

INDUSTRY IN LEAN MODE, CAN MONITOR ELECTRICITY CONSUMPTION AT LOAD ENDS INSTANTLY & AFFORDABLY NOW, AND TARGET ITS REDUCTION

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The industry in the lean mode of working, during the Re-startup phase of first few months can monitor its Electricity consumed in each of the machine in the production and utility areas. Till date, the industry matched its utility to the full load of production, now the industry has to run at say 30 to 50 % loading of the rated production. Here the SEC, the Specific Energy Consumption at lean mode, will shoot up the above that of normally loaded pattern. So production costing goes up at lean mode, due to the higher energy consumption & loading or production & utility matching needs to be optimized.

EXISTING PROBLEMS DUE TO LACK OF POWER MONITORING:-

1. Tare load KW, KVA, PF & KVAR at machine's no-load & load – instant data not available because they could not be measured.
2. The relative energy consumption of machine to machine varies by 10 % around, especially in the inefficient loadings, to monitor.
3. The load end PF compensation is not done till date, and each machine PF at around half the loading is around 0.70 PF.
4. Mismatched capacitor sizes at the power house, hence industry is facing PF penalty due to excess capacitors switched ON.
5. Capacitors have gone de-rated and not checked, coupled with load, whether the same in Tee connection is giving KVAR?
6. Higher voltages at the incoming leads to excess KVA consumption, the same voltages, still not optimized, due to non-OLTC TR.
7. The motors are rewound many times, the KW, KVA, PF, KVAR per phase is different reference to others, abnormal value.
8. PF compensation done at load end, either failed in any of the 3 phases, or overcompensated at load end, but not noticed.
9. PF corrected at Power house only, the DG could be loaded to 60 % only because of reduced capacity at < 0.8 PF, uncorrected PF.
10. Servo stabilizers put at load ends, are operated at 415 volts, if part-loading parameters are measured, volts still not lowered.

WHY THE INDUSTRY NEEDS ELECTRICIAN-FRIENDLY CLAMP ON POWER METER?

Our approximation of energy consumptions will vary by 10 to 20 % to arrive at the macro specific power consumption of the process / machines because we do neither have the time to micro level monitor - MLM the individual machine consumption, nor plan the time to Macro Level Analyse - MLA on the energy consumption. One of the reasons for this gap in assumption of power consumption is that either we don't have the power analyzer or even if have, we don't have time routinely to take measurements.

Now we understand, why Load End Compensation is required for our 3-Phase motors rated above 5 HP?					
Output		Power factor			
kW	hp	¼L	½L	¾L	FL
3.7	5	0.44	0.55	0.62	0.7
7.5	10	0.58	0.64	0.72	0.76
15	20	0.6	0.62	0.7	0.75
18.5	25	0.62	0.64	0.72	0.77
45	60	0.68	0.75	0.77	0.79
75	100	0.72	0.8	0.85	0.87

Clamp on Power Meter is Electrician Friendly. Instead of assuming PF of machine and guess-estimating the KW values of running motor, it is better to measure at spot first. PF variations depends on loading, size of HP, brands, Rewound to IE 1,2,3 versions. So measure 4 power parameters in each phase first & Target now.



Suggestion to procure Low Cost Branded Meters Like Above, cost around Rs.10 K, idea is not to promote the brands, but industry can buy any other alternative Low Cost rugged meter better than this. See our motors' PF at around 60 % loading is LOW.

We plan for KW, KVA measurement accuracy of 0.5 % in meter & postpone our meter purchase worth few Lakh Rs for many years. But today, we can walk the talk with 2 % accuracy & spend Rs.10 K to measure the same KW, KVA, PF, KVAR instantly! Many industries in the segment have bought POWER ANALYZERS costing few Lakh Rs, few years back but the same is sparingly put to use during routine maintenance. Buy a CLAMP-ON POWER METER costing around Rs.10,000/- to measure immediately the instantaneous power parameters of KW, KVA, KVAR, PF apart from the basic measurements of V,A, etc. Your Electrician can take instant power readings in any machine, within 10 minutes. They can measure the motor input power in the 3 phases one by one phase, with respect to neutral and individually each phase power parameters and sum the same for total power consumption. By this, the user gets an idea of the difference between the three phases in case of rewound motor or loose contacts at the feed end.

