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Optimal utilization of renewable energy-based IPPs for industrial load management

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ABSTRACT

Share of power generation from renewable energy sources has been steadily increasing all over the world, mainly due to the concern about clean environment. Cost of renewable power generation has reduced considerably during the last two decades due to technological advancements and at present some of the renewable energy sources can generate power at costs comparable with that of fossil fuels. In this paper, application of renewable energy-based power generation is proposed, for load management. The formulation utilizes non-linear programming technique for minimizing the electricity cost and reducing the peak demand, by supplementing power by renewable energy sources, satisfying the system constraints. Case study of twenty-two large-scale industries showed that, significant reduction in peak demand (about 34%) and electricity cost (about 14%) can be achieved, by the optimal utilization of the renewable energy from independent power producers (IPPs).

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1. Introduction

Electricity supply industry finds it difficult to grow in tune with the increasing demands, leading to energy and peak demand shortages in many countries. In order to meet the higher demand during peak hours, the utility has to increase its generation capacity and to operate the costly peak generating units. Load management (LM) programs, which focus on reducing customer use or to supplement power by non-utility means of generation at the time of high utility system loads, have emerged as an effective tool to handle the peak demand deficit faced by the utilities. Load management in industrial sector assumes importance, as the industrial sector consumes about 41% of the total electrical energy generated on a worldwide basis [1]. Moreover, time of use (TOU) tariffs implemented by the utilities with the objective of flattening the load curve, causes additional financial burden by way of penal rate for consumption during peak hours.

Electricity derived from any renewable energy source (RES) is considered “green” because of the negligible impact on greenhouse gas emissions [2]. Earlier the interest in green power was driven by the goal of replacing fossil fuels to minimise the dependence on oil. Now the perspective is wider with a broader goal of minimizing the emission of global warming gases resulting from burning of fossil fuels. RES offer a viable option to meet the challenge of achieving higher growth while conserving the natural resources base, which has considerably deteriorated due to rapid growth in population, urbanization and fossil fuel consumption. During the last two decades, electricity generation from renewable energy sources (RES) has been steadily increasing and the contribution from RES in the total electricity generation is about 2.2% at present on a worldwide basis [1]. In many countries, the growth rate of this sector is very much above the world average. For example in India, the installed capacity of RES has grown to 11,125.41 MW at present and it constitute about 8% of the total [3].

Small hydro power (SHP) plants are small-scale decentralized power generating systems, which can generate electric power at low cost. SHP as a renewable energy source is proven, clean and environmentally benign. With considerable amount of potential remaining untapped, SHPs can offer a major contribution to electrical power generation. Wind is the next most popular source of green electricity around the world. The cost of wind-generated electricity has declined about 90% over the last 20 years [2]. At present, large wind farms at excellent wind sites are generating electricity at a cost which is competitive with that of electricity from conventional power plants. With an estimated 14,000 MW of annual worldwide installed generation capacity, biomass power is the third largest source of renewable electricity, behind hydro and wind. It is expected that the continued need for onsite industrial power, waste reduction, stricter environmental regulations, and rising consumer demand for renewable energy will provide enough motivation for the growth of power generation from biomass. Among the various RES options, SHP, biomass and wind power

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Table 1
Tariff Rates.

Tariff Rate	Base Demand Charge Rs./kVA	Base Energy Charge Rs./kWh	Differential Rate	
			Demand	Energy
Tariff 1	245	2.90	1:1.8:0.75[a]	1:1.8:0.75[a]
Tariff 2	245	3.40	1:1.8:0.75[a]	1:3.6:0.75[a]

Normal time: 6.00 AM to 6.00 PM.
Peak time: 6.00 PM to 10.00 PM.
Off peak time: 10.00 PM to 6.00 AM.
[a] For normal, peak and off peak periods.

alone are considered for LM application, as these systems have matured technologies, which can generate electricity at a cost comparable with that of fossil fuel power.

The performance and impact of a decentralized biomass gasifier-based power generation system in an un-electrified village has been discussed [4]. Attempts have been made to estimate the sustainable biomass production potential in various countries [5,6] and the cost of biogas based electricity production [7]. Potential areas in India, where provision of electricity through renewable energy-based decentralized generation options can be financially more attractive as compared to extending the grid, are identified [8]. Hybrid energy systems, incorporating combination of several renewable energy sources, for electrification of remote rural areas have been developed [9]. Development of SHPs in Turkey and the sustainability it can bring in has been discussed [10].

