Residential Solid Fuel and Air Pollution Study

North South Ministerial Council (NSMC)

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Executive summary

Air pollution is the largest contributor to the burden of disease from the environment. The World Health Organisation (WHO) estimated that air pollution in 2012 was responsible for 7 million premature deaths worldwide, with almost 600,000 occurring in the WHO European Region. This is equivalent to one in eight of the total number of deaths worldwide. This finding more than doubles previous estimates[1] reflecting the improved scientific understanding of the damage that air pollution causes, even at low levels, and underscores the renewed current focus on clean air policy in the EU and in Ireland and Northern Ireland.

Premature deaths translate into substantial years of life lost (YLL, a life year is one year lost for one person). In addition, air pollution is responsible for a range of diseases, contributing to the overall burden of disease, which affects quality of life and imposes costs on the economy, for example, through increased health care costs and decreased work attendance.

Estimates of the economic cost of the air pollution health impact in the countries of the WHO European Region have been made. As of 2010, the overall annual economic cost of health impacts and mortality from air pollution, including estimates for morbidity costs, stood at US$ 1.575 trillion[1]. This represents a substantial health impact and shows that the economic cost of air pollution, and hence the benefits of cleaner air, are very large.

The Committee on the Medical Effects of Air Pollutants (COMEAP) calculated that air pollution, based on $PM_{2.5}$, for the UK in 2008 had a mortality burden equivalent to 29,000 deaths and an associated loss to the population of 340,000 life years. Similar calculations for Northern Ireland estimated 553 adult deaths attributable to air pollution and 6,063 life years lost in 2010. Calculations completed in this study for Ireland based on PM_{10} data suggests that there were 1,148 deaths in 2011 with 13,566 years of life lost. These data are similar to those published recently by the European Environment Agency who estimated premature deaths attributable to $PM_{2.5}$ exposure in 2012 were 1,200 for Ireland (and 37,800 for UK).

More recent data published on the health impact of ambient NO_2 pollution in the UK estimates an equivalent 23,500 deaths each year (based on 2010 data)[2]. A 2015 report from the European Environment Agency[3] suggests that there are no deaths in Ireland due to the low levels of NO_2, though a separate number for Northern Ireland is not available. It is therefore reasonable based on this evidence that the mortality impact from both PM and NO_2 for the island of Ireland is estimated to be at least 1,700 deaths per year and possibly in excess of 2,000 deaths per year.

Given this public health understanding it is imperative that Government at all levels plays a key role to improve the health of its citizens by devising, implementing and enforcing policies and legislation to reduce pollutant emissions. It is with this understanding, and the background that one of the key sources of pollution in Northern Ireland and Ireland is residential solid fuel burning, that the North South Ministerial Council representing Ireland and Northern Ireland announced the commissioning of the joint North-South study on Residential Solid Fuel and Air Pollution.

The announcement coincided with World Asthma Day an annual event organised by the Global Initiative for Asthma (GINA) to improve asthma awareness and respiratory care around the world. The joint North-South study was agreed between Minister, Phil Hogan T.D. and Alex Attwood M.L.A, respective former Environment Ministers for Ireland and Northern Ireland, at a North South Ministerial Council (NSMC) Environment Meeting.

During the discussions the importance of policy initiatives at local, regional and national level, as well as cooperation between neighbouring Member States, was recognised as a vital element to complement EU policy so as to tackle air pollution effectively. At a Clean Air Conference on 28th September 2015 to mark the 25th anniversary of the 'smoky' coal ban in Dublin, Minister for Environment, Alan Kelly TD announced a policy direction[4] that the smoky coal ban in Ireland is to be extended nationwide, leading to a complete transition from the use of smoky coal for home heating in a maximum timeframe of 3 years.

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[1] WHO and OECE (2015) Economic cost of the health impact of air pollution in Europe – Clean Air, Health and Wealth
[2] Defra (2015) Draft plans to improve air quality in the UK.
[3] European Environment Agency (2015) Air quality in Europe – 2015.
[4] http://www.environ.ie/en/Environment/Atmosphere/AirQuality/SmokyCoalBan/News/MainBody,42814,en.htm

Traditionally, both jurisdictions have tackled residential solid fuel pollution with similar policies including smoke control areas in Northern Ireland and smoky coal bans in Ireland, both of which have been demonstrated to be effective for management of air quality. Notwithstanding these historic successes, there remains concern, and further scrutiny of policy was deemed appropriate given the increased knowledge of the public health threat from air pollution, even at low levels. This study provides an assessment of the current situation in relation to the use of residential solid fuel on the island of Ireland including the following:

- current levels of air pollution (including PM_{10}, $PM_{2.5}$, and PAHs) in the context of EU standards and WHO guideline values
- significance and pollution intensity of residential heating and 'smoky' coal burning as a source of current air pollution
- health impact of air pollution in general and specifically from residential solid fuel emissions
- solid fuel markets (including relative cost data for heating fuels on an energy basis, import data) and the wider residential heating market considering barriers to move from dirtier fuels such as coal and petcoke to cleaner alternatives e.g. gas, oil
- smoke control legislation and enforcement
- potential tensions between clean air and climate policy particularly in relation to the promotion of biomass as a residential fuel
- fuel poverty
- a review of policy measures implemented across Europe to tackle high emissions from residential solid fuel combustion.

This evidence review found the following:

- Recent measurements of concentrations of $PM_{2.5}$ were less than the EU Directive limit value at all sites. However, the WHO 24-hour guideline was exceeded at all sites in Northern Ireland and most sites in Ireland. Measured concentrations of benzo[a]pyrene have generally decreased from 2010 levels so that the EU target value was met at all sites in Ireland and Northern Ireland in the most recent reported year (2012 and 2013 respectively). However, concentrations at sites in Northern Ireland remain close to the target value and substantially above the UK objective for polycyclic aromatic hydrocarbons.
- The WHO 24-hour guidelines for $PM_{2.5}$ and PM_{10} were exceeded most frequently during the winter months. Similarly, measured benzo[a]pyrene concentrations were also substantially higher in the winter which, along with PM, is indicative of solid fuel for home heating being a significant emissions source. However, high winter concentrations may also be related to other factors affecting dispersion of emissions.
- Analysis of the emission inventories indicates that PM_{10} and $PM_{2.5}$ emissions in Ireland decreased by approximately 12% between 2000 and 2013 with no clear discernible year on year trend, with emissions increasing in 2013 by 7% on the previous year. Coals (bituminous coal, anthracite & manufactured ovoids and lignite) make the single largest contribution to $PM_{10/2.5}$ emissions accounting for just half of all emissions in 2013, with its use up 13% year on year. The decline in peat use (-27% over the period) is a significant part of the overall reduction. There is a substantial contribution to PM emissions from biomass (10%); however, natural gas, kerosene and gas oil provide the major part of residential energy use but do not contribute much to $PM_{2.5}$ emissions in Ireland. Wood burning made the largest contribution to residential PM_{10} emissions in Northern Ireland in 2011 but the statistics regarding wood use in Northern Ireland are highly uncertain. Coal, solid smokeless (low smoke)[5] fuel and peat use also make large contributions to total emissions. Emissions from petroleum coke continue to contribute to emissions in Northern Ireland.
- Analysis of 2011 Small Area census data in Northern Ireland indicates that emission densities may be much higher in some small areas than shown in the NAEI 1 km maps.
- Ireland and Northern Ireland have long-established but different legislative instruments to mitigate public health impacts from use of solid fuels – smoky coal ban areas in Ireland and smoke control areas in Northern Ireland.

