Programme Area: Distributed Energy

Project: Micro DE

Title: Distributed Energy Monitoring System

Abstract:

Please note this report was produced in 2010/2011 and its contents may be out of date. This deliverable is number 8 of 9 in Work Package 1. It describes the monitoring system and methodology to be used in the field trial of micro-generation systems in the project. The field trial will provide data to the consortium in order to fill gaps in technical understanding and user behaviour.

Context:

The project was a scoping and feasibility study to identify opportunities for micro-generation storage and control technology development at an individual dwelling level in the UK. The study investigated the potential for reducing energy consumption and CO2 emissions through Distributed Energy (DE) technologies. This was achieved through the development of a segmented model of the UK housing stock supplemented with detailed, real-time supply and demand energy-usage gathered from field trials of micro distributed generation and storage technology in conjunction with building control systems. The outputs of this project now feed into the Smart Systems and Heat programme.

Micro Distributed EnergyProject

Monitoring Requirements

Hazel Preston-Barnes 10th March 2010

This document sets out the requirements for the monitoring system for the 20 home field trial for the ETI Micro Distributed Energy Project. It specifies the monitoring required within and external to the property as well as for each type of DE equipment that might be selected.

This version of the document does not cover any details of monitoring of the interventions to be made part way through the project as these cannot not yet determined.

PassivSystems Limited
Medway House, Newbury Business Park
Newbury, Berkshire RG14 2PZ, United Kingdom
Tel +44 1635 525 050 **Fax** +44 8082 800 490
www.passivsystems.com

Revision History

Date	Version	By	Comments
26th November 2009	0.1	HPB	Draft for internal review
14th December 2009	0.2	HPB	Revisions following review by N Watson
22nd December 2009	0.3	MCP	Minor revisions following partner teleconference on 22/12/09
30th December 2009	0.4	HPB	Revisions following ETI Partner meeting
11th January 2010	0.5	HPB	Revision following internal QA and BRE review
18th January 2010	0.6	HPB	Revision to correct formatting
17th February 2010	0.7	HPB	Updates to record latest decisions
10th March 2010	1.0	HPB	Minor amends – version released to ETI for Stage gate 1
ETI Doc No 3			

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1 Introduction

PassivSystems is the lead partner for the ETI project entitled 'Micro Distributed Energy and Energy Services Management – Application to existing UK residential buildings' - which is a feasibility study for a much larger trial to commence within two years.

The partners in this project are the Buildings Research Establishment (BRE), EDF Research & Development/EDF Energy/Eifer and University College London (UCL).

The main objective of the trial is the production of a model that defines the potential for the use of Micro Distributed Energy applications within the UK domestic building stock in 2030 for use by the ETI. This work will be based around a number of scenarios (still to be defined), with a model created from a number of existing models which the partners have already created or to which they have approved access.

Alongside the model the project will install monitoring equipment into 20 homes that have existing Micro Distributed Energy systems in place in order to fill gaps in technical understanding and user behaviour. The precise technologies for the homes is the subject of a separate document – hence this document will detail the monitoring points for all DE technology candidates which are still candidates for selection.

In selection of the trial homes it is intended to provide a mix of levels of performance of the technologies to provide an insight into which technologies perform well under what conditions thus providing criteria for the modelling of the likely performance of technologies in the field rather than in a lab environment.

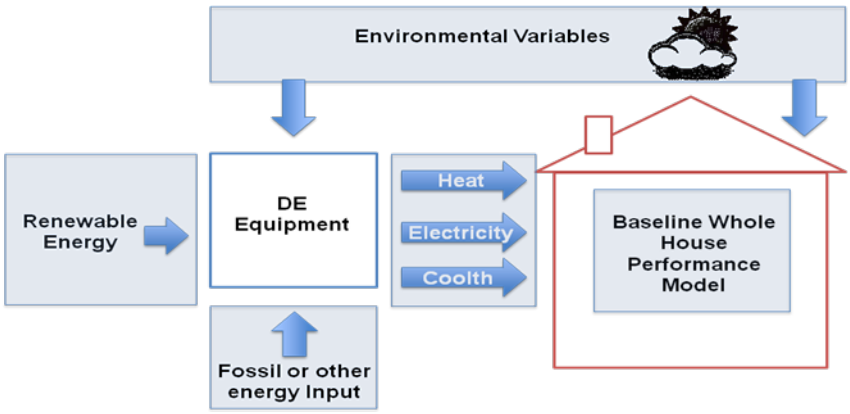
Approximately half way into the monitoring period (or earlier if issues identified) there will be a number of interventions made to a small number of the homes (approximately 6), such as improved control systems, additional technologies, or correction of faults that may also need to be monitored. The additional monitoring requirements are not covered in this document but will be documented at the appropriate time.

