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FUZZFIED APPROACH FOR ENERGY MANAGEMENT IN ELECTRICAL DEMAND

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Abstract: An advanced control and optimization technique is widely accepted as a cost-effective solution for increasing plant performance. It has been proven to breathe new life into older, less efficient plants by enabling them to do what once seemed not possible, that is a simultaneously produce more power, maximize profits, and become more ecologically friendly. This study proposes a comprehensive fuzzy strategy to optimizing a GenCos profit in a competitive power market while also taking into account energy management. Energy efficiency and conservation are major economic and environmental problems for any company in today's environment. The industrial sector in India accounts for nearly half of all commercial energy use. There is a massive opportunity for energy savings of between 15 and 25 percent. Energy management is necessary since it appears that energy conservation doubles as energy production. The suggested method generates an optimal profit fuzzy function that represents energy management and assists in risk hedging.

Keyword: Energy Management, Fuzzy Logic, Electrical Demand.

I. Introduction

Electrical consumers can be broadly divided into five categories: Agriculture, Commercial, Domestic, Industrial and others. So far as the category wise number of consumers are concerned, domestic connections top the list through the consumption under this category is only 25% of the total energy consumed [1]. Of the total energy consumed by all homes, only one third is used for lighting. The rest is used for fans/air conditioning (30%) refrigeration (13%), water heating (8%) and other services (14%). Industry which is only 2% of the connection consumes nearly 37%.

People use a variety of equipment like bulbs, tube lights, motors, pump sets (with motor) etc which consume electricity. These different uses can divided into three broad classes[2]

(a) Motors,

(b) Electrolysis and heading

(c) Lighting & OTHERS.

Consumption of electricity is nearly 75% to 80% by motors, 10 to 15 % by electrolysis and heading and 5 to 10 % by lighting & others. Thus, electricity means different things to different consumers[3].

An electricity bill is calculated using the energy consumed in a billing period, which is typically one month. For big consumers the charge may depend on the amount of connected load (measured in KW or KVA), the time of use of electricity, power factor etc.[4] The quantum of electricity consumed(in KWH) by a piece of machinery or equipment in a month of 30 days can be calculated if we know the power in watts and the number of hours of use.[5] Thus if a 100 watt bulb is used from 6 in the evening to 10 at night every day (i.e. 4 hours per day), the monthly consumption will be (100 x 4 x 30)/ 1000 i.e. 12KWH or 12 units.

Using this method, one can see that a poor household with three bulbs(60 watt each, used for four hours per day), and a fan(50 watt, used for 10 hours per day) consumed about 40 units in a month. 60% is used for lighting. Nearly 60% for existing 10.5 lakhs domestic consumers in Jharkhand state belong to this category.

A rich household with 5 rooms uses about 700 units a month. The break-up would be as follows: to lights in each room totaling 160 watts used for 4 hours per day, 1 fan of 50 watts in each room running for 10 hours per day, a fridge (300 W, on for 10 hours per day), A.C.(1400 W, 6 hours per day), geyser(325W , 1 hours per day) TV(120 W, 6 hour per day), Toaster(1000W, 1 hour per day), Vacuum cleaner(750W, 1 hour per day), VCD/DVD(40W, 6 hours per day). Only 15% of it is used for lighting. About 2% of the consumers in Jharkhand belong to this class [6].

Similarly, we can calculate that a jewellery shop with 300 sq.ft. area will have a monthly consumption of 1000 units(out of 10 working hours 2 hours are in night, lights work in the day also-also outdoor lights are off-10 lights of 100 W each, 2 A.C(1400 W each), 6 small fans of 40w each and outdoor lights of 240w. Factory and offices use many kinds of equipment. The power needed is normally mentioned on the name plate. Monthly energy consumption can be calculated after ascertaining the type of equipment, number and hours of use. This can be checked against various norms available for the standard values of energy consumption for shops, process industries, offices etc depending on the size operation. For example, the Aluminum industry consumes around 16000–17000 KWH per tonne and a cement industry 110-112 KWH per tone[7].

