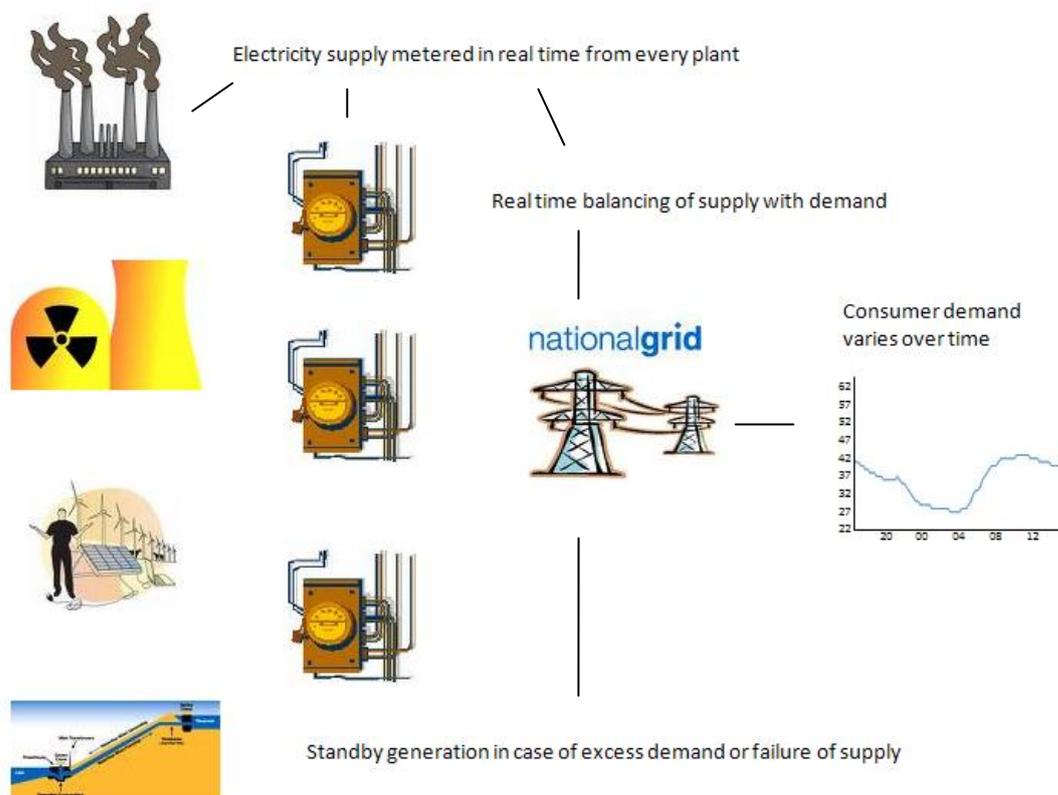


# realtime carbon Project Methodology

[Realtimecarbon.org](http://Realtimecarbon.org) is a joint project by [AMEE](http://AMEE) and [Demand Logic](http://Demand Logic), sponsored by a charitable grant from [Dynamic Demand](http://Dynamic Demand).

By providing a value for the carbon intensity of electricity, RealtimeCarbon.org helps electricity consumers make decisions around the carbon intensity of their consumption.



**Figure 1: Overview National Electricity Grid <sup>1</sup>**

Figure 1 is a simplified picture of the relationship between supply and demand across the national electricity grid. The key concepts are:

1. A mix of sources of energy are used to produce the electricity supplied across the [National Grid](http://National Grid). These sources include fossil fuels such as oil, coal and gas; nuclear power; hydro, and renewables such as wind and solar power.
2. All individual plant (power stations, wind farms, solar arrays, hydro, etc) above a certain output, have contribution to the grid monitored in real-time.
3. Large industrial and commercial consumers have their consumption of electricity metered in real-time.

<sup>1</sup> 'National Grid' is a term used to refer to the physical network of cables to distribute electricity and the name of the company which has responsibility to ensure electricity supply is available to meet demand.

4. [National Grid](#), as the system operator, has a duty to ensure supply always matches demand. If there is as much as a 1% difference, there will be blackouts.

- a. Forecasts are made to estimate demand in the future. Complex trading arrangements help suppliers match anticipated demand with contracts for output from generators.
- b. The National Grid pays some generators to operate in standby mode so that they can start output if the need arises (e.g. unexpected levels of demand, or a traditional plant that fails, or wind speeds not as they were forecast).

Together these operations are known as the **Balancing Mechanism**.

5. National Grid supplies information regarding its forecasts, contracted supply and the current state of supply and demand. [Elexon](#) manages this data under the 'Balancing Mechanism Reporting System' which includes the BM Reports website: <http://www.bmreports.com>

## The Future for Real Time Carbon

### Carbon Accounting:

AMEE is now in a position to provide consumers with more accurate recording and benchmarking of emissions arising from consumption of electricity.

