Cleaner Air for Scotland Strategy Review Report
Annexes

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A1. <u>Annex 1 - Process, Remit, Structure and Timeline</u>

Process

1.1 The Review:

- Engaged and briefed the various group members to identify and share relevant materials and experience to bring all members to a shared position of general awareness;
- Took a view on the drivers, pressures and state of air quality, based on the available evidence, including a consideration of progress made in this period and the nature of Scotland's position now and the trajectory Scotland's future air quality is on;
- Considered what potential gaps in knowledge and data arose, and assessed these alongside the powers to obtain, monitor and enforce environmental, health and other relevant data and standards in Scotland, including in the context of the UK's exit from the EU; and
- Based on the assessment of state and trend, has recommended the approach to be taken to interventions and other actions likely to lead to improving air quality further.

1.2 This has included consideration of regulatory, behavioural, service, monitoring and other relevant actions and approaches, together with assessment of barriers and accelerators to progress and the likely resource, infrastructural, legislative or other issues needed to deal with these.

1.3 The review was formally announced by the Cabinet Secretary for the Environment, Climate Change and Land Reform on 6 November during a visit to British Heart Foundation Scotland's Centre for Research Excellence at ERI in Edinburgh. The Cabinet Secretary said:

"There is a clear relationship between air pollution and human health impacts, and although we have made significant progress over recent years, more remains to be done.

The Scottish Government is determined to drive down pollution levels still further, which is why I am delighted Professor Campbell Gemmell has agreed to chair a wide ranging independent review into our ambitious Clean Air for Scotland strategy.

"The review will bring together research being undertaken by the British Heart Foundation here in Edinburgh and others elsewhere to determine how we as a nation can take further positive steps to mitigate the impact of this hugely important subject."

1.4 In accepting the chair role for the steering group, Campbell Gemmell observed:

"Air pollution in Scotland has already improved significantly. It is a complex multi-dimensional challenge: connecting health, environment, climate change, planning, transport and business dimensions, among others. As a result, it needs careful assessment in order to understand the issues, identify solutions and provide advice on the necessary next steps to continue to deliver long-term improvements in air

quality and quality of life for everyone in Scotland. This review aims to provide Scottish Government with the best advice available on the way ahead."

Review Remit

1.5 The review was charged with:

- Reviewing the progress and impact of actions under the current strategy
- Identifying and assessing new evidence and developments since CAFS was published in 2015
- Considering whether there are any significant evidence gaps, and which of these may be addressed as part of the review
- Making recommendations for future objectives for air quality policy, including measurable outcomes, milestones and indicators against which progress on improving air quality can be measured
- Making recommendations on the actions needed to achieve those outcomes, milestones and indicators, and any areas for future research/analysis
- Setting out a strategic vision and focus on the necessary framework, processes and actions for delivery of the new strategy.

Review Structure

1.6 The review process was led by a steering group, chaired by Campbell Gemmell. The steering group provided strategic direction to the review, and has taken responsibility for the conduct and conclusions of the review. It oversaw a number of thematic working groups tasked with considering policy areas in more detail.

1.7 The steering group was responsible for deciding the content and recommendations of the review report. This was planned and is still expected to form the basis of a consultation exercise, which will be conducted in parallel to a series of consultation workshops to allow wider collaboration and participation beyond the group memberships.

Review Timeline

1.8 The initial indicative timeline for the review was as follows:

6 December 2018	Initial meeting of steering group.
December 2018	Working group members invited and group remits confirmed.
10 January 2019	Workshop for steering and working group members.
January to April 2019	Working groups to meet four times on a monthly basis; steering group to meet three or four times on approximately six weekly basis.
End April 2019	Working group reports returned to steering group. (Revised to mid-May)
May 2019	Steering group recommendations returned to Scottish Government; consultation paper produced. (Revised to end

	May/early June)
May to July 2019	Public consultation.
June 2019	Consultation workshops held (tbc).

1.9 As the review progressed, it became clear that completion was not feasible within this timeframe. The latter part of the process was thus revised as follows:

End June 2019	Steering group recommendations returned to Scottish Government.
July/August 2019	Consultation paper developed based on these recommendations, along with Strategic Environmental Assessment.
September – December 2019	Public consultation on recommendations and SEA, including stakeholder workshops.

A2. <u>Annex 2 - Steering Group and Working Group Roles and Membership</u>

Steering Group

Role

2.1 The role and key areas of focus for the Steering Group were set out by Scottish Government:

- Overall leadership of the project;
- Identification of the strategic issues to be addressed by the review;
- Agreement of a plan for the review in line with the broad timeline set out by Ministers;
- Oversight of working groups including confirmation of group topics/remits/chairs and consideration of progress;
- Decide and agree content of report and recommendations;
- Identify effective governance structure for delivery of the new strategy;
- Consider synergies and opportunities to align work on air quality with other policy areas including climate change; and
- Develop an overall narrative for the new strategy which explains the direction of travel, the reasons for key recommendations and their impact and requirements.

Key areas of focus

2.2 Some of the key areas of focus of the steering group were:

- Reviewing and critically assessing the successes, challenges and learning to date;
- Identifying future challenges and overall objectives/targets for protection of health and the environment;
- Developing an understanding of the pressures and the required action at both sectoral and operational levels;
- Considering the challenges, obstacles and risks in meeting the identified objectives and targets; and
- Making recommendation for the actions and investments needed to assist in addressing and mitigating them.

2.3 The steering group met approximately every four to six weeks between December 2018 and May 2019.

Membership:

2.4 Steering Group members were:

- Independent Chair – Prof. Campbell Gemmell
- Scottish Government (Environment) - Donald McGillivray, Deputy Director, Environmental Quality
- Scottish Government (Transport Scotland) - Hugh Gillies, Director for Roads
- Local Government – Jim Valentine, SOLACE representative, Deputy CEO of Perth and Kinross Council, and Robert Nicol, Chief Officer, Environment and Economy, CoSLA[1]
- SEPA – Jo Green, Chief Officer, Performance and Innovation
- Health Protection Scotland – Dr Colin Ramsay, Consultant Epidemiologist
- Friends of the Earth Scotland – Dr Richard Dixon, Director
- Scottish Council for Development and Industry – Gareth Williams, Head of Policy
- Independent experts – Professor Tom Rye, Director of Transport Research Institute, Edinburgh Napier University; Dr Annalisa Savaresi, Lecturer in Law, University of Stirling; Mary Pitcaithly, former Chief Executive, Falkirk Council[2].

Working Groups

2.5 The Steering Group was supported by four working groups (WG) which helped to segment and deliver the review's work. These groups under a chair and deputy connected to the Steering Group established their own remits in conjunction with the steering group chair.

2.6 The working groups developed their own programme of work, meeting three or four times, corresponding and then providing a report on their discussions and recommendations[3].

2.7 The four working groups were:

- WG1 Health and Environment, chaired by Dr Colin Ramsay;
- WG2 Emissions - Agricultural, Domestic and Industrial, chaired by Dr Stefan Reis;
- WG3 Planning and Placemaking, chaired by Gillian Dick; and
- WG4 Transport, chaired by Professor Adrian Davis.

2.8 The overarching themes of communications, engagement and behaviour change as well as data, governance and delivery focus were considered overarching and cross-cutting and dealt with by the Steering Group.

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[1] Joined in April 2019
[2] Mary Pitcaithly stepped down in March 2019
[3] Working Group reports

2.9 Working with the chair of the Steering Group and the secretariat support, each working group chair was responsible for:

- Determining working group members and remit in conjunction with the steering group.
- Managing communications with working group members.
- Producing meeting agendas, chairing meetings of their working group and producing minutes.
- Participating in teleconferences with other working group chairs and the steering group.
- Recording and feeding back findings to the steering group via a short final report.

2.10 The Scottish Government provided overall secretariat resource and admin support to the steering group and working groups and the initial stakeholder workshop. Secretariat support also came from Transport Scotland and SEPA in support of the steering group and working groups.

Health and Environment Working Group Members

MEMBER	**ORGANISATION**
Graham Applegate*	SEPA
James Curran	Scottish Environment Link
Richard Dixon	Friends of the Earth Scotland
John Howie	Health Scotland
Fintan Hurley	Institute of Occupational Medicine
Duncan Lee	University of Glasgow
David McColgan	British Heart Foundation Scotland
Vincent McInally	Glasgow City Council
Robert Nicol	COSLA
Richard Othieno	NHS Lothian
Dr Colin Ramsay (WG Chair)	Health Protection Scotland
Frank Toner	British Lung Foundation Scotland
Bruce Whyte	Glasgow Centre for Population Health

* Secretariat

Agriculture, Industry and Domestic Emission (AIDE) Working Group Members

MEMBER	**ORGANISATION**	**Subgroup**
Mark Aitken	SEPA	Ag
Graham Applegate	SEPA	Ag
Claire Campbell	SEPA	Ag
Karen Dobbie	SEPA	Ag
Shauna Clarke	City of Edinburgh Council	Dom, Ind
Dave Freeman	Agricultural Industries Confederation	Ag
Andrew Midgley	National Farmers Union Scotland	Ag

	(NFUS)	
Dennis Milligan	Stove Industry Alliance	Dom
Janice Milne	SEPA	Ind
Tim Minett	CPL Industries	Dom
Stefan Reis	Centre for Ecology & Hydrology	Chair
Annalisa Savaresi	University of Stirling	Ag
Ewen Scott	Scottish Government	Ag
Ian Speirs	Scottish Government	--

Transport Working Group Members

MEMBER	ORGANISATION
Graham Applegate	SEPA
John Bynorth	Environmental Protection Scotland
Prof. Adrian Davis (WG Chair)	Transport Research Institute, Edinburgh Napier University
Shauna Clarke	City of Edinburgh Council
Chris Day	Transform Scotland
Dr. Richard Dixon	Friends of the Earth Scotland
Andy Eastlake	Low Carbon Partnership
Gloria Esposito	Low Carbon Partnership
Tom Flanagan	Society of Chief Officers of Transportation Scotland
Colin Gillespie	SEPA
Stuart Hay	Living Streets
Alan Hills	SEPA
Daniel Jones	British Heart Foundation Scotland
George Mair	Confederation of Passenger Transport
Vincent McInally	Glasgow City Council
Alex Quayle	Sustrans
Cllr. Anna Richardson	Glasgow City Council
Mags Simpson	Freight Transport Association
Clare Sloan*	Transport Scotland*
Stephen Thomson	Transport Scotland*
Julie Vinders	SesTRANS

* Secretariat

Placemaking Working Group Members

MEMBER	ORGANISATION
Irene Beautyman	Improvements Service
Johnny Cadell	Architecture & Design Scotland
Gillian Dick (WG Chair)	Glasgow City Council (representing Heads of Planning Scotland)

Will Garrett	City of Edinburgh Council
Katherine Lakeman	SEPA
Tracy McKen	Scottish Government (representing Place Standard)
Craig McLaren	Royal Town Planning Institute Scotland
Sandy Robinson	Scottish Government
Fiona Stirling	SNH
David Torrance	Transport Scotland
Gareth Williams	Scottish Council for Development and Industry

A3. Annex 3 – Air Quality Policy and Legal Framework

3.1 Statutory measures, policies and programmes framing air quality management originate from international treaties which become legislation within the EU, UK and Scotland. The main relevant pieces of EU legislation on air quality are Directive 2008/50/EC on ambient air quality and cleaner air for Europe ('the Directive')[4], Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air ('the 4th air quality Daughter Directive')[5] and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants (National Emissions Ceilings Directive or NECD)[6]. The Directive sets health and environment-based objectives and values for limits of certain air pollutants (particulate matter (PM), sulphur dioxide, nitrogen dioxide and oxides of nitrogen, lead, benzene, carbon monoxide, and ozone) and the NECD sets national emissions ceilings (mass emissions) for certain pollutants (oxides of nitrogen, sulphur dioxide, non-methane volatile organic compounds, ammonia and PM) which must be met by Member States (MS) by prescribed dates. Air quality is devolved and these legal requirements are the responsibility of Scottish Ministers.

3.2 At the UK and Scotland level, the Environment Act 1995 (EA95)[7], the Pollution Prevention and Control Regulations 2012 (PPC)[8], and the Clean Air Act 1993 (CAA93)[9] are particularly relevant regulatory drivers for protecting air quality.

3.3 The **EA95** establishes the Local Air Quality Management (LAQM) system which requires local authorities to regularly review and assess air quality in their areas against objectives for several pollutants of concern for human health. Where an authority identifies a risk of an objective being exceeded at a relevant location, an Air Quality Management Area (AQMA) must be declared after which the authority must prepare an air quality action plan setting out how it proposes to tackle the issues identified. SEPA provides regulatory oversight and has reserve powers under Section 85 of the Act (with the approval of Scottish Ministers) to direct local authorities to fulfil their duties and also provides significant support and advice to local authorities on LAQM and wider air quality matters.

3.4 Under **PPC2012** SEPA regulates prescribed industrial activities which require a permit to operate. Permits contain measures to control emissions to air (such as abatement systems) and suitable emission limit values (ELVs) for both point and fugitive sources for certain substances, and require monitoring to be conducted which allows compliance to be assessed. In setting appropriate permit conditions, SEPA must have regard to the requirements of the Air Quality Strategy for England, Scotland, Wales and Northern Ireland (the AQS)[10].

