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Research Innovation Action

CleAnweb Gamified Energy Disaggregation

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Deployment Instructions

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Executive Summary

ChArGED solution is based on a complex architecture and combination of technologies, protocols and sub-systems. This document provides a summarized, simplified overview of the steps required to deploy the ChArGED solution and each specific component.

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1 Introduction

ChArGED aims to develop a framework that will leverage IoT enabled, low-cost devices (NFC or BLE Beacons) to improve energy disaggregation mechanisms that provide energy use and -consequently- waste at the device, area and at end user levels. This energy waste will be targeted by a gamified application that will feed personalized real time recommendations to each individual end user and will thus implement a novel social innovation process based on human incentive factors and will help users to understand the environmental implications of their actions and adopt a greener, more active and responsible behaviour.

This document provides the deployment guidelines for the CHARGED system and each specific component.

2 Hardware components / sensors

2.1 Architecture overview

This figure presents an overview of the architecture to support the understanding of the system topology outlined below. Each of the components are analysed separately.

The system architecture consists of four main groups of functional blocks:

- The Data/Core Back-end group is responsible for providing an environment in which data, assets and users are stored and managed. The Back-end components provide the software infrastructure on which the ChArGED application is developed. That group of components is application agnostic, however it is tuned towards the needs of ChArGED project.
- The Gateway group is responsible for integration of energy use and environmental data to the Back-end system, to determine variations over the energy context within the building.
- The Analytics Back-end component is responsible for delivering insights that will enable the ChArGED application to deliver custom and targeted feedback and incentives to the end-users.
- The Gamification group is responsible for processing field data and insights created from such data and make decisions as to the evolution of the game for each user, i.e. what the next step is towards more energy savings. That group also delivers the mobile app the end-users interact with which acts as an interface between the user and the charged system updating the user with the current game state and also provides information to the system about the users' behaviour towards the energy saving goals set.

The architecture also includes an external system that is utilized to provide a solar power microgeneration forecast based on weather predictions for the specific location. It serves to maximize the building energy savings, increase end user awareness as well as to enable the use of the mobile app to maximize the solar-based electricity consumption during production, avoiding the need for energy storage

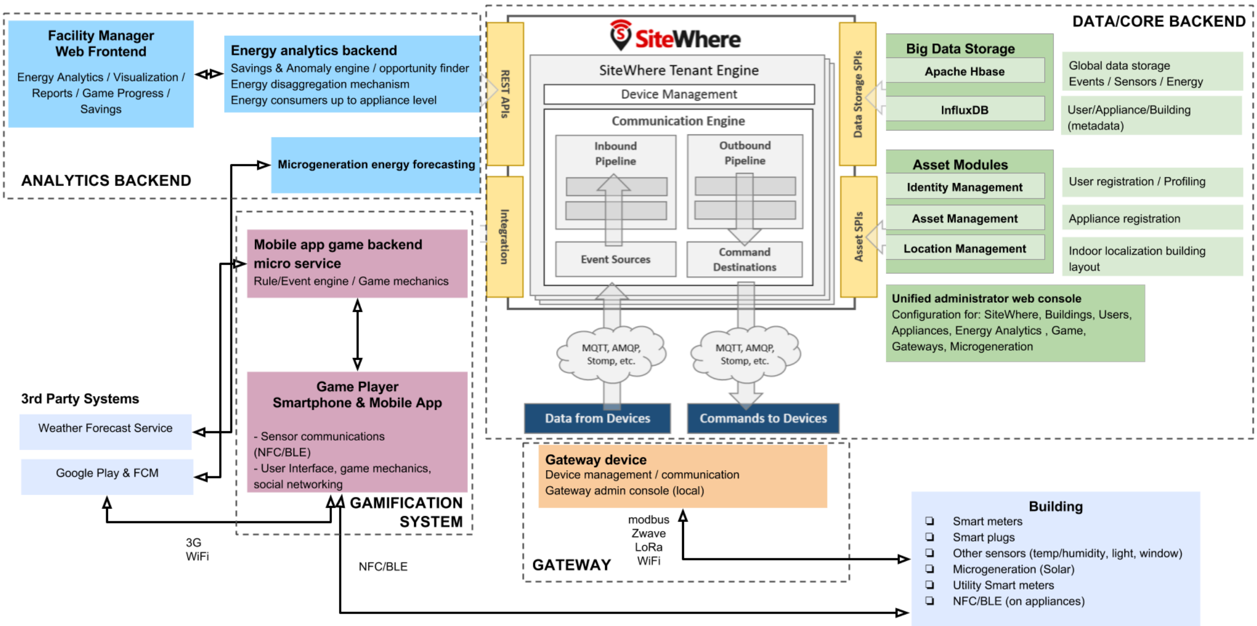


Figure 1 ChArGED architectural overview

2.2 SiteWhere Server

The Data/Core Back-end system components and infrastructure were implemented in SiteWhere[1]. The available functionalities are the following:

- Each new asset or entity (i.e. a sensing device, an appliance, a specific location area, a person) is assigned a unique id and can be autonomously monitored via external software. Specifically, a model for standard types of generated event data is provided for each device (which includes measurements, alerts issued and location updated by the device). The logged events are stored in massively scalable time series datastores (InfluxDB).
- Devices (appliances such as printers, air conditioners, a PCs etc) can be assigned to / associated with other entities. A can be associated with a person, a location or another sensor device of our infrastructure thus giving us the ability to establish ownership room/location metadata and establish relationships with device.
- Devices can be grouped together according to a common role they fulfil, something that enhances efficiency by simplifying the way the devices can be retrieved by other backend processing services.
- Every top-level entity is modelled as a tenant and can have a completely different configuration and structure without affecting other tenants. This can be used for modelling infrastructures that are unrelated to each other such as different locations, different buildings, pilot users etc on the same server.

Registration of new or existing devices (building appliances and sensors)

SiteWhere devices can be created manually with API calls, or they can be self-registered. In later case, the device provides a unique hardware ID and a specification token to the system which in turns creates a new device record that can start accepting events. SiteWhere assumes that each device will have a unique ID in the system so it can be independently addressed. The specification token passed at startup indicates the type of hardware the device uses and references a device specification that already exists in the system. Devices send a registration event when they boot or connect to the network and SiteWhere either creates a new device record or finds an existing one.

Registration of electrical circuits (monitored by submeters and smart plugs)

Power measurements retrieved by the ChArGED gateway from the deployed submeters and smart plugs need to be uploaded to SiteWhere and be associated to devices. The type of device depends on the entity being monitored, for example, if a multi-channel submeter monitors 18 single-phase circuits, 18 'Circuit' devices must be registered in SiteWhere to hold the measurements. If a smart plug is used to monitor a specific computer, power measurements will be associated to a 'PC' device.

[1] Sitewhere: The Open Platform for the Internet of Things, https://www.sitewhere.org/

Figure 1: List of Sitewhere Device entities that can be created to hold measurements by the metering and IoT infrastructure

Physical electrical circuits feed wall plugs, lighting fixtures and air conditioning equipment within locations of a building, as such 'Circuit' devices registered in SiteWhere must reflect that setup. 'Circuit' devices are therefore assigned to 'Location' assets, see example below.

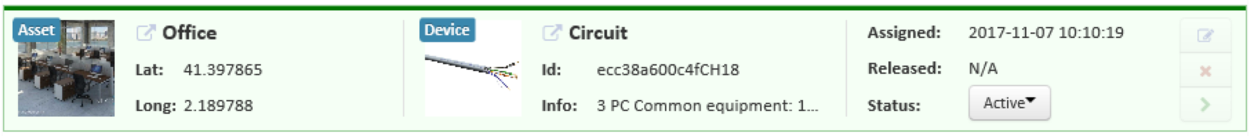


Figure 2: Illustration of the assignment of SiteWhere Circuit devices to building Locations

The ID used when registering the 'Circuit' device should be globally unique. This is the ID that the gateway will use when pushing data to SiteWhere.

The naming convention chosen when using the 18-channel meter from Accuenergy is to set the ID as <metermacaddress>CHx, with <metermacaddress> to be replaced by the mac address of the meter in lowercase without space, and x the channel number. For example, the screenshot above shows that the ID is ecc38a600c4fCH18.

For Zwave smart plugs, the ID is the device specification token automatically assigned by SiteWhere when device is registered.

Figure 3: Illustration of Zwave smart plug device registration within SiteWhere

2.2.1 Asset Modules

Assets represent objects in the physical world – people, places, and things. Device specification assets are used to describe the hardware information/configuration for a type of device. Rather than hard-coding a schema for assets in the system, SPIs will be defined for general asset types, allowing asset modules to be plugged in to provide asset definitions. This allows existing identity management systems to be used in providing a list of available person assets. It also allows product catalog systems to be used in defining available hardware assets. The concept of asset categories which reside in the datastore will also be provided.

