ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2014

Enhancement of Available Transfer Capability Using Facts Devices and Evaluation of Economics of Operating De-Regulated Power Systems

J. Namratha Manohar[1], J.Amarnath[2]

Research Scholar, Department of Electrical and Electronics Engineering, JNTU, Hyderabad, India[1]

Professor, Department of Electrical and Electronics Engineering, JNTU, Hyderabad, India[2]

ABSTRACT: The paper presents the implementation of Thyristor Controlled Series Compensator Flexible Alternating Current Transmission System Device, for optimizing the Available Transfer Capability. The goal of the optimization is to find the best location of a given number of FACTS devices for loss minimization.The successful application of a device in a power system requires considering not only the Technical Feasibility but also the economical feasibility. IEEE 30-Bus Test Power System has been considered for the study. The Technical Objective of the study is Reduction of Losses by implementing TCSC FACTS device, and the Economical Objective is determining the Cost-Benefit of applying TCSC.

Keywords: Thyristor Controlled Series Compensator, Flexible Alternating Current Transmission System, Technical Objective, Economical Objective, Cost - Benefit.

I. INTRODUCTION

The growth in demand for electric power, restructuring of Electric Power industry, diverse methods of Electric Power Generation, Transmission and Distribution and the Competitive market demands[1] systematic approaches for effective and efficient management of Electric Power System. The Objective of Managing Electric Power System is i) framed in view of the present perspective and the future, with basis drawn from the past history of its performance, ii) the Objectives are classified into two major categories to meet the growing demand of Electric power in terms of Quantity and Quality. The first category of Objective is Technical Objective and the second category is Economic and Financial Objective. The Technical objective is to provide Electric Power continuously at the rated voltage and frequency at all time to all customers. To Optimize the Technical Objective several sub-optimal objectives are framed depending upon several factors such as the type of loads to be served and the socio economic factors. Some of the sub-optimal objectives are enhancing the Available Transfer Capability (ATC), increase in line flow on the transmission lines and reduction of losses.

According to the report of NERC (1995) [2], transfer capability refers to the ability of transmission systems to reliably transfer power from one area to another over all transmission paths between those areas under given system conditions. The mathematical definition of ATC given in the report of NERC (1996) [3] is ‘ . . . *the Total Transfer Capability (TTC) less the Transmission Reliability Margin (TRM), less the sum of existing transmission commitments and the Capacity Benefit Margin (CBM)*’:

$$\text{ATC} = \text{TTC} - \text{TRM} - \text{existing transmission commitments (including CBM)}. \qquad (1.0)$$

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2014

TTC refers to the maximum amount of electric power that can be transferred over transmission systems without violating system security constraints. The accuracy of the ATC calculation is highly dependent on the accuracy of available network data, load forecast, and the estimation of future energy transactions.

FACTS is defined by the IEEE as "a power electronic based system and other static equipment that provide control of one or more AC transmission system parameters to enhance controllability and increase power transfer capability."[4] FACTS Technology consists of electronic based equipment with real time operating control. Research studies are widely being conducted to decide on the technical aspects of FACTS such as location, size and the number of FACTS devices to be installed in a power system for its performance optimization.

The implementation of any system or device involves finance. System Planners have to consider a variety of options and they have to take decisions based on technical and cost consideration.

The paper aims to conduct studies with the i) technical objective of determining the optimal location of the FACTS devices for reduction of losses and enhancement of Available Transfer Capability and ii)the economic objective of determining the cost of investment for the FACTS device.

The remainder of the paper is organized as follows: Section II Related Work, Section III Available Transfer Capability, Section IV FACTS Devices, Section V Mathematical Modeling of TCSC FACTS Device, Section VI Proposed Approach, Section VII Case Study, Section VIII Results and Discussion, Section IX Conclusions.

II. RELATED WORK

Several studies have been conducted for fast, accurate determination of Available Transfer Capability and enhancement by application of FACTS Devices. Placement of FACTS Devices is an important factor for optimizing the performance of the Power System. For transmission networks, one of the major consequences of the non-discriminatory open-access requirement is a substantial increase of power transfers, which demand adequate available transfer capability (ATC) to ensure all transactions are economical. In this paper, report is presented on the study conducted for enhancement of ATC with the objective of minimizing active power transmission losses and use of TCSC FACTS device. Researchers have proposed the computation of ATC using AC power transfer distribution factors (ACPTDF) [5]-[7]. New methods of evaluating ATC in a competitive environment are proposed in previous research [8], [9]. Manikandan et.al. [1] have adopted Particle swarm optimization (PSO) algorithm to obtain the optimal settings of FACTS devices. The installation cost is also calculated. The study had been carried out on IEEE 30 bus and IEEE 118 bus systems for the selected bilateral, multilateral and area wise transactions and determined that there is considerable boost in ATC with FACTS Devices. Jigar S.Sarda et. al. [10] have presented a novel method for optimal location of FACTS devices in a multi machine power system using Genetic Algorithm(GA).Using the proposed method, the location of FACTS controllers, their type and rated values were optimized simultaneously. The proposed algorithm has been applied to IEEE-30 bus system and results proved that there is considerable decrease in losses and increase in power flow.

