CHAPTER 4

REACTIVE POWER COST ESTIMATION IN WIND FARMS
USING HYBRID ITERATIVE OPTIMAL POWER FLOW
ESTIMATION AND A NOVEL LOAD TRACING

4.1 INTRODUCTION

In the past few decades, wind energy depicts the fastest growth rate of any form of electricity generation. The new electrical sector regulation highlights the role of competitive markets for the procurement and pricing of ancillary services. Reactive power is regarded as one of the ancillary services in deregulated environment. Wind energy is capable of supplying large amount of power but its presence is highly unpredictable due to wind fluctuations. System voltages must be maintained within the permissible limits in order to deliver the active power through the lines. Reactive power is mandatory for the loads like motor loads and other inductive loads for their operation.

In the upcoming power systems, the new development of power generation, distributed power generation technologies are most important. Deferring or avoiding the transmission, expanding the distribution are the benefits of distributed generations. Common distributed generation is represented and used as small scale power generation resources and deployed on the customer side. The various distributed generation resources consist of certain generators like diesel and combustion turbines, and power sources of renewable technologies, such as, photovoltaic and wind power. Wind, solar, etc. is some of the generally used renewable energy resources used nowadays. To provide reactive power, due to cost, diesel generation is widely used in the distributed systems as the reactive power resource.
In the vertically integrated utility (VIU) structure, generation, transmission, and distribution were owned by a single entity, and consequently reactive power provision and voltage support were bundled with other services in supplying electricity to the customers. Therefore, an accurate method of determining the active and reactive power costs results in fair pricing and consequently, ensures that the producers will participate with enough incentive as well as the consumers to utilize as much electrical energy as required. The pricing mechanism should include the capital cost of the components which are remarkably high. In other words, reactive power pricing is a multiobjective approach that all effective factors should be taken into account during price setting.

4.2 REACTIVE POWER PRICING

Pricing of electrical power is one of the outstanding issues in the process of deregulated electric industry. Reactive power management is indispensable for the transfer of real energy and support power system stability because it affects the voltages throughout the system. Reactive power pricing and management under open-access will depend upon two important developments: (1) the efficient unbundling of services that support the reactive power and voltage control service and (2) grid rules to assist the coordination between generation and transmission systems for reliable system operation. Pricing based on power factor penalties is inconsistent and inadequate. Developing an accurate and feasible method for reactive power pricing becomes vital in the electricity market.

Further, this pricing methodology has to satisfy the following objectives:

- Reactive power suppliers should be benefitted with a normal profit.
- Pricing should be accurate so that economic efficiency of service providers is improved which helps in making intelligent decisions.
• Certain incentives need to be provided to the consumers for the utilization of reactive power compensation devices.
• Pricing must be non-discriminative and correct both for the usage and conservation of reactive power.
• It must be simple, widely acceptable and transparent.

The reactive power supplied for each transaction must meet the reliability requirements for maintaining the transmission voltage within the limits. The value of reactive power service depends on the choice of reactive power compensation devices, location of the reactive power source in the system and the load demand characteristics.

The losses charge to consumers is independent on the number of transmission lines but dependent on the magnitude of contributed losses. The reactive loss of this line is equivalent to the difference between reactive powers at both ends.

4.2.1 Line Loss Calculation

For a total of ‘i’ buses the calculated voltage at any bus \(l\), where \(i \neq l\),

\[
V_l = \frac{1}{Y_{ll}} \left( \frac{P_l - Q_l}{V_l^*} - \sum_{i=1}^{N} Y_{li} V_i \right)
\]  

(4.1)

\[P_l - jQ_l = (Y_{ll} V_l + \sum_{i=1}^{N} Y_{li} V_i) V_l^*
\]  

(4.2)

For \(i=l\),

\[P_l - jQ_l = (V_l^* \sum_{i=1}^{N} Y_{li} V_i)
\]  

(4.3)

\[Q_l = -\text{Im} (V_l^* \sum_{i=1}^{N} Y_{li} V_i)
\]  

(4.4)

where \(V_l^* = \text{Updated voltage at bus } l\)

\(P_l = \text{Real power at bus } l\)
\[ Q_l = \text{Reactive power at bus } l \]
\[ Y = \text{Admittance} \]
\[ \text{Magnitude} = |V_k| \quad (4.5) \]

where \( V_k \) is a complex value

\[ \text{Angle} = \tan^{-1} \left( \frac{Q_l}{P_l} \right) \times \frac{180^0}{\pi} \quad (4.6) \]

### 4.2.2 Cost Estimation

The objective function is framed as a minimization function of total cost of reactive power comprising of three parts namely loss cost, installation cost and production cost [34].

