Appendix I

Requirements Specification
Appendix I
Trial Evaluation of Domestic Demand Side Management - Requirements Specification

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1. Requirements
SHEPD contracted Smarter Grid Solutions (SGS) to produce a requirements specification for the project. This was reviewed and updated at each stage of the project delivery.

1.1 Local Interface Controller Requirements Specification
This section defines the requirements that apply to the Local Interface Controllers (LICs) developed as part of the six home trial.

For the Tier 1 project, the Central Interface will manipulate Active Setpoints, Day Ahead Schedules and Variable Droop Characteristics to control the operation and response of domestic heating. This provides the capability required to prove the functionality desired within the Tier 1 trial. The phrase “Device Controller” refers to the controller used by the controlled load, generator or storage device. The Dimplex Controller is an example of a Device Controller.

1.1.1 General Functionality and Physical Characteristic Requirements
§ The LIC shall emulate the functionality of an Active Network Management (ANM) scheme by autonomously supplying all necessary signals to the Device Controller.
§ The LIC shall be able to operate independently of the Central Interface, Central ANM Controller or other higher-level system. The link from the LICs to the Device Controllers implemented in the six home trial will remain the same for the full ANM scheme implementation.
§ The LIC shall include a computing platform that is capable of performing computations and executing the algorithms necessary to translate the stored and received data into instructions issued to the Device Controllers.
§ The LIC shall support “uplink” communications with a Central Interface.
§ The LIC is required to support communications with an isolated remote Central Interface. The LIC shall not support simultaneous communications with multiple remote masters. In the six home trial, the link between the LICs and Central Interface provides for remote configuration and updates of the LIC as required to prove functionality.
§ The LIC shall support “downlink” communications with up to four connected Device Controllers via serial or network communication links. Each LIC shall support communication with up to four locally connected Device Controllers via serial or network links. For reference purposes, a maximum of 32 devices may be connected on the multidrop RS485 type links to be used with the LICs.
§ The LIC shall support serial and network communications using various protocols. The core LIC functionality will be implemented on a single hardware module. The following protocols shall be supported within the “core” LIC module:
  o Modbus RTU (master) via RS485: This capability shall provide for communication with the connected Device Controllers.
  o CIP via Ethernet: This capability shall provide for communications with the Central Interface.
The LIC shall include a single 1000Mbps RJ45 network port, which shall support uplink communications (supporting slave protocols) and downlink communications (supporting master protocols). This port shall provide the capability for the LIC to communicate with the Central Interface and connected Device Controllers via any protocol that supports network communications.

The LIC shall include a 9-pin Sub-D serial port connector which is switchable to support RS232 and 2-wire/4-wire RS422/485.

The port shall provide the capability for the LIC to communicate with connected Device Controllers via any protocol that supports RS232/422/485 serial communications.

The LIC shall include at least 128Kb of non-volatile memory. The core LIC module shall include at least 128Kb of non-volatile battery-backed memory in order to store configuration information and other data required for run time operations.

The LIC shall have the ability to be installed within a cabinet space as specified and provided by Glen Dimplex. The LIC must fit inside an industrial steel panel provided by Glen Dimplex.

1.1.2 Day Ahead Schedule Processing

The LIC shall have the ability to store Day Ahead Schedules within non-volatile memory for two different device types. The Day Ahead Schedule shall comprise of 96 quarter-hour values to represent the associated load charge cycle for one full day. In the Six Home Trial there will be two device types, Immersion Heaters and Storage Heaters.

The LIC shall have the ability to store a Default Day Ahead Schedule within non-volatile memory for two different device types. A Default (or “failsafe”) Day Ahead Schedule shall be stored within the LIC. This schedule shall be used whenever the link is lost between the Central Interface and the LIC. The failure of this link shall be detected by means of a watchdog between the Central Interface and the LIC.

The LIC shall have the ability to issue setpoints to each Device Controller in real-time and in accordance with the Day Ahead Schedules (or Default Day Ahead Schedules).

The LIC shall be configured to send the appropriate setpoint to each Device Controller every quarter hour according to the values stored within the Day Ahead Schedules (or Default Day Ahead Schedules). Setpoints sent to a Device Controller will be stored within the volatile memory of the Device Controller and shall remain active until either a new Setpoint is sent or a watchdog failure occurs and the Device Controller reverts to a Default (failsafe) Setpoint.

The LIC shall have the ability to receive a new Day Ahead Schedule transmitted at any time from the Central Interface for each Device Controller type. The LIC shall be capable of receiving an updated Day Ahead Schedule for each Device Controller type from the Central Interface at any time, subject to communications being available. It is anticipated that during the project updates to the Day Ahead Schedules will be implemented for system testing purposes only.

The LIC shall have the ability to be aware of the current time and date such that the Day Ahead Schedules (or Default Day Ahead Schedules) can be executed correctly. Each of the setpoints comprising a typical Day Ahead Schedule (or Default Day Ahead Schedule) must be executed at a specific time each day (every quarter hour). As such, the LIC must be aware of the current time in order
to transmit the appropriate setpoint at the appropriate time. Accordingly, the LIC shall contain a Real Time Clock (RTC) that shall:

- Be configured with the current time and date.
- Maintain a consistently accurate time over a long period.
- Store the current date and time within non-volatile battery-backed memory (and thus maintain the correct time even during a power failure).

The LIC shall have the ability to receive a time synchronisation command from the Central Interface and adjust the time stored by the LIC accordingly. The LIC must provide the facility for its time to be synchronised from the Central Interface. This is required to take into account British Summer Time and also to prevent any significant scheduling errors due to an inaccurate real time clock.

The LIC shall have the ability to manipulate multiple Day Ahead Schedules for distribution to the disparate Device Controllers they are intended for. It will be possible for an LIC to connect to up to four Device Controllers managing two different types of device. Each device will have potentially unique static and real-time operating characteristics. For the Tier 1 project each LIC will control an Immersion Heater and up to three Storage Heaters. The LIC is required to manage the Day Ahead Schedules for both types of device. This will include receiving and storing two types of Day Ahead Schedule and Default Day Ahead Schedule that define the active setpoints to be issued to the two types of Device Controller.

### 1.1.3 Active Setpoint Processing

The LIC shall have the ability to receive an Active Setpoint command from the Central Interface. The LIC must be capable of receiving an Active Setpoint command directly from the Central Interface. The Active Setpoint command will take the same format as a Day Ahead Schedule charging value. An Operational Active Setpoint shall override all current scheduled setpoints and the same value will be implemented on all Device Controller types.

The LIC shall have the ability to receive an Active Setpoint Operational signal (Enable or Disable) from the Central Interface. Each Active Setpoint shall be preceded and succeeded by an Active Setpoint Operational command. The preceding command shall enable the transmitted Active Setpoint to be taken into account. Equivalently, the succeeding command shall disable the previously transmitted Active Setpoint. The LIC must then revert to use of the appropriate scheduled setpoints for each device type the given time of day.

The LIC shall have the ability to clear the Active Setpoint Operational signal upon loss of communications with the Central Interface. The Active Setpoint Operational signal is required to be cleared upon loss of communications with the Central Interface. This requirement is necessary because if this value were maintained during a communications failure, when the LIC returned to service it would apply a historical Active Setpoint value that may be irrelevant to current system conditions.

The LIC shall have the ability to issue Active Setpoint commands to the Device Controllers. An Active Setpoint received by the LIC shall immediately update the setpoint transmitted to all the connected Device Controllers (so long as the Active Setpoint Operational signal is enabled). This will override the current setpoint from the Day Ahead Schedules.
1.1.4 Droop Characteristic Processing

The LIC shall have the ability to store Droop Characteristics for each individual Device Controller within non-volatile memory. Droop Characteristics shall be stored for each individual device that is controlled by an LIC. Each stored Droop Characteristic shall be completely characterised by two values, namely:

- **Deadband**: Value indicating the Frequency Response Deadband on either side of 50Hz within which the Device Controller shall not implement any form of frequency responsive control. The Deadband may be any value but would typically be in the order of 0.2Hz.
- **Gradient**: Value indicating the gradient of the Frequency Response Droop Characteristic which applies below (50 - Deadband) Hz and above (50 + Deadband) Hz. The gradient of the Droop Characteristic shall be zero from (50 - Deadband) Hz to (50 + Deadband) Hz.

The LIC shall have the ability to receive updated Droop Characteristics from the Central Interface. Operators may use the Central Interface to send commands to the LIC at any time to update the Droop Characteristics stored within the LIC. This may include disabling the frequency response implemented by the connected Device Controllers. This may be achieved by either setting the Deadband to a very large value or setting the Gradient to zero.

The LIC shall have the ability to issue Droop Characteristics to any connected Device Controller. When the LIC receives updated Droop Characteristics (Deadband or Gradient) from the Central Interface it shall immediately transmit updated values to the appropriate Device Controllers. Device Controllers are then required to update their stored Droop Characteristics. Thus, the Droop Characteristic shall be stored both within the LIC and within the Device Controller.

1.1.5 Ramp Rate Processing

The LIC shall have the ability to store Ramp Rate Characteristics for each individual Device Controller within non-volatile memory. Each controlled device shall have a maximum permissible “upwards” and “downwards” ramp rate for increasing and decreasing power consumption (or production). Although the ramp rate of some devices may be theoretically infinite, practical considerations mean that the upwards and downwards ramp rates of most devices are controlled to avoid sudden changes in load (or generation) which could cause network disturbances. Limiting the maximum permissible ramp rates serves to dampen the response of the device under control and prevent flicker.

The ramp rates apply to all power variations including those triggered by the transmission of a LIC setpoint or those triggered by the autonomous frequency responsive control within each Device Controller. It shall be possible to provide unique Ramp Rate Characteristics for all connected Device Controllers. Ramp Rate characteristics shall be completely characterised by two values, namely:

- **Upwards Ramp Rate**: Value indicating the maximum rate of increase in power consumption or decrease in power production, expressed as Watts/second.
- **Downwards Ramp Rate**: Value indicating the maximum rate of decrease in power consumption or increase in power production, expressed as Watts/second.
The LIC shall have the ability to receive updated Ramp Rate Characteristics from the Central Interface. Operators may use the Central Interface to send commands to the LIC at any time to update the Ramp Rate Characteristics stored within the LIC.

The LIC shall have the ability to issue Ramp Rate Characteristics to any connected Device Controller. When the LIC receives updated Ramp Rate Characteristics (Upwards or Downwards) from the Central Interface it shall immediately transmit updated values to the appropriate Device Controllers. Device Controllers are then required to update their stored Ramp Rate Characteristics. Thus, the Ramp Rate Characteristic shall be stored both within the LIC and within the Device Controller.

1.1.6 Set-Point Limits Processing

The LIC shall have the ability to store an Upper Load Setpoint Limit for the Controlled Devices. Each Storage Heater will have an associated Upper Load Setpoint Limit that takes precedence over all other control. The Upper Load Setpoint Limit is the maximum power that can be consumed by each Storage Heater. This requirement is desired as it allows the prevention of overloading a network constraint location by limiting the power consumed by loads in that network area. The LIC must be capable of receiving this value from the Central Interface at anytime and storing it in the associated memory register. Additionally, the LIC must issue the Upper Load Setpoint Limit to the Storage Heater Device Controller. The Device Controller will compare this limit to any load setpoint in operation and constrain the output in line with the Upper Load Setpoint Limit. The Upper Load Setpoint Limit will comprise a single value between 0 and 100% of rated power, independent of the actual rated power of the device.

The LIC shall have the ability to receive an updated Upper Load Setpoint Limit from the Central Interface. Operators may use the Central Interface to send commands to the LIC at any time to update the Upper Load Setpoint Limit stored within the LIC.

The LIC shall have the ability to issue Upper Load Setpoint Limit to any connected Device Controller. When the LIC receives an updated Upper Load Setpoint Limit from the Central Interface it shall immediately transmit updated values to the appropriate Device Controllers. Device Controllers are then required to update the Upper Load Setpoint Limit in their stored memory. Thus, the Upper Load Setpoint Limit shall be stored both within the LIC and within the Device Controller.

1.1.7 Other Configurable Values Processing

The LIC shall have the ability to receive, store and issue a Minimum Tank Temperature for the Immersion Heater Device Controller. Each Immersion Heater will have an associated Minimum Tank Temperature value to ensure minimum comfort levels are maintained. The Minimum Tank Temperature will be a value in degrees Celsius. The LIC must be capable of receiving this value from the Central Interface at any time and storing it in the associated memory register. Additionally, the LIC must issue the Minimum Tank Temperature to the Immersion Heater Device Controller. The Device Controller locally stores this value and uses it to control the minimum temperature of the Immersion Heater tank.

The LIC shall have the ability to receive, store and issue a User Set-Point Temperature for the Storage Heater Device Controllers. Each storage heater will have a user set-point temperature. This is the
minimum allowed core temperature of the heater. Once this value is reached, the heaters will trickle charge at the current load set-point. The LIC must be capable of receiving this value from the Central Interface at any time and storing it in the associated memory register. Additionally, the LIC must issue this value to the storage heater device controller.

The LIC shall have the ability to receive, store and issue an Average Ambient Outside Temperature for the Storage Heater Device Controllers. The average ambient outside temperature is used by the storage heater charge controller algorithm. The LIC must be capable of receiving this value from the Central Interface at any time and storing it in the associated memory register. Additionally, the LIC must issue this value to the storage heater device controller.

1.1.8 LIC to Device Controller Communications

The LIC shall support downlink communication protocols supported by the Dimplex Device Controller. The LIC is required to manage the communication interfaces to multiple Device Controllers as appropriate in each of the six homes. The Modbus RTU (Serial) protocol is the preferred method for downlink communications between each LIC and corresponding Device Controllers. This protocol is bandwidth efficient and requires low computational power. The serial communications link shall be configured to operate at a variable baud using 8 data bits, no parity and 1 stop bit. The data transferred over this link is minimal and therefore the speed of this link is of little consequence. As such, the lowest feasible baud rate shall be used in order to provide a data transmission most immune to electrical interference.

The LIC shall support RS485 2-wire communications with the Device Controller. 2-wire RS485 will be used to connect the devices. The Device Controllers will be connected directly to the mains without isolation. Therefore, it is required to have a form of electrical isolation on the serial communication lines between the Device Controllers and the LIC.

The LIC shall support RS485 2-wire communications over a distance of at least 100m. SGS expect the distances between the LIC and the Device Controllers in the homes to be no greater than 100m. Factory testing shall be performed with suitable cable lengths in order to prove the feasibility of such communications. 1200m is the theoretical maximum limit for RS485.

The LIC shall have the ability to be configured with the number of Device Controllers it is required to communicate with. Each Device Controller connected to any given LIC must be configured with a unique Modbus slave address. This shall be achieved by using a DIP switch on each Device Controller. This DIP switch shall be used to set a unique Modbus address for each Device Controller at installation time. Addresses shall always commence at 1 and shall extend to the number of Device Controllers connected to any given LIC. The LIC is required to be configurable to communicate with the correct number of Device Controllers. The number and type of Device Controllers may vary from home to home but it is expected to be three or four in each of the six homes.
1.1.9 LIC to Central Interface Communications

The LIC uplink shall support communications with the Central Interface using CIP over Ethernet. The Central Interface shall send various messages to the LIC such as the Day Ahead Schedules, Active Setpoint commands, Droop Characteristics and Time Synchronisation commands. For the Tier 1 project, these messages are required to be sent using CIP over Ethernet.

Ability for the communications link between the Central Interface and the LICs to be safe and secure. The communications link between each LIC and the Central Interface will be secured using industry standard security procedures. The use of secure channels (such as VPNs) may be simpler than the use of secure protocols (such as DNP3 over SSL).

1.1.10 LIC Programming and Remote Controllability

A remote link is required to the LICs installed in the six homes participating in the Tier 1 project. This link shall use 3G/GPRS and be secured via VPN (using an external VPN upstream of the LIC itself). 3G/GPRS shall easily support the modest data transfer requirements.

The link will provide a programming interface into each LIC such that the all settings may be modified at any time. The link will also be used to retrieve data on command or on a continuous basis to be logged in a database at the Central Interface. This feedback data will record the operation of the system over the entire period of the Tier 1 project.

Ability to provide an engineering interface on the LIC in each of the six trial homes for the purpose of local monitoring and control of the LIC. The LIC is required to allow internal parameters to be viewed and edited locally. This requirement is necessary so that control signals may be modified locally on the LIC if required.

The LIC shall have the ability to be remotely reprogrammable via the link to the Central Interface. The LIC shall include battery-backed non-volatile memory to store the functional code. It will be possible to remotely reprogram the LIC via the link to the Central Interface. It is expected that reprogramming an LIC will necessitate a short disruption to the real-time communications link with the Central Interface.

1.1.11 Watchdogs and Error Handling

A “watchdog” signal shall be transmitted between each LIC and the Central Interface in order to determine communications health. Each LIC shall be configured to detect when the watchdog has failed for a pre-defined contiguous period of time. In such case, the LIC shall enter a “failsafe” mode and shall:

- Instruct the LIC scheduling function to use the Default Day Ahead Schedules for each connected device.
- Cancel any current Active Setpoint command by setting the Active Setpoint Operational signal to disabled. Equivalently, the Central Interface will detect a watchdog failure with any LIC. In such case, the Central Interface shall set a flag that will signify any data logged is invalid. Once communications are re-established, the Central Interface will clear the watchdog failure flag.
- Requirement to implement a “watchdog” between each LIC and all connected Device Controllers. A “watchdog” signal shall be transmitted between each LIC and all connected Device Controllers to determine communications health. The Device Controller will be configured to detect when the watchdog
has failed for a pre-defined contiguous period of time. In such case, the Device Controller shall enter a
“failsafe” mode.

§ Equivalently, the LIC shall be configured to detect watchdog failures with any Device Controller. In such
case, the LIC will set a flag high to notify the Central Interface of the system communication failure.