3.5 Finally, emissions to air of smoke which are not captured by PPC may be controlled through the provisions of the **CAA93**. This is not a permitting regime, but action is taken by local authorities in response to public complaints. The Act seeks to control

[4] Directive 2008/50/EC on ambient air quality and cleaner air for Europe
[5] Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air ('the 4th air quality Daughter Directive')
[6] Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants National Emissions Ceilings Directive or NECD)
[7] Environment Act 1995
[8] Pollution Prevention and Control (Scotland) Regulations 2012 (as amended)
[9] Clean Air Act 1993
[10] *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland*, Defra and the Devolved Administrations, 2007

emissions of dark smoke, smoke, grit, dust and fumes from smaller-scale/non-PPC activities, and the provisions can cover both domestic and commercial premises. The Act does not apply to activities which have a PPC permit. Local authorities can monitor for air pollution from these activities and take action via investigations, notices and prosecutions. SEPA also has powers in relation to the declaration of Smoke Control Areas (SCAs) but has no regulatory powers under the Act.

A4. Annex 4 – EU Court of Auditors Report Summary and EU/EEA Context for Main Pollutants

EU Court of Auditors and EEA Reports

4.1 The EU Court of Auditors made clear in their Special Report no 23/2018, *Air Pollution: Our health still insufficiently protected*[11], "that EU action to protect human health from air pollution had not delivered the expected impact. The significant human and economic costs have not yet been reflected in adequate action across the EU". The report goes on, "EU quality standards were set almost twenty years ago and some of them are much weaker than WHO guidelines and the levels suggested by the latest scientific evidence on human health impacts. While air quality has been improving, most Member States[12] still do not comply with the EU's quality standards and (are) not taking enough effective action to sufficiently improve air quality." In concluding and providing recommendations for the Commission and Member States, the Auditors indicated that Air Quality Plans and Member State data provision needed to be improved, EU policies and funding needed to be better aligned and integrated where they related to air pollution impacts, and public information and awareness, including access to justice for citizens all also required improvement to reduce harm to humans, infrastructure and the environment. Finally, the Auditors observed that air pollution continued to affect mostly urban populations and shortened lives as well as being linked to a range of damaging conditions.

4.2 A more recent report on urban air quality implementation challenges[13], provides further context for this review. It observes, "Over the past decade, air quality has slowly improved in many of Europe's cities, as a direct result of more robust air quality policies across various governance levels, the introduction of targeted measures and actions, and technological improvements that have reduced emissions from various sources. Nevertheless, many cities and regions still experience exceedances of the regulated limits for air pollution". Based on a review of 10 cities, including Dublin and Malmö – likely to be at least in part comparable with the Scottish context – the report finds that challenges in implementing air quality improvement measures, faced now, include "how to effectively communicate air quality issues to the public, and how to achieve governance across various administrative levels, in particular in terms of analysing the co-benefits of measures implemented in the areas of climate change, noise, urban planning and air quality."

4.3 The EEA advocated that all cities and administration seeking to deliver improvement plans should use a multi-disciplinary and integrated approach and use shared data platforms and networks to maximise the value of research and development effort, minimise wasted resources, time and effort re-inventing strategies, and speed engagement and progress towards effective pollution reduction.

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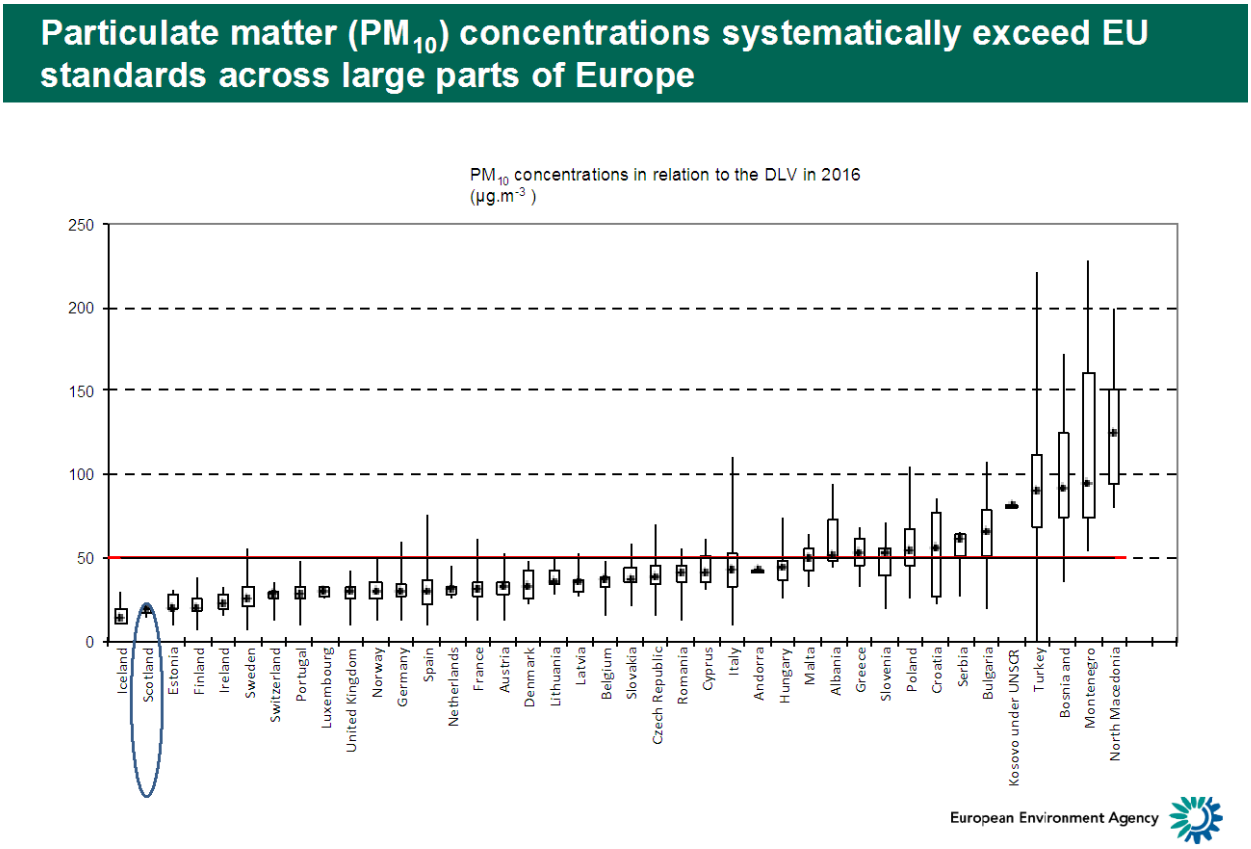
[11] *Air Pollution: Our health still insufficiently protected*, European Court of Auditors, 2018
[12] Including the UK for NO_2 limit value exceedance in the latest reported data, for 2016.
[13] *Europe's urban air quality – re-assessing implementation challenges in cities*, EEA Report, 2019

EU/EEA context for main pollutants

4.4 In terms of EU Directive related performance and data for the major pollutants, these are presented annually in reports by the European Environment Agency (EEA)[14]. Discussions with the Air Quality team in the EEA allowed consideration of Scotland's situation in a broader European context, among EU and EEA states. This highlighted some issues with data generally[15] but revealed a positive position in relation to PM_{10} (see Figures 1a and 1b) and $PM_{2.5}$ (Figure 2). The picture for NO_2, shown in Figure 3, is more challenging, largely due to pollution from single points in Glasgow and Aberdeen.

4.5 Consideration of a similar breakdown for other pollutants and comparison between Scotland and other similar states now and over time could provide useful scope for comparative learning and networking in relation to developing and implementing effective interventions.

Figure 1a: EEA data on PM_{10} Concentrations 2016 – Daily Limit Value



[14] Air Quality in Europe, 2018, EEA Report No.12/2018; includes Europe-wide data and an assessment of health impacts in section 10, consistent with the findings of this review.
[15] This leads to an early observation for the review. There are only 6 data points for Scotland and the data are visible nearly three years late. Greater utility might be expected from more and more representative data and from their more timeous availability.

