BEFORE THE VIDYUT OMBUDSMAN

:: Present ::

C. Ramakrishna

Date: 02-07-2014

Appeal No. 58 of 2013

Between

M/s. G.V.K. Industries Ltd.

Jegurupadu, Kadiam (M)

Near Rajahmundry, E.G. Dt 533 126

... Appellants

And

1. The Divisional Engineer, Operation, Rajahmundry
2. The Senior Accounts Officer, Circle Office, Rajahmundry
3. The Divisional Engineer, Technical, Circle Office, Rajahmundry

… Respondents

The above appeal filed on 27-04-2013 has come up for final hearing before the Vidyut Ombudsman on 19-05-2014 at Rajahmundry. The appellants as well as respondents 1 to 3 above were present. Having considered the submissions of the appellants, the respondents and the material available on record the Vidyut Ombudsman passed / issued the following:

AWARD

2. The appeal arose out of the dismissal of the complaint of the appellants herein by the CGRF. The appellants approached the CGRF complaining about the back billing assessment for the period September 2001 to November, 2001. The CGRF dismissed the complaint upholding the order of the Appellate Authority. Aggrieved by the order of the CGRF, the appellants filed the appeal.

3. The appellants are engaged in the generation of power through their generating station located at Jegurupadu, near Rajahmundry. They have a HT service connection under Category VI for their Staff Colony. This service connection was released to them in September, 1995. On October 18, 2001 the appellants addressed the 1st respondent stating that they have noticed errors in kVAh recording in the meter provided to them for the last 4 to 5 days and informed him that they have stopped drawing power through the service connection and kept the AB switch in open condition from 17-10-2001. They sought a testing of the meter. Even as the respondent DE did not get the meter tested, on and from November 6, 2001 the appellants started drawing power again, duly informing the respondents of the same. In spite of this second letter also, as there was no action from the respondent DE, the appellants again informed the respondent DE on 07-11-2001 that a testing of the meter be arranged as the meter is recording lower consumption. The service of the appellants was inspected on 15-11-2001 and the respondent DE, Operation issued a notice of provisional assessment on 07-12-2001 assessing

the appellants for shortfall in consumption of units for the period September, 2001 to November, 2001. At the time of inspection, it was noticed that the meter was recording -63.89% error in kWh element and +2.09% in kVAh element. The respondents have fixed a new meter to the service on 15-11-2001. The whole dispute is about the assessment period and the quantity of shortfall units that are assessed, apart from the issue of payment of FSA and monthly minimum bill for a short duration of 3 days.

4. The respondent DE issued an assessment notice for Rs. 84,444/- on 07-12-2001. Even as objections to the assessment were submitted by the appellants, the SE, Operation, Rajahmundry issued another provisional assessment notice dtd: 14-03-2002 (curiously signed on 13-03-2002 itself!) again reiterating the same assessment. In spite of objections filed against it, the SE, Operation, Rajahmundry confirmed the assessment on 20-12-2004. On 10-01-2005, the appellant preferred an appeal before the CGM, O&CS, APEPDCL against the assessment made by the SE, Operation, Rajahmundry. After keeping the matter pending till 30-11-2012, the CGM informed the appellants herein that the back billing assessment cannot be revised at so late a stage. The appellants then approached the CGRF, Visakhapatnam which also dismissed their complaint.

5. The appellants stated in their appeal before this authority that back billing for the month of September, 2001 is unwarranted since the recording of the kWh element in the meter was free from any defect; that the assessment of shortfall kWh units for the month of October, 2001 is unsustainable for the reason that when they are added to the actual recorded

6,371 kWh units, the total kWh consumption for the month amounts to 17,644 kWh with a power factor of 2.33, which is a technically unfeasible value and hence confirms that the shortfall assessment is wrong; that the assessment of shortfall kWh units (3,312 kWh) for the period 22-10-2001 to 15-11-2001 also is unsustainable for the same reason that when they are added to the actual recorded 1,872 kWh units, the total kWh consumption for the month amounts to 5,184 kWh with a power factor of 1.49, which is a technically unfeasible value and hence confirms that the shortfall assessment is wrong; that the delay in disposal of the appeal made by them before the CGM, O&CS was not on account of any fault on their part; that the assessed shortfall of 3,312 kWh for the period 22-10-2001 to 15-11-2001 was in fact billed for and paid by them in November, 2001 CC bill; that the power factors of 2.59, 2.33 and 1.49 for the months of September, 2001, October, 2001 and for the period 22-10-2001 to 15-11-2001 obtained after adding the assessed shortfall units to the recorded units are technically not valid; and that the shortfall / back billing assessment for the month of October, 2001 and for the period 22-10-2001 to 15-11-2001 be restricted to 649 & 1364 units respectively.

6. They assailed the assessment of back billing on the following grounds:

   a. The SE, Operation, Rajahmundry was wrong in assessing the shortfall kWh units in spite of affirming that the average consumption from the service connection was 6,577 units per month.

   b. The observation of the SE, Rajahmundry that the LT TVR meter of consumer has recorded less consumption is not in order. Had

the appellant consumed his quota of 6000 to 6500 units every month from the DISCOM as assumed by the SE, in view of the lower recording of the kWh element by -63.89% in the DISCOM's HT TVR meter, the consumption recorded by the LT TVR meter of the appellant must have been more, but not less.

c. The assumption of colony consumption being 40,000 units per month is not correct, as the consumption of units recorded in the LT TVR of the appellants compared favourably with the consumption of the corresponding months in the previous year.

d. Considering the display of "Reverse CT-B" for assessment purpose is wrong because it was noticed only on 15.11.2001 but not at any time before that day. Moreover, "Reverse CT-B" was noticed only in the meter display but not at the CTPT set terminals.

e. Finding that the recording of the kWh, kVAh, kVArh (G) & (D) elements are not tallying with each other, without applying all the errors found in the HT meter testing that was done on 15.11.2001, assessment of shortfall units is not correct. When all the errors found at the time of meter testing are applied, the relationship between kWh, kVAh and kVArh (G) elements holds good exactly in a similar manner to that of the previous months and for latter months. Tallying of kVArh (D) element with the other elements need not be considered as it is not a billing parameter and is only the reactive energy export to 11 kV network from their installation.

f. The % error arrived between the units recorded by the HT TVR

(DISCOM's) and LT TVR (Consumer's) meters after adding 3% DTr losses to the consumption recorded by the LT TVR meter was quite normal when compared to the % errors in the previous months from April 2001 to August 2001.

7. They further contended that the low PF surcharge of Rs. 1325.17 levied on them in the October, 2001 CC bill is refundable because when the assessment is made considering the shortfall, the PF would be 0.95 and as such the levy of low PF surcharges needs to be refunded; that the unrecorded 3,312 kWh units assessed for the period 22-10-2001 to 15-11-2001 were already included in the bill for November 2001 and paid for by the appellants and hence these units need to be excluded from the back billing assessment; and they finally arrived at a figure of Rs. 45,063/- as refundable to them.