2 The Monitoring System

PassivSystems subsidiary Digital Living has created a remote monitoring system, known as SEMS (Smart Energy Management system), based on smart meters, sensors and white goods monitors, collecting consumption data for the whole house on electricity & gas as well as more detailed energy consumption data from individual devices (white & brown goods) within the home at 5 minute intervals. The system has evolved over 4 years and is currently running in a successful trial of 8 homes.

The proposed monitoring system is based upon this existing system – although using different sensing and monitoring – some of which has been updated since the previous installations (wireless rather than wired technology) and some of which has not been used before but is relevant to the devices and environment being monitored in this trial.

The objective is to install a 'base' monitoring system for each home which will capture comparable points of energy consumption, and environmental conditions within and external to each home. In addition to this, there will be a specific monitoring element for each home that will provide details of energy used by, and the output from, the DE equipment – Heat, Electricity, or exceptionally Coolth.



The monitoring system will comprise of industry standard monitoring and metering equipment and sensors, designed to collect energy usage data from homes on a 24 hour, 7 days a week basis. It will regularly communicate this data to a server using Broadband or GSM/GPRS technology.

The central data collection point within the home is the Tridium JACE gateway which can be connected to a variety of appliances and devices via its comprehensive physical connection points and its ability to support a wide range of device drivers. For example, it can support the connection of:

- Electric, Gas, Water and Heat Meters

- Domestic Appliances, connected via a White Goods Monitor (WGM)
- Temperature and other environmental sensors, Occupancy sensors
- Boiler Controllers (for monitoring purposes)
- Specialist monitoring equipment for Solar radiation, Wind speed/direction

The equipment chosen for this system (see section 4) will be provided by suppliers used for the existing SEMS and a supplier that has previous experience of integrating their products with the JACE gateway monitoring DE technologies.

Devices can be connected to the gateway using a variety of protocols including:

- Wired connection such Modbus, Mbus
- Wireless, such as Zigbee or Z Wave
- Power Line Carrier, such as Lonworks

Data is be collected at pre-set times and the proposed system will poll each device at 5-minute intervals where practical. The data collected is time stamped and the register reading at that time is recorded.

Data is transmitted to PassivSystems servers and stored in a database from which it can be made available in a variety of ways including SQL database or CSV files.

The following types of data have been considered for this project and the PassivSystems recommendation for inclusion is provided below.

Major in house consumption

To be Monitored	Recommendation	What	How
Whole House Gas (or Oil) consumption	Yes	Heating & cooking consumption	Pulse meter via pulse to Modbus module
Boiler gas consumption	Yes	Heating consumption	Pulse meter via pulse to Modbus module
Electricity Whole House	Yes	Energy consumption of whole house and individual loads particularly those related to the Micro DE generation or use	Communicating whole house secondary meter via M-Bus interface
Electricity large loads	Yes	Individual loads particularly those related hot water usage at a circuit level	Secondary meters for individual loads including parasitic energy such as pumps for solar heating, via M-Bus interface
Energy Used by Micro DE Equipment	Yes	Parasitic energy used to run technology	Communicating secondary meter via M-Bus interface
Water Meter	Yes	Domestic Water usage	M-Bus output secondary metering via M-Bus to Modbus module
White Goods/Cooling	TBD	Large consumers of energy such as Fridges/Freezers, TVs and associated devices, PCs and peripherals	Plug in monitors via gateway
CH Boiler Flow & return Temperatures	TBD		Temperature sensors attached to flow & return pipes
Hot Water Consumption	Yes	Domestic Hot Water usage	M-Bus Output water meter on input to hot water cylinder or boiler

Environmental Measures

To be Monitored	Recommendation	What	How
Internal temperature x 3 (minimum)	Yes	Internal temperature – 3 provides some redundancy if any readings lost. Use additional for fuller coverage of larger homes	Wireless device Upstairs (main bedroom), downstairs (main living area) plus hallway. Additional units required for any annex, 3rd floor etc
Internal humidity x 3 (minimum)	Yes	Indoor Air quality Humidity levels in main areas	Wireless device. Combined unit with Temperature sensor Upstairs (main bedroom), downstairs (main living area) plus hallway. Additional units required for any annex, 3rd floor etc
Internal CO_2 Sensor x 2	Yes	Indoor Air quality	Wireless device Upstairs (main bedroom), downstairs (main living area)
External temperature	Yes	General outside air temperature.	Wireless Device. Sheltered North facing away from any heat source
External Humidity	Yes	Outside Humidity	Wireless device – combined with Temperature sensor
Occupancy	Yes		Attach to Security System or button at exit. Also derive status from humidity and CO_2 levels, and water usage.
Solar Radiation	Yes	Strength of sunlight	Array plane Solarimeter or Pyranometer either direct wired or connected via Wireless I-O module depending on location.
Wind speed & Direction	No	Not required as no wind technologies being monitored	

Ground temperature	Yes	Input temperature at location of ground source heat pump	Decision on depth of measurement & position relative to building. Also decision on whether water temperature coming in from ground would be suitable
Air Temperature	Yes	Ambient temperature at inlet to pump	Wireless External Temp sensor. Must not be in airflow (to avoid chill factor)

DE Equipment

As appropriate to the technology installed – see the diagrams in section 3 for detailed points of what monitoring is proposed for each type of technology.

