Rural Feeder Segregation Plan in India: A Case Study using Loss Minimization and Power Factor Correction Method

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***Abstract*— The share of agriculture in total electricity consumption was 23% in 2011, while revenues from agriculture were only 7% of the total. This needs urgent attention. One way is to do the segregation of agricultural load. This paper attempts to formulate a loss minimization scheme that will be applicable to a segregated non-agricultural feeder and can be served as a collateral program. In the above paper method has been proposed based on conservation voltage reduction (CVR) along with optimal capacitor placement (OCP). To encourage the states to align towards Forum of Regulator road map, a cost-benefit analysis has been performed ensuring a huge financial gain by the utilities within a planning period of 10 years. The method is suggested for rural intensive Indian states.**

Keywords— Conservation voltage reduction (CVR), feeder segregation plan (FSP), loss sensitivity factor (LSF), maximum loading index (MLI), optimal capacitor placement (OCP).

I. INTRODUCTION

Government of India is working for separate electricity infrastructure for rural agriculture and non-agriculture power consumers since 1996 but this has been effectively implemented since 2013. The main motivation for implementing feeder segregation scheme in India is to gain accountability in the subsidy provided to agricultural consumers. Other key objectives includes: providing 24x7 three phase supply to rural consumers, improved load management through a better ability to regulate supply to agricultural customers, reducing line losses and improved management of environmental resources through husbanding ground water resources.

Today, almost all agriculture intensive states subsidize electricity to agricultural customers either fully or partially [1]. The state government is required to meet the subsidy but any delayed or partial release of the subsidy by the state government, places an unplanned and unbudgeted burden on the utilities. This constraint often incentivizes utilities to restrict power to non-remunerative agricultural pump sets to about 6-8 hours a day.

Since in many Indian states, same supply line is used to feed both agricultural pumps and rural households, non-agricultural consumers in villages are also restricted to 6-8 hours supply per day. Due to this limited supply time, many public services in the rural areas including health, education and growth of cottage and tiny industries are also affected. This makes strong case for the, segregation of the agricultural & non-agricultural feeders in rural area so utilities can provide 24 hours power supply to the rural sector while maintaining a limited supply to the agriculture feeders.

Punjab is the first Indian state that initiated the work of segregation of agricultural feeders in 1996-97. Subsequently, segregation projects were executed on turnkey basis in 2003-04 [1]. Followed by Punjab, Gujarat opted for virtual segregation prior to 2003 and physical segregation through the Jyoti Gram Yojna. Andhra Pradesh initially adopted virtual segregation and later took up a pilot for physical segregation in 2010 to access the benefit of physical segregation. Many other Indian states like Haryana, Karnataka, Uttar Pradesh, Bihar, Maharashtra and Madhya Pradesh etc. have recently started physical segregation while Rajasthan has opted for feeder renovation program (FRP).

Analyzing the growing trend of feeder segregation in many states, government of India thought to bring up a national level scheme that will guide, monitor, finance and promote the process of feeder segregation in different agricultural intensive states. Thus, Ministry of Power requested the forum of regulators (FOR) to work upon a framework to draw up a scheme at national level for feeder segregation of rural and agricultural consumers and suggest measures for effective metering. The report recommended that a national level program for feeder segregation be implemented in a calibrated manner while allowing states to have the flexibility to design the project to suit their specific requirements, subject to adequate power being available at national level. However, during their study, the Sub committee of FOR found following issues:

1. Virtual segregation did not prove successful and was abandoned due to high accident rate and failure.
2. Post segregation results into high technical and commercial losses in the range of 50%-70% in Punjab [1].
3. Aggregate losses rose from 8.07% to 10.10%, after feeder segregation Telangana (Earlier Andhra Pradesh)
4. This scheme involves significant financial commitment which may not generate adequate financial returns.

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5. Space constraint in the substations due to non-availability of additional bays for the duplicated feeders.
6. Right of Way (RoW) objections.
7. Additional supply of electricity to the agricultural consumers who are willing to pay for additional electricity requirement is not possible.
8. Limited supply to people living in farmhouses away from the village.