### Demand Response:

It is not only intended for people to access the feed via a browser. The aim is to encourage incorporation of the feed into embedded computing devices that already control electrical loads. That will include Building Management Systems that control heating, ventilation and air conditioning loads in commercial buildings. It includes a growing range of applications that will help people manage activities at home where they can afford to be flexible. Washing cycles or water heating are examples of where there may be some flexibility in time of use.

The aim is to flatten out the peaks in demand which make keeping the grid in balance such a complicated job. In the short-term, active management of demand can reduce the need for older, more polluting stations to be switched on to 'catch the peak' and thereby reduce emissions. Longer term active demand management can help to match demand with times when there is an abundance of clean renewable energy eg when the wind is blowing.

### Next Steps

The approach at present is limited in two key aspects and RealtimeCarbon.org is keen to work with anyone who can help tackle them.

### Accuracy:

The approach is a certain improvement on the current fixed standard. It is important to distinguish between different fuel types as the proportion of CO<sub>2</sub> to electricity generated changes significantly. However, it does not go far enough. The difference between different generating plant of the same fuel type are significant too. Power stations operate with different efficiencies. In addition, some are further from the grid than others and will, therefore, incur additional transmission losses.

Additionally, some power stations are asked to operate in a partly-loaded state so they can provide Spinning Reserve. This is significantly less efficient than operating at full (design) output and an improved methodology could try to take this into account.

We are also aware that some thermal stations may be co-firing with biomass which may affect the carbon content of the electricity produced at these stations. Again we would like to explore if this can be incorporated in the methodology in a meaningful way.

### Forecasting:

Comparison between emissions associated with a unit of electricity now and the Government standard, as well as recent averages are helpful. However, consumers can only delay consumption for so long. If the approach is to leverage the full benefits in terms of emissions savings, consumers should have the benefits of forecasts. Most obviously, this will include weather forecasts which affect the volumes of wind energy available. However, the forward-contracts of the Balancing Mechanism provide a detailed account of likely sources of generation into the future.

RealtimeCarbon.org would like to work with consumers, the National Grid, Elexon and others, to help us all favour the most efficient, least polluting forms of electricity generation.

## 5 Minute Generation by Fuel Type

The [www.bmreports.com](http://www.bmreports.com) website is full of information regarding the current state of the national electricity grid. One small item of information is critical to RealtimeCarbon.org and license to use it has been gratefully received on behalf of the project by Dynamic Demand.

The item is a data feed which is updated every 5 minutes:

<http://www.bmreports.com/bsp/additional/soapfunctions.php?element=generationbyfueltypetable>

The feed breaks the mix of the electricity supply down by fuel type. Listing 1 gives an example of the data received.

### Listing 1: Example Generation by Fuel Type data feed

```
<INST AT="2009-07-03 16:35:00" TOTAL="40350">
  <FUEL TYPE="CCGT" IC="N" VAL="16415" PCT="40.7"/>
  <FUEL TYPE="OCGT" IC="N" VAL="0" PCT="0.0"/>
  <FUEL TYPE="OIL" IC="N" VAL="0" PCT="0.0"/>
  <FUEL TYPE="COAL" IC="N" VAL="14070" PCT="34.9"/>
  <FUEL TYPE="NUCLEAR" IC="N" VAL="8365" PCT="20.7"/>
  <FUEL TYPE="WIND" IC="N" VAL="113" PCT="0.3"/>
  <FUEL TYPE="PS" IC="N" VAL="298" PCT="0.7"/>
  <FUEL TYPE="NPSHYD" IC="N" VAL="98" PCT="0.2"/>
  <FUEL TYPE="OTHER" IC="N" VAL="0" PCT="0.0"/>
  <FUEL TYPE="INTFR" IC="Y" VAL="991" PCT="2.5"/>
  <FUEL TYPE="INTIRL" IC="Y" VAL="0" PCT="0.0"/>
</INST>
```