1) Cost of system loss after reactive power compensation

For a given time-interval, the load of the distribution system is assumed as constant, while the outputs of wind power generators vary with the changes in wind speed. The cost of the system loss \( S \) is sum of the loss costs of all wind power output statuses, as given below

\[ S = K \times \sum_{t=1}^{T} T_t P_t (x) \quad (4.7) \]

where \( P_t(x) \) is the active power loss for the wind power output status \( t \); \( T_t \) is duration of status \( t \); \( K \) is energy price. Minimizing the cost of the active power losses of the power system is equivalent to the minimization of the cost of the active power of the slack generator.

2) Reactive power support cost of SVC

The cost of SVC is usually represented by an approximated linear function with a fixed installation cost and a variable operation cost. The cost of SVC ‘F’ can be formulated as
\[
F = \sum_{i=1}^{I} e_i ( r_i Q_{ci}^0 + c_i )
\]

(4.8)

where \( r_i \) and \( c_i \) represent the marginal cost and fixed installation cost of the SVC at node \( i \) respectively. The value of binary variable \( e_i \) depends on whether the SVC is installed \( (e_i = 1) \) or not installed \( (e_i = 0) \) at node \( i \). \( Q_{ci}^0 \) represents the required capacity of the SVC placed at node \( i \) to accommodate all wind turbine output statuses.

3) Reactive power production cost of diesel generator

The distributed generators can supply local loads directly without long distance transmission to control the voltages of distribution systems. Reactive power cost function for generator has been framed using a quadratic cost function to represent the operation cost and opportunity cost of providing reactive power. The production cost \( R \) can be manipulated as

\[
R = \sum_{i=1}^{T} \sum_{t=1}^{I} ( a_i + b_i Q_{DG_i}^t + c_i Q_{DG_i}^t )^2
\]

(4.9)

Where \( I \) denotes the total number of nodes. \( a_i, b_i \) and \( c_i \) are the coefficients of the production cost function of the diesel unit at node \( i \). \( Q_{DG_i}^t \) is the reactive power output of the diesel unit at node \( i \) under the wind turbine output status \( t \).

4) Objective Function

For a distribution system with distributed generations, the objective function of the reactive power planning model is to minimize the sum of the above three cost functions as shown in (4.10)

\[
\min f = K \ast \sum_{t=1}^{T} T_p \Psi_t (x) + \sum_{i=1}^{I} e_i ( r_i Q_{ci}^0 + c_i ) + \\
\sum_{i=1}^{I} \sum_{t=1}^{T} ( a_i + b_i Q_{DG_i}^t + c_i Q_{DG_i}^t )^2
\]

(4.10)
4.2.2.1 Hybrid Iterative Optimal Power Flow Estimation with Load Tracing (HIOPFE-LTMSA)

4.2.2.1.1 Iterative Optimal Power Flow Estimation (IOPFE)

Consider an IEEE/Standard $\xi$ bus system, where $\vec{B}$ vector represents bus and line data with coefficients $\vec{b}_d$ and $\vec{b}_l$. $N_b$ and $N_l$ represents the total number of buses and lines. Load parameters from $F_b$ to $t_b$ as per the nominated IEEE bus system is derived. To solve the power flow or “load flow” of the electric system, a nodal analysis is performed. Each node, usually referred to as a “bus”, has four variables like voltage ($V$), voltage angle ($\theta$), real power ($P$), and reactive power ($Q$). The buses are assigned a type ($F_b$ or $t_b$). The system has one reference bus or slack bus ($) which has a specified $V$ and $\theta$. A load bus has known or specified $P$ and $Q$ values. A voltage controlled or generator bus has known or specified $P$ and $V$ values. The line data is represented in a matrix form with from and to bus, resistance ($R_{pu}$) and reactance ($X_{pu}$) in per unit. The data is defined in an admittance matrix ($Y_{mat}$).