§ The LIC shall have the ability to automatically resume normal operation following a power failure. The
non-volatile memory and Real Time Clock within each LIC shall be used to ensure that all necessary
data is maintained in each LIC during any power outage. Communications with the Central Interface and
each Device Controller will resume upon return of power.

§ The LIC shall have the ability to initialise all connected Device Controllers without user intervention upon
initialisation of the LIC. The LIC shall initialise all connected Device Controllers upon start-up of the LIC.
In this case, the LIC shall send data to all connected Device Controllers to configure them appropriately.
This includes Droop Characteristics, Ramp Characteristics, Limiting Values, Active Setpoints, Day Ahead
Schedules and/or Default Day Ahead Schedules (as appropriate).

§ The LIC shall have the ability to control connected Device Controllers automatically following the clearing
of a watchdog failure between the LIC and the respective Device Controller. The LIC shall initialise any
connected Device Controller once a watchdog failure is cleared with the respective Device Controller. In
such case the LIC shall send data to the relevant Device Controller to configure it appropriately.

1.1.12 Device Characteristics Reporting and Feedback

§ The LIC shall have the ability to retrieve operational characteristics from the Device Controllers.

§ The LIC shall be customised in its operation according to the type and characteristics of each device
under its control. The LIC shall be programmed to request relevant information from each connected
Device Controller. Both the immersion heater and storage heater device controllers will make available
the following values:
- Device ID
- Appliance Type ID
- Rated Power
- Maximum Storage Capacity
- Remaining Storage Capacity
- Instantaneous Power Consumption
- The immersion heater device type makes available the following additional values:
  - Water Temperature 1
  - Water Temperature 2
- The storage heater device type makes available the following additional values:
  - Core Temperature
  - Maximum Allowed Core Temperature
  - Room Temperature
  - Charge Controller Fan Status
  - User Interface Set-Point
  - Boost Status
  - Fan Duct Temperature
1.2 Central Interface Requirements Specification

The Central ANM Controller proposed for the NINES project will not be used for the Tier 1 Six Home Trial. Instead, a Central Interface specific to the requirements of the Tier 1 project will be implemented. This will reside in the SGS offices in Glasgow. The Central Interface shall have the ability to:

- Connect to the LICs through the communications infrastructure provided for the project. The Central Interface is required to work with the method of communications provided for the project. Communications will be via 3G/GPRS and be secured via VPN. SHEPD will provide the necessary router and all configuration information to allow the Central Interface to be connected. 3G/GPRS shall easily support the modest data transfer requirements of the Tier 1 architecture.

- Update all settings and values in each LIC. The Central Interface will provide an operator with the means to update the operational characteristics of each LIC. This includes all settings and values listed above as LIC requirements.

- Retrieve all settings and values from each LIC. The Central Interface will provide an operator with the means to examine and retrieve the operational characteristics of each LIC. This includes all settings and values listed above as LIC requirements. Each LIC retrieves data locally and acts as a data aggregator for the Central Interface.

- Automatically retrieve values from all connected LICs. The Central Interface shall retrieve the operational characteristics of each LIC, and therefore also all Controlled Devices, in real-time. The communication bandwidth and latency on any uplink channel limits the frequency at which data may be polled. The Central Interface shall log data periodically once every minute from a subset of the available feedback signals.

- Update the functional code within each LIC. The Central Interface will be capable of updating remotely the functional code that determines the operation of each LIC. This will allow an operator to implement code changes and updates without having to visit any of the six homes.

- Create a historical record within a database. The Central Interface will save a subset of issued and retrieved data in a database to form a historical record of the operation of the LICs and Device Controllers. It will be possible for the historical data to be extracted and issued to SHEPD and this will done on a regular basis for the duration of the project, as defined in the project proposal or subsequent change requests. The database will be maintained for a period of five years following the end of the project, or a shorter period if agreed with SHEPD.
Appendix II

Functional Design Specification
Appendix II
Trial Evaluation of Domestic Demand Side Management – Functional Design

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Table 4 - Modbus RTU Data Request Field Format

Table 5 - Modbus RTU Data Response Field Format (Function Code 03)

Table 6 Downlink Bandwidth Analysis

Table 7 - Modbus RTU Character Framing

Table 8 - Typical Baud Rates

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Figure 1 - System Architecture June 2011

Figure 2 - Micrologix PLC Files

Figure 3 - Phase 1 RS485 Wiring Diagram
2. Function Design
This section describes the functional design for the project.

2.1 High Level System Architecture
The project shall include equipment installed in six homes to control Immersion Heaters and Storage Heaters. A Central Interface shall be configured at SGS’ Glasgow offices to gather and store information from the six trial homes (via a GPRS link). This server will also provide the capability to remotely interrogate and program the LICs in the six trial homes. Figure 1 shows the final high-level system architecture for the project.

The MicroLogix 1100 PLC (performing the role of the LIC) in each of the trial homes shall be connected to a single Dimplex Immersion Heater Controller and up to three Dimplex Storage Heater Controllers via an RS485 multi-drop serial connection.

The communications path between the central and remote routers will use the Internet and Vodafone 3G/GPRS networks to establish an IPSec tunnel connection. This connection enables secure two-way communication of data for control and logging purposes.

SHEPD requested access to the central router located at SGS’ Glasgow offices. SGS will provide remote access to the central router by provision of Telnet access to SHEPD.
Figure 1 - System Architecture June 2011
2.2 Logical Functionality
This section discusses the means by which various logical functions performed by each LIC shall be achieved.

2.2.1 Setpoint Distribution
Each LIC will connect to a number of controlled loads. In each home in the trial this shall include an Immersion Heater and two or three Storage Heaters. Each of these controllable loads shall have differing characteristics. For example:
- Immersion Heater standing losses shall differ from the Storage Heater standing losses.
- Storage Heaters may have different power ratings (dependent upon the characteristics of the rooms in which they are installed).
- Energy requirements of any given Storage Heater within a given household will differ from the energy requirements of other Storage Heaters within the same household. In general, a large (or poorly insulated) room will have higher energy requirements than a small (or well insulated) room.

It is beneficial that the devices controlled by the LIC exhibit differing operational characteristics because it provides the LIC with the flexibility to distribute an incoming power setpoint across the superset of controlled loads in order to:
- Ensure that the comfort requirements imposed by the householder are met under most circumstances.
- Ensure that any instantaneous power setpoint received from the Central Interface is matched as closely as possible at all times.
- Ensure that the energy transfer requirements of each load are met over any given interval.

During normal operation, the LIC will determine the correct setpoint element from a 24 hour charging schedule. Each daily quarter hour timeslot has a corresponding charging setpoint that will be sent to the Device Controller when the LIC system clock corresponds to the charging schedule time slot.

The LIC shall enable comparison of the setpoint that it commanded of each device with the corresponding Instantaneous Power reported from each Device Controller. If these values diverge then it is an indication that either the Frequency Response or Operational Constraint functions within the Device Controller are active. The Frequency Response function of the Device Controller follows a characteristic Droop Curve sent from the Central Interface. If the frequency of the network strays outside a specified bandwidth, Immersion and Storage heaters will increase or decrease load accordingly to support network stability. Operational constraints of the device control minimum comfort values that override the setpoint sent from the central controller to the Device Controller via the LIC.

2.2.2 Watchdog and Error Handling
The LIC to Device Controller watchdog counters exist for two primary reasons:
- To enable the LIC to inform the Central Interface system of the LIC to Device Controller communications status.
- For the Device Controller to know when to operate in normal or backup mode.

For the Watchdog counters, two values will be passed between the LIC and the Device Controller.
A ‘LIC Watchdog Counter’ will be sent from the LIC to Device Controller and a ‘Device Controller Watchdog Counter’ will be read from the Device Controller by the LIC. Both Watchdogs will only assume communications have been lost if the Watchdog Counter value from the other device has not been updated after 5 minutes. For the LIC, this means a comparison of the ‘Device Controller Watchdog Counter’ will be made and if unchanged a 5 minute timer will initiate. If the watchdog value remains unchanged for the 5 minute period then it will be assumed communications have been lost and a Watchdog Failure will be flagged back to the Central Interface. For the Device Controller, a comparison of the ‘LIC Watchdog Counter’ will be made in a similar manner. If the ‘LIC Watchdog Timer’ times out then the Device Controller will enter a default control state. The default control state of the Device Controller must operate independent of the LIC while satisfying the comfort of the homeowner.

The LIC to ‘Central Interface Controller Watchdog Counter’ exists to enable validation of the logged data. The LIC Watchdog Counter will be sent from the LIC to the Central Interface that hosts the logging functionality. Data is logged with a 60 second period and consequently the central control system will assume communications have been lost if the ‘LIC Watchdog Counter’ has not been updated in 45 seconds. If communications are observed to be down, a Watchdog Flag will be set that informs the operator of the validity of the data for that period. Upon restoration of communications, the ‘LIC Watchdog Counter’ will resume counting and the Watchdog Flag will cease to be set. This will inform the system user that logged data is valid again.

The LIC will also monitor the watchdog counter that it receives from the Central Interface. The LIC will monitor and compare this watchdog and if unchanged initiate a 5 minute timer. If the watchdog value has not changed within this 5 minute timer period the LIC will enter a failsafe mode and revert to operating on default control values.

2.3 Elementary Data Types

This section describes the various elementary data types that shall be used for data transfer between the Central Interface, LICs and Device Controllers. Various data values shall be handled as part of these transfers. In most cases, 16-bit Signed Integers shall be used to store and exchange data values. Each such value shall provide a range of -32,768 - 32,767. Signed Integers are used to simplify the data processing requirements and reduce the load on all communication links. The permissible data type ranges are respected in the handling and definition of all elementary data types.

2.3.1 Setpoint Processing

Load Setpoint

Setpoints shall not be expressed as specific power levels in Watts (since such a solution would be inflexible when used to control disparate devices). Rather, setpoints shall be expressed as a percentage of the rated power of the controlled device. The Day Ahead Charging Schedule held on the LIC will be made up of 96 quarter hourly Load Setpoints. The Raw Setpoint shall represent the value which is transferred and stored by all devices and shall be determined based upon the following formula:

\[
\text{Raw Setpoint} = \text{ROUND} \left( \frac{\text{Desired Power Setpoint}}{\text{Device Rated Power}} \times 10,000 \right)
\]
The multiplier of 10,000 is used to ensure optimum accuracy of the resultant value whilst respecting the bounds of the signed integer used to transfer the Raw Setpoint. It allows for the setpoint to be supplied with a precision of 0.01% of the rated power of the device under control. This shall provide sufficient granularity of control for all practical devices.

For example, consider a device with a rated power of 4 MW where the desired power setpoint is 2.594 MW. In such case, the Raw Setpoint value would be calculated as follows:

\[
\text{Raw Setpoint} = \text{ROUND}\left(\frac{2.594 \, \text{MW}}{4 \, \text{MW}} \times 10,000\right) = 6,485
\]

Note that this setpoint is equivalent to 64.85% of the devices rated power. The resultant Raw Setpoint value may be converted back to a Desired Power Setpoint as follows:

\[
\text{Desired Power Setpoint} = \left(\frac{\text{Raw Setpoint} \times \text{Device Rated Power}}{10,000}\right)
\]

In the preceding example, this may be calculated as:

\[
\text{Desired Power Setpoint} = \left(\frac{6,485 \times 4}{10,000}\right) = 2.594 \, \text{MW}
\]

The permissible raw and engineering setpoint ranges shall be as follows. Positive values shall be used for loads and negative values shall be used for generators:

- **Raw**: \(-10,000 \rightarrow 10,000\)
- **Engineering**: \(-100 \rightarrow 100 \, (\% \text{ of Rated Power})\)

**Active Setpoint Operational**

The Active Setpoint Operational signal is a value that indicates whether the Active Setpoint is taken into account (thus overriding the setpoint from the Day Ahead Schedule or Default Day Ahead Schedule). The Active Setpoint Operational signal may take the values 0 and 1 where:

- **Active Setpoint Disabled** = 0
- **Active Setpoint Enabled** = 1

**Active Setpoint**

The Active Setpoint signal is the value that will be sent to the Device Controller in place of the Day Ahead Schedule Load Setpoint when the Active Setpoint Operational is enabled. Consequently, the Active Setpoint will be represented in a similar way as the Load Setpoint.

The permissible raw and engineering setpoint ranges shall be as follows:
Upper Setpoint Limit
The Upper Setpoint Limit signal is an integer value which indicates the maximum possible load to be used by a device as a percentage of that device’s rated power. This feature is required to manage possible network constraints, e.g. to control loads connected to network feeders where it may not be acceptable to have all the devices connected to that feeder running at full power simultaneously. The Upper Setpoint Limit takes priority over all other forms of control including but not limited to Load Setpoint, Frequency Response and Operational Constraints. The Upper Setpoint Limit is represented in a similar manner to the Load Setpoint value and as such can be represented with similar scaling:

\[
\text{Raw: } -10,000 \rightarrow 10,000 \\
\text{Engineering: } -100 \rightarrow 100 \text{ (% of Rated Power)}
\]

2.3.2 Droop Characteristic Processing
The following section describes the data types that shall be used in conjunction with droop characteristic management.

Droop Characteristic Deadband
A typical Droop Characteristic Deadband is 200 mHz (0.2 Hz) which corresponds to a Deadband of 49.8 · 50.2 Hz. The Droop Characteristic Deadband is not expected to exceed a value of 3 Hz. The Raw Droop Characteristic Deadband represents the value that is transferred and stored by all devices. It shall be determined based upon the following formula:

\[
\text{Raw Droop Characteristic Deadband} = \text{ROUND} (\text{Deadband \times 10,000})
\]

The multiplier of 10,000 is used to ensure the optimum accuracy of the resultant value whilst respecting the bounds of the signed integer used to transfer the Raw Droop Characteristic Deadband. With Deadband specified in Hz, the multiplier allows for the Raw Droop Characteristic Deadband to be supplied with a precision of 0.0001 Hz. This shall provide sufficient granularity of control for all practical devices. For example, the Raw Droop Characteristic Deadband value would be calculated as follows for a desired Deadband of 250 mHz (0.25 Hz):

\[
\text{Raw Droop Characteristic Deadband} = \text{ROUND} (0.25 \times 10,000) = 2500
\]

The resultant Raw Droop Characteristic Deadband is converted back to an engineering Droop Characteristic Deadband (Hz) as follows:

\[
\text{Droop Characteristic Deadband} = \left( \frac{\text{Raw Droop Characteristic Deadband}}{10,000} \right)
\]
In the preceding example, this may be calculated as:

\[
\text{Droop Characteristic Deadband} = \left(\frac{\text{2500}}{10,000}\right) = 0.25 \text{ Hz}
\]

The permissible raw and engineering Droop Characteristic Deadband ranges shall be as follows:

\[
\begin{align*}
\text{Raw: } 0 & \rightarrow 30,000 \\
\text{Engineering: } 0 & \rightarrow 3 \text{ Hz}
\end{align*}
\]

**Droop Characteristic Gradient**

It is possible to represent a Droop Characteristic Gradient using units related to the specific response expected of the device in Watts. Therefore, Droop Characteristic Gradients will be represented according to a percentage of the rated power of the controlled device. The Raw Droop Characteristic Gradient shall represent the value which is transferred and stored by all devices and shall be determined based upon the following formula:

\[
\text{Raw Droop Characteristic Gradient} = \text{ROUND}\left(\left(\frac{\text{Droop Characteristic (W/Hz)}}{\text{Device Rated Power (W)}}\right) \times 1,000\right)
\]

The multiplier of 1,000 is used to ensure the optimum accuracy of the resultant value whilst respecting the bounds of the signed integer used to transfer the Raw Droop Characteristic Gradient. For example, consider the case where a Droop Characteristic Gradient of 4kW/Hz is required of an Immersion Heater with a rated power of 3kW. In such case the Raw Droop Characteristic Gradient would be calculated as follows:

\[
\text{Raw Droop Characteristic Gradient} = \text{ROUND}\left(\left(\frac{4\text{kW/Hz}}{3\text{kW}}\right) \times 1,000\right) = 1,333
\]

Here 133\% of the rated power of the device shall be used (per Hz) for the Droop Characteristic response. Practical loads would not implement a Droop Characteristic Gradient greater than 10x the rated power of the device per Hz. This implies that the maximum value of the Raw Droop Characteristic Gradient would be 10,000.

The resultant Raw Droop Characteristic Gradient may be converted back to an engineering Droop Characteristic Gradient as follows:

\[
\text{Droop Characteristic} = \left(\frac{\text{Raw Droop Characteristic Gradient} \times \text{Device Rated Power}}{1,000}\right)
\]

In the preceding example, this may be calculated as:

\[
\text{Droop Characteristic} = \left(\frac{1,333 \times 3,000}{1,000}\right) = 3,999 \text{ W/Hz}
\]
Note that the calculated Droop Characteristic Gradient of 3.999 W/Hz is not identical to the desired Droop Characteristic Gradient of 4,000 W/Hz. This is simply an artefact of the rounding process that is required in order to make use of signed integers to store and transfer the raw value.

