Issue Form - BSCP40/04	Issue 109 *(mandatory by BSCCo)*

Issue Title

Treatment of domestic solar self-consumption within Settlement

Issue Description

Growing numbers of domestic customers are installing solar photovoltaics (PV) generation in their homes, connected to the customer's electrical installation behind the Boundary Point Settlement Meter System, allowing customers to benefit from self-consumption of the renewable generation and receive payment for electricity exported through the Smart Export Guarantee (SEG) scheme. With the roll-out of smart metering and Market-wide Half-Hourly Settlement (MHHS), both Import and Export metering and Settlement will be on a half-hourly basis in the coming years.

Domestic solar PV systems are typically sized to have a maximum generation power output ranging between 3.68kW up to around 6kW. For a significant portion of time the generated power output is lower (in the order of hundreds of watts or low kilowatts) due to time of day, weather or seasonal conditions. This is below the instantaneous power consumption of common domestic household appliances and loads.

Across a settlement period, the customer's solar PV generates a volume of energy and a volume of energy is consumed by the home, but the generated power and consumed power will not be matched on an instantaneous, second-by-second basis. During normal household activity, a customer's instantaneous power consumption can fluctuate above or below their solar PV generation power output causing instantaneous Import from or Export to the electricity system to balance the customer's instantaneous power shortfall or surplus.

The Boundary Point Settlement metering measures electricity Import and Export on an instantaneous basis, those instants where generation exceeds consumption result in Export to the system accumulating on the Export register. Those instants where consumption exceeds generation result in Import from the system accumulating on the Import register.

A significant issue arises from this; within a Settlement Period, surpluses of energy generated at particular instants in time are being recorded against the Export register and do not automatically off-set deficits of energy consumed at other instants, these being recorded against the Import register. Across the whole Settlement Period, a volume of energy is being generated behind the meter and a volume is consumed behind the Meter, but the volumes recorded by the Boundary Point Settlement Meter are not the signed sum of those two volumes. The Meter measures the result of the instantaneous interaction between generated and consumed power which includes the component that is the movement of energy back and forth between the home and the Total System resulting from those instantaneous imbalances of generation and consumption. This component has a net volume of zero and is not a true surplus or deficit of energy transferred to the system.

For example, a home generating 1kWh and consuming 1kWh behind the meter within a settlement period, would have zero energy surplus or deficit on a volumetric basic across the settlement period. However, due to the instantaneous mismatch between generation and consumption, there will be instants of Import and instants of Export meaning that the customer will accumulate import and export volumes against which they are billed. Likewise the Import and Export Suppliers will have volumes assigned to them despite the household having zero energy surplus or deficit across the settlement period.

These volumes arise from the instantaneous power balancing service provided to the customer and will vary depending on the particular appliances or load being used.[1]

Currently, Settlement Supplier Volume Allocation processes handle Import and Export volumes separately. They do not 'net off' volumes and do not have a mechanism to separately consider the volume that has been exchanged back and forth within a Settlement Period. Under current arrangements, the Import is assigned to the Import Supplier and the customer pays the Import tariff with the various Supply Charges and levies on their Import. The Export is assigned to the Export Supplier who pays Export payments to the customer for the Export.

The current arrangements present problems for consumers and potential issues with Settlement processes:

- There is a significant disparity between the charges applied to Imports and the credits applied to Exports causing a substantial disparity between Import and Export tariffs. Hence, domestic customers pay high "round trip" costs for using the electricity system to balance their instantaneous power generation and demand within a Settlement Period.
- For a customer to self-consume their generated energy they have to ensure that on an instantaneous, second-by-second basis their power demand is matched by generation. This is a very challenging requirement to place on domestic consumers and is arguably inconsistent with an electricity settlements system based on the measurement, accounting and trading of energy volumes within Settlement Periods.
- A customer's self-consumption and their energy bills are now affected by the instantaneous power consumption patterns of their loads and appliances and its interaction with instantaneous generation, rather than the volume of energy those loads consume and generate which has implications for the operating cost of appliances.
- There is a risk of consumer detriment because many customers are unlikely to be aware of the complexities of the interaction between instantaneous generation and consumption and the implications of metering and Settlement design. This can result in lower levels of self-consumption and higher energy bills and may lead to sub-optimal consumer choices when purchasing new appliances.
- Metered Import and Export volumes going into Settlement are inflated by the component which is energy moving back and forth between the home and the electricity system to balance the instantaneous power deficits and surpluses, this component having a net sum of zero.
    - The problem is analogous to Reactive Power where energy moves back and forth across the boundary. For Reactive Power, this is occurring on a sub-cycle basis and over the measurement period of a cycle it sums to zero. In the case of Active Energy Settlement it is occurring on a second-by-second or minute-by-minute basis, but over the measurement period of a half-hour Settlement Period it sums to zero.

Justification for Examining Issue

1. Growing numbers of domestic customers are installing solar PV generation and will be affected:

UK government figures[2] indicate there are 1.169 Million 0-4kW solar installations in Great Britain as of June 2023, with an installed capacity of 3.35 GW (though some of this total will be small-scale commercial installations). NGC ESO's Future Energy Scenarios 2022[3] report estimates current installed domestic solar capacity higher at 4.2 GW. It forecasts future installed domestic solar PV capacity in 2030 as ranging between 5.35GW and up to 13 GW which would equate to approximately 1.5 – 3.5 Million domestic customers with solar by 2030, with all new systems installed after 2020 and subject to SEG affected.

[1] See appendix for examples of typical household appliances and the instantaneous power balancing service being provided by the electricity system to the domestic consumer within a settlement period.
[2] https://www.gov.uk/government/statistics/solar-photovoltaics-deployment
[3] https://www.nationalgrideso.com/future-energy/future-energy-scenarios

These domestic customers are using the electricity system in a new way to balance their instantaneous power generation and demand, routinely Importing and Exporting within the same Settlement Period. This is a new and distinct type of usage of the electricity system that existing Settlement arrangements, with their separate treatment of Import and Export volumes, are poorly optimised to accommodate.

2. Existing settlement arrangements create a number of problems:

Problems from the existing arrangements include:

- Risk of consumer detriment from the complex interactions between generation, consumption and metering and Settlement arrangements.

- High round-trip costs for balancing instantaneous consumption and generation within a Settlement Period.

- Challenging requirements for consumers to match instantaneous consumption and generation in order to self-consume their own generation. Sensitivity of customer bills to the particular type of appliance or load and its patterns of instantaneous power consumption (rather than the energy consumed). This has the effect of a form of demand charge; loads with high and peaky instantaneous power consumption patterns are more likely to result in instantaneous imports from the System resulting in greater operating cost to the consumer, as compared to loads with the same total energy consumption but with a lower, steady pattern of instantaneous power consumption (see Appendix 1).

3. Impacts competitiveness of electricity system and its ability to integrate distributed generation:

Current arrangements will likely be detrimental to the long-term competitiveness of the GB electricity system as a provider of electricity services to domestic customers. Until recently, consumers with solar generation had few alternatives to using the electricity system to balance their instantaneous consumption and generation. With the falling cost of Battery Energy Storage Systems (BESS) consumers can now purchase home BESS or hybrid solar inverters that incorporate BESS which provide an alternative means of delivering real-time balancing of instantaneous power surpluses or shortfalls from behind the Meter.

Without a mechanism to separately measure, accurately price and charge for the balancing service the electricity system is providing to domestic customers, the electricity system's share of this service will likely be lower than would otherwise be, because domestic customers may opt to install home battery storage once this is the lower cost alternative. This would reduce the electricity system's utilisation and metered volumes of energy over which electricity system costs can be apportioned.

This risks an inefficient economic outcome overall with domestic customers making investment decisions based on incorrect price signals from the electricity system arising from deficiencies in the Settlement and charging processes for the services it is providing. This may result in domestic customers potentially investing in and using BESS to balance their instantaneous generation and demand, when the use of the electricity system could be a more efficient alternative if the charges applied more accurately reflected the actual costs.