Figure 1b: EEA data on PM_{10} Concentrations 2016 – Annual Limit Value

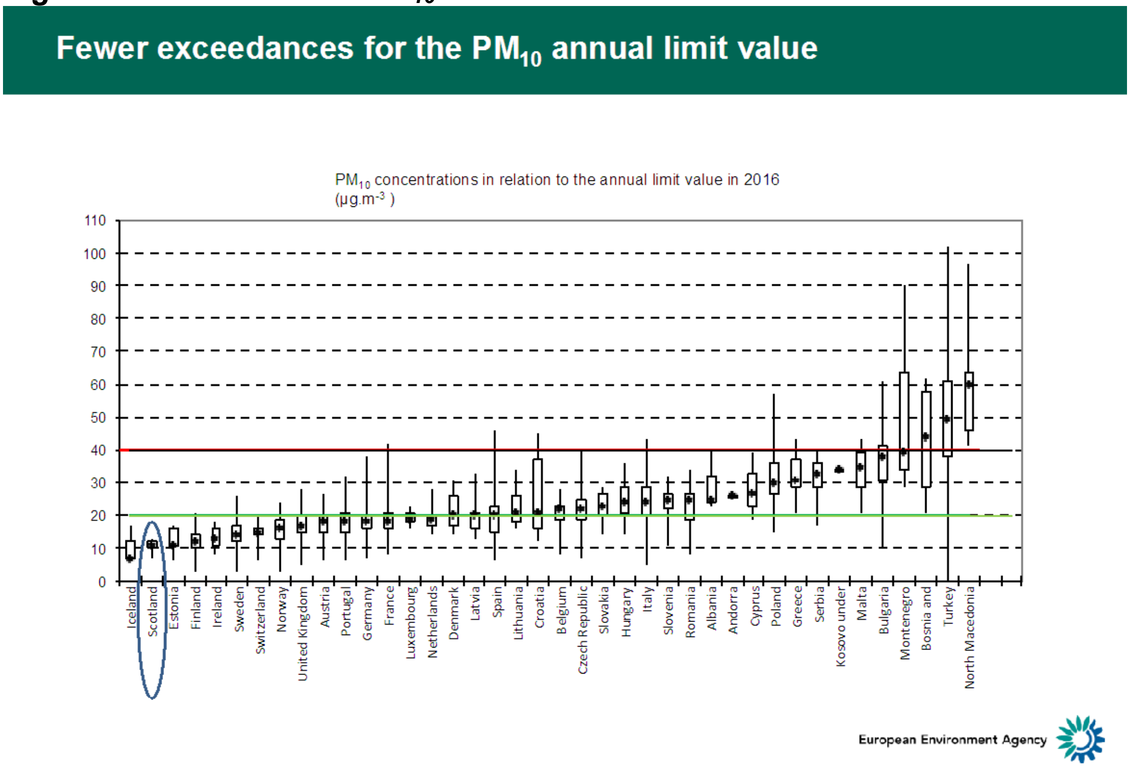


Figure 2: EEA data on $PM_{2.5}$ Concentrations 2016 – Annual Limit Value

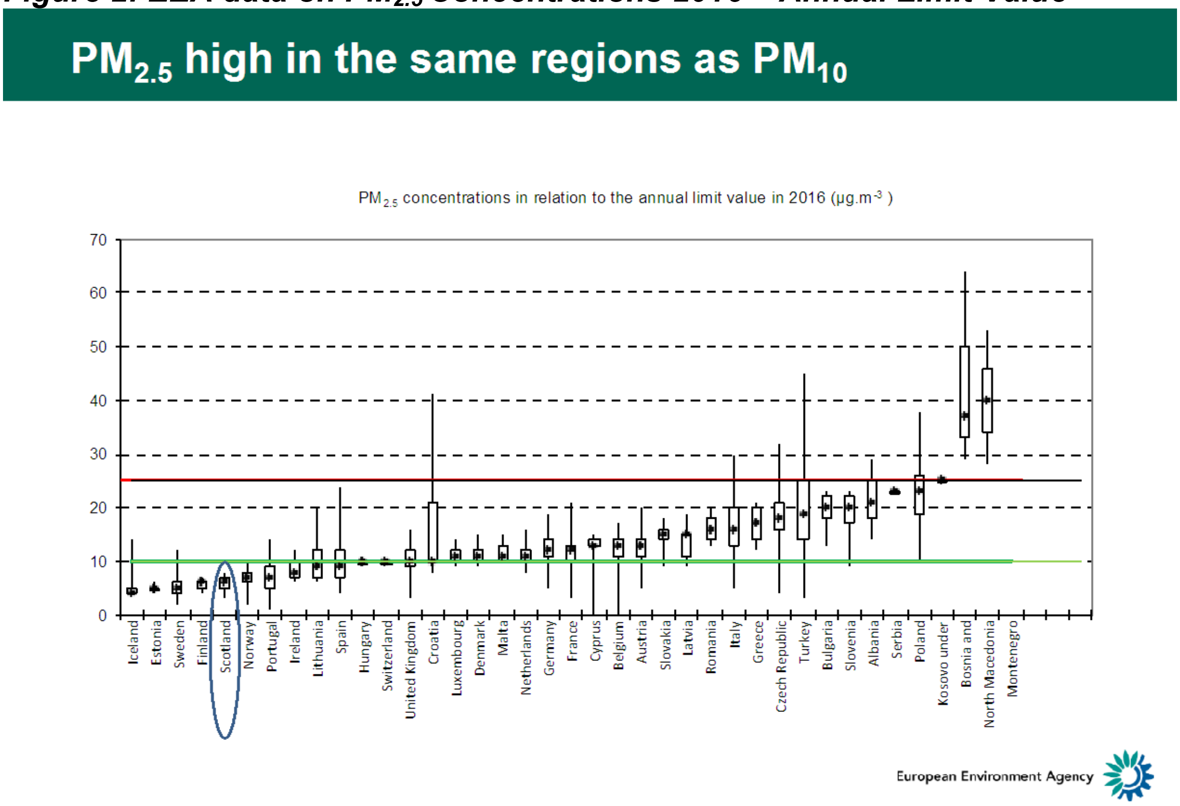
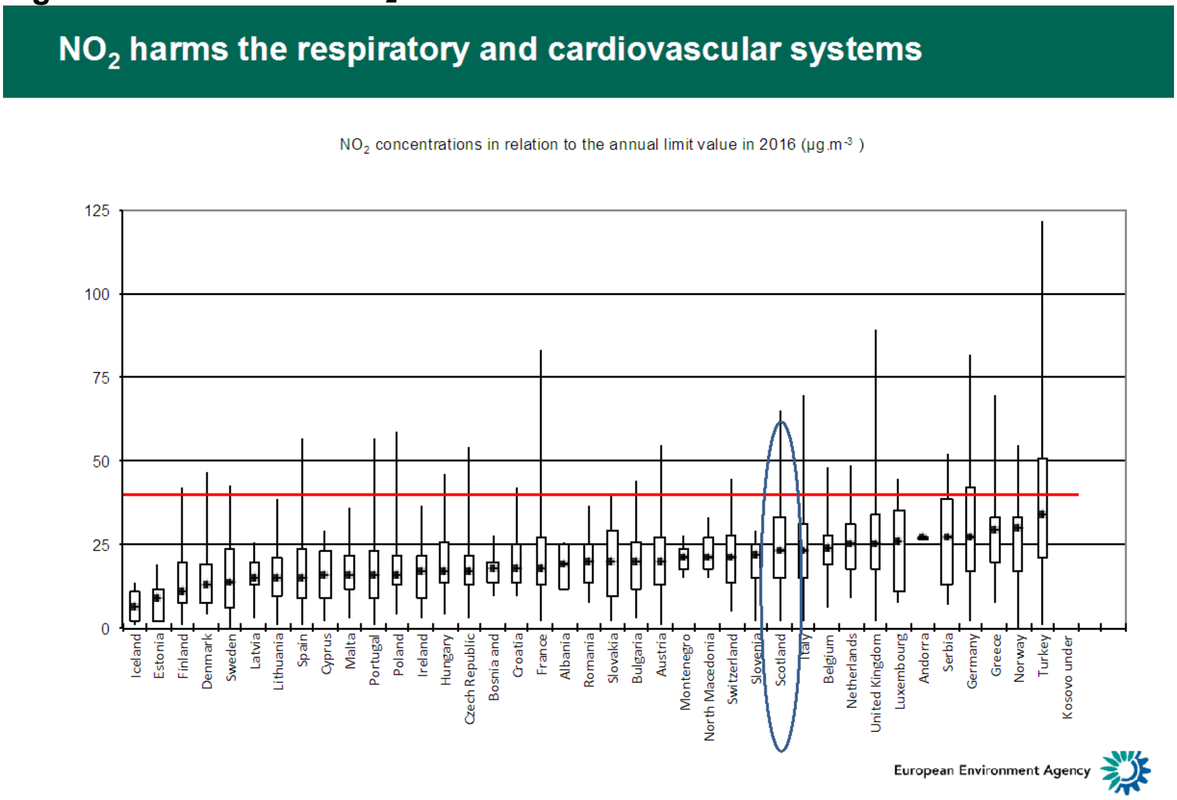


Figure 4 EEA Data on NO_2 concentrations in 2016 – Annual Limit Value



A5. Annex 5 – Health and Environment

A5a) What are the human health impacts of exposure to air pollution?

Introduction

5.1 There is a wealth of good quality evidence linking outdoor air pollution with impacts on human health. It is now widely accepted by expert assessment groups (e.g. the World Health Organisation (WHO), the Global Burden of Disease (GBD) team, the International Agency for Research on Cancer, UK Committee on the Medical Effects of Air Pollutants (COMEAP), US Environmental Protection Agency (USEPA)) that outdoor air pollution causes damage to human health across a wide range of conditions, from pre-birth to old age; and that air pollution globally is the most serious of all environmental health problems. Scientifically robust conclusions derived from toxicology, epidemiology and experimental studies informs our understanding of which pollutants may be causing most damage to human health. International epidemiological studies have also formed the basis for estimating the size of the impacts on populations and quantifying the likely benefits of reducing pollution levels. The current international consensus and evidence from more local Scottish studies have been used to help interpret the significance of health impacts in Scotland.

Epidemiological evidence reported from international studies

5.2 The WHO Review of Evidence on Health Aspects of Air Pollution (REVIHAAP) assessment[16] is currently the most comprehensive review of international evidence on air pollution and health. This found significant evidence of adverse effects associated with three main pollutants: PM (especially $PM_{2.5}$ and PM_{10}), ozone and NO_2.

PM, cardiovascular and respiratory outcomes and deaths due to all causes

5.3 REVIHAAP reviewed evidence linking PM with changes in cardiovascular (CV) (heart and circulatory system) functioning, respiratory (lung) function and premature (earlier) death. This included some long-term studies of association between mortality and $PM_{2.5}$ at levels below the current WHO limit value (10 µg/m^3). No evidence of a threshold was found (i.e. a level below which effects could not be detected) leading to the conclusion that "*public health benefits will result from any reduction in $PM_{2.5}$ concentrations, whether or not the current levels are above or below the limit values*".[17]

5.4 The UK COMEAP concluded[18] that public health would benefit from reductions of both primary PM and secondary particles (produced by chemical interactions) and more recently COMEAP found additional evidence of a wider range of CV effects,

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[16] *Review of evidence on health aspects of air pollution – REVIHAAP Project*, World Health Organisation, 2013

[17] *Review of evidence on health aspects of air pollution – REVIHAAP Project*, World Health Organisation, 2013, p38

[18] Statement on the evidence for differential health effects of particulate matter according to source or components, COMEAP, 2015

concluding that the association of $PM_{2.5}$ and CV impacts identified in epidemiological studies is likely to be causal[19].

5.5 WHO also concluded that, although there was less evidence for coarse particles ($PM_{10-2.5}$) than for fine particulates ($PM_{2.5}$) these are also related to excess morbidity and mortality and that it was therefore important to control PM_{10} as well as $PM_{2.5.}$

5.6 The WHO Health Risks of Air Pollution in Europe (HRAPIE)[20] project set out to quantify the effects of pollution on a range of health outcomes. It reported the highest confidence in estimating the effects of $PM_{2.5}$ on (i) all-cause and cause-specific mortality using (long-term) cohort studies and (ii) respiratory and CV hospital admissions from (short term) time series studies. It reported less confidence in quantifying the effects on: infant mortality; days of restricted activity and work days lost; exacerbation of asthma in young people; and on chronic bronchitis. COMEAP later[21] questioned if the relationships with chronic bronchitis were causal.

5.7 For all-cause mortality in adults, WHO[20] recommended using an estimate of a 6% increase (95% CI 4% to 8%) for age-specific death rates per 10 µg/m^3 annual average $PM_{2.5.}$ COMEAP in 2010 adopted this estimate and, following an updated review, again endorsed it for use in the UK[22]. COMEAP in 2010 used this estimate to calculate that air pollution in the UK (based on data from 2008 for average anthropogenic PM $_{2.5}$) resulted in a reduction in life expectancy from birth across the whole population of approximately 6 months for the UK, or 3-4 months for Scotland, equivalent to approximately 2000 attributable (premature) deaths in Scotland. This figure was updated[23] using the latest annual mean concentration for human sourced $PM_{2.5}$ of 5.3µgm^{-3}, giving an estimate of approximately 1700 attributable deaths in Scotland. It is important to note that attributable deaths are not actual recorded deaths in a particular year; the figure is a statistically derived estimate, intended to convey as faithfully as possible the amount of excess mortality caused by air pollution across the population as a whole. As explained by COMEAP[24], this figure should not be interpreted as the number of individuals in any year where air pollution has made some contribution to earlier death; that number is unknown but is almost certainly much larger.

5.8 Research on the biological mechanisms potentially underlying the associations between particulate air pollution and cardiovascular disease also supports the case for a causal link and was assessed by WHO as "*strongly supportive of a causal association between $PM_{2.5}$ and cardiovascular disease and mortality*"[25]. Research at the University of Edinburgh (funded by the British Heart Foundation) examined the effects on cardiovascular function of diesel exhaust (DE), a source of particulates

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[19] *Effects of long-term exposure to ambient air pollution on cardiovascular morbidity: mechanistic evidence*, COMEAP, 2018, pviii and ix.

[20] *Health risks of air pollution in Europe – HRAPIE project. Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide*, World Health Organisation, 2013

[21] *Long-term exposure to air pollution and chronic bronchitis*, COMEAP, 2016

[22] *Statement on quantifying mortality associated with long-term average concentrations of fine particulate matter*, COMEAP, 2018

[23] *Air Pollution and Health Briefing Note. Mortality Associated with exposure to fine particulate matter ($PM_{2.5}$ Attributable Mortality) in Scotland*, Health Protection Scotland, 2018,

[24] *The mortality effects of long-term exposure to particulate air pollution in the United Kingdom*, COMEAP, 2010

[25] *Review of evidence on health aspects of air pollution – REVIHAAP Project*, WHO, 2013

including ultra-fine nanoparticles. DE particulates can generate free radicals, activate inflammatory cells and directly impair vascular function, suggesting that DE particulates would be capable of promoting cardiovascular disease[26]. After inhaling DE at levels resembling a heavily polluted urban environment (between 100 to 300μgm^{-3} of PM), the ability of blood vessels in healthy volunteers to relax was found to be impaired, an effect persisting for at least 24 hours[27]. Exposure to DE was also associated with increased arterial stiffness, a marker of vascular dysfunction[28]; with promotion of blood clotting[29] and with reduced ability to remove blood clots[30].

5.9 Experiments in human volunteers also showed that inhaled gold nanoparticles passed into the blood circulation, supporting the previously postulated existence of a pathway to explain how inhaled PM might result in widespread effects throughout the body[31] This and other international mechanistic research provides evidence of a biologically plausible mechanism, whereby PM could induce cardiovascular effects; and suggests that people with existing cardiovascular disease (CVD) may be especially susceptible to the effects of air pollution.

Ground-level ozone, **respiratory and cardiovascular impacts**

5.10 In 2013 WHO[32] reviewed numerous time series (short-term exposure) studies of links between ozone, respiratory hospital admissions and deaths from respiratory causes and, less clearly, CVD causes. There was an absence of relevant powerful studies at low ozone concentrations and no specific threshold was established (i.e. a level at which adverse effects stop occurring). HRAPIE[33] recommended quantifying the effects of ozone on mortality and hospital admissions for respiratory (and for some CVD outcomes but not stroke) but only at levels above 70μgm^{-3} or above 20μgm^{-3} for a maximum daily 8-hr mean concentration. COMEAP in 2015 concluded that, because there is no convincing evidence of a threshold, quantification of impacts down to zero level is reasonable[34]. There is also some evidence of

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[26] *Direct impairment of vascular function by diesel exhaust particulate through reduced bioavailability of endothelium-derived nitric oxide induced by superoxide free radicals,* Miller *et al*, 2009, Environ Health Perspect. 2009; 117:611-6; *From particles to patients: oxidative stress and the cardiovascular effects of air pollution*, Miller *et al,* 2012, Future Cardiol. 2012; 8:577-602; *Diesel exhaust particulate--exposed macrophages cause marked endothelial cell activation*, Shaw *et al*, Am J Respir Cell Mol Biol. 2011; 44:840-51; *Protein corona formation in bronchoalveolar fluid enhances diesel exhaust nanoparticle uptake and pro-inflammatory responses in macrophages*, Shaw *et al*, 2016, Nanotoxicology. 2016; 10:981-91.

[27] *Persistent endothelial dysfunction in humans after diesel exhaust inhalation*, Tornqvist *et* al, 2007, Am J Respir Crit Care Med. 2007;176:395-400.

[28] *Experimental exposure to diesel exhaust increases arterial stiffness in man*, Lundback *et al*, 2009, Part Fibre Toxicol. 2009; 6:7.

[29] *Diesel exhaust inhalation increases thrombus formation in man*, Lucking *et al*, 2008, European Heart Journal 2008; 29; 3043-3051

[30] *Diesel exhaust inhalation causes vascular dysfunction and impaired endogenous fibrinolysis. Circulation*, Mills *et al,* 2005; 112:3930-6.

[31] *Inhaled Nanoparticles Accumulate at Sites of Vascular Disease*, Miller *et al,* 2017, ACS Nano. 2017; 11:4542-4552; *Correction to "Inhaled Nanoparticles Accumulate at Sites of Vascular Disease"*, Miller *et al,* ACS Nano. 2017; 11:10623-10624.