WAKE UP CALL TO INDUSTRY (IN LEAN MODE) AS TO HOW TO AVOID PF PENALTY:-

1. Daily monitor basic, power and energy parameters in the EB meter, during start up months, recorded KWH, KVAH, PF etc. In parallel, monitor your MFT meter at the MV panel, for easy access and routine recording of all parameters every shift as well.
2. Check your daily increment in KWH / KVAH gives a steady value of 0.95 PF and above. If not happening, it is due to Low PF, capacitor bank issue, where single phasing occurred. Unbalanced capacitor consumes more Watts, and delivers very less KVAR.
3. During lean mode, try to measure the no load KVAR of all the machine motors, including the transformer. The no load PF of Transformer is around 0.35 PF only, each industry must have fixed now, the Reactance coupled capacitor as transformer Secondary Standby capacitor, when transformer is feeding to a mixture of linear and non-linear loads, to maintain PF at no-load.
4. Fix Load End PF compensation capacitor (sized to motor's no-load KVAR) to 5 HP & above motors to reduce KVA demand.
5. Whichever motor is used for the day, this will automatically compensate at each load end, so confirm the PF above 0.90 there.
6. Your capacitor banks are meant for total load of maximum demanded KVA; always keep constant watch on excess banks if any.
7. For the given KWh consumed daily, check that required KVAR in capacitor banks are brought into circuit manually correctly. If you have APFC functioning, try to have 3 CT sensor based APFC to have average PF maintained above 0.95 steadily. If you have not installed APFC till date, please plan this during later start up months, otherwise, you may be incurring heavy low PF penalty.
8. **The ups and downs in your daily accumulated PF is like that of UPS & DOWNS happening in our life too. The PF Raise will happen very slow daily, but PF Fall will be quick instantaneous (may be due to excess cap), suddenly drops heavily to low PF.**
9. Industry Electrical team's alert duty is to keep constant watch and maintain the daily average PF averaged accumulated. When the industry is loaded only say around 50 % part loading KVA only, here only, the alert electrician's duty is to maintain the PF and he should take extra care not to switch on excess capacitor banks overnight and land into low PF penalty. **This is how few industries in April 2020, during their lean mode paid Low PF penalty due to Excess capacitors switched on in the MV panel.** Because their PF was lagging till second week of month, their Electrical team had overdone by switching on Excess capacitors that too overnight. This pulled down their PF deeply & they paid for overcompensating briefly, done without measurements.
10. **Maintaining the PF above 0.95 is Electrical team's responsibility in the industry, but the management must facilitate this by proper metering arrangements of the same, and automate thro APFC. This practice may become mandatory post Covid phase.**

INDUSTRY PF PENALTY - EXISTING CASE STUDY

- case study with ref to Industry EB bill in April 2020
- Industry is running on essential loading machines only.
- Monthly EB kwh units consumed 43000 @6.35= Rs.3 Lakh
- Sanctioned Demand 1100 KVA, recorded 500 KVA.
- KVAh recorded: 97000units for 43000 Kwh consumed.
 - MONTHLY AVERAGE PF = 0.44 LAGGING.
- Low Penalty PF- @2 % of CC charges-92 % -Rs.4.15 Lakh
- Low PF charges in monthly bill 4.15 Lakh/11 Lakh = 38 %
- This can happen to any industry running at part loading during the start up phase as capacitor banks are sized to full load of machines, and no Automatic PF control here.
- Alert Electrical team in your Industry to monitor now.

