ANCILLARY EFFECTS OF GREEN HOUSE GAS MITIGATION POLICIES

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INTRODUCTION

1. Ancillary effects of greenhouse gas (GHG) mitigation policies arise in addition to direct reductions of GHG emissions. For example, a policy that reduces emissions of gases such as CO2, NOx, and SOx, will not only mitigate global warming (the focus of the policy), but may also improve local air quality, and yield potential improvements to public health. This additional benefit is an ancillary effect[1]. When assessing GHG mitigation policy it is important that such ancillary effects are considered.

2. Consideration of ancillary effects may influence policy design by determining what policies are adopted, the extent of mitigation action taken, the timing of any such action and which sectors of the economy are the focus of policy.

3. Whilst the full benefit of GHG mitigation in terms of reduced climatic change may only be experienced by future generations, the ancillary benefits are often tangible to the current generation. Improvements in air quality, reduced congestion, and greater environmental amenity can be achieved in the short term, helping to offset current mitigation costs. In this sense, ancillary benefits should not be thought of as additional side effects of mitigation, but as ‘co-benefits’ that are an integral aspect of such policy.

4. It is commonly understood that reducing GHG emissions yields a global benefit in terms of GHG mitigation. This positive external effect gives little incentive for any one country to act alone to address climatic change. Similarly, reduction of the negative impacts of climate change in any location is also dependent on a reduction of GHG emissions globally. However, ancillary benefits are typically experienced on a local or regional level. Reduction of traffic congestion resulting from policies that reduce energy demand impacts directly on urban quality of life, ameliorating infrastructural pressures, improving public health, and reducing noise pollution. To the extent that ancillary benefits can be attributed to mitigation action taken by any individual country and can be felt by that individual country at the time of mitigation action being taken, consideration of such benefits makes GHG mitigation policies more attractive.

5. In what follows, firstly, an attempt has been made to identify the ancillary benefits that may arise from GHG mitigation. Then a summary of estimates of the magnitudes of ancillary benefits from current literature is given. The Annex to this paper starts to bring together available estimates of ancillary benefits for the UK associated with different types of policies.

[1] The term ‘ancillary effect’ recognises that both additional benefits and costs may arise from GHG mitigation.

ANCILLARY EFFECTS OF INDIVIDUAL MITIGATION POLICIES

6. Ancillary effects of GHG mitigation are generally policy specific. Different abatement policies will typically give rise to various ancillary effects. In addition, a single mitigation policy might result in different ancillary effects depending on the location of the policy being undertaken. This makes it difficult to attribute a generic set of ancillary effects to any mitigation policy.

7. This paper aims to summarise the potential ancillary effects of GHG mitigation arising from different forms of abatement of GHG emissions. It does not incorporate ancillary effects related to infrastructure costs and energy efficiency gains, which have been considered in other work.

Ancillary effects associated with different types of mitigation policies

8. Table 1 presents a summary of potential ancillary effects of GHG mitigation policies for different abatement measures and sectors of the economy that are affected. Ancillary effects associated with different mitigation policies generally lead to beneficial effects via their impact on 'end-points' such as health, ecological systems and materials damage. In some cases however ancillary effects can result in a loss of welfare (these are highlighted in square brackets in Table 1).

9. Ancillary effects that the table does not include are improved resource efficiency, lower energy related costs for both households and industries, reduction of fuel poverty, requirements for new transport and energy infrastructure, disposal cost related to GHG capture and sequestration using end of pipe technologies.

10. The following sections provide a more detailed discussion of the potential ancillary benefits of GHG mitigation policies by looking in turn at health and non-health effects.

Table 1: Types of ancillary effects of GHG mitigation for different mitigation policies and affected sectors

