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Implementation of the Optimal Electrical Energy Management System for the Industrial Center Considering Participation in the Operational Reserve Plan

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Abstract
One of the main factors in load response plans is persuading subscribers to participate in consumption management programs. One of the upcoming solutions is determining the appropriate incentive rate. Since 2013, for the participation of industries in peak reduction plans, a program called operational reserve has been implemented and implemented. Industrial load management, due to its high share of energy consumption, can play a key role in managing demand during peak consumption. By using this set of plans, the possibility of managing the prevailing load of industries has emerged to a large extent. Considering the cement production process, the capacity of this industry can be used to further reduce the peak load. Due to its high flexibility, the cement process has the ability to transfer load from high load hours to low load hours and help reduce network load, increase reliability and reduce line congestion during peak load times. In this research, by carefully examining the cement production process and simulating it, process optimization and ways to achieve maximum profit in the operational reserve plan are investigated. By examining the performance of a sample factory, it can be seen that naturally, the factory reduces its consumption during peak hours. Therefore, in this research, an effort has been made to maximize the profit of the factory and to improve the effectiveness of the operational reserve plan by using the tariff table. Investigating the performance process of each of the factory units and storage warehouses during the operational storage plan, as well as the construction of a solar power plant in the factory for use during peak hours and its advantages and disadvantages have been investigated. Tehran city has a good amount of sunlight. Due to the timing of the operational reserve plan and the summer season, which has the highest amount of sunlight, the cement factory can benefit from the profitability of the construction of the solar power plant in addition to using the benefits of cooperation in the operational reserve plan. In order to minimize costs and achieve maximum profit, an optimization problem has been defined, the answer of which has been obtained using the genetic optimization algorithm.
Keywords: management, electric energy, cement industry

Introduction

The demand for electrical energy is always growing and increasing due to industrial developments and living standards. This dramatic growth in electric energy consumption has created problems for its producers in order to supply this amount of energy [1]. Since the amount of energy demand is changing and increasing, energy production sources are forced to increase their production level to supply the required electricity. In particular, during peak consumption hours, the producer must increase his production capacity so that he can provide the power required by the consumer in this period of time by spending an exorbitant amount of money. In the past, the production of electrical energy followed the amount of load consumption and according to its increase, the production also increased [2]. Today, supplying the energy required for limited peak hours requires spending exorbitant costs to build new power plants. In order to avoid these costs and preserve capital, power companies are leaning towards demand side management methods. Incentives and incentives for subscribers in these programs encourage them to cooperate. As a result, by cooperating in these projects, the subscribers benefit from financial benefits, and the network operator, in addition to postponing the construction of new power plants, also benefits from the uniformity of the load curve (valleying and peaking). In traditional power systems, consumption management programs were used to overcome some power system problems. In the meantime, load response programs were also mentioned as part of these programs. But after the restructuring of power systems, these programs were gradually abandoned due to their incompatibility with the nature of the market. But after some time due to the problems such as price instability and the re-implementation of consumption management programs, they were noticed again. Several factors, including increasing load growth, high investment costs in the electricity industry, environmental issues, technical and stability issues, and reliability, etc., have caused demand side management methods to be at the top of the agenda of electric companies [3]. . It includes a range of activities that are designed by the power company and the government in order to change the amount or time of electricity consumption by the subscribers for the common interests of the society, the power company and the consumers. In other words, demand side management includes all management functions related to directing demand side activities, which include planning, evaluation, implementation and monitoring. The objectives of demand side management can be listed as follows:

- Peaking and filling the network load curve valley
- Load handling
- Creating a flexible load curve
- Increasing strategic consumption
- Increasing energy efficiency
- Reducing energy production costs
- Improving environmental issues

The increase in the consumption of electrical energy in electrical systems causes problems in the supply of electricity to consumers. For example, the power system in India in 2010 was about 9% short of energy production.

This shortage has reached 15.2% during peak consumption hours [8]. Responding to the peak load every year requires the construction of new power plant units, load management plans, repairs and proper maintenance of existing facilities for their maximum utilization. Providing such conditions to meet the peak load requires a lot of money. Although this heavy cost is for a limited number of hours during the year, so that only 3% of the time (less than 300 hours per year) the network load reaches more than 90% of the peak load; In other words, if consumption can be controlled in 3% of the year, most of the problems of electricity supply will be solved [9]. In recent years, serious concerns have arisen for the electricity industry due to the lack of financial credit in order to establish the infrastructure of the electricity industry and the growth of about 4% of the annual peak consumption and the prediction of the continuation of this trend in the coming years [10].

