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Customer Load Active System Services
The CLASS Dashboard

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CLASS
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CONTENTS

VERSION HISTORY

Version	Date	Author	Status	Comments
V.1.0	03/07/2015	K. Bailey	Final	

1 INTRODUCTION

The aim of this report is to provide an explanation of the functionality of the CLASS dashboard. The CLASS dashboard, hosted in within the GE Power On Fusion (POF) Network Management System (NMS), is a Graphical Universal Interface (GUI) that enables the user to select/control a set of pre-defined functions to provide the following:

- Demand reduction at peak times
- Voltage control to absorb reactive power
- Demand boost to increase generation output
- Demand response for frequency events.

The following sections will provide an overview of the CLASS Project, objectives and the functionality and features of the CLASS dashboard.

2 CLASS PROJECT

Electricity North West is leading Customer Load Active System Services (CLASS), a Low Carbon Networks (LCN) funded project. The aim of CLASS is to demonstrate an innovative, low cost and easily deployable solution to provide active voltage management for demand response capabilities and network voltage regulation services. By implementing the voltage management functionality, CLASS has the potential to:

- Defer or remove the need for costly and carbon intensive traditional network reinforcements
- Provide voltage control to NETSO by absorption of reactive power
- Offer alternative balancing services by demand reduction during frequency events.

3 CLASS SITE SELECTION

A comprehensive selection process was carried out on approximately 350 primary substations within the Electricity North West network to select the most suitable locations for implementation of the CLASS Trials. The screening and selection process considered:

- System configuration
- Planned system works
- Generator connections
- Practical and technical implications.

From this detailed process 60 sites were selected for the CLASS Trials. Following the site selection it was then necessary to understand and classify the load types for each of the primary substations. This was carried out using historical load data and customer load profile classes.

Further information about the CLASS Trial selection can be found in the **CLASS Trials substation selection methodology document**.

4 CLASS TRIALS

The CLASS Trials were developed to determine the feasibility of using voltage regulation techniques to provide peak demand reduction, fast acting demand reduction frequency response and reactive power absorption to control high network voltages at times of low load. A broad set of Trials were developed to robustly evaluate the hypothesis outlined in the Full Submission document. The following outlines each of the Trials:

4.1 Trial 1 – Demand/voltage relationship

This Trial will determine the voltage/demand relationship and with the University of Manchester developing a demand matrix table for demand response during all hours of the day.

4.2 Trial 2 –Voltage regulation techniques for peak demand reduction

This Trial will determine if a DNO can deliver a demand response to reduce peak demand at a primary substation.

4.3 Trial 3 – Frequency response by demand management

This Trial will determine if it is possible to provide a fast acting demand response frequency service for National Electricity Transmission Operator (NETSO).

4.4 Trial 4 – Reactive power absorption

This Trial will determine if tap staggering techniques can be implemented to provide a reactive power absorption service to NETSO.

Table 1: Summary of CLASS Trials

Trial Ref	Description	Objective	Technique	Trial Period
T1	Load modelling	Establish voltage demand relationship	Raise and lower tap positions	Across entire annual cycle
T2	Peak demand reduction	Demand response for peak reduction	Lower tap position	Peak demand
T3a	Stage 1 frequency response (49.7hz)	Response to reduce demand when frequency falls	Switch out transformer	Any time
T3b	Stage 2 frequency response		Lower tap position	Ant time
T4	Reactive power absorption	Reduce high volts on transmission network	Stagger tap position	Minimum demand

Further information about the CLASS Trials can be found in the **CLASS Trials design document**.

5 CLASS DASHBOARD

The CLASS dashboard, hosted within the GE Power On Fusion (POF) Network Management System (NMS), has been developed to provide a Graphical Universal Interface to allow the user to select pre-defined functions. The dashboard allows the user to select a CLASS function as well as provide real-time real and reactive power demand response.

