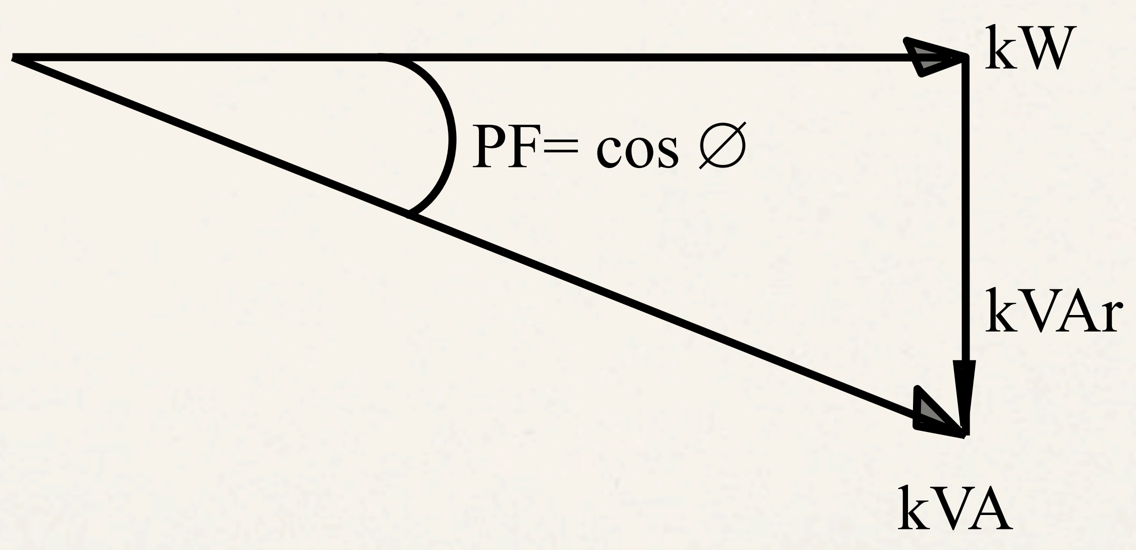
RMS Automation Systems Ltd.

Presentation for State Electricity Boards

Advantages of Power Factor Improvement on Electrical Distribution System

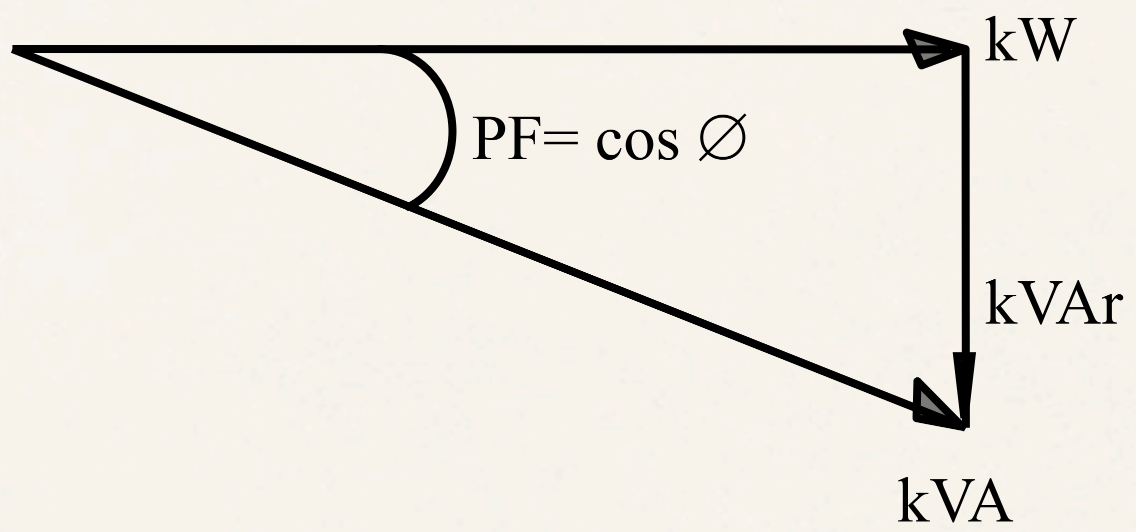


Did You Know?

