Lessons from the Past Inform the Future about Air Quality

2nd Atmospheric Pollution at Southampton Conference
7 September 2017

OVERVIEW BY IAN WILLIAMS

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Pollution in UK (London)

- 1257: earliest recorded pollution incident – Queen Eleanor (wife of Henry III) forced to leave Nottingham for the country because of stench of coal smoke. She was worried about her health ……
- 1272: King Edward I, urged by noblemen and clerics, banned burning of sea-coal. Anyone caught burning or selling sea-coal was to be tortured or executed
  - First offender caught was summarily put to death – made no difference
- 1285: Commission set up to investigate problem of coal burning in London
- 1288: Commission re-convened …..

Pollution in UK (London)

- 1306: Proclamation from Edward I cu
London. Prohibited coal during sessi
- Richard III (1377-1399) and Henry V
curb the use of sea-coal
- 1578: City's Company of Brewers de
wood in their breweries because of c
Elizabeth
- 1606: Shakespeare's *Macbeth* first p
foul is fair: Hover through the fog and
- 1661: John Evelyn "Fumifugum"

Early Legislation

1843: Select committee on smoke nuisance

1845: Select committee on smoke nuisance

1845: Railway Consolidation Act

1847: Trains Improvement Act

1853: Smoke Nuisance Abatement Act

1858: Sanitary Act

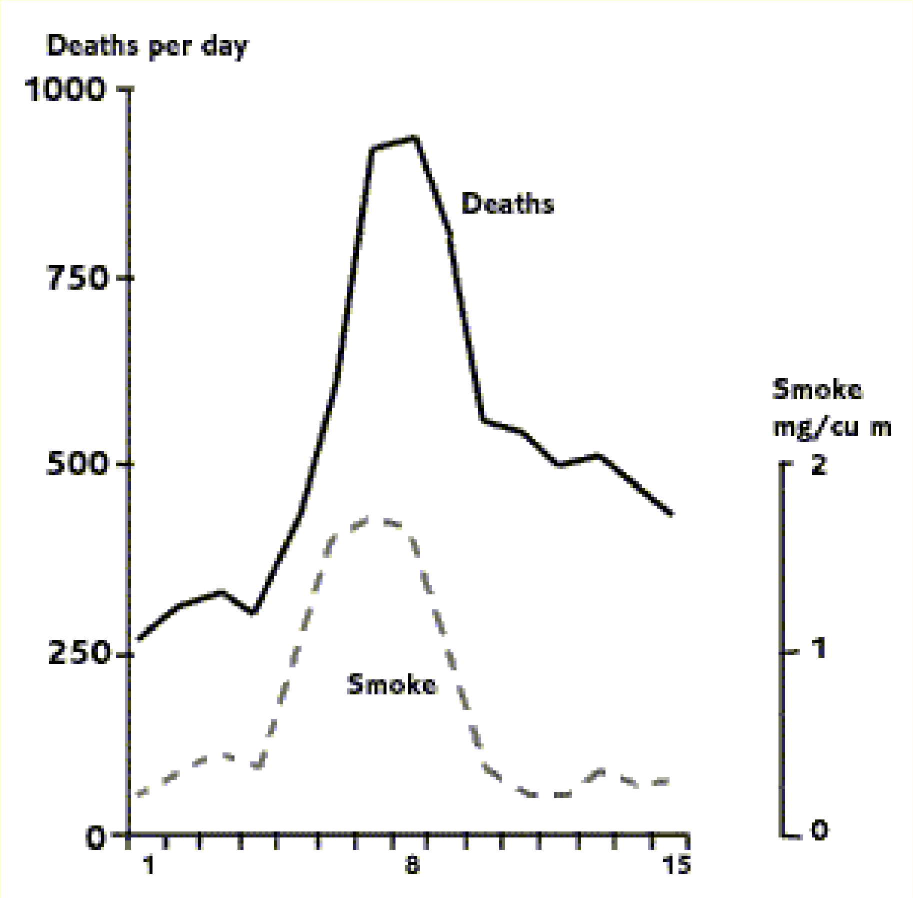
1866: Sanitary Act

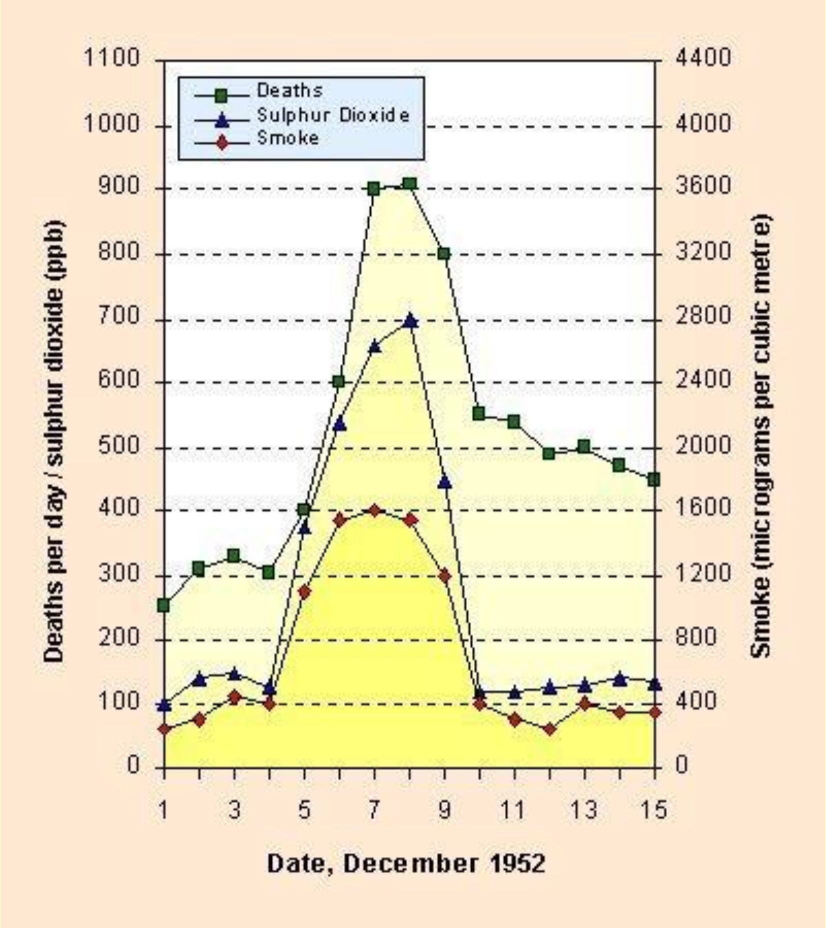
1875: Public Health Act

London Fogs

1800s:	> million London residents burning soft-coal,; winter "fogs" became a nuisance.
1813:	Dense and persistent fog for over a week.
1873:	Coal-smoke saturated fog, thicker and more persistent than natural fog, hovered over the city of days. As we now know from subsequent epidemiological findings, the fog caused 268 deaths from bronchitis.
1879	Fog lasted November to March, 4 long months of sunshineless gloom.
1900-1924	Many fatal accidents, road and rail transport stopped. Football matches/race meetings abandoned.
1927	February; dense and persistent fog for 6 days. Many serious road and rail accidents. Shipping on the Thames completely stopped.
1930	December; visibility so bad that many people walked into canals and rivers. Severe traffic disruption.
1934-36	Dense and persistent fogs. Many deaths. Shipping at a standstill.
1948	December; ~300 excess deaths .

London Smog, 1952





Aftermath

Jan 1955:

- "The Dark Day"

Feb 1955:

- Gerald Nabarro's Clean Air (Anti-smog) Bill

July 1956:

- Clean Air Act

1968 Clean Air Act; Tall Chimneys

- Tall chimneys: basic principal for the use of tall chimneys for industries burning coal, liquid or gaseous fuels

Dec 1957 and 1962:

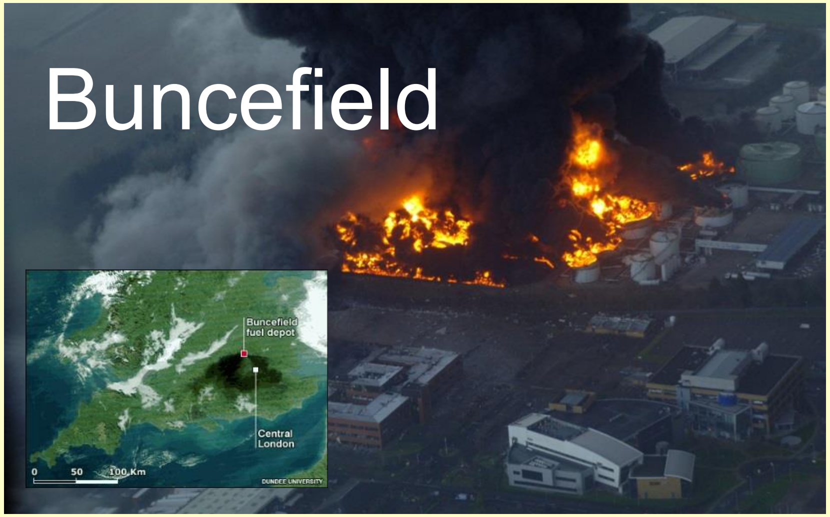
- Severe smogs; 800-1000 excess deaths ……..

