National Measurement Law Review

Submission by Dr Martin Gill

Unverified quantities are currently being used to bill Australian electricity consumers. It is suggested the lack of a standard definition of these quantities contributes to the continued failure to verify and valid the measurements.

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Summary of Submission

Electricity meters are used to bill Australian consumers for their electricity use. The introduction of so called 'smart meters' creates opportunities for utilities to calculate consumer electricity bills using new quantities, including 'interval data' and 'demand'. While consumer bills are calculated using these new quantities neither has a standard definition.

Requirements outlined in the National Measurement Act can be summarised as:

If a measuring instrument is used for trade, it must be approved and verified

It is argued the lack of a standard definition means it is impossible to approve and verify the measurement instrument (electricity meter). This appears to contravene Australia's National Measurement Act. Specifically should consumers be billed for quantities based on these unapproved and unverified measurements?

Introduction

Undefined quantities create the potential for undesirable outcomes. Since the quantity is undefined it cannot be meaningfully tested. Without testing, measurements of the same quantity can lead to different values. Major issues then arise when these different values are subsequently used to bill consumers. The purpose of approval and verification is to provide consistency across the measurements, and ultimately confidence customers are being correctly billed.

Approval and verification requires an unambiguous standard definition. This unambiguous definition then supports the creation of standards supporting the verification of measurement instruments. Approved instruments support consistent measurements (to the required accuracy).

This submission focusses on two measurements made by electricity meters. Despite both measurements currently being used to bill customers their definition is ambiguous. This allows multiple electricity meters making the same measurement to produce different results.

Interval Data Recording

Historically consumers were billed for the total amount of electricity used over a number of months (typically 3 months). Approved meters are required to show a kWh register and meter testing checks the accuracy of the kWh register.

Increasingly consumer electricity bills are calculated using the 'interval data' recorded by smart meters. The interval data is not shown on the front of the meter and more significantly no testing of interval data is included in meter verification tests.

It is suggested a reason no attempt is made to verify the accuracy of interval data is the lack of a standard definition. The following shows potential problems arising from this lack of a standard definition.

Limited Measurement Resolution

The following analysis assumes a constant load of 2.3kW (e.g. 10Amps x 230Volts) which is stored in 5 minute intervals with a resolution of 0.1kWh. The following table shows the effect of truncation and rounding:

Quantity	Value
Actual Value (0.001kWh resolution)	0.191
Interval Increment (rounded to 0.1kWh)	0.2
Rounding Error	4.3%
Interval Increment (truncated to 0.1kWh)	0.1
Truncation Error	-47.8%

The above example shows limiting the resolution of the interval data directly affects the accuracy of the recovered value. In the above example the accuracy of interval data recovered from the meter exceeds requirements for domestic electricity meters, Class 2 or 2% accurate (the Appendix discusses why meter vendors limit the resolution).

Warning: It cannot be assumed truncation errors will always result in lower consumer electricity bills. For example if the interval data is recording solar generated energy then truncation errors result in the consumer receiving a lower feed in credit than they should.

This is an interval data problem

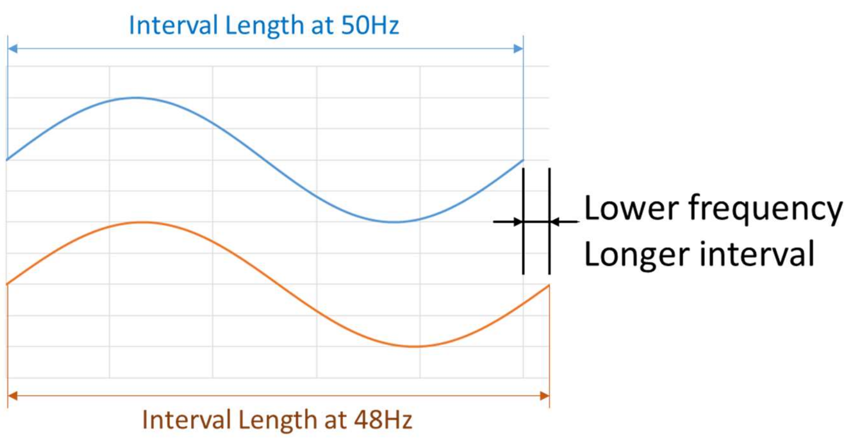
Traditional spinning disk, electro-mechanical meters also had limited resolution. These meters were only read four times per year, equivalent to an interval period of 3 months. Over these long time periods the limited resolution of the measurement, compared to the final total value, falls within the measurement accuracy of the electricity meter.

Consumer interval data has primarily been used to calculate Time of Use tariffs. Over the 3 month billing period the Peak, Shoulder and Off-Peak values are calculated by summing multiple intervals. As for the spinning disk meters the summation effectively increases the measurement period, so the limited resolution of each interval becomes less of a problem. *PROVIDED* there is no bias in the timing of the intervals.

