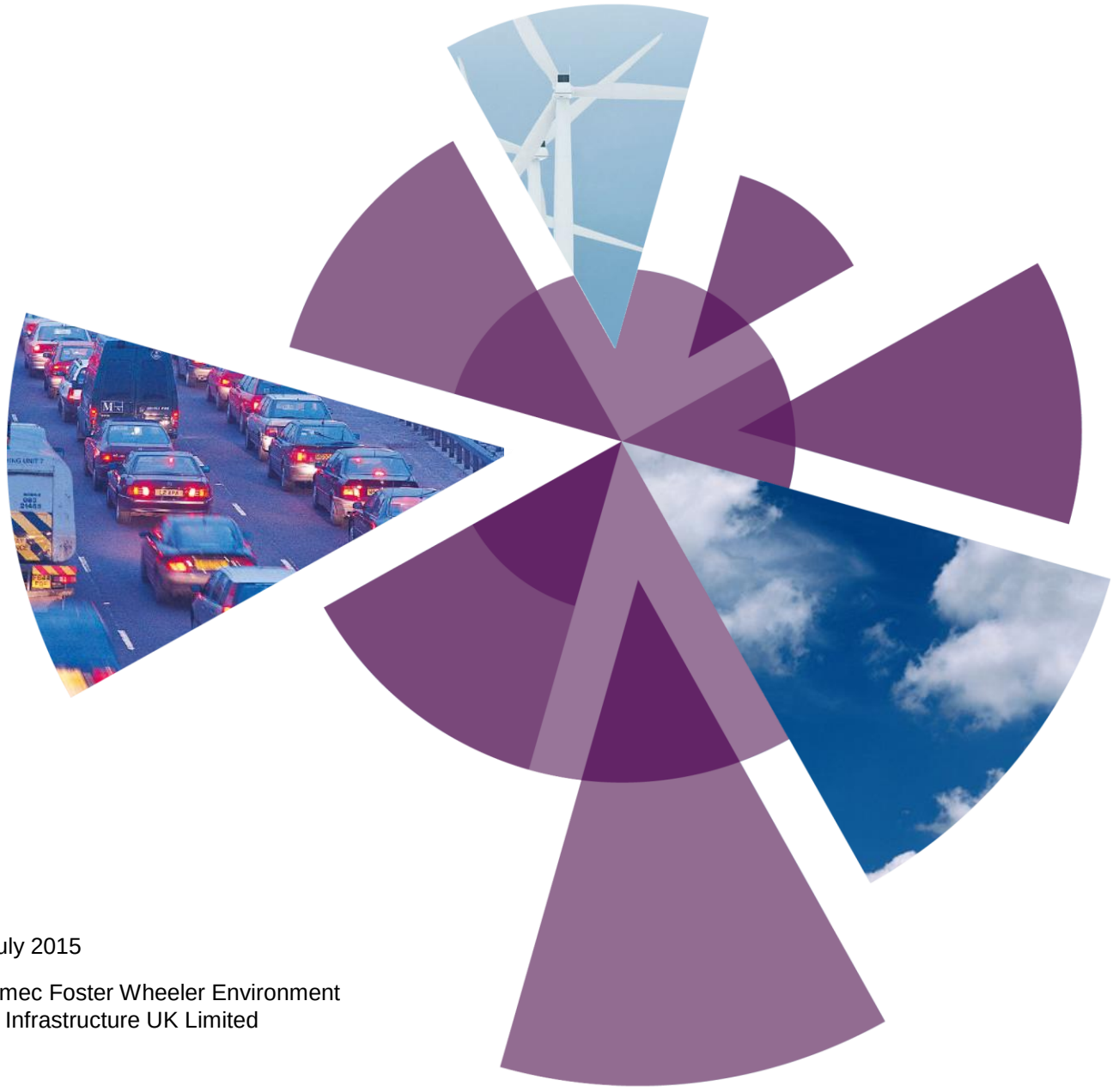
Defra

Assessing wider impacts of air quality policy (AQ0961)

Final Report



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Document revisions

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1	Draft Final report	10/04/15
2	Final report	05/06/15
3	Final report i2	15/07/15

Executive summary

UK air quality modelling allows assessments of impacts of policy measures, such as impact on air quality in the UK and related population exposure. This model adds to the existing tools and methods for assessing the wider impacts of air quality policies, which extends Defra's capacity to estimate potential benefits and costs of options for air quality interventions.

The potential wider impacts of air quality measures, and methods for their appraisal have been identified through literature research and consultation with UK Government Departments and experts in undertaking regulatory impact assessments. This focused primarily on reviewing existing guidelines and best practices for undertaking policy impact assessments. The impacts identified in the literature and through consultation with experts were screened using a defined set of criteria concerning the relevance and significance of the impact to the potential air quality measures, complexity of the assessment methodology and associated uncertainty of the results. As a result of the screening process, the following impacts were identified and agreed with Defra for inclusion in the model: congestion, safety and noise (transport related policies only), modal shift, health impacts of walking and cycling, greenhouse gas emissions, affordability for business, affordability for individuals and employment. Methodologies to appraise these impacts, wherever available, follow the best practice guidance developed by UK Government Departments.

The model developed in this study allows a high level assessment of the potential scale of impacts relevant to air quality policies. Assessment of these impacts can be challenging, as in some instances methodologies have not been well established or covered by relevant guideline documents. Results from the wider impacts model require appropriate interpretation, and should be complemented with appropriate qualitative assessments. Where the assessment using the wider impacts model indicates that an impact could be of significant scale, then further investigation of the impacts could be undertaken where appropriate. The user of the model needs to determine the correct balance between the quantitative and qualitative assessment of impacts as appropriate for the policy being assessed. This is in accordance with the HM Treasury guidance that the resources invested in appraising the impacts of an intervention should be proportionate to the anticipated scale of the impact.

Many wider impacts have been identified as potentially relevant to air quality policies but it has not been possible to include all of them in the model. Therefore when undertaking the assessment of potential policy interventions, the user should also consider the applicability and relevance of impacts beyond those included in the model and where necessary undertake bespoke assessment of those impacts.

Contents

1. Introduction

This section describes overall context for the study: "Expanding Defra's modelling capacity to assess wider impacts of air quality policy (AQ0961)", its key objectives and deliverables.

1.1 Context

HM Treasury require all public investment to be appraised using cost-benefit analysis. This study aimed to expand the range of impacts existing modelling tools can assess, by developing a suitable tool to appraise potential wider impacts of air quality policy options and to deliver more comprehensive estimation of potential benefits and costs of options for interventions. The model adds particular value to the assessment of transport related interventions as it allows quantification of the costs and benefits linked to changes in traffic intensity (specifically congestion, noise and safety). It also allows quantification of health impacts resulting from switching from car travel to active modes of transport (cycling or walking). The model has a capability to assess impacts on greenhouse gases, where it goes beyond the existing IAG spreadsheet tool in allowing the user to assess greater variety of fuels, input them in different units, and in case of transport interventions, to directly calculate the GHG impacts resulting from the change in vehicle kilometres[1]. The model allows estimating affordability of proposed policies to businesses of various sizes. This could specifically inform assessment of impacts on micro businesses and SMEs. The model also provides information to support analysis of distributional impacts on households and on employment which are absent from any existing tools developed to support impact assessments of UK policies.

1.2 Objectives of the project

In the context of the above, this main objectives of the project were to:

- Systematically review modelling literature and guidance to identify wider impacts of policy options to improve air quality.
- Identify, assess and develop the methodologies to appraise, quantify and monetise wider impacts.
- Build a model which would allow an assessment of wider impacts of air quality policy measures, while ensuring compatibility with existing models (such as PCM) .
- Use the model to provide estimates of the wider impacts of selected policy measures, in order to test the suitability of the model for appraisal of air quality policies and measures.

1.3 Anticipated use of the wider impacts model

The model developed in this study allows a high level assessment of the potential scale of impacts relevant to air quality policies. It informs a decision on whether a more in-depth analysis of an impact may be required outside of the model. More detailed investigation of impacts is justified where the initial quantitative assessment using the wider impacts model supplemented with qualitative analysis indicates that an impact could be significant. If the impacts from the quantified assessment using the tool are estimated to be low then use of these results may be sufficient when complemented with qualitative analysis to provide further context. This is in accordance with the HM Treasury guidance that the resources invested in appraising the impacts of an intervention should be proportionate to the anticipated scale of the impact.

[1] This functionality is not available in the existing IAG spreadsheet toolkit for valuing changes in greenhouse gas emissions

As discussed in this report, many wider impacts have been identified as potentially relevant to air quality policies but it has not been possible to include all of them in the model. Therefore when undertaking the assessment of potential policy interventions, the user should also consider the applicability and relevance of impacts beyond those included in the model and where necessary undertake bespoke assessment of those impacts.

1.4 Purpose of this report

This report documents the approach taken to develop the wider impacts assessment model. This is presented in the following steps:

- Identification of potential wider impacts of air quality policy.
- Selection of the impacts for inclusion in the model.
- Methods for assessing the selected impacts.
- Model development.
- Recommendations for future model development.

This report is complemented by a User Guide and a Technical Specification documents targeted towards the users of the model to provide specific detail on the model structure and underlying assessment methods.

2. Identification of potential wider impacts of air quality policy

This section provides an overview of the literature research and analytical considerations given to identify the potential wider impacts of air quality measures. This focused primarily on reviewing existing guidelines and best practices for undertaking policy impact assessments.

2.1 Identification of potential wider impacts of air quality policy

We have identified a range of publicly available resources, such as government guidelines and relevant academic literature, covering wider impacts of policy measures and methodologies for their appraisal. The final list of sources identified included over 100 references across a range of policy sectors. The list includes sources published by UK government departments and agencies as well as literature from outside the UK and grey literature. These resources have been found through internet searches, references and at the suggestion of experts contacted as part of the consultation process (see section 2.1.3). The full list of sources identified is provided in Appendix A. In the literature review sources published by the UK Government departments and agencies relevant to the identification of wider impacts and existing appraisal methods have been prioritised and were the key primary sources of information used in this study.

Prioritising UK Government best practice guidelines allowed the identification of existing approaches in the UK as well as identification of areas for which the Wider Impacts model could expand on the current methods. The following criteria have been considered when selecting sources for review:

- Policy sectors: The sample selected captured guidance or reports published by different departments across several policy fields, including HM Treasury, Defra, Department for Transport (DfT), Department of Energy and Climate Change (DECC), Department for Business Innovation and Skills (BIS), Homes and Communities Agency (HCA), Office for National Statistics (ONS) and the former Office for Fair Trading (OFT).
- Scope and content of the document: On the basis of a preliminary review of the documents identified the team has reviewed the sources that appeared to be the most relevant for the purpose of this study (e.g. supplementary guidance to the Green Book) taking into account the wider impacts and appraisal methodologies covered and the extent to which these were described and currently applied in practice.
- Date of publication: The selection process has given preference to the most recent sources, with the sample covering materials published after 2008.

In order to ensure a consistent approach to the review of literature and existing appraisal methods, we have developed an assessment framework where we have extracted information on the impacts covered by each of the sources against the criteria shown in Table 2.1.,

The assessment framework included four categories of criteria to assess existing methodologies. The appraisal methods category contains criteria to establish whether methods are described in the sources, what type of assessment is recommended (qualitative versus quantitative) and what metrics were used. The accuracy criteria related primarily to the quality of the description of the method provided and its transparency in terms of the assumptions made. In the case of existing models, these have been evaluated against specific criteria concerning best practices in model development. The methods were then assessed for their robustness. For the method description, this looked at limitations of using the methods and the likelihood of introducing a bias. For spreadsheet

tools, this looked at whether the model is easy to follow and whether it is accompanied by a user guide or other documentation. Finally the key strengths and weaknesses of the methods were assessed.

Table 2.1 Assessment framework used for the review of existing sources and methodologies

Category	Criteria
Appraisal methods	Method description How is the impact assessed? Is it clear what information is required to apply the method / model? If the impact is quantified, what metric is used? If the impact is quantified, what is the recommended source of data for the metric? Can the results be presented graphically? What other data is required to use the method?
Accuracy	Are the underlying assumptions explained and transparent? When following the method is it clear who will be affected? Can the calculations be easily repeated? Can the calculations be changed in the future? Is the model / method easily adaptable? Is there a built-in checking error function? Is there a risk of double-counting? Are the outputs clear and could be used in other calculations? Is the sensitivity of results to specific factors discussed and explained? Does the model calculate sensitivity?
Robustness	Is the method / model easy to follow/ user friendly? Is there a user guide / other documentation accompanying the model / spreadsheet? Is there evidence of the successful use of the method for impact appraisal in policy making? What are the possible limitations in using the method? What factors could introduce bias?
Strengths and weaknesses	What are the key strengths / benefits of the model / method? What are the key weaknesses of the model/ method?

In reviewing the literature, although a large number of documents were identified, few contained sufficient information to enable full evaluation against all of these criteria. Many sources provide high level guidance, without defining specific input parameters, providing examples of calculations or detailed description of limitations. For that reason we do not present a detail assessment of sources against these criteria as part of this report.

In addition to the literature review, representatives of UK Government Departments (Defra, BIS, HM Treasury, DECC, DfT, DCLG) have been contacted by the project team to identify best practices in undertaking impact assessments and to gather their views on how the wider impacts assessment tool could be developed in this study to ensure it is fit for purpose and consistent with the approaches used across UK Government departments.

2.2 Existing guidance to assess wider impacts of policy measures

This section presents a high level description of the key information sources reviewed, which have subsequently been used to inform screening of impacts and method development. For each of the sources we have provided a summary of its scope and key findings from the review.

Department for Environment, Food & Rural Affairs (DEFRA)

Defra's supplementary guidance to the Green Book relating to the policy appraisal of air quality and environmental impacts provides high-level step by step guides for the appraisal of these impacts and includes helpful links to secondary sources, including studies providing valuation methods and evidence on a number of impacts (e.g. noise, ecosystem services). The scope of the guidance was evaluated to identify whether any information could be relevant to the development of the wider impacts tool. For the most part, these guidelines

were not used further during the method and model development stage given that the purpose of this project is to go beyond the impacts already contained therein.

The scope of other sources published by Defra and reviewed in this study is summarised in Table 2.2 below.

Table 2.2 Summary of the literature review – publications by Defra

Title and years	Summary
Accounting for environmental impacts: Supplementary Green Book guidance (2012)	This document provides a step by step guide for valuing environmental effects of policies that are designed to have one or more specific environmental effects. Principles for the identification of relevant impacts and techniques for their valuation are explained. The use of the ecosystems framework is presented as a tool to avoid double counting where there are multiple environmental effects from a measure. The guide includes links to various environmental valuation sources. Overall the guidance is high level and no worked examples are provided.
Valuing Environmental Impacts: Practical Guidelines for the Use of Value Transfer in Policy and Project Appraisal (2010)	The supporting Green Book guidance on accounting for environmental impacts (2012) makes reference to the use of value transfer approaches as a proportionate and effective method for valuing the environmental/ecosystem services effects. Value transfer, also known as benefits transfer, is the process of taking evidence on economic values from one context and transferring it to another context. This document provides a step by step guide to valuing environmental effects using value transfer approaches. These guidelines provide help in selecting the most appropriate approach to value transfer and an appropriate level of effort. The guidelines also offer assistance in selecting the most suitable economic value evidence from the literature and practical assistance in applying the valuation evidence appropriately to the new policy appraisal context.
An Economic Valuation of Noise Pollution – developing a tool for policy appraisal (IGCB(N), 2008)	This document intends to lay the ground for the development of dose-response factors able to directly monetise the impact of noise in several areas: human health, amenity, productivity and ecosystems. The report does not detail a specific method. Instead, it provides an account of evidence and literature as well as potential challenges and further research needs to value each of the factors studied. It also includes an initial estimate of the cost of noise pollution in England based on the study published by the WHO.
Noise & Health – Valuing the Human Health Impacts of Environmental Noise Exposure (IGCB(N), 2010)	This report builds on a previous IGCB (N) report from 2008 (described above) and revises the conclusions. It recommends the use of dose-response functions for valuation of the impact of noise on 1) acute myocardial infarction, 2) hypertension and 3) self-reported sleep disturbance. It also recommends the use of established methods for the valuation of noise impact on amenity using DfT WebTAG, and impacts on hearing impairment using the method described in 1990:1999 ISO standards. These methods allow to directly monetise noise impacts from a few inputs (such as decibels and number of households affected). However, the authors note that there are a series of uncertainties and sensitivities associated with them. It should also be noted that they only represent some of the impacts on human health, the real cost probably being higher than what can be confidently estimated.

Department for Energy and Climate Change (DECC)

The Green book supplementary guidance on valuation of energy use and greenhouse gas (GHG) emissions for appraisal (2014) provides government analysts with a set of approaches and guidelines for valuing energy impacts, fuel security and GHG emissions. DECC's report (2013) **"Estimated impacts of energy and climate change policies on energy prices and bills"** includes an assessment of the distributional impacts of such policies using the DIMPSA model – developed by the Centre for Sustainable Energy for DECC. Details about DIMPSA's methodology and data sources have been obtained from the report **"Distributional impacts of UK Climate Change Policies"** (CSE / ACE and EAGA, 2010)".

Table 2.3 Summary of the literature review – publications by DECC

Title and years	Summary
Green book supplementary guidance on valuation of energy use and greenhouse gas (GHG) emissions for appraisal (2014)	This document provides specific guidance on how to quantify and value energy use and emissions of greenhouse gases (GHGs) as a result of policies, programmes, projects, etc. It also outlines the reporting requirements for compliance with carbon budgets. This guide offers general guidance on the process of conducting the assessment as well as detailed calculations for the quantification of GHG emissions. This quantification is based on applying emission factors to changes in fuel consumption, supplemented with other key data such as energy retail prices, carbon price, etc. The central tool is the IAG toolkit spreadsheet, an Excel-based model that guides the user step-by-step through the valuation process, prompting for inputs and providing direct outputs. Additional guidance for using the tool, as well as table and background information detailing assumptions and limitations can also be downloaded to support the assessment.
Estimated impacts of energy and climate change policies on energy prices and bills (2013)	This document focuses primarily on the impact current policies and other geo-political factors will have on average household gas and electricity bills at present and in the future. The report examines the impact that policies (including building regulations, the feed in tariff, the electricity market reform bill, smart meters etc.) trading schemes (renewables obligation, EUETS), energy demand and wholesale energy costs will have on existing bills in 2013, 2020 and 2030. Section 4.4 of the report provides an assessment of the distributional impact of each of the policies in 2020. Annex A details the DIMPSA model – developed by CSE for DECC to assess these distributional impacts. The annex provides an overview of the data sets used, but does not give details of how the calculations are undertaken.
CSE / ACE and EAGA: Distributional impacts of UK Climate Change Policies (2010)	This report from 2010 provides an appraisal of the distributional impacts arising from the governments Low Carbon Transition plan. This includes the following policies, supplier obligations and schemes: EUETS, CERT, CESP, RO, and FIT, Smart meters, energy using product policies and the RHI. The analysis uses the DIMPSA model, which was used latterly by DECC for the Estimated impacts of energy and climate change policies on energy prices and bills 2013. Whilst this report is outdated in terms of further policies coming on line (e.g. Green Deal and ECO), it provides further details about the DIMPSA's methodology and sources that are absent from the DECC 2013 report described above.
DECC's Final Stage Impact Assessment for the Green Deal and Energy Company Obligation (2012)	The impact assessment monetises a number of impacts including comfort impacts (i.e. warmer homes), improved air quality, traded and non-traded carbon savings. Several wider impacts are included within the report; these include employment, health impacts, meeting renewables targets and reducing the number of rogue traders in the construction sector. The report does not provide a methodology for how these impacts could be monetised or quantified. In itself it helps to indicate the level to which these impacts are presently assessed within impact assessments. Furthermore helpful links to secondary sources are included, some of which give methods for assessing wider impacts.
DECC: Domestic Renewable Heat Incentive Impact Assessment	The direct impacts covered in this assessment include: traded and non-traded CO_2 savings and air quality impacts. The wider impacts included are meeting renewables targets, diversified heating mix, technology impacts (including innovation, improved UK green technology competitiveness, reduced technology costs) however these are not monetised. Each of these wider impacts has been qualitatively identified but has not been quantified. The reasons given for these include: difficulties in monetisation of benefits, or lack of information on the future policy frameworks for supporting deployment for renewable heat. There are a limited number of useful sources for wider impact assessment methodologies within this document.

