Reference:	2019 - 06 Clarifying definition of Point of Connection
Question 1: Do you agree with the Authority's problem definition? If not, why not?	

I do not agree with the Authority's problem definition.

- The existing Point of Connection definition is correct.
- That definition is intended to ensure that three-phase metering is correctly configured and accurately measures the quantity of electricity according to Schedule 10.1 Table 1 of the Code.

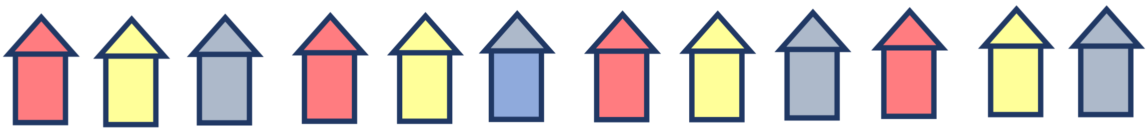
> *a point at which **electricity** may flow into or out of a **network** and, for the purposes of **Technical Code** A of Schedule 8.3, means a **grid injection point** or a **grid exit point**.*
>
> It has been put to the Authority that this definition means a three- phase metering installation is, in fact, three points of connection. A participant contends that each phase of a three-phase metering installation is a separate "point" of connection between load and/or generation, and the network to which the load and/or generation is connected.

- If a three-phase metering installation has been incorrectly fitted with three separate single-phase import-export meters, then each phase connection has become a separate *point at which electricity may flow into or out of a network*.
- It is not physically possible to meter phase-phase connected loads like this. All correctly configured multi-phase meters add the three single-phase measurements together to produce instantaneous three-phase totals of real power (kW) and reactive power (kVAr).

Why is having a separately metered point of connection for each phase *fundamentally* incorrect for a multi-phase supply?

- Consider a street of houses, each on a single-phase supply with plug sockets that look like this:

- If the network company has done a reasonable job of balancing the load across the phases of their supply transformer, most houses in the street will be connected to a different Red-Yellow-Blue phase in sequence.



Let us imagine we wish to connect a 20 kW 400V commercial oven for a street party.

- Our electrician runs a cable over the fence and carefully connects the oven between Red house and Yellow house.
- Our regulator observes that there is something very wrong with this arrangement and asks the electrician which house will be paying for the electricity.
- The electrician consults the *Handbook for Electricity Metering* for a long time* and says that the measurement on each house's meter depends on the load power factor and any voltage unbalance in the system.

  *The calculation is not trivial. It is much easier to connect a load and look at actual meter measurements.

The other end of the load is connected to a different phase voltage that the meter knows nothing about. Won't the single-phase meters just give spurious readings?

- Yes of course they will. It's an electricity meter not a mind-reader - it doesn't know that the load current phase angle has been artificially changed by the phase-phase load connection.
- There is a voltage phase-angle difference of 120 degrees between the red and yellow houses which the meter can't see but the oven (which is connected between the two houses) does.
- The phase angle of the load current through the oven is set by the voltage between the two houses.
- For this (1.00 unity power factor) 20 kW oven load, each meter reads approximately 10 kW of real power and a false 5.7 kVAr of reactive power. *(Attachment 1 - EDMI meter test commentary)*.
- Both houses show a grossly incorrect power factor of 0.86.

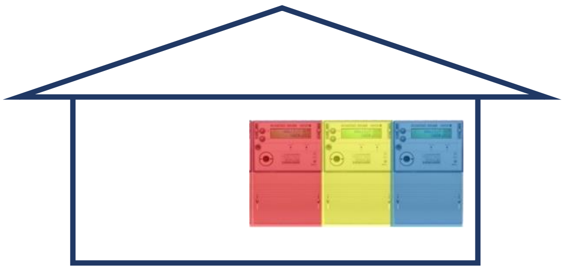
That's not very good. What happens if the power factor of the load is not 1.00?

- As soon as the oven power factor moves off unity the even kW split between the houses changes.
- The meters read 5% difference between them in the kW reading at only 0.996 power factor.
- If one house happened to be exporting from a solar panel the real power (kW) export measurement would incorrectly increase or decrease according to the reactive (kVAr) loading of the oven.
- If the power factor of the oven happened to be less than 0.5 the difference in the meter readings will be greater than 100% and the meter on one of the houses will register real power export without any solar generation being connected.

Who cares? This isn't a real problem and you're not allowed to connect loads between two Points of Connection anyway.

- Quite right. This is not a problem that the Code has to deal with.

However, now we do as the Authority is proposing and hang three of our single-phase meters on a factory where the plug sockets are as shown below, and all the loads are connected phase-phase:



The Authority would like to define this metering arrangement as a single point of connection. Has the new definition done anything to fix the incorrect meter measurements?

- No. Unsurprisingly the individual meters still give defective readings.
- The only difference is that the phase-phase connected loads are now inside the factory and there's no cable over the fence.
- Sections 10.6 and 10.13 of the Code require multi-phase meters to correctly measure phase-phase connected loads, and s10.37 requires Category 2 and above meters to correctly measure reactive power.

How does a normal multi-phase meter handle this problem?

