Research Journal of Management Reviews. Vol., 8(2), 36-41, 2023
Available online at http://www.rjmrjournal.com
ISSN 2149-3316 ©2022
DOI: 10.52547/jss.8.2.36

The Management of Electric Energy Supply in an Industrial Center with Regards to its Potential Participation in an Operational Reserve Plan.

Sajjad MirAkbari

M.Sc. of Power Engineering, Science and Research Unit, Islamic Azad University, Yazd, Iran

*Author Email: a.shishebori@setarehcable.com

Abstract
background and aim: A crucial element in load response strategies is to incentivize customers to engage in demand-side management initiatives. One potential solution involves the determination of an optimal incentive rate. The implementation of a program known as operational reserve has facilitated the involvement of industries in peak reduction plans since 2013. Given its significant contribution to overall energy consumption, industrial load management can serve as a crucial tool for demand management during periods of peak consumption. The implementation of this particular set of plans has significantly increased the potential for effectively managing the current industrial workload. Given the cement production process, it is possible to utilize the industry's capacity to further mitigate peak load. The cement process exhibits a notable degree of flexibility, enabling it to effectively redistribute load from high to off peak hours. This feature contributes to the reduction of grid load, enhancement of reliability, and alleviation of line congestion during peak load periods.
Method: The present study involves a meticulous analysis of the cement production process, followed by its simulation. The aim is to optimize the process and identify strategies to attain maximum profitability in the operational reserve plan.
Results and implications: Through an analysis of the operational efficiency of a representative manufacturing facility, it is evident that the factory exhibits a tendency to decrease its energy consumption during periods of high demand. This study aims to optimize the factory's profitability and enhance the efficiency of the operational reserve strategy through the utilization of a tariff table. The study examined the operational storage plan's efficacy for each factory unit and storage warehouse, in addition to evaluating the feasibility of constructing a solar power plant within the factory to meet peak-hour energy demands. The benefits and drawbacks of implementing such a system were also analyzed. Mashhad is characterized by a substantial level of solar irradiation. The cement factory stands to gain profitability from the construction of a solar power plant, in conjunction with the advantages of participating in the operational reserve plan. This is due to the optimal timing of the plan's implementation during the summer season, which boasts the highest levels of sunlight. An optimization problem was formulated with the aim of reducing expenses and maximizing profits. The solution to this problem was obtained through the utilization of the genetic optimization algorithm.
Keywords: management, electric energy, cement industry

Introduction

The escalating need for electrical energy is attributed to the progress in industrialization and advancements in societal living standards. The substantial increase in electric energy consumption has posed challenges for energy producers in meeting the demand for such a significant quantity of energy [1]. Due to the fluctuating and escalating energy demand, energy generation sources are compelled to augment their production capacity in order to meet the requisite electricity supply. Especially during periods of high demand, the producer is compelled to augment their production capacity in order to meet the energy requirements of the consumer, incurring significant costs in the process. Historically, the generation of electrical power was contingent upon the level of demand and correspondingly increased in tandem with its escalation [2]. Currently, meeting the energy demands during specific peak hours necessitates significant expenditures towards constructing new power plants. Power companies are increasingly adopting demand side management techniques to conserve capital and mitigate expenses. The provision of incentives and rewards to subscribers within these programs serves as a motivating factor for their active participation and collaboration. Through collaborative participation in these initiatives, subscribers can reap financial advantages while grid operators can delay the construction of additional power plants and achieve load curve stabilization through Peak shaving and valley filling.