KVA demand reduced by 30 % from Motors at 0.70 PF and compensated at 0.95 PF at load end – Courtesy – EATON

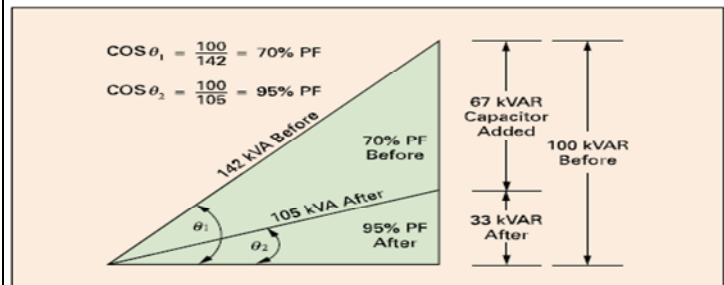


Figure 7. Required Apparent Power Before and After Adding Capacitors

Above Industry pays 38 % of its monthly EB bill to Low PF penalty charges. This had happened now in April 2020 due to part loading pattern. Please do not allow this to happen in your industry during few months of re-start up phase now, Keep an alert watch on your PF average. You can always play this safe by load end compensation at your motors from 0.70 to 0.95 PF always.

DRAWBACKS IN THE EXISTING ELECTRICAL DISTRIBUTION:-

So with our sanctioned demand KVA today, we are feeding to mixture of Linear & Non-linear loads in the industry. The decade-old thumb-rule of capacitors sizing to the today's industry loads, and the wrong location of majority of the cap banks at the Power house have increased the demand KVA, leading KVARH, PF voltage fluctuations, Total Demand Distortion, failures of sensitive electronic devices due to scattering of Harmonic Distortion, Increase in Line Losses from Load end to Power House due to increased current values, more than the rated Voltage drops from Feed end to Load end, and ultimately the machines strained to run due to lower voltages because of line losses and hence KW loss happening at the machine ends.

When the industry was commissioned many years back, the industry did not have many VFD and other Non-linear loads within their premises. Even if they have, they would have installed for few of their critical production productions. So, during the

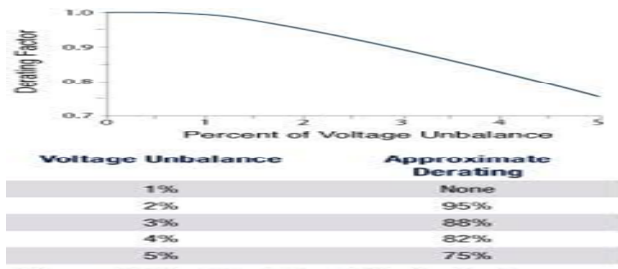
stage of project commissioning from the Electrical aspects, the industry decided to install around 40 % KVAR of the sanctioned demand, as capacitor banks in fixed and APFC formats, mostly in Power House & few in some SSB at field. This thumb rule automatically gets changed for mixed loads feeder now. Assess the nature of your loads & accordingly PF compensate from load ends.

Case study load end PF compensation

Improved Power Factor Correction on typical 50HP Motor gives significant results.

50 HP motor Without Cap	50 HP motor (with Cap)	% Change in parameters
37.3 KW	36.2 KW	3% Decrease
28 KVAR	15.1 KVAR	46% Decrease
46.6 KVA	38.4 KVA	17% Decrease
0.8 PF	0.92 PF	15% improvement

Motor de-rates to 75 % capacity when 5 % unbalance in Incoming volts results in 40 % current unbalance here. This will reduce motor efficiency, and when load demands the motor to feed its full capacity, motor overloads.



Load end compensation of 50 HP motor case study, shows reduction of Line loss, KVA, & volts drop. Unbalanced Motor Input voltage leads to De-rating of motor for given load. This can happen to any of your machines, till date not noticed, but can be done.