[5] The term 'smokeless fuel' is somewhat of a misnomer in relation to solid fuels as such fuels can have significant smoke emissions when compared to gas or oil. The term will be replaced with 'low smoke solid fuel' in solid fuel regulations in Ireland in 2015.

- There are air quality and climate co-benefits of reducing energy use from residential energy use. The air quality co-benefits are particularly evident when solid fuel is replaced by cleaner energy sources, like renewable electricity or cleaner fuels like gas or oil.
- The pathways by which fuel poverty affects health are complex. Excess Winter Mortality provides a statistical measure of the increased number of deaths in winter and is used as a measure of fuel poverty. Fuel poverty arises from a wide range of complex and inter-related factors including the level of energy demand or need, available income, and the price of fuel. None of these factors is uniquely or exclusively responsible for fuel poverty. However, almost all of the identified residential pollution hot spots in Ireland are in deprived or very deprived areas. Fuel poverty is widespread throughout Northern Ireland with a substantial proportion of fuel-poor households in each of the Local Government Districts. In both jurisdictions, these areas predominantly use coals or peat for heating with little use of oil or gas and thus the potential exists for impacts on air quality to elevate mortality and add to deprivation in these areas.

Following on from this evidence review, polices and measures were put forward for consideration. Where any of these measures, were already in place, they were further scrutinised to see how they could be further shaped to result in lower pollutant emissions. Key stakeholders were consulted on the effectiveness of existing policy and legislation and questions were asked as to the most appropriate and effective policy changes. Stakeholders included industry experts, local government, public health officials and non-government organisations across the spectrum of interests.

Clean air policy is typically wide in scope and often involves a range of measures to ensure efficient emission reduction and public health improvements whilst minimising fuel poverty. It is clear from the evidence presented in this report that a range of measures is likely to be most effective in improving public health in this regard. In particular the following policies should be considered:

- Further expansion of smoky coal ban (Ireland) / smoke control areas (Northern Ireland);

- These expansions should be implemented alongside policies on energy efficiency, as well as fiscal measures to promote the uptake of low emission fuels supplemented by raising the information and communication profile of the issue;

- It is clear that a tightening of such policies would bring public health benefits, though care needs to be given to provide support mechanisms for their implementation, including education and communication and especially by ensuring that, where possible, fuel poverty does not arise as a consequence of this policy making process;

Reported total NO_x emissions in Ireland are above the EU National Emission Ceiling (NEC) directive limit and if an upward trend is consolidated in future years, Ireland should consider additional measures to reduce NO_x emissions in the residential sector where solid fuels emit approximately twice as much NO_x per unit energy as other fuels. This issue does not arise in the case of Northern Ireland as UK emissions are below the specified NEC directive ceilings.

It is recognised that this evidence review and policy recommendations has focussed, deliberately, on one emissions source – residential solid fuel. Poor air quality is most often derived from many sources of emission. A further recommendation to Governments across all Ireland, therefore, is that while focus should rightly be targeted on key sources of emission, it should be acknowledged that in some areas of both jurisdictions, other pollution sources, for example road traffic emissions will be relevant. In the interests of improving public health all key sources of emission should be tackled where relevant in pollutant hotspot areas. A range of measures to reduce emissions from residential solid fuel combustion together with a similarly effective approach for other sources of air pollution will result in the best outcome to reduce the *ca.* 2,000 deaths each year across the island of Ireland.

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Appendices

1 Project overview

On the 7th May 2013 Ireland and Northern Ireland announced the commissioning of a joint North-South study on Residential Solid Fuel and Air Pollution given the threat posed to air quality and public health by such fuels and the links between the solid fuel markets in both jurisdictions.

The announcement coincided with World Asthma Day an annual event organised by the Global Initiative for Asthma (GINA) to improve asthma awareness and respiratory care around the world. The joint North-South study was agreed between Minister, Phil Hogan T.D. and Alex Attwood M.L.A, respective former Environment Ministers for Ireland and Northern Ireland, at a North South Ministerial Council (NSMC) Environment Meeting. The NSMC Environment Meeting took place in April following the Informal Council of EU Environment Ministers, which took place in Dublin as part of Ireland's EU Presidency programme.

During the discussions the importance of policy initiatives at local, regional and national level, as well as cooperation between neighbouring Member States, was recognised as a vital element to complement EU policy so as to tackle air pollution effectively.

2013 was designated by former Commissioner Janez Potočnik as the EU Year of Air and saw the revision of the EU's Thematic Strategy on Air Pollution, which was published in December 2013 as the EU's Clean Air Policy Package. The aim of the Clean Air Policy Package is to improve European air quality and public health over the next decade and beyond moving towards the WHO standards. One of the key factors to deliver this objective will require improved cooperation among environmental authorities across shared borders.

This joint all-island study is an example of such an initiative. Co-operation provides an opportunity to further improve air quality and deliver health benefits for the citizens of both Ireland and Northern Ireland. The aim of the study is to help develop policy options to reduce emissions from residential solid fuels and from smoky coal in particular. The work is intended to provide a summary of the environmental and human health benefits achievable and to assess the impacts of alternative policy options.

Currently Ireland has enforced restrictions on the marketing and use of 'smoky' (bituminous) coal in certain urban areas including all those with a population greater than 15,000. At a Clean Air Conference on 28th September 2015, which marked the 25th anniversary of the 'smoky' coal ban in Dublin, Minister for Environment, Alan Kelly TD announced a high level policy direction that the smoky coal ban in Ireland is to be extended nationwide, leading to a complete transition away from the use of smoky coal for home heating in a maximum timeframe of 3 years.

Northern Ireland has legislation which allows designation of Smoke Control Areas in which the emission of smoke from residential properties is not permitted. To achieve this, only authorised (smokeless (low smoke)) solid fuels may be burnt unless an 'Exempted Fireplace', designed to operate using specified fuels without substantial smoke, is used.

This study comprises of an evidence review to support the assessment of potential policy options to improve air quality and an assessment of the potential effects of policy proposals in relation to residential fuel markets and to vulnerable sections of the population.

The evidence review provides an assessment of the following topics on a Northern Ireland/Ireland/all-island basis:

- current levels of air pollution (including PM_{10}, $PM_{2.5}$, and PAHs) in the context of EU standards and WHO guideline values
- significance and pollution intensity of residential heating and 'smoky' coal burning as a source of current air pollution
- health impact of air pollution in general and specifically from residential solid fuel emissions
- solid fuel markets (including relative cost data for heating fuels on an energy basis, import data) and the wider residential heating market considering barriers to move from dirtier fuels such as coal and petcoke to cleaner alternatives e.g. gas, oil
- smoke control legislation and enforcement
- potential tensions between clean air and climate policy particularly in relation to the promotion of biomass as a residential fuel
- fuel poverty

The assessment of the current and potential policy approaches to reduce residential emissions includes the following:

- evaluate regulatory and enforcement options including
  - enhanced enforcement of existing smoke control legislation
  - increased legislative measures
  - further controls on the marketing of smoky coal and promotion of alternative cleaner residential fuels
- consult with relevant stakeholders including institutional, regulatory, industry and public health stakeholders and other interested parties
- consider relevance of the upcoming revision to EU Thematic Strategy on Air Pollution.

