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ARTICLE

Forecast of Using Renewable Energies in the Water and Wastewater Industry of Iran

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Abstract: Since water and wastewater are considered as one of the most prominent energy consumers in the field of urban industries, the main objective of this study is to provide a new assessment approach in applying renewable energy in the water and wastewater industry. In this paper, an essential review of current energy storage options for different cases processes using different renewable energy and heat sources with a focus on heat storage systems and battery energy storage is given. High energy requirements currently priced by fossil fuels are expensive. The use of alternative energy sources is essential for the growing demand for water desalination. Different methods have been proposed to show the energy recovery techniques and use of renewable energy in the treatment of wastewater containing wastewater. The results indicated that increase in water supply and electricity consumption was evidenced by the increase in Tehran's annual population. In addition to the higher emissions of carbon dioxide (CO_2) from diesel and oil power plants than the natural gas-fueled plants, by increasing the carbon tax to more than 30 USD per ton of CO_2, it is expected that the emissions will be reduced by 30 % in all fossil-fueled power plant types.

Keywords: Prediction model, Renewable energy, Greenhouse gases, Electricity consumption, Carbon tax

1. Introduction

Developing a renewable energy system enables it to improve the reliability of energy consumption and organic fuel economy, solving local problems, water supply, increasing the conditions of living and working for local people, development, and implementation of a renewable energy project in rural areas that can create job opportunities and, therefore, minimize migration to urban areas [1]. Decentralized energy harvesting is one of the options to meet the needs of rural and small energy in a reliable, cost-effective, and sustainable environment [2,3]. Renewable energy technologies are considered as clean and sustainable sources of energy for the current and future social and economic needs [4]. The optimal use of these resources can minimize environmental impacts and secondary waste [5].

The use of renewable energies to generate electricity and energy will not only solve the problem of carbon

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emissions, but because they do not require water unlike fossil-power plants, they can reduce the consequences of the water crisis in the world, whose dimensions are not less severe if the global warming crisis is not severe [6]. According to the plan map of the International Energy Agency roadmap in case of achieving the goals of renewable energy in the world, 4.5 billion tonnes of carbon emissions will decline in 2050 [7]. Biomass is a term used in cellulosic materials such as agricultural waste, waste of paper and forest wastes, 10% of the world's final energy consumption of renewable sources, 10% of which is used for heating, and 3.4% of which is hydropower [8].

The increase in water consumption for industrial, farm, and household needs and careful implementation of water quality regulation have contributed to a significant increase in water filtration and water transmission [9]. Moreover, a large amount of water consumption in the agricultural sector is due to the aggravation of cultivation and expansion of irrigation fields to supply the growing demand for food and fuel resources. These activities generally require a large amount of energy, resulting in an increase in energy consumption in the water sector in many parts of the world, which ultimately affects the emissions of greenhouse gases [10].

Freshwater is becoming increasingly important in many parts of the world. In arid regions, drinking water is very scarce and the establishment of a human habitat in these areas depends strongly on how it depends on the water and energy of the two irreconcilable goods that govern the lives of mankind and promote civilization [11]. The first attempt to control water power has occurred more than 2000 years ago when the energy gained is mainly used for the milling of seeds [12]. By 2030, the water shortage will affect the water shortage of up to 94% of the world's population [13]. It is the best way to convert water into fresh water [14]. The cleaning of processes can be classified into two main types: thermal processes and membrane processes [15]. Nutrients can be recovered from wastewater and treated wastewater may be reused, including for irrigation and industrial processes. For many years, many economists use carbon pricing as an efficient tool to reduce CO_2 emissions. More jurisdictions throughout the world use this tool as the Emission Control System (ETS). Carbon pricing is a major political tool for achieving carbon reduction [16]. It has made extensive use of fossil fuels, carbon dioxide (CO_2) into the largest greenhouse gas emissions [17].