Use electricity only when it is required and as efficiently as possible. Whenever possible, use natural lighting and cooling sources. Compact Fluorescent lamps(CFL) and tube lights are much more efficient than ordinary bulbs. Switch off when you do not need a bulb or fan. If all the 10.5 lakhs domestic consumers in the state of Jharkhand put off one 60W bulb each, the total power demand in the state will come down by 60MW, which is approximately 5% of the states peak demand[8].

This reduction is peak demand is equal to half the present generation of Patratu Thermal Power station. One simple act by all the households in Jharkhand put off this 60W bulb in kitchen for one hour every day throughout the year, the drop in annual energy consumption will be 23MW. That is about the energy generated in the state in two days[9].

Tube lights today are available with 49W and 36W power rating. Both give the same amount of light, have a similar life span and cost the same. Assuming that one fourth of the 10.5 lakhs domestic consumers in Jharkhand use tube lights, and if half of them replaced one of their 40W tube lights with the slim 36 W tube lights, the MW saving would be 0.5 MW. Both types of tube lights cost the same and they need to replace only when their existing on stops working. Thus, this one time saving of nearly Rs. 3 crores(considering a cost of Rs. 6 crores/MW at the consumer end) can be achieved without any additional investment.

The potential to save in offices and factories is much higher, motors should be sized properly to meet the requirement, unwanted motors should be turned off, energy leakage must be plugged and process improvements carried out to improve energy efficiency. It is estimated that an average of about 15-25% energy saving is possible in most industries.

While utilizing electricity, it is important to protect consumer interest. In addition to ensuring that the tariff is reasonable, this includes prevention of electrical shock, protecting electrical equipment from bad quality power, keeping track of the quality of power supply, ensuring high efficiency of use and learning to attend to minor problems[10].

II. PROBLEM FORMULATION

The suggested GenCos' generation schedule is developed as an issue where the goal is to maximize GENCO's profit based on forecasted demand, reserve, and market rates.

$$Maximize \sum_{i=1}^{N}\sum_{t=1}^{T} Revenue(i,t) - Cost(i,t) \quad (1)$$

Where

$$Revenue(i,t) = \{[\rho P(i,t)P(i,t) + rR\rho R(i,t)]xI(i,t) + rN\rho N(i,t)N(i,t)\}$$

The setup and operational costs for the GenCo

$$Cost(i,t) = \{(1 - r_R - r_N)C_i(P(i,t)I(i,t))\} + \{(r_R - r_N)C_i([P(i,t) + R(i,t)]I(i,t))\} + \{r_N C_i([P(i,t) + R(i,t)]I(i,t) + N(i,t))\} + S(i,t)I(i,t)[1 - I(i,t-1)] \quad (3)$$

In this paper, the reserve is only paid when it is used. System Constraints (Reserve Limits, Emission Constraint), and Unit Constraints (Generation Limits, Minimum operational mode(ON/OFF), Ramping Constraints, Fuel Constraints) are the constraints on GenCos' problem that are subject to [1]: The Energy and Reserve Limits for the GenCos are

$$\sum_{i-1}^{N} P(i,t)I(i,t) \leq P(t) \qquad t = 1,2,\ldots\ldots T \quad (4)$$

$$\sum_{i-1}^{N} R(i,t)I(i,t) \leq R(t) \qquad t = 1,2,\ldots\ldots T \quad (5)$$

$$\sum_{i-1}^{N} N(i,t)I(i,t) \leq R(t) \qquad t = 1,2,\ldots\ldots T \quad (6)$$

III. ENERGY MANAGEMENT AND FUZZY SETS

A membership function indicated by x, which corresponds to the crisp set's characteristic function and has values between zero and one, gives each item x in a fuzzy set X a membership value. In fuzzy sets, x is more related to X the closer it is near 1.0 [5]. Fuzzy sets are functions that transfer and map each member of the set to a value between zero and one, corresponding to its actual degree of membership, and they are used to denote uncertainty.