For a total of $N_b$ buses, the calculated voltage at any bus $b_v$, where $n \neq b_v$, is specified as

$$V_{b_v} = \frac{1}{Y_{mat_{b_v,b_v}}} \left( P_{b_v} - j Q_{b_v} - \sum_{n=1}^{N_b} Y_{b_v,n} V_n \right) \quad (4.11)$$

For a bus where voltage magnitude rather than reactive power is specified, the components of the voltage for $n \neq b_v$ are found from

$$P_{b_v} - j Q_{b_v} = \left( Y_{mat_{b_v,b_v}} V_{b_v} + \sum_{n=1}^{N_b} Y_{b_v,n} V_n \right) V_{b_v}^* \quad (4.12)$$

For $n = b_v$,

$$P_{b_v} - j Q_{b_v} = \left( V_{b_v} * \sum_{n=1}^{N_b} Y_{b_v,n} V_n \right) \quad (4.13)$$

$$Q_{b_v} = -Im \left( V_{b_v} * \sum_{n=1}^{N_b} Y_{b_v,n} V_n \right) \quad (4.14)$$
where \( V_{b_v} \) represents the calculated voltage at any bus \( b_v \),

\( Y_{mat_{b_v,b_v}} \) represents the admittance matrix of buses \( b_v \times b_v \),

\( P_{b_v}, Q_{b_v} \) represents the real and reactive power of bus \( b_v \),

\( Y_{b_v,n} \) represents the admittance of the line connecting the bus \( b_v \) and node ‘n’.

4.2.2.1.2 Flowchart

Firstly, the proposed technique performs power flow results based tracing, that is, all the parameters from power flow results (such as generator’s and load’s power, line flow, and losses) are not modified as obtained from IOPFE and used directly in the tracing algorithm. To be more precise, there is no need to modify the condition of power system and it is used in the proposed algorithm as it is. The flowchart for the hybrid algorithm for optimal path selection and cost estimation is depicted in Figure 4.1. It is observed that real, reactive power and voltages supplied to buses are calculated using Iterative Optimal Power Flow Estimation (IOPFE) and load tracing is performed by Meta-heuristic search algorithm (Tabu Search) which creates Tabu’s list for load tracing. TS algorithm finds optimum solution in a lesser time period in comparison with other tracing algorithms.
The procedural steps for HIOPFE-LTMSA algorithm is furnished below:

**Step 1:** Initializing input bus data and line data for processing.

**Step 2:** Admittance $Y_{mat}$ Calculation for each bus ($F_b$)

**Step 3:** Power flow Estimation & Optimization (real and reactive power and voltages supplied to buses) using IOPFE
Step 4: Power flow Optimization - Calculate updated voltage, updated real and reactive power for buses/generator

i. Update power for slack bus

ii. Data re-formatting for output

4.2.2.2 Load Tracing using Meta-heuristic Search Algorithm (LT-MSA)

4.2.2.2.1 The Concept of Tracing

The participation of generators and loads can be determined with the aid of generation and load tracing. The method for tracing the power participated or extracted by individual load is called load tracing which has been developed considering the physical power system constraints. This concept facilitates power flow tracing as well as the losses associated with each transaction in transmission service.

The power flow tracing algorithm is a mechanism for tracing the contribution of each user on a transmission system to allocate charges for the usage of the transmission line.

4.2.2.2.2 Tracing algorithms

4.2.2.2.1 Bialek’s tracing

This algorithm is applied for lossless flows when the flows at the start and end of each line remain the same. It adopts tracing by upstream looking algorithm and downstream looking algorithm. It also implements a simple topological method of tracing both the real and reactive power flow in transmission networks considering the apportioning of the total transmission loss to individual sinks or sources.

This method provides additional insight into power system operation and can be used to adjust the existing tariffs of charging for transmission loss,
reactive power and transmission services. It can also be employed to work out the contribution of various generators to every line and load within the given network based on the calculation of topological distribution factors and for the transmission evaluation within the deregulated market. It is mainly adopted due to its simplicity but it requires the inverse of a sparse matrix of the rank equal to the number of network nodes. But the drawback of this method lies in less accurate results for transmission pricing.

