AN OPTIMIZED PROBABILISTIC APPROACH FOR OPTIMAL ECONOMIC DISPATCH, A CASE STUDY OF GESCOM

HANUMANTHA RAO A
Research scholar, Department of EEE,
MEWAR University Gangrar, Chittorgarh,
Rajasthan-312901
hanbabu@gmail.com

Dr.K.VIJAYA BHASKAR REDDY
*Professor, Department of EEE,*BVRIT
Vishnupur, Narsapur, Telangana 502313

Abstract

The concept of probabilistic analysis has been gaining momentum in recent years as opposed to the more passive approach of the 19th century. A broad variety of complex strategies has been established for probabilistic modeling. A common theory behind each factor mentioned is that power systems are basically stochastic, a concept illustrated by the formulation and analysis of both input condition and case parameters as probability variables. The Optimisation Approach in the power system research reflects a primary examination of the importance of power systems for the future development of power resources, reliability and quality. In order to carry out the case study of the Gulbarga Electricity Supply Company Ltd. (GESCOM), a standard approach for economic dispatch with possible load variations has been suggested for this study.

Index Terms*- Power system Optimization, Economic Dispatch (ED), GESCOM, PAVAGADA solar park*

Introduction

Electricity generation, transmission, and distribution is one of the most dynamic systems which is growing rapidly as the market for electricity demand increases, and the non-conventional sources including solar energy, wind, bio energy, small hydro energy etc. are being integrated. FACTS controllers are now a component of the overall device regulation [1-2]. At all stages, such a dynamic machine should be operating at its best. Economic dispatch and optimum power flow are used in various ways to achieve proper functioning. These experiments, including power flow studies, consider loads of Active and Reactive powers as constants – a probabilistic method of study, whereas probabilistic techniques are used to resolve inconsistencies in load consumptions [3-4]. Further advances in probabilistic approaches applicable to power structures, such as security analysis, contingency analysis, unit engagement, transient flexibility etc. [5]

In this study, we concentrate on the traditional economic dispatch methodology for optimum power system control, and we consider load variance to simplify the study, even though ED and other forms are possible for solving optimization problems. Fig. 1 defines the ED issue as the distribution of the load to the power units at a particular moment. Typically called a negative load from the limited inclusion of renewable energy. To ensure the frequency of the system and meet consumer requirements by maintaining the same load. There is no two-way coordination between the utilities and the user. The utilization of individual consumer load is impossible for the utility to regulate. The origin of electricity is determined by the growth of civilization and generally by the installation of modern power plants, previously which contribute to a costly solution. The modern power grid is a natural expectation with the massive development of intelligent and user-friendly communications systems[6].