[32] *Review of evidence on health aspects of air pollution – REVIHAAP Project*, World Health Organisation, 2013

[33] *Health risks of air pollution in Europe – HRAPIE project. Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide*, World Health Organisation, 2013

[34] *Quantification of mortality and hospital admissions associated with ground-level ozone*, COMEAP, 2015

additional effects of long-term chronic exposure, especially on respiratory mortality[35]. COMEAP however considered that there were too many unknowns to support quantification of these effects at that time.

NO_2, respiratory and cardiovascular impacts

5.11 The evidence relating to NO_2 is particularly relevant to Scotland, in that many of the current Air Quality Management Areas (AQMAs) in Scotland are in place because of breaches of NO_2 standards. Numerous time series (short term) studies have shown associations between daily concentrations of NO_2 with respiratory and CVD morbidity and mortality on the same or immediately following days (a very short lag effect). Many cohort studies have shown associations between annual average (long term) NO_2 and age-specific risks of death, although it is unclear if these associations are due to NO_2 itself or to co-pollutants from similar sources, especially PM from traffic.

5.12 WHO concluded in 2013 that there is some adverse effect of NO_2 alone, additional to that linked to PM or ozone[32]. Although other pollutants may also be contributing, based on studies of short-term impacts associated with daily variations in $NO_{2,}$ WHO agreed that NO_2 itself had some causal role. The evidence for causality in studies of long-term exposure was thought to be weaker. COMEAP implicitly accepted this view in 2015[36] but later[37] failed to reach a consensus on whether long-term exposure to NO_2 had a causal role, cautioning against naively interpreting observed health associations with NO_2 as being due to NO_2 alone.

Estimating effects due to $PM_{2.5}$ and NO_2 together

5.13 In 2018 a majority of COMEAP members favoured quantifying the impact of air pollution on mortality in the UK using relationships for NO_2 as well as $PM_{2.5}$[37]. The effect associated with both $PM_{2.5}$ and NO_2 combined was estimated to be equivalent to between about 28,000 to 36,000 attributable deaths per year UK-wide (i.e. only slightly more than the earlier estimate using $PM_{2.5}$ alone). This estimate assumed that it is valid to extrapolate effects identified at the levels studied down to lower ones not actually recorded. Alternative figures were also quoted in the report where extrapolation was not used, giving lower estimates of between 16,000 and 19,000 attributable deaths in the UK. COMEAP did not provide results specific to Scotland. However, using Health Protection Scotland (HPS)'s 2018 estimate of 1700 attributable deaths in Scotland for $PM_{2.5}$ alone[38] and based on internationally derived risk estimates (assuming that extrapolation to lower levels is appropriate), a combined estimate equivalent to about 2,000 attributable deaths annually may be reasonable.

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[35] *Long-Term Ozone Exposure and Mortality*, Jerrett *et al*, 2009, NEngl J Med 2009; 360:1085-1095
[36] *Statement on the evidence for the effects of nitrogen dioxide on health*, COMEAP, 2015
[37] *Associations of long-term average concentrations of nitrogen dioxide with mortality*, COMEAP, 2018
[38] *Air Pollution and Health Briefing Note. Mortality Associated with exposure to fine particulate matter ($PM_{2.5}$ Attributable Mortality) in Scotland*, Health Protection Scotland, 2018

Evidence of additional health effects associated with air pollution

5.14 In 2013 WHO reviewed the smaller evidence base then available[39] on other health impacts potentially associated with air pollution. Considerably more studies on non-cardiovascular, non-respiratory impacts have been published since. For this report, HPS carried out a rapid scan of international English language papers published between January 2015 and March 2019 that had reviewed primary papers on such other health effects; 31 review papers[40] were identified that met the inclusion criteria. These reviews addressed dementia and cognitive decline (three review papers), diabetes (seven), birth outcomes (seven) and child development (four). Some of the reviews addressed multiple outcomes. In addition as an update, 12 reviews of more recent studies on respiratory outcomes were also considered.

5.15 These reviews consistently reported finding associations of varying statistical significance between air pollution (generally and for individual pollutants) and dementia, Alzheimer's disease, type 2 Diabetes, preterm birth, miscarriage, and Autism Spectrum Disorder. With other outcomes (e.g. other child development outcomes, Parkinson's Disease etc.) reviews reported finding either conflicting conclusions or commented that the reviewed studies provided insufficient or inconclusive evidence of associations[41]. In the newer respiratory outcomes reviews, associations with COPD-related morbidity, asthma development and exacerbation were consistently reported.

5.16 The review authors consistently noted limitations in the studies. Many reviews providing meta-analyses of primary study findings that had reported increased risks, gave pooled odds ratios or risk estimates that were statistically significant though often the risks were only marginally elevated. In some cases the small margin of the increased risks meant that one additional negative study could have altered the findings to be non-significant. In terms of applicability, many of the primary studies reviewed were conducted in countries where the air pollutant concentrations were notably higher than is prevalent in Scotland, so their findings may not be directly transferable.

Epidemiological evidence on health effects specific to Scotland

5.17 There is a relatively small published literature on the effects of air pollution based on studies carried out specifically in Scotland. This evidence is important however, in developing an understanding of the local epidemiology of air pollution impacts and how this compares with the corresponding international findings. Differences in the types of study carried out in Scotland make cross comparison of their findings difficult[42]. It is not therefore possible to provide pooled estimates of health effects in Scotland equivalent to those calculated in international studies.

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[39] *Review of evidence on health aspects of air pollution – REVIHAAP Project*, WHO, 2013; *Health risks of air pollution in Europe – HRAPIE project. Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide*, WHO, 2013

[40] Listed in the Health Working Group's report

[41] Some German research, specifically focused on LEZ areas and changes in health condition as well as recent US work on air pollution impacts on pregnancy loss have also been reviewed and such work may be expected to develop further. Gehrsitz 2017, building on Wolff 2014 and Ha and Mendola 2019. Gehrsitz appears the most robust and conclusive of these and suggests significant reductions in particulate pollution occur after stringent LEZs are fully operational but health benefits are not thus far measurably significant.

[42] *Estimating the health impact of air pollution in Scotland, and the resulting benefits of reducing concentrations in city centres*, Lee *et* al, 2019, Spatial and Spatio-temporal Epidemiology, 29, 85-96.

Nonetheless, valid conclusions can be drawn by assessing the balance of evidence provided by these studies of impacts on the Scottish population.

All-cause mortality

5.18 Scottish evidence linking air pollutants (NO_x, NO_2, $PM_{2.5}$, PM_{10} and black smoke) with all-cause mortality (all deaths) is inconclusive. Some studies found some significant (and some non-significant) associations but others found none[43].

Pregnancy outcomes

5.19 Evidence regarding air pollution in Scotland and pregnancy outcomes is mixed. Significant associations of NO_2 and PM_{10} with low birth weight were found using cohort data (1994 to 2008)[44]. Risks for very preterm birth (birth between 28-32 weeks) were raised but were non-significant. A separate individual level study in north-east Scotland[45] reported mixed evidence linking maternal exposure to particles (PM_{10}, $PM_{2.5}$) and NO_2 with measures of foetal growth.

Respiratory disease

5.20 The evidence from Scottish studies convincingly suggests associations between air pollution and the risk of respiratory disease and respiratory mortality, consistent with the international evidence. Studies found strong and largely consistent associations across all study types and various outcomes. Statistically significant effects were found for NO_X, NO_2, $PM_{2.5}$, PM_{10} and black smoke with: (i) prescribing rates for respiratory medication[46]; (ii) respiratory hospitalisations[47]; and (iii) respiratory deaths[48].

Cardiovascular disease

5.21 The evidence from Scottish studies over the years has identified no consistent association between air pollution and cardiovascular disease outcomes, such as hospital admissions or mortality[49]. These studies used a variety of epidemiological

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[43] Details in the Health Working Group report

[44] *Place of work and residential exposure to ambient air pollution and birth outcomes in Scotland, using geographically fine pollution climate mapping estimates*, Dibben and Clemens, 2015, Environmental Research, 140, 535-541.

[45] *Maternal exposure to ambient air pollution and fetal growth in North-East Scotland: A population-based study using routine ultrasound scans*, Clemens *et al*, 2017, Environmental International, 107, 216-226.

[46] *A locally adaptive process-convolution model for estimating the health impact of air pollution*, Lee, 2018, Annals of Applied Statistics, 12, 2540-2558.

[47] *Using spline models to estimate the varying health risks from air pollution across Scotland*, Lee, 2012, Statistics in Medicine 31, 3366-3378; *Multivariate space-time modelling of multiple air pollutants and their health effects accounting for exposure uncertaint*y, Huang *et al.*, 2018, Statistics in Medicine, 37, 1134-1148.

[48] *Association between long-term exposure to air pollution and specific causes of mortality in Scotland*, Yap C, *et al*, 2012, Occupational and environmental medicine 69, 916-924; *Associations between short/medium-term variations in black smoke air pollution and mortality in the Glasgow conurbation, UK*, Beverland I, et al. 2014, Environment International, 62, 126-132.

[49] *Urban air pollution and cardiopulmonary ill health: a 14.5 year time series study*, Prescott G, et al. 1998, Occupational and environmental medicine 55, 697-704; *Does deprivation index modify the acute effect of black smoke on cardiorespiratory mortality?* Carder M, et al. 2010, Occupational and Environmental Medicine 67, 104-110; *Association between long-term exposure to air pollution and*

methods in different time periods and considered multiple pollutants (NO_x, NO_2, $PM_{2.5}$, PM_{10} and black smoke). Occasional significant associations were found, though finding an isolated significant result in a larger set of non-significant results can result from multiple statistical testing[50]. This finding contrasts with the international evidence finding associations of air pollution (especially PM) with cardiovascular illness and deaths.

5.22 The most recent study by the Universities of Glasgow and Strathclyde[51], using Scottish data for 2015 and 2016, reinforced the main conclusions from earlier Scottish work; finding consistent significant associations of pollution (particulates and nitrogen oxides) with respiratory disease outcomes, while finding no associations with all-cause mortality or cardiovascular endpoints.

Comparison of the international and specifically Scottish evidence.

5.23 The international epidemiological evidence indicates that, all things being equal, we might expect to find some increased risk of CVD associated with exposure to air pollutants, even in Scotland. In addition to epidemiological evidence, there is good quality mechanistic evidence to support the view that (particulate) air pollutants have direct effects on the cardiovascular system, albeit at much higher levels (around 100 - 300 μgm^{-3}) than those normally prevalent in Scotland (around 10μgm^{-3}). Yet, studies in Scotland consistently fail to confirm such an association for reasons we do not understand.

5.24 Studies elsewhere in the UK have likewise failed to find evidence of association with CVD[52]. However, other studies in non-UK countries, with similarly low levels of PM pollution to Scotland, have found such effects[53]. Further analysis of such studies is needed to understand possible reasons for this variation in findings.

5.25 There are many possible factors that might contribute to the different findings in Scotland but it is not possible to investigate or eliminate all the possible explanations systematically at present. It is unlikely that one single or simple explanation exists for the Scottish CV disease findings; a combination of factors is probably responsible. Meantime, we simply do not know what the explanation is, nor how best to interpret the different findings on CV disease. More research would be needed, particularly into long-term effects of ambient pollution in Scotland (e.g. using a cohort study approach), to explore this issue further. The variation in findings is important however, in that it adds additional uncertainty to estimating and quantifying

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specific causes of mortality in Scotland, Yap C, et al., 2012, Occupational and environmental medicine 69, 916-924; *Cardiovascular disease and air pollution in Scotland: no association or insufficient data and study design?* Willocks L, et al, 2012, BMC Public Health, 12:227; *Associations between short/medium-term variations in black smoke air pollution and mortality in the Glasgow conurbation, UK*, Beverland I, et al. 2014, Environment International, 62, 126-132.

[50] *Multiple testing in descriptive epidemiology*, Catelan D, and Biggeri A. 2010, Geospatial health, 4, 219-229.

[51] *Estimating the health impact of air pollution in Scotland, and the resulting benefits of reducing concentrations in city centres*, Lee D, et al. 2019, Spatial and Spatio-temporal Epidemiology, 29, 85-96.

[52] *Mortality associations with long-term exposure to outdoor air pollution in a national English Cohort*, Carey *et al*., 2013, Am J Respir Crit Care Med, 187, (11) 1226-1233; *Traffic pollution and the incidence of cardiorespiratory outcomes in an adult cohort in London*, Carey *et al.* 2016, Occupational & Environmental Medicine, 73 (12).pp. 849-856.ISSN 1470-7926.

[53] *State of Global Air 2019*, Health Effects Institute, 2019

the cardiovascular impacts of air pollution in Scotland. This uncertainty also has implications for predicting the size of health benefits that would occur from future air pollution control policy in Scotland.

Interpretation of epidemiological and other evidence.

5.26 Epidemiological research requires careful interpretation due to the potential limitations of studies. Despite the best efforts of experienced research teams, individual studies are at risk of bias; the effects of confounding; limitations in exposure and outcome assessment methods and difficulty in attributing potential associations to any specific pollutant. Literature reviews need to take account of publication bias (whereby negative studies may be under-represented, leading to overestimation of positive effects) and the need to consider potential heterogeneity of studies (differences that make valid comparisons more difficult). The fact that such difficulties *can* occur should however not be taken to imply that in general (positive) results should not be accepted; the checks and balances and the transparency of epidemiology are designed to ensure that valid conclusions are drawn, despite these difficulties.