The dashboard will display the MW/MVAr demand response associated for respective commands for all 60 individual primary substations and group totals. The algorithm used in the PoF network management system to estimate the MW/MVAr response is based on a static load model with a look up table to identity parameters at a specific time of day (Based on research carried out by University of Manchester). The estimated capability is shown for each function at primary and group level.

A similar dashboard has been developed in the National Grid NMS to interact with the POF Electricity North West dashboard via an Inter Control-Centre Protocol (ICCP) link.

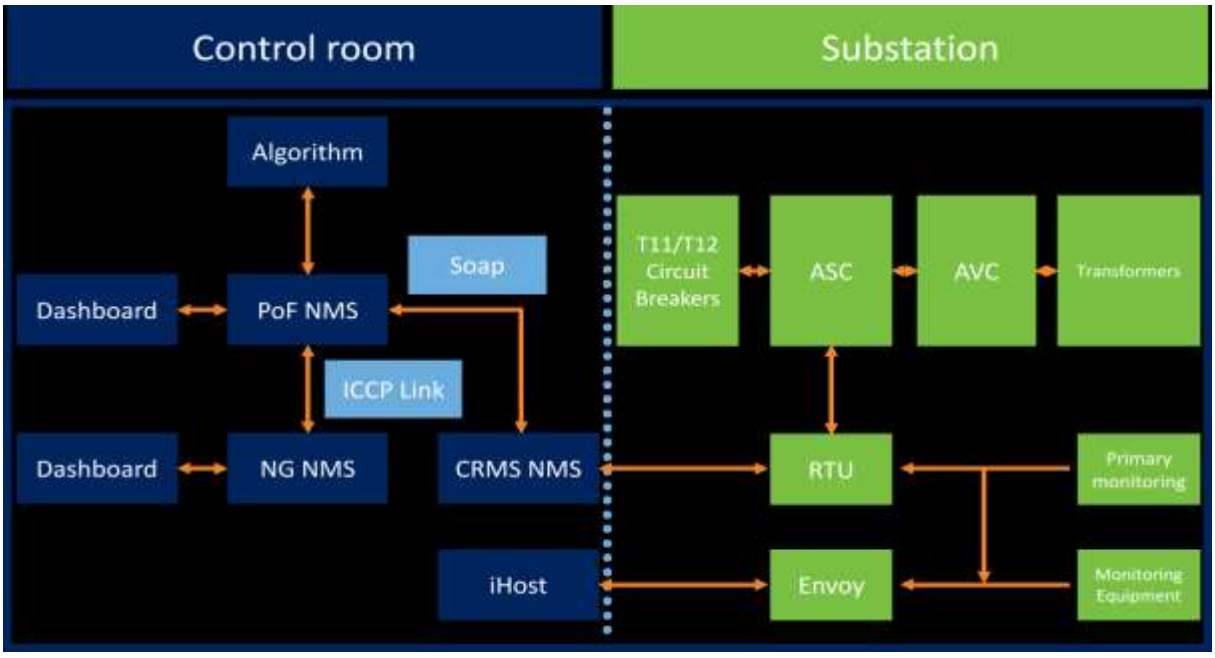
Inter-Control Centre Protocol (ICCP) is a standard real-time data exchange protocol which provides a mechanism for real-time data exchange between utility control centres. The control centres may have different network management systems provided by different vendors, therefore ICCP provides provision for a standard means of exchanging data between the systems.

The PoF software interfaced with Electricity North West's CRMS, is currently being utilised by the CLASS Project to present availability data and dispatch capability for all CLASS functionality. The ICCP link provides National Grid with the ability to access this functionality,

ICCP links have been used previously by NGT and other DNOs for the exchange of data only. The CLASS Project is the first to use an ICCP with NGT to provide control functionality.

Figure 1 below shows the CLASS Solution system diagram, which uses a no. of interconnected technologies. These technologies are split between (i) Electricity North West's control room, (ii) primary substations and (iii) National Grid's control room.

Figure 1: CLASS system diagram



5.1 CLASS commands

The CLASS commands were developed to meet the Trial requirements. Table 2 below lists the full set of CLASS commands along with a brief description.