Attempts were made to address some of the important issues of utility wind integration that can affect utility system planning and operations [11]. Voltage source converter based HVDC transmission system technology has been used, to connect large doubly fed induction generator based wind farms over long distance, and the system performances during three-phase grid ac faults has been studied [12]. Wind power penetration in existing power systems have been studied to determine the right amount of wind power penetration, both from the reliability and economic point of view [13,14]. Most of these reported works are focused mainly on technological challenges and social benefits the RES bring in and do not generally address the problem of peak demand problem faced by the utilities.

The possibility of utilizing the renewable energy resources to reduce the level of peak demand in Northern Cyprus has been examined [15]. The study relies on available renewable energy potential of the country, rather than a comprehensive mathematical model to decide the optimal operating strategies of RES plants. Suitability of power generation from renewable sources to fill the gap between peak load power demand and availability of power at the regional level in India has been evaluated [16]. The problem is formulated for the optimum allocation of the various renewable energy options to meet the peak demand. Linear programming (LP) methodology is used as a tool for the solution of selecting of the optimal mix of the renewable energy scheme. The model is developed, based on the estimated potential of various RES, without considering the techno-economic feasibility aspects and the non-linear characteristics.

In the context of prevailing power shortage and peak demand deficit, application of RES based power generation is proposed, for load management in industrial sector. For reducing the peak demand and electricity cost of the industries, an optimal operating strategy has to be developed, which require the utilization of power from IPPs with least cost function. This necessitates a generalised model to determine the optimal operating strategy of the industries, to achieve the objective of minimizing the electricity cost and reduce peak demand under the specified electricity tariff, satisfying the system constraints. In this paper, a model for optimal utilization of renewable power for industrial load management is proposed. Non-linear fuel cost characteristics of the RES plants have been considered in the model.

2. Mathematical formulation

Normally power is supplied to the industries by the utility alone. IPPs, some of which are renewable energy based, are interactively connected to the utility grid. The utility allows third party sales and the industries have the freedom to purchase power from the IPPs utilizing the utility grid.

Table 2
Result of utilization of IPPs with renewable energy source – Tariff 2.

Industry	Utility Power		Utility Power + IPPs (RES)		Savings/Annum Rs. Million	Savings %	Peak Demand Reduction %
	Electricity Charge/Month Rs. Million	Peak Demand MVA	Electricity Charge/Month Rs. Million	Peak Demand MVA			
1	17.00	7.30	15.98	4.37	12.21	5.98	40.08
2	40.18	17.57	38.54	12.24	19.64	4.07	30.31
3	47.98	20.61	44.74	13.16	38.86	6.74	36.13
4	23.86	10.38	22.98	8.00	10.54	3.68	22.98
5	39.06	16.63	36.66	9.97	28.86	6.156	40.00
6	57.09	25.00	53.15	15.00	47.30	6.90	40.00
7	18.58	8.08	17.16	4.84	17.06	7.65	40.02
8	25.64	11.07	24.01	7.70	19.54	6.35	30.41
9	19.22	8.41	18.30	6.68	11.08	4.80	20.60
10	18.73	8.14	18.10	6.34	7.55	3.36	22.05
11	53.72	22.87	50.49	15.83	38.86	6.02	30.77
12	8.41	3.80	7.95	2.65	5.58	5.53	30.29
13	12.49	5.46	11.77	3.81	8.60	5.74	30.22
14	7.66	3.57	7.12	2.5	6.54	7.10	30.00
15	4.81	2.24	4.46	1.57	4.26	7.37	30.04
16	33.11	13.97	30.62	8.38	29.80	7.50	40.00
17	14.00	5.96	12.87	3.57	13.58	8.08	40.17
18	8.70	4.02	8.048	2.40	7.8	7.55	40.10
19	10.61	4.81	9.83	2.88	9.2	7.29	40.04
20	8.66	3.26	7.97	1.954	8.18	7.87	40.00
21	4.92	1.83	4.52	1.10	4.81	8.14	40.00
22	6.43	3.00	5.98	1.78	5.39	6.99	40.47
Total	480.97	208.08	451.35	136.82	355.54	6.16	34.24

Table 3
Result of utilization of IPPs with renewable energy sources – Tariff 2.