To be Monitored	Recommendation	What	How
Electricity exported	Yes	Energy generated by technology	Electricity export meter Some PV systems may already have these – can we connect/collect the info
Electricity imported/exported	Yes	Parasitic energy used by technology versus energy generated (note some solar technologies use a small photovoltaic array to power the pump)	Import/Export Electricity Meter. Some PV systems may already have these – can we connect/collect the info
Heat meter	Yes	Measuring system heat output	Temperature of flow and return + Flow rate input to M-Bus readable Heat Meter
Electricity Storage	Yes	Monitoring of storage from Solar Thermal/Photo Voltaic	Battery meter
Hot Water storage	Yes	Monitoring of Hot water storage	

3 Micro DE Technologies to be monitored

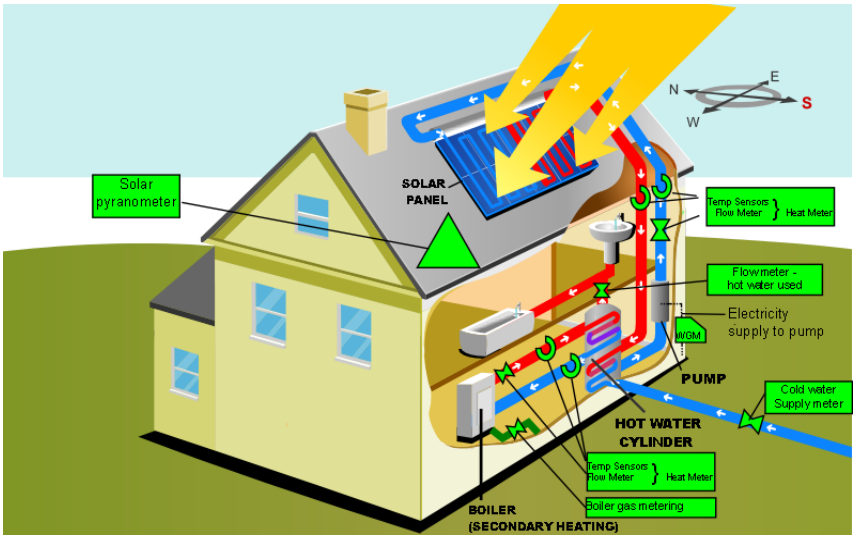
The choice of technologies to be monitored is the subject of a separate workstream feeding in to this document. The current thinking is that Wind, Stirling engine micro-CHP boiler, Fuel cell micro-CHP boiler and Hydro are not to be included, however data from other trials on MicroCHP and fuel cells has been offered to the trial.

The following technologies (including any combinations of technologies) have been chosen for the trial:

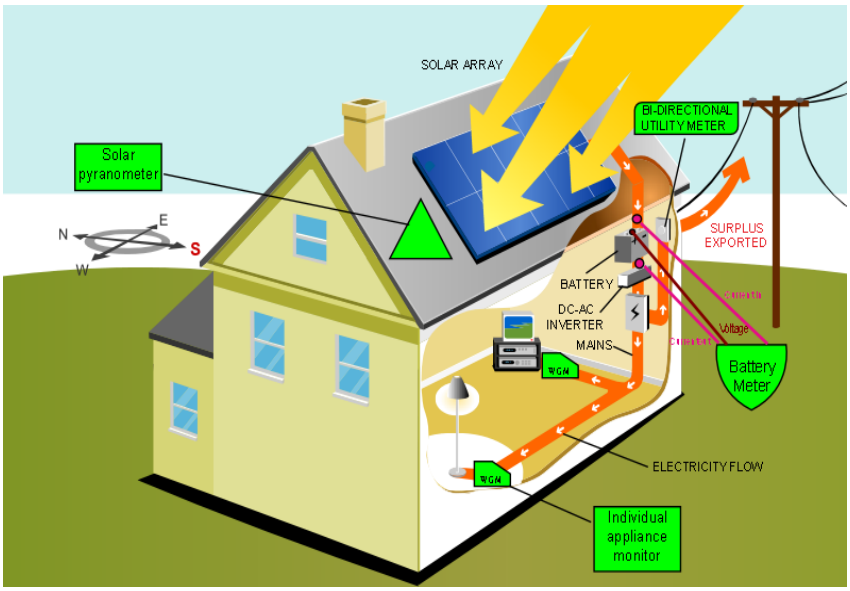
Micro-DE Equipment to be monitored in the field			
Solar Thermal optionally with Solar PV or other heat generation	**8**	**Biomass** optionally with Solar Thermal or other heat generation	**2**
Air Source Heat Pumps optionally with Solar PV or other heat generation	**8**	**Ground Source Heat Pumps** optionally with Solar PV or other heat generation	**2**