4.2.2.2.2 Kirschen’s tracing

This is a proportional sharing principle (PSP) based power flow tracing including the concept of domains, commons and links. This method of tracing first identifies the buses reached by the power produced by each generator. Later on, it finds out the sets of buses supplied by the same generators. Based on proportionality assumption, it can calculate how much each generator contribute to the loads and flows. In this method, the ratio of inflow traced to a particular generator is assumed to be equal to the ratio of outflow traced to the same generator. This method can be applied to both alternating current (AC) and direct current (DC) load flow solutions. This allocation method based on tracing does not depend on a linear network model and hence it is not restricted to incremental changes in injections. The results obtained by this tracing method are 100% accurate and proved to be the best way of transmission pricing for lesser generation in the system. The main drawback is that when more generators use the lines simultaneously, this method provides only smaller allocation percentages to each generator.

4.2.2.2.3 Meta-heuristic Search Algorithm (Tabu Search)

Tabu Search (TS) is one of the most efficient heuristic techniques because it finds quality solutions in relatively short running time. Heuristics refer to local search approaches which are widely utilized in obtaining “close-to-
optimum” solutions for these problems in a “reasonable” amount of time. The adaptive memory feature of TS enables the solution procedures to perform the search in an effective and economical way. This powerful optimization procedure is applicable to a number of combinatorial optimization problems successfully because of its robustness to its own parameter settings, ability to avoid entrapment in local optimal solution and the avoidance of cycling by using flexible memory. TS algorithm involves four major steps: Initialization, mutation, recombination, evaluation and selection. Mutation and recombination being the diversification and intensification strategies respectively, the historically attractive regions can be investigated thoroughly.

In tracing, it is essential to use the reactive power flow to compute the share of reactive power consumed on load buses, because the reactive power and real power may have different directions. Reactive power extracted by a load is traced using Tabu search (TS) which finds the nearby generating source for the respective load; thereby it reduces the reactive power cost of the load.

The steps of the hybrid algorithm are

- Calculation of total real and reactive power loss from all buses / generator. This is done by IOPFE.
- Cost Calculation for Lower Load, Higher Load and Average Cost Calculation
- Meta Heuristic Search Routine Process

1. Random selection of a chromosome from the current population and decoding from decimal to binary form.
2. For the selected chromosome, a few neighbor solutions are arbitrarily generated and their fitness function values are evaluated.
3. The neighbors are sorted in an ascending order according to their fitness value and the following test is performed on the set of neighbors one by one until one of them is accepted.
4. The selected neighbor is checked. If it is a TABU, the satisfaction of aspiration value (AV) is checked. If it is not a TABU, the solution is accepted and step 5 is adopted.

5. If AV is satisfied, the solution is accepted and step 5 is pursued. Otherwise the neighbor is rejected and the next neighbor is taken.

6. If the required number of solutions is reached, the process goes back to the main program. Otherwise it will go to step 1.

7. The process can be stopped if maximum allowable number of iterations (generations) is reached.

In the Tabu Search (TS) algorithm, tabus are occasionally too powerful. Even though, there is no danger of cycling, tabus may forbid attractive moves or may lead to an overall stagnation of the search process. Therefore, it becomes essential to utilize algorithmic devices that will revoke (cancel) tabus which are called aspiration criteria. When TS produces a solution whose objective value is better than that of the current best solution (which is not previously visited), AV allows a tabu move and this is adopted in almost all TS implementations. The flowchart representing the step-by-step procedure of TS algorithm is depicted in Figure 4.2.
4.3 EXPERIMENTAL ANALYSIS

The proposed hybrid algorithm is programmed in MATLAB environment and applied to four different test bus systems like IEEE 14-bus system, IEEE 26-bus system, IEEE 30-bus system and IEEE 57-bus system and the error and computational time are calculated. Comparative study consisting of various Artificial Intelligence (AI) optimization techniques such as the original Blended Crossover Continuous Ant Colony Optimization (BX-CACO), Continuous domain Ant Colony Optimization (ACO\textsubscript{R}), Evolutionary Programming (EP) and Genetic Algorithm (GA) is carried out on four test
systems like IEEE 14-bus, IEEE 26-bus, IEEE 30-bus and IEEE 57-bus system as tabulated in Table 4.1.