Industry	Utility Power		Utility Power + IPPs (RES)		Savings/Annum Rs. Million	Savings %	Peak Demand Reduction %
	Electricity Charge/Month Rs. Million	Peak Demand MVA	Electricity Charge/Month Rs. Million	Peak Demand MVA			
1	26.00	7.30	21.94	4.37	48.69	15.60	40.08
2	61.67	17.57	54.34	10.54	87.92	11.87	40.01
3	73.40	20.61	61.77	14.37	139.63	15.85	30.24
4	36.60	10.38	33.52	8.68	36.93	8.40	16.40
5	59.62	16.63	51.158	11.602	101.57	14.19	30.24
6	87.64	25	74.32	17.04	159.88	15.20	31.83
7	28.50	8.08	23.75	5.64	56.93	16.64	30.17
8	39.25	11.07	34.00	7.69	62.98	13.36	30.50
9	29.51	8.41	26.60	5.73	34.91	9.85	31.87
10	28.72	8.14	26.04	4.87	32.25	9.35	40.10
11	82.01	22.87	71.00	13.72	132.15	13.42	40.00
12	13.02	3.80	11.36	2.27	19.84	12.70	40.21
13	19.18	5.46	16.72	3.27	29.60	12.85	40.11
14	11.95	3.57	10.34	2.14	19.39	13.51	40.00
15	7.50	2.24	6.40	1.346	13.15	14.60	40.00
16	50.43	13.97	42.02	8.38	100.99	16.68	40.00
17	21.20	5.96	17.24	3.57	47.48	18.66	40.17
18	13.52	4.02	11.25	2.40	27.30	16.81	40.10
19	16.42	4.81	13.70	2.88	32.63	16.56	40.04
20	12.83	3.26	10.62	1.95	26.55	17.23	40.00
21	7.27	1.83	5.99	1.10	15.40	17.64	40.00
22	10.01	3.00	8.37	1.78	19.76	16.44	40.47
Total	736.38	208.08	632.55	135.43	1246.04	14.10	34.91

Fuel cost model of the rth biomass power plant is given by a quadratic approximation

$$C(PB_{pri}) = A_r \times (PB_{pri})^2 + B_r \times (PB_{pri}) + C_r \ Rs./h \tag{1}$$

where PB_{pri} is the power delivered by the rth biomass power plant to pth industry in kW at any interval i and A_r, B_r and C_r are the fuel cost parameters of the rth BG plant.

The cost function of the rth wind power plant is given by a linear approximation

$$C(PW_{pri}) = WC_r \times (PW_{pri}) \ Rs./h \tag{2}$$

where PW_{pri} is the power delivered by the rth wind power plant to pth industry in kW at any interval i and WC_r is the wind power cost parameter, taking into consideration the mutually agreed cost of wind power between the IPP and utility.

The cost function of the rth small hydro power plant (SHP) is given by a linear approximation

$$C(PH_{pri}) = HC_r \times (PH_{pri}) \ Rs./h \tag{3}$$

where PH_{pri} is the power delivered by the rth SHP to pth industry in kW at any interval i and HC_r is the small hydro power cost parameter, taking into consideration the mutually agreed cost of small hydro power between the IPP and utility.

The cost function of the utility power is approximated to piecewise linear, considering the TOU tariff followed

$$C(PU_{pi}) = E_i \times PU_{pi} \ Rs./h \tag{4}$$

where PU_{pi} is the power supplied by the utility to pth industry in kW at any interval i and E_i is the time dependant cost parameter under TOU tariff at any interval i. Both the maximum demand cost and energy cost, according to the TOU tariff followed by the utility company, are accounted in the cost parameter E_i.

