Abstract—The main aim in the economic dispatch problem is to minimize the total cost of generating power at various stations while satisfying the load and the loss in the transmission system. The economic operation of power system means to schedule the committed generator to meet the load and maintain voltage and frequency within prescribed tolerances and minimize operating cost with higher efficiency without stressing the equipment. This Restructuring and deregulation of the electricity industry is a movement with the aim of achieving lower prices to customers through cost savings. The deregulation of electric power systems in many parts of the world has changed the mechanism of electricity pricing. The evolution of power restructuring and deregulation policies in India needed to be considered to produce full benefits from power utility deregulation. An important possible effect of deregulation may be a reduction in maintenance and in new investments.

Key Words: Economic Operation, integrated power systems, Deregulated Power System

I. INTRODUCTION

Power system is a very large, complex and interconnected network having generation, transmission, distribution and loads. Since loads are far away from generating stations, the electrical energy generated has to be carried over by long transmission lines. The main objective of power system is to provide a reliable power supply with cheapest cost. In order to achieve this, the power system must be monitored, analyzed and controlled at every moment. Optimal placement of Distributed Generation (DG) is necessary for the maximization of reliability and stability in power system.

Distributed power generation is a technology that could help to enable efficient, renewable energy production both in developed and developing world. Distributed generation (DG) is related with the use of small generating units installed at strategic point of electric power system or locations of load centre’s. Distributed generation is an electric power source connected directly to the distribution network or on the customer site of the meter. DG can be used in an isolated way, supplying the customer’s local demand, or integrated into the grid supplying energy to remainder of the electric power system. DG can meet all or part of a customer’s power needs. If connected to a distribution or transmission system, power can be sold to the utility or a third party. The main reasons for the increasingly widespread use of DG can be summed up as follows: [1]

- It may be more economic than running a power line to remote locations.
- It provides primary power, with the utility providing backup and supplemental power.
- It can provide backup during utility system outages, for facilities requiring uninterrupted service.
- It can provide higher power quality for electronic equipment.
- For reactive supply and voltage control of generation by injecting and absorbing reactive power to control grid voltage.
- For network stability in using fast response equipment to maintain a secure transmission system.
- For system black-start to start generation and restore a portion of the utility system without outside support after a system collapse.[1]

As demand of electricity is rising, the grid is being expanded all over the world, in developing and developed countries, to cover the most remote and less populated areas. Nevertheless, there is an increasing interest for stand-alone systems, either for residences that remain off-grid, or for various minor applications in isolated areas. Hybrid power generation systems are becoming very popular for such cases due to advances in renewable energy technologies and high prices of petroleum products. Solar energy is a non-polluting source of alternative energy and solar photovoltaic is proven technology for power generation. In addition, wind power plants are widely utilized in most countries not only for stand-alone applications but also as an important contributor in the power generation sector. In this way the Hybrid Power generation system is more economical for the less populated areas. [4]

II. BASIC CONCEPTS AND DEFINITIONS

A. Maximum Capability of Power Supply Revenue:

The maximum capability of power supply revenue is defined as the maximum revenue generated from electricity sales where the power distribution system is supplying loads continuously at the full level of maximum power supply capability, in a unit of time (usually in a year, 8760 hours). This maximum revenue reflects the potential economic benefits inherent in the distribution system, which can be expressed in equation (1):

$$PA_{max} = S_{N-1} \cos \varphi (1 - \Delta P\%) \tau (P_0 - P_i)$$ (1)

Where, $PA_{max}$ is the maximum capability of power supply revenue of the system; $SN-1$ is the maximum power supply capability of the system, which is determined by the system’s architecture and equipments’ types, and has nothing to do with the actual loads and loads’ characteristics; $\cos \varphi$ is the power factor of the system, which is usually preferable to 0.95 in practical application; $\tau$ is the unit of time, which is preferable to a year that is 8760 hours in application, $\Delta P\%$ is the loss rate of the system $P_0$ is the average selling price of electricity, $P_i$ is the average purchase price of electricity. [5]From (1), it can be improving the system’s maximum power supply capability and reduce the networks’ losses can both bring out potential
economic benefits. Meanwhile, the system’s maximum revenue generated when supplying load in maximum power supply capability, is jointly determined by the selling price and the purchase price of electricity.[5]