- It adds up the real power quantities of all three single-phase meters. By the magic of Blondel's Theorem the errors in each of the single-phase measurements cancel out and the result is the total kW loading of the installation.
- It is the same for the reactive power. We add up the reactive power measurements of the three meters and get the total kVAr loading of the installation.
- Installation power factor is cos ($\tan^{-1}$ (reactive power total / real power total)).

What does this mean for the Authority's proposed Point of Connection definition?

- Reality can be irksome. The Point of Connection definition must be consistent with the electrical theory of a three-phase power system and ensure that the end-user's load is accurately metered.
- For phase-phase connected loads each single-phase meter measurement contains components of the other phase measurements.
- They cannot be treated independently (no matter how ideologically convenient this might be), and they certainly cannot be separated and placed in different meter registers as soon as one of them has a negative sign.

Question 2: Do you agree with the Authority's proposed solution? If not, why not?

I do not agree with the Authority's proposed solution.

- The right thing to do is to install correctly configured three-phase meters.
- Where incorrectly configured meters have been installed, the meters must be reconfigured or replaced.
- Current industry practice *(Attachment 2 – Memo to Participants)* has installed incorrectly configured meters which are imposing significant costs on a single class of solar-generation participant who happen to have a three-phase supply.
- The fact that this class of participants are already incurring these costs is not a reasonable basis for continuing with the practice.

Question 3: Do you have any comments on the Authority's proposed Code drafting?

No amount of Code re-drafting is going to make these meters measure correctly.

- Therefore, the proposed amendment is adding to an ever-increasing complexity of the Code for no useful reason.

Question 4: Do you agree with the objectives of the proposed amendment? If not, why not?

I do not agree with the objectives of the proposed amendment.

- The proposed amendment is intended to retrospectively allow incorrectly configured three-phase metering installations to meet modified Code provisions. *(Attachment 3 - EDMI Mk10D meter test summary).*
- It is not physically possible for a metering installation consisting of three single-phase meters to meet the requirements of s10.6 for phase-phase connected loads. *(Attachment 4 - EDMI Mk10D metering problem summary).*
- The correct action is to reconfigure the meters that have already been installed and clarify the Code to ensure that future metering installations are correctly configured.
- The proposed amendment removes any possibility of a market for reactive power or levying penalties for poor power factor (for phase-phase connected loads the *measured* per-phase power factor never gets above 0.86 even for 1.00 power factor loads).
- The proposed amendment removes any possibility of time-of-use metering for solar installations (how *is* the retailer going to explain a consumers' solar installation exporting in the middle of the night?).

Question 5: Do you agree the benefits of the proposed amendment outweigh its costs? If not, why not?

I do not agree that the benefits of the proposed amendment outweigh the costs.

Any discussion of cost vs benefit requires at least an attempt to quantify the inputs. Quantification requires numbers and there do not seem to be any in the Authority's Evaluation.

Let's try some order of magnitude numbers:

We quantify the dis-benefits to solar participants of the incorrectly configured metering:

- Typical solar installation = 3 kW x say 10 hours a day = 30 kWh per day.
- Let's say the incorrectly configured meter means that half is exported on one phase at 8¢ per kWh instead of being correctly aggregated with load on the other two phases at 28¢ per kWh (i.e. the participant loses 20¢ of value per incorrectly exported kWh).
- Loss to each solar participant is 15 kWh x 20¢ = $3 per day, $1095 per year.
- We guess there might be 2000 solar participants with faulty meters = 2000 x $1095 = $2.2 M of lost solar generation value per year to one sub-class of participants.

And estimate a cost to fix the metering:

- We estimate a cost of $100 per meter to reinstall the manufacturers standard configuration firmware.
- One-off cost to fix the problem properly = 2000 x $100 = $200 k.

There is no obvious need for sophisticated financial analysis. A continuous cost to participants of $2.2 M per year vs a one-off cost of $200 k to fix the faulty meters would seem conclusive.

Question 6: Do you agree the proposed amendment is preferable to the other options?

If not, please explain your preferred option in terms consistent with the Authority's statutory objective in section 15 of the Electricity Industry Act 2010.

I do not agree that the proposed amendment is preferable to the other options.

- The preferred option is to install correctly configured three-phase meters.
- Where incorrectly configured meters have been installed, the meters must be reconfigured or replaced.
- The proposed amendment is inconsistent with the Authority's statutory objective in s15 of the Electricity Industry Act 2010.

  15 Objective of Authority

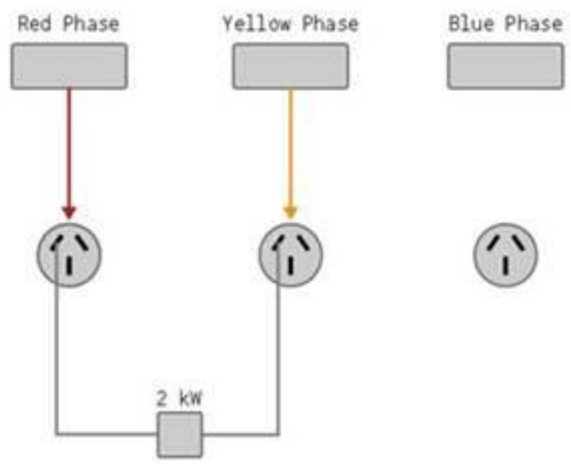
  The objective of the Authority is to promote competition in, reliable supply by, and the efficient operation of, the electricity industry for the long-term benefit of consumers.
- Amending the Code to permit the installation of incorrectly configured meters is clearly not for the long-term benefit of consumers with embedded solar generation and a three-phase connection.
- The proposed amendment is also inconsistent with the MBIE Energy Strategy 2011-2021 and inconsistent with the National Policy Statement for Renewable Electricity Generation.