5.27 Using internationally derived data to estimate the size of impacts, by transposing epidemiological findings from other countries to Scotland, involves uncertainties and some potentially unrealistic assumptions. A study from another country may not be directly comparable to Scotland due to different levels and composition of air pollution; underlying levels of health; genetic factors; geographical and meteorological conditions; and types of confounding factors that drive ill health generally (e.g. diet, levels of activity, smoking rates, social and health inequalities).

5.28 The evidence internationally is that relationships identified between air pollution and health are remarkably robust to differences such as these: (i) they seem not to depend strongly on level or composition of pollution; (ii) typically they are represented as % effect on background rates, and so allow for differences in background rates because of genetic or other factors, including healthcare systems; (iii) the ability to adjust for meteorology in time series studies is well established and is not an issue for cohort studies; and (iv) while the available major cohort studies such as the American Cancer Society clearly show an effect of smoking, there is no clear evidence that smoking habit affects the estimated % effect of air pollution. In practice despite the limitations outlined above, all quantifications by WHO, GBD, COMEAP, US EPA and other expert groups, depend on transferability of identified relationships from one location to another.

5.29 Compared globally, air pollution levels in Scotland are relatively low. Studies in other countries are often based on levels higher than those encountered in Scotland. Applying this international evidence to Scotland therefore assumes that associations identified at higher concentrations also hold true for the lower concentrations experienced here. Such extrapolation beyond the range of reported study data is not an ideal approach, in that it introduces additional uncertainties and requires an understanding that there is no supporting data for those lower concentrations.

5.30 It is also worth noting that all attempts to set health based limit values at thresholds where no effects will occur, have in due course been amended downwards as new studies find effects at lower concentrations. Consequently, health based limits have progressively reduced over time. Also we know that if there is no pollution, then there will be no pollution associated health impacts. In reality, the lack of evidence of a no-effect threshold for $PM_{2.5}$ exposure (a level at which there is no known excess risk) means that effects at low pollutant levels are likely to be somewhere between those reported at higher levels and no effect at all.

A5b) Potential Co-benefits to Public Health of Reducing Air Pollution

Health and cost impacts of interventions reducing traffic sourced air pollution

5.31 Evidence from the National Institute for Health and Care Excellence (NICE), Public Health England (PHE)[54] and others has identified interventions that are effective at reducing traffic sourced air pollution as well as having co-benefits for health. Reducing emissions from existing vehicles, planning for active travel and public transport and reducing demand for polluting vehicles were all identified as effective interventions for reducing transport-related pollution.

5.32 The scale and sustainability of investment helps determine the effectiveness of interventions. In Scotland, the national budget for active travel has doubled in recent years, with widespread multi-sectoral support for prioritising walking, cycling and public transport as "*the best investment for physical activity*"[55]. Public transport investment in Edinburgh, alongside a commitment to supporting active travel, led to modal shift away from private car use and toward active and sustainable travel[56]. The Dutch government invested almost €0.5 billion per year in cycling facilities over recent decades; the population level health benefits associated with their national cycling levels are estimated as equivalent to preventing 6,500 deaths per year or adding a half-a-year longer to life expectancy, with high benefit-cost ratios in the long-term[57]. Greater investment would be needed in Scotland to replicate Dutch levels of health benefit from active travel.

5.33 Air pollution and the consequent health burden demonstrate inequalities. International evidence suggests that exposure can fall disproportionately on disadvantaged or vulnerable populations; typically, people living in more deprived areas, those with pre-existing health problems, the very young and the old[58]. Few studies of interventions to reduce air pollution have assessed impacts on health equity specifically[59]. Pedestrian casualties are higher in more deprived areas and higher for children than for adults[56]. This suggests potential synergies between improving air quality alongside road safety to reduce inequality in the prevalence of

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[54] *Air pollution: outdoor air quality and health*, NICE, 2017; *Review of interventions to improve outdoor air quality and public health*, PHE, 2019

[55] *Tackling vehicle emissions and physical inactivity. Scottish Government doubles active travel budget*, Campbell et al. 2019. Br J Sports Med 2019; 53:466-467.

[56] *Trends in pedestrian and cyclist road casualties in Scotland*, Whyte and Waugh, 2015, GCPH,

[57] *Dutch cycling: Quantifying the health and related economic benefits*, Fishman et al. 2015 Am J Public Health. 2015; 105(8):e13-e15.

[58] *Socioeconomic status, particulate air pollution, and daily mortality: differential exposure or differential susceptibility*, Forastiere et al. 2007, Am J Ind Med. 2007; 50(3):208–216; *Associations between air pollution and socioeconomic characteristics, ethnicity and age profile of neighbourhoods in England and the Netherlands*, Fecht et al. 2015, Environ Pollut. 2015; 198: 201-210

[59] *Addressing equity in interventions to reduce air pollution in urban areas: a systematic review*, Benmarhnia et al. 2014, Int J Public Health (2014) 59: 933.

harmful impacts; e.g. by creating more livable public spaces, reducing traffic speeds and through-flow. Placemaking is a recognised and endorsed approach to development in Scotland[60]. A Place Standard tool has also been developed for use by communities, public agencies, voluntary groups and others to identify those aspects of a place that need to be targeted to improve people's health, wellbeing and quality of life[61].

A5c) Public Perceptions of Air Pollution

Public Attitudes to Air Quality survey, DEFRA

5.34 DEFRA published qualitative research involving car users, public transport users and other identified groups, gauging levels of knowledge, public understanding and attitudes to the issues[62]. A wide range and hierarchy of factors were found to determine people's beliefs and views on the issues. Environmental issues were not seen as one of the most important concerns in respondents' everyday lives. However, those who were more concerned about environmental issues in general were also more knowledgeable about air pollution and more likely to be taking action already or more willing to in future. Younger people, members of an ethnic minority group and those with higher levels of education were more likely to be concerned. Those living in urban areas, especially where air quality was known to be poorer and those living with existing health conditions (making them more susceptible to impacts) were more aware and more concerned. However, socio-economic and demographic factors had less influence in determining attitudes and levels of concern.

Annex A5d) Air pollution and noise

Impacts of noise exposure for wildlife and humans

5.35 Noise has been shown to impact negatively on wildlife; disrupting communication, navigation, foraging, and avoidance of predators and danger. Individual studies have shown disturbed behaviours, reduced feeding and abandonment of young and depleted species richness[63]. In humans, noise is defined as an unwanted intrusion and results in physiological (endocrine and nervous system) responses.

5.36 Noise exposure in humans is associated with annoyance and with symptoms including anxiety, high blood pressure, sleep disturbance and cardiovascular disease. An increased risk of myocardial infarction (MI) was identified associated with exposure to long-term residential road traffic noise in a Danish urban cohort study[64]. Impairment in schoolchild academic performance has also been noted[65].

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[60] *Scottish Planning Policy*, Scottish Government 2014; See also section 8 of main Review Report.
[61] The Place Standard tool, NHS Health Scotland, 2019
[62] *Public Attitudes to Air Quality*, DEFRA, 2018
[63] Shout Out for Peace and Quiet, Curran J. 2019, The Ecologist,
[64] *Road Traffic Noise and Incident Myocardial Infarction: A Prospective Cohort Study*, Sørensen M et al. 2012, *PLOS One*, 7(6), (e39283)
[65] *Noise in Europe*, EEA, 2014

A5e) Indoor Air Pollution – sources and health impacts

5.37 The literature on indoor air pollution health effects is much less comprehensive than that for outdoor air pollution. The WHO estimated in 2017 that up to 117,000 (early) deaths each year in Europe could be attributable to indoor air pollution; including up to 3% of all heart disease, 3% of chronic pulmonary disease, 3% of stroke and 2% of lung cancer fatalities[66].

5.38 Sources of indoor air pollutants differ depending on the indoor setting (e.g. home, school, workplace) and include: combustion particles and gases (CO, CO_2, NOx) from burning fuels for heating and cooking and from tobacco smoke; chemicals used for cleaning and disinfection; perfumed products; chemicals, including volatile organic compounds (VOCs) released from building materials, furniture, fixtures and fittings such as carpets and wall coverings[67]. The US Environmental Protection Agency reported[68] that, on average, the level of many VOCs is between two and five times higher inside houses compared to outdoors. Indoor pollutants can also include naturally occurring gases that accumulate inside buildings; e.g. radioactive radon gas originating in geologically sensitive areas; and CO_2 and methane migration in ex-mining areas. Pollutants present and mobile, in the regolith and near surface ground waters, also have the potential to enter properties. Building on former landfill or other polluted sites carries a related hazard potential.

5.39 The degree of correlation between indoor and outdoor air quality depends on physical factors including the rate of air exchange. However, modern housing and other buildings are increasingly being designed to reduce active heating needs and associated carbon emissions, by making them more air tight. Whilst a positive in some respects, it may also lead to pollution remaining in the occupied space.

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66 *Preventing noncommunicable diseases (NCDs) by reducing environmental risk factors*, World Health Organization, 2017

67 *WHO guidelines for indoor air quality. Chemical indoor air pollutants: selected pollutants*, WHO, 2010

68 *Volatile Organic Compounds' impact on indoor air quality*, USEPA, 2017

A6. Annex 6 – Agriculture, Industrial and Domestic Emissions (AIDE)

A6a) Domestic combustion emission sources, pollutants and trends in Scotland

6.1 The Department for Business, Energy and Industrial Strategy (BEIS) Domestic Wood Usage Survey that the estimated volume of wood burnt in the UK was tripled in 2015[69]. The Stove Industry Alliance (SIA), the log suppliers and the Forestry Commission in England all question the BEIS estimate of 6 million tonnes, and the Forestry Commission estimates the volumes of logs consumed as between 2.3 and 2.5 million tonnes. The SIA and log suppliers are comfortable with the Forestry Commission estimate which ties in with recent user survey research[70]. DEFRA is currently undertaking further research to verify the volume of wood being used but the results are not expected until late 2019. This had led to significant debate regarding the actual emissions of $PM_{2.5}$ produced from domestic burning.

6.2 Trade sources suggest that c. 80 Ktonnes of coal is burned in Scottish homes. This is a significant contributor to $PM_{2.5}$ due to the high particulate output of coal compared to approved smokeless fuels.[71] Non-approved fuels also account for significant SO_2 emissions and such fuels range up to c.7% in sulphur content.

6.3 The National Atmospheric Emissions Inventory data (NAEI) for Scotland shows a continuous reduction in $PM_{2.5}$ over recent years to below World Health Organisation (WHO) recommended limits. Research commissioned by DEFRA[72] showed that emissions from wood burning in UK cities, including Glasgow, Edinburgh and Dundee were going down between 2009 and 2015. This was against a background of increasing stove sales. The main reason given for the drop in emissions is the replacement of open fires and older stoves with more modern appliances that produce lower amounts of particulate matter (PM_{10} and $PM_{2.5}$).

6.4 While it is likely that similar measures to those outlined in the DEFRA strategy will result in emission reductions, it would be useful to have an estimate of the reduction in emissions that will come about. Establishing key performance indicators (KPIs) to track improvement is not likely to be easy. A major hurdle is linking the emissions from chimneys and flues with the atmospheric emission inventories. The latter needs further effort to increase their accuracy and utility.

6.5 Further monitoring of $PM_{2.5}$ levels, particularly in urban areas is desirable. Local area concentrations of $PM_{2.5}$ show significant peaks as demonstrated by the SAPPHIRE study[73] in Ireland, where regional towns' $PM_{2.5}$ emissions were 10-15 times above WHO limits and background levels. However there is considerable uncertainty about measurement and source attribution methods. This needs further research.

Other domestic sources

6.6 Whilst this is not a comprehensive assessment of all possible domestic level air pollution issues and sources, it is worth noting that the primary domestic heating and cooking source remains gas. Properly fitted, maintained and operated equipment and systems will minimise combustion and fugitive emissions. In the joint context of tackling climate change pressures as well as air pollution, it is important to consider that potentially harmful particulate, methane, carbon monoxide and dioxide as well

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[69] *The Digest of UK Energy Statistics*, BEIS, 2018

[70] The SIA has recently co-ordinated a survey of over 10,000 wood users. The results are currently being analysed.

[71] 20-25 g/hour -v- 5 g/hour – source HETAS and Kiwa Gas Tech.

[72] *Airborne particles from wood burning in UK cities*, Kings College/NPL, 2017

[73] *SAPPHIRE Project Overview*, University College Cork, 2016

as derived impurities also will contribute to both issues. This should also be addressed by moving to low carbon domestic systems. An assessment of the levels of gas releases from the domestic cooking and heating system would be helpful to obtain.

A6b) DEFRA Clean Air Strategy recommendations for domestic combustion, and how these relate in the Scottish context

6.7 The DEFRA Clean Air Strategy[74] recognises that wood burning emissions depend on the type of appliance and the dryness of the wood. Other factors include the way the householder uses the appliance and burns the wood. Maintenance of the appliance and the chimney also have an impact. For solid fuel the amount of sulphur released depends on the sulphur content of the fuel. Burning practice and particularly "slumbering"[75] have an impact.