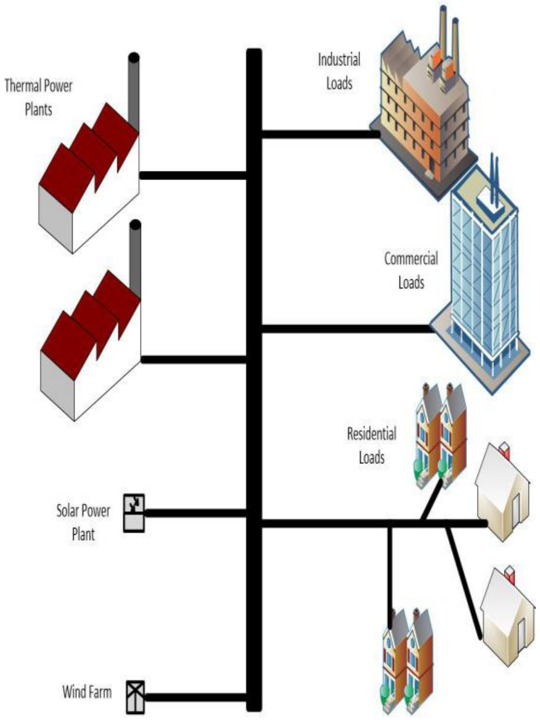


Fig. 1. ED problem in the current power network

In particular, a method of calculation is based on the power flow for static state operation of power systems [7]. As the proportion of unsteady power energy such as biomass and PV generation in the grid increases, the number of indeterminate different factors in the electricity grid increases. The role of solar park project at Pavagada plays important role in the KSPDCL. In 8 segments with an output of 250 MW each has been designed for the solar park. For each 250 MW section for forward solar transmission, a pooling substation 220/66 kV or 220/33 kV is planned. In addition, 250 MW sections are grouped into five blocks with a capacity of 50 MW each. At 220/66kV or 220/33KV pooling substation, each 50MW block shall first be linked with a solar park by 66kV/33kV underground cables, in which the voltage is raised up to 220kV, which will be raised by up to 400kV at the planned PGCIL station of 400kV/220kV at a solar park. The PGCIL station would also be 400kV/220kV linked with a PGCIL station 765kV/400kV at Vasanthanarasapur in Tumkur and a PGCIL station 400/220kV at Gooty in Andhra Pradesh[8]. Electrical systems of strong renewable sources are referred to as a grid with a significant proportion of unstable forms of resources. The POPF technique for the load prediction of electricity grids with significant proportions of sustainable energy attributed to unspecified variables is suitable, based on the probabilistic rule and the mathematical law. The POPF approach is acceptable.

FACTS devices, on the other hand, have become very popular to improve overall power system performance, under both constant conditions. In the literature, numerous work experiments with Information instruments were carried out and used in the study and optimization of power systems. They addressed the monitoring technique of FACTS systems with multi-objective OPF [9-10]. The FACTS fast control nowadays require this goal to be implemented and accomplished in order to give greater organizational efficiency and a more organized management of the power flow. The FACTS concept is made possible through the use of elevated-power electronic devices. It is well-known that stabilization limits could be increased with Facts devices in real time. Facts devices can also contributing to both big and medium signal vehicle characteristics of the power system, in addition to constant state controlling the power flux and voltage. FACTS controllers can broadly described as policy makers, shunt and series shunt controls combined. This study addresses the issue of optimum sizing and optimal power flow by UPFC as a FACTS device for achieving goals in terms of better low frequency operations, voltage regulation, transient and dynamic stability [11].

II. Problem formulation

The common formulation for the issue of ED optimization is as follows:

A. Economic load dispatch Thermal problem

$$min\ (F_C + C_L + P_V)$$

(1)

$$F_C = \sum_{i=1}^{Ng}(\alpha i + \beta i\ p_i + \gamma i\ P_i^2)\$/h$$

(2)

Where F_C denotes net generator fuel cost, Ng represents total no. of generator units, Pi denotes generator output power, where i, a_i, b_i and c_i are coefficients of fuel cost.

$$C_L = \sum_{i=1}^{N_d} h_i L_i^{SC} + kue_i EL_i^{ue} + koe_i\ EL_i^{oe}$$

(3)

Here C_L denotes net load reduction cost, N_d represents the total no. of units used in load reduction, L_i denotes the availability of load reduction from area i, L_i^{SC} represents predicted load reduction power for the ith area, EL_i^{ue} denotes expected value of $L_i > L_i^{SC}$ for the ith area, EL_i^{oe} is the expected value of $Li < L_i^{SC}$ for the ith area, h_i, kue_i and koe_i are the available, penalty, and coefficients of reserve cost for the i^{th} area respectively.