As per fuzzy set theory, a set X's subset A is described as a mapping from its members to the values in the range between [0, 1], i.e.,

$$\mu A(x) \to 0 \leq \mu A(x) \leq 1; \qquad x \in A \quad (7)$$

In electricity markets where prices are competitive, energy management is linked to generation. As seen in Figure 1, a triangle membership function simulates the energy management (price).

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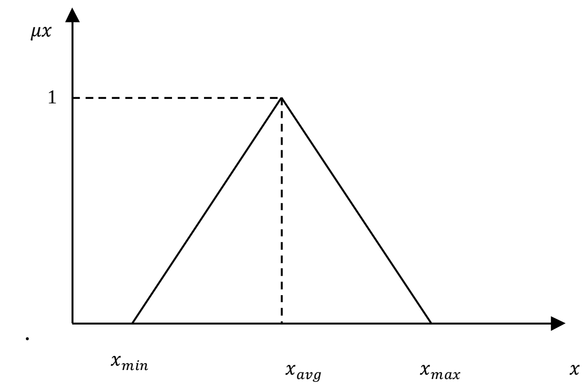

Figure-1:- A triangle membership function simulates the energy management for Price and probability.

*** note:- Minimum utilization Average Utilization and maximum utilization**

In general, the Profit (price) is subject to error. Figure-1 illustrates how a triangle membership function simulates the pricing uncertainty

The best estimate for the parameter x in Figure-1 is x_{avg}, and it will never fall below x_{min} or rise higher x_{max}. The triangular numbers x_{min}, x_{max}, and x_{avg} are an example of this [4].

The fuzzy memberships for market pricing uncertainties and the probability of energy management would occur are also similar to those in Figure-1.

If the total power during a particular hour is less than $P_{min(t)}$, the membership function should be set to 1 and decrease as the overall power increases.

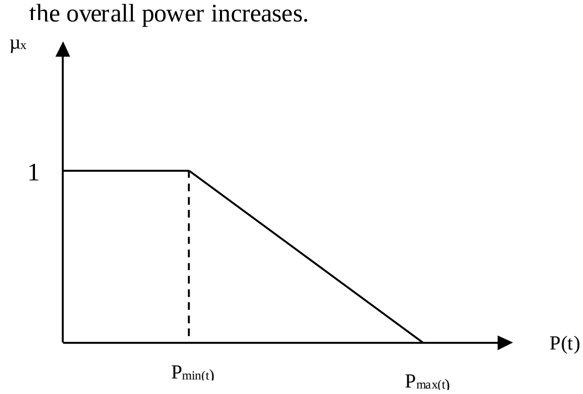

Fig. .2. .Fuzzy membership function for total electricity produced.

As shown in Figure-2, if the total power generated exceeds $P_{max(t)}$, this membership must be set to zero. The minimum profit, which, as showed in the figure-3, has a fuzzy membership function, is the main consideration for GenCos in this paper. If the profit is less than minimum GenCos Decision Maker Target (DMT_a), the membership function is set to be zero; if it is more than GenCos Decision Maker Target (DMT_b), it is set to be one. As the minimal profit increased from (DMT_a) to (DMT_b), the membership function increased.