6.8 DEFRA proposals include a ban on the burning of bituminous coal, due to the high $PM_{2.5}$ emissions from the fuels. In terms of appliances the main policy instrument is Ecodesign (ED)[76]. ED will introduce stricter emission limits[77] for particulate matter (PM), carbon monoxide (CO), oxides of nitrogen (NO_x) and organic gaseous carbon (OGC). DEFRA has incorporated ED in its Clean Air Strategy stating that '*they will only permit the cleanest stoves to be sold and installed'*.

6.9 When it comes to fuels, firewood log manufacturers believe that it will take legislation to change behaviour. Retailers will always be under pressure to supply a cheaper, if poorer quality, product. Removing that option creates a level playing field and allows log suppliers to concentrate on achieving the desired moisture content. DEFRA picked this up in its strategy and is planning to legislate that the supply of logs up to two cubic metres must have an average moisture content of 20%. Such logs will be mainly kiln dried. Most cut wood available has much higher moisture content[78]. It will be necessary to address commercial supply as well as own-wood resource use to manage impacts in future.

6.10 Estimates of the proportion of $PM_{2.5}$ in DEFRA's Clean Air Strategy are based on *all* domestic combustion. This includes open fires, bonfires, open-fired pizza ovens, conventional chimneys and older stoves as well as higher specification new stoves.

6.11 In the Clean Air Strategy, DEFRA highlights that 50% of all emissions are transboundary, although how applicable this observation is to Scotland is unclear. In

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[74] *Clean Air Strategy 2019*, DEFRA, 2019
[75] Damping down or sealing over a household fire to keep it running overnight, for example, at a low level. Partial combustion produces poorer pollution results and dirtier fire and chimney conditions over time.
[76] Ecodesign (ED) is the European-wide programme to lower emissions and improve efficiency. It is due to come into effect in the UK in 2022 for wood burning and solid fuel stoves. The UK government has brought the European legalisation into UK law so that the Ecodesign regulations will still be applicable to the UK after Brexit.
[77] DEFRA Exemption currently only looks at PM and CO. The most significant emission from wood burning is PM. The PM emissions limit in ED is 55% lower than for DEFRA Exemption and the limit for CO is 80% lower.
[78] Research carried out by Leeds and Manchester universities confirmed independent tests from Kiwa that PM emissions increase significantly as the moisture content of wood increases above 20%. Freshly cut wood can have a moisture content between 60% and 80% depending on the species.

any case, Scottish policy should consider this and develop a coherent approach, at national and local scales.

6.12 DEFRA and the industry have concluded that improving air quality will require action on the appliance, fuel, consumer behaviour and appliance/flue installation and maintenance. This review supports that position.

6.13 In terms of interventions for the domestic sector, a weakness in ED is that it only applies to new stoves and doesn't affect the existing stock. Reducing domestic source pollution, however, requires that the existing stock be addressed too. Householders with open fires and older stoves should ideally be encouraged to upgrade their appliances to ED stoves, in the light of the 90% and 80% respective reductions in emissions this could achieve. Changes to fuel regulations provide immediate reductions in emissions produced from domestic burning, with smokeless fuels and controlled dried wood reducing $PM_{2.5}$ emissions by c.80% when compared to coal and wet wood. The implementation of such measures would complement advances in stove design, which require these fuels, and provide further certainty regarding achieving particulate emissions reductions.

6.14 Existing Clean Air Act provisions, including the Smoke Control Areas (SCAs) identified, are outdated, poorly understood by householders, difficult to enforce and have not hitherto stopped burning of wood in open fires or burning of unauthorised fuels in SCAs. A national scheme enforcing fuel standards (i.e. smokeless fuels and dry wood) and stove standards at the point of sale would have an immediate impact on emissions.

6.15 Effective co-ordination with spatial planning policies would also be helpful to manage wood burning stoves and other domestic combustion to minimise both nuisance and pollution. In addition to links to operational guidance around wood moisture and materials in use, flue and chimney conditions and building standards and control elements, there is a fundamental issue around permitted development status for most domestic flues, meaning that it is almost impossible to assess the impact of emissions on both neighbouring properties and the wider area. Initial planning and design interventions may be necessary as well as guidance on use and cumulative or specific local trigger thresholds where nuisance becomes an issue. Advice and guidance could be developed jointly between different local authority departments (environmental health, planning, trading standards and building standards) and SEPA. A review of installer training and requirements might also be useful.

6.16 Enforcement could be a particular challenge, given current resource levels in local authorities. However, a key measure would be enforcing the control of solid fuel standards at the point of sale rather than the point of use, with retailers facing significant risk of inspection and detection of infringements.

6.17 Alongside fuel type and condition, care and maintenance of fires, stoves and flues, etc. appear crucial in achieving efficient domestic combustion and minimising emissions and nuisance. Chimney sweeps play a useful role in checking chimney/flue systems, stove functioning and giving helpful information to householders, provided sweeps have appropriate training, skills and experience. The full working group report provides further detailed insights and recommendations here, relating to SIA, HETAS, Ecodesign and Woodsure/Ready to Burn schemes and other arrangements.

A6c) Industrial emissions

6.18 A summary of the emission trends from SEPA-regulated sites since 2002 is included in the full working group report[79]; with some of the main points of interest being:

- Emissions of PM10, NOx and SO2 have decreased significantly since 2006 and the downward trend is continuing;
- Emissions of PM2.5 are generally low with one site producing high emission levels during 2013/14;
- Emissions of NH3 have decreased since 2008, although the trend has become static and levels have started to increase again;
- Emissions of NMVOCs have decreased since 2002 but have levelled-off since 2007 and now started to increase;
- Emissions of CO have decreased since 2002 and the downward trend is continuing; and
- Emissions of Pb have decreased since 2004, along the trend has been very variable since then with increases and further reductions.

6.19 Anomalies of increased annual emissions may be due to mode of operation of the installations (e.g. increase in production), site-specific operational issues (e.g. abatement not performing correctly) and installations coming into regulation (i.e. starting to report for the first time). With the exception of emissions of NMVOCs (mostly from the food and drink and chemical sectors) and Pb (from combustion) industrial emissions are now only a relatively small component of Scotland's total emissions compared to transport, agriculture, and domestic, commercial and public sector combustion. It is anticipated the general downward trends of industrial emissions will continue while the current system of regulation is in place.

6.20 The full dataset for emissions to air from industrial processes is available on SEPA's Scottish Pollutant Release Inventory[80].

A6d) Industrial Emissions Directive/PPC

6.21 There are some flexibilities in IED/PPC that could be used to further reduce levels and impacts on air quality from industrial activities. Best available techniques (BAT) conclusions present mandatory emission limit values (ELVs) as a range, however installations in Scotland tend to be permitted at the upper end of this range. Where air quality improvements are identified as a driver to reduce industrial emissions, controls for PPC Part A Installations could be reviewed and set towards the lower end of the range. It is also the case that while permitting decisions for PPC Part A installations are BAT conclusion-led, the legislation does allow SEPA the ability to include ELVs for any form of emissions control. This means SEPA could potentially require wider emissions improvements from currently regulated activities where ELVs have not previously been set or abatement not installed.

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[79] AIDE Working Group Report
[80] Scottish Pollutant Release Inventory, SEPA

6.22 SEPA also considers domestic Environmental Quality Standards (EQSs) in permitting, compliance assessment and enforcement of regulated sites. While it is not a strict legal requirement to meet these standards, it plays an important part in SEPA's decision-making. There is clear guidance issued by SEPA for PPC Part A[81] and PPC Part B[82] activities on how permits are determined and issued (further details are provided in the AIDE WG Report[83]).

6.23 The system for ensuring domestic EQSs are considered by SEPA in PPC permitting is considered robust and effective. The role of local authorities in having to work towards domestic requirements, captures the current legal status effectively and gives clarity in the roles and responsibilities. At this time SEPA indicates it has no plans to approach Scottish Government to request a change to these requirements as part of the CAFS Review.

A6e) <u>Policy context for agricultural emissions and the natural environment</u>

6.24 The UK Government reports on the impact of air pollution on ecosystems, under the National Emissions Ceilings Directive (NECD). The Effects of Air Pollution on Natural Ecosystems Reports[84] describes how the UK will meet this obligation. The report considers inadequate what is currently included in this reporting for Scottish terrestrial ecosystems. However, there is good coverage for freshwaters and atmospheric chemistry. In Scotland it is likely that we will need monitoring of more parameters at a broader range of terrestrial habitats before we can detect ecological effects of air pollution and its abatement with any confidence.

6.25 The NECD has set targets for air pollutants as percentage reductions by 2020 and 2030. The UK National Air Pollution Control Programme (NAPCP)[85] projections for the reductions that may be achieved by England's Clean Air Strategy exceeds the targets. However, there is large uncertainty in the projected reduction and it may be strongly affected by uptake of measures.

6.26 The EU Clean Air Programme for Europe[86] includes a target for a reduction by 35% of the ecosystem area subjected to eutrophication by 2030, compared with 2005. Applying this in Scotland would set a target of bringing a further 2,875 km^2 of habitat below critical load exceedance for nutrient nitrogen relative to 2015.

6.27 Differing approaches to reducing ammonia emissions from agriculture have been tested in England, Denmark, the Netherlands and Germany. Analysis of these systems could inform development of a tailored Scottish approach. It seems likely that across the EU and specifically for Scotland, given the approach to be taken to

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[81] *IED-PPC-TG4 - Pollution Prevention and Control (PPC) Technical Guidance: A practical guide for Part A activities*, SEPA, 2017
[82] *The Pollution Prevention and Control (Scotland) Regulations 2000, A practical guide for Part B activities*, SEPA, 2014
[83] AIDE Working Group Report
[84] *Effects of Air Pollution on Natural Resources*, DEFRA, 2018
[85] *UK National Air Pollution Control Programme*, DEFRA, 2019,
[86] *Reduction of National Emissions – Guidance on ecosystem monitoring*, European Commission, 2019

tackling climate change, an integrated approach will be needed and explicit targets should be set[87].

6.28 It will be important that the sector is made aware of any differences between ammonia mitigation policies in Scotland compared to England, given that most of the media promotion on ammonia to date has been as a result of the DEFRA Clean Air Strategy, and not a Scottish specific strategy.

A6f) Trends and impacts of ammonia and other air pollution emissions from agriculture in Scotland

6.29 Since 1990, decreasing animal numbers and a decline in fertiliser use reduced emissions. An increase in the use of urea-based fertilisers recently has however led to higher emissions. This results in a plateauing of emissions since 2008, with an increase between 2013 and 2016. Cattle manure management[88] accounted for 38% of agricultural emissions in 2017 (non-dairy: 28%; dairy 10%), followed by cattle manure applied to soils (19%) and inorganic fertiliser application (16% total; 9% to tillage, 7% to grassland). Anaerobic digestion activity, particularly from the spreading of non-manure digestates on agricultural land, has increased the contribution from the waste sector.

6.30 Agriculture also produces appreciable amounts of particulates (PM_{10}: 14.4% and $PM_{2.5}$ 7.2% of totals) and volatile organic compounds (VOCs) (12.2% of total). Sources of PM_{10} include farm operations (31%) and manure management (cattle (25%), sheep (20%), laying hens (9%), other poultry and broiler chickens (6% each). Most emission sources have decreased since 1990, however those associated with laying hens has increased, especially since 2008.

6.31 $PM_{2.5}$ emissions arise from manure management (cattle (57%), sheep (22%)) and farm operations (14%). Manure management associated with laying hens, other poultry and broiler chickens contribute 2% each. Emissions of $PM_{2.5}$ from all sources have declined or remain unchanged since 1990, with little further change since 2010.

6.32 VOC emissions are dominated by cattle manure management (66%), followed by cultivated crops (14%). Most emission sources of VOCs have decreased since 1990, except for poultry.

6.33 Visible smokes and their amenity impacts and PM pollution profiles may also need further consideration in the Scottish context. Both muirburn and stubble–burning could be seen as significant nuisance issues as well as potential health hazards. A specific assessment could be merited and downwind impacts into urban areas should be considered, along with appropriate management responses and interventions.

[87] See full AIDE Working Group Report
[88] Manure management in the National Atmospheric Emissions Inventory includes emissions from livestock buildings, open yard areas and manure or slurry stores, EMEP/EEA air pollutant emission inventory guidebook 2016: Technical guidance to prepare national emission inventories, EEA, 2016

A7. Annex 7 – Transport

7.1 Additional context and evidence which supports the recommendations within the main body of the report.

Technological fixes vs demand management/behaviour change

7.2 Technology can bring lower pollution per unit, and the planned transition from diesel and petrol only vehicles to hybrids, EVs and stop-start engine management etc., will all contribute to reduced unit pollution outputs over the next decade or so. However, if the number of vehicles, vehicle km travelled and/or units increases, disbenefits of congestion[89], loading or the scale of non-combustion particulates from EVs with increased brake wear etc., may counter the benefits of the technological improvements. Whilst it is clear that an electric train powered from a renewable source is cleaner than a diesel unit, we note evidence that in terms of EVs, three times as much PM_{10} is generated from tyre and brake wear than conventional vehicle exhausts.[90] In any event, we also note that there is some significant investment in EV support infrastructure from Transport Scotland, including targeting rural, highland and island communities.[91] Progress may not be without challenges[92] and we may be looking at interim solutions rather than what is appropriate for the longer-term.