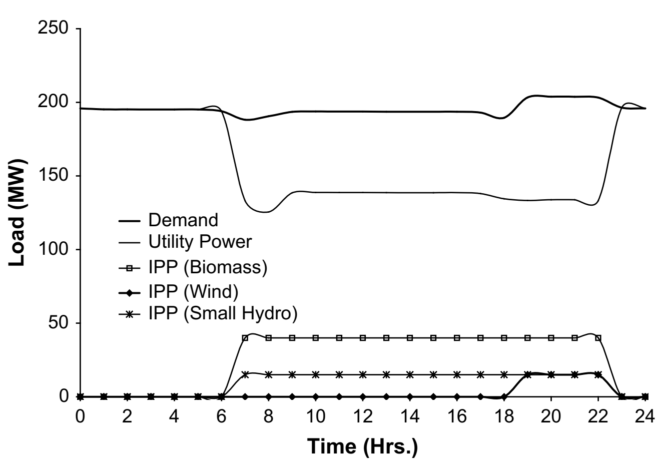

Fig. 1. Load curve – Tariff 1.

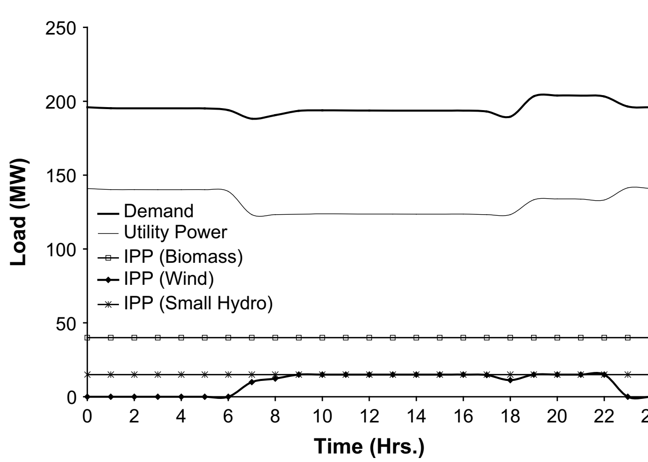

Fig. 2. Load curve – Tariff 2.

The time horizon under consideration, say one day, is split into K intervals of equal duration [17]. The objective function to minimise the monthly electricity cost of the industries, both of the utility power and power generation from renewable energy sources is

$$Min \sum_{i=1}^{K} \sum_{p=1}^{N} \left\{ C(PU_{pi}) \times t_{pi} + \left[\sum_{r=1}^{L} C(PB_{pri}) + \sum_{r=1}^{M} C(PW_{pri}) + \sum_{r=1}^{R} C(PH_{pri}) \right] \times t_{pri} \right\} \times D \tag{5}$$

where

t_{pi} - time of operation of pth industry during the interval i
t_{pri} - time of operation of rth renewable energy source power plant during which power is delivered to pth industry during the interval i
N - number of industries.
L, M, R are the number of renewable energy source power plants connected to the grid (Biomass, Wind and SHP respectively).
D - number of days in the month.

Total power delivered by all the biomass power plants to pth industry at any interval i is

$$PB_{pi} = \sum_{r=1}^{L} PB_{pri} \tag{6}$$

where PB_{pri} is the power delivered by the rth biomass power plant to pth industry at any interval i.

Total power delivered by all the wind power plants to pth industry at any interval i is

$$PW_{pi} = \sum_{r=1}^{M} PW_{pri} \tag{7}$$

where PW_{pri} is the power delivered by the rth wind power plant to pth industry at any interval i.

Total power delivered by all the SHP plants to pth industry at any interval i is

$$PH_{pi} = \sum_{r=1}^{R} PH_{pri} \tag{8}$$

where PH_{pri} is the power delivered by the rth SHP plant to pth industry at any interval i.

The constraint to ensure that PD_{pi}, the demand of pth industry at any interval i is met from the utility power and power from renewable energy sources is

$$PD_{pi} = PU_{pi} + PB_{pi} + PW_{pi} + PH_{pi} \tag{9}$$

Total power demand of all the industries at any interval i

$$PD_i = \sum_{p=1}^{N} PD_{pi} \tag{10}$$

Total power drawn from the utility by all the industries at any interval i

$$PU_i = \sum_{p=1}^{N} PU_{pi} \tag{11}$$

Total power delivered by all biomass power plants to industries at any interval i is

$$PB_i = \sum_{p=1}^{N} PB_{pi} \tag{12}$$

Total power delivered by all the wind power plants to industries at any interval i is

$$PW_i = \sum_{p=1}^{N} PW_{pi} \tag{13}$$

Total power delivered by all the SHP plants to industries at any interval i is

$$PH_i = \sum_{p=1}^{N} PH_{pi} \tag{14}$$

The constraint to ensure that, the total demand of the industries is met by supplying power from the utility and renewable energy sources, at any interval i