III. AVAILABLE TRANSFER CAPABILITY (ATC)

The maximum power that can be transferred from one area to another area is called transfer capability[11]. In 1996, North American Electric Reliability Council (NERC) established a framework for Available Transfer Capability (ATC) definition and evaluation. According to the NERC definition, ATC is the transfer capability remaining between two points above and beyond already committed uses (NERC, 1996). The ATC value between two points is given as:

$$ATC = TTC - TRM - CBM - ETC \qquad (1)$$

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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Vol. 3, Issue 1, January 2014

Where TTC is total transfer capability, TRM is transmission reliability margin, CBM is capacity benefit margin and ETC is existing transmission commitment including customer services between the same two points.

According to the NERC definition in Equation 1, utilities would have to determine adequately their ATCs to ensure that system reliability is maintained while serving a wide range of transmission transactions. ATC must be calculated, updated and reported continuously to Load Servicing Entities(LSE) in normal and contingency situation. The ATC calculation must cove all below principles:

1. Provide the logical and reliable indication of transfer capability.
2. Identification time-variant conditions, synchronous power transfers, and parallel flows.
3. Considering the dependence on points of injection / extraction.
4. Considering regional coordination.
5. Covering the NERC and other organizational system reliability criteria and guides.
6. Coordinate reasonable uncertainties in transmission system conditions and provide flexibility.

Operating studies commonly seek to determine limitations due to the following types of problems:
1. Thermal overloads Limitation
2. Voltage stability Limitation
3. Voltage limitation
4. Power generated Limitation
5. Reactive power generated Limitation
6. Load Power Limitation

IV. FACTS DEVICES

Flexible AC Transmission System (FACTS)[12][13] incorporates power electronic-based and other static Controllers to enhance controllability and increase power transfer capability. The significance of power electronics and other static Controllers is that they have high speed response and there is no limit to the number of operations. FACTS Controllers can dynamically control line impedance, line voltage and active and reactive power flow. They can absorb or supply reactive power and with storage they can supply and absorb active power as well. FACTS technology allows practically complete utilisation of the capacity of transmission elements up to their limits and provides different kinds of devices which could redirect the power in real-time. FACTS Devices are classified in three ways:
1. Based on Technology as First Generation and Second Generation
2. Based on the way of connecting to the ac power system as Seris and Shunt
3.Basedd on the Parameter they control
These classifications are independent, existing for example, devices of a group of the first classification that can belong to various groups of the second classification.

Table I lists the several types of FACTS device models.. [14]. The application of the various FACTS devices as a solution for the corrective action of the problems that arise in a Power System are furnished in Table II.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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Vol. 3, Issue 1, January 2014

TABLE I
TYPES OF FACTS DEVICE MODELS

Type Designation	Parameter Controlled	FACTS Devices
Type A	Series P and Q	UPFC
Type B	Series P	TCSC ,Phase Angle Regulator
Type C	Series Q	SVC,STATCOM

SVC = Static Var Compensator
STATCOM = Static Compensator
TCSC = Thyristor Controlled Series Capacitor
UPFC = Unified Power Flow Controller

BENEFITS OF UTILIZING FACTS DEVICES

· Better utilization of existing transmission system assets
· Increased transmission system reliability and availability
· Increased dynamic and transient grid stability and reduction of loop flows
· Increased quality of supply for sensitive industries
· Environmental benefits

TABLE II. STEADY STATE APPLICATIONS OF FACTS

Issue	Problem	Corrective Action	Conventional solution	FACTS device
Voltage limits	Low voltage at heavy Load.	Supply reactive power	Shunt capacitor, Series capacitor	SVC, TCSC, STATCOM
	High voltage at light Load.	Remove reactive power supply	Switch EHV line and/or shunt capacitor	SVC, TCSC, STATCOM
		Absorb reactive power	Switch shunt capacitor, shunt reactor	SVC, STATCOM
	High voltage following outage	Absorb reactive power	Add shunt reactor	SVC, STATCOM
		Protect equipment	Add arrestor	SVC
	Low voltage following outage	Supply reactive power	Switch shunt capacitor, reactor, series capacitor	SVC,STATCOM
		Prevent overload.	Series reactor, PAR	TCPAR,TCSC
	Low voltage and overload	Supply reactive power and limit overload	Combination of two or more devices	TCSC,UPFC,STATCOM,SVC
Thermal limits	Line or transformer Add line or transformer overload	Reduce overload	Add line or transformer	TCSC,UPFC,TCPAR
	Tripping of parallel		Add series reactor	SVC,TCSC