Table 4.1 Performance comparisons on various algorithms

<table>
<thead>
<tr>
<th>Test system</th>
<th>Algorithm</th>
<th>$E$</th>
<th>$t_c$ (minutes)</th>
<th>PS</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 14-bus</td>
<td>HIOPFE-LTMSA</td>
<td>$2.45 \times 10^{-5}$</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>BX-CACO [19]</td>
<td>$3.5 \times 10^{-3}$</td>
<td>3</td>
<td>5</td>
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<tr>
<td></td>
<td>ACO$_R$ [19]</td>
<td>$6.6 \times 10^{-4}$</td>
<td>12</td>
<td>5</td>
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<tr>
<td></td>
<td>EP [19]</td>
<td>$5.0 \times 10^{-3}$</td>
<td>13</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>GA [19]</td>
<td>$3.3 \times 10^{-2}$</td>
<td>12</td>
<td>50</td>
</tr>
<tr>
<td>IEEE 26-bus</td>
<td>HIOPFE-LTMSA</td>
<td>$1.53 \times 10^{-3}$</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>BX-CACO [19]</td>
<td>$2.4 \times 10^{-3}$</td>
<td>20</td>
<td>5</td>
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<tr>
<td></td>
<td>ACO$_R$ [19]</td>
<td>$3.3 \times 10^{-3}$</td>
<td>20</td>
<td>5</td>
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<td>EP [19]</td>
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<td>IEEE 30-bus</td>
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<td>EP [19]</td>
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<td></td>
<td>GA [19]</td>
<td>$4.6 \times 10^{-1}$</td>
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<td>IEEE 57-bus</td>
<td>HIOPFE-LTMSA</td>
<td>$1.3 \times 10^{-2}$</td>
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<td></td>
<td>BX-CACO [19]</td>
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<td></td>
<td>EP [19]</td>
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<td></td>
<td>GA [19]</td>
<td>$5.7 \times 10^{-1}$</td>
<td>240</td>
<td>50</td>
</tr>
</tbody>
</table>

where $E$, $t_c$, and PS are the error in optimal objective function, computation time and population size respectively. The error $E$ is normally calculated the individual generation-demand balance error and it has no unit. The capability
of the proposed hybrid algorithm, HIOPFE-LTMSA in performing the optimization is analyzed in terms of speed of computation and achievement of optimal solution. The computation time is quite high for small test systems, which is taken from [19] for BX-CACO, ACO_R, EP and GA. This is due to the computation of line losses during load tracing of ant colony algorithms whereas EP and GA may fail to converge to global optimal solution. For the proposed hybrid algorithm, computation time is less compared to those conventional algorithms. Figure 4.3 depicts the convergence graphs containing the Error, E versus Computational time, t_c (minutes) for all algorithms applied to IEEE 57-bus system. For plotting such curves, the values of \( \xi \) and \( \alpha \) are 0.95 and 0.01 respectively.

![Convergence graph](image)

**Figure 4.3 Convergence graphs**

Compared to other algorithms, HIOPFE-LTMSA and BX-CACO perform the fastest optimization process for the first three test systems where atmost 30 minutes is required for convergence. But for IEEE 57-bus system, a
significant difference is observed where the resulted computation time is 95 minutes for HIOPFE-LTMSA, which is 50 minutes earlier than BX-CACO and 85 minutes earlier than ACO_R. However, the resulted computation time by EP and GA has larger difference especially for IEEE 30-bus and IEEE 57-bus system, where both of them finish the optimization about an average of 80 minutes after the ant colony algorithms. Such significant difference in computation time is due to the required population size, where only 5 individuals are required by ant colony approaches as compared to EP and GA which require 50 individuals in the population.

4.3.1 Cost Estimation of Practical 75-bus Indian System

For reactive power tracing in practical 75-bus Indian system WFs, it is considered that reactive power from the source is extracted by the individual reactive sinks which consist of generators, transmission lines and load buses. Flow pattern of power is considered as given in the single line diagram shown in Figure A.1 in Appendix.

Elements of the practical 75-bus Indian system in the proposed work are referred from the electricity board. Those elements are 15 generators, 97 transmission lines and 60 load buses representing 400, 220, and 132 KV. The proposed algorithm HIOPFE-LTMSA has been tested on IEEE 14-bus, IEEE 26-bus, IEEE 30-bus and IEEE 57-bus systems to prove faster convergence and reduced error rate when compared to other algorithms namely BX-CACO, ACO_R, EP and GA. Later on, it is compared with other tracing algorithms like Bialek’s and Kirschen’s tracing on practical 75-bus Indian system Wind Farms (WFs) to prove the solution optimality. Figure 4.4 depicts the comparison chart of these tracing algorithms on practical 75-bus Indian system.
From the chart, it is clear that optimal cost of active power is obtained for our proposed hybrid algorithm. Then, this proposed hybrid algorithm is utilized for the estimation of cost of reactive power on practical 75-bus Indian system WFs in an optimal manner.