Radcliffe et al. [18] indicated that the water-sensitive productivity in the drinking water and wastewater sector in Australia has decreased for 10 years. Findings - First, the paper shows that using the integrated system, the diffusion relationship-energy - energy framework is used in this study. In doing so, water companies can prevent a separate collision with each issue. Second, a wide range of variables can affect the water-energy relationship. Eltawil et al. [19] showed that solar energy can be directly used to evaporate water from sea/saline and other sources for domestic water resources or community. Solar construction is still simple and suitable for areas that are difficult to use, solar distillation is limited, an economic advantage over other technologies available for use of free energy, and very low operating costs. Distillation with solar energy is the most desirable process for low water, which can be considered in geographical locations.

Mardani et al. [20] highlighted the complexity of influencing factors, the trend of the water industry decision making in RE therapy based on experts' opinions, results suggest that the investments in RE therapy are mostly produced by it. Considering that electricity is the second tenet of water and sewage costs, it is reasonable to conclude that if the price of electricity continues to grow, it is likely that a fixed incentive to consider alternative energy sources as a strategy to reduce costs and emissions beyond the renewable electricity generated by itself. For this reason, investments in RE therapy may be considered as an option only if economically feasible economically. Lin et al. [21] achieved the minimum energy use with RO desalination. One promising way to reduce the energy of detoxification by using advanced membranes is materials and the application of innovative techniques. Creative technologies to the front and the polar ion concentration are promising, but long-term action is low, the integration of renewable energy sources is needed to reduce the emission of greenhouse gases and eliminate the reduction of energy costs. Selection of appropriate renewable energy sources depends on factors such as plant size, salinity, plant location, availability of grid power, technical infrastructure availability, availability of local renewable energy resources, and storage options.

Raluy et al. [22] used renewable energies in desalination. However, some problems, such as capacity, periodic production, or legal framework, limit the program. However, this is not extremely low in energy consumption, flexibility and management of production and shutdown periods can also reduce energy-related costs, in addition to providing sufficient power tariffs. Unfortunately, the development of emerging technologies represents small steps for industry, but it has promising programs, such as energy production using salt slopes. It is not expected to be a substantial change in technology over the next few years, and, in any case, proximity to thermodynamic limit becomes important to reduce the use of energy. Ghoneim et al. [23] In their paper, various methods for energy recovery and use of renewable energies in sewage systems, one of the largest of them, will contribute to the power consumption of technologies discussed in this paper to many developing countries like Egypt - which will contribute to the lack of energy resources - to save energy. The use of heat conversion of solid-solid materials is becoming more harmful from the burning of waste into gas, and it has a heating effect as a method of burning negative effects on the environment.

Kettab et al. [24] indicated that the main purpose of wastewater treatment plants (WWTP) is to remove undissolved and soluble substances from wastewater (cooking fats and oils, road gravel, nutrients such as carbon, nitrogen, and phosphorus, etc.). Hence, WWTP networks play an essential role in health engineering and water pollution control. Recently, the additional potential of WWTP networks to generate energy beyond the on-site combustion of digestible gas or the simultaneous generation and recovery of resources by wastewater professionals is appealing. This article hopes to encourage researchers and physicians to take full account of this energy source in its quest for more sustainable energy strategies.

As can be seen from previous studies, the optimization of energy consumption and reduction of greenhouse gases are among the priorities of water companies. The purpose of this study is to present a new evaluation approach to the possibility of using renewable energies (solar, wind, and biomass) in the water and wastewater industry. Tehran's Water and Water Co. has been made up of six regional districts. In this research, we aim to measure the potential of using renewable energy in the water and wastewater industry and desalination of seawater and desalination technologies, and the use of renewable energy to generate electricity and energy and reduce greenhouse gas emissions and air pollution control by wastewater treatment and regression functions and equations with specification of Tehran climate.