Examples of how the likely candidates will be monitored are provided in the diagrams below with the monitoring elements specific to the technology shown in bright green:

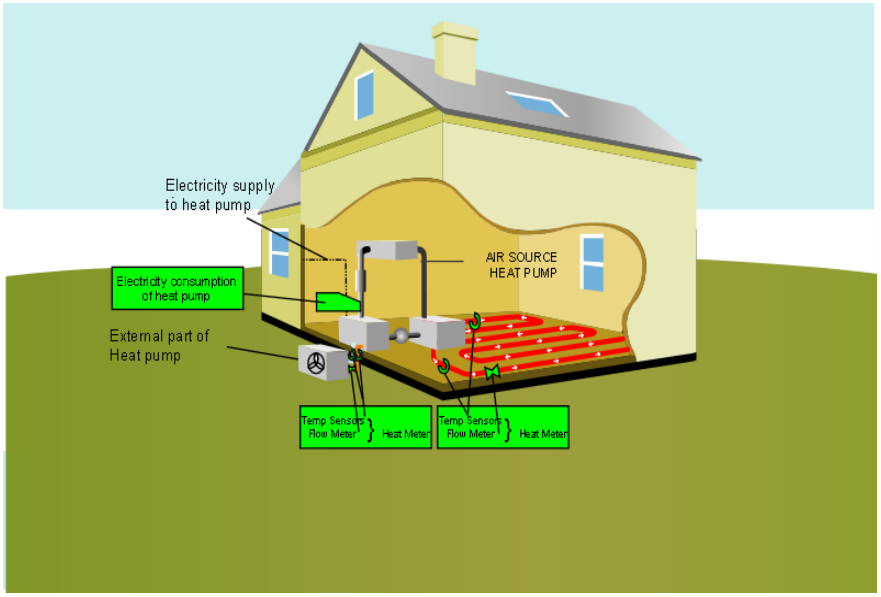
Solar Thermal Water Heating



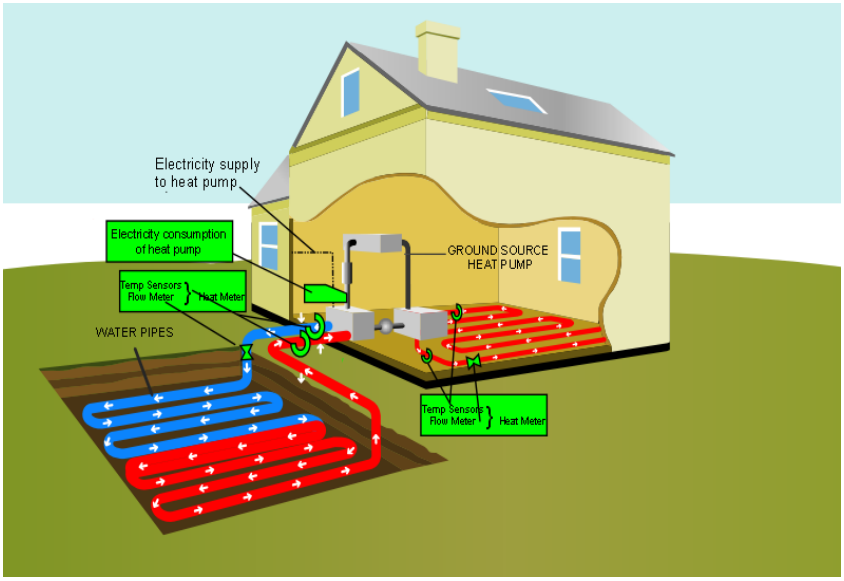
Solar Electricity/Photo Voltaic



