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Power supply management of an industrial center by considering participation in the Operating Reserve plan

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Abstract

Background and Aim: One of the main factors in load response schemes is encouraging subscribers to participate in consumption management plans. One of the solutions ahead is to determine the appropriate incentive rate. Since 2014, an Operating Reserve plan has been implemented to participate in courier reduction projects. Due to its high share of energy consumption, industrial load management can play a crucial role in managing demand during peak consumption. Using this set of plans makes it possible to manage the dominant load of industries to a large extent. Due to the cement production process, the capacity of this industry can be used to reduce the peak load further. Due to its high flexibility, the cement process can move load from high load hours to low load and help reduce grid load, increase reliability and reduce line density during peak load. Research Method: In this research, by carefully examining the cement production process and its simulation, the process optimization and ways to achieve maximum profit in the Operating Reserve plan are examined. Findings and Conclusion: By examining the performance of a sample factory, it is observed that the factory naturally reduces its consumption during peak hours. Therefore, in this study, an attempt has been made to maximize the factory profit and to improve the effectiveness of the Operating reserve plan by using the tariff table. The performance process of each of the factory units and Reserve warehouses during the Operating Reserve plan and the construction of a solar power plant in the factory for use during peak hours and its advantages and disadvantages have been reviewed. The city of Mashhad has a good amount of sunlight. Considering the concurrence of the Operating Reserve plan period and the summer season, which has the highest amount of solar radiation, the cement factory can use the benefits of cooperation in the Operating Reserve plan and benefit from the profitability of constructing a solar power plant. In order to minimize costs and achieve maximum profit, an optimization problem has been defined, the answer to which has been obtained using a genetic optimization algorithm.

Keywords: management, electricity, cement industry

Introduction

The electricity demand is constantly growing due to industrial advances and living standards. This dramatic increase in electricity consumption has created problems for its producers to supply energy (Chaik, 2016). As energy demand changes and increases, energy producers have to increase their production levels to supply the electricity they need. Especially in peak hours, the manufacturer must increase its production capacity to provide the power required by the consumer in this period by spending a considerable amount of money. In the past, the production of electrical energy followed the amount of load consumption. According to the rate of increase, the production also increased (Arman Fard & Ghaeni, 2018). Today, providing the energy needed for limited peak hours requires the exorbitant cost of building new power plants. In order to avoid these costs and save capital, power companies have shifted to demand-side management methods. The motivations and incentives in these plans motivate the subscribers to cooperate. As a result, the subscribers will benefit from financial benefits by cooperating in these projects. In addition to delaying the construction of new power plants, the grid operator will also benefit from the uniformity of the load curve (deforestation and peak shaving).

Demand-side management

In traditional power systems, consumption management plans overcame some power system problems. In the meantime, load response plans were also introduced as part of these plans. However, after the restructuring of power systems, these plans were gradually abandoned due to inconsistencies with the nature of the market. But after a while, due to problems such as price instability and re-implementation of consumption management plans. Numerous factors such as increasing load growth, high investment costs in the electricity industry, environmental issues, technical issues, sustainability, reliability, etc., have made demand-side management methods at the top of power companies' plans (Arasnejad et al., 2015). It includes a range of activities designed by the electricity company and the government to change the amount or timing of electricity consumption for the common good of society, the electricity company, and consumers. In other words, demand-side management is all the management functions related to directing demand-side activities, including planning, evaluation, implementation, and monitoring. Demand-side management goals can be listed as follows:

- Peak shaving and load leveling
- Load shifting
- Create flexible load curves
- Increase strategic consumption
- Increase energy efficiency
- Reduce energy production costs
- Improving environmental issues

The need to reduce the annual peak load

Increasing electrical energy consumption in electrical systems causes problems in supplying electricity to customers. For example, the power system in India in 2010 was about 9% short of energy production.

This shortage rate in peak hours has reached 15.2% (Oud Nejad et al., 2016). Responding to peak load each year requires the construction of new power plant units, load management plans, and proper maintenance and maintenance of existing facilities to maximize their utilization. Providing such conditions to meet the peak load requires much money. However, this is a high cost for a limited number of hours during the year, so that only 3% of the time (less than 300 hours per year) the grid load reaches more than 90% of the peak load; In other words, if consumption can be controlled at 3% of the time of the year, most of the power supply problems will be solved (Iran Electricity Grid Management Company, Ariana Management Consulting Company, 2016). In recent years, due to the lack of financial credit to build the infrastructure of the electricity industry and the growth of about 4% of annual peak consumption, and the continuation of this trend in the coming years, serious concerns have arisen for the electricity industry (Mohsenpour et al., 2016).