2.2.2 Object Model

A comprehensive object model captures the relationships between all of the various concepts in tracking device data. The diagram below shows some of the core objects in the model and their relationships:

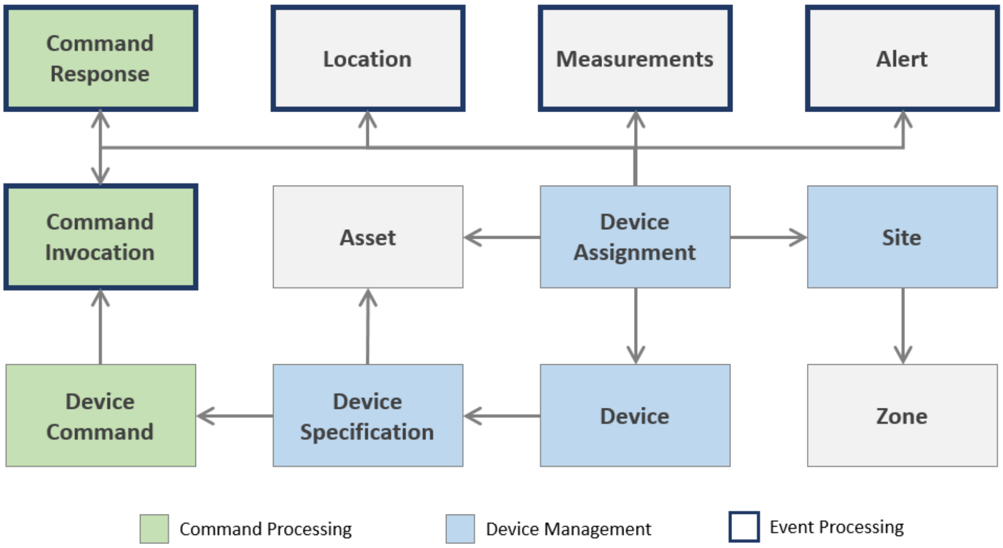


Figure 4: ChArGED entities overview

2.2.3 Sites - Buildings

Sites are used to organize devices that are cross-related so that their events can be looked at from a grouped perspective. The primary use case for sites is in location-aware devices. A site provides a containing entity to which a map can be assigned so that location data can be viewed in the context of that map.

2.2.4 Zones - Rooms

Another important feature for location-aware applications is the concept of zones that carry special meanings. For instance, in a building, there are areas where certain devices can be used (e.g. photocopy machines) so when a person enters a this zone the energy consumed by those devices can be associated with this person.

2.2.5 Device - Appliance Specifications

Specifications are used to capture characteristics of a given hardware configuration. A device specification contains a reference to a hardware asset which provides the basic information about the hardware including name, description, image URL, etc.

2.2.6 Devices - Appliances

Devices are a representation of connected physical hardware that conforms to an assigned device specification. Each device will be addressable by a unique hardware ID that identifies it uniquely in the system. A new device can register itself in the system by providing a hardware id and device specification token.

2.2.7 Device - Appliance Groups

Device groups allow multiple related devices or subgroups to be organized into logical units. The groups can then be used for performing operations collectively rather than performing them on a per-device basis. Each group can have zero or more roles assigned to it, allowing arbitrary groupings based on application needs. Devices may belong to multiple groups and may be assigned zero or more roles within the group

2.2.8 Device Assignments

Events are not logged directly against devices, since a given device may serve in a number of contexts. For instance, a visitor badge may be assigned to a new person every day interacting with appliances and their energy. Rather than intermingle event data from all the people a badge has been assigned to, the concept of a device assignment allows events to be associated with the asset they relate to. A device assignment is an association between a device, a site, and (optionally) a related asset. Some assignments do not specify an asset and are referred to as unassociated.

2.2.9 Device - Appliance Events

Device events are the data generated by connected devices interacting with system with types of events such as **Measurements.** Measurement events send measured values from a device to the core system. Measurements are name/value pairs that capture information gathered by the device. For instance, a smart plug sensing device will send measurements for total energy and instant power.

2.3 Solar Microgeneration Inverter

Figure 5: ChArGED solar inverter - Kaco blueplanet 5.0 TL3

ChArGED system takes advantage of a solar energy generation net metering solution in one of the pilot sites, maximizing the building energy savings, increasing end user awareness and also maximizing the solar-based green electricity consumption during production, avoiding the need of energy storage.

The solar solution is based on the solar inverter (Kaco blueplanet 5.0 TL3) which provides rich energy metadata information via both modbus TCP communication and web based / dsv export capability, enabling the detailed monitoring of the generated electricity assisting production forecasting mechanisms.

Solar inverter is connected via the gateway and its gateway middleware IoT integration software mBS SH. Through the device abstraction of the mBS SH the data are prepared for the ChArGED backend and sent via MQTT to the ChArGED core platform and distributed to all other system components.

2.4 Multi-channel smart meters

Public buildings are supplied with three-phase power to be able to deliver power to both single-phase end-loads e.g. lighting and wall-plug appliances, and three-phase end-loads e.g. air conditioning.

Three-phase meters are generally used in non-residential settings to measure electrical energy consumption of an entire distribution board using three current transformers (CTs), each clamped to a different phase of the supply line.

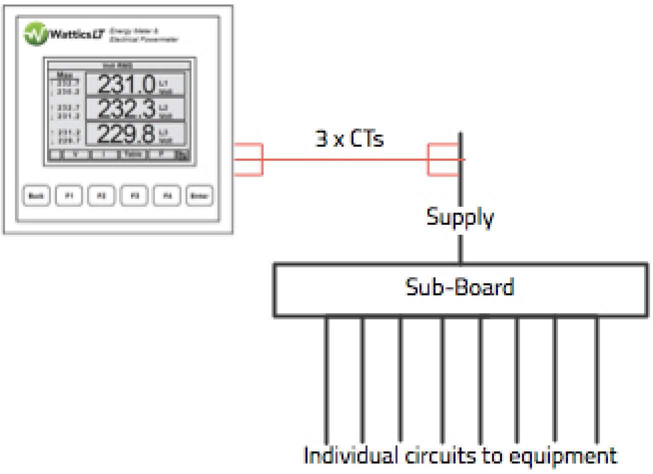


Figure 6: Illustration of a three-phase meter monitoring the electrical supply of a distribution board with three current transformers clamped to the three phases of the supply line

Because small loads are widespread in public buildings, e.g. lighting units and plugs for computers and office equipment, electrical panels are generally made of many single-phase circuit breakers, feeding lighting fixtures and plugs individually.

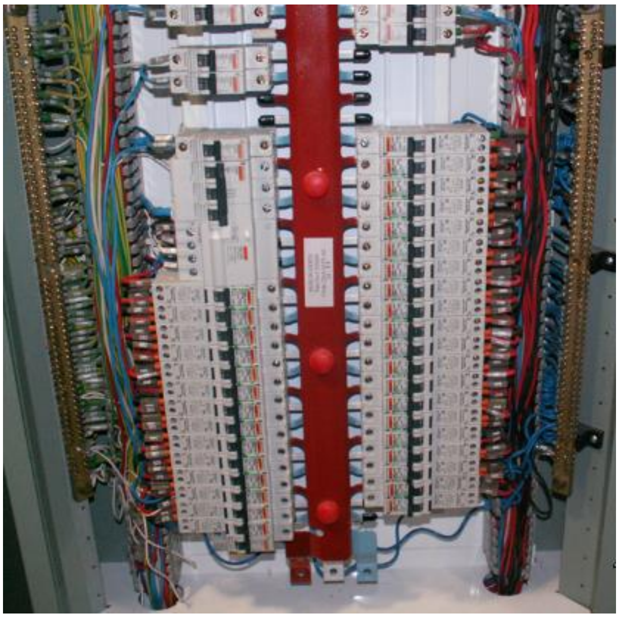


Figure 7: Example of office building electrical panel, showing many single-phase circuits feeding equipment on the floor plan

In that setup, all circuits must be monitored individually with dedicated CTs in order to measure energy use and demand variation for equipment fed by such circuits. Multi-channel meters offer a cost-effective solution for monitoring multiple circuits, by allowing many CTs to be connected to a single meter.

Figure 8: Photo of the Accuenergy AcuREV2000 18-channel meter used for monitoring single-phase circuits in public building environments

Accuenergy offers with their AcuREV 2000 series a 18-circuit power metering system that monitors kilowatt-hour (kWh), power, energy, demand, peak demand and time-of-use (TOU) in high-density applications. It is best used for tenant submetering, commercial facilities and branch circuit monitoring where multiple circuits require monitoring.

2.5 Gateway and zwave controller

2.6 zwave smart plugs

Zwave smart plugs are installed into any power outlet and that outlet is instantly smarter that captures the energy that is used through this outlet. This information is sent through the zwave network to Sitewhere in the CHARGED system.

Figure 9: Zwave plugs

2.7 zwave window contact sensors

Door window sensors serve a simple purpose: they capture events related to a door or a window opening or closing. When connected to Z-Wave network this information can is captured in Sitewhere.

Figure 10: Zwave window sensors

2.8 zwave 4in1 sensors

This is a 4in1 sensor which monitors motion, temperature, humidity, and light level and transmits those to the Sitewhere.

Figure 11: zwave 4in1 sensors

2.9 NFC tags

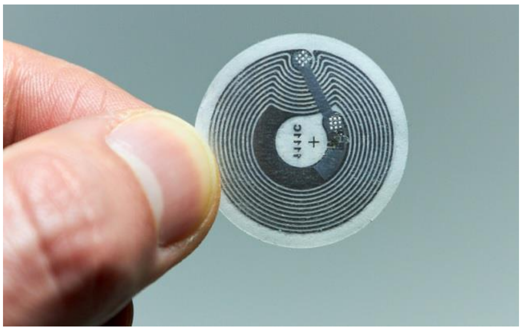


Figure 12: NFC sensor tag

NFC sensors **NTAG213** at 38mm diameter provide the lowest-cost while keeping a very fast reading speed and long range. ChArGED mobile app is designed to capture the NFC events and trigger the verification of a user action, through the energy disaggregation mechanism, ie. if a user swaps the phone over a turned-on computer, means that he turns it off, and this is confirmed by the analysis of the energy comsumption measurement in the energy disaggregation engine.

