Brighton Beach Frequency Response Exemption Impact Assessment

Submission Summary:

Details contained in Exemption Plan document.

An exemption is requested from the requirement to provide normal speed governing action on the steam turbine.

This limitation will remain in effect for the life of the equipment.

Plan to operate with exemption in place:

The gas turbine load control system will be programmed to provide an effect station droop characteristic subject to the constraints of the gas turbine unit's operation, specifically:

1. During decreases in system frequency, sustained increases in plant output will not occur if the gas turbines are operating at limits such as combuster temperature.
2. During increases in frequency, sustained decreases in plant output below a pre-defined minimum output limit will not be possible based on environmental regulations and to prevent tripping of the steam turbine generator.

Reliability of Grid/non-discriminatory access/impact on IMO-administered market/undue preference:

Brighton Beach's assessment of this application is that:

- It does not materially threaten the ability of the IMO to direct the operations and maintain the reliability of the IMO-controlled grid;
- It does not materially threaten the ability of the IMO to ensure non-discriminatory access to the IMO-controlled grid;
- It does not materially affect the ability of the IMO to operate the IMO-administered markets in an efficient, competitive and reliable manner;
- It does not provide Brighton Beach with an undue preference within the IMO-administered markets;
- No additional costs will be imposed on the IMO or other Market Participants through the approval of this exemption.

Impact on Brighton Beach of exemption not being granted:

It is unclear without further analysis whether Brighton Beach can meet the full compliance requirements with the conventional combined cycle design without risking plant equipment or failing to meet environmental regulations. As a minimum, if Brighton Beach was not granted exemptions for non complying capabilities, significant capital investment in new controls would be required, and the units would have to be operated at sub-optimal efficiencies.

Brighton Beach Frequency Governor Exemption Plan

Summary

This exemption request is for an exemption from the requirement to supply normal speed governing, relating to the requirements of Chapter 4, Appendix 4.2, Reference 16 of the Market Rules.

The exemption is required for the following equipment: steam turbine speed governor. The exemption is required for the life of the equipment.

Background

The Brighton Beach combined-cycle facility will consist of two gas turbines (GTs) and a single steam turbine (ST) fed from Heat Recovery Steam Generators (HRSGs).

The combined cycle steam turbine is a slave to the dictates of the upstream steam producers and will not be able to provide any controlled governor droop frequency response action to a grid induced low frequency excursion. In other words, there is insufficient steam reserve capacity in the HRSG's to provide any significant transient or sustained steam flow changes to the steam turbine without a change to the combustion turbine exhaust flow. It is intended to operate the station in a sliding pressure, steam turbine follows HRSG control mode, with the steam turbine control valves normally wide open. In this configuration, there is a change in steam production with a change in combustion turbine loading. These changes have a time constant in the order of 2-3 minutes as the change in flue gas flow and flue gas temperature makes its way through the various pressure stages of the HRSG and steam system. The relationship between combustion turbine changes and steam turbine changes varies, but in very general terms, one combustion turbine firing at 100% will roughly result in 50% output on the steam turbine once steady state is achieved.

Allowing the steam turbine to respond to grid high frequency excursions would result in cascading steam header pressure transients, potentially jeopardising continued operation of the connected HRSG's and thus their associated combustion turbines. We therefore propose the application of a deadband to the steam turbine governor such that it will not respond to any grid induced frequency excursions between 56.4 and 60.2 Hz. However, we do recognize that it would be imprudent to allow the steam turbine not to respond at all to major grid high frequency excursions, and we therefore propose to allow the steam turbine to respond with free governor action to all excursions exceeding 60.2 Hz.

Due to constraints imposed by our environmental approval, it is possible that occasions will arise where a grid high frequency excursion would result in free governor action that would reduce the combustion turbine generation output to a level that would result in a change in combustion modes and therefore the production of NOx emissions that would exceed the levels normally allowed by our environmental approval. Similarly, this same level of frequency excursion may drive the combustion turbine generation level to a point that would result in the significant loss of combustion turbine exhaust temperature, and hence HRSG steam outlet temperature. This would detrimentally impact upon the continued operation of the steam turbine, requiring it to be taken off line. We therefore propose to allow the synchronized combustion turbines to initially respond with free governor action to the excursion, then to allow the overall block load controller to integrate the combustion turbine generation levels back to a frequency compensated net site setpoint, which would allow for continued operation at a minimum combustion turbine operating point, thereby ensuring continued low NOx production levels, and adequate steam temperatures for the steam turbine. This minimum operating point is anticipated to be 50-60% of the ambient temperature compensated combustion turbine generation capability (i.e., percentage capability corrected back to ISO ambient temperature conditions).

Proposed Frequency Compensated Station Load Control

It is our proposal to include a sustaining frequency response-compensating factor in our block load controller that would drive the synchronised combustion turbines to deliver an overall station 5% droop response. This station response would compensate for the lack of response from the steam turbine, but would be limited by the rate of change of loading of the combustion turbines.

From a ramp rate point of view, the rate of change of GT gross MW setpoint based on frequency is basically instantaneous. As identified above, allowing the droop characteristic of the governor response initially gives a response that is limited by the governor characteristic of the machine, but responds reasonably fast to the initial frequency step change. The difference then in the setpoint more gradually brings the units back to the station load master frequency compensated setpoint. If you take a simple case of station configuration with only a single combustion turbine operating, when a frequency excursion occurs, the initial response by the governor (assuming a 5% droop), and the station controller derived setpoint (assuming a station droop of 5%), would be the same, resulting in the machine responding initially on free governor action, and then remaining at the new load point as long as the frequency excursion lasted (as directed by the compensated setpoint). In this case, normal loading ramp rates are not a consideration. If the GT governor were set to a droop other than 5%, the unit would respond initially based on governor action and then ramp toward the block controller setpoint at the ramp rate (e.g. 12 MW/min).

The proposed controller is shown in the simple block diagram on the following page. The calculation runs in real time and changes the setpoint instantly based on system frequency changes. From here, the setpoint is divided amongst the synchronised combustion turbines released to load control. Thus, the combustion turbines are allowed to respond on their normal droop characteristic, but will then be moved ultimately to a point that is in keeping with an overall station droop response. The algorithm also accounts for the change in configuration or number of units, in the calculation of synchronised capacity. Minimum levels are applied at the combustion turbine load control level, to prevent the load master from driving the setpoint below the NOx violation/exhaust gas temperature limits.

As identified above, block load controller response to frequency excursions would not occur below the generation level which would be required to support continued low NOx production/low steam temperature limits or above the exhaust temperature limited ceiling for the synchronized combustion turbines.