Concept Consulting Group

Electricity Emission Factor Review

Prepared for NZ Climate Change Office

Concept Consulting Group

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1 Introduction

The Climate Change Office has engaged Concept Consulting Group (Concept) to review its "electricity emission factor". This factor is intended to represent the average reduction in carbon dioxide emissions over the period 2008 to 2012[1] that would result from the addition of 1 GWh of new electricity supply with no emissions. The emission factor is used to evaluate emission reducing projects in Climate Change Project tender rounds[2]. The second project tender opened on 31 August 2004.

2 Approach

The emission factor used in the 2003 tender round, was estimated by Concept. It was based on a supply and demand scenario specified by the Ministry of Economic Development and the Climate Change Office. The supply and demand scenario and our approach to estimating the current emission factor were presented in a detailed report published by the Climate Change Office in 2003. The 2003 report ("An Electricity Emission Factor") can be found on the Climate Change Office website[3].

In reviewing the emission factor for the second tender we have followed the same approach described in the 2003 report. Accordingly, this report is limited to discussing the changes in key scenario assumptions impacting on likely emission levels between 2008 and 2012 and summarising the results of our analysis. Readers unfamiliar with the issue should read both the 2003 and 2004 reports.

3 Nominal Supply and Demand Scenario

As in the 2003 analysis, the Ministry of Economic Development and the Climate Change Office were responsible for specifying key supply and demand assumptions. The analysis has been based on gross electricity demand - the requirement for total supply including transmission and distribution losses.

3.1 Electricity Demand

Electricity demand assumptions are essentially the same as in the 2003 analysis. Demand is assumed to grow at 2% pa over the period to 2012 from a figure of 42,024 GWh for the 2004 calendar year (Figure 1). The 2004 figure represents 2% growth over the 2003 calendar year nominal gross demand assumption.

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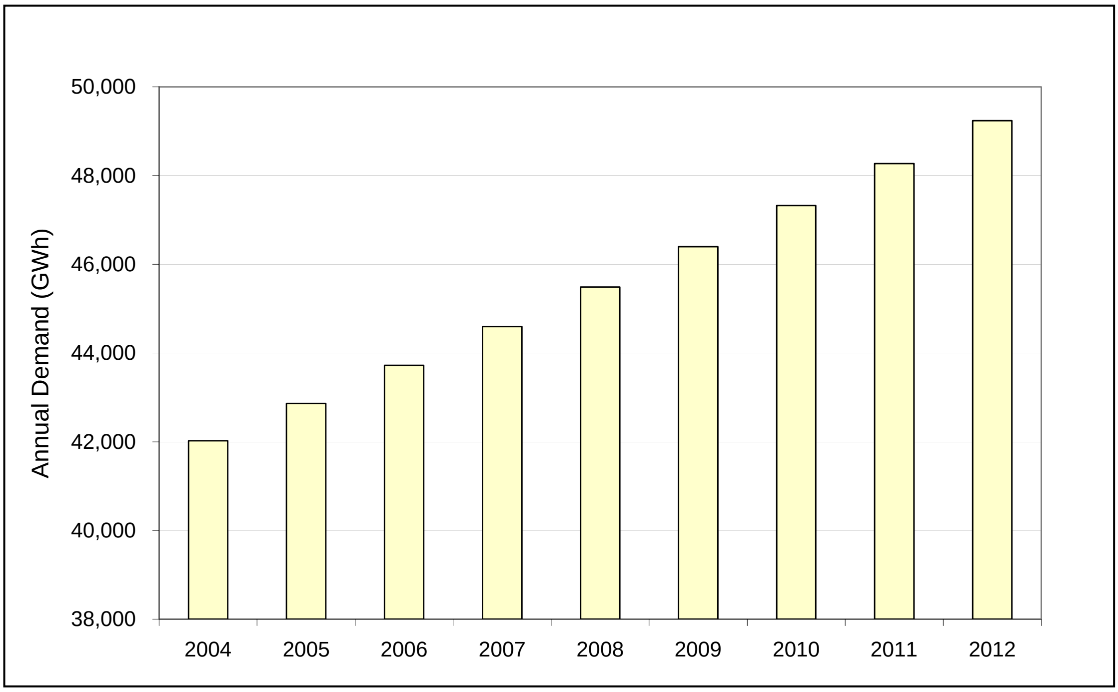
1 2008 to 2012 is the first commitment period under the Kyoto climate change protocol.