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ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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	circuit (line)			
		Limit circuit (line) Loading		UPFC,TCSC
Loop flows	Parallel line load sharing	Adjust series reactance	Add series capacitor/reactor	UPFC,TCSC
		Adjust phase angle	Add PAR	TCPAR,UPFC
	Post-fault sharing	Rearrange network or use “Thermal limit” actions	PAR, Series Capacitor/Reactor	TCSC,UPFC,SVC,TCPAR
	Flow direction reversal	Adjust phase angle	PAR	TCPAR,UPFC
Short circuit levels	Excessive breaker fault current	Limit short circuit current	Add series reactor, new circuit breaker	SCCL,UPFC,TCSC
		Change circuit breaker	Add new circuit breaker	
		Rearrange network	Split bus	
Subsynchronous resonance	Potential turbine /generator shaft damage	Mitigate oscillations	series compensation	TCSC

SCCL = Super-Conducting Current Limiter
TCPAR = Thyristor Controlled Phase-Angle Regulator

V. Mathematical Modeling of TCSC FACTS Device

TCSC controllers use thyristor-controlled reactor (TCR) in parallel with capacitor segments of series capacitor bank. TCSC, the first generation of FACTS, can control the line impedance through the introduction of a thyristor controlled capacitor in series with the transmission line. A TCSC is a series controlled capacitive reactance that can provide continuous control of power on the ac line over a wide range. The functioning of TCSC can be comprehended by analyzing the behavior of a variable inductor connected in series with a fixed capacitor. TCSC is an effective and economical means of solving problems of transient stability, dynamic stability, steady state stability and voltage stability in long transmission lines.

For static applications, FACTS devices can be modeled by Power Injection Model (PIM) [15]. The injection model describes the FACTS as a device that injects a certain amount of active and reactive power to a node, so that the FACTS device is represented as PQ elements. The PIM doesn’t destroy the symmetrical Characteristic of the admittance matrix and allows efficient and convenient integration of FACTS devices in to existing power system analytical tools. This is the main advantage of PIM.

During the steady state condition, the TCSC can act as capacitive or inductive mode, respectively to decrease or increase the impedance of branch. The TCSC is modeled with variable series reactance. Its value is function[16] of the reactance of line, X_L , where the device is located. The upper and lower limit of TCSC reactance is given in equation (2).

$$0.8\, X_L \leq X \leq 0.2\, X_L \qquad (2)$$

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
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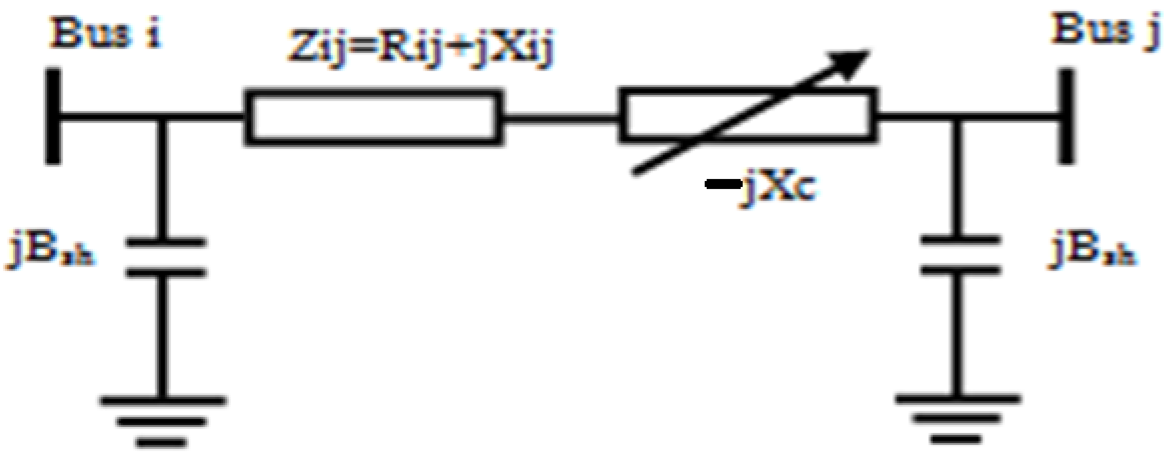

Fig. I. Single line diagram of compensated transmission line

In Fig ., it shows the model of transmission line with TCSC connected between buses *i* and *j*. The transmission line is represented by its lumped π equivalent parameters connected between the two buses and TCSC as a variable reactance.