2. Case Study

The city of Tehran, an area of approximately 730 square kilometers, is the largest and most populous city in Iran, divided into 22 regions and 112 districts [25]. Tehran is located between the mountainous region and the plain. Three factors play an effective role in Tehran climate: Alborz mountains range, western wet winds, and province size [26]. The cold season lasts three or four months. In March, the chill of the air tends to decrease, and in late April the weather is getting warmer, and in early June the weather is relatively warm. It has long winters in the desert and south-humid areas, in the cold semi-humid areas, and the cold-weather regions along with long winters.

Three geographical factors play an effective role in the overall construction of Tehran's climate:

- Dessert or desert plain: arid regions such as Qazvin plain, Qom plain and arid regions located adjacent to Tehran province are negative factors affecting the weather in Tehran province, causing heat and dryness, along with dust and dust.
- Alborz Mountains: This mountain range reduces the climate.
- Wet and rainy westerly winds: These winds have an effective role in regulating the scorching heat of the desert, but do not neutralize its effect.

Tehran Province can be divided into three sectors [27]:

- The climate of the northern slopes: On the southern slopes, the central Alborz Mountains lie at a high altitude of 3000 meters, and humid and humid climate and frosty weather with cold winters have long and cold winters.
- Mountain climate: This climate is located at an altitude of two to one thousand meters above sea level and has a semi-humid and cold climate and relatively long winters. Ab Ali, Firoozkooh, Damavand, Lavasan, Amir Kabir Dam, and Taleghan are located in this climate.
- Semi-arid and dry climate: with short winters and hot summers, it is located at altitudes less than 1000 meters. As the altitude decreases, the dryness of the environment increases. Varamin, Shahriyar, and south of Karaj city are located in this climate.

Tehran province is one of the provinces with medium rainfall in terms of rainfall with an average of 230 mm of long-term annual rainfall. The amount of renewable water in this province is about 4.2 billion cubic meters per year, which due to its very high population, has very low per capita renewable water. This figure, which is currently equivalent to 350 cubic meters per person per year, is about one-sixth of the country's per capita renewable water. However, according to international standards, the per capita volume of renewable resources below 500 cubic meters per year represents an absolute crisis and severe water stress in the region [28]. The main source of drinking water in Tehran is the Karaj, Jajroud, and Lar rivers, which are supplied by three dams installed on them. As water consumption increases, part of the drinking water is obtained from groundwater by deep wells. There are several seasonal rivers in Tehran that have little effect on the city's water supply. Golabdareh, Hesarak, Tajrish, and Kan are the most important ones [29].

The duty of Tehran Province Water and Sewerage Company is to distribute drinking and sanitary water and collect sanitary wastewater in urban areas of Tehran

Province. Although this province, with an area of 12,981 square kilometers, constitutes about 1.2% of the country's area, with a population of about 14 million people, of which 92% is urban, it has about 20% of the country's population. In terms of country divisions, 13 cities and 54 cities are located within the province. In terms of industry, about 44% of the country's industries are located in Tehran province [30]. Underground water of Tehran has been polluted; they are used directly in agriculture and provide part of Tehran's drinking water. Abstract one of the most important elements that exist because of the influence of human and animal flows in underground aquifers of Tehran is nitrate. The exhaustion of Tehran's drinking water infrastructure also helps in most water pollution [31].

3. Methodology

Regression is a way of predicting a variable from one or more variables. linear regression is a linear predictor of the linear predictor variable in which the dependent variable that is expected to be predicted is multiplied by a linear combination of the independent variables, which means that each of the independent variables is multiplied by a factor of the estimate for that variable; the final solution of the sum of the variables is in addition to a constant value given by the estimator [32].

Simple Linear regression:

In statistics, linear regression is a linear model of response (with one or more variables). Regression is often used to explore the linear relationship model between variables. In this case, it is assumed that one or more explanatory variables whose value is independent of the rest of the variables or under the control can be effective in predicting the response variable whose value is not dependent on descriptive variables and is not controlled by the researcher. The purpose of regression analysis is to identify the linear model of this relationship. We use the dependent variable instead of the dependent variable and the independent variable instead of the explanatory variable. Since it may have a role in determining the dependent variable in addition to independent variables, we consider the regression model with the most appropriate number of independent variables and consider the amount of error as representative of other random factors that could not be identified [33].