2 Air quality monitoring

Box 1: Summary of Section 2

Measured concentrations of sulphur dioxide, carbon monoxide, benzene and lead were generally substantially less than EU Directive limit values and WHO guidelines at monitoring sites in Ireland and Northern Ireland. These pollutants will therefore not be considered further in this study.

Measured nitrogen dioxide concentrations were generally less than the EU Directive limit values and WHO guidelines at monitoring sites in Ireland. The concentrations exceeded the EU directive limit values at several monitoring sites in Northern Ireland: however, these sites are all roadside, kerbside or urban centre sites that are likely to be affected by the emissions from road traffic. The concentrations were less than the EU limit values and WHO guidelines at the Derry Brooke Park urban background site.

Recent measurements of concentrations of particulate matter $PM_{2.5}$ were less than the EU Directive limit value at all sites. However, the WHO 24-hour guideline was exceeded at all sites.

Recent measurements of concentrations of particulate matter PM_{10} were less than the EU Directive annual limit value at all sites. The measured concentrations were also less than the EU Directive 24-hour limit value at all sites except at Newry Canal Street in 2013. However, the WHO 24-hour guideline was exceeded at most sites.

Measured concentrations of benzo[a]pyrene have generally decreased from 2010 levels so that the EU target value was met at all sites in Ireland and Northern Ireland in the most recent reported year (2012 and 2013 respectively). However, concentrations at sites in Northern Ireland remain close to the target value and substantially above the UK air quality objective for polycyclic aromatic hydrocarbons.

The Ireland smoky coal ban was extended to cover Ennis with effect from August 2011. There was a substantial reduction in annual mean $PM_{2.5}$ and PM_{10} concentrations at the Ennis monitoring site between 2010 and 2012.

The WHO 24-hour guidelines for $PM_{2.5}$ and PM_{10} were exceeded most frequently during the winter months when emissions from residential heating are likely to be highest. Measured benzo[a]pyrene concentrations were also substantially higher in the winter. However, high nitrogen dioxide concentrations at roadside sites in Northern Ireland also occurred most frequently in winter, which suggests that high winter concentrations generally may not be entirely related to higher emissions. Adverse dispersion conditions in winter, for example, may contribute to the high concentrations.

2.1 Introduction

The combustion of solid fuels used for residential heating produces various pollutants that are potentially harmful to human health. These pollutants include particulate matter (smoke and dust), polycyclic aromatic hydrocarbons (PAHs), oxides of nitrogen, sulphur dioxide, carbon monoxide, benzene and lead.

The World Health Organisation (WHO) and the European Union (EU) have reviewed the available evidence to assess whether there is a safe level of exposure to air pollution for each pollutant and whether a reduction in pollutant concentrations will result in health benefits. WHO and EU have set guideline or limit values based on the safe thresholds where these have been identified. Where safe threshold concentrations have not been identified, the WHO have set guideline values based on health criteria. The EU, in a stepwise move towards the WHO guidelines, has set legally binding limit values with the aim of lowering concentrations in the context of local constraints, capabilities and public health priorities. These standards were last updated in 2008. This section provides a summary of the WHO guideline values and EU limit values for relevant pollutants.

The UK Expert Panel on Air Quality Standards (EPAQS) also reviewed the available evidence on the health impacts of specific pollutants. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland has adopted more ambitious health protection objectives for sulphur dioxide, benzene and PAHs following EPAQS advice.

Pollutant concentrations are measured at monitoring stations at selected locations in Ireland and Northern Ireland. This section provides a summary of current levels of air pollution in the context of EU standards and WHO guideline values. It compares recently measured concentrations with the standards and guideline values.

2.2 WHO guidelines

WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide: global update 2005[6] provides guideline concentrations for the protection of human health. The guideline concentrations relate to a range of averaging times to take account of the long term and short term effects of the pollutants. Table 2-1 lists the guideline concentrations and their corresponding averaging times.

The effect of particulate matter on human health depends on the particle size. The WHO provides separate guideline concentrations for particulate matter with diameter less than 2.5 µm ($PM_{2.5}$) and for particulate matter with diameter less than 10 µm (PM_{10}).

[6] http://whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf?ua=1

Table 2-1: WHO air quality guidelines 2005 global update

Pollutant	Averaging time	Guideline concentration
$PM_{2.5}$	Annual	10 µg m^{-3}
	24-hour	25 µg m^{-3}
PM_{10}	Annual	20 µg m^{-3}
	24-hour	50 µg m^{-3}
Nitrogen dioxide	Annual	40 µg m^{-3}
	1-hour	200 µg m^{-3}
Sulphur dioxide	24-hour	20 µg m^{-3}
	10-minute	500 µg m^{-3}

The WHO has recently conducted a review of evidence on health aspects of air pollution – the REVIHAAP Project[7]. The project report concluded that the guidelines should be revised for some pollutants.

The REVIHAAP project report recommends that the current WHO guidelines for particulate matter should be updated because the evidence for the association between PM and short-term, as well as long-term, health effects has become much stronger. This is particularly important as recent long-term studies show associations between PM and mortality at levels for $PM_{2.5}$ well below the current EU limit values and below the annual WHO air quality guideline.

The REVIHAAP Project concluded that there is a need to revisit the evidence base for setting the WHO air quality guidelines for SO_2 (very short-term and short-term). Since the 2005 global update of the WHO air quality guidelines, some new studies on toxicological and health effects of SO_2 have been published. A reanalysis of the previous chamber study literature suggests a need to consider whether to increase the safety factor for the 10-minute guideline. For the 24-hour average guideline, the new studies give similar results to the previous studies. The new studies were conducted at a similar range of concentrations as the previous studies, so the 24-hour average guideline does not need to be changed if using the same method (using a concentration at the low end of the range of concentrations observed in the studies) to set the guideline.

The REVIHAAP Project concluded that recent evidence provides support for updating the current WHO air quality guidelines for NO_2, to give: (a) an epidemiologically based short-term guideline; and (b) an annual average guideline based on the newly accumulated evidence from outdoor studies. In both instances, this could result in lower guideline values.

WHO Air Quality Guidelines for Europe, Second Edition 2000[8] provides guideline values for various other pollutants. The guideline values for carbon monoxide are:

- 100 mg m^{-3} (90 ppm) for 15 minutes
- 60 mg m^{-3} (50 ppm) for 30 minutes
- 30 mg m^{-3} (25 ppm) for 1 hour
- 10 mg m^{-3} (10 ppm) for 8 hours

The Guidelines for Europe report considers the health effects of exposure to PAHs, benzene and lead in ambient air but does not provide concentration guideline values for these pollutants. The report concludes that the levels of these pollutants in air should be kept as low as possible.