Equality constraint:

$$\sum_{i=1}^{Ng} P_{Gi} = \sum_{i=1}^{Nb} P_{Di} + P_L$$

(4)

$$\sum_{i=1}^{Ng} Q_{Gi} = \sum_{i=1}^{Nb} Q_{Di} + Q_L$$

(5)

Inequality constraint:

$$\boldsymbol{P_{G_i}^{min}} \leq P_{Gi} \leq \boldsymbol{P_{G_i}^{max}}\ (\boldsymbol{i = 1, 2, 3}, \dots .Ng)$$

(6)

$$\boldsymbol{Q_{G_i}^{min}} \leq Q_{Gi} \leq \boldsymbol{Q_{G_i}^{max}}\ (\boldsymbol{i = 1, 2, 3}, \dots .Ng)$$

(7)

Nb represents total no. of power system buses. P_{Gi} denotes the generation of real power. P_{Qi} denotes the generation of reactive power. P_{Di} denotes demand due to real power. Q_{Di} denotes demand due to reactive power. P_L denotes the loss due to real power. Q_L denotes the loss due to reactive power. $\boldsymbol{P_{G_i}^{max}\ and\ P_{G_i}^{min}}$, represents the upper and lower limits of generations for real power, respectively. $\boldsymbol{Q_{G_i}^{max}}\ and\ \boldsymbol{Q_{G_i}^{min}}$**,** represents the upper and lower limits of generations for reactive power, respectively

2. Economic load dispatch PV problem

The primary aim of the issue of ED is to minimize grid power imports. PV power plant operations are directly linked to the electricity economy, in both the financial and self-generating utility. By reducing demand for load on the grid, the costs feature must be increased. The objective functions can be articulated as:

$$F_i(C_i) = \sum_{i=1}^{n} U_i T$$

(8)

Where $F_i(C_i)$, Total cost of the power import from the grid, U_i represents the number of consumed units on ith day and T denotes the Tariff unit in Rupees

In a Grid coupled PV plant some constraints related to the power balance is given by,

$$\sum P_V = \pm P_G - P_D - P_L = 0$$

(9)

Where P_V denotes the PV plant generation, P_G represents the total power import-export from the grid, $P_L and\ P_D$ denotes the net power loss and demand respectively.

The PV plant and grid share the net load via the standard bus bar. The power may be imported or exported from the grid as required by load. The import and export energy shall be as follows:

Case-1: If $P_D < P_V$

Here $P_G = 0$, Total power demand $P_D = P_V$

In this case total load demand is less than PV plant generation, so excess energy will be export to grid as follow:

$$P_G^i = P_V - P_D - P_L$$

Here P_G^i denotes the total power exports to grid.

Case-2: If $P_D \geq P_V$

Total power demand, $P_D = P_V + P_G$
In this case total load demand is greater than PV plant generation, so excess energy, which will be export to grid, import back as follow:

$$P_G = P_D$$

Here, P_G denotes the total energy import from grid .

Net Units consumed from grid as follow:
In **Case-1** when demand is less than PV generation, the energy export to the grid, suppose here total U_G units are Export to the grid.

In **Case-2** when demand is more than PV generation, the energy import from the grid, suppose here total U_G' units are import from the grid.

Total units are consumed from grid , $U_{Net} = U_G' - U_G$ Here units are payable to grid. The excess units export to grid is going to adjust in next month.

Procedure used for solution details applications built on MATLAB[12]. The system load pd is supposed to have a constant parameter in the analysis, but in present world it is a randomly shifting variable. The changes have to be taken into consideration, typically prediction methods are used.

III. FACTS controllers – Unified Power Flow Controller (UPFC)

The UPFC is a flexible FACTS controller unit that uses its Shunt Controller to control the important variables and parameters in the power system such as voltage and phase angle, line reactance with its series controller UPFC is an efficient model of power flow, for analytical purposes the exact pi model[19-21], figure 1 displays UPFC in a line and figure 2 shows the pi-model

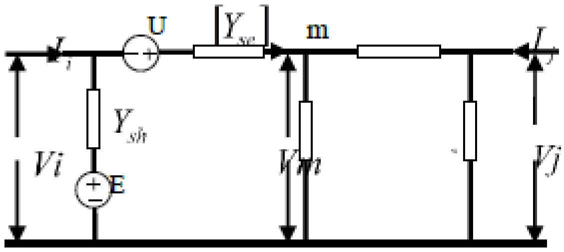


Fig 2 Shows UPFC-inserted in line

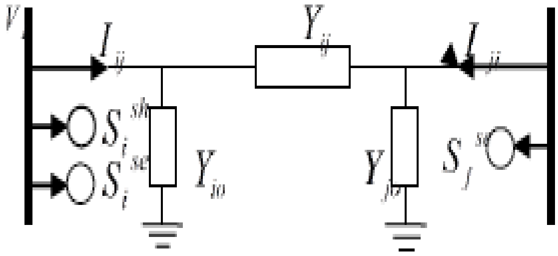


Figure 3 . The equivalent injection Pi-model.