Demand side management (DSM)

Consumption management programs were traditionally employed in power systems to address certain issues within the system. Meanwhile, programs pertaining to load response were also cited as constituents of these programs. Following the reorganization of power systems, these initiatives were progressively discontinued owing to their incongruity with market dynamics. However, subsequent to a certain period, they garnered attention once more as a result of issues pertaining to price volatility and the reintroduction of initiatives aimed at managing consumption. Electric companies have placed demand side management methods at the forefront of their agenda due to various factors such as escalating load growth, substantial investment costs in the electricity industry, environmental concerns, technical and stability issues, and reliability, among others [3]. Demand-side management encompasses a variety of initiatives developed by both governmental and power company entities aimed at modifying the quantity and timing of electricity usage among consumers, with the ultimate goal of promoting the collective welfare of society, the power company, and individual consumers. Demand side management encompasses various management functions that pertain to the regulation of demand side activities. These functions comprise planning, evaluation, implementation, and monitoring. The aims of demand side management can be enumerated as follows:

- Peak shaving and valley filling
- Load shifting
- flexible load curve
- strategic load growth
- Increasing energy efficiency
- Reducing energy generation costs
- Improving environmental issues

A requirement to decrease the yearly maximum demand.

The escalation of electrical energy usage within electrical systems poses challenges in the provision of electricity to end-users. In 2010, the power system in India experienced a deficit of approximately 9% in energy generation.

The current deficit has attained a percentage of 15.2% during hours of maximum consumption, as reported in reference [8]. Meeting the annual peak load necessitates the erection of fresh power plant units, the formulation of load management strategies, the execution of repairs, and the implementation of appropriate maintenance measures to optimize the utilization of current infrastructure. The provision of such conditions to meet the peak load necessitates a significant financial investment. The cost incurred is substantial, albeit for a restricted number of hours annually, with grid load exceeding 90% of peak load for only 3% of the time (equivalent to less than 300 hours per annum). In essence, effective management of consumption during this 3% period would effectively address the majority of electricity supply issues [9]. The electricity industry has been facing significant concerns in recent years due to insufficient financial credit for infrastructure establishment and an annual peak consumption growth rate of approximately 4%, which is predicted to persist in the upcoming years [10].

Solar Energy

The utilization of solar energy as an inexhaustible power source represents a cutting-edge technological advancement in contemporary society. The photovoltaic process, which involves the conversion of solar radiation into electrical energy, is considered a viable alternative to conventional production methods. The novel approach, in conjunction with wind turbines, mitigates the environmental impact resulting from the utilization of nonrenewable energy sources and alleviates apprehensions associated with the escalating reliance on such sources. The benefits of photovoltaic power plants include straightforward installation, minimal upkeep requirements, quiet and uncomplicated operation, and the ubiquitous availability of solar energy across the globe. Iran has been identified as a nation with significant potential in the realm of solar energy, owing to its average radiation levels of 4.5-5.5 kilowatt hours per square meter per day. Whilst the central regions of the country exhibit the greatest potential for solar energy, it is noteworthy that all regions, with the exception of the northern area of the Caspian Sea basin, possess radiation conditions that are conducive to solar energy utilization.

Photovoltaic generators can be broadly categorized into two groups based on their connection to the national electricity grid: those that are connected to the grid and those that operate independently from it. In response to the Ministry of Energy's imperative to augment the capacity of electric energy generation, a number of incentive laws have been ratified with the aim of fostering greater receptivity among both industrialists and ordinary consumers towards these power plants. In numerous countries across the globe, incentive laws have been sanctioned and executed to provide economic rationale for the scheme and offset the substantial upfront expenses of such power facilities. The injection tariff has been widely adopted as the most efficacious incentive policy in numerous countries across the European Union, America, Canada, and other regions. This policy involves the injection of energy generated by photovoltaic systems into the national electricity grid, which is subsequently sold at a justifiable rate. The Ministry of Energy in Iran has implemented policies aimed at promoting the renewable energy sector, with a particular focus on photovoltaic technology. The most recent and impactful policy is the introduction of an injection tariff.

As per extant legislation in the nation, renewable energy facilities, such as generators, are entitled to a 20-year assured procurement of their generated power. The installation of solar generators is contingent upon the applicant's preferred capacity and the aggregate electricity output, irrespective of domestic consumption levels. The electricity was directly sold to the national grid through the utilization of a distinct meter. In the event that a generator is installed within the current year, the cost of a one megawatt generator is 4900 Rials per kilowatt hour. Additionally, a transfer fee of 150 Rials per kilowatt hour will be levied in accordance with the prevailing legislation. The aforementioned sum is remitted over a period of two decades and serves as a form of assurance, disbursed bi-monthly in a manner akin to the issuance of electricity invoices.

