**Note in relation to the Urban air quality modelling of Dublin report**

The EU Ambient Air Quality and Cleaner Air for Europe (CAFE) Directive (2008/50/EC) sets binding limits for concentrations of air pollutants, which consider the effects of each pollutant on the health of those who are most sensitive to air quality. The Directive was transposed into Irish legislation by the Air Quality Standards Regulations 2011. Each Member State is required to undertake monitoring of air quality at representative locations against the limit concentrations.

While not currently a requirement under the CAFÉ Directive, modelling of air quality allows the provision of information for locations between monitoring stations and supports identification of the source of poor quality air. EPA is currently developing this capability under the National Ambient Air Monitoring Programme 2017 – 2021 (AAMP).

**CERC modelled urban air quality assessment**

As part of the modelling pillar of the AAMP, the EPA in conjunction with Cambridge Environmental Research Consultants Ltd (CERC) carried out a modelled urban air quality assessment of Dublin City for 2015 and 2017, which included the modelling of $NO_2$, $PM_{10}$ and $PM_{2.5}$ concentrations. Measured annual average $NO_2$, $PM_{10}$ and $PM_{2.5}$ concentrations from automatic monitors throughout Dublin City in 2015, 2016 and 2017 were used in the modelling exercise to verify outputs. The modelled concentrations show good agreement with the measured data.

The outputs of this model in relation to $NO_2$ were published in the report Urban Environmental Indicators – Nitrogen dioxide levels in Dublin.[1]

**Resources and time frames to complete work**

The initial work on the Dublin city wide study took a considerable amount of time to complete (approximately 12 months).

Model Inputs: The report from 2019 was the first time such a detailed study using a dispersion model was completed, a considerable amount of time was spent in assembling and processing the raw data. One of the key areas was getting access to good quality terrain data. This was sourced for the Dublin area through the OPW. In relation to traffic data, Dublin City Council provided these data. All other sources of data were reasonably straight forward to access (see Appendix 1 for the types of data used by the model).

**Running the model including future model runs**

Entire city for one year: City divided into 12 sectors. Each sector took 3 days to run. >30 days CPU processing time plus data processing time. This would require a level of support from model application providers to ensure the model set up is consistent.

Specific streets: Much quicker than city wide. With correct input data, runs can be complete within 10 days. This can be completed inhouse by EPA, subject to assignment of staff resources.

Source apportionment studies for $NO_2$: The facility to assess the contribution from each specific category of vehicles on certain roads also exists. This can be completed internally by EPA although it would need accurate traffic configuration information to reflect the scenario being assessed.

[1] http://www.epa.ie/pubs/reports/air/quality/urbanenvironmentalindicatorsnitrogendioxidelevelsindublin.html

Additional modelling assessments
Newly developed air quality modelling tools and verification methodologies could be used in conjunction with the existing local information where applicable.

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**Appendix 1: Information on the model used and data driving it**

ADMS-Urban is a scientifically advanced but practical air pollution modelling tool, which has been developed to provide high resolution calculations of pollution concentrations for all sizes of study area relevant to the urban environment. The model can be used to look at concentrations near a single road junction or over a region extending across the whole of a major city. ADMS-Urban has been extensively used for the Review and Assessment of Air Quality carried out by Local Authorities in the UK and for a wide range of planning and policy studies across the world. More details can be found on the CERC web site[2].

The model used detailed emissions data, together with a range of other input data, to calculate the dispersion of pollutants.

1. Emissions data

Emissions inventories were compiled for Dublin and the surrounding area using the CERC emissions inventory toolkit (EMIT). The emission types covered: road traffic emissions, industrial sources and other sources (see Table 1).

**Major road traffic emissions**

Traffic data were provided by Dublin City Council for the majority of the city area. The data comprised hourly traffic counts, speeds and percentage HGV for each road. The traffic counts were taken from the City's SCATS traffic management system. The light/heavy vehicle split was derived from the City's annual Cordon Count, which counts the traffic entering the inner city over all bridges on the Grand and Royal Canals. The map below shows the annual average daily total (AADT) traffic flows for the city.