Linear regression model:

If only one independent variable is used to identify and predict the dependent variable, the model is called "Simple Linear Regression". The form of a simple linear regression model is as follows:

$$Y=\beta 0+\beta 1X+\epsilon \quad (1)$$

If used to identify and predict the dependent variable only from an independent variable, they call the model "simple linear regression" (Simple Linear Regression). The form of a simple linear regression model is as follows: As shown in this equation, above equation is a line that is added, including the fault, or the same ϵϵ. The parameters of this linear model are the width of the source (β - 0) and the line slope (β1 - 1). The line slope in the simple linear regression model indicates the extent to which the dependent variable is dependent on the independent variable. It means that by increasing one unit to the value of the dependent variable, the dependent variable will change. The width of the origin also represents a value of the dependent variable, which is calculated as the value of the independent variable equal to zero. In other words, a fixed amount of origin can be considered as the mean value of the dependent variable on the return of the independent variable. The regression model sometimes takes into account the regression model regardless of the origin and β0 = 0 is 0 = 0. This means that with zero the value of the independent variable, the dependent variable value must also be considered zero. This model is considered when the researcher is confident that the regression line must cross the origin of the coordinates. It should be noted that the linear relationship in the regression model is the existence of a linear relationship between the coefficients, not between the independent variables. For instance, this model y = β0 + β1x2 + ϵy = β0 + β1×2 + ϵ can also be considered linear while they = β0× = 1 + ϵy = β0× is no longer linear and is known as the exponential model. estimation of simple linear - regression parameters [34]: In order to estimate the parameters of the simple linear - regression parameters, it is sufficient to minimize the least-squares error function. In order to do so, the following steps should be taken, Calculate the sum of the power of the second error [35]:

$$\sum(Yi-(\hat{}\beta 0+\hat{}\beta 1xi))2 \quad (2)$$

Derivative of the sum of squares of error in terms of parameters ˆβ0β^0:

$$\sum(-yi+\hat{}\beta 0+\hat{}\beta 1xi) \quad (3)$$

Find the root for the resulting equation in terms of ˆβ0β ^ 0:

$$\beta_0^n = \bar{}y - \beta 1\bar{}x \quad (4)$$

Derivative of the sum of squares of error according to the parameter ˆβ1β ^ 1:

$$\sum(-2xiyi+2\hat{}\beta 0xi+2\hat{}\beta 1x2i) \quad (5)$$

Place ˆβ0β ^ 0 and find the root for the resulting equation in terms of ˆβ1:

$$\hat{}\beta 1=\sum(xi-\bar{}x)(yi-\bar{}y)/\sum(xi-\bar{}x)2 \quad (6)$$

In this way, the estimation of the parameters of the linear model will be as follows:

$$\hat{\beta}_1=\sum(x_i-\bar{x})(y_i-\bar{y})/\sum(x_i-\bar{x})^2 \quad (7)$$

$$\hat{\beta}_0=\bar{y}-\hat{\beta}_1\bar{x} \quad (8)$$

For ease of calculation, the $\beta_1\beta_1$ estimate can be written in another form:

$$\hat{\beta}_1=n(\bar{xy}-\bar{x}\bar{y})/(n-1)\sigma^2 x \quad (9)$$

If $\hat{y}$ is the estimated value for the dependent variable, we can consider it as the average of the observations for the dependent variable for the constant value of the independent variable. So assuming that the average error sentence is also zero, we will have:

$$\hat{y}=E(Y|X=x)=\hat{\beta}_0+\hat{\beta}_1 x \quad (10)$$

On the other hand, the variance of the error sentence according to the initial hypotheses for the regression model should be constant and equal to $\sigma^2\sigma^2$. The variance estimate for the error sentences is as follows

$$\sigma^2=\sum(y_i-\hat{y}_i)/2n-2 \quad (11)$$

Test related to the model and its parameters.