Table 2: CLASS dashboard commands

Ref	Command	Description
1	APFR	**Automatic Primary Frequency Response (set to 49.7Hz in ASC).** *ENABLED on site via either NGT or ENW dashboard. The ASC, which has a frequency relay, will operate automatically on detection of a frequency of 49.7Hz, tripping the LV CB of one of a pair of primary transformers. The function will alternate tripping of primary LV CBs. The estimated demand reduction (P_{MW}) is shown on the dashboard.*
2	MPFR	**Manual Primary Frequency Response** (makes ASC act as if 49.7Hz occurs). *ACTIVATED directly from ENW dashboard and sends a signal to trip the LV CB of one of a pair of primary transformers. The function will alternate tripping of the primary LV CBs each time it operates. The estimated demand reduction (P_{MW}) is shown on the dashboard.*
3	ASFR	**Automatic Secondary Frequency Response** (set to 49.8Hz in ASC). *ENABLED on site via either NGT or ENW dashboard. The ASC, which has a frequency relay, will operate automatically on detection of a frequency of 49.7Hz, causing both primary transformers to tap down to their lower safe limit. The estimated demand reduction (P_{MW}) is shown on the dashboard.*
4	DBF (Full)	**Demand Boost Function Maximum** (ASC taps up to upper safe limit). *ACTIVATED directly from the ENW dashboard. The primary transformers will tap up to boost the system voltage up to ~1.05%, increasing load and generation export capabilities where export constraints exist. The estimated demand increase (P_{MW}) is shown on the dashboard.*
5	DBF (Half)	**Demand Boost Function Half** (ASC taps up ½ way to upper safe limit). *ACTIVATED directly from the ENW dashboard. The primary transformers will tap up to boost the system voltage up to ~1.03%, increasing load and generation export capabilities where export constraints exist. The estimated demand increase (P_{MW}) is shown on the dashboard.*
6	DRF (NGT/ Full)	**Demand Reduction Function** (ASC taps down to lower safe limit). *ACTIVATED directly from the ENW dashboard. The primary transformers will tap down the system voltage to ~95%, reducing load as per the voltage/demand matrix. The estimated demand reduction (P_{MW}) is shown below the function on the dashboard.*
7	DRF (NGT/ Half)	**Demand Reduction Function.** (ASC taps down to ½ way to lower safe limit*). ACTIVATED directly from the ENW dashboard. The primary transformers will tap down the system voltage to ~97%, reducing load as per the voltage/demand matrix. The estimated demand reduction (P_{MW}) is shown below the function on the dashboard.*
8	ADRF (NRD)	**Automatic Demand Reduction Function for Network Reinforcement Deferral**. *ENABLED on site via from ENW dashboard. ASC taps down at individual primaries to keep demand below firm capacity*
9	*TSF (1)	**Tap Stagger Function** – tap stagger for VAR absorption works on a circulating current method – 5% of demand which generally gives a 1 tap difference. *ACTIVATED directly from either NGT or ENW dashboard. The estimated Q_{MVAR} absorption is shown on the dashboard*
10	*TSF (2)	**Tap Stagger Function** –tap stagger for VAR absorption works on a circulating current method – 7.5% of demand which generally gives a 2 tap difference. *ACTIVATED directly from either NGT or ENW dashboard. The estimated Q_{MVAR} absorption is shown on the dashboard*
11	*TSF (3)	**Tap Stagger Function** – tap stagger for VAR absorption works on a circulating current method – 10% of demand which generally gives a 3 tap difference. *The ACTIVATED directly from either NGT or ENW dashboard. The estimated Q_{MVAR} absorption is shown on the dashboard*

Each of the CLASS dashboard commands is selected at primary and/or group level as well controlled by Electricity North West and/or NGT. Table 3 below shows the command activation levels and control authority.