- About 30% of Electricity Generated is lost in Transmission and Distribution in India!
- Power Factor is being maintained only in the range of 0.81
- You can save up to **Rs. 10.13 Cr** per MW by just improving your Power Factor from 0.81 to 0.98

We will show you how to reduce the Transmission and Distribution Losses and save those Rs. 10.13 Cr

Power Factor



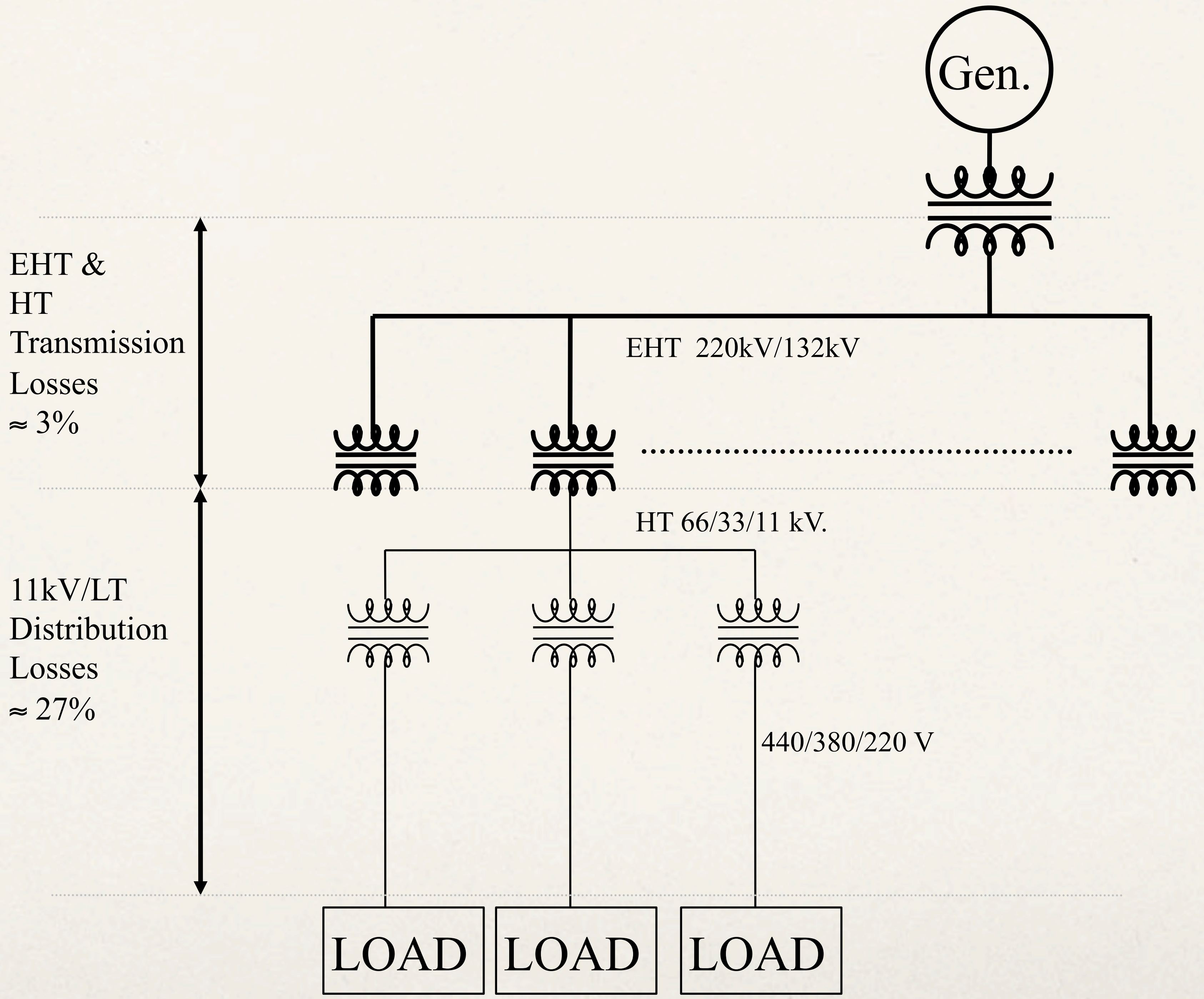
Power Factor is defined as the Real (Active) Power divided by the Apparent Power i.e. kW/kVA

Or P.F. = Cos ø

Problems Due to Poor Power Factor

- Losses in Transmission and Distribution Network
- Overloading in Supply System
- Increase in Maximum Demand
- Poor Voltage Regulation
- Supply Network Instability

Distribution Schematic



Many State Electricity Boards do not generate Electricity but purchase it from Generating Plants.