8. The appellants marshalled lot of evidence in support of their contention and submitted the same along with the appeal and also during the course of the hearings.

9. The respondents were issued a notice for hearing the appeal directing them to submit their written submissions in the matter. The respondents submitted their written submission on 05-02-2014 confirming, among various other things, that it is based on the written request of the consumer appellant that the meter of the service was tested on 15-11-2001; that during the testing it was found that the HT meter of the said consumer was found recording the kWh element with an error of -63.89%; that an erratic meter behaves erratically and the consumer appellant's focus on wrong power factor

confirms this erratic behaviour; that in spite of there being a provision for assessment of back billing up to six months, the SE, Operations, Rajahmundry limited the assessment to only 3 months; that the consumer has not originally questioned the total back billing assessment before the CGM, O & CS and requested only for deduction of the already paid amount, whereas in the appeal before the Vidyut Ombudsman, he is asking for the refund of already paid 50% of the assessed amount -- a thing which cannot be considered; that the consumer made a representation to CGM, O & CS after a gap of nearly 7 years; that the back billed units for the period 22-10-2001 to 15-11-2001 which were already included in the CC bill for November, 2001 will be reconciled and will be rectified / deducted; that on 26-08-2011, they received a notice of termination from the consumer for the service connection; that on 22-11-2011, the final readings were taken and the AB switch sealed in the presence of the consumer's representative; that the refund of the Security Deposit was not made in view of the pendency of W.P. No. 5214/2011 in the Hon'ble AP High Court against consumer's service connection bearing number RJY351; that as per clause 5.9.4.2 of GTCS, the agreement was terminated with effect from 26-11-2011; that they have received instructions in March, 2013 from their higher authorities for collection of FSA from all bill stopped consumers; and that soon after receipt of further clarifications from their Corporate Office, refund of the Security Deposit would be made.

10. During the course of the hearings, the appellants argued and filed written submissions on 28-02-2014 & 19-05-2014 essentially reiterating the same points and further stated that the DISCOM went for back billing considering the error of -63.89% in kWh element only and ignored the error of

+2.09% in kVAh element which was recommended by the testing authority; that in two part tariff billing, the energy recorded by kWh, kVAh and kVArh (lag) elements of the HT TVR meter satisfy the energy triangle relationship in such a way that the performance of any one of the three elements can be verified / checked from the reading of the other two elements; that with the shortfall kWh units arrived by applying -63.89% error to the recorded units, the energy triangle relationship between these three elements did not satisfy in any manner for the entire period of assessment from September 2001 to 15-11-2001; that in view of the fact that the HT TVR meter installed by the DISCOM are configured in Quadrant -1, the ratio of the sum of recorded kWh units and shortfall kWh units assessed to the kVAh units is more than unity, an unsustainable value because it is technically not valid; that from 19-07-2001 to 15-11-2001, the consumption recorded by the kWh element to the HT TVR meter was more than the LT meter upto 29-09-2001, whereas it was less than consumption recorded by the LT meter from 29-10-2001 to 15-11-2001 and there afterwards, the kWh units recorded by the HT TVR meter gradually fell upto 15-11-2001 as compared to the units recorded in the LT meter; that they have suffered unnecessarily for the delay in the disposal of their appeal by the Appellate Authority (CGM, O&CS), as the appeal was dismissed without citing any provision of law; that demanding CC charges of Rs. 7,925.10/- for the period 23-11-2001 to 25-11-2001 as the HT agreement is set for termination with effect from 26-11-2001, in spite of disconnecting the service on 22-11-2001 is not correct; that the security deposit of Rs. 3,26,700/- made by them for this HT service needs to be refunded with interest in accordance with Regulation 6 of 2004 of APERC; and that the FSA charges for FY 2010-11 and 2011-12 amounting to Rs. 79,107.76/- cannot be adjusted

against the Security Deposit amount lying with the DISCOM for the reason that their collection is authorized by the APERC to be made along with the monthly CC bills of October, 2012 to September, 2013 and October, 2013 to September, 2014 respectively and that CC bills for their HT service having been stopped with effect from November, 2011 adjusting them against Security Deposit would run contrary to the Regulations of the Hon'ble APERC.

11. Even after the hearings were concluded on 19-05-2014 and the orders were reserved, the appellants again submitted written submissions on 23-05-2014 & 31-05-2014. They were not looked into because, the hearing of the case was closed and the filing of written submissions cannot be an endless process.

12. The respondents filed their written submissions again on 04-03-2014 & 19-05-2014 stating that scientific study on behaviour of an erratic meter and comparing it with actual Engineering parameters cannot be possible in most cases and it requires further R&D to comment on the reply of the consumer; that it is a case of back billing and not analysis of the behaviour of the erratic electronic meter; that the tests conducted on the meter showed that the errors were varying and that for the purpose of this assessment, error was estimated duly taking average power factor as 0.916 and load as 0.65 A; that it is not certain that the average load will prevail with the average power factor throughout the day and month on this particular meter of the consumer; that the FSA on the consumption from 4/2010 to 11/2011 is still to be paid by the consumer and that in view of the termination of the agreement, the same would be recovered from the Security Deposit available;

and that the period of 3 months mentioned in the notice of termination given by the consumer was to expire by 25-11-2011 and hence raising demand till the last day of agreement termination i.e., 25-11-2011 is in order.

13. A perusal of the various contentions raised by both the sides reveals one thing clearly -- that the issue has not been dealt with the seriousness that it deserves by the authorities below -- i.e., the CGM, O&CS in his capacity as the appellate authority for the short billing assessment made and the CGRF. While the CGM, O&CS has taken more than 7 years to dispose of the appeal before him and that too dismissed it saying that it cannot be considered at so late a stage, the CGRF did not go into the whole gamut of issues raised in the appeal and also dismissed it without as much giving a patient hearing or discussing the issues raised. Hence, both their orders are liable to be set aside.

14. Let us now examine whether the contention raised by the appellants that the assessment of shortfall units made by the SE, Operation, Rajahmundry is liable to be set aside. The appellants have taken lot of pains to hammer out the point that the assessment of shortfall units taking only the kWh element that was found to be recording lower by -63.89%, totally ignoring the other factor viz., kVAh that was showing a +2.09% error is not correct. Their main contention is that the quantum of assessed shortfall units is not correct because it does not satisfy the energy triangle relationship. In addition, they are also basing their argument on the relationship that exists between the kWh element and the kVAh element, which is defined as “Power Factor” by the GTCS.