After performing the regression steps, using the "Analysis of Variance" table, the accuracy of the created model and its efficiency can be measured. The basis of the work in analysis of variance is the analysis of variance of the variable depends on two parts, the part of the change or scatter that can be represented by the regression model and the part that is determined by the error sentence. So the following relation can be written accordingly

$$SST=SSR+SSE \quad (12)$$

Each of which is defined as follows:

$$SST = \sum (y_i - \bar{y})^2 \quad (13)$$

The value of SST can be considered as the sum of the squares of the difference between the observations of the dependent variable and their mean, which is the form of the variance fraction of the dependent variable. This quantity can be divided into the two parts. It is worth mentioning that the SSE value is also called the sum of squares of error, which was obtained in the regression model by minimizing the model parameters. The next section is also shown with SSR:

$$SSR = \sum (\hat{y}_i-\bar{y})^2 \quad (14)$$

If the regression model is appropriate, we expect the SSR share of the SST to be large, so that most of the dependent variable changes are described by the regression model. To calculate the variance from each of the squares, it is sufficient to divide the result by the number of their members. This creates new values called "Mean squared error" (MSE), "Regression squared mean" (MSR). Note the Table 1 is known as the analysis of variance table [36].

This table shows that if the average square is as SSR the variance source will be as regression, if the average square is MSE type, the variance will be like error type.

Table 1. Variance table

Statistics of F	Average squares	Sum of squares	Degree of freedom	The source of change
F=MSR/MSE	MSR=SSR/k-1	SSR	k-1	Regression
F=MSR/MSE	MSE=SSE/n-k	SSE	n-k	Error
-	-	SST	n-1	Total

4. Results and Discussion

Current and projected amounts of electricity consumption in different areas of Tehran Water and Sewerage Company are calculated. Figure 1 shows the amount of electricity consumption in areas 1 to 6 of the Tehran Water and Sewerage Company from 2015 to 2030. The minimum and maximum values are for Zone 5 (about 50 million kWh) and Zone 2 (about 124 million kWh), respectively.

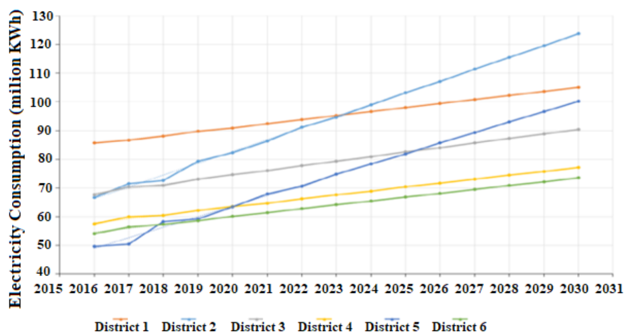

Figure 1. Current and projected amounts of electricity consumption in different areas of Tehran Water and Sewerage Company is calculated.

The current and expected total electricity consumption of Tehran Water and Sewerage Company is shown in Figure 2. In this figure, the independent and dependent variable shows the time and amount of electricity consumption in regions 1 to 6 of Tehran Water and Sewerage Company, respectively. Increasing the annual population of Tehran increases electricity consumption and increases the supply of drinking water in all areas of Tehran.

Emission of greenhouse gases in power plants (g/kWh) is calculated. Table 2 indicates the amount of greenhouse gas emissions and pollutants from power plants. According to this table, the amount of pollutants emitted in diesel power plants is higher than fuel oil and natural gas power plants. Also, natural gas-fired power plants have lower emissions than other types, but the emissions of CH_4 and

CO_2 greenhouse gases are very high.