Table 3: Command activation level and control

Ref	Command	Activation Level		Control Authority	
		Group	*Primary*	*NGT*	*ENW*
1	APFR	*Yes*	*Yes*	*Yes*	*Yes*
2	MPFR	No	Yes	No	*Yes*
3	ASFR	Yes	*Yes*	*Yes*	*Yes*
4	DBF (Full)	Yes	*Yes*	*Yes*	*Yes*
5	DBF (Half)	Yes	*Yes*	*Yes*	*Yes*
6	DRF (Full)	Yes	*Yes*	*Yes*	*Yes*
7	DRF (Half)	Yes	*Yes*	*Yes*	*Yes*
8	ADRF (NRD)	No	Yes	No	*Yes*
9	*TSF (1)	Yes	*Yes*	*Yes*	*Yes*
10	*TSF (2)	Yes	*Yes*	*Yes*	*Yes*
11	*TSF (3)	Yes	*Yes*	*Yes*	*Yes*

5.2 CLASS command functions

The desired command function state is selected via a drop menu. Table 4 below lists the full set of CLASS functions for each command along with a brief description. The commands can be selected for an individual primary, group, area or company level – see dashboard figures 2 – 5 below in section 5.3.

Table 4: CLASS command functions

Function	Description
Inhibit	Automatically activated by Electricity North West CRMS on receipt of specific alarms. This prevents all functions from being ACTIVATED/ENABLED when the system is running abnormal. This function is only available at primary level.
Disabled	Manually selected from the drop down list where a function is not required. A disabled state would be changed to enabled automatically if a group command function was enabled. Eg. If the command ADFR (NRD) was disabled for Harwood primary but then the Kearsley group command ADFR (NRD) was enabled, Harwood would change state to enabled.
Enabled	Manually selected from the drop down list. ENABLES a command on site. The ASC will then be armed and will automatically operate when a specific programmed operating level is reached i.e APFR – Will trip a transformer LV CB if the frequency reached 49.7Hz.
Activated	Manual activation directly from the Dashboard. This will cause the required command to operate immediately.
Manual over ride	Prevents a function at primary level from being from being command by a group/area/company command. Manually implemented.

5.3 Dashboard design

The CLASS dashboard has been designed to provide a simple interface to select a desired function at a single primary site or multiple primary sites as declared by (i) Grid supply point

group (ii) Region or (iii) Global network group. The 60 CLASS sites are spread across 16 grid supply points which provide the infeed to the Electricity North West distribution network from the National Grid transmission system. The dashboard window is expanded to show the different control window.

5.3.1 Individual primary dashboard data

For each primary substation the following real-time system data is shown:

- Tap position
- Demand – Amps/MW/MVAr
- Voltage.

