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Research paper

Transmission Expansion Planning for 133 Bus Tamilnadu Test System Using Bacterial Foraging Optimization Algorithm (Bfoa)

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Abstract-

In a creating nation like Indian, necessary energy infra framework has to be ramped up to fulfill the increasing requirement for energy. Development of Transmitting System is a vital factor in providing ability to the desperate areas. Lack of transmission potential in Tamilnadu in some areas, it is not able to leave wind energy to its full level. In this document, a multiple purpose operate is integrated which contains financial requirements as well as technological and adequacy requirements. Usually Economic requirements include the investment price, the servicing price and the function price but due to market circumstances it comes with price escalation due to venture wait, price escalation due to rising prices and price escalation due to Right of Way. In this document an method for Transmitting Expansion Planning (TEP) is developed by presenting a Transmitting Preparing Index (TPI). TPI is developed as a multi-objective operate and enhanced using different methods like Genetic Algorithms (GA) and Bacterial Foraging Optimization Algorithm (BFOA). The suggested strategy is verified by executing TEP for 133 Bus TNS (Tamil Nadu System). Blockage price also analyzed for the different circumstances in this paper

***Keywords**-Transmission Expansion Planning, GA, BFOA,TPI.*

1. Introduction:

Power has become an essential product which describes the economic success of a country. Accessibility to electrical energy has affected the growth and development of a community and has provided as an catalog for its development. Evacuation of produced energy has been found to be a much larger issue than creation of energy in country like Indian. According to the Central power Authority (CEA) fill creation balance review, various energy manufacturers lost around 1.93 billion units models of creation due to transmitting potential non accessibility or transmitting bottlenecks [1]. The loss to the nation's GDP due to energy shortages during the time interval 2012-13 alone is around 68 billion dollars $, which is roughly around 0.4 percentage of nation's GDP [1]. Between Tenth and Eleventh 5 year strategy interval the creation potential of the united states has expanded by around by 51% where the transmitting potential has improved by roughly 27% [1]. On one hand there is a fast growth and development of creation potential while the transmitting potential could not be enhanced to deal with the surge in creation. From the above determine it can make sure that the development in creation and development are not proportionate. It can be deduced from the determine that the during the Eleventh Plan interval the gap is around 24 %. While the creation potential has seen a greater of 51 % the transmitting potential has been enhanced only by 27%.So, Transmission Expansion Preparing can no longer be a central and a synchronized action. Also variation of open access will allow the user to choose from all available transmitting lines. Under sucha situation there will be a fast increase in the demand side potential major to further frustration of the issue, if the transmitting potential is not improved effectively. All these information points to the requirement of having

Transmission Expansion Preparing that is extensive in its strategy comprising various stakeholders, the needs and system restrictions.

Facilities perform a vital part in the economical development of a nation. Facilities investment strategies in Indian have been growing regularly [2]. In each five year plan government entities sets an committed focus on which is higher than the first one. Although the industry is considered to be a key car owner of financial development, efforts and cost overruns endanger to limit the sector's potential to help achieve the development and ensure efficient capital expenses [3]. Reasons for venture time overruns across venture lifecycle in nation like Indian are due to Pre-planning, Preparing and design, performance and Tracking and Closing and handover [3].The reasons for project time overruns due to preplanningare [3]:

- Delay in regulating mortgage approvals.
- Unavailability/delayed accessibility to resources.
- Land/site handover.
- Lack of venture managers/commercial supervisors with
- Adequate preparing abilities.
- Lack of price supervisors.
- Lack of protection officers/environmental experts.

The factors for venture time overruns due to Planning and style are [3]:

- Lack of powerful R&R guidelines.
- Ineffective purchasing preparing.
- Design/scope modify.

Literature Survey is explained as follows: The TEP is considered as an optimization issue with an objective function constrained to so many power system constraints. The TEP has to be prepared by considering the different power system constraints. Different techniques like LP [3], DP [4], NLP [5] and MIP [6] are explained for TEP. Benders decomposition for TEP is explained in the paper [7] and BBA for TEP is also explained in [7]. Two mathematical models for TEP considering uncertainty in load is explained in [8]. We present Abilevel model for TEP is presented in [9]. Taguchi's orthogonal Method for TEP is explained in [10]. Ordinal optimization for multilayer TEP is explained in [11]. TEP is explained for hike in load and generation using various methods is explained in [12]. TEP explained using N-1 Criterion in [13]. TEP considering uncertainties in load is given in [14]. TEP considering uncertainties in short term and long term are elucidated in [15]. TEP was elucidated by considering generation demandconditions in [16]. TEPwas studied using application of an accelerated Benders decomposition algorithm in [17]. TEP was formulated by using combination of cost allocation method and cooperative game theory in [18].