The permissible raw and engineering Droop Characteristic Gradient ranges shall be as follows.

\[ Raw: 0 \rightarrow 10,000 \]
\[ Engineering: 0 \rightarrow 1,000 \text{ (% of Rated Power)}/Hz \]

\subsection*{2.3.3 Commanded Operational Characteristics}

\textbf{Maximum Positive Power Step}

The Maximum Positive Power Step is a limit set to control the positive ramp rate of the controlled device. This rate is set to prevent instantaneous switching of large loads on to the network and avoid the associated network problems that can consequently arise from this, e.g. noise and flicker. The Maximum Positive Power Step can be calculated as follows:

\[ Raw \text{ Maximum Positive Power Step} = ROUND(\text{Percentage of Rated Power Change Per Cycle} \times 100) \]

The multiplier of 100 is used to ensure the optimum accuracy of the resultant value whilst respecting the bounds of the signed integer used to transfer the Raw Maximum Positive Power Step. For example, consider the case where a Maximum Positive Power Step of 5% of rated power per cycle is required for an Immersion Heater with a rated power of 3 kW. In such case, the Raw Maximum Positive Power Step value is calculated as below:

\[ Raw \text{ Maximum Positive Power Step} = ROUND(5 \times 100) = 500 \]

In such case, 500 represents a 5% change in device rated value. The permissible and raw engineering Maximum Positive Power Step ranges shall be as follows:

\[ Raw: 0 \rightarrow 10,000 \]
\[ Engineering: 0 \rightarrow 100 \text{ (% of Rated Power change)/cycle} \]

\textbf{Negative Power Step}

The Maximum Negative Power Step is a limit set to control the negative ramp rate of the controlled device. This rate is set to prevent instantaneous switching of large loads off of the network and avoid the associated network problems that can consequently arise from this, e.g. noise and flicker. The Maximum Negative Power Step can be calculated as follows:

\[ Raw \text{ Negative Positive Power Step} = ROUND(\text{Percentage of Rated Power Change Per Cycle} \times 100) \]
The multiplier of 100 is used to ensure the optimum accuracy of the resultant value whilst respecting the bounds of the signed integer used to transfer the Raw Maximum Negative Power Step. For example, consider the case where a Maximum Negative Power Step of 5% of rated power per cycle is required for an Immersion Heater with a rated power of 3 kW. In such case, the Raw Maximum Negative Power Step value is calculated as below:

\[
\text{Raw Maximum Negative Power Step} = \text{ROUND}(5 \text{ (%/cycle)} \times 100) = 500
\]

In such case, 500 represents a 5% change in device rated value. The permissible and raw engineering Maximum Negative Power Step ranges shall be as follows:

\[
\text{Raw: } 0 \rightarrow 10,000 \\
\text{Engineering: } 0 \rightarrow 100 \text{ (% of Rated Power change)/ cycle}
\]

**Minimum Water Temperature (Immersion Heater Only)**
The Minimum Water Temperature is a configurable value to allow the minimum energy storage capacity of the Immersion Heater to be altered. The LIC will provide this value to the Dimplex Controller in degrees Celsius (°C) with a resolution of 1°C. The Minimum Water Temperature Value will be configurable from the Central Interface.

**Absolute Minimum Water Temperature (Immersion Heater Only)**
The Absolute Minimum Water Temperature value set to prevent the formation of legionnaires disease within the stored water. The LIC will provide this value to the Dimplex Controller in degrees Celsius (°C) with a resolution of 1°C. The Minimum Water Temperature Value will be configurable from the Central Interface.

**Upper Setpoint Limit (Storage Heater Only)**
Storage heaters are permitted to exceed their load set-point, for example when the minimum permitted core temperature has not been reached. The Upper Setpoint Limit value specifies an absolute maximum power consumption which storage heaters are not permitted to exceed. This value is expressed as ±100% of rated power output. To store this value as an integer, the engineering value will be multiplied by 100 to provide accuracy to two decimal places. The raw and engineering values will therefore be as follows:

\[
\text{Raw: } -10000 \rightarrow 10000 \\
\text{Engineering: } -100 \rightarrow 100 \%
\]

**User Setpoint (Storage Heater Only)**
The user setpoint is the minimum allowed core temperature of the storage heater. The valid range of values for this property is 0° to 750°C.
**Average Ambient Outside Temperature (Storage Heater Only)**

The average ambient outside temperature is used by the storage heater charge controller. The valid range of values for this register are -20°C to 50°C. The LIC will store average ambient outside temperatures for the twelve months of the year which can be updated by the Central Interface. The correct value will be selected for the current month to be stored within the Device Controller.

**2.3.4 Static Operational Characteristics Reporting**

Each Dimplex Controller shall be aware of a number of static operational characteristics of the corresponding device under control. An awareness of these characteristics is required in order for the Dimplex Controller to monitor and control the connected device appropriately. Each LIC shall periodically request these values from the connected Dimplex Controllers. Subsequently, each LIC shall store these values, use them to perform logical functions and make them accessible to the Central Interface.

**Device Rated Power**

The rated power of the device connected to each Device Controller shall be expressed in Watts. For the purposes of the trial, the devices under control will not exceed rated power levels of around 5 kW (5000 W). Such values can be stored and transferred using Signed Integers.

**Maximum Energy Storage Capacity**

The Maximum Energy Storage Capacity of the device connected to each Device Controller shall be expressed in Watt-hours (Wh). For the purposes of the trial, the devices under control will not exceed energy capacities of around 24 kWh (24,000Wh). Such values can be stored and transferred using Signed Integers.

**2.3.5 Dynamic Operational Characteristics Reporting**

Various Dynamic Operational Characteristics shall be maintained within each Device Controller representing the dynamic state of the device under control. Each LIC shall periodically request all Dynamic Operational Characteristics from the connected Device Controllers. Subsequently, each LIC shall store these values, use them in logical functions and make them accessible to the Central Interface. The following describes the Dynamic Operational Characteristics that will be retrieved from Dimplex Controllers attached to the Immersion and Storage Heaters.

**Remaining Energy Storage Capacity**

The Remaining Energy Storage Capacity shall not be expressed as a specific Watt Hour value (since such a solution would be inflexible when used with disparate devices). Rather, Remaining Energy Storage Capacity shall be expressed as a percentage of the Maximum Energy Storage Capacity of the device. The Raw Remaining Energy Storage Capacity represents the value that the Device Controller, LIC and Central Interface will transfer and store. It shall be determined based upon the following formula:

\[
\text{Remaining Energy Storage Capacity} = \frac{\text{Raw Remaining Energy Storage Capacity}}{\text{Maximum Energy Storage Capacity}} \times 100\%
\]
The multiplier of 10,000 is used to ensure the optimum accuracy of the resultant value whilst respecting the bounds of the signed integer used to transfer the raw value. It is expected that practical energy storage devices would be unable to store more than 100x the rated power of the controlled device.

For example, consider a 3 kW Immersion Heater that has a Maximum Energy Storage Capacity 24 kWh. If the heater has 50% of the energy storage capacity left, i.e. 12 kWh of Remaining Energy Storage Capacity representation shall be expressed as:

\[
\text{Raw Remaining Energy Storage Capacity} = \text{ROUND}\left(\frac{12 \text{ kWh}}{24 \text{ kWh}} \times 10,000\right) = 5,000
\]

This means that 50% of the device’s energy storage capacity is still available. In this example, the calculation uses kWh. However, it may equally be expressed in Wh, MWh, GWh, etc.

The resultant Raw Remaining Energy Storage Capacity may be converted back to an engineering Remaining Energy Storage Capacity as follows:

\[
\text{Remaining Energy Storage Capacity} = \left(\frac{\text{Raw Remaining Energy Storage Capacity} \times \text{Maximum Energy Storage Capacity}}{10,000}\right)
\]

In the preceding example, this may be calculated as:

\[
\text{Remaining Energy Storage Capacity} = \left(\frac{5000 \times 24 \text{ kWh}}{10,000}\right) = 12 \text{ kWh}
\]

**Temperature**

The Dimplex Controller will provide temperature data in degrees Celsius (°C) with a resolution of 1°C. For Immersion Heaters this shall represent the Immersion Heater Water Temperature. Two separate temperature sensor values will be provided by the Immersion Heater controller. For Storage Heaters this shall represent the Storage Heater Core Temperature.

**Instantaneous Power**

Instantaneous Power shall not be expressed as a specific power levels in Watts (since such a solution would be inflexible when used with disparate devices). Rather, Instantaneous Power shall be expressed as a percentage of the rated power of the controlled device. The Raw Instantaneous Power represents the value that will be transferred and stored by each devices. It shall be determined based upon the following formula:

\[
\text{Raw Instantaneous Power} = \text{ROUND}\left(\frac{\text{Instantaneous Power}}{\text{Device Rated Power}} \times 10,000\right)
\]
The multiplier of 10,000 is used to ensure the optimum accuracy of the resultant value whilst respecting the bounds of the signed integer used to transfer the raw value. It allows the Instantaneous Power to be supplied with a precision of 0.01% of the rated power of the device under control.

For example, consider an Immersion Heater with a rated power of 3 kW where the Instantaneous Power is 2.245 kW. In such case, the Raw Instantaneous Power would be calculated as follows:

\[
\text{Raw Instantaneous Power} = \text{ROUND} \left( \frac{2.245 \text{ kW}}{3 \text{ kW}} \times 10,000 \right) = 7,483
\]

This represents 74.83% of the Device Rated Power. The resultant Raw Instantaneous Power value may be converted back to an engineering Instantaneous Power as follows:

\[
\text{Instantaneous Power} = \left( \frac{\text{Raw Instantaneous Power} \times \text{Device Rated Power}}{10,000} \right)
\]

In the preceding example, this would be calculated as:

\[
\text{Instantaneous Power} = \left( \frac{7,483 \times 3}{10,000} \right) = 2.245 \text{ kW}
\]

The permissible raw and engineering Instantaneous Power ranges shall be as follows:

Raw: \(-20,000 \rightarrow 20,000\)

Engineering: \(-200 \rightarrow 200\) (% of Rated Power)

Charge Controller Maximum Core Temperature
A maximum core temperature value is generated by the storage heater charge controller which is used to limit the maximum allowed core temperature of the heater during the summer. The register has a minimum value of 0° and a maximum value of 750°C.

Room Temperature
The storage heater charge controller will measure the room temperature. The valid range of values for this measurement are between 10 and 50°C.

Charge Controller Fan Status
The storage heater charge controller will generate a value that indicates whether or not the fan is currently operational. This will be a 1 byte value with the least significant bit set to 1 if the fan is on or set to 0 if the fan is off. For storage in the LIC, the value will be converted to a signed integer. The raw and engineering values will therefore be as follows:

Raw: \(0 \rightarrow 1\)

Engineering: 0 (Fan Off) \(\rightarrow 1\) (Fan On)
**User Interface Set-Point**
The storage heater charge controller will generate a value which indicates the set-point currently active on the heater’s user interface. The user interface setting has a minimum value of 0 and a maximum of 8 and therefore the raw and engineering values for this characteristic will be as follows:

\[ \text{Raw: } 0 \rightarrow 8 \]
\[ \text{Engineering: } 0 \rightarrow 8 \]

**Charge Controller Boost Operation Status**
The storage heater charge controller will generate a value if the boost mode is in operation. This will be a single byte value with the least significant bit set to 1 if boost is on or 0 if boost is off. For storage in the LIC, the value will be converted to a signed integer.

**Fan Duct Temperature**
The storage heater will provide a value indicating the fan duct air outlet temperature. This will be a value between 0 and 300°C. The value will be stored using a signed integer.

**2.3.6 Watchdogs and Error Handling**

**Watchdog Counters**
The following counters shall be maintained in order to support the various watchdogs in the system:
- Device Controller Watchdog Counter for each device (maintained within the LIC).
- LIC Watchdog Counter (maintained within the Device Controller and Central Interface).
- Central Interface Watchdog Counter (maintained within the LIC).

**Watchdog Status**
The following watchdog status indicators shall be maintained:
- Device Controller Watchdog Status for each device (maintained within the LIC).
- LIC Watchdog Status (maintained within the Device Controller).
- LIC Watchdog Status (maintained within the Central Interface).
- Central Interface Watchdog Status (maintained within the LIC).

**2.4 Data Schedules**
This section describes the LIC and Device Controller data schedules. Schedules describe the precise information stored in each LIC and each Device Controller as part of the project. All values stored and exchanged by all devices shall be expressed as signed integers. This includes all values stored in (and exchanged between) the Central Interface, LICs and Device Controllers.

Each data point is provided with an associated source and destination where the:
- Source represents the location from whence the data originates.
- Destination represents the location where the data is to be transferred.
The Source and Destination may be:

\textit{ANM}: Indicating that the source or destination for the data point is the Central Interface.
\textit{LIC}: Indicating that the source or destination for the data point is the LIC.
\textit{DC}: Indicating that the source or destination for the data point is the Device Controller.

Data points may have multiple Destinations, e.g. a data point within the LIC may be sent to a connected Device Controller and to the Central Interface.

\textbf{2.4.1 Central Interface Data Schedule}

A Central Interface shall be located in SGS’ Glasgow offices which shall simulate certain aspects of the function of a future ANM controller. This Central Interface shall include a data historian (FactoryTalk Transaction Manager + SQL Server) along with a programming interface (RSLogix 500). The programming interface shall provide the capability to alter the programs running on the LICs in the field. This shall allow manual intervention to simulate and test aspects and operation of a future ANM controller.

This trial is being implemented in each of the six homes in two distinct phases:

\textit{Phase One}: comprises the installation of a single Immersion Heater connected to a LIC.

\textit{Phase Two}: comprises the installation of two or three Storage Heaters connected to a LIC.

An intermediate installation trip will be performed by SHEPD to install remote GPRS enabled routers to provide remote connectivity to the LICs from SGS’s Glasgow office. This trip will be undertaken between Phase One and Phase Two installations.

Table 1 shows the data that shall be sent and retrieved from each LIC covering both Phase One and Phase Two of the trial. All of the data retrieved for Phase One shall also be retrieved as part of Phase Two. The quantities specified in Table 1 are for a single home. Therefore, these figures must be multiplied by six to account for the total storage requirements of the project.

FactoryTalk Transaction Manager and RSLogix 500 shall be configured to communicate with the LICs via the RSLinx package and over the GPRS link. Neither FactoryTalk Transaction Manager nor RSLogix 500 shall be configured to autonomously send commands to the LICs in the field. Any commands will be performed manually by modification of the memory within the LICs using RSLogix 500.
Table 1 - Central Interface Data Schedule

<table>
<thead>
<tr>
<th>Data</th>
<th>Device</th>
<th>Quantity</th>
<th>Type</th>
<th>Raw Range</th>
<th>Eng Range</th>
<th>Eng Units</th>
<th>Source</th>
<th>Dest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day Ahead Schedule</td>
<td>IH</td>
<td>96</td>
<td>Integer</td>
<td>-10,000 → 10,000</td>
<td>-100 → 100</td>
<td>% of Rated Power</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Default Day Ahead Schedule</td>
<td>IH</td>
<td>96</td>
<td>Integer</td>
<td>-10,000 → 10,000</td>
<td>-100 → 100</td>
<td>% of Rated Power</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Day Ahead Schedule</td>
<td>SH</td>
<td>96</td>
<td>Integer</td>
<td>-10,000 → 10,000</td>
<td>-100 → 100</td>
<td>% of Rated Power</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Default Day Ahead Schedule</td>
<td>SH</td>
<td>96</td>
<td>Integer</td>
<td>-10,000 → 10,000</td>
<td>-100 → 100</td>
<td>% of Rated Power</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Active Setpoint</td>
<td>All</td>
<td>1</td>
<td>Integer</td>
<td>0 – 10</td>
<td>0 → 1</td>
<td>N/A</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Active Setpoint Operational</td>
<td>All</td>
<td>1</td>
<td>Integer</td>
<td>0 → 1</td>
<td>0 → 1</td>
<td>N/A</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Device Number</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>1 → 10</td>
<td>1 → 10</td>
<td>N/A</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Load Setpoint</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>-20,000 → 20,000</td>
<td>-200 → 200</td>
<td>% of Rated Power</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Upper Setpoint Limit</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>-10,000 → 10,000</td>
<td>-100 → 100</td>
<td>% of Rated Power</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Droop Characteristic Deadband</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>0 → 50,000</td>
<td>0 → 3</td>
<td>Hz</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Droop Characteristic Gradient</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>0 → 10,000</td>
<td>0 → 1,000</td>
<td>% of Rated Power / Hz</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Default Droop Character Deadband</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>0 → 50,000</td>
<td>0 → 3</td>
<td>Hz</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Default Droop Character Gradient</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>0 → 10,000</td>
<td>0 → 1,000</td>
<td>% of Rated Power / Hz</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Positive Power Step</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>0 → 10,000</td>
<td>0 → 100</td>
<td>% of Rated Power</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Negative Power Step</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>0 → 10,000</td>
<td>0 → 100</td>
<td>% of Rated Power</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Minimum Water Temperature</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>0 → 99</td>
<td>0 → 99</td>
<td>°C</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Absolute Minimum Water Temp</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>0 → 99</td>
<td>0 → 99</td>
<td>°C</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Device Controller Watchdog Counter</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>0 → 32,797</td>
<td>0 → 32,797</td>
<td>N/A</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Device Controller Watchdog Status</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>0 → 1</td>
<td>0 → 1</td>
<td>N/A</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Device Rated Power</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>32,797 → 32,797</td>
<td>32,797 → 32,797</td>
<td>Watts</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Maximum Energy Storage Capacity</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>0 → 32,797</td>
<td>0 → 32,797</td>
<td>Watt Hours</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Remaining Energy Storage Capacity</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>0 → 20,000</td>
<td>0 → 100</td>
<td>% of Maximum Energy Storage</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Temperature</td>
<td>IH</td>
<td>2</td>
<td>Integer</td>
<td>0 → 100</td>
<td>0 → 100</td>
<td>°C</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Instantaneous Power</td>
<td>IH</td>
<td>1</td>
<td>Integer</td>
<td>-20,000 → 20,000</td>
<td>-200 → 200</td>
<td>% of Rated Power</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Device Number</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>1 → 10</td>
<td>1 → 10</td>
<td>N/A</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Load Setpoint</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>-20,000 → 20,000</td>
<td>-200 → 200</td>
<td>% of Rated Power</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Upper Setpoint Limit</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>-10,000 → 10,000</td>
<td>-100 → 100</td>
<td>% of Rated Power</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Droop Characteristic Deadband</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 50,000</td>
<td>0 → 3</td>
<td>Hz</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Droop Characteristic Gradient</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 10,000</td>
<td>0 → 1,000</td>
<td>% of Rated Power / Hz</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Default Droop Character Deadband</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 50,000</td>
<td>0 → 3</td>
<td>Hz</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Default Droop Character Gradient</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 10,000</td>
<td>0 → 1,000</td>
<td>% of Rated Power / Hz</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Positive Power Step</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 10,000</td>
<td>0 → 100</td>
<td>% of Rated Power</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Negative Power Step</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 10,000</td>
<td>0 → 100</td>
<td>% of Rated Power</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Device Controller Watchdog Counter</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 32,797</td>
<td>0 → 32,797</td>
<td>N/A</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Device Controller Watchdog Status</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 1</td>
<td>0 → 1</td>
<td>N/A</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Device Rated Power</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>32,797 → 32,797</td>
<td>32,797 → 32,797</td>
<td>Watts</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Maximum Energy Storage Capacity</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 32,797</td>
<td>0 → 32,797</td>
<td>Watt Hours</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Remaining Energy Storage Capacity</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 10,000</td>
<td>0 → 100</td>
<td>% of Maximum Energy Storage</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Temperature</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 750</td>
<td>0 → 750</td>
<td>°C</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Instantaneous Power</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>-20,000 → 20,000</td>
<td>-200 → 200</td>
<td>% of Rated Power</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>User Setpoint</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 750</td>
<td>0 → 750</td>
<td>°C</td>
<td>ANM</td>
<td>LIC</td>
</tr>
<tr>
<td>Average Ambient Outside Temp</td>
<td>SH</td>
<td>X * 12</td>
<td>Integer</td>
<td>-20 → 50</td>
<td>-20 → 50</td>
<td>°C</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Maximum Core Temperature</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 750</td>
<td>0 → 750</td>
<td>°C</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Room Temperature</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>10 → 50</td>
<td>10 → 50</td>
<td>°C</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Charge Controller Fan Status</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 1</td>
<td>0 → 1</td>
<td>N/A</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>User Interface Set-Point</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 10</td>
<td>0 → 10</td>
<td>N/A</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Boost Operation</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 1</td>
<td>0 → 1</td>
<td>N/A</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Fan Duct Temperature</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>0 → 300</td>
<td>0 → 300</td>
<td>°C</td>
<td>LIC</td>
<td>ANM</td>
</tr>
<tr>
<td>Charge Profile (Accumulated Energy)</td>
<td>SH</td>
<td>X</td>
<td>Integer</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>LIC</td>
<td>ANM</td>
</tr>
</tbody>
</table>