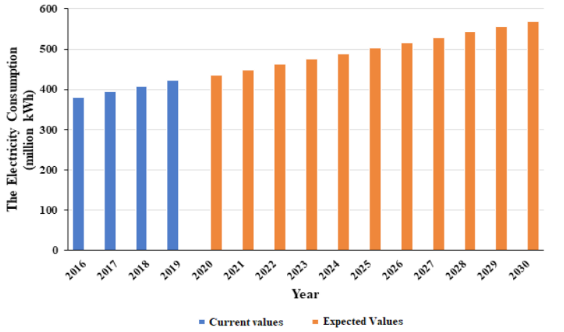

Figure 2. The current and expected total electricity consumption of Tehran Water and Sewerage Company

Table 2. Emission of greenhouse gases in power plants (g / kWh)

Type of power plants fuel	SO_2	N_2O	CH_4	CO_2
Natural Gas		0.4	17.99	201.8
Diesel		2.2	35.97	266.5
Mazut		2.2	35.97	278.42

Forecast of electricity consumption of Tehran Water and Sewerage Company until 2030 (considering 30% of renewable energy) is obtained. Figure 3 predicts that fossil fuels, solar energy, wind energy, and biogas will increase in the coming years.

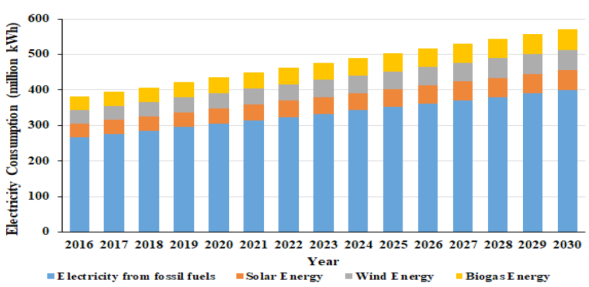

Figure 3. Forecast of electricity consumption of Tehran Water and Sewerage Company until 2030 (considering 30% of renewable energy)

CO_2, CH_4 emissions in the two scenarios are compared in Figure 4. Two scenarios are designed to calculate greenhouse gas emissions. In the first scenario, the total electricity consumption of the Water and Sewerage Company will be supplied by fossil fuel power plants by 2030, and in the second scenario, 30% of fossil energy will be replaced by solar energy. As can be seen in the figure, CO_2 and CH_4 emissions from diesel power plants are much higher than other types. The results show that the CO_2 emissions from natural gas, diesel, and fuel oil power plants in 2030 will be around 115,000 tons, 152,000 tons, and 158,000 tons, respectively.

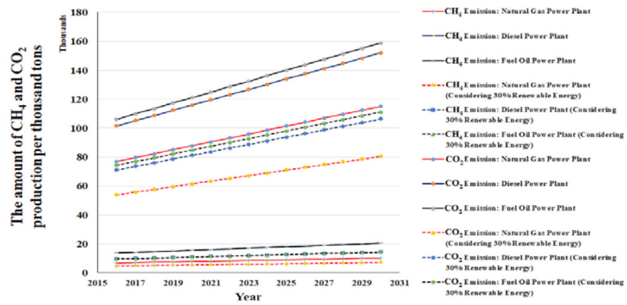

Figure 4. Comparison of CO_2, CH_4 emissions in the two scenarios

NO_2, SO_2 emissions in the two presented scenarios are compared in Figure 5. The results show that NO_2 emissions in the diesel power plant are higher than the natural gas power plant with a 30% share of solar energy by the Tehran Water and Sewerage Company by 2030. Comparing the results of the proposed scenarios, it can be concluded that the emission rate from diesel power plants is higher than other types of power plants. Therefore, by replacing 30% of fossil fuels with solar energy, natural gas power plants have the lowest greenhouse gas emissions among other power plants.