Air Pollution: Disasters

Bhopal

Chernobyl

Seveso



Buncefield

Air Quality Management

- Strategic planning:
  - Monitoring networks/ modelling employed to spatially identify exceedance hotspots (AQMAs, LEZs)
- Air quality Index:
  - Includes four bands for PM_{10}, O_3, CO, SO_2, NO_2
  - AQI < 50 is considered safe zone for all, including those with sensitivities (typically Beijing AQI soars to 755)
- Air quality Legislation:
  - The Urban and Rural National Air Quality Scheme is part of a UK drive to meet stringent EU directives on air pollution

Directive 2008/50/EC on ambient air quality and cleaner air for Europe

This Directive lays down measures aimed at the following:

- Defining and establishing objectives for AAQ designed to avoid, prevent or reduce harmful effects on human health and the environment
- Assessing AAQ in MS using common methods & criteria
- Obtaining information on AAQ to combat air pollution and nuisance and to monitor long-term trends & improvements resulting from measures
- Ensuring that information on AAQ is made available to public
- Maintaining AQ where it is good and improving it in other cases
- Promoting increased cooperation between MS in reducing air pollution

http://ec.europa.eu/environment/air/quality/legislation/existing_leg.htm

Air Quality Legislation

- The UK Air Quality Standards Regulations 2010
  - limit values, target values, long term objectives, etc.
  - based on EU limit values and sets standards for following pollutants:
    - Sulphur dioxide (SO_2)
    - Nitrogen dioxide (NO_2)
    - Oxides of nitrogen (NO_X)
    - Particulate matter (PM_{10} and $PM_{2.5}$)
    - Lead
    - Benzene
    - Carbon monoxide (CO)
    - Benzo(a)pyrene
    - Ozone (O_3)

Local Air Quality Management (LAQM)

- Enforced by the UK Environment Act 1995 to identify hotspots of poor air quality in LAs
- Applies a ‘human health effects-based approach’ following the National Air Quality Strategy (2007)
- Ensures UK compliance of the European Ambient Air Quality Framework Directive
- Local air quality management: Policy guidance (PG09) (www.defra.gov.uk)

Air Quality Management Areas (AQMAs)

- Under LAQM, LAs are prescribed following steps:
  - Step 1 (technical): conduct review and assessment of air quality and designate AQMA
  - Step 2 (management): develop and implement an Air quality Action Plan (AQAP) to meet the AQ objectives
- To date, over 230 of LAs (approximately 60%) have declared one or more AQMAs for different pollutants (predominantly NO_2 and PM_{10})
- Transportation identified as the main source of pollution in the majority of the AQMAs (approx. 92%)
- Pooling Local Transport Planning with AQ policies

Low Emission Zones (LEZs)

- Effective in most EU countries for NO_2, PM, O_3
- Spatial AQ management strategy, restricting heavy duty polluting diesel vehicles entering a zone/road
  - usually over 3.5 tonnes Gross Vehicle Weight (GVW)
- Over 70 cities and towns in 8 countries around Europe operate (or are preparing) LEZs
  - Most LEZs operate 24 hours a day, 365 days a year
- New $PM_{2.5}$ exposure reduction responsibilities (EC)
  - LAs required to reduce the overall background concentrations and not just focused on hotspots

AQ information/ decision support tools

- Meso-scale models: emission toolkit + dispersion + GIS mapping
  - OpenAir – (http://www.openair-project.org/)
  - ADMS – Urban (Cambridge Environmental Research Centre, CERC, UK) (www.cerc.co.uk/)
  - AIRVIRO – (SMHI, Sweden) (www.smhi.se/airviro)
- Macro-scale models: regional forecasting
  - Community Multi-scale Air Quality Model – CMAQ (USEPA, US states air quality management tool)
  - WRF-Chem (NCAR, NOAA, US)
- Integrated models for CAPs, VOCs and GHGs
  - Harmonized Emissions Analysis Tool - HEAT+ (Local Governments for Sustainability, ICLEI) (www.heat.iclei.org/)

Global to local (Glocal) management

- Local to global scale policy synergies
- Local Governments for Sustainability - ICLEI
  - http://www.iclei.org/
- Transport/ domestic
  - www.howpollutedismyroad.org.uk/
- City regions
  - between 30-40% of air pollution in London is generated from sources outside of Greater London
- Urban-rural fringes
  - ‘sustainable’ heat and power via CHPs ought to generate additional sources of PM_{10}, NO_2 in peri-urban areas

Monitoring and Measuring Air Pollution

Automatic Networks
UK

- For the purpose of monitoring and reporting air pollution, UK has been divided into regions (or zones)

The Automatic Urban and Rural Network

- UK's largest automatic monitoring network; includes automatic air quality monitoring stations measuring:
  - Oxides of nitrogen (NOx)
  - Sulphur dioxide (SO_2)
  - Ozone (O_3)
  - Particles (PM_{10} and $PM_{2.5}$)
- Sites provide high resolution hourly information communicated via electronic, media and web platforms

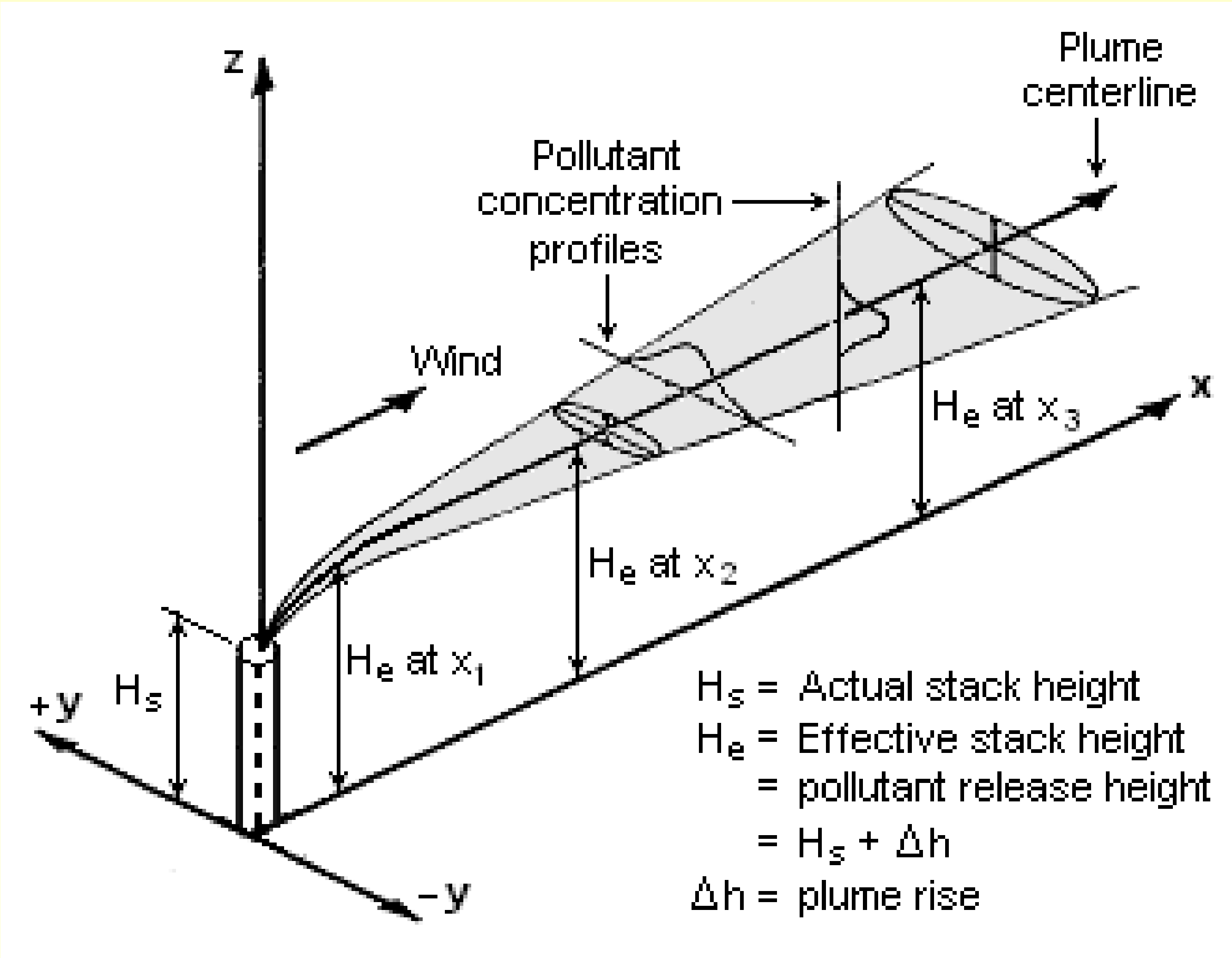
UK Non-Automatic Networks

Include:

- UK Eutrophying & Acidifying Network (UKEAP)
- Acid Waters Monitoring Network
- Urban Heavy Metals Network
- Rural Metals Network
- Nitrogen Dioxide Diffusion Tube (1993 to 2005)
- Smoke and Sulphur Dioxide
- Black Carbon Network
- PAH
- TOMPs
- Non-Automatic Hydrocarbon Network
- Particle Numbers and Concentrations Network

