Annex B – further information on the AQ emission factors by sector

Power Generation

Power generation is covered by eleven modules of which only two would cover activities that have an impact on air quality:

- I.a Biomass/coal power stations
- I.b Carbon capture storage (CCS)

Both modules cover the use of hydrocarbon fuels to generate power. For 2010 emission factors are based on existing NAEI emission projections UEP38 (2009 NAEI base year) for all fuels and pollutants, except for NOx and PM_{10} from burning of biomass where emission factors from a recently-completed review (Hodgson, 2011)[1] have been used instead.

For the 2050 low innovation scenario, the existing NAEI projections to 2025 have been kept constant. The emission factors from Hodgson (2011) relate to future use of biomass and have also been held constant to 2050. Expert judgement has been used to derive the 2050 high innovation scenario

Bioenergy

Use of biofuels is accounted for separately in every module (except for transport sector), by use of scaling factors which are fuel and pollutant specific. These factors are calculated from the ratio of biofuel emission factors to those for fossil fuels for the same source (NAEI 2009), and an average indicative factor applied across all modules. This methodology is not intended to give an accurate estimate of biomass emissions which can be reported separately, but to provide a minor adjustment to the existing emissions totals, to indicate the likely direction of change of emissions as a result of different biomass usage rates. For road transport, EFs derived for the 2050 calculator have taken into account the limited uptake of biofuel according to the targets required by the EU Biofuels Directive (with assumptions that they are bioethanol or biodiesel produced from vegetable oils and blended with conventional fossil fuel at very low strength). For the NAEI, the current biofuel AQ EFs for road transport are expressed as scaling factors relative to fossil fuels and they were developed in 2008[2] based on limited literature available at that time. The emission scaling factors developed have high levels of uncertainty and in some cases, even the directional change in emissions is not certain. The scaling factors are for different biofuel strengths and there is not necessarily a linear relationship, e.g. an engine using pure biofuel has a different EF to one using a weak blend. As a result, separate biofuel AQ EFs have not been developed as information on what mixture strength is required and the 2050 Calculator seems to only provide information on the relative quantities of

[1] Hodgson, N. (2011), Future Use of Biomass in the UK, AEA Technology, Report No AEA/ED48954605 Issue 1, March 2011

[2] Murrells, T. and Li, Y. (2008), Road Transport Emissions from Biofuel Consumption in the UK, Report No. AEAT/ENV/R/2662, July 2008.
http://uk-air.defra.gov.uk/reports/cat15/0901151441_NAEI_Road_Transport_Biofuels_report_2008_v1.pdf

total biofuel and fossil fuel used. For other transport, the impact of biofuels on air quality is not currently taken into account as there are very few data available.

Agriculture and waste

Agriculture & waste is covered in three modules, of which two cover activities that have an impact on air quality:

- VI.a Agriculture and land use
- VI.b Volume of waste & recycling

Emission factors are based on existing NAEI emission projections UEP38 (2009 NAEI base year) for all fuels and pollutants. for 2010 and 2050 low innovation scenario and expert judgement for 2050 high innovation scenario.

Hydrogen Production

Production of hydrogen for use as an alternative fuel to hydrocarbons is covered in one module:

- VIII.a H_2 production for transport

This sector is not covered in existing NAEI projections because it does not currently exist as a significant source, and is not considered to become a significant source over the period covered by those projections. The 2050 Calculator estimates gas used to produce the hydrogen and factors for this have been based on NAEI projections for gas used in the reformation of methane to produce hydrogen for ammonia production, since this is a similar process and on expert judgement.

Space Heating & Hot Water

Energy used to provide space heating and hot water is covered in two modules:

- IX.a Domestic space heating and hot water
- IX.b Commercial space heating and hot water

Both modules include the same thirteen technological options for meeting space heating and hot water requirements. Five of these options do not require the use of fossil fuels in-situ so emission factors are not required. Emission factors have been derived for the remaining eight options as described below.

Small scale gas-fired boilers are divided into two classes, described as 'old' and 'new'. New boilers have a higher energy efficiency. There is no comparable distinction in the NAEI projections, although those projections do recognise that emission rates for NOx are decreasing due to technological improvements. This is assumed to be a separate issue to energy efficiency however, and so the NAEI emission factors are applied to both classes of gas fired boilers, for both domestic

and commercial space heating systems. The better energy efficiency of the 'new' systems means that NOx emissions will be lower for a given space heating or hot water requirement, compared with the old systems, since emissions are related to the energy input, rather than the energy output. Emission factors for other pollutants are either zero (SO_2) or kept constant across the time-series (PM_{10}).

Emission factors for oil-fired are based on the assumption that the figure of 120 mg/kWh given in the current draft of the Eco Design Directive is retained and comes into force for new equipment by 2017. It is then also assumed that all oil-fired boilers are replaced every 15 years so that all devices meet the Eco Design Directive figure by 2032. Prior to 2017 all existing and replacement systems are assumed to emit approximately 250 mg/kWh, which is based on the historical NAEI factors for domestic combustion of oils.

Emission factors for solid fuel-fired boilers are taken from the NAEI projections UEP38 (2009 NAEI base year) which reduce over time because they assume there are changes in the nature of the solid fuels burnt over time with an increasing proportion of domestic solid fuel being wood.

Two types of micro-CHP systems are identified in the 2050 Calculator – those based on a Stirling Engine, and those based on fuel cells. For Stirling Engine-based systems, we have used the same emission factors as for gas-fired boilers, while for fuel cell systems, we have assumed no emissions of NOx, SO_2, NMVOCs or PM_{10}.