2.10 BLE beacons

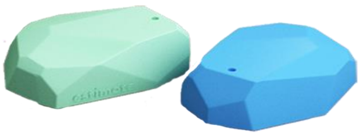


Figure 13: BLE Beacons

Estimote Proximity Beacons are used for indoor localization. Battery life time is 2 years by default. The estimote mobile app can be used to "lock" the write ability of the BLEs.

2.11 Smartphone

Figure 14: Samsung K8 Smartphone-CHARGED recommended

Recommended and tested smartphone for Charged application is the Samsung Galaxy K8 2017 are used due to their low cost, Android 7, and BLE/NFC capability.

3 Installation Guide

3.1 Overview of deployment steps – high-level

The following presents an overview of the steps that are needed to install and deploy the CHARGED components, which are further detailed in the following chapters:

1. Setup RPi gateway as the ChArGED gateway and configure according to Prosyst's 10 page instructions (is included from chapter 3.2 following)
    a. Linux admin or developer skills required
2. Open Prosyst web console (e.g http://192.168.1.25:81/system/console/hdm)
    a. go to zwave controller (node1) change mode to "adding"
        i. Repeat as needed
3. Power up new every zwave device, one by one
    a. Triple click to pair (or follow manufacturer's instructions)
    b. Add a paper sticker with node id given to device by controller (visible in /system/console/hdm)
    c. Repeat with all plugs, 4in1, window contacts
4. Place new plug/4in1/contact in appropriate location, keep note on a document* for later update in SiteWhere
5. Program each NFC sticker using ChArGED app in admin mode (or NFC TOOLs app)
    a. Make a node of the UUID of each NFC on a document*
6. Place every sticker on appropriate location and keep notes on a document* for updating SiteWhere later
7. Identify BLEs and record their Mac Addresses on a document, as they will be registered later to SiteWhere. The identification of the BLEs can be done by using ChArGED app in admin mode (or Estimote app) identify each BLE.
    a. Take all BLEs away a few meters from the smartphone, keep one close and read it's Mac Address(Estimote app requires BLE owner to be logged in)
    b. ALTERNATIVE approach: scan the internal NFC of the beacon and via the estimote cloud find out the BLE Mac Address
8. Place every BLE on appropriate location and make a node on document* for later update in SiteWhere
    a. Select locations that maximize variation of distance between users / and differentiate
9. Install multi-channel meters at electrical panels to monitor circuits feeding plug-load, lighting and air conditioning equipment of the floor plan
    a. Registered electrician will need to be contracted to conduct the installation wrk
    b. Labeling work will be required before installation to identify which circuits to monitor for the needs of the ChArGED application

*keeping notes of Mac Addresses on document makes deployment slower, cumbersome and prone to errors. These actions should be fully automated and be part of the game process even if the end-users will not perform the deployment.

3.2 Gateway preparation

3.2.1 Required Hardware

1. Raspberry Pi 3 Model B / SD card / PSU / Enclosure.
2. USB ZWave controller attached to the one of Raspberry Pi USB ports (serial controller http://www.vesternet.com/z-wave-me-razberry-2-pi-gpio-daughter-card-gen5 is supported also).
3. ZWave Smart Plug with Power Metering http://www.vesternet.com/z-wave-fibaro-wall-plug-schuko-gen5 http://www.vesternet.com/z-wave-aeon-labs-smart-switch-6-gen5, optional.
4. ZWave Window contact sensor http://www.vesternet.com/z-wave-fibaro-universal-door-window-sensor, optional.
5. ZWave Motion 4-In-1 sensor http://www.vesternet.com/z-wave-fibaro-motion-sensor-gen5, optional.
6. Modbus Power meter AcuRev 2000, optional.
7. Modbus Solar Inverter Powador 12.0, optional

3.2.2 Required Software

1. ProSyst runtime installation file
2. Oracle ejre on Raspberry
3. cdc_acm module on RaspBerry. Check if available with 'lsmod | grep cdc_acm'. If the ZWave USB stick is attached 'ls /dev' should show one /dev/ttyACMx (e.g dev/ttyACM0) device.
4. SSH Client program like Putty https://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html
5. SFTP client like WinSCP for Windows https://winscp.net/eng/download.php]

3.3. Installation

1. The installation archive is called com.prosyst.clients.funded.charged.image.runtime-x.x.x.tar.gz, where x.x.x is the installation version.
2. The archive has to be copied into the Raspberry PI to a temporary folder, for example '/home/pi/mbs-install'. For file transfer from Windows machine it could be used WinSCP.
3. Login in Raspberry PI with your client application (Putty) and extract the archive from the respective directory with the command:

```
tar xvzf com.prosyst.clients.funded.charged.image.runtime-1.0.2.tar.gz
```

4. After extracting, you have to make the script 'install.sh' executable and to start it:

```
chmod +x install.sh
sudo ./install.sh

output:
Executing pre-install script...
Executing pre-install script... done!
MAC Address: b827eb45fe87
Serial Number: 00000000fc45fe87
```

```
Configuring stack with:
Provisioning SPID: b827eb45fe87
PRM Manager URL: ssltcp://35.157.248.28:2443

insserv: warning: script 'mbssh.setenv.sh' missing LSB tags and overrides
Executing pre-install script...

Note: When using serial USB devices ensure that usb-to-serial modules are available for this kernel

The stack will start automatically after reboot
Manual start via:
 /etc/init.d/mBSSH.sh start

Installation complete.

Executing post-install script...
Executing post-install script... done!
```

5. Warning may be printed like:

   ```
   insserv: warning: script 'mbssh.setenv.sh' missing LSB tags and overrides
   ```

   The installation will produce following folders:

   ```
   /mbs - program location
   /mbs-data - data location for storage and logs
   ```

   It is using 'update-rc.d' command with 'defaults' parameter for auto starting runtime after reboot of the system.

   Manual start or stop is possible via several ways:

   ```
   'sudo /etc/init.d/mBSSH.sh start' or 'sudo /etc/init.d/mBSSH.sh stop'
   or/and
   'sudo /mbs/mbsa/bin/mbsa_start.sh' and 'sudo /mbs/mbsa/bin/mbsa_stop.sh'
   ```

6. Configure the system as shown in section 4.
   Modify the SiteWhere siteToken as descibed in section 4.1. (If not modified the devices will be attached to ProSyst site.) Define Modbus devices as shown in section 4.2)
7. Reboot the system via:

   ```
   sudo reboot
   ```

8. The runtime will be started automatically after reboot.

3.4 Pairing of Zwave devices

1. Read the ZWave device vendor instructions first.
2. Set the ZWave Controller in Adding mode:
   a. open http://<RPi-ip>:<port>/system/console/hdm (port should be 80, 8080 or 81)
   b. click on icon 'i' (right) of the ZWave Controller
   c. find Device Class ZWaveNetworkController table
   d. set **mode** to Adding
   e. click 'set property value' button (right arrow)
3. Set the end device in pairing mode via the vendor instructions. (It is popular to be quick triple click of a button)
4. After a few seconds the ZWaveNetworkController **mode** property should change to Normal and at http://<RPi-ip>:<port>/system/console/hdm should appear new end device with Online Status.

If the end device was paired to another network before it must be removed from this network first. This is ZWave protocol specifics. If this is the case set ZWaveNetworkController **mode** to Removing and follow the vendor instructions.

Figure 15: Photo of ChArGED 4-in-1 sensor deployed in ICAEN office floor plan

3.5 BLE placement

BLEs are used to capture the location of users. This is particularly necessary for offices with many rooms and areas for example DAEM where one BLE is placed per room. In the case of big spaces with a lot of desks one BLE will be placed for small groups of desks (for example every 4 desks). The local administrator will need to log in at the account of the BLE provider at google play (where there is ESTIMOTE app [https://play.google.com/store/apps/details?id=com.estimote.apps.main&hl=en)](https://play.google.com/store/apps/details?id=com.estimote.apps.main&hl=en) (the email and password used when buying the BLEs is required) and configure each BLE. In the configuration screen disable all options except for the IBeacon protocol which is the one used in CHARGED. Set the the Advertising Interval = 300ms. Also set in the same tab:

a. if the BLE covers a whole office, Transmit Power (Tx) = Weak (-20 dBm) (coverage radius~3.5m)
b. if the BLE covers a small area of around four desks close to each other in the same room, Transmit Power (Tx) = Weak (-40 dBm) (coverage radius~0.25m).

The MAC address of the BLE is then retrieved through the ChArGED app and mapped to all the users it corresponds to in a separate document which should be then sent to ED to integrate in the SiteWhere. In case of a common area (for example kitchen) or elevator the same process can be followed with Transmit Power (Tx) = Weak (-20 dBm) is the BLE is placed in a room or Transmit Power (Tx) = Weak (-40 dBm) for an elevator.

3.6 NFC placement

Each NFC should be placed according to the map on the building as follows: An NFC is placed at each desk, one for each room (towards the exit of the room) and one in the middle of each flight of stairs, one for each shared device. Each NFC is empty in the beginning. Using the ChArGED Deployment app (see below in the app section) each NFC is registered to SiteWhere with specific metadata that will be needed to identify it during the actual game. The NFC will also be automatically locked by the app so it cannot be further modified.

It is recommended to first design and number the NFCs on the map so that all of them are well representing the devices in the building. The guidelines detailed below present the process to be followed for the NFC configuration in the SiteWhere and CHARGED system.