Where X is the number of storage heaters connected to the LIC.
The LIC and Device Controller contain similar data schedules.
2.5 PLC Memory Maps
The functionality of each LIC shall be implemented using a MicroLogix 1100 PLC. A number of “PLC Files” shall be used to store all necessary data within each LIC. Signed Integers shall be stored using N type PLC Files. Each LIC shall include interfaces to the Central Interface and all connected Device Controllers. The Central Interface shall be located at SGS’ Glasgow offices running a historian (SQL Server) and programming software (RSLogix 500). Data shall be exchanged bi-directionally on both the “uplink” and “downlink” interfaces. The following distinct PLC files shall be used within each LIC to store and transfer the required data values:

- N23: Data retrieved from the Device Controllers by each LIC
- N24: Data written to the Device Controllers by each LIC
- N25: Data retrieved from each LIC by the Central Interface
- N26/N28: Data written to each LIC by the Central Interface.

This may be represented graphically as shown in Figure 2:

![Figure 2 - Micrologix PLC Files](image)

Each LIC shall include a function that copies data between these PLC files as required. For example, an Active Setpoint transmitted by the Central Interface will initially be written into the N26 PLC file. This setpoint shall subsequently be analysed by the LIC and a resultant Load Setpoint shall be copied to the N24 PLC file for transmission to the connected Device Controllers. Similarly, data retrieved from the Device Controllers by the LIC shall be written into the N23 PLC file. This data shall subsequently be copied to the N25 PLC file before being retrieved by the Central Interface.

All PLC files will be sized according to the connection of a single Immersion Heater Controller and up to 3 Storage Heater Controllers. The N27 PLC File shall be used to store data which is required for the internal operation of the LIC.

FactoryTalk Transaction Manager shall not be configured to autonomously send commands to the LICs. Rather, the RSLogix 500 software will be used to manually modify the contents of the PLC Files N26 and N28. Changes to the N26 and N28 PLC Files shall be detected by the LIC as having originated in the Central Interface. The LIC shall immediately take into account such changes.
Full details of the PLC Memory maps for each N type file are tabulated in the SGS Functional Design Specification.

2.6 Data Communications
This section describes in detail the data transfer methodology that will be adopted for both the:
- **Uplink**: from the LIC to the Central Interface
- **Downlink**: from the LIC to all connected Device Controllers

2.6.1 Uplink via 3G/GPRS (CIP)
The uplink shall be implemented using CIP (Ethernet), a protocol natively supported by MicroLogix PLCS. Data is retrieved from the MicroLogix PLCS using the RSLinx software package running on the Central Interface. The communications link is supported over a 3G/GPRS link. The communications architecture will use RSLinx as the conduit to provide communications between the Central Interface and the LICs in the field. RSLinx will provide bidirectional transfer of data between these systems in an effectively transparent manner, i.e. the LIC need not consider the details of the underlying CIP protocol.

RSLogix 500 shall be used to manually write commands into the N26/N28 PLC Files via RSLinx. This includes the tasks of updating the Day Ahead Schedule and Droop Characteristics. Similarly, FactoryTalk Transaction Manager will be setup to automatically retrieve all data from the N25 PLC File (via RSLinx) and thereafter store the data in an SQL Server database. FactoryTalk Transaction Manager will be configured to retrieve all data in the N25 PLC File every 60 seconds. This interval may be tuned if it is determined that the desired 60 second period is impractical due to communications latency (or other processing overhead). The system architecture and components necessary to support Uplink communications are displayed in Figure 1.

2.6.2 Downlink via RS485 (Modbus RTU)
The Modbus RTU protocol will be used for the bidirectional transfer of data between the LIC and the connected Device Controllers. In Phase One each LIC shall be connected to a single Device Controller, which shall be assigned the Modbus slave address of 1. In Phase Two each LIC shall be connected to up to four Device Controllers. The Device Controllers shall each be assigned unique Modbus slave addresses from 1 to 4.

The data in the N24 PLC File represents values that will be transferred from the LIC to the Device Controllers across the Modbus link. The data in the N23 PLC File represents the values that are to be transferred from the Device Controllers to the LIC across the Modbus link.

Each data item shall be assigned a unique Modbus holding register address for the purposes of data transfer. For the Storage Heater Device Controllers being implemented in Phase Two, the holding register addresses used for the Modbus commands sent from the LIC to the Device Controller are offset from the addresses used for data retrieved by the LIC from the Device Controller by 100. This provides room for expansion should further feedback data become available from any given Device Controller.
The Modbus protocol does not support the native transfer of Long (32-bit) values. Therefore, where such values are required, they shall be split and transferred using two separate Integer (16-bit) values. The high order bytes shall be placed in the first holding register and the low order bytes shall be placed in the subsequent holding register. This need for Long values has become redundant for the Six Home Trial project and this statement is leftover from the previous requirement when devices with larger storage capabilities may have been controlled.

The Modbus protocol used as part of the trial does not provide support for unsolicited reporting. Consequently, each LIC shall explicitly poll all connected Device Controllers in order to retrieve the requisite data.

The Modbus protocol supports the transfer of either an individual holding register or multiple holding registers within a given command. The transfer of multiple registers within a single command shall reduce communication line loading and the overhead required to process Modbus messages. The LIC shall periodically retrieve data items on every programme scan. It shall retrieve these items using a single “Read Holding Registers” command.

The LIC shall transmit data items to the Device Controller on every programme scan, after a LIC to Device Controller watchdog failure is cleared and during the LIC power-on sequence.

2.6.3 Modbus Device Addressing and DIP Switches
Communication to multiple devices using the Modbus protocol over RS485 requires each device to have a unique Modbus device address. The Modbus Master, in this case the LIC, uses this address to communicate to devices individually. It is necessary for the LIC to be configured according to the total number of devices it will communicate with. Some means must be provided to set a unique Modbus device address on each Device Controller and set the total number of controlled devices on the LIC.

The Modbus standard reserves address number 0 for broadcast.
The Immersion Heater Device Controllers respond to Modbus device address 1.
The Storage Heater Device Controllers will use 4 DIP switches to configure a unique address between 0 and 15, which will actually be set to either 2, 3 or 4 on up to three Storage Heaters installed in each home.
The LIC will be pre-programmed with the number of controlled devices. Future versions of the LIC may use external DIP switches to allow configuration upon installation or re-configuration when new devices are added.

2.6.4 Downlink Bandwidth Analysis
Analysis of the bandwidth requirements for the Modbus RTU RS485 multi-drop downlink between the LIC and the connected Device Controllers assumes the presence of a single Immersion Heater Controller and up to 3 Storage Heater Controllers connected to each LIC. The baud rate used on the RS485 link shall be kept as low as practicable in order to minimise any potential problems with electrical noise and interference. The following analysis dictates the target baud rate that is required for the downlink.
By nature, RS485 supports communications with only a single multi-drop device at any given time. As such, each Device Controller shall be polled in a round-robin fashion by the LIC in order to retrieve the requisite information. There are up to three Device Controllers associated with each LIC. The general message format for communication between a Modbus RTU master and slave is shown in Table 2.

**Table 2 - Modbus General Message Format**

<table>
<thead>
<tr>
<th>Message Header</th>
<th>Data Field</th>
<th>Cyclic Redundancy Check (CRC)</th>
</tr>
</thead>
</table>

The format of the message header is the same for master to slave communications as it is for slave to master communications. For Modbus RTU the message header format is shown in Table 3.

**Table 3 - Modbus RTU Message Header Format**

<table>
<thead>
<tr>
<th>Data</th>
<th>Size (bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slave Address</td>
<td>1</td>
</tr>
<tr>
<td>Function Code</td>
<td>1</td>
</tr>
</tbody>
</table>

The format of the data field differs for requests and responses. A data request message from the master to the slave specifies the starting address and the quantity of registers to be read. Registers are addressed starting from 0. The format of a data request field is shown in Table 4.

**Table 4 - Modbus RTU Data Request Field Format**

<table>
<thead>
<tr>
<th>Data</th>
<th>Size (bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting Address High Byte</td>
<td>1</td>
</tr>
<tr>
<td>Starting Address Low Byte</td>
<td>1</td>
</tr>
<tr>
<td>Number of Registers High Byte</td>
<td>1</td>
</tr>
<tr>
<td>Number of Registers Low Byte</td>
<td>1</td>
</tr>
</tbody>
</table>

A data response message from the slave to the master comprises a byte count specifying the number of bytes to follow, followed by the number of data bytes specified. The format of a data response field for Function Code 03 (Read Holding Registers) is shown in Table 5. The response to Function Code 03 is packed as 2 bytes per register where the first byte contains the high-order bits and the second contains the low-order bits.

**Table 5 - Modbus RTU Data Response Field Format (Function Code 03)**

<table>
<thead>
<tr>
<th>Data</th>
<th>Size (bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Byte Count</td>
<td>2</td>
</tr>
<tr>
<td>Data[0]</td>
<td>2</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Data[Byte Count]</td>
<td>2</td>
</tr>
</tbody>
</table>
Thus, we may derive the following equation for determining the size of a request message for Function Code 03:

\[
\text{Request Size} = \text{size of} (\text{Slave Address} + \text{Function Code} + \text{Starting Address High Byte} \\
+ \text{Starting Address Low Byte} + \text{Number of Registers High Byte} \\
+ \text{Number of Registers Low Byte} + \text{CRC})
\]

Considering that the Cyclic Redundancy Check (CRC) is 2 bytes long we may therefore determine the size of a request for Function Code 03 is as follows:

\[
\text{Request Size} = 1 + 1 + 1 + 1 + 1 + 2 = 8 \text{ bytes}
\]

Note that this request size remains fixed irrespective of the range of addresses that are requested.

We may equally derive the following equation for determining the size of a response message for Function Code 03:

\[
\text{Response Size} = \text{size of} (\text{Slave Address} + \text{Function Code} + \text{Byte Count} + \text{Data} + \text{CRC})
\]

Considering that the CRC is 2 bytes long we may therefore determine the size of a response for Function Code 03 as follows:

\[
\text{Response Size} = 1 + 1 + 2 + \text{size of} (\text{Data}) + 2 = 6 + \text{size of} (\text{Data})
\]

where data is equivalent to the number of registers requested multiplied by 2 (since each register is composed of 2 bytes).

Each entry in Table 6 represents an individual data transfer between a Device Controller and the corresponding LIC. Each entry includes both a request and a response (since unsolicited reporting shall not be used). The LIC shall send an individual request for each required range of registers and wait for the corresponding response before continuing.
Table 6 Downlink Bandwidth Analysis

<table>
<thead>
<tr>
<th>Device</th>
<th>Request</th>
<th>Response</th>
<th>Device Controller Latency</th>
<th>Polling Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Start Address</td>
<td>End Address</td>
<td>Size(^{15})</td>
<td>#Registers</td>
</tr>
<tr>
<td>IH</td>
<td>40001</td>
<td>40008</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>SH #1</td>
<td>40001</td>
<td>40010</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>SH #1</td>
<td>40021</td>
<td>40027</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>SH #2</td>
<td>40001</td>
<td>40010</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>SH #3</td>
<td>40021</td>
<td>40027</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>SUB TOTALS</td>
<td>56</td>
<td>59</td>
<td>141</td>
<td></td>
</tr>
<tr>
<td>IH</td>
<td>40100</td>
<td>40108</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>SH #1</td>
<td>40100</td>
<td>40108</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>SH #2</td>
<td>40100</td>
<td>40108</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>SH #3</td>
<td>40100</td>
<td>40108</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>SUB TOTAL</td>
<td>32</td>
<td>36</td>
<td>84</td>
<td></td>
</tr>
</tbody>
</table>

\(^{15}\) This represents the total number of bytes required for the request sent from the LIC to the Device Controller. This includes all of the Modbus RTU framing information such as headers and trailers, etc. However, it does not include start bits, parity bits and stop bits.

\(^{16}\) This represents the total number of bytes required for the response sent from the Device Controller to the LIC. This includes all of the Modbus RTU framing information such as headers and trailers, etc. However, it does not include start bits, parity bits and stop bits.

Each time that the master transmits a request to the slave, the master shall wait for the corresponding response. For the purposes of this analysis it is presumed that the latency within each Device Controller is 2 ms (the time between the reception of a request and the transmission of the corresponding response).

Therefore, during each 1 second interval the time that the line will be idle (whilst awaiting a response) shall be:

\[ \text{Line Idle Time (Device Controller)} = 14\text{ms} + 8\text{ms} = 22\text{ms} \]

Where the first element (14ms) represents the time delay incurred in processing the 7x read requests sent every second and the second element (8 ms) represents the time delay incurred in processing the 4x write requests sent every second. In addition, there is a line idle time of 2 bytes (16 bits) both before and after each Modbus RTU message (requests and responses). The total number of requests which shall be transmitted per second is:

\[ \frac{\text{Requests}}{\text{Sec}} = 7 + 4 = 11 \]

Therefore, the total number of requests and responses per second is:
Presuming a baud rate of 9,600 baud (bits/sec) and a total line idle time of 2 bytes (16 bits) per message, we may determine the additional idle time per message as follows:

\[
\text{Line Idle Time (Modbus RTU)} = \frac{22 \text{messages} \times 16 \text{bits}}{9,600 \text{bits/sec}} = 37\text{ms}
\]

Thus, the time which remains out of every second for transferring the requisite data is as follows:

\[
\text{Time Remaining} = 1000 - 16 - 37 = 947\text{ms}
\]

Messages shall be transferred across the Modbus multi-drop link using 8 data bits, no parity and 1 stop bit. The character framing for each byte of transmitted data using Modbus RTU without parity is shown in Table 7. The 8 bits of the data byte are transmitted from the Least Significant Bit to the Most Significant Bit.

### Table 7 - Modbus RTU Character Framing

<table>
<thead>
<tr>
<th>Start</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>Stop</th>
</tr>
</thead>
</table>

Thus, it can be seen that for each byte of data (8 bits) there are an extra 2 bits of framing information which must also be transmitted (start bit, parity bit and stop bit).

Based on the data in Table 6 we may deduce the number of bytes which shall be transferred across the multi-drop Modbus RTU RS485 downlink channel every second as follows:

\[
\text{Bytes} = 56 + 151 + 32 + 84 = 323
\]

This figure must then be increased by a factor which takes into account the extra 2 bits of framing information which must be transmitted along with each byte of data in order to determine the actual number of bits which must be transmitted:

\[
\text{Bits} = (323 \times 8) + (323 \times 2) = 3,230
\]

Finally, we may deduce the number of bits per second which shall be transferred across the multi-drop Modbus RTU RS485 downlink channel as follows (taking into account the line idle times as previously determined):

\[
\frac{\text{Bits}}{\text{Sec}} = \frac{3,230}{0.957} = 3375
\]
Typical baud rates for serial communications are as follows:

Table 8 - Typical Baud Rates

<table>
<thead>
<tr>
<th>Baud Rate</th>
<th>Baud Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200 baud</td>
<td>19,200 baud</td>
</tr>
<tr>
<td>2400 baud</td>
<td>38,400 baud</td>
</tr>
<tr>
<td>4800 baud</td>
<td>57,600 baud</td>
</tr>
<tr>
<td>9600 baud</td>
<td>115,200 baud</td>
</tr>
</tbody>
</table>

As such, a baud rate of 9,600 shall be employed on the downlink between the LIC and the attached Device Controllers. This shall provide sufficient bandwidth to support the data transfer requirements with a single Immersion Heater and the 3 Storage Heaters. For reference purposes, it should be noted that RS485 supports up to 32 multi-drop devices. Therefore, if a future configuration were to connect more than 4 Device Controllers to a single LIC then the calculations in this section would need to be revisited and it is likely that a higher baud rate would need to be adopted.

