# Comparison of the technical and economic feasibility of using EDS systems to replace the earth well in order to provide suitable electric earth with existing methods

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**ABSTRACT**

The present study was conducted with the aim of Studying the use of metal wall pipes of water wells to provide electric earth and technical and economic feasibility of using EDS to replace earth wells in installation equipment. The research method was descriptive, analytical and applied. The results of the research showed that the use of the well wall pipe in water pumping stations as the ground electrode may contribute to their corrosion due to the passage of electric current.

## 1 Introduction and Preliminary

Grounding and earthing: Grounding and earthing are the same words that are used for earthing. Grounding is a general term used in standards such as IEEE, NEC, ANSI and UL [1].
The resistance of the entire earth well and the system of electrodes connecting to the ground (without connecting to the neutral) should be less than 2 ohms.
The resistance of all electrodes connected to the ground up to a radius of 100 meters from the power post should not exceed 5 ohms.
The resistance of all the electrodes connecting to the ground of the power supply circuits of the stations, whether aerial or cable (metal sheath or insulation sheath) whose length is 200 meters, should not exceed 5 ohms.
In the electricity industry, earthing is also called earth connection system. The main task of the earthing system is to completely transfer any electric current that enters the system to the ground. If the body of all the electrical devices of the water and sewage systems and in general any type of electricity consumer is connected to the ground electrode by a string of wire, an earthing system is created. The purpose of creating this system is that if the electric circuit in question has a current leakage, this current leakage will be transferred to the ground by the earth wire and it will be prevented from electrocution or in cases of connection of the device.

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The water pipe system in a structure cannot be the only source of connection to the ground. In this case, an additional electrode such as a ground rod should be installed in place. The figure below shows the connection system, water pipes and rod as the ground electrode.

**Electronic Earth and EDS device (Electric Discharge System):**

In connection with electronic earth and EDS device, no scientific source was found in such a way that its relationship with the earthing system and the possibility of replacing it with earth wells is investigated. The search for sources showed that in a study titled "Review of Electric Discharge Plasma Technology for Wastewater Treatment" and another study titled "Effectiveness of Electric Discharge System in Destroying Microorganisms in Domestic and Industrial Wastewater" the term "Electrical Discharge System" was used.

In response to the question of whether there is an alternative to the earthing system, i.e. the earth well and its components. For example, can systems and devices such as electronic earth system and EDS (Electrical Discharge System) be used as a substitute for earth wells? As mentioned, this issue cannot be confirmed by citing scientific sources. Perhaps the experimental evidence of the creation of a pilot sample of the application of the intended device will show other results that will be carried out in the next stage of research. The examples that have been done in the country so far have not replaced the earthing system in practice. The most important reason is that according to the safety rules, the construction of an earth well is necessary to establish an earthing system.

In the electronic earth system, when the body is connected without affecting the main power, the power is cut off in the form of switching, preventing electrocution in case of body connection and quick power cut, absorption of induced voltages and currents on the metal body of the electrical installation and stabilization of the metal body at zero , has the property of detecting water penetration into electrical installations and quick power cut when water penetrates into electrical installations, low cost compared to earth well and easy installation.

Bonding and in other words integration of connections between insulation points in water well wall pipes is suggested as a temporary measure to prevent further damage. One of the weaknesses of the earthing system in Arak city water facilities is the incomplete connection of the earthing network. This problem was observed in most of the studied water pumping stations. As a result, the station's earthing system, in addition to not performing its protective function well, in the long term provides the basis for further corrosion of the metal pipes of the water well wall.

Metal corrosion can also be caused by the activity of various microorganisms, which is called microbial corrosion (MIC). Microbial corrosion can have a wide range of short-term to long-term destructive effects on water wells. These include, but are not limited to, a significant reduction in the useful life of the casing and wellhead, and a significant increase in the cost of operating the well due to its effects (eg, reduced specific capacity, reduced well efficiency, and increased power consumption).

A very important issue for optimizing the earthing system is that the contact voltage and, if necessary, the step voltage reach less than the permissible value. The effect of network conductor radius on ground surface potentials is insignificant (at least when the radius varies from 0.005 m to 0.25 m). However, when the radius of the conductor increases, the resistance decreases on average (if the radius increases from 0.005 m to 0.25 m, the resistance decreases by 25%). Therefore, the radius of the conductor is usually considered constant and the ground resistance depends more on the characteristics of the soil and the length of the electrode burial (Association, 2008). The value of soil resistance is one of the primary parameters for the design of a new ground system, and it changes from time to time in a small range of soil. In addition, the resistance depends on the moisture content and chemical properties of the soil. Measurement of soil resistance and ground resistance is very important for designing a standard ground system. In addition, it should be kept in mind that the effective parameters can be the contact voltage, the limit value for the contact voltage and the cost of doing the work.