2 Refer http://www.climatechange.govt.nz/policy-initiatives/projects/.

3 Refer http://www.climatechange.govt.nz/resources/reports/electricity-factor-aug03/.

Figure 1: Nominal Gross Demand Assumptions



3.2 New Supply Capacity

New supply capacity assumptions to 2012 are summarised in Table 1 alongside the assumptions used in the 2003 analysis. The table shows the additional supply capacity assumed to come on line between now and 2008 and then for each calendar year thereafter. As in last year's analysis, we understand that the scenario assumptions are based on a number of potential new supply developments and an assessment of how many are likely to proceed. For our purposes new supply assumptions have been presented as generic options except where firm. Approximately 1,400GWh of electricity supply from the 2003 abatement projects has been included within these generic assumptions.

Table 1: New MW Supply Capacity Assumptions - 2004 Analysis

MW Capacity	to 2008		2009		2010		2011		2012	
Scenario	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**
Gas	360	405	-	-	-	-	-	-	-	-
Geothermal	155	252	10	10	10	10	10	10	10	10
Hydro	312	66	-	-	-	-	-	71	262	16
Wind	164	343	20	20	20	20	20	20	20	20
Other	30	97	5	-	5	-	5	-	5	-
Coal								100		
Total	*1,021*	*1,163*	*35*	*30*	*35*	*30*	*35*	*201*	*297*	*46*

The key differences in Table 1 are as follows:

Gas: The Genesis Power e3p combined cycle gas turbine (CCGT) project[4] capacity has been increased from 360MW to 365MW. The new 40MW gas turbine recently commissioned by Genesis has also been added.

Geothermal: Approximately 100MW of additional new capacity has been added in the period to 2008.

Hydro: The recent cancellation of Project Aqua (524MW) by Meridian Energy. This was previously assumed to be on line between 2008 and 2012 in two tranches of 262MW. These tranches have been removed from the period 2008 to 2011 (Aqua stage 1) and from the 2012 (Aqua Stage 2). In contrast, just 16MW of new hydro capacity has been added in the period to 2008 with a further 71MW added in 2012.

Wind: Approximately 180MW of additional capacity has been added prior to 2008.

Coal: A 100MW station has been added in 2011.

Other: 67MW of additional supply, primarily cogeneration, has been added in the period to 2008.

4 A combined cycle gas turbine (or CCGT) power station achieves relatively high thermal efficiency levels by using the exhaust heat from a gas turbine to heat steam which in turn powers a steam turbine.

3.3 Fuel Supply Issues

As noted in the 2003 analysis, Genesis Power has an 8 year coal supply contract with Solid Energy. Over the period 2008 to 2011, the supply of 1.7m tonnes of coal per annum to Huntly power station is expected under that contract. Genesis has in the last 12 months established the capability to import additional coal through the port of Tauranga and announced that it is looking also at additional domestic coal options.

The baseline scenario assumes that Contact Energy and Genesis Power will have sufficient gas to operate their combined cycle gas turbine plants over the period to 2012. However the nominal scenario assumes that there will be less overall gas supply and that this will be less flexible than assumed in the 2003 scenario. The 2004 scenario assumes that a small amount of gas is also likely to be used at Huntly and in particular given overall supply assumptions. The scenario assumes that additional gas could be available at higher electricity prices.

In the 2003 scenario it was difficult to accommodate assumed coal contract volumes. On average, coal stocks would have increased over the contract period from 2008 to 2011. In addition, some coal would have been held over until 2012 assuming that commercial arrangements would provide for that. As discussed later, lower overall gas supply and the loss of Project Aqua mean greater reliance on coal in the 2004 scenario. This means that the coal contract can be accommodated more easily and that coal stockpile constraints are less. This and additional short term coal procurement flexibility are important to compensate for gas supply contracts being less flexible and the addition of more inflexible new supply than in he 2003 scenario. This is important given the level of hydro supply variability that needs to be accommodated.

4 Analysis

The nominal supply and demand scenario has been modelled in detail over the period 2007 to 2012 using Concept's electricity market model (EMOS) following the same approach outlined in the 2003 report[5].

Thermal generation offers were tuned to reflect the likely relativity between fuel costs and efficiencies at each station taking into account expected relative fuel contract flexibility and the impact of a carbon charge on generator short run costs.

Figure 2 shows average generation, by type, for the 2003 and 2004 scenarios.

5 The assumed supply and demand scenario was assessed over a representative range of hydro inflow events using 1971 to 2001 hydro inflow sequences.