[7] http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf?ua=1

[8] http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf

2.3 European Union Air Quality Limit Values

European Union Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe (the CAFE Air Quality Directive) sets limit values for ambient concentrations of sulphur dioxide, nitrogen dioxide, particulate matter (PM_{10} and $PM_{2.5}$), lead, carbon monoxide, benzene and ozone for the protection of human health. In addition, the Directive also requires that in areas where pollutant levels are already below the limit values then these levels shall be maintained.

Ozone does not result directly from solid fuel combustion in quantities sufficient to have a significant effect on air quality and is not considered further. Table 2-2 lists the CAFÉ Directive limit values for the main pollutants that are emitted as solid fuel combustion products.

Any member state that fails to meet the mandatory standards laid down in the directive may be liable to infraction proceedings and potential financial penalties. Both Northern Ireland and Ireland are subject to these directives. The CAFE Directive was transposed into Irish legislation by the Air Quality Standards Regulations 2011 (S.I. No. 180 of 2011and into the Air Quality Standards Regulations (Northern Ireland) 2010(SI 2010 no.188) in Northern Ireland.

Table 2-2: EU limit values for solid fuel combustion products

Pollutant	Averaging period	Limit value
Particulate matter, PM_{10}	One day	50 µg m^{-3} not to be exceeded more than 35 times in a calendar year
	Calendar year	40 µg m^{-3}
Particulate matter, $PM_{2.5}$	Calendar year	25 µg m^{-3} to be achieved by 1 January 2015 (Stage 1) 20 µg m^{-3} to be achieved by 1 January 2020 (Stage 2)
Sulphur dioxide	One hour	350 µg m^{-3} not to be exceeded more than 24 times in a calendar year
	One day	125 µg m^{-3} not to be exceeded more than 3 times in a calendar year
Nitrogen dioxide	One hour	200 µg m^{-3} not to be exceeded more than 18 times in a calendar year
	Calendar year	40 µg m^{-3}
Carbon monoxide	Maximum daily eight-hour mean	10 mg m^{-3}
Benzene	Calendar year	5 µg m^{-3}
Lead	Calendar year	0.5 µg m^{-3}

The CAFE Directive consolidated earlier air quality directives and introduced new standards relating to fine particulate matter ($PM_{2.5}$), which is considered to be especially harmful to human health. Furthermore, all Member States are required to calculate the current exposure of their population to $PM_{2.5}$ and to take steps by 2020 to meet a $PM_{2.5}$ Exposure Reduction Target (ERT), which is determined by current ambient $PM_{2.5}$ levels. The Exposure Reduction Target is applied to the Average Exposure Indicator (AEI), which is the three-calendar year running annual mean concentration averaged over all urban background sampling points. The Directive requires countries to reduce the AEI by 2020 by a specified percentage dependent on urban background concentration levels (a reduction of between and 20%) of the AEI in the reference year 2010. The higher the urban background levels the higher the reduction required, however, reductions are not required below 8.5 µg m^{-3} which is deemed a threshold for reasons of practicability.

European Union Directive 2004/107/EC (the Fourth Daughter Directive) specifies target values for ambient concentrations of arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons. The fourth Daughter Directive was transposed into Irish legislation by the Arsenic, Cadmium, Mercury, Nickel and Polycyclic Aromatic Hydrocarbons in Ambient Air Regulations 2009 (S.I. No. 58 of 2009).The Air Quality Standards Regulations (Northern Ireland) 2010 also includes these target values. The Directive does not specify a target value for PAHs as such because the term PAH represents a complex mixture of compounds. The Directive specifies a target value for benzo[a]pyrene as an indicator of PAH concentrations. The target value for benzo[a]pyrene in the PM_{10} fraction is 1 ng m^{-3} averaged over a calendar year. This value was selected on the basis that it would give rise to a lifetime cancer risk of 1 in 10,000. The WHO REVIHAAP report states that the current lifetime cumulative risk for benzo[a]pyrene causing cancer that is associated with the current guideline (1 ng m^{-3}) is somewhat high. It recommends that the acceptability of the level of risk associated with the current target value should be reviewed and discussed.

2.4 Air Quality Strategy for England, Scotland, Wales and Northern Ireland

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland[9] sets out air quality objectives for various pollutants. The objectives for most pollutants correspond to the EU Directive limit values. However, the Strategy sets potentially more stringent objectives for sulphur dioxide, benzene (in Northern Ireland and Scotland only) and polycyclic aromatic hydrocarbons (benzo[a]pyrene). Table 2-3 lists these additional objectives.

Table 2-3: Additional objectives for sulphur dioxide, benzene and polycyclic aromatic hydrocarbons in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland

Pollutant	Averaging period	Limit value
Sulphur dioxide	15-minute	266 µg.m^{-3} not to be exceeded more than 35 times a year
Benzene	Rolling annual mean	3.25 µg m^{-3}
PAHs	Annual mean	0.25 ng m^{-3} benzo[a]pyrene

2.5 Measured pollutant concentrations

The EU Air Quality Directive sets minimum requirements for monitoring air quality. The minimum number of monitoring stations depends on several factors including the distribution of the population and the measured pollution concentrations. Concentrations are measured at more than the minimum number of sites in Ireland and Northern Ireland in order to provide further information about local pollution.

The Environmental Protection Agency (EPA) is the competent authority in Ireland for ambient air quality monitoring and is responsible for reporting to stakeholders, including the public and the EU. The EPA coordinates the National Ambient Air Quality Monitoring Network, which comprises 29 monitoring stations situated across the country in 2012. There are also a further 6 stations operated by local authorities. The monitoring stations each measure the concentrations of one or more pollutants. Air quality data are available through the EPA Air Quality website[10].

During 2012, there were 26 automatic air quality monitoring stations in Northern Ireland, each equipped with continuous monitoring equipment for one or more of the pollutants for which automatic methods are used: CO, NO_x, SO_2, PM_{10}, $PM_{2.5}$ and O_3. These sites provide high-resolution hourly information on a wide range of pollutants. Data from the continuous monitoring sites are communicated rapidly to the public via the website www.airqualityni.co.uk Six of the automatic monitoring sites (Belfast Centre,

[9] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69336/pb12654-air-quality-strategy-vol1-070712.pdf

[10] http://www.epa.ie/air/quality/
http://erc.epa.ie/safer/resourcelisting.jsp?oID=10136&username=EPA%20Air%20Quality

Belfast Stockman's Lane, Derry Brooke Park, Armagh Lonsdale Road, Ballymena Ballykeel and Lough Navar) are part of the UK's national monitoring network, and are used to assess compliance with the Air Quality Directive.

This section provides a summary of the measured concentrations. The data for Ireland was extracted from the EPA's SAFER Data Archive[11]. The data for Northern Ireland was extracted from the Department of Environment Northern Ireland Air Quality Data and Statistics Database[12].

2.5.1 Particulate matter, $PM_{2.5}$

Table 2-4 shows a summary of recent measured concentrations at monitoring sites in Ireland and Northern Ireland. It shows the annual mean and maximum daily concentrations and the number of valid daily measurements at each site. It also shows the number of 24-hour concentrations greater than the WHO 24-hour guideline value of 25 µg m^{-3} for the whole year and for the winter months, January-March and October-December.