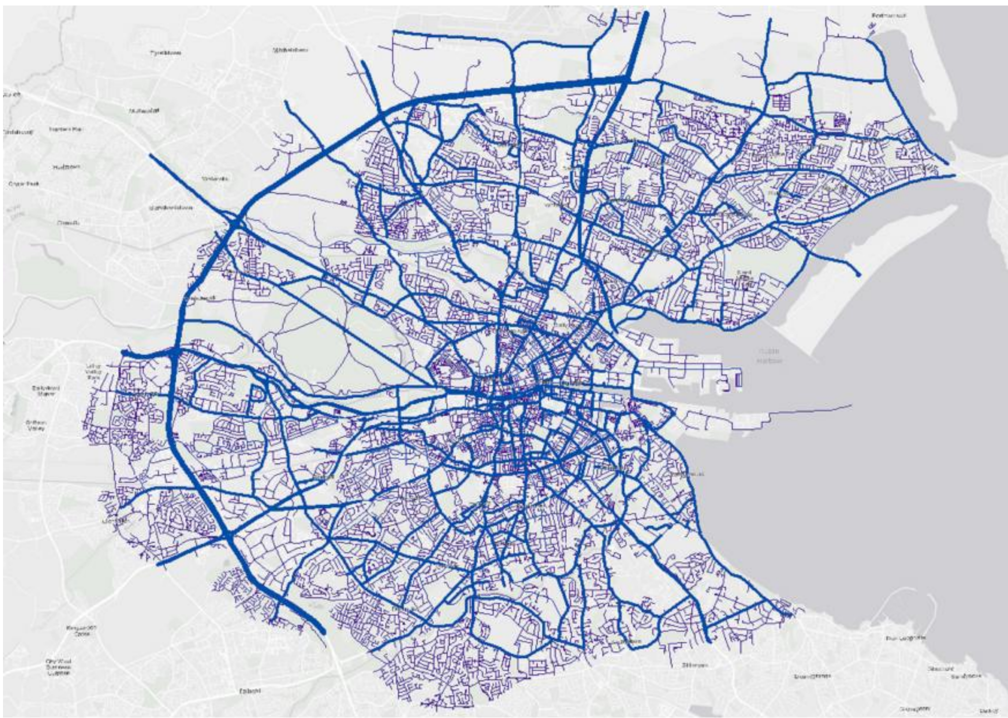

**Figure 1**: Daily traffic flows for modelled roads in Dublin

[2] www.cerc.co.uk

Some anomalies were identified in the traffic data during the data processing; changes were made, where possible, based on the traffic flow on neighbouring roads and local knowledge. Flows for minor roads Pembroke Lane and Wellington Road were provided by DCC and flows for major roads M2, N3 and M50 were taken from TII's traffic count website[3].

**Traffic emission factors:** Traffic emissions of $NO_x$, $NO_2$, PM10 and PM2.5 were calculated from traffic flows using emission factors from the Emission Factor Toolkit (EFT) version 8.0 published by the UK Department for the Environment Food and Rural Affairs (Defra). This dataset includes factors for different vehicle types based on their Euro vehicle emissions category, fuel type, engine size and technology based on the COPERT 5 emission factors[4].

Concentrations of PM10 and PM2.5 at roadside locations are affected by brake, tyre and road-wear, and concentrations of PM10 are also affected by resuspension. With the exception of resuspension, these non-exhaust road traffic emissions were calculated using EFT v8.0 emission factors. Resuspension emission factors were taken from a report produced by TRL Limited on behalf of Defra.

**Vehicle fleet composition:** The vehicle-specific emission factors described above were applied to the traffic flows using city-wide fleet composition data. These data represent the proportion of each vehicle type with each combination of Euro engine, engine size, fuel type and technology. The fleet composition for Dublin was calculated from vehicle population and distance data split by vehicle type for Ireland.

**Traffic speed:** Traffic speed limits were provided for each road. The average vehicle speed was taken to be half of the speed limit, to reflect the congested nature of Dublin's streets.

**Major and minor roads:** All major roads with an AADT greater than 2,500 were included in the model as road sources. Emissions from all other roads were modelled as aggregated 1-km resolution grid sources.

**Daily traffic variation:** The variation of traffic flow during the day was taken into account by applying a set of hourly profiles to the road emissions. Hourly traffic data for the M50, N31, R108 and N32 published by TII (Transport Infrastructure Ireland) for Saturday, Sunday and workdays were used to calculate a profile, as shown in Figure 2. These profiles were applied to all major roads in the modelling area and grid sources, representing emissions of minor roads, and other emissions, aggregated on 1-km square basis (see *Other emissions*).

[3] https://www.nratrafficdata.ie/c2/gmapbasic.asp?sgid=ZvyVmXU8jBt9PJE$c7UXt6

[4] NOx emission factors were modified based on recently published Remote Sensing Data (RSD) 7 for vehicle NOx emissions in London.