15. Let us first examine the claim about the requirement to satisfy the so called "Energy Triangle" relationship. In view of the lack of proper defence from the respondents for the argument put forth by the appellants in this regard, reliance is placed on physics textbooks and academic papers which discuss about the issue. One such academic paper that is relied on by this authority is the paper titled "Can the Apparent Energy - kVAh be Computed as a Vector Sum of the Active and Reactive Energies?" authored by Dr. Vithal N. Kamat, which is enclosed to this order for a better understanding / appreciation of the issue by all the stakeholders. Conventional engineering textbooks are unequivocal in saying that in single phase systems, apparent power is related to active and reactive power, and given any two quantities the third can be computed from the other two. However, in case of energy qua energy and not power, when the load is not constant -- as is usually the case -- there is no relation between any two of the three energy quantities -- apparent energy, active energy and reactive energy. Therefore, given any two quantities, it is not possible to compute the third energy quantity in single phase systems. The case becomes more complicated in respect of three phase systems, as we are presently dealing with an HT consumer who is given three phase supply. The energy consumed in each of the three phases is independent of the other two. Therefore, the combined active energy in a three phase load over a time duration can be only given as an arithmetic sum of the active energy consumed in each of the three phases. Energy is not a vector quantity; it is a scalar quantity. The active, reactive and apparent energies are not related to each other. In case of three phase systems, even the active, reactive and apparent power are not related to each other. In

other words, the apparent energy kVAh cannot be computed as a vector sum of active energy kWh and reactive energy kVArh. Thus, given any two elements of these three, it is not possible to derive the third element. Therefore, the question of any of these elements -- especially derived kWh element -- not satisfying the energy triangle relationship and hence not being reliable, does not arise.

16. Let us now turn to another of the relationships that the appellants have been harping upon in their defence. It is about the technical impossibility of power factor being more than unity when computed with the assessed shortfall units. The appellants' contention is that when the power factor is computed with the kWh units assessed and the corrected kVAh units, the resulting power factor is going beyond unity, which is a technical impossibility and hence, the assessed units cannot be correct. This authority is not inclined to agree with this argument either. The reason being that when two of the elements are in error, and one of them only is taken into account for arriving at the shortfall units, taking into account the other element -- with or without correction -- to compute the power factor and saying that because it has gone beyond unity, the assessment of shortfall units itself needs to be adjusted to satisfy the power factor requirement is not correct. The electrical utility is interested only in the kWh element for billing purpose. GTCS of the DISCOM as applicable at that time also mentioned kWh as a unit for the purpose of billing. The mentioning of the kVAh or kVArh elements in the test results is only incidental and cannot be the basis to question the assessment of kWh units. It is true that the appellant's records show that a power factor of 0.95 was being maintained by the appellant both

before and after the disputed period of assessment. But, that by itself does not mandate that the assessment of shortfall units needs to be tweaked to suit the power factor of 0.95. Based on these two reasons, the gargantuan exercise taken up by the appellant to convince this authority of the assessment of shortfall kWh units being abnormal, is not being given credence to and is liable to be ignored.

17. The shortfall assessment done by the respondents cannot be found fault with. It is also common knowledge that the meters are calibrated to measure the element of significant importance for the purpose of billing. No record is placed before this authority to prove that the meter of the consumer was calibrated and fine tuned to record all the elements viz., kWh, kVAh & kVArh, within the allowable range of errors, throughout the operating range of the meter. In the absence of the record, it is but natural to assume that the meter -- as usually all the HT meters were -- was calibrated to measure the kWh element, as that happened to be the most significant element for the purpose of billing. The test results that aided the assessment of kWh element cannot be found fault with for this reason, in the absence of any evidence to the contrary.

18. Some other assertions and contentions raised by the appellants in regard to the assessment of shortfall units need to be examined now. The assertion that assessment of shortfall kWh units for the month of September, 2001 is unwarranted as the meter was free from any defect during that month, cannot be given credence to. This authority is of the view that the DISCOM is not bound to be guided only by the affirmations made by the

appellants. There is a procedure laid down for the DISCOM in the GTCS as to what has to be done if a defective meter is noticed. The SE, Operation, Rajahmundry acted in accordance with those provisions and felt it adequate to assess the shortfall units for a period of 3 months instead of the maximum of 6 months allowed by the GTCS provisions.

19. The appellants' assailing the observation of the SE that the LT TVR meter of the consumer has recorded less consumption is also not being taken note of by this authority for the reason that the mere observation of the SE does not alter the final outcome or necessity for assessment of shortfall units. The LT TVR meter belongs to the appellant consumer and the DISCOM has no control whatsoever over it. Therefore, there was no necessity for the DISCOM to have observed anything that was recorded in it.

20. The assertion of the appellants that "Reverse CT-B" was never noticed prior to 15-11-2001 and hence cannot be taken into account for assessment of shortfall units is not being accepted for the simple reason that it is not the assertions of the consumer based on which a DISCOM has to carry out its functions. There is a set procedure for it and it has to follow it. As long as it has followed that laid down procedure, mere assertions of the consumer cannot be taken note of.

21. The assertion of the appellants that when all the errors found at the time of meter testing are applied, the relationship between the kWh, kVAh and kVArh(G) elements holds good exactly in a similar manner to that of the previous months and for the latter months, is not tenable for the reason that

there exists no vectorial relationship between these three elements, as discussed supra.

22. The contention of the appellants that the low PF surcharge of Rs. 1325.17 levied on them in the month of October, 2001 CC bill is refundable appears to be right. When the meter of the appellants is malfunctioning and this has resulted in assessing them for the shortfall kWh units, the calculations of low PF surcharge would obviously undergo modification and the same has to be allowed by the respondents.

23. The appellants contend that the assessed shortfall units of 3,312 kWh for the period 22-10-2001 to 15-11-2001 were in fact billed by the respondents and were paid for by the appellants in November, 2001 CC bill. This is a simple question of fact and the respondents have been forthright in saying that they wouldn't mind to verify the records once again and account for the same.

24. One thing needs to be taken note of in this whole episode. It was the consumer who brought the malfunctioning of the meter to the notice of the respondent officers. In spite of their informing about the malfunctioning of the meter on 18-10-2001, the respondent officers did not act till 15-11-2001. This is pathetic to say the least. For a high value consumer like the present one, the respondents ought to have been more alert and should have acted with more alacrity than what was on display. For this lethargy, the respondents have to accept responsibility.