To address the above issues, the Sub committee of FOR suggested to include the following collateral programmes along with FSP:

1. A minimum metering infrastructure: compulsory feeder metering and DTR metering.
2. Inclusion of one or more collateral programs that will help in reduction of commercial and/or technical losses.
3. No standard model for feeder segregation. Each discom has to design and implement a model to suit its specific requirements. But the broad options available for feeder segregation are virtual segregation and physical segregation.
4. Among the agricultural consumers, metered consumers should be given better subsidy incentive in order to promote metering among the agricultural consumers.

For reducing the AT&C losses that increases significantly with feeder segregation, the SG has suggested various collateral programmes to be included with FSP. The suggested programmes are i) HVDS/ less LT projects for agricultural feeders and ii) Low cost T&D loss reduction programmes for non-agricultural feeders that includes: shifting of meters outside consumer premises - pole mounted or pillar box, replacing bare LT conductor and main/sub mains in the villages with four core XLPE cable to prevent direct hooking of lines, upgrading/replacing 11 kV conductor, adding distribution transformers, load balancing on all distribution transformers and providing robust earthling across the system.

The above suggested methods for loss reduction requires a huge capital investment. Although the central government of India has agreed to act as a major source of funding, huge financial burden leading to high fiscal deficit may create a hurdle for the central government in near future. In the present situation agricultural subsidy is higher than the expenditure on health and rural development for some of the states [2]. With feeder segregation, agricultural as well as domestic consumption will be increased as the supply hours will increase, and hence the overall subsidy money required will be increased.

Hence in this paper, a method has been proposed which requires less capital than the above suggested measures and it can also ensures an adequate return on investment by the utility. The proposed method is based on an available technique called conservation voltage reduction (CVR). Optimal capacitor placement (OCP) has been integrated with CVR. Based on the results of economic analysis, the proposed method has been recommended as a collateral programme along with FSP.

The remaining part of the paper is organized as follows: Section II describes CVR and OCP. Section III discusses the problem formulation for the proposed methodology along with the objective functions designing in section IV. Proposed methodology has been tested on IEEE 33-bus test system using ETAP and various test results are discussed in section V. Benefits and future scopes of the technique have been discussed in section VI followed by conclusion in section VII.

II. CONSERVATION VOLTAGE REDUCTION (CVR) AND OPTIMAL CAPACITOR PLACEMENT (OCP)

CVR is a technique in which, demand reduction or loss minimization is achieved by lowering the distribution system voltage in a controlled manner while keeping the lowest customer utilization voltage consistent with the level determined by regulatory commissions and standardizing organizations [3]. CVR implementation has generated lot of interest among various utilities[1] in past as well as in present situation due to its potential for rapid reduction in demand and line loss. The experiences from various utilities reports 0.3% to 1% load reduction per 1% voltage reduction. If CVR deploying in all distribution feeders in USA, 3.04% of reduction in the national energy consumption is possible [4]. But CVR implementation faces a critical issue of voltage stability. Thus to eradicate the issue of voltage stability, OCP has been integrated with CVR.

III. PROBLEM FORMULATION

In this section, various mathematical formulations and concepts required to design different objective functions for loss minimization and cost-benefit analysis have been derived.

A. Network Loss Calculation

Power loss in a line section joining any two buses i-1 and i of a network can be calculated by using following equation:

$$P^1_{los(i-1,i)} = R_{i-1,i}\left[\left|V_i^1 - V_{i-1}^1\right|\left|y_{i-1,i}^1\right|\right]^2 \tag{1}$$

And the total network loss will be:

$$P_{loss}=\sum_{i=1}^{m} P^1_{los(i-1,i)} \tag{2}$$

Superscripts 1 in the above equations indicate fundamental component and m is the number of buses. $R_{i-1,i}$ is the resistance of the line section. V_i^1 & V^1_{i-1} are the sending end (i-1) and receiving end (i) bus voltages respectively.

