# **CHAPTER 4**

## **4.1 INTRODUCTION**

This project aims at integrating renewable energy into GEP, TEP and DEP. RE energy is intermittent and stochastic in nature and for it to be added into the transmission network proper planning have to be made. Capacity planning aims to achieving the best decision during planning that will arrive at the minimum cost of investment. The assumptions made in this project is that there will be a constant energy demand and the model under study is a dc power flow.

Research conducted is an action quantitative research where all data collected is numerical. The samples collected include the cost of renewable generation units, load demand, power losses in the grid etc. This data is analyzed using statistical methods such as mean and standard deviation are used. Other tools for analysis will be used such as graphs and pie charts for comparison of data.

Data from archival research and literature reviews was collected and used for analysis. A visit to the generation, transmission and distribution companies was conducted and data was collected from their previous recordings on load demand, power generated and power transmitted.

## **RESEARCH DESIGN**

In this project a model is developed where renewable energy is integrated into GEP, TEP and DEP. The procedure to be used in the optimization method is as follows

1. Initialize assessment of potential sites for wind
2. Determine parameters affecting power generation, transmission and distribution.
3. Evaluate the amount of power delivered from site. If there is not viable then go back to (1)
4. Develop a hybrid system
5. Determine uncertainties and constraints affecting the TNEP model
6. Check if it meets load demand plan for a friendly cost
7. Check if the plan is cost effective if not go back to (vi)
8. If the cost function has been minimized then the objective function would have been met

Determine renewable energy parameters

Initialize assessment of renewable energy location

no

Does the site produce enough power?

Yes

Develop a hybrid system

Determine constraints and uncertainties

Select optimal power plan

Determine cost of optimal power plan is it viable

Objective function is achieved

YES

END

## **4.3 DELIMITATIONS**

The project will involve research in power generation, transmission and distribution, renewable energy integration and power expansion planning. The project will find the best decision expansion plan that is cost friendly by using a mathematical model.

## **4.4 DATA COLLECTION AND COLLECTION TOOLS**

Data in this proposal was collected from archival research from previous studies. Recordings from previous studies on load demand, power produced from RES helps us in familiarizing with data and after doing the analysis we can definitely predict what to expect. A visit to the generating, transmission and distribution station was also made, where samples of data were collected through interviews and collection of already sampled data.

## **4.5 DATA COLLECTION METHOD**

### **4.5.1 Sampling**

Samples of data were collected in the stations where only relevant and most consistent data was taken.

### **4.5.2 Archival research**

Previous recordings from literature reviews and internet were also used.

## **4.6 OPTIMIZATION**

Optimization involves finding the best solution to a power system planning problem. This involves maximizing the wanted attributes and minimizing the unwanted ones. Optimization finds the best optima decision in power planning by reducing investment costs while taking into account factors such as uncertainty.

It is desirable that solution of power system problems should be optimum globally, for this to happen we must use optimization methods to find the best solution.

Optimization methods can be classified into 3 categories:

1. Mathematical optimization methods
2. Artificial intelligence techniques
3. Hybrid optimization techniques

### **4.6.1 MATHEMATICAL METHODS**

These methods select the best decision by use of statistical data and mathematical operation. Advantages of mathematical methods are:

1. Some algorithms require very accurate optimality which is only obtained mathematically
2. Mathematical methods are rich in techniques used to approach a power system problem

Mathematical methods include:

#### **Linear programming method (LP)**

This technique optimizes a linear objective function and linear constraints. LP is divided into two simplex and IP method, where the simplex method handles computation and IP moves the solution found in simplex to optimality

#### **NON-LINEAR PROGRAMMING METHOD (NLP)**

This technique optimizes a nonlinear objective function and nonlinear constraints

#### **INTEGER AND MIXED INTEGER PROGRAMMING**

This optimization problem only takes integers values as variables, if the integer values are continuous it takes them as mixed integer these variables are limited only to “1” or “0”.

**4.6.2 ARTIFICIAL INTELLIGENCE TECHNIQUES**

These techniques uses algorithm developed to arrive at a global optimum. They are more competent than mathematical techniques. The large class of problems experienced in power system made the solution to be elusive or not accurate enough. These problems require:

1. Experience gained over a long period of time
2. Categorization of uncertainties, load variation etc.
3. Operator judgement especially in practical situations

These techniques include:

#### **ARTIFICIAL NEURAL NETWORK**

ANN are information based system inspired by the working of the nervous system e.g. the brain . ANN model learns over time and by building knowledge from the data set it is able to give the right solution if asked upon. It is categorized by its architecture, topology and learning regime. ANN is used in power system to solve complex algorithms and predict the horizon years. Its main advantages are :

1. It is does take long for it to process data
2. Very intelligent and can learn quickly
3. Adapt quickly to data
4. Robust

Disadvantages

1. Has a very large dimensionality
2. Choice of training methodology is hard

#### **GENETIC ALGORITHM (GA)**

GA is a metaheuristic technique that uses the concept of population selection to produce a global optimum. solutions called chromosomes ae generated. Chromosomes are used as control variables and lead to optimization.