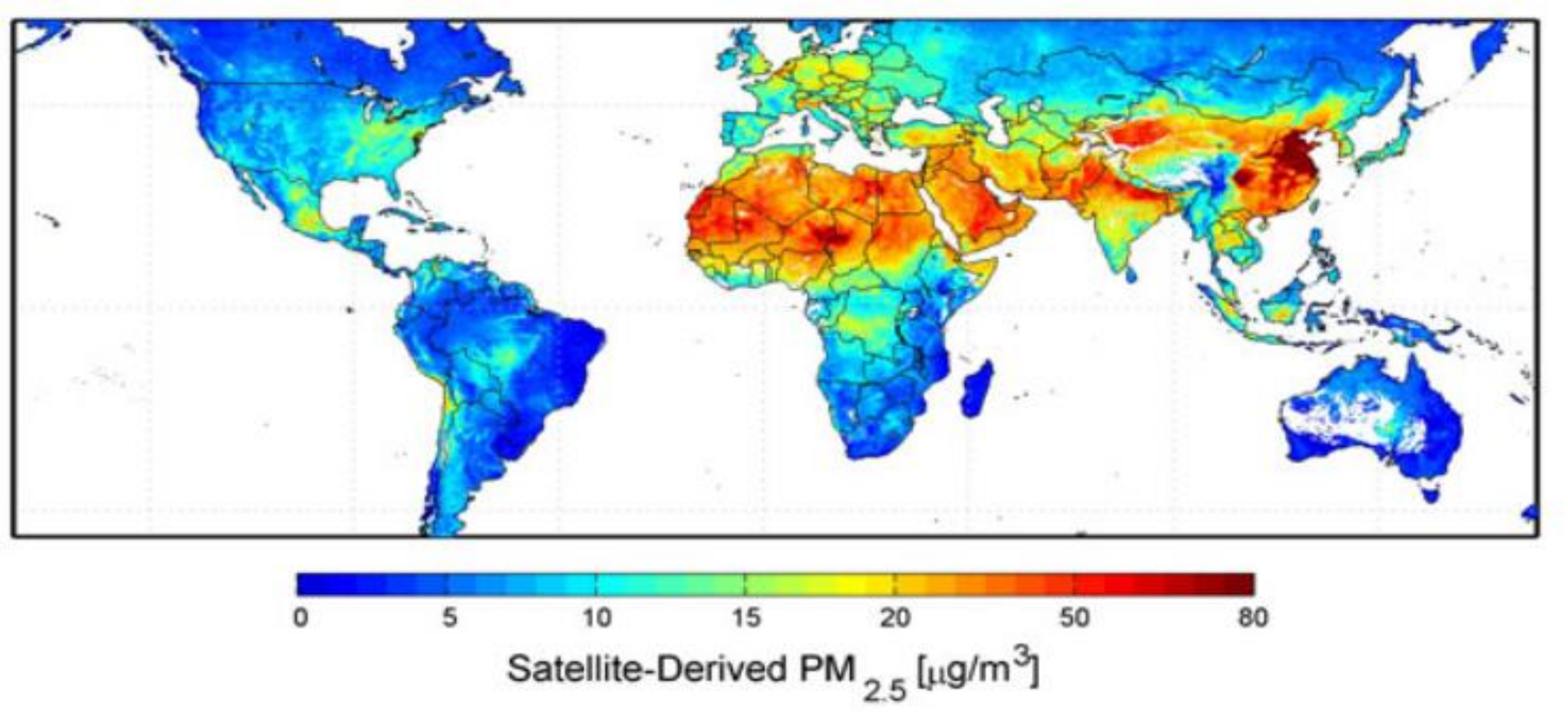
Non-automatic networks

Modelling Air Pollution



Gaussian air pollution plume

Modelling - global



•NASA's satellite-derived map of $PM_{2.5}$ air pollution (Courtesy: Dalhousie University, Aaron van Donkelaar).

Public Registers

- Environment Agency obliged by law to make a certain amount of information about its licencees and their operations available to the general public
- Information has been collected into public registers, and it is held in the Environment Agency's Area offices
- Access via Customer Services Centre at local Area office
- Can use the online search to get the contact details of your local Area office - just enter e.g. postcode

UK and EU Emissions Inventories

- Accuracy is difficult to assess
  - Lack of reference data
  - Some data is difficult to collect *eg* HGV
- National emissions inventories
  - Often revised annually
  - Improvements in methodology applied retrospectively
  - By source
  - By type of fuel

Hyperlinks:

- UK - National Atmospheric Emissions Inventory
- UK – National Emissions Factors Database
- CORINAIR Study/software

London Congestion Charging Scheme: change in pollution concentrations and years of life gained (YLG) over ten years by area and deprivation group

From Tonne et al, OEM, 2008

NO_2	Pre-concentration	Pre-post difference	Mortality rate /10^5	YLG over ten years	YLG over 10 years per 10^5
Area					
GL	39.87	-0.10	799	1,888	26
CCZ	54.72	-0.73	812	683	183
Non-CCZ	39.43	-0.07	798	1,256	18
Deprivation group					
1	38.15	-0.02	693	54	5
2	41.85	-0.07	731	321	19
3	43.30	-0.09	812	379	24
4	44.58	-0.14	871	563	36
5	47.01	-0.24	908	812	60

Carbon footprinting for climate change management in cities

Carbon Management (2011) 2(1), 49–60

Laurence A Wright[1], Jonathan Coello[1], Simon Kemp[1] & Ian Williams[†1]

A significant proportion of anthropogenic GHG-generating activities are concentrated in cities. As centers of high consumption, wealth and creativity, cities must play a significant role in tackling climate change. Action to reduce emissions at a local level requires that municipal and local governments have a good understanding of emissions sources and reduction potentials. To achieve this, municipal governments require adequate tools and resources to enable effective policy decision making. The carbon footprint is becoming an increasingly recognized tool for the management of climate change. The term carbon footprint originated in the 'gray literature', and it is widely recognized in the public arena. It offers the opportunity to municipal governments to develop models to inform climate change strategy decision making, and enables municipal authorities to localize the issue of climate change and promote the benefits of climate change mitigation at the local level. Existing framework guidance often fails to include all relevant emissions or follow widely varying methodologies, limiting comparability. This article examines the concept of climate change localization and management. The carbon footprint is explored in the context of a tool for municipal government management of GHG emissions. We conclude by suggesting that the carbon footprint become a cost-effective, practical and repeatable metric that can be adopted by municipal governments across the globe as a 'baseline' indicator.

The threat posed by global climate change requires international action that includes commonly agreed approaches for the measurement and management of GHG emissions, target setting and the development of climate change mitigation measures. Cities are areas of high consumption and population density, often responsible for a plethora of environmental problems [1]; more than two-thirds of the world's energy was consumed in cities in 2006 [2] and at least half of the world's population now lives in urban areas, with the numbers of mega cities (populations greater than 10 million) increasing rapidly [3]. As a consequence, the activities within cities and management of cities are disproportionately important in terms of global climate change policy-making.

Local and regional governments are responsible for many decisions that affect climate change management in cities, including transport and land-use planning, zoning and setting building standards as well as the management of their own activities [4,5]. These governments must play a central role in reducing GHG emissions. In order for this to happen, a better understanding of local responsibilities in relation to national targets must be developed [6]. This requires the localization of national climate change legislation and targets. Political emphasis has traditionally focused on global solutions negotiated through agreements such as the Kyoto Protocol [7] and national legislation such as the UK's Climate Change Act 2008 [8]. A shift to subnational, regional and municipal climate change governance has emerged in recent years, giving rise to programs such as Cities for Climate Protection (CCP) [9].

In pursuit of climate change localization, the concept of the 'carbon footprint' is increasingly being recognized as a valuable tool in GHG emissions management. Despite its proliferating use, there is still little consensus in the academic community as to what it

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FUTURE SCIENCE

'Carbon footprinting': towards a universally accepted definition

Carbon Management (2011) 2(1), 61–72

Laurence A Wright[1], Simon Kemp[1] & Ian Williams[†1]

As the threat of climate change becomes more acute, so does the need for adequate measures of impact(s), management and mitigation. Although carbon footprints are increasingly being used by organizations in the public and private sectors, a number of challenges and questions need to be addressed; among them, what does the term 'carbon footprint' actually mean? The term needs a universally accepted definition before a consistent, accurate, comparable and transferable methodology can be developed. This article investigates the range of current definitions proposed for a carbon footprint in the context of inventoried emissions, applications, boundaries and limitations. We argue that to only account for CO_2 emissions would result in the omission of almost a third of GHGs and a significant gap in their global management, whilst inclusion of all GHGs is very time-consuming and expensive, and should be considered only in system-specific life cycle-based assessments; this requires a separate definition, name and methodology. We suggest that as data collection for CO_2 and CH_4 emissions is relatively straightforward, these two carbon-based gases should be used in the determination of a carbon footprint. This should allow the carbon footprint to become a cost-effective, practical and repeatable metric that can be adopted by all types of organizations across the globe as a 'baseline' indicator. However, it is likely that a more comprehensive metric will be required in some circumstances and by some organizations, so we also propose further GHG inclusion for full life cycle assessment-based assessments; where complete data is obtainable it can be used to provide a 'climate footprint'. This name reflects the addition of noncarbon-based gases and encompasses the full range of gases used in the global political community's response in managing climate change. We conclude by considering lessons learnt with the proposal of sound and pragmatic definitions.

The threat posed by global climate change is now widely recognized and the Intergovernmental Panel on Climate Change urges that action must be taken to limit global average temperature rise to 2°C above preindustrial levels to avoid the worst effects [1]. Robust approaches for the measurement and management of GHG emissions are required for target setting and assessing the success of climate change mitigation measures. 'Carbon footprints' are increasingly being recognized as a valuable indicator in the field of GHG and carbon emissions management [2].