They are charged on Basis of

- kWh
- Maximum Demand in terms of kVA
- kVArh Consumption

But!!

- About **30%** of Electricity Generated is lost in Transmission and Distribution (T&D)
- Increase in kVA Maximum Demand by approximately 20%
- Increase in kVArh Consumption by around 40%

These are the things that are certainly not desired by the Electricity Boards!

How can we fix this?

Solution

We can do it in two different ways

- Enhance the Generating and T&D Capacity to meet the demand

OR

- Improve the Power Factor at all levels in Transmission and Distribution

Ideally, PF should equal to 1. Possible only when kW = kVA or Cos ø = 0

Thats what we will try to achieve.

We can reduce the losses by making it mandatory for Electrical Consumers to maintain a PF near 1.

But this may be too much to ask of customers, who may not be wanting to spend money on equipments they don’t fully understand. Only Big Industrial consumers may understand the reason.

So the next best alternative to maintain a PF as close to 1 as possible is by the using *Dynamic Compensators* at LT Distribution Level.

Now if the PF is improved from 0.81 to 0.98, the kVA demand on the supply system is reduced by 20%.

This means that without enhancement in the capacity of the distribution system or without increasing the generating capacity, PF improvement alone is capable of meeting the demand.

Now lets compare the financial aspects to achieve the same.

- By Enhancing the capacity of T&D and Generation to meet the additional power requirement
- Meeting additional power requirement through Improvement in Power Factor

Capacity Increase vs. PF Improvement

Lets take a case with 5 MVA Distribution System. PF=0.81

Capital Expenditure required to Increase T&D and Generation Capacity by 20%, 1 MVA

Initial Investment

Generation = Rs. 3.5 Cr /MVA x 1 MVA = Rs. 3.5 Cr.

T&D = Rs. 1.5 Cr / MVA x 1 MVA = Rs. 1.5 Cr. (If designed with Safety, margins can be neglected)

1 Year Running Cost=Rs. 5.6 Cr./MVA x 1MVA= Rs. 5.56 Cr/yr

Total = **Rs. 10.56 Cr.**

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Loss Reduction vs. PF Improvement

Now, achieving the same by improving the Power Factor

With 5 MVA installed system, 20% VA is improved is by installing 2.1MVAr capacitors. i.e. 1 MVA extra capacity available by installing 2.1 MVAr Dynamic Compensators.

Cost of 2.1 MVAr Dynamic Compensator ≈ **Rs. 0.42 Cr**.

So, with P.F. Improvement, you spend only 4% of Rs. 10.56 Cr (Generation and T&D Cost) required to meet the additional power requirement of 1 MVA.

Thus, the investment to generate additional 1 MVA would be Rs. 10.55 Cr and meet the same requirement through P.F. improvement the investment would be Rs. 0.42 Cr. A net saving of 10.13 Cr/MVA!!

Case of reduced T&D Losses

- So far, we have analyzed the the financial implications for generating 1 MVA power and meeting the same requirements with P.F. improvement.

- Now let us consider that there is no demand for additional power (though absolutely impossible!).

  In that case saving to the distribution company would come through reduced T&D losses, reduced MVAH charges and reduced MVARH charges.

- In Indian Electricity Boards, Avg. 30% of Generation is lost in Distribution.
- In a 5 MVA (5000 KVA) distribution network with P.F. of 0.81, the load in terms of KW would be 4050
- At improved Power Factor of 0.98, the KVA is reduced from 5000 to 4133 KVA.
- Losses would be reduced in the square of P.F. proportion. So, with 4050 KW Load, 30% loss amounts to 1215 KW. Hence, reduction in T&D Losses with P.F. improvement:
  = 1215 x 1-(0.81/0.98)2 = 1215 * 0.32 = 389 KW.
  i.e. reduced from 4050 to 3661

T&D Loss Reduction

Considering a load factor of 65%, the annual savings to the distribution company will be

= 389 kW x 365 Days x 24 Hours x 0.65 = 22,14,966 kWH

Considering the power purchased at Rs. 2.50/kWH, the savings are **Rs. 55.37 Lacs**

And the investment required for Dynamic Compensator is
42 Lacs ONLY!!