2.7 Software Components and Configuration

SGS shall procure an engineering laptop to act as the Central Interface Controller for the purposes of the trial. The engineering laptop will be located at SGS’ Glasgow offices for the duration of the six home trial period. This engineering laptop shall:

- Run a historian which shall be used to gather real-time data from the 6 PLCs in the field.
- Provide the capability to remotely update the 6 PLCs in the field.

The following software shall be installed on the engineering laptop:

2.7.1 SQL Server 2008 R2 Express (32-bit)

- http://www.microsoft.com/express/database/
- This shall be used as the repository for all historical data. The product is free.

2.7.2 FactoryTalk Transaction Manager Standard Edition (P/N: 9356-STD2350)

- http://www.rockwellautomation.com/rockwellsoftware/data/transmgr/
- This shall be used to extract data from LIC controllers (using the RSLinx Classic OPC Control Connector) and to transfer the data to SQL Server (using ODBC).
- This product is available with licenses for 150, 300, 1500 or 5000 tags. A license for 5000 tags shall be procured for the trial. This will allow for the retrieval and storage of all desired data.
- OS Support: XP SP2, Server 2003 SP2.
2.7.3 RSLinx Classic (P/N: 9355-WABSNENE)
βhttp://www.rockwellautomation.com/rockwellsoftware/design/rslinx/
βThis shall be used as the conduit to retrieve data from the 6x MicroLogix PLCs and transfer the data to FactoryTalk Transaction Manager.
βIt shall also be used as the conduit to program the PLCs using RSLogix 500.
βThe integrated “RSLinx Classic OPC Control Connector” shall be used to transfer data with FactoryTalk Transaction Manager.

2.7.4 RSLogix 500 Standard (P/N: 9324-RL0300ENE)
βhttp://www.rockwellautomation.com/rockwellsoftware/design/rslogix500/
βThis shall be used to program the MicroLogix PLCs remotely and to manually change settings and parameters within the PLCs, e.g. Manual changes to the Day Ahead Schedule stored within the PLCs.
βNotably, a copy of “RSLinx Classic Lite” is included with RSLogix 500 Standard. However, this does not meet the requirements of the project since it does not provide OPC server support.
Windows XP Professional is supported by all of the aforementioned suites and shall be installed on the laptop for the purpose of the trial.

2.8 Hardware Components and Configuration
The following describe a number of hardware components of the system and the manner in which such components shall be configured.

2.8.1 Hardwired Inputs
The LIC shall have no hardwired inputs. Future versions of the LIC will have a hardwired input, possibly a DIP switch, to configure the number of connected Device Controllers. All inputs for the project will be communication signals.

2.8.2 RS485 Serial Communications
A 2-wire RS485 multi-drop link shall be established between each LIC (MicroLogix PLC) and the corresponding Dimplex Immersion and Storage Heater Controllers. Figure 3 shows the means by which this connection shall be established. For the connection of multiple devices the Modbus connection will be multi-dropped along the RS485 connected to each device.

2.8.3 LIC - MicroLogix PLC
An Allen Bradley MicroLogix 1100 PLC will be used as the platform to implement the LIC in each of the six homes. Rockwell Automation’s, the manufacturer of the PLC, proprietary software RSLogix 500 will be used to program and download the functional code onto the PLC.
2.8.4 Central Controller
The Central Interface (a pre-cursor to the Central ANM System) will be implemented on an engineering laptop. The Central Interface will be installed with software capable of remotely programming the LIC, altering Operational Control values, logging supervisory data and storing that data in a database.

2.8.5 Communication Routers
The remote and central communication routers for the Domestic DSM communications will be provided and configured by SHEPD. SGS will facilitate the connection of this router into their Glasgow office network.

Figure 3 - Phase 1 RS485 Wiring Diagram
The Modbus circuit board on the Dimplex Immersion Heater Controller shall be powered by the 24V supply on the PLC which is accessible via 2x terminals (not part of the 8-pin mini DIN connector). The Dimplex Storage Heater Controllers shall be powered by their own supplies.
A multi core RS485 cable shall be used to connect the LIC and Dimplex Controllers via the 8-pin mini DIN socket on the PLC. The cores shall be allocated as follows:
1. GND (Brown)
2. DATA + (Black)
3. DATA – (Blue)
Appendix III

Statement of Good Practice
STATEMENT OF GOOD PRACTICE

This Statement of Good Practice confirms our commitment to standards and customer service.
Contents

Introduction 2
Trials 3
Contacting the Customer 3
Privacy Policy 4
Visiting the Customer’s Property 6
Passwords 8
Keeping Appointments 8
Interruptions to the Customer’s Supply 8
How We Can Be Contacted 9
Introduction

Scottish and Southern Energy Power Distribution ("SSEPD") is the trading name of Scottish Hydro Electric Power Distribution plc and Southern Electric Power Distribution plc.

We look after the safe delivery of electricity through the electricity distribution network to the customer’s home. Through the Low Carbon Network Fund (LCNF) we are striving to improve the distribution network currently in use. By using innovative processes and working with new technologies, we aim to improve value to stakeholders and help the UK transition to a low carbon economy.

The following Statement of Good Practice is used to outline our commitment to aiding the customer throughout each stage of the trials.
Trials

The projects we will be undertaking as part of the LCNF will trial new technologies, operational practices and novel commercial arrangements to identify how best we can reduce carbon emissions in line with our own and Government targets.

The aim is to involve the customer with our trials allowing them to help develop the future of our network. The trials will provide us with the opportunity to test up and coming technologies and see how we can use them to adapt the network that we use today.

During these trials we will ask the customer to aid us in getting the best out of the installed technologies and with their consent, we will obtain data to help analyse what effect the technologies have on our network. Wherever possible, the trials will also be aimed at saving the customer money through a new, more efficient use of our network.

Contacting the Customer

Throughout the trials we will be in contact with the customer to discuss the various stages that will affect them.

Initial contact will be via letter to inform the customer of the trials. If feasible, we will offer to visit the customer to explain the project in person. If the customer has any concerns regarding the trials, they can call the number provided on the project information letter for further information. Consent will be sought from the customer to use anonymous data for the purposes of managing the system and to generate learning. We will send a copy of our Statement of Good Practice along with the consent form to advise the customer what they can expect from us and how they can contact us throughout the trial.

We will explain all aspects of the project’s use of the customer’s data, who will have access to it and for what purposes, how long the data will be held for, and the customer’s rights with regards to access and opting out of the projects.
Once we have received the customers consent, we will contact them via their preferred communication method. For telephone calls, we will aim to contact the customer within 5 working days of the receipt of the consent to discuss the next stage of the trial. If they wish to be contacted via post we will aim to respond to their consent within 10 working days.

Throughout the trials we will contact the customer to arrange appointments for installation, maintenance, upgrade and, in some cases, de-commissioning of the equipment. Such appointments will be made with the customers consent and we will provide them with at least 5 working days notice prior to any works taking place.

During all our communication with the customer we will be logging the information within our communications plan. The communication plan will be in place to record all communications between ourselves and the customer, including records of the customers' consent.

Contacting your Supplier
If the work we are doing is likely to have an impact on the customer’s supplier OR has the potential to conflict with works being carried out by their supplier we will contact the supplier direct to inform them of our activity.

**Privacy Policy SSEPD**

We are committed to ensuring that the customer’s privacy is protected. This privacy policy explains how we use the information we collect about the customer and how they can instruct us if they prefer to limit the use of that information.

For the purposes of the Data Protection Act 1998, the Data Controller/Processor is Scottish and Southern Energy plc (SC117119) having its registered address at Inveralmond House, 200 Dunkeld Road, Perth PH1 3AQ and its group of companies.

The University of Strathclyde (SC015263), having its address at 16 Richmond Street, Glasgow, G1 1XQ will also act as a Data Controller/Processors and Hjalttland Housing Association (SC031954), 2 Harbour Street, Lerwick, Shetland, ZE1 0LR.
1. The information we collect and how we use it

(a) All information gathered, such as customer contact details and energy usage will not be provided to any other 3rd party or SSE business unit outside the scope of the project that the customer has consented to participate in.
(b) We will use the information from the customer to assess how the network is reacting to the changes made by the technologies installed in their property.
(c) We will aggregate information and statistics for the purposes of monitoring the customer’s energy usage and mapping it against network demand. These statistics will not include information that can be used to identify any individual, or specific household.
(d) We will not collect more information from you than is required.

2. How we protect your information

(a) We endeavour to take all reasonable steps to protect the customer’s personal data against unauthorised or unlawful processing, accidental loss by storing all information in secure drives.
(b) We will also keep the customers information confidential. Our internal procedures cover the storage, access and disclosure of their information.

All information will be managed in accordance with SSE’s data protection policy and information handling guidelines summarised as:

- Only individuals with a direct requirement to access the data for the purposes of the project will be given access to do so. This access will be revoked as soon as it is no longer needed.
- Customer’s data will not be shared internally with other business units.
- Customer’s data will not be shared with business partners or sub-contractors unless it is in direct relation to work on the project.
- Customer data will only be retained for the specified period, after which it will be removed from all SSE systems.
- Any business partner who had access to customer data for the purpose of the project will be required to adhere to these rules.

A full copy of the policy and guidelines is available on request.
3. Sale of business

If this business is sold or integrated with another business the customers details may
be disclosed to our advisers and any prospective purchasers and their advisers and
may be passed on to the new owners of the business.

4. Updating your details

If the customer moves home or requires any of their details updated, they should
inform us by sending an email to NINES@sse.com or sending a letter to Customer Liaison, Future Networks and Policy, SSE Power Distribution Plc, Inveralmond House, 200 Dunkeld Road, Perth, PH1 3AQ.

5. Customers consent

By submitting information the customer consents to the use of that information as set
out in this privacy policy. If we change our privacy policy we will inform the customer
of the changes and give them an opportunity to opt out if the changes are not acceptable.

6. Access to information

The customer has the right under the Data Protection Act 1998 to access the
information we hold on them. However the majority of this data will be collected anonymised, and hence unavailable soon after collection. Due to the research nature of the project certain data may be unavailable as per section 33 of the DPA.

Visiting the Customer’s Property

During the trials there will be times when we will need to visit or require access to the customers’ property for installation, maintenance and, in some cases, de-
commissioning of the equipment. For these instances, with the exception of emergencies, we will contact the customer in advance. Furthermore, should the customer identify an issue with the installed equipment we may require access to their property for repair work to be completed.

We have a code of practice in place so that the customer can be sure that all visits are made by properly trained, genuine staff or contractors. All of our employees and contractors will carry an identity card showing their company’s trading name, their own name and a colour photograph of the individual.
Where possible, all vehicles used for visits to the customer’s premises will carry the SSEPD or contractor’s logo.

Where possible, all SSEPD employees will wear clothing indicating they are from SSEPD.

All SSEPD employees and contractors will be able to inform the customer of the emergency telephone number as well as the enquiries number upon request.

SSEPD employees will be able to give the customer an explanation and information on matters relevant to the purposes of their visit.

Should an external contractor be used on behalf of us, they will adhere to this code of conduct. The customer will also be informed that we will be using an external contractor and will receive all the relevant information i.e. name, contact details etc.

When a representative leaves the employment of the company, or when an identity card has expired, we make sure the card is returned and then destroyed.

If the customer has any doubts about whether a caller is genuine, they should not let them into their home.

We will ensure that our employees and contractors are aware of the contents of this code and will comply with it at all times. Our staff will be suitable, appropriately qualified and fully trained for the purpose of the visit and will be calm and courteous at all times in their dealings with the customer and give clear and accurate explanations as well as respecting their premises. We may also visit on behalf of suppliers to install, change, maintain or read the customer’s meter. If we do we will also abide by the suppliers code of practice that includes similar safeguards.
Passwords

We can agree a password with the customer when we make an appointment. The customer can choose a password and agree it with us. We will only give their password to our representatives who need to know it. They will say the customer’s personal password when they call so the customer can be sure the caller is genuine. We provide services for blind or partially sighted customers. We can provide any information in large print, Braille and on audio tape, on request.

Keeping Appointments

We carry out our appointments within normal working hours, which are usually 8am to 6pm Monday to Friday. If this is not convenient, we will call at a reasonable time outside these hours by agreement with the customer. If we agree an appointment with the customer, we will do our best to keep it, however if we have to re-arrange an appointment, we will work with the customer to agree a suitable alternative.

Interruptions to the Customer’s Supply

In some instances during the trials the customers supply may be interrupted to allow for work to take place safely. When we have to cut off the electricity supply to carry out work to install or remove appliances we will agree times and dates with the customer in advance.

We will contact the customer via an appropriate communication method to advise them about a planned interruption to the electricity supply at least 5 days in advance. If the customer depends on electricity for special medical equipment (e.g. kidney dialysis or oxygen concentrators) or have other special needs they can contact us to discuss their situation. We will aim to keep any disruption to a minimum.

If the customer requires any further information or advice about a specific planned interruption, they can contact us using the phone number on the top of the notification letter we send out advising of the interruption.
How We Can Be Contacted

If the customer has any queries and would like to talk about the project that they are participating in, they can contact:

*
Appendix IV

Safety Documentation
Trial Evaluation of Domestic Demand Side Management

Pre-Installation Site Report
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1 - Introduction

Phase two of the trial evaluation of Domestic Demand Side Management (DDSM) covers the installation of new storage heaters in six homes on the Shetland network. A programme of work shall be carried out in the week commencing 13th June 2011.

Inspection of the six properties has taken place by Scottish & Southern Energy Power Distribution (SSEPD), Hjaltland Housing Association (HHA), Westside Electrical Services (WES) and Glen Dimplex. This inspection seeks to assess the risks and issues that might affect the safe delivery of the works programme. The purpose of this Pre-Installation Site Report (PSR) shall be to highlight these risks to all parties and set out how they shall be controlled.

The PSR shall therefore be used as a **Stage 1 Risk Assessment** for the project and should be thoroughly reviewed before commencing work.

2 - Site Inspection

All stakeholders should be familiar with the six homes from the work carried out in phase one of the project. Photographs of the existing storage heating configuration can be found at Section 4. A general risk assessment was also carried out.

The homes at * and * have steps leading up or down to the property from the car park. This shall add complexity to the **manual handling** of the equipment and increase the risk of **slips, trips and falls** occurring. Additional trip hazards were also present in the home, some of which cannot be removed – such as a child safety gate – and as such extra care should be taken at all times.

Hatches will be removed to carry out wiring back to the Dimplex Controller and will require **working in confined spaces**. * is an upstairs flat therefore wiring will be installed by **working in loft spaces**. During both circumstances additional time should be allocated for each task required.

Working in a domestic property introduces additional hazards to a customer’s home. Compounded by the fact that a large working party will be carrying out the work in a small home with **customers, children and pets** these risks are increased further. Compared to the Water Cylinder installation, where work could be carried out in a tank and meter cupboard, the Storage Heater installation is a lot more ‘invasive’. Work will be carried out in the customer’s main living areas therefore greater emphasis should be put on customer safety briefs.

The **control of substances hazardous to health (COSHH)** shall be applied if the use of hazardous substances is required. Each substance shall be accompanied by a material safety data sheet and a COSHH assessment.

**Avoiding working live** presents another risk. Correct procedures for isolating the load and removing the main fuse – if required – should be followed and all mandatory PPE worn.

The controls for all these risks are presented in Section 3.
### 3 - Stage 1 Risk Assessment

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Control Measures</th>
<th>Further Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manual Handling</strong></td>
<td>- Manual handling training. &lt;br&gt;- Assess each lift. &lt;br&gt;- Use of appropriate lifting techniques. &lt;br&gt;- Use of PPE as per matrix.</td>
<td>Read and follow Method Statement Appendix B.</td>
</tr>
<tr>
<td><strong>Slips, Trips and Falls</strong></td>
<td>- Wear Appropriate Footwear. &lt;br&gt;- Remove trip hazards or take extra care where not possible. &lt;br&gt;- Keep work area even, clean and tidy. &lt;br&gt;- Clear up spillages immediately.</td>
<td>Read and follow Method Statement Appendix C.</td>
</tr>
<tr>
<td><strong>Working in Confined Spaces</strong></td>
<td>- Allocate extra time for each task.</td>
<td>None.</td>
</tr>
<tr>
<td><strong>Avoiding Working Live</strong></td>
<td>- Work in accordance with Distribution Safety Rules. &lt;br&gt;- Appropriate authorisation and training. &lt;br&gt;- Use of correct tools. &lt;br&gt;- Follow correct procedure for isolating load and removing main fuse. &lt;br&gt;- Use of PPE as per matrix.</td>
<td>Read and follow Method Statement Appendix D.</td>
</tr>
<tr>
<td>Hazard</td>
<td>Control Measures</td>
<td>Further Actions</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>Drilling Near Concealed Cables</td>
<td>✅ Identify position of any concealed cables or pipes before drilling/chasing walls or floors.</td>
<td>Read and follow Method Statement Appendix E.</td>
</tr>
<tr>
<td>Hazardous Substances</td>
<td>✅ Use substance only when a Material Safety Data Sheet (MSDS) and COSHH assessment has been obtained and consulted.</td>
<td>Read and follow Method Statement Appendix F.</td>
</tr>
<tr>
<td>Working in Loft Spaces</td>
<td>✅ Carry out a pre-task risk assessment in accordance with Method Statement Appendix G.</td>
<td>None.</td>
</tr>
<tr>
<td></td>
<td>✅ Use of crawling boards if necessary.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>✅ Use of PPE as per matrix.</td>
<td></td>
</tr>
<tr>
<td>Customers, Children &amp; Pets</td>
<td>✅ Follow Method Statement Appendix H regarding customer safety briefs.</td>
<td>Stay alert to changing conditions.</td>
</tr>
</tbody>
</table>
4 - Existing Storage Heater Configuration

4.1

- Hall

- Sitting Room
4.2

- Kitchen
- Sitting Room
- Hall
4.3

* – Hall

* – Sitting Room
4.4 •

• – Hall

• – Sitting Room
* – Sitting Room

* – Hall
4.6

* – Hall

* – Sitting Room
Method Statement

For

Trial Evaluation of Domestic Demand Side Management

At

6 Homes, Lerwick, Shetland
CONTENTS

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1 Purpose

The purpose of this Method Statement is to ensure that all work specified for the Trial Evaluation of Domestic Demand Side Management (DDSM) is carried out in a controlled manner that ensures consistency of working practices and quality whilst minimising the risk of injury or damage. Its basis shall apply to all work carried out by Scottish and Southern Energy Power Distribution (SSEPD) staff and/or contractors under their control. This Method Statement shall be taken as guidance, and its content used either in whole or in part for on site activities.