25. Let us now consider the other contentions raised in the appeal. The appellants have questioned the proposed recovery of minimum charges for the period 23-11-2011 to 26-11-2011 from the security deposit. The appellants sought a termination of the service agreement through their letter dated 26-08-2011. This letter gives an advance notice of 3 months for the termination sought for. On 22-11-2011, at the time of taking monthly reading, the ADE, Operation, Rural, Rajahmundry disconnected the service. The appellants contend that this disconnection is against the provisions of the GTCS in as much as it was affected without their consent and without waiting for the expiry of the notice period of 3 months and hence they should not be charged the minimum charges for the three day period from 23-11-2011 to 25-11-2011. The respondents contend that they have not disconnected the service on their own and that at the time of meter reading, the representative of the appellants who was present informed them that in view of the termination of the service applied for, the service may be disconnected. It was based on this request that the disconnection was done and the AB switch was kept open. The respondents produced record at the time of hearings to prove their point that the disconnection was got authenticated by the representative of the appellants also. They contend that, had the representative of the appellants objected to the disconnection, he would not have appended his authentication at the time of disconnection and would have demanded that the service be kept in live condition till the expiry of the notice period. As this was not the case, there is no substance in the contention of the appellant that the disconnection was unilaterally done. This authority is inclined to accept the defence put forth by the respondents in this regard. The appellants are not a small firm. Their knowledge of rules

and regulations is quite high. It appears that the representative of the appellants did not completely grasp the nuances of asking for the disconnection of the service on 22-11-2011 and authenticating the same without any murmur of protest. It also appears that the ADE, Operations, Rural, Rajahmundry could have bonafidely acted only on the request of the representative of the appellants, as it is quite unlikely that he would have been in the know of complete details of the letter addressed by the appellants to the SE, Operations. Therefore, the appellants' contention that they should not be charged the minimum charges for the three days in question i.e., 23-11-2011 to 25-11-2011 is not tenable. Had the appellants really wanted to ensure that the disconnection is not affected before 25-11-2011, they would have raised an alarm either on 22-11-2011 or soon thereafter and sought that the connection be restored till 25-11-2011. The fact that this was not done gives credence to the respondents' contention that the disconnection was done at the behest of the appellants' representative. Clause 5.9.4.2 speaks of the termination of the agreement. Nothing prevented the appellants from demanding the service be not disconnected before the agreement is terminated. Nor is there anything on record to show that in spite of the request of the appellants to not disconnect the service before the expiry of the notice, the respondents had disconnected the service against the appellants' will. Therefore, the respondents are right in seeking to withhold the minimum charges for the three days from the security deposit available with them.

26. The next contention of the appellants is about refund of their security deposit with interest. They appear to have paid a security deposit of Rs.

3,26,700/-. In view of the termination of the agreement w.e.f 25-11-2011, this security deposit needs to be refunded to them not later than one month from the date of termination in accordance with clause 9 of Regulation 6 of 2004. Any adjustments that need to be made or deductions that need to be affected ought to be affected well before the expiry of one month from the date of termination of the agreement. For the entire period beyond one month from the date of expiry of the termination of the agreement, the DISCOM is liable to pay interest at twice the applicable bank rate as per clause 9 of Regulation 6 of 2004.

27. One last contention of the appellants is about the proposed recovery of FSA charges from the security deposit by the respondents. They contend that as per the proceedings of the Hon'ble APERC dated 20-09-2012, the FSA for the FY 2010-11 is to be collected along with the monthly CC charges from October, 2012 to September, 2013 and for the FY 2011-12 from the monthly CC charges from October, 2013 to September, 2014. But, in view of there being no CC charges for them from November, 2011 consequent to the termination of the agreement, the proposed recovery of FSA charges is contrary to the Hon'ble Commission's directions. The respondents contend that FSA on the consumption for the period April, 2010 to November, 2011 has not been recovered because, it is a bill stopped case but that the same is payable in view of the instructions from their higher authorities. In regard to FSA charges also, the appellants appear to be stretching logic merely on technical grounds. Just because the Hon'ble Commission had said that the FSA for the financial years 2010-11 & 2011-12 be collected along with the CC bills for the period October, 2012 to September, 2013 and October, 2013 to

September, 2014 respectively, it doesn not mean that all those consumers who are no longer issued CC bills during that period need not pay FSA charges. The FSA charges are liable to be paid. Any order or regulation needs to be viewed in the larger perspective and given a harmonious construction. Mere non-mentioning of the procedure that needs to be adopted regarding collection of FSA charges from bill stopped cases, is not reason enough to escape liability from the charges. Therefore, the higher authorities of the respondents are not wrong in instructing that the FSA charges be collected from the security deposit amount available with them.

28. The respondents' submission that the appellant made an appeal to the CGM, O&CS after a gap of nearly 7 years, is factually incorrect. In fact it is the CGM, O&CS who slept over the appeal for more than 7 years. This is highly reprehensible.

29. The respondents further submitted that the security deposit was not refunded in view of the pendency of W.P. No. 5214/2011 in the Hon'ble AP High Court. This is also view with great displeasure by this authority. The said W.P is with reference to a totally different service connection of the appellants. No proper reason or rule was marshalled before this authority by the respondents to substantiate their procedure of withholding one service connection's security deposit based on the dispute in another service connection. Hence, the act of withholding the security deposit of the appellant for the service connection in question is found highly objectionable. For this, the respondents liable to pay interest at twice the applicable rate of interest (bank rate) as per clause 9 of Regulation 6 of 2004.

30. Therefore, it is hereby ordered that:

a. the assessment of short billing, made by the SE, Operations need not be interfered with;

b. the FSA charges for the period April, 2010 to November, 2011 are liable to be paid by the consumer appellant and the same may be recovered from the security deposit available with the respondents;

c. minimum charges for the three days from 23-11-2011 to 25-11-2011 are liable to be paid by the appellants and the same may be recovered from the security deposit available with the respondents;

d. the low PF surcharge of Rs. 1325.17 levied on the appellants in the CC bill for October, 2001 shall be suitably modified keeping the assessment of shortfall units made by the SE, Operations, Rajahmundry;

e. verification of the inclusion of the assessed shortfall units for the period 22-10-2001 to 15-11-2001 in the bill for November, 2001 shall be made by respondents and suitable adjustment shall be made;

f. the respondents are liable to pay interest at twice the bank rate applicable on the security deposit that is remaining with them as on 25-12-2011 after adjusting the short billing assessment dues, if any, and the minimum charges remaining unpaid as on 25-11-2011; and

g. the FSA charges shall be recovered / adjusted from the security

deposit and accrued interest thereon, at one go on the date of Hon'ble Commission's orders on FSA for each relevant quarter.

31. This appeal presented an instance of a Designated Officer sitting over the appeal made by the consumer for more than 7 years. Such behaviour constitutes deficiency in service. But this deficiency in service is not defined as one of the service areas in the Standards of Performance regulation issued by the Hon'ble Commission. Therefore, this authority is constrained to bring this to notice of the Hon'ble Commission by duly marking a copy of this order to the Secretary to the Commission for incorporating this sort of deficiency as a service area by bringing about an amendment to Standards of Performance regulation, if and as felt necessary by the Hon'ble Commission.