Mains Frequency

Recently the effect of renewable generation on the stability of the electricity grid has been hotly debated. What is not discussed is the mains frequency across Australia's National electricity network has always varied throughout the day. Like a car attempting to drive up a steep hill, the grid frequency slows during periods of high electricity demand.

Electricity meters often use the mains frequency to measure the interval period. As the mains frequency slows the length of each interval period increases. As the interval period increases larger amounts of energy are attributed to these intervals.



The problem is slower mains frequencies coincide with the Peak Time of Use period. Summating interval data to calculate energy use during the Peak periods is likely to include a systematic measurement bias, in favour of the utility.

Determining the scale of the problem depends on multiple factors. Firstly Australia's Electricity Market Operator does a good job of managing the mains frequency. During periods of high demand the mains frequency rarely falls below 49.75Hz, suggesting the described measurement bias is less than 0.5%.

While the National Measurements Institute is only concerned about the measurement error, consumers want to know the effect on their electricity bill. The above measurement bias applies to the Peak Time of Use rate, where electricity costs are typically five times higher than off peak periods and three times higher than traditional fixed/flat tariffs. Using the lower figure of three times higher, suggests the measurement bias could result in bills up to 1.5% higher than they should be. While still within the required measurement accuracy it is emphasised this measurement bias is always in favour of the utility as it results in consumes paying more.

For completeness it is noted the Australian Energy Market Operator (AEMO) ensures the mains frequency averaged over a full day is 50Hz. To compensate for lower mains frequencies during periods of high electricity demand AEMO deliberately increase the mains frequency above 50Hz during periods of low demand. This is why electricity meters (and other appliances) use the mains frequency as the basis of their time keeping. The problem described here is the systematic measurement bias created by using the mains frequency during the recording of interval data.

Standard meter tests check the accuracy of the meter clock. This testing is considered inadequate when the clock is also being used to measure short time periods. Specifically the testing fails to specify error limits for these shorter time periods or ensure there is no measurement bias caused by variations to the mains frequency.

Demand Tariffs

The Australian Energy Market Commission has mandated the rollout of cost reflective network tariffs. Most networks are interpreting this mandate as a requirement to introduce Demand Tariffs.

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> Some retailers offer plans with *demand charges*. These are extra charges on top of usage and supply charges.

The lack of a standard definition

There is no standard definition of 'demand'. Indeed the descriptions accompanying most demand tariffs are incorrect and misleading. For example "the maximum amount of energy measured over a 30 minute period". This is wrong because in this case it is known the demand tariff is calculated using the 30 minute interval data recorded by the electricity meter. Hence the 30 minute interval starts on the hour and half-hour boundaries. The difference can be significant, for example using a high demand appliance from 3:45 to 4:15 results in a totally different demand value compared to running the same appliance from 4:00 to 4:30.

Of potentially greater concern is any attempt to introduce demand measurements not calculated from the interval data. Meter testing does not include any accreditation of these 'instantaneous' peak demand measurements. Consumers should only be billed for metered quantities which are validated to be correct.

Why is this a problem?

Demand tariffs charge consumers an additional fee based on the calculated demand. The charge is typically applied to the maximum amount of energy accumulated in ONE interval period.

Multiple failings affect the accuracy of these demand measurements:

- Current meter testing does not test interval data
- The limited resolution of interval data recording **greatly** affects measurement accuracy when only one interval is used

- Timing accuracy affecting the interval data

These failings have been discussed above but it is important to understand the potential impact on consumer electricity bills. Assuming the demand charge is $15 per kW applied to a maximum demand of 6kW. The truncation/rounding error on a 6kW load measured using 5 minute interval is 20%. This error is well outside the Class 2 (2% accuracy) requirement for approved electricity meters. The correct $90 demand charge could be as high as $108.45 (once the 0.5% mains frequency measurement bias is also included).

Need to investigate the problem

The lack of a standard definition of demand is a problem. If a definition existed then appropriate testing could be included in metering standards and/or NMI pattern approval documentation. This would provide consumers with the certainty their electricity bills accurately reflect their energy use.

It is suggested the National Measurement Institute investigate the fairness of current methods of calculating consumer demand tariffs. This will involve a review of interval data measurements.

Adequacy of current meter testing

A separate (but closely related) topic is the adequacy of meter accuracy testing.

The vast majority of meter accuracy tests involve applying a constant voltage and current to the meter. External test equipment is then used to confirm a light (led) on the front of the meter flashes at the correct rate. It is suggested this old fashioned testing is no longer adequate to ensure consumers are billed correctly for their electricity use. Specifically consumers are not billed using the light (led). Instead they are billed from the interval data stored by the meter. Meter testing should be updated to validate the interval data measurements.