4.3.1.1 Considerations

Figure A.1 in Appendix shows the 75-bus Indian system WF model divided into 4 zones of which the third zone is selected for cost allocation. Buses 63 and 47 are considered as low and high consumption areas respectively.

4.3.1.2 Tracing

- Reactive power cost to every load bus is fed through cost estimation.
- Cost of the load buses is estimated by calculating the reactive power.
4.3.1.3 Calculation

- Average cost for total buses is calculated in sorted cost path.
- Lower average cost route is selected for low consumption area.
- Higher average cost route is selected for high consumption area.

4.4. RESULTS AND DISCUSSION

For practical 75-bus Indian system WFs, the cost of reactive power in Rs./MVAr is furnished in Table 4.2. This cost can be allocated to various Load Serving Entities (LSEs) according to their utilization of reactive power for system security, constant voltage profile and power factor improvement.

Table 4.2 Reactive power cost estimation using HIOPFE-LTMSA

<table>
<thead>
<tr>
<th>From bus</th>
<th>To bus</th>
<th>Reactive power (MVAr)</th>
<th>Cost (Rs./MVAr)</th>
<th>From bus</th>
<th>To bus</th>
<th>Reactive power (MVAr)</th>
<th>Cost (Rs./MVAr)</th>
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In a way to meet the fair cost allocation to end consumers, reactive power cost of the generation and transmission are fairly allocated to the consumers based on their utilization levels. The reactive power cost is calculated by IOPFE and then traced through TS algorithm for fair allocation. TS algorithm creates Tabu’s list for load tracing. Comparison of 75-bus Indian system results for different methods which indicates clearly that HIOPFE-LTMSA provides better results in providing a near optimal active power pricing compared to other tracing algorithms like Bialek’s Tracing and Kirschen’s Tracing when tested on practical 75-bus Indian System WFs. This methodology can also be applied to estimate the reactive power cost optimally on the same practical 75-bus Indian System WFs.

Figure 4.5 (High consumption cost ranges), Figure 4.6 (Low consumption cost ranges) represents cost ranges of different bus loads of the Tabu’s list.

Based on the levels of reactive power consumption, the cost ranges are allocated as shown in Figures 4.7 and 4.8 (selected cost ranges) which provides the efficient billing for low and high consumption areas respectively.
Thus from overall inspection, it is justified that for even larger transmission grid, the proposed hybrid algorithm meets the demand.

**Figure 4.5**   Available cost ranges for high consumption areas through load bus 47 in practical 75-bus Indian system

**Figure 4.6**   Available cost ranges for low consumption areas through load bus 63 in practical 75-bus Indian system
Figure 4.7 Selected cost ranges for low consumption areas

Figure 4.8 Selected cost ranges for high consumption areas
4.5 SUMMARY

The proposed algorithm HIOPFE-LTMSA when tested on various test systems like IEEE 14-bus, IEEE 26-bus, IEEE 30-bus and IEEE 57-bus systems provide faster convergence and reduced error rate than other algorithms like BX-CACO, ACO_R and so on. Further, when compared with other tracing algorithms like Bialek’s Tracing and Kirschen’s Tracing for active power pricing on all the 15 generators in practical 75-bus Indian system WF's proves the solution optimality. Then estimation of reactive power pricing is performed using the proposed algorithm on the same practical 75-bus Indian system (WFs) in an optimal manner.

Tracing method utilize the net line flow of the electrical network whereas the conventional value based approach use the sensitivity factor. Tracing imposes a higher reactive supply cost to reactive load than sensitivity analysis. Thus, tracing indicates the requirement of improving the lagging load power factor to consumers. It can also find out the amount of line charging supplied to reactive power load. This methodology of reactive power pricing makes the pricing stable since it produces a near optimal solution. It is also observed that the new framework for reactive power pricing is suitable, reliable and flexible for the real-time calculations of price signals.