32. This order is corrected and signed on this 2nd day of July**, 2014**.

VIDYUT OMBUDSMAN

Encl: Paper titled "Can the Apparent Energy - kVAh be Computed as a Vector Sum of the Active and Reactive Energies?" authored by Dr. Vithal N. Kamat, Electrical India, published by Chary Publications, 14 Sidh Prasad, Pestom Sagar Road, 3 Tilak Nagar P. O., Chembur, Mumbai, 400 089, Vol. 39, No. 23. December 15th, 1999, pp.11-17

To

1. M/s. G.V.K. Industries Ltd., Jegurupadu, Kadiam (M), Near Rajahmundry, E.G. Dt 533 126
2. The Divisional Engineer, Operation, Rajahmundry
3. The Senior Accounts Officer, Circle Office, Rajahmundry
4. The Divisional Engineer, Technical, Circle Office, Rajahmundry

Copy to:

5. The Chairperson, CGRF, APEPDCL, P & T Colony, Seethammadhara, Near Gurudwara Junction, Visakhapatnam - 530 013.
6. The Secretary, APERC, 11-4-660, 5th Floor, Singareni Bhavan, Red Hills, Hyderabad - 500 004.
7. The Superintending Engineer, Operation, APEPDCL, Ullithota Street, Near Godavari Bund, Rajahmundry - 533 101.
8. The CGM, O&CS, APEPDCL, P & T Colony, Seethammadhara, Near Gurudwara Junction, Visakhapatnam - 530 013.

Can the Apparent Energy - kVAh be Computed as a Vector Sum of the Active and Reactive Energies?

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1. INTRODUCTION

Since the publication of the CBIP Specifications for A.C. Electrical Energy Meters [1] there has been a great deal of confusion on what should be the appropriate technique for apparent energy or VAh measurement. This is because in [1], in the section "Guidelines for Combined kWh, kVArh, kVAh Measurements" (Clause Nos. 3.5.4 and 4.6.1)" p. 39, there are a number of statements which define kVAh in an inappropriate manner.

This document has been released to clear the confusions that relate to the definitions of apparent power- kVA, apparent energy - kVAh and their measurement.

2. ELECTRICAL THEORY

The electrical theory given here is compiled from electrical engineering text books[2][3].

Initially, let us concentrate on a single phase electrical system. Let us consider a practical situation where the current and voltage waveforms are not purely sinusoidal - i.e. harmonics are present.

The instantaneous value of the voltage impressed on a circuit can be given as

$$e = E_1 \sin(\omega t + \phi_1) + E_3 \sin(3\omega t + \phi_3) + E_5 \sin(5\omega t + \phi_5) + \ldots \quad (1)$$

The instantaneous value of current flowing in this circuit can be given as

$$i = I_1 \sin(\omega t + \phi_1 - \theta_1) + I_3 \sin(3\omega t + \phi_3 - \theta_3) + I_5 \sin(5\omega t + \phi_5 - \theta_5) + \ldots \quad (2)$$

2.1 Active Power

The instantaneous value of active power in the circuit can then be given by

$$\begin{aligned} p = ei = {} & E_1 I_1 \sin(\omega t + \phi_1)\sin(\omega t + \phi_1 - \theta_1) + E_3 I_3 \sin(3\omega t + \phi_3)\sin(3\omega t + \phi_3 - \theta_3) \\ & + E_5 I_5 \sin(5\omega t + \phi_5)\sin(5\omega t + \phi_5 - \theta_5) + \ldots \\ & E_1 I_3 \sin(\omega t + \phi_1)\sin(3\omega t + \phi_3 - \theta_3) + E_3 I_1 \sin(3\omega t + \phi_3)\sin(\omega t + \phi_1 - \theta_1) \\ & + E_1 I_5 \sin(\omega t + \phi_1)\sin(5\omega t + \phi_5 - \theta_5) + \ldots \end{aligned} \quad (3)$$

The average or mean value of power, units in Watts (W) or kilowatts (kW), in the circuit is

$$P = \frac{1}{\pi}\int_0^{\pi} ei.d(\omega t)$$

$$= \frac{1}{\pi}\int_0^{\pi} [E_1 I_1 \sin(\omega t + \phi_1)\sin(\omega t + \phi_1 - \theta_1) + E_3 I_3 \sin(3\omega t + \phi_3)\sin(3\omega t + \phi_3 - \theta_3)$$
$$+ E_5 I_5 \sin(5\omega t + \phi_5)\sin(5\omega t + \phi_5 - \theta_5) + \ldots \quad (4)$$
$$E_1 I_3 \sin(\omega t + \phi_1)\sin(3\omega t + \phi_3 - \theta_3) + E_3 I_1 \sin(3\omega t + \phi_3)\sin(\omega t + \phi_1 - \theta_1)$$
$$+ E_1 I_5 \sin(\omega t + \phi_1)\sin(5\omega t + \phi_5 - \theta_5) + \ldots] d(\omega t)$$

Since the integrals of all terms where the frequencies of the two sine waves that are multiplied together are different is zero, these terms, such as $E_1 I_3 \sin(\omega t + \phi_1)\sin(3\omega t + \phi_3 - \theta_3)$, can be eliminated. Thus, average power is

$$P = \frac{1}{\pi}\int_0^{\pi} [E_1 I_1 \sin(\omega t + \phi_1)\sin(\omega t + \phi_1 - \theta_1) + E_3 I_3 \sin(3\omega t + \phi_3)\sin(3\omega t + \phi_3 - \theta_3)$$
$$+ E_5 I_5 \sin(5\omega t + \phi_5)\sin(5\omega t + \phi_5 - \theta_5) + \ldots] d(\omega t)$$
$$= \frac{1}{\pi}[\frac{\pi}{2}(E_1 I_1 \cos\theta_1 + E_3 I_3 \cos\theta_3 + E_5 I_5 \cos\theta_5 + \ldots)] \quad (5)$$
$$= \frac{1}{2}(E_1 I_1 \cos\theta_1 + E_3 I_3 \cos\theta_3 + E_5 I_5 \cos\theta_5 + \ldots)$$

Let $E'_1, E'_3, E'_5, \ldots,$ and $I'_1, I'_3, I'_5, \ldots$ be the r.m.s. values of the harmonic components of voltage and current. Then the mean power in the circuit can be given as

$$P = E'_1 I'_1 \cos\theta_1 + E'_3 I'_3 \cos\theta_3 + E'_5 I'_5 \cos\theta_5 + \ldots \quad (6)$$

Now, $E'_1 I'_1 \cos\theta_1$ is the mean power due to the fundamentals of the two waves, $E'_3 I'_3 \cos\theta_3$ is the mean power due to the third harmonic, and so on. Thus, the average or mean power in the circuit is the sum of the mean powers due to the various components of the current and voltages. It is important to note that (average) active power has no vector relation with the voltage or current vectors and in this respect is a scalar quantity.

The only vector relationship the average active power has is with respect to the other power component - reactive power which is in quadrature with the active power (see Section 2.4).