2 Project Information

The Trial Evaluation of DDSM seeks to install highly efficient immersion water cylinders, storage heaters and communications equipment in six homes. Delivery of the project was split into two phases. In Phase 1, the water cylinder and communications equipment were installed. This method statement focuses on Phase 2, the storage heater installation.

<table>
<thead>
<tr>
<th>Site Address: 6 Homes, Lerwick, Shetland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Works Programme: 5 Days</td>
</tr>
<tr>
<td>Monday 13th June *</td>
</tr>
<tr>
<td>Tuesday 14th June *</td>
</tr>
<tr>
<td>Wednesday 15th June *</td>
</tr>
<tr>
<td>Thursday 16th June *</td>
</tr>
<tr>
<td>Friday 17th June *</td>
</tr>
<tr>
<td>Normal Working Hours: 08:30 – 17:00 hours, Monday – Friday</td>
</tr>
</tbody>
</table>
3 Roles and Responsibilities

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Point of Contact</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SSEPD</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Manager:</td>
<td>Alistair Steele</td>
<td>▶ Overall running of project.</td>
</tr>
<tr>
<td>Site Supervisor:</td>
<td>Nathan Coote</td>
<td>▶ Ensuring adequate resources are available to progress works safely and efficiently.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Making sure good channels of communication exist at all levels between contractor, customer and other interested parties.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Site supervision as required.</td>
</tr>
<tr>
<td><strong>Hjaltland Housing Association</strong></td>
<td>Paul Leask</td>
<td>▶ Commercial arrangements for works.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Customer’s first POC.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Facilitating access to customer premises.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Decommissioning of existing heating systems.</td>
</tr>
<tr>
<td><strong>E&amp;H Building Contractors</strong></td>
<td>Bobby Elphinstone</td>
<td>▶ Principle Contractor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Accepting delivery and storage of Energy Storage Heaters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ All joinery as required.</td>
</tr>
<tr>
<td><strong>Westside Electrical Services</strong></td>
<td>Bryden Irvine</td>
<td>▶ Subcontractor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Installation of thirteen Storage Heaters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ All wiring as specified by SSEPD and Glen Dimplex.</td>
</tr>
<tr>
<td><strong>Smarter Grid Solutions</strong></td>
<td>Ryan Sims</td>
<td>▶ Testing of SGS supplied control equipment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Site commissioning of SGS supplied control equipment.</td>
</tr>
<tr>
<td><strong>Glen Dimplex</strong></td>
<td>Damian Shields</td>
<td>▶ Design &amp; production of thirteen Storage Heaters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Testing and certification to all relevant standards.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Delivery of thirteen Storage Heaters to principle contractor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Providing necessary training for installation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▶ Providing operating instructions and demonstration to customer.</td>
</tr>
</tbody>
</table>
4    Safety, Health and Environment

4.1    Legislative and Statutory Provisions

Craft trades require a significant amount of information to help them carry out their duties safely to exacting technical and standards. The main legislative and statutory requirements are listed below:

- Health & Safety at Work Act 1974
- Management of Health & Safety at Work Regulations 1999
- Electricity at Work Regulations 1989
- Electricity Safety, Quality and Continuity Regulations 2002
- Control of Substances Hazardous to Health (COSHH)
- Construction Regulations 1996
- Provision & Use of Work Equipment Regulations (PUWER) 1998
- Personal & Protective Equipment Regulations 1992
- Noise at Work Regulations 2005
- Construction, Design, Management Regulations (CDM) 2007
- Reporting of Injuries & Dangerous Occurrences Regulations (RIDDOR)
- Lifting Operations & Lifting Equipment Regulations (LOLER) 1998
- Workplace (Health, Safety & Welfare) Regulations 1992
- Confined Spaces Regulations 1997
- Environmental Protection Act 1990
- The Construction (Head Protection) Regulations 1989

4.2    Risk Assessment

Risk assessment is the first step towards accident prevention. To control and formalise the risk assessment process, SSEPD use the Injury Prevention Process (IPP) – 4 stages which must be completed by stakeholders working on site.

Stage 1 – The Planning Stage

All relevant stakeholders will have visited the customer’s homes to familiarise themselves with the work required and obtain advance notice of the known hazards before arriving on site to work.
Based on these findings SSEPD shall issue a *Pre-Installation Site Report* and an *IPP Form* for completing stages 2-4.

**Stage 2 – Pre-Task Risk Assessment**

All contractors intending to work on site MUST review the *Pre-Installation Site Report* and confirm you have done so by completing the appropriate section on the *Pre-Work Checklist* (see Appendix I). This should be repeated on a daily basis.

Next carry out a full risk assessment of the work using the following risk assessment procedure:

- Identify hazards present but not previously recorded.
- Decide who might be harmed.
- Evaluate the risks involved (i.e. the likelihood of a hazard causing you or others harm) and decide if the existing precautions are adequate or if more should be done to:
  - Eliminate
  - Reduce
  - Isolate or
  - Control

the risks by using the correct working methods, PPE and other safety equipment.

- Record your findings and action taken.
- Review your assessment from time to time.

Record your findings and Controls that you have implemented on your IPP form.

**Stage 3 – Continual Risk Assessment**

Every time you do something or complete a task during your job, think about

- Are you doing this safely?
- Are the controls you have implemented still working?
- Are you using the correct working methods and PPE?
- Do you need to stop and review the task/again?
- Has the situation changed?

Record your findings and actions on your IPP form.

**Stage 4 - Feedback**

Use this part of your IPP form to record any information you think SSEPD needs to know that may help assess the effectiveness of controls or identify repetitive hazards. This may save someone else from having an accident. On completion of each job the IPP form should be returned to the Site Supervisor.
4.3 **First Aid**

The nominated first aider for the duration of the works is Nathan Coote.

4.4 **Incident Reporting**

The procedure for reporting an accident or incident is located at Appendix L.

4.5 **Contingency Plans**

In the event of unforeseen circumstances which may cause a change to the method of work detailed in this method statement or may be detrimental to the safe continuation of site operations, then work will be stopped. A re-assessment of the work to be carried out will be undertaken and recorded. This Method Statement shall then be updated to reflect these changes or a new Method Statement shall be written as appropriate. Any changes to the method of work must be communicated and understood by all those involved.

4.6 **Personal Protective Equipment**

The minimum Personal Protective Equipment (PPE) to be used in conjunction with the Injury Prevention Process is specified at Appendix A. All PPE must be maintained in good condition, checked before use and always available.

4.7 **Safe Systems of Work**

Establishing safe systems of work is a key objective of this method statement. The following table outlines the location of relevant safety information which all contractors working on site should be familiar with:

<table>
<thead>
<tr>
<th>Safe Systems of Work</th>
<th>Appendix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual Handling</td>
<td>B</td>
</tr>
<tr>
<td>Slips, Trips and Falls</td>
<td>C</td>
</tr>
<tr>
<td>Avoiding Working Live</td>
<td>D</td>
</tr>
<tr>
<td>Drilling Near Concealed Cables</td>
<td>E</td>
</tr>
<tr>
<td>COSHH</td>
<td>F</td>
</tr>
<tr>
<td>Working In Loft Spaces</td>
<td>G</td>
</tr>
<tr>
<td>Customer Safety Briefs</td>
<td>H</td>
</tr>
</tbody>
</table>

Prior to commencing work on site, a Pre-Work Checklist should be completed. This is located at Appendix I.
5 Method

β Dimplex shall design, produce and test thirteen Energy Storage Heaters to all relevant certifiable standards.
β Dimplex shall deliver the thirteen Energy Storage Heaters to Shetland with delivery and storage acknowledged by E&H.
β Dimplex shall produce operating instructions for the Storage Heaters with input from HHA and SSEPD. These shall be left at the customer’s home.
β HHA shall arrange access to customer properties for the working party as per the agreed Programme of Work.
β All relevant stakeholders shall visit the 6 Homes to familiarise themselves with the work and the risks involved. SSEPD shall produce a Stage 1 Risk Assessment and distribute to all stakeholders.
β Dimplex shall provide suitable training for E&H and WES.
β All stakeholders shall sign the Method Statement at – or prior to – 0800 on Monday 13th June.

For each of the 6 Homes:
β WES shall collect and take responsibility for pass keys and cabinet keys from HHA.
β The working party on site shall complete a stage 2 risk assessment, pre-work checklist and stage 3 risk assessment as appropriate.
β WES shall safely isolate all heating circuits.
β E&H shall lift floor hatches as required.
β WES shall remove the existing Storage Heaters and transport to HHA store at the Old Water Works.
β HHA shall take responsibility for decommissioning of the existing heating system.
β WES shall carry out all wiring in the home as specified by Dimplex (see Appendix J – Energy Storage Heater and Appendix K – Immersion Water Cylinder).
β WES shall fit the new Storage Heaters and connect cables (see installation instructions and detailed wiring instructions sent separately).
β WES shall connect the Storage Heaters to the 24 hour heating circuit and label this change clearly.
β E&H shall carry out all necessary joinery work to fittings and furnishings.
β WES shall carry out an earth loop impedance test on the heaters.
β WES shall complete the Electrical Installation Minor Works Certificate for the electrical work carried out.
β SGS shall test the controller is working correctly and commission accordingly.
β SSEPD shall download temperature data from the logger installed in the home.
β The working party shall remove all tools and materials and leave the customer’s premises neat and tidy.
β Dimplex shall communicate how to use the Storage Heaters to the customer if appropriate.
β WES shall secure the property if it is unoccupied and return keys to HHA.
6 Declaration

By signing this method statement, each stakeholder agrees to adhere to its contents at all times. SSEPD will not be liable for injury or damage caused by failing to comply with this method statement and may take legal action against those accordingly.

Method Statement prepared by:

Signed Date

Print Name Nathan Coote
Project Engineer

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Signed</th>
<th>Print Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSEPD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hjaltland Housing Association</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E&amp;H Building Contractors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Westside Electrical Services</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Smarter Grid Solutions</td>
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<td></td>
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<tr>
<td>Glen Dimplex</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
### 7 Appendices

#### Appendix A PPE

The following table shows the MINIMUM PPE required for each task. Should a combination of tasks be required you will need to wear all the PPE listed in the appropriate rows.

<table>
<thead>
<tr>
<th>TASK</th>
<th>Hard hat</th>
<th>Bump cap</th>
<th>Safety glasses</th>
<th>Safety goggles</th>
<th>Visor</th>
<th>Kevlar gloves</th>
<th>Rigger gloves</th>
<th>Electrical gloves</th>
<th>Long leather gloves</th>
<th>Long sleeved shirt/boiler suit</th>
<th>Ear defenders or plugs</th>
<th>Fall arrest harness</th>
<th>Toolbelt</th>
<th>FP 3 Dustmask</th>
<th>Hi – viz jacket</th>
<th>Safety footwear</th>
<th>Knee pads</th>
<th>Disposable overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working in loft spaces</td>
<td></td>
<td>Y</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>O</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>O</td>
<td></td>
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<tr>
<td>Working from steps&lt;2mtrs from ground</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>Y</td>
<td>Y</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Working from steps &gt;2mtrs from ground</td>
<td>Y</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>Y</td>
<td>Y</td>
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<td>Working on ladders</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td></td>
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<tr>
<td>Working at or above eye level e.g. removing light fittings</td>
<td>O</td>
<td>Y</td>
<td>Y</td>
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<td>Y</td>
<td>Y</td>
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<tr>
<td>Chasing walls, floors etc</td>
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<td>Y</td>
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<td>O</td>
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<td>Drilling walls, joists etc</td>
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<td>O</td>
<td>Y</td>
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<td></td>
</tr>
<tr>
<td>Work in dusty/dirty areas</td>
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<td>A</td>
<td>A</td>
<td>Y</td>
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<td>O</td>
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<td>Y</td>
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<tr>
<td>Using noisy equipment</td>
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<td>A</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>O</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Working in or near roads</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>Y</td>
<td>Y</td>
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</tr>
<tr>
<td>Handling heavy/sharp items</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Using grinding/sawing equipment</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>O</td>
<td>Y</td>
<td>Y</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>Removing/replacing main fuse links</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>Y</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Working on materials containing asbestos</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Other general tasks</td>
<td>A</td>
<td>A</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
</tbody>
</table>

Y = Minimum requirements

O = Normally required but may be risk-assessed off

A = Alternatives either/or as long as one is worn
Appendix B  

Manual Handling

Poor risk assessment and poor manual handling techniques are by far the greatest cause of accidents and injuries to the spine, hernias, fractures and wounds to other parts of the body. Back injuries in particular are painful, debilitating and often long term or even permanent.

In common with all the other tasks you undertake, risk assessment is the first and most vital process. When completing a risk assessment for a manual handling task there are 4 key factors to consider:

<table>
<thead>
<tr>
<th>Task</th>
<th>Some tasks such as lifting, carrying and lowering can be more strenuous than pushing or pulling. Is there a need to twist? How far do you need to carry the load? Can this be reduced?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>The stature and fitness of a person has a bearing on their ability to handle loads manually. Strength is not enough on its own. Experience and training are far more important.</td>
</tr>
<tr>
<td>Load</td>
<td>The weight, size, shape and condition of the packaging must be assessed. Small heavy loads can often present fewer risks can large light loads. Does the packaging help or hinder you? Can you remove it? Is there any information on the packaging which may help you?</td>
</tr>
<tr>
<td>Environment</td>
<td>Distance, terrain, space available, number of steps and floor covering may all contribute to fatigue and the temptation to break the manual handling rules you have been taught. Look out for tripping hazards, restricted spaces and children, pets or adults in the area.</td>
</tr>
</tbody>
</table>

The techniques of safe lifting and handling are summarised below:

- **Stop and Think:** Before you start, concentrate and plan the task.
- **Unlock the Knees:** This releases pressure on your knees and lower back.
- **Position feet Correctly:** Place your feet flat on the ground and approx. hip width apart with one foot facing the direction you wish to travel.
- **Getting Down:** Bend the knees and tuck your chin in. Do NOT bend from the hips.
- **Hand Grip:** Use palms and roots of your fingers. Do not use your fingertips.
- **Test the Load:** Lift one corner to test the weight. Know your limitations and do not exceed them.
- **The Lift:** Bring your head up, use your thigh muscles, keep arms straight and the load close to your body.
- **Position of Load while Carrying:** Keep your elbows close to your body and arms straight. With good palm grip and footwork the effort required will be greatly reduced.
- **Do Not Twist:** Turn your whole body at the same time by positioning your lead foot first. Turn from the feet not the shoulders.
- **Suitable PPE:** Ensure correct PPE is worn and provides adequate protection for task.
- **Putting the Load Down:** Putting the load down is as important as picking it up. Ensure a good stable base and bend using knees, not the hips.
Appendix C  Slips, Trips and Falls

Slips trips and falls are the most common cause of major injuries at work. The main causes of which are:

- Walking over uneven ground, particularly when carrying large or unwieldy and awkward objects.
- Tripping over building material not stacked correctly or waste material carelessly disregarded.
- Tripping over trailing cables.
- Slipping caused by wet, gritty or icy surfaces.
- Falling over due to soft and poor ground conditions.
- Trips caused by small or sudden changes in level.

Preventing an accident requires all those working on site to take responsibility for their own and others health and safety. The following shall be adopted at all times:

- Wear suitable footwear.
- Ensure you have adequate lighting available.
- Remove trip hazards or take extra care where this is not possible.
- Make sure your work area is even and clean.
- Safely store cables.
- Clear up spillages immediately.
- Consider safety measures for customers.
Appendix D   Avoiding Working Live

Live work can only be carried out by electricians who have been authorised to do so in accordance with Scottish and Southern Energy’s Code of Practice or the Distribution Safety Rules. Electricians are not authorised and must not work on or with live equipment.

Precautions should be taken to ensure all equipment and circuits you are planning to work on are correctly isolated and cannot be switched on without your consent. It is common practice to remove the main fuse during work on the meter, meter tails or consumer unit.

The golden rule is: - **The load MUST be isolated before the main fuse is removed.**

Before removing the fuse you must carry out a risk assessment of the task and consider the following:

- The condition of the cut-out?
- The correct method of ensuring the load is isolated when the fuse is removed?
- Are there any unauthorised connections to the tails, cut-out or meter?

Do **NOT** remove the main fuse if:

- The cut-out shows signs of heat damage or is damaged – Contact SSE and ask them to attend to it for your customer.
- There are some unauthorised connections to the cut-out – Contact SSE and ask them to investigate as soon as possible.
- For any reason you cannot be certain the load is disconnected.

Despite completing your risk assessment, there is still a real possibility of a very dangerous flashback. Whilst this is a rare occurrence, if it happens it is very likely you would suffer from serious burns and/or loss of sight. It is therefore vital you are wearing the correct PPE when removing or replacing ALL main fuses.

**Procedure for removing the main fuse**

- Complete your inspection and risk assessment as above.
- Carry out a polarity check and isolate all load.
- Ensure you have adequate lighting before and after the main fuse is removed and you are wearing long sleeved clothing.
- Break the seal then apply your safety visor and electrical gloves. If there is a chance of mechanical damage to your gloves, wear your leather overgloves on top of your electrical gloves.
- Remove the main fuse.
Procedure for replacing the main fuse

- Complete your inspection and risk assessment as above.
- Ensure all load is still isolated.
- Ensure you have adequate lighting and you are wearing long sleeved clothing.
- Apply your safety visor and electrical gloves. If there is a chance of mechanical damage to your gloves, wear leather overgloves on top of your electrical gloves.
- Replace the main fuse then re-energise the load.
- Carry out a polarity check.