A salient aspect of the proposal put forth by the Ministry of Energy pertains to the annual escalation in pricing, which is attributed to fluctuations in the Euro exchange rate and the retail value of materials. The yearly escalation in price, also known as the adjustment rate, ensures enhanced economic rationality and mitigates investment risk across diverse economic scenarios. One provision outlined in the enacted legislation entails a reduction of 30% in the payment amount during the second decade of the contractual agreement, specifically from the 11th to the 20th year.

The estimated cost of turnkey installation of a conventional power plant, which encompasses expenses related to equipment procurement, transportation, installation, commissioning, and post-sales services, amounts to 42,000,000,000 Rials.

The determination of the power plant's revenue involves the utilization of PVSyst software, which is widely recognized as a dependable software within the solar industry, to compute the energy generation. As per the simulation results, the energy output is recorded to be 6.1688 megawatt hours, which is commensurate to a duration of 6.4 hours of sunshine. The installation of the aforementioned generator and its provision of energy serves to prevent the annual production of 1182 tons of carbon dioxide by fossil fuel generators. The reduction in carbon dioxide emissions achieved by solar power plants is significant, equivalent to the carbon sequestration capacity of 44,436 trees, thus representing a major benefit of this technology.

The installation of a power plant with a capacity of one megawatt necessitates an area of approximately 2000 square meters, although it may be feasible to install it in compact spaces through the utilization of specialized structures.

Economic evaluation of a proposed plan for the construction of a solar power plant

This section presents an economic evaluation of the proposed conventional power plant plan with the aim of determining its profitability. The computation of economic indicators such as net present value, capital return rate, and investment return period has been conducted.

The analysis presented takes into account the following assumptions:

. Based on the prevailing economic circumstances of the nation, it can be inferred that the mean interest rate (1) and yearly inflation rate (j) are both estimated to be 12 and 10 percent, correspondingly. The initial yearly energy output of the traditional power facility located in Mashhad is 6.1688 megawatt hours. The present value of income is computed under the assumption that the power plant's energy output will experience an annual decrease of 0.5%. To account for the declining efficiency of solar cells in the country, the prevailing interest rate (1) and annual inflation rate (3) have been set at 12% and 10%, respectively.

The conventional power plant located in Mashhad city has an annual energy generation of 6.1688 megawatt hours during its first year of operation. The computation of the current value of revenue necessitates the assumption that the power plant's energy output will experience an annual reduction of 0.5%. This factor has been taken into account to reflect the decline in the efficiency of solar cells and other electrical equipment over time, thereby enhancing the realism of the findings.

The adjustment rate that is taken into account throughout the project's useful life is equivalent to the 2017 adjustment rate, which stands at 10%. The aforementioned rate has been postulated in light of the notable escalation in the exchange rate and the corresponding correlation.

It is assumed that the yearly maintenance expenses of the power plant are equivalent to 0.2 times the initial cost, and these costs escalate annually in accordance with the inflation rate. The proposed plan adheres to conventional standards and exhibits a return rate on investment exceeding 30%, which is more than twice the interest rate offered by banks. Additionally, the plan demonstrates a net present value of 17,239,234,3542 rials. One notable benefit of the project is its capacity to absorb over 70% of the revenue, factoring in both the interest rate and inflation, within the initial decade of its implementation. To clarify, a substantial portion of the generated income will be consumed during the initial half of the operational lifespan of the power plant infrastructure. As per the elucidations furnished, the establishment of a photovoltaic power plant, besides being financially alluring with a yearly gain of approximately 30%, furnishes a perpetual revenue stream for a duration of two decades with minimal ecological and acoustic disturbance and negligible human labor.