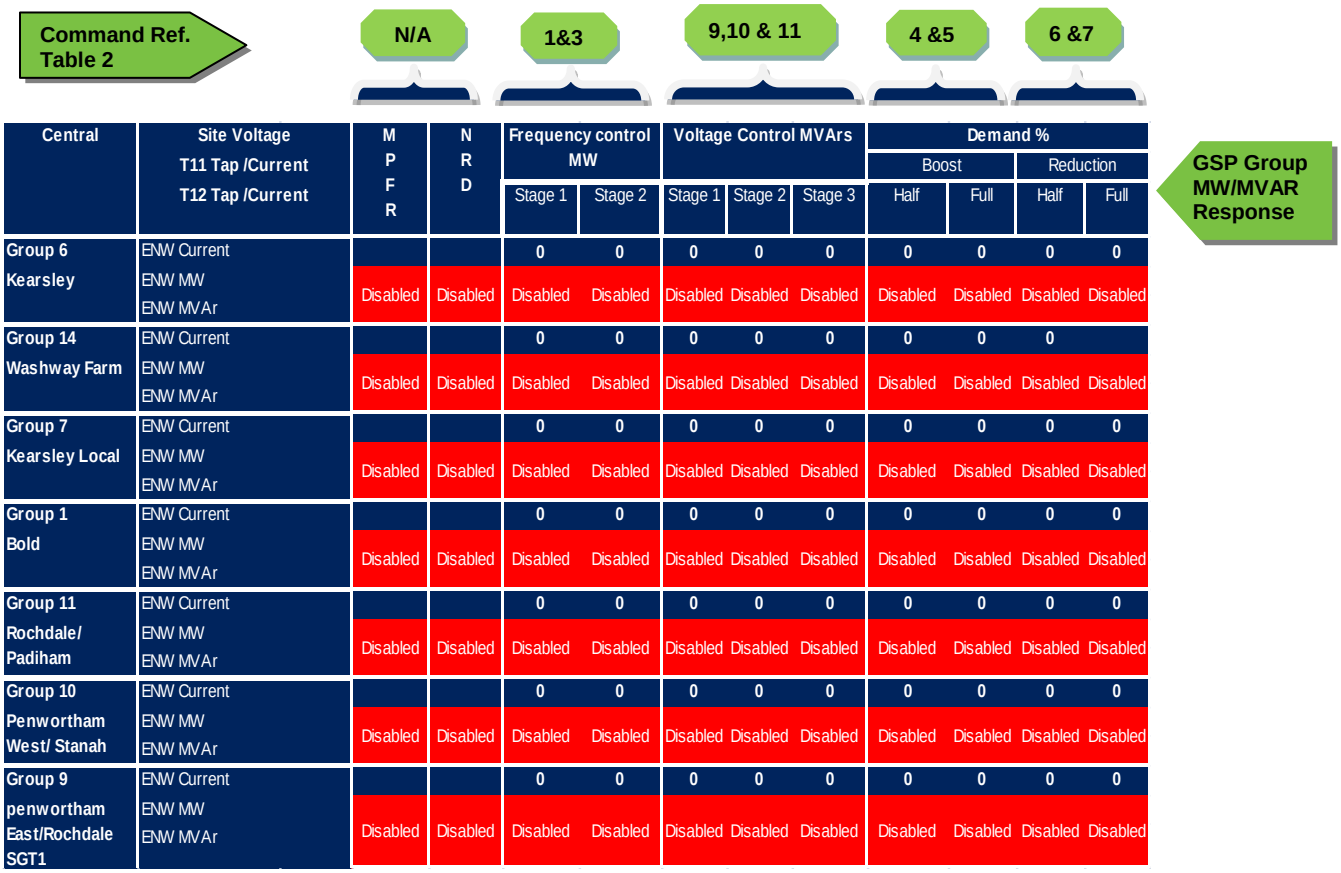
The status of each command is shown on the dashboard, along with the calculated MW/MVAR response for enabled/activated functions. The required command function is selected from the dashboard via a drop down menu. Figure 2 below shows a snapshot of the primary dashboard control window.

Figure 2: CLASS dashboard – individual primary control window

5.3.2 GSP group dashboard data

The GSP group dashboard control window provides the facility to enable/activate/disable group commands for a full GSP group. The MPFR and ADRF (NRD) commands are not selectable at group level. The GSP group control window shows the total MW/MVAr response available for enabled/activated commands by summing the individual primary MW/MVAr response. Figure 3 below shows a snapshot of the GSP group dashboard control window.