IV. FUZZY OPTIMIZATION METHODOLOGY

The following different steps can be used to implement the fuzzy optimization approach:-

1) 1) First the generated power, spinning and non-spinning for each unit at each hour in the study time horizon. This can be the approach that maximizes GenCos' profit based on the forecasted parameters
2) Evaluate the profit triangular fuzzy number($profit_{min}$, $profit_{avg}$, $profit_{max}$) by substituting (ρ^P_{min}, ρ^R_{min}, ρ^N_{min}, r^R_{min}, r^N_{min}), (ρ^P_{avg}, ρ^R_{avg}, ρ^N_{avg}, r^R_{avg}, r^N_{avg}), and (ρ^P_{max}, ρ^R_{max}, ρ^N_{max}, r^R_{max}, r^N_{max}) in 1
3) The GenCos' Decision Maker Target (DMT) satisfaction has been defined to measured by using a function, which is as follows:

$$Maximize\{\min(\mu P, \mu R, \mu N, \mu min - profit)\} \quad (8)$$

Updated constraints 4-6 specify the upper limit of generated power and reserves by GenCos, as well as the emission constraint, unit constraints (generation limits, minimum operational mode(ON/OFF), ramping constraints, and fuel constraints)[1]

$$\sum_{i-1}^{N} P(i,t)I(i,t) \leq P_{max}(t) \quad t = 1, 2, \ldots \ldots T \quad (9)$$

$$\sum_{i-1}^{N} R(i,t)I(i,t) \leq R_{max}(t) \quad t = 1, 2, \ldots \ldots T \quad (10)$$

$$\sum_{i-1}^{N} N(i,t)I(i,t) \leq N_{max}(t) \quad t = 1, 2, \ldots \ldots T \quad (11)$$

The GenCos' target satisfaction is measured using the minimum profit.

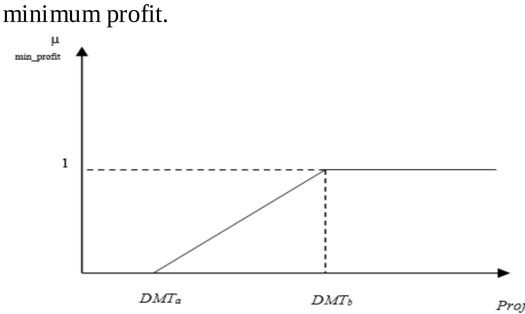

Figure-3. The minimum profit function for generation companies (GenCos') is fuzzy.

Figure-4:- Optimal profit for GenCos' fuzzy membership function.

4) GenCo does not take this profit but it sets the membership of this profit to zero if the minimum profit does not match GenCos' target, then the minimum profit is less than the DMTa. In the event that the minimum profit exceeds the target of GenCos' (DMTb), the GenCo accepts the profit and changes the profit's membership to one. The membership changes otherwise according to Figure-3, where the minimal profit is between DMTa and DMTb.

5) Next the electricity generated, both spinning and non-spinning, for each unit was updated once an hour during the study period in order to maximise the profit for the GenCos.

6) Steps 3–5 are Repeated until the GenCos' obtained the target.

V. Methodology:

C++ is used to execute the concept to obtain the solution. The forecasted energy management is assumed that reserves will make up 5 percent of the load. Energy management reserves are called with a 0.005 probability. The variables for the fuzzy function describing the maximum profit are taken to be DMTa = 469,775 and DMTb = 594,304. Figure-4 displays the ideal profit fuzzy function for GenCos. The assumed level of market price uncertainty (between 8 and 15 percent) and the probability that energy management reserves exist are reflected in this fuzzy optimal solution.

VI. Conclusion

Lighting, heating, cooling, shaft power for manufacturing, air movement (fans), and water pumping are all examples of how electricity is used. The most efficient conversion of electrical energy to demand is in the consumer's best interests. This cuts down on electricity use and emissions. The Indian standards have established efficiency, equipment life, and other criteria, ensuring the optimum conversion of efficiency and consumption of electricity.

The GenCos generation scheduling problem is resolved using a complete fuzzy set-based approach due to the uncertainty of the global power market. The model takes into account demand ambiguity, spinning and non-spinning reserves, market price, and the possibility of calling and generating reserves. GenCos can employ the suggested approach to boost profitability and protect the market risks. The program results were tested on a system with 36 generating units.

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