$$P_i^{se} = V_iU\,[(G_{bii}Cos(\theta_i-\delta) + B_{bii}\,Sin\,(\theta_i-\delta)] \quad (10)$$

$$Q_i^{se} = ViU\,[\,(-B_{bii}Cos(\theta_i-\delta) + G_{bii}\,Sin\,(\theta_i-\delta)] \quad (11)$$

$$P_i^{se} = V_iU\,[\,(G_{bii}Cos(\theta_i-\delta) + B_{bii}\,Sin\,(\theta_i-\delta)] \quad (12)$$

$$Q_i^{se} = ViU\,[\,(-B_{bii}Cos(\theta_i-\delta) + G_{bii}\,Sin\,(\theta_i-\delta)] \quad (13)$$

$$P_i^{sh} = ViE\,[\,(G_{bij}Cos(\theta_i-\beta) + B_{bii}\,Sin\,(\theta_i-\beta)] \quad (14)$$

$$Q_i^{sh} = ViE\,[\,(-B_{bii}Cos(\theta_i-\beta) + G_{bii}\,Sin\,(\theta_i-\beta)] \quad (15)$$

$$P_j^{se} = V_jU\,[\,(G_{bji}Cos(\theta_j-\delta) + B_{bii}\,Sin\,(\theta_j-\delta)] \quad (16)$$

$$Q_j^{se} = V_jU\,[\,(-B_{bii}Cos(\theta_j-\delta) + G_{bii}\,Sin\,(\theta_j-\delta)] \quad (17)$$

where Y_{se} and Y_{sh} are the series and shunt admittances)associated with the series converter and the shunt converter, respectively, where $Y_{se} = G_{se} + JB_{se}$ and $Y_{se} = G_{sh} + JB_{sh}$. The complex voltage $U = U\angle\delta$ and $U = E\angle\beta$ are the controllable voltages inserted from the series branch and the shunt branch respectively, $V_i = V_i\angle\theta_i$, $V_m = V_m\angle\theta_m$ and $V_j = V_j\angle\theta_j$ and are the complex voltages at nodes i, m, and j, respectively.

IV. GESCOM Load curve

The Approximately 800MW in GESCOM , consist of parallel double circuited transmission lines of 400KV, Twin ACSR 'MOOSE' conductor and 220KV, single ACSR 'ZEBRA' conductor . The50 percentage of MW value for power factor of 0.9 and1/3 of MW value for power factor of 0.95. The transmission lines length is around (70-80)Kms

The GESCOM load forecasting is analyzed in this study in which specifically focus on the some station such as GADAD-G, HALVARTHI, KUDLIGI,KUSTAGI,MALLAT and SEDAM. The net load parameter and voltage deviation parameter is analyzed as shown in the table 1