The measured concentrations are less than the Stage 1 and Stage 2 EU limit values.

Measured concentrations in Northern Ireland in 2011-2013 were greater than the WHO annual guideline of 10 µg m^{-3} at all sites. The measured concentrations in Ireland were less than the annual guideline at most of the sites. The lowest concentrations were observed at the Mayo Claremorris rural background site. The annual guideline was exceeded at the Dublin Rathmines urban background site in both 2011 and 2012; at the Cork Old Station Road urban traffic site in 2011; and at the Ennis suburban background site in both 2011 and 2012.

The measured concentrations exceeded the WHO 24-hour guideline of 25 µg m^{-3} on several days at all of the monitoring sites. The guideline was exceeded most frequently at the Ennis site in Ireland in 2011 and at Derry Brooke Park in Northern Ireland in 2012. The guideline was exceeded at these sites on more than 10% of days throughout the year.

The marketing, sale and distribution and use of bituminous coal is banned in most large towns and cities throughout Ireland. The ban was extended to include Ennis with effect from August 2011. The data shows that the annual mean, annual maximum and number of days exceeding the WHO 24-hour guideline decreased substantially between 2011 and 2012. The annual mean concentration also decreased substantially between 2010 and 2011: note also that the data for 2010 does not include the period January-April inclusive. Although the data is not sufficient to prove a definitive causal link, the data suggest that the introduction of the ban in Ennis has been an effective policy initiative in reducing $PM_{2.5}$ concentrations and thereby improving public health.

Table 2-4 shows that the great majority of the days when the concentration exceeds the WHO 24-hour guideline occur in winter, when solid fuel consumption is greatest. High winter concentrations can occur because of increased emissions: they may also occur because of adverse meteorological conditions that affect pollutant dispersion.

[11] The EPA Secure archive for environmental research data (SAFER) available here : http://erc.epa.ie/safer/
[12] DOENI air quality data available here : http://www.airqualityni.co.uk/data.php?n_action=data

Table 2-4: Summary of measured $PM_{2.5}$ concentrations[13][14]

Country	Year	Site	Annual mean, µg m^{-3}	Maximum daily mean, µg m^3	No. of valid days	No. of days >25 µg m^{-3}	No. of winter days >25 µg m^{-3}
Ireland	2012	Mayo Claremorris	5.6	32	359	3	3
		Longford Town	9.4	46	202	7	7
		Dublin Rathmines	10.6	57	366	20	20
		Dublin Marino	8.1	35	319	8	7
		Dublin Coleraine St	9.7	51	333	20	19
		Cork Old Station Road	9.4	54	366	12	12
		Clare Ennis	11.6	70	348	30	30
	2011	Dublin Rathmines	12.2	60	179	22	18
		Longford Town	8.9	52	298	27	23
		Mayo Claremorris	5.9	37	249	4	4
		Dublin Marino	8.9	68	310	21	18
		Dublin Coleraine St	11.2	87	348	31	26
		Cork Old Station Road	11.7	78	359	32	27
		Clare Ennis	13.6	152	353	50	46
	2010	Clare Ennis	16.4	148	231	43	43
Northern Ireland	2013	Belfast Centre	11.5	63	290	15	9
		Derry Brooke Park	11.4	68	276	21	21
		Lisburn Dunmurry Seymour Hill	12.0	63	273	23	19
	2012	Belfast Centre	10.3	64	353	15	15
		Derry Brooke Park	15.1	71	341	46	46
		Lisburn Dunmurry+ High School	12.1	50	108	8	8
		Lisburn Dunmurry Seymour Hill	11.6	53	105	3	3
	2011	Belfast Centre	14.0	77	289	27	19
		Derry Brooke Park	14.2	102	199	18	18
		Lisburn Dunmurry High School	13.1	69	251	25	20

+The Lisburn Dunmurry High School site was closed in 2012 and replaced with the Seymour Hill site

2.5.2 Particulate matter, PM_{10}

Table 2-5 and Table 2-6 show summaries of recent measured concentrations at monitoring sites in Ireland and Northern Ireland. They show the annual mean and maximum daily concentrations and the number of valid daily measurements at each site. They also show the number of 24-hour concentrations greater than the EU 24-hour limit value and WHO 24-hour guideline value of 50 µg m^{-3} for the whole year and for the winter months, January-March and October-December. The tables show data for the

[13] EPA, "EPA Ireland Archive of PM 2.5 Monitoring Data". Associated datasets and digitial information objects connected to this resource are available at: Secure Archive For Environmental Research Data (SAFER) managed by Environmental Protection Agency Ireland http://erc.epa.ie/safer/resource?id=0dc73e08-7e15-102b-aa08-55a7497570d3 (Last Accessed: 2014-07-11)
[14] http://www.airqualityni.co.uk/data_selector.php

most recent two years with available data for all sites. Data for Ireland was available for 2011 and 2012: data for Northern Ireland was available for 2012 and 2013.

Table 2-5 also shows data for the Clare Ennis site for earlier years (2006, 2010) in order to identify longer term trends. This site was selected because it was considered representative of solid fuel burning areas in Ireland. Data for 2007-2009 has not been reported here because of low data capture.

Table 2-6 also shows data for earlier years for Ballymena Ballykeel (2009-2011) and Lisburn Dunmurry High School (2008-2011). The sites were selected as representative of solid fuel burning areas in Northern Ireland. Measurement data using an indicative method is available for these sites for years before 2008/2009 but is not directly comparable with the current method of measurement.

The annual mean concentration at all the sites was less than the EU annual limit value.

The daily average concentrations at the Clare Ennis site in Ireland exceeded the limit of 50 µg m^{-3} on 34 days in 2010, just below the 35 day limit. The concentrations exceeded the limit on significantly fewer days in 2011 and 2012. The marketing, sale and distribution of bituminous coal was banned in Ennis in August 2011 and it is likely that the ban contributed to the significant reduction in the number of exceedences of the daily limit. The daily average concentration exceeded the limit value on fewer than 35 days in a year at the other sites in Ireland.

The daily average concentrations at the sites at the Newry Canal Street site in Northern Ireland exceeded the limit of 50 µg m^{-3} on more than 35 days in 2013. This site is a roadside site and vehicle emissions are expected to contribute substantially to concentrations at this site; it is known, however, that there are problems arising from the relatively enclosed location of this monitor, which does not comply with Local Air Quality Management guidelines, and therefore this site is due to be re-located. It is important to note also, that the Newry Canal Street site is not a national UK (AURN) monitoring site, but rather a District Council site. As such, it is used for assessing compliance with UK Air Quality Strategy objectives, and not for official compliance with the EU Air Quality Directive. The daily average concentration exceeded the limit value on fewer than 35 days in a year at the other sites in Northern Ireland.

The annual mean concentration substantially exceeded the WHO guideline of 20 µg m^{-3} at the Clare Ennis site in 2010 and 2006. However, the annual mean concentration decreased in 2011 and decreased further in 2012 so that it achieved the WHO guideline. The marketing, sale and distribution of bituminous coal was banned in Ennis in August 2011 and it is likely that the ban contributed to the reduction in the annual mean concentrations.