A study was carried out to achieve the optimal earthing network to achieve safe contact voltage and step voltage and considering economic considerations. This study was based on qualitative criteria. For this purpose, the effects of the thickness of the soil layers, the number and length of vertical bars, soil resistance and earth surface potential (ESP) have been studied. Earth's magnetism is produced on its surface). As mentioned, an approach has been introduced in this study to optimize the design of the grounding network to reduce the design cost and reach the contact and step voltages within or below their safe limits. For example, the increase in the length of the vertical rod caused a decrease in the potential of the ground surface due to a decrease in the ground resistance, and therefore the contact voltage and step voltage decreased with the decrease in the depth of the soil layer due to the high resistance of the soil in this area. The dimensions of the optimized earth network for meshes 36 and 100 are 611.4 x 151.4 meters and 417.5 meters x 200.4 meters, respectively. The dimensions of the optimized network with and without vertical bars are 417.5 x 200.4 m and 463.5 x 205.5 m, respectively. The optimal cost for the network with and without vertical bars was ($1,806,337) and ($2,003,625.9), respectively [2].

Optimization is used to minimize the cost of establishing the ground system in water facilities, taking into account all operational constraints, including safety criteria. In a study, Qonim et al. determined the optimal ground network criteria using artificial intelligence techniques, ground resistance, contact voltage, and step voltage, in which considering the IEEE Std 80-2013/Cor 1 standard, the objective function based on cost Network conductor material and installation cost are formulated. The performance evaluation showed that the available grid area and the number of vertical bars greatly affect the optimization of the grounding system design [3].

As mentioned, the ground system must meet the criteria of safety of people and equipment in addition to the economic cost. Therefore, achieving optimal safety is an important priority for ground systems of electrical installations. The main purpose of the grounding system is to carry and dissipate the fault current in abnormal internal and external conditions. Also, the grounding system improves the continuity of the set and prevents unwanted interruptions. The design of ground systems should consider the safety requirements in IEEE Std 80-2015 and achieve an economical solution. Some constraints such as contact voltage, step voltage, and ground potential gain (GPR) should be considered in the optimal grounding system.

Regarding the safety of the air distribution system and electricity input to the water facilities, although it is less used in the water pumping stations of Arak city, but due to the importance of the issue in terms of employee safety, an innovative and practical proposal is mentioned. Massimo Mitolo et al conducted a study on a cost-effective solution for clearing high-impedance ground faults in low-pressure air lines [4]. Faulty distribution conductors used in overhead distribution systems may not be a concern for equipment, but pose a serious challenge to human safety. Standard overcurrent protective devices may not be able to detect the magnitude of currents caused by high resistance ground faults. For this reason, in some countries, complex relays capable of detecting ground faults with high impedance have been provided to electric companies. However, their implementation is relatively uncommon, especially in developing countries, due to their costs. In this study, the authors propose a possible cost-effective solution for low-voltage overhead lines with a neutral wire. This includes a metal hook under the line conductors that is connected to the neutral wire. In case of failure, such as line breakage, the hook is connected and the line is shorted to the neutral wire. This event activates existing standard overcurrent devices and eventually leads to power supply failure. The working process is as follows: the metal hook is connected to the part below the conductors of the line and to the neutral wire. If the line conductor breaks, the falling conductor contacts the hook and causes a short to neutral, which positively activates the standard overcurrent relays available. So the power goes off. The installation of the hook is done on the electric poles, and its installation and preparation does not require much time and workload, and the actual cost of the materials in the worst case is less than 9 euros [4]. This arrangement, although simple, provides an effective solution to avoid contact voltage caused by dead conductors and can increase the level of electrical safety of people. In fact, hook installation is a low-cost and high-efficiency solution for rapid energy discharge from low-voltage overhead lines, under high-resistance ground fault conditions, which can be an effective alternative to complex protective relays. This method is being developed in countries that use low voltage distribution overhead lines. In our country, depending on the case and necessity, the feasibility and appropriateness of methods like this can be considered.

