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## em6: Carbon Methodology

November 2023

Vers. 1.1

## Document History

Version	Date	Status	Edited By	Revision Description
0.1	1 March 2021	Draft	Ed Oosterbaan	Initial Draft
0.8	10 May 2021	Draft	Ed Oosterbaan	Change to HLY units after review by Genesis Energy
0.9	23 February 2022	Final	Ed Oosterbaan	Minor edits and Final status change
1.0	7 August 2023	Final	Nick Warren	New Emissions Factors and other edits
1.1	20 November 2023	Final	Nick Warren	Emissions factor for KOE1101 NGB0 updated, Solar as a generation type added

# em6 Carbon Intensity

## Background

Transpower as the Grid Owner and System Operator publishes an average carbon intensity indicator by trading period available to consumers. We believe a near real-time indicator of carbon intensity and or CO<sub>2</sub> output to be a valuable feature for NZ consumers.

## Methodology

Transpower uses figures derived from generators, as well as publicly available reports from the MBIE website<sup>1</sup>. These different factors are applied to the different generator types in NZ in near real-time. The NZ aggregate carbon intensity in tCO<sub>2</sub>/MWh is published as well as the carbon intensity in tCO<sub>2</sub>/MWh by aggregated generator types.

The NZ carbon intensity  $NZ$  at time  $t$  is found by weighting the carbon intensity factor for each fuel type  $C_i$  by the generation of that fuel type  $G_t$ . This is then divided by the NZ national grid demand  $D_t$  to derive the carbon intensity for NZ.

$$NZ_t = \frac{C_i \times G_t}{D_t}$$

This provides a real-time total of tonnes of CO<sub>2</sub> per MWh consumed, as well as a break down on the volume weighted average of tonnes of CO<sub>2</sub> generated by the following generation types; Coal (CG), Gas (GAS), Geothermal (GEO), Co-generation (COG) and Liquid (LIQ). The following carbon intensity factors are currently in use. EMS updates the carbon intensity factors intermittently, with the most recent update applied on 19 April 2023.

CO <sub>2</sub> producing Generator Nodes	Emission factor (tCO <sub>2</sub> e/MWh)	Generation Type
HLY2201 HLY1	1.010	CG
HLY2201 HLY1	0.589	GAS
HLY2201 HLY2	1.010	CG
HLY2201 HLY2	0.589	GAS
HLY2201 HLY4	1.010	CG
HLY2201 HLY4	0.589	GAS
HLY2201 HLY5	0.400	GAS
HLY2201 HLY6	0.568	GAS

<sup>1</sup> <https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/new-zealand-energy-sector-greenhouse-gas-emissions/>

HLY2201 HLY6	0.733	LIQ
HWA1102 WAA0	0.683	COG <sup>†</sup>
JRD1101 JRD0	0.548	GAS <sup>†</sup>
KAW0111 TAM0	0.060	GEO <sup>*</sup>
KAW0112 ONU0	0.060	GEO <sup>*</sup>
KAW1101 KAG0	0.123	GEO <sup>*</sup>
KIN0112 KIN0	0.364	COG <sup>†</sup>
KOE1101 NGB0	0.000 <sup>x</sup>	GEO <sup>†</sup>
KPA1101 KPI1	0.683	COG <sup>†</sup>
MKE1101 MKE1	0.569	GAS <sup>†</sup>
NAP2201 NAP0	0.063	GEO <sup>*</sup>
NAP2202 NTM0	0.064	GEO <sup>*</sup>
OKI2201 OKI0	0.266	GEO <sup>**</sup>
PPI2201 PPI0	0.038	GEO <sup>**</sup>
SFD2201 SFD21	0.513	GAS <sup>†</sup>
SFD2201 SFD22	0.513	GAS <sup>†</sup>
SFD2201 SPL0	0.400	GAS
THI2201 THI1	0.040	GEO <sup>**</sup>
THI2201 THI2	0.040	GEO <sup>**</sup>
TWH0331 TRC1	0.632	COG
WHI2201 WHI0	0.760	LIQ
WKM2201 MOK0	0.052	GEO <sup>*</sup>
WRK0331 RKA0	0.084	GEO <sup>*</sup>
WRK0331 TAA0	0.053	GEO <sup>**</sup>
WRK2201 WRK0	0.018	GEO <sup>**</sup>

<sup>†</sup> Sourced directly from generator

<sup>\*</sup> 2020 MBIE Future Generation Geothermal Stack

<sup>\*\*</sup> Contact Energy 2022 Annual Report

<sup>x</sup> From October 2023, Ngawha Generation reinject carbon back into the ground, resulting in zero emissions for this node

Using these emissions factors, the CO<sub>2</sub> output per MWh can be determined.