Finally, these modules include gas and solid fuel-fired community-scale CHP. Since these types of system are relatively uncommon in the UK, the NAEI does not consider them separately. So for this work, we have derived estimated NOx emission factors based on the emission limit value (ELV) given in guidance for medium (20-50MWth) gas turbines regulated by local authorities (60 mg/m^3 at 15% O_2) and the limit of 500 mg/m^3 at 5% O_2 for compression ignition and spark ignition engines, given in the Gothenburg Protocol. Community-scale CHP for the domestic sector are then assumed to be 100% engines, while community-scale CHP for the commercial sector are assumed to be a 50/50 mixture of turbines and engines. For SO_2 and PM_{10}, the same factors are used for community-scale CHP as for gas-fired boilers and solid fuel-fired boilers.

Lighting, Appliances & Cooking

Gas used for cooking is covered in two modules:

- X.a Domestic lighting, appliances, and cooking
- X.b Commercial lighting, appliances, and cooking

The NAEI did not consider gas used for cooking separately so instead we have used default emission factors for small scale gas combustion taken from the 2009 EMEP/CORINAIR Guidebook[3] for the 2010 and 2050 low innovation scenario and expert judgement for 2050 high innovation scenario.

[3] 2009 EMEP/CORINAIR Guidebook, available online at http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009

Industrial Processes

Emissions from the use of fuels by industrial processes are covered by a single module:

XI.a Industrial processes

In the case of NOx emissions from the industrial combustion of gas, emission factors are based on those used in the NAEI projections UEP38 (2009 NAEI base year), however the methodology has been extended to 2050 while the original NAEI projections only extend to 2025. For all other fuels and other pollutants, emission factors are based on the NAEI projections to 2025, after which the 2025 emission factor is assumed to apply up until 2050.

Module XI.a is also assumed to cover process-related emissions from industry i.e. non-fuel related emissions such as those that occur from chemical processes or mineral processing. Emission projections for these types of sources have been taken from the NAEI projections up to 2020. After that point, the NAEI projections assume constant emission rates for most or all of these sources while the level of industrial activity can be varied in the 2050 model. Therefore the emissions from industrial non-fuel related sources are, from 2020, linked to industrial activity in the model.

Transport

Emissions from transport are covered by the following modules:

- XII.a Domestic passenger transport
- XII.b Domestic freight
- XII.c International aviation
- XII.e International shipping

For road transport (i.e. both domestic passenger and freight), the EFs were derived from the latest NAEI road transport emission projections (Base 2010) up to year 2025. Future EFs (post-2025) are kept constant as the makeup of the fleet will almost reach the current maximum emission standard (Euro 6) by this time period. For hybrid vehicles, the EFs were based on vehicles that meet Euro 5 and 6 Emission Standard, with the assumptions that there will be no additional improvement in AQ pollutant emissions, but there will be a 30% reduction in fuel consumption. Sulphur content of both petrol and diesel fuels are assumed to meet the EU Fuel Quality Directive limit of 10ppm from 2010 onwards. It should be noted that the road transport EFs that we derived for the 2050 calculator have already taken into account the limited uptake of biofuel according to the targets required by the EU Biofuels Directive (with assumptions that they are bioethanol or biodiesel produced from vegetable oils and blended with conventional fossil fuel at very low strength). For PM_{10}, the emission factors have also incorporated emissions from non-exhaust sources (i.e. road abrasion, tyre and brake wear) as they are dependent on the level of traffic activity. All transport powered by electricity or full cell is assumed to emit zero tailpipe emissions.

For rail, EFs are provided for passenger and freight diesel trains. The EFs are weighted by the different classes of engine units used for Intercity and regional passenger trains and the units used for freight trains. The EFs also take into account emission standards affecting new diesel engines up

to Stage IIIB to be implemented from 2012 onwards and the use of low sulphur fuel (<10ppm) from 2011. Assumptions are made for the turnover in the rail engine fleet that 1000 new engine units are sold each year with a lifetime of 30 years based on earlier work done by AEA for the Strategic Rail Authority in 2005.

For aviation, the EFs are based on just the landing and take off (LTO) part of the cycle which is most appropriate for AQ pollutants. Future EFs are kept constant at the factors implied by the 2009 NAEI on the grounds that improvements in emissions will follow improvements in fuel efficiency, so there would not be any changes in EFs in the required units.

The EFs for national navigation and international shipping were derived based on data provided by AMEC (previously known as Entec[4]) who developed the shipping inventory for the 2009 NAEI and projections data for 2020. The factors that we derived are operation-averaged EFs (i.e. covering all parts of shipping movements, engine types and fuels). It is assumed that emission factors to 2050 remain at the levels implied by AMEC's projections for 2020.

Petroleum Refineries

Emissions from the use of fuels by petroleum refineries are covered by a single module:

- XV.a Petroleum refineries

Emission factors are based on those used in the NAEI projections UEP38 (2009 NAEI base year) for 2010 and 2050 low innovation scenario and expert judgement for 2050 high innovation scenario.

2.10 Fossil Fuel Production

Emissions from the use of fuels in the manufacture of fossil fuels (e.g. coal, crude oil & gas) are covered by a single module:

- XV.b Indigenous fossil-fuel production

Emission factors are based on those used in the NAEI projections UEP38 (2009 NAEI base year) for 2010 and 2050 low innovation scenario and expert judgement for 2050 high innovation scenario.

[4] Entec (2010) UK Ship Emissions Inventory.
http://uk-air.defra.gov.uk/reports/cat15/1012131459_21897_Final_Report_291110.pdf