  It fails to recognize the importance of behind-the-meter renewable energy and substantially penalizes a sub-class of consumers with multi-phase installations and embedded generation.

EDMI Test Result Commentary

If we have a pair of 1000 W unity power factor loads connected phase-neutral on each phase, we must expect to see **1000 W + 0 VAr** on each meter (total 2000 W).

If we take the diagram below and instead connect our 2000 W unity power factor load between phases, we expect the same numbers, ie: if the load is 1000 W @ unity power factor per phase, we expect a reading of **1000 W + 0 VAr** on each meter (total 2000 W).



What we actually get (highlighted below) is 1000 W + 577 VAr on one meter and 1000 W - 577 VAr on the other meter

The phase-segregated meters have created false VAr readings (it is a unity power factor load, there are no actual VArs).

All Class 2 meters are required to measure VArs by s 10.37 of the Code.

These (phase segregated) meters cannot measure VArs on unbalanced loads, the per phase VAr readings are <u>always</u> wrong no matter what the load power factor is.

No Class 2 or above phase-segregated meter can meet the s 10.37 Code requirements.

Table 1 Test Cases

Load type	VA	VB	VC	IA	IB	IC	IA phase	IB phase	IC phase	PF	WA	WB	Total W	varA	varB	Total var
Balanced	250	230	230	4.8	4.8	0.0	-28.6	31.4	0.0	1.00	1056	944	2000	-576	576	0
Balanced	240	230	230	4.9	4.9	0.0	-29.3	30.7	0.0	1.00	1028	972	2000	-577	577	0
Balanced	230	230	230	5.0	5.0	0.0	-30.0	30.0	0.0	1.00	1000	1000	2000	-577	577	0
Balanced	220	230	230	5.1	5.1	0.0	-30.7	29.3	0.0	1.00	970	1030	2000	-577	577	0
Balanced	210	230	230	5.2	5.2	0.0	-31.5	28.5	0.0	1.00	939	1061	2000	-576	576	0
Balanced	250	230	230	5.1	5.1	0.0	-10.4	49.6	0.0	0.95	1245	755	2000	-229	886	657
Balanced	240	230	230	5.2	5.2	0.0	-11.1	48.9	0.0	0.95	1218	782	2000	-239	896	657
Balanced	230	230	230	5.3	5.3	0.0	-11.8	48.2	0.0	0.95	1190	810	2000	-249	906	657

If we alter the power factor of the load we do not expect the per-phase W measurement to change (the load is still 1000 W per phase)

What we actually get (highlighted below) is 810 W + 906 VAr on one meter and 1190 W - 249 VAr on the other meter.

The phase-segregated meters have both changed their W measurement with load power factor.

Both meters are grossly outside class, they are supposed to be measuring 1000 W per phase.

Table 1 Test Cases

Load type	VA	VB	VC	IA	IB	IC	IA phase	IB phase	IC phase	PF	WA	WB	Total W	varA	varB	Total var
Balanced	250	230	230	4.8	4.8	0.0	-28.6	31.4	0.0	1.00	1056	944	2000	-576	576	0
Balanced	240	230	230	4.9	4.9	0.0	-29.3	30.7	0.0	1.00	1028	972	2000	-577	577	0
Balanced	230	230	230	5.0	5.0	0.0	-30.0	30.0	0.0	1.00	1000	1000	2000	-577	577	0
Balanced	220	230	230	5.1	5.1	0.0	-30.7	29.3	0.0	1.00	970	1030	2000	-577	577	0
Balanced	210	230	230	5.2	5.2	0.0	-31.5	28.5	0.0	1.00	939	1061	2000	-576	576	0
Balanced	250	230	230	5.1	5.1	0.0	-10.4	49.6	0.0	0.95	1245	755	2000	-229	886	657
Balanced	240	230	230	5.2	5.2	0.0	-11.1	48.9	0.0	0.95	1218	782	2000	-239	896	657
Balanced	230	230	230	5.3	5.3	0.0	-11.8	48.2	0.0	0.95	1190	810	2000	-249	906	657

If we alter the voltage of one phase we do not expect the per-phase W measurement to change (the load is still 1000 W per phase)

What we actually get (highlighted below) is 1056 W + 576 VAr on one meter and 944 W - 576 VAr on the other meter.

The phase-segregated meters have both changed their W measurement with phase voltage unbalance.

Both meters are now well outside +/- 2.5% class, they are supposed to be measuring 1000 W per phase.