$$PD_i = PU_i + PB_i + PW_i + PH_i \tag{15}$$

The power generation of the rth renewable energy source at any interval i shall be within the specified limit, so that

$$PB_{ri} \le BCap_r \tag{16}$$

$$PW_{ri} \le WCap_r \tag{17}$$

$$PH_{ri} \le HCap_r \tag{18}$$

where $BCap_r$, $WCap_r$ and $HCap_r$ are the maximum power generation capacity of biomass, wind and SHP plants respectively.

The voltage magnitude of rth renewable energy source power plant at any interval i shall be within the specified limits, so that

$$V^{min} \le VB_{ri} \le V^{max} \tag{19}$$

$$V^{min} \le VW_{ri} \le V^{max} \tag{20}$$

$$V^{min} \le VH_{ri} \le V^{max} \tag{21}$$

where V^{min} and V^{max} are the lower and upper bounds of the system bus voltage and VB_{ri}, VW_{ri} and VH_{ri} are the voltage magnitude of biomass, Wind and SHP plants respectively at any interval i.

A minimum level of raw material has to be maintained at the biomass power plant to ensure uninterrupted power generation. Constraint to ensure the availability of minimum quantity of biomass, BR^{min} at rth biomass power plant is

$$BR_{ri} \ge BR^{min} \tag{22}$$

where BR^{min} is the raw material availability at the rth biomass power plant at any interval i.

For the satisfactory operation of the wind power plant, the wind speed has to be within the specified limits, such that

$$WS^{min} < WS_{ri} \le WS^{max} \tag{23}$$

where WS_{ri} is the wind speed at the rth wind power plant and WS^{min} and WS^{max} are the lower and upper bounds of the wind speed.

The constraint to ensure that HF^{min} a minimum water flow rate is assured all the time in the rth SHP plant is

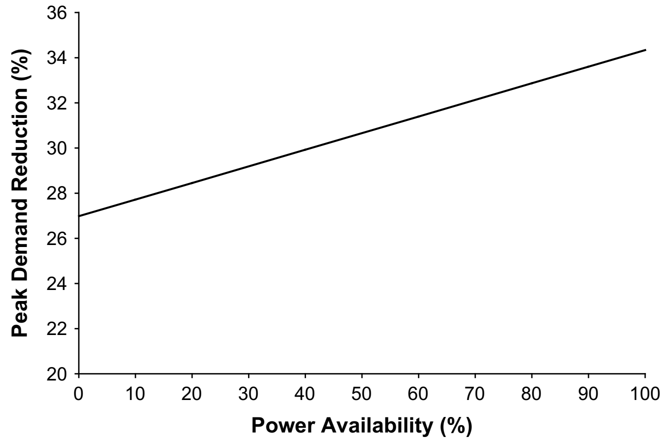

Fig. 3. Impact of wind power availability on peak demand reduction.

$$HF_{ri} \geq HF^{min} \tag{24}$$

where HF_{ri} is the water flow rate in the rth SHP plant at any interval i.

The solution to the above non-linear programming formulation, for minimizing the electricity cost satisfying the constraints, provides the optimal operating strategy of renewable energy sources integrated to the grid for peak load management.

3. Case study

The proposed model is illustrated through the case study of 22 major industries having connected load exceeding 2500 kVA in the state of Kerala, India [18]. The industries are getting power normally from the state owned utility, Kerala State Electricity Board (KSEB). IPPs including renewable energy-based IPPs are interactively connected to the utility grid. Contribution of the industries considered for the case study towards system peak demand is about 8%.

For the extra high tension industrial consumers, the utility follows differential pricing system for both energy and maximum demand, the details of which are given in Table 1 [19]. Tariff 1 is the prevailing tariff for the industries. All industries considered in the case study are included in the group of power intensive industries, and the utility is planning to charge the industries as per the provisions of the power intensive tariff (Tariff 2) shortly.