<u>Payback within just 9 months!</u>

Review

- In case additional power requirement is met through Power Factor improvement instead of Additional Generation, the savings would be Rs . 10.13 Cr per MVA.
  - ≈ Rs . 2.5 Cr will be the saving for the Distribution Company.
  - Balance will be Generating Company's Savings
- In case there is no additional power requirement, but reduction of T&D losses is considered, the savings would be Rs . 11.00 Lacs per MVA per annum, which will accrue to the Distribution Company.

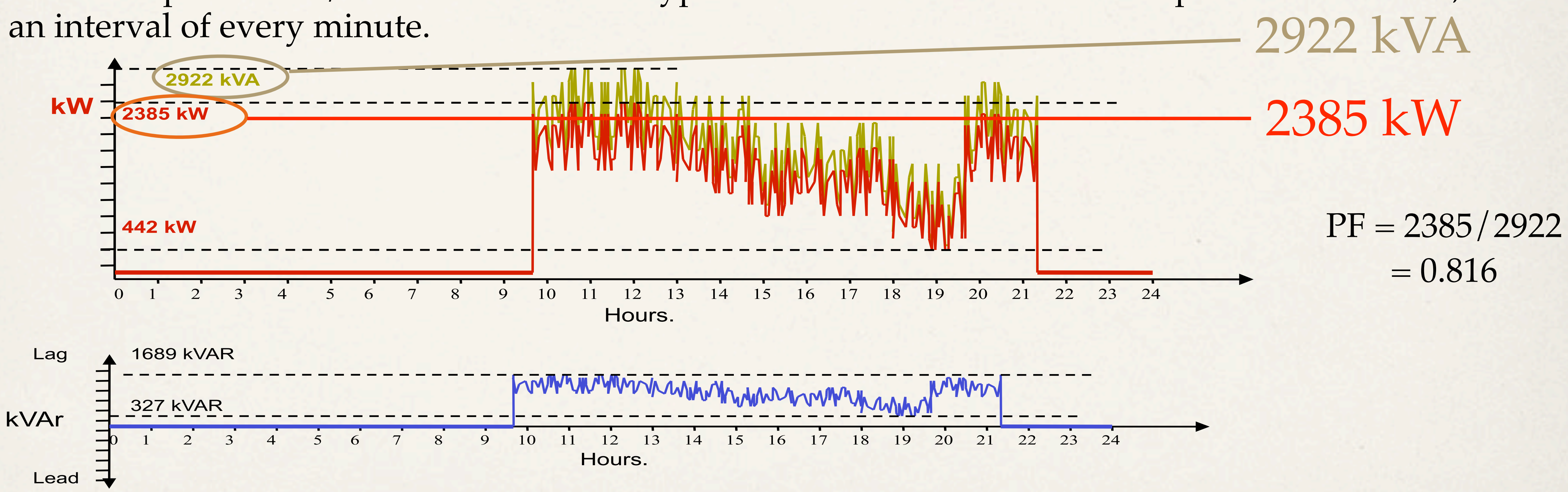
Sure makes a lot of Economic Sense in using

Dynamic Compensators

Case Study for Dynamic Compensator

In the present day conditions, the loading on the supply system is quite variable and full of harmonics. The harmonic problem solution has quite a different approach. But Variable loading causes variable kVAr requirements on the supply system.

Observe the plot of kW/kVA and kVAr on a typical 11 kV feeder. This is over a period of 24 hours, taken at an interval of every minute.