Mitigation Policy	Affected Sectors	Ancillary Effects
Energy Efficiency		
Reduction of demand for energy (*)	Energy Supply	Lower emissions of SOx, NOx, CO, Particulates, VOCs Lower levels of Ozone formation
	Industry	Lower emissions of SOx, NOx, CO, Particulates, VOCs Lower levels of Ozone formation Opportunities for innovation
	Surface Transport	Lower emissions of SOx, NOx, CO, Particulates, VOCs, Lead, Butadiene and Benzene. Effect on congestion [could be welfare gain or welfare loss]
	Air Transport	Aviation - lower air pollution from take-off & landing emissions of NOx, PM10, HC, SO2 Reduced noise pollution
	Households	Improved ambient air quality (& indoor air quality?)
	Agriculture	Lower levels of Ozone formation
Fuel Switching		
Moving from oil and coal to low or no emissions sources	Energy Supply	Lower emissions of SOx, NOx, CO, Particulates, VOCs Lower levels of Ozone formation Opportunities for innovation Increased methane emissions from natural gas [welfare loss]
coal/oil to gas	Industry Transport	Lower emissions of SOx, NOx, CO, Particulates, VOCs Lower levels of Ozone formation Opportunities for innovation Lower emissions of SOx, NOx, CO, Particulates, VOCs, Lead, Butadiene and Benzene. Opportunities for innovation
[Specific ancillary effects of switching…] to CHP	Energy Supply	Increased NOx emissions in urban areas [welfare loss]
petrol to diesel	Transport	Increase in emissions of non-carbon gases [welfare loss]
to energy from waste		Lower emissions of methane from landfills Reduction in other externalities associated to landfilling
to nuclear	Energy Supply	Disposal of waste [welfare loss] Risk of accidents and proliferation
to hydro-electric		Damage to river ecosystems [welfare loss]
New Renewables		
(switch to wind, wave Solar, etc.)	Energy Supply	Lower emissions of SOx, NOx, CO, Particulates, VOCs Lower levels of Ozone formation Land restoration activities New rural development Prevention of erosion Habitat for wildlife Visual 'pollution' (e.g., from wind farms) [welfare loss]

Capture & Sequestration of Carbon		
Increase forested area Manage forests to store more carbon	Forestry	Habitat for wildlife Increase biodiversity Increased recreational benefit Improved visual landscape? Reliance on monoculture [welfare loss] Opportunities for timber
Reduced Agricultural Emissions		
Fertiliser practice, general agronomy, slurry management. Waste management, and enteric fermentation in ruminants.	Agriculture	Reduce N_2O emissions Reduction of inorganic nitrogen and organic fertilisers Reduction of ammonia emissions from pollution swapping. Increased crop yields from efficiency gains Improved water quality Reduced CH4 emissions

(*) The extent of ancillary benefits arising from policies promoting energy efficiency will depend upon income and substitution effects and to what degree increased efficiency reduces demand for energy.

Health effects

11. Health effects associated with improved air quality typically account for 80% of the total value of the ancillary effects of GHG mitigation policies[2]. Reduced emissions of air pollutants generate health benefits in terms of a reduction in the number of deaths brought forward each year and a reduction in the number of admissions to hospital for treatment of respiratory disease.

12. An individual GHG mitigation policy may not reduce emissions of all air pollutants. Therefore, the ancillary health benefits arising will depend upon which pollutants are affected by the policy. A brief summary of the health effects associated with different air pollutants is provided below:

Benzene

13. The majority of emissions of benzene arise from petrol vehicle exhaust and petrol refining processes. Benzene is carcinogenic, and exposure to high levels can result in excess risk of leukaemia.

1,3-Butadiene

14. Combustion of petrol is the main source of emissions of butadiene, which is also a carcinogen. The main health risk from exposure is the development of lymphomas and leukaemia.

Carbon Monoxide

15. Combustion of carbon fuels from mainly road transport accounts for the majority of carbon monoxide emissions. Exposure to it can lead to the formation of carboxyhaemoglobin, which reduces the capacity of blood to carry oxygen to tissue. The main health risks are to those individuals with existing diseases that affect the delivery of oxygen to the brain or heart, such as angina.

Lead

16. The main source of lead emissions is petrol vehicle exhaust (although this has already declined significantly due to the reduction of lead content in petrol), and industrial processes, in particular secondary non-ferrous metal smelters. Exposure to high levels of lead may result in toxic biochemical effects; causing problems in the synthesis of haemoglobin, effects on kidneys, gastrointestinal tract, joints and reproductive system, and acute or chronic damage to the central nervous system. A particular cause for concern is the possible effect of lead on brain development in children.