Table 1 Test Cases

Load type	VA	VB	VC	IA	IB	IC	IA phase	IB phase	IC phase	PF	WA	WB	Total W	varA	varB	Total var
Balanced	250	230	230	4.8	4.8	0.0	-28.6	31.4	0.0	1.00	1056	944	2000	-576	576	0
Balanced	240	230	230	4.9	4.9	0.0	-29.3	30.7	0.0	1.00	1028	972	2000	-577	577	0
Balanced	230	230	230	5.0	5.0	0.0	-30.0	30.0	0.0	1.00	1000	1000	2000	-577	577	0
Balanced	220	230	230	5.1	5.1	0.0	-30.7	29.3	0.0	1.00	970	1030	2000	-577	577	0
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Balanced	250	230	230	5.1	5.1	0.0	-10.4	49.6	0.0	0.95	1245	755	2000	-229	886	657
Balanced	240	230	230	5.2	5.2	0.0	-11.1	48.9	0.0	0.95	1218	782	2000	-239	896	657
Balanced	230	230	230	5.3	5.3	0.0	-11.8	48.2	0.0	0.95	1190	810	2000	-249	906	657

Note below a demonstration of Blondel's Theorem whereby the total W and total VAr columns remain constant no matter what combinations of voltages and load power factor are placed on the meter.

As soon as the loads are connected anything other than phase-neutral these two totals (total W and total VAr) are the ***only*** measurements that a three-phase meter can generate within class.

This is why all conventional IEC-compliant three phase meters work on this principle.

Table 1 Test Cases

Load type	VA	VB	VC	IA	IB	IC	IA phase	IB phase	IC phase	PF	WA	WB	Total W	varA	varB	Total var
Balanced	250	230	230	4.8	4.8	0.0	-28.6	31.4	0.0	1.00	1056	944	2000	-576	576	0
Balanced	240	230	230	4.9	4.9	0.0	-29.3	30.7	0.0	1.00	1028	972	2000	-577	577	0
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Balanced	220	230	230	5.1	5.1	0.0	-30.7	29.3	0.0	1.00	970	1030	2000	-577	577	0
Balanced	210	230	230	5.2	5.2	0.0	-31.5	28.5	0.0	1.00	939	1061	2000	-576	576	0
Balanced	250	230	230	5.1	5.1	0.0	-10.4	49.6	0.0	0.95	1245	755	2000	-229	886	657
Balanced	240	230	230	5.2	5.2	0.0	-11.1	48.9	0.0	0.95	1218	782	2000	-239	896	657
Balanced	230	230	230	5.3	5.3	0.0	-11.8	48.2	0.0	0.95	1190	810	2000	-249	906	657
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Why is this a fatal problem for these meters ?

Apart from the fact that they cannot measure VArs on a per-phase basis, these meters are required to accurately measure export generation.

If we add an increasing amount of generation (either three-phase or single phase) to the unbalanced load, one of the phase elements will eventually declare a negative quantity. Instead of summating it with the other phases as a conventional meter would, these meters will immediately place this negative W quantity into the export register.

Because of the errors arising from the load measurement, this declared quantity of export generation will change depending on the load power factor and any unbalance in the source voltages.

In the example above, if we added 1000 W of generation connected phase B-neutral, the declared export quantity on phase B will move all the way from 0 W export to 200 W export just by changing the load power factor from unity to 0.95.

This meter would be measuring out-of-class at 0.99 power factor and be showing a gross export error of 200 W at 0.95 load power factor.

This is unacceptable in any IEC-compliant meter and such meters cannot and do not comply with part 10 of the Code.

Memo

To	Participants
From	Grant Benvenuti
Date	31 October 2016
Subject	Export metering on multiphase metering installations

For your information

The Authority has recently received a request to clarify the requirements in the Electricity Industry Participation Code 2010 (Code) for import/export metering on multiphase metering installations.

Clauses 10.13 and 10.24(b) and (c) and clause 4(2)(a) of Schedule 10.7 of the Code work together to require respectively:

- the metering equipment provider to ensure that all electricity conveyed through a point of connection (in either direction)[1] is accurately quantified (clause 10.13) and is not configured to use subtraction (clause 4(2)(a) of Schedule 10.7)
- the trader to ensure that subtraction is not used to determine submission information where the metering information is used for reconciliation (clauses 10.24(b) and (c)).

Any injection for any one phase or register back into the distributor's network is an "injection" under the Code, regardless of what is happening on the other phase(s) or register(s). Therefore, each phase or register that is capable of injection and extraction needs to have both values separately metered, and not subtracted from the measurement of other phases or registers, which would be "net metering".

Note that for multiphase supplies, under the Code, an injection on any one or more of the phases is still 'electricity conveyed' on the distributor's network even if there is matching import on other phases.

Grant Benvenuti
Manager Market Operations

1 Clause 10.13(4) provides exceptions for unmetered load or electricity supplied by an embedded generator who has given the reconciliation manager a notification (gifting certificate) under clause 15.13.