METERING ACCURACY TO BE WEIGHED ON PRIORITY BASIS:-

- Inside the industry, this process of routine sharing of instant power parameters of machines between production and maintenance allowed the industry, to know that they were operating the machines safely and were to able to achieve the optimal energy conserving patterns on machines. **Reg the accuracy part of measurement, when no routine power readings were done, industry manager talks only at 10 to 20 % inaccuracy, with respect to production but could not act further on deviations.**
- Now after buying this clamp on meter measurements, today the same industry manager can pin point the losses now at 2 % accuracy. **To circumvent the problem of low PF measured during motor no load parameters, they can connect across the motor terminals, the sized capacitor and take power readings so as to improve PF & maintain accuracy in no-load KW measurements.**
- The sophisticated metering used with 3 CT or 4 CT mode again depends on the dynamic load variations which normally happen in electronic driven non linear machine loads. Hence we have to plan to use the above meters to suit to the application and process variables. **For the given linear load of motor, though the theory says it is a balanced load, but still 3 phase 4 wire method of measurement gives an accurate individual phase parameters and the sum of power parameters in 3 phases.**
- **This article is addressing the power metering application to small and medium scale industries who find it difficult to meet both the ends that is how to maximize the usage of sanctioned quota of KWH, KVA so as to get better production with the sanctioned quota.** LT service has a monthly EB bill of around One Lakh Rs and if they realize machine to machine variations in power consumption as measured by clamp on meter & corrected, then ROI – Return on Investment will be around one month only.
- **This exercise may sound trivial to large scale industries since they had already MODBUSSED the Integrated Power & Production parameters and are dynamically monitoring, historic trending by windows-compatible mode as ENMS systems covering the entire plant. But still, each shift Electrician must have this metering tool for any random or quick trouble shooting needs.**
- Now the industry is getting only Rationed Electricity. Industry is aware of kwh cost difference when run on DG. This makes us to use Electricity rationally and we want to maximize use of sanctioned KVA & KW given to us, by reducing the losses. **Priority to the industry now is to run our existing equipment efficiently first and next comes planning to buy energy efficient equipment.**

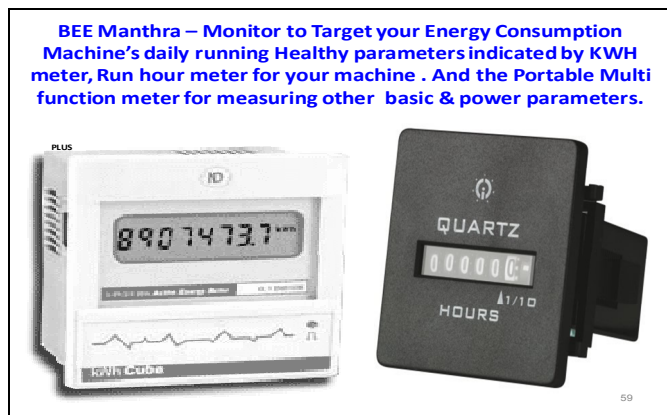
FIRST MONITOR YOUR BASIC & POWER PARAMETERS FIRST, TO TARGET NEXT ON REDUCTION:-

- Here, we have to see that our motor is matched to load now. The industry has to visualize the motor is not like 2000 watts bulb which draws always only 2 KW during its usage anytime, but 2.2 KW motor consumes power to match to its load demand say from 1 KW to 3 KW. Lighting load is constant and visible to us where as motor loads are varying & the losses not visible to us.
- Looking thro an aerial eye view of the industry power consumption pattern, the invisible losses that is seen between the cup and the lip from the transformer up to motor terminals and beyond that at the inefficient loadings, it is mandatory for the

industry to have multiples of instant power clamp-on meters, KWH meters to be given to the shift Electricians, than being contented with one sophisticated power analyzer for the whole plant.

WHEREVER POSSIBLE MEASURE FIRST, NEVER GUESS-ESTIMATE KW, KVA & PF:-

- **What the best operating practices call for and as per the BEE guidelines is that any motor 10 HP & above, operating at two shifts a day or 6000 hours an year, needs mandatory KWH metering.** 'To use the above meter or in-situ power meter readings monthly or routinely' can also be made mandatory. This metering is a must not only for the HT consumers but also for the LT consumers as well, Basic, power and Energy parameters can be monitored at each of their machines as well.
- Ultimately this helps the consumer to know precisely what he consumes at each of his loads in KW, KVA, PF etc; sump up and then he can optimize the loads accordingly. **The power data displayed in this type of Low end clamp-on power meter can reach the bottom most Electricians inside the industry and he is made aware of what is he measuring in each of the machines compared to the machine power ratings.** This deviation will prompt him to find out the KW loss relative to each machine. In fact, the harmonic levels THD in volt & current are displayed in these meters now, and meters also can give instant THD % values.