Nitrogen Dioxide

17. Nitrogen dioxide is emitted by all combustion processes. The transport sector accounts for approximately 50% of UK emissions, the electricity sector 20%, and industry 17%. Both short term and long term (especially in people with asthma) health effects arise from nitrogen dioxide emissions.

[2] See Burtraw, B. & Toman, M (2000)

Relatively high concentrations cause inflammation of the airways, whilst longer-term exposure may effect lung function and enhance response to allergens in sensitised individuals.

Ozone

18. Ground and low-level ozone occurs due to chemical reactions between nitrous oxides and volatile organic compounds (VOCs) from industrial sources. Exposure to high concentrations may cause slight irritation to the eyes and nose. Very high levels of exposure experienced over several hours damages airway lining and causes inflammatory reactions.

Particles

19. Particulate matter arises from a wide range of sources. The major sources are combustion processes (especially from transport), secondary particles mainly formed by sulphate and nitrate from chemical processes, suspended soils and dust, and particles from construction. Particles are associated with a range of effects on health, including effects on respiratory and cardiovascular systems, asthma and mortality. Particulate air pollution can also cause excess deaths among individuals with pre-existing lung and heart disease. There is also a distinct relationship between higher concentration levels and greater health effects.

Sulphur Dioxide

20. Sulphur dioxide emissions occur due to combustion of sulphur containing fossil fuels, particularly coal and heavy fuels. Exposure can cause constriction of the airways, with those suffering from asthma and lung disease being more susceptible.

Non-health effects

21. The non-health ancillary effects of GHG mitigation affect many different areas and include aspects such as impacts to ecological systems, agriculture and crops, materials damage, and visibility, as well as interacting with a whole range of economic and social factors.

Impacts to ecological systems from air pollution

22. The largest benefits to ecosystems accrue where there is significant reduction in waste residuals, such as air pollutants, from energy production and use. The most significant benefits arise from nitrogen and sulphur reductions, the two most important pollutants causing acidification and eutrophication. Both acidity and nutrient levels in natural ecosystems determine biodiversity. Managing and maintaining carbon sink reservoirs (forests) affects landscape and can have an influence on biodiversity.

23. ***Sulphur dioxide and its secondary pollutants*** are responsible for forest damage directly and indirectly via effects on pests, and with pathogens and other pollutants. Sulphate aerosols give rise to acidic deposition that

damage forest, freshwater and other semi-natural ecosystems, as well as affecting biodiversity.

24. ***Nitrous oxides and its secondary pollutants*** also affect trees in a similar fashion to sulphur dioxide both directly and indirectly. Nitrate aerosols lead to acidification and loss of biodiversity, particularly in aquatic ecosystems. Nitrogen deposition causes eutrophication.

25. ***Low-level ozone*** causes forest damage and influences biodiversity through direct effects on vegetation, and indirect interactions with pests, pathogens and other pollutants.

Impacts to ecological systems from agricultural pollution

26. Approximately half of UK nitrogen dioxide emissions and a quarter of methane emissions arise from agriculture, forestry and land-use practices[3]. Mitigation policies[4] focussed at reducing nitrogen dioxide and methane emissions from the agricultural sector may yield significant ancillary benefits. Primarily, these benefits will potentially ameliorate eutrophication and acidification of ecosystems that arises from use of ***nitrogen*** in fertilisers[5]. The typical ancillary benefit of reduction of these processes will be less damage to ecological systems and biodiversity. In addition, water quality will be improved by polices that reduce emissions of ammonia, and also polices that improve agricultural use of nutrients, thus reducing nitrate pollution of water.

Materials damage

27. Materials damage refers to two categories of impacts. Acidic deposition causes physical damage and loss or erosion of materials from buildings and physical capital, whilst the soiling of building surfaces is caused by particle deposition. Such damage occurs to residential and commercial property, historic buildings, and objects of cultural value.

28. Dry deposition of ***sulphur dioxide*** has the most corrosive effect of all atmospheric pollutants on building surfaces. Secondary pollutants formed of sulphur and nitrous oxides act through wet deposition (rain acidity) but have a weaker corrosive effect. ***Particulate matter*** can act as a catalyst for erosion of stone, whilst low-level ozone damages polymeric materials such as paints, plastics and rubbers. Particles arising from combustion processes are the main cause of soiling of building materials.

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[3] *Climate Change: The UK Programme*, DETR 2000.