Using the table above JRD1101 JRDO is a gas generator, and it has the emission type OCGTG, 0.548 tCO<sub>2</sub>e/MWh. If the SCADA 30 min reading for JRD1101 JRDO is 132MW:

$$\begin{aligned} JRD \frac{CO_2}{MWh} &= (132MW \times 0.5) \times 0.548 \\ &= 36.17 \text{ tonnes } CO_2 \end{aligned}$$

If JRD1101 was the only emitting generator, and the total generation in NZ was 1150MW in a 30 min SCADA reading, then the national carbon intensity figure for that trading period would be:

$$\begin{aligned} &= \frac{36.17 \text{ tCO}_2}{1150MW \times 0.5} \\ &= 0.0629 \text{ tonnes } CO_2/MWh \\ &= 62.90 \text{ kg } CO_2/MWh \\ &= 62.90 \text{ g } CO_2/kWh \end{aligned}$$

### Carbon Equivalent Units

We also take into account methane and nitrous oxide that may be produced when burning each fuel type and convert them into carbon equivalent units. However, these equivalents add only a very small amount compared to carbon – in most cases less than half a percent.

Given the API and carbon emissions dial on our dashboard are intended as a high-level overview of the situation, and that CO<sub>2</sub> makes up the vast majority of the emissions total, we use CO<sub>2</sub> as our unit and not CO<sub>2</sub>e.

### Huntly Units

Some of the generation units at Huntly can use multiple fuels to run their generation units. EMS integrates with Genesis Energy’s API to get a real-time feed of the gas percentage they are using as fuel in their units. This allows us to make an estimate of carbon intensity for these units. This applies to the Rankine Units (Units #1 - #4, and unit #6). This data is only used to provide aggregate generation information, not by unit.

Huntly Generator Nodes	Gas Percentage	Trading Period	Trading Date
HLY2201 HLY1	0%	16	21/12/2020
HLY2201 HLY2	4%	16	21/12/2020
HLY2201 HLY3	0%	16	21/12/2020
HLY2201 HLY4	0%	16	21/12/2020

HLY2201 HLY5	100%	16	21/12/2020
HLY2201 HLY6	0%	16	21/12/2020

Using the above example for unit 2 @ 203.097 MW, trading period 16 on 21-Dec-2020:

$$\begin{aligned}
 HLY2201 HLY2 (Unit 2 - GAS) &= 203.097 MW \times 4\% \\
 &= 8.124 MW \\
 &= (8.124 MW \times 0.5) \times 0.589 \\
 &= 2.393 \text{ tonnes } CO_2
 \end{aligned}$$

$$\begin{aligned}
 HLY2201 HLY2 (Unit 2 - COAL) &= 203.097 MW \times 96\% \\
 &= 194.973 MW \\
 &= (194.973 MW \times 0.5) \times 1.01 \\
 &= 98.461 \text{ tonnes } CO_2
 \end{aligned}$$

### Limitations

Transpower has no visibility of generation in the network behind the grid exit point (GXP), which is called embedded generation. As such these intensity figures only apply to the aggregate net demand at each GXP across NZ.

Using the generation measured at the generator accounts for the losses of the generation to the GXP but does not account for losses once the electricity leaves the Transpower grid.

### Renewable Percentage Determination

The total New Zealand renewable generation  $NZR$  at time  $t$  treats Hydro (HYD), Geothermal (GEO) Wind (WIN), Solar (SOL) and Battery (BAT) as renewable energy sources. The sum of the renewable generation is divided by the total NZ generation to determine the overall renewable percentage.

$$NZR_t = \left\{ \frac{\sum_t HYD_t, GEO_t, WIN_t, SOL_t, BAT_t}{NZG_t} \right\} \times 100\%$$

## em6 Generation Type API with Carbon Intensity

This API is included in the Market Dashboard data feed for em6 subscribers.

**Description:** API to return the last 24 hours of NZ generation information aggregated by generation type, including carbon intensity. Eg: Hydro.

This includes a generation type called 'NZ'. This will aggregate the NZ generation, NZ generation capacity and determine the carbon intensity.