B. Compensation Effect of Capacitor

The compensation effect of capacitor placement has been described in [8]. As per this reference, the network loss is having two components P_{L1} and P_{L2}. Capacitor placement will affect P_{L2} and the affected value will be given by:

$$P^!_{L2} = \frac{R\,Q^0}{3\,V_L^2\,sin^2\emptyset}\cdot(Q - Q_C) \tag{3}$$

C. Index for Maximum Loading

The loading limits of different lines have been calculated by using a factor called maximum loadability index (MLI) published by [9] , given below.

[1] Northwest Energy Efficiency Alliance (NEEA) [5], Hydro Quebec (HQ) [6], and Dominion Virginia Power [7].

$$MLI = \frac{V_i^2[-(r_{ik}P_{ik}+x_{ik}Q_{ik})+\sqrt{(r_{ik}^2+x_{ik}^2)(P_{ik}^2+Q_{ik}^2)}\ ]}{2.(x_{ik}P_{ik}-r_{ik}Q_{ik})^2} \quad (4)$$

Here, P_{ik} & Q_{ik} respectively are the active and reactive power flowing at the receiving end of a line connecting two nodes i and k. r_{ik} & x_{ik} respectively are the resistance & reactance of the line.

D. Loss Sensitivity Factor (LSF)

The loss sensitivity factor (LSF) published by [10] has been used to find the candidate buses. As per LSF approach, the value for $|V_i|/0.95$ will be calculated for all buses. Where, $|V_i|$ is the voltage magnitude of i^{th} bus (expressed in terms of the percentage bus rated voltage). If the value of LSF is less than 1.0 for any bus, then that bus will be considered as a candidate bus.

IV. OBJECTIVE FUNCTIONS

The objective function for the proposed technique can be formulated as a mixture of maximization and minimization problem.

A. Maximization of saving produced by reduction in energy losses due to voltage reduction, f_{VS}.

When CVR is not applied to the network, the inherent I^2R loss will take place in the network, which is given by $P_{loss}=\sum_{i=1}^{m} P_{loss(i-1,i)}$. But with the application of CVR, network loss decreases and can be calculated by using the same formula but with reduced nodal voltages i.e. $P_{loss}^{!}=\sum_{i=1}^{m} P_{loss(i-1,i)}$. The difference between the inherent loss during normal operation and the loss during CVR application should be maximized. i.e.

$$\text{Max } f_{VS} = \max(\Delta P_{loss}) = max\ (P_{loss} - P_{loss}^{!}) \quad (5)$$

B. Maximization of saving produced by reduction in energy losses due to compensation effect of capacitor, f_{CS}.

This saving in energy due to capacitor placement is to be maximized.

$$Max\ f_{CS} = max\ (\Delta P_L) = max\ \{(P_{L1} + P_{L2}) - (P_{L1} + P_{L2}^{!})\} = max\ \{\frac{R\ Q^0}{3\ V_L^2\ sin^2\emptyset} . Q_C\} \quad (6)$$

C. Maximization of the avoided cost due to investment deferral in the expansion of the network over a considered period, f_{IDC}.

The release in network capacity due to reduction in line losses and curtailment in load will prevent the investment required for further expansion in network capacity to meet the growing demand. Let C_R be the capacity released in MVA/KVA, and C_P be the capacity charge (related to the fixed cost of the network) in \$/KVA/month. Then the maximization function for investment deferral in network expansion is

$$Max\ f_{IDC} = max\ \{C_R * C_P * T\} \quad (7)$$

Where, T is the planning period.

D. Maximization of the voltage reduction limit very close to the lower acceptable limit, f_V

The reduction in node voltages should be maximized such that the limit reaches very close to the lower specified value

i.e. $$\text{Max } f_V = \max_{x \to 0.95} xV_j \quad j = 1, 2, \dots, m \quad (8)$$

E. Maximization of the deviation of actual demand with respected to its rated demand at different load buses, f_s.

This objective attempts to minimize the load drawl at different nodes. This is done by maximizing the difference between the actual load drawl at normal operation and the load drawl at reduced voltage, at a node.

$$Max\ f_S = \max_j \begin{cases} P_{lj} - P_{Dj} \\ Q_{lj} - Q_{Dj} \end{cases} \quad j=1, 2, \dots, m \quad (9)$$

Where, P_{lj} and Q_{lj} are the actual load drawl at normal operation at bus j. P_{Dj} and Q_{Dj} are the load drawl at reduced voltage at bus j.