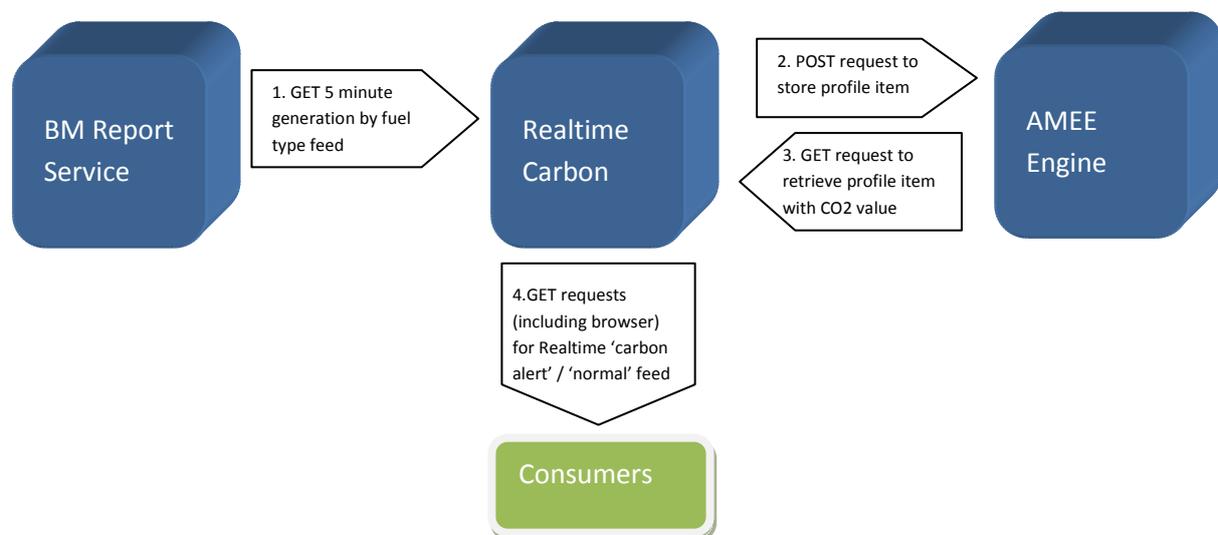
The data is in a format known as XML and is quite intuitive. The opening line states that the current ‘instantaneous’ profile is produced for the time 16:35:00 on 3<sup>rd</sup> July, 2009. It states that the total generation at this time is 40,350 megawatts.

The lines beginning with <FUEL TYPE are in regard to each of the fuel types. The less obvious ones include CCGT for closed cycle gas turbines, OCGT for open cycle gas turbines, PS for pump storage and NPSHYD for non-pump storage hydro. Also listed are imports over the interconnectors to France (INTFR) and Ireland (INTIRL).

The next value in each fuel type entry is IC which stands for interconnector.

Then comes VAL, which is the amount of generation for that fuel type in megawatts and PCT which stands for percent of the total.

## From BM Reports to RealtimeCarbon.org



The next step is to consume the feed when it is refreshed, apply a carbon factor associated with each fuel type and store the result. The consumption of the feed is undertaken by an application on RealtimeCarbon.org, and the carbon intensity calculation applied and stored by AMEE. The application of carbon factors and storage of the result is the principle reason for the existence of the AMEE platform.

AMEE allows clients to record information about energy use while applying accepted CO<sub>2</sub> factors (the CO<sub>2</sub> conversions for each generation type can found at the bottom of this document). It means consumers (individuals or organisations) are able to benchmark energy use and be confident that the factors applied are consistent with others.

To enable RealtimeCarbon.org to record details of 5 minute generation by fuel type, a data structure known as a Profile was created in the AMEE engine. In this case, the Profile mirrors the breakdown of the fuel types with a field for each fuel type. Additionally there are fields to capture metadata including the time period to which each entry relates.

AMEE is accessible via RESTful web services. The beauty of this approach is that it harnesses the same communications infrastructure and protocols as the world-wide web: that makes them available through a host of existing hardware, programming languages and desktop or server-based applications.

### Listing 2: a typical POST operation to record a 5 minute generation profile item in AMEE

```
POST /profiles/A24BEF662687/realtimeelec HTTP/1.0
Accept: application/xml
authToken:
sn51PnrG0w8/j5iHWa67NTOY3JCirRLd0ybwJy/nbQjzJxNK+JtEphlwJ6xsgx5dYTj7W
snQ/ARL0q9eczZY46h7xgQ0pY3zmIX7Gr92lU=
Host: stage.amee.com
Content-Type: application/x-www-form-urlencoded
Content-Length: 111
dataItemUid=E87215DDA5DB&name=elxon&startDate=2009-05-
21T15:10:00Z&ccgt=16534000&coal=15193000&nuclear=5886000
```

This POST requests a new 'profile' item to be created. If successful, CO<sub>2</sub> arising from the volume of generation by each fuel type in the item are evaluated and stored in the 'value' field. The RealtimeCarbon.org now sends a GET request to AMEE