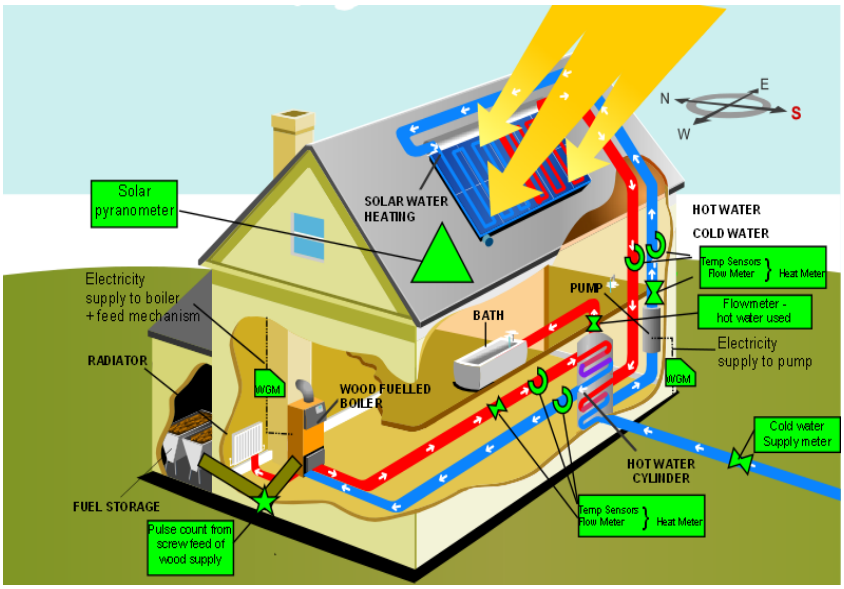
Air Source Heat Pump



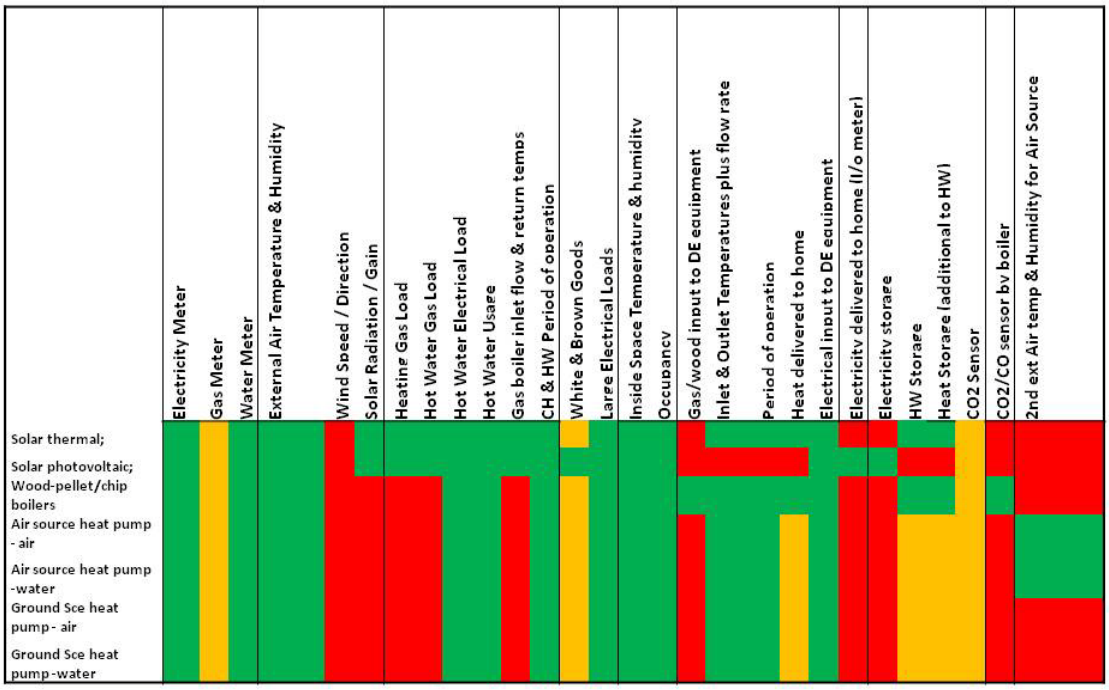
Ground Source Heat Pump



Wood Fuelled (Biomass) Boiler with Solar Water



The following chart provides a cross reference for the monitoring points proposed for each technology:



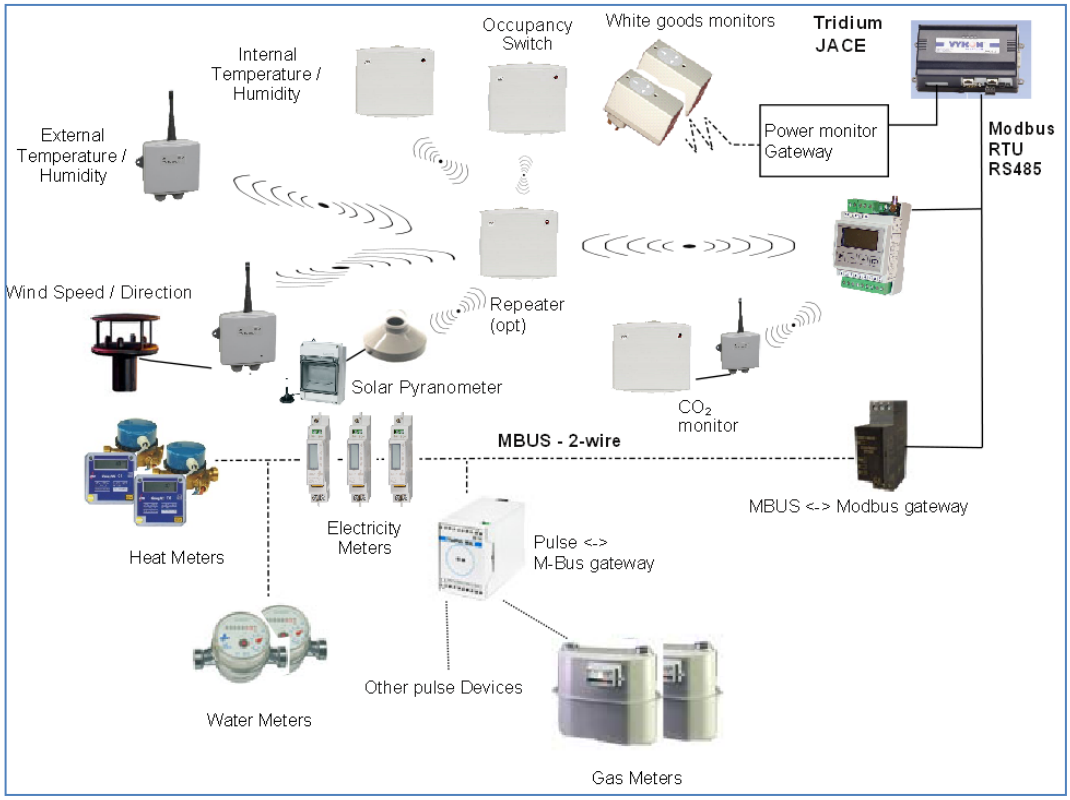
Green - represents to be monitored

Orange – possibly monitored

Red – not monitored

4 Monitoring System Description

A schematic of the proposed monitoring technology is provided below:



The system will consist of the components according to the monitoring requirements of the individual site:

The Jace Gateway

The Tridium JACE is the gateway controller for the data recording system. It is designed for remote monitoring and control applications and combines integrated control, alarm, data logging, scheduling and network management functions in a compact housing. The JACE is able to communicate with a remote server either by broadband using the local router or via inbuilt or external GSM modem – the choice of communications medium will be dependent upon the property being monitored.

It is recommended that the standard JACE 236 is used for this trial. The Jace will be mounted on a rail and enclosed inside a box along with the MODBUS Gateway IO unit (see below) and any other equipment required such as a Gateway Interface Unit for powerline connections.

The JACE is solid state technology and will not lose any of the data that has been collected should there be a power outage. By virtue of its local storage capability, the JACE has the facility to accommodate a period of network loss without incurring loss of data.

The JACE runs the Niagara framework, a JAVA based operating platform, which is incorporates a number of drivers providing the ability to connect to any number of external devices and collect data using a variety of protocols.

The JACE will retrieve the readings from the attached devices at pre-specified time intervals (see table below) to collect the current readings. Should any poll fail, a number of re-tries will be made until a successful poll is achieved. This may result in an interval of greater than 5 minutes between some of the readings. Similarly should any impedance occur within the network it may introduce delays in the polling times, however each poll (and therefore reading) will be time stamped.

On a regular, pre-defined, basis the JACE will be polled by the central server and the data collected within the JACE since the last poll will be uploaded to the server. At the server the data is loaded into an SQL database by the Niagara Supervisor software.

Should any of the scheduled communication time slots be missed the data will continue to be stored within the JACE until the next scheduled poll slot. However there is limited storage so missing a number of slots through communication problems over a period of days may mean that the data is overwritten within the JACE on a first come/first lost basis.

MODBUS Gateway IO Module (Wireless Control Module)

The MODBUS Gateway IO module attaches to the RS485/Modbus port of the JACE. It is the interface for all of the wireless devices to the Modbus network which the JACE uses to communicate with them. Other Modbus devices and gateways are also connected to the RS485 network as shown in the diagram at the start of this section.

MODBUS IO Module

Electricity Meter

For both whole house consumption and major loads a range of single phase secondary class 1 meters will be deployed that will use M-BUS protocol. An M-Bus to Modbus converter is used to attach to the Modbus network in a daisy chain arrangement and thereby readings are collected by the JACE gateway.

M-Bus meter **M-Bus/Modbus converter**

The proposed loads to be captured are:

- Whole house electricity
- Electricity used by
    - any DE technology
    - Immersion heater
    - Shower
    - Lighting (if power generated from DE equipment)

Gas Meter

A G4 pulse output meter will be used for whole house gas and gas used by the Boiler (provided space is available to install a secondary meter). A pulse to M-Bus convertor which is connected to the M-Bus network and is connected via an M-Bus to Modbus gateway to the JACE will be used to capture the pulse output. The Pulse to M-Bus converter retains the sum of the pulses and is battery backed.