Figure 16: Photos of NFC stickers deployed at ICAEN officefloor plan near lighting control switches

Figure 17: Photos of NFC stickers installed near computing and kitchen equipment at ICAEN office to allow users to inform the system when equipment is switch off for energy saving purposes

3.6.1 Password protect the NFC tags

Upon (or before) placing the NFC stickers use the ChArGED Deployment app (See below) to pre-configure the URI Package so that only ChArGED app will handle the tags and password protect NFC stickers to ensure no tampering is possible.

3.7 ChArGED Deployment App

3.7.1 Overview

The app can be downloaded at

https://drive.google.com/file/d/1Q1fv2TMuXSQz4YAHeZjnC9ZR9Pao93B-/view)

The app supports the deployment in order to easier gather the NFC and BLE IDs. It is capable of reading/writing NFCs, listening to BLEs and storing the data in the smartphone in two separate csv files. The files can then be emailed through the app.

The data are stored in the following format

1,<NFC_id1>,NFC

2,<NFC_id2>,NFC

3,<NFC_id3>,NFC

the same for bles.

We also need to have a map of the building where we will note the NFC/ble number 1,2,3,4 etc. Then we can then find the corresponding id from the mapping.

3.7.2 Description

1. The app has two tabs one for the NFC and one for the BLE IDs to support the configuration of NFC and BLEs respectively. In the NFC tab one can scan NFCs that have already been written by the app. On the BLE tab the app will identify and display the closest BLE to the smartphone.

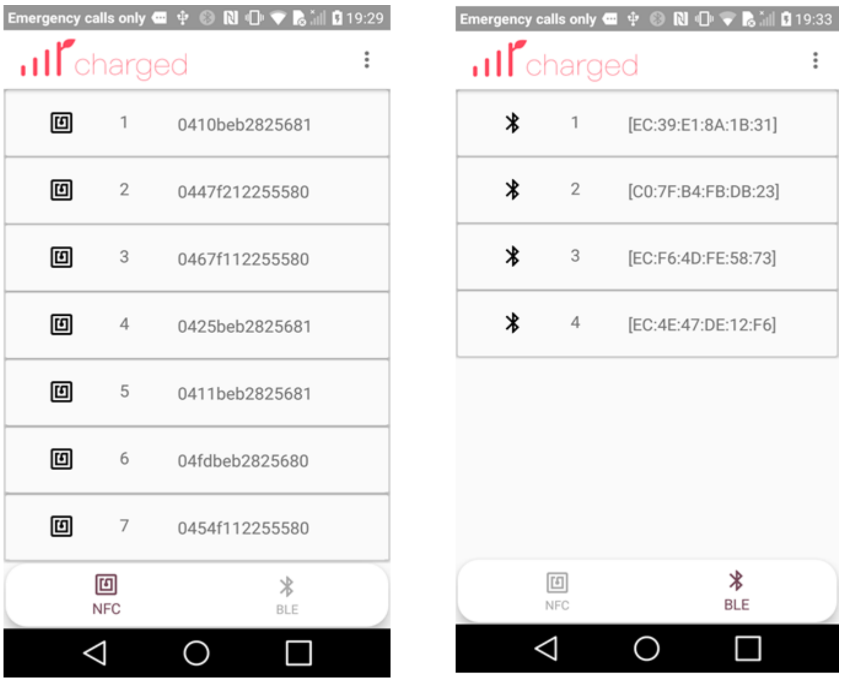


Figure 18: Screenshots of the ChArGED Deployment App showing how NFC stickers and BLE beacons deployed on the floor lan can be registered and assigned a unique ID for mapping to floor plan location and use for the game application

2. All the data are written in the Document/Charged folder in the ble-mappings.csv and NFC-mappings.csv files. The files aree visible for most devices through the File Manager but in some they may marked as private and hidden. In either case you will be able to send them via email through the app.

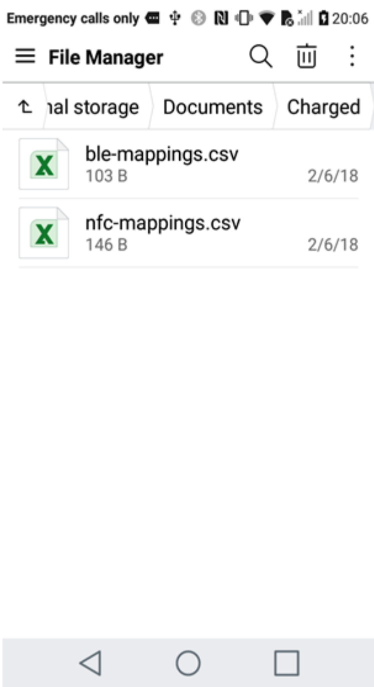


Figure 19: Screenshot showing the CSV files created by the ChArGED Deployment app to export the registered NFC stickers and BLE beacons for configuration of SiteWhere

3. From the menu select Write/Lock NFC. The app will ask you to scan, the NFC and write on it the CHARGED metadata (the given name/number you have selected from the map). The NFC will also be locked by the app so it can't be modified later.

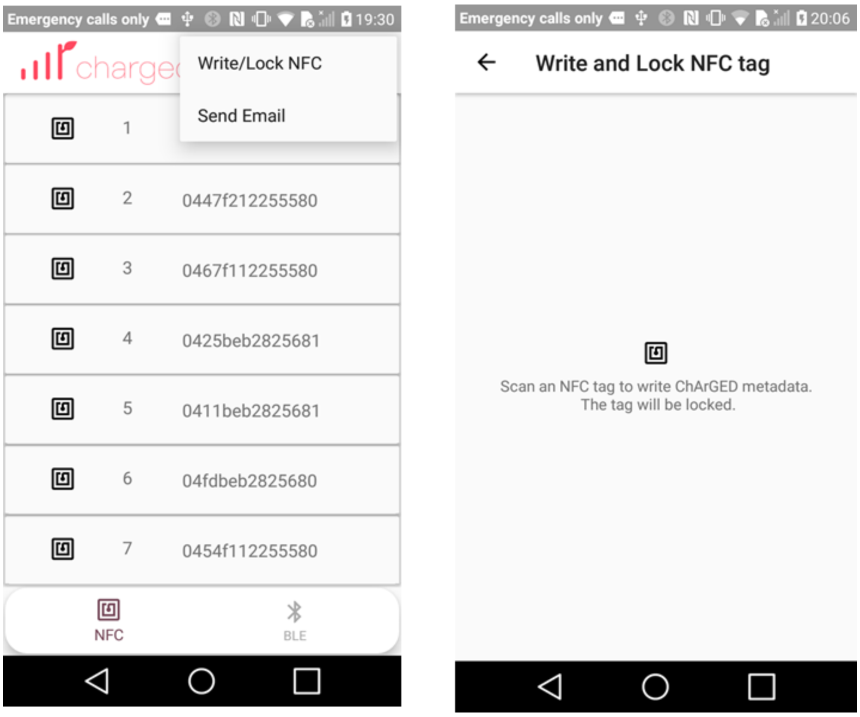


Figure 20: Registration of NFC stickers starts by writing the ChArGED metadata using the Write/Lock NFC feature

4. Each NFC and BLE ID can only be stored once. If an ID has already been stored a message with its details is provided.

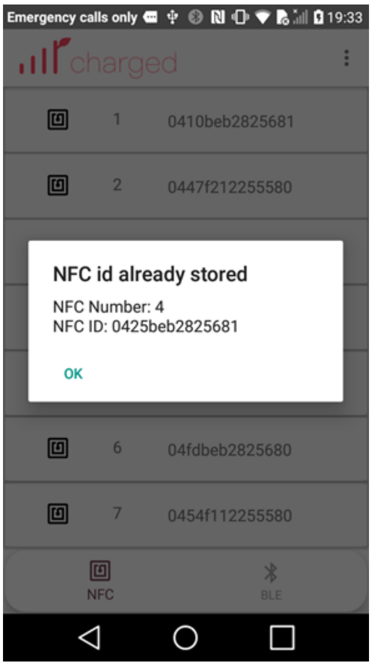


Figure 21: Screenshot showing that duplicate NFC sticker registration is prevented

5. When the deployment is finished select Send Email from the menu to send the files via email. For the beginning they can be sent to the default email preconfigured.

