

Title: **Operation of electricity meters when energy flowing in reverse**

Synopsis: To document the impact of reverse energy flow of whole current 'import' electricity meters

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1. Introduction

1.1. Purpose

This document describes the impact of an import whole current electricity meter when it encounters reverse operation due to net export (micro-generation) conditions. The intended readers are staff involved in Meter Operation, Electricity Suppliers, Network Operators and Microgeneration Certification Scheme (MCS) installers.

Legislation requires the 'settlement' or 'billing' import meter to accurately measure the import energy to a premise. Ofgem, National Measurement Office ([NMO](#)), Elexon and customers all have an interest in ensuring this occurs. In recent years there has been an increase of customers fitting micro-generation which may export onto the distribution network at times of the day. Some import meters do not respond to this 'export' energy appropriately. This document describes the issue and identifies some of the aspects that the industry should be mindful of.

1.2. Background

Historically, generation and export of energy has been associated with larger installations in industrial & commercial sites which have had half hourly current transformer (CT) metering. In recent years the government policies, particularly the Feed in Tariffs (FiTs) have encouraged an increase in micro-generation installations at small domestic and small non-domestic premises. These installations are designed to export energy onto the distribution network when there is low demand within the metered premises. The metering at these smaller premises is normally whole current [metering equipment](#).

Whole current metering equipment at domestic and smaller non-domestic premises has, at times, been designed, or configured, on the assumption that the energy flow is *always* from the distribution network into the customer premises. In the 1970/80's a number of illegal activities were identified which attempted to reduce the energy recorded on the meter by reversing the meter, or forcing reversed energy flow through the meter.

As a result of these attempts of energy theft, electromechanical meters procured after c.1985 were fitted with a 'backstop'. The backstop stopped the disc rotating in the wrong direction. However, meters without backstops are still in use across the country as a result of the meter being removed, refurbished, recertified and re-installed. Electronic meters also offered the ability to 'flag' the data if there was any 'reverse energy flow' detected. Some electronic meters were configured to add any reverse energy flow to the import register. These issues mean that the import metering may not operate correctly when a customer with microgeneration is genuinely exporting energy.

It should be recognised that when a meter was first installed, conditions at that time would likely to have been "Appropriate" (per the Electricity Act) for the design of meter. But when circumstances have changed, (e.g. export now possible) a meter can become "Inappropriate", and therefore will need to be changed.

There are no circumstances where the 'import' meter is intended to rotate backwards, reducing the import register, nor is the meter intended to add any exported energy to the import register.

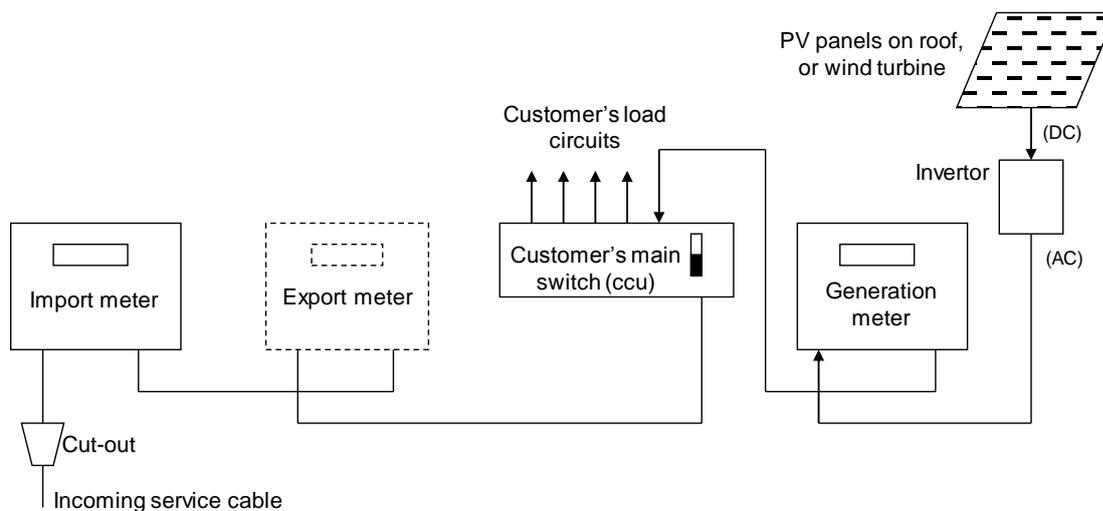
The financial design of the Feed in Tariffs (FiTs) for microgeneration were developed on the basis that the import meter records all import energy and does *not* run backwards when the microgeneration is causing a net export. The exported energy is either 'deemed' or explicitly measured using an 'export' meter.