Findings

The cement production process is characterized by a lack of flexibility, necessitating the division of each department's study periods into four-hour intervals. The daily load curve of the national grid exhibits two distinct peak loads, one during the day and another during the night. As stated, the cement manufacturing plant typically decreases its usage during periods of high demand throughout the day. This study has incorporated two low-load periods, two intermediate-load periods, and two peak-load periods within a 24-hour period, as outlined in Table 1, with the aim of achieving uniformity in the daily load curve.

Table 1: the proposed tariff.

Tariff type	Hour	Rate (riyals per kilowatt hour)
On peak	13-17	1114
middle peak	19-23	557
off peak	17-19	278.5

On a typical day, the mean energy consumption is 18 megawatts per hour. However, during the days when the operational reserve plan is implemented, the average consumption reduces to approximately 12 megawatt hours. The factory's energy consumption has exhibited a reduction of 6 to 7 megawatts on average during the days of participation. The subsequent analysis will evaluate the operational efficiency of various departments within the factory over the course of the project duration. The operational reserve plan incorporates the performance of the raw material mill.

Cement mills are the primary consumers of energy in the cement production process. Unlike furnaces, they are not constrained by technical limitations that restrict their ability to power on and off. Consequently, cement mills are pivotal in the load reduction program. The raw material mill's storage capacity is comparatively lower than that of other units. Additionally, load reduction maneuvers are implemented on the mills, leading to their temporary shutdown during certain times of the day. As a result, the raw material mill warehouse's storage capacity is depleted to zero during certain hours. arrives. It is postulated that the solar power plant will generate 8.4 megawatt hours per day during the implementation period of the operational reserve plan, owing to the elevated levels of radiation that surpass the seasonal average in summer. The subsequent analysis will focus on the financial gain derived from the trade of the electricity generated by the power facility.

As per the electricity tariff schedule, the energy utilization of the factory in the specified duration amounts to 3982550 Iranian rials. To determine the revenue generated by the power plant through the sale of electricity, the calculation basis for the entire twenty-year income, as presented in Table 4-5, is considered. The resulting average monthly income for the power plant is calculated to be 1646537317 Rials, while the daily income during summer months is estimated to be 53114100 Rials. When considering the expenses associated with the establishment and upkeep of the power plant, and assuming a land cost of 4,000,000,000 Rials for an area of 2,000 square meters, the resulting monthly cost would amount to 195,194,541 Rials, or 6,296,500 Rials per day. A profit of 46817600 rials has been generated by subtracting the cost from the income. This amount is noteworthy when considering the daily electricity consumption expenses.

In the event of engaging in the operational reserve program, the factory stands to gain a considerable sum of 22,228,000 Rials on average over the plan's duration for every 12 days of participation. This profit is attributed to the reduction in energy consumption during the days of collaboration, leading to a decrease in electricity costs. is. Moreover, ensuring the avoidance of potential power interruptions on crucial days will sustain the scheduled cement manufacturing procedure. An additional benefit of the operational reserve strategy is its lack of requirement for initial investment and expenditure. The cement sector is particularly well-suited to leveraging this approach due to its notable adaptability.

The construction of a solar power plant, as previously indicated, is expected to yield a profit of 4,681,7600 riyals. If an individual takes part in the operational reserve plan, their overall earnings will amount to 69045600 Iranian rials. Taking into account the total expenses associated with electricity consumption, encompassing energy, power, and seasonal pricing, the mean cost is estimated to be 300,000,000 rials. Through the implementation of the operational reserve initiative and the establishment of a one-megawatt power facility, 23% of the total cost of electricity consumption has been successfully covered, representing a suitable proportion. This phenomenon pertains to the allocation of cognitive resources towards a particular stimulus or task.

Table 2: an overview of the advantages associated with the proposed plans.