Figure 3: CLASS dashboard – area/GSP group control window

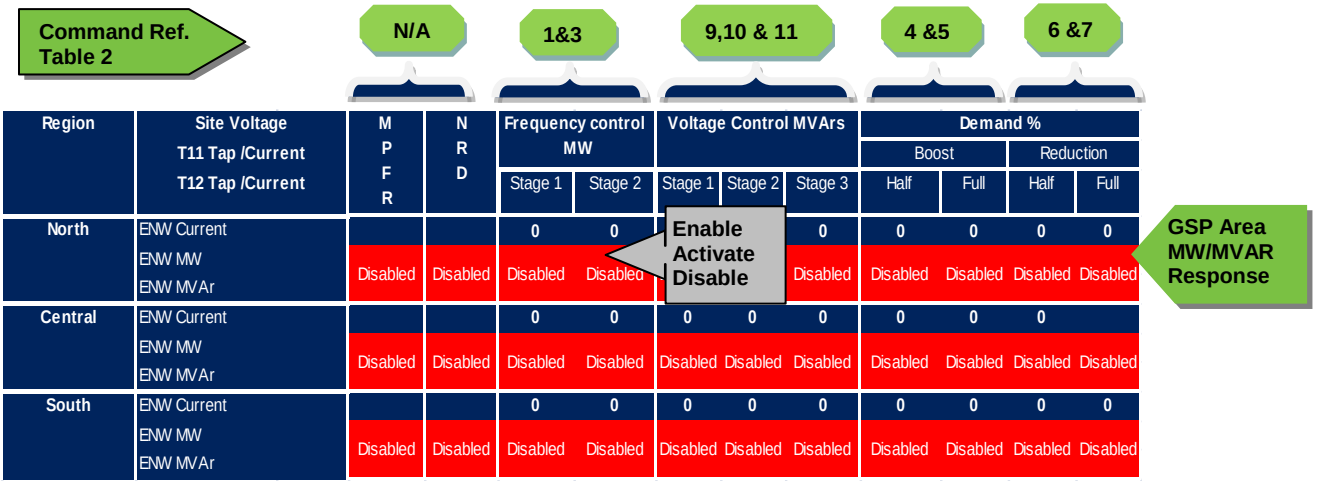


Central	Site Voltage T11 Tap /Current T12 Tap /Current	MPFR	NRD	Frequency control MW		Voltage Control MVArs			Demand %			
									Boost		Reduction	
				Stage 1	Stage 2	Stage 1	Stage 2	Stage 3	Half	Full	Half	Full
Group 6 Kearsley	ENW Current			0	0	0	0	0	0	0	0	0
	ENW MW ENW MVAr	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Group 14 Washway Farm	ENW Current			0	0	0	0	0	0	0	0	
	ENW MW ENW MVAr	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Group 7 Kearsley Local	ENW Current			0	0	0	0	0	0	0	0	0
	ENW MW ENW MVAr	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Group 1 Bold	ENW Current			0	0	0	0	0	0	0	0	0
	ENW MW ENW MVAr	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Group 11 Rochdale/ Padiham	ENW Current			0	0	0	0	0	0	0	0	0
	ENW MW ENW MVAr	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Group 10 Penwortham West/ Stanah	ENW Current			0	0	0	0	0	0	0	0	0
	ENW MW ENW MVAr	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Group 9 penwortham East/Rochdale SGT1	ENW Current			0	0	0	0	0	0	0	0	0
	ENW MW ENW MVAr	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled

5.3.3 GSP area group dashboard data

The GSP area group dashboard control window provides the facility to enable/activate/disable group commands for a full GSP area group. The MPFR and ADRF (NRD) commands are not selectable at group level. The GSP area group control window shows the total MW/MVAr response available for enabled/activated commands by summing the individual GSP group MW/MVAr response associated with the specified area. Figure 4 below shows a snapshot of the GSP group area dashboard control window.