Department for Transport (DfT)

The **Web-based Transport Appraisal Guidance (WebTAG)** and its supporting spreadsheets, studies and tools have been reviewed in order to identify potential inputs that could be considered for the appraisal of air quality polices.

Relevant information for this study has also been obtained from the report prepared for the DfT (2013): **"Assessment of Methods for Modelling and Appraisal of the Sub-National, Regional and Local Economy Impacts of Transport".** This document provides an assessment of the methods which are being used, or could potentially be used, to estimate the economic impacts of a transport intervention at a sub-national, regional and local level.

Table 2.4 Summary of the literature review – publications by DfT

Title and years	Summary
TAG Unit A1.3 User and Provider Impacts	This unit of the suite of DfT's Appraisal Guidance provides specific guidance on how impacts on transport users and transport providers (including travel time and vehicle operating cost changes) should be estimated, valued and reported in transport appraisals.
TAG Unit A2.1 Wider Impacts (includes Wider impacts dataset and Functional urban regions lookup workbook)	Guidance is provided to appraise the economic impacts of transport that are additional to standard transport user benefits. This is necessary because markets are not perfectly competitive so the direct user benefits do not accurately estimate all welfare benefits (as they would under economic theory of perfect competition). The benefits considered are: Agglomeration; Output change in imperfectly competitive markets; and Tax revenues arising from labour market impacts (from labour supply impacts and from moves to more or less productive jobs). All these benefits can be monetised and the guidance gives clear instructions in how to carry out the calculations, including the determination of the change in "effective density" which is a measure of accessibility between employment locations of the same type (four categories are used) crucial for the determination of the agglomeration impact. Two additional spreadsheets are provided to determine if the scheme applies to an area within a Functional Urban Region (a subset of Local Authority Districts [LADs]), in which case it is eligible for appraisal, and to provide the data required for the calculations at LAD level. Standard Green Book discounting rates are used to appraise Net Present Value over a 60 year horizon. The key strengths of the methods are that they are easy to apply and can be modified if needed, they have been used in appraising many schemes in the UK and represent a standard practice for the DfT. Its weaknesses are that it can sometimes overestimate agglomeration impacts from small transport changes in the vicinity of major employment centres (and only operates at LAD level) and that there is uncertainty in the theoretical basis for the methodology and sensitivities which are currently being re-worked by DfT.
Assessment of Methods for Modelling and Appraisal of the Sub-National, Regional and Local Economy Impacts of Transport	This study reviewed various methods of appraisal at the Sub-National, Regional, and Local level. It identified the different types of modelling and appraisal methods that could be used for assessment; created a set of criteria to be applied against each method (robustness, practicality etc.); assessed the methods against the criteria and identified key strengths and weaknesses. It also provided detailed options for further research on the development of the modelling and appraisal methods. Employment is the main indirect impact that can be assessed from the various methods outlined in this study, with different options for differing scales of assessment, from large corridor wide or regional schemes to smaller localised projects. The study focused on developing models e.g. LUTI or UDM, or methods that require a significant amount of data collection and are relatively complex.
The Effects of Smarter Choice Programmes in the Sustainable Travel Towns: Summary Report (DfT, 2010)	This report is a summary of the work detailed in the full report of the same name. The report details an assessment of the impacts of the work carried out as part of the "Sustainable Travel Towns" designation in Darlington, Peterborough and Worcester. These included: workplace, school and personal travel planning; public transport information and marketing; cycle and walking promotion; and travel awareness campaigns. The study showed that the percentage of car trips per person fell in all three towns, while the percentage of bus, cycle and walking trips per person rose substantially. This led to noticeable positive impacts in carbon emissions and road casualties and the report also cites evidence that could have similar impacts on economic growth, improved health and quality of life.
TAG Unit A5.4 Marginal External Costs and TAG data book – Autumn 2013	The MEC method for estimating decongestion benefits can be used in the absence of a multi-modal model. The method is based on changes in external costs (congestion, noise, air pollution, infrastructure and accident costs) arising from an additional (or removed) vehicle on the network. The method does not take into account all of the responses available to those who switch mode (destination change) or the effect of the initial change in traffic levels on costs and subsequent demand, therefore sensitivity testing would be needed. There are alternative methods which use highway flows or trips, where a multi-modal model is not present, but these would also need sensitivity testing.

Title and years	Summary
Transport Statistics GB (DfT, ONS, 2013)	This is an annual report bringing together the full range of transport statistics and is the main general statistical reference source for transport in Great Britain. As the main official UK government source for transport statistics, this is both a highly current and officially sanctioned source for mode share and trip length statistics to provide default values for assumptions during the current modelling process. The current versions provide data tables in Excel spreadsheets which allows ready updating when new versions are released (the next annual publication, TSGB 2014, is scheduled for December 2014).

Department for Business, Innovation and Skills (BIS)

A central document used in policy appraisal is the **"Better Regulation Framework Manual: Practical guidance for UK officials"** published by the BIS in 2013. The Impact Assessment toolkit contained in this guide provides assistance in assessing the general wider impacts (social, economic, environmental) from regulatory policies, with an emphasis on regulation and de-regulation of businesses. It does not provide a specific valuation method or any metrics to quantify impacts but refers to several external sources for further details on assessing specific impacts.

Department for Communities and Local Government (DCLG)

An important element in policy appraisal is to assess the net benefit that an intervention will generate compared to what would have happened anyway (reference scenario). A standard method for calculating this additional benefit is provided in the supplementary guidance to the Green Book: **"Additionality guide: A standard approach to assessing the additional impact of interventions"** published in 2008 by one of the DCLG's former Agencies, English Partnerships (now part of the Homes and Communities Agency). This guidance describes in detail how to calculate the additional benefit of an intervention and the range of factors that need to be considered in the calculation which include deadweight, leakage, displacement, substitution and economic multipliers.

Office for Fair Trading (OFT)

Despite the OFT closing in April 2014, the supplementary guidance to the Green Book: **"Completing competition assessments in Impact Assessments – Guidance for policy makers"** published in 2007 by the Office for Fair Trading is a useful guide when assessing the direct and indirect effects of the proposed regulation on competition and identifying potentially affected markets.

Office for National Statistics (ONS)

The contribution to the economy of policies and public interventions can consider at the appraisal stage a range of parameters, including, where possible, gross value added (GVA). A report published by the ONS, **"Measuring the economic impact of an intervention or investment"** has been identified to address this issue. It is formed of two separate papers examining the sources, existing methods and concepts which surround the measurement of the impact of Interventions or Investments (IOIs) consistent with methods used to produce official GVA estimates. On this basis, it recommends using primary data from beneficiary surveys where possible.

The datasets published by the ONS has also been reviewed to inform the method development. These primarily focused on business and employment statistics and are discussed in more detail in section 4.

Other literature sources

Several sources published by international institutions, such as the European Commission or the International Energy Agency, provide useful guidance on the assessment of impacts of policies. The European Commission's Impact Assessment Guidelines provide general rules for undertaking impacts assessments for Commission's policy proposals and is accompanied by thematic guidance documents on assessment of specific impacts. Economic

data published by the Eurostat have been reviewed to inform the method development in cases where the required information was not available from the ONS or other official UK based sources.

The IEA's report **"Capturing the Multiple Benefits of Energy Efficiency"** provides an overview of the methods used for valuing impacts of energy efficiency measures. The document has been reviewed to investigate whether any methods for estimating these wider impacts could be used analogously for air quality. This provided a useful and comprehensive overview and generally a useful guidance for developing assessments, but did not reveal any detailed calculation methods for quantifying the impacts.

OECD's **Competition Assessment Guidance** provides information on key concepts used in the competition impact assessments, as well as an indication of the types of policies and regulations that may have an impact on competition on the national and regional level and step-by-step methodology to follow when assessing competition impacts.

Table 2.5 Summary of the literature review – other sources

Title and years	Summary
European Commission, 2009, Impact Assessment Guidelines	This general guidance sets the quality standards for undertaking the impact assessment work for the European Commission. It sets out the procedural steps and provides guidelines on defining the scope and level of the analysis required as well as undertaking stakeholder consultation. The document also provides information on the key analytical steps to be undertaken when assessing the impacts. The guidelines are accompanies by 13 annexes including guidelines on assessing some specific impacts such as on the number and quality of jobs, on fundamental rights, impacts on technological development and innovation, impacts on SMEs and businesses, as well as non-market impacts such as on environment and health. Depending on the type of impact, the guidelines provide varying amount of detail with regard to the potential methods and data inputs.
CEPS, 2013, Assessing the costs and benefits of regulation	This study has been developed in the context of updating the European Commission's IA Guidelines with new evidence and methods developed since its publication. The document defines various types of costs and benefits of regulations, identifies methods for their estimations and assesses key strengths and weaknesses of various approaches. Furthermore guidance is provided on when and how methods can be deployed and what data could be used for that purpose. Impacts covered include direct and indirect costs and benefits. The guidance also provides key steps to check how robust the results of the analysis are, specifically considering sensitivity analysis on key variables (e.g. using different values of discount rate) and checking for typical pitfalls in the cost-benefit analysis such as double counting, using inconsistent base currency etc.
IEA, 2014, Capturing the Multiple Benefits of Energy Efficiency	This document gives an overview of the multiple (i.e. wider) benefits of energy efficiency measures with various case studies of how the benefits have been captured in former assessments. The overview spans a very comprehensive range of impacts. This report was examined in detail to seek out ways of assessing energy security, energy delivery, energy prices, poverty alleviation, health and wellbeing, employment and resource management. Whilst the report gave a useful overview these impacts it did not provide an explicit methodology for quantifying the impacts we deemed useful for inclusion in the model that could be used universally.
OECD Competition Assessment Toolkit Volume II: Guidance	This document provides an overview of the type of policies at the national and regional level that can have potential impact on competition. It provides a step-by –step methodology to assess the impacts, however this is limited to qualitative assessments. Interestingly the guidance provides a case study of the competition assessment for air quality regulations. This case study has compared potential impacts on competition between four alternative policy options intended to improve the air quality; the assessment is done qualitatively.
The demand for public transport: a practical guide (TRL Limited, 2004)	This report was published by the Transport Research Laboratory (TRL) with the input of a wide range of organisations from across all major transport sectors. The document reports on the outcome of a collaborative study undertaken to produce guidance material into how different factors influence the demand for public transport, with the aim of providing guidance on demand estimation for public transport services. The primary source of the information is drawn from an extensive literature search and review drawing from academic studies and national and international government and industry expertise. The report provides useful insights into cross-elasticity between modes although the data used is now relatively old.

2.3 Potential impacts considered for inclusion in the model

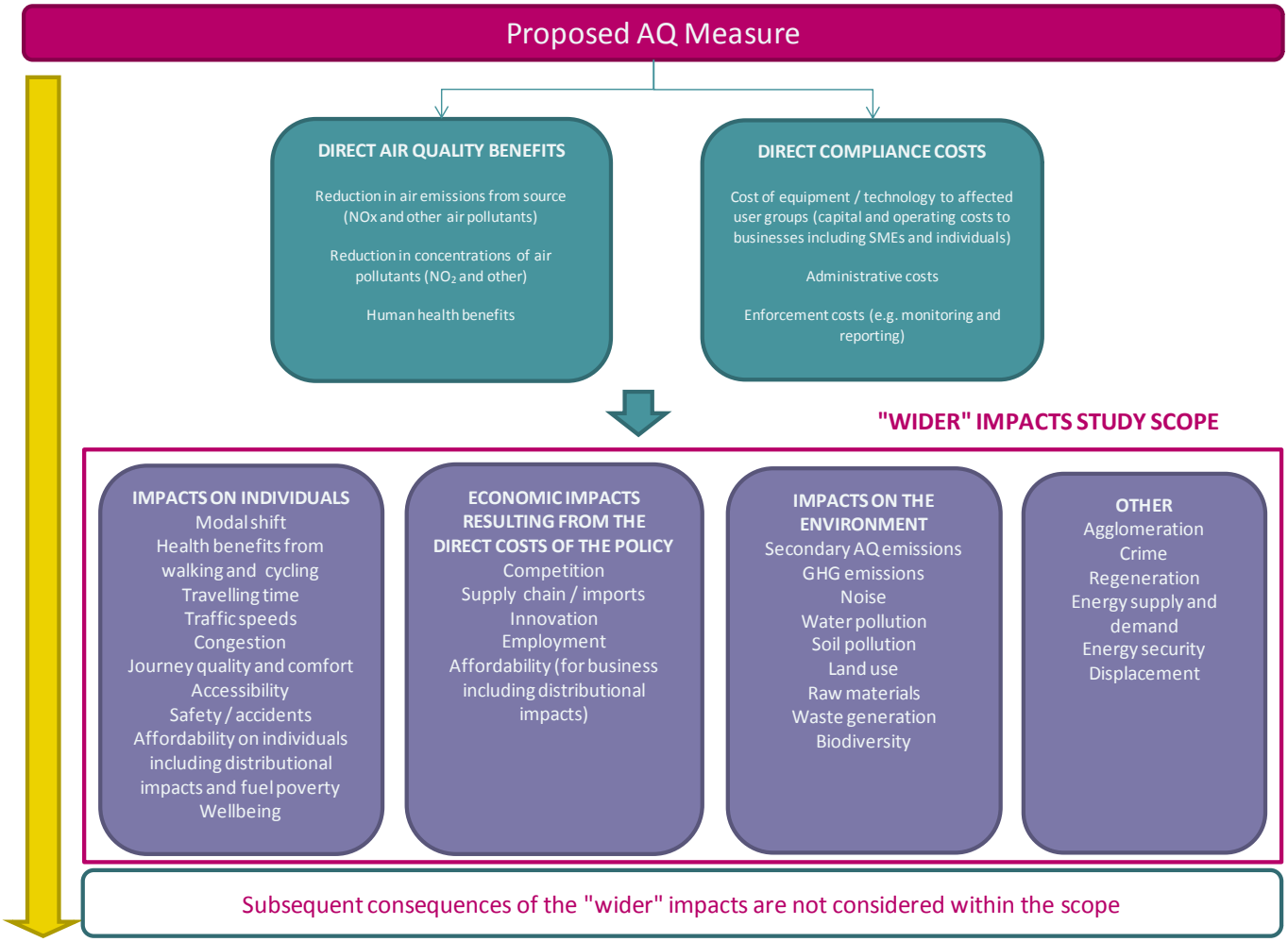
The first steps of the research undertaken has focused on identifying potential wider impacts of policy measures. This has been driven by Defra's expectation for the model to be universal and "future proof" from potential future changes in the type of policy levers assessed.

The term "wider impacts" does not have a uniform definition in the theory of policy appraisal. It is defined and understood differently depending on the context and intent of the policy being assessed. For that reason it was necessary to set the boundaries for the impacts falling within the scope of this project, in the context of assessing potential air quality measures. We have considered that the objective of any air quality measure proposed will be to reduce direct air quality impacts on the environment (reduced concentrations of pollutants in air) and on human health (lower exposure). This could be achieved by various policy levers intended at reducing the emissions of air pollutants at source.

Figure 2.1 below illustrates the direct impacts of the air quality measures such as direct air quality benefits (benefits for human health and the environment), as well as associated direct compliance costs (costs of equipment to users, administrative and enforcement costs). The economic impacts of this expenditure (e.g. impact on market competition, SMEs, employment) together with impacts not linked directly to the objectives of the proposed policies form the boundary for the "wider impacts" assessment in this study. The figure also lists which wider impacts were identified and taken forward to the screening stage.

The subsequent consequences of the wider impacts are excluded from the scope of this study. These are impacts further down the causality chain, including for example economic impacts from greater demand for raw materials, impacts on the economy from improved productivity due to reduced exposure to noise etc.

Figure 2.1 System boundaries and “wider impacts” identified



Inevitably, some of the impacts shown in Figure 2.1 are inputs to the assessment of other impacts. The methods to assess the impacts have been developed with caution to avoid double counting of associated costs and benefits of such interdependent impacts. For example, results of modal shift assessment are the parameters required for the assessment of health impacts from walking and cycling.

As illustrated above, the following direct impacts have been assumed outside the scope of this study:

- Compliance costs (cost to affected groups, administrative, monitoring and reporting costs);
- Impacts on emissions and concentrations of primary air pollutants; and
- Impacts on human health.

3. Selection of the impacts for inclusion in the model

This section summarises results of the impacts screening and justification behind inclusion and exclusion of impacts from the wider impacts assessment tool.

3.1 Selection of the wider impacts

The impacts identified in the literature and through consultation with experts were screened by Amec Foster Wheeler using criteria developed for this project, as shown in Table 3.1 below. A traffic light system was used to illustrate how well the impact performed against each of the criteria.

Table 3.1 Criteria and scoring used for impact screening

	Scoring system
	Scores well against the criterion (e.g. it is relevant, significant, not complex, certain)
	Scores satisfactorily against the criterion
	Scores low against the criterion (e.g. it is not relevant, insignificant, complex, uncertain)
	Screening criteria
Relevance	What is the relevance of the impact to potential interventions?
	Is the impact a gap in the existing modelling capacity?
Significance	How significant may this impact be on the UK public sector / the Exchequer?
	How significant may this impact be on individuals / consumers?
	How significant may this impact be on businesses?
	How significant may this impact be on SMEs?
	How significant may this impact be for the environment?
Complexity	Does guideline to assess the impact exist?
	How can the impact be assessed?
	What is the level of complexity of the calculations required to appraise the impact?
	Is the data on parameters required to calculate the impact publicly available?
	Is the method to assess the impact the same for all sectors affected by potential air quality measures?
Uncertainty	How certain is the input data required to assess the impact?
	How certain are the methods used to assess the impact?

3.2 Results of impacts screening

The screening of impacts was undertaken according to the criteria presented above. Overall the impacts that scored mostly green and orange were suggested to be taken forward to the method development stage. Once the initial screening was completed, it was discussed and agreed with Defra which of the top scoring impacts would be taken forward to the method development stage. Full results of the wider impacts screening are presented in Appendix C.

3.3 Rationale for including impacts in the model

The literature research, consultation with representatives of government departments and experts in undertaking impact assessments have led to identification of 30 potential wider impacts of air quality policies. The selection of impacts for inclusion in the wider impacts model (i.e. those impacts scoring mostly green in the screening process) was determined by their relevance and potential significance in the context of air quality measures. Furthermore, the selection was dependent on the availability of a quantitative methodology that would be suitable for assessment of any air quality policies. In several instances, while the quantitative assessment of the impact is feasible when analysing a specific policy, the methods were not transferable to a generic approach that could be implemented in the generic model. Impacts that are usually assessed qualitatively were also excluded from the scope of the model given its purpose is to provide monetised costs and benefits.