2.2 Apparent Power

The r.m.s value of a complex current wave is equal to the square root of the sum of the squares of the r.m.s values of its individual components[3, p. 315]. Using the notations above, the r.m.s. values of the complex current, *I*, can be given as follows.

$$I = \sqrt{I'^2_1 + I'^2_3 + I'^2_5 + \ldots} \quad (7)$$

Similarly, the r.m.s value of a complex voltage wave is equal to the square root of the sum of the squares of the r.m.s values of its individual components. Using the notations above, the r.m.s. values of the complex voltage, E, can be given as follows.

$$E = \sqrt{E'^2_1 + E'^2_3 + E'^2_5 + \ldots} \tag{8}$$

The apparent power in the circuit can then be defined as,

$$VA = EI = \sqrt{E^2}\sqrt{I^2} = \sqrt{E^2 I^2} = \sqrt{(E'^2_1 + E'^2_3 + E'^2_5 + \ldots)(I'^2_1 + I'^2_3 + I'^2_5 + \ldots)} \tag{9}$$

The unit of apparent power is volt-amperes (VA) or kilovolt-amperes (kVA).

2.3 Power factor

If the voltage and current waves are purely sinusoidal then the power factor of the circuit on which this voltage is applied is the cosine of the angle of the phase difference between the voltage and current waves. In our case, since the voltage and current waves are non-sinusoidal, the angle of the phase difference between them is indefinite. In this case, the power factor of the circuit can be defined as the cosine of the phase difference between two equivalent sine waves having the r.m.s. values equal to those of the voltage and current in the circuit[2]. If ϕ_e is the phase difference between the two equivalent sine waves of voltage and current whose r.m.s values are E and I respectively, and P is the mean power in the circuit, and then

$$\cos\phi_e = \frac{P}{EI} \qquad \text{or} \qquad P = EI\cos\phi_e \tag{10}$$

Thus, the apparent power, $VA = EI$, consists of two components - (a) a constant active component that is given by $P = EI\cos\phi_e$, and (b) a pulsating reactive component that does not contribute to actual power since its average value over a complete cycle is zero. The former component is the active power and was defined earlier, while the latter component is the reactive power and is discussed below.

2.4 Reactive Power

The reactive power is the component of the apparent power that is in quadrature with the active component. It is also known as the `wattless' component or the `idle' component and is denoted as VAr or kVAr. The reactive power can be expressed in terms of the equivalent voltage and current sine waves, whose r.m.s. values are E and I respectively, as follows.

$$VAr = EI\sin\phi_e \tag{11}$$

The unit of reactive power is volt-amperes-reactive (VAr) or kilovolt-amperes-reactive (kVAr).

From Equations (10) and (11), we have, the apparent power,

$$VA = \sqrt{P^2 + VAr^2} = \sqrt{E^2 I^2 \cos^2\phi_e + E^2 I^2 \sin^2\phi_e} = EI \tag{12}$$

Since, the reactive power, VAr, is a pulsating component whose average value is zero, it does not contribute to actual power, or work, or heat, in the load. It nevertheless requires the current to flow in the circuit. Since the conductors that connect to the load have a finite resistance, say R_c, this results in a loss that equals $I^2 R_c$.

2.5 Three Phase Active, Reactive and Apparent Power

The active, reactive and apparent power defined above is for a single phase voltage and its associated single phase current. In a single phase system, the three power quantities are related to each other by Equation 12. However, such a relation cannot be generally established for a three phase system.

In case of three phase, it is usually required to compute three phase active power in order to compute the total heat generated in the load or the total work done by the load. The total heat generated is the sum of the heat generated by the three individual phases. The total work done is similarly obtained as an arithmetic sum. This leads to the following three statements.

Statement 1. The three phase active power is computed as an arithmetic sum of the active power in the three individual phases.

Statement 2. The three phase reactive power is computed as an arithmetic sum of the reactive power in the three individual phases.

Statement 3. The three phase apparent power is computed as an arithmetic sum of the apparent power in the three individual phases.

It is important to note that it is not generally possible to relate the above three power quantities in a three phase system. This is due to the fact that the current and voltage waveforms, their amplitude and the equivalent power factor for each phase is usually different. Therefore the square of the three phase apparent power will usually be different than the sum of the squares of the three phase active power and the three phase reactive power.

In other words, it is not possible to establish a vector relationship between the three numbers of three phase power quantities. Since, the three phase power quantities are not vectors, it is, therefore, also not possible to define a new combined power factor that can give the angle between the active and apparent three phase power quantities.

In order to illustrate this with the help of an example consider the voltage and current vectors as shown in Figure 1. Consider a balanced voltage of 230 volts per phase. The theoretical values of the different parameters in this three phase system are tabulated in Table 1. In order to show that no two (total) power quantities are related, let us try to compute the reactive three phase power as a vector difference (as we do in a single phase system).

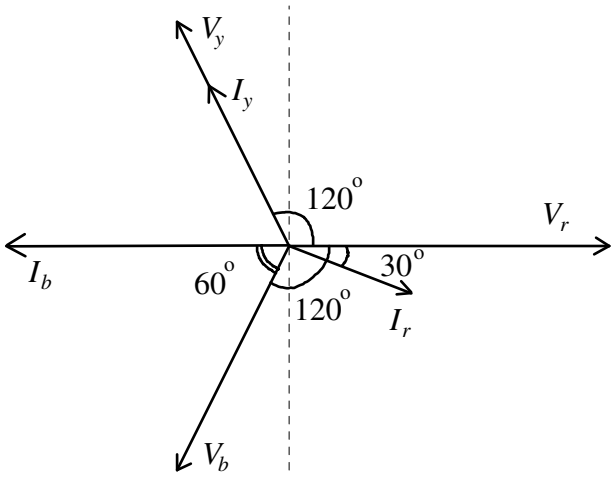


Figure 1. An example to illustrate 3 phase power quantities, kVA, kW and kVAr.

Theoretical $3\phi\ kVAr = 3.563$

$$\neq \sqrt{(6.9)^2 - (5.021)^2}$$

$$\neq 4.733$$

Thus, the three quantities of three phase power (active, reactive and apparent) are scalar quantities and not related to each other.

Table 1. Power values calculated for the example given in Figure 1

Parameter	R phase	Y phase	B phase	3 ϕ theoretical power
Voltage	230 Volts	230 Volts	230 Volts	

Current	5 Amps	10 Amps	15 Amps	
Power Factor	0.8666	1.0	0.5	
Active Power	0.996 kW	2.300 kW	1.725 kW	5.021 kW
Reactive Power	0.575 kVAr	0.0 kVAr	2.988 kVAr	3.563 kVAr
Apparent Power	1.150 kVA	2.300 kVA	3.450 kVA	6.900 kVA

2.6 Single Phase Active, Reactive and Apparent Energies

Energy is integration of power over real time. Let t_1 and t_2 be two time instants such that $t_2 > t_1$. Then the active energy consumed over a time duration $\Delta t = t_1 - t_2$ in seconds is given by

$$Ws = \int_{t_1}^{t_2} P = \int_{t_1}^{t_2} EI \cos\phi_e \, . \tag{13}$$

Only if the power is constant (i.e. voltage amplitude, current amplitude and power factor are constant) over this time duration then,

$$Ws = EI \cos\phi_e \Delta t \, . \tag{14}$$

However, in practice, the load keeps changing and, hence, this simplified Equation 14 is not applicable. The unit of active energy is watt-second (Ws). A larger unit is kilowatt-hour (kWh).