Gas Meter **M-Bus Pulse counter** (2 channel)

Water Meter

A M-Bus output water meter will be installed as a secondary water meter inside of the property. The M-Bus output will be wired to the M-Bus to Modbus interface and thence to the JACE gateway in the same way as for the heat meters.

Water Meter

Internal Temperature & Humidity Sensor

A combined Wireless Temperature and Humidity sensor will be placed in the main living area, main sleeping area and hallway of each home. If a home has more than two floors (or an annex) additional units will be installed in prime living/sleeping areas.

Temperature & Humidity Sensor

The readings will be requested and received wirelessly by Wireless control module attached by MODBUS to the JACE

External Temperature & Humidity Sensor

A wireless, external temperature / humidity sensor will be placed in a sheltered area on the northern side of each home away from sources of heat (e.g. boiler or extractor outlets). The readings will be requested and received wirelessly by a Wireless control module attached by MODBUS to the JACE

Wireless External Temperature / Humidity sensor

Heat Meter

Heat meters will be used to measure the flow rate of the heating/cooling liquid and also the flow and return temperatures. They communicate by M-Bus to the M-Bus to Modbus converter thence to the JACE.

Heat Meter

Solar radiation

A Solarimeter/Pyranometer is placed in the same plane as (each) solar collector and is connected to a generic wireless input-output module. The readings will be requested and received wirelessly by Wireless Control Module attached by MODBUS to the JACE or wired to a generic Modbus input module depending on location.

Solarimeter

Pipe Temperature Sensor

Pipe temperature sensors are connected to a generic wireless input-output module. The readings will be requested and received wirelessly by Wireless Control Module attached by MODBUS to the JACE.

Occupancy

To denote whole house occupancy a switch could be wired directly to an input of the Wireless Control Unit. Alternatively a Generic wireless I-O unit could be used in the same way depending on the location required for the switch.

Wireless Generic I-O Module

Battery Meter

Battery voltage and current measurements will be accomplished with the low-current inputs to a Generic Wireless Input-Output module together will appropriate resistance elements. The readings from the generic Input Output module will be requested and received wirelessly by Wireless Control Module attached by MODBUS to the JACE

Import/Export Meter

The import-export meter will be connected to either an M-Bus interface module, or to a pulse counting module and thence via Modbus to the Jace.

White & Brown Goods (to be supplied at a later date)

Plug in units will be used to collect energy consumption of white and brown goods. These units will either use powerline or wireless technology to transmit readings back to the JACE through a gateway.

White Goods Monitor

PassivSystems recommend monitoring only the higher consumption devices which include:

- Fridges and freezers
- TV and audio devices with associated equipment
- PCs and associated peripherals

The following tables provide the specific details of the equipment chosen for the monitoring system:

Monitoring equipment	Protocol	Make	Model	Resolution	Range	Accuracy	Power
M2M Jace	N/a	Tridium	M2M 236	n/a	n/a	n/a	Mains / UPS
Wireless Modbus Receiver	Wired	SyxthSense	FLTA Wireless Control Module	n/a	n/a	n/a	Mains
Internal House							
Gas Meter Boiler gas load	Pulse output	SyxthSense	G4 or G6	1 pulse = 0.01m^3			Battery
Electricity Meter	M-Bus	SyxthSense (DHZ)	DHZ-63A-M-Bus	0.1kWh	230V 63A 50Hz	Class 1 (1%)	Mains
Large electrical loads DE Electricity delivered to home	M-Bus	SyxthSense (DHZ)	DHZ-63A-MBus	0.1kWh	230V 63A 50Hz	Class 1 (1%)	Mains
Water Meter	M-Bus	SyxthSense		1 pulse = 10 ltrs	30 l/hr -> 5m^3 /	< 3% dep on flow rate	Battery

Monitoring equipment	Protocol	Make	Model	Resolution	Range	Accuracy	Power
					hr		
Internal Temp sensor	Wireless > Modbus	SyxthSense	TEFL-RH	0.1C	0-50^{0}C	0.5^{0}C	Battery
Humidity sensor				1%	0 - 100%	+/- 2%	Battery
CO2 Sensor					0 - 2000ppm	+/-40ppm	Mains
Occupancy	Wireless > Modbus	SyxthSense	LA-FL	n/a	n/a	n/a	
White & Brown goods	Wireless	? Current Cost		Class 2			Mains
Heating & Hot Water							
Hot Water Usage	M-Bus	Syxthsense	WZK-M-1-5-80				Battery
CH & HW period of boiler firing/operation	M-BUS > MODBUS	Syxthsense	WZCD-M-BUS-1-5-D				Battery
HW Storage		Syxthsense	TEPK PT1000 Strap-on		25-90^{0}C	3%	Battery
DE Output Flow Rate	MODBUS	Syxthsense	WZW-M-bus-1-5-110				Battery
(Heat Meter)	M-bus	Syxthsense	WZCD-M-BUS-1-5-D		120^{0}C		Battery