THE TABLE BELOW COMPARES THE BEHAVIOUR OF 5 H.P MOTOR AT HIGHER THAN 400 VOLTS

Study taken by Reputed Servo stabilizer Manufacturer
 The savings are more visible in lower HP motors than the higher HP motors in the industry.

Input Voltage	Current	KVA	PF
400	7.5 Amps	5.2 Kva	0.8
425	8.3 Amps 11% More	6.2 Kva 18% More	0.7

Portable clamp-on power meter instantly measures. But KWH and Run hour meter if fixed on intermittently-run machines, this can indicate your machine's daily health. Also, during Re-start on partly loaded industry, we may face high voltage from EB side, this increases losses in partly loaded motors. Better to reduce EB Incoming volts thro OLTC / Servo Stab or contact EB.

MONITOR & RECORD THE MOTOR & MACHINE RPM:-

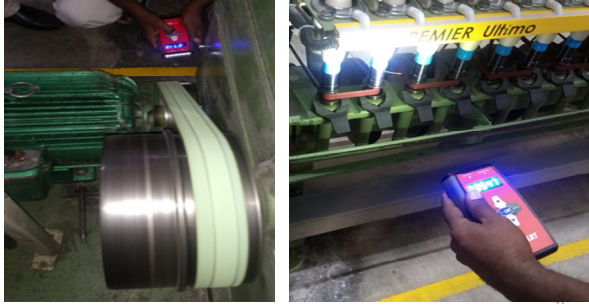
Use your stroboscope or non-contact tacho to measure the slip that is happening in load & no-load stage running of your machine. When your motor is getting unbalanced Volts, the motor de-rates for the given load demanded. When motor is not allowed to breathe out, and could not ventilate out its heat thro fins, repeatedly greased with excess & ordinary MP3 grease, worn-out at bearings, overloaded from load side, trying to run > full load, Incoming Low voltage, motor consumes more KW to maintain speed.

Having generated say 1470 RPM at 15 KW from your 20 HP motor, say this is getting lost say by more than 30 RPM at the motor & machine pulley. This is a visible loss, you are allowing to lose RPM from your hands, that amount of productivity loss happens in many of your belt driven machines. **Condition Monitor the deviation in RPM in motor name plate, pulley speed ratio & machine rpm.**

Also physically check the inner surface of the V pulley for grip or is it glassy / dished out / worn out conditions. If the surface is smoothened & polished looking, better to replace the pulley with optimum reduction in diameter with cogged belts, also inspect all V belts, for damages and plan to swap with cogged belts. They are less weight, have more power carrying capacity, their life is normally double that of V belts. **Mind you, your Pulley life is only 40,000 hours say 5 years only and if you run more than that, then visible worn-out pulley is the main culprit to your motor-to-machine power transmission loss and does not restore productivity. You will plan to change equipment assuming it has de-rated, but precisely the new pulley & belts will restore your productivity.**

In a variable load application like centrifugal blowers, pumps etc, 5% of blower speed reduction gives 14 % power savings, 10 % blower speed reduction gives 27 % power savings. So optimization of the above machines using first by the cogged Belt & re-sized pulley sizes, and simultaneously by VFD retrofit here, you have ample scope of 30 to 40 % energy savings based on the part load efficiency of motor's & blower's variable torque application. Motor efficiency band is flat and wide between 55 to 90 % loading, but variable torque equipment like blower or fan etc have a narrow and umbrella type curve. So optimize your equipment speed at its Best Energy Efficiency point where the top slope of both the motor & blower overlap, to match to the process demanded requirements. **This is very low cost and ROI Return on Investment on your new cogged belt, pulley and VFD is few months only.**

RPM – is the tool to productivity, the industry manager to check routinely. Today you BUY a Non-contact Tacho / Stroboscope to monitor your RPM @ LS Mills Theni



Having given input KW to your motor, speed in RPM is delivered to the machine, we have to monitor & confirm the same. Some industries reported around 5 to 10 % RPM dropped at the machine, but Many industries are not aware of drop in RPM in their variable torque load machines.