### Listing 3: Extract from AMEE Profile Item XML response to GET

```
<ItemValue uid="02FE557A02FE">
  <Path>massCO2PerEnergy</Path>
  <Name>mass CO2 per energy</Name>
  <Value>0.45806159466899943</Value>
  <Unit>kg</Unit>
  <PerUnit>kWh</PerUnit>
  <StartDate>2009-06-04T11:25:00+01:00</StartDate>
  <ItemValueDefinition uid="93EA3EEB01CD">
    <Path>massCO2PerEnergy</Path>
    <Name>mass CO2 per energy</Name>
    <ValueDefinition created="2007-07-27 09:30:44.0"
      modified="2007-07-27 09:30:44.0"
      uid="45433E48B39F">
      <Name>amount</Name>
      <ValueType>DECIMAL</ValueType>
      <Description/>
      <Environment uid="5F5887BCF726"/>
    </ValueDefinition>
    <Unit>kg</Unit>
    <PerUnit>kWh</PerUnit>
    <FromProfile>true</FromProfile>
    <FromData>false</FromData>
  </ItemValueDefinition>
</ItemValue>
```

Listing 3 gives just an extract of the information that can be retrieved. In practice, a whole item can be retrieved including the volumes of electricity by fuel type.

## RealtimeCarbon.org 5 Minute Feed

The first iteration of the feed provides a much simplified version of the AMEE feed with the addition of two values by which to compare the current CO<sub>2</sub> emissions. One of these is the official Government standard for UK 'average' grid electricity, and the other is a rolling average of the previous values recorded by the RealtimeCarbon.org feed.

Listing 4 shows the response to a GET request as would be returned to a browser.

### Listing 4: Extract from AMEE Profile Item XML response to GET

```
<electricityCO2Item
uri="http://www.realtimecarbon.org/ws/electricity/services/co2profile
/5minute/item">
  <uid>FF15434D6171</uid>
  <amount>0.41186386950497544</amount>
  <units>kgCO2 per kWh</units>
  <startDateGMT>2009-07-14T17:35:00+00:00</startDateGMT>
  <endDateGMT>2009-07-14T17:40:00+00:00</endDateGMT>
  <hhRollingMean>
    <value>0.42402200551086715692</value>
    <units>kgCO2 per kWh</units>
    <startDateGMT>2009-07-14T11:00:00+00:00</startDateGMT>
    <endDateGMT>2009-07-14T17:00:00+00:00</endDateGMT>
    <hhSampleSize>13</hhSampleSize>
  </hhRollingMean>
  <officialStandard>
    <value>0.527</value>
    <units>kgCO2 per kWh</units>
  </officialStandard>
</electricityCO2Item>
```

First, the feed provides the amount of CO<sub>2</sub> emitted as a result of each unit of electricity consumed, the units in which they are given and the period to which the amount applies defined by a start and end date. In this case:

```
<amount>0.41186386950497544</amount>
<units>kgCO2 per kWh</units>
<startDateGMT>2009-07-14T17:35:00+00:00</startDateGMT>
<endDateGMT>2009-07-14T17:40:00+00:00</endDateGMT>
```

Next are values to which the amount can be compared. The first is an average (mean) value. This value is derived from the previous week's figures. In other words it is a seven day rolling average. In fact, it is an average derived from the half-hourly figures that are published as part of the BM Report feed. This is parsed and processed via AMEE in parallel to the 5 minute feed. The key part is the number between the <value></value> tags. This provides the comparison for the alert and graph.

```

<hhRollingMean>
  <value>0.42402200551086715692</value>
  <units>kgCO2 per kWh</units>
  <startDateGMT>2009-07-14T11:00:00+00:00</startDateGMT>
  <endDateGMT>2009-07-14T17:00:00+00:00</endDateGMT>
  <hhSampleSize>13</hhSampleSize>
</hhRollingMean>

```

The last part is the official standard of 0.527 kgCO<sub>2</sub> per kWh. This is included in the feed but not currently displayed on the site. The standard conversion factor has relevance for Government policies such as the CRC (more information and discussion can be found on the [forum](#)).

## CO<sub>2</sub> conversion factors

The conversion factors we currently use for each generation type are as follows:

Generation type	Conversion factor (kgCO <sub>2</sub> per kWh)
Closed cycle gas turbine (CCGT)	0.360
Coal	0.910
Electricity from France interconnector (INTFR)	0.083
Electricity from Ireland interconnector (INTIRL)	0.699
Non pumped storage hydro (NPSHYD)	0.0
Nuclear	0.0161
Open cycle gas turbine (OGCT)	0.479
Oil	0.610
Pump storage	0.0
Other	0.610

More details on the generation types and the source of each conversion factor can be found in on the AMEE wiki.

## Getting Involved

RealtimeCarbon.org is a collaborative project; if you would like more information or better still to get involved by using the feed or helping to improve it, please go to:

[www.realtimecarbon.org/forum](http://www.realtimecarbon.org/forum)