Potential Solution(s)

The following is intended to sketch an outline of how this problem might be approached:

- A customer’s Import and Export volumes should be determined from the volumes of energy generated and consumed across the whole Settlement Period, irrespective of the instant in time when generation and consumption occur and irrespective of the instantaneous coincidence of generation and consumption. This could be achieved by netting the metered Import and Export volumes.

- The customer’s use of the system for balancing their instantaneous generation and consumption should be measured using a new type of volume; the volume of netted energy within a Settlement

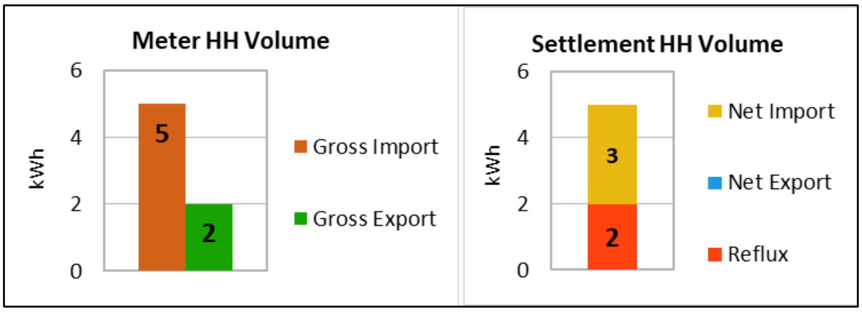
Period and an appropriate charging arrangement applied to that volume to cover the costs it imposes on a system and its share of Use of System costs.

1. Definition of a new type of volume within the settlements process and settlements terminology:

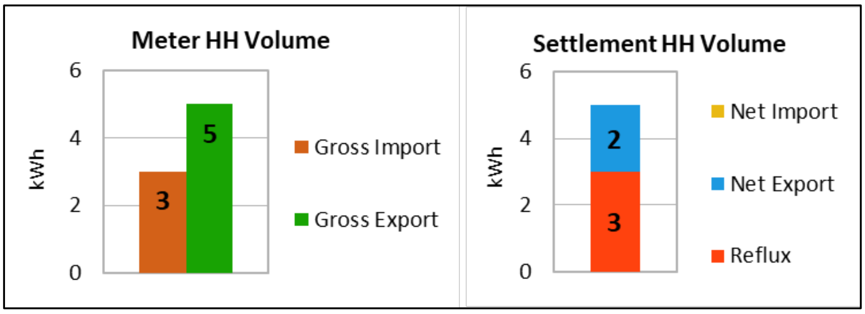
Define a new type of volume within the Settlements process as a volume which represents the 'netted' energy which has been exchanged across a Boundary Point Meter within a Settlement Period. For the purposes of this Issue Proposal, this will be referred to as the 'Reflux' volume meaning *to flow backwards or return.*

For clarity, these volumes are being determined as shown below (import volume shown without negative signing):

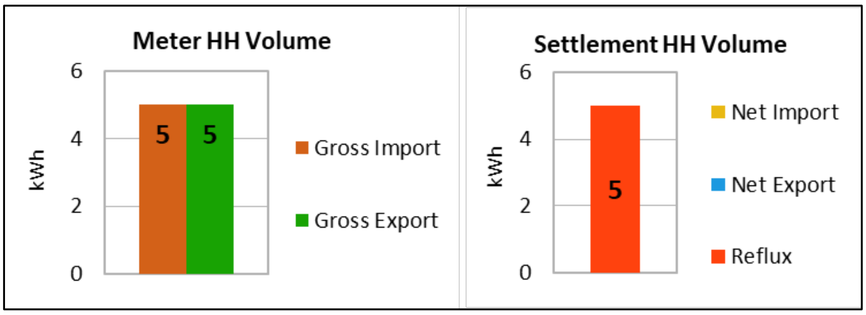
Imports greater than Exports:



Imports less than Exports:



Imports equal Exports:



Example metering and settlement volumes:

(kWh)	...	**SP16** 07:30 – 08:00	**SP17** 08:00 – 08:30	**SP18** 08:30 – 09:00	**SP19** 09:00 – 09:30	**SP20** 09:30 – 10:00	**SP21** 10:00 – 10:30	**SP22** 10:30 – 11:00	**SP23** 11:00 – 11:30	...
Gross Import		-1	-2	-1	-2	-2	-0.5	-1	0	

Gross Export		0	1.5	2	2	2.5	2	2	2	
Net Import		-1	-0.5	0	0	0	0	0	0	
Net Export		0	0	1	0	0.5	1.5	1	2	
Reflux		0	1.5	1	2	2	0.5	1	0	

2. Determine the costs that Reflux volumes impose on the electricity system:

With a defined term and mechanism for determining the Reflux volume, analyse key parameters of the costs to the electricity system of handling the Reflux volumes and the various system charges (Distribution Use of System, Balancing Services Use of System, Transmission Network Use of System, etc), levies and credits which should or should not apply.

A key topic would be the application of Import levies and the extent to which they would and should apply to Reflux volumes. Confirming these details would have the advantage of making these costs clearly visible and subject to scrutiny on whether current 'round trip' costs are a reasonable and a fair reflection of the actual costs these volumes impose on the electricity system and the charges applied to these volumes.

3. Identify a suitable charging regime for Reflux volumes:

Based on the outcome of the cost determination consider whether, for domestic customers with on-site generation, there is a case for changing their Settlement from the use of metered Gross Import and Gross Export volumes, to using either Net Import and Net Export, or to using a three volume approach using Net Import, Net Export and Reflux volume.

The simplest outcome is if the costs of Reflux volumes are determined to be negligible, or if no charge is necessary or economical to apply, in which case this would amount to simple netting of the Import and Export volumes.

This seems potentially unlikely because those Reflux volumes use the electricity system and the distribution network and benefit from the system's real-time balancing and overall service. As a result some system charges would be expected to apply to these volumes. Further, the service of balancing a customer's instantaneous power generation and consumption within a Settlement Period has value to the customer so that service should carry some system costs although it seems likely those costs would be significantly lower than existing arrangements.

Proposer's Details

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Date: *10th June 2023*

Appendix:

To illustrate the instantaneous power flows occurring at the settlement meter within a settlement period and the balancing service being provided by the electricity system to the domestic customer, simplified examples are provided for typical domestic loads.

All of the examples are designed such that:

- Constant solar generation power of 1kW, so generation of +0.5kWh within the settlement period.
- Loads chosen so that total energy consumption within the settlement per is always -0.5kWh.
- Behind-the-meter energy consumption and energy generation within the settlement period are equal, having net volume of zero.
- Due to the different instantaneous power demand patterns of the loads, the volume of energy exchanged across the boundary settlement meter is different in every example.

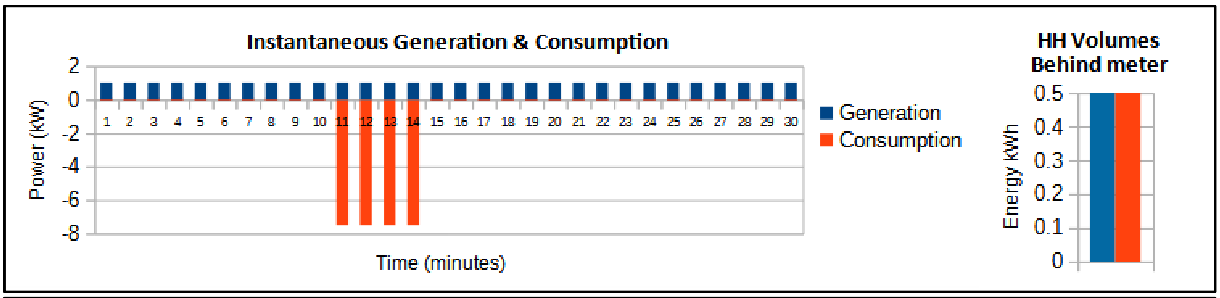
These examples are intended to illustrate the back-and-forth flow of energy between the household and the electricity system during the settlement period, accruing import and export volumes at the boundary meter but where across the settlement period as a whole there is no net import or export to the electricity system. They illustrate how different household appliances and their respective instantaneous power consumption shapes result in different degrees of usage of the electricity system to balance the instantaneous power flows, producing significant variation in the volumes of imported and exported energy as measured by the settlement meter on the boundary and hence volumes assigned to the import and export suppliers and the final cost to the consumer.