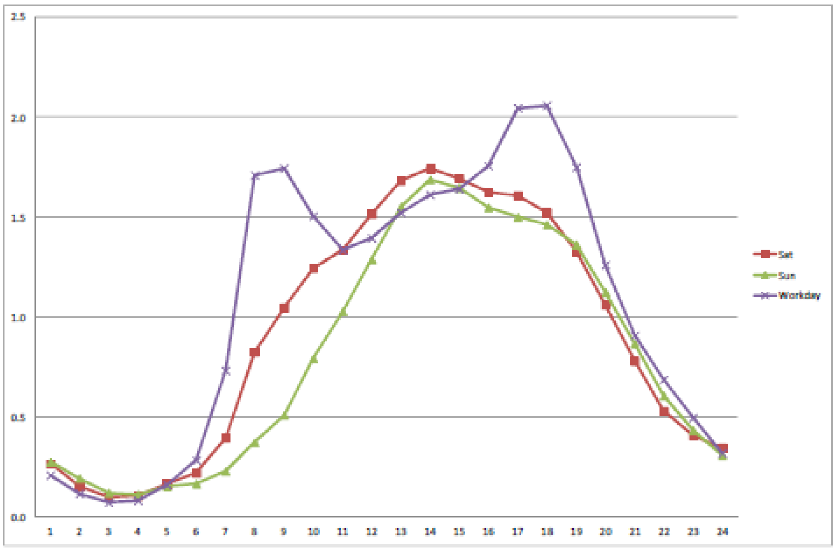


***Figure 2:*** *Diurnal profiles for road traffic emissions*

**Industrial sources**

Industrial sources were included in the modelling. Fourteen large point sources were modelled explicitly using data including emission rates, stack height and diameter, emission temperature and velocity. These sources are shown in Figure 3. Emissions from smaller industrial sources were modelled as aggregated 1-km grid sources (see *Other emissions*).

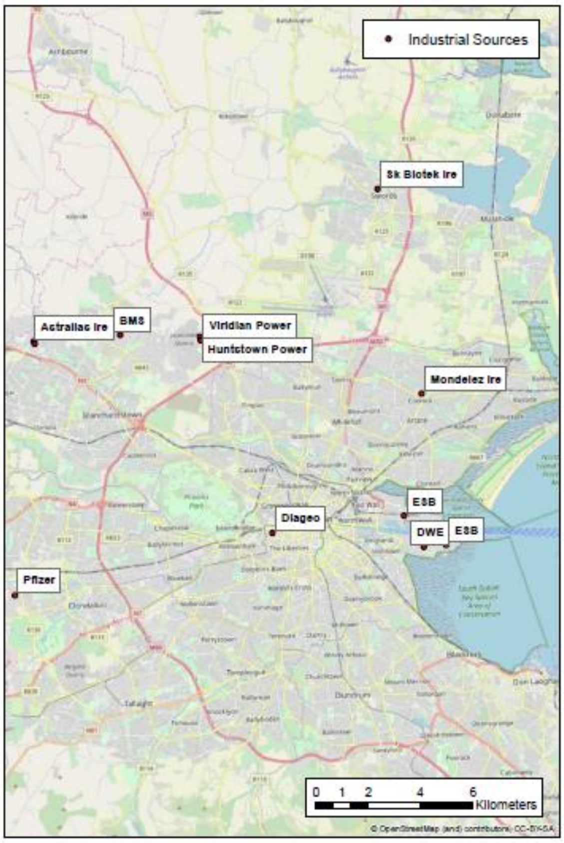


***Figure 3****: Explicitly modelled industrial sources*

**Other emissions**
Emission rates for all other sources were taken from the output of the national emission mapping model 'MapEIre', which uses emissions from the national emission inventory and is output on a spatial resolution of 1 km x 1 km for Ireland 10. Gridded emissions from the national inventory are split into the fifteen groups as described in Table 1.

Where explicit emissions data were available, the emissions were subtracted from the appropriate gridded emissions category. This includes all Public Power emissions and a proportion of the Industry emissions. All Road Transport emissions were removed where traffic data were available; grid Road Transport emissions were retained for the outskirts of Dublin, where traffic data were unavailable.

*Table 1 Other emission sources (gridded)*

| Group | Description |
|---|---|
| A_Public Power | Emissions from plants producing electricity and/or heat for the public grid |
| B_Industry | Emissions from combustion and processes in industry |
| C_OtherStationaryComb | Emissions from small combustion sectors, e.g. commercial, institutional, residential and agricultural |
| D_Fugitive | Fugitive emissions associated with production, refining, transport and storage of fuels. |
| E_Solvents | Emissions from the use of solvents |
| F_RoadTransport | Emissions from road transport |
| G_Shipping | Emissions from domestic navigation, i.e. navigation between two domestic ports. Fishing is included under "I_Offroad" |
| H_Aviation | Emissions from landing and take-off (LTO) both for domestic and international flights |
| I_Offroad | Emissions from machinery used in industry, households, agriculture as well as from railways and fishing vessels |
| J_Waste | Emissions associated with waste handling. Waste incineration with energy recovery is included under "A_PublicPower" or "B_Industry" |
| K_AgriLivestock | Emissions associated with animal husbandry and manure management |
| L_AgriOther | All other agricultural emissions, e.g. from application of mineral or organic fertilizer, crops and field operations |
| O_AviCruise | Emissions from the cruise phase of both domestic and international flights |
| P_IntShipping | Emissions from international navigation |
| Q_LULUCF | Emissions from land use, land use change and forestry |