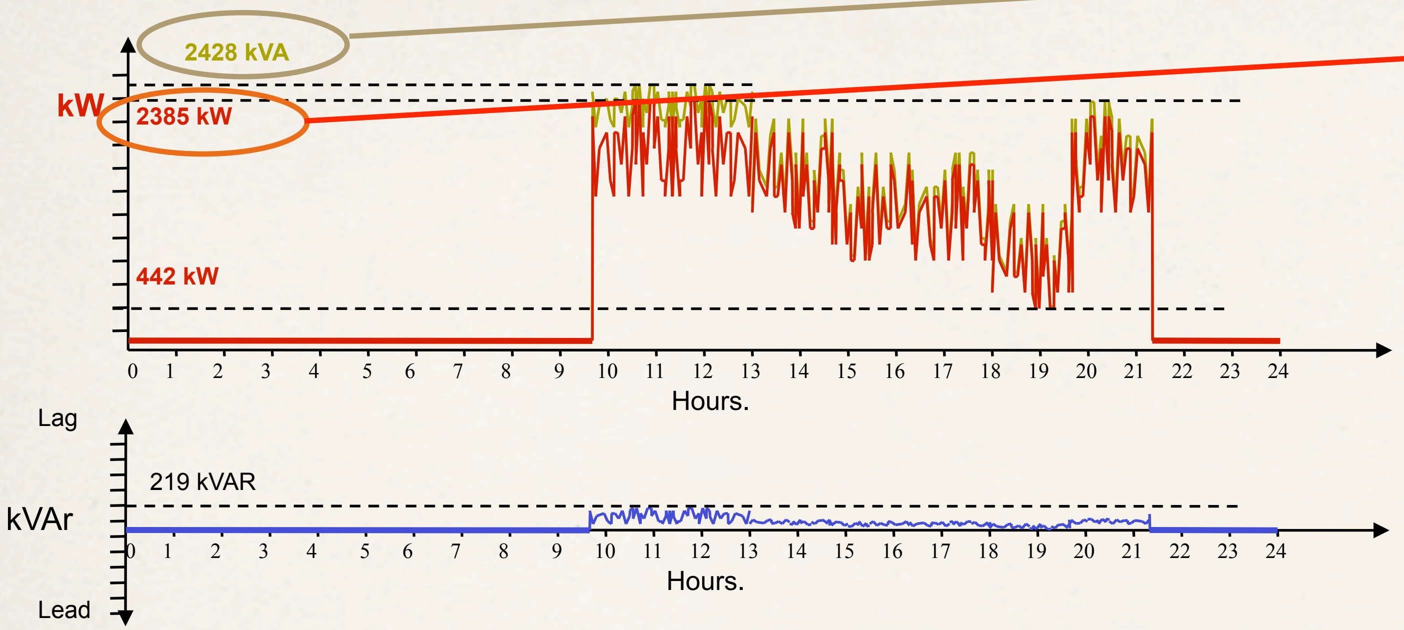


The above plot is on one of the agricultural feeder. In-operation hours are 9:30 Hrs. The plot is taken when there is no capacitive compensation provided on the feeder. Total number of APFC systems per feeder to be provided 45 No.(various ratings)

