System Operator for Northern Ireland

# Minimum Function Specification

## for centrally dispatched

## Closed Cycle Gas Turbines (CCGT)

April 2010 Rev 1.1

# CCGT Generation

## 1.0 Introduction

This Minimum Functional Specification (MFS) is applicable to all Closed Cycle generating units (CCGT's) connected to the Northern Ireland transmission system that have a power output greater than 5 MW.

Northern Ireland has a small Transmission system with a maximum demand of circa 1900 MW and a minimum demand of 500 MW. With the minimum demand being approximately a quarter of the maximum demand, a situation can occur where a small number of large generators may supply the entire NI system load. There is interconnection to Great Britain via the Moyle Interconnector and also to the ROI transmission system. Although unlikely, it is conceivable that it could run as an island system again during abnormal conditions.

Due to the nature of the NI transmission system i.e. large generating units with relatively low demand, it is possible that the frequency could drop to as low as 47Hz in the event of a large generator fault. This places an extra operational difficulty that other, larger electricity systems would not experience.

Within recent years there has been increasing pressure on Governments to replace conventional generation with renewable sources. Due to this there has been a massive penetration of renewable energy sources in NI, and this is expected to continue in the foreseeable future. The Seven Year Generation Capacity Statement 2010-16 assumes that wind generation capacity will exceed 950 MW by 2016. The variability and uncertainty of this type of generation alone, requires that operating the system will become more complex than ever before. It is with complexity in mind that this MFS has been written to ensure that new CCGT plant will be capable of operating in this new environment, allowing the system operator to manage conventional generation alongside renewable sources. In order to provide stability and security of supply, generating units connected to the Northern Ireland network will require greater flexibility than previously experienced

## 2.0 PLANT CONTROL EQUIPMENT

### 2.1 General

The Generator will provide models and parameters of all control equipment to the TSO to allow simulation studies to be carried out to demonstrate stable operation of the plant. These should include models and parameters for the generator, excitation control system, power system stabiliser, turbine governor, step-up transformer and tap-changer. Some parameters may be subject to approval by the TSO. The TSO requires that excitation controllers and governors are dual channel controllers.

The TSO will require commissioning tests to be carried out in line with the appropriate SONI document reference (Guidance for the exchange of data and for testing of new or modified generation connected to the NI Transmission system, 2009, Rev D) to demonstrate gird code compliance with the requirements. The Generator shall supply interim and final Reports within t he timelines specified. Prior to these tests satisfactory factory test certification must be submitted to the TSO for its approval.

### 2.2 Voltage Control

Each generating unit covered by this MFS must be capable of contributing to voltage control by continuous modulation of reactive power. It is expected that those generating units will be fitted with continuously acting, fast response and automatic excitation control systems. It is also expected that the associated generator transformers will be fitted with on-load tap-changers.

#### a) Excitation Control

The excitation control system should be capable of maintaining, without instability, the generator terminal voltage to within 0.5% of the voltage set-point when the output MVA is gradually changed from zero to rated MVA at rated load and frequency. The excitation control system shall be fitted with appropriate excitation limiters and shall be designed in line with best modern practice. The required transient response of the excitation control system will be defined by the TSO prior to the commissioning tests.

**b) Power System Stabiliser**

Currently the TSO requires that each generating unit covered by this MFS is fitted with a power system stabiliser (PSS) to enhance the transient performance of the unit to events such as sudden load changes or system short circuits. Whatever design of PSS is employed, the design should ensure that damping torque is improved without a consequent reduction in the available synchronising torque. After the commissioning tests described in ref [2], the TSO will notify the owner whether the PSS is to be in commission or not.

**c) On-Load Tap-Changer (OLTC)**

The OLTC and the chosen transformer parameters must ensure that the full range of reactive power as required by section 3 of this MFS can be exported or imported over the full range of grid voltage variation. The transformer tapping range and tap step size will be subject to the approval of the TSO.

### 2.3 Frequency Control

Each generating unit covered by this MFS must be capable of contributing to frequency control by continuous modulation of active power. The prime mover must be fitted with a fast acting, proportional speed governor to provide frequency control under normal operational conditions.

Governors must be designed with a nominal droop of 4% but the droop setting must be capable of continuous adjustment in the range 3% to 8%. Governors for steam turbine units in CCGT plants should also meet the relevant requirements of BS EN 60045-1.

Under abnormal conditions, such as when a generating unit becomes isolated from the rest of the NI system because of system separation or islanding but is still supplying customers, the speed governor must be able to control the frequency of the islanded system to below 52 Hz after the transient is over unless this would mean operation at below the minimum stable generation load.  (Grid Code CC.S1.5.2).