The annual mean concentration exceeded the WHO guideline of 20 µg m^{-3} at several sites in Northern Ireland in 2012 and 2013. The annual mean concentrations were particularly high at the Newry Canal Street roadside site.

The daily mean concentrations exceeded the WHO guideline of 50 µg m^{-3} on at least one day per year at most of the sites in both Ireland and Northern Ireland. However the guideline was met in 2012 at four sites in Ireland.

Figure 2-1 shows the trend in measured annual mean concentrations at Ballymena Ballykeel and Lisburn Dunmurry High School. The concentrations at Ballymena Ballykeel appear to have decreased steadily over the period 2009-2013. There is no clear trend in the measurements from Lisburn Dunmurry High School with the highest concentration observed in 2010 and the lowest in 2011.

Table 2-5 and Table 2-6 show that the great majority of the days when the concentration exceeds the WHO 24-hour PM_{10} guideline (as they do for $PM_{2.5}$) occur in winter, when solid fuel consumption is greatest. High winter concentrations can occur because of increased emissions: they may also occur because of adverse meteorological conditions affecting dispersion.

Table 2-5: Summary of measured PM_{10} concentrations in Ireland[15]

Country	Year	Site	Annual mean, µg m^{-3}	Maximum daily mean, µg m^{3}	No. of valid days	No. of days >50 µg m^{-3}	No. of winter days >50 µg m^{-3}
Ireland	2012	Wicklow Bray	16.7	57.5	365	5	4
		Monaghan Kilkitt	8.8	53.6	327	1	1
		Mayo Claremorris	10.4	43.9	359	0	0
		Galway Bodkin	5.6	59.7	317	1	1
		Dublin Winetavern St	12.6	47.6	352	0	0
		Dublin Rathmines	14.2	65.7	366	3	3
		Dublin Phoenix Park	11.0	47.1	361	0	0
		Dublin Dun Laoghaire	12.2	52.5	269	2	2
		Dublin Balbriggan	17.3	49.1	228#	0	0
		Cork Old Station Road	17.0	88.0	366	7	7
		Cork Heatherton Park	3.3	63.0	290	1	1
		Clare Shannon	10.7	57.2	176	1	1
		Clare Ennis	19.2	81.2	348	8	8
	2011	Mayo Castlebar	14.3	89.6	338	6	6
		Monaghan Kilkitt	9.4	55.6	334	1	0
		Galway Bodkin	17.1	64.6	312	4	3
		Dublin Winetavern St	14.4	96.9	357	7	4
		Dublin Tallaght	13.2	68.3	232##	5	2
		Dublin Ringsend	19.7	99.9	330	17	12
		Dublin Blanchardstown	15.9	120.3	350	11	8
		Dublin Dun Laoghaire	14.8	76.8	353	11	7
		Dublin Rathmines	16.1	80.2	363	10	7
		Clare Ennis	21.2	176.8	353	24	22
		Clare Shannon Town	11.3	50.8	245#	1	0
		Cork Heatherton Park	16.6	79.0	335	10	10
		Cork Old Station Road	20.6	95.0	344	19	16
	2010	Clare Ennis	27.5	168.7	304	34	35
	2006	Clare Ennis	26.1	103	279	19	19

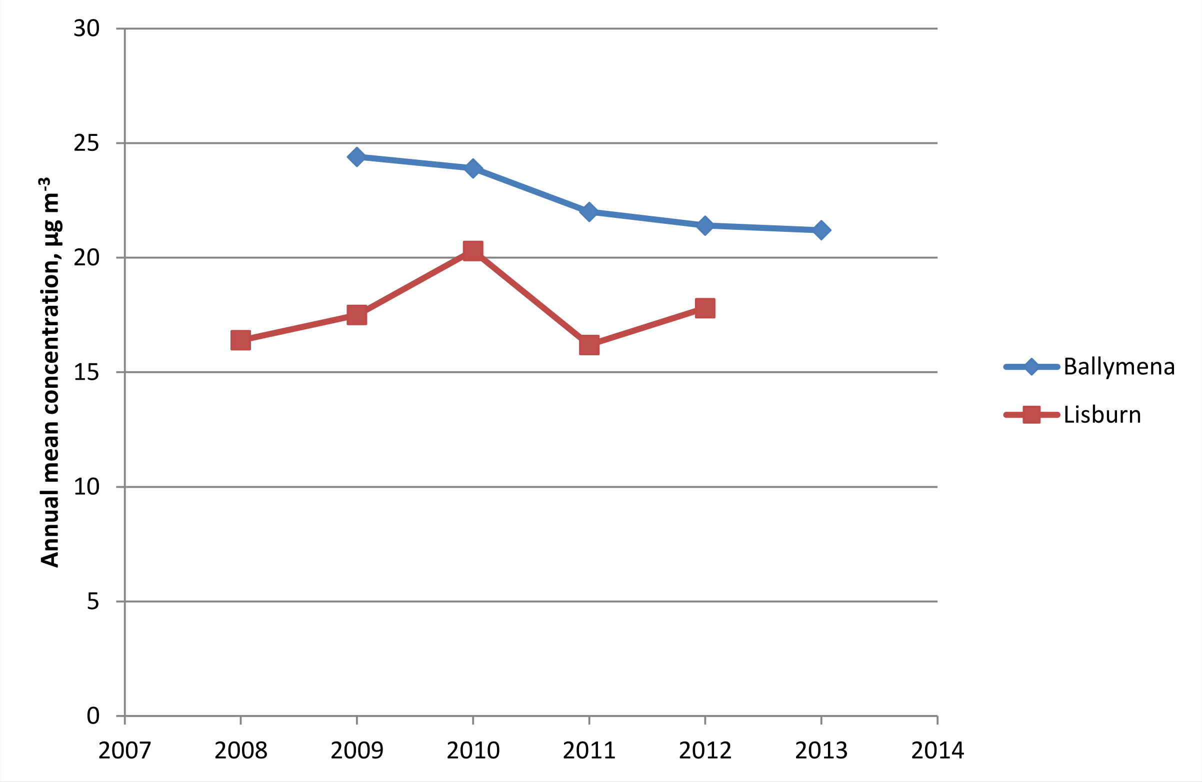
10. EPA, "EPA Ireland Archive of PM10 Monitoring Data". Datasets Available At: Secure Archive For Environmental Research Data managed by Environmental Protection Agency Ireland http://erc.epa.ie/safer/resource?id=154a12f7-76e4-102b-aa08-55a7497570d3 (Last Accessed: 2014-07-11)