Energy management makes the use of cement factory equipment more appropriate. In a factory, energy management has become a necessity for material developers to reduce the energy demand for new equipment. Designers and manufacturers are asked in contracts to have maximum energy savings in their designs. To optimize energy consumption in the industrial sector, it is necessary to study the sectors and units that have more energy losses in order to provide areas for saving. In the field of global competition, at the top of production, as many countries as possible, societies and industries will be more successful in this competition with research and studies to find solutions to prevent waste in energy consumption. Industry is one of the major consumers of energy in different societies. In the past few decades, the scientific and technological progress in the countries of the world and the promotion of productivity in different fields and fields have been the most important factors of economic growth and development. During the next decade, various energy costs for various purposes such as: heating, cooling, lighting and driving force in the process of industrial production, etc., will grow significantly and in the field of global competition, in line with the production of as many countries and societies as possible. And industries will be more successful if they succeed in finding solutions to prevent waste in energy consumption in this competition with research and studies. On the other hand, the country is undoubtedly one of the largest countries with energy resources. And as the experience of Iran and Han during the last decades of this century shows, the political authority and national independence and cultural prosperity of any country is a function of

scientific, technical and economic growth, which at the same time is directly dependent on factors such as energy and interest. It has a desirable and optimal version.

The ever-increasing increase in energy consumption in all aspects of life and the limitation of energy resources on the one hand and its excessive consumption by different societies on the other hand, in addition to environmental pollution and wasting the main and national capital, have made the future life of mankind a danger. Although Iran has the richest energy resources, its waste and improper use imposes irreparable damages on the country's annual budget. Therefore, the rational use of energy and planning in this field have a special priority. For example, in cement factories, the amount of peak reduction since the beginning of 2017 by installing a programmable ACM meter on the incoming electricity of these factories and making it possible for us to access consumption information, and according to the relevant graphs and curves, in terms of reducing consumption in We get a better position in terms of the peak of the network and the small deviation from the standard. Therefore, it can be seen that load management in order to reduce peak consumption in two factories in Tehran and Abek, there are efforts to manage load. The cement industry in the world today is responsible for the production of construction and welfare products. The use of this product not only has such special importance in the present era, but also in previous ages it has shown its merit in the progress of works and construction and welfare projects in different ways.

An introduction to solar energy

Supplying electricity from the sun as an infinite source is one of the most up-to-date technologies in the world. The process of converting the sun's radiant energy into electrical energy, which is known as photovoltaic, is known as a suitable alternative to traditional production methods. This new solution, along with wind turbines, while eliminating the pollution caused by the consumption of fossil fuels, reduces the concerns caused by the increasing dependence on these fuels. Simple installation, very little maintenance, simple and noiseless operation and availability of solar energy in all parts of the world are among the advantages of photovoltaic power plants. In the meantime, Iran has been introduced as one of the countries with high potential in the field of solar energy, benefiting from the average radiation of 4.5-5.5 kilowatt hours per square meter per day. Although the central regions of the country have the highest solar energy potential, all the regions of the country, except for the northern area of the Caspian Sea basin, have suitable radiation conditions.

In a general classification, photovoltaic generators are classified into two categories connected to the national electricity grid and separated from the grid. According to the need of the Ministry of Energy to increase the capacity of electric energy production, several incentive laws have been approved in order to increase the acceptance of industrialists and ordinary customers towards these power plants. These incentive laws have been approved and implemented in many countries of the world in order to economically justify the plan and compensate the high initial cost of these power plants. The most effective incentive policy implemented in many countries of the European Union, America, Canada, etc. is the injection tariff, in which the energy produced by the photovoltaic generator is injected into the national electricity grid and sold at a very reasonable price. In Iran, in recent years, the Ministry of Energy has adopted policies for the development of the renewable energy industry, especially in the photovoltaic field, and the latest and most effective of these policies is the injection tariff.