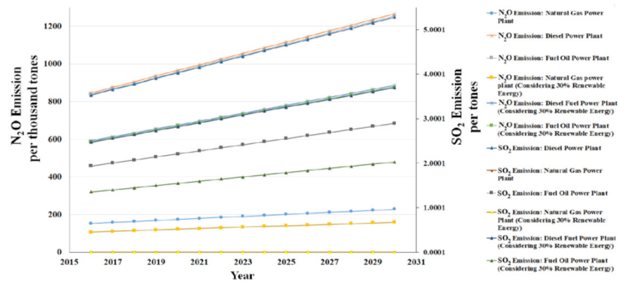

Figure 5. Comparison of NO_2, SO_2 emissions in the two presented scenarios

Carbon tax rate in dollars from 2016 to 2030 is shown in Figure 6. This figure shows the carbon tax forecast rate in millions of dollars. According to the National CO_2 Price Forecast in 2016, CO_2 is expected to be around \$4.5 million in 2016 and around \$13.5 million in 2030.

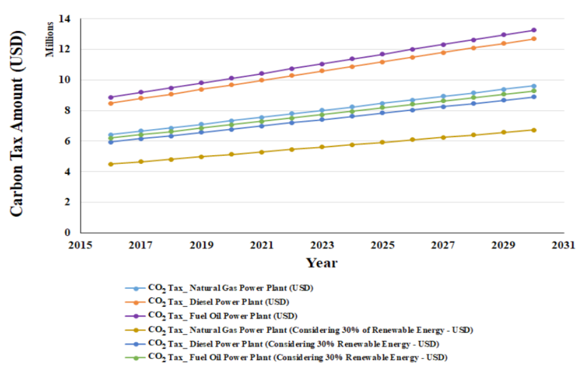

Figure 6. Carbon tax rate in dollars from 2016 to 2030

Electricity costs in six areas of the Water and Sewerage Company are calculated. Figure 7 shows the cost of electricity consumed in the six areas of the Water and Sewerage Company. The amount of electricity consumption in regions 1 to 6 of the Tehran Water and Sewerage Company is shown from 2016 to 2030. It shows region 5 (about 1 hundred thousand dollars) and region 2 (about 380 thousand dollars).

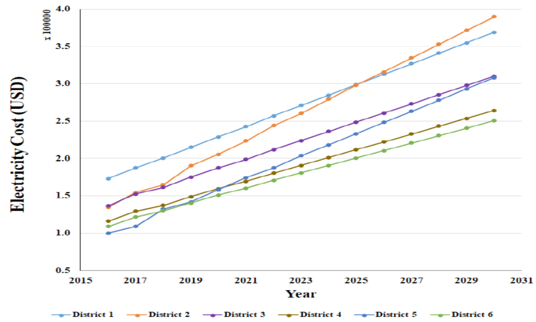

Figure 7. Electricity costs in six areas of the Water and Sewerage Company

Electricity cost of the two proposed scenarios is drawn in Figure 8. The first scenario without the use of renewable energy, which in 2016 was close to 800 thousand dollars and in 2030 is estimated at about one million and nine hundred thousand dollars. In the second scenario, the production of 30% of the electricity required by renewable energy, which in 2016 will cost about 550 thousand dollars and for 2030 is estimated to cost about one million and one hundred and fifty thousand dollars.

Electricity cost of the proposed scenarios according to the impact of carbon tax is shown in Figure 9. The economic benefits of using some of the alternative energy mentioned above increase over time. Due to the projected rate of water supply-demand and as a result of infrastructure development in areas 2 and 5 of the Water and Sewerage Company, these areas are a priority for energy management. Replacing conventional electricity generation with renewable energy generators should start in these two areas to effectively control the company's electricity costs.