2. Problem Definition

Different problems are affecting Transmission Expansion Planning in Deregulated Power Systems in our country. TEP has to suggest a plan such a way that it has to satisfy the limits at the same time produce minimum cost plan. The Principal cost plays vital role in identifying a new transmission line using TEP techniques. Various cost effective factors to be considered in this work are Principal cost, cost owing to Maintenance, cost owing to Operation, cost incurred owing to Project Delay, price incurred owing to Inflation and price incurred owing to Right of Way. The objective function is defined for TEP is:

$$C_i = \sum_{i=1}^{nT} (C_{iIt} + C_{iMt} + C_{iOt} + C_{iDt} + C_{iRoWt} + C_{iInft}) \quad (1)$$

Where,
C_i : The total Cost owing to Plan i.
C_{iIt} : Principal cost.
C_{iMt} : Cost owing to Maintenance.
C_{iOt} : Cost owing to Operation.
C_{iDt} : Cost owing to Project Delay.
C_{iRoWt} : Cost owing to Right of Way.
C_{iInft}: Cost owing to Inflation.
nT : Number of years for planning.

In this work Cost owing to Project Delay can be taken as 7% of Cost of TEP [19], Cost owing to Inflation can be taken as five percentages for every year of planning horizon [20] and Price owing to Right of Way can be taken as10% of Cost of TEP [21].

The objective function (1) is constrained to the following limits to prepare proper TEP:

2.1. Power Balance Equation:

Power Balance equation can be given as [1]:

$$P_{Gj}=P_{Dj}+Pj \quad (2)$$
for j=1, 2 ….NB

P_{Gj}, P_{Dj} and $P_j$are Generation of Real Power, Demand for Real Power and Real Power losses at bus j, respectively.

2.2. Real Thermal Power Limits for Transmission Lines

Real Thermal Power Limits for Transmission Lines of transmission lines [1] can be given as:

$$|P_{xy}| \le (n_{xy}^0 + n_{xy})P_{xy}^{max} \quad (3)$$

P_{xy}, P_{xy}^{max}, n_{xy} and n_{xy}^0 are total Real Power in line x-y, maximum Real Power in line x-y, number of lines can be augmented in line x-y and number of lines in actual system [1], respectively.

2.3. Real Power Generation Limits

Real Power Generation Limits for TEP is defined as [1]:

$$P_{gj}^{min} \le P_{gj} \le P_{gj}^{max} \quad (4)$$

P_{gj}, P_{gj}^{min} and $P_{gj}^{max}$are Real Power Generation at bus j, the minimum and maximum Real Power Generation limits at bus j, respectively.

2.4. Right of Way

Right of way has to be included in TEP which gives information about number of lines shall be added toexisting system withou
t violating any limits [1]. Right of Way for TEP is given as [1]:

$$0 \le n_{xy} \le n_{xy}^{max} \quad (5)$$

n_{xy} and $n_{xy}^{max}$are the total number of lines shall be augmented across line x-y and the maximum number of lines available in line x-y, respectively.

2.5. Voltage Phase Angle Limit

Voltage Phase angle Limit plays key role TEP, hence it has to be incorporated in transmission planning. Voltage phase angle limit is given as [1]:

$$|\alpha_j^{cal}| \le |\alpha_j^{max}| \quad (6)$$

$\alpha_j^{cal}$is voltage phase angle obtained from load flow study which has to be less than α_j^{max} which is specified voltage phase angle at a particular bus.
Some of the contingencies are to be considered for TEP which gives stable and Reliable plan as mentioned below:

2.6. Generator Outages:

Generator outages are to be considered for proper TEP which occurs due to internal outages, planned outages; repairs etc. owing to outages of generators, imbalance in generation and demand causes reliability issues in the system [22].

