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OBJECTIVE BASED INTEGRATED RESOURCE PLANNING: A CASE STUDY OF INDIA

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Abstract—**This paper proposes the various generations planning approach along with the demand side management strategies which when applied in combination with the generation planning approach proposed can result in large saving of energy along with the economical or ecological generation as per the objective of planning. The approach proposed takes availability factors also into consideration by applying upper limit of capacity of a particular plant as per the availability. The proposed approach is also helpful in encouragement of a particular power plant by imposing a lower limit in the capacity of a power plant as the cost component is variable. This approach is can be applied to both grid as well as the distributed generation planning.**

Keywords- DSM, Intregrated resourse planning, energy efficiency.

I. INTRODUCTION

Over the past few decades, many new approaches have been developed for power sector planning, and power companies applied these approaches to their business development. Integrated resource planning (IRP) is one of the methods which are widely adopted by many countries. In IRP approach all the available resources are considered and the resource mix is done in such a way that optimum utilization of resources is achieved.

Limited applications of the IRP were introduced by Swisher et al [1]. Malik and Sumaoy studied local integrated resource planning (LIRP) in the southern Philippines [2]. The researchers calculated the total cost savings of the LIRP and compared the cost of the individual demand-side management programs against the investment of power supply plants. Shrestha and Marpaung used an IRP model to examine the implications of a carbon tax for power sector development, demand-side management programs, and emissions in Indonesia[3].Using the IRP model, Shrestha and Marpaung continued their study on power sector planning, taking into account the carbon dioxide (CO2) emission mitigation constraints [4].

II. ENERGY EFFICIENCY AND DEMAND SIDE MANAGEMENT PROGRAMS (DSM)

There is a very much need to reduce the losses in the developing countries like India this could be achieved by implementing the various energy efficiency and demand side management programs. Demand side management or the load management seeks to reduce the demand and the energy efficiency program reduces the system losses and increases the efficiency of the system. The various steps that could be taken to increase the energy efficiency and reduce the demand can be:-

1. *Improvement in lightening efficiency:* Considerable percentage of the total electricity available is used for the lightening purposes. The lightening consists of florescent lamps, incandescent lamps and the energy efficient lamps. if all the lightening is replaced by the energy efficient lamps considerable amount of energy is saved on account of that.
2. *Electric motors*:**-** Motors consume the maximum percentage of total electricity in a power system. Out of the total motors maximum are the inefficient motor which causes considerable loss. Thus considerable amount of energy is saved by replacing the inefficient motors with the efficient motors.
3. *Transformers*:**-** The maximum energy which goes waste in a power system is basically due to the in efficient transformers. It causes loss in transmission as well as the distribution side basically there are four types of transformers used in a power system they are the S6,S7,S9

and S11 transformers. All the transformers have their importance according to the applications but they are not placed according to the application hence they cause more losses.S6 and S7 transformers are considered as the inefficient transformers while the S9 and S11 are considered to be the efficient transformers. Hence replacing the inefficient S6 and S7 transformers with the efficient S9 and S11 transformers can cause a tremendous energy saving.

III. INDIAN ELECTRICITY SECTOR

India is the world's largest democracy with 1.1 billion inhabitants, and it is one of the developing world's largest consumers of energy. India ranks amongst the top twenty users of commercial energy in the world[5]. In 1991, India embarked on an economic reforms programmed, with a view to integrating its economy with the global economy. The Government of India, since independence in 1947, has been giving priority to the electricity sector, and as a result, India has become the fifth largest country in generation with installed capacity of 2,01,637 MW in April 2012. Along with the growth in installed generation capacity, there has also been a phenomenal increase in the transmission and distribution (T&D) capacity. Bulk transmission[1]has increased from 3708 circuit Kms in 1950 to more than 265,000 circuit Kms in 2007[2].

However, despite these achievements, the power sector has not kept pace with the growth in demand with the result that the country has always faced energy and peaking shortages[6].For example, during 2000-01, total energy shortage was 39,816 million units, i.e., 7.8% and peak shortage was 10,157 MW,i.e., 13% of the peak demand (Mop, 2001). To bridge its future demand–supply gap, India would need capacity addition of nearly 100,000 MW in the coming 10-12 years.

The Ministry of Power (Mop) estimates that the additional capacity requirement to meet these shortages is about 80,000 MW every year. This translates into an investment of about US$10 billion per annum. In this scenario, to fulfill the aim of Indian Government to provide power to all by 2012[3]appears ambitious and practically difficult to achieve. To bridge the gap between investment requirements and available public resources, the active and large-scale participation of the private sector is necessary, and also the current operations of the utilities need to be made efficient to enable internal savings. Both of these factors however required reforms of the electricity sector as a prerequisite.

IV. ANALYSIS APPROACH IN THIS STUDY

To meet the objective of GOI for 80,000 MW capacity additions per year planning is proposed in the above paper. The data used are taken by CEA reports and planning commission of GOI [7],[8], [9]. The per unit operation cost of Renewable Energy Sources (RES) is assumed. Assumption is also made for maximum allowable construction cost; maximum allowable operation cost for 5 years and maximum allowable CO2 emission for is also assumed. The upper and lower limit of capacity is also assumed.

The analysis optimization is done with the help of MATLAB programming. Table 1 shows the construction data and capacity addition of the various plants of India.