In this case, the price of EDS devices varies from at least 80 million Rials for single-phase electronic and telecommunication equipment to 400 million Rials for electric motors. The manufacture of electronic earthing device for electric motors is produced on an order basis due to limited demand and has not been used in water and sewage companies so far to be a basis for comparison. These devices are installed independently for each device. Therefore, it will cost at least 700 million Rials for each regular water pumping station with minimal facilities. Also, if the company wants to install more facilities such as a counter to record possible errors on the system, the final amount of the device will increase. With this description and with an approximate calculation, if these devices are considered only for water pumping stations in Arak city, the installation cost will include about 60 billion Rials. It should also be kept in mind that EDS devices may malfunction and not perform their protective function well. This happened in the process of implementing the pilot project at Sadeghieh station, and only one month after the implementation of the project, the electronic earth device failed.

According to the speed of operation and its mechanism, the electronic earth can be useful in protecting the body connection or ground fault in high voltage electric motors and power systems and protect against explosion or strong electrical connections at high speed and cut off the power. slow However, due to the fact that the electronic earth device is placed in series with the consumer and uses equipment such as contactors and compacts, the cost of implementation will be high unless the local equipment is equipped with contactors or compacts.

In water installations, safety values lower than the contact voltage for humans in the vicinity of the installation must be provided.

This study shows the role of vertical ground rods, which are added to the grounding network to reduce the contact voltage to a value that is safe for the public and humans. Adding vertical bars to the earth grid also reduces the design cost. The resistance of the network and the increase of the ground potential decrease with the increase of the burial depth.

Its performance can be improved by changing network settings or minimizing fault current. If it is difficult to minimize the fault current, changes in the shape and size of the network in general by changing the distance of the conductors, the dimensions of the network, the length of the conductor, the depth of the network and the addition of vertical rods can be effective in he performance of the ground system as well as cost optimization [5].

The type of soil model (homogeneous or multi-layered soil), electrode diameter, conductor and material size, ground potential increase (GPR), tolerable step and contact voltages, maximum permissible fault current and fault duration are key elements in determining the performance of the earthing system. The optimal design of the earthing system can be obtained by minimizing the cost function.

Pavel, S. G., *et al*, in a study titled Measuring Vertical Earth Ground with Rectangular Contour by Minimizing Costs, stated that earth system design costs are reduced by reducing the distance between electrodes. Also, the results of the study showed that for specific goals and different options, finding a solution that leads to the minimum cost is necessary for each plan [6].

## 2 t-test with two independent groups methods

This test compares the average of two groups of speakers' answers. In other words, in this test, the averages obtained from random samples are judged.

This method is based on the normal t distribution and for small samples, it is best used when the variable data being compared in independent groups has a normal distribution.

Presumptions of t test with two independent samples:

A) The variable whose average is compared in two independent groups must be quantitative (that is, its scale is interval or relative).

b) The scale of the variable in which the comparison is made must be qualitative and at the nominal level (two-dimensional).

c) The variable in which the average is compared must be independent and different from two populations.

d) The distribution of variable data whose average is compared in two independent groups should be normal.

How can independent samples t-test method be useful for the organization?

The independent sample t test method of hypothesis testing can be used to meet different needs in different types of industries and organizations.

Safety: Has the earth resistance measured when the earthing wire is connected to the metal wall pipe of the water well decreased compared to when the earthing wire was not connected to the metal wall pipe of the water well?

**Sociology:** Are men more satisfied with their jobs than women? Do they earn more?

**Biology:** Are foxes larger in one habitat than another?

**Economy:** Is the economic growth of developing countries higher than the economic growth of the first world?

**Marketing:** Does customer segment A spend more on groceries than customer segment B?

To better understand the benefits of independent sample t-test analysis, let's look at two use cases:

**Use Case 1**

Safety Problem: An electrical safety expert wants to find out whether connecting an earth wire to the metal wall pipe of a water well has a greater effect than not connecting the earth wire to the metal wall pipe of a water well in reducing the measured earth resistance. Here, the dependent variable will be "ground resistance".

Ground Resistance Reduction: After the test is completed, a p-value is generated that indicates whether there is a statistical difference between the incomes of the two groups. Based on this value, an electrical safety professional can conclude whether the average income earned by female employees is statistically different from that of male employees. If the difference is statistically significant, they can further conclude which method is better for reducing ground resistance.

**Use Case 2**

**Business Problem:** A grocery store sales manager wants to know whether customer segment A spends more on groceries than customer segment B. Here, the dependent variable will be 'Purchase Amount'.

**Business Profit:** After the experiment is completed, a p-value is generated that indicates whether there is a statistical difference between the purchase amounts of both segments. Based on this value, the grocery store manager can decide on marketing strategies for better sales and increased revenue.