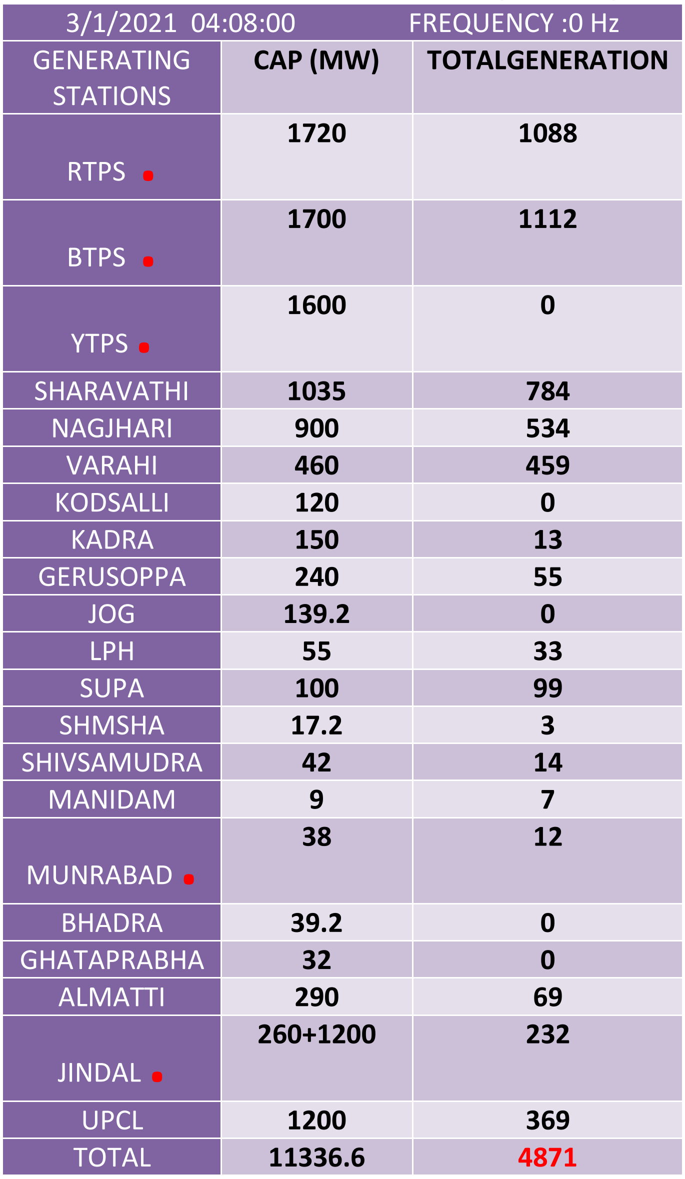
Table 1: GESCOM Load monitoring parameters

GESCOM LOAD MONITORING								
STATION	TRANSFORMER CAPACITY(MVA)	TRANSFORMER LOAD	OTHER INJECTIONS	NET LOAD	ENTITLEMENT	DEVIATION FROM ENTITLEMENT	ENERGU ENTITLEMENT UP TO CURRENT BLOCK (MU)	CUMMULATIVE ENERGY UP TO CURRENT BLOCK (MU)
ALIPUR	2x100	99.7	43.7	143.4	152	-8.6	2.31	1.75
GADAG-G	-	0.0	11.5	11.5	0	11.5	0	0.03
HALBURGA	2x100	-23.4	136	112.6	130	-17.4	1.98	1.18
HALVARTHI	2x100	42.4	0.0	42.4	0	42.4	0	0.37
HAVERI-G	-	0.0	0	0	46	-46	0.72	0
HUMNABAD	2x100	25.9	79.3	105.2	109	-3.8	1.65	0.84
ITTAGI	2x100	4.8	117	121.8	154	-32.2	2.39	1.23

KALYANI STEELS	**EHT**	**35**	**0.0**	**35**	**35**	**0**	**0.51**	**0.51**
KAPNOOR	**2x100**	**112.3**	**7**	**119.3**	**158**	**-38.7**	**2.41**	**1.45**
KUDLIGI	**2x100**	**-4.4**	**9.1**	**4.7**	**0**	**4.7**	**0**	**0.09**
KUSTAGI	**2x100**	**10.4**	**124.1**	**134.5**	**122**	**12.5**	**1.86**	**1.44**
LINGAPUR	**2x100**	**73.2**	**14.9**	**88.1**	**133**	**-44.9**	**2.02**	**0.96**
LINGASUGAR	**2x100**	**24.2**	**29.4**	**53.6**	**68**	**-14.4**	**1.03**	**0.79**
MALLAT	**2x100**	**6.2**	**0.0**	**6.2**	**0**	**6.2**	**0**	**0.09**
RAICHUR	**2x100**	**93.1**	**78.8**	**171.9**	**173**	**-1.1**	**2.64**	**1.81**
SEDAM	**2x100**	**58.8**	**9.2**	**68**	**55**	**13**	**0.84**	**0.93**
SHABAD	**2x100**	**-40.8**	**57.5**	**16.7**	**79**	**-62.3**	**1.22**	**-0.34**