VI. PROPOSED APPROACH

The proposed methodology to study the enhancement of Available Transfer Capability using FACTS Devices and study the economics of FACTS has two stages:

Stage 1: Technical Objective Stage
Stage 2: Economic Analysis Stage

VI.1 Technical Objective Stage

The Technical Objective is determining the Optimal Location of FACTS device for real power loss reduction and thereby enhance the Available Transfer Capability of the Power System. The Objective for placement of the FACTS device is reduction of real power losses[17][18]. The criteria for placement of FACTS device is the lines with maximum Active Power(MW) loss[19]. Mathematically stating :

Objective function:
Minimize $\sum P_{Li}$ (3)

Where P_{Li} = Power Loss on Line i: **i = 1…n** **And 'n' is the no. of lines**

While solving the optimization problem, power balance equations are taken as equality constraints. The power balance equations are given by,

$$\sum P_G = \sum P_D + \sum P_{Li} \,.. \qquad (4)$$

Where $\sum P_G$ = Total power generation
$\sum P_D$ = Total power demand
$\sum P_{Li}$ = Total power loss

The power flow equations are:

$$P_k = \sum_{j=1}^{N} |V_k||V_j|\left(G_{kj}\cos(\theta_k - \theta_j) + B_{kj}\sin(\theta_k - \theta_j)\right) \quad (5)$$

$$Q_k = \sum_{j=1}^{N} |V_k||V_j|\left(G_{kj}\sin(\theta_k - \theta_j) - B_{kj}\cos(\theta_k - \theta_j)\right) \quad (6)$$

Where
P_k = Real power injected at bus k
Q_k = Reactive power injected at bus k
Θ_k, Θ_j = Phase angles at buses k and j respectively;
V_k , V_j = Voltage magnitudes at bus k and j respectively;
G_{kj}, B_{kj} = Elements of Y-bus matrix

VI.2 Economic Objective Stage

The Objective of Economic Analysis is to determine the cost of TCSC FACTS devices. The range of cost of major FACTS devices is presented in Siemens AG Database [20]. Based on this, a polynomial cost function of FACTS devices is derived and used for FACTS allocation study as used in [21][22]. The cost function of TCSC is given by equation (7).

$$C_{TCSC} = 0.0015S^2 - 0.7130S + 153.75 \quad (7)$$

where C_{TCSC} is the cost of TCSC in US$ / KVar and S is the operating range of TCSC in MVAr. and Annual capital cost of FACTS in US$/year can be found as:

$$C^A_{TCSC} = C_{TCSC} \times S \times 1000 \times r(1+r)^n / ((1+r)^n - 1) \quad (8)$$

$$\text{Where } S = |Q2| - |Q1| \quad (9)$$

and Q_2 and Q_1 are the reactive power flow in the line after and before installing FACTS device in MVAR respectively.

The cost of TCSC for different operating ranges' of TCSC has been computed as per equation 7.The Range selected is from 5MVAr to 750MVAr. The range has been categorized into two groups:

Low Operating Range : 5MVAr to 95MVAr
High Operating Range : 100MVAr to 750MVAr

The graphs of 'TCSC Operating Range Vs Cost of TCSC in US$/KVAr for the Low Operating Range is Figure II and for the High Operating range is Figure III. It can be seen from the graph that the Optimum Operating range of TCSC is between 225MVAr – 275MVAr.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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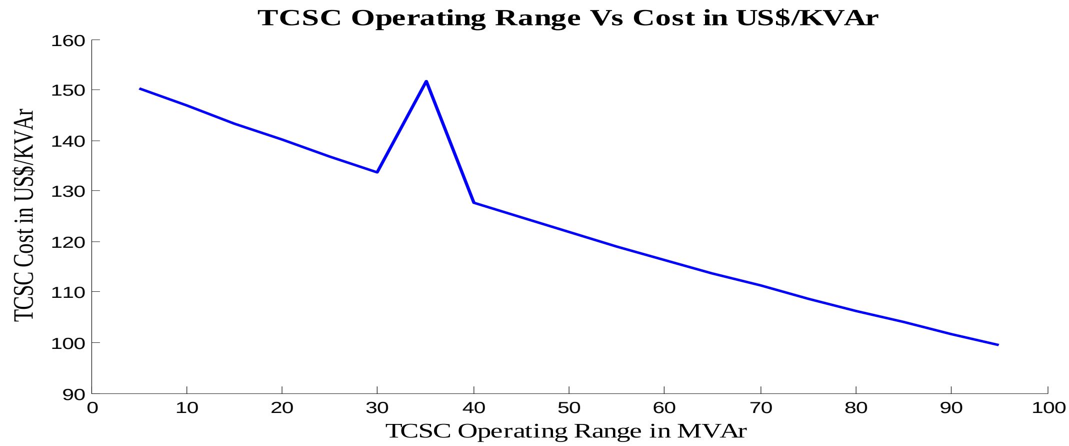

Fig. II. TCSC Low Operating Range Vs Cost

In Fig. II, it shows the graph of the TCSC Operating Range Vs Cost in US$/KVAR. This graph is for low operating range upto 95MVAr.