Figure 4: GSP area group control window

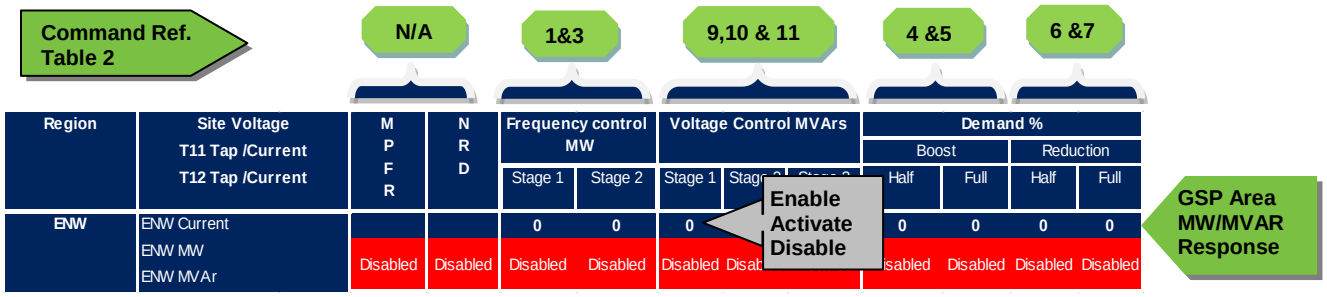


Region	Site Voltage T11 Tap /Current T12 Tap /Current	MPFR	NRD	Frequency control MW		Voltage Control MVArs			Demand %			
									Boost		Reduction	
				Stage 1	Stage 2	Stage 1	Stage 2	Stage 3	Half	Full	Half	Full
North	ENW Current			0	0			0	0	0	0	0
	ENW MW ENW MVAr	Disabled	Disabled	Disabled	Disabled			Disabled	Disabled	Disabled	Disabled	Disabled
Central	ENW Current			0	0	0	0	0	0	0	0	
	ENW MW ENW MVAr	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
South	ENW Current			0	0	0	0	0	0	0	0	0
	ENW MW ENW MVAr	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled

5.3.4 Full Electricity North West dashboard data

The Electricity North West dashboard control window provides the facility to enable/activate/disable group commands for the full Electricity North West system (all 60 sites). The MPFR and ADRF (NRD) commands are not selectable at group level. The group control window shows the total MW/MVAr response available for enabled/activated commands by summing the GSP area MW/MVAr response. Figure 5 below shows a snapshot of full Electricity North West dashboard control window.

Figure 5: CLASS dashboard – Electricity North West control window



6 SECOND FUNCTION AVAILABILITY

The CLASS dashboard design allows for secondary function activation in some instances. Table 4 below shows the combinations of permitted secondary functions.

Table 5: Secondary functionality

Activated / Required	Frequency response Stage 1	Frequency response Stage 2	Reactive power Absorption Stage 1	Reactive power Absorption Stage 2	Reactive power Absorption Stage 3	Demand Reduction	Demand Boost
Frequency stage 1	NA	YES	YES	YES	Yes	NO	YES
Frequency Stage 2	YES	NA	YES	YES	YES	NO	YES
Reactive power Absorption Stage 1	NO	YES	NA	YES	YES	YES	YES
Reactive power Absorption Stage 2	NO	YES	NO	NA	YES	YES	YES
Reactive power Absorption Stage 3	NO	YES	Yes	YES	NA	YES	YES
Demand Reduction	NO	NO	YES	YES	YES	NA	NO
Demand boost	NO	NO	YES	YES	YES	NO	NA

7 NGT DASHBOARD

NGT dashboard only shows groups unlike the Electricity North West PoF dashboard which also shows primaries. If a primary is inhibited or disabled in the Electricity North West PoF dashboard the group function can still be enabled/activated by both the Electricity North West PoF & NGT dashboards but it will not include the inhibited primary.

The NGT CLASS dashboard will be updated via the ICCP link approximately every minute to reflect the status of the PoF CLASS dashboard but only at the GSP/group level.

8 FUTURE WORKS

Like all new and innovative projects such as CLASS the learning and dissemination is one of the most important factors in assessing the successfulness of the Project. Not only is the Project aimed at evaluating the hypothesis but it is also important that the technologies and methodologies are reviewed to understand what improvements could be made, whether this be from the Trials to the installation phase or to the technologies used.

The POF dashboard has been an integral part of the CLASS technology and has provided the basis to develop the functionality, operability and technology further:

- The CLASS dashboard could be developed in a single NMS thus removing the need for an additional communication link
- Alarm handing needs to be developed such that the NMS system is not swamped with potentially hundreds of alarms for CLASS events
- Manually apply Inhibits to allow individual functions to be inhibited rather than the full site.

Following the success of the CLASS Trials, work is ongoing to develop the dashboard within Electricity North West's new NMS system. It is the view that some features could be implemented as business as usual. However there are a number of functions which could also be implemented but these could only be considered following commercial review/agreement following the completion of the CLASS Project.