Following the impacts screening, eight impacts were selected for potential inclusion in the model:

- Modal shift.
- Health impacts of walking and cycling.
- Congestion.
- Safety/ accidents (transport only).
- Noise (transport only).
- GHG emissions.
- Affordability (for business and for individuals).
- Employment (gross jobs).

Table 3.2 below shows the definitions of the impacts taken forward for development in the model and provides justification for their inclusion.

Table 3.2 Justification for including impacts in the wider impacts assessment tool

Impact	Definition	Justification for inclusion
Modal shift	The change in trips made by alternative modes of transport in response to the scheme.	Potentially relevant for transport related policy levers and pricing mechanisms. It is considered to have an effect on all stakeholders, but particularly on individuals. Approximate methods, applicable to the assessments at the national level exist to assess this impact. The method is suitably generic to apply to assessment of any potential future air quality policies that could lead to modal shift. The main uncertainties are associated with fixed input data to be applied in the model specifically the use of diversion factors to determine the shift from one mode of transport to another. The outputs are especially relevant for active modes (walk/cycle) and could be potentially relevant to the assessment of health impacts and GHG emissions.

Impact	Definition	Justification for inclusion
Health impacts from walking /cycling	Reduced morbidity through increased health and fitness from using active modes of transport.	Potentially relevant for transport related policy levers. Considered to have an effect on individuals and the regulator/state, but less so on businesses. A spreadsheet tool for assessment of this impact was under development by DfT at the time of this project. The method is based on the WHO HEAT methodology recommended internationally for the assessment of this impact, hence the method to assess the impact would follow best international practices. The method is easily transferable into spreadsheet based calculations and is suitably generic to handle various types of policies that may lead to an increased number of trips made by active modes of transport. Methodological uncertainty is limited to inputs.
Congestion	Change in traffic congestion and thus vehicle speeds/times.	Potentially relevant for transport related policy levers and considered to have an effect on all stakeholders. Method to assess congestion impact at the national level is available based on DfT guidelines (monetised through a Marginal External Cost approach). The method can be easily replicated in the spreadsheet based tool, allowing assessment of the generic set of policies affecting levels of traffic. Time and speed form part of this methodology. Methodology has been considered as robust, given it is covered by official government guidelines and uses well established inputs (WebTAG).
Safety / accidents	Change in accident rates.	Potentially relevant for transport related policy levers. Varying relevance for policy levers in other sectors. For road transport, an equivalent method is applied as for congestion (accidents linked to changes in traffic), hence it is considered similarly robust and also follows DfT guidelines. In other sectors (e.g. industrial), it is not expected that air quality measures (e.g. retrofitting) will have a significant enough impact to justify the assessment. Also, no generic methodology to assess this impact has been identified. In instances where this is relevant a bespoke assessment would be required.
Noise	Change in noise levels.	Potentially relevant for some transport-related policy levers, including those which significantly alter traffic flows or replace large numbers of internal combustion engines (road or rail) with quieter technology (e.g. electric). Less relevance for other sectors. For road transport, an equivalent method is applied as for congestion (noise linked to changes in traffic) hence it is considered similarly robust and also follows DfT guidelines. In other sectors (e.g. industrial), it is not expected that air quality measures (e.g. retrofitting) will have a significant enough impact on noise to justify the assessment. Also, no generic methodology to assess this impact has been identified. In instances where this is relevant a bespoke assessment would be required.
Affordability (for individuals and business)	Change in households' or business' disposable income.	Potentially relevant for all air quality policy levers. Considered to have an effect on either individuals and/ or businesses. Methods to assess the impacts of affordability on business exist and are generally well-established in the regulatory impact assessment approaches used in the UK and the EU. They are transferable into a spreadsheet tool and are suitably generic to allow assessment of impacts of any potential future air quality policy. Distributional impacts on households are covered by WebTAG guidelines, however, these are applicable to specific transport interventions and hence would not be applicable to other policies affecting households (e.g. changing domestic fuel use) or to national level assessments. A methodology for the assessment of this impact could be developed based on the methods used to assess distributional impacts of energy efficiency policies in the DIMPSA model (maintained on behalf of DECC). Simplification of the DIMPSA methodology allows development of the generic approach to assess distribution of costs and benefits of policies (changing both travel behaviours and domestic energy use) on households in different income groups.
GHG emissions	Change in emissions of greenhouse gases - – direct emissions and	Likely to be impacted by many air quality policy levers. For emissions resulting from energy use, methods are well-established and are well-described in the official guidance issued by DECC and Defra. The methods

Impact	Definition	Justification for inclusion
	emissions associated with change in energy use.	are transferable into spreadsheet calculations, and a spreadsheet tool for GHG and energy valuation is part of official government guidelines. Scope to increase the functionality of the existing IAG tool has been identified, for example to provide greater flexibility in terms of user inputs. Inclusion of the GHG impact in the wider impacts model with this extended functionality is considered as value added.
Employment	Change in jobs.	Potentially relevant for all air quality policy levers. Considered to have an effect on individuals, businesses and regulator/state and is highly relevant to assessment of impacts of any potential future policies. Quantification of employment impacts is complex and requires bespoke assessments. Care is needed to distinguish between the creation of additional jobs and the displacement of jobs from one location/employer/sector to another. No robust methodology was identified that could be directly transferable to a spreadsheet based tool. Nevertheless employment is of central interest in policy making and given this relevance it was decided to include the impact in the model and develop approximate methods for the assessment.

3.4 Basis for excluding impacts from the model

The impacts not taken forward to the development stage following the screening process were primarily those that were not considered particularly relevant to the air quality measures, which could not be quantified and monetised and/or those for which the methodology was too complex or too bespoke to a particular policy measure. For example, impacts on competition were screened out as it was not considered feasible to quantify these. On the other hand the relevance of the potential waste impacts of air quality measures was considered relatively small, especially in the context of generating value from recycling; and the application of the "circular economy" approach was considered too complex to be used in this study.

In addition, the biggest challenge/ constraint was that it was often not possible to identify existing robust methods for assessing impacts and the time and resources available for this project precluded the creation of significant extensions to existing modelling and/ or appraisal methodology.

Table 3.3 below presents all impacts that were excluded from development in the model, their definitions and justification for their exclusion.

Table 3.3 Justification for excluding impacts from the wider impacts assessment tool

Impact	Definition	Justification for exclusion
Embodied GHG emissions	Emissions of greenhouse gases emitted during the manufacture, transport and construction of goods or infrastructure.	The methods for assessing the amount of 'embodied carbon' in different types of infrastructure are bespoke, due to the wide variation in the type and source of materials involved. It is unlikely that sufficient input data would be readily available as part of a general initial appraisal of air quality measures.
Quality and comfort	Change in amenity/ attractiveness of travel, or comfort of individuals in homes or buildings.	Considered to have an effect primarily on individuals but not on other stakeholders. No clear methods identified to assess and monetise the impact at the national level and methods would therefore need to be bespoke to individual policies
Increased/ decreased access to facilities and services	Change in the level of access to facilities such as retail, leisure, health services or employment). Note: This does not refer to "inclusion", i.e. impact on those with mobility impairments.	These impacts are usually only relevant for schemes which significantly change the provision of public transport services and are therefore unlikely to be relevant for appraising air quality-related schemes WebTAG accessibility appraisal methods are largely qualitative and localised and would be difficult to incorporate in a generic process for quantifying or monetising the accessibility-related impacts of policies or schemes.

Impact	Definition	Justification for exclusion
Well-being	Change in the mental well-being of affected individuals.	Complex methods are required to assess this impact; and it is unlikely that the impact could be quantified or monetised (i.e. MCA was one of the possible approaches identified). Methods and inputs are highly uncertain.
Secondary air quality emissions	Change in the formation of secondary pollutants in the atmosphere, including impacts on ozone.	Assessment of impact on secondary air quality emissions requires complex modelling and methods are already partially covered by the existing models available to Defra. Resource and time needed to incorporate it were beyond the scope of this project.
Water and soil pollution	Change in water and soil pollution (e.g. secondary emissions to water and land).	Methods to assess this impact are complex and no robust methods of monetisation were found. Some aspects, such as deposition, are already covered by existing modelling available to Defra. Resource and time needed to incorporate it were beyond the scope of this project.
Land use	Change in the land use patterns.	Land use is unlikely to be significantly affected by air quality measures. Specific cases likely to be localised and of small scale (e.g. retrofitting on industrial sites). Methods to assess this impact would need to be bespoke to individual policy measures and no generic methodology transferable to a spreadsheet based tool was available. .
Raw materials	Change in the demand and supply of raw materials.	Limited relevance for air quality measures. Changes in availability of raw materials could potentially affect all stakeholders and the environment but impacts from air quality policy are not expected to be high. No guidance was identified to assess and monetise the impact at the national level. Methods to assess are relatively bespoke for different measures / sectors, complex and uncertain. Hence the impact was not considered to be transferable to a spreadsheet-based tool.
Waste generation	Change in waste generation, including on the potential value created down the waste management chain (e.g. as a result of recycling).	The methods would be bespoke and complex as it is dependent on the material types and disposal routes used. Significant uncertainties on whether benefits would be realised within the UK (due to international nature of the waste supply chain).
Biodiversity	Change in value provided by biodiversity.	Complex and bespoke methods required to assess this impact. High uncertainty in input data and methods concerning valuation of ecosystem services meant that assessment of this impact was not considered transferable to a spreadsheet based tool.
Competition	Change in competition in affected markets.	Existing methods and guidance are qualitative in nature and not suitable for implementing within a quantitative approach
Supply chain / imports	Changes in demand on the supply chain and for imports. (Linked to competition assessment).	Bespoke and complex methods required; unlikely to be able to quantify the impact on a generic basis
Innovation	Change in costs / investment and capacity to innovate.	Method and guidance exist but the only assessment considered possible would be qualitative. The outputs of the assessment would be highly uncertain. No robust methods were identified hence the impact was excluded from the scope of the tool.
Crime	Change in level of crime.	Not considered relevant for many air quality measures. Bespoke assessments would be required and no robust methodology for the assessment of the impact was identified.
Regeneration	Change in development and amenity/quality enhancements of an area.	Impact not considered relevant for many air quality measures. Covered by government guidance but complex to assess. Ideally a land use model interacting with a transport model is needed and this

Impact	Definition	Justification for exclusion
		is rarely available. Hence it was not feasible to develop suitable methodology for inclusion of the impact in the wider impacts tool.
Energy supply and demand	Change in the ability of the energy supply to meet required demand.	Moderately relevant for air quality measures. The method is complex; ideally requires use of DECC's dispatch model. Development of the simplified but robust methodology was not considered feasible in the timescales and resources available for the study.
Energy security	Change in the security of energy supply.	Assessment of this impact requires complex calculations with no guidelines currently existing. No robust methodology transferable to the spreadsheet based model was identified. Methods and inputs highly uncertain.
Displacement	Change in activity across groups/locations leading to positive impacts on one group/location being offset by negative impacts on another group/location.	Complex and bespoke methods required for the assessment. No robust method transferable to a spreadsheet based tool was identified.

4. Methods for assessing selected impacts

This section provides an overview of the methodologies used in the wider impacts model to assess the impacts selected at the screening stage.

4.1 Common aspects of the methodology for all impacts

Appraisal period

According to the HMT Green Book the appraisal period for cost and benefit assessment should 'cover the period of usefulness of the assets encompassed by the options under consideration'.

In the model, the user is required to input:

- The current year the assessment is undertaken against (to determine price base year);
- The start year of the policy/ measure;
- The end year of the appraisal period over which the costs and benefits of the proposal are to be assessed; and
- The year the costs are to be inflated/deflated to.

The user of the model has responsibility for selecting an appropriate appraisal period for the type of policy measure under assessment. The appraisal period could be taken to be the lifetime of the policy/measure or the economic lifetime of technologies taken up for compliance.

Cost inflating

Gross Domestic Product (GDP) deflators, which can be viewed as a measure of general inflation in the domestic economy, are used to inflate/deflate any direct cost inputs to the year of the assessment. The GDP deflators have been sourced from HM Treasury (2014) "GDP deflators at market prices, and money GDP" published on 9 October 2014.The user is required to specify the year for which the input costs are provided to allow the appropriate deflator to be applied in the model.

Discount rate

The discount rate of 3.5% as recommended in the HMT Green Book is a default discount rate used in the model. This is selected on the assumption that the timeframes of the policies to be assessed in the model will be less than 30 years. In order to provide flexibility to use the model to assess the impacts over a longer period of time, the declining long term discount rates as provided in the HMT Green Book are pre-coded in the model (these decline to 3.0% for the appraisal period 31-75 years). In addition, we included an option for the user of the model to select higher discount rates; the pre-coded values are 7%, 10% and 15%. These higher discount rates may be selected for scenarios assessing policies expected to have significant impacts on businesses, as they are closer to the rates businesses would apply when considering new investment.

Net Present Value

Each monetised impact is expressed using the Net Present Value. The discount factor is calculated according to the following equation as presented in the HMT Green Book:

$$Dn = \frac{1}{(1+r)^n}$$

Where: n – year of the assessment; r – discount rate; D_n – discount factor

The discount factor is applied to calculate the present value for cost/benefit for each year of the assessment period. The sum of the discounted costs/benefits for the whole assessment period is taken as the NPV.

Presentation of costs and benefits

The Wider Impacts model does not calculate direct compliance costs. These are considered inputs to the model (relevant to assessment of affordability for business and for individuals).

For each impact covered by the tool (with the exception of the modal shift impact and the impacts of affordability for individuals and for business), the resulting costs/ benefits of the measures are presented as:

- **Transitional** costs/ benefits – one off cost/ benefit usually in the first year of the policy/ measure in order to achieve compliance with the policy; and
- **Annual** costs**/** benefits – re-occurring annual cost/ benefit resulting from compliance with the policy/ measure; these may differ from year to year.

This allows the outputs of the model to be carried over in to the Impact Assessment Calculator (BIS, 2013)[2]. Where sufficient information is available for each impact, costs and benefits are presented to business, the regulator and society /individuals.

Measuring uncertainty

Two different systems are used to assess uncertainty:

- The **quantitative system** is based on three uncertainty scenarios: central (or best), low and high estimates. If inputs are entered for all three scenarios in each of the control sheets (user inputs), the results will display the final impact for each uncertainty scenario. The low and high values provide an indication of the uncertainty range associated with the central (or best) estimate. This system allows for sensitivity tests between scenarios.
- The **qualitative system** is based on uncertainty indicators (or scores) attributed to each of the inputs (both user and fixed inputs). Scores are carried through the calculations and a weighted system displays the uncertainty category associated with the final results. Details about the methodology can be found in the Technical Specification.

4.2 Methodologies used for assessment of individuals impacts

Overview

The method development for individual impacts was closely guided by the best practice guidelines published by UK Government departments. Where these were absent, methodologies were based on approaches used in the previous impact assessment or similar work. Table 4.1 presents all impacts included in the tool with a high level summary of the approach and reference government guidelines used.

[2] Available from https://www.gov.uk/government/publications/impact-assessment-calculator--3

Table 4.1 Overview of the methods and supporting government guidelines used in their development

Impact	Summary of the approach	Reference guidelines supporting method development
Congestion	Marginal external costs are used to monetise the estimated change in congestion costs (value of time lost relative to free flow conditions).	Department for Transport, 2014, TAG Unit A5.4 Marginal External Costs
Safety/accidents	Marginal external costs are used to monetise the estimated benefits of lower likelihood of accidents due to removal of vehicle kilometres.	Department for Transport, 2014, TAG Unit A5.4 Marginal External Costs
Noise	Marginal external costs are used to monetise the estimated benefits of lower levels of noise due to removal of vehicle kilometres.	Department for Transport, 2014, TAG Unit A5.4 Marginal External Costs
Modal shift	Diversion factors based on the National Transport Model are used to provide an indication of potential modal shift due to removal of vehicle kilometres.	Department for Transport, 2014, TAG Unit A5.4 Marginal External Costs Diversion factors based on the National Transport Model
Health impacts of walking and cycling	Monetisation of health benefits from increased physical activity (cycling or walking).	Department for Transport, 2015, Investing in Cycling and Walking The Economic Case for Action and accompanying toolkit Consistent with the World Health Organisation's (WHO) Health Economic Assessment Tool (HEAT)
Greenhouse gases	Monetisation of benefits and costs of the changes in greenhouse gas emissions using carbon price. Emission factors are applied to change in energy use to quantify the corresponding change in GHG emissions.	DECC's supplementary Green Book guidance and toolkit for quantifying and valuing changes in GHGs as well as energy use in policy appraisal Defra Greenhouse Gas Conversion Factor Repository http://www.ukconversionfactorscarbonsmart.co.uk/
Affordability for business	Affordability and distributional impact on businesses (depending on their size) applies a cost ratio methodology with gross operating surplus used as an indicator for the share of revenue available to the business for investment.	European Commission, 2015, Better Regulation Guidelines
Affordability for individuals	Affordability and distributional impact on households (depending on their income) is assessed using the changes in household's expenditure on domestic energy and transport and average disposable income of household in different income quintiles.	Department for Transport, 2014, TAG Unit A4.2 Distributional Impact Appraisal (approach modified for the purpose of the model) Centre for Sustainable Energy and Association for the Conservation of Energy, 2010, : Distributional Impacts of UK Climate Change Policies (approach modified for the purpose of the model)
Employment	Possible scale of employment impact is assessed by comparison of the average cost to business against the costs of employment in a given economic sector.	Approximate method developed for the purpose of the model DWP (2010) Impact Assessment of Workplace Pension Reform

Congestion, safety and noise

The wider impacts model monetises the impact of change in congestion, safety and noise.

Congestion has an impact on both the speed of travel and on the reliability of travel conditions with the latter to be of greatest concerns to individuals and businesses[3]. If congestion is removed by avoiding car journeys, the impacts

[3] Transport Research Centre, European Conference of Ministers of Transport, Managing Urban Traffic Congestion

of relieving congestion are dependent on the time and place of the avoided journey; benefits will be larger for travel at peak hours and in busy areas, but lower for off-peak travel. TAG Unit A5.4 provides guidance on how decongestion benefits should be estimated when a multi-modal model is not used. The Marginal External Cost (MEC) method is based on the change in these external costs arising from an additional (or removed) vehicle (or vehicle km) on the network. Values should be negative if there is a reduction in vehicle kilometres and positive if there is an increase. The calculation of "congestion" costs include an estimate of vehicle operating cost changes.

Estimates of the external costs of accidents and noise are also monetised in addition to the congestion costs. They are assumed to grow in line with GDP per capita reflecting increases in people's willingness to pay. The NTM accounts for tighter vehicle emissions standards in line with DEFRA guidance.

A shift to public transport achieves benefits due to transfer to a more sustainable mode, but for active travel there is likely to be a significant increase in accident costs because walkers and cyclists are more vulnerable to road accidents. It is recognised that relatively large changes in traffic flows are required to bring about significant changes in the noise levels in the long term. The results provided by the wider impacts model for congestion, noise and accidents impacts can be either costs (positive values) or benefits (negative values).

Traffic is a major source of air pollution. Policies that reduce traffic (vehicle kilometres) will, with all other things being equal, proportionately reduce polluting emissions and concentrations. Conversely, policies that increase vehicle kilometres will, with all other things being equal, lead to proportionately increased emissions. A change in the volume of traffic due to a policy/measure would have an impact on level of congestion, noise and safety.