### 2.4 Load Control

Where a generating unit is fitted with a unit load controller it must be in operation at all times required by the TSO and in accordance with the settings previously agreed with the TSO.   It is important that the action of the load controller does not interfere with the satisfactory provision of response during system frequency events.

## 3.0 PLANT PERFORMANCE REQUIREMENTS

### 3.1 Minimum Generation

The CCGT module must be capable of continuous stable operation at 50% of the module MCR with satisfactory emissions. When gas turbine units in a CCGT module are running in Open Cycle mode they should be capable of continuous stable operation at 35% of the unit MCR with satisfactory emissions.

### 3.2 Reactive Power Capability

CCGT units must be capable of continuous operation within that shaded part of the generator capability chart (Figure 1) that lies above the Minimum Generation level at all temperatures within the site design temperature range. Units must be capable of providing reactive power under short-term or transient operation in the lower shaded area.

The six corners of the total area are defined as:

| | | |
|---|---|---|
| At MCR MW | **A** 0.8 power factor lagging | **B** 0.95 power factor leading |
| At 35% MCR MW | **C** 0.4 power factor lagging | **D** 0.5 power factor leading |
| At 0 MW | **E** the intersection of a vertical line dropped from **C** to 0 MW | **F** the intersection of a vertical line dropped from **D** to 0 MW |

**Table 1 – Extremes of Power Factor Range**

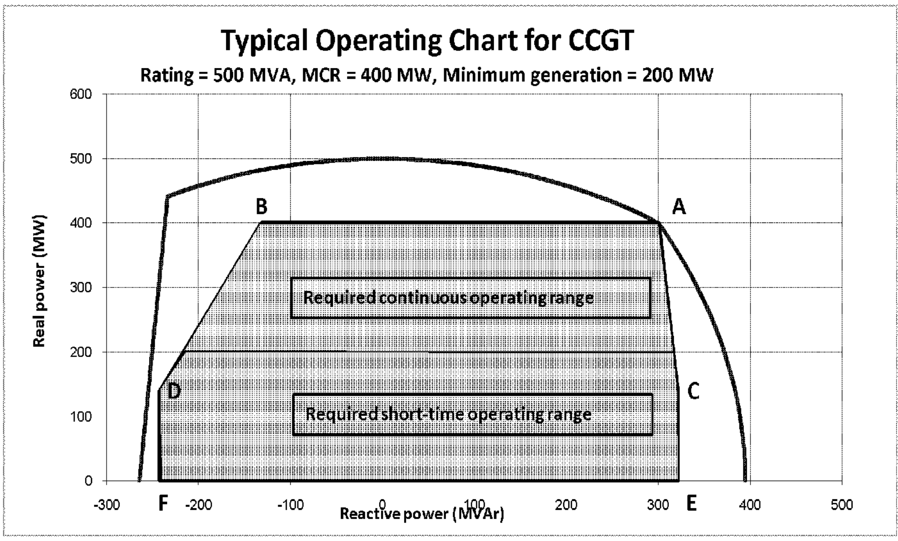


**Figure 1 – Capability chart showing required operating range**

### 3.3 Short Circuit Ratio

Generating units should be designed with a short circuit ratio of 0.5 or greater.

### 3.4 Frequency Response Capability

All generation plant must be capable of automatically providing a change of output in response to rapid changes in system frequency as stated in the Grid Code (OC3.4.2). Response is required to both falling and rising frequency and is based on a nominal governor droop of 4%. The generating plant must be capable of providing response over four timescales as follows:

| | **Available in** | **Sustained to** | **Expected Response** |
|---|---|---|---|
| Initial Response | 3 seconds | 15seconds | 40% MW response |
| Primary Response | 5 seconds | 15 seconds | 60% MW response |
| Secondary Response | 15seconds | 90 seconds | 100% MW response |
| Tertiary Response 1 | 90 seconds | 5 minutes | Maintain 100% MW response |
| Tertiary Response 2 | 5 minutes | 20 minutes | Maintain 100% MW response |

**Table 2 – Response Timescales**

The minimum MW response required from CCGT plant following a 0.5 Hz change in frequency is +18% MCR for a fall in frequency and -10% MCR for an increase in frequency. The response varies with loading according to Figure 2.