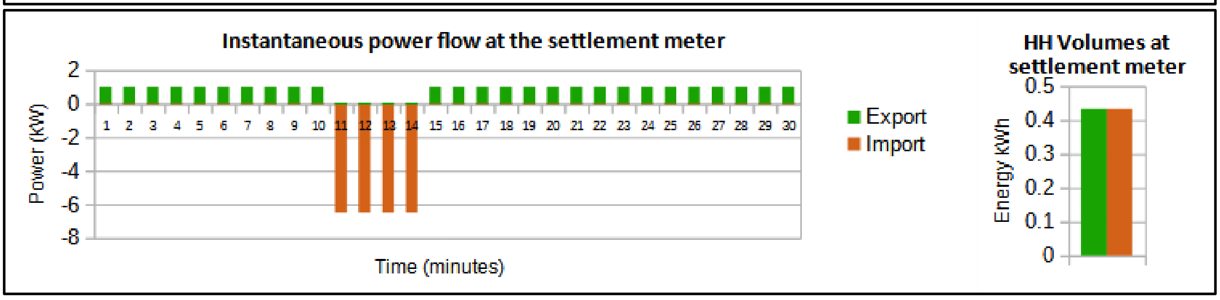
In practice, generation and consumption will not be perfectly balanced, generation will vary, there will be other household loads operating so in most settlement periods there will be an overall net import or net export, but in addition to that that net import or export, there will be the volumes exchanged with the energy system and going into settlement and against which the customer is billed which represent no net transfer of energy.

Electric Shower:

A 7.5kW electric shower in use for 4 minutes.

Generation:	+1kW x (30min / 60min)	+0.5kWh	**Export:**	+1kW x (26min / 60 min)	+0.433 kWh
Consumption:	-7.5kW x (4min / 60min)	-0.5 kWh	**Import:**	(-7.5kW + 1kW) x (4min / 60 min)	-0.433 kWh