F. Minimizing the deviation of bus voltages with respect to substation voltages, f_{vb}.

An attempt to flatten the voltage profile along the feeder can be achieved through this objective. If V_s is the substation voltage and V_j is the voltage of jth node, then

$$Min\ f_{Vb} = min(\Delta V_j) = \min(V_s - V_j) \quad j=1,2\dots,m \quad (10)$$

G. Minimizing capacitor cost: purchase cost plus installation and maintenance cost, f_C.

The cost for the capacitor includes three parts. The first part represents the purchase cost (C_{cpl} in \$/kVAr); second part represents the installation cost (C_{im} in \$/kVAr), while the third part represents operation and maintenance cost (C_{col} in \$/kVAr-year). If B_C is the number of candidate buses, C_l is the size of the capacitor bank(s) and x is the number of banks; then

$$Min\ f_C = Min\{\textstyle\sum_{l=1}^{B_C}(C_{cpl} .x. C_l + C_{col} .x. C_l) + B_C . C_{im}\} \quad (11)$$

H. Constraints

H.A. Reactive Power compensation limit

$$Q_{Ci} \le Q_{Cmax;.} \quad (12)$$

H.B. Bus voltage limits

$$V_i \le \min_x\{x = (0.95 - 1.05)\} \quad (13)$$

H.C. Line loading limits

$$P_{ik} + jQ_{ik} \le \text{MLI}^* (P_{ik} + jQ_{ik}) \quad (14)$$

V. SIMULATION RESULTS AND DISCUSSIONS

The proposed methodology has been implemented for power loss reduction of IEEE 33 bus test system [11]. The simulation is conducted on a 64-bit PC with 1.80-GHz CPU and 8 GB RAM. The academic version of ETAP 12.5.0 package is used to solve the optimization problem. Its one-line diagram is shown in figure I. The base MVA is 100 MVA and the base kV is 12.66 kV. The details of the other relevant parameters involved in the optimization are described below.

The nominal energy price has been taken as 0.05 \$/kWh [12]. The constants adopted for installation cost and operational cost are $C_{im} = \$\ 3/kVAr$ and

$C_{col} = 3\$/$kVAr/year respectively. The value of the purchase cost C_{cpl} in (\$/kVAr) for any size of capacitor bank (optimally selected) can be deduced from Table 1 using regression analysis. Again, while performing different economic analysis, interest rate has been assumed to be zero.

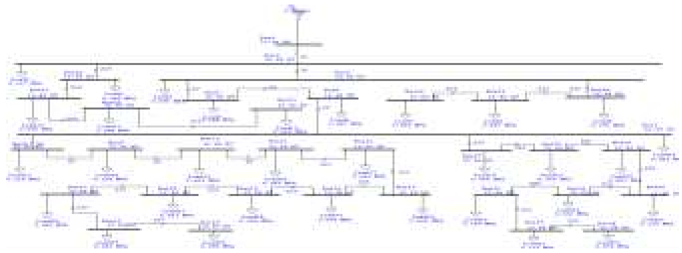

Fig. 1: One-line diagram of the test system

Table 1: Commercially available capacitor size and cost [10]

Size (kVAr)	150	300	450	600	900	1200
Cost (\$)	750	975	1140	1320	1650	2040

The capacitor sizes for solving the optimization problem have been selected totally based on desired voltage condition at different candidate buses i.e. a voltage very close to, but not less than 95% of bus rated voltage. Hence hit and trial method is adopted to find the capacitor size; for which the buses operating at desired voltage label are maximum in number. A load flow has been run by including the optimally selected capacitor and based on the obtained load flow report; an economic analysis is performed for a planning period of 10 years. 10 year is being selected because the capacitor life lies between 10 to 15 years. Following operating situations are being tested.