7.3 Approaches to addressing modal shift, inter-modal connectivity, broadband and low-pollution goods delivery and reducing air pollution generally also need to take account of differing solutions required for users in different parts of Scotland. How we facilitate longer necessary journeys, access to and from and mobility within remote and rural areas and an appropriate strategy for pooling/sharing, enhanced public transport services and improved vehicle charging facilities and connecting to urban centres will need to be developed over the next decade.

7.4 There is significant potential for active travel to substitute short car trips, with sizeable impacts on carbon emissions from personal travel. In research focused on Cardiff, half of all car trips were less than three miles long.[93] Taking into account individual travel patterns and constraints, walking or cycling could realistically substitute for 41% of short car trips, saving nearly 5% of CO_2 equivalent emissions from car travel. This was on top of 5% of 'avoided' emissions from cars due to existing active travel. Given that the majority of short trips take place in urban areas, their contribution - if made by car – to local air pollution is much more significant and the concomitant gains from a switch to active travel therefore greater. However, the researchers concluded that the evolving high quality active travel infrastructure in the case study area was unlikely to promote a significant reduction in carbon emissions from (displaced) car journeys on its own.

7.5 In addition, there are discernible trends in travel behaviour which are supporting lower emissions, not least 'peak car'. Young adults in Great Britain, men in particular, are driving less now than they did twenty years ago. Whilst it is unclear if recent trends will continue, it is important to understand why younger people have

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[89] *Tackling Pollution and Congestion*, Begg and Haigh, Greener Journeys, 2017

[90] *What is air quality on the road network and how does this vary by road type, location and time of day?* Technical Note 21, Transport for London,

[91] c. £10m in the last year provided by Transport Scotland to local authorities for EV charging infrastructure.

[92] www.theguardian.com/technology/2019/may/30/electric-vehicle-drivers-at-risk-by-charging-from-home-mains-supply

[93] *Assessing the potential for carbon emissions savings from replacing short car trips with walking and cycling using a mixed GPS-travel diary approach*, Neves, A., Brand, C. 2018., *Transportation Research Part A*, 123: 130-146.

not taken up car use as much as predecessors. Driving licence ownership among young people peaked in 1992/4, with 48% of 17-20 year olds and 75% of 21-29 year olds holding a driving licence. By 2014, driving licence holding had fallen to 29% of 17-20 year olds and 63% of 21-29 year olds. Between 1995-99 and 2010-14 there was a 36% drop in the number of car driver trips per person made by people aged 17-29 with a fall of 44% for men and 26% for women. The difference in the amount of car driving between young women and young men became negligible by 2010-14. Young people generally travel less now, with the total number of trips per person made by young men falling by 28% between 1995-99 and 2010-14, whilst the number of trips made by young women fell by 24%.[94]

7.6 One of the six main conclusions from the above study was that for current generations of young people in terms of transport and mobility, learning to drive and owning a car have become less attractive, being perceived as more difficult and costly. In areas where the availability of alternatives to driving, including reliable public transport and infrastructure for cycling and walking, has improved, cars are now less desirable or necessary for some young people, at least in urban areas and for the able-bodied, and are subject to other possible disadvantages. This begs the question of the provision of supportive infrastructure in cities through which to meet mobility needs without recourse to private transport and demand management, as noted above, that facilitates/supports this lifestyle behaviour. For example, the propensity for people to park bicycles at railway stations suggest that there may be significant demand for similar facilities at key nodes on the bus network, and at park and ride sites, particularly as an alternative to car use in access-charged zones. Cycle use has increased on certain corridors where infrastructure has been provided. For example, on the South West City Way in Glasgow there has been a 20% in the past year (207,013 to 240,134 in 2018).[95] However, across the country trip rates have not risen noticeably and the Cycling Action Plan for Scotland's 2020 vision (reflected in the CAFS 2015 strategy) only serves to provide an example of a policy implementation failure. Careful monitoring of trends and analyses and planning fitting these to place-making and service provision will be important.

Trunk Roads

7.7 The Scottish Roads programme focuses on increasing trunk and motorway road network capacity. While T15 of the Progress Note on the existing targets/objectives within the current CAFS[96] notes that Trunk road impacts of AQMAs will be reviewed and there should be mitigation where trunk roads are the primary contributors to air pollutants, this fails to acknowledge that adding to the trunk road and Motorway network encourages more use. The continuing support for road building and expansion appears to serve as a perverse incentive, via signalling and funding support, in a time of clear need to reduce vehicle numbers and impacts. The overall road transport funding regime appears to remain geared towards the maintenance of car use as the dominant mode. Given other government targets and commitments, this begs the questions: why and for how much longer? The Standing Advisory Committee on Trunk Road Assessment (SACTRA) noted that new roads induce

[94] *Young People's Travel – What's Changed and Why? Review and Analysis*, Chatterjee, K.*et al*, 2018
[95] Data provided by Glasgow City Council
[96] *Progress on the existing targets/objectives contained within the current CAFS strategy and an assessment of their status*, 2019, Scottish Government;

additional traffic and "lock in" traffic growth.[97] As Goodwin has noted, "further studies have found that the evidence has been consistent, recurrent, unchallenged by serious countervailing evidence, but repeatedly forgotten".[98] At the same time the evidence that new road building drives additional economic growth (as opposed to moving growth around spatially by changing patterns of accessibility) is, according to the most recent meta-review on the topic, limited[99]. There was therefore majority support on the transport Working Group for ending additions to the Scottish trunk and motorway network[100].

7.8 At the national level there is also the issue that motor vehicle occupants' travel time is monetised at a higher value than that of travellers by most other modes. This is prejudicial and provides a further perverse incentive for investment in private motorised travel modes. Another example of a perverse incentive is that local authorities can lose sorely needed funding revenues such as when removing car parking spaces to encourage modal shift. More generally there is concern about reducing incomes from car parking spaces and other sources with a move away from a carbon intensive economy[101]. Government support is needed to get out of this 'catch-22' situation. Funds reallocated from road building and widening schemes could deliver much greater Benefit to Cost Ratios, if spent on smaller scale and active travel schemes, reflecting the improved health outcomes and lower costs of such schemes.

7.9 This review did not go on further to consider road pricing issues in detail but they clearly could apply here too. Subject to LEZ charging generally as well as approaches in future to hybrid and EV road use changes, there could be a need for a complete overview of mobility costs structures. Again, a careful consideration of rural versus urban and trunk/longer range options and how these fit with current and future social and economic needs would be required, especially given clearly perceived and articulated views in the Borders and Highlands.

Densification

7.10 Higher densities are generally associated with reduced travel distances, less driving and more travel by other modes. Compact urban places can reduce private motor vehicle miles travelled by around 30% in comparison to lower density

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[97] SACTRA reported that additional private motorised traffic growth creates a vicious spiral of increasing private motorised travel. Their logic was that more road space equals more car use equals less public transport use, and so fares go up and frequency goes down, with the result that more people transfer to cars and the new equilibrium point is a lower level of service in both cars and public transport; SACTRA, 1994. Trunk roads and the generation of traffic. Standing Advisory Committee on Trunk Road Assessment. London: HMSO.

[98] *Induced traffic again. And again. And again,* Goodwin, P, 2006. Local Transport Today, 450:17.

[99] *Evidence review 7: Transport*, What Works Centre for Local Economic Growth, 2015

[100] Assessing both road building levels and their incentive impact are more challenging than they appear. New building is perhaps more visible but is less significant than on-line improvements and maintenance. Also local roads play a part and these are often connected with new residential and retail developments. The LA road network is growing at c 100km/a according to TS. This in turn is a draw on LA funding in the longer term to maintain.

[101] The Glasgow Connectivity Commission showed in their report (p.17) that there is sufficient space in Glasgow's under-utilised car parks to accommodate a consolidation from on-street parking in the city centre.

developments[102]. Compact settlements on their own are likely to be insufficient without additional measures to promote sustainable transport, such as:

- locations within say 3km of existing major centres
- complementary incentives to reduce trip length
- provision and encouragement of use of public and non-motorised transport
- and/or increase the adoption of lower emitting vehicle technologies[103]

New housing

7.11 There are concerns that new housing needs to cater for freight deliveries and essential services while not encouraging or even enabling car-centric urban lifestyles. Moves to encourage more individuals to move away from private car ownership and use requires some new ways of designing for goods/freight and other essential deliveries. This is a challenge needing a solution. This is being fuelled by increasing home deliveries, including free deliveries and return offers, and the continued rise of on-line food delivery orders, with estimates of between 13 and 14% of e-commerce deliveries failing first time adding extra costs[104], air pollution and other environmental impacts.

Best practice examples

7.12 A range of learning examples was identified by the Transport Working Group and is represented also in EU/EEA[105] research reports and these deserve consideration and replication where appropriate. Several inform the group's recommendations.

7.13 ***Car Sharing*** The rise of the concept of Mobility as a Service (MaaS)[106] and the increase in the number of car-sharing, ride-sharing, and bike sharing schemes across major cities, indicates that the attitude towards private car ownership is changing[107]. An analysis of Bremen's car sharing scheme in 2017 suggests that each car-sharing car replaced 16 privately owned cars[108]. Reclaiming and reallocating road space will be essential if other sustainable transport modes, such as public transport, walking and cycling are to be encouraged. The Bremen study concluded that car-sharing has positive effects on the use of public transport and bicycles, and that three out of four trips previously taken with a private vehicle were now taken with more sustainable modes of transport[108]. Car-sharing can therefore be an effective tool to encourage behavioural change and can have a positive knock-on effect on air quality by encouraging people to rethink their travel choices and opt for more sustainable modes. For these reasons, car-sharing (including electric car-

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[102] *Growing cooler: The evidence on urban development and climate change*, Ewing, R. *et al* (eds), 2007, Washington: Urban Land Institute.
[103] *The effects of urban form on ambient air pollution and public health risks: A case study in Raleigh, North Carolina,* Mansfield, T. *et al*, 2015, *Risk Analysis*, 35(5); 901-917.
[104] *All change? The future of travel demand and the implications for policy and planning,* Commission on Demand Management, 2018, ISBN: 978-1-899650-83-5.
[105] *Europe's urban air quality – re-assessing implementation challenges in cities*, EEA Report no.24/2018 ISSN 1977-8449
[106] Transport Scotland is expected to announce the projects to benefit from Scotland's MaaS Investment Fund in mid-June 2019 - www.scotlandis.com/news/2019/may/maas-investment-fund-pre-interest-registration-now-open/
[107] *Why mobility as a service holds the key to better air quality in cities*, Wixey, S, 2019
[108] *Analysis of the Impacts of Car-Sharing in Bremen, Germany*, Schreier, H. *et al.*, 2017

sharing) should be recognised as a form of sustainable transport and effective tool to improve Scotland's air quality.

7.14 ***Denmark*** Copenhagen is home to the largest car-free area in Europe. The city has reduced carbon emissions by 40% since 1990, despite a population increase of 50%, and aims to be carbon neutral and fossil fuel free by 2050. This progress has been achieved through a combination of car-free policies and investment in active transportation infrastructure. A bike share system, segregated biking lanes, adequate bike parking facilities, and a "Green Wave Route" (cyclists traveling 12.4 mph will hit all green lights) have resulted in 35% of trips taken by bicycle within the city.[109] Almost 50% of all trips are completed via active transportation and further development of bicycle-exclusive lanes are expected to increase cycling by another 15–20%.

7.15 ***Germany*** Berlin and other German cities have used low-emission zones that restrict the use of vehicles which do not attain specific emission standards in certain areas. Some of the LEZs in Germany were studied and found to decrease measured annual mean PM_{10} by an additional 2 ug/m^3 compared to the reductions in PM_{10} outside the environmental zones. In a study of 25 German cities with LEZs, researchers reported significant decreases in urban PM_{10} levels that can be attributed to their introduction.[110] This study reviewed the impact of LEZs across Germany[111]. They found three types of LEZs:

- Type 1 LEZs only ban very high-emitting vehicles from entering the zone
- Type 2 LEZs ban high-emitting and medium emitting vehicles
- Type 3 LEZs only grant access to low-emitting vehicles

In all three stages of LEZs, certain exceptions apply, e.g. for vehicles on medical emergency calls, the police and fire brigades. The study found that more stringent (Type 2) zones reduced PM_{10} concentrations more than three times as much as Type 1 zones. The researchers translated these changes in PM_{10} levels into health impacts using a concentration response function, which they applied to the 3.96 million inhabitants of the 25 LEZ-cities of their sample. The mean health benefits amounted to £912 million in the year 2010 if all LEZ-cities are assumed to have implemented Stage 1 zones. The total mean health benefits are £2.8 billion for Stage 2 zones, if assumed to be applied in all 25 cities.

7.16 ***Seville, Spain*** Seville built a network of bike lanes which increased cycling and reduced car use in a few years in the first decade of the 21st century. The city cut air pollution and the number of days it exceeded EU regulations on air quality from 152 to 40 per year. Now a Bus&Bici scheme allows public bus passengers of the Seville Metropolitan transport consortium to use public bicycles for free. The Bus&Bici initiative started during the 2006 European Mobility week as a pilot project. Today, it is a service linked to the use of the public buses, whereby bus passengers

[109] www.cycling-embassy.dk/facts-about-cycling-in-denmark/statistics/, accessed 9th May 2019.
[110] *The impact of Low Emission Zones on particulate matter concentration and public health*, Malina, C., Scheffler, F., 2015, *Transportation Research Part A*, 77: 372-385.
[111] It is worth noting that some LEZ evidence from Germany suggests that there is marginal but potentially significant evidence of "spill-over" or displacement effects, whereby drivers of non-compliant vehicles, for example, or to avoid congestion or charging, drive around LEZ areas and increase pollution in these areas. Comparisons with the inner zone of the LEZs still show a positive differential and both areas may also still decline.

in the Seville metropolitan area can also use a public bicycle for free. The only condition is that they have travelled on a bus on the same day and have a proof of this, e.g. a stamped bus ticket that they present with their ID card.