[4] Mitigation policies in agriculture include; Improved general agronomy, fertiliser practice, and slurry management to address N2O and management of waste and enteric fermentation in animals to address methane.

[5] Pollution from nitrogen in fertilisers is a complex process. In addition to emissions of nitrogen oxides from fertiliser use, emissions of ammonia also arise. This occurs due to ‘pollution swapping’, the result of nitrogen contained in manure and mineral fertiliser, that, when not taken up by the growing plant or trapped in the soil, can be emitted in pollutant form; ammonia and nitrogen oxides to the atmosphere, and nitrates leached to water.

Crop damage from air pollution

29. Common urban environment concentrations of ***low-level ozone*** have a harmful affect on vegetation. In terms of an exposure-response relationship ozone has the most important direct effect on reducing crop yields. ***Sulphur dioxide*** and ***nitrous oxides*** also influence crop yields through acidic depositions. Air pollution generally has an indirect effect on agriculture through interactions with insect pests, pathogens and drought.

Impact on visibility

30. Whether air pollutants significantly affect visual range is not certain. However, if they do, the contributors are likely to be ***particulate matter*** and ***secondary particles from nitrogen dioxide, nitrates and sulphate aerosols***.

Impact on congestion

31. Mitigation polices that address emissions from road transport and result in lower transport volume will have an ancillary effect in the form of reduced traffic congestion. This will in turn yield benefits in terms of time savings and reductions in the environmental externalities associated to traffic volume (e.g., noise).

32. It should be noted that energy efficiency measures in the transport sector may not necessarily lead to reductions in road congestion. More efficient cars, holding other factors constant, will enable drivers to travel more kilometres from a litre of petrol. Improved fuel efficiency may lead to a net reduction in emissions, but may actually increase levels of congestion, and therefore increase road traffic noise, road accidents and road maintenance requirements.

33. A switch from petrol to diesel or biofuels blended with diesel will incur an ancillary cost in terms of negative impacts on local air quality, particularly from nitrous oxides emissions.

34. Closely linked to benefits arising from congestion is the issue of road safety. An indirect benefit of mitigation polices that results in reduced traffic volume may be a reduction in both non-fatal and fatal traffic accidents.

Ancillary effects of carbon sequestration through forestry

35. Managing and increasing forested land for purpose of carbon sequestration is likely to yield ancillary benefits. Currently there is a great deal of economic and scientific uncertainty regarding this form of mitigation action. On the scientific side there is still need for study on the effect of tree planting on soil carbon (particularly on peaty soils, where planting trees may release soil carbon into the atmosphere). On the economic side,

there is not currently a comprehensive assessment of the costs and benefits of carbon sequestration forest management regimes.

36. The ancillary effects will depend very much on the type of forest management regime that is adopted. Any forest will sequester carbon, but the sequestration levels will vary according to species of tree and the way in which the forest is managed. Possible ancillary benefits include improvements in biodiversity, wildlife habitats, visual and landscape, timber supply and also recreational opportunities.

37. On the other hand, development of carbon sinks through large ‘tree farms’ and a reliance on monoculture may damage forest ecosystems. If a forest was managed purely for carbon sequestration, it would tend to be densely planted, with less consideration for biodiversity, landscape and recreation. However, if some open spaces and recreation facilities were created in the forest, this would increase its value for biodiversity and recreation. The forest would still sequester carbon but to a slightly lesser degree, highlighting the likely trade off between sequestration and different ancillary benefits.

38. Managing forests for carbon sequestration may also involve trade-offs with timber production. If a harvest restriction is imposed for 99 years, the rotation length would exceed its optimum, delaying timber receipts for forest owners/managers. If however, forests intended for amenity rather than timber production were also planted for carbon sequestration, then this issue would not arise.

Other impacts

39. GHG mitigation may also result in some significant ancillary costs to ecological systems. For example, switching to hydro-electrical power can damage river eco-systems. New renewable technologies introduce concerns over external effects such as ‘sight pollution’ and impacts to microclimates from wind farms. Fuel switching abatement options e.g. moving to CHP might increase NOx emissions in urban areas.