A. *Feeders Fed at Rated Substation Voltage*

Different feeders are supplied at rated voltage. But at this voltage condition 11 buses faces voltage instability. Hence OCP has been done to boost their voltages. These 11 buses fulfil the criteria for candidate locations as per LSF. Apart from candidate selection, the size of the capacitor to be placed is required to be filled in the capacitor info page of OCP study case editor in ETAP. Hit and trial method has been used to find the optimal sizes, as shown in table 2.

Table 2: Capacitor sizes and their effects on bus voltages

Capacitor Banks(kVA)	108	120	135	150	300	1500
Buses	Bus Operating Voltages in terms of %rated bus voltage					
8	96.665	96.348	95.890	95.985	96.393	97.673
9	96.576	96.162	95.631	95.693	96.104	97.735
10	96.486	95.969	95.356	95.445	95.726	97.851
11	96.443	95.917	95.301	95.387	95.662	97.827
12	96.365	95.821	95.201	95.288	95.552	97.794
13	96.271	95.535	95.043	95.061	95.223	98.276
14	96.301	95.439	95.073	95.053	95.151	98.724
15	96.313	95.354	95.077	95.023	95.121	99.080
16	96.298	95.274	95.045	95.001	95.099	99.461
17	96.344	95.099	95.008	95.132	95.230	99.278
18	96.328	95.047	95.001	95.130	95.279	99.223
28	95.969	95.927	95.844	95.811	96.153	97.265
29	95.473	95.456	95.403	95.401	95.681	97.155
30	95.221	95.231	95.170	95.178	95.457	97.078
31	95.042	95.054	95.037	95.071	95.264	97.577
32	95.009	95.026	95.016	95.055	95.249	97.826
33	95.018	95.039	95.033	95.078	95.319	97.801

In table 2, the optimal capacitor size is 135 kVAr. Hit and trial testing started from 108 kVAr because below this particular value, ETAP does not accept the capacitor values and asks for either to reduce the minimum voltage limit or to add more candidate buses. Again testing has also been done for various upper values up to 1500 kVAr; it has been found that the buses operating at voltages very close to (but not less than) 95% of bus rated voltages are less in number as compared to 135 kVAr applications. Also for each value of capacitor banks, testing has been carried out by placing more than one capacitor bank at a particular bus; none of them produces a result better than the case of placing 135 kVAr at each candidate locations. Also the total kVAr required by the RDS is high for all different cases. A brief comparison of the bus (candidate) voltages obtained by placing different sizes of capacitor banks has been depicted in Fig. 2.

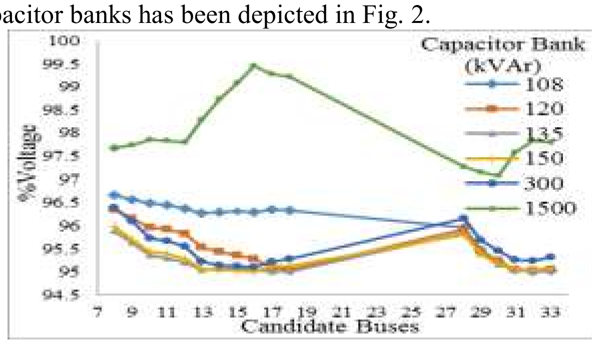

Fig. 2: Brief comparison of the bus (candidate) voltages obtained by placing different sizes of capacitor banks

An economic analysis for the loss minimization (due to compensation effect of capacitors plus reduction in line flows due to curtailed demand) has been depicted in table 3.

Table 3: Economic analysis

Yr	Cost (\$)		Saving (\$)		
	Installation Plus Purchase	Operation	Loss Reduction	Yearly Profit	Accumulative profit
1	13365.00	4455.00	16949.24	870.76	-870.76
2	0.00	4455.00	16949.24	12494.24	11623.48
3	0.00	4455.00	16949.24	12494.24	24117.73
4	0.00	4455.00	16949.24	12494.24	36611.97
5	0.00	4455.00	16949.24	12494.24	49106.21
6	0.00	4455.00	16949.24	12494.24	61600.45
7	0.00	4455.00	16949.24	12494.24	74094.70
8	0.00	4455.00	16949.24	12494.24	86588.94
9	0.00	4455.00	16949.24	12494.24	99083.18
10	0.00	4455.00	16949.24	12494.24	111577.40

As the operating voltages at different buses are low (but within limit) as compared to their rated voltages, there is a significant reduction in load drawl as well as total technical losses. Also there is a gain in branch capacity of 2.928 MVA.