The optimization model as per Eq. (5) is developed, based on the data collected from the industries. The corresponding non-linear programming formulation for minimizing the electricity cost has

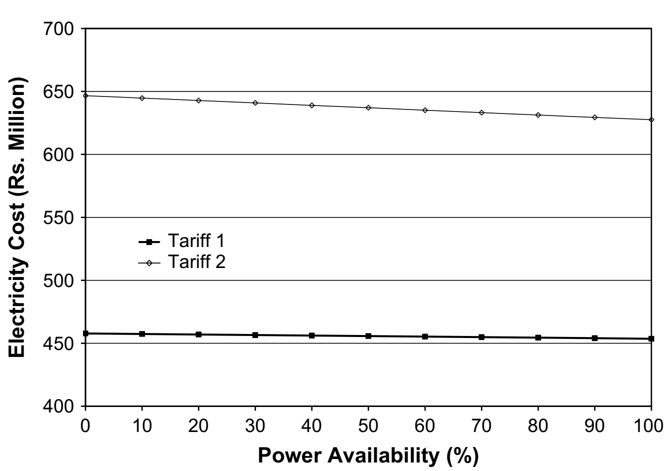

Fig. 4. Impact of wind power availability on electricity cost.

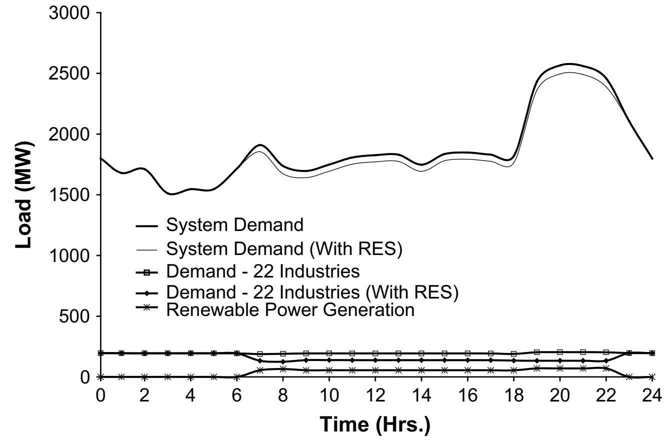

Fig. 5. Impact of RES integration on utility's system load curve.

6288 variables and 3817 constraints and is solved using non-linear programming technique.

4. Results and discussion

Results of utilization of renewable energy-based power for load management, when applied to 22 large-scale industries, under two different TOU tariffs are shown in Tables 2 and 3. Consequent changes occurred on the combined load curve of all the industries for a typical day, are shown in Figs. 1 and 2. It is observed that, all the industries are benefited from utilization of power from RES, as their electricity cost has been reduced considerably. From Table 2, it is observed that integration of RES results in system peak demand reduction of about 72 MVA (34.24%) under Tariff 1. Total annual saving in electricity cost is about Rs. 355.54 million (6.16%). Industry No. 4 is least benefited in terms of electricity cost reduction as the peak demand reduction of this industry is only 22.98%. It can be seen that, at an average 6–7% reduction in electricity cost is achieved for the industries where about 40% reduction in peak demand is achieved.

Under Tariff 2, peak demand reduction achieved is almost same as Tariff 2. Since the electricity cost under this tariff is higher than Tariff 1, the annual saving in electricity cost has increased substantially to Rs. 1246.04 million (14.10%). The saving achieved assumes importance as all the industries considered are power intensive industries and the utility planning to charge them, as per the provisions of Tariff 2. Here also the industries where peak demand reduction is about 40% get maximum saving in electricity cost.

4.1. Sensitivity analysis

Availability of wind will naturally affect power output of wind power generators. Sensitivity analysis has been carried out to examine the impact of wind availability on peak demand reduction and saving in electricity cost. Fig. 3 shows the variation of peak demand reduction with respect to wind availability. It is observed that sensitivity of peak demand reduction does not differentiate between tariffs. The variation of total electricity cost is plotted against wind power availability and shown in Fig. 4. As expected, it is observed that, the electricity cost is less sensitive to wind power availability under Tariff 1.

4.2. Impact on utility's system load curve

Utilization of renewable energy-based power by the industries for load management will naturally affect the utility's system load curve. Attempt has been made to assess the impact resulting from the application of optimization model to all the 22 industries considered in the case study. The utility's load curve for a typical day has been plotted from the data collected. System peak demand is 2560 MW. The consequent changes on the load curve, due to application of the model are shown in Fig. 5. At an average 55 MW and 70 MW of load get reduced during normal and peak periods respectively. The system load factor has shown a marginal improvement from 0.73 to 0.74. Hence it can be seen that, utilization of renewable power reduces the load during normal and peak periods and thus tries to flatten the load curve.