- Road traffic congestion, caused by reaching maximum capacity of a road network, increases journey time and emissions of air pollutants which have detrimental effects to health and reliability of travel conditions. In TAG Unit 5.4, congestion is defined as time lost relative to free flow conditions.
- Accident rates on the road can be reduced or increased depending on the level of safety measures that will be or have already been put in place. A shift from private vehicles to public transport, walking or cycling would impact safety and accident rate.
- Noise pollution is consistently ranked very high amidst the list of citizen's concerns. Traffic is considered the most widespread source of environmental noise with such examples of high noise level exposure leading to adverse health effects, i.e. sleep disturbance, disturbed cognitive functioning, cardiovascular disease and mental health effects.

Overview of the assessment method

The primary method for estimating the impacts on congestion, noise and safety of the potential future policy interventions, in the absence of a multi-modal model, is based on marginal external costs (MECs). For vehicle use, these external costs include congestion, air pollution, noise, infrastructures, greenhouse gases, indirect taxation and accident costs. The MEC method is based on the change in these external costs arising from an additional (or removed) vehicle (or vehicle km) on the network. The MEC factors for congestion, noise and safety (WebTAG A5.4) assess the change assuming that only petrol or diesel cars are impacted by the policy.

For the impacts of Congestion, Safety/ Accidents, and Noise, the WebTAG Marginal External Cost (MEC) approach is used from TAG unit A5.4 which uses the TAG Data book (from May 2014). The WebTAG A5.4 MEC method was selected as it is part of official UK Government (DfT) guidance, and is a proportionate approach suitable for the current tool.

Assessing the cost of the impacts of congestion, safety/ accidents and noise

The WebTAG A5.4 MEC method is superior to a generic elasticity-based method (which would attempt to determine a high-level relationship between kilometres reduced and level of congestion/noise/accidents), as it is the result of the modelling of regional traffic flow levels and congestion levels within the National Transport Model (NTM), and as such provides a useful shortcut to the relevant impact parameters based on the region, area type,

and existing road congestion levels. No significant adjustments have been made to the methodology in order to build the WebTAG A5.4 MEC approach into the tool.

Data from WebTAG provide MEC values for congestion, accidents and noise in pence per car km for every five year interval and for different areas and road types. Each MEC value is multiplied by the proportion of traffic in each area and road type where the policy/measure will apply. For example, if a measure is taking place in London only the MEC values for London (motorways, A roads and other roads) will be applied. Then the resulting weighted MEC is multiplied by the total number of car kilometres expected to change due to the policy or measure for the different scenarios.

Interpretation and use of results

The results of the Wider Impact Model provides aggregated impacts to businesses, regulator and society as the assessment methodology does not allow differentiation between the parties affected. In case no user inputs are provided for the years between the minimum required five year intervals, the results of the assessment are interpolated.

The geographical scope for the Wider Impacts model is the whole of the UK. The best available information regarding distribution of traffic between roads is for Great Britain and therefore this is used as a proxy when the policy under assessment applies to the whole UK. Default data on distribution of traffic between road types for different regions has been incorporated in the model or specific data can be added manually by the user.

Data from WebTAG currently covers up to 2035. However, updates to future versions of the relevant parameters (which are typically released annually) are facilitated through consistency in format with the TAG data book Excel spreadsheet.

Limitations

- MEC impacts can only currently be used to assess impacts up to 2035. This is because fixed inputs from WebTAG are only available up to this date.
- The MEC method does not take into account all of the responses available to those who switch mode (for example those changing destinations) or the effect of the initial change in traffic levels on costs and subsequent demand.
- The method used to asses congestion, safety and noise impacts assumes that the alternative journeys taken in the ‘without scheme’ and ‘with scheme’ scenarios have the same origin and destination area types. This simplifying assumption is necessary in the absence of a trip distribution mode.
- No significant adjustments needed to be made in order to build the WebTAG A5.4 MEC approach into the tool. Updates to future versions of the relevant parameters (which are typically released annually) are facilitated through links to relevant cells in the TAG data book.
- The results are provided directly in monetised terms discounted over the appraisal period. The limitations of the approach are that pro rata effects of vehicle km change by road type must be assumed (unless vehicle km changes are provided to the same level of detail as the WebTAG traffic data). Furthermore, this approach cannot match the detailed localised accuracy of full transport modelling, but detailed modelling would greatly extend the scope and complexity of the wider impacts model.
- During the impact identification and screening, traffic and vehicle speeds as well as travelling time were considered as separate, but correlated, impacts to the congestion impact. Traffic/vehicle speed changes are the result of the change in vehicle km due to the potential air quality measures affecting highway congestion levels. The speeds themselves are not directly monetised but the resulting travel time changes can be. However, these speed changes and resulting travel time changes are precisely the impacts which have already been monetised through the MEC method for congestion impacts

assessment, so attempting to monetise them again would result in double counting. Therefore, both of these impacts should be considered as already accounted for and monetised by the MEC Congestion Impact indicator and are not proposed to be assessed separately.

Congestion impact

- The above method accounts for both the direct estimation of congestion levels from assessment of the difference between free-flow (i.e. uncongested) vehicle hours and congested vehicle hours using outputs from a detailed local highway traffic assignment model (including the effects of blocking back and interacting traffic flows at junctions), and use of approximate elasticity-based techniques to estimate changes in congestion from given input changes in vehicle km.

Safety/ Accidents impact

- The above method accounts for both link and junction accident rate analysis using outputs from a network-based local highway traffic assignment model, and third party accident rate estimation tools

Noise Impact

- The above method accounts for detailed exposure level assessment using outputs from a network-based local highway traffic assignment model, and an estimation of population density within different distance bands of highway links.

Modal shift

The approach used for estimating modal shift impacts is referred to in WebTAG Unit 5.4. Modal shift impact uses estimates of changes as either decrease or increase in car kilometres and diversion factors based on the National Transport Model to calculate the total change in the number of trips made by each mode of transport (i.e. car, walking, cycling, bus or rail).

Personal motor vehicles consume more energy and are greater emitters of air pollutants per passenger kilometre than other travel modes; this can effectively be reduced by restraining the growth in car use.

Public transport is considered favourably from a socially and economically sustainable point of view because it gives both higher mobility to people who don't have access to a private car and it is less expensive to provide additional capacity by expanding bus or rail services than building new roads or bridges. The development of new rail and/or bus services can be an effective measure for diverting car users to carbon-efficient modes while providing existing public transport users with upgraded service[4]. The prospect of reducing emissions by switching from cars to non-motorised transport such as walking and cycling is dependent on local conditions.

A modal shift occurs when one mode (e.g. bus) has a relative advantage in a similar market over another (e.g. car). These advantages can take various forms, such as costs, capacity, time, flexibility or reliability[5]. Specifically, a mode shift from car to active transport modes (cycling and walking) can provide benefits in terms of personal health, welfare costs, air quality and climate change[6].

Overview of the assessment method

The method developed for estimating modal shift is based on use of mode diversion factors derived specifically for the purpose of this study based on information from the DfT National Transport Model (NTM). As the requirement

[4] IPCC Fourth Assessment Report, Climate Change 2007: Working Group III: Mitigation of Climate Change
[5] The Geography of Transport Systems, Dr. Jean-Paul Rodrigue, Dept. of Global Studies & Geography, Hofstra University, New York, USA
[6] Can a mode shift to walking and cycling benefit health and climate?, James Woodcock and Felix Creutzig, The European Dahrendorf Debate Symposium, 2013

was to estimate mode shift in response to a change in car kilometres, NTM sensitivity test runs were used in which only car costs were directly affected. The resulting changes in car kilometres and corresponding changes in trips by non-car modes were then related on a regional basis consistent with the WebTAG A5.4 MEC methodology. The details of this derivation and subsequent adjustments are described below.

In order to assess the impact, the user of the model is required to input total change in car kilometres in each year of the policy. The model then applies diversion factors to provide estimate of the number of overall trips diverted (as a result of AQ measures) from car to the following transport modes:

- Car
- Walk
- Cycling
- Bus
- Rail

The diversion factors are dependent on the area types consistent with WebTAG A5.4 MEC method (i.e. London, Inner and Outer Conurbations, Other Urban, Rural and Great Britain).

Justification for the use of diversion factors from the National Transport Model

The Department for Transport's NTM has been used as a reference to derive modal shift responses to use in the wider impacts model. The NTM has been used because:

- It provides a consistent national standard transport model basis. It is a source for the National Road Traffic Forecasts which feed into WebTAG forecasts such as those used in the MEC methodology described above. Thus use of the NTM data ensures consistency between the modal shift assessment and methodologies used for other transport related impacts.
- NTM has comprehensive coverage of Great Britain and includes information on the different levels of service of different modes within the geographical areas (consistent with MEC methodology, i.e. London, Inner & Outer Conurbations, Other Urban, and Rural). Thus it provides localised relevance which would not be obtained from abstracting values from potentially atypical local transport models, nor from the very limited sample reported in the literature (which proved unsatisfactory in an earlier iteration of the tool).
- NTM derived factors are available for use as a default within the tool. Local transport model data for all possible application scenarios are either impractical to include or (commonly) unavailable.

Derivation of modal diversion factors

The NTM tests used to derive modal diversion factors were a central case and two sensitivity tests for a 2020 forecast year. The two sensitivity tests involved adjusting the cost of fuel: one test used lower fuel costs than the central case and the other used higher costs. These cost changes only affected the car mode. There are known limitations to the transferability of the results of such a test as longer distance trips are more sensitive to fuel price changes than shorter trips, however this has been considered the best available data for inclusion in the model at the time of its development.

As a result of changes in costs (in this case car costs only) the NTM operates as transport models generally do in forecasting changes of mode and changes of destination. Both the reduction in car (driver) trips made (in response to a fuel cost rise) and changes in choice of destination contribute to a change in car vehicle km. Every trip which is diverted away from cars is made instead by an alternative mode – there is no trip suppression in the NTM outputs (i.e. choice of not travelling at all; zero deadweight loss). This is common practice in transport modelling when the model considers all travel modes (including non-motorised) and was based on longitudinal research using National Travel Survey (NTS) statistics which appeared to show a reasonable constancy of overall trip-making rates over

many years prior to the 2000s, especially for suitably detailed population segments such as used in NTM. However, more recent NTS research has shown a drop in trip rates since 2000 so modelling trip suppression is increasingly forming a part of newer models.

Knowing, by geographical area, the change in car vehicle km (resulting from the NTM tests for a fuel cost increase) and the change in trips by mode, the number of car trips diverted away per decrease in (thousand) car vehicle km was calculated. All trips diverted from car are allocated to the competing modes on the basis of their attractiveness and service level in the area type in question. This formed the basis for calculation of the geographically-specific modal shift diversion factors for transfer from car to each of the other modes.

In response to comments on the NTM mode diversion factors provided by Defra and DfT during the model development stage, further analysis was carried out to compare NTM elasticities to change in fuel costs with those from other WebTAG-compliant models. While the car traffic elasticity (change in car vehicle km) with respect to fuel price in the NTM is almost identical to that specified in WebTAG realism test guidance (-0.30), the response in terms of change in car person trips is far weaker than in other models due to the inclusion of a separate car passenger mode as explained below. In a model such as TfL's London Transportation Studies Model or other similar models utilised around the country, a car person trip elasticity with respect to fuel cost is expected to be approximately -0.06.

An unconventional element of the NTM is the inclusion of the option to interchange between car driver and car passenger at the lowest (most sensitive) level of the choice model hierarchy. This means that the primary response to a fuel cost change in the NTM is a switch from driver to passenger (that is, every car driver's first response is to ride as a passenger in someone else's car, and thus increase car occupancy). As a consequence the overall car person trip elasticity in NTM is very low at ~-0.02. Analysis of alternative models (and WebTAG) and literature from revealed preference analyses have provided evidence that this is too weak a value.

After discussion with DfT and Defra, and given the concerns about low implied diversion rates taken from the NTM, the number of car person trips diverted was scaled-up by a factor of 3.0 which corresponds to the level found in standard regional / urban models compliant with WebTAG. This adjustment allows retaining the additional information the NTM provides in terms of the proportions switching to different modes by area type and the consistency with other use of NTM (e.g. in the MEC methodology).

Interpretation and use of results

The Wider Impact Model provides the following results from the assessment:

- Change in number of trips per year – this provides the user with information on the change in the number of trips as compared with before the policy/measure were implemented. Change in car kilometres entered by the user are converted to change in car trips diverted to other transport modes such as walking, cycle, bus and rail.
- Total change in number of trips for the whole appraisal period – the users are provided with aggregated total number of trips for the appraisal period by different region/areas (i.e. London, inner and out conurbations, other urban and rural) from the diversion of cars to other transport modes.

Limitations

The factors derived for this method were calculated from outputs of the DfT's NTM which uses an aggregate demand model to simulate travel behavioural responses for Great Britain. In common with other models, the approach has limitations. Particular elements to note in this regard are:

- The tests used were based on responses in a forecast year (2020);
- The NTM base year and calibration is now out of date. The demand model was calibrated to a base year of 2000 using data derived from an aggregation of several years' of National Travel Survey data

spanning the late 1990s and very early 2000s. The fit to traffic levels was further calibrated to a 2003 base.

- Car km change can be caused by many factors. In this case the tests concerned the response to changes in fuel cost. While this does only impact car directly (as intended) it is essentially equivalent to a distance-based charge, rather than an area-based charge (such as the Central London Congestion Charging Scheme or a Low Emissions Zone). Thus the behavioural response to a cost increases for destination choice while retaining the car mode is primarily to reduce distance driven rather than simply change destination (as a LEZ might induce). This may cause some unreliability in the application of the method to LEZ modelling or other AQ policy policies.
- The changes in both car km and modal trips are calculated for all trips from a given area type to all destinations, rather than simply within an area type. This was the only possible approach to ensure that no suppression of trips was included in the factors (since the tests caused a change in trips between intra-area and inter-area)[7].

Nevertheless, the use of the NTM model has produced mode shift factors which are based on a much more comprehensive set of inputs than were available otherwise from a literature research. The NTM is also the source of the factors used in other impact calculations within this study as well as the official UK government National Road Traffic Forecasts and using it is therefore consistent with DfT's current Best Practice. Use of the NTM will provide consistency with other elements of the current model and with other tools used for national policy-making. A new version of the NTM is being produced which will be more fully compatible with recent developments in best practice and new guidance. We recommend that this is used to update the relevant elements of the Defra Wider Impact Model when it becomes available.

Health impacts of walking and cycling

This impact monetises the overall benefits to human health associated with increased number of people cycling and/ or walking. The method is consistent with the DfT Use of Cycle & Walking Business Case Toolkit developed by DfT.

Active forms of travel such as walking and cycling are associated with a number of health benefits including a reduced risk of premature death and prevention of chronic diseases such as heart disease, stroke, depression, dementia and cancer. The increased use of car has been a deterrent factor of walking and cycling in the UK. The lack of investment in walking and cycling infrastructure and a poor urban design has resulted in the decline of the active travel[8]. The suppression of active travel is linked with higher level of physical inactivity and sedentary lifestyles contributing to higher level of morbidity and mortality. Transport interventions have important potential impacts on health and should be taken into consideration by policy makers to promote general improvement in the quality of life and wellbeing of local populations[9].

Overview of the assessment method

The method used to assess the health impacts included in the wider impacts model is based on the most recent version of WebTAG "Investing in cycling and walking: the economic case for action toolkit", which was released by the DfT in March 2015. The WebTAG tool uses the principles developed for the Health Economic Assessment Tool[10] (HEAT) for calculating health benefits for walking and cycling. HEAT was developed by the WHO (World

[7] Other diversion factors considered for the use in the Wider Impacts model assumed a fixed suppression rate. Use of the NTM-derived diversion factors allowed setting the suppression rate to zero. This is in keeping with standard NTM and other common transport modelling practice and is therefore consistent with methods used in WebTAG and also elsewhere within the Wider Impacts model.
[8] Healthy transport=Healthy lives, British Medical Association, July 2012
[9] Devon and Torbay Local Transport Plan 2011 – 2026, Equality and Health Impact Assessment, Devon County Council, January 2011
[10] Health economic assessment tools (HEAT) for walking and cycling, Economic Assessment of Transport Infrastructure and Policies, World Health Organisation, Methods and user guide, 2014 update

Health Organisation) for use in Ministry of Health funded workshops to increase the capacity of the health sector and estimate reductions in mortality due to cycling (transportation) and walking (recreation and transportation). User inputs are usually obtained by destination based surveys, travel surveys, traffic counts, route user surveys and pedometers. There are two types of assessments when using HEAT tool:

1. Using data from a single point in time; this option is used when assessing the status quo, such as valuing current levels of walking and cycling in a city or if data on the results of an intervention only are available; and
2. Using before and after data; it is used when assessing the impact of an actual intervention or hypothetical scenarios. Pre- and post- measures are used to calculate health benefits and associated financial savings.

The wider impacts model applies the second type of assessment following the same approach as WebTAG Use of Cycle & Walking Business Case Toolkit. It is based on a reduction in the risk of dying prematurely due to physical activity and it is directly related to time cycled/walked. The assessment of the health impacts of walking and cycling consist of two modules:

- Modal shift module – this monetises the health benefits resulting from the diversion of car kilometres to trips cycled or walked as calculated in the modal shift assessment (see section above).
- Standalone assessment module – this allows the user to monetise the health benefits of other policies encouraging cycling and walking, independently from the modal shift assessment.

Assessing the health benefits of trips being diverted into cycling and walking from modal shift

In this assessment, results from modal shift appraisal are used as inputs. The model monetises the health benefits of the number of trips being diverted from cars into cycling and walking respectively. The rest of inputs (most importantly average trip length and speed) can be entered by the user. Alternatively, default values in line with those used in the DfT Toolkit apply.

The overall methodology for this impact consists of calculating the average time cycled or walked by the user as a result of the policy. A “risk reduction factor” is then applied to the number of minutes travelled. This factor considers that the risk of dying prematurely decreases proportionally to the time spent doing physical activity (i.e. number and duration of cycling/walking journeys). A different risk reduction factor is applied for walking and cycling. The application of this factor allows for an estimation of the number of lives that will be saved, which are then monetised, discounted and deflated as appropriate. Health benefits achieved by physical activity have a limit. Therefore, a cap in risk reduction is applied, following the HEAT methodology.

The approach linked to modal shift is recommended when the user wants to assess the general health benefits of a policy aimed at reducing car kilometres and when specific inputs on number of cycling and walking journeys are not available.

Assessing the health benefits of cycling and walking as a standalone assessment

These two assessments monetise the changes independently from the modal shift impact (i.e. shift from car to active transport modes). The standalone assessment calculates the health impact of cycling and walking following the same methodology as the “modal shift” module described above. The only difference is that the inputs are directly entered by the user instead of feeding from the modal shift appraisal. The standalone assessment is recommended when the user wants to assess a policy or measure targeting directly an increase in cycling and walking as transport modes, and data on anticipated number of new journeys by these modes is available.

Interpretation and use of results

The Wider Impacts Model provides the following results from the assessment:

- Impacts to society/ individual – Modal Shift approach: cycling – this provides the user with the monetised health benefits resulting from the new trips cycled as provided from the modal shift assessment only.
- Impact to society/ individual – Modal shift approach: walking - this provides the user with the monetised health benefits from the new trips walked as provided from the modal shift assessment only.
- Impact to society/ individual – Standalone approach: cycling – this provides the user with the monetised value of health impacts from cycling from the standalone assessment.
- Impact to society/ individual – Standalone approach: walking – this provides the user with the monetised value of the health impacts from walking from the standalone assessment.