The issues can be grouped as follows:

Issue	Effect during export conditions	Suitable for 'import' meter
Electromechanical meter with no backstop	The meter will operate in reverse reducing the import register	No
Electronic meter configured to increment export consumption	The meter will add the export consumption to the import register	No
Multi-phase meter not designed for Import and Export	The import register may <i>not</i> deduct the export energy from the import occurring on another phases(s) (when Export less than Import) i.e. does not correctly net the exports from the imports.	No
Electronic meter configured to display a warning	The meter will display a message or set a warning LED, or display "rEd" (reverse Energy detected). The meter will record the import energy correctly	Yes. But be aware of potentially misleading warning messages

1.3. Terminology

The diagram below illustrates a typical single phase whole current microgeneration arrangement.



Notes:

- 1 For smaller sites the Export meter is optional. If fitted, it is either part of the Import meter or adjacent to it. In future it will be incorporated in compliant Smart meters. Export consumption is 'deemed' when an export meter is not fitted.
- 2 The Generation meter is installed within the customer's installation. It may be included as part of the Inverter. FiTs payments are made against the advance of the Generation meter.
- 3 Only a single line flow has been shown for clarity, and no control isolators/switches.

2. Who knows when meter is likely to export?

2.1. Customer/MCS Installer

The customer and the Microgeneration Certification Scheme (MCS) installer knows of the installation of equipment capable of exporting energy onto the distribution network through the import electricity meter.

The MCS Installer should inform the distribution network operator of the installation of microgeneration in accordance with [Engineering Recommendation G83](#). The customer will normally contact their import supplier to obtain FiTs payments.

The customer or installer may identify that the meter is not operating as expected. They should contact their electricity supplier to initiate checks and/or meter replacement.

Where a meter operates in reverse during export energy conditions, the individual customer is seeing an inappropriate reduction in their 'import' energy bill. This 'unrecorded energy' then forms part of the industry 'losses' and is effectively added to the charges of all other customers.

2.2. Distributor

The following was published in the Elexon newscast on 11 Feb 2013:

"The Supplier Volume Allocation Group (SVG) has noted that not all Licensed Distribution System Operators (LDSOs) appear to be following the BSC's requirement to notify Suppliers when small distribution-connected generating equipment (e.g. solar panels) is installed at demand sites.

Section 3.12 of [BSCP515 'Licensed Distribution'](#) requires an LDSO to tell the Import (demand) Supplier, by sending a D001 flow, of the existence of any Small Scale Third Party Generating Plant where the LDSO has been informed by the customer. This is because the customer may use a third-party installer and will not necessarily inform its Import Supplier directly. However, the customer is legally required outside the BSC arrangements (by the Electricity, Safety, Quality and Continuity Regulations) to tell its LDSO about any distribution-connected generation (e.g. through a notification under Engineering Recommendation G83 for microgeneration).

The SVG is aware that Ofgem is considering the issues associated with Meters running backwards, and that the topic is also the subject of some press interest. The SVG has asked us to remind Distributors of the BSC requirements in this area. The [Metering](#) page of our website also provides further guidance on the BSC rules for metering demand sites with generating equipment installed.

The SVG also notes that customers may themselves not be notifying LDSOs in all cases. The G83 notification process sits outside the BSC, the Master Registration Agreement (MRA) and the Microgeneration Certification Scheme (MCS) administered by Gemserv. However, Gemserv intends to use its MCS contacts with installers and their certification bodies to remind installers of their G83 obligations. ..."