Distribution of ancillary benefits & costs

40. Ancillary benefits arising from GHG mitigation will typically be dominated by public health improvements resulting from air quality improvements. In particular populations located close to specific sources of emissions are likely to benefit most in terms of improved health. Furthermore, lower air pollution on a regional scale will also yield benefit to populations affected. Since the sources of GHG emissions are unevenly distributed across the UK, the distribution of these public health benefits may be unevenly distributed across the entire population and different socio-economic groups.

41. Improvements to public health will have a positive knock-on effect for healthcare services, potentially reducing episodes of air pollution related

illnesses. In addition to health service, the agricultural sector may experience significant ancillary benefits in terms of reduced crop damage from lower levels of air pollution. Forestry, National Parks, fisheries and other water systems will also benefit from reductions in atmospheric, aquatic and soil pollution.

42. In summary, the distribution of ancillary benefits arising from GHG mitigation will be location specific, and focussed mainly on public health and environmental factors.

THE MAGNITUDE OF ANCILLARY EFFECTS

43. This section explores available evidence on the magnitude of ancillary effects in the current literature. An attempt to identify factors that play a crucial role in determining these estimates has also been made.

44. Health benefits from reduced exposure to various forms of air pollutants typically account for 80% of the total estimated value of ancillary benefits of GHG mitigation in economic assessments in the US and other developed countries[6]. Studies have attempted to quantify and monetise both the health and the non-health ancillary effects of GHG mitigation policies, though controversy remains regarding magnitudes of non-health effects. As mentioned in the previous section, ancillary effects are very policy and location specific. Therefore it is extremely difficult to attribute a single value to ancillary effect associated with a unit abatement of GHG emissions. A summary of such available values is presented below.

Estimates of ancillary benefits

45. Table 2 presents a summary of 20 estimates of the monetary value of ancillary benefits from the literature. These estimates of ancillary benefits are mainly from the USA and other developed countries. . Figures reported in the table are converted to UK £ per tonne of carbon reduced[7]. The table summarises location, pollutants and impacts that are analysed by each study.

46. Estimates range from £2 per tonne of carbon reduced to £334 per tonne of carbon reduced. The average ancillary benefit, calculated from all studies presented in the table is approximately £70 per tonne of carbon reduced. However, the validity of this figure is limited, since most studies differ in methodology, analysis techniques and aspects included. Commensurability of various studies reported is limited, and therefore robustness of figures calculated from them is questionable.

47. The majority of estimates (13 out of 20) are less than £50 per tonne of carbon reduced. It is evident from Table 2 that studies concentrating purely on health impacts from a limited selection of pollutants tend to report the lowest estimates. Studies considering a wider range of pollutants and additional impacts such as materials damage, visibility and ecological damage generally estimate higher values for the ancillary benefits of mitigation.

48. The majority of studies concentrate on a carbon tax as the GHG mitigation policy implemented to reduce emissions. Taxes considered range from

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[6] Burtraw, B. & Toman, M (2000)
[7] £:$ exchange rate used, £1 = $1.52.

£6.50 per tonne of carbon to £45 per tonne of carbon[8]. The reduction in pollutants generated by the mitigation policy is then used to determine the extent of ancillary benefits.

Differences in estimates of ancillary benefits

49. Table 2 illustrates the large variance in monetary estimates of ancillary benefits. Variation in estimates between different studies reflects a whole range of factors. Aside from variations in the coverage of pollutants and impacts, differences in estimates are generated by different assumptions and the modelling methodology applied. The IPCC (2001) study highlights the important methodological features of estimating ancillary benefits:

- *Baseline*: the prospective policy scenario needs to be measured against key economic, demographic, regulatory, environmental and technological conditions, in order to determine potential benefits.
- *Economic modelling*: estimates can either be derived by 'top down' analysis or 'bottom up' analysis.
- *Emissions and environmental media modelling*: the extent of detail with which the interaction between pollutants and health effects are considered (i.e., whether secondary particulate formation is considered[9]) will crucially affect the estimates of the latter
- *Health effects modelling*: studies often vary in choice of concentration-response functions, implying differing values for health effects.
- *Valuation of effects*: studies usually differ in the employment of the 'value of statistical life' technique used to estimate mortality risk reductions, the most significant monetary benefit of reduced GHG emissions.
- *Treatment of uncertainty*: uncertainty needs to be accounted for throughout the modelling and valuation process. Sensitivity regarding the actual ancillary benefits and mitigation costs is likely to differ from study to study.