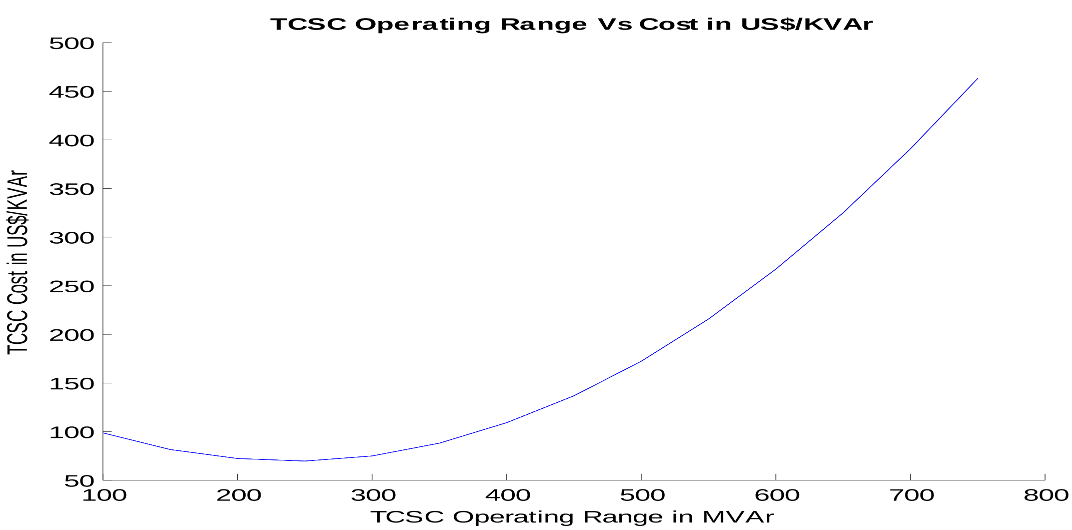

Figure III. TCSC High Operating Range Vs Cost

In Fig. III, it shows the graph of the TCSC Operating Range Vs Cost in US$/KVAR. This graph is for high operating range from above 95MVAr to 750MVAr..

VII. CASE STUDY

VII.1 Stage 1: Technical Analysis

The proposed approach is applied to the IEEE 30BusTest System. The steps of the study are:
1. Prepare the One-Line Diagram of the System for study.
The One-Line Diagram of the 30 Bus System is shown in Figure IV. The System Parameters are furnished in Table III.
2. Run the Base Case Optimal Power Flow(OPF) Algorithm to obtain the Base Case Results.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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3. From the Base Case Results determine the Branches with maximum Real Power Losses. In this Case Study the five branches identified are between buses 1-3,2-4,2-6,24-25 and 25-27 which are having maximum MW loss.
4. TCSC is placed in these lines. OPF is executed after placement of TCSC. Table IV gives the losses on the lines before and after placing TCSC FACTS devices in the selected lines of step 3.
5. The results obtained without placing of TCSC and after placing of TCSC are compared and analyzed. The analysis of the results reveals a reduction of real power loss of 9.4% with TCSC.

Figure V depicts the Losses in all the lines of 30-Bus Test System Before and After placing TCSC.

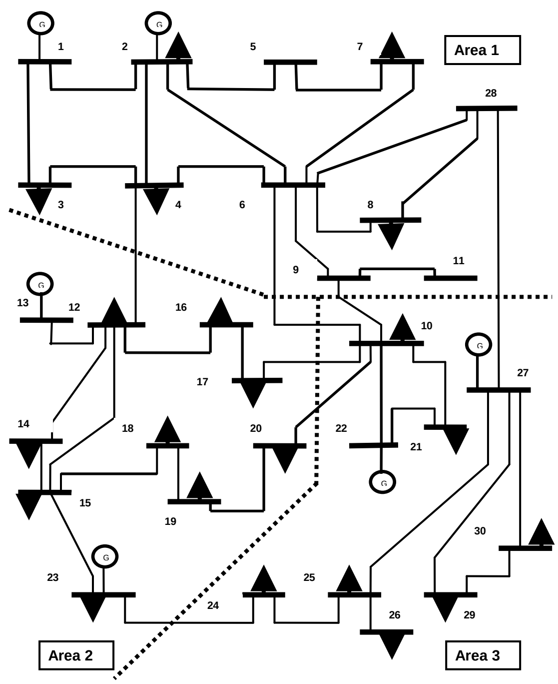

Fig. IV. IEEE 30Bus Test system

In Fig. IV, it shows the One Line Diagram of the IEEE 30 Bus Test System. The One Line diagram is the graphical representation of the electric power system which shows the interconnection of the buses with the transmission lines called branches, and the generators and loads at the various buses.

TABLE III
IEEE 30 – BUS TEST SYSTEM PARAMETERS

Parameter	Quantity
No. of Buses	30
No. of generators	6

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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No. of Loads	20
No. of Branches	41
No. of Areas	3

VII.2 Stage 2: Economic Analysis Stage of Case Study

In the Technical Analysis Stage the size, number and the Location of TCSC has been determined. In the second stage, which is the Economic Analysis Stage the cost of TCSC is calculated from equation 6, 7 and 8. The Reactive Power on the lines where TCSC is placed is determined for the system with TCSC(Q_1) and without TCSC(Q_2). The valus of S is computed and applied in equation 6 to determine the cost of TCSC. The Annual Cost of TCSC is computed by equation 7.

