Comments on the Aurora Application for a LNG Plant Sited at Prince Rupert

Introduction

The proposed Aurora LNG plant will use large gas turbines to generate electrical power as well as to compress natural gas in a gas liquefaction plant. Although the proposed gas turbines will utilize low-emission technology to minimize NOx (oxides of nitrogen) emissions, their combined emissions still have the potential to seriously impact ambient air quality standards and therefore to adversely affect human health in nearby communities. The Interim 2014 BC Ambient Air Quality One-Hour Standard for NO2 (nitrogen dioxide) is 188 micrograms per cubic meter (mcg/m^3) or equivalently, 100 parts per billion (ppb). These values are subject to revision. Ambient NO2 concentrations above these levels may result in adverse health effects, such as breathing difficulties and increased lung disease.

How ambient NO2 concentrations are estimated

Ambient NO2 levels are estimated using computer models developed by the USA Environmental Protection Agency (EPA) and subsequently adopted by the BC Ministry of Environment. These models (AERMOD and CALPUFF) calculate ambient NOx concentrations (mcg/m^3), given the NOx emissions from combustion sources, in terms of grams/second NOx. The ambient NOx concentrations are then converted in a post-processor to ambient NO2 concentrations, which can then be compared to ambient air quality standards. A commonly used Tier 3 NOx post-processor algorithm is the Ozone Limiting Method (OLM). The OLM computes ambient NO2 from ambient NOx, given the ambient ozone (O3) concentration and given the fraction of NOx already converted to NO2 in the stack, before being emitted to the atmosphere. The fraction of NOx conversion, or in-stack ratio (ISR), for NO2/NOx was traditionally assigned a default value of 0.10, which was typical of many industrial NOx sources (e.g. internal combustion engines, coal-fired power plants, etc.).

However, following an extensive survey of the measured values of ISR for different combustion sources, the EPA is now recommending using a default value of O.5 for the ISR, unless reliable source-specific ISR data is available, in which case the measured values should be used. (See page 9 of the EPA 2014 report by Owen and Brode https://www3.epa.gov/scram001/guidance/clarification/NO2_Clarification_Memo-20140930.pdf) The estimated value of NO2 for locations close (i.e. within a few kilometers) of the emission sources is sensitive to the assumed value for the ISR.

The EPA database (https://www3.epa.gov/scram001/no2_isr_database.htm) for measured ISR values includes only a single source for a low-emission gas turbine. It is expected that the ISR value for this gas turbine will be similar to those proposed by Aurora. The ISR values for this low-emission gas turbine were measured under various gas turbine power levels and the results varied from 0.07 to 0.32. The corresponding NOX values did not increase with load as expected, hence the accuracy and reliability of the measurements may be in doubt. However, we will take a value of **0.3** as a reasonable ("best-guess") value for the ISR for a low-emission gas turbine under full load, and use this to replace the default ISR value of 0.1 that is still used by some modellers in the AERMOD and CALPUFF models. The NO2 modeling estimates made in the Aurora application were done using the traditional ISR default value of 0.10. The next section of this memo will look at the changes to the estimated ambient NO2 concentrations for two sensitive locations when the ISR value is changed from 0.1 (traditional default value) to 0.3 (a measured value).

Revised estimate of ambient NO2 concentrations at two communities located close to the proposed Aurora LNG plant

Two sensitive locations were examined using revised values for the ISR:

1. Central Dodge Cove residential area (D337D in Aurora Appendix R Human Health, p.131)
2. Graham Avenue Childcare in Prince Rupert (between PR259 and PR260 D337D in Aurora Appendix R Human Health, p.104)

For simplicity it was assumed that an ISR value of 0.30 would be applicable to **all** of the Project NOx emissions, instead of just the gas turbine NOx emissions, since some will be combustion sources with a low ISR value whereas others may be more appropriately applied to the EPA recommended default ISR value of 0.50. For Base NOx sources (existing non-project sources) an ISR value of 0.20 is assumed as this is the EPA recommended default ISR value for distant sources (*loc. cit*.).