<b>URL:</b>	{URL}/generation_type/24hrs/[generation_type_id]
<b>Method:</b>	GET
<b>Query parameters:</b>	
<b>Generation_type_id</b>	Hydro <b>HYD</b> , Coal <b>CG</b> , Gas <b>GAS</b> , Wind <b>WIN</b> , Cogen <b>COG</b> , Battery <b>BAT</b> , Liquid <b>LIQ</b> , Geothermal <b>GEO</b> , Solar <b>SOL</b> – <i>Optional blank for all</i>

### Examples:

1. {em6\_url}/generation\_type/24hrs/
2. {em6\_url}/generation\_type/24hrs/?generation\_type\_id=WIN

Truncated Generation Type Example Response: {em6\_url}/generation\_type/24hrs

```
{
  "items": [
    {
      "timestamp": "2021-02-15T00:00:00Z",
      "trading_period": 27,
      "generation_type": [
        {
          "generation_type_name": "Battery",
          "generation_mw": -0.188,
          "generation_capacity_mw": 1,
          "generation_carbon_t": null
        },
        {
          "generation_type_name": "Co-Gen",
          "generation_mw": 152.123,
          "generation_capacity_mw": 216,
          "generation_carbon_t": 37.319565
        },
        {
          "generation_type_name": "Coal",
          "generation_mw": 452.724,
          "generation_capacity_mw": 750,
          "generation_carbon_t": 228.62562
        },
        {
          "generation_type_name": "Gas",
          "generation_mw": 650.718,
          "generation_capacity_mw": 1280,
          "generation_carbon_t": 154.3511815
        },
        {
          "generation_type_name": "Geothermal",
          "generation_mw": 848.079,
          "generation_capacity_mw": 1061.5,
          "generation_carbon_t": 34.755419
        },
        {
          "generation_type_name": "Hydro",
          "generation_mw": 3098.977,
          "generation_capacity_mw": 5398,
          "generation_carbon_t": null
        },
        {
          "generation_type_name": "Liquid",
          "generation_mw": 0,
          "generation_capacity_mw": 156,
          "generation_carbon_t": 0
        },
        {
          "generation_type_name": "Wind",
          "generation_mw": 79.309,
          "generation_capacity_mw": 818,
          "generation_carbon_t": null
        },
        {
          "generation_type_name": "Solar",
          "generation_mw": 5.459,
          "generation_capacity_mw": 35,
          "generation_carbon_t": null
        },
        {
          "generation_type_name": "NZ",
          "generation_mw": 5281.742,
          "generation_capacity_mw": 9680.5,
          "generation_carbon_t": 455.0517855
        }
      ]
    }
  ]
}
```



## Current Carbon Intensity API

This API is free to call, check our integration guide on [ems.co.nz/services/em6](https://ems.co.nz/services/em6) for details.

**Description:** API to return the aggregated recent carbon intensity for NZ in the last 24 hours, including the following:

	Info	Example
<b>nz_carbon_t:</b>	Total Tonnes of CO2 produced in the trading period	184
<b>nz_carbon_gkwh:</b>	Grams of CO2 produced per kWh generated	22.95
<b>nz_carbon_change_gkwh:</b>	Change in grams of CO2 produced per kWh generated from the previous trading period	5.23
<b>nz_renewable:</b>	Percentage of NZ generation that is 'renewable'	81.23
<b>max_24hrs_gkwh:</b>	The <b>max</b> Grams of CO2 produced per kWh in the last 24hrs	43.47
<b>min_24hrs_gkwh:</b>	The <b>min</b> Grams of CO2 produced per kWh in the last 24hrs	10.56
<b>current_month_avg_gkwh:</b>	The average Grams of CO2 produced per kWh generated in the current month	22.89
<b>current_year_avg_gkwh:</b>	The average Grams of CO2 produced per kWh generated in the current year	45.89
<b>Pct_current_year_gkwh:</b>	The current Carbon output as a percentage of the rolling <b>12 month max</b> output	35.61

<b>URL:</b>	{URL}/current_carbon_intensity/
<b>Method:</b>	GET
<b>Query parameters:</b>	