Advantages of GA are:

1. Doesn’t need a detailed information of the objective function
2. Works on multiple solution and therefore is able to converge on the global optima

Its main disadvantage is that it consumes a tremendous amount of time

#### **PARTICLE SWARM OPTIMIZATION (PSO)**

PSO is an optimization method which provides initial population based on searching algorithm where each particle changes its position according to time. It is based on behavior of birds, a number of particles are randomly generated to form a population. The particles move in the multidimensional space searching for the optimal solution.

#### **TABU SEARCH**

TS is an optimization approach used to solve global optimization problem. It searches for the optimal solution by searching for the greatest neighborhood. TS components include Tabu list, moves and aspiration level .TS is used in planning, load forecasting and hydro scheduling.

#### **BAT ALGORITHM**

BA is an optimization technique that is derived from the behavior of micro-bats, this techniques mimics the echo-location behavior of bats .it has frequency tuning parameters and very strong control parameters. BA can be used to solve OPF.

### **HYBRID OPTIMIZATION TECHNIQUES**

Hybrid optimization methods involves integrating several optimization method to achieve the best global optima. Integration helps in to combine strengths of the specific methods and limit each other’s weakness to generate a hybrid solution.

They include GA-TS, ABC – PSO and fuzzy neural networks.

### **PROPOSED OPTIMIZATION METHOD**

The proposed optimization method is a BA, the proposed method uses the concept of echolocation of bats. A bat searches and finds a prey by changing its frequency, emission of pulse and loudness.BA uses this techniques to also find the global optimum.

The bat algorithm uses rules as listed below:

1. Bats use echolocation to locate and sense prey and locate barriers .
2. BA uses velocity vi and position xi .This technique uses frequency and loudness to reach get close to the optima .They can adjust the frequency of pulse emission
3. There is an increase in pulse and loudness as one gets close to the prey

#### **FREQUENCY AND VELOCITY OF THE BAT**

Bat movement is simulated using the following equations:

minimum frequency

maximum frequency

a random vector (0,1)

Xi  current location

velocity of bat

Near best solution

#### **LOCAL SEARCH**

For the local search each bat carries out a random search based on the optimal solution

Is a random number

Average loudness of all bats at current time step

Solution randomly picked from current optimal solution

Average loudness of all bats

#### **LOUDNESS AND PULSE EMISSION RATE**

Pulse emission rate and loudness are adjusted using the following equations:

Is the initial velocity

Randomly selected initial loudness

#### **ADVANTAGES OF BA**

1. Takes a short time to process data
2. Gives reliable global solutions
3. Solves very complicated problems
4. Simple ,flexible and efficiently solves problems

#### **DISADVANTAGES OF BA**

1. Convergence rate deteriorates with advancement I.e. quick at the early stages but begins to slow

### **MAPPING OF THE PROBLEM**

Echolocation

Echolocation represents the objective function which is to plan for an optimal site to build our hybrid unit. It also involves planning for the power so that it can meet the demand. The prey is the problem. When the bat finally catches the prey, the objective is achieved. This is when minimum costs are incurred.

Loudness

If a bat finds its prey, it will reduce the impulse response and its loudness will decrease. Loudness represents the demand to be met. The higher the power deficit is, the more the loudness. When this deficit is met, the loudness decreases. It represents the number of possible sites to choose from to get the best site. In the case of demand and supply, it represents the total number of generation units required to supply power. In our case its 5 generators which comprise of 2 solar generators,1 wind generator, 1 hydro generator and 1 thermal generator.

Frequency

When a bat finds its prey, it increases its pulse emission frequency. The minimum frequency is the minimum power generated from all the generators. The power generated by the hybrid unit is affected by the solar and wind parameters. When minimum power is produced, the profits are minimal since extra costs will be incurred when supplementing for the power deficit. When maximum power is produced, the demand is met and the return profits are maximum.

## **VALIDATION TECHNIQUE**

The proposed bus system to be used is the Garver bus system which consist of 6 buses , 3 generators and 5 loads .