The reactive energy consumed during the same duration, considering that the load is not constant, can be given as follows. The unit of reactive energy is volt-amperes-reactive-second (VArs). Larger unit is kilovolt-amperes-reactive-hour (kVArh).

$$VArs = \int_{t_1}^{t_2} VAr = \int_{t_1}^{t_2} EI \sin\phi_e \, . \tag{15}$$

The apparent energy consumed during the same duration, considering that the load is not constant, can be given as follows. Unit is volt-amperes-second (VAs). Larger unit is kilovolt-amperes-hour (kVAh).

$$VAs = \int_{t_1}^{t_2} VA = \int_{t_1}^{t_2} EI \, . \tag{16}$$

Returning back to the power quantities in Equation 12, it is clear that the apparent power is related to active and reactive power, and given any two quantities the third can be computed from the two.

However, in the case of energy, as can be observed from Equations 13, 15 and 16, when the load is not constant, *there is no relation* (in terms of the already defined quantities) *between any two of the three energy quantities - apparent energy, active energy and reactive energy*. Therefore, given any two energy quantities it is *not* possible to compute the third energy quantity.

In order to illustrate that there exists no relation between the three energy quantities consider the example shown in Figure 2.

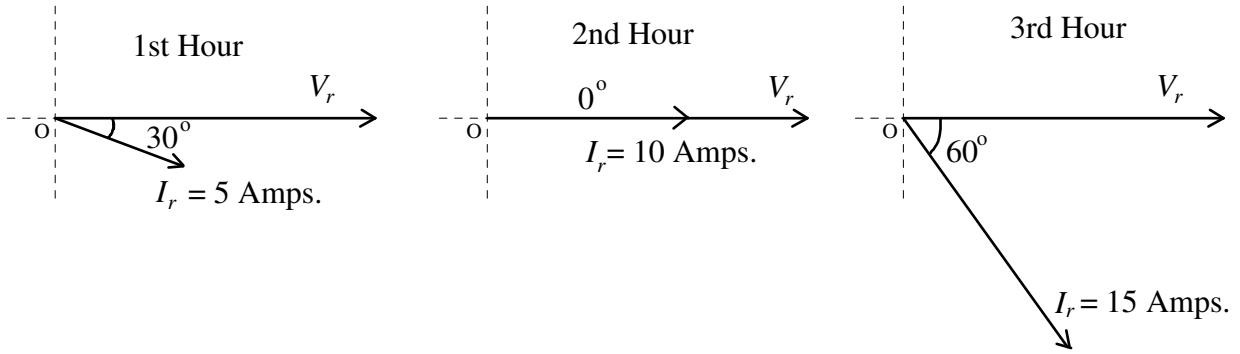


Figure 2. An example showing the phase relationships between voltage and current in three consecutive hours

For simplicity, let us assume that the voltage, current and phase relationship between them remain constant during a complete hour. In this scenario, for each one hour interval any of the three power values would match the corresponding energy value (say active power in kW would match active energy in kWh for that hour).

Table 2. Energy values calculated for the example given in Figure 2

Parameter	1st Hour	2nd Hour	3rd hour	Total theoretical energy over 3 hours
Voltage	230 Volts	230 Volts	230 Volts	
Current	5 Amps	10 Amps	15 Amps	
Power Factor	0.8666	1.0	0.5	
Active Energy	0.996 kWh	2.300 kWh	1.725 kWh	5.021 kWh
Reactive Energy	0.575 kVArh	0.0 kVArh	2.988 kVArh	3.563 kVArh
Apparent Energy	1.150 kVAh	2.300 kVAh	3.450 kVAh	6.900 kVAh

The theoretical energy values calculated over a total period of three hours are tabulated in Table 2. In order to show that no two (total) energy values over the three hour duration are related, let us try to compute the reactive energy from the apparent and active energies as we could do in the case of single phase power quantities.

Total theoretical reactive energy over three hours in *kVArh*

$$= 3.563 \qquad \neq \sqrt{(6.9)^2 - (5.021)^2}$$

$$\neq 4.733.$$

Thus, there exists no relation between the three single phase energy quantities and it is not possible to compute the third energy quantity given any two energy quantities.

2.7 Three Phase Active, Reactive and Apparent Energies

The energy consumed in each of the three phases is independent of the other two. Therefore the combined active energy in a three phase load over a time duration $\Delta t = t_1 - t_2$ in seconds can be only given as an arithmetic sum of the active energy consumed in each of the three phases and is given as follows.

$$Ws = \int_{t_1}^{t_2} (P_r + P_y + P_b) = \int_{t_1}^{t_2} (E_r I_r \cos\phi_{er} + E_y I_y \cos\phi_{ey} + E_b I_b \cos\phi_{eb}) . \quad (17)$$

where the subscripts *r*, *y* and *b* refer to the R, Y and B phase quantities.

The reactive energy consumed during the same duration, can be given as follows.

$$VArs = \int_{t_1}^{t_2} (VAr_r + VAr_y + VAr_b) = \int_{t_1}^{t_2} (E_r I_r \sin\phi_{er} + E_y I_y \sin\phi_{ey} + E_b I_b \sin\phi_{eb}) . \quad (18)$$

The apparent energy consumed during the same duration can be given as follows.

$$VAs = \int_{t_1}^{t_2} (VA_r + VA_y + VA_b) = \int_{t_1}^{t_2} (E_r I_r + E_y I_y + E_b I_b) \quad (19)$$

From Equations 17, 18, and 19, it becomes clear that in a three phase circuit, the three energy quantities are not related to each other in terms of the already defined quantities. This also becomes clear from Figure 3, which shows the measurement process for the three phase energy quantities.