Isolating Circuits, Appliances and Accessories

Again it is vital that you carry out a risk assessment of the task and consider the following:-

- What is the correct method of ensuring the circuit is isolated?
- How you will ensure the circuit cannot be re-energised without your consent?
- How you will check the circuit when the fuse is removed?

Having completed your risk assessment the following procedure should be completed:

- Identify the circuit to be isolated.
- Switch off any significant load on the circuit.
- Identify the correct fuse, MCB or RCD to be removed or switched off.
- Check your test lamp on a known live supply.
- Test the circuit to be isolated.
- Isolate the circuit and test it.
- Re-check your test lamp against a known live supply.
- Use a locking device to ensure the circuit cannot be re-energised. Alternatively remove the fuse and keep it with you until you wish to replace it.
- If necessary, fit your yellow notice - ‘Danger, Live Apparatus’ or red notice - ‘Caution, Do Not Interfere With This Point of Isolation’ to the consumer unit or isolation switch.

NOTE: It is often necessary to gain access to live connections, terminals etc to test your test lamp. Extreme care must be taken to avoid any contact with them.
Appendix E  Drilling Near Concealed Cables

When drilling or chasing into a wall, floor or ceiling it is possible that there is a concealed cable or pipe is in close proximity to the area. Consequently there is a significant risk of you damaging the cable or pipe or even come into contact with a live cable.

‘Safe zones’ are described in the IEE regulations as areas in which cables can be run at a depth below 50mm without installing additional protection from mechanical damage. It is therefore most likely that these are the areas that will contain any concealed cables. Drilling/chasing within them should be avoided if at all possible.

If it is necessary to drill within a ‘safe zone’ you must firstly carry out your risk assessment and isolate any hazards as described in the next section.

Example of Safe Zones

The Risk Assessment

Objective - To identify the positions of any concealed cables or pipes before you drill/chase walls or floors so you can eliminate the hazards and risks associated with coming into contact with them.

Before drilling/chasing, ask yourself the following questions:

- Do you need to drill into an area where it is possible there are concealed cables/pipes?
- Are there any electrical accessories or surface pipes level with or directly above/below the area you wish to drill/chase?
Are you drilling in the ‘safe zone’ as defined by the IEE Regulations where it is deemed safe to conceal unprotected cables? (see ‘Avoiding Safe Zones’ above)

If you wish to drill in a ‘safe zone’, can you identify the route the cables/pipes take? - Remove accessories and/or check for other clues that they may be concealed in the area e.g. filled-in chases, cables/pipes/trunking showing at top or bottom of wall.

If cables are likely to be close to the area you wish to drill/chase, can you identify their precise position by using your detector (see ‘Using Cable Detectors’ below) so you can avoid drilling close to them?

If you can't identify the precise position of the cables/pipes you must:

Consider drilling elsewhere where you are reasonably certain there are no cables / pipes. Isolate the electrical / water supply before drilling.

Use your experience and judgement to make a decision where you will drill.

Ensure all supplies in this property are 30mA protected via your temporary supply board.

**Using Cable Detectors**

Cable detectors can be used to identify the precise position of a cable/pipe. Their accuracy in doing this will depend upon the depth the cables are concealed. Use them to confirm the routing of a cable/pipe but do not rely on them alone to confirm there are none in the area - other checks have to be made as well.
Appendix F  COSHH

Using chemicals or other hazardous substances at work can put your health at risk. The law requires employers to control exposure to hazardous substances to prevent ill health.

Hazardous Substances

Three types of substances we are likely to come into contact with:

- Substances used directly in work activities e.g. silicone sealant.
- Substances generated during work activities e.g. plaster or brick dust.
- Naturally occurring substances e.g. bacteria.

Effects of Hazardous Substances

Effects of hazardous substances include:

- Skin irritation
- Breathing problems
- Loss of consciousness
- Cancer
- Infection
- Blindness

COSHH Requirements

To comply with COSHH regulations employers must follow all eight important steps:

- Assess the risks.
- Decide what precautions are needed.
- Prevent or adequately control exposure.
- Ensure control measures are used and maintained.
- Monitor the exposure.
- Carry out appropriate health surveillance.
- Prepare plans and procedures to deal with accidents, incidents and emergencies.
- Ensure employees are properly informed, trained and supervised.

Before working with any hazardous substance, a COSHH assessment must be carried out. This will require obtaining a Material Safety Data Sheet (MSDS) for the substance you want to use. The supplier of the product is obliged by law to provide a MSDS to anyone who requests one.

SSEPD use the Sypol COSHH Management System to prepare their COSHH assessments and shall for the duration of the works be happy to assist with providing COSHH assessments to contractors if required.
Appendix G Working in Loft Spaces

Working in roof spaces is effectively working at height. The work involves some of the most significant hazards and risks likely to be experienced in a domestic property.

This is because the ceiling material between the joists is not capable of supporting your weight. If you were to slip and fall between the joists you would fall 8ft or more to the floor below and could seriously injure yourself.

*It is therefore vital that you carry out your pre-task risk assessment before you start work.* You must then evaluate the risks and decide what you must do to ensure you have safe places to tread/walk/kneel/sit and:

- Eliminate;
- Reduce;
- Isolate or;
- Control the risks.

Hazards to consider in a roof space are:

- The size and likely strength of the joists – *Will they hold your weight? Are there any signs of damage or woodworm which would weaken them?*

- The space between the joists – *This varies greatly and may affect the security of your footholds and number of contact points you can have on the joists.*

- Overhead obstructions – *Low beams, protruding nails etc*

- Insulation – *Can conceal the joists and cables or an obstruction which you may trip over.*

- Customer’s belongings – *Particularly hazardous if there is a large amount in an unboarded loft.*

- Lighting – *Is there a loft light? If not you will need to ensure you provide adequate lighting.*

- Temperature – *How hot is it in the roof space? In the summer you may need to take frequent breaks and drink plenty of water to avoid becoming fatigued.*

- Poor wiring, exposed connections, broken joint boxes etc – *All of which may be concealed but you could inadvertently touch them whilst you are moving around the loft and installing new cables.*

The standard rule regarding 3 points of contact on steps & ladders still apply to roof spaces. You should use your feet, hands and knees or arms to achieve this regardless of the position you are working in.

If you are kneeling or sitting down, try to use 2 joists instead of one to support your weight. This will also reduce the risk of you falling between the joists.

Obviously you cannot usually avoid working in a loft space but you may be able to eliminate some hazards if you avoid working in difficult areas by fishing cables etc.
You may be able to **reduce or isolate** the hazards by:

- Clearing obstructions from the work area.
- Providing adequate lighting.
- Removing some insulation.
- Isolating the existing wiring.
- Wearing the correct PPE.
- Using crawling boards etc.

### Crawling Boards

These are designed to fit across 2 joists with the minimum of overhang. They may be fixed by screwing them to the joists with at least 2 screws in the pre-drilled holes. If necessary you may drill additional hoes in the boards to match varying distances between joists. The boards do not need to be fixed if you need to move them around a lot (e.g. rewiring lighting) but extra care must be taken if they are not.

Use crawling boards whenever you identify significant slip, trip or fall hazards such as:

- Thin, widely spread joists.
- Woodworm in joists.
- Difficult access and cluttered areas.
- Heavy work, large items to be fixed or moved.
- Long periods of work in one area.

Because of the varying distance between joists, there may be an area of the boards that overhangs them. Do not put your weight on this area even if you have screwed the boards down.
Appendix H Customer Safety Briefs

Working in a domestic property introduces additional hazards to a customer’s home. Customers often do not heed advice given to them as they do not realise the safety implications involved with having electrical work completed in their home whilst they and other members of the family etc are present. As a result, accidents occur which could be avoided.

We have a responsibility to ensure, as far as reasonably practical, the health and safety of everyone in the property.

Accidents shall be eliminated by making the occupants of the property fully aware of the hazards associated with the work you will be completing and agree any precautions or actions required by you and your customers to: Eliminate, Reduce, Isolate or Control them.

Having arrived at the property, discussed the work with your customer and carried out your 1st stage IPP with a general risk assessment of the work, you will now be sufficiently aware of the work to be done and the hazards involved. The briefing must then be completed BEFORE you start work or bring in tools and materials to the property.

There is no strict method of carrying out the briefing but you must ensure you tactfully explain the risks and controls required for any of the following that are relevant:

- **Storage of tools and equipment** - Agree where they can be stored safety.

- **Work areas** - Explain where you will be working and ask your customer to refrain from entering those areas or let you know if and when access is essential. Remember to explain and use appropriate hazard warning signs.

- **Floorboards removed** - One of the most serious hazards for your customer which must be explained and eliminated by ensuring they know they should not enter areas where boards are removed.

- **Extension leads, cables** etc - These may be laid on the floor in several places at once and can easily be tripped over.

- **Dustsheets** - If laid incorrectly they can be a trip hazard that must be controlled.

- **Carpets lifted, furniture moved** - All are trip hazards your customers need to be aware of.
Other occupants, children & pets - They all need to be controlled. Remember children may come home from school whilst you are working and need to be briefed as soon as they arrive. Steps and ladders can be particularly tempting for any budding climbers.

Electricity switched off - Discuss the implications with equipment, e.g. Computers and ensure you keep your customer informed when it is necessary to switch the electricity off. If it is dark and there is no means of lighting, ask them to sit in one place until it is restored.

In many cases the brief may only take 1-2 minutes.

Additional hazards may occur as work progresses so it's vital you stay alert to changing conditions, keep risk assessing, review your precautions and keep your customer informed throughout the course of your work.
## Appendix I  Pre-Work Checklist

The following questions must be answered prior to ANY WORKS commencing:

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you have a completed Stage 1 Risk Assessment?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you understand it?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you completed a Stage 2 Risk Assessment?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are all those involved aware of and understand its findings?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have the control measures been implemented?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are all persons on site competent in their assigned task?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the appropriate tools and equipment on site for the assigned task?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are they fit for purpose and if necessary calibrated or certificated?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have all necessary 3rd party permissions been sought and given?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you have, and are you wearing the appropriate Personal Protective</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment for the task?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can you carry out the works whilst maintaining the safety of yourself,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>your colleagues, third parties and the public?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you read the method statement and signed the acceptance form</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>confirming that you understand the requirements set out?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If you have answered “no” to any of the above questions **DO NOT START WORK**, take the appropriate actions to rectify the situation.

When you have answered every question (if applicable) with “yes”, then proceed.

**Remember, the safety of everyone will always be the number one priority.**
Appendix J  Wiring Diagram for Dimplex Energy Storage Heaters

All wiring to be installed as per local wiring regulations.

- **Live Conductor**
- **Neutral Conductor**
- **Earth**
- **Modbus cable**

**Consumer Unit**

**Dimplex Wall mounted controller**

- **Existing Wiring from consumer unit to spur units.**
- **Modbus Wiring - 3 Core screened cable.**
  - Modbus cable should not run in close proximity to mains cables.

- **Modbus cable screening on the in and out cables to be crimped together**

Wiring from spur unit into heater should have a minimum temperature rating of T85 and should be sized accordingly for high temperature ambient conditions.

Each heater shall be isolated using a Double Pole spur with neon indicator - Fuse rating as per local requirements.
Wiring for Dimplex Water Cylinder Controller

All wiring to be installed as per local wiring regulations.

- Double Pole spur with neon indicator - Fuse rating as per local requirements.
- 2 Core thermistor cable
- Top immersion element - 3kW
- Lower element 1 - Rating 750W
- Lower element 2 - Rating 750W
- Lower element 3 - Rating 1500W

3 Core Flex - cable sizing depending on element rating and cable rating.

Existing Wiring
### Appendix L  Incident Reporting

**Your Actions if something goes wrong.....**

**Deal with the immediate risks** – treat the injured; make the area safe; initiate emergency plans.

| 112 or 999 | Emergency Services |
| 0800 300 999 | Electrical Emergency Calls to Control |

**Secure the area** to preserve evidence for the investigation.

and then **within 30 minutes** of a serious accident or incident call:

| * | Potential Lost Time |
| * | HSE Reportable Incidents |
| * | Class 1 RTC |
| * | Any ELECTRICITY or HP STEAM incident |
| * | Significant Environmental Incidents |

and then contact one of the below:

| * | Nathan Coote Project Engineer |
| * | Alistair Steele Project Manager |
| * | Frank Clifton NINES Development Project Manager |
| * | Stewart Reid Head of Future Networks and Policy |
| * | Alan Broadbent Head of Engineering |

**MAKE POSITIVE CONTACT** DO NOT RELY ON VOICE MESSAGES OR EMAILS

**Site Location & contact details:**

| Site Address | Site Telephone |
| * | * |

**Electrical Emergency**

Loss of supplies, contact with, damage to, or any signs of distress in plant or equipment.

**Potential Lost Time Injuries**

If the extent of the injury requires the person to be taken off site for treatment or it is suspected that the person will not be able to carry out their normal duties.

**HSE Reportable Injuries**

Certain types of injury must be reported to the HSE immediately via SSE

**Class 1 Road Traffic Collisions (RTCs)**

Vehicle speed during incident more than 20mph, Vehicle leaves the road, vehicle overturns, any occupant or pedestrian is taken to hospital for treatment and load being towed by SSE vehicle leaves the road, overturns or breaks free

**Communication with the HSE, Scottish Environmental Protection Agency (SEPA) or the Environmental Agency (EA)**

All communications with the above external agencies must be routed through SSE.
Appendix V
Commissioning
MINOR ELECTRICAL INSTALLATION WORKS CERTIFICATE
(REQUIREMENTS FOR ELECTRICAL INSTALLATIONS — BS 7671 [IEE WIRING REGULATIONS])

To be used only for minor electrical work which does not include the provision of a new circuit

Copyright © The Electrical Contractors' Association of Scotland
The Electrical Contractors' Association
This certificate is not valid if the number is defaced or altered

PART 1: DESCRIPTION OF MINOR WORKS

1. Description of the minor works.

2. Location/Address.

3. Date minor works completed.

4. Details of departures, if any, from BS 7671:2008

PART 2: INSTALLATION DETAILS

Tick boxes as appropriate

1. System earthing arrangements (where known) TN-C-S □ TN-S □ TT □

2. Method of fault protection

   Automatic disconnection of supply

   Other □

3. Protective device for the modified circuit

   Type: ........................................ Rating: ...................... A

Comments on existing installation, including adequacy of earthing and bonding arrangements: (see Regulation 131.8):

PART 3: ESSENTIAL TESTS

Tick boxes as appropriate

Earth continuity satisfactory □

Insulation resistance:

Live/live: ........................................... MΩ (where practical)

Live/earth: ........................................... MΩ

Earth fault loop impedance (Zs): ..................................... Ω

Polarity satisfactory □

RCBO/RCD operation (if applicable). Rated residual operating current Iₘᵦ: ......... mA and operating time of: ........... ms (at Iₘᵦ)

INSTRUMENTS USED

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Type</th>
<th>Serial Number</th>
<th>Date Accuracy Verified</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PART 4: DECLARATION

I/WE CERTIFY that the said works do not impair the safety of the existing installation, that the said works have been designed, constructed, inspected and tested in accordance with BS 7671:2008 (IEE Wiring Regulations), amended to: ............... and that the said works, to the best of my/our knowledge and belief, at the time of my/our inspection, complied with BS 7671 except as detailed in Part 1 above.

Name: ........................................... Signature: ...........................................

For and on behalf of: ........................................... Position: ...........................................

Address: ........................................... Date: ...........................................
MAINS PRESSURE HOT WATER STORAGE SYSTEM COMMISSIONING CHECKLIST

This Commissioning Checklist is to be completed in full by the competent person who commissioned the boiler as a means of demonstrating compliance with the appropriate Building Regulations and then handed to the customer to keep for future reference.

Failure to install and commission this equipment to the manufacturer’s instructions may invalidate the warranty but does not affect statutory rights.

Customer Name _______________________________________________________________________

Telephone Number ___________________________________________________________________

Boiler Make and Model __________________________________________________________________

Boiler Serial Number ___________________________________________________________________

Commissioned by (print name) ___________________________________________________________________

CORGi ID Number ___________________________________________________________________

Company Name _____________________________________________________________________________

Company Telephone Number __________________________________________________________________

Company Address _________________________________________________________________________

Commissioning Date _______________________________________________________________________

To be completed by the customer on receipt of a Building Regulations Compliance Certificate:

Building Regulations Notification Number (if applicable) ________________________________

ALL SYSTEMS PRIMARY SETTINGS (indirect heating only)

Is the primary circuit a sealed or open vented system?  ________________

Sealed ☐  Open ☐

What is the maximum primary flow temperature? ________________ °C

ALL SYSTEMS

What is the incoming static cold water pressure at the inlet to the system? ________________ bar

Has a strainer been cleared of installation debris (if fitted)? Yes ☐ No ☐

Is the installation in a hard water area (above 200ppm)? Yes ☐ No ☐

If yes, has a water scale reducer been fitted? Yes ☐ No ☐

What type of scale reducer has been fitted? _______________________________________________________________________

What is the hot water thermostat set temperature? ________________ °C

What is the maximum hot water flow rate at set thermostat temperature (measured at high flow outlet)? ________________ l/min

Time and temperature controls have been fitted in compliance with Part I of the Building Regulations? Yes ☐

Type of control system (if applicable) YPlan ☐ SPlan ☐ Other ☐

Is the cylinder solar (or other renewable) compatible? Yes ☐ No ☐

What is the hot water temperature at the nearest outlet? ________________ °C

All appropriate pipes have been insulated up to 1 metre or the point where they become concealed Yes ☐

UNVENTED SYSTEMS ONLY

Where is the pressure reducing valve situated (if fitted)? _______________________________________________________________________

What is the pressure reducing valve setting? ________________ bar

Has a combined temperature and pressure relief valve and expansion valve been fitted and discharge tested? Yes ☐ No ☐

The hot and discharge pipework have been connected and terminated to Part G of the Building Regulations Yes ☐

Are all energy sources fitted with a cut out device? Yes ☐ No ☐

Has the expansion vessel or internal air space been checked? Yes ☐ No ☐

THERMAL STORES ONLY

What store temperature is achievable? ________________ °C

What is the maximum hot water temperature? ________________ °C

THERMAL STORES ONLY

The hot water system complies with the appropriate Building Regulations Yes ☐

The system has been installed and commissioned in accordance with the manufacturer’s instructions Yes ☐

The system controls have been demonstrated to and understood by the customer Yes ☐

The manufacturer’s literature, including Benchmark Checklist and Service Record, has been explained and left with the customer Yes ☐

Commissioning Engineer’s Signature

Customer’s Signature

(to confirm satisfactory demonstration and receipt of manufacturer’s literature)

*All installations in England and Wales must be notified to Local Authority Building Control (LABC) either directly or through a Competent Persons Scheme.