The term carbon footprint has become a commonly recognized phrase, frequently used to describe the concept of relating a certain amount of GHG emissions to a certain activity, product or population. The term is also used interchangeably with other terms such as 'carbon accounting' or 'carbon inventory'. The use of the term has been driven largely by media, government, industry and nongovernmental organizations, captivating the interest of business, consumers and policy makers [2], although the term has only recently been adopted by the academic community, where effort has traditionally focused on life cycle assessment (LCA). As a result, previous authors suggest that there is confusion and little consensus over what the term actually means or what the process measures [2–5].

Prior to establishing a definition of a carbon footprint, a number of issues demand answers. First, what does the carbon footprint actually measure: is

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FUTURE SCIENCE

Carbon footprinting in the UK waste management sector

Carbon Management (2011) 2(6), 677–690

David A Turner, Simon Kemp & Ian Williams*

The UK waste management sector is under increasing pressure to measure, report and manage its GHG emissions. In recent years, it has become common for large waste management companies to report their annual carbon footprint, and a sector-specific standard has been developed, the Entreprises pour l'Environnement Protocol. In this article, we have critically evaluated approaches taken within the waste management sector to measure, report and verify its carbon footprint. Although the Entreprises pour l'Environnement Protocol has been made freely available, its use has been limited. With no commonly agreed sector-specific standard, carbon footprinting has become highly subjective. This has resulted in high levels of inconsistency between companies and the reporting of inaccurate, incomplete and noncomparable carbon footprints. Consequently, calculated carbon footprint information is ineffective in guiding corporate GHG management. There is a need for a robust, transparent, commonly agreed waste management sector-specific standard that facilitates accurate measurement, reporting and verification of organizational GHG emissions.

The UK waste management sector is coming under increasing pressure from the public and central government to measure, report and manage its GHG emissions [1–3]. GHG emissions from the sector comprise approximately 3% of the UK's total [4], with approximately 89% of the sector's contribution stemming from CH_4 emissions, a potent GHG 25-times more powerful than CO_2 (as measured by global warming potential [GWP] over a 100 year time horizon [GWP_{100}] [5]), principally arising from landfill gas. However, certain waste management activities have the potential to reduce the sector's climatic impacts indirectly, either by generating energy, which could substitute an equivalent quantity produced from fossil fuels, or through the recovery of materials. Thus, the challenge for the waste management sector is to maximize its resource efficiency whilst simultaneously reducing its GHG emissions.

Carbon footprinting, a concept increasingly being recognized as a valuable indicator in the field of GHG emissions management, can help waste management companies better assess the link between GHG emissions and their activities. Key aspects of the carbon footprint definition debate are discussed in Wright *et al.* [6], while Finkbeiner outlines its numerous methodological challenges [7]. We support the definition proposed by Wright *et al.* that a carbon footprint should be defined as, "a measure of the total amount of CO_2 and CH_4 emissions of a defined population, system or activity, considering all relevant sources, sinks and storage within the spatial and temporal boundary of the population, system or activity of interest" [6].

The waste management sector: scope

The UK waste management sector comprises local authorities, a relatively small number of large private employers and a large number of small-to-medium enterprises (SMEs). Waste management is defined by the 2008 European Waste Framework Directive as, "the collection, transport, recovery and disposal of waste, including the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker" [8]. Aulakh and Thorpe, following

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FUTURE SCIENCE

A beginner's guide to carbon footprinting

Carbon Management (2012) 3(1), 55–67

Ian Williams*, Simon Kemp, Jonathan Coello, David A Turner & Laurence A Wright

Carbon footprinting is one of the foremost methods available for quantifying anthropogenic environmental impacts and for helping tackle the threat of climate change. However, for any person undertaking a carbon footprinting analysis for the first time, they will almost certainly be struck by the broad array of definitions, approaches and terminology surrounding the field. This paper provides an introductory guide to some basic concepts in carbon footprinting for researchers and lay people interested in the area. Each stage of calculating a carbon footprint is considered and an introduction to the main methodologies is provided. The advantages and disadvantages of the various approaches are discussed and a rough framework of procedures is provided for the calculation of carbon footprints over a variety of subjects. Some general data sources are included and a glossary of key carbon footprinting terminology is available in supplementary data online.

In recent years the need to tackle anthropogenic GHG emissions has become increasingly urgent as our understanding of the risks of climate change has advanced [1]. For this reason, mechanisms to bring about a reduction in the quantities of anthropogenic GHG emissions must be devised and perfected, in order that responsibility for anthropogenic climate forcing may be equitably assigned and specific, pragmatic emission-reduction targets can be set and progress measured [2].

The carbon footprint has, since its inception some-time around the millennium, become a commonly recognized phrase for relating a given human activity with a certain amount of GHG emissions [3–5]. The origin of the term stems from the concept of 'ecological footprinting', which was introduced in the mid-1990s as a methodology for estimating the area of the Earth's surface needed to provide all necessary resources to, and process waste and pollution from, a given population, organization or activity [6].

The term 'carbon footprint' has been criticized in the past as a misnomer, given that it does not have a unit of area while the word 'footprint' suggests a form of land take [7]. However, there is already wide acceptance of the term 'footprint' as a measure of human environmental impact and, thus, the fact that the carbon footprint does not apply literally to an amount of land area is not a conceptual problem with the use of the term. Furthermore, the additional uncertainties introduced by converting to a unit of land take makes such a calculation step undesirable [4].

A multitude of definitions for the carbon footprint have been forwarded in both the academic press [3,4,8] and grey literature [101,102]. Some definitions include only CO_2 emissions [4], others include all GHGs [8], some involve all direct and indirect GHG emissions [5], while others stipulate that only direct fuel and energy use should be included [103]. To reduce confusion surrounding the definition of a carbon footprint, Wright *et al.* recently proposed a definition aimed at being practicable, requiring only relatively easily obtainable data, whilst still capturing the bulk of anthropogenic climate forcing [3]. For the purposes of this article, we adopt the definition for a carbon footprint as proposed by Wright *et al.* [3], as we believe it to be the most clear, pragmatic and accurate definition available.

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FUTURE SCIENCE

Towards standardization in GHG quantification and reporting

Carbon Management (2012) 3(3), 223–225

"As international climate change mitigation takes increasing precedence in the coming years, the sooner a convergence towards a standardized approach to GHG quantification and reporting is reached, the more valuable such a tool can be in informing decision-makers."

David Turner, Ian Williams*, Simon Kemp, Laurie Wright, Jon Coello & Erin McMurtry

Keywords: carbon footprint ▪ climate footprint ▪ environmental reporting ▪ GHG inventory ▪ standardization

The requirement to tackle anthropogenic GHG emissions has become increasingly urgent as human understanding of the risks of climate change has advanced. The scientific community has been developing mechanisms to bring about a reduction in the quantities of anthropogenic GHG emissions in order that responsibility for anthropogenic climate forcing may be equitably assigned and specific, pragmatic emissions reduction targets can be set, and progress measured.

The 'carbon footprint' is increasingly being recognized as a valuable indicator in the field of GHG emissions management. For ease of application, the definition of 'carbon footprint' has been limited to the inclusion of emissions of CO_2 and CH_4 by Wright *et al.* [1]. However, in some cases a more complete measure is needed that includes the full array of Kyoto 'basket' GHGs – CO_2, CH_4, N_2O, sulfur hexafluoride, hydrofluorocarbons and perfluorocarbons. Outside of the academic literature the conventional approach is to term this metric a 'GHG inventory' [2,3]. However, in the academic literature, the term has been used to account for various different collections of GHGs and other climate-influencing gases, leading to confusion over the definition of the 'GHG inventory'. Consequently, an alternative term, the 'climate footprint', has been proposed [1,4], which aims to eliminate this confusion. The question is: should we continue using the commonly used term, 'GHG inventory', and endeavor to impose and promote a strict definition, or should we introduce a new, rigorously defined term, the 'climate footprint'?

Arguments for the 'GHG inventory' & against the 'climate footprint'

The 'GHG inventory' is a well-established term in the academic literature. A search of the terms 'GHG inventory' and 'climate footprint' was conducted through ScienceDirect (10/01/12), with the term 'GHG inventory' returning a total of 2355 articles in comparison with a return of 16 articles for the term 'climate footprint'. An identical search of the same two terms was conducted on Google Scholar (10/01/12), returning 7110 articles for 'GHG inventory' and 283 articles for the 'climate footprint'.

The term 'GHG inventory' is also used as convention in international standards and protocols: under Article 7 of the Kyoto Protocol, Annex I Parties are required to submit to the UNFCCC an annual 'GHG inventory', which is to consist of a quantitative list of that nation's

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FUTURE SCIENCE

The role of business and industry in climate management after Durban

Carbon Management (2012) 3(5), 431–433

"...it is unrealistic to expect most businesses to act beyond their means for purely moral and ethical reasons."

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Keywords: business ▪ industry ▪ standardization ▪ sustainability

On one level, it could be concluded that the 17th COP at Durban saw the same quarreling, lack of movement and national protectionism that has plagued recent COPs. A cynic might claim that the overriding message was that 'a plan was made to make a plan' and that no real progress was made.

However, a more balanced conclusion might be that we are making slow but steady progress to address the long-term challenge of climate change, collectively and comprehensively. The were two key positive messages to emerge from the meeting:

- Driven by the EU countries, a pathway towards an international climate regime was agreed. A legally binding agreement, based upon sound science, covering both developed and developing countries, will be negotiated by 2015, which would cover post-2020 emissions targets and actions;
- Real progress was evident on some key issues, including technological advances, REDD+ and adaptation.