5. Conclusion

An optimization model for utilization of renewable energy sources based IPPs for industrial load management has been developed. The model assumes importance, in the context of ongoing deregulation of electricity supply industry and encouragement given to IPPs to setup generation using renewable energy sources. The model, when applied to 22 large-scale industries connected to the utility grid, showed very encouraging results under two different TOU tariffs. It resulted in significant reduction of electricity cost of all the industries. Coincident peak demand of the industries also got reduced considerably. By optimally integrating the renewable energy-based IPPs to the grid, the industries can reduce their operating cost, which in turn can result in significant reduction in peak demand of the utility companies.

References

[1] Key world energy statistics – 2007. Paris: International Energy Agency. Available from: <http://www.iea.org>; 2007.
[2] Rahman Saifur. Green power: what is it and where can we find it? IEEE Power Energy Magazine 2003:30–7.
[3] Annual report – 2007. Ministry of New and Renewable Energy Sources, Government of India. Available from: <http://www.mnes.nic.in>; 2007.
[4] Ravindranath NH, Somashekar HI, Dasappa S, Jayasheela Reddy CN. Sustainable biomass power for rural India: case study of biomass gasifier for village electrification. Current Science 2004;87(7):932–41.
[5] Bhattacharya SC, Abdul Salam P, Pham HL, Ravindranath NH. Sustainable biomass production for energy in selected Asian countries. Biomass and Bioenergy 2003;25(5):471–82.
[6] Ravindranath NH, Somashekar HI, Nagaraja MS, Sudha P, Sangeetha G, Bhattacharya SC, et al. Assessment of sustainable non-plantation biomass resources potential for energy in India. Biomass and Bioenergy 2005;29(3):178–90.
[7] Walla C, Schneeberger W. The optimal size for biogas plants. Biomass and Bioenergy 2008;32(6):551–7.
[8] Nouni MR, Mullick SC, Kandpal TC. Providing electricity access to remote areas in India: an approach towards identifying potential areas for decentralized electricity supply. Renewable and Sustainable Energy Reviews 2008;12(5):1187–220.
[9] Ashok S. Optimised model for community-based hybrid energy system. Renewable Energy 2007;32(7):1155–64.
[10] Balat Havva. A renewable perspective for sustainable energy development in Turkey: the case of small hydropower plants. Renewable and Sustainable Energy Reviews 2007;11(9):2152–65.
[11] Charles Smith J, Milligan Michael R, DeMeo Edgar A, Parsons Brian. Utility wind integration and operating impact state of the art. IEEE Transactions on Power Systems 2007;22(3):900–8.
[12] Xu Lie, Yao Liangzhong, Sasse Christian. Grid integration of large DFIG-based wind farms using VSC transmission. IEEE Transactions on Power Systems 2007;22(3):976–84.
[13] Soder Lennart, Hofmann Lutz, Orths Antje, Holttinen Hannele, Wan Yih-huei, Tuohy Aidan. Experience from wind integration in some high penetration areas. IEEE Transactions on Energy Conversion 2007;22(1):4–12.
[14] Karki Rajesh, Billinton Roy. Cost-effective wind energy utilization for reliable power supply. IEEE Transactions on Energy Conversion 2004;19(2):435–40.
[15] Ilkan M, Erdil E, Egelioglu F. Renewable energy resources as an alternative to modify the load curve in Northern Cyprus. Energy 2005;30(5):555–72.
[16] Dudhani Surekha, Sinha AK, Inamdar SS. Renewable energy sources for peak load demand management in India. Electric Power and Energy Systems 2006;28(6):396–400.
[17] Babu CA, Ashok S. Peak load management in electrolytic process industries. IEEE Transactions on Power Systems 2008;23(2):399–405.
[18] Annual report 2007–08. Cochin, India: The Kerala High Tension and Extra High Tension Industrial Electricity Consumer's Association; 2008.
[19] Schedule of tariff. Thiruvananthapuram, India: Kerala State Electricity Regulatory Commission. Available from: <www.erckerala.org>; 2008.