50. In addition to the points listed above, the treatment of location is vitally important in estimating the ancillary benefits of GHG mitigation. Models that are highly (spatially) aggregated are less sensitive to location, whereas disaggregated models increase the precision of estimates for that particular location. Disaggregated models[10] will account for factors such as the source location of emissions, transport of emissions through the atmosphere, and exposure of affected population. The magnitude of benefits derived from emissions reductions will depend crucially upon the size of the population exposed to the emissions. For example, the benefits from reduced emissions from a plant sited in rural area are likely to be

[8] Reported by IPCC (2001). Taxes range between US $ 10 – 67 / tC.
[9] Of all pollutants, particulates have the greatest affect on public health. Secondary particulate formation from SO2 and NOx has a significant impact on health in developed countries. Omission of secondary particulates from analysis is likely to lower estimates of ancillary benefits (IPCC 2001).
[10] The Burtraw et al (1999) model is an example of highly location-specific models.

lower than those accruing from reduction of emissions from a plant in an urban area.

51. In the context of the UK, consideration of specific European factors that may not be accounted for by the majority of studies is required. Factors that are likely to raise the estimates of ancillary benefits in Europe above those set out in Table 2 (mostly based on US studies) include:
    - the tendency of wind patterns to direct more emissions over populated areas;
    - the fact that population density is generally higher in Europe; and
    - the tendency for willingness to pay for ecological benefits to be higher in Europe.

52. Review of the estimates of ancillary benefits of GHG mitigation from the current literature suggests an average value of approximately £70 per tonne of carbon reduced. However there is substantial variance in estimates, which is most likely accounted for by the extent of coverage of studies in terms of impacts covered. Lower coverage of impacts, and in particular focus on human health effects from a few specific pollutants, will tend to provide lower value estimates, than consideration of a broader range of impacts. Consequently, current estimates regarding the ancillary benefits of GHG mitigation policies are confined to considering only the short-term health benefits that may accrue.

53. In addition to differences in coverage, the estimates reviewed are very sensitive to assumptions and methodologies. It is difficult to compare individual studies, since they normally differ in scope and extent of analysis. Estimates that account for location-specific factors will tend to be more robust, although all studies lack sufficient coverage of non-health benefits to be considered to be comprehensive.

Table 2: Available monetary estimates of ancillary effects

Study	Country	Average Ancillary Benefit (£ / tC abated)	Coverage of Study
HAIKU / TAF (1999)	USA	2	Health effects from NOx, incl. PM, excl O3
ICF / PREMIERE / Holmes et al (1995)	USA	2	Health effects from NOx, incl. PM, excl O3
PREMIERE / Dowlatabadi et al (1995)	USA	2	Health effects from NOx, incl. PM, excl O3
Burtraw et al (1999)	USA	2	Health effects from SO2 & NOx
Coal / PREMIERE (1997)	USA	5	Health effects from NOx, incl. PM, excl O3
Coal / PREMIERE /RIA (1996)	USA	17	Health effects from NOx, incl. PM, excl O3
EXMOD (1995)	USA	17	Health, visibility, environmental effects from NOx, SO2, incl. PM, excl O3
Goulder / Scheraga & Leary (1993)	USA	21	Health effects from SO2, NO2, CO, Pb
Abt Assocs. & Pechan-Avanti Grp (1999)	USA	25	Health, visibility and materials damage from SO2, NO2, O3, CO, PM, Pb
Boyd et al (1995)	USA	26	Health and visibility effects from SO2, NO2, O3, CO, PM, Pb
Scheraga & Leary (1993)	USA	27	Health effects from TSP, PM, SOx, NOx, CO, & VOC
Garbaccio et al (2000)	China	34	Health effects from SO2 & PM
Cifuentes et al (2000)	Chile	41	Health effects from SO2, NOx, CO, HC, PM & dust
Viscusi et al (1994)	USA	57	Health and visibility effects from SO2, NO2, O3, CO, PM, Pb
Barker & Rosendahl (2000)	W.Europe	101	Human & animal health, materials damage and vegetation effects from SO2, NOx & PM
Brendemoen & Vennemo (1994)	Norway	162	Health and environmental effects from SO2, NOx, CO, CO2, VOC, CH4, NO2 & PM plus traffic noise, road maintenance, congestion, accidents
Dessus & O'Connor (1999)	Chile	170	Health effects from 7 air pollutants (not specified)
Ekins (1996)	Not specified	180	Not specified
Lutter & Shogren (1999)	USA	197	Not specified
Aunan et al (2000) Kanudia & Loulou (1998)	Hungary	334	Health, materials damage, vegetation damage from TSP, SO2, NOx, CO, VOC, CO2, CH4, NO2