Conversely, the key negative messages were that:

- There was little progress on how we might close the gap between countries' emissions levels and what is required to maintain the planet within 2°C of warming;
- Proposed funding levels are probably too low to facilitate the proper implementation of the Cancun Agreements, especially in terms of assisting developing nations to deal with the effects of climate change;
- There is still no agreed common accounting framework for carbon emissions; without this, meeting the 'within 2°C goal' will be extremely difficult.

Unfortunately, we feel that one of the overriding messages to emerge from Durban is that there is not an urgent need for industry and business to develop an effective GHG management strategy until a long-term international climate change agreement is established, or at least been drafted . This is not likely to be until at least 2015. Ultimately, businesses are concerned with the bottom line and, until more is known about the specifics of any economic mechanisms to be put in place by governments, they will not be in a position to introduce effective emissions abatement strategies.

Business and industry can only act on solid information. At present, nothing has been agreed about emissions reduction targets or how they will be achieved. From 2015 we will have some idea what measures may be put in place. By 2020 we will know which countries

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FUTURE SCIENCE

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Review

Direct carbon dioxide emissions from civil aircraft

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H I G H L I G H T S

- Impacts of technological, operational and policy mitigation-measures are reviewed.
- Aviation growth-rates will continue to out-pace emissions reduction-rates.
- Specific measures reduce airline fuel-bills and can be driven by market-forces.
- A global regulator with '*teeth*' is required but likely to be resisted.
- Constraining demand with price-rises gives up to 100-fold increases in CO_2 values.

A R T I C L E I N F O

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A B S T R A C T

Global airlines consume over 5 million barrels of oil per day, and the resulting carbon dioxide (CO_2) emitted by aircraft engines is of concern. This article provides a contemporary review of the literature associated with the measures available to the civil aviation industry for mitigating CO_2 emissions from aircraft. The measures are addressed under two categories – policy and legal-related measures, and technological and operational measures. Results of the review are used to develop several insights into the challenges faced.

The analysis shows that forecasts for strong growth in air-traffic will result in civil aviation becoming an increasingly significant contributor to anthropogenic CO_2 emissions. Some mitigation-measures can be left to market-forces as the key-driver for implementation because they directly reduce airlines' fuel consumption, and their impact on reducing fuel-costs will be welcomed by the industry. Other mitigation-measures cannot be left to market-forces. Speed of implementation and stringency of these measures will not be satisfactorily resolved unattended, and the current global regulatory-framework does not provide the necessary strength of stewardship. A global regulator with '*teeth*' needs to be established, but investing such a body with the appropriate level of authority requires securing an international agreement which history would suggest is going to be very difficult.

If all mitigation-measures are successfully implemented, it is still likely that traffic growth-rates will continue to out-pace emissions reduction-rates. Therefore, to achieve an overall reduction in CO_2 emissions, behaviour change will be necessary to reduce demand for air-travel. However, reducing demand will be strongly resisted by all stakeholders in the industry; and the ticket price-increases necessary to induce the required reduction in traffic growth-rates place a monetary-value on CO_2 emissions of approximately 7–100 times greater than other common valuations. It is clear that, whilst aviation must remain one piece of the transport-jigsaw, environmentally a global regulator with '*teeth*' is urgently required.

"International air transport has helped bring our world closer together … Yet, these advances have not been without cost. Looking forward, we must ensure that international aviation is as energy-efficient as possible and minimizes harmful impacts on our climate and ecosystems"

UN Secretary-General Ban Ki-moon.

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Carbon management at universities: a reality check

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A B S T R A C T

Carbon dioxide emissions from the higher education sector are globally significant. This study compares the performance of 20 institutions in English research-intensive universities to their self-set targets, using three key performance indicators. Emissions increased for all but two institutions and consequently, targets are extremely ambitious and almost certainly unachievable. Observations are supported by a 10-point appraisal that measures the environmental value of each carbon management plan and a 'reality check' equation to classify them as either pragmatic or ambitious. A paradox is highlighted: institutions that set realistic but relatively low targets can be penalised in league tables and lambasted for apparent lack of ambition even when they may be more likely to succeed in delivering environmental improvements. The results of a staff and student questionnaire at the University of Southampton suggest that increasing awareness on impacts of energy usage will promote a cultural shift towards becoming more energy efficient to reduce emissions. Current carbon management plans are not a good indicator of future performance. The English higher education sector has underestimated the challenge of carbon emissions reduction. Pledged targets seem unlikely to be met by English universities and the likely environmental costs may jeopardise the global competitiveness of the sector. Methods for assessing Scope 3 emissions need refining and standardizing, given they are likely to be the most significant portion of a typical university's carbon footprint. The use of appropriate key performance indicators to foster action and promote realistic target-setting is required at sector-level to achieve the 2020 goal.

1. Introduction

1.1. Rationale

There is little doubt in the scientific community that significant and reliable evidence reveals that anthropogenic Greenhouse Gases (GHGs) directly influence the climate system (IPCC, 2007; Hoffman et al., 2009; Collins et al., 2010). The United Kingdom's (UK) Climate Change Act 2008 is the world's first carbon-related regulation and drives the UK towards an 80% reduction in scope 1 and 2 carbon emissions by 2050; each sector of the UK must be committed to emission reduction in order to attain this. Scope 1 emissions are direct emissions within the organisational boundary from sources the organisation owns or controls i.e. combustion of fuels and scope 2 emissions are emissions from purchased electricity which occur as a result of its activities and are not directly owned or controlled (Ranganathan et al., 2004; Pino et al., 2006).

There is a clear need to reduce the emissions of the United Kingdom's Higher Education (HE) sector; carbon emissions have increased steadily from 1.78MtCO_2 in 1990 to 2.05MtCO_2 by 2005 (HEFCE, 2010b). With more than 2.4 million students (Williams and Ongondo, 2011), 380,000 staff (HESA, 2012) and 129 universities (Universities UK, 2013), the HE sector contributes 11% of the UK's public sector emissions (Ward et al., 2008). In response to this and external government pressure, responsibility for carbon management within the English HE sector has fallen on the Higher Education Funding Council for England (HEFCE), which has prescribed a sector target of 34% reduction below 1990 levels in scope 1 and 2 emissions by 2020, equating to a reduction of 43% of the 2005/06 baseline (HEFCE, 2010a). How these targets will be met remains to be seen and forms the focus of this paper.

This study compares the carbon performance of the English Russell Group[1] institutions by creating an emissions baseline and

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[1] The Russell Group represents 24 UK (England, Wales, Scotland and Northern Ireland) institutions dedicated to world-leading research and teaching. Member institutions garner 80% of the HEFCE's research funding (Lipsett, 2009), produce over 80,000 graduates and contribute £22.3 billion to the UK economy per annum (Russell Group, 2011).

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Local government authority attitudes to road traffic CO_2 emissions modelling: a British case study

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ABSTRACT

Local government authorities (LGAs) play a key role in facilitating mitigation of road traffic CO_2 emissions and must engage in emissions modelling to quantify the impact of transport interventions. Existing Emissions Model (EM) methodologies range from aggregate to disaggregate approaches, with more detail normally entailing more resources. However, it is not clear which approaches LGAs actually utilise. This article reports results of a survey designed to discover the level of detail considered practical by British LGAs ($n = 34$). Results show that resource scarcity is important, with particular importance attached to EM reusability and convenient input data sources. Most LGA EMs use traffic variable inputs (predominantly traffic flow and traffic average speed), with this approach being the best-fit for LGA resources. Link-by-link sources of data rated highly for convenience are Road Traffic Models and Urban traffic control systems.

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Local government; questionnaire survey; road traffic model; emissions model; greenhouse gas; air quality

1. Introduction

Ultimately, governments are responsible for providing road infrastructure and for achieving agreed greenhouse gas (GHG) emissions reduction targets. Typically, motorways and major trunk roads (the strategic road network, SRN) are administered by central government agencies (e.g. Highways England and Transport Scotland), whilst responsibility for all other adopted[1] roads is devolved to local government authorities (LGAs). For comparison, the national total of 417 billion vehicle-kilometres travelled (VKT) in England in 2012 was split between 33% (136.3 billion VKT) carried by SRN roads and 67% (280.7 billion VKT) carried by non-SRN roads (DfT 2013). Those British[2] LGAs responsible for non-SRN roads are known as local highways authorities (LHAs).[3] Under the complex system of local government in Britain, not all LGAs are LHAs. Only first tier LGAs (County Councils) and single tier LGAs (Unitary Authorities, London Borough Councils and Metropolitan District Councils) are LHAs. Second tier LGAs (District Councils, Borough Councils and those City Councils that are not Unitary Authorities) are not responsible for the roads in their region, with the appropriate first tier LGA being

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The impact of communicating information about air pollution events on public health

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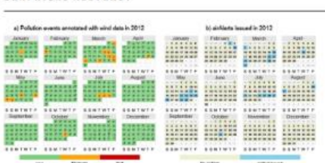
H I G H L I G H T S

- Investigation of relationship between hospital admissions and poor air quality
- Air quality forecasting service to reduce preventable hospital admissions evaluated
- Impacts of air quality on emergency admissions quantified using relative risks
- Pollution episodes cause admissions despite background concentrations in EU limits.
- Air quality forecasting service proved ineffective at reducing hospital admissions.