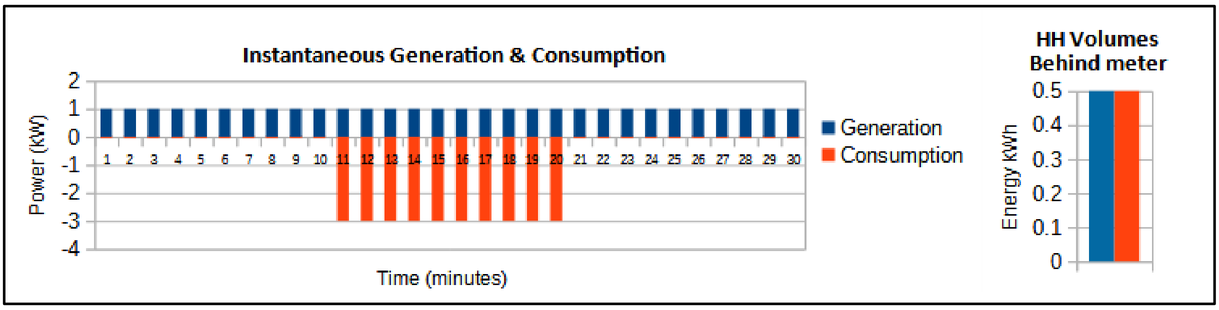


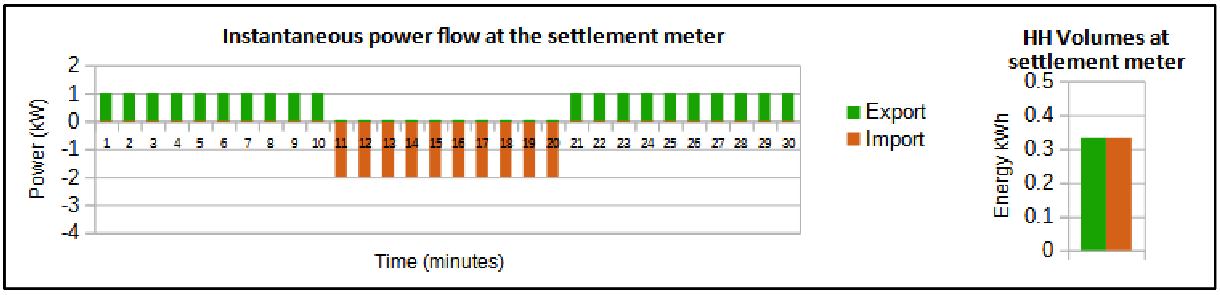


Immersion Water Heater:

Hot water cylinder immersion heater rated at 3kW, switched on by the thermostat, on for 10 minutes.

Generation:	+1kW x (30min / 60min)	+0.5 kWh	**Export:**	+1kW x (20min / 60 min)	+0.333 kWh
Consumption:	-3kW x (10min / 60min)	-0.5 kWh	**Import:**	(-3kW + 1kW) x (10min / 60 min)	-0.333 kWh

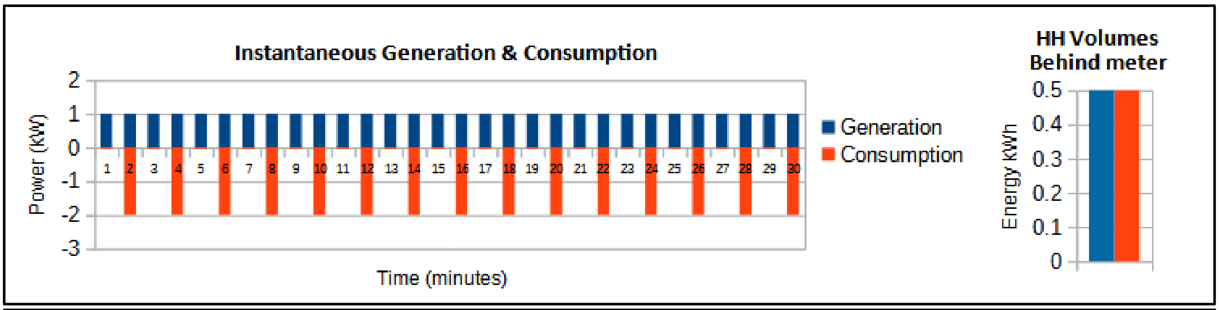


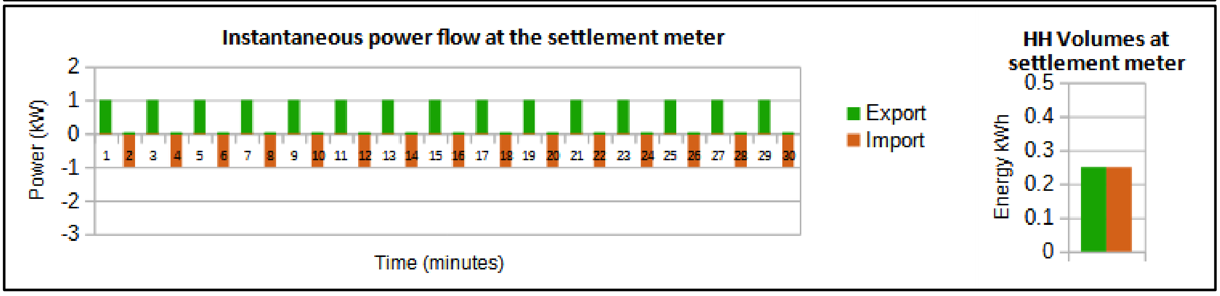


Electric Cooker:

Electric cooker using simple time-proportional control to manage heat output of an oven, switching a 2kW heating element on for 1 minute, off for 1 minute, repeating, to control the average heat output at 1kW. This type of control is relatively common in heating appliances such as cooker hobs or other temperature or power regulated heating devices. Switching times are often faster than this, with heating loads switching on and off every several seconds. In this example, the switching of the 2kW heating element causes power flow across the settlement meter to reverse every minute.