A Building Regulations Compliance Certificate will then be issued to the customer.

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www.centralheating.co.uk
Appendix VI

Frequency Response Test Plan
Test Plan
For
Frequency Response Testing
Trial Evaluation of Domestic Demand Side Management
Lerwick, Shetland
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1 Objectives

The objective of these Works is to carry out grid frequency response testing of new Glen Dimplex devices. The tests aim to determine the rate of response and prove the functionality of each device prior to a large roll out.

2 Site Address and Programme

| Site Address: | * |
| Works Programme: | 1 Day – 27th August 2012 |

3 Roles and Responsibilities

SITE

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Point of Contact</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSEPD</td>
<td>Nathan Coote</td>
<td>§ Method statement and test plan. § Site access and risk assessment. § Ensuring adequate resources are available to progress works safely and efficiently. § Making sure good channels of communication exist at all times.</td>
</tr>
<tr>
<td>SSEPD</td>
<td>Martin Lee</td>
<td>§ Safely connecting PQM to hot water cylinder and storage heaters for testing. § Setting up PQM to capture test results and analysing data.</td>
</tr>
</tbody>
</table>

SUPPORT

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Point of Contact</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSEPD</td>
<td>Graham Irvine</td>
<td>§ Modifying network frequency in conjunction with SVT as per test plan.</td>
</tr>
<tr>
<td>Smarter Grid Solutions</td>
<td>Liam MacIsaac</td>
<td>§ Updating Droop Characteristics and Load Setpoints as instructed by SSEPD.</td>
</tr>
</tbody>
</table>
4 Test Plan

4.1 Hot Water Cylinder

The Power Quality Monitor (PQM) shall be connected to the hot water cylinder. SGS shall update the Setpoint and Droop Characteristics as instructed. The LPS Control Room Supervisor shall increase the network frequency to 50.3 Hz and decrease the frequency to 49.7 Hz as required for each test. Frequency will be maintained at these limits for just a few seconds before returning to ~50 Hz.

Test 1 – No Deadband – 100% Load / Hz

<table>
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<tr>
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<tbody>
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<td>Upper Load Setpoint</td>
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<tr>
<td>Droop Deadband</td>
<td>0</td>
<td>0 Hz</td>
</tr>
<tr>
<td>Droop Gradient</td>
<td>1000</td>
<td>100%/Hz</td>
</tr>
<tr>
<td>Maximum Positive Power Step</td>
<td>10000</td>
<td>100%/Cycle</td>
</tr>
<tr>
<td>Maximum Negative Power Step</td>
<td>10000</td>
<td>100%/Cycle</td>
</tr>
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</table>

Anticipated result – This test simulates both over and under frequency events. Droop Gradient is set at 100%/Hz or 2625 W/Hz. With no Deadband set, the system should recognise a frequency excursion of 0.3Hz. Therefore at 50.3Hz, there should be a corresponding load increase of 30%. At 49.7Hz there should be a corresponding load decrease of 30%. Based on the Dimplex Group number assigned to the water cylinder (9) the device should increase load to 71.42% (1875W) and decrease load to 14.29% (375W).
**Test 2A – 100mHz Deadband – 1000% Load / Hz**

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<tbody>
<tr>
<td>Active Setpoint Operational</td>
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<tr>
<td>Droop Deadband</td>
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</tr>
<tr>
<td>Droop Gradient</td>
<td>10000</td>
<td>1000%/Hz</td>
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<td>Maximum Negative Power Step</td>
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</tbody>
</table>

Anticipated result – This test simulates an over frequency event. Droop Gradient is set at 1000%/Hz or 26250 W/Hz. Deadband is set at 100mHz therefore the system should recognise a frequency excursion of 0.2Hz. The test should show load has increased from 0% to 100% (2625W) by 50.2Hz.

**Test 2B – 100mHz Deadband – 1000% Load / Hz**

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<tbody>
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</tr>
<tr>
<td>Active Setpoint</td>
<td>10000</td>
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<tr>
<td>Upper Load Setpoint</td>
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</tr>
<tr>
<td>Droop Deadband</td>
<td>1000</td>
<td>0.1 Hz</td>
</tr>
<tr>
<td>Droop Gradient</td>
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<td>1000%/Hz</td>
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<tr>
<td>Maximum Positive Power Step</td>
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<td>100%/Cycle</td>
</tr>
<tr>
<td>Maximum Negative Power Step</td>
<td>10000</td>
<td>100%/Cycle</td>
</tr>
</tbody>
</table>

Anticipated result – This test simulates an under frequency event. Droop Gradient is set at 1000%/Hz or 26250 W/Hz. Deadband is set at 100mHz therefore the system should recognise a frequency excursion of 0.2Hz. The test should show load has decreased from 100% to 0% (0W) by 49.8Hz.
**Test 3A – 100mHz Deadband – 400% Load / Hz**

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<td>Droop Deadband</td>
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<tr>
<td>Maximum Negative Power Step</td>
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<td>100%/Cycle</td>
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</tbody>
</table>

Anticipated result – This test simulates an over frequency event. Droop Gradient is set at 400%/Hz or 10500 W/Hz. Deadband is set at 100mHz therefore the system should recognise a frequency excursion of 0.2Hz and a corresponding change in load of 80%.

Based on the Dimplex Group number assigned to the water cylinder (9), at 50.3Hz the test should show load has increased from 0% (at 50.1Hz) to either 85.71% (2250W) or 71.42% (1875W).

**Test 3B – 100mHz Deadband – 400% Load / Hz**

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<tr>
<td>Droop Deadband</td>
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<td>Droop Gradient</td>
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Anticipated result – This test simulates an under frequency event. Droop Gradient is set at 400%/Hz or 10500 W/Hz. Deadband is set at 100mHz therefore the system should recognise a frequency excursion of 0.2Hz and a corresponding change in load of 80%.

Based on the Dimplex Group number assigned to the water cylinder (9), at 49.7Hz the test should show load has decreased from 100% (at 49.9Hz) to 14.29% (375W).
4.2 Storage Heaters

The Power Quality Monitor (PQM) shall be connected to both storage heaters. SGS shall update the Setpoint and Droop Characteristics as instructed. The LPS Control Room Supervisor shall increase the frequency to 50.3 Hz and decrease the frequency to 49.7 Hz as required for each test. Frequency will be maintained at these limits for just a few seconds before returning to ~50 Hz.

Test 4 – No Deadband – 100% Load / Hz

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<tr>
<td>Maximum Negative Power Step</td>
<td>10000</td>
<td>100%/Cycle</td>
</tr>
</tbody>
</table>

Anticipated result – This test simulates both over and under frequency events. Droop Gradient is set at 100%/Hz. With no Deadband set, the system should recognise a frequency excursion of 0.3Hz. Therefore at 50.3Hz, there should be a corresponding load increase of 30%. At 49.7Hz there should be a corresponding load decrease of 30%. Based on the Dimplex Group numbers assigned to the storage heaters – living room (3), hall (5) – both devices should increase load to 66.66% (1600W and 1300W respectively) and decrease load to 0%. 
Test 5A – 100mHz Deadband – 1000% Load / Hz

<table>
<thead>
<tr>
<th>Raw</th>
<th>Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Setpoint Operational</td>
<td>TRUE</td>
</tr>
<tr>
<td>Active Setpoint</td>
<td>0</td>
</tr>
<tr>
<td>Upper Load Setpoint</td>
<td>10000</td>
</tr>
<tr>
<td>Droop Deadband</td>
<td>1000</td>
</tr>
<tr>
<td>Droop Gradient</td>
<td>10000</td>
</tr>
<tr>
<td>Maximum Positive Power Step</td>
<td>10000</td>
</tr>
<tr>
<td>Maximum Negative Power Step</td>
<td>10000</td>
</tr>
</tbody>
</table>

Anticipated result – This test simulates an over frequency event. Droop Gradient is set at 1000%/Hz. Deadband is set at 100mHz therefore the system should recognise a frequency excursion of 0.2Hz. The test should show load has increased from 0% to 100% (2400W and 1950W) by 50.2Hz.

Test 5B – 100mHz Deadband – 1000% Load / Hz

<table>
<thead>
<tr>
<th>Raw</th>
<th>Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Setpoint Operational</td>
<td>TRUE</td>
</tr>
<tr>
<td>Active Setpoint</td>
<td>10000</td>
</tr>
<tr>
<td>Upper Load Setpoint</td>
<td>10000</td>
</tr>
<tr>
<td>Droop Deadband</td>
<td>1000</td>
</tr>
<tr>
<td>Droop Gradient</td>
<td>10000</td>
</tr>
<tr>
<td>Maximum Positive Power Step</td>
<td>10000</td>
</tr>
<tr>
<td>Maximum Negative Power Step</td>
<td>10000</td>
</tr>
</tbody>
</table>

Anticipated result – This test simulates an under frequency event. Droop Gradient is set at 1000%/Hz. Deadband is set at 100mHz therefore the system should recognise a frequency excursion of 0.2Hz. The test should show load has decreased from 100% to 0% by 49.8Hz.
**Test 6A – 100mHz Deadband – 400% Load / Hz**

<table>
<thead>
<tr>
<th>Raw</th>
<th>Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Setpoint Operational</td>
<td>TRUE</td>
</tr>
<tr>
<td></td>
<td>1 (Enabled)</td>
</tr>
<tr>
<td>Active Setpoint</td>
<td>10000</td>
</tr>
<tr>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Upper Load Setpoint</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0%</td>
</tr>
<tr>
<td>Droop Deadband</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td>0.1 Hz</td>
</tr>
<tr>
<td>Droop Gradient</td>
<td>4000</td>
</tr>
<tr>
<td></td>
<td>400%/Hz</td>
</tr>
<tr>
<td>Maximum Positive Power Step</td>
<td>10000</td>
</tr>
<tr>
<td></td>
<td>100%/Cycle</td>
</tr>
<tr>
<td>Maximum Negative Power Step</td>
<td>10000</td>
</tr>
<tr>
<td></td>
<td>100%/Cycle</td>
</tr>
</tbody>
</table>

Anticipated result – This test simulates an over frequency event. Droop Gradient is set at 400%/Hz. Deadband is set at 100mHz therefore the system should recognise a frequency excursion of 0.2Hz and a corresponding change in load of 80%.

Based on the Dimplex Group number assigned to the storage heaters (3) and (5), at 50.3Hz the test should show load has increased from 0% (at 50.1Hz) to 66% (1600W and 1300W).

**Test 6B – 100mHz Deadband – 400% Load / Hz**

<table>
<thead>
<tr>
<th>Raw</th>
<th>Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Setpoint Operational</td>
<td>TRUE</td>
</tr>
<tr>
<td></td>
<td>1 (Enabled)</td>
</tr>
<tr>
<td>Active Setpoint</td>
<td>10000</td>
</tr>
<tr>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Upper Load Setpoint</td>
<td>10000</td>
</tr>
<tr>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Droop Deadband</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td>0.1 Hz</td>
</tr>
<tr>
<td>Droop Gradient</td>
<td>4000</td>
</tr>
<tr>
<td></td>
<td>400%/Hz</td>
</tr>
<tr>
<td>Maximum Positive Power Step</td>
<td>10000</td>
</tr>
<tr>
<td></td>
<td>100%/Cycle</td>
</tr>
<tr>
<td>Maximum Negative Power Step</td>
<td>10000</td>
</tr>
<tr>
<td></td>
<td>100%/Cycle</td>
</tr>
</tbody>
</table>

Anticipated result – This test simulates an under frequency event. Droop Gradient is set at 400%/Hz. Deadband is set at 100mHz therefore the system should recognise a frequency excursion of 0.2Hz and a corresponding change in load of 80%.

Based on the Dimplex Group number assigned to the storage heaters (3) and (5), at 49.7Hz the test should show load has decreased from 100% (at 49.9Hz) to 0%.
## Results

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Response Time¹</th>
<th>Did the device respond as anticipated?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6B</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹Response time is measured as the time difference between a frequency excursion out with the Deadband limits occurring and a change in load of the device.
Introduction
This questionnaire is an opportunity for you to provide feedback on your experiences as a participant in the Trial Evaluation of Domestic Demand Side Management (DDSM). Before completing the questionnaire, please read through the information below. If you have any further questions, please contact:

Tel: *
E Mail: *

What is the purpose of the questionnaire?
Your feedback will be used in the NINES research project by Scottish Hydro Electric Power Distribution [SHEPD] and the project partners to help develop the next phase of the trial for the new domestic heaters and hot water systems. In the long term, this research will help improve energy services for customers in Shetland and throughout the UK.

What will happen to the information from the questionnaire?
The information you provide will be held by SHEPD. The questionnaire results will be analysed by SHEPD staff and may be used by SHEPD and other NINES project partners in research reports and presentations about the Trial Evaluation of DDSM.

The information you provide will be used and presented anonymously – this means it won’t be associated with your name, address or any other personal details.

How to complete the questionnaire:
Please fill in as many questions as possible. Please follow guidance for completing each question, some ask you to circle an answer, others have boxes for you to fill in your own words. There is a section at the end if you need extra space or have further comments.

It is not compulsory to fill in the questionnaire, however all answers you provide will be very valuable in helping us to improve services for future users of the new heating systems.
Trial Evaluation of DDSM Questionnaire

Section 1: Before Installation

1. Did you receive enough information before installation? Please circle yes or no:

   Yes | No

2. What additional information would have been useful?

3. If additional information would have been useful, what would be the best way to provide this information?

Section 2: The Installation Process

4. How would you rate your experience of having the new hot water and heating systems installed? Please circle a number from 1 (unsatisfactory) to 5 (very satisfactory):

   Unsatisfactory | 1 | 2 | 3 | 4 | 5 | Very satisfactory

5. During installation were you able to ask questions? (please circle yes or no)

   Yes | No

6. If you asked questions during installation, how would you rate the answers you received? Please circle a number from 1 (not useful) to 5 (very useful):

   Not useful | 1 | 2 | 3 | 4 | 5 | Very useful

7. How could the installation process be improved?
Section 3: Using the new hot water system and energy storage heaters

8. How would you rate the training you received on how to use the hot water system?  
   Please circle a number from 1 (not useful) to 5 (very useful):

   Not useful | 1 | 2 | 3 | 4 | 5 | Very useful

9. How could the training for the hot water system be improved?

10. How would you rate the hot water system now?  
    Please circle a number from 1 (very poor) to 5 (very good):

    Very poor | 1 | 2 | 3 | 4 | 5 | Very good

11. Please explain why you have given the hot water system this rating?

12. How would you rate the training you received on how to use the energy storage heaters?  
    Please circle a number from 1 (not useful) to 5 (very useful):

    Not useful | 1 | 2 | 3 | 4 | 5 | Very useful

13. How could the training for the energy storage heaters be improved?

14. How would you rate the energy storage heaters now?  
    Please circle a number from 1 (very poor) to 5 (very good):

    Very poor | 1 | 2 | 3 | 4 | 5 | Very good

15. Please explain why you have given the energy storage heaters this rating?
16. Overall, how do you think the new heating system will affect your energy use? 
Please circle an answer:

<table>
<thead>
<tr>
<th>Energy use will decrease</th>
<th>Energy use will stay about the same</th>
<th>Energy use will increase</th>
<th>Don’t know</th>
</tr>
</thead>
</table>

17. How much change do you think you will see in your electricity bill each month? (in £s or %?)

18. How well do you understand how your heating system supports renewable energy on Shetland? 
Please circle a number from 1 (understand a little) to 5 (understand very clearly)

<table>
<thead>
<tr>
<th>Understand a little</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Understand very clearly</th>
</tr>
</thead>
</table>

19. Would you like to understand more about how your heating system supports renewable energy on Shetland? 
Please circle yes or no:

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

20. Would you recommend your new heating system to a friend? 
Please circle yes or no:

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

21. How important are the following features of a heating system (not just your new one)? 
Please rank in order of importance from 1 (most important) to 10 (least important):

<table>
<thead>
<tr>
<th>Feature</th>
<th>Rank Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>The look of the heaters</td>
<td></td>
</tr>
<tr>
<td>Running costs</td>
<td></td>
</tr>
<tr>
<td>Ease of installation</td>
<td></td>
</tr>
<tr>
<td>Ease of use</td>
<td></td>
</tr>
<tr>
<td>Reliability</td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td></td>
</tr>
<tr>
<td>Level of comfort</td>
<td></td>
</tr>
<tr>
<td>Controllability</td>
<td></td>
</tr>
<tr>
<td>Environmental issues</td>
<td></td>
</tr>
<tr>
<td>Where they are made</td>
<td></td>
</tr>
</tbody>
</table>
Section 4: Additional Information

22. Do you have any other comments on any aspect of the heating systems, the installation process or your involvement in the trial?