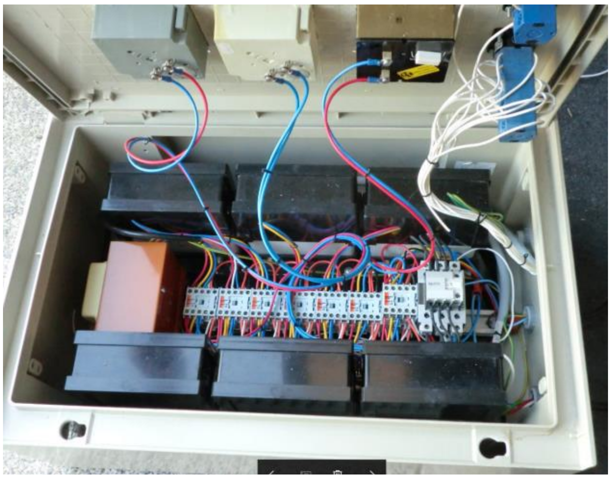
EDMI MK10D Phase-Segregated Meter Test

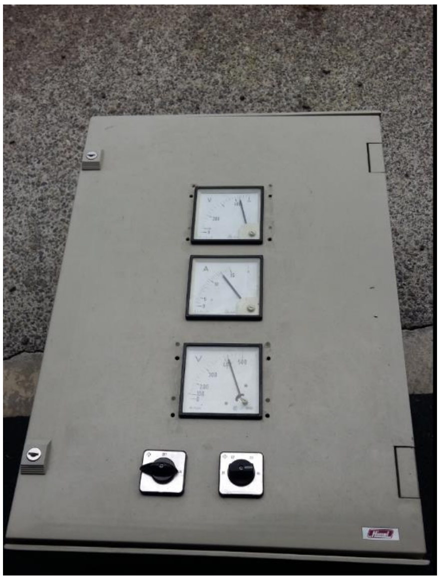
Phase-Phase Connected Reactive Load

Tested B. Palamountain 04-05-2019

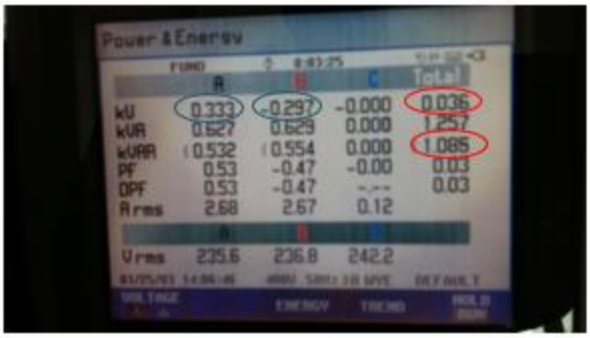
Test instrumentation: Fluke 434 Power Analyser with i400s current probes set at 10 mV/A CT ratio.

1) We arrange a purely reactive load of 5 kVAr.

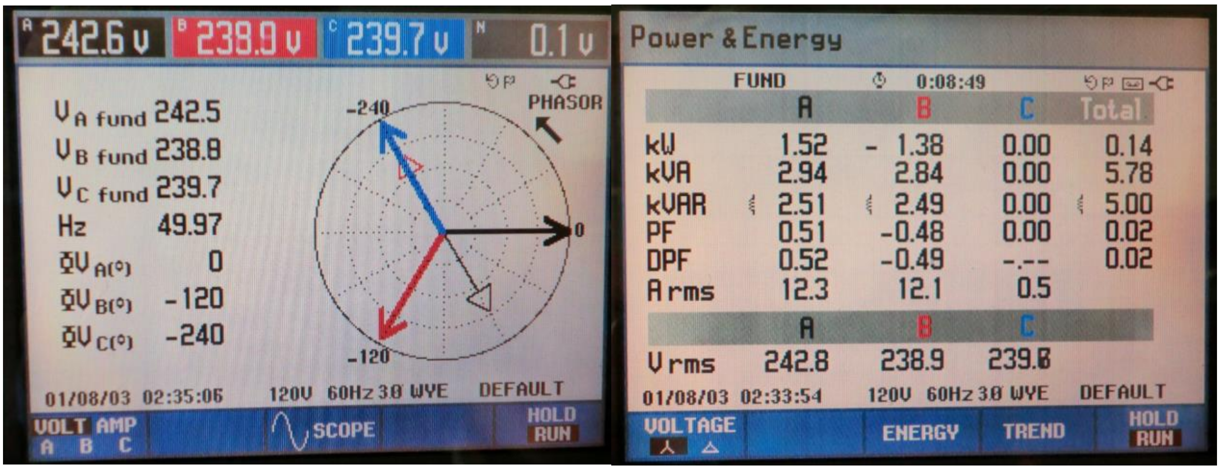




2) From previous tests (see Export-W Test 2) we expect to see a false per-phase measurement of 0.3 kW per kVAr of phase-phase load.



3) We turn all other load off and connect our 5 kVAr load between phases A and B of our installation.



4) As expected, we see a false measurement of +/- 1.5 kW per phase (= 5 x 0.3 kW), with a total load of 0.14 kW (losses) and 5.00 kVAr.

5) Note the demonstration of Blondel's Theorem in that the Total column on the right has the correct 0.14 kW/5.00 kVAr totals that a correctly configured polyphase kWh meter would be measuring.