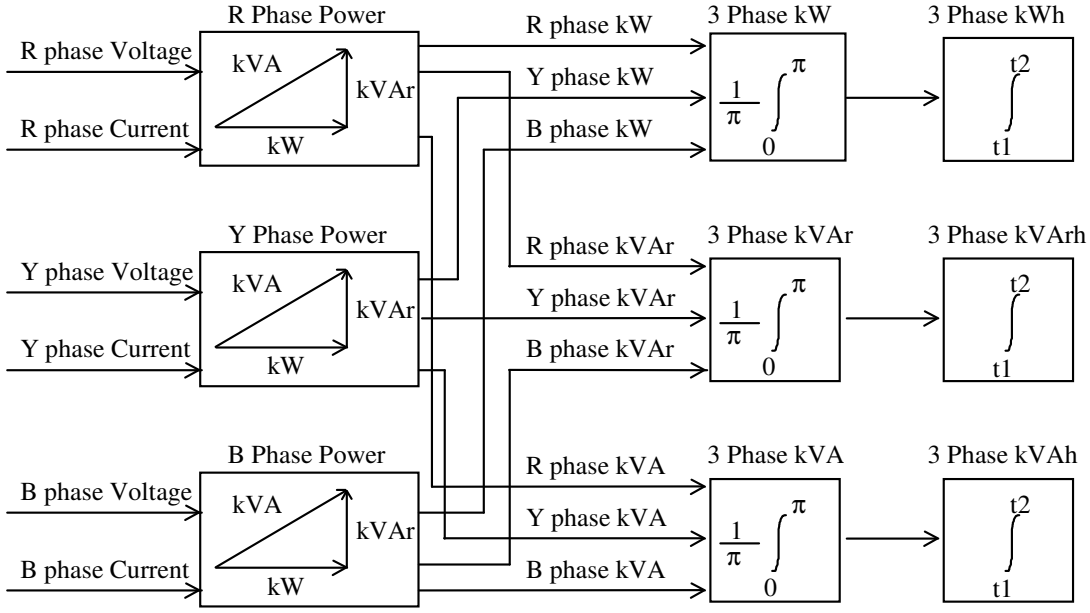


Figure 3 Block diagram showing the measurement of the three phase active, reactive and apparent energies.

Having obtained the active, reactive and apparent energies in the three phase load, it is not possible to generate the relationship between them. It is also not possible to define a new power factor that can relate them.

Some utilities find it useful to compute the `average power factor' over the billing period (usually a month) for imposing a penalty. However, there is no consistency in the way they define the `average power factor' over the month. Some calculate the `average power factor' by dividing the total number of active energy units consumed in the month by the total number of

apparent energy units consumed over the same period. Others take the cosine of the angle obtained by taking the inverse tan of the ratio of the total number of reactive energy units consumed in the month by the total number of active energy units consumed over the same period. Both these techniques give different results. Neither of them is correct, since the energy quantities are not vectors and are also not directly related to each other.

These findings have important repercussions. *If any of the two energy quantities are known, it is not possible to compute the third from these two.* Regardless of whether we have a single phase or a three phase system, *the three energy quantities - active energy, reactive energy and apparent energy have to be independently obtained by separately integrating single phase active power, reactive power and apparent power, respectively.*

Therefore, if a utility wishes to penalize those customers who lower the power factor of the system, *then the appropriate technique would be to have a tariff that is based on kVAh and not to penalize on `average power factor'.*

Earlier, *the electromechanical trivector meter technologies used to give a quantity that was wrongly referred to as the kVAh. Today, with microprocessor based technologies, it is possible to compute kVAh in a manner that is consistent with the electrical theory.*

3. CLARIFICATIONS

Having looked at electrical theory, an attempt is made to correct the statements in [1]. Consider the following statements from [1].

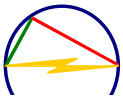
> *" Generally two different measurement techniques are adopted for VAh measurement, namely vector sum and arithmetic sum principles.*
>
> *Vector sum volt-ampere is the vector sum of active energy and reactive energy in a 3 phase balanced or unbalanced circuit.*
>
> *Arithmetic sum volt-ampere is the arithmetic sum of the three products of line current and associated phase voltages in a three phase balanced or unbalanced circuit."*[1]

The technical terms `vector sum' and `arithmetic sum' for the definitions above *are inappropriate*. These terms are reserved to differentiate between vector and scalar quantities and their operations. Therefore, on lines similar to the vector sum volt-ampere defined in [1], the term `Arithmetic sum volt-ampere' may be defined as a arithmetic (scalar) sum of active energy and reactive energy in a 3 phase balanced or unbalanced circuit. This is not the same quantity as the one defined in the clause in [1] shown above.

Moreover, active energy and reactive energy are not vectors and it is therefore not possible to take the vector sum.

Also, in the statements in [1], apparent power and apparent energy are interchangeably used which is incorrect and further adds to the confusion.

Further the same clause in [1] reads...



> *"In case of electro-mechanical meters, kVAh as measured by above principles, are generally different. However, for static three parameter meters having high speed microprocessor adopting kVArh computation at very high rates, the vector sum value of kVArh tends to the arithmetic-sum value in the limiting case. Therefore, it is suggested to consider that wherever kVAh has appeared in this specification, it is same as the vector sum value."*[1]

This gives an impression that the term vector sum (as defined in [1]) is superior to the term arithmetic sum (again as defined in [1]). However, it is vice-versa.

Electrical theory defines each of the electrical quantities such as Voltage, Current, VA and so on. We believe that an attempt should not be made to redefine any of these quantities. Also, no measurement techniques (at present or in the future) can alter the definitions as put forward by the eminent scientists in electrical theory.

The objective of any measurement technique is to match the measured value with the theoretical value as defined by electrical theory. Generally, it is expected that a measurement technique based on newer technologies would possess better accuracy. The quantity, such as kVAh, measured by a static technology is expected to be more accurate than the corresponding quantity measured by an electro-mechanical meter. A mechanical kVAh meter could be based on a ball and disc friction gearing or a five geared mechanical system or it could use bridge rectifiers [4, pp. 391-394]. However, *none of these mechanical kVAh meter measures the desired theoretical kVAh.* The clause in [1] under consideration gives an impression as though the `vector sum' as measured by electromechanical meters is superior.

Further, the clause in [1] continues as follows.

> *"Thereby, it becomes easier to check the kVAh accuracy by determining errors of kWh and kVArh Meters only in terms of kWh and kVArh measurement standards.(Clause 4.6.1 Table 11, in [1])."*

This statement is *not* correct. This is because the kVAh computation is independent of, and need not necessarily follow, the kWh and kVArh computations. Therefore, the accuracy of the three energy quantities should be independently tested. To achieve this, three separate test outputs (in the form of distinct 5 mm LEDs) should be provided in the trivector meter. However, the specification document [1] does not mention the number of test outputs required, nor does it give the specifications for these outputs.

4. Conclusions

Energy is a *scalar* quantity. *The active, reactive and apparent energies are not related to each other*. In case of a three phase system, even the active, reactive and apparent three phase power are not related to each other.

The only vector relation that exists is between the single phase active, reactive and apparent power. This also means that the *only power factor that can be correctly defined is the instantaneous power factor* that determines the vector relationship between the single phase power quantities (vectors) - namely active power, reactive power and apparent power.

Returning to the question raised in the title, the answer is NO. The apparent energy - kVAh CANNOT be computed as an vector sum of active energy kWh and reactive energy kVArh. In fact, the *apparent energy cannot be computed by any method from the active and reactive energies*.

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[1] Specifications for A.C. Static Electrical Energy Meters, Technical Report No. 88, Central Board of Irrigation and Power, Malcha Marg, Chanakyapuri, New Delhi - 110021, Revised July 1996.

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[4] A. K. Sawhney, A Course in Electrical and Electronic Measurements and Instrumentation, 3rd Edition, Dhanpat Rai and Sons Publishers, Delhi, 1981.