Introduction to Solar Energy

Power supply from the sun as an infinite source is one of the most up-to-date technologies in the world. The process of converting solar radiation into electrical energy, known as photovoltaics, is a viable alternative to traditional production methods. Along with wind turbines, this new solution eliminates the pollution caused by the consumption of fossil fuels. It reduces the worries of increasing dependence on these fuels. Easy installation, low maintenance, simple operation without noise, and availability of solar energy in all parts of the world are among the advantages of photovoltaic power plants. Meanwhile, Iran has been introduced as one of the countries with high potential in solar energy, benefiting from average radiation of 5.5-5.5 kWh per square meter per day.

Although the country's central regions have the greatest potential for solar energy, all areas except the northern part of the Caspian Sea basin have good radiation conditions.

In a general classification, photovoltaic generators are divided into two categories, connected to the mains and separately. Due to the Ministry of Energy's need to increase the electricity generation capacity, several incentive laws have been approved to increase the acceptance of craftsmen and ordinary subscribers to these power plants. These incentive laws have been approved and implemented in many countries to justify the economic plan and compensate for the high initial cost of these power plants. The most effective incentive policy implemented in many countries of the European Union, the United States, Canada, etc., is the injection tariff. The energy produced by the photovoltaic generator is injected into the national grid and sold at a very reasonable price. In Iran, in recent years, the Ministry of Energy has adopted policies to develop the renewable energy industry, especially in photovoltaics, the latest and most influential of which is the injection tariff.

According to the current law in the country, a 20-year guaranteed purchase of generated energy by renewable power plants, including generators, each applicant can depend on their desired capacity, install a solar generator and the entire generated electricity, regardless of domestic consumption) Sold directly to the national grid through a separate meter. For example, suppose a generator is installed this year. In that case, the amount paid for a 1 MW generator is 4900 Rials per kilowatt-hour, to which 150 Rials per kilowatt-hour will be added for the transmission cost (according to the law). This amount is paid under a 20-year contract and guaranteed every two months (similar to electricity billing times).

A prominent feature of the proposal 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 more economic justification and reduces investment risk in different economic conditions. Another note in the announced law is a 30% reduction in the amount paid in the second decade of the contract (eleventh to the twentieth year).

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

In order to calculate the power plant revenue, its energy production is calculated through PVSyst software, which is one of the reliable software in the solar field. According to this simulation, the energy produced is 1688.6 MWh and is equivalent to 6.4 hours of sunshine. By installing this generator and supplying the above energy, fossil fuel generators' production of 1182 tons of carbon dioxide per year will be prevented. This amount of savings in carbon dioxide emissions corresponds to the performance of 44,436 trees, which is one of the most significant benefits of using solar power plants.

The space required to install a 1 MW power plant is about 2,000 square meters; however, it is possible to install in areas with less space as unique structures.

An economic evaluation of the solar power plant construction plan

This section presents the economic evaluation of the proposed conventional power plant design to know its profitability. Economic indicators include net present value, return on investment and return on investment.

In the presented analyzes, the following assumptions have been considered:

According to the current situation in the country, the average interest rate (1) and annual inflation (j) are considered equal to 12 and 10 percent, respectively. The amount of annual energy production of a conventional power plant in Mashhad in the initial year of operation equals 1688.6 MWh. In order to calculate the present value of revenues, it is assumed that the energy produced by the power plant will be reduced by half a percent each year; This issue is considered due to the decrease in the efficiency of solar cells over time following the current conditions of the country, the average interest rate (1) and annual inflation (3) are equal to 12 and 10 percent, respectively.

The amount of energy produced annually by a conventional power plant in Mashhad in the initial year of operation equals 1688.6 MWh. In order to calculate the present value of revenues, it is assumed that the energy produced by the power plant will be reduced by half a percent each year; This is due to the declining efficiency of solar cells over time (similar to other electrical equipment) and in order to make the results more realistic.

The adjustment rate considered during the project's useful life is equal to the adjustment rate in 2018, equal to 10%. This rate is assumed due to the significant increase in the exchange rate and the relationship proposed in this regard.

The annual cost of maintaining the plant is assumed to be equal to two-tenths of one percent of the initial cost, which increases each year due to inflation. The conventional plan has a rate of return of more than 30% (more than twice the bank interest) and a net present value of 172392343542 Rials. Another benefit of the plan is that it absorbs more than 70% of the revenue generated (considering interest rates and inflation) in the project's first ten years. In other words, a significant part of the revenues will be absorbed in the first half of the useful life of the power plant. 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 twenty years with the least amount of environmental and noise pollution and no employment of the workforce.

Findings

Due to the possibility of rapid changes in the cement production process, the courses studied in each section are divided into 4-hour yields. In the daily load curve of the national grid, there are two peak loads, daily and night. As mentioned, the cement plant typically reduces its consumption at peak daily load. In order to make the daily load curve uniform, in this study, in 24 hours, two low load intervals, two short load intervals, and two peak load intervals have been considered according to Table 1.