The details of the Cost computations are Tabled in Table V.

Table IV - 30 Bus Loss on Lines Before and After Placing TCSC FACTS Devices

Line No.	From Bus	To Bus	Active Power Loss(W)	
			Without TCSC	With TCSC
1	1	2	92	96
2	1	3	220	207
3	2	4	232	284
4	3	4	35	32
5	2	5	108	151
6	2	6	300	183
7	4	6	36	43
8	5	7	109	153
39	6	7	49	31
10	6	8	108	106
11	6	9	0	0
12	6	10	0	0
13	9	11	0	0
14	9	10	0	0
15	4	12	0	0
16	12	13	0	0
17	12	14	30	33
18	12	15	32	40
19	12	16	47	45
20	14	15	6	4
21	16	17	10	9
22	15	18	71	68
23	18	19	14	13
24	19	20	10	10
25	10	20	58	60
26	10	17	18	18
27	10	21	46	25
28	10	22	67	44
29	21	22	99	82
30	15	23	124	101

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31	22	24	31	13
32	23	24	12	16
33	24	25	235	143
34	25	26	42	42
35	25	27	246	176
36	28	27	0	0
37	27	29	78	78
38	27	30	149	149
39	29	30	30	30
40	8	28	69	66
41	6	28	47	40

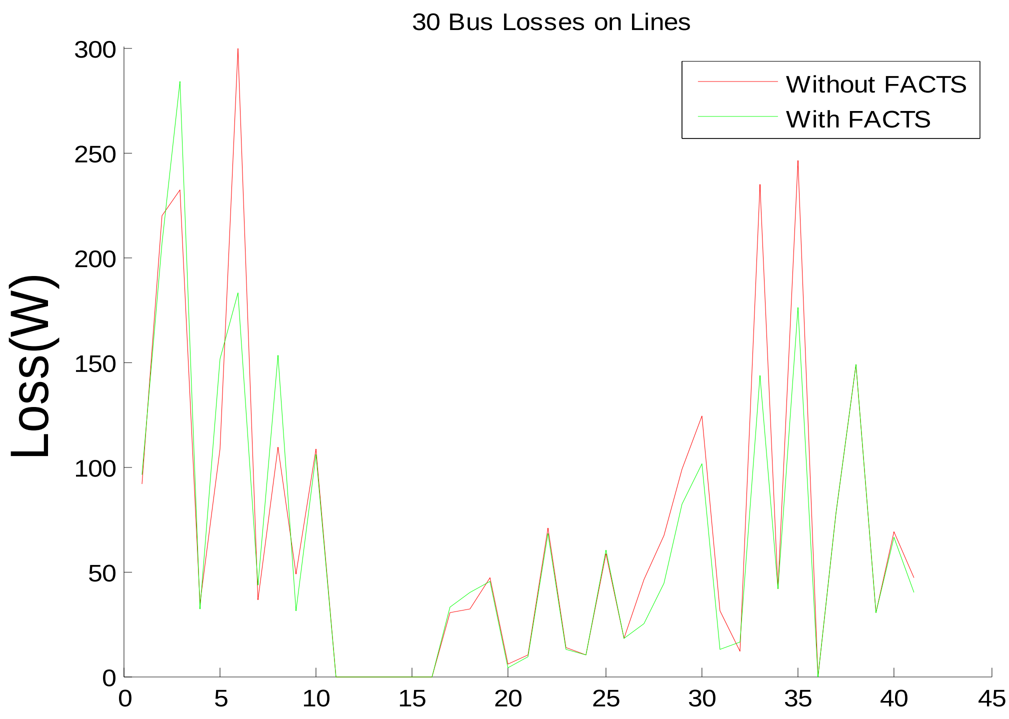

FIGURE V IEEE 30 – BUS LOSSES WITH AND WITHOUT TCSC

In the Fig. V, it shows the graph of Losses on the branches of IEEE 30 – Bus Electric Power System in Watts, without FACTS Device and with FACTS Device. There are 41 branches in the System. A branch is a transmission line interconnecting two buses. The X-Axis indicates the branch number and the Y-Axis the corresponding Losss in Watts on the branch. The graph in Red is the graph without FACTS Device and the graph in Green with FACTS Device. It is observed from the graph that there is a decrease in Losses with FACTS Device.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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TABLE V
COST COMPUTAION OF TCSC FACTS DEVICES

Parameter	Value
Optimum size of TCSC (MVar)	5
Capital cost of TCSC (USmillion$/kVar) perUnit	0.155
Total capital cost of TCSC (USmillion$) per unit	0.775
Discount rate (%)	10
No. of Units	5
Project evaluation period (years)	5
Annual capital cost of TCSC (US$ million) (5 Units)	1.02

The total Cost of the five TCSC placed has been determined to be 0.77million dollars / MVAr.