G R A P H I C A L A B S T R A C T



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Forecasting
Coastal city

A B S T R A C T

Short-term exposure to air pollution has been associated with exacerbation of asthma and chronic obstructive pulmonary disease (COPD). This study investigated the relationship between emergency hospital admissions for asthma, COPD and episodes of poor air quality in an English city (Southampton) from 2008–2013. The city's council provides a forecasting service for poor air quality to individuals with respiratory disease to reduce preventable admissions to hospital and this has been evaluated. Trends in nitrogen dioxide, ozone and particulate matter concentrations were related to hospital admissions data using regression analysis. The impacts of air quality on emergency admissions were quantified using the relative risks associated with each pollutant. Seasonal and weekly trends were apparent for both air pollution and hospital admissions, although there was a weak relationship between the two. The air quality forecasting service proved ineffective at reducing hospital admissions. Improvements to the health forecasting service are necessary to protect the health of susceptible individuals, as there is likely to be an increasing need for such services in the future.

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Assessment and mitigation of the environmental burdens to air from land applied food-based digestate

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OFMSW

A B S T R A C T

Anaerobic digestion (AD) of putrescible urban waste for energy recovery has seen rapid growth over recent years. In order to ascertain its systems scale sustainability, however, determination of the environmental fate of the large volume of digestate generated during the process is indispensable. This paper evaluates the environmental burdens to air associated with land applied food-based digestate in terms of primary pollutants (ammonia, nitrogen dioxide) and greenhouse gases (methane and nitrous oxide). The assessments have been made in two stages – first, the emissions from surface application of food-based digestate are quantified for the business as usual (BAU). In the next step, environmental burden minimisation potentials for the following three mitigation measures are estimated – mixed waste digestate (MWD), soil-incorporated digestate (SID), and post-methanated digestate (PMD). Overall, the mitigation scenarios demonstrated considerable NH_3, CH_4 and N_2O burden minimisation potentials, with positive implications for both climate change and urban pollution.

1. Introduction

Digestate, the semi-solid residue obtained post biogas extraction in anaerobic digestion (AD), is considered a vital source of organic matter and nutrients, especially nitrogen. It is increasingly being applied as soil conditioner/amendment (on urban gardens, farmlands, recreation/sports grounds, fish ponds, etc.), or alternatively for developing energy crops on brownfield/marginal land and sports turf production (WRAP, 2013). This is mainly due to its two attributes – one, for providing a low carbon substitute for fossil fertilisers (Chambers and Taylor, 2013; WRAP, 2011); two, for restoring soil organic matter and for closed-loop nutrient recycling, especially mineral nitrogen (Fricke et al., 2007; Karagiannidis and Perkoulidis, 2009; Möller and Stinner, 2009). Consequently, digestate field application has been identified as a sustainable practice in terms of meeting the EU standards for good agricultural and environmental condition (GAEC) (RPA/Defra, 2012). However, with greater emphasis on strategies for diverting biowastes from landfill and their sustainable re-utilisation through valorisation in AD, the volumes of digestate are expected to increase rapidly (typical digestate represents 70–95% of the feedstock volume) (Lukehurst et al., 2010). Digested slurries have been found to be significant sources of ammonia (NH_3), methane (CH_4) and nitrous oxide (N_2O) emissions (Amon et al., 2006; Bacenetti et al., 2013; Nkoa, 2014; Wulf et al., 2002a), with potential implications for local-to-regional climate (NRC, 2002; Ravishankara et al., 2009) and human health (Peel et al., 2013). Nkoa's (2014) detailed review has suggested that digestates can be considered as organic amendments (or organic fertilizers) only when properly handled and managed.

The content and quality of digestate depends largely on both the feedstock and the hydraulic retention time (HRT) of the digester; usually longer HRT reduces the organic content owing to more effective methanogenesis (Szűcs et al., 2006). Digestate quality is further affected by maturing in storage tanks (Menardo et al., 2011). Rigid compliance criteria for Class I digestate have been set by the European Commission (EC) and the British Standard Institution (BSI) (BSI, 2010; EC, 2014). Although the scale of AD operation dedicated to organic waste treatment is at an all-time high (and on the rise), there is still relatively little published information on the composition and potential environmental behaviour of digestate,

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Including congestion effects in urban road traffic CO_2 emissions modelling: Do Local Government Authorities have the right options?

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Local government

A B S T R A C T

Tailpipe emissions from vehicles on urban road networks have damaging impacts, with the problem exacerbated by the common occurrence of congestion. This article focuses on carbon dioxide because it is the largest constituent of road traffic greenhouse gas emissions. Local Government Authorities (LGAs) are typically responsible for facilitating mitigation of these emissions, and critical to this task is the ability to assess the impact of transport interventions on road traffic emissions for a whole network.

This article presents a contemporary review of literature concerning road traffic data and its use by LGAs in emissions models (EMs). Emphasis on the practicalities of using data readily available to LGAs to estimate network level emissions and inform effective policy is a relatively new research area, and this article summarises achievements so far. Results of the literature review indicate that readily available data are aggregated at traffic level rather than disaggregated at individual vehicle level. Hence, a hypothesis is put forward that optimal EM complexity is one using traffic variables as inputs, allowing LGAs to capture the influence of congestion whilst avoiding the complexity of detailed EMs that estimate emissions at vehicle level.

Existing methodologies for estimating network emissions based on traffic variables typically have limitations. Conclusions are that LGAs do not necessarily have the right options, and that more research in this domain is required, both to quantify accuracy and to further develop EMs that explicitly include congestion, whilst remaining within LGA resource constraints.

Introduction

More than half the world's population now live in urban areas (UNFPA, 2007), where concentrated travel requirements can often overwhelm transport systems during peak periods, leading to congestion. For urban road networks, carrying increasingly large numbers of vehicles results in increasingly large amounts of tailpipe emissions, including both greenhouse gases (GHGs) and pollutants detrimental to air quality (AQ), with the problem exacerbated by the stop-and-go nature of congestion increasing emissions yet further. This problem is particularly relevant in developing countries because towns and cities in the developing world are projected to constitute 80% of urban humanity by 2030 (UNFPA, 2007). Consequently,

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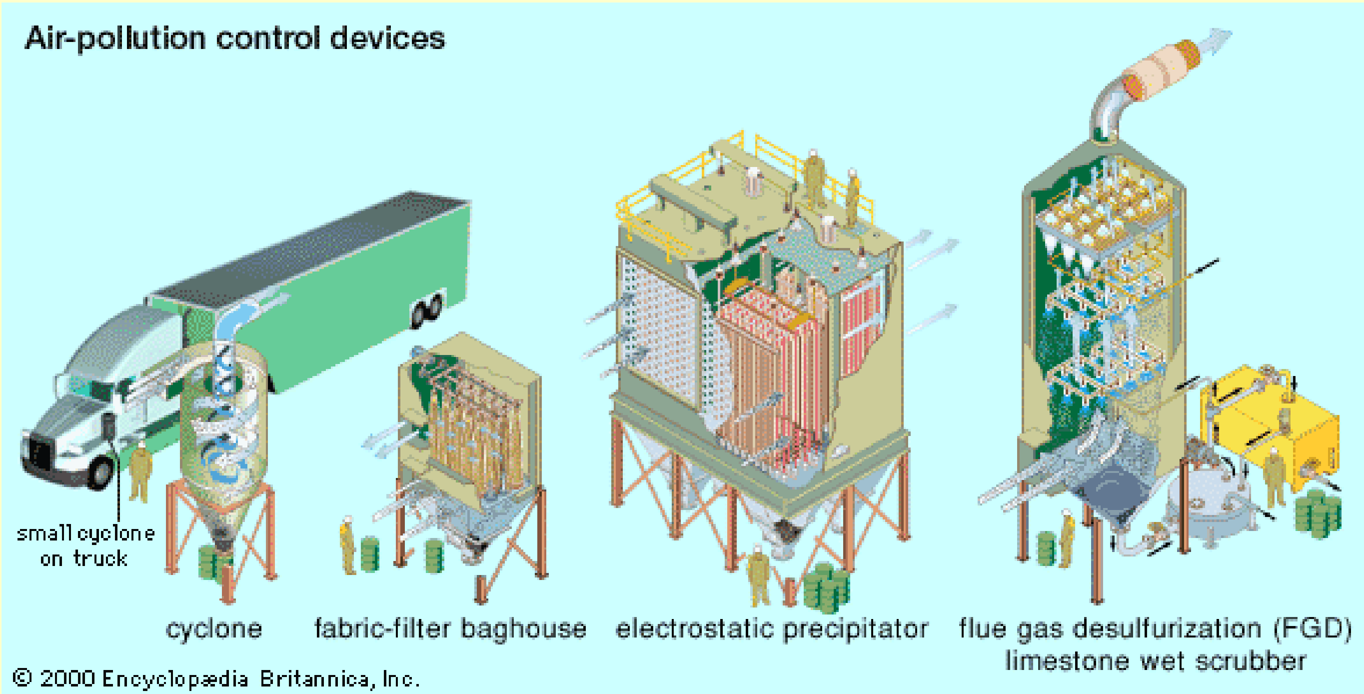
Control Technology



Clean Air Southampton

Launched in April 2016 with a visit from the Smogmobile (courtesy of Enviro Tech Ltd).

Mapped City's real-time emissions using electric van and on-board PM_{10} and NOx monitors.

Coverage on BBC TV South, BBC Radio Solent, the Daily Echo, That's Solent TV – and much more since…..