<u>We know that the per-phase +/- 1.5 kW measurements are false because it is a purely reactive load (there are no actual kW).</u>

6) We begin our test.

7) At 17 seconds the meter shows an instantaneous kW reading of 0.072 kW (72 W). This is as expected (it is a purely reactive load, there are no actual kW).

8) The corresponding import register values are 13349.55 kWh Import

9) With an export register value of 4616.08 kWh Export.

10) We wait for one hour.

11) The import register is now 13351.07 kWh Import

12) And the export register 4617.53 kWh Export.

13) The instantaneous meter reading remains essentially unchanged at 0.067 kW.

14) While maintaining a correct instantaneous kW reading of approximately zero (0.07 kW) for an hour, the meter registers have increased by:

    13351.07 kWh - 13349.55 kWh = 1.52 kWh Import
    4617.53 kWh - 4616.08 kWh = 1.45 kWh Export

<u>These are the +/- 1.5 kW false measurements observed in 4) above integrated for 1 hour by our incorrectly configured phase-segregated meter.</u>

<u>Conclusions:</u>

A. The meter is incorrectly integrating false real power (kW) components in a purely reactive power (KVAr) load. Any real-power meter that measures KVAr as kW is defective *by definition* and shall be replaced.

B. The meter is faulty. Over an hour its registers have incremented by 1.5 kWh Import and 1.4 kWh Export with no actual kWh being consumed by the installation.

C. The meter is deceptive. Its internal kWh registers are integrating (and charging for) a different instantaneous kW value to the one shown on the meter display.

D. The meter is not IEC compliant. The IEC definition of active power for a polyphase element is the sum of the active powers in all phase elements.

> en **active power**, <for a polyphase element>
> sum of the active powers in all phase elements of a polyphase element
>
> Note – For a symmetric polyphase element, under symmetric conditions, the active power is equal to the active power for any phase element multiplied by the number of phases.
>
> [SOURCE: 131-11-42]

E. The meter is inequitable. It disadvantages an embedded generator by forcing their generated energy to be exported at a low price on one phase while simultaneously requiring high priced energy to be imported from the retailer for loads on the other phases.

Phase-Segregated Polyphase Metering

Real-Power Measurement Errors with Phase-Phase Connected Loads

1.0 Background

1. A normal three-element four-wire polyphase meter has its three measuring elements internally connected to multiply each phase current with the same phase-neutral voltage.
    - Such a meter will correctly measure phase-neutral connected loads no matter whether generation or consumption is occurring on each phase.
    - However, a normal four-wire three-phase supply allows loads to be connected in six different ways (three phase-neutral connections and three phase-phase connections).
    - The meter must also correctly measure phase-phase connected loads and generation.

2. A load that is connected between two supply phases has its phase-phase load current simultaneously measured by two phase-neutral connected metering elements.
    - It is important to note that phase-phase load currents are driven by the phase-phase voltage and the resulting load current is not in phase with the two phase-neutral voltages which the meter measuring elements are using to measure it.
    - Each phase-neutral connected metering element measures incorrect real and reactive power quantities because of this phase shift.
    - This does not matter with a correctly configured polyphase meter as it summates the real and reactive power quantities calculated by both meter elements and any symmetrical measurement errors caused by the phase shift cancel out.
    - Such a meter is Blondel-compliant (after the French scientist and engineer Andre Blondel who settled the matter for the rest of the developed world in 1893).
    - There is a good easily-readable explanation on Wikipedia (Blondel-compliance) which there is no need to repeat here.
    - If the meter is incorrectly configured such that positive and negative real-power quantities are placed in different registers these symmetrical errors are not cancelled out and are integrated into an incorrect import and export kWh quantities.

3. It should not be thought that low power factor loads are uncommon or are disallowed by the lines company if they are less than some arbitrary number (e.g. 0.95).
    - All embedded-generation loads that contain reactive components (e.g. a transformer) pass through zero power factor as the real-power direction moves from import to export.
    - This is why we meter reactive power (VArs), not power factor.

4. The same symmetrical-error effect can be seen with phase voltage unbalance.
   - If the phase voltage magnitude of both phases is not identical it alters the phase angle of the phase-phase load current.
   - This causes the same symmetrical measurement errors as changing the load power factor of the phase-phase current.

2.0 Phase-Segregated Measurement Error with Load Power Factor

Below is a graph showing the percentage error in each element of a phase segregated meter as the power factor of a phase-phase connected load is varied.

- The meter is measuring out of class (>2.5% error) at 0.999 power factor.
- The meter error is 19% at 0.95 power factor.