With APFC Panels Installed

2428 kVA

2385 kW



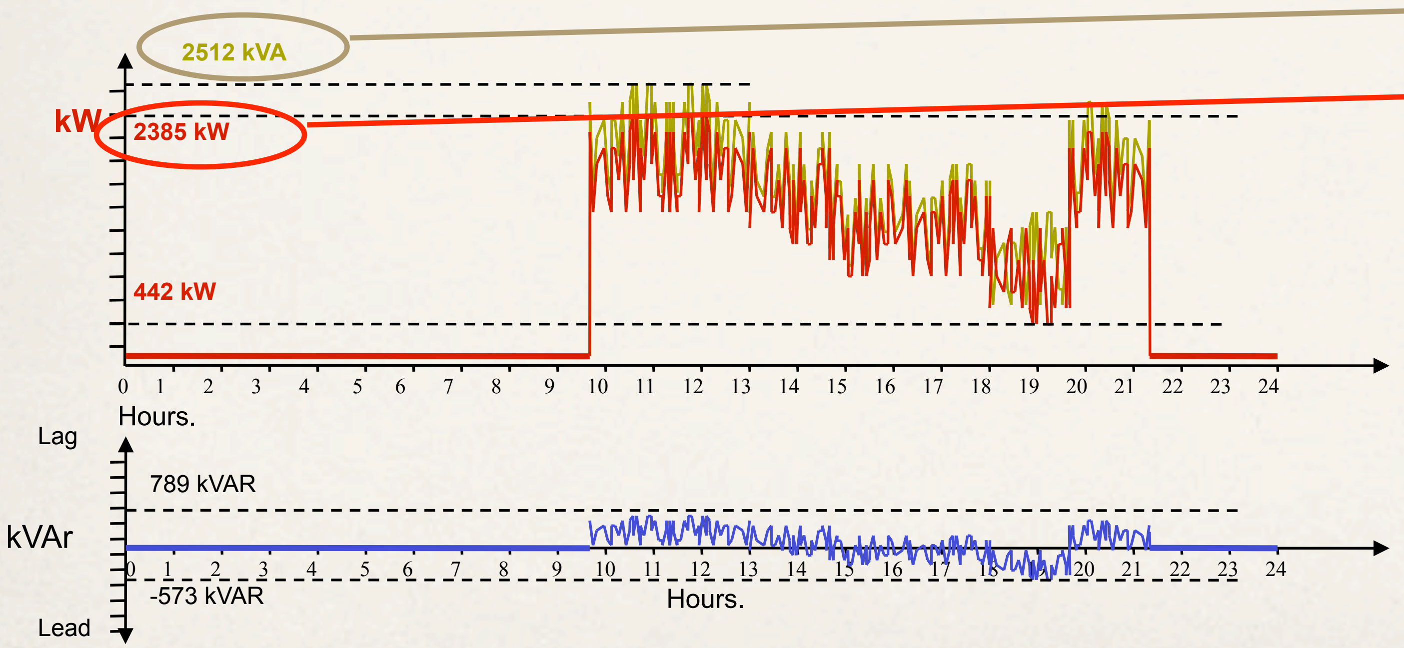
$$PF = 2385/2428$$
$$= 0.98$$

With fixed compensation: Total feeder compensation 900kVAr.

Achieved by putting Dynamic Compensators panels in fixed compensation

2512 kVA

2385 kW



$$PF = 2385/2512$$
$$= 0.94$$

Cost Differential - Payback Calculation

In the logged data of 11 KV feeder example, fitted with 45 no of Dynamic Compensators, ≈ 170 KVA is reduced, considering both the lag and lead conditions in comparison with fixed capacitors. This reduction includes the electricity consumed by the excess fixed capacitors under low load conditions (in P.F. Lead situation)

The losses would be deduced in the square of kVA proportion $= 1 - (2428/2512)^2$

$= 6.58\ \%$

If we assume that on the 11kV feeder supplying 3000 kVA with a load factor of 0.65, the maximum load is 1950 kVA.
The average kW would be (0.81 PF) = 1580 kW

If we consider the total feeder loss factor to be 30% of average kW
Total loss = 474 kW
6.58% of total losses = 31 kW

Average working per day assuming to be 12 hrs. Total kWh lost per day = 12 x 20.79 = 372 kWh

Per month loss = 30 days x 372 kWh = 11,160 kWh

Assuming cost of Electricity to EB = Rs. 2.50 per unit, total loss per month = Rs. 27,900

Per Year loss = **Rs. 3,34,800** **IF** fixed compensators are used instead of Dynamic Compensators

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Cost Differential - Payback Calculation

Cost differential between APFC and Fixed Capacitance ≈ Rs. 15,000 (Averaging Basis)

Total cost differential of 45 systems = 45 x Rs. 15,000 = Rs. 6,75,000

i.e. APFC additional cost payback period (by comparison with fixed compensation too)

= Rs. 6,75,000 / 3,34,849 = **2 years**

We can further reduce this Payback Period.

Cost Differential - Payback Calculation

Annual Rate of Transformer Damage due to Over Loading is estimated to be about 18% of the Installed Capacity

In case Dynamic Compensator is provided with each Transformer, the Current Loading and Damage on the Transformers can be reduced.