The results which are linked to the modal shift assessment are a direct result of cars being taken off the road. It is based on the assumption that if a number of cars kilometres are removed, some users will turn into cycling and walking, and will experience health benefits as a result. For the standalone assessment, there is no direct relationship between the modal shift and the health impacts of cycling and walking. This approach only considers the number of journeys directly attributable to the studied policy/measure as defined by the user of the model.

Limitations

- HEAT method is likely to produce conservative estimates as it does not account for disease-related benefits.
- HEAT method does not take into consideration differences in the intensity of cycling or the possibility that less well-trained individuals may benefit more from the same amount of cycling.
- The age groups who are usually evaluated using the HEAT method are adults, mainly because the most commonly studied disease end-points such as coronary heart attack or death are rare in children.
- HEAT method should not be used in population with high physical activity levels as the result could possibly underestimate the effect in very sedentary population groups.

Greenhouse Gases

The wider impacts model monetises the impact on greenhouse gases as a result of change in energy consumption or vehicle kilometres. The method developed to assess this impact follows DECC's supplementary Green Book guidance and toolkit for quantifying and valuing changes in GHGs as well as energy use in policy appraisal[11]. Introducing new air quality policies may result in changes to energy use and greenhouse gas (GHG) emissions. Generally the impacts of such policies are considered beneficial i.e. a measure designed to reduce air pollutants may also reduce GHG emissions and energy use (and vice versa for climate mitigation policies). For example, low emission zones or measures driving modal shift from road transport to cycling will reduce both types of emissions. However this is not always the case, such as some measures that may result in an increase of GHG emission (e.g. introduction of end-of-pipe abatement to reduce NO_X and primary particulate matter (PM) emissions may be associated with a fuel penalty and hence lead to an increase in GHG emissions). There will be occasions where trade-offs may exist.

Overview of the assessment method

The assessment method quantifies and values the net change in GHG emissions resulting from the implementation of air quality measures. It incorporates the valuation of the net change in energy use as well as of any primary rebound effects that might occur (i.e. in the case of energy efficiency policies). It provides additional tools to

[11] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

conduct sensitivity analysis for different scenarios and to assess the cost-effectiveness of measures in terms of carbon and energy.

The model quantifies and monetises the net change in GHG emissions resulting from net changes in energy use where these energy changes have been quantified. For other measures (e.g. related to industrial process emissions) the method only allows monetisation of emissions if these have been quantified by the user and entered to the model.

The method developed follows DECC's supplementary Green Book guidance and toolkit for quantifying and valuing changes in GHGs as well as energy use in policy appraisal[12]. The inputs for the assessment have been revised compared to the original DECC's toolkit, in order to align them with the inputs required for assessment of other impacts, and to improve the method's applicability to air quality measures. Further functionality has been added by incorporating a wider range of conversion factors[13]. The module to value air quality impacts originally present in DECC's toolkit has been excluded from the method as detail assessment of this impact can already be undertaken by Defra using other models.

Assessing the net change in energy consumption

Net changes in energy consumption are first converted to kWh or litres from user inputs before they are monetised. The long-run variable costs of energy supply (LRVCs) are applied to the quantified net changes in energy use. The monetised value of energy change is discounted and deflated.

Assessing the net change in GHG emissions

The net change in energy is quantified into CO_2e using emission factors. The change in CO_2e is then monetised using traded and non-traded carbon prices, depending on whether the net change in energy has occurred in a traded or non-traded sector. The monetised GHG emissions are then discounted and deflated.

Assessing the rebound effects

Potential scale of the rebound effects has to be entered by the user of the model. Rebound effects are first converted to kWh or litres before being monetised using projected retail energy prices. The monetised rebound effects are then discounted and deflated.

Interpretation and use of results

The Wider Impact Model provides the following results from the assessment:

- Net carbon emissions in ktonnes CO_2e – this gives users information on the total change in net carbon emissions per year, distinguished between traded and non-traded sectors, transport, non-fuel emissions and total quantities of CO_2e.
- Discounted monetised value of carbon emissions – referring to the net carbon emissions calculated previously, the carbon emissions are then monetised and discounted as appropriate to provide yearly values.
- Discounted monetised value of change in energy consumption – referring to the net change in energy consumption calculated in the model. Monetisation of changes in energy consumption is only available for major fuel types and vehicles.
- Discounted monetised value of rebound effects – the rebound effects are considered to have the opposite sign of the assessed policy (i.e. if the policy reduces energy consumption, rebound effects

[12] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal
[13] Conversion factors extracted from Defra's Greenhouse Gas Conversion Factor Repository: http://www.ukconversionfactorscarbonsmart.co.uk/

will be considered as cost; if the assessed policy increases consumption, rebound effects will be considered as benefits).

- Total monetised impact – All monetised impacts for the change in GHG emissions, energy consumption and rebound effects are aggregated showing the total impact per year expressed as Net Present Value.

Valid conclusions on whether a measure leads to a net change in emissions or provides good-value for money need to be based on the full appraisal of energy and emission changes, including those emissions that result from non-fuels. Therefore, when valuing the outputs the user should critically assess the significance of any changes that have not been considered within the model.

Limitations

- Outputs contain some level of uncertainty; in part due to the uncertainties associated with the following fixed inputs:
  - Carbon and fuel price estimates.
  - Estimated changes in net energy use.
  - Quantification of GHG emissions resulting from non-fuel changes.
  - Estimation of rebound effects.
- The method is restricted to identify changes in energy consumption as a result of a policy, and how this is reflected in changed GHG emissions. Changes related to non-fuel GHG emissions (e.g. formation of CO_2 through use of limestone in wet scrubbing) are not captured in the methodology. The change in the level of non-fuel GHG emissions will be variable depending on the technology or measure used and the sector to which it applies (i.e. how this leads to changes in process emissions). A bespoke quantification on the basis of specific evidence would therefore be more suitable than the use of a generic model, results of which would involve high levels of uncertainty. If data on net changes in non-fuel GHG emissions are available, the user of the model will be able to input them so that they are valued alongside energy related GHG emissions.
- The model is not designed to calculate the embedded carbon associated with policies (unless the net energy change accounts for this) due to the high levels of uncertainty associated with such assessments and low availability of data on materials used.
- Monetisation of change in energy consumption is limited to major fuels (gas, oil, coal and transport fuels). This is due to the absence of energy price projections for minor or uncommon fuels.

Affordability for business

The wider impacts model quantifies the impact on business affordability as a result of additional costs of compliance with the policy under assessment. The approach used in this model is based on cost ratios in line with EU Commission Impact Assessment guidelines.

Air quality measures can imply costs on businesses in several ways, e.g. through the need to purchase low emission vehicles, retrofit equipment, etc. This can impact businesses differently depending on the economic sector and business size. Particular challenges may concern small and medium enterprises (SMEs) and/or businesses with limited or no ability to pass on additional costs to downstream users or consumers. In practice, a company's behavioural response to new air quality measures could range from a combination of passing on the costs of regulation in full through prices, implementing cost reduction measures, raising productivity or accepting reductions in margins.

SMEs may lack the resources and scale to absorb costs and/or make the necessary capital expenditure, hence they can be disproportionally affected by new policies. The Better Regulation Framework Manual (BIS, June 2013) requires that all new regulatory proposals are designed and implemented in a manner that aims to mitigate disproportionate burdens among SME businesses. Similarly, the EU Commission's guidelines on Impact Assessment (2009) require that impact assessments "analyse whether SMEs are disproportionately affected or disadvantaged compared to large companies". Annex 8.4 of the latter provides guidance on the recommended method to assess distributional impacts on businesses. It notes that a quantitative analysis of the distribution of the potential costs of a given policy with respect to the business size could be done by using cost ratios; for example comparing costs identified to the total company (or relevant product line) turnover.

Overview of the assessment method

The primary method for estimating the impacts on business affordability of the potential future policy interventions is based on the relationship between additional costs to businesses and their capacity to cope with these costs.

The approach used in this model for both the "affordability" and "distributional" impact is based on cost ratios (in line with EU Commission Impact Assessment guidelines). In this context we define "affordability" as the ability of a business to meet the costs resulting from a given policy without incurring financial difficulties. This is assessed by comparing the policy cost against an indicator of the level of financial resources available to the business.

The chosen indicator is the Gross Operating Surplus (GOS). GOS is the capital available to incorporated companies which allows them to repay their creditors, to pay taxes and eventually to finance all or part of their investment[14]. The Office for National Statistics defines operating surplus in its glossary as "the balance on the generation of income account. Households also have a mixed income balance. It may be seen as the surplus arising from the production of goods and services before taking into account flows of property income"[15]. Furthermore the ONS data source[16] describes gross operating surplus/mixed income (GOS/MI) as: "includes profits, non-market capital consumption and holding gains as well as self-employment and rental income".

Considering that GOS can be used for financing investment, it is therefore a relevant indicator as to how much money a business has available to face an increase in costs before capital charges. Following other precedents[17], we therefore use it as the default metric for assessing the economic impacts of a proposed measure on businesses. While it is not a perfect proxy for company's robustness to costs of new policies, it is the best available and consistent statistic found as part of this project, which helps to judge the likely liquidity available to firms for dealing with increased costs. Differences in sectors structure are also considered. In order to account for distributional effects, and to allow assessment of potential impacts on SMEs, the assessment considers different size of businesses. Data has been extracted from two official sources at UK level. These are the Department for Business Innovation and Skills (for business numbers and turnover), and the Office of National Statistics for the GOS.

In order to assess affordability on business, the user is required to input the total annualised cost to business, per sector and business size, from the implementation of the policy. This is then compared to average GOS per business in a given sector and for a given business size. The resulting cost ratio is compared to four different thresholds that can be specified by the user of the model. The application of thresholds allows the model to calculate a number of businesses potentially affected by the policy above the specified levels.

[14] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Gross_operating_surplus_(GOS)_-_NA
[15] http://www.ons.gov.uk/ons/rel/naa1-rd/united-kingdom-national-accounts/the-blue-book--2013-edition/glossary.html
[16] ONS, Gross Operating Surplus/Mixed Income of the UK (2012), by industry section, showing self-employment and rental income components
[17] See section 7 of the Impact Assessment of the Transposition of Articles 14(5)-(8) of the Energy Efficiency Directive (2012/27/EU) undertaken for DEFRA:
http://www.doeni.gov.uk/defra_uk_wide_regulatory_impact_assessment_on_the_energy_efficiency_directive.pdf

Interpretation and use of results

The Wider Impact Model provides the following results from the assessment:

- Comparison of cost as proportion of GOS and affordability threshold – this provides information to the user on the level of financial resources available to the business.
- Cost as percentage of GOS for businesses unable to pass costs – this provides information on the proportion of businesses **unable** to pass costs.
- Cost as percentage of GOS for businesses able to pass costs – this provides information on the proportion of businesses **able** to pass costs.
- Number of businesses unable to pass costs – this quantifies the total number of businesses **unable** to pass costs from the implementation of the policy/ measure.
- Number of businesses able to pass costs – this quantifies the total number of businesses **able** to pass costs from the implementation of the policy/ measure.
- Number of businesses with significant impact – provide the final output of total number of businesses that will be significantly impacted by division/size in the uncertainty scenarios under each of the affordability thresholds. This is done by comparing cost (as a proportion of GOS) for each size category with the thresholds.
- Percentage of businesses with significant impact – this provide the user with the proportion of impacted businesses compared to the total number of businesses in that division/size for the central scenario using each of the thresholds.

Limitations

- The tool for this impact can handle a maximum of 94 rows, that is, unique combinations of industry division and sizes. If the user selects divisions and business size categories in excess of 94, s/he will need to split the assessment in two different files and merge the outputs separately.
- The default thresholds in the model has been used to provide the user with a range of possible impacts. The thresholds are not supported by evidence found in the literature or through direct liaison with businesses. Determination of what is considered “affordable” for a business is dependent on the economic activity of the business and its size. It is advisable that in order to obtain results specific for a given sector affected by the policy, the affordability thresholds are determined by the users through industry surveys or defined on the basis of previous studies.
- The tool can provide the number of businesses that would be impacted and an estimation of the degree of this impact at division and business size level. However, in reality different businesses within the same division and size will be impacted to a different degree. This level of details could not be captured by the generic modelling undertaken in the wider impacts tool.
- For some business sectors, publicly available data from the fixed inputs is limited, being sometimes not disclosed and marked as confidential.

Employment

The wider impacts model quantifies the impact on employment of additional costs of compliance, resulting from a given policy measure. No existing studies or guidelines were found to provide a methodology that could be directly replicated. A simplified, bespoke method[18] was therefore developed for the Wider Impacts Model.

[18] Based on the DWP (2010) Impact Assessment of Workplace Pension Reform

Employment is one of the key measures of the economic impact of a policy intervention. According to the HM Treasury Green Book, assessment of employment impacts is required when a policy considered is likely to have an impact on the supply-side. Potential new air quality measures can impact employment by either increasing or decreasing the number of jobs, by moving jobs from one sector of the economy to another (an effect called displacement) or from one location to another (an effect called relocation). In practice, a company's behavioural response to new air quality measures could range from a combination of passing on the costs of regulation in full through prices, implementing cost reduction measures, raising productivity or accepting reductions in margins. As a result, the net employment impact of environmental regulations can be minor.

Overview of the assessment method

Assessment of net employment impacts in quantitative terms, spatially and by sector, requires the use of macro-economic models. These models are capable of addressing legislative proposals and assessing impacts at regional and national scale. Simpler approaches are used to assess impacts of projects on employment, for example as part of the socio-economic impact assessments for new construction projects (in the context of air quality these could be for example new wind farms). These often assess supply chain impacts using multiplier analysis and are preceded with detailed reviews of the labour market in the impacted areas.

Given the complexities of the methodologies to assess potential impacts of environmental regulation on employment, and lack of specific UK Government guidelines on the potential methods to be used, a simplified method was proposed for the inclusion in the Wider Impacts Model. Because the model is intended to serve as a tool for initial assessment of the scale of potential impacts, the assessment method was developed to assist the user in answering the following questions:

- *How labour intensive are the industries affected by the air quality measures?* Answer to this question is informed in the Wider Impacts Model by calculation of "Labour cost as a share of total turnover (%)".
- *How many jobs could potentially be affected if the businesses in these sectors face an increase in production costs?* Answer to this question is informed in the Wider Impacts Model by a calculation of "Equivalent number of jobs".
- *How many jobs would be at risk (i.e. could potentially be lost), if the businesses are forced to cut jobs in light of the disproportionate increase in production costs?* Answer to this question is informed in the Wider Impacts Model by a calculation of "Number of jobs potentially lost".

The methodology used in the model to answer the above questions, and calculate associated metrics, is closely linked to the assessment of affordability for business. The two primary sources of underlying data for the assessment are:

- Office for National Statistics, 2013, Annual Business Survey (2013 Provisional Results).
- Department for Business Innovation and Skills, October 2013, Business Population Estimates for the UK and Regions.

Labour cost as a share of total turnover (%)

This is a measure of labour intensity of the sector and is calculated by dividing total employment costs by total turnover in the sector. Both figures are sourced from the Annual Business Survey published by Office for National Statistics (reference year 2013).

Assessing equivalent number of jobs

Assessment of the equivalent number of jobs is undertaken separately for businesses that are able to pass on costs to their customers (thus face reduced impact on their affordability) and for businesses that are unable to pass on costs. Businesses that can pass a share of their costs on to their customers are expected to be less affected by the compliance costs of a new policy, hence the potential employment impacts for these businesses is expected to

be lower compared to businesses unable to pass on the costs. The "equivalent number of jobs" has been selected as an indicator to provide a potential scale of the impact on employment. The first step of the calculation divides the annualised cost of compliance of the policy measure per business (user input to the model), by the total cost to business of employing one employee[19]. The resulting figure provides a high-level estimate of the number of potential jobs that can be lost/gained or moved across the sector due to compliance costs in a given sector.

Assessing potential jobs lost

Assessment of the number of jobs likely to be lost as a result of increased productions costs of a policy is undertaken separately for businesses that are able to pass on costs to their customers and for businesses that are unable to pass on costs. As explained above, it is expected that potential employment impacts will be lower for businesses able to pass on a share of their costs to customers.

In this method it is assumed that all compliance costs of the policy will directly translate into an increase in non-wage labour costs.). The elasticity of labour demand to changes in non-wage labour cost of -0.5 is assumed. This implies that 1% increase in labour costs will result in 0.5% fall in employment. The figure for elasticity of labour demand has been previously used in DWP (2010) and considering all the limitations described below, has been agreed with Defra to be an approximate but appropriate method to calculate upper bound (worst case scenario) impact on employment in the Wider Impacts Model.

The percentage change in non-wage labour costs is calculated by dividing total annualised compliance cost per business (user input) by total employment cost per business at a size level[20]. The resulting change in non-wage labour costs is then halved (because of the elasticity of labour demand of -0.5) to obtain the potential percentage change in employment figures. This percentage is then applied to the total number employees in a given sector to provide total number of potential jobs lost in sectors affected by the policy.

Interpretation and use of results

The model generates two sets of results, which are not directly comparable with each other because they are calculated using two different methods:

- "Equivalent number of jobs" provides the number of jobs the additional compliance costs are equal to by simply comparing an additional cost to business as a result of the policy with the average employment cost in a given economic sector.
- "Number of jobs potentially lost" is based on the assumptions that if faced with extra compliance costs, employers will decide to cut jobs. Hence the figures presented show the worst case scenario.

The results of the employment assessment obtained from the Wider Impacts Model should be interpreted with caution. The model provides only theoretical set of values to inform users' thinking on what the potential impacts might be. In reality, the impacts of environmental policy on employment may be significantly lower.

"Labour cost as a share of total turnover" is provided solely to inform the user of the model on how labour depended businesses are in a given sector. The measure of "equivalent number of jobs" does not take into account how various businesses would respond to the increased production costs and hence it is likely to significantly overestimate the real impacts. Similarly the "number of potential jobs lost" provides the worst case scenario for potential employment impact. Both results should be therefore interpreted as upper bounds of potential impacts, and should only be used as a first indication on whether compliance costs to business may lead to negative impacts on employment. This should be followed by detailed assessment of employment impacts in the likely affected sectors, which should in addition consider potential benefits on employment from the policy.

[19] Derived for each sector by dividing 2013 values of the total employment costs per each economic sector, by the average number of employees in the sector during the year; both from the ONS, 2013, Annual Business Survey.
[20] Derived using ONS (2013) total employment cost and BIS (2013) data on the number of businesses and total number of employees per size of business

Limitations

The method applied in the Wider Impacts Model has the following limitations and uncertainties:

- The tool can provide the number of equivalent jobs in affected sectors that would be impacted and an estimate of the number of jobs lost. However, in reality different businesses within the same division and size will have employment impacted to different degrees, which cannot be captured in the model.
- The underlying employment and turnover data from BIS provides information on employment in businesses classed as “No employees”. Examining the data demonstrates that employment figures are generally greater than the number of businesses in that category across the sectors. This suggests that businesses in this size category have at least one employee (presumably reflecting self-employment or one or more owners). For that reason, assessment of the impact on employment includes impacts on companies categorised as “No employees”. If the user of the model wants to exclude these companies from the assessment, zero cost to business for that business size category should be entered in the model.
- There is no evidence of applying the elasticity of labour demand to changes in non-wage labour costs in the context of environmental legislation. Furthermore, despite use of an elasticity figure for the purpose of calculations by DWP in the Impact Assessment of Workplace Pension Reform (2010), results of the consultation supporting the Impact Assessment state that only 7% of employers affected would consider absorbing costs through restructuring its workforce. The calculations made in the model do not consider potential responses by businesses to increased productions costs (other than passing costs onto customers which is a user input of the model).
- No consideration is given to displacement and hence the model does not attempt to calculate net employment effects.
- The method does not assess the impacts further down the supply chain for the affected sectors.
- It focuses solely on cost to business and not on potential employment benefits that can be gained in the economy.