There has been a dramatic increase in the number and type of electricity appliances used in the typical Australian household. Many of these modern appliances no longer present a constant load. For example energy efficient inverter air-conditioners and variable speed pool pumps constantly adjust their electricity use. Many appliances now include switch mode power supplies which can introduce significant current (and voltage) harmonics.

Despite these significant changes meter testing continues to use static waveforms. These static waveforms do not reflect the highly dynamic waveforms typically encountered when multiple modern (electronic) appliances are in use. Side-by-side testing of “approved” meters reveals measurement differences falling well outside required accuracy limits. This leads directly to questions of whether consumers are being billed correctly for their actual electricity use.

Conclusion

Consumer electricity bills are no longer calculated using the total kWh register shown on the front of the electricity meter. Instead consumer electricity bills are calculated using the interval data stored in the meter. Despite this significant change meter testing has not been updated to include validation of interval data. A standard definition of ‘interval data’ would provide a starting point for this verification. The absence of this standard definition ensures consumers will continue to be billed for quantities which are not tested, validated or verified.

The problem is exacerbated by two recent rule changes made by the Australian Energy Market Commission. The first requires distributors offer cost reflective tariffs to consumers, which are typically being implemented as demand tariffs. The second requires all smart meters installed after the 1st Dec 2018 be capable of recording 5 minute interval data. Without a standard definition implementations can vary, with this submission showing some implementations will be extremely sensitive to measurement errors. Importantly the measurement errors associated with demand tariffs are not currently being tested, validated or verified.

The lack of testing, validation and verification of quantities currently being used to bill consumers does not appear to align with requirements outlined in the National Measurement Act.

Appendixes

Clarifying why meter vendors limit the resolution of interval data

Many people assume interval data recording involves the meter storing the total accumulation register. This assumption may or may not be correct.

Not all meters store the total accumulation register each interval

Australia's National Energy Rules requires electricity meters to store 210 days of 5 minute interval data. Assuming this is stored using 4 bytes per interval indicates 236kbytes of storage is required. The AEMC smart meters must be capable of storing both import and export doubling storage to a minimum of 473kbytes.

Rather than storing the full 4byte accumulation register it is possible to build a cheaper electricity meter by only storing the amount of energy used in a single interval. The maximum increment over one 5 minute interval is 1.667kWh[1]. With a resolution of 0.1kWh this is easily stored using 1 byte per interval. Using 1 byte per interval reduces total memory requirements to 59kbytes. This smaller, and therefore cheaper, memory is easily supported using low cost 16 bit processors resulting in additional savings.

There are further advantages moving to 1 byte. The AEMC requires all new smart meters be read remotely. The geographically dispersed meters are read using commercial cellular networks. The less data transferred per month the lower the negotiated telecommunications charges. Hence a meter offering 1 byte interval data typically incurs lower reading costs than one using 4 bytes per interval.

The standard definition of 'interval data' would describe what must be stored. It would also clarify the accuracy of individual interval data measurements. Note a requirement to maintain the measurement accuracy **per interval** is preferred to specifying a minimum resolution.

Examples of interval data testing

Testing Interval Data Recording

Apply a constant voltage and current to the meter for a 24 hour test period. Download the 5 minute interval data and confirm the sum of the 288 periods is within the claimed measurement accuracy when compared to the external reference standard. The test should be repeated at a number of different currents.

Testing Demand Measurements

Apply a constant voltage and current to the meter for a 24 hour test period. Download the 5 minute interval data and confirm the maximum difference from the largest to the smallest is within the meter's claimed measurement accuracy. The test should be repeated at a number of different currents around I_b.

Time Keeping Test

The accuracy of interval data recording should be tested at different mains frequencies. Apply constant voltage and current to the meter. Starting at a mains frequency of 48Hz slowly increment the mains frequency to 52Hz over the 24 hour test period. Download the 5 minute interval data and confirm the maximum difference from the largest to the smallest is within the meter's claimed measurement accuracy. Note this test focusses on the use of interval data for demand tariffs.

[1] Assuming a single phase current of 80A (the new household fuse limit) and a network voltage of 250V

About Dr Martin Gill

Dr Martin Gill is an independent consultant specialising in the provision of consumer advice based on a deep understanding of the Australian energy industry and strong analytical skills. As a consultant he has prepared advice for consumer advocates, government regulators, electricity distributors, electricity retailers, asset operators and equipment vendors.

He currently represents the interests of consumers on a range of Standards Australia committees including metering, renewable power systems, battery storage, electric vehicles and demand management.

Dr Gill is a metering expert. During the National Smart Metering Program he facilitated the development of a specification for Australian smart meters. Innovative metering products developed by his teams have been externally recognised with the Green Globe Award, NSW Government's Premier's Award and Best New Product by the Australian Electrical and Electronics Manufacturers Association.

Citation

Please accurately attribute all quotes and references to this submission. It would be appreciated if references also included the author's website drmartingill.com.au.

Comments or Questions?

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