2.3. Supplier

Suppliers should know of a micro-generation installation directly from the customer. It is understood that the majority of customers in receipt of FiTs payments obtain these from the same supplier as the import supplier. It is unusual for a separate MPAN to be created for the export energy, the export consumption is normally 'deemed'.

Distribution businesses should inform the supplier of the connection of generation equipment, see above.

However the supplier identifies that the customer has generation equipment installed, they should check that the import meter is appropriate for use where microgeneration is fitted. The supplier should have available the list of meters which require specific checking, see below.

If the meter requires specific checking, then they should ask the Meter Operator to check and/or replace the existing import metering equipment when the metering equipment is found to be inappropriate.

2.4. Meter Operator

The Meter Operator does not know about installation of microgeneration equipment. Where a supplier has concern about the suitability of the import meter following an installation, then they should request the Meter Operator to confirm its suitability and/or request it to be replaced.

2.5. Data Collector

One of the validation checks within the BSC is for the NHHDC ([BSCP504](#) Appendix 4.2 - Validate meter data) is to ensure that the meter register for a meter reading has advanced from the previous reading, if not, then it should fail validation and be subject to investigation. So an electromechanical meter without a backstop which would rotate in reverse, reduce the reading below the previous meter reading, should cause a validation failure. However, if the exported generation is not greater than the import energy in the period since the last reading then the meter will have advanced, but not as far as it should have done, although it will pass the validation check.

So the NHHDC may identify significant problems, but will not identify scenarios where the meter is still advancing between reads, albeit at a reduced level.

Data Collectors may also identify warning messages indicating reverse energy flow. Dependent upon the make/model/configuration this may also trigger an investigation.

Any concerns should be raised using normal industry methods to the Meter Operator and/or supplier for investigation & resolution.

3. Engineering issues

3.1. Electromechanical meter with no backstop

As the result of illegal interference electromechanical meters manufactured after c.1985 were expected to have backstops fitted. Whole current meters normally have a certified life of 20-30 years. Some older meters may have been refurbished & “re-certified” and therefore still be in legitimate use, although the numbers are projected to be reducing rapidly.

3.2. Electronic meter configured to increment export consumption

As the result of illegal interference in the 1980’s some electronic meters may have been configured to add any ‘reverse energy’ or export energy to the import register. This was probably configured at the time of manufacture at the request of the procurer of the meter. The requirements of various meter procurers will have been different and will have changed over time. Therefore, an identical meter make/model may be configured to operate in different ways. The exact configurations of meter batches (by serial number) is not something that stakeholders still have an accurate record.

Other electronic meters were configured with a ‘fraud’ warning lamp or a display which showed “rEd” to indicate ‘reverse energy detected’. In many cases the meter continues to operate correctly.

3.3. Multi-phase meter not designed to net exports from imports

Import multi-phase meters should operate as an integral device so the meter should record the sum of the imports less any exports. The result should be the same as if all of the load were taken through a single phase meter.

For instance, if the customer has net import load of 1 and 4 kW on two phases, and a net export of 2 kW on the third, then the net consumption (over a period) recorded by the meter should be based on 3 kW (=1+4-2). Some meter types/configurations ignore the export so would record a consumption based on 5 kW.

Some meters are not designed to allow for Export; others may be configurable, and not correctly configured. In the latter case, there will be variance identified across the installed meter population for the same make/model.

The three phase issue is best described by an example:

“We have recently removed a meter from site, which was originally fitted with specific knowledge that is to be used with micro-generation.

The site is somewhat unusual as the micro-generation (solar panels in this instance) are spread over all three phases but the normal property load is only connected to ‘Red’ phase. As such ‘Red’ phase can be either import or export, but ‘Yellow’ and ‘Blue’ phase are only export.

Evaluation in the meter operator laboratory identified that the meter appeared to be configured to calculate consumption on a ‘per phase basis’ so if ‘Red’ phase was importing but the other phases exporting, the meter incremented the total Import Register irrespective of the contribution of the other two phases. The analogy was as though it was performing as three separate single phase meters which then summed the net advance across all three elements.