From the load flow result it has been found that the reduction in loss as well as deviation in load demand increases with the reduction in supply voltage label. As the reduction in voltage label is the maximum possible and permissible value, loss reduction and load deviations obtained are also their respective maxima. The obtained branch capacity release is also the maximum possible value. The reduction in total loss and the branch capacity release also includes the compensation effects of capacitors. Hence the obtained results satisfy the objectives A-E in section IV. Again, it can be seen from load flow result that there is not much differences between bus voltages of different distant nodes and the substation end node (i.e. bus 1). This satisfies objective F. As far as objective G is concerned, the OCP analysis in ETAP makes use of the optimization technique (genetic algorithm) to minimize the total cost of capacitor placement and based on that it calculates the optimal values and locations.

During every steps of planning, all the constraints have been taken care. The total compensation limit is within the maximum allowed value, which is considered to be the total connected reactive load in to the test system. None of the bus voltages has excided the defined limits, ever during any stage of operation. The maximum loading limits of all the lines of the test system was being calculated using equation (4). The actual loadings during different operating situations did not excided their respective maximum values.

B. Feeders Fed at a Voltage Higher than Rated Substation Voltage

In practical operation, the substation is necessarily required to feed a voltage of at least 13.109 kV (103.55% of substation rated voltage) to ensure the availability of minimum required voltage at each and every bus. But feeding such higher value at the substation causes an increase in voltage beyond rated voltage at many buses. These over voltages causes increased load drawl at such buses which in turn increase the total technical losses in the network.

C. Feeders Fed at a Voltage Lower than Rated Substation Voltage

Case I: In this case, the substation voltage is maintained at such a value that the first nearest load bus gets a supply voltage equal to its lower limit of operation. For the present case this value is 12.06 kV. Under such situation, many buses receive a voltage lower than their minimum acceptable limit. Hence OCP is being done to boost the bus voltages.

Like previous case, an economic analysis is performed for this case. It has been found that, the accumulative profit after 10 years is negative. This indicates: integration of OCP with CVR during lower substation voltage, is not a feasible option. Again the overall network technical loss obtained are significantly very high. Branch capacities released are also negatives; which indicates network branches are overloaded.

Case II: A test is being carried out by reducing the substation voltage to a value ranging from (99%-90%) with a marginal steps of 1%. For all these reduced substation voltage conditions (10 cases), capacitor placement was being done to recover the voltage stability of different buses. All the possible sizes of capacitor banks (ranging from lower possible value to the higher value) were placed for each case and an economic analysis was also done. It has been found that the economic analysis results into a negative accumulated benefit at the end of 10^{th} year for all the 10 cases irrespective of all the possible capacitor bank sizes. Also the overall network technical losses in these cases are significantly very high and the branch capacities released are also negatives. Hence it can be concluded that the integration of OCP with CVR is not a better option, if the reduction in substation voltage goes below the rated value.

D. Cost-Benefit Analysis and Comparisions

The economic analysis discussed in sub-section 'A' for OCP has been deduced from the result of ETAP OCP analyzer. In this result, the saving from loss reduction (table 3) has been calculated by taking the difference in network active losses during rated substation voltage (12.66 kV) condition and the condition after optimal capacitor placement. But the network loss during the rated substation voltage condition is not the actual technical loss of the network. But the actual saving in the loss is the difference between the losses during 13.109 kV (which is the common practice for distribution operation) and the condition after optimal capacitor placement. Fig. 3 shows the total network technical losses taking place in the system during different operating voltage conditions.

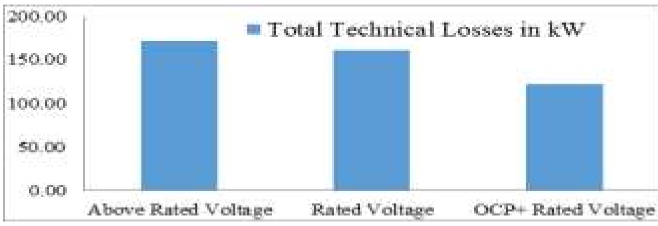

Fig. 3: Total network technical losses taking place in the system during different operating voltage conditions.