Table 2. ShowsNCEP and PAVAGADA solar generation

01/03/2021 15:54	
FREQUENCY :49.75	**STATE UI : 434**
STATE DEMAND	**11847**
STATEGENERATION	**4806**
CGS	**3866**
NCEP GENERATION	**3182**
PAVAGADA KSPDCL : 1314	
BESCOM : 5287	
HESCOM : 2026	**GESCO : 1605**
CESC : 1394	**MESCOM : 1031**

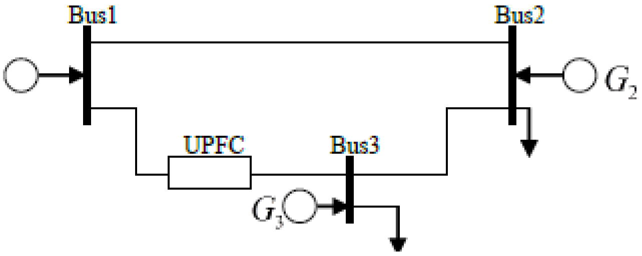


3/1/2021 04:08:00		FREQUENCY :0 Hz
GENERATING STATIONS	CAP (MW)	TOTALGENERATION
RTPS ●	1720	1088
BTPS ●	1700	1112
YTPS ●	1600	0
SHARAVATHI	1035	784
NAGJHARI	900	534
VARAHI	460	459
KODSALLI	120	0
KADRA	150	13
GERUSOPPA	240	55
JOG	139.2	0
LPH	55	33
SUPA	100	99
SHMSHA	17.2	3
SHIVSAMUDRA	42	14
MANIDAM	9	7
MUNRABAD ●	38	12
BHADRA	39.2	0
GHATAPRABHA	32	0
ALMATTI	290	69
JINDAL ●	260+1200	232
UPCL	1200	369
TOTAL	11336.6	4871

Table 3. Thermal stations – RTPS, BTPS, YTPS and other private ones – JINDAL are seen to the main providers. Hydro sources, Renewable NCES and CGS central grid provision for optimum dispatch are not regarded.

V. Results and Discussion

The critical control characteristics of UPFC can be helpful with low loss precision. A basic 3-bus method is used with UPFC in line 1-3 to illustrate the operating process and also shows the optimum scheduling.



$$G_1;\ C_1 = 220 + 10P_1 + 0.016P_1^2$$

$$G_2;\ C_2 = 200 + 11P_2 + 0.016P_2^2$$

$$G_3;\ C_3 = 240 + 13P_1 + 0.016P_1^2$$

Generation limits

$$G_1(50, 400)MW, (-100, 100)MVAR$$

$$G_2(50, 350)MW, (-100, 100)MVAR$$

$$G_3(150, 400)MW, (-100, 100)MVAR$$

$$with\ R = 0.17, X = 0.35\frac{B}{2} = 0.17\ for\ all\ 3\ lines$$

When UPFC parameters assumed

$\delta_{se} = 174.7^0$, $\delta_{sh} = 179.7^0$, $V_{se} = 0.65^0$ and $V_{sh} = 0.1^0$