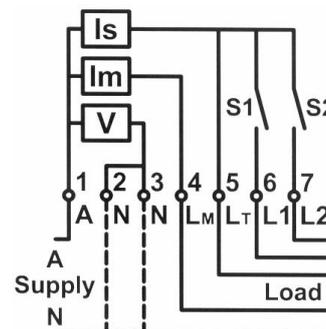
The meter was replaced with an alternative electronic meter programmed to calculate Total Import across all three phases (performing akin to a 3 phase electromechanical meter).

Please note that the original meter at the centre of the investigation can be programmed to work in a number of ways including that of the replacement meter.”

Multi-phase installation metered using three single phase meters will also result in a similar error and should be replaced with a suitably configured three phase meter. The correct approach can be described as an analogue of a Ferraris meter with three discs on a single shaft, with backstops. A multi-phase installation should always have a single MPAN for the import (and another if export is measured & settled).

3.4. Twin element meters

Over many years, pre and post privatisation, the GB electricity industry has developed a range of tariffs to support efficient electricity usage. This has led to variants of metering equipment, one of which is the ‘twin element meter’. This has been used to promote electricity usage at cheaper times of day. A typical installation may have a primary measuring element (I_m) which is always energised but may switch tariff registers following an Economy7 tariff. In addition there may be a switched load, such as water heating, which is switched at different times, typically all night but also having a boost in the afternoon. This would be physically wired on a separate metered secondary element (I_s) with the energy recorded on a different register. This registered energy would typically be charged at a different p/kWh to the Economy7 rates.



The micro-generation will always be connected to the primary element (I_m in the diagrams). Most micro-generation fitted recently has been photo-voltaic such that it generates during the daylight hours, although CHP, wind or water turbines will generate anytime through the day & night. The secondary, or switched, measuring element (I_s) is used to control an ‘off-peak’ supply, typically water heating and/or space heating.

In practical terms a non-smart twin element meter operates as two separate meters within the same physical box.

In an operational scenario when the customer is:

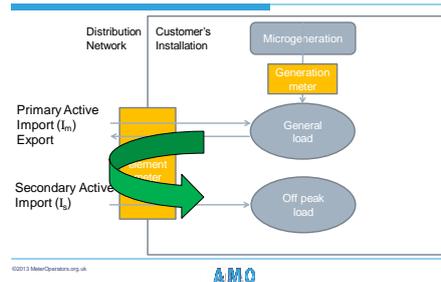
- exporting energy to the network on via the primary element, while also
- simultaneously consuming on the off-peak secondary element, then

the export energy will be exported through the primary element (I_m) and recorded as export, while also being “re-imported” on the secondary element (I_s) and recorded as imported energy.

The customer does not get the financial benefit of the micro-generated energy being used within the premises by load equipment connected to second element (I_s).

Take a scenario where customer has 5kW wind turbine, twin element meter, where secondary element is switched on to supply a 3kW water heater, general household load of 1kW.

Twin Element Meter – export & consuming



Metering scenario	Generation meter	Primary element	Secondary element
Existing non-smart twin element meter	Records 5kW generation	Deemed export of ‘x’ kW based on rules	Import of 3kW

3.5. Future

The government policy requiring the installation of smart meters by 2020 will result in these older meters designs being replaced. So this issue is a time limited issue whose impact will decline more rapidly during the roll-out of smart meters. As at August 2013, the [SMETS](#) smart meter specification will correctly meter import and export energy by whole current meters, although it does currently replicate the issue described above for twin element meters.

4. Customer issues

All stakeholders are concerned about these issues and have received approaches from customer representative groups and directly from customers. Which consumer magazine ran an article in February 2013 on the backward running meter scenario:

www.which.co.uk/energy/creating-an-energy-saving-home/guides/feed-in-tariffs-explained/meters-running-backwards/

AMO members have highlighted some blogs on this subject, which illustrate the customers concerns:

<http://forums.moneysavingexpert.com/showthread.php?t=3191844>

<http://paulaowenconsulting.co.uk/2011/11/21/electricity-meter-going-backwards-a-need-for-clear-guidance-from-pv-installers/>

Ofgem have updated the [FITs guidance for Suppliers](#) refers to the issue in paragraph 4.16:

4.16. Licensed electricity suppliers should note a generator's import supply meter may be affected by the installation of FITs generation, eg an import supply meter that does not have a backstop fitted (so the import supply meter register rolls back when electricity is being exported), or a meter that is configured to treat exported electricity as imported electricity (so the exported electricity is added to the amount imported). Unless a generator has offered to supply an appropriate meter themselves, the Licensed Electricity Supplier must ensure the installation and maintenance of an appropriate meter. We expect that where licensed electricity suppliers are notified of an issue with the import supply meters, they will take the necessary steps to investigate and resolve this at the earliest opportunity, treating consumers fairly, and in accordance with any relevant legislation and the relevant back-billing principles.

Ofgem have raised these concerns directly with Energy UK and the smaller suppliers. Ofgem (and NMO) have highlighted the obligation under Schedule 7 of the Electricity act, notably:

"1 (1) Where a customer of an authorised supplier is to be charged for his supply wholly or partly by reference to the quantity of electricity supplied, the supply shall be given through, and the quantity of electricity shall be ascertained by, an appropriate meter. ...

(6) For the purposes of this paragraph a meter is an appropriate meter for use in connection with any particular supply if it is of a pattern or construction which, having regard to the terms on which the supply is to be charged for, is particularly suitable for such use. ..."

Since January 2013 a series of industry meeting have occurred to consider the scope and scale of this issue. This has resulted in a series of activities, including:

- The AMO has compiled this document to explain the issue and published a list of meters which may be regarded as not 'appropriate' in the circumstances described.
- Energy UK member companies are reviewing existing microgeneration customers to ensure that the installed metering equipment is appropriate, if not then meter changes and billing corrections will be initiated
- Energy UK members have agreed to apply their [Code of Practice for Accurate Bills](#) to ensure customers are accurately billed
- The Energy UK and MCS have commenced discussion to seek to identify suspect meters, so they can be changed, prior to installation of microgeneration equipment

5. Meters which are suspect

The AMO members do not warrant the accuracy of this information, but provide the information in good faith to assist stakeholders. If any errors or improvements which any stakeholder identifies should be communicated to the contact on the front of this document so it's quality can be improved.

5.1. Identification



If this symbol is present on the LCD display of an electronic meter, it means that the meter has experienced reverse (export) energy flow whilst not being configured to measure export energy.

This symbol may be present on the information plate of an electro-mechanical meter to show that an anti-reverse device is fitted.

The logo has not always been used on meters, so cannot be used as sole indicator.

In c.1985 some meter manufactures included an “H”, “h” or “-9” in the meter model type to identify when a backstop had been included.

5.2. List of suspect meters

The AMO members have prepared a list of suspect meters based upon the [NMO Schedule 4](#). It is not anticipated that MID approved meters should have the same concerns.

The AMO list identifies meters which are suitable for use to measure the import energy where the meter may encounter export energy. For the reasons described in this document it is difficult to be categorical about all meters which do not deal appropriately with reverse energy flow.

All meters which are dated 1985 or earlier should be changed when associated with microgeneration. The serial number format includes the date of manufacture, See UKMF [publication M1/1](#) for examples of non-smart metering conventions.

The AMO list identifies meters which are known to have issues:

- Meters which may identify reverse energy (rEd), but are recording the energy correctly – identified in **green** - no meter changes are required, but customer and meter reading staff should be aware of erroneous alerts.
- There are some meters which are suspect, but not yet been fully confirmed – identified in **blue** - if in doubt the relevant Meter Operator should be contacted.
- Meters which are not suitable for use at premises with microgeneration installations – identified in **red** as “meter requires changing”, subject to any stated caveats.
- Some meters which are outside of certified life and should be replaced as part of ‘business as usual’ and microgeneration sites with meters prior to 1985 are not specifically included in the list, except where there is some commentary highlighted in **white**

This document and associated list is a living document as new information becomes available it will be updated. If a customer has any concern about their meter then they should contact their supplier. The supplier will liaise with the Meter Operator, who can investigate and, if necessary, initiate a revision of the list.

The list is updated as new information becomes available www.meteroperators.org.uk/news.php