B. Utilization Hours of Maximum Power Supply Capability:

The utilization hours of maximum power supply capability is similar with the commonly used annual peak load utilization hours, which is a hypothetical time, refers to a period of time that the system’s loads are operating continuously in full level of the system’s maximum power supply capability. During this period of Time, the electricity consumed equals exactly to the annual consumption of electricity load. Therefore, this period of time can be defined as the maximum power supply capability utilization hours. The relationship between this maximum utilization hours and annual peak load utilization hours can be expressed as equation (2):

\[ T_{(N-1)\text{max}} = \frac{P_{\text{max}}}{S_{N-1} \cos \phi} T_{\text{max}} \]  

(2)

Where, \( T_{(N-1)\text{max}} \) is annual utilization hours of maximum power supply capability, \( P_{\text{max}} \) is yearly peak load of the system, \( T_{\text{max}} \) is the annual peak load utilization hours, \( S_{N-1} \) is the maximum power supply capability of the system, \( \cos \phi \) is the average power factor of the system.[5]

III. PROBLEM FORMULATION

The total active power loss for a radial distribution system with N-1 branches is given by (1)

\[ P_{\text{Loss}} = \sum_{i=1}^{N-1} I_k^2 R_k \]  

(3)

where \( I_k \) and \( R_k \) are the real part of current magnitude and resistance, respectively, of branch k. N is the total number of bus while N-1 is the total number of branches in the system. The branch current can be obtained from the load flow solution. The total power loss in the system is the sum of real power loss and reactive power loss respectively. The objective function is to minimize real power loss of the radial distribution system by injecting real power of DG(PDG) for DG placement subjected to restrain voltages along the radial system within 1 ± 0.05 p.u. and power generation limit i.e. maximum DG size is selected as total load size of the system. The maximum number of DG which can be installed in a DG is also restricted to NDG = 3.[1] This optimization problem is converted to a single objective problem and the mathematical formulation of the problem is expressed as follows:

To minimize: \( f (PDG) = P_{\text{Loss}}[1] \)

Subject to constraints:

1. \[ |V_i| \leq 1 \pm 0.05 \text{ p.u.}, \quad i = 1, 2, 3, \ldots, N \]
2. \[ 0 \leq \text{PDG} \leq P_{\text{load}} \]
3. \[ 0 \leq \text{NDG} \leq 3 \]

IV. RESTRUCTURING OF THE INDIAN POWER SECTOR

In the modern restructured power industry, the role played by generation, transmission and distribution in power sector are independent. Main benefits obtained from restructuring of power system are, cheaper electricity, efficient capacity expansion planning, cost minimization, more choice and better service. Because everyone want the cheaper electricity for their daily use. Electricity reform has been motivated by: technological developments, the need for increased investment, especially in developing countries such like India, high electricity prices and a shift away from the view that electricity supply is a natural monopoly. It is recognized easily that India is not yet ready for electricity restructuring. The first and major restructuring problem is the gap between demand and generation. [2]

- Bridge the gap between power demand and electricity generation
- Decentralize the planning process for an easy entry of generators
- Increase the intrastate transmission lines
- Increase the tariffs incrementally
- Reduce the direct government control
- Establish an independent regulating authority
- Privatize and commercialize the power entities
- Establish a competitive power market

V. POWER SYSTEM MOVING TOWARDS DEREGULATION

Since the mid-1980s the electrical power supply industry around the world has experienced a period of rapid and critical changes, regarding the way electricity is generated, transmitted and distributed. The need for more efficiency in power production and delivery has led to privatization, restructuring and finally deregulation of the power sectors in several countries traditionally under control of federal and state governments. Deregulation is a relatively recent concept, who’s economic, regulatory and implementation structure continues to be adopted to the specific needs of each nation. The need for more efficiency in power production and delivery has led to a restructuring of the power sectors in several countries traditionally under control of federal and state governments. Many countries like England, United States of America, Canada, Australia, New Zealand, Chile, Argentina, Peru, Colombia and Scandinavian are already exercising with deregulated electricity industry. Even some of the developing countries, there have been a strong drive toward deregulation and a more intense participation of privately own third party generation through a wheeling process. Though there are some pitfalls here and there, the end users of the electricity are enjoying the fruits of the deregulated electricity industry tree [2].