Figure 2: Average Supply under 2003 and 2004 Scenarios

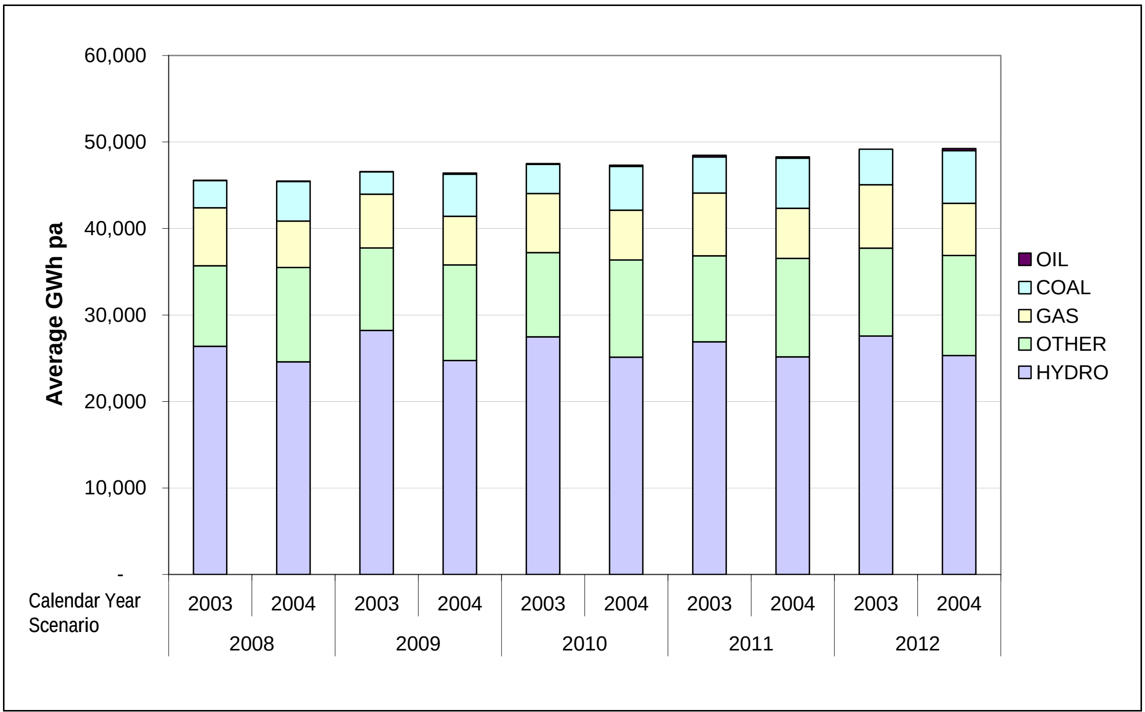


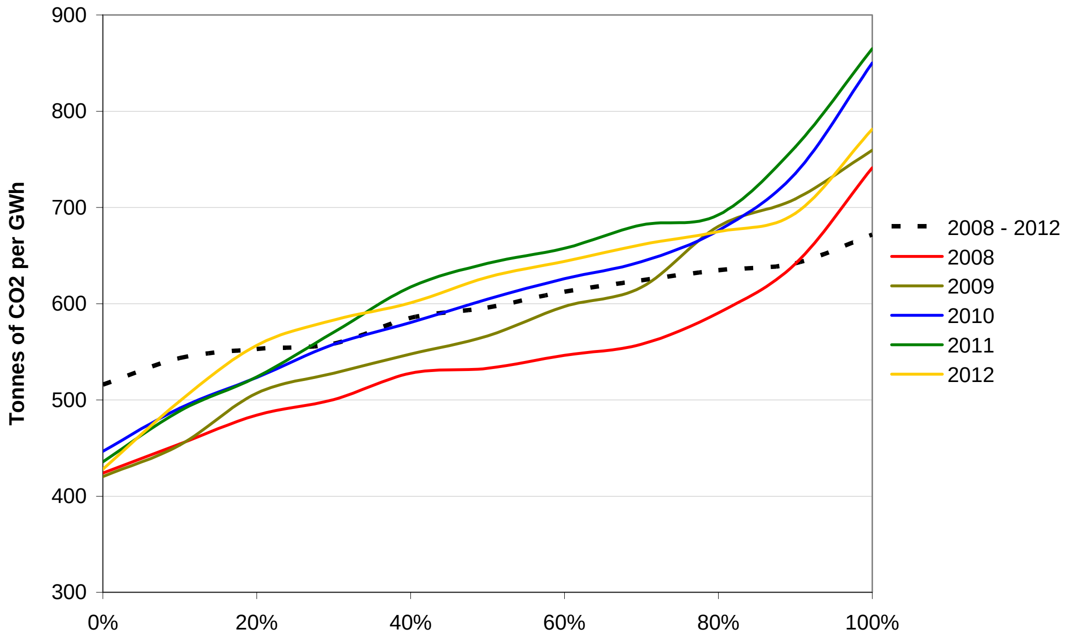
Figure 2 indicates that:

- On average hydro generation has reduced with the cancellation of Project Aqua.
- Other renewable supply (under "Other") has increased and compensates for more than half the lost Aqua generation in most years.
- Average gas fired generation has decreased consistent with the overall gas supply assumptions discussed previously.
- Coal usage has increased by about 50% on the previous analysis, compensating for the reduced gas usage and most of the balance of Project Aqua.
- Oil use is generally steady although there is greater expected use in 2012 when the loss of the second stage of Aqua has not been fully compensated by other supply.

As in the 2003 analysis, the market simulation was repeated with a tranche of new supply (50MW base-load) added. The differences in production at each thermal power station were then analysed and converted into net CO_2 emissions per GWh of additional supply.

Figure 3 shows the range of emission factors that could be expected for the 31 inflow sequences over the period 2008 to 2012 including for the individual years.

Figure 3 - Emission Factor Difference vs Hydrology



Curves are shown for each individual year in the commitment period and for the commitment period as a whole. Each curve indicates the likelihood[6] of a particular emission factor being exceeded, for the nominal supply and demand scenario over the range of hydrological sequences modelled. Depending on the time of year and inflow and storage conditions at the time, the 50MW increment of base load supply will displace hydro, gas or coal.

In any one year, the emission factor therefore ranges between 400 and 900 tonnes per GWh depending on hydrological variability. Over the full five years, the annual variability is attenuated significantly although there is still substantial variation driven by year-to-year changes in hydrology.

Figure 4 shows how the average change in CO_2 emissions per GWh alters for each quarter over the study period.

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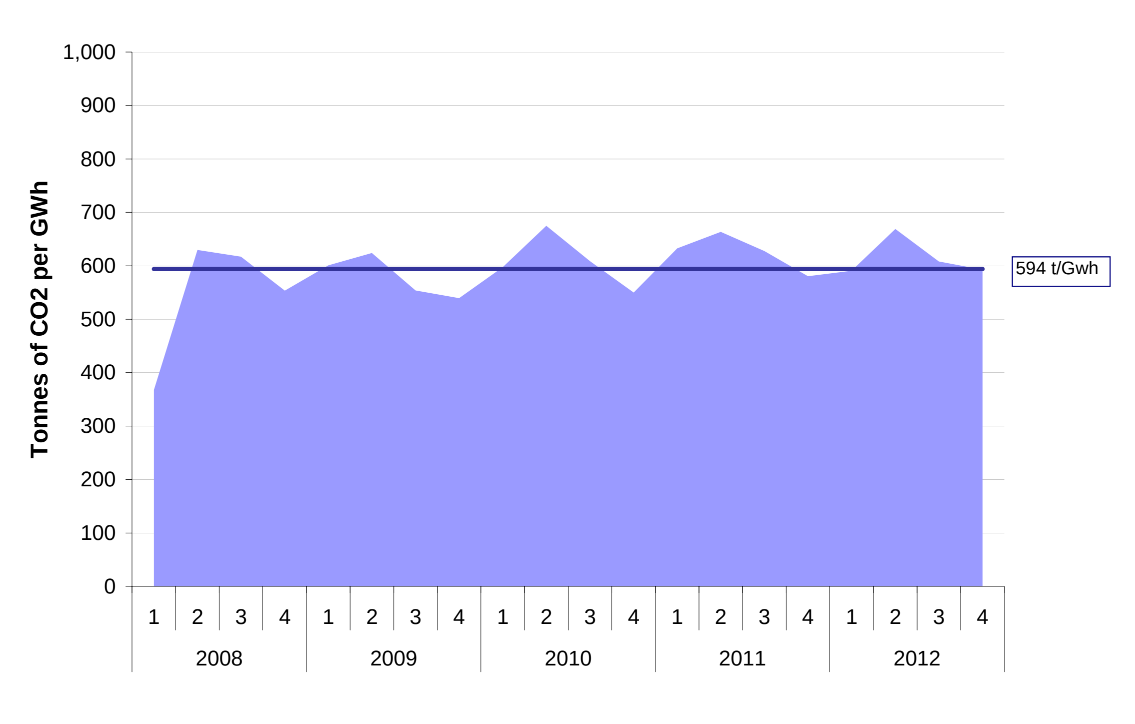
6 Calculated as percentiles.