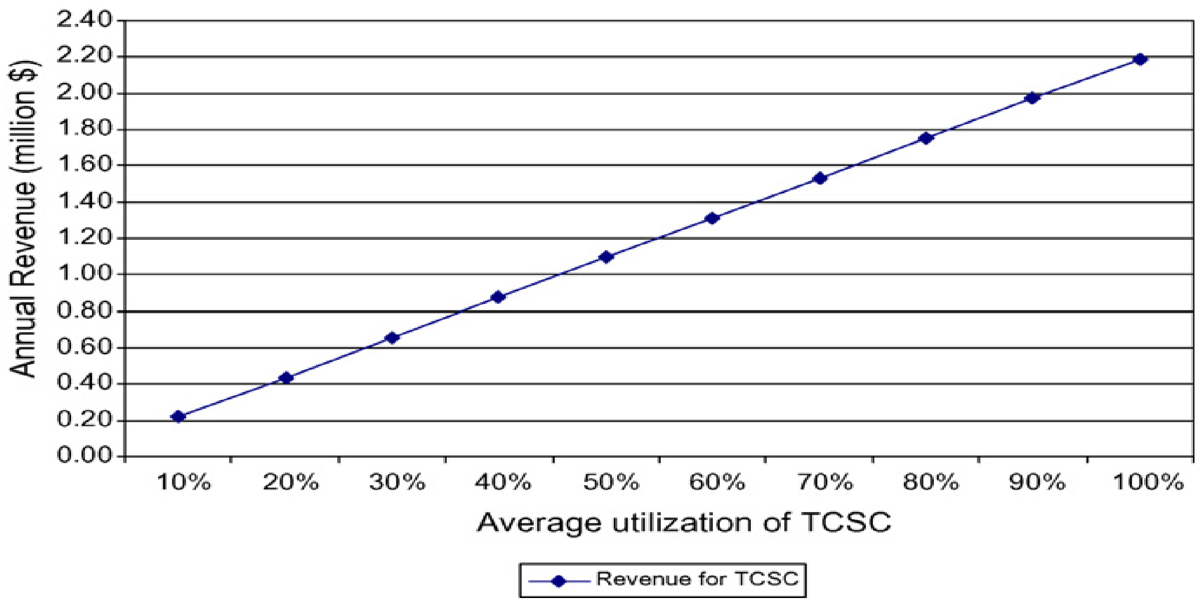

Figure VI. Annual revenue at different TCSC utilization factor

In Figure VI, it shows the change in annual revenue generated for TCSC investment recovery, when average utilization of TCSC is changed. From Figure VI it can be clearly determined that for the 30 Bus system under study, the investment on five TCSC units can be realized in 5 years with about 45% utilization. The same amount considering 10years of evaluation period can be realized with even 28% utilization.

VIII. Results and Discussion

30 Bus Test system was considered for the study. The Technical Objective results obtained show the reduction of losses with TCSC. The economic analysis has shown the investment cost of TCSC and its realization rate.

IX. CONCLUSIONS

FACTS devices have proved an effective method for Loss reduction. The effectiveness of TCSC is demonstrated on 30 – Bus IEEE Power Systems. The main conclusions of the paper are: i) The time of convergence is less. ii) The placement of Facts devices mitigates real power loss. iii) The simple and direct method of placing TCSC in the lines having maximum power loss has shown effective results in loss reductio. iv) TCSC Facts devices have proven Technical and Economical benefits**.**

REFERENCES

[1] B.V. Manikandan, S. Charles Raja, and P. Venkatesh, "Available Transfer Capability Enhancement with FACTS Devices in the Deregulated Electricity Market", *Journal of Electrical Engineering & Technology Vol. 6, No. 1, pp. 14~24, 2011* DOI: 10.5370/JEET.2011.6.1.014.
[2] A Reference Document for Calculating and Reporting the Electric Power Transfer Capability of Interconnected Power Systems, NERC, 1995.

[3] North American Electric Reliability Council (1996) Available Transfer Capability Definitions and Determination. Princeton, NJ: NERC.
[4] Proposed terms and definitions for flexible AC transmission system(FACTS), IEEE Transactions on Power Delivery, Volume 12, Issue 4, October 1997, pp. 1848–1853. doi: 10.1109/61.634216.
[5] J.Weber, "Efficient Available Transfer Capability Analysis using Linear methods", *PSERC internet seminar*, UL, USA, Nov 7, 2000.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2014