2.7. Line Outages

One of the important outage that has to be incorporated in TEP is Line outage which occurs due to foul weather conditions, over loading of lines, imbalance of generation and demand, etc which has to be considered for stable and reliable TEP [22].

2.8. Uncertainties in Load

Load is a random parameter, it has to be forecasted accurately because to obtain stable and reliable TEP i.e. load forecasting should be more accurate [22], hence it is also to be included in TEP.

3. Methodology

3.1. Genetic Algorithm (GA):

The fundamental inspiration of GA is to reproduce the process of regular selection which is mostly depended on survival of the fittest. GA cadges a group from the procedure of organic choice and progression. In GA, each remedy might be exposed as a Chromosome [23]. These Chromosomes are analyzed for their fitness and wellness and are rated in correspondence with its fitness value. Parent Chromosomes are defined as arbitrary generation of Chromosomes in the early stage and next generation of Chromosomes are called as Child or off-springs [23]. The fundamental principal of GA is to engage better Parent with an endeavor to create better Children. In GA, better Chromosomes are moving to upcoming scenarios and remaining will be excluded from the system [24]. In GA, three special operators like selection, crossover and mutation are used to produce better solutions. In this work paper, GA is implemented for TEP using MATLAB. The GA parameters used in this work are given below:

Population size	20
Elite count	10%
Selection	Tournament based selection
Mutation	Adaptive feasible mutation
Mutation factor	0.20
Crossover probability	0.80

The algorithm for TEP using GA is explained below [24]:

Step 1: Assuming GA parameters for TEP.
Step 2: Generating a random Transmission Expansion Plan.
Step 3: Simulating power flow study to verify various constraints mentioned.
Step 4: Finding value of Fitness function by evaluating Objective Function for particular TEP.
Step 5: Identifying the Ranks of the transmission expansion plans produced by GA and in turn applying all the three operators selection, Crossover and Mutation to get ultimate plan or forwarding to subsequent step.
Step 6: Verifying the stopping criteria. If stopping criteria is fulfilled than go to step 7 otherwise go to step 3.
Step 7: Obtaining stable and reliable transmission expansion plan.

3.2. Bacterial Foraging Optimization Algorithm (Bfoa):

The foremost benefits of BFOA are its capability to have similar distribution processing, inattentiveness to primary value and ability to accomplish global Optimization [25]. In BFOA, the bacteria experiences four stages like Chemotaxis, Swarming, Reproduction and Elimination and Dispersal [25]. The duty of Chemotaxis is to hunt for the solution space. The reproduction operator ensures that the identification of fitter individuals to take part in subsequent phases of progression [26]. The Elimination and Dispersion operator ensures global Optimization and avoid untimely convergence. Chemotaxis is accomplish the two moments swim or tumble and Bacteria exchanging between these two approaches of process i.e. swims or tumbles, in its entire life cycle, so, it make sure the progression of bacteria on the way to locating the nutrients (solutions) [27]. In this work, BFOA is simulated using MATLAB and the parameters of BFOA for stable and reliable TEP is mentioned below:

The variety of Bacteria	50
Number of Chemotaxis steps	20
Limit duration of a swim	4
The variety of duplication steps	4
The variety of Elimination-Dispersal events	2
The variety of viruses reproductions	2
The Chance of Removal /dispersion	0.2

The algorithm for TEP using BFOA is mentioned as follows:

Step 1: Assuming BFOA parameters for TEP.
Step 2: Generating Random Transmission Expansion Plan.
Step3: Simulating Power Flow Study for checking various limits.
Step 4: Calculating the Fitness value using Objective Function for TEP.
Step 5: Assuming Chemotaxis Tumble / Run for TEP.
Step 6: Verifying for End of Chemotaxis if say yes move on to Step 7 else move on to Step 4.
Step 7: Initializing the Reproduction.
Step 8: Verifying if it is conclusion of Reproduction as initiate, if yes move on to Step 9 else move on to Step 4.
Step 9: Starting Elimination and Dispersion procedure.
Step 10: If it is conclusion of Elimination and Dispersion then move on to next Step, or else move on to Step 4.
Step 11: Producing the Optimized Transmission Expansion Plan.