Affordability for individuals

The wider impacts model quantifies the impact on households’ disposable income (for households in each income quintile) as a result of additional costs of compliance with the policy under assessment. The methodology used is a modified approach presented in the Centre for Sustainable Energy and Association for the Conservation of Energy (2010) Distributional Impacts of UK Climate Change Policies.

This impact investigates the affordability of a policy to households of different incomes: the direct financial impact of the proposed policy upon a household. It incorporates both the anticipated costs and the benefits of the policy for households in different income quintiles. An understanding of affordability is important to any policy analysis, since the economic implications faced by householders will be central to a policy’s economic and social justice, and therefore its public and political acceptability.

Overview of the assessment method

Central to the investigation of affordability is an appreciation of the distributional impacts of a policy. The costs and benefits of a policy will be borne to differing extents by different people, depending upon a variety of characteristics which influence their response to the policy. In the Wider Impacts Model the distributional impacts of a policy are assessed using differences in households’ income. The model covers only direct costs and benefits for households, through looking at changes in consumption levels, changes to prices and the affordability of capital expenditure required to comply with the proposed policy. The method in the model has been designed to assess affordability of transport related interventions (e.g. scrappage scheme or increase in price of transport fuel or cost of public transport) and domestic related interventions (e.g. energy efficiency measures, increase in prices of

domestic fuels). While the method does not directly replicate methodology applied in other assessment tools published by UK Government Departments, it has been based on the methods used in the DIMPSA model[21] and the WebTAG Distributional Impact Appraisal guidance[22].

Assessing impact on households from transport related interventions

Impact on households' affordability for transport related interventions is calculated based on the user inputs of annual change in kilometres travelled by car, annual change in number of trips using public transport, annual change in transport fuel costs and annual change in costs of public transport. The method first calculates counterfactual travel expenditure on a typical household for each income quintile, by transport mode and year of the assessment. The scenario travel costs (i.e. cost of travel after the policy is implemented) are calculated using user inputs provided. For each income quintile the total change in expenditure per household compared to counterfactual is calculated by summing up the changes in expenditure for each transport mode.

The total change in household expenditure between the scenario and counterfactual costs is then calculated and compared against:

- Counterfactual costs – according to WebTAG[23] any change in travel related expenditure greater than 10% relative to counterfactual is considered significant for household's expenditure;
- Average disposable income per household per income quintile – this information is taken from the Office for National Statistics, Family Spending Survey 2014.

In addition a dedicated function to calculate impact of household's participation in a car scrappage schemes on their affordability has been built into the model. This assumes that households participating in the scheme will not face the full capital costs of purchasing a new vehicle, but only the difference in costs as a result of accelerating the purchase of new vehicle. This is done by comparing the age of the car to be replaced with the assumed lifespan of a car.

Assessing impact on households from domestic related interventions

The impact on households' affordability for domestic related interventions is calculated based on the user inputs of annual change in energy consumption and annual change in price of domestic fuels (electricity, gas, coal and oil). The method first calculates counterfactual household's energy expenditure for a typical household for each income quintile, by type of fuel and year of the assessment. This considers the differences in energy mix and fuel consumption patterns for different income quintiles. The scenario energy expenditure is calculated using user inputs provided. For each income quintile the total change in expenditure per household compared to counterfactual is calculated by summing up the changes in expenditure for each domestic fuel.

The total change in households' expenditure between the scenario and counterfactual costs is then calculated and compared against:

- Counterfactual costs – unlike for the assessment of transport related measures, no guidelines have been identified providing a threshold for what level of change can be considered significant for household's expenditure.
- Average disposable income per household per income quintile – similar to the transport related assessment, this information is taken from the Office for National Statistics, Family Spending Survey 2014.

In addition the model is able to assess the impact of capital cost expenditure (e.g. costs of insulation, new boiler, microgeneration etc.) on average household per income quintile. When entering the estimated capital cost per

[21] Distributional Impacts Model for Policy and Strategic Analysis, maintained by CSE
[22] Department for Transport, 2014, TAG UNIT A4.2, Distributional Impact Appraisal, January 2014
[23] Department for Transport, 2014, TAG UNIT A4.2, Distributional Impact Appraisal, January 2014

household, the user can also specify the number of years over which the capital costs would be incurred. This may be useful when assessing schemes designed to have a transition period before the full compliance has to be achieved.

Interpretation and use of results

The Wider Impact Model provides the following results from the assessment:

- Change in travel expenditure per average household in each income quintile – this provides the user with information on the absolute change in 'transport" expenditure after the implementation of the policy/ measure in each year of the appraisal period.
- Percentage of change in travel expenditure relative to disposable income – this provides the user with information on the change in transport expenditure relative to average disposable income per household in each income quintile.
- Transitional cost for households in transport (i.e. scrappage scheme) – all transitional cost due to scrappage scheme is assumed to occur in the first year of the policy.
  - Average additional cost due to early purchase, per income category in NPV – these values represent only the additional cost associated with the early purchase of a car as a result of a scrappage scheme.
  - Weighted cost as percentage of annual household disposable income.
  - Total capital investment in NPV – these figures are the result of summing the cost associated with early buying plus the cost of the car (excluding any benefits or incentives).
  - Weighted cost as percentage of annual household disposable income.
- Change in domestic energy expenditure per household in each income quintile – this provides user with information on the absolute change in "domestic" expenditure after the implementation of the policy/ measure in each year of the appraisal period.
- Percentage of change in domestic expenditure relative to disposable income – this provides user with information on the change in domestic expenditure relative to average disposable income per household in each income quintile.

The results of the assessment are presented per "average household" per income quintile. When assessing transport related interventions, "average household" in the model is assumed to travel by petrol and diesel car, and use all types of public transport. In the underlying data the actual travel patterns for households in a given income quintile are averaged out across the sample. In reality, it is expected that some households will not own the car, or will only own a petrol or a diesel car. It is also possible that some households do not use public transport at all or rely only on one mode of public transport (e.g. rail) rather than both rail and bus. In case of domestic interventions, the average household in the model is assumed to use electricity, gas and other fuels for the purpose of space and water heating. In reality, it is expected that some households will only rely on a single energy source (e.g. electricity only) or on two (e.g. electricity and gas).

The concept of an "average household" in each income quintile reflects therefore an average behaviour of households in a given income quintile, rather than behaviour of a single household with specific characteristics. Therefore in cases of some households, the impact on the affordability would be underestimated (e.g. in case of a household owning more than the average number of cars in a given income quintile), while in case of other households, they would be overestimated (e.g. in case of a household not owning a car). This should be considered when interpreting the results of the assessment.

The results of the model provide initial indication on whether households in any specific income quintile would be disproportionally affected by the policy. Should this be the case, the more detailed assessment of the distributional impacts of the policy should be undertaken.

Limitations

The method applied in the Wider Impacts Model has the following limitations and uncertainties:

- The method used has been developed specifically for the purpose of the wider impacts model. While the comparison of scenario and counterfactual costs forms core of methods used in other tools assessing distributional impacts on households (e.g. DIMPSA model), the method is not directly comparable with methods used elsewhere.
- The results of the assessment present possible impact on the average household in each income quintile – the concept of average household has been described above. As such, real impacts across households in a specific income quintile may be higher or lower than presented by the model results.
- The model takes into consideration differences between income quintiles (e.g. in average car ownership, average consumption of energy, average use of public transport) however it does not provide further disaggregation of the results on specific user groups within a given income quintile (e.g. households with or without a car, households using gas for space heating, households using electricity for space heating etc.). The results of the model should therefore be primarily used for screening to establish whether distributional impacts of the policy assessed should be investigated in more detail.

5. Model development

This section provides an overview of the model and accompanying documentations

5.1 Overview of the model and accompanying documentation

Model

The schematic diagram presenting key elements of the model is illustrated in Figure 5.1. The model is a spreadsheet based model. It was developed in Microsoft Excel 2013 and is contained within a single file with no interlinked spreadsheets.

The model contains a number of Control sheets in which the user enters input data specific for the policy assessed or selects options from drop down lists. For the majority of the impacts, there are dedicated Control sheets developed in the model. That is because there is generally little overlap between the user inputs required for the assessment of individual impacts and for some impacts there are a large number of input parameters required. The Control sheets are the main interface for the user.

There are subsequent data sheets containing fixed inputs. These should be updated by the user when updated underlying data sets are published. A Reference sheet provides a list of all the reference sources and weblinks of the fixed input data to assist the user for this updating process. Several fixed inputs for the calculations have been provided by Department for Transport for the purpose of the model specifically. These sources are not expected to be available in the public domain in the future and as such the ability for the user to update them will rely on obtaining the data from DfT or other relevant stakeholders. Inputs for which this is the case have been clearly indicated in the model.

Both the user-defined and the fixed inputs tables require entry of data in the appropriate units, format, year etc. as per the headings and labels. Often the user is given flexibility of choosing from a selection of units when entering the inputs

Calculations for the assessment of each impact are each presented in a separate sheet. There is little interaction between different impacts and so calculations are performed independently. An exception is modal shift which is linked to health impacts of walking and cycling. Data from the Control and Inputs sheets are imported into the Calculation sheets, as relevant for the assessed impact, based on the options selected in the Control sheets. The next steps calculate the quantified values and then (where applicable) monetise these values, in accordance to the methods specified in the Technical Specification.

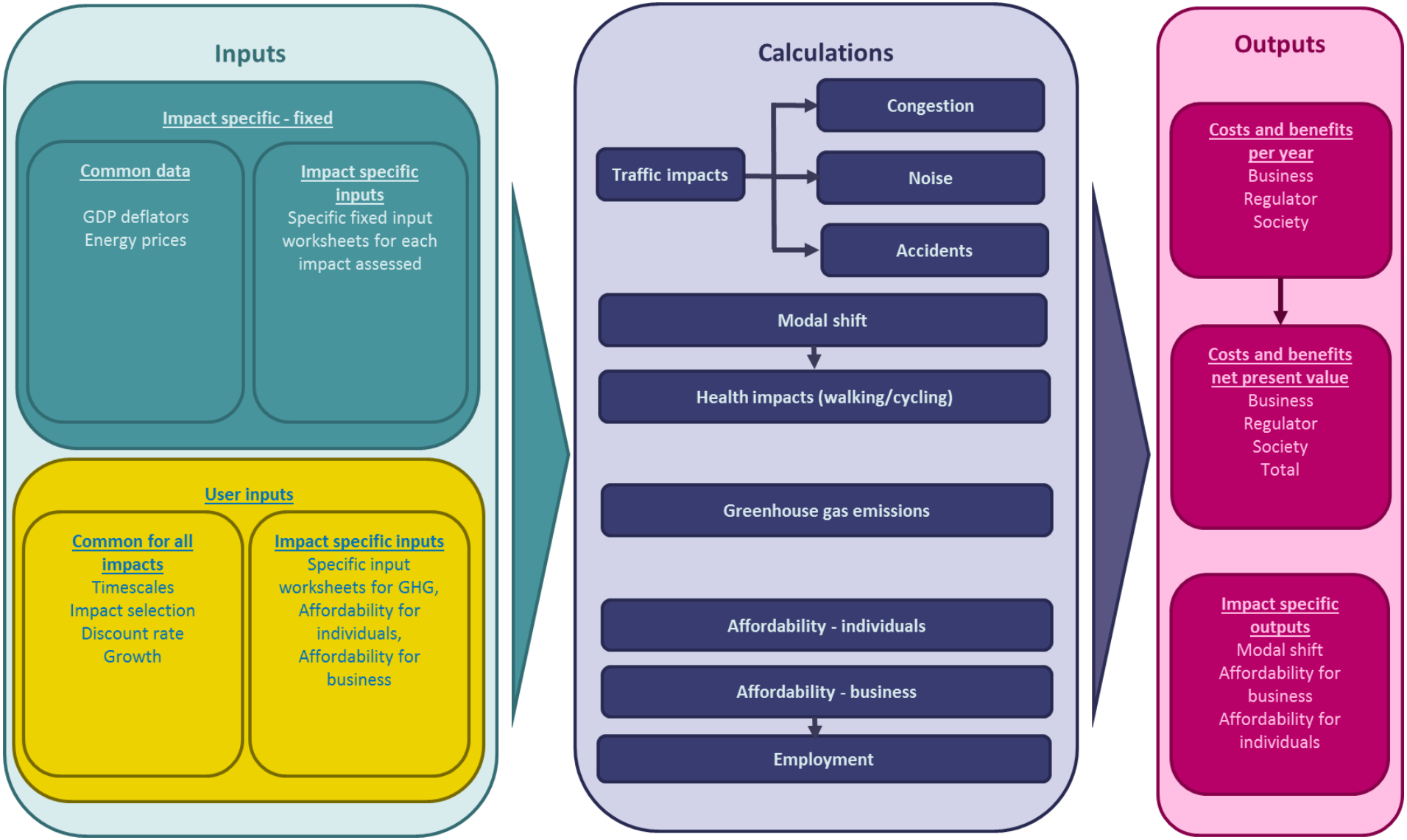
Intermediate outputs are presented for each impact separately showing the transitional and recurring costs and benefits for most impacts. This is to allow the user to extract these data, and when relevant add them to equivalent data on costs of other direct or indirect impacts which may be estimated using bespoke methods outside of this model. For certain impacts it is not possible to monetise the impact and therefore alternative, appropriate presentation of quantified impacts is presented. This is discussed in sections on individual impacts below.

A summary of the output costs and benefits, or other numerical results, for each impact are presented in a single "Results summary" sheet so the user can see each of the impacts that are relevant for the measure assessed[24]. For impacts for which monetisation is possible, the net present value (NPV) of the costs for each impact is calculated and presented using a consistent approach to the Impact Assessment Calculator (BIS, 2013). Each

[24] The costs are not summed up to avoid misleading a user into thinking that these costs are the total costs from all wider impacts. There are several impacts for which it has not been possible to develop a generic method to estimate the costs and in a regulatory impact assessment, depending on the policy lever under consideration, these costs may need to be calculated by other means.

impact is expected to affect different sectors of society (e.g. while impact on GHG will affect the whole society, impacts on affordability for businesses will affect businesses). In the Control sheet, the user has the option to select different discount rates and assessment periods to suit the purpose of the appraisal.

Figure 5.1 Structure of the Wider Impacts Model



User guide

The User Guide was developed to explain the functionality of the modelling tool as a step by step guide for an unfamiliar user. It guides the user on which inputs need to be entered and options that can be selected, explains the basis and source for the fixed input parameters and explains the output results that are produced. It also includes an appendix with a series of case studies, their inputs and associated outputs to serve the user as examples. This User Guide does not go into the details of the assessment methodology or provide information on the formulas used in the model.

Technical specification

A technical specification of the modelling tool was developed. This document describes in detail the methods used for the calculation of the impacts, as well as assumptions, limitations and uncertainties. The explanations in the document highlight which parts of the model relate to each aspect of the method. This document intends to facilitate future developments and updates to the model.

5.2 Testing

Two rounds of model testing were conducted. The objective of the first round was to identify any major methodological flaws, technical issues associated with the model design including individual inputs, calculations and outputs for each impact, and to evaluate overall user experience and how it can be enhanced. Following the first round of testing, a list of potential changes and improvements to the model was developed. Priority was given to issues which directly affected the appropriateness and accuracy of the results obtained.

Once necessary changes had been applied, the tool was presented to Defra and a workshop was organised with potential users of the tool. The aim of this workshop was to gather feedback on the functionality of the tool and agree on the final improvements to be made to the model. After applying improvements agreed with Defra, a second round of testing was conducted. The aim of the second round of testing was to review the impacts of the changes made following the first round, assess the robustness and functionality after applying the improvements suggested by Defra following the workshop and check whether the most critical issues had been resolved. Special attention was paid to those impacts that have been significantly modified and to those that showed major issues in the first round (i.e. GHG and affordability for individuals).

Whenever possible, the agreed case study inputs were used for the second round of testing, including the validation of the tool against other equivalent models (i.e. DECC's GHG assessment toolkit and WebTAG "Investing in cycling and walking: the economic case for action toolkit"). For impacts where direct comparison of results with results of assessments done outside of the tool was not possible, a theoretical set of inputs was used for testing. Example inputs for the testing and the associated outputs from the model has been included in the appendix to the user guide in order to provide the user with real life examples of working with the model.

No major issues were identified during the second round of model testing. Minor comments regarding technical issues and formatting were addressed. Detailed information on the testing methodology and testing results is available in Appendix D.

5.3 Quality assurance

As detailed in the quality assurance plan (Appendix C) Defra's and in-house best modelling practices have been applied through the whole model development process. This included use of colour coding, detailed logging of major changes and reviews, appropriate review at key milestones and fluent feedback between Defra, the developers and the wider project team.

The model was subject to regular QA at relevant steps. Following the development of each impact, the model was subject to an internal review from the developer of the model and additional review from an analyst not involved in the development of the tool. The aim was to ensure that the relevant calculations have been correctly entered into the model and to sanity check the results. Every impact within the tool has therefore been subject to several reviews in accordance with the QA plan.

QA was done using a standardised log which details the parameters and aspects of the model that need to be checked. Following every review, a list of issues was recorded and addressed by the modelling team. All major changes and reviews are recorded in the front page of the model, allowing for an easy traceability. Copies of the model have been saved at all stages of development, particularly before major developments, reviews and submission. Full log of QA results has been provided to Defra together with the model.