7.17 ***Urban Freight Consolidation: Bristol UK*** Deliveries to Bristol City Centre from the Bristol Bath Urban Freight Consolidation Centre (BBUFCC) demonstrated a reduction of 74% of delivery trips in the city within the BBUFCC scheme[112]. Since 2004 businesses in Bristol and Bath have been using Freight Consolidation to manage their deliveries more effectively through the BBUFCC. This consolidation service is a partnership between the courier service DHL, Bristol City Council and Bath and North East Somerset Council. An evaluation of the deliveries to Bristol City Centre from the BBUFCC between January 2011 and May 2012 showed that:

- for every 100 Heavy Goods Vehicle deliveries to the BBUFCC only 26 consolidated distribution trips were necessary. This equates to 74% of the delivery movements in the scheme being avoided altogether and the others made with a smaller, cleaner vehicle
- deliveries to Bath city centre from the BBUFCC showed a clear economic benefit for the freight operators in the scheme in terms of fuel costs avoided
- there is a health benefit to the wider public in terms of reduced emissions
- however, Urban Freight Consolidation is still a niche market e.g. construction sites, shopping malls, high density high streets.[112]

[112] *The Bristol Method: how to reduce traffic and its impacts*, Bristol City Council, 2015

A8. Annex 8 – Placemaking and Planning

8.1 This Annex provides wider policy context to the Placemaking and Planning recommendations in the main report.

National and International Planning Context

European Commission

8.2 In 2015 the European Commission stated that we are facing a broad range of challenges, such as unsustainable urbanisation and related human health issues, degradation and loss of natural capital and the ecosystem services they provide (clean air, water and soil), climate change and an alarming increase of natural disaster risks. There is growing recognition and awareness that nature can help provide complementary and new viable solutions that use and deploy the properties of natural ecosystems and the services that they render in a smart, 'engineered' way, working with regulation and other interventions and policies. These nature-based solutions provide sustainable, cost-effective, multi-purpose and flexible alternatives for various objectives. Working with nature, rather than against it, can further pave the way towards a more resource efficient, competitive and greener economy. It can also help to create new jobs and economic growth, through the manufacture and delivery of new products and services, which enhance the natural capital rather than deplete it[113]. The value of Nature Based Solutions and visions for future European cities are explored further in the placemaking Working Group's full report[114].

UK Government / Scottish Government

8.3 Both the UK and Scottish Governments are committed to supporting the delivery of the UN Sustainable Development Goals (SDGs)[115]. Several goals are directly relevant to the use of Placemaking and Nature Based Solutions to deliver cleaner air, including 3, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16 in particular. The Scottish Government has now linked its deliverables for the National Planning Framework and Scottish Planning Policy to the UN SDGs.

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113 https://ec.europa.eu/research/environment/index.cfm?pg=nbs
114 *Placemaking Working Group* full report
115 https://sustainabledevelopment.un.org/?menu=1300

National Planning Framework 3

8.4 National Planning Framework 3 (NPF3)[116] re-emphasises the importance of place by stating that its vision is of places as “successful, sustainable, low carbon, natural, resilient and connected”.

Place Principle

8.5 The Place Principle[117] agreement is as follows:

“ We recognise that: Place is where people, location and resources combine to create a sense of identity and purpose, and are at the heart of addressing the needs and realising the full potential of communities. Places are shaped by the way resources, services and assets are directed and used by the people who live in and invest in them. A more joined-up, collaborative, and participative approach to services, land and buildings, across all sectors within a place, enables better outcomes for everyone and increased opportunities for people and communities to shape their own lives. The principle requests that: All those responsible for providing services and looking after assets in a place need to work and plan together, and with local communities, to improve the lives of people, support inclusive growth and create more successful places. We commit to taking: A collaborative, place based approach with a shared purpose to support a clear way forward for all services, assets and investments which will maximise the impact of their combined resources.”

Glasgow’s Connectivity Commission and H2020 Connecting Nature

8.6 The Scottish Government sought to deliver an LEZ within one of the main Scottish cities by December 2018. Glasgow was identified as the preferred location. In the midst of the delivery work for the LEZ, a Connectivity Commission was set up in Glasgow led by Prof. David Begg. The Commission noted that major cities are cities of contradictions. They may be really good at some things, for instance in Glasgow’s case having the largest suburban rail network in the UK outwith London, but as passenger numbers have grown the network has struggled to cope. In contrast, in a city with below average car ownership levels, major road construction projects such

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[116] *Scotland’s Third National Planning Framework*, Scottish Government, 2014

[117] *Place Principle, introduction*, Scottish Government, 2019

as the M74 extension/completion continue to be given the go ahead. The report states[118];

"Along with other successful major cities, Glasgow is facing the key urban challenge of our times – how to repurpose transport networks built for the unsustainable, high carbon economy in order to prioritise pedestrians and create attractive, people-centred places supporting thriving populations in a clean and healthy city centre environment."

8.7 Glasgow continues to view its Open Spaces – the blue, grey and green as key assets that can help create a cleaner, more human scale environment that can help to support and instigate modal shifts in transport choices and behavioural change. Work is ongoing in the city on innovation around the use of Open Space and this is supported by the H2020 Connecting Nature Project[119] that is looking to introduce more nature based solutions to some of the climate adaptation and mitigation challenges that the city faces.

Additional placemaking perspectives

8.8 A recent development from a UK perspective appears particularly relevant. In Infrastructure Intelligence (2019) Guido Pellizzaro – Air Quality Director at Waterman Infrastucture and Environment writes[120] that, in the context of English examples, "A national guide to air quality design, setting out good air quality design principles for new planning developments, is vital if the UK is to reduce urban air pollution and meet housing targets". He went on,

"Currently in the UK there is no concise checklist of air quality design principles that urban planners should be adhering to when in the design stages of a new development.

At the highest strategic level, the National Planning Policy Framework states that opportunities to improve air quality or mitigate air quality impacts should be identified at the plan-making stage. Yet no further assistance is provided on the air quality design measures the government is seeking. It is left open for urban designers, consultants and local authorities to use professional judgement on what is deemed appropriate, often leading to conflict between individuals.

Given this conflict, there has been an increase in the refusal of planning applications based on air quality grounds...At the highest strategic level, the National Planning Policy Framework states that opportunities to improve air quality or mitigate air quality impacts should be identified at the plan-making stage. Yet no further assistance is provided on the air quality design measures the government is seeking. It is left open for urban designers, consultants and local authorities to use professional judgement on what is deemed appropriate, often leading to conflict between individuals.

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118 *Connecting Glasgow; creating an inclusive, thriving, livable City,* Glasgow Connectivity Commission

119 www.connectingnature.eu

120 *Why the UK needs a national guide to air quality design*, Guido Pellizzaro, 2019, Infrastructure Intelligence

“In general terms, developments by their nature can increase traffic by attracting new users, and the servicing of new uses. In addition, developments can release emissions through new energy and heating combustion plants. In areas already exceeding air quality standards, even a small increase in air quality could result in planning refusal as the development could be seen as being non-compliant or delaying compliance with air quality standards. Case laws have now set the precedent for this refusal.

“To enable the granting of planning permission, local planning authorities are requesting that the effect of air quality mitigation is quantified (in µg/m3) in order to demonstrate how mitigation will translate into actual air pollution reductions. However, there is a lack of evidence to enable the success of non-vehicle and non-combustion emissions mitigation to be quantified.

“Sustainable transport provisions such as walking incentives and cycling routes are based on behavioural characteristics. But how can the success of such walking and cycling incentives be accurately quantified, especially when behavioural changes might change from day to day (e.g. a person may decide to drive rather than cycle on a rainy day). Furthermore, the success of green infrastructure (e.g. a wall covered in ivy beside a road) is site-specific, based on factors such as local dispersion characteristics. To add complexity, what is considered as acceptable air quality mitigation can differ between neighbouring local authorities..

“What is required is a national guide to air quality design. This would ensure all developments include good air quality design, endorsed at the national and local level, which could avoid planning refusal due to a lack of quantifiable evidence on air quality mitigation. A national design framework could reduce urban air pollution and would provide an opportunity for the UK to improve air quality in the shortest timescale possible. Importantly it would reduce professional conflicts and allow the UK to continue to meet housing targets.”

Whilst a set of observations from England, there is considerable resonance with the Scottish context, and approaches to planning and design in Scotland should learn from this.

A9. Annex 9 – Engagement, Behaviour Change and Public Information

Input received from Transport Scotland on levels of public awareness of LEZs

9.1 To support a programme of targeted communication actions around LEZ introduction, Transport Scotland commissioned research to gauge the general public and business awareness, knowledge. This was aimed at establishing the level of public awareness and understanding of LEZs from public and businesses in Scotland. 1480 people from the general population and 672 businesses were interviewed.

9.2 Just over half of those interviewed had heard of LEZs, 35% were aware of an LEZ in Scotland and of those 77% knew of the Glasgow LEZ. Questions asked about vehicles, views of how LEZs should work, and the need for pollution reduction revealed concern about costs to change, restrictions or penalties for bringing vehicles into the cities and showed city centre dwellers and cyclists to be the most aware of the air hazard and the general sample seeing traffic as the main cause of poor urban air quality.

9.3 Businesses were somewhat more aware of LEZs, their necessity and purpose, and a significant proportion owned fleet vehicles most of which were diesels. Their emissions status was quite a low priority versus reliability, fuel costs, safety and tax. Three quarters of businesses thought their future fleet decisions would factor-in emissions as important but only 41% felt LEZs would affect their business. This research appears to contain useful granular information for further targeted policy and communications effort and would appear to be worth repeating to assess trends and the impact of engagement effort.

Academic insight into factors influencing behavioural change

9.4 The review also received useful input from Dr Rachel Howell at Edinburgh University and she provided a range of insights as well as access to an MSc dissertation[121] investigating why car use is lower in Edinburgh than in most other UK cities. It illustrated that the primary factors influencing low car use and higher levels of bus and active travel in Edinburgh compared to other cities are structural. Similar issues appear to arise from a comparison between UK commuting habits and those in countries such as the Netherlands (or indeed comparisons between the UK now and 50-60 years ago).

9.5 Dr Howell observed that her research experience into factors influencing behavioural change, led her to the conclusion that, *"too much focus is put on trying to influence individual choices through psychological and economic 'drivers' of change. Values and attitudes may play some part in some people's travel choices, but travel behaviours do not correlate at all well with pro-environmental attitudes, and everyday travel (commuting, the school run etc.) is inelastic to increases in pricing. Financial*

[121] *Why is car use lower in Edinburgh than in other UK cities?,* Patrick Miner, https://static1.squarespace.com/static/564914a1e4b00af65e3211a5/t/5b9adc1e575d1f26b6d380bb/1536875558370/Research_Summary_Patrick_Miner.pdf

‘rewards’ or subsidies may work, but often only as long as they exist. There are some interventions that may make a little difference, e.g. promoting active travel/public transport use when people are preparing to move house/job, before new travel habits have been set. But … to make significant advances in promoting public transport/active travel, these options have got to become the easiest and/or cheapest and/or most ‘normal’ ones. People are strongly influenced by social norms, although they don’t recognise this and are resistant to the idea.

“This will probably involve not only promoting active travel and bus transport in various ways, but acting to make car use much less convenient, relatively cheap, and normal (except for disabled people). Rather than assuming that people will get out of their cars *because* they are taking up alternatives (as was stated in the draft Climate Change Plan the ECCLR committee asked me to comment on a couple of years ago), I think it is much more likely that people will take up alternatives – at least in part – because other factors make the car less attractive. Habits are deeply engrained and there often need to be ‘push’ factors to encourage people to give them up, not just ‘pull’ factors promoting an alternative. Really tackling poor air quality will involve major, holistic policies such as congestion charging, road closures/one-way systems (to make way for better cycling and walking infrastructure and clearer routes for buses), strict parking restrictions etc.

“The Scottish Government has an excellent tool for analysing policies and planning for change in the ISM model – but it needs to use it better. For example, after hearing that people are put off cycling because they perceive it to be unsafe, it is not enough to plan merely for cycle training to equip riders to become more assertive. This is to focus on the individual level of the model exclusively. Cycling is objectively not as safe as other modes of transport, and the material levels need to be addressed (e.g. separating bikes and cars; considering adopting policies from the Netherlands/Nordic countries about responsibility for collisions between drivers and riders etc.) The social level could also be addressed through campaigns to try to change social norms so e.g. it is no longer seen as being a ‘good parent’ to drive children to school but instead ‘responsible’ to cycle or walk with them.

“There is ongoing interest in actions to improve air quality around schools by banning cars from driving to the school gates. It seems that these work better when pupils themselves are involved in going out to the gates and talking to parents, explaining the policy. However, often the problem is merely displaced elsewhere, with parents parking a little way away. This is why holistic policies are necessary.”