3.3. 133 Bus Tamilnadu Test System:

The Power Map of Tamilnadu which is part of Southern Grid has contributions from both the Central and State units. The Power System of Tamilnadu can be considered as one of the best examples of large scale and complex real world Systems. As of January 2015, the State has a total installed capacity of 13,868.54 MW [28]. The Generation mix includes Thermal Power Stations, Hydal Power Stations, Nuclear Power Stations, Gas-based Power Plants, contribution from Independent Power Producers (IPP) and Renewable Power Stations. There is a significant contribution from the Central Power Generation utilities to the tune of 5,299.0 MW. The contribution from different Generation mix for the total installed capacity for the Tamilnadu is given below (Table.1):

Table 1: Contribution from different generating plants in Tamilnadu

S.No	Type of Generation	Capacity (MW)
1	Thermal Generation	9170.0
2	Hydro Generation	2125.5
3	Nuclear Generation	899.0
4	IPP	1158.16
5	Gas Generation	515.88
Total		13868.54

The following plot illustrates the Power share between the State and Central generating units:

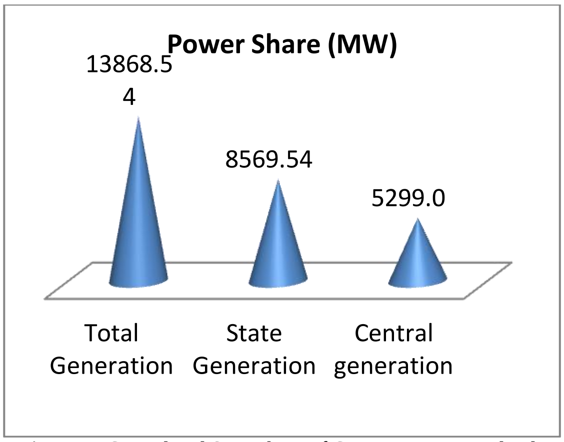

Figure.1: Central and State share of Generation in Tamilnadu

Power from these generation utilities is transferred across Tamilnadu with the help of Transmission lines. 220 KV and 400 KV lines do the bulk of transmission and the length of transmission Network is 18,233 CKm with 7,576 CKm in the form of Central lines and 10,657 CKm through State lines. Typically, these transmission lines are of types Quad Moose, Twin Moose, Single Zebra, Kundah, AAAC Zebra and ACSR Mink. These transmission lines are part of 133 Bus System which comprises of 73 lines that belongs to Central government and 206 lines that form the part of State share. These lines evacuate Power from different generating stations situated across Tamilnadu to 79 designated Load Centers serving a total peak load of around 14,000 MW.

The Single Line Diagram of 133 Bus Tamilnadu Test System (TNS) is illustrated in the Figure 7.2.

The following Table 2 summarizes the details about Tamilnadu Power System.

Table 2: Details of 133 Bus Tamilnadu Test System

S.No	Total Generation (MW) #	Peak Load (MW)	Number of Buses	Number of Lines	Length of CKm
1	13868.54	14000	133	276	18233

\# As of January 2015.

In addition to the above furnished information about 133 Bus Tamilnadu Test System, the following Table 7.3 provides the Tamilnadu Transmission System.

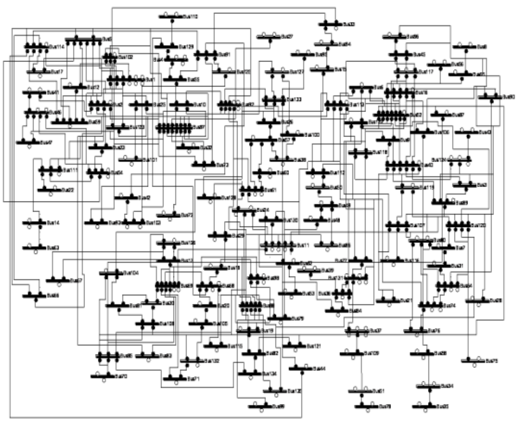

Figure2: Single line diagram of 133 Bus Tamilnadu Test System

Figure3: Power Map of Tamilnadu

Table 3: Transmission System Data of Tamilnadu

S.No	Item	Table Number
1	Bus Data	Table AIV.1
2	Line Data	Table AIV.2
3	Generation Data	Table AIV.3
4	Reliability Data	Table AIV.4

The Power Map of Tamilnadu indicating the lines along with details about locations of buses, load points and generating units is shown in the Figure 3.