Appendix A
Literature register

No.	Document title	Year	Author
1	Measuring the economic impact of an intervention or investment; Paper One: Context & rationale	2010	Office for National Statistics
2	Measuring the economic impact of an intervention or investment; Paper Two: Existing sources and methods	2010	Office for National Statistics
3	A Rapid Evidence Assessment evaluating the impact and implementation of complex environmental policies on complex systems	2014	Watson, B., Watson, T., Elliott, B., Vanner, R., Shaw, B. and Morris, S
4	Valuing Environmental Impacts: Practical Guidelines for the Use of Value Transfer in Policy and Project Appraisal	2009	Eftec
5	Additionality guide: A standard approach to assessing the additional impact of interventions	2008	English Partnership
6	Valuation of energy use and greenhouse gas (GHG) emissions for appraisal	2014	DECC
7	Assessing the costs and benefits of regulation	2013	CEPS
8	The Department for Work and Pensions Social Cost- Benefit Analysis Framework; Methodologies for estimating and incorporating the wider social and economic impacts of work in Cost-Benefit Analysis of employment programmes	2010	Department for Work and Pensions
9	The wider impacts of rail-based transport investment on urban and economic development	2014	Sintropher
10	Developments in the Appraisal of Transport Infrastructure Investments in the UK and other European Countries and in its Influence on Decisions	2014	Sintropher
11	International Comparisons of Transport Appraisal Practice	2013	Institute for Transport Studies
12	Completing competition assessments in Impact Assessments: Supplementary guidance to the Green Book	2007	Office for Fair Trading
13	Update of the Handbook on External Costs of Transport	2014	Ricardo-AEA Report for the European Commission
14	Measuring innovation: the European Innovation Scoreboard	no date	Hugo Hollanders
15	Guidance on the preparation of socio-economic analysis as part of an application for authorisation	2011	ECHA

No.	Document title	Year	Author
16	Reference Manual for the Integrated Assessment of Trade-Related Policies	2001	UNEP
17	Handbook for Trade Sustainability Impact Assessment	2006	European Commission
18	A guide to competition screening	no date	European Commission
19	Competition assessment toolkit	2011	OECD
20	Better Regulation Framework Manual: Practical guidance for UK officials	2013	Department for Business Innovation and Skills
21	The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK	2012	Department of Energy and Climate Change
22	Final Stage Impact Assessment for the Green Deal and Energy Company Obligation	2012	Department of Energy and Climate Change
23	The Future of Heating: A strategic framework for low carbon heat in the UK	2012	Department of Energy and Climate Change
24	Community Energy Strategy	2014	Department of Energy and Climate Change
25	Domestic Renewable Heat Incentive Impact Assessment	2013	Department of Energy and Climate Change
26	Policy impacts on prices and bills	2013	DECC
27	Air Quality and Climate Change: Integrating Policy within Local Authorities	2011	Environmental Protection UK
28	Review of Effectiveness of Local Authority Action Plans and Future Policy Options for LAQM	2013	Air Quality Consultants (for Defra)
29	Healthy Transport = Healthy Lives	2012	British Medical Association
30	Emission factors 2009: Final Summary Report, Boulter et al	2009	TRL (for DfT)
31	Review of Bus Fleet Compositions and Implications for Emissions Reduction Strategies	2009	Air Quality Consultants
32	Handbook on estimation of external costs in the transport sector, Produced within the study Internalisation Measures and Policies for All external Cost of Transport (IMPACT)	2008	CE Delft

No.	Document title	Year	Author
33	Powering Ahead: How to put Electric Vehicles on Scotland's Roads	2012	Jane Robinson, Dr Sam Gardner
34	Local Measures for NO_2 Hotspots in London	2010	Air Quality Consultants, TRL (for TfL)
35	TAG UNIT A2.1 Wider Impacts	2014	DfT
36	WebTAG: Economic impacts worksheets - Wider impacts dataset	2013	DfT
37	WebTAG: Economic impacts worksheets - Functional urban regions lookup workbook	2013	DfT
38	Transport, Wider Economic Benefits, and Impacts on GDP	2005	DfT
39	Transport and the Economy: Full Report (SACTRA)	1999	DETR
40	Guidance on Preparing an Economic Impact Report	2003	DfT
41	The Eddington Transport Study – Main report	2006	DfT
42	Use of integrated transport land use models in the wider economic benefits calculations of transport schemes	2008	David Simmonds Consultancy/ MVA Consultancy
43	Wider Economic Benefits of Transport Improvements	2005	Dr DJ Graham, Centre for Transport Studies, Imperial College
44	Distributional impacts of UK Climate Change Policies	2010	Centre for Sustainable Energy
45	Air Quality Modelling Reports	no date	
46	UK modelling under the Air Quality Directive (2008/50/EC) for 2009 covering the following air quality pollutants: SO_2, NO_x, NO_2, PM_{10}, $PM_{2.5}$, lead, benzene, CO, and ozone	2010	Ricardo-AEA
47	Assessment of Methods for Modelling and Appraisal of the Sub-National, Regional and Local Economy Impacts of Transport	2013	Report for Department of Transport
48	Surface Transport Costs & Charges		ITS Leeds

No.	Document title	Year	Author
49	Improving road transport-related air quality in England through joint working between Environmental Health Officers and Transport Planners	2011	Olowoporoku, D., Hayes, E., Longhurst, J., Parkhurst, G., ,
50	The rhetoric and realities of integrating air quality into the local transport planning process in English local authorities	2012	Olowoporoku, D., Hayes, E., Longhurst, J., Parkhurst, G., ,
51	Environmental injustices of children's exposure to air pollution from road-transport within the model British multicultural city of Leicester: 2000–09	2012	Jephcote, C., Chen, H., ,
52	Geospatial analysis of naturally occurring boundaries in road-transport emissions and children's respiratory health across a demographically diverse cityscape	2013	Jephcote, C., Chen, H., ,
53	Elemental carbon as an indicator for evaluating the impact of traffic measures on air quality and health	2012	Keuken, M.P., Jonkers, S. Zandveld, P., Voogt, M., Elshout van den, S., ,
54	Residential satisfaction close to highways: The impact of accessibility, nuisances and highway adjustment projects,	2014	Hamersma, M., Tillema, T., Sussman, J., Arts, J.,
55	Development of an alternative transport appraisal technique: the transport quality of life model		Carse, A.T.,
56	An economic analysis to inform the air quality strategy	2007	Defra
57	Air Quality Appraisal - Valuing environmental limits	2010	Defra
58	Macroeconomic effects of efficiency policies for energy-intensive industries: The case of the UK Climate Change Agreements, 2000–2010	2007	Barker, T, Ekins, P, Foxton, T
59	Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US?	2010	Wei, M, Patadia, S, Kammen, D
60	A different route to health: implications of transport policies	1999	Dora, C
61	Addressing the unintended health impacts of road transport policies and interventions: translating research evidence for use in policy and practice	2008	Thompson, H, Jepson, R, Hurley, F, Douglas, M
62	Air quality and public health impacts of UK airports. Part II: Impacts and policy assessment	2013	Yim, S, Stettler, M, Barrett, S
63	Fiscal impacts of energy efficiency programmes: The example of solid wall investment in the UK	2014	Rosenow, J, Platt, R, Demurtas, A

No.	Document title	Year	Author
64	Jobs, growth and warmer homes: Evaluating the economic stimulus of investing in energy efficiency measures in fuel poor homes	2012	Consumer Focus
65	A survey of the employment effects of investment in energy efficiency of buildings	2012	Janssen, R, Staniaszek, D
66	The social return on investment in the energy efficiency of buildings in Germany	2010	Kuckshinrichs, W, Kronenberg, T, Hansen, P
67	Impacts of air pollution on ecosystems, human health and materials under different Gothenburg Protocol scenarios	2012	UN Economic and Social Council (plus Defra, NERC, UNECE, CHE)
68	Valuation of air pollution effects on ecosystems: A scoping study	2001	Defra
69	Air quality and social deprivation in the UK: An environmental inequalities analysis	2006	Defra
70	Spreading the Net: the multiple benefits of energy efficiency improvements	2012	IEA
71	The Macroeconomic Benefits of Energy Efficiency	2012	Holmes, I, Mohanty, R
72	The macroeconomic rebound effect and the UK economy	2008	Barker, T, Foxton, T
73	Evaluating the co-benefits of low-income energy efficiency programmes	2011	Heffner, G, Campbell, N
74	Climate change policies and the UK business sector: Overview, impacts and suggestions for reform	2013	Bassi, S, Dechezlepretre, A, Fankhauser, S
75	Solving a taxing puzzle: Making environmental taxes work for business	2012	CBI
76	Induced technical change in energy and environmental modelling: Analytic approaches and policy implications	2002	Grubb, M, Kohler, J, Anderson, D
77	Towards a new complexity economics for sustainability	2013	Foxton, T, Kohler, J, Michie, J, Oughton, C
78	Modelling induced innovation in climate change policy	2001	Nordhaus, W
79	The impact of a stimulus to energy efficiency on the economy and the environment: A regional computable general equilibrium analysis	2006	Hanley, N, McGregor, P, Swales, J, Turner, K
80	EmplyRES: The impact of renewable energy policy on economic growth and employment in the European Union	2009	Various

No.	Document title	Year	Author
81	The regional employment impacts of renewable energy expenditures: The case for modelling	2011	Allen, G, Gilmartin, M
82	Guidelines for employment impact assessment of renewable energy deployment – general aspects and net employment studies	2012	Breitschopf, B, Nathani, C, Resch, G
83	An empirical analysis of the impact of renewable energy development on local sustainability	2009	del Rio, P, Burguillo, M
84	Assessing the impact of renewable energy development on local sustainability: Towards a theoretical framework	2008	del Rio, P, Burguillo, M
85	Investigating the relationship between air pollution, health and social deprivation in Leeds, UK	2008	Namdeo, A, Stringer, C
86	Forecasting environmental equity: Air quality responses to road user charging in Leeds, UK	2005	Mitchell, G
87	Environmental inequality in England: Small area associations between socio-economic status and environmental pollution	2008	Briggs, D, Abellan, J, Fecht, D
88	Analysis of Air Pollution and Social Deprivation	2000	King, K, Stedman, J
90	The Energy Saving Trust Economic Impacts Model: Data and Assumptions	2010	Energy Saving Trust
91	Valuing impacts on air quality: Supplementary Green Book guidance	2013	Defra
92	An Economic Assessment of Low Carbon Vehicles	2013	Cambridge Econometrics & Ricardo-AEA
93	The Clean Air Policy Package	2013	European Commission
94	Air Quality in Europe - 2013 report	2013	European Environment Agency (EEA)
95	Keep Your Clunker in the Suburb: Low Emission Zones and Adoption of Green Vehicles, Economic Journal. Doi: 10.1111/ecoj.12091	2014	Hendrick Wolff, Department of Economics, University of Washington
96	Review of evidence on health aspects of air pollution – REVIHAAP Project	2013	World Health Organisation - Regional Office for Europe
97	Guidance on evaluating the impact of interventions on business	2011	BIS
98	Accounting for environmental impacts Supplementary Green Book guidance	2012	Defra

No.	Document title	Year	Author
99	Noise & Health – Valuing the Human Health Impacts of Environmental Noise Exposure	2010	Interdepartmental Group on Costs and Benefits Noise subject group (IGCB(N))
100	An Economic Valuation of Noise Pollution – developing a tool for policy appraisal	2008	Interdepartmental Group on Costs and Benefits Noise subject group (IGCB(N))
101	Accounting for the Effects of Climate Change: Supplementary Green Book Guidance	2009	Defra
102	Carbon Valuation in UK Policy Appraisal: a Revised Approach, DECC	2009	DECC
103	Economic Valuation of the Benefits of Ecosystem Services delivered by the UK Biodiversity Action Plan	2011	Defra
104	Scoping study on agricultural landscape valuation	2007	Defra
105	Research to improve the assessment of additionality	2009	BIS
106	Policy Appraisal and Health	2004	Department of Health
107	Transport Analysis Guidance (TAG) UNIT A5.4 Marginal External Costs	2014	Department for Transport
108	Transport Analysis Guidance (TAG) Databook	2013	Department for Transport
109	Impact Assessment of Workplace Pension Reform	2010	DWP

Appendix B
Questionnaire supporting consultation with representatives of UK Government Departments

1. Are “wider” impacts of policy measures evaluated by your department as part of the policy appraisal process?
2. If so, is there a standard characterization that allows you to distinguish these from “direct” impacts?
3. For which types of policies or interventions is the evaluation of wider impacts particularly relevant?
4. Has any guidance or best practice been issued on this subject? If not, are any sources of guidance external to government regularly referred to?
5. Which types of wider impacts are captured within your appraisal process? These could be economic (e.g. market/ national competition, effect on investment), social (e.g. employment, distributional impacts/effects on SMEs) or environmental (e.g. change in land use, biodiversity, ecosystems services).
6. Is the evaluation of wider impacts either mandatory or recommended for any type of policies or interventions? (i.e. for measures that meet certain criteria the evaluation of a specific wider impact might be mandatory).
7. Are there any impacts prioritised or considered of higher relevance as part of the evaluation process? Where wider benefits do not fall within the remit of your department, do they retain equal value within your evaluation, or is their value discounted?
8. Are there any wider impacts that you believe could be helpful to evaluate that are not presently included within your appraisal process?
9. Could you indicate which impacts are typically evaluated (or where you would expect them to be evaluated) based on:
    a. Monetary valuation
    b. (other) Quantitative assessment
    c. Qualitative review and expert judgement
    d. A combination of approaches
10. In what ways, if at all, are qualitative evaluations integrated into policy risk assessments/ cost-benefit analyses/ the overall appraisal process?
11. In terms of existing approaches to evaluating wider effects noted above, are modelling tools used to evaluate any of these? If so are these run in-house or by contractors? Would it be possible to obtain copies of either the models or associated guidance?
12. With regards to existing approaches used (including modelling), in your opinion:
    e. Is the method/model easy to follow and user-friendly? (e.g. guidance provided is clear)
    f. Is it suitable for assessing the impacts under consideration?
    g. What affects the use of the method/model including scope limitations and biases?
    h. What are your views on the method/model outcomes in terms of accuracy and robustness?
    i. Are there any particular strengths or weaknesses in the method/ model used?
13. To what extent do your present valuation methods safeguard against double counting
14. Are you aware of any research programmes within government/your department or policy area where wider impacts are being considered?
15. Can you point us to any other relevant sources of information on the wider impacts of policy measures and the methodologies used for their appraisal?
16. Are you aware of any other relevant contacts that may be able to provide additional information?

Appendix C
Results of the impacts screening

Results of the wider impacts screening

	Screening criteria	Modal shift	Health impact of walking/ cycling	Congestion	Quality and comfort (journeys, homes, etc)	Safety/ accidents	Accessibility	Affordability (on individuals)
Relevance	What is the relevance of the impact to potential interventions?							
	Is the impact a gap in the existing modelling capacity?							
Significance	How significant may this impact be on the UK public sector / the Exchequer?							
	How significant may this impact be on individuals / consumers?							
	How significant may this impact be on businesses?							
	How significant may this impact be on SMEs?							
	How significant may this impact be for the environment?							
Complexity	Does guideline to assess the impact exist?							
	How can the impact be assessed?							
	What is the level of complexity of the calculations required to appraise the impact?							
	Is the data on parameters required to calculate the impact publicly available?							
	Is the method to assess the impact the same for all sectors affected by potential air quality measures?							
Uncertainty	How certain is the input data required to assess the impact?							
	How certain are the methods used to assess the impact?							

	Screening criteria	Well-being	Secondary AQ emissions	GHG emissions	Noise	Water pollution	Soil pollution	Land use	Raw materials	Waste generation
Relevance	What is the relevance of the impact to potential interventions?									
	Is the impact a gap in the existing modelling capacity?									
Significance	How significant may this impact be on the UK public sector / the Exchequer?									
	How significant may this impact be on individuals / consumers?									
	How significant may this impact be on businesses?									
	How significant may this impact be on SMEs?									
	How significant may this impact be for the environment?									
Complexity	Does guideline to assess the impact exist?									
	How can the impact be assessed?									
	What is the level of complexity of the calculations required to appraise the impact?									
	Is the data on parameters required to calculate the impact publicly available?									
	Is the method to assess the impact the same for all sectors affected by potential air quality measures?									
Uncertainty	How certain is the input data required to assess the impact?									
	How certain are the methods used to assess the impact?									

	Primary screening criteria	Biodiversity	Competition	Supply chain/imports	Innovation	Employment	Affordability for business
Relevance	What is the relevance of the impact to potential interventions?						
	Is the impact a gap in the existing modelling capacity?						
Significance	How significant may this impact be on the UK public sector / the Exchequer?						
	How significant may this impact be on individuals / consumers?						
	How significant may this impact be on businesses?						
	How significant may this impact be on SMEs?						
	How significant may this impact be for the environment?						
Complexity	Does guideline to assess the impact exist?						
	How can the impact be assessed?						
	What is the level of complexity of the calculations required to appraise the impact?						
	Is the data on parameters required to calculate the impact publicly available?						
	Is the method to assess the impact the same for all sectors affected by potential air quality measures?						
Uncertainty	How certain is the input data required to assess the impact?						
	How certain are the methods used to assess the impact?						

	Primary screening criteria	Agglomeration	Crime	Regeneration	Energy supply and demand	Energy security	Displacement
Relevance	What is the relevance of the impact to potential interventions?						
	Is the impact a gap in the existing modelling capacity?						
Significance	How significant may this impact be on the UK public sector / the Exchequer?						
	How significant may this impact be on individuals / consumers?						
	How significant may this impact be on businesses?						
	How significant may this impact be on SMEs?						
	How significant may this impact be for the environment?						
Complexity	Does guideline to assess the impact exist?						
	How can the impact be assessed?						
	What is the level of complexity of the calculations required to appraise the impact?						
	Is the data on parameters required to calculate the impact publicly available?						
	Is the method to assess the impact the same for all sectors affected by potential air quality measures?						
Uncertainty	How certain is the input data required to assess the impact?						
	How certain are the methods used to assess the impact?						

Appendix D
Quality assurance

The following sections explain the QA procedures that have been implemented at each step of the model development.

Model scoping and prototype

Task description

The first modelling task was to finalise the scoping phase[25] and to develop a prototype for the model. There were two parts to the prototype; a flow chart graphic and a mock-up of the user interfaces.

QA

The spreadsheet model was fronted with a version control worksheet in which a record was maintained of all changes made to the model, the date and who the changes were made by. The file name follows Amec Foster Wheeler's standard spreadsheet naming approach, which is "*{Project number} {Title} {Date of last major change}"*. Prior to each major change a back-up copy of the spreadsheet was made to keep as a reference and to provide a back-up to return to should the major change result in undesired consequences.

Given the low complexity of the model prototype at this stage the review has been at a relatively high level. This review has been performed by senior team members of both Amec Foster Wheeler and Systra teams to ensure consistency with the project objectives, suitability of the prototype and feasibility of developing the model on this basis.

Development of the model

Task description

Amec Foster Wheeler developed the model, with consideration of Defra's feedback and comments on the results of literature review and impacts screening. This was conducted by our expert modellers with the guidance from the wider project team.

Best practices in model development have been applied as prescribed in Defra's best practice spreadsheet guidance, UK Government guidance for QA in analytical models and in-house best practice processes, which are well established following years of experience in model development. This included use of suitable colour coding for inputs, calculations and outputs; clear structure for easier QA and updates; simple and easy-to-copy formulae to facilitate the understanding of each stage in the calculation, adaptation and expansion of the model, indirect cell references to minimise errors; in-built error checking; and intuitive and clear presentation of the outputs.

QA

The reviewer performed frequent checks of the model during its development. On completion of each element of the model, it was checked to ensure the following:

- Is it correct – Have the correct inputs been used? Are the detailed calculations/functions correct?
- Is it sufficient – Does it fulfil the aim of that element of the model?
- Is it clear – Is the structure logical? Are labelling/descriptions correct, concise and relevant? Is it well presented, aesthetically pleasing and user friendly?
- Will it stand up to scrutiny – Are all assumptions and caveats clearly stated? Are limitations explicit? Are exclusions clear? Is it referenced (where relevant)? Does it show false accuracy/precision? Is there appropriate uncertainty analysis?

These checks have been logged in the version control sheet, and written comments on the checks were provided to the modeller.

Two interim versions of the model were submitted to Defra for comment, prior to completion and submission of the model before the testing stage. Prior to each of these submissions a first and second level review was undertaken. As part of the final submission review, following amendments from the second level review, a

[25] As documented in the Interim Report to this project, issued to Defra on 1st October 2014.

user test was also performed. A member of the project team not directly involved in the development of the model conducted the user test to ensure the model is usable by individuals unfamiliar with model development and software. The tests included an assessment of inputs, calculation steps and outputs to ensure that the model is as functional, transparent, well presented and user friendly as required. Feedback from the testing was used to modify the model as required.

To facilitate the second interim and final reviews, the model was tested with a sample dataset to reproduce the typical use of the model after its finalisation. This dataset was dummy set of numbers developed solely for testing purposes.

These checks were logged in the version control sheet, and written comments on the checks provided to the modeller. The second level reviewers completed the QA log spreadsheet, scoring the model against each of the criteria.

Documenting the model

Task description

A series of documents to support the model and its handover was developed in parallel to the model itself.

- The user guide was developed to explain the functionality of the model to an unfamiliar user. This explains the basis for the fixed input parameters, guide the user on which user determined inputs can be changed and explain the output results that will be produced.
- The technical specifications report describes all development steps, assumptions, limitations, sense checks and uncertainties. Thorough explanation of how the model works facilitates future development and updating of the model.