The main economical benefits expected from deregulation include improved quality of electricity service by allowing rates and non-interrupted power supply, that more closely track the true cost of service and by differentiating the product quality, for example, offering new products with different degrees of power reliability. Table 1 shown as main Characteristics of modern and traditional regulating approach in deregulated electricity market.[2]

<table>
<thead>
<tr>
<th>Sr No.</th>
<th>Traditional approach</th>
<th>Modern approach</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Dominant individual</td>
<td>Joint responsibility</td>
</tr>
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shown in figure 3. Electrical energy would become a product, which could be bought or sold and transported from one place to another. [2]

C. Deregulated Power System:
The structure components representing various segments of the electricity market are given below. Depending on the structure and regulatory framework, some of these components may be consolidated together, or may be further unbundled. In some Asian countries various regional, state, provincial or independent generators coexist. In these cases the financial and technical interrelationship are murky and are in a process of rapid evolution[5, 6].

Generation companies (Gencos): Gencos are responsible for operating and maintaining generating plants in the generation sector and in most of the cases are the owners of the plants. In some case individual generators do not market their output, but only genco market the output of all its generators. Build operate and transfer (BOT): plant or independent power producers (IPPs) BOT or IPPs can act as its own generator-serving entity and independently market its output to a trading entity or to a load–serving entity. [2]

Transmission companies (Transcos) and transmission owners (TOs): Transcos moves power in bulk quantities from where it is produced to where it is delivered. In most deregulated industry structures, the Transmission companies owns and maintain transmission lines under monopoly franchise and are called Transmission Owners (TOs), but they do not operate them. The independent system operators do that.

Distribution companies (Discos) and retailers: Discos assume the same responsibility on the distribution side as in a traditional regulatory supply utility. However, a trend in deregulation is that DisCos may now be restricted to maintain the distribution network and provide facilities for electricity delivery while retailers are separated from Discos and sell electric energy to end consumers.

Independent system operator (ISO): The ISO is the supreme entity in the control of transmission system. The basic requirement of an ISO is disassociation from all market participants and absence from any financial interest in the generation and distribution business.

Power exchanger (PX): The PX handles the electric power pool, which provides a forum to match electrical energy supply and demand based on bid prices. The time horizon of the pool market may range from half an hour to a week or longer. The most usual is the day-ahead market to facilitate energy trading one day before each operating day.

Scheduling coordinators (SCs): SCs aggregate participants in the energy trade and are free to use protocols that may differ from pool rules. In other words market participants may enter an SC’s market under SC’s rules through bilateral and multilateral transactions.[2]

VI. CONCLUSION
It is evident that the deficit in power availability in India is a significant impediment to the smooth development of the economy. The power market deregulation, introduction of clean energy and increasing of disasters are gradually having major effects on the reliability of electric power systems. Deregulation process primarily focuses on enhancing system efficiency, improving service standards
and developing competitive market. The methodology of the planning for power restructuring is very important.

To make up the insufficiency of traditional methods, an economic evaluation method is proposed for the distribution system considering the N-1 guidelines, which based on the maximum power supply capability under the N-1 criteria. The main achievements are as follows:

1) The concepts of maximum capability of power supply revenue and utilization hours of maximum power supply capability are proposed, in which the fundamental properties of power supply capability and the economic benefit are combined.

2) An economic evaluation method is proposed for the distribution system considering the N-1 guidelines, through which the economic costs of power supplying under certain reliability and certain quality can be valued accurately.

3) A complete economic evaluation index system is also proposed, including static profitability indexes and dynamic investment economic indexes, which provides an effective tool for economic evaluation on the static distribution system and the distribution system planning.

REFERENCES