Generation:	+1kW x (30min / 60min)	+0.5 kWh	**Export:**	+1kW x (15min / 60 min)	+0.25 kWh
Consumption:	-2kW x (15min / 60min)	-0.5 kWh	**Import:**	(-2kW + 1kW) x (15min / 60 min)	-0.25 kWh

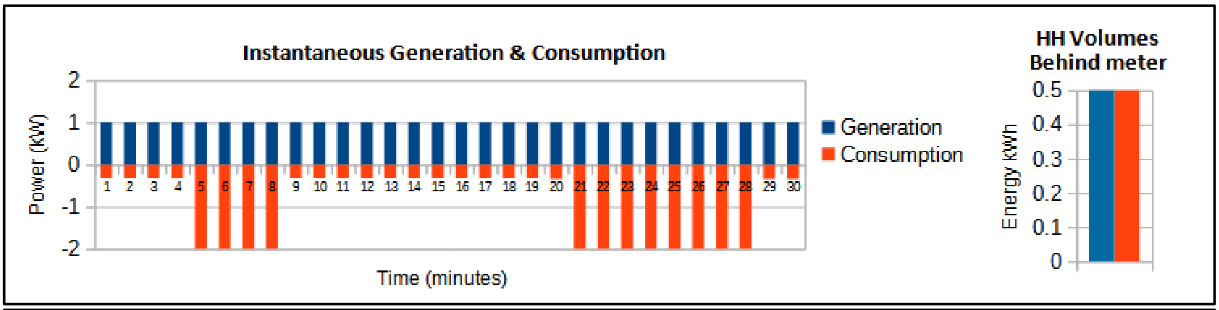


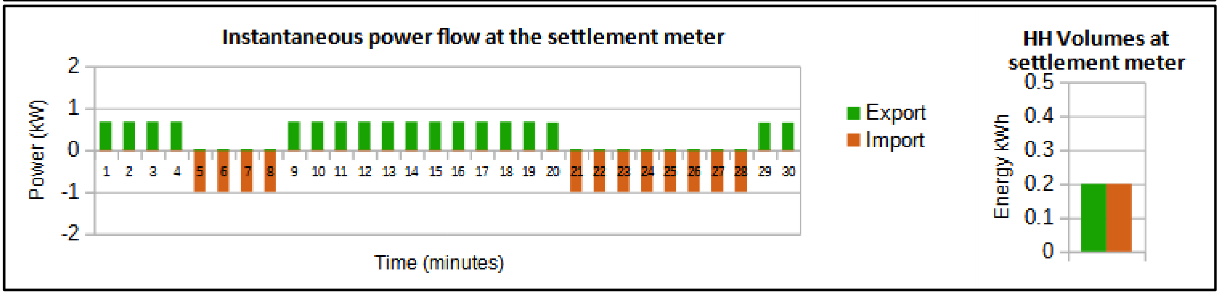


Dishwasher:

A simplified example of a wet-appliance, having a steady low power demand associated with operation of water circulation pumps, with periods of higher power demand during water heating cycles. In this example, a dishwasher on a rapid wash, with a steady power demand of -0.33kW, rising to -2kW for 12 minutes during the periods of water heating.