QA

The QA process for the documentation was simultaneous to the review and testing of the model. The documentation was tested for suitability as part of the reviews, to ensure it provides sufficient support to any non-technical user and enhances the user experience.

Testing

Task description

This task was to test the model further with potential policy measures provided by Defra. This part of the project had an important learning component. Using the model to assess wider impacts of a number of policy measures revealed some inflexibility of methodologies used, or for example required improvements in the way inputs and outputs of the model are presented.

QA

During the testing periodic checks were performed to ensure that the relevant information has been correctly entered into the model and to sanity check the results. Prior to model finalisation a first and second level review was undertaken to validate the results. These checks have been logged in the version control sheet, and written comments on the checks provided to the modeller.

Model revisions and lessons learnt

Task description

Testing identified errors or aspects of the model for improvement that were over-looked during the model development. As a result the model and supporting documentation were modified to address these aspects. These updates also reflect comments reported by Defra during the presentation of the model and the training session delivered by Amec Foster Wheeler.

QA

Any modification made to the model and supporting documentation were subject to an equivalent review process as for the main model development.

QA statement

The QA statement includes a series of spreadsheets used to document the record of the reviews undertaken in each model development stage.

Detail results of model testing

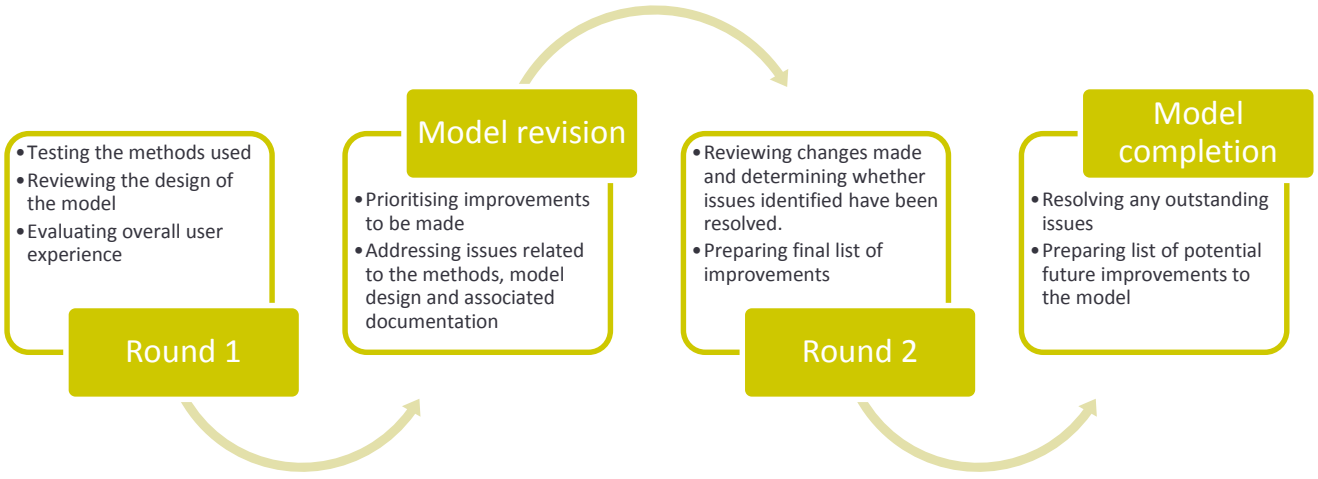
This section describes the results from the testing of the wider impacts model undertaken using two separate rounds of testing during the development of the model (not on the final version). **All issues identified during the testing phase and discussed in the sections below have been corrected and eliminated from the final version of the model**, unless otherwise indicated**.**

The scenarios used for testing were designed to reveal any inflexibilities of the methodologies used and inconsistencies in results obtained when compared to the assessments done outside of the model. Additionally the testing phase was aimed at identifying any areas for improvements in the overall user experience of working with the model.

Methodology

The approach to testing and further development of the model in stage 3 of the study is illustrated in figure below. The first round of testing was prepared to identify any major methodological flaws, technical issues associated with model design including individual inputs, calculations and outputs for each impact, and to evaluate overall user experience and how it can be enhanced. Following the first round of testing, a list of potential changes and improvements to the model was prioritised by the project team in agreement with Defra. Priority was given to issues which directly affected the appropriateness and accuracy of the results obtained when assessing impacts using the model. Following necessary changes, the second round of testing was undertaken. The aim of the second round was to review the impacts of the changes made following initial testing and check whether the most critical issues have been resolved. Final changes to the model were made to address any new problems identified in this final testing stage. Remaining comments resulting from both scenarios which could not be addressed within the scope of the study are listed in Section 6 of this report to guide development of the model in the future.

Approach to testing of the model in stage 3 of the project



Testing methods

Testing of the wider impacts model have been built in consultation with Defra and DfT based on:

- Examples/ case studies accompanying description of the methodologies recommended in existing guidance published by UK Government departments;
- Previous impact assessments or supporting studies which utilised similar assessment methodologies to those applied in the wider impacts model; and
- Other assessment toolkits developed by UK Government departments to support evaluation of policies.

For some impacts, specifically affordability for individuals, affordability for business and employment impacts, the methodologies applied in the model do not follow specific methodologies described in Government guidelines. These methodologies have been specifically designed for the purpose of the wider impacts model that is intended to assess any potential future policies for improvement of air quality and hence may apply more generic approach than would be required for regulatory impact assessment. For these impacts it was not possible to identify examples in published studies that would follow the same methodology. Nevertheless comparison of results from the model with results of similar assessment from other studies has been undertaken whenever feasible, in order to better understand the limitations of the methodology used and scope for potential future improvements.

Testing results

Round 1 – Initial testing of the model

Congestion, Accidents and Noise Impacts

The outputs for impacts on noise, accidents and congestion have been compared to the outputs of the WebTAG Cycling and Walking case study (Appendix B, Tag Unit A5.4). This provided input data for change in vehicle kilometres. Both models assume the same split of vehicles by road type in London, the results therefore were expected to be directly comparable.

For congestion and accidents, the results from each model followed the same pattern, with the Wider Impacts model results vertically offset to show slightly greater financial benefits. WebTAG Accident case study showed the stepped pattern which was due to rounding to no decimal places. When smoothed, the data followed the same pattern as the Wider Impacts model results.

The WebTag Noise case study provides £0 net cost result across all years. The Wider Impacts model showed all noise values to be <£0.35 (thousand). The difference can be explained by rounding of figures to no decimal places in the WebTAG case study. If the wider impacts results were rounded to no decimal point this would also show a £0 net cost. Due to lack of more detailed data on the results in the WebTAG case study, it was not possible to investigate this any further.

The offset of all results to show slightly greater benefits using the Wider Impacts model is due to differences in the input data. In the WebTAG model, data is input for each year, whilst in the Wider Impacts model it is input at five year intervals and the interim years are interpolated (this approach has been taken because the underlying MEC figures are only available for five year intervals). The interpolated input figures do not provide an identical match to the WebTAG input figures, particularly in earlier years. This is because interpolation between five year periods would miss any potential peaks in the data. For example, in the WebTAG input data a peak vehicle km reduction of 218,000km is seen in 2012, whilst in the Wider Impacts model, interpolated input data for 2012 is only 64,000km. This explains why the discrepancy in results is greater for the earlier years of the policy (i.e. in the scenario analysed the discrepancy in input data is greatest in these years).

Whilst this interpolation method does reduce the precision of the Wider Impacts model somewhat, the impact upon the output is not significant. Allowing for input of additional data years would reduce this discrepancy, but would rely upon the user having a greater quantity of available data. Simplifying the model in this way is therefore acceptable, providing greater accessibility at the cost of only limited reduction in precision.

Health Impacts of Cycling and Walking

The output of the Stand Alone Health Impacts has been tested using inputs in the Webtag A5.1 Toolkit the Walking and Cycling example. The input data for change in vehicle km is the same as that used in the Congestion, Accident and Noise comparison above; additional data was taken from the WebTag example for

changes in number and distance travelled by cyclists. The same input data was then used in the DfT WebTAG A5.1 model which includes assessment of health impacts of walking and cycling.

The results of the two models are not directly comparable because the methodology used in the WebTAG model (which served as a guidance for the methodology for these impacts) have changed since the impact has been built into the Wider Impacts model. Specifically, the WebTAG model utilises a different methodology for calculation of relative reduced risk, includes decay rate and combines the health impact of both walking and cycling (the Wider Impacts model currently only looks at health impacts of cycling due to lack of sufficient data during stage 2 of the project). Furthermore the input data assumes the policy starts in 2012 and deflates costs to 2012 values (in the Wider Impacts model it was not possible to set the policy start date pre-2015[26]– this issue is described in further detail below). However, despite this, it would be expected that the two models should produce similar outputs.

The Wider Impacts model resulted in much higher benefits than the WebTAG model, with the cumulative benefits from 2015-2032 almost three times greater than when the assessment is done using the WebTAG model. This large discrepancy in values is due to the different methodology used to calculate relative reduced risk factor, with the Wider Impacts model predicting a slightly higher reduction in risk (using methodology previously used by the DfT), which is multiplied up to give significantly greater health savings.

Both models showed an exponential decline in benefit over time, though this is more pronounced in the WebTAG results. This is because the WebTAG model applies a 10% decay rate and ramp-up of benefits in the initial years which is not currently applied in the Wider Impacts model.

In light of these results, the method to appraise health impacts of cycling and walking was revised to align it with the WebTAG A5.1 Toolkit.

In addition to the stand-alone Health Impacts model, the Wider Impacts model also calculates Health Impacts based on the results of Modal Shift assessment. This uses standardised assumptions on the number of new cyclists/walkers for every km reduction in vehicle miles, rather than estimated changes in cycling based on specific policy projections. Subsequently, this gives much lower values for health impacts, as it assumes only a very small proportion of additional trips is attributed to cycling. This method is therefore applicable when investigating the effects of a policy which does not specifically attempt to increase levels of cycling, but will not be applicable to any policy which attempts to elevate cycling levels above what may naturally occur. The testing revealed that differences in these methods should be made clearer in the user guide, to ensure model users appreciate the different applications for the two model projections.

Greenhouse Gas emissions

The outputs for impacts for Greenhouse Gases have been compared to the outputs of the IAG spreadsheet tool for valuing changes in greenhouse gas emissions. Theoretical input data was used in both spreadsheet tools, for a policy where 165,000 fewer litres of diesel and 450,000 fewer litres of petrol would be burnt between 2015 and 2020. Each tool allows input data for change in petrol and diesel burnt for each year, therefore the results are expected to be directly comparable.

A comparison is shown graphically below. There was a slight divergence between the total GHG emissions saved between each tool, despite having exactly the same inputs. It appears that the two tools are using slightly different conversion factors. The CO_2 intensity for petrol and diesel will vary dependent on the amount of biofuel deemed to be part of the mix. It is possible that the tools are using CO_2 factors from a different year.

The valuation of GHG emissions appeared to show a much wider disparity between the DECC / IAG tool, which was identified to be due to an error in a conversion factor used within the wider impacts model.

Affordability for individuals (domestic fuel prices)

There were no external tools available to directly compare the results of assessment of affordability for individuals in the same way it has been done above for other impacts. Instead, in order to test the results of

[26] The wider impacts model was created in 2015, it is intended for assessment of policies starting in 2015 or later.

the wider impacts model, they have been compared with the analysis presented in DECC's final impact assessment[27] of the Green Deal and ECO.

The outputs for affordability for individuals of changes in fuel prices have been created using data available about the current delivery costs of the Energy Company Obligation (ECO). DECC's final impact assessment[28] of the Green Deal and ECO provides an assessment of the extent to which households in each income decile will be affected by the Green Deal and ECO. The impact assessment states that only the costs of ECO, rather than the Green Deal, will be borne out by domestic energy prices. The assessment estimates the delivery costs of ECO will be £1.3bn per year. However, the impact assessment does not explicitly indicate the change in unit cost of electricity and gas prices that the policy will have.

The wider impacts model requires a percentage change in domestic fuel prices are given for each year of the policy compared to 2013. DECC's 2013 assessment of the delivery costs of ECO[29] (subsequent to the impact assessment) estimates that the cost passed through, per customer per year is £50 – this corresponds to a total annual cost of the programme of £1.3bn which matches the initial impact assessment.

For the purposes of this testing we have therefore compared a policy which increases the average combined domestic gas and electricity bill by £50 per annum.

To evaluate the distributional impacts of changes in fuel costs, the wider impacts tool requires the user to input the percentage change in domestic fuel prices (compared to 2013) as a result of the policy. Therefore in order to input the assumed additional £50 per year on combined electricity and gas bills it was necessary to estimate what percentage increase in gas and electricity prices would give rise to a £50 increase in annual bills.

To do this we took the average household expenditure (for all households) on electricity and gas in 2013 used in the tool and added the £50 to this. It has been assumed that the costs are equally shared between gas and electricity costs – hence £25 was added to gas expenditure and £25 to electricity expenditure. This was then divided by the estimated average gas and electricity consumed per household to give the new average fuel tariff for gas and electricity. The percentage difference was assessed between the fuel tariffs with and without the £50 per annum. This was calculated to be an increase in fuel costs of approximately 4%.

The results indicate that for this policy the wider impacts tool provides comparable results to DECC's impact assessment. The DECC assessment outputs the average impact on energy bill as a percentage of average income for each income decile, whereas the wider impacts tool provides the average impact on energy domestic energy expenditure as a percentage of disposable income for each income quintile. These two metrics are not directly comparable – however the two assessments show outputs within similar orders of magnitude.

The wider impacts scenario can be compared to the DECC scenario "Households with no Green Deal or ECO Measure" as these are households that have effectively had £50 added to their fuel bills without the benefit of any energy savings. This is comparable to the scenario modelled in the wider impacts tool. The wider impacts tool estimates that for the bottom income quintile a percentage change is 0.4%. For the top quintile the impact is only 0.1%. The DECC assessment shows that for the bottom 2 deciles a percentage change is between 0.5% and 0.3% and for the top decile a percentage change of around 0.1%

Overall the model was judged as easy to use, and the user guide as informative. Errors were identified and high priority issues were corrected in a revision to the model.

[27] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/70265/5533-final-stage-impact-assessment-for-the-green-deal-a.pdf
[28] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/70265/5533-final-stage-impact-assessment-for-the-green-deal-a.pdf
[29] https://www.gov.uk/government/publications/energy-company-obligation-eco-delivery-costs

Round 2 – testing of the model following revisions

Health Impacts of Cycling and Walking

Following the changes to the Health Impacts of Cycling and Walking module of the AQ Wider Impact model, the output of the standalone assessment for walking and cycling were validated against the most recent version of the DfT "Investing in cycling and walking: the economic case for action toolkit". The inputs used were almost identical to the central scenario of the case study agreed with Defra for the final testing, included as an appendix in the user guide. The only modification was the addition of a decay period of five years. This was done in order to assess the full functionality of the tool and ensure all the options in the model work correctly. The table below summarises the main inputs used both in the Wider Impacts tool and the DfT toolkit. The rest of inputs were left as default.

Parameter	Input
Appraisal period	2015-2025
Number of cycling trips per day	64,000 (for each year of the appraisal period)
Number of walking trips per day	64,000 (for each year of the appraisal period)
Decay rate	10%
Year decay starts	2020
Current year and price year	Set to 2010 in the Wider Impacts model. This was done because the DfT tool considers 2010 as the base year.

Both models offered exactly the same results regarding annual monetised benefits (undiscounted), being £22,633,022 per year for cycling and £21,168,704 for walking.

When looking at the final benefits, once discounted and other modifiers being applied, there was a slight difference between the models. The table below shows the yearly final results in £thousands for the sum of walking and cycling benefits.

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
DfT toolkit	7,726	15,221	22,498	29,534	36,466	36,024	31,908	28,265	25,042	22,190	19,685
Wider Impacts model	7,376	14,253	20,657	26,611	32,139	31,052	27,002	23,480	20,417	17,754	15,438

The difference was investigated further. It was found that ramp up, decay and discounting are applied equally in both models. The reason for the observed difference is the fact that the DfT toolkit automatically applies a minimum growth associated to GDP. In the Wider Impact model growth is optional and applies a fixed rate for all years. Once the GDP growth was excluded from the results of the DfT model, both models were offering an identical set of yearly results.

Given that both the standalone assessment and the assessment linked to modal shift use the same methodology (changing only the inputs), it was not deemed necessary to test the latter.

Greenhouse Gas emissions

Given the disparity in monetised value observed in the first round of testing, the module to assess GHG was revised and the range of outputs available to the user enlarged. Because of these changes it was considered that its inclusion in the second round of testing would be beneficial.

The outputs for impacts for Greenhouse Gases were compared to the outputs of the IAG spreadsheet tool for valuing changes in greenhouse gas emissions. The inputs used were almost identical to the central scenario of the domestic policy case study agreed with Defra for the final testing, and included as an appendix in the user guide. The only modification was the addition of a rebound effect of 10% for domestic coal. This was done in order to assess the full functionality of the tool. The table below summarises the main inputs used both in the Wider Impacts tool and the IAG tool.

Parameter	Input
Appraisal period	2015-2025
Inputs Wider Impacts (each year of the assessment)	Domestic natural gas: 236,100,000 kWh Domestic coal: - 28,170 tonnes Domestic coal: 10% rebound effect
Inputs IAG tool (each year of the assessment)	Domestic natural gas: 236.1 GWh Domestic coal: - 236.1 GWh (IAG tool only accepts GWh as input for coal) Domestic coal: 10% rebound effect
Current year	2014
Price year	2014

Detailed outputs from both tools were compared offering identical results. Detailed results for the whole appraisal period are displayed in the table below. Air quality costs and benefits are not shown as they are not part of the Wider Impacts model.

	Value
Change in CO2 emissions (kt)	-402
Discounted monetised value of carbon emissions (£k)	-21,833
Discounted monetised value of change in energy consumption (£k)	-54,396
Discounted primary rebound effects	12,253

Despite both models offering identical yearly and total detailed results, when comparing the final total cost in NPV, they differ substantially. It was £88.5 million benefit for the IAG tool (excluding impact on air quality) and £64 million for the Wider Impacts model. The reason is that the two tools took a different approach in the way rebound effects were considered. In this example, where rebound effects were applying to the reduction on coal consumption, the IAG tool considered rebound effects as a benefit (i.e. comfort taking) that should be valued and added to the total benefits. On the other hand, the wider impacts model treated them as a cost. This has been corrected in the final version of the model and both IAG tool and the Wider Impacts Model now produce identical results.

Affordability for businesses, individuals and employment.

These three impacts were independently reviewed and tested using dummy numbers. Stress testing was also conducted. The lack of comparable tools and models prevented any validation of results. A number of technical and formatting issues were raised during the review and addressed as appropriate.

Any errors identified and high priority issues were corrected in a final revision to the model.

Limitations

Impacts on congestion, safety and noise were not subject to a second round of testing as results in the first round were generally positive and the methodology has not changed substantially between rounds.

The methodologies for affordability for individuals, affordability for businesses and employment were tailored for this project and, although thoroughly reviewed, the results have not been validated and tested against established sources. Dummy numbers have been used through the internal testing and review, not being representative of any real case study. This implies that caution should be taken when interpreting the results from these impacts and comparison with complementary analysis is desirable. It should also be noted that the whole AQ Wider Impact model is intended to provide an estimation of costs and benefits but it is not a substitute of a detailed, proportionate and adequate analysis.