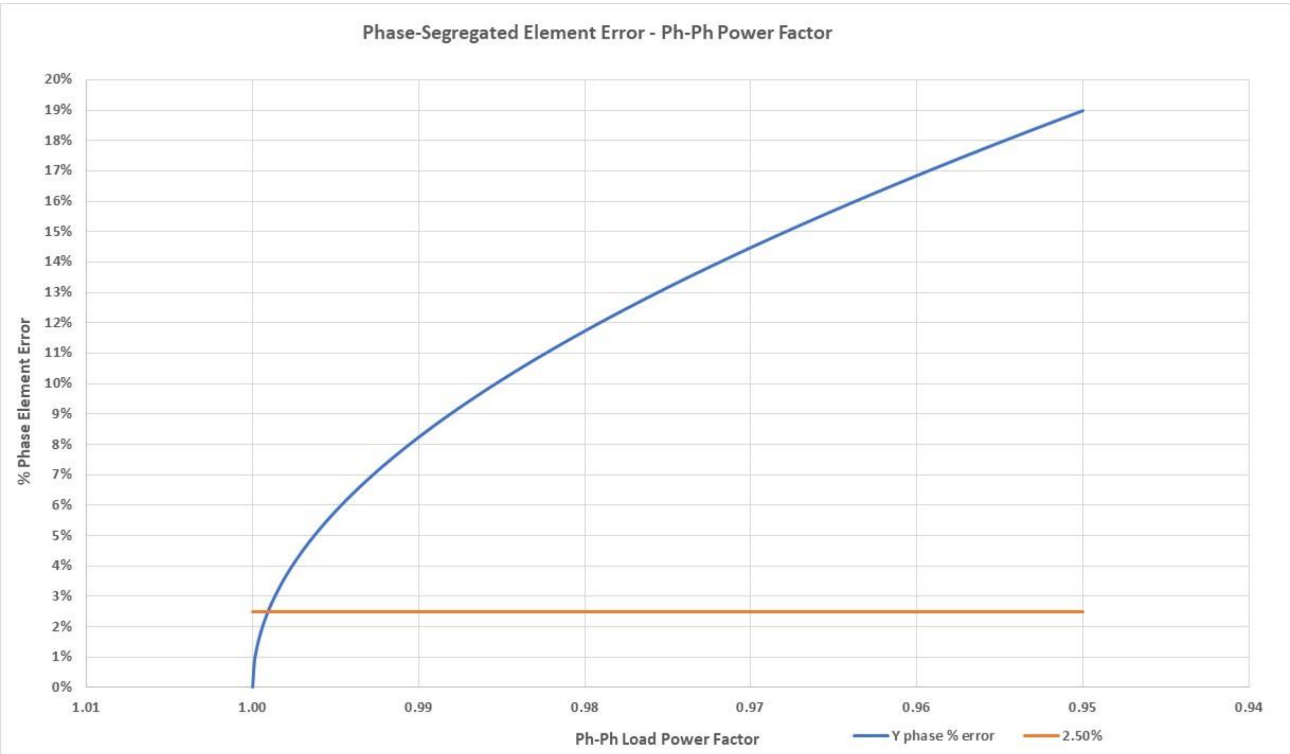


Figure 1: Phase segregated element error with varying load power factor

3.0 Phase-Segregated Measurement Error at Low Power Factor

Below is a graph showing the percentage error in each element of a phase segregated meter when the power factor of a phase-phase connected load is low.

- The measurement error reaches 100% at 0.5 power factor.
- Between 1.0 and 0.5 power factor, export generation exposes the error as soon as the individual element measured quantity is placed in the export register and is not summated with the import quantity measured by the other element.
- Less export generation is required to expose the error as the power factor of the phase-phase load decreases towards 0.5.
- At a power factor of 0.5 the measured real-power quantity of one phase element becomes negative and the measured value will be separately placed in the export register even with no export generation in the installation.
- At a power factor of zero the percentage measurement error is infinite by definition, as there is no real power being consumed and any incorrectly measured real power quantity is infinitely large by comparison.