Table 1. Proposed tariffs

Tariff	hour	Rials per kilowatt hour
High peak	17-13 23-19	1114
Medium peak	19-17 13-7	557
Low peak	7-23	278.5

The average energy consumption of a typical day is 18 MW per hour. In contrast, on the days of participation in the Operating reserve plan, the average consumption is reduced to about 12 MWh.

On average, factory consumption has decreased by 6 to 7 MW in the days of participation. The following will examine the performance of different factory units during the design period.

Raw material mill performance in Operating Reserve plan

Cement mills have the highest energy consumption in the cement production process. Since, unlike kilns, they do not have the technical limitations of turning on and off, they play the most crucial role in the load reduction plan.

Because the Reserve capacity of the raw material mill is less than other units and the load reduction maneuver has been performed on the mills, which causes them to shut down at certain times of the day, the Reserve capacity of the raw material mill warehouse is also zero in some hours.

Because in summer, the amount of radiation is higher than the average, during the implementation period of the Operating Reserve plan, it is assumed that 8.4 MWh per day will generate revenue from the energy cost of the solar power plant. In the following, the profit from the sale of energy produced by the power plant will be examined.

According to the electricity tariff table, the cost of energy consumption of the factory during this period is 3982550 Rials. To calculate the revenue from the sale of electricity generated by the power plant, if we consider the basis for calculating the total 20-year revenue mentioned in Table 4-5, the average monthly revenue of the power plant will be 1646537317 Rials and daily income for the summer months will be 53114100 Rials. شد. Suppose the costs of construction of the power plant and maintenance are taken into account. The cost of 2,000 square meters of land is assumed to be equal to 400,000,000 Rials. In that case, the cost will be 195194541 Rials per month and 6296500 Rials per day. With the difference of cost from income, the profit is 46817600 Rials, which will be a significant amount considering the cost of electricity consumed in one day.

In case of participation in the Operating reserve plan, on average during the plan period, for 12 days of participation, the amount of 22228000 Rials will be a profit for the factory, which is a significant amount due to the reduction of consumption on cooperation days, which reduces electricity costs. Is. Also, preventing possible power outages on critical days will continue the planned cement production process. Another advantage of the Operating reserve plan is that there is no need for initial investment and cost, and the cement industry, due to its high flexibility, can make the most of this plan.

With the construction of the solar power plant, as mentioned above, a profit of 46817600 Rials will be obtained. In the case of participation in the Operating reserve plan, the total income will be equal to 69045600 Rials. If we consider the average cost of electricity consumption (including energy costs, power, and season price) in the whole period equal to 300,000,000 Rials, by cooperating in the Operating Reserve plan and construction of a 1 MW power plant, 23% of the cost of electricity consumption is provided, which is a decent amount. It is noteworthy.

Table 2. Benefits of the proposed plans

Options used	Income	Percentage reduction in electricity consumption
operating reserve plan	22228000	7
operating reserve plan + photovoltaic power plant	69045600	23

Conclusion

The cement industry is one of the most consumed electricity industries. The ratio of electricity consumption in this industry to revenue from cement production is significant. The industrial Operating reserve plan is one of the incentive-oriented plans implemented in the country. As explained, the partner industries in this project will be awarded benefits such as readiness and participation bonuses. In this study, the cooperation of a sample cement factory was investigated. The work process of different units and the benefits and advantages of participation were studied. The results show a 10% reduction in the cost of electricity consumed per day of the project for the factory, which, given the high cost of electricity, leads to good profitability for the factory. Examining the plan to build a 1 MW solar power plant in the factory and calculating costs and revenues, it was observed that with the profit from the sale of the solar power plant and cooperation in the Operating reserve plan, the cost of electricity consumption of the plant would be compensated 31%. Previously, it tripled. Since the cement plant typically reduces its consumption during peak hours, participation in the Operating Reserve plan without changing the amount of production leads to good profitability for the plant.

The performance trend of different units of the factory shows that with the increase of electricity consumption tariff, the consumption of different units

The factory's power consumption is reduced to one-third of the maximum demand. This shows the high potential of the cement industry in moving loads and reducing consumption at peak times.

Unit warehouses play an essential role in the cement production process. By increasing the capacity of Reserve warehouses, units can provide the required feed for peak hours during off-peak hours and reduce their power consumption to zero at the required time.

Overall, participating in an Operating Reserve plan for a cement plant is profitable. Also, due to the trend of expanding the use of renewable energy and Iran's high potential in solar radiation, the construction of a solar power plant and increasing energy production and grid reliability brings financial and profitability benefits for the plant.

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