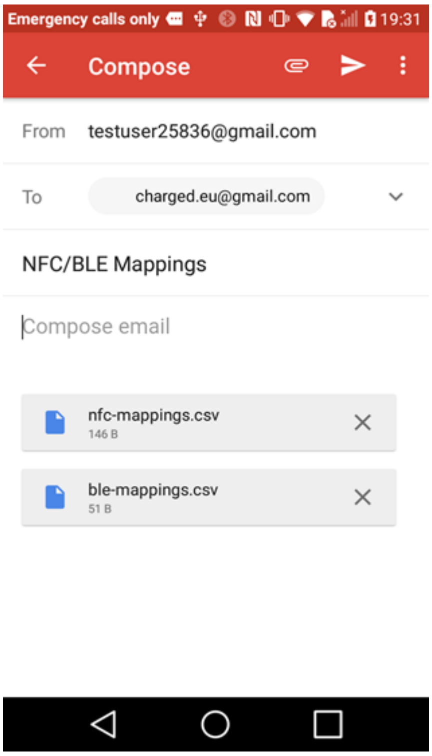


Figure 22: Screenshot showing how lookup tables for NFC stickers and BLE beacons can be exported by email

3.8 Multi-channel meter installation

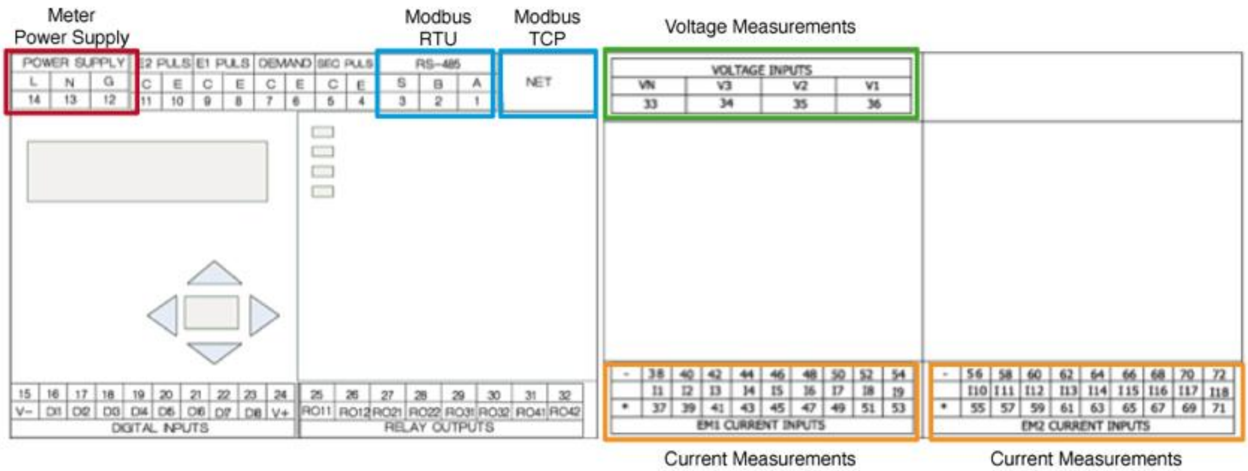


Figure 23: Schematics of the Accuenergy AcuREV 2020 18-channel meters showing the terminals used for voltage and current measurements, as well as power supply lines and Ethernet port for Modbus TCP communication with the ChArGED gateway.

Installation of the meters must take place according to the steps below, using suitable equipment and tools. Be careful to consider the following advises in this process:

- Devices must be installed without voltage applied and by qualified personnel.

- General safety regulations and nationally applicable accident prevention guidelines must be observed.
- Electrical installation must be carried out according to the relevant safety guidelines

STEP 1: Prepare the meter installation report

The meter has 18 terminal inputs (I1 to I18) to connect 18 CTs that will monitor 18 monophase circuits. Before the actual electrical wiring starts it is good practice to plan and document which CT will be used for which circuit, and how they will be connected back to the meter.

- The first step is to choose CTs with the most suitable primary rating for the circuit being monitored (e.g. a CT with a 300A primary rating for a circuit fed through a 250A circuit breaker).
- You can then label all the CT heads to facilitate deployment and not get mixed with all the CTs around (e.g. a CT head labeled S3 will be clamped to circuit called S3).
- The labeling of the CT leads is also useful to avoid getting the leads mixed when pulling them through the distribution board, and to quickly identify where to connect the CT leads back at the meter terminals (e.g. a CT lead labeled S3-15 will be clamped to the meter input terminal I15).

Important: it is necessary that the following is respected:

- All circuits fed from L1 (phase A) must be connected to inputs I1, I2, I3, I10, I11 and I12
- All circuits fed from L2 (phase B) must be connected to inputs I4, I5, I6, I13, I14 and I15
- All circuits fed from L3 (phase C) must be connected to inputs I7, I8, I9, I16, I17 and I18

For example, a single-phase lighting circuit fed from L2 can be clamped with a CT wired back to meter terminal input I4, I5, I6, I13, I14 or I15. Similarly, a three-phase circuit fed from L1, L2, L3 can be clamped with three CTs wired back to meter terminal inputs I1, I4 and I7 for example.

The table below shows how 18 monophase circuits can be wired based on their supply phase.

		CT inputs																	
		I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
Supply phase	L1	1	2	3							10	11	12						
	L2				4	5	6							13	14	15			
	L3							7	8	9							16	17	18

Figure 24: Mapping table showing how monophase circuits can be wired to the 18 terminal inputs of the Accuenergy AcuREV 2020 meter based on their supply phase.

Now that the wiring setup is pre-configure, fill in a meter installation report.

Wattics	Wattics Limited	31-33 The Triangle, Ranelagh, Dublin 6, Ireland Tel. +353 1 532 7875 e-mail: support@wattics.com
Customer Name	WATTICS LTD	
Site Name	HEAD OFFICE	
Site Address	RANELAGH, DUBLIN, IRELAND	
Electricity Supplier Name	AIRTRICITY	
Installation Date	01/03/2016	

Area Name	Circuit monitored	Meter input (I1..I18)	Phase monitored	CT size (A)	Parent circuit	Meter serial number
1st Floor	C5	I1, I4, I7	1,2,3	250		ecc21f21045
1st Floor	C1	I2, I5, I8	1,2,3	250	C5	ecc21f21045
1st Floor	C2	I3, I6, I9	1,2,3	250	C5	ecc21f21045
1st Floor	C3	I10, I13, I16	1,2,3	250	C5	ecc21f21045
1st Floor	C4	I11, I14, I17	1,2,3	250	C5	ecc21f21045

A WattREV-6 Meter Installation Report template is available for download [HERE].

STEP 2: Provide voltage references to the meter

Wire the meter voltage reference inputs to a Type C 6AMP 3P breaker to provide voltage reference for power calculation. Make sure the breaker is in the OFF position.

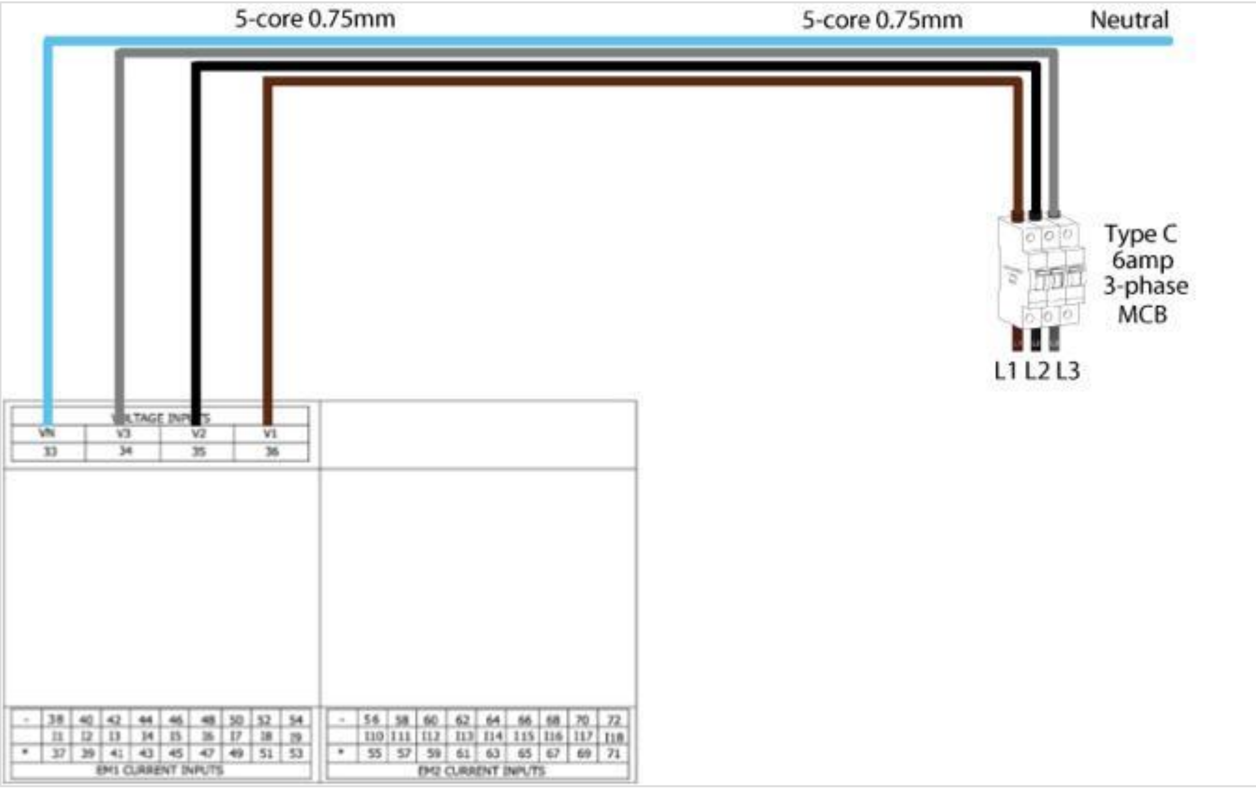
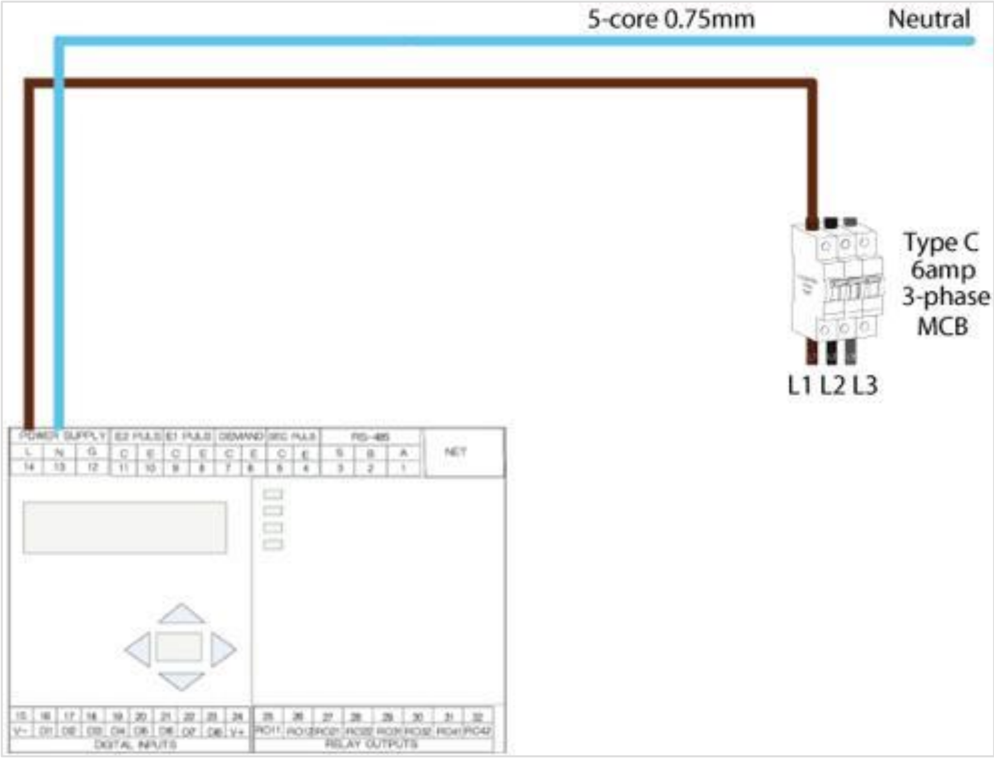