Sources: Adapted from OECD (2001), IPCC (2001) & Burtraw & Toman (2000)

CONCLUSIONS AND RECOMMENDATIONS

54. Ancillary benefits of GHG mitigation policies arise in addition to direct reductions of GHG emissions. Ancillary benefits are typically experienced on a local and regional scale in the near term by the current generation. Furthermore they are location specific, depending upon how and where mitigation takes place.

55. The IPCC (2001)[11] estimates that globally ancillary benefits may be 30% to over 100% of abatement costs. Typically, improvement to public health and the knock-on effect to health services resulting from reductions in air pollutants account for approximately 80% of the estimated total value of ancillary benefits of GHG mitigation in the USA and developed countries[12]. In addition, there are likely to be ancillary benefits to ecological systems, agriculture and crops, building and materials, and visibility.

56. The literature reviewed here mainly look at estimates of ancillary benefits in the USA and developed countries. These estimates of the overall magnitude of ancillary benefits range from £2 per tonne of carbon reduced to £334 per tonne of carbon reduced with the average ancillary benefit being approximately £70 per tonne[13]. The majority of estimates from studies are less than £50 per tonne of carbon reduced reflecting the fact that most studies concentrate purely on the short-term health impacts from a limited selection of pollutants. Studies that evaluate a wider range of pollutants and additional impacts such as materials damage, visibility and ecological damage are likely to estimate much higher values for the ancillary benefits of mitigation.

57. In addition to differences in coverage, the estimates reviewed are very sensitive to assumptions and methodologies Estimates crucially depend on baseline assumptions (e.g. what is likely to happen to quantities and effects of any particular pollutant with time as regulations change); economic, environmental and health effect modelling and valuation techniques used. It is difficult to compare individual studies, since they normally differ in scope and extent of analysis. Estimates that account for locational factors will tend to be more robust, although all studies lack sufficient coverage of non-health benefits to be considered to be comprehensive.

58. In the context of the UK, consideration of specific European factors that may not be accounted for by the majority of studies is required. These factors include; the tendency of wind patterns to direct more emissions over populated areas, the fact that population density is generally higher in Europe, and that there is a tendency for willingness to pay for ecological benefits to be higher in Europe. Such factors are likely to raise the

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[11] IPCC (2001); *Climate Change 2001 Mitigation, Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change* ; Cambridge University Press, Cambridge.
[12] Both IPCC (2001) and OECD (2001) suggest approximately 80%.
[13] See paper; 'The Ancillary Benefits of GHG Mitigation: Overall Magnitude of Impacts'

estimated value of ancillary benefits in Europe above those set out above (most studies are from the US).

59. In order to accurately assess the extent of ancillary benefits for the UK, some degree of quantification for each specific benefit is required. Different mitigation policies would be expected to generate very distinct ancillary benefits. For example, domestic energy efficiency policies are unlikely to derive the same ancillary benefits as those associated with transport or carbon sequestration policies. Estimates of this kind are likely to be best achieved via a bottom up methodology, which captures geographic and other specific factors.

Recommendations

60. **Despite uncertainty surrounding the quantification of ancillary effects, the studies reviewed in this paper suggest that the ancillary benefits of GHG mitigation may amount to a substantial proportion of mitigation costs. Ancillary effects should therefore be an important consideration in GHG policy decisions.**

61. **As ancillary effects are typically policy specific and location specific, it is not possible to readily use the monetary figures that are available in the international literature to estimate the ancillary effects associated with different mitigation policies for the UK**.

62. **More work could be usefully taken forward in order to estimate the value of policy specific ancillary effects for the UK covering the main types of mitigation policies.**