According to the current law in the country, the 20-year guaranteed purchase of energy produced by renewable power plants, including generators, each applicant can install a solar generator depending on their desired capacity and the total electricity produced without considering the amount of domestic consumption. It sold directly to the national electricity grid through a separate meter. For example, if a generator is installed this year, the amount paid for a 1 MW generator is 4900 Rails per kilowatt-hour, to which an amount of 150 Rails per kilowatt-hour will be added for the transfer fee (according to the law). This amount is paid during a 20-year contract and as a guarantee once every two months (similar to the times of issuing electricity bills).

One of the prominent features of the plan proposed by the Ministry of Energy is the price increase at the end of each year due to changes in the exchange rate (Euro) and the retail price of materials. This annual price increase (adjustment rate) ensures greater economic justification and reduces investment risk in different economic conditions. Another note in the promulgated law is a 30% reduction in the amount paid in the second decade of the contract (11th to 20th year).

The cost of installing a conventional power plant on a turnkey basis, including the cost of supplying and transporting equipment, installation and commissioning, and after-sales services, is estimated at 42,000,000,000 Rails.

In order to calculate the power plant's income, its energy production is calculated through PVSyst software, which is one of the most reliable software in the solar field. According to this simulation, the amount of energy produced is 6.1688 megawatt hours and is equivalent to 6.4 hours of sunshine. By installing this generator and providing the above energy, the production of 1182 tons of carbon dioxide per year by fossil fuel generators is prevented. This amount of savings in carbon dioxide production corresponds to the performance of 44,436 trees, which is one of the biggest advantages of using solar power plants. The space required to install a one megawatt power

plant is about 2000 square meters; Although it is possible to install in areas with less space in the form of special structures.

Economic evaluation of solar power plant construction plan

In this section, the economic evaluation of the proposed conventional power plant plan is presented in order to know its profitability. Economic indicators including net present value, capital return rate and investment return period have been calculated.

In the presented analysis, the following assumptions are considered:

According to the current conditions of the country, the average interest rate (1) and annual inflation (j) are considered equal to 12 and 10 percent, respectively. The annual energy production of the conventional power plant in Tehran city in the first year of operation is equal to 6.1688 megawatt hours. In order to calculate the present value of income, it is assumed that the energy produced by the power plant will decrease by half a percent every year; This issue is considered to be equal to 12% and 10% according to the current conditions of the country, the average interest rate (1) and annual inflation (3) due to the decrease in the efficiency of solar cells over time.

The amount of annual energy production of the conventional power plant in Tehran and in the first year of operation is equal to 6.1688 megawatt hours. In order to calculate the present value of income, it is assumed that the energy produced by the power plant will decrease by half a percent every year; This issue has been considered due to the drop in efficiency of solar cells over time (similar to other electrical equipment) and in order to make the results as realistic as possible.

The adjustment rate considered during the useful life of the project is equal to the adjustment rate in 2017 equal to 10%. This rate has been assumed due to the significant increase in the exchange rate and the relationship raised in this regard.

The annual maintenance cost of the power plant is assumed to be equal to two-tenths of the initial cost, which increases every year according to the inflation rate. The conventional proposed plan has an investment return rate of more than 30% (more than twice the bank interest) and a net present value of 17,239,234,3542 Rails. Another advantage of the project is the absorption of more than 70% of the income (taking into account the interest rate and inflation) in the first ten years of the project. In other words, the significant part of the revenues will be absorbed in the first half of the useful life of the power plant construction. According to the explanations provided, the construction of a photovoltaic power plant, in addition to being economically attractive with an annual profit of about 30%, provides a permanent source of income for a period of twenty years with the least amount of environmental and noise pollution and the lack of human employment.

Findings

Due to the fact that there is no possibility of rapid changes in the cement production process, the periods studied in each department are divided into 4 hours. In the daily load curve of the national network, there are two peak loads, day and night. As mentioned, the cement factory normally reduces its consumption during the daily peak load. In order to make the daily load curve uniform, in this research, in a 24-hour period, two low-load periods, two intermediate-load periods and two peak-load periods have been considered according to Table 1.

Table 1: Proposed tariff

Tariff Type	Rate (Riyals per kilowatt hour)	Hour
low load	1114	13-17 19-23
middle load	557	17-19 7-13
low load	278.5	23-7

The average energy consumption on a normal day is equal to 18 megawatts per hour, while on the days of participation in the operational reserve plan, the average consumption decreases to about 12 megawatt hours.

On average, during the participation days, the amount of 6 to 7 megawatts of the factory's consumption has decreased. In the following, the performance of different units of the factory during the project period will be investigated.