Figure 25: Illustration showing the way voltage reference should be provided to the Accuenergy AcuREV 2020 meter via a 3P Type C breaker

Note: the breaker must be fed from the same transformer as the circuits being monitored to ensure that the correct voltage references are applied for power calculations.

STEP 3: Supply power to the meter

Wire the meter L and N voltage supply inputs to the breaker L1 and N output terminals or short the V1 and VN reference voltage lines to the L and N voltage supply lines as shown in the figure below.



or

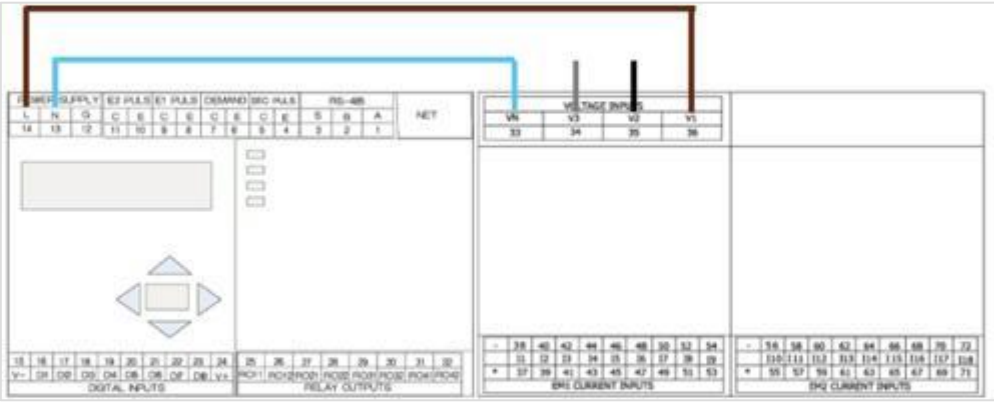


Figure 26: Illustration showing how the power supply line of the Accuenergy AcuREV 2020 meter can be wired, either from a circuit breaker or by creating a loop from the voltage reference lines

Figure 27: Photo showing the wiring of the voltage reference and power supply lines of the AccuenergyAcuREV 2020 meter deployed at the ICAEN pilot site

STEP 4: Prepare the meter for Rogowski coil or CT connections

Carefully attach the meter to din rail pre-mounted within the meter compartment or enclosure. This process can also be done once all the Rogowski Coils and CTs are wired in the case wiring is made easier with the meter outside the meter compartment.

Figure 28: Electrician adding an enclosure to locate the meter outside of the electrical panel compartment

Now remove the two current measurements terminal blocks from the meter (see below cover and terminal). The left terminal block has 9 inputs (I1 to I9, left to right), and the right terminal block has 9 inputs (I10 to I18, left to right).

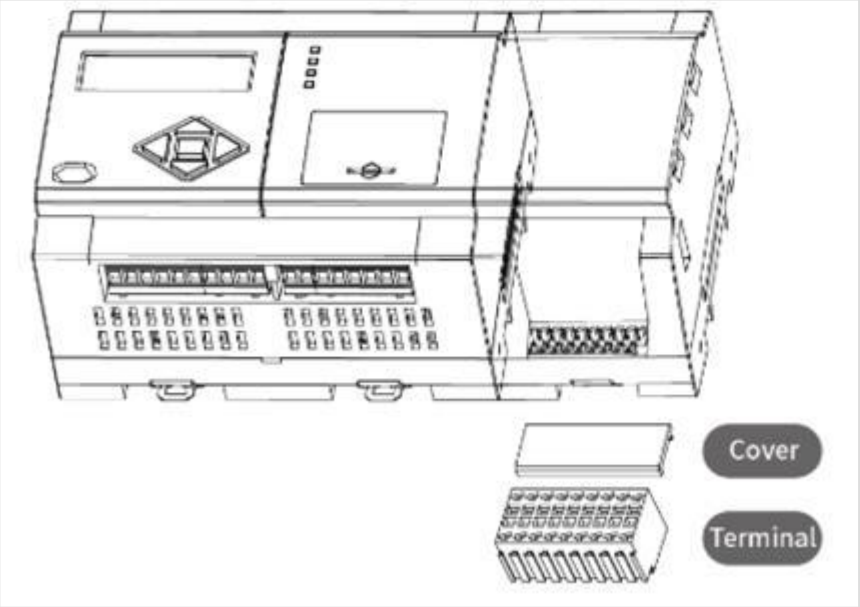
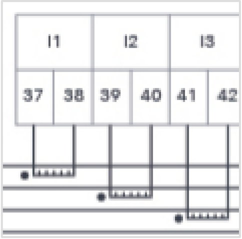


Figure 29: Diagram showing how the current terminal block can be removed for easy wiring of the CT end cables to the AcCuenergy AcuREV 2020 meter.

STEP 5: Deploy the CTs

The next step is to clamp the CTs to the electrical circuits and wire them back to the meter current measurements terminal blocks. This procedure must be conducted as follows with extreme precautions:

- Power the circuit down temporarily (working with live circuits may be possible if all safety precautions are taken and under agreement from the customer)
- Position the CT next to the circuit to be clamped, but do not clamp them until the CT lead has been wired to the meter to avoid major safety risks (this is valid for CTs with 1A or 5A output, however 333 mV CTs do not require shorting blocks or prior connection to the meter because they have a burden resistor built into the CT that limits the output voltage to a safe 333mV under all conditions.)
- Pull the CT lead back to the meter via pre-mounted cable glands, trunken and other covers.
- Wire the two CT lead wires to the correct meter terminal input. Take the positive (white or red) lead wire and insert it into the lower circular opening of the current measurement terminal (e.g. I1 37, I2 39, etc). A tiny screwdriver should be inserted into the upper square opening and pressed down to allow the lead wire to be inserted properly.



White/Red wire = + (positive)

Black/Brown wire = – (negative)

- Repeat for all CTs you plan on deploying and place the terminal block back into the meter module when the wiring is complete.
- Clamp the CT heads to the circuit paying attention to the labels to ensure that you clamp the correct circuit and to the direction in which you clamp the circuits.

  The red/white leads will be your positive wire and the black will be the negative wire. Also, on the CTs there is an arrow which dictates the polarity. The arrow should be facing the load. If you have the arrow towards the load and the red/white lead and black lead in the correct positive and negative terminals of the meter's CT input channels then the kWh will accumulate correctly.