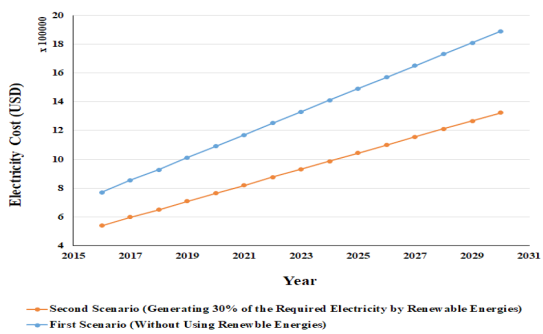

Figure 8. Electricity cost of the two proposed scenarios

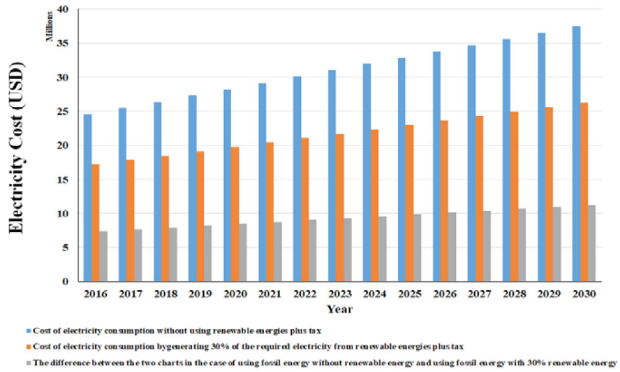

Figure 9. Electricity cost of the proposed scenarios according to the impact of carbon tax

The difference between the two diagrams related to the use of fossil energy without renewable energy and the use of fossil energy with 30% renewable energy is shown in Figure 10. This figure indicates that by reaching the next years, the cost of electricity consumption grows and it will be duplicated in the near future.

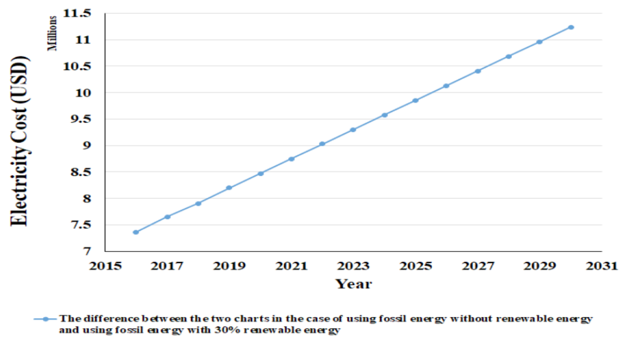

Figure 10. The difference between the two diagrams related to the use of fossil energy without renewable energy and the use of fossil energy with 30% renewable energy

5. Conclusions

Due to the current crisis in energy consumption for drinking water and also collection of municipal waste water, a comprehensive approach was evaluated in this study. Tehran has a high potential in using renewable energy in power generation. Therefore, the use of renewable energy sources is very useful regarding the case study mentioned in this study. On the other hand, urban water supply management is limited to the strengths and potentials of each city. In this study, factors affecting energy consumption in Tehran water and wastewater company are investigated. In addition, a new approach to assess the effect of renewable energy in reducing air pollution is presented. Generating electricity or heating or cooling energy using solar energy; generating electricity using small hydropower plants, wind energy, energy storage; generating electricity or heat using geothermal energy or biomass energy. Also in this research, annual monthly demand load was predicted using seven dynamic models and datasets of 6 related variables in Tehran. Recurrent and deep regression model could predict the data in Tehran with an acceptable error (less than 5%). Renewable energy use in wastewater industries' forecast major variables could be linearly modeled using regression. The model covered 100% of the total variance

The results showed that CO_2 emission will be decreased by about 30% by replacing the conventional power plants with renewable energy plants based on the Tehran Water and Wastewater Company electricity demand. Also if carbon tax legislation contains tax imposition between 10 USD and 30 USD per ton of CO_2, an immediate reduction of greenhouse gas emissions will be predictable. Besides, by increasing carbon tax more than 30 USD per ton of CO_2, a significant decrease in air pollution of power generators will be expectable. Plans to develop distribution network alongside renewable energy sources and economic optimization can provide evidence that using wastewater is a competitive substitutional method that needs high attention in the future. Application of wastewater energy significantly reduces negative environmental impacts.

Conflict of Interest

There is no conflict of interest.

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