The performance of the raw material mill in the operational reserve plan

Cement mills have the highest amount of energy consumption in the cement production process and since, unlike furnaces, they do not have the technical limitation of turning on and off, they play the biggest role in the load reduction program. Considering that the storage capacity of the raw material mill is less compared to other units and the load reduction maneuver has also been carried out on the mills, which causes them to shut down at some times of the day, the amount of storage of the raw material mill warehouse is reduced to zero in some hours.

arrives. Considering that the amount of radiation is higher than the average in summer, it is assumed that 8.4 megawatt hours per day will be generated from the energy cost of the solar power plant during the implementation period of the operational reserve plan. In the following, the profit from the sale of the energy produced by the power plant will be examined.

According to the electricity tariff table, the energy consumption of the factory during this period is 3982550 Rials. In order to calculate the income from the sale of electricity produced by the power plant, if we consider the basis of the calculation for the entire twenty-year income mentioned in Table 4-5, the average monthly income of the power plant will be equal to 1646537317 Rials and the daily income for the summer months will be equal to 53114100 Rials. became. If the construction and maintenance costs of the power plant are taken into account and the cost of 2,000 square meters of land is assumed to be 4,000,000,000 Rials, the cost will be 195,194,541 Rials per month and 6,296,500 Rials per day. By the difference of the cost from the income, a profit of 46817600 Rials is obtained, which will be a significant amount considering the cost of electricity consumed in one day.

In case of participation in the operational reserve plan, on average during the plan period, for 12 days of participation, the amount of 22,228,000 Rials will be profitable for the factory, which is a significant amount due to the reduction of consumption on the days of cooperation, which will reduce the cost of electricity consumed. is. Also, preventing possible power outages during critical days will continue the planned cement production process. Another advantage of the operational reserve plan is that there is no need for initial investment and spending money, and cement industries have the ability to make maximum use of this plan due to their high flexibility.

By constructing a solar power plant, as mentioned above, a profit of 4,681,7600 riyals will be obtained. In case of participation in the operational reserve plan, the total income will be equal to 69045600 Rials. If we consider the average cost of electricity consumption (including the cost of energy, power and seasonal price) in the whole period as 300,000,000 Rials, with the cooperation in the operational reserve plan and the construction of a one-megawatt power plant, 23% of the cost of electricity consumption has been provided, which is the appropriate amount. It is attention.

Table 2: The benefits of the proposed plans

Options used	Income (Rials)	Percentage reduction in electricity consumption
Operational reserve plan	22228000	7
Operational reserve plan + photovoltaic power plant	69045600	23

Conclusion

The cement industry is one of the most electricity consuming industries. The ratio of the cost of electricity consumed in this industry to the income from cement production is significant. The industrial reserve plan is one of the incentive plans implemented in the country. As explained, the collaborating industries in this plan are given privileges, including rewards for announcing readiness and participation. In this research, the collaboration of a sample cement factory was investigated in the project and the work process of different units and the benefits and benefits of participation were studied. The results show a 10% reduction in the cost of electricity consumed in each day of the plan for the factory, which, considering the high cost of electricity, leads to good profitability for the factory. By examining the plan for the construction of a 1 megawatt solar power plant in the factory and calculating the costs and revenues, it was observed that with the profit from the sale of electricity from the solar power plant and cooperation in the operational reserve plan, the cost of the factory's electricity consumption will be compensated by 31%, which is a cost reduction compared to the state Before, it has tripled. Since the cement factory normally reduces its consumption during peak hours, participating in the operational reserve plan without changing the production rate leads to a good profitability for the factory.

The performance trend of different units of the factory shows that with the increase in electricity consumption tariff, the amount of consumption of different units is reduced and the amount of power consumption of the factory is reduced to one third of the maximum consumption demand. This shows the high potential of the cement industry in moving loads and reducing consumption during peak times.

Storage units play an important role in the cement production process. By increasing the capacity of storage warehouses, the units can provide the feed required for the peak consumption hours during low load hours and reduce their power consumption to zero when needed.

All in all, participating in the operating reserve plan for the cement plant is quite profitable. Also, considering the trend of expanding the use of renewable energy and Iran's high potential in solar radiation, the construction of a solar power plant, in addition to increasing energy production and increasing the reliability of the network, also brings financial and profitable benefits to the factory.

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