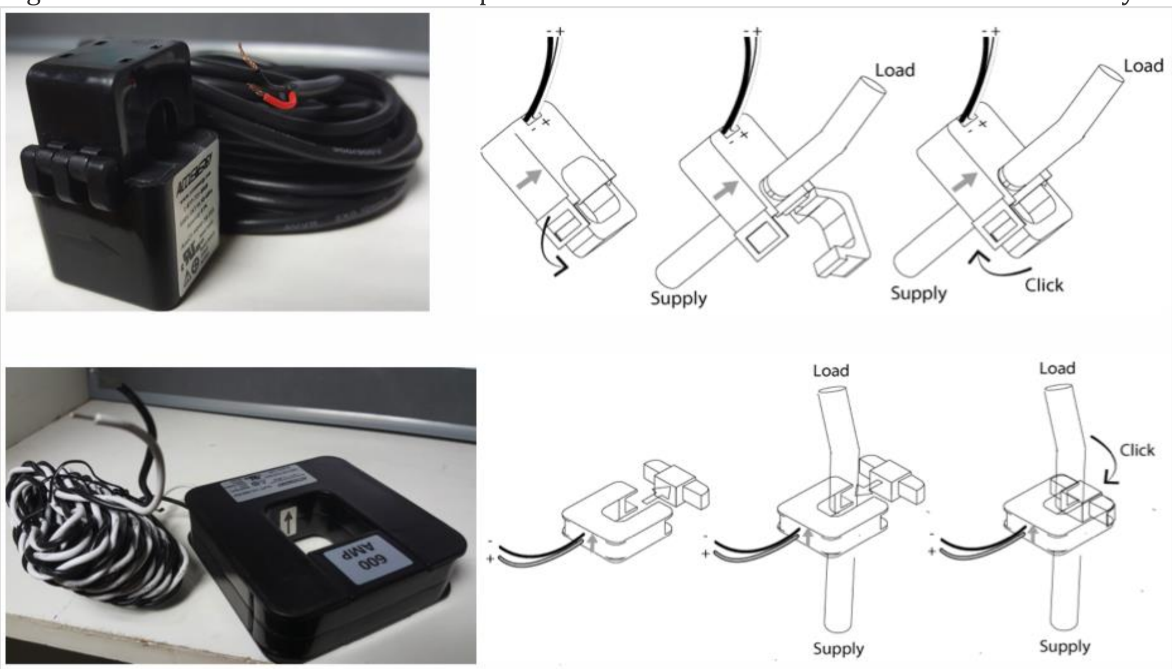


Figure 30: Illustration showing how different types of current transformers should be clamped to an electrical circuit

- Power the circuits back up after all Rogowski Coils or CTs have been deployed
- At this stage, the meter is wired to the circuit breaker and all CTs are clamped and wired back to the meter.

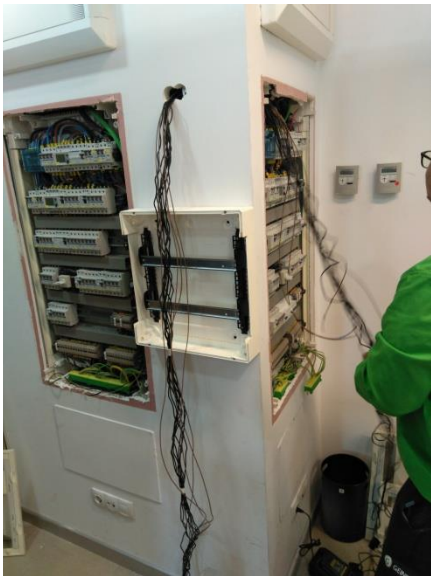


Figure 31: Photo showing the current transformers end cables being pulled from the electrical panel to the meter enclosure where they will be wired to the meter current terminal block

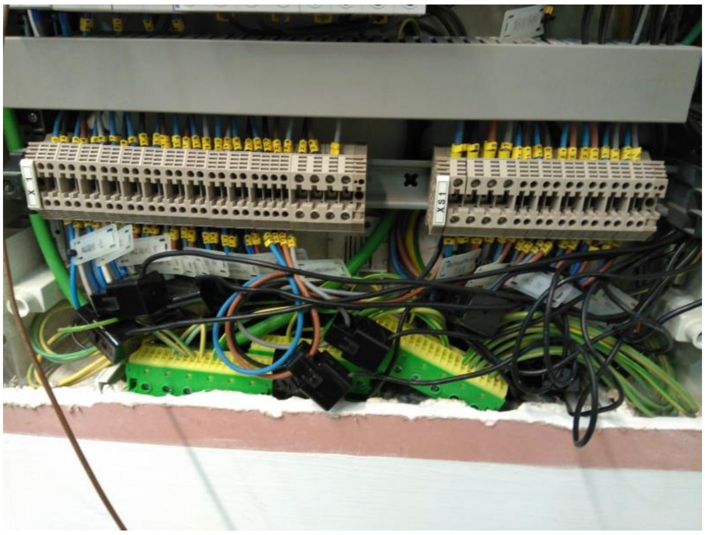


Figure 32: Photo showing the current transformers heads clamped to the electrical circuits

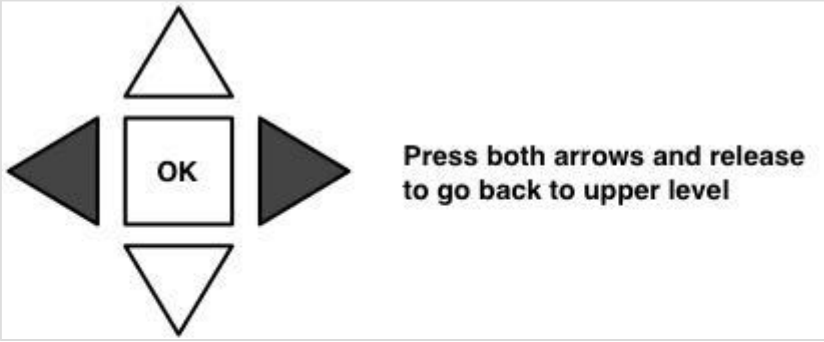
STEP 5: Switch the breaker on to power up the meter

Switch on the breaker to supply power to the new meter. The meter will power up and will after a few seconds emit a red LED light (L1).

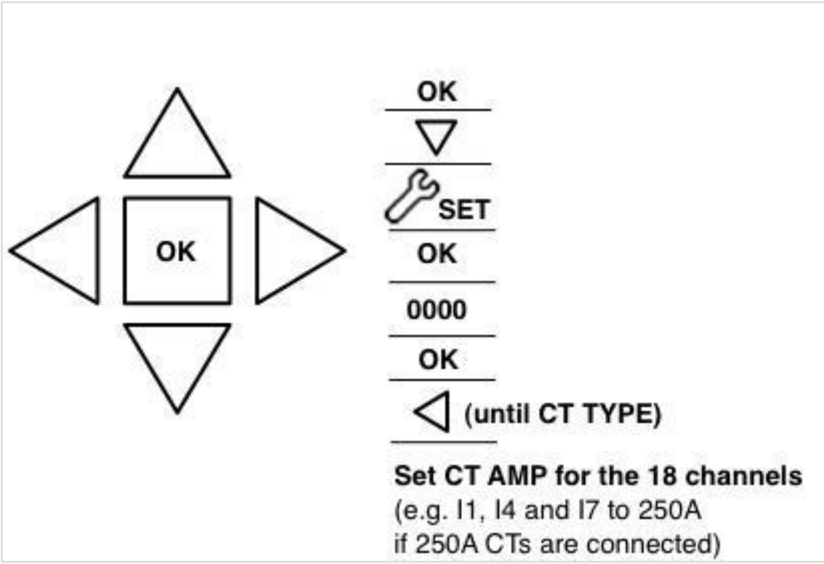
STEP 6: Configure the meter

The meter has a total of 18 current measurements terminal inputs called channels (I1 to I18), that are connected to up 18 CTs used to monitor 18 single-phase circuits or a mix of single-phase and three-phase circuits. You must now configure your meter terminal inputs to the correct primary rating size of the CTs wired to them (e.g. if a 300A CT is wired to the channel I1 then I1 must be configured to 300A). This procedure is executed via the meter display:

- Press the meter display's left and right arrows together to go back to top menu



- Select the Settings menu, enter the password 0000, then press the cursor left until you reach the CT TYPE submenu. There you need to set the correct AMPERE size for each terminal input, one by one. For example, if you used a WattRCT16-2500 Rogowski Coil to monitor the three phases of your circuit 5, you need to set a value of 2500 for the meter channels I11, I14 and I17.



- Press the OK button to register each AMPERE value, and move on to the next channel until you are done. At the end verify that all channels are configured properly in case you didn't save correctly, this is extremely important as you will otherwise get incorrect readings.

STEP 7: Provide network access to your meter

- Connect an Internet cat5 cable to the meter's Ethernet port.
- Press the meter display's left and right arrows together to go back to top menu
- Select the NET menu, enter the password 0000 and press OK. Then press OK to enter the DHCP Setting configuration.
- You must either enable DHCP (so the meter gets discovered and is assigned an IP address automatically), or change its IP address to be within the correct IP range. To

enable DHCP, set the DHCP Setting tab to AUTO and press OK to save it. If you want to assign a static IP address, follow the steps below:

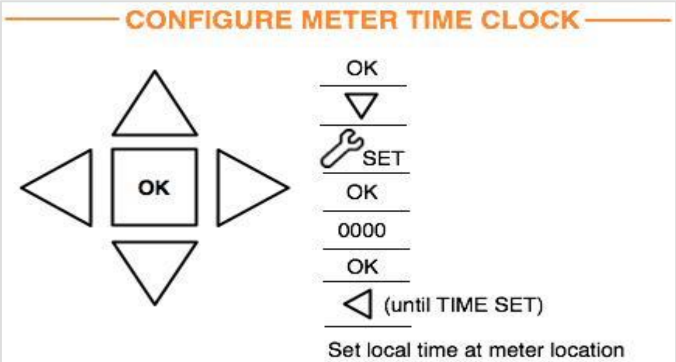
- Press the right cursor until you reach the DHCP Setting tab, press OK and set to MANU. Press OK to save.
- Press the right cursor until you reach the IP ADDRESS tab and register the IP address to be used.
- Press the right cursor until you reach the SUBNET MASK tab and register the IP address to be used.
- Press the right cursor until you reach the GATEWAY IP ADDRESS tab and register the IP address to be used.

- The meter network interface must be rebooted to enable the new network settings. Turn the meter off via its MCB circuit breaker for 5 seconds and turn it back on.
- Press the meter display's left and right arrows together to go back to top menu
- Select the NET menu, enter the password 0000 and press OK. Press the right cursor until you reach the IP ADDRESS configuration.
- Write down the IP address of your meter, you may need it to access the meter's webserver configuration page.