[6]A.Kumar and S.C. Srivatsava, "AC Power Distribution Factors for allocating Power transactions in a deregulated environment", *IEEE Power Engineering Review*, pp. 42-43, 2002.
[7] A. Kumar, S.C. Srivatsava and S.N.Singh, "ATC determination in a competitive electricity market using AC Distribution Factors", *Electrical Power components and Systems*, Vol. 32, No. 9, pp. 927-939, 2004.
[8] A.M. Leite da silva, J.G.C. Costa, L.A.F. Manso and G.J. Anders, "Evaluation of transfer capabilities of transmission systems in competitive environments", *Electrical Power and Energy systems*, Vol. 26, No. 4, pp. 257-263, 2004.
[9] M.M Othman, A. Mohamed and A. Hussain, "Fast Evaluation of Available Transfer Capability using Cubic-spline interpolation technique", *Electric Power systems research*, Vol. 73, No. 3, pp. 335-342, 2005.
[10] Jigar S.Sarda, Vibha N.Parmar, Dhaval G.Patel, Lalit K.Patel, "Genetic Algorithm Approach for Optimal location of FACTS devices to improve system loadability,and minimization of losses", *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, ISSN 2278 – 8875, *Vol. 1, Issue 3, September 2012*
[11] Mojgan Hojabri and Hashim Hizam, "Available Transfer Capability Calculation ", Universiti Putra Malaysia, Applications of MATLAB in Science and Engineering , www.intechopen.com.
[12] Narain G. Hingorani, Life Fellow, IEEE,"FACTS Technology – State of the Art, Current Challenges and the Future Prospects", 1-4244-1298-6/07/$25.00 ©2007 IEEE.
[13] N. G. Hingorani and L. Gyugyi, "Understanding FACTS Concepts and Technology of Flexible AC Transmission Systems, IEEE Press".
[14] K.Vijayakumar, SRM University, Kattankulathur, Chennai, "Optimal Location of FACTS Devices for Congestion Management in Deregulated Power Systems", International Journal of Computer Applications (0975 – 8887), Volume 16– No.6, February 2011.
[15] Nadaraj10ah Mithulananthan , Naresh Acharya, "A proposal for investment recovery of FACTS devices in deregulated electricity markets", Electric Power Systems Research 77 (2007) 695–703.
[16] Abouzar Samimi, Peyman Naderi, " A New Method for Optimal Placement of *TCSC* Based on Sensitivity Analysis for Congestion Management", Scientific Research, Smart Grid and Renewable Energy, 2012, 3, 10-16, http://dx.doi.org/10.4236/sgre.2012.31002 Published Online February 2012 (http://www.SciRP.org/journal/sgre)
[17]J.Namratha Manohar, J. Amarnath, P.C. Rao, "Optimization of Loss Minimization Using FACTS in Deregulated Power Systems", Innovative Systems Design and Engineering www.iiste.org, ISSN 2222-1727 (Paper) ISSN 2222-2871 (Online), Vol 3, No 3, 2012.
[18] N.M. Tabatabaei, Gh. Aghajani, N.S. Boushehri, S. Shoarinejad ," Optimal Location Of FACTS Devices Using Adaptive Particle Swarm Optimization Mixed With Simulated Annealing", ISSN 2077-3528 IJTPE Journal www.iotpe.com ijtpe@iotpe.com June 2011 Issue 7 Volume 3 Number 2 Pages 60-70
[19] Jigar S.Sarda, Vibha N.Parmar,, Dhaval G.Patel, , Lalit K.Patel, "Genetic Algorithm Approach for Optimal location of FACTS devices to improve system loadability and minimization of losses", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 1, Issue 3, September 2012, ISSN 2278 – 8875, http://www.ijareeie.com/upload/september/2_Genetic%20Algorithm%20Approach%20for.pdf
[20] K. Habur, D. O'Leans, "FACTS-flexible alternating current transmission systems: for cost effective and reliable transmission of electrical energy", available at www.worldbank.org/html/fpd/em/transmission/facts siemens.pdf.
[21]L.J. Cai, I. Erlich, G. Stamtsis, "Optimal choice and allocation of FACTS devices in deregulated electricity market using genetic algorithm", in: IEEE PES Power System Conference and Exposition, New York, USA, October 10–13, 2004.
[22] A. B.Bhattacharyya, B. S.K.Goswami, "OPTIMAL Placement of FACTS Devices by Genetic Algorithm for the Increased Load Ability of a Power System", World Academy of Science, Engineering and Technology 75 2011.

BIOGRAPHY

J. Namratha Manohar has acquired her B.E Degree in Electrical Engineering from Osmania University in the year 1982, MCA from IGNOU in the year 2004; M.Tech from IASE in the year 2006.She is presently a Research Student in the Department of Electrical and Electronics Engineering at J.N.T.U, Hyderabad. Her research areas include Power System, Performance Optimization. She has published about 10 papers.

J. Amarnath has acquired his B.E Degree in Electrical Engineering from Osmania University in the year 1982, M.E from Andhra University in the year 1984 and Ph.D from J.N.T. University, Hyderabad in the year 2001. He is presently Professor in the Department of Electrical and Electronics Engineering, JNTU College of Engineering, Hyderabad, India. He presented more than 120 research papers in various national and international conferences and journals. His research areas include Gas Insulated Substations, High Voltage Engineering, Power Systems and Electrical Drives.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2014