4. Results and Discussion:

4.1. Case 1:

In this work, one of the situations i.e. 20% of hike in load along with 20% hike in generation is assumed. This situation shows upcoming transmission expansion plan for the coming 4 years i.e. there will be a load hike of 5% in each and every year [29]. In this paper, TEP is calculated for homogeneous rise in load and generation. By observing Table 4, the plan suggested by GA augmented 64 new lines with a length of 4212.89 CKm which costs 9268.5 Crore Rupees which is summation of Investment cost for addition of new transmission lines which is around 9268.5 Crore rupee as estment cost, cost due to inflation is 2317.12 Crore Rupees, cost owing to project delay is 648.79 Crore Rupees and Cost due to Right of Way is 926.8 Crore Rupees. The Transmission Expansion plan proposed by BFOA enhanced 60 new transmission lines with a length of 3792.27 CKm which Costs 8342.99 Crore Rupees which is summation of Investment cost for addition of new transmission lines which is around 2085.74 Crore Rupees, cost due to inflation is 8342.99 Crore Rupees, cost owing to project delay is 590.30 Crore Rupees and Cost due to Right of Way is 834.2 Crore Rupees. It can be observed that TEP specified by BFOA is better compared with result produced by GA.

Table 4: TEP for IEEE 24 bus RTS for 20% hike in both load and generation

Parameter / Method	GA	BFOA
N_{new}	64	60
L_{new} (CKm)	4212.89	3792.27
C_{new}(Crore Rupees)	9268.5	8342.99
C_{inf}(Crore Rupees)	2317.12	2085.74
C_d (Crore Rupees)	648.79	590.30
C_{RW} (Crore Rupees)	926.8	834.2
C_{total}(Crore Rupees)	13161.21	11853.23

4.2. Case 2:

In this work, one of the situations i.e. 45% of hike in load along with 45% hike in generation is assumed. This situation shows upcoming transmission expansion plan for the coming 9 years i.e. there will be a load hike of 5% in each and every year [29]. In this paper, TEP is calculated for homogeneous rise in load and generation. By observing Table 3, the plan suggested by GA augmented 79 new lines with a length of 5735.0 CKm which costs 1164.70 Crore Rupees which is summation of Investment cost for addition of new transmission lines which is around 718.96 Crore Rupees, cost due to inflation is 323.53 Crore Rupees, cost owing to project delay is 50.32 Crore Rupees and Cost due to Right of Way is 71.89 Crore Rupees. The Transmission Expansion plan proposed by BFOA enhanced 5 new transmission lines with a length of 5645.2 CKm which Costs 12419.6 Crore Rupees which is summation of Investment cost for addition of new transmission lines which is around 12419.6 Crore Rupees, cost due to inflation is 20740.77 Crore Rupees, cost owing to project delay is 869.37 Crore Rupees and Cost due to Right of Way is 1241.9 Crore Rupees. It can be observed that TEP specified by BFOA is better compared with result produced by GA. Table 5 gives the new lines added by GA and BFOA for this case.

Table 5: TEP for IEEE 24 bus RTS for 45% hike in both load and generation

Parameter / Method	GA	BFOA
N_{new}	79	77
L_{new}(CKm)	5735.0	5645.2
C_{new}(Crore Rupees)	12617.1	12419.6
C_{inf}(Crore Rupees)	6308.55	6209.8
C_d (Crore Rupees)	883.19	869.37
C_{RW} (Crore Rupees)	1261.7	1241.9

C_{total}(Crore Rupees)	21070.54	20740.67

5. Conclusion

The results of TEP for 133 BUS tamilnadu IEEE 24 Bus RTS have been explained in this paper for 3 different cases like 20% increase in both in load and Generation and 45% increase in both in load and Generation and 70% hike in both in load and Generation. It can be deduced from results explained in the previous section, the performance of BFOA is better than the performance of GA. The efficiency of BFOA method by considering lesser number of lines and length of new lines particularly for higher load and generation hikes clearly indicates the aptness of this method for long-term TEP. It can be observed that, the performance of the BFOA in terms of Cost of New Transmission Lines to be installed after TEP.

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