Generation:	+1kW x (30min / 60min)	+0.5 kWh	**Export:**	(+1kW-0.33kW) x (18min / 60min)	+0.2 kWh
Consumption:	-2kW x (12min / 60min)+ -0.33kW x (18min / 60min)	-0.5 kWh	**Import:**	(-2kW + 1kW) x (12min / 60 min)	-0.2 kWh

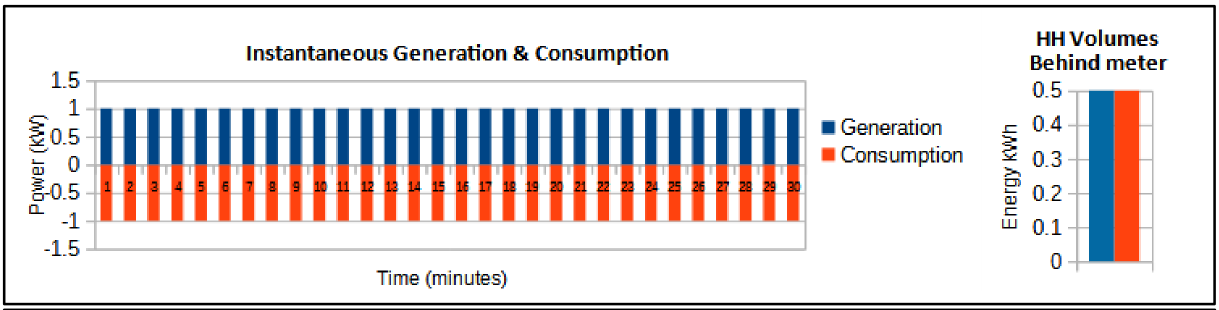


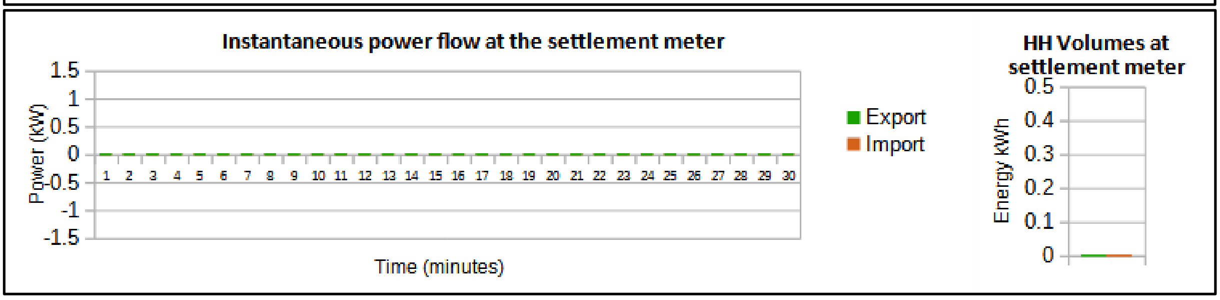


Electric fire:

A simple 1kW electric fire, with a constant 1kW power demand, the instantaneous power demand being equal to the instantaneous generation at all times, resulting in zero energy flow across the boundary meter.

Generation:	+1kW x (30min / 60min)	+0.5 kWh	**Export:**	(+1kW – 1kW) x (30min / 60 min)	+0 kWh
Consumption:	-1kW x (30min / 60min)	-0.5 kWh	**Import:**	(+1kW – 1kW) x (30min / 60 min)	-0 kWh





	Behind-the-meter volumes:		**Boundary Settlement Meter Volumes:**		**Self-consumption:**
Example Load	**Generation**	**Consumption**	**Export**	**Import**	**Instantaneous**
Electric Shower	+0.5 kWh	-0.5 kWh	+0.433 kWh	-0.433 kWh	0.067 kWh
Immersion Water Heater	+0.5 kWh	-0.5 kWh	+0.333 kWh	-0.333 kWh	0.167 kWh
Electric Cooker	+0.5 kWh	-0.5 kWh	+0.25 kWh	-0.25 kWh	0.25 kWh
Dishwasher	+0.5 kWh	-0.5 kWh	+0.2 kWh	-0.2 kWh	0.3 kWh
Electric Fire	+0.5 kWh	-0.5 kWh	0 kWh	0 kWh	0.5 kWh