Apart from the saving from loss reduction, other economic benefits include the saving from reduced load consumption due to reduced voltage level plus the savings from the investment deferral due to network capacity released (capacity charge). The capacity charge (related to the fixed cost of the network) considered here is 120 \$/kVA/year [13]. Considering all these facts, a modified economic analysis has been done for case A and has been depicted in table 4.

Table 4: Modified economic analysis for case A

Sr No.	Cost ($)		Saving ($)			
	Installation plus Purchase	Operation	Loss Reduction	Capacity Released	Yearly Profit	Accumulative profit
1	13365	4455	22031.40	351360	355571.40	355571.40
2	0	4455	22031.40	351360	368936.40	724507.80
3	0	4455	22031.40	351360	368936.40	1093444.20
4	0	4455	22031.40	351360	368936.40	1462380.60
5	0	4455	22031.40	351360	368936.40	1831317
6	0	4455	22031.40	351360	368936.40	2200253.40
7	0	4455	22031.40	351360	368936.40	2569189.80
8	0	4455	22031.40	351360	368936.40	2938126.20
9	0	4455	22031.40	351360	368936.40	3307062.60
10	0	4455	22031.40	351360	368936.40	3675999

Apart from the saving components (Loss Reduction+ Capacity Released), another additional component is the savings due to load curtailment. The effect of this component has not been projected into the accumulative profit calculated above. Following table 5 compares the savings due to load curtailment for cases A and case B.

Table 5: Comparison of economic values for cases A and B

Particulars	Case A		Case B	
	MW	($)	MW	($)
Saving from Curtailed Load	0.243	1064340	-0.088	-385440
Total Loss	------	--------	0.1725	755550
Accumulative profit	------	3675999	--------	--------
Total Saving	--------	4740339	--------	-1140990

The negative sign for the curtailed load for case B indicates that an extra load of 0.088 MW has been drawn than the total connected load. From the above tables 4 & 5, it is clear that a benefit of $ 4740339 was gained for case A while a loss of $ 1140990 was incurred for case B within 10 years. Apart from this, there is a decline in the overall lives of different appliances for case B as compared to case A, due to higher voltage. Hence the operation of the distribution system with respect to the strategy of case A provides a far better option than case B.

VI. BENEFITS AND FUTURE SCOPES

The proposed method is a convenient and cost-effective. It can be employed through demand-side management (DSM) and can be initiated by utilities rather by consumers. The load end power factor is also being improved due to capacitors placed. By reducing peak demand, a utility can avoid paying high prices when purchasing power or it may sell the surplus power at high prices. Again with the minimization of system losses, consumer obtains savings through; reduced demand, loss allocation charges and energy charges.

CVR implementation is in real time, thus by observing the measurements from automated metering infrastructure (AMI) or phasor measurement unit (PMU) data may open the gate for future research. Again the issue of coordination mismatches between CVR and DG penetration is need to be addressed.

VII. CONCLUSION

With the goal of setting a national level scheme for feeder segregation, it becomes necessary to develop a collateral plan, which must be integrated with FSP for reducing commercial and/or technical losses. In this paper a comprehensive method to reduce AT&C loss to achieve the national target has been proposed with a view to ensure adequate return on investment by the utilities in adopting FSP. The result of the proposed method applied on IEEE 33 bus test system indicates that a significant loss reduction is possible if applied to a no-agricultural feeder. The financial gain for a planning period of 10 years has been calculated by the use of the method. A huge financial gain obtained from economic analysis indicates that the method can encourage different utilities to align towards FSP. The proposed method is simple, cost-effective and is having huge potential for loss reduction. The impact of the proposed method on load curtailment and system capacity release is also reported. Integration of OCP has made it possible to operate the system very close to the lower permissible limit of voltage, which ensures maximum benefit gain from CVR.

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