The independent sample t-test is a useful statistical method for hypothesis testing when an organization wants to determine whether there is a statistical difference between two categories, groups or items and, in addition, if there is a statistical difference, whether this difference is significant or not.

Table 1: Comparison of the difference between the measured ground resistance values in two groups (independent t-test)

| *P value* | *Mean ± standard deviation* | | |
|---|---|---|---|
| | *without connecting the earth wire to the metal wall pipe of the water well (N=60)* | *By connecting the earth wire to the metal wall pipe of the water well (N=60)* | |
| *0.000* | *4.81 ±8.36* | *2.12 ± 3.54* | ***Ground resistance (Ohm)*** |

According to Table 1, the amount of ground resistance in ohms in the group with the connection of the earth wire to the metal wall pipe of the water well is lower than without the connection of the earth wire to the metal wall pipe of the water well. Also, based on the results of the independent t test, there is a significant difference between the performance scores of the two groups with and without connection, P = 0.000. Therefore, it can be said that the level of ground resistance in the conditions of connecting the earth wire to the metal wall pipe of the wells The water with an average of 2.12 ± 3.54 is significantly lower than the condition without connecting the earth wire to the metal wall pipe of the water well with an average of 8.36 ± 4.81.

## 3 Discussion

The most important point that should be kept in mind from an economic point of view is that all of the above are in the condition that the existing facilities including earth wells, earthing network and protective equipment will also be established at the same time as the installation of electronic earth devices in water pumping facilities/stations. As a result, cost savings are not made in other departments. In this way, because by choosing electronic earthing devices (EDS) for installation in the station, the existing options for providing electrical and protective earthing are not eliminated, the economic comparison of two independent options is not possible in this study.

- According to the things mentioned from a technical point of view, the issue of replacing the electronic earthing device (EDS) with an earthing well in order to provide electric earthing is ruled out, and clearly these two are not on the same level in terms of functionality.
- For comparison, the electronic earth device can be technically placed next to the identification and circuit breaker equipment. In this case, the EDS device is installed in series with the equipment and acts as an electrical protector and prevents damage to the sensitive equipment due to risks such as overvoltages of the electrical network, neutral floating of the network and two-phase electricity, phase connection to the body and phase short circuit. and null prevents. In terms of the difference in performance, common protective switches operate based on leakage current, while the operation of electronic earthing devices is based on voltage and current. This means that whenever the voltage of the leakage current exceeds 50 volts with respect to the ground of the location and is of an alternating type, it gives the disconnection command and considers it as an error in the power grid. Also, in the condition of passing the fault current, the output of the EDS device is cut off electronically and in less time. Based on EDS specifications, it is faster than other available protection switches. In this case, unlike common methods that are usually mechanical and use thermal switches, minimal electrical stress is applied to the sensitive parts of the system. As mentioned, these items must be tested and approved by competent authorities, and it does not have an external sample so that it can be evaluated with certain criteria.
- The review of the EDS device from an economic point of view shows that choosing this option to increase the safety of employees and improve the performance of the devices is not cost-effective. In this case, the price of EDS devices varies from at least 80 million Rials for single-phase electronic and telecommunication equipment to 400 million Rials for electric motors. These devices are installed independently for each device. Therefore, it will cost at least 700 million Rials for each regular water pumping station with minimal facilities. This is due to the fact that the existing facilities, including the earthing network and protective equipment, will also be maintained, and as a result, there will be no cost savings in other sectors.
- If the question is raised, what benefits will be created for the water and sewage company with the additional costs that are made. The answer to this question is presented in different parts of the chapter, including that according to the claim of the EDS machine manufacturers, changes in the local soil conditions do not have a negative effect on the performance of the EDS machine. The output cut-off time is less than 100 milliseconds, and thus its speed is faster than common protection switches. Also, the electronic grounding device (EDS) shows its best performance in weak and sensitive electronic and telecommunication current equipment and devices and specifically removes unwanted noise. And that the EDS device protects the system against intense and transient voltages such as lightning. The set of these advantages will reduce the maintenance costs of the devices located in the water pumping station in the long term and increase the safety

of employees and equipment. Of course, all this is assuming that the claims of the manufacturers of the device are correct, which has not been confirmed by the competent authorities.

- Another point that is mentioned from the economic point of view is that in high voltage electric motors, because the electronic earthing device is placed in series with the consumer and equipment such as contactors and compactors are used in it, the total implementation cost increases unless the local equipment is equipped with these facilities, which is not always true.

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