TABLE 1: CAPACITY ADDITION AND CAPITAL COSTS

Sector (2009-2-17)	Addition to Installed Capacity (MW)	Cost (Rscrore/MW;$ million/MW
Thermal	63,505	4.15;0.88
Hydro	34,656	4.86;1.03
Nuclear	14,180	6.58;1.40
RES	28,559	4.60;0.98
Total Installed Capacity	140,900	4.66;0.99

SOURCE: CEA (2011) [8]

Four types of power plants are being considered in this study for generation planning: thermal, hydroelectric, nuclear and the renewable energy source (RES) which include the solar power plant, the wind power plant, small hydro power plant

[1] Transmission at more than 132 KV is known as bulk transmission.

[2] The country's transmission perspective plan for tenth and eleventh 5-year plans focus on the creation of a National grid in a phased manner by adding over 60,000 circuit kms of transmission network by 2012. Such an integrated grid shall evacuate additional 1,00,000 MW by the year 2012 and carry 60% of the power generated in the country. The existing inter-regional power transfer capacity is 9,000 MW, which is to be further enhanced to 30,000 MW by 2012 through creation of "Transmission Super Highways". For creation of such a grid, an investment of Rs. 71,000 Crore is envisaged. Out of this, Rs. 50,000 Crore is planned to be mobilised by Powergrid and remaining Rs. 21000 Crore is envisaged through private sector participation [8].

[3] In India as many as 84,754,881 households comprising 44.2% of total households of which 6,664,007 (12.4%) were in urban areas, were still without electricity in 2001[7]

and biomass power station. These four types of power plant that is been considered have their individual benefits and accordingly their capacity is planned as per the objective ofPlanning. There are three objectives of planning that is being considered in the above paper:

1. Minimization of construction cost.
2. Minimization of the operation cost that would occur in 5 years of operation if plant is assumed to run for full capacity all time.
3. Minimization of CO2 emission in 5 years if plant is assumed to run for full capacity.

Construction wise a thermal power plant is most economical, operation cost wise a hydroelectric power plant is most economical, ecological wise only a thermal power plant causes the CO2 emission. These properties of various plants are used to obtain the optimized resource mix through the MATLABoptimizationtool. Along with that some construction cost limit, the operating cost limit for 5 years if plant is assumed to operate for rated capacity although and the CO2 emission limit for 5 years if plant is assumed to operate for rated capacity is applied as constraints. In this way we control these values as per the requirement. Also the upper limit and lower limit of the capacity is fixed accordingly with the resources available and encouragement requirement for a particular power plant respectively. The planning approach is chosen according to the objective of planning.

Abbreviations

Ci=construction cost per MW of ith plant.

Oi=operation cost per MWh of ith plant.

Ei=CO2 emission per MWh of ith plant.

Pi=capacity of ith plant after iteration.

CT=total construction cost.

OT=total operation cost for 5 years if run for full capacity always.

ET=total CO2 emission for 5 years if run for full capacity always.

Om=maximum allowable operation cost for 5 years.

Em=maximum allowable CO2 emission for 5 years.

PLi=lower limit of ith plant capacity.

PUi=upper limit of ith plant capacity.

Mathematical Formulation

Taking total of j types of power plants into consideration

$$C_T = \sum_{i=1}^{i=j} C_i * P_i$$

$$O_T = \sum_{i=1}^{i=j} (O_i * P_i) * 5 * 8760$$

$$E_T = \sum_{i=1}^{i=j} (E_i * P_i) * 5 * 8760$$

1) *Planning by minimization of construction cost.*

Objective function

f = min (CT)

Subjected to constraints

OT $\leq$ Om

ET $\leq$ Em

PLi $\leq$ Pi $\leq$ PUi

2) *Planning by minimization of operation cost for 5 years if plant is assumed to run for full capacity all time.*

Objective function

f = min (OT)

subjected to constraints

CT $\leq$ Cm

ET $\leq$ Em

PLi $\leq$ Pi $\leq$ PUi

3) *Planning by minimization of CO2 emission for 5 years if plant is assumed to run for full capacity.*

Objective function

f = min (ET)

subjected to constraints

CT $\leq$ Cm

OT $\leq$ Om

PLi $\leq$ Pi $\leq$ PUi

V. RESULTS

After running MATLAB optimization tool following results were obtained for the three cases:

s.no.	Capacity obtained using different approaches	P Thermal	P Hydro	P Nuclear	P RES	cost
1	1st approach	45662 MW	15338MW	4000 MW	15000MW	construction cost of Rs359360 crore
2	2nd approach	31000 MW	30000 MW	4000 MW	15000MW	operation cost for 5 year is Rs 92540 crore
3	3rd approach	25000 MW	30000 MW	10000 MW	15000MW	

1) The capacity obtained using 1st approach is PThermal=45662 MW,PHydro=15338MW,PNuclear=4000 MW and PRES=15000MW with the construction cost of Rs359360 crore.

2) The capacity obtained by 2nd approach is PThermal=31000 MW, PHydro=30000 MW, PNuclear=4000 MW and PRES=15000MW with the operation cost for 5 year is Rs 92540 crore.

3) The capacity obtained by 3rd approach is PThermal=25000 MW, PHydro=30000 MW, PNuclear=10000 MW and PRES=15000MW with the CO2 emission for 5 year obtained is 7.1175e+008 tCO2.

VI. Conclusion

The three approaches illustrated in this paper can be utilized for various different types of objective it proves helpful in planning the power system economically.The planning of the construction of plant will take care of availability factor and also controls the costs as well as CO_2 emission hence proves very helpful to plan clean and economical generation.

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