- FLOW \propto RPM
- HEAD \propto RPM²
- POWER \propto RPM³

10% speed reduction = 27% energy savings

RPM	FLOW	HEAD	POWER
100%	100%	100%	100%
90%	90%	81%	73%
80%	80%	64%	51%
70%	70%	49%	34%
60%	60%	36%	22%
50%	50%	25%	13%
40%	40%	16%	6%

Motor & Machine Output RPM monitoring and targeting is the area, till now industry has not focused into. Non-contact Tacho cost Rs.2000/- or Stroboscope above Rs.10 K will instantly tell you what is the RPM lost between motor & machine immediately.

CONCLUSION:-

- **BEE Mantra is Monitoring to Target the Energy / Electricity Reduction. 1 KW of Electricity saving per hour in the industry equals to Rs.50,000/- saving per Annum, in industry running with 3 shifts per day. We have to account for every unit of Electricity used in our industry. The existing practice in the industry is that we are now guess-estimating the energy losses in the routine check-up of machine / process parameters. This needs to be changed to condition based monitoring & targeting now.**
- Energy conservation can be achieved in an industry only by Energy Education to the bottom most employee. When the same employee measures the power parameters and compares this to the rated parameters, then automatically he will come back to the Maintenance Manager with more avenues for saving. **The Good Things & Bad Things HAPPEN TO US BECAUSE OF US ONLY and others can only Catalyze.** So cultivate good House Keeping & Monitoring Habits to visualize & reduce Internal Invisible Losses rather than showing to others that we reduced the visible losses externally especially on constant watt lighting circuits.
- **It is the duty of every Electrician to have this type of clamp on power meter for his professional cum personal use. When so many LT service industries in the MSME sector and in the Micro sector run by proprietor-cum-worker are struggling to pay their monthly Electricity bills, you can impart your part time services by using the above said meter and bail them out of low PF penalty. Every Electrical Engineer's passion must be to improve the PF to above 0.97 and serve to the surrounding EB consumers.**
- The industry management's view was like this few years back. Manager thought that when the PF was maintained near unity, his Electrical team was working efficiently, because of PF bonus near to UPF (unity power factor) was given by the EB Authorities. Still many industries are still maintaining the UPF as they want their monthly KWH to match near-fully with monthly KVAH. Only in KVAH billed States, this nearing to UPF is a gain to them. But in States, with KWH & KVA demand, it is prudent to keep monthly average PF around 0.97 to 0.98 Lagging, when the industry is running with mixture of Linear & non-linear loads presently.
- **The writer is of the above article had published this article in Electrical India in the year 2010, now in 2020 still this holds good. The writer does not promote any Electricity metering brands, and the only desperation is that the industry is delaying this small clamp on power meter purchase, because they question what this meter can deliver? The deviations in measurements made out of this meter, will deliver results. Now they can affordably procure immediately today during the startup phase now, to assess no-load electrical parameters of all their machines & utilities during the lean period & conserve Energy by optimization.**
 - **By energy conservation in the industry, we try to recover the losses which go as waste.**
 - **By Energy Measurement, we draw a line between Avoidable and Unavoidable Losses and plan to minimize same.**
 - **So Measurement is the first step to Conserve Energy, first measure the instant power & then Trend further now.**

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The Objective:- SHARING KNOWLEDGE TO SAVE OUR ENERGY!

CONSERVING OUR ENERGY IS OUR COLLECTIVE RESPONSIBILITY TODAY, FOR A BETTER TOMORROW!