Table 2-6: Summary of measured PM_{10} concentrations in Northern Ireland

Country	Year	Site	Annual mean, µg m^{-3}	Maximum daily mean, µg m^{3}	No. of valid days	No. of days >50 µg m^{-3}	No. of winter days >50 µg m^{-3}
Northern Ireland	2013	Armagh Lonsdale Road R	18.9	70	272	8	6
		Ballymena Ballykeel UB	21.2	86	312	6	5
		Belfast Westlink Roden Street R	22.8	102	277	13	10
		Belfast Stockmans Lane R	23.5	72	339	11	9
		Belfast Centre UC	17.6	75	266	5	3
		Derry Brooke Park UB	14.7	52	317	1	1
		Lisburn Dunmurry Seymour Hill UB	17.7	69	322	5	2
		Lough Navar	11.3	52	288	1	0
		North Down Holywood R	23.2	56	353	7	5
		Newry Trevor Hill R	21.8	91	344	21	19
		Newry Monaghan Row UB	17.7	85	361	13	11
		Newry Canal Street R	34.4	127	362	57	45
		Strabane Springhill Park UB	20.0	70	357	4	2
	2012	Armagh Lonsdale Road R	16.4	71	294	1	1
		Ballymena Ballykeel UB	21.4	64	331	6	6
		Belfast Westlink Roden Street R	26.4	81	328	11	11
		Belfast Stockmans Lane R	24.2	76	137	2	2
		Belfast Centre UC	14.7	68	352	7	7
		Castlereagh Dundonald	17.9	62	291	4	4
		Derry Brooke Park UB	17.1	67	183	2	2
		Lisburn Dunmurry High School UB	17.8	62	169	3	3
		Lisburn Dunmurry Seymour Hill UB	12.6	57	129	1	1
		Lough Navar	7.9	27	278	0	0
		North Down Holywood R	17.4	62	347	4	4
		Newry Trevor Hill R	18.1	92	305	10	10
		Newry Monaghan Row UB	14.5	114	277	7	7
		Newry Canal Street R	25.7	103	363	27	25
		Strabane Springhill Park UB	17.8	62	313	4	4
	2011	Ballymena Ballykeel UB	22.0	14	243	10	7
		Lisburn Dunmurry High School UB	16.2	7.4	351	11	7
	2010	Ballymena Ballykeel UB	23.9	107	115	11	11
		Lisburn Dunmurry High School UB	20.3	119	302	10	10
	2009	Ballymena Ballykeel UB	24.4	74	323	6	6
		Lisburn Dunmurry High School UB	17.5	62	338	2	2
	2008	Lisburn Dunmurry High School UB	16.4	59	312	2	2

+The Lisburn Dunmurry High School site was closed in 2012 and replaced with the Seymour Hill site

Figure 2-1 Trend in measured PM_{10} concentrations, Ballymena Ballykeel and Lisburn Dunmurry High School



2.5.3 Benzo[a]pyrene

Table 2-7 shows a summary of recent measured concentrations at monitoring sites in Ireland and Northern Ireland. It shows the annual mean and winter mean (January-March, October-December) at each of the sites where measurements took place.

The benzo[a]pyrene concentration was less than the EU target value of 1 ng m^{-3} at each of the monitoring sites in Ireland in 2011 and 2012. The concentration was less than the EU target value at each of the sites in Northern Ireland in 2013, although the concentrations remain above the objective of 0.25 ng m^{-3} set out in the Air Quality Strategy for England Scotland, Wales and Northern Ireland.

The measured concentrations of benzo[a]pyrene have decreased substantially since 2010 in both Ireland and Northern Ireland.

The winter mean concentrations approach twice the annual mean concentrations at most sites. The consumption of residential solid fuel which has the most significant Benzo[a]pyrene emission factors is greatest in the winter months. The higher concentrations monitored over the winter months can occur for a number of reasons including increased emissions from home heating which can accumulate locally and regionally because of adverse meteorological conditions affecting dispersion which are more prevalent in the winter. High concentrations measured in 2010 in Northern Ireland have been attributed to very cold winter weather[16].

[16] DoENI : Air Pollution in Northern Ireland 2013 available here http://www.airqualityni.co.uk/documents/1141128_AQ_NI_2013_Final.pdf

Table 2-7: Summary of measurements of benzo[a]pyrene concentrations

Country	Year	Site	Annual mean, ng m^{-3}	Winter mean, ng m^{-3}
Ireland	2012	Monaghan Kilkitt	0.04	0.03
		Galway Bodkin	0.13	0.19
		Dublin Winetavern Street	0.21	0.37
		Dublin Rathmines	0.16	0.26
		Cork Heatherton Park	0.18	0.26
	2011	Monaghan Kilkitt	0.14	0.26
		Galway Bodkin	0.14	0.26
		Dublin Winetavern Street	0.44	0.82
		Dublin Rathmines	0.25	0.47
		Cork Heatherton Park	0.97	1.89
	2010	Monaghan Kilkitt	0.18	0.30
		Galway Bodkin	0.46	0.81
		Dublin Winetavern Street	0.74	1.36
		Dublin Rathmines	0.97	1.89
		Cork Heatherton Park	1.09	1.93
Northern Ireland	2013	Kilmakee Leisure Centre	0.47	0.85
		Ballymena Ballykeel	0.83	1.39
		Derry Brandywell	0.89	1.40
	2012	Ballymena Ballykeel	1.03	1.64
		Derry Brandywell	0.85	1.20
	2011	Ballymena Ballykeel	1.12	2.01
		Derry Brandywell	0.91	1.60
		Lisburn Dunmurry High School	0.81	1.52
	2010	Ballymena Ballykeel	2.04	3.43
		Derry Brandywell	1.97	3.51
		Lisburn Dunmurry High School	1.25	2.29

2.5.4 Sulphur dioxide

Table 2-8 provides a summary of recent measured concentrations at monitoring sites in Ireland and Northern Ireland. It shows:

- Annual mean concentration
- Percentage hourly data capture
- Number of hours greater than the EU limit of 350 µg m^{-3}
- Number of days greater than the EU limit of 125 µg m^{-3}
- Number of days greater than the WHO guideline on 20 µg m^{-3}

There were no measured exceedences of the EU hourly or 24-hour limits in Ireland or Northern Ireland in 2012. There were no exceedences of these limits in Northern Ireland in 2013.

There were no measured exceedences of the WHO daily guideline of 20 µg m^{-3} in Ireland in 2012. There was one exceedence at each of two sites in Northern Ireland that year: however, there were no exceedences in the following year, 2013.

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland provides an objective of 266 µg m^{-3} as a 15 minute mean not to be exceeded more than 35 times in a calendar year. There were no exceedences of the objective in Northern Ireland in 2012 or 2013.

The WHO provide an additional guideline value of 500 µg m^{-3} as a 10-minute mean. 10-minute mean concentrations are not reported in Ireland or Northern Ireland. However, it would be surprising for this guideline to be exceeded where the maximum 15-minute average is less than 266 µg m^{-3}.