STEP 8: Configure the meter time clock

Set the meter time clock to your local time via the meter display menu:

- Press the meter display's left and right arrows together to go back to top menu
- Select SETTINGS at the main screen and press 'OK'.
- Enter the meter password (default is 0000) and press 'OK'.
- Press the left cursor until you reach the TIME SET tab.
- Set the local time and press 'OK'



3.9 SiteWhere entities

After the deployment we need to model all the entities of our system. An entity is created inside sitewhere in the following way.

We navigate to the devices tab and there click create new device. We give the device id a unique identifier and a specification (which denotes the type of the device for example pc,NFC,ble,hvac etc).

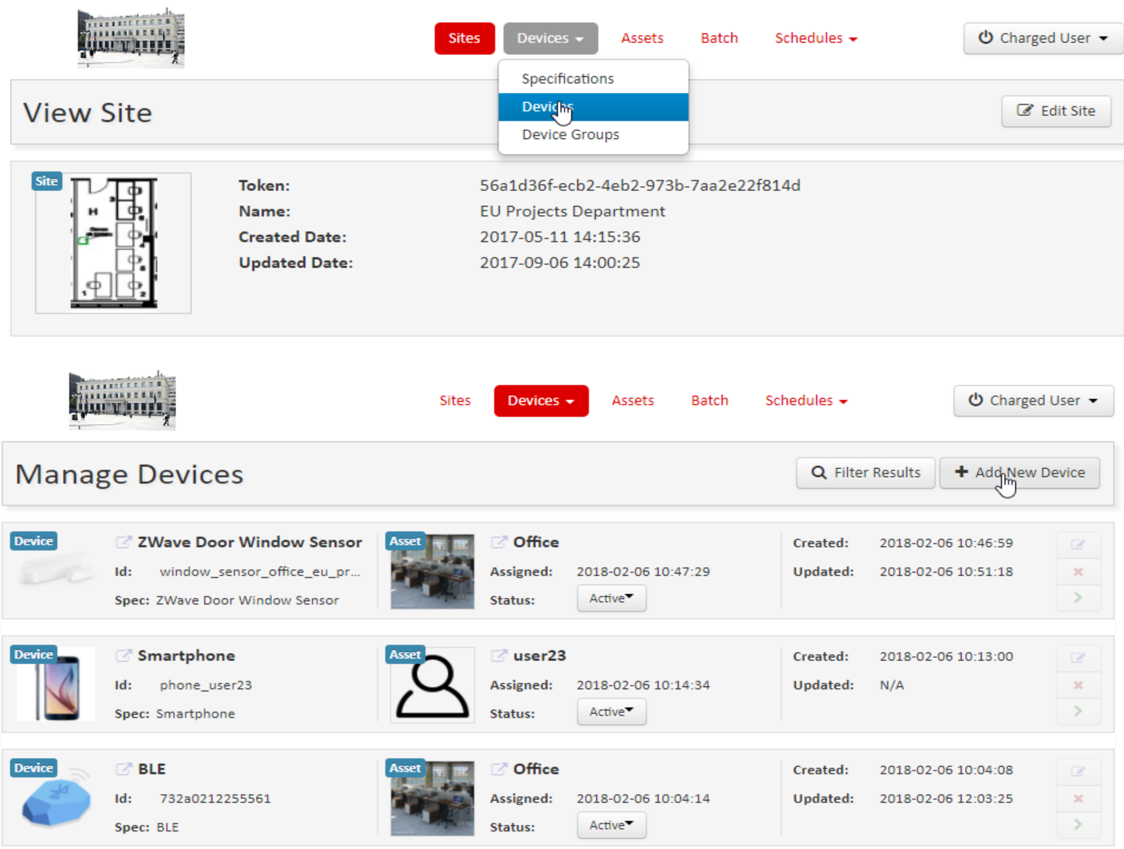


Figure 33: Manage devices screen in SiteWhere

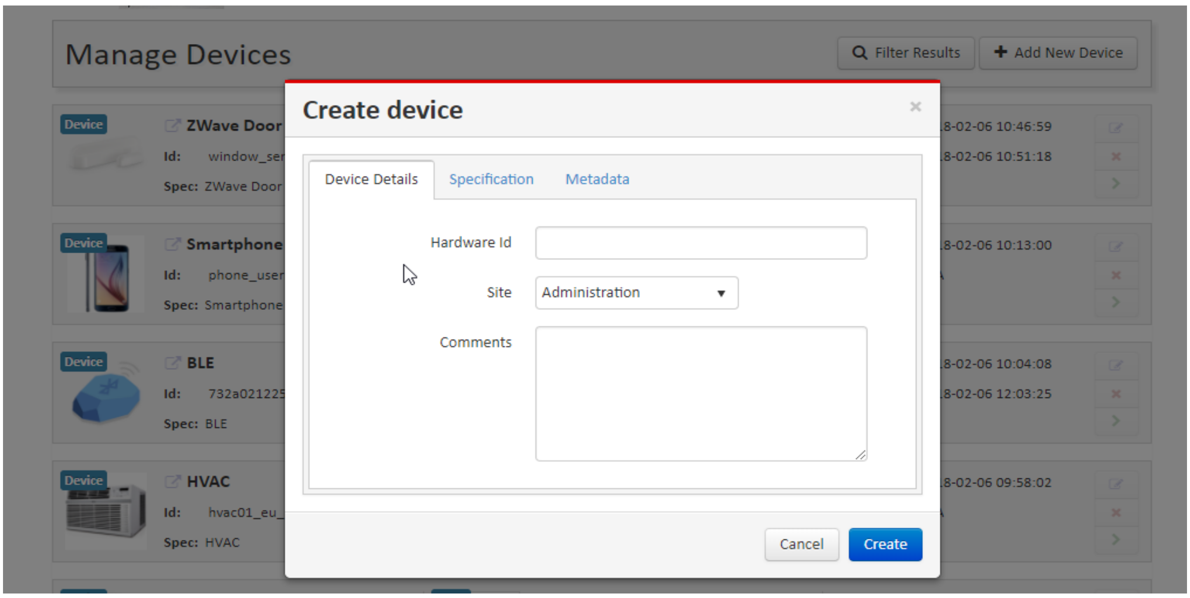


Figure 34: Create Devices screen in SiteWhere

When the device is created we also associate it with another asset. For example an NFC can be associated with a pc if it is on a desk, with a room if it is placed close to a light switch, with a common place like stairs etc.

Figure 35: Configured devices in SiteWhere

4 Maintenance and support guide

4.1 Zwave Battery monitoring

Battery liefetime should last the pilot time. If battery powered device isn't sending any updates anymore, battery should be changed. No battery watchdog was implemented during the project.

4.2 Zwave battery types to replace

Battery Types of Window Contacts and 4in1 Sensors an be checked in the vendors manual.

4.3 Troubleshooting

4.3.1 Multi-channel meter

KW values shown are wrong

It is very likely that the CTs have not been wired correctly at the meter. Check that the CTs of the circuit with incorrect kWh values are connected meter inputs with the correct phase lines, i.e. CTs connected to first three current inputs of the meter (I37/I38, I39/I40 and I41/42) should monitor the L1 phase of three different three-phase circuits, etc). When using 333mV CTs, white wires will go into 37 and black to 38, white to 39 and black to 40 etc. When using Rogowski Coils RCTs, white wires will go into 37 and brown to 38, white to 39 and brown to 40 etc.

kW values are negative

The voltage and current may not be aligned. Make sure your voltage references V1. V2 and V3 come from L1, L2 and L3, and that CTs wired to L1, L2 and L3 current inputs are clamped to L1, L2 and L3 circuits.

The CTs may be mounted in the reverse direction or the CT leads are wired to the meter in the opposite direction. Make sure the P1/S1/H side of the CT faces the utility/source and that the black and white leads of the CTs are connected in the way specified by the CT manufacturer.

Power Factor values are very low

This indicates an incorrect wiring, either of the voltage lines or the CTs. Check wiring of the meter's V1, V2, V3 and VN from circuit breaker, and wiring of the circuit breaker from main supply, to ensure no cables were switched or fed from incorrect voltage line which would lead to incorrect voltage references. Check that the CTs of the circuit with incorrect kWh values are connected meter inputs with the correct phase lines, i.e. CTs connected to first three current inputs of the meter (I37/I38, I39/I40 and I41/42) should monitor the L1 phase of three different three-phase circuits, etc).

Both kW and kWh values are wrong

Check that the electrical system is the same as the one specified in the project specifications. It may be that the system is in reality different (e.g. Delta instead of Wye), meaning that the meter must be reconfigured for the correct system.

Voltage values are wrong

Check wiring of the meter's V1, V2, V3 and VN from circuit breaker, and wiring of the circuit breaker from main supply, to ensure no cables were switched or fed from incorrect voltage line which would lead to incorrect voltage references.

AMP values are wrong

Verify that the size of the CTs used is equal to the CT rating mentioned in the project spec and pre-configured in the meter (see CT TYPE setting).

If not the same, CT ratio must be modified via the meter's web interface using laptop, see AcuREV user manual.

AMP values are zero

Confirm that the CTs are closed properly around the circuit cables

Confirm that the wiring of CTs at the meter is good and not loose. Pull on CT cables and check that no wire comes out.

kWh are zero

Confirm that the CTs are wired in the right direction (arrow facing the load) as per installation manual.

Data holes

Identify if the meter could be powered off by staff or during ongoing works