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

Conclusion

The cement industry is recognized as a significant consumer of electricity. The ratio between the expenses incurred from electricity consumption in this particular industry and the revenue generated from cement production is noteworthy. The Industrial Reserve Plan is among the incentive schemes that have been implemented within the nation. As elucidated, the cooperative industries in this scheme are granted certain privileges, such as incentives for declaring preparedness and involvement. This study examines the collaboration of a selected cement factory in a project, analyzing the work processes of various units and assessing the advantages and benefits of participation. The findings indicate a decrease of 10% in the daily electricity consumption expenses for the factory's operational plan. Given the substantial expense associated with electricity consumption, this outcome is expected to yield favorable profitability for the factory. Through an analysis of the blueprint for a 1 megawatt solar power plant installation within the factory, coupled with a comprehensive assessment of the associated costs and revenues, it was determined that the factory's electricity consumption expenses could be offset by 31% through the profits generated from the sale of electricity from the solar power plant, as well as participation in the operational reserve plan. This represents a threefold reduction in costs compared to the previous state. The cement factory can achieve favorable profitability by participating in the operational reserve plan without altering its production rate, as it typically curbs its consumption during peak hours.

The empirical data on the performance of various units within the factory indicates that an escalation in electricity consumption tariffs is associated with a decrease in the consumption levels of these units. Consequently, the overall power consumption of the factory is reduced to a third of its maximum demand. This demonstrates the considerable potential of the cement sector in facilitating transportation and minimizing energy consumption during periods of high demand.

Storage facilities are a crucial component in the process of cement manufacturing. By augmenting the storage warehouses' capacity, the units can furnish the necessary feed to meet the peak consumption hours during off peak period and curtail their power consumption to nil at the designated time.

Overall, engaging in the operational reserve program for the cement manufacturing facility is a highly lucrative endeavor. Given the current trend of augmenting the utilization of sustainable energy sources and Iran's substantial capacity in solar radiation, the establishment of a solar power facility not only enhances energy generation and grid dependability, but also yields financial and lucrative advantages for the enterprise.

References

[1] Seyed Mahdavi Chaik, "Study on the implementation of interruptible tariffs and determination of economic tariffs for industrial customers including cement and steel", Khorasan Regional Electricity Company, March 2021

[2] S. Arman Fard, M. Qaini, "Electricity price calculation for load response considering grid losses", 26th Iran Electrical Engineering Conference, Mashhad, May 2023.

[3] M. Ares Nejad, M. Rajabi Mashhadhi, h. Eidi, "TOU tariff design for heavy customers of Khorasan regional electricity according to the load pattern", National Conference on Technology, Energy and Data with Electrical and Computer Engineering Approach, Kermanshah, Khordad 2022.

[4] I. Lampropoulos, W. L. Kling. P. F. Ribeiro, and J. van den Berg. "History of Demand Side Management and Classification of Demand Response Control Schemes," in IEEE Power and Energy Society General Meeting (PES). (Vancouver, BC), pp. 1-5. 2022.

[5] A. Faruqui. A. Hajos, R.M. Hledik, S.A. Newell, "Fostering economic demand response in the Midwest ISO" Energy, Vol 35, pp 1544-1552 Issue 4 April 2020.

[6] S. Kucuk, F. Arsalan, M. Bayrak, G. Contreas, "Load Management of Industrial Facilities Electrical System Using Intelligent Supervision Control and Monitoring Systems". T. 17 International Symposium on Grids, Computers and Communications (ISNCC).

[7] M. Ares Nejad, "Providing effective implementation solutions for the participation of heavy industries in demand side management (DSM)" master's thesis, Kermanshah Azad University, Shahrivar 2018

[8] M. Od Nejad, M. Rajabi Mashhadhi, h. Eidi, "Study of the effect of implementation of industrial load response programs in reducing the national grid peak", 31st International Electricity Conference, Tehran, November 2019

[9] Iran Electric Grid Management Company, Ariana Management Consulting Company, "Achievements of load management with the participation of industries in the operational reserve plan of Titan Industries 2018.

[10] F. Mohsenpour, M. Qaini, M. Ares Nejad, "Presentation of a new method to determine the incentive in the industrial operational reserve plan based on the annual load curve", 26th Iran Electrical Engineering Conference, Mashhad, May 2018.