN PARLIAMENT - Green Paper on the security of energy supply. http://europa.eu/legislation_summaries/energy/external_dimension_enlargement/127037_en.htm, vizulizat 2020/11/08, 19:30
 38. EUROPEAN PARLIAMENT - Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings (recast) {SEC(2008) 2864} {SEC(2008) 2865} of document: 13/11/2008 of transmission: 19/12/2008. <http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52008PC0780:EN:NOT>, vizualizat 2020/11/10, 14:00
 39. EUROPEAN PARLIAMENT - Energy Efficiency in Buildings. http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm, vizualizat 2021/07/03, 10:00
 40. X X X – Revista "Instalații pentru construcții" – colecție.
 41. X X X – Revista "Instalatorul" – colecție.
 42. X X X – Revista "Detectivii apei pierdute" – colecție 2012-2021.
 43. X X X – SR 1343-1 iunie 2006.
 44. X X X – Legea 311- 28 iunie 2004.
 45. X X X – Standarde și normative în vigoare.
-