Figure 4 - Average Quarterly Variation in Emission Factor



The average five year value, approximately 600 tonnes of CO_2 per GWh, is consistent with an assessment of the impact of a tranche of renewable base load supply over the full first initial commitment period (2008 to 2012). Given that the objective is to identify an emission factor for the first commitment period, the expected change in emissions per GWh applies for the full five year period.

We note that this is less than figure of 630 tonnes per GWh estimated in the 2003 analysis. This may seem counter intuitive given that the overall level of thermal generation, particularly for coal, has increased in the 2004 scenario.

However, the analysis is intended to be a marginal assessment of the effect of adding a 50MW tranche of new supply with no emissions. This assessment needs to take into account the nature of the changes in the 2004 scenario including time of year and hydrology variability and changes in the overall supply curve. Detailed market simulations over a range of inflows are required to do this. However, the following factors provide some insights into the results of the 2004 analysis:

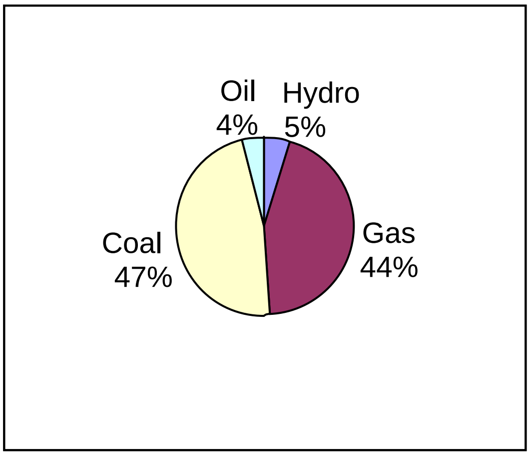
- Less gas flexibility will tend to force higher CCGT minimum running levels requiring other supply to back off at times of lower demand or plentiful hydro supply

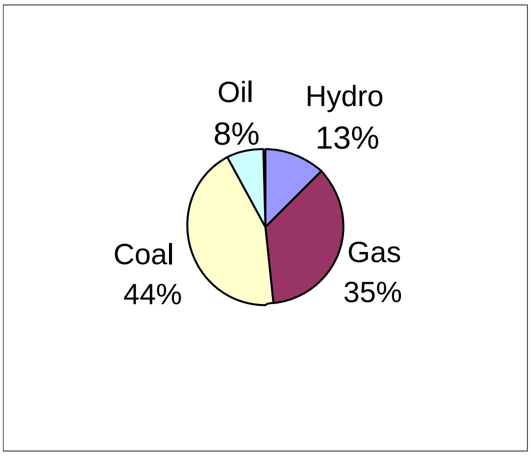
- To an extent, more coal flexibility would tend to offset this effect but the significant increase in renewable supply, which tends to be inflexible, will exacerbate the effect, especially over the spring and summer when inflows are higher and demand lower with correspondingly higher spill risks

- The assumption that overall gas supply will be less than assumed in the 2003 analysis will tend to result in hydro variability having to be accommodated by coal and (to the extent practical) hydro storage with the marginal burden shifting more to coal and water (including at times spill)

It may be helpful to consider Figure 5 which shows the relative displacement of generation by fuel type for each of the 2003 and 2004 analyses due to the addition of a 50MW base load tranche of new supply.

Figure 5 - Comparison of Displaced Energy between 2003 Analysis and 2004 Analysis





2003 **2004**

5 Sensitivity Analysis

Analysis has also been undertaken to check the sensitivity of the emission factor to a number of parameters:

- Increased coal flexibility tends to increase the factor
- Increased gas flexibility/availability, depending on the coal assumptions, tends to slightly decrease the factor
- The results are relatively sensitive to the level of new supply assumed. Reducing the new supply assumptions to those of the 2003 analysis increased the factor to approximately 660 tonnes per GWh

Overall, sensitivity analysis has tended to indicate that most realistic variations on the nominal scenario assumptions would tend to push the factor up rather than down.

6 Conclusions

The analysis presented in this report is based on a supply and demand scenario based on Climate Change Office and Ministry of Economic Development requirements.

Based on this analysis, and taking into account sensitivity analysis, an emission factor in the vicinity of 600 to 650 tonnes of CO_2 per GWh appears to be appropriate for the second tender.