Southern Daily Echo

Saturday 1 October 2016

Breathe Easy - major campaign to clean up city air quality

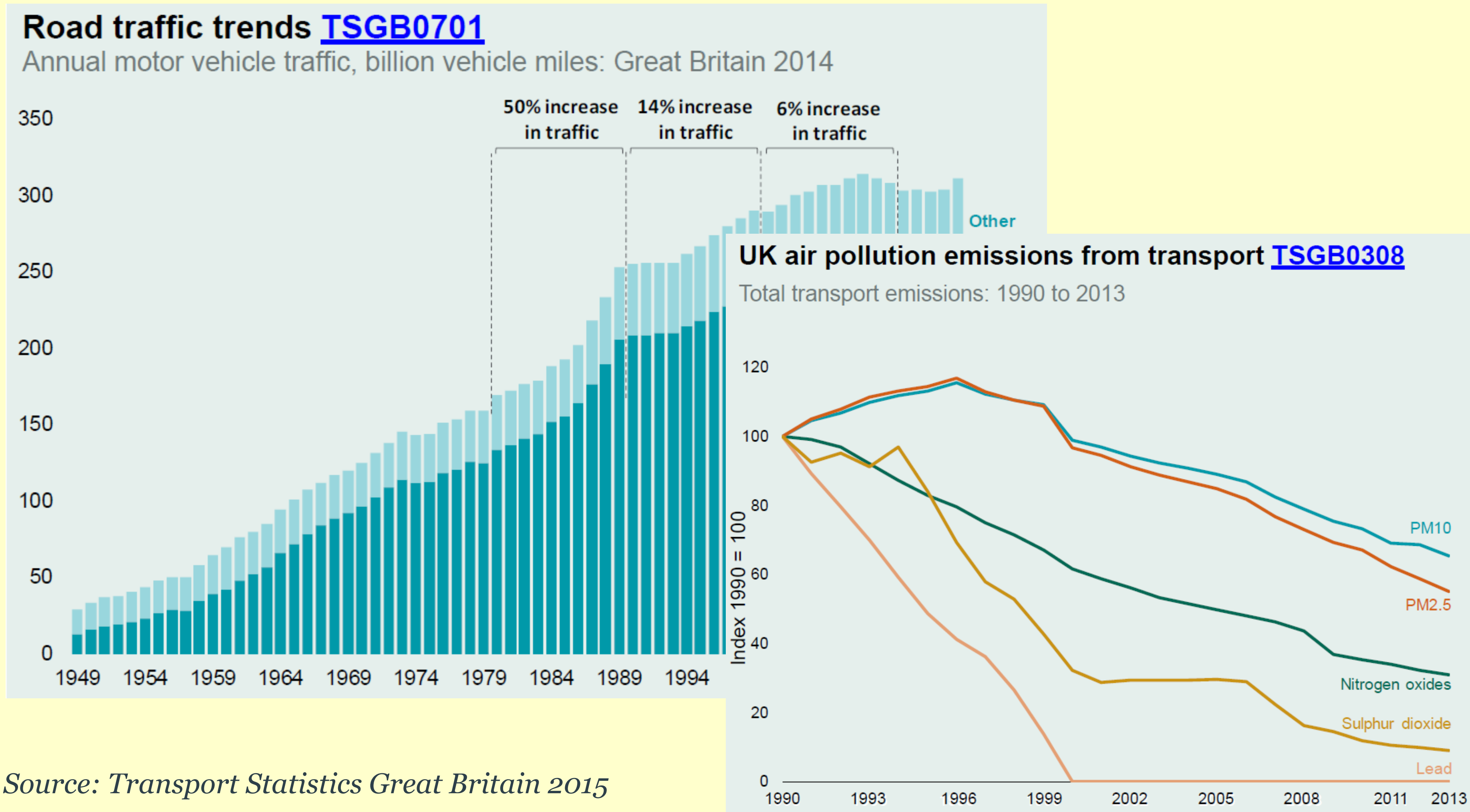
Breathe Easy - major campaign to clean up city air quality

1 day ago / **Sian Davies**, Education Reporter / dailyecho_sian

113 comments

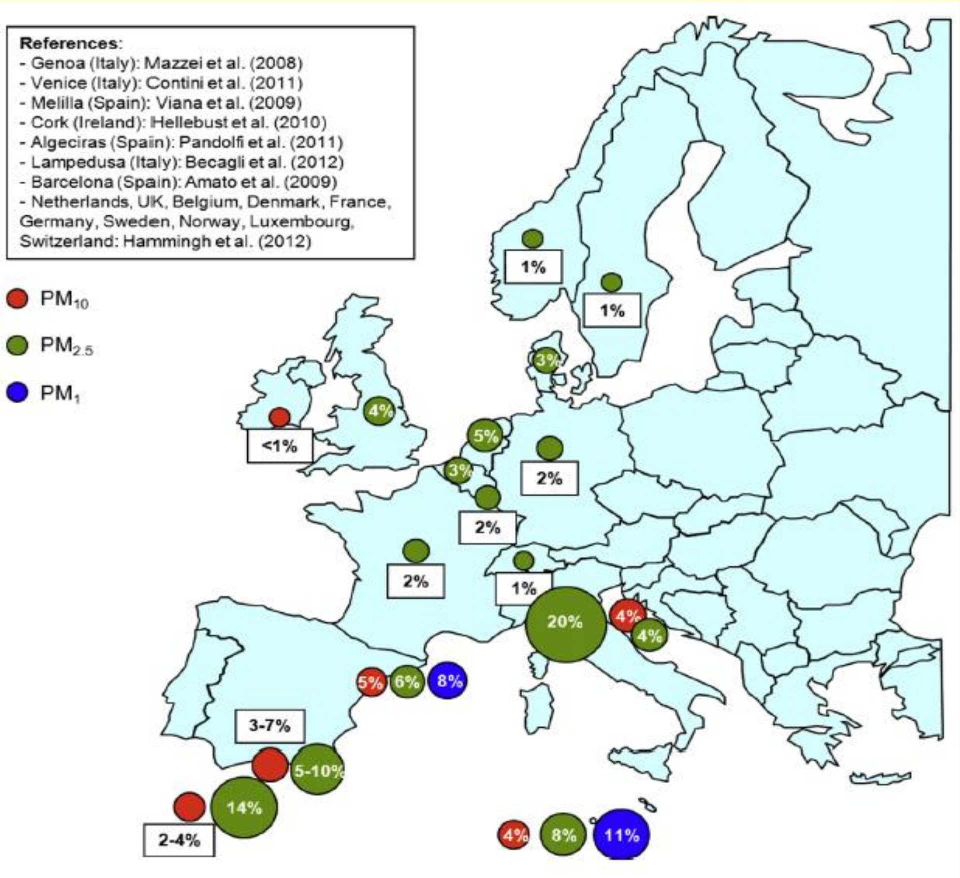
Scandals….