Monitoring equipment	Protocol	Make	Model	Resolution	Range	Accuracy	Power
External Ambient							
External temperature /humidity sensor Air Temperature	Wireless> Modbus	SyxthSense	TEU-PT1000	0.1C	-50^{0}C – 120^{0}C	+/- 0.5^{0}C at 0^{0}C +/- 2%	Battery
Wind speed & direction	Wired > Wireless> Modbus	SyxthSense	TUNA 20		0 - 20 m/s -50^{0}C – + 50^{0}C	^{0}C 20% +/- 0.5^{0}C	
Solar radiation (Array plane solarimeter)	Wired > Wireless> Modbus	SyxthSense	WS-SOLRAD		300 - 2800nm	+/- 10%	
DE Equipment							
Inlet & Outlet Temps CH Boiler inlet, flow and return temperatures Ground temperature Heat delivered to home	Wireless > Modbus	SyxthSense	TEP-1000	0.1C	-50^{0}C – 120^{0}C	+/- 0.5^{0}C at 0^{0}C	Battery

Monitoring equipment	Protocol	Make	Model	Resolution	Range	Accuracy	Power
Period of operation	Two wire relay or derived from heat meter						Mains
Electricity Storage (Battery meter)	Modbus	Laurel Electronics	LTM2000DCV1	10mV / 1mA	0 - 200V 0-5A (could be scaled)	0.01%FSD	n/a

5 System Design

There will be twenty trial homes. Each home will have a basic monitoring system to capture the in-home energy consumption (major gas, electricity loads) and environmental (temperature, humidity, C02) data. Details for each home will be provided in this document once the monitoring points have been agreed and the homes engaged.

At a later date, a maximum of 10 monitors will be installed per house - to be labelled A through O, to capture white and brown goods consumption.

The communications route back to the server is also still to be determined and may be decided on a house by house basis. Broadband is the preferred method as that is faster, more reliable and cost effective whilst allowing remote monitoring and diagnosis of any issues, however this decision will depend upon the customer's installation.

The server will request a data upload from each house on a daily basis. The server data will be backed up to an alternative server each night with off-site storage back-ups taken on a weekly and monthly basis.

DE TYPE	Naming convention for data
Air Source Heat Pump	ASH001-008
Solar Thermal	STH001 -008
Biomass	BIO001 – 002
Ground Source Heat Pump	GSH001-002

Item	Frequency of data capture/polling from JACE	JACE label
Whole house electricity usage	Every 5 minutes.	Whole House Electricity
Whole house gas usage	30 minute only	Whole House Gas
Boiler usage	30 minute only	Boiler Gas
Water usage	30 minute only	Whole House Water
Lighting, shower, immersion heater loads	Every 5 minutes	Names of loads
Plug-in white and brown goods (max 10)	Every 5 minutes	ETI001A –001J ETI002A –002J Etc
Internal Air Temperature /Humidity x3	Every 5 minutes (or when a change is detected?)	LIVING Temp LIVING Humid BEDROOM Temp BEDROOM Humid HALLWAY Temp HALLWAY Humid
External Air Temperature/Humidity	Every 30 mins	EXTERNAL Temp EXTERNAL Humid
CO_2 Sensor	Every 5 minutes	Internal CO2 Living Internal CO2 Bedroom
Occupancy	As it changes	Occupancy status
Hot water Usage	Every 5 minutes	Hot Water Usage
CH & HW period of operation	As status changes	CH Status HW Status

CH Flow & Return Temperatures	Every 5 mins	CH Flow Temp CH Return Temp
HW Storage	Every 5 mins	HW Storage
DE output flow rate	Every 5 mins	DE Output
DE Air In/Out flow temp	Every 5 mins	DE In Temp DE Out Temp
Ground Temperature	Every 30 mins	Ground Temp
Wind Speed & Direction	Every 5 mins	Wind Speed Wind Direction
Solar Radiation	Every 5 mins	Solar
Electricity Storage	Every 5 mins	Electricity Storage

ALARMS

Alarms to be included within this system as defined below:

ALARM	Where Recognised	No. of Failures before Alarm	How Presented
Jace Not Receiving data download	Server by Niagara Supervisor	One	Message on Server
Device not responding to poll from Jace	JACE	3 polling 5 min intervals	Message from JACE
Device not responding to poll from Jace	JACE	10 polling 5 min intervals	Jace passes Alert to Server