When ambient NO2 concentration has been estimated, using one of the two models mentioned above, it is difficult to back-calculate what the corresponding ambient NOx concentration would be unless there is only a single source emitting the NOx. In large projects there may be many sources contributing to the existing NOx ambient concentrations (Base case) and many new sources contributing to the Project-related NOx ambient concentrations. The Cumulative case results when all sources are modeled. Note that the Cumulative NOx value will usually not be equal to the sum of the Base and the Project values. This is because the 1-hour weather conditions that result in the maximum group values are different for each of the three groups.

Below we will attempt to estimate revised ambient NO2 values using two different simplified approaches. First we recalculate the Cumulative case NO2 assuming an ISR value of 0.30 for all sources, instead of the traditional value of 0.10. Secondly, we recalculate the NO2 for the Base case using an ISR

value of 0.20 and recalculate the NO2 for the Project case using an ISR value of 0.30 for all project sources and then add up the two NO2 concentrations to approximate the Cumulative case NO2.

1. **Central Dodge Cove residential area**. Here the reported 1-hour Project NO2 concentration was 106.6 mcg/m^3 while the 1-hour Base NO2 concentration was 43.7 mcg/m^3, using an ISR value of 0.10. The Cumulative estimated NO2 value was 132 mcg/m^3.

   a) Single-Group Estimate: Using the OLM formula with an ISR of 0.10, ozone 50 ppb and Cumulative NO2 of 132 mcg/m^3 the ambient NOx is back-calculated to be 477 mcg/m^3. Using the OLM with ISR=0.3 we then estimate the ambient NO2 to be **209 mcg/m^3**. This value is well above (111%) of the allowable Standard of 188 mcg/m^3.

   b) Three-Group Estimate: Using a similar approach as above, the Project-related NOX is 222.7 mcg/$m^3$and hence the NO2 (ISR= 0.3) is 132.3. The reported Base NO2 of 43.7 mcg/m^3does not change since it was assumed that all of the Base-related NOx is converted to NO2 when the NOx < O3. Hence an estimate of the total NO2 is the sum of 132.3 + 43.7 = **176 mcg/m^3**. This value is close to (94%) of the allowable maximum value of 188 mcg/m^3.

2. **Graham Avenue Childcare in Prince Rupert.** Here the reported 1-hour Project NO2 concentration was 105.4 mcg/m^3 while the 1-hour Base NO2 concentration was 61.2 mcg/m^3, using an ISR value of 0.10. The Cumulative estimated NO2 value was 134.4 mcg/m^3.

   a) Single-Group Estimate: The single-group estimate (ISR = 0.3) is **216 mcg/m^3**, or 115% of the allowable maximum.

   b) Three-Group Estimate: The three-group estimate is **190 mcg/m^3** , or 101% of the maximum allowable 1-hour NO2 concentration.

Conclusions & Recommendations

We have seen that the most recent EPA recommendations for updating the Ozone Limiting Method, which is used for estimating ambient NO2 from modeled values of NOx, uses a default ISR (in-stack NO2/NOx ratio) value of 0.5 instead of 0.1. This reflects updated knowledge of modern combustion sources which often embody some sort of NOx control. The EPA also states that measured values of ISR should be used, when available. Measured values for a low-emission gas turbine indicate that an ISR of 0.3 would be an appropriate value.

The ambient NO2 values at two sensitive receptors (Dodge Cove community and Graham Avenue Childcare Center) were estimated using the revised ISR values and using previously modeled NO2 values,

which used an ISR value of 0.1. The estimates were carried out using two different, simplified approaches. In each case the estimated maximum NO2 concentrations at the sensitive receptors either approached or exceeded the allowable maximum NO2 concentrations.

In light of this result it is highly recommended that the modeling be redone, using the revised values for the ISR, and if the modeling results continue to demonstrate high NO2 levels at sensitive locations, that the LNG plant proponent find ways to reduce NOx emissions from the plant.