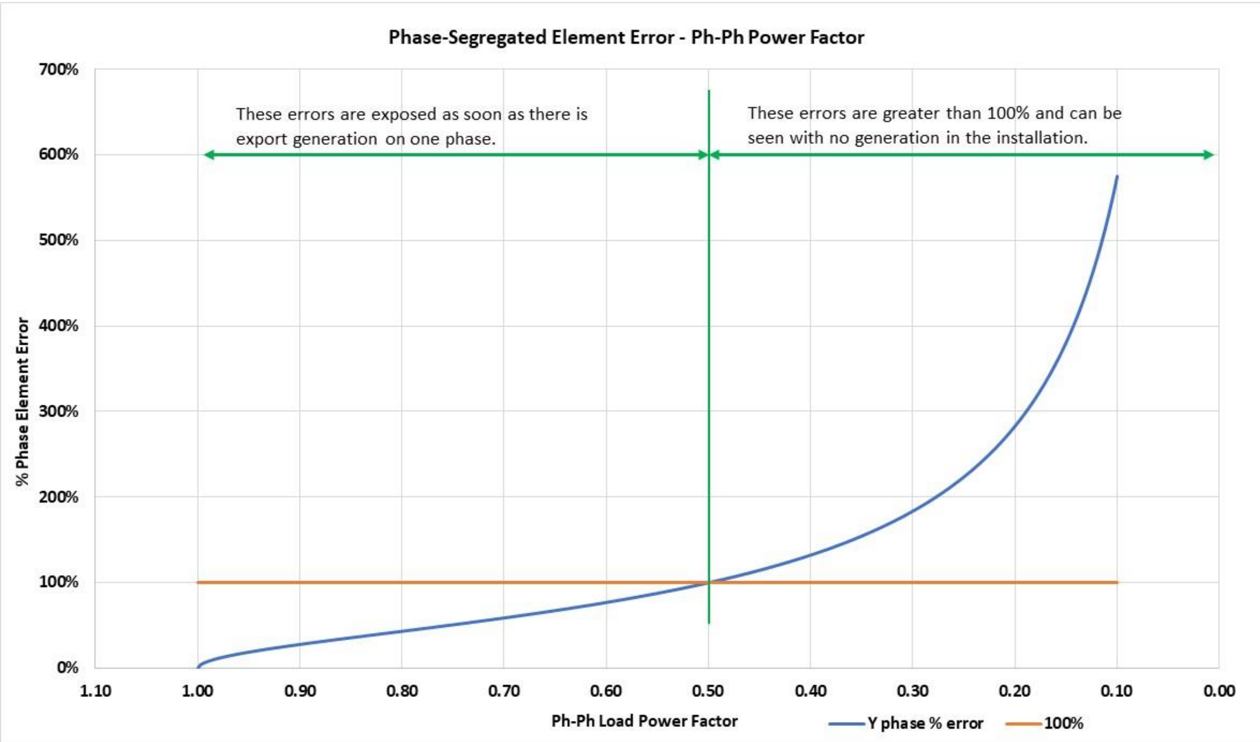


Figure 2: Phase segregated element error at low power factors

4.0 Phase-Segregated Measurement Error with Voltage Unbalance

Below is a graph showing the percentage error in each element of a phase segregated meter when the voltage of one phase is low.

- The effect is not as marked, but the meter is measuring out of class (>2.5% error) at 96.3 % voltage on one phase. This is well within the +/- 6 % supply voltage allowance.
- A similar effect will be seen with varying phase angle of one phase voltage due to unbalanced reactive volt drop in the supply transformer.

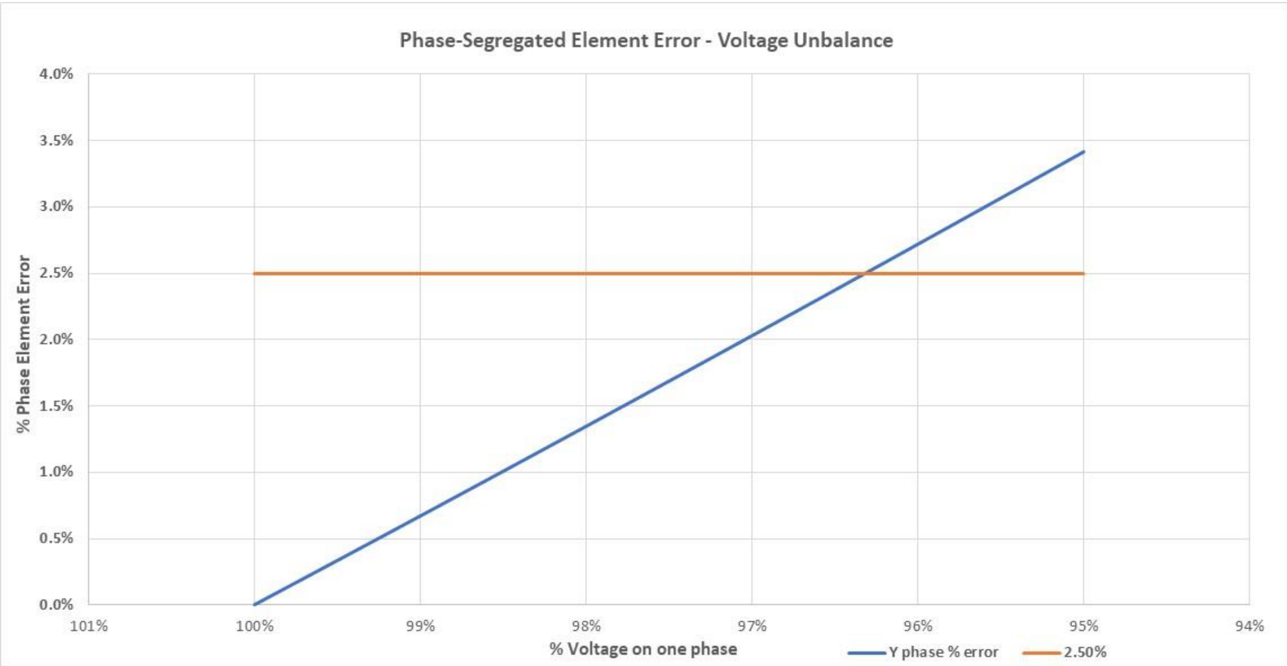


Figure 3: Phase segregated element error with low voltage on one phase

5.0 Conclusions

- A phase segregated meter measures phase-phase loads out of class (>2.5% error) at 0.999 power factor.
- A phase segregated meter measures phase-phase loads out of class (>2.5% error) at 96.3 % voltage on one phase.
- Phase segregated import-export meters cannot and do not comply with the Code.