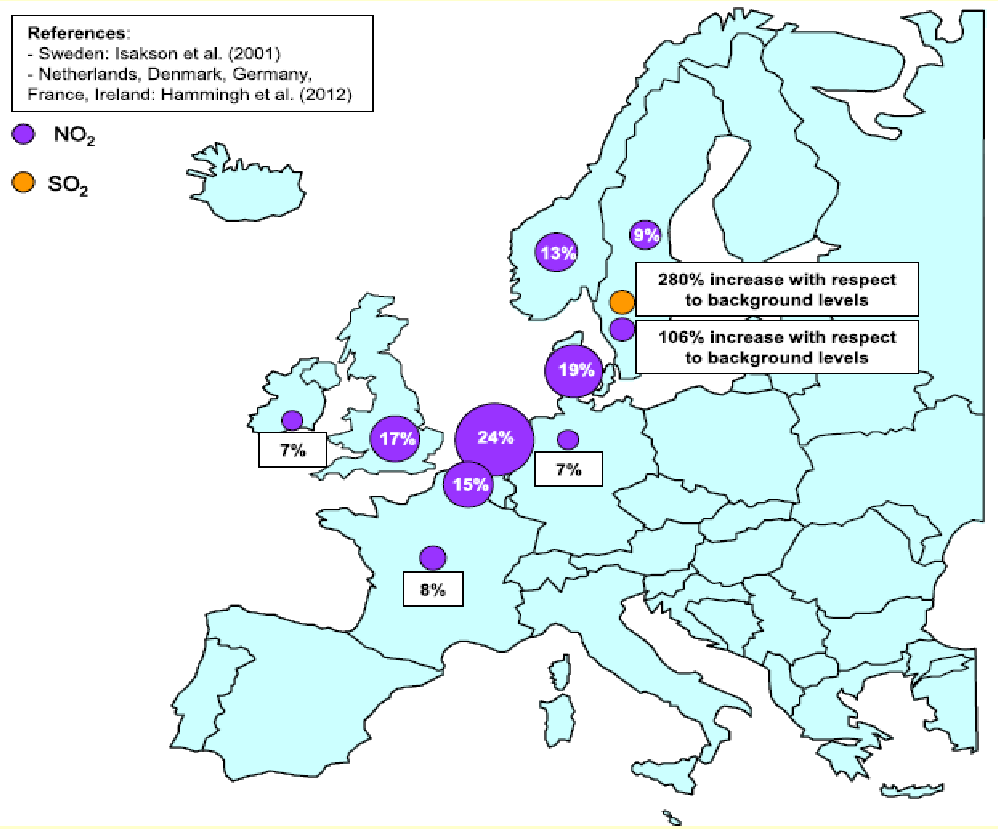
Trends in Road Travel



Source: Transport Statistics Great Britain 2015

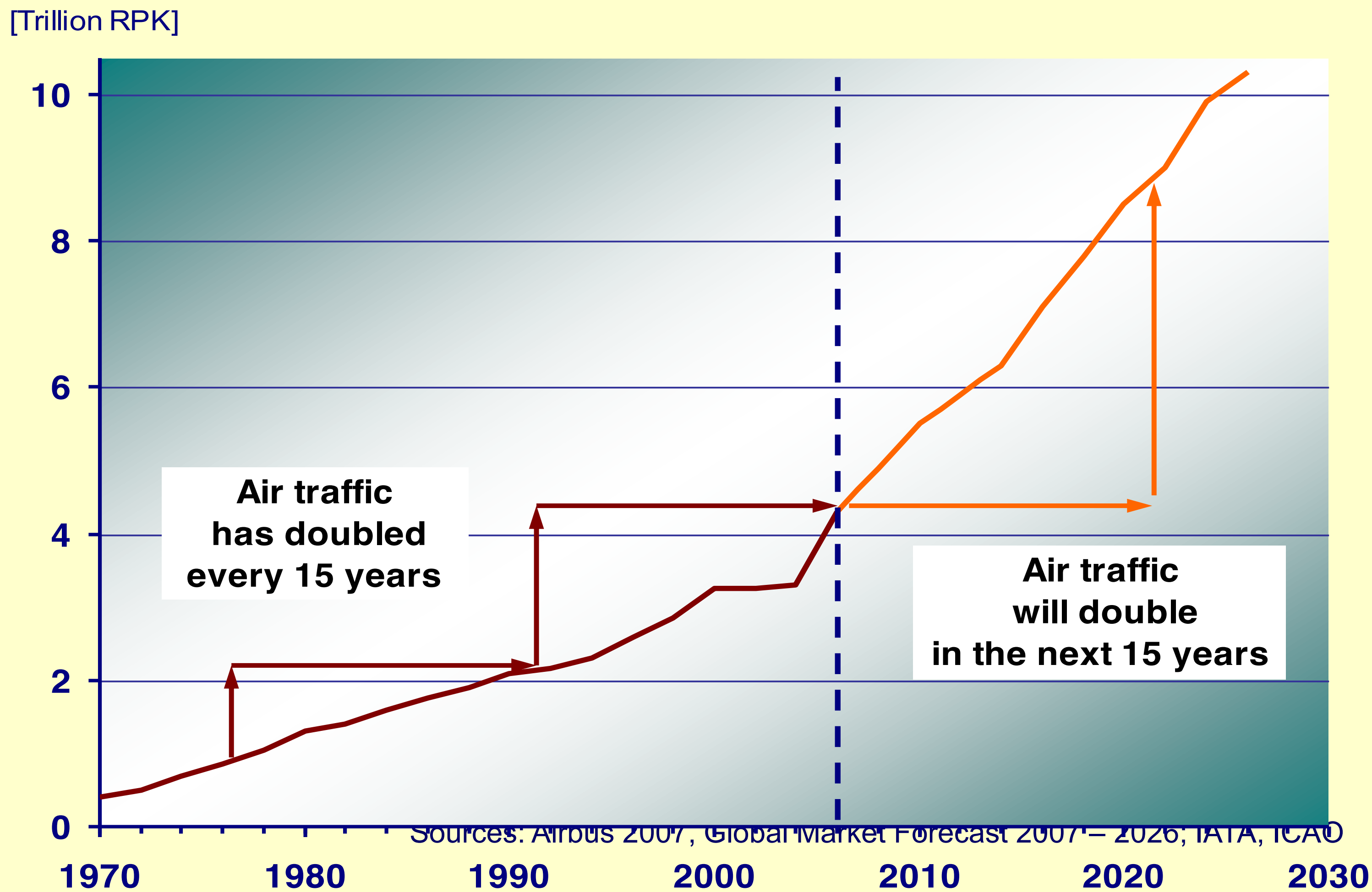
Contribution of Shipping to Air Pollution





Viana (2014) Atmospheric Environment 90:96-105

Aviation Growth



Sources: Airbus 2007, Global Market Forecast 2007 – 2026; IATA, ICAO

All This Activity Has NOT Improved Air Quality

- Even if all mitigation measures are successfully implemented, traffic growth-rates will almost certainly continue to out-pace emissions reduction-rates
- Securing international agreements, setting action plans, regulations and carbon standards will require political leadership at a global level ……..
- We want air emissions to reduce but we also want business and economic growth, opportunities for employment and global connectivity
- Huge tension between what we feel we should do to address dangerous climate change caused by anthropogenic emissions and what we will actually do
- To improve our air quality, we have to change our lifestyles….

National evaluation of Scotland's smoke-free legislation

A study of nine Scottish hospitals found a 17 per cent fall in admissions for heart attacks in the first year after the smoke-free legislation came into force. The research is part of a national evaluation of the impact of Scotland's smoke-free legislation which shows that the smoke-free legislation has had an overwhelmingly positive effect.

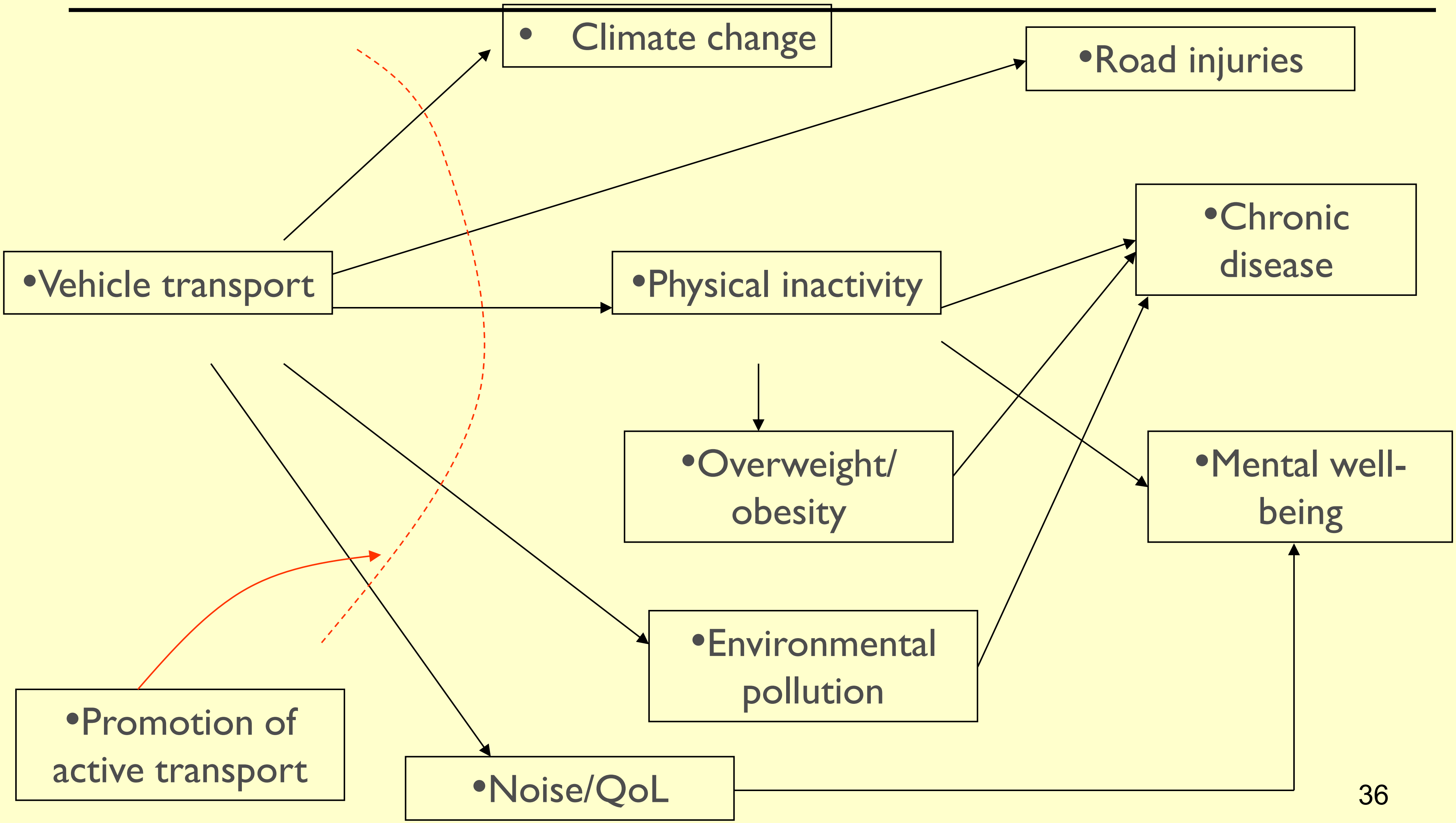
The evaluation found that after the legislation came into force there was:

- a reduction in the rate of child asthma admissions of 18% per year compared to an increase of 5% per year in the years preceding it
- a 17 per cent reduction in heart attack admissions to nine Scottish hospitals. This compares with an annual reduction in Scottish admissions for heart attack of 3 per cent per year in the decade before the ban
- a 39 per cent reduction in second-hand smoke exposure in 11-year-olds and in adult non-smokers
- an 86 per cent reduction in second-hand smoke in bars
- an increase in the proportion of homes with smoking restrictions
- no evidence of smoking shifting from public places into the home
- high public support for the legislation even among smokers, whose support increased once the legislation was in place.

Resources

Smoke-free public places – ten years on

Active Transport & Health



Active Transport Gains

For an average car driving women 35-44 years…

- 15 g fat tissue per day
- 5.6 kg fat tissue per year
- Decrease
  - 20–40% in risk of premature mortality
  - 25% in breast cancer risk
  - >20% all cancer risk
  - >30% diabetes mellitus


CLIMATE
SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
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• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• etc. etc.
JOEL PETT
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THANK YOU