Lets see the reduction in current loading of a 100 kVA distribution transformer having 75 kW Load and Maintaining 0.85 Power Factor. It is assumed that the power factor has improved to 0.98 after installation of Dynamic Compensator

$$\text{Current (I)} = \text{kW}/(\sqrt{3}\ \text{x}V\text{x}P.F.)\ \text{x}1000$$

$$\text{Current}_{P.F = 0.85} = 75/\ (1.732 \times 415 \times 0.85) \times 1000$$

$$= 75/\ 611\ \text{x}1000$$

$$= 122.74 \text{ Amps}$$

$$\text{Current}_{P.F = 0.98} = 75/\ (1.732 \times 415 \times 0.98) \times 1000$$

$$= 75/\ 704 \times 1000$$

$$= 106.74 \text{ Amps}$$

The current loading on the transformer is reduced by 16.27 Amps (≈13.25%), thus ensuring better health and longer life to the Transformer.

Payback Period

Considering 45 Transformers on an 11 kV Feeder Line, Annual Transformer Damage to be 18%, Average cost of a Distribution Transformer to be Rs. 70,000 and that after the installation of Dynamic Compensator, the Transformer Damage can be brought down by **50%** Minimum, we can reach the following conclusion:

Only 4 Transformers Damaged v/s 8 Transformers if Dynamic Compensators are not used. Therefore, cost reduced from Rs. 5,60,000 to Rs. 2,80,000. Savings of **Rs. 2,80,000**

If we add these savings to previous savings, then the payback period will be

Rs. 6,75,000 / Rs. 6,14,800 (3,34,840 + 2,80,000) = 1.09 years i.e.

1 Year 1 Months ONLY!

Other Advantages of APFC

- Instantaneous Power factor is near unity, not just average. This improves the output voltage stability. Any over-voltages on supply line (even if it is 5%) can cause the motor magnetizing losses to be increased and causing motor efficiency to be dropped by about 3 to 5%. Most of the agricultural pumps are induction motor pumps, the increase in the kW consumption.

- APFC provides a complete protection to capacitors against over-voltage, harmonics and supply transients. It even avoids the system resonance phenomenon that can have disastrous effects. Fixed compensation cannot provide such preventive protection. All it can provide is a failed capacitor protection by usage of MCBs in the circuit.

Other Advantages of APFC

- The APFC system performance is continuously monitored by data logging and/or by GSM communication. This is possible due to the intelligent controller provided. With fixed compensation, the health monitoring of the systems is not possible. Only a manual checks that are extremely laborious in nature can check these fixed capacitors health.

- Regular monitoring available can even provide a complete clue on Assets and Capacity utilization. This can make the EB organization to operate efficiently by appropriate capital goods capacity utilization.

Track Record

- Supplied and Maintaining more than 2,20,000 kVAr of Dynamic Compensator of 300 kVAr and 200 kVAr rating in BSES (Reliance Energy) and NDPL (TATA Power) Distribution Network in Delhi
- 1100 Dynamic Compensators installed in DHBVN Distribution Network
- 180 Dynamic Compensators installed in Electricity Distribution Network of Orissa
- 500 Dynamic Compensators installed in Electricity Distribution Network of Maharastra

Turnkey Power Projects

- Rural Electrification and Transmission & Distribution (T&D)
- Dedicated team of Qualified personal to provide services in Supply, Installation, Commissioning and Maintenance of Transformers, ACSR Conductors, LT/HT Cables, Power Cables, Air Bunched Cables, Electrical Poles, Insulators, Hardware Accessories, Transmission Towers etc.
- Capable of putting up 33 kV, 11 kV and LT Lines
- Already undertaken construction of 11kV lines and 11kV Substations in Orissa.
- Manpower : Workforce of 500 persons for timely execution of the projects

Rural Load Management Scheme

- Main objective is to ensure uninterrupted 3 Phase Power supply to Rural Consumers
- Ensure scheduled Power supply to Irrigation pump sets with compensations during the interruptions.

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Summary

- You spend only Rs. 0.41 Cr. v/s Rs. 10.55 Cr. to deliver extra 1 MVA to consumers without increasing the capacity of your network
- You save up to Rs. 10.13 Cr. per MW
- You improve your current Power Factor
- Healthier Supply Network
- Payback period of only 1 year 1 months
- APFC provides a complete protection to capacitors against over-voltage, harmonics and supply transients
- Continuous System Monitoring by Data Logging and/or by GSM Communication
- Reduction in transformer overloading and resultant damage

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Thank You