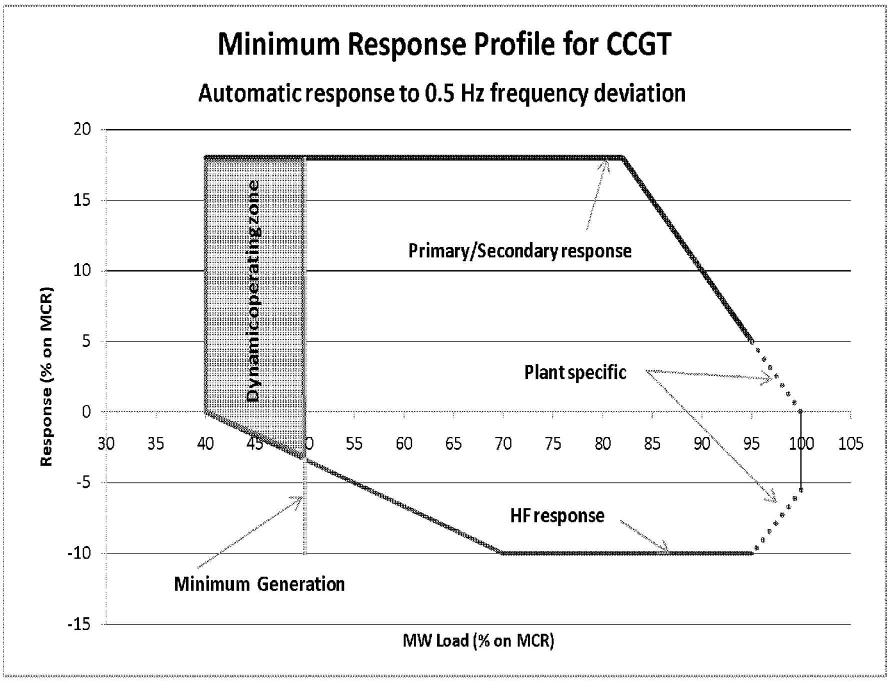


**Figure 2 – Minimum Response Profile for CCGT**

### 3.5 Frequency Variation

The NI system frequency can in exceptional circumstances vary between 47 Hz and 52 Hz and all generating plant must be capable of operation in accordance with the table below. In view of the possibility of the NI system operating in island mode, all plant must be able to remain synchronised if the frequency changes at a rate that could reach 1.5 Hz/sec.

| | |
|---|---|
| Between 47.5 Hz and 52 Hz | Continuous stable operation |
| Between 47 Hz and 47.5 Hz | For a period of at least 20 seconds on each occasion that the frequency is below 47.5 Hz |

**Table 3 – Expected Frequency Range**

Within the frequency range 49.5 Hz to 50.5 Hz there should be no reduction in output on falling frequency. Plant should be appropriately rated to ensure compliance with this requirement. Between 49.5 Hz and 47 Hz the output should not fall at a rate greater than 2%MCR/Hz.

### 3.6 Start-up Rates and Ramp Rates

It is required that the plant is capable of load cycling or 2-shifting. All plant will have three defined heat states which will then determine various process times as shown in Tables 5 and 6.

| CCGT Plant | Off-load time |
|---|---|
| Hot condition | T < 8 hours |
| Warm condition | 8 hours < T <48 hours |
| Cold condition | 48 hours < T |

**Table 4 – Plant Condition Definitions**

The maximum time to synchronise and the minimum ramp rates expected for a CCGT module are dependent on the heat state and are as given in Table 5 below.

| CCGT Plant | Maximum Time to Synchronise | Loading Rate<br>Module % MCR/minute | Deloading Rate<br>Module % MCR/minute |
|---|---|---|---|
| Hot condition | 90 minutes | 4.5 | 4.5 |
| Warm condition | 4 hours | 4.5 | 4.5 |
| Cold condition | 8 hours | 4.5 | 4.5 |

**Table 5 – Process Times**

The maximum time to synchronise and the minimum ramp rates expected when gas turbine units in a CCGT module are running in Open Cycle mode are as given in Table 6 below.

| Maximum Time to Synchronise | Loading Rate Module %MCR/minute | Deloading Rate Module %MCR/minute |
|---|---|---|
| 10 minutes | 30 | 30 |

**Table 6 – Process Times**

The maximum block load to be applied on synchronising must be no more than 10% unit MCR.

Within any 24 hour period all CCGT plant shall be capable of 1 cold start, or 1 warm start, or 2 hot starts.

### 3.7 Load Cycling

The TSO requires that all CCGT plant is capable of ramping between minimum generation and MCR on a regular daily basis.

## 4.0 GENERAL PROVISIONS

All the preceding operating characteristics represent minimum requirements and all plant shall register and perform in a manner giving maximum flexibility of operation appropriate to their type of plant and in accordance with good industry practice.

The provisions of this document should be read in conjunction with the NI Grid Code and in particular the Connection Conditions. Nothing in this document will supersede the provisions of the NI Grid Code.

## 5.0 REFERENCES

[1] The SONI Grid Code.

[2] Guidance for the Exchange of Data and for Testing of New or Modified Generation Connected to the All Island transmission system, 2009, Rev D.

[3] The Seven year generation Capacity Statement 2010-2016

## 6.0 CONTACT INFORMATION

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