Table 2-8: Summary of measurements of sulphur dioxide concentrations

Country	Year	Site	Annual mean, µg m^{-3}	Data capture, %	No of hours >350 µg m^{-3}	No. of days >125 µg m^{-3}	No. of days >20 µg m^{-3}
Ireland	2012	Westmeath Mullingar	2.7	21	0	0	0
		Monaghan Kilkitt	2.7	92	0	0	0
		Limerick Shannon Estuary	2.3	80	0	0	0
		Dublin Winetavern St	0.3	99	0	0	0
		Dublin Tallaght	3.5	35	0	0	0
		Dublin Ringsend	3.3	17	0	0	0
		Dublin Rathmines	2.5	99	0	0	0
		Dublin Coleraine St	0.8	88	0	0	0
		Dublin Balbriggan	3.1	77	0	0	0
		Cork Old Station Road	3.5	97	0	0	0
Northern Ireland	2013	Ballymena Ballykeel UB	2.3	96	0	0	0
		Belfast Centre UC	1.8	98	0	0	0
		Derry Brooke Park UB	3.7	96	0	0	0
		Lisburn Dunmurry Seymour Hill UB	1.7	86	0	0	0
		Strabane Springhill Park UB	3.3	87	0	0	0
	2012	Ballymena Ballykeel UB	4.0	84	0	0	0
		Belfast Centre UC	2.4	99	0	0	0
		Derry Brooke Park UB	4.2	99	0	0	1
		Lisburn Dunmurry High School UB	2.7	36	0	0	0
		Lisburn Dunmurry Seymour Hill UB	4.7	35	0	0	1
		Strabane Springhill Park UB	3.6	92	0	0	0

+The Lisburn Dunmurry High School site was closed in 2012 and replaced with the Seymour Hill site

2.5.5 Nitrogen dioxide

Table 2-9 provides a summary of recent measured nitrogen dioxide concentrations at monitoring sites in Ireland and Northern Ireland. It shows the annual mean and maximum hourly concentrations and the number of valid hourly measurements at each site. It also shows the number of 1-hour concentrations greater than the EU limit and WHO 24-hour guideline of 200 µg m^{-3} for the whole year and for the winter months, January-March and October-December.

The EU Directive annual mean and hourly mean limit values were met at all the continuous monitoring sites in Ireland in 2012. The WHO annual guideline of 40 µg m^{-3} was also met at all the monitoring sites in Ireland. The WHO hourly guideline was met at all the monitoring sites in Ireland in 2012, except for one hour at one site (Dublin Swords).

The EU Directive annual mean limit value and the WHO annual guideline of 40 µg m^{-3} was exceeded at several of the sites in Northern Ireland. The WHO hourly guideline of 200 µg m^{-3} was exceeded several times: the hourly concentration exceeded 200 µg m^{-3} more than 18 times in a calendar year at Limavady Dungiven and Newry Canal Street in 2012 and 2013 and at Belfast Stockman's Lane in 2012. However, all the sites with concentrations in excess of the limit values or guidelines are roadside, kerbside or urban centre (Belfast Centre) sites that are substantially affected be oxides of nitrogen emissions from motor vehicles. The EU limit values and WHO guidelines for nitrogen dioxide were met at the only urban background site in Northern Ireland (Derry Brooke Park).

The great majority of the exceedences of the WHO hourly guideline occurred in the winter months at the Northern Ireland roadside sites. Road traffic is broadly constant throughout the year so that it may be concluded that other factors, such as adverse meteorological conditions, make a substantial contribution to the winter exceedences. This suggests that adverse meteorological conditions may also contribute to high winter concentrations of other pollutants.

Table 2-9: Summary of measured nitrogen dioxide concentrations

Country	Year	Site	Annual mean, µg m^{-3}	Maximum daily mean, µg m^3	No. of valid hours	No. of hours >200 µg m^{-3}	No. of winter hours >200 µg m^{-3}
Ireland	2012	Westmeath Mullingar	6.8	62	2012	0	0
		Monaghan Kilkitt	3.8	42	7542	0	0
		Mayo Castlebar	7.9	74	8565	0	0
		Kilkenny Seville Lodge	4.4	62	7912	0	0
		Dublin Winetavern St.	29.1	136	8669	0	0
		Dublin Swords	14.9	241	8718	1	1
		Dublin Ringsend	25.3	122	1523	0	0
		Dublin Rathmines	21.2	138	8753	0	0
		Dublin Dun Laoghaire	18.0	136	6489	0	0
		Dublin Coleraine Street	25.6	142	7900	0	0
		Dublin Blanchardstown	29.7	194	6594	0	0
		Dublin Balbriggan	9.2	87	6877	0	0
		Cork Old Station Road	22.8	121	7461	0	0
		Cork Glashaboy	4.5	41	7707	0	0
		Clare Shannon	9.5	74	4382	0	0
Northern Ireland	2013	Armagh Lonsdale Road	26.5	202	8670	1	1
		Ballymena North Road	28.5	279	8521	2	2
		Belfast Westlink Roden Street	38.4	228	8523	2	2
		Belfast Ormeau Road	54.0	207	2136	2	2
		Belfast Stockman's Lane	53.3	317	8648	13	13
		Belfast Centre	31.2	209	8492	2	2
		Belfast Newtownards Road	37.1	199	8104	0	0
		Castlereagh Dundonald	32.1	164	8501	0	0
		Derry Dales Corner	30.3	172	8466	0	0
		Derry Marlborough St.	60.3	189	7999	0	0
		Derry Brooke Park	14.1	118	8500	0	0
		Downpatrick Roadside	40.0	207	8030	1	1
		Lisburn Lagan Valley Hospital	27.2	291	4112	1	1
		Limavady Dungiven	36.6	291	4793	19	19
		North Down Holywood A2	29.0	298	8449	8	8
		Newtownabbey Antrim Road	39.3	193	7879	0	0
		Newry Trevor Hill	55.5	205	6076	3	0
		Newry Canal St.	47.0	252	8256	29	27
		Armagh Lonsdale Road	27.3	126	8440	0	0
		Ballymena North Road	27.5	346	7951	9	9
		Belfast Westlink Roden Street	39.1	254	8732	13	13
	2012	Belfast Ormeau Road	53.0	233	8337	3	2
		Belfast Stockman's Lane	58.4	296	5884	32	31
		Belfast Centre	29.3	339	8659	5	5
		Belfast Newtownards Road	37.9	262	8693	3	3

Country	Year	Site	Annual mean, µg m-3	Maximum daily mean, µg m3	No. of valid hours	No. of hours >200 µg m-3	No. of winter hours >200 µg m-3
		Castlereagh Dundonald	29.9	258	8769	3	3
		Derry Dales Corner	34.5	195	8132	0	0
		Derry Marlborough St.	63.5	208	8478	3	3
		Derry Brooke Park	15.0	99	8722	0	0
		Downpatrick Roadside	38.4	195	8244	0	0
		Lisburn Lagan Valley Hospital	24.5	157	7186	0	0
		Limavady Dungiven	48.6	323	7301	27	19
		North Down Holywood A2	33.5	488	8233	18	18
		Newtownabbey Sandyknowles	35.5	246	2209	2	2
		Newtownabbey Ballyclare Main St.	37.9	206	2148	1	1
		Newtownabbey Antrim Road	41.8	224	8519	3	3
		Newry Trevor Hill	51.1	193	8349	0	0
		Newry Canal St.	47.4	333	8674	75	75

2.5.6 Benzene

Table 2-10 shows the annual mean benzene concentrations measured at monitoring stations in 2012. The measured concentrations are all substantially less than the EU Directive limit of 5 µg m^{-3}. The measured annual mean at Belfast Centre is sufficiently low that it is very unlikely that the UK Air Quality Strategy objective of 3.25