### Examples:

1. {em6\_url}/current\_carbon\_intensity

## Current Carbon Intensity Example Response: {em6\_url}/current\_carbon\_intensity

```
{
  "items": [
    {
      "trading_date": "2021-02-15T11:00:00Z",
      "trading_period": 21,
      "timestamp": "10:00",
      "nz_carbon_t": 459.95,
      "nz_carbon_gkwh": 171.34,
      "nz_carbon_change_gkwh": null,
      "nz_renewable": 76.52,
      "max_24hrs_gkwh": 205.74,
      "min_24hrs_gkwh": 163.89,
      "current_month_avg_gkwh": 78.38,
      "current_year_avg_gkwh": 71.17,
      "pct_current_year_gkwh": 83.28
    },
    {
      "trading_date": "2021-02-15T11:00:00Z",
      "trading_period": 22,
      "timestamp": "10:30",
      "nz_carbon_t": 458.14,
      "nz_carbon_gkwh": 170.99,
      "nz_carbon_change_gkwh": -0.35,
      "nz_renewable": 76.52,
      "max_24hrs_gkwh": 205.74,
      "min_24hrs_gkwh": 163.89,
      "current_month_avg_gkwh": 78.38,
      "current_year_avg_gkwh": 71.17,
      "pct_current_year_gkwh": 83.11
    },
    {
      "trading_date": "2021-02-15T11:00:00Z",
      "trading_period": 23,
      "timestamp": "11:00",
      "nz_carbon_t": 450.52,
      "nz_carbon_gkwh": 168.02,
      "nz_carbon_change_gkwh": -2.97,
      "nz_renewable": 76.93,
      "max_24hrs_gkwh": 205.74,
      "min_24hrs_gkwh": 163.89,
      "current_month_avg_gkwh": 78.38,
      "current_year_avg_gkwh": 71.17,
      "pct_current_year_gkwh": 81.67
    },
    {
      "trading_date": "2021-02-15T11:00:00Z",
      "trading_period": 24,
      "timestamp": "11:30",
      "nz_carbon_t": 451.51,
      "nz_carbon_gkwh": 168.41,
      "nz_carbon_change_gkwh": 0.39,
      "nz_renewable": 77.05,
      "max_24hrs_gkwh": 205.74,
      "min_24hrs_gkwh": 163.89,
      "current_month_avg_gkwh": 78.38,
      "current_year_avg_gkwh": 71.17,
      "pct_current_year_gkwh": 81.86
    },
    {
      "trading_date": "2021-02-15T11:00:00Z",
      "trading_period": 25,
      "timestamp": "12:00",
      "nz_carbon_t": 454.93,
      "nz_carbon_gkwh": 170.04,
      "nz_carbon_change_gkwh": 1.63,
      "nz_renewable": 76.68,
      "max_24hrs_gkwh": 205.74,
      "min_24hrs_gkwh": 163.89,
      "current_month_avg_gkwh": 78.38,
      "current_year_avg_gkwh": 71.17,
      "pct_current_year_gkwh": 82.65
    }
  ],
}
```

## Historic Carbon Intensity API

This API is included in the Current and Historic Carbon Intensity data feed for em6 subscribers.

**Description:** API to return the aggregated carbon intensity for NZ by trading date:

	Info	Example
<b>nz_carbon_t:</b>	Total Tonnes of CO2 produced in the trading period	184
<b>nz_carbon_gkwh:</b>	Grams of CO2 produced per kWh generated	22.95
<b>nz_renewable:</b>	Percentage of NZ generation that is 'renewable'	81.23

<b>URL:</b>	{URL}/carbon_intensity/[from_trading_date] [to_trading_date]
<b>Method:</b>	GET
<b>Query parameters:</b>	
<b>from_trading_date</b>	<b>21/07/2020</b> - Required
<b>to_trading_date</b>	<b>21/07/2020</b> - Required

### Examples:

1. {em6\_url}/carbon\_intensity/?from\_trading\_date=30/07/2020&to\_trading\_date=30/07/2020
2. {em6\_url}/carbon\_intensity/?from\_trading\_date=01/07/2020&to\_trading\_date=30/11/2020

Historic Carbon Intensity Example Response: {em6\_url}/carbon\_intensity  
?from\_trading\_date=01/02/2021&to\_trading\_date=16/02/2021

```
{
  "items": [
    {
      "trading_date": "2021-01-31T11:00:00Z",
      "trading_period": 1,
      "timestamp": "00:00",
      "nz_carbon_t": 260,
      "nz_carbon_gkwh": 136.55,
      "nz_renewable": 80.98
    },
    {
      "trading_date": "2021-01-31T11:00:00Z",
      "trading_period": 2,
      "timestamp": "00:30",
      "nz_carbon_t": 260.47,
      "nz_carbon_gkwh": 140.56,
      "nz_renewable": 80.37
    },
    {
      "trading_date": "2021-01-31T11:00:00Z",
      "trading_period": 3,
      "timestamp": "01:00",
      "nz_carbon_t": 259.46,
      "nz_carbon_gkwh": 143.25,
      "nz_renewable": 80.11
    },
    {
      "trading_date": "2021-01-31T11:00:00Z",
      "trading_period": 4,
      "timestamp": "01:30",
      "nz_carbon_t": 258.53,
      "nz_carbon_gkwh": 145.61,
      "nz_renewable": 79.97
    },
    {
      "trading_date": "2021-01-31T11:00:00Z",
      "trading_period": 5,
      "timestamp": "02:00",
      "nz_carbon_t": 256.51,
      "nz_carbon_gkwh": 145.98,
      "nz_renewable": 80.01
    },
    {
      "trading_date": "2021-01-31T11:00:00Z",
      "trading_period": 6,
      "timestamp": "02:30",
      "nz_carbon_t": 256.5,
      "nz_carbon_gkwh": 147.24,
      "nz_renewable": 79.95
    }
  ]
}
```