**Summary of emissions:**

The total annual emissions of the key pollutants for the modelled area are given in Table 2.

*Table 2: Total annual emissions for the modelled area (tonnes/year)*

| Emissions Group | $NO_2$ | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | Modelled explicitly | Modelled as gridded emissions |
|---|---|---|---|---|---|---|
| Modelled Roads > 2500 AADT | 1036 | 4149 | 223 | 140 | ✓ | |
| Modelled Roads < 2500 AADT | 121 | 394 | 23 | 15 | | ✓ |
| Industrial Sources | 41 | 834 | 1 | 0 | ✓ | |
| B_Industry | 59 | 1183 | 224 | 218 | | ✓ |
| C_OtherStationaryComb | 102 | 2041 | 503 | 471 | | ✓ |
| D_Fugitive | 0 | 0 | 0 | 0 | | ✓ |
| E_Solvents | 0 | 0 | 0 | 0 | | ✓ |
| F_RoadTransport* | 109 | 2172 | 167 | 122 | | ✓ |
| G_Shipping | 2 | 40 | 0.8 | 0.7 | | ✓ |
| H_Aviation | 41 | 820 | 15 | 15 | | ✓ |
| I_Offroad | 10 | 195 | 6 | 5 | | ✓ |
| J_Waste | 0.3 | 7 | 0.2 | 0.1 | | ✓ |
| K_AgriLivestock | 0 | 0 | 17 | 6 | | ✓ |
| L_AgriOther | 0 | 0 | 197 | 10 | | ✓ |
| O_AviCruise | 0.4 | 8 | 0.3 | 0.3 | | ✓ |
| P_IntShipping | 0.3 | 6 | 0.1 | 0.1 | | ✓ |
| Q_LULUCF | 0 | 0 | 0 | 0 | | ✓ |

*Gridded road transport emissions outside domain of traffic data

2. Other data
   - **Meteorological data**: the model used hourly sequential meteorological data measured at Dublin Airport and Casement Airport (with a simple correction for differences in the surface roughness at the met sites compared to across the city) for the years being modelled.
   - **Surface roughness**: a parameter used in the model to characterise the study area in terms of the effects it will have on wind speed and turbulence, which are key factors in the modelling. A value of 0.5 m was used to represent the modelled area generally, however, additional effects of the buildings in the city on wind speeds and turbulence was taken into account using the ADMS-Urban urban canopy option.
   - **Urban canopy flow:** the model calculated changes in the vertical profiles of velocity and turbulence caused by the presence of buildings in an urban area, allowing the flow field within urban areas to be characterised on a neighbourhood-by-neighbourhood basis. The velocity and turbulence profiles are displaced by the building height, and flow within the building canopy is slowed by the buildings. Urban canopy data were calculated from GIS building data and associated building heights calculated from LIDAR surface and terrain height data.

- **Monin-Obukhov length:** In urban and suburban areas a significant amount of heat is emitted by buildings and traffic, which warms the air within and above a city. This is known as the urban heat island and its effect is to prevent the atmosphere from becoming very stable. In general, the larger the urban area the more heat is generated and the stronger the effect becomes. In the ADMS-Urban model, the stability of the atmosphere is represented by the Monin-Obukhov parameter.
- **Street canyons:** The modelling used the advanced street canyon modelling option in ADMS-Urban which allowed for the effect on dispersion of pollutants from a road source according to the presence and properties of canyon walls on one or both sides of the road. Street canyon data were calculated from GIS building data and associated building heights calculated from LIDAR surface and terrain height data.
- **Background data:** Background (national) concentrations of nitrogen dioxide ($NO_2$), ozone ($O_3$), particulates (PM10 and PM2.5) and sulphur dioxide ($SO_2$) were obtained from rural air quality monitoring locations in Ireland. And the chemical reactions taking place in the atmosphere were taken into account using background concentrations, meteorological data and modelled emissions data.

Further technical details on the modelling work are available on
https://www.epa.ie/pubs/reports/air/quality/Technical_report_NO2_modelling_Dublin.pdf