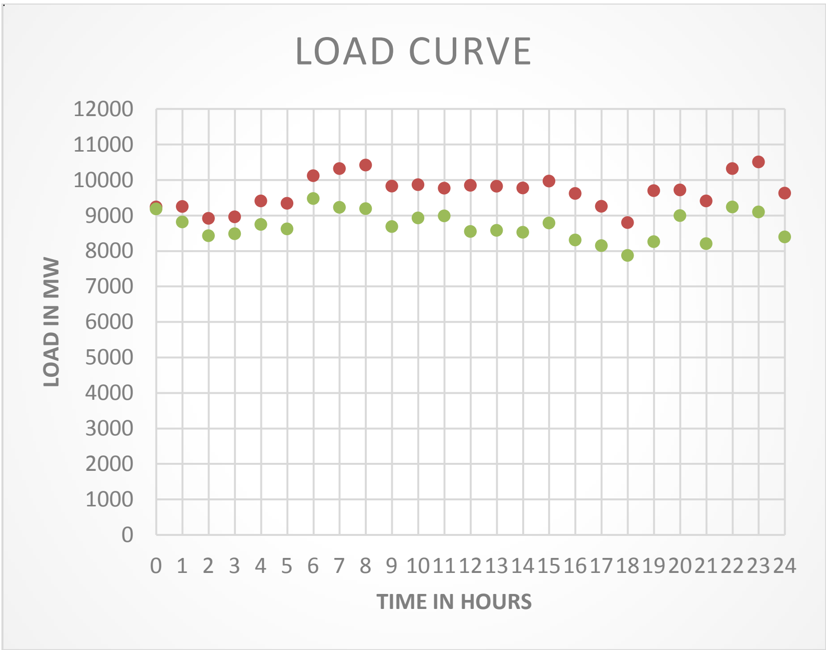
Table 4: Results of the 3 bus test system

	Case 1(without UPFC)	Case 2(with UPFC)
P_{12}	113.13	142.552
P_{13}	201.603	246.
P_{23}	85.591	102.621
P_1	315.243	389.009
P_2	274.407	263.82
P_3	171.666	116.146
Total loss(MW)	11.530	17.516
Total Gen(MW)	761.961	764.885
Total cost($\$/MWh$)	10341.28	10304.08

01/-3/2021 16:36:01KARNATAKA NCEP's FREQUENCY :49.96						
EXCOMS	BIO-MASS (140 MW)	COGEN (1520 M)	MINI – HYDRO (846 MW)	WIND (4794.745 MW)	SOLAR (6972.655 MW)	TOTAL (13544.8 MW)
BESCOM	11	7	2	34	557	603

ESCOM	0	0	42	2	0	45
CESC	2	34	15	4	147	205
GESCO	6	11	12	74	733	798
HESCO	0	318	0	106	331	716
TOTAL-IPPS	21	371	73	222	1770	2461
PAVAGADA SOLAR PARK	SECI (200M) 84	KARNATAKA (1850 MW) 804			(NCLUDING PAVAGADA 1850 MW)2572	3266

Table 5: shows the NCEP load monitoring



GESCOM Load variation with time

The Load curve details of GESCOM

Time	Frequency	2020	2019
0	49.83	9243	9187
1	50.02	9256	8820
2	50.01	8922	8432
3	49.92	8964	8488
4	49.95	9412	8750
5	49.02	9345	8624
6	50.02	10123	9480
7	50.04	10324	9232
8	50.09	10423	9195
9	49.96	9830	8690
10	49.82	9870	8933
11	50.00	9772	8991
12	49.97	9852	8552
13	50.05	9827	8583
14	50.01	9778	8529

15	**49.89**	**9972**	**8791**
16	**49.88**	**9623**	**8312**
17	**49.97**	**9261**	**8153**
18	**50.01**	**8802**	**7876**
19	**49.95**	**9702**	**8264**
20	**50.04**	**9722**	**8999**
21	**49.86**	**9412**	**8209**
22	**49.87**	**10324**	**9242**
23	**49.88**	**10511**	**9102**
24	**49.96**	**9632**	**8398**

VI. Conclusion

In this article, a probabilistic approach to economic planning of a real power is used to obtain optimum power flow using an optimal FACTS controller configuration. However more variance in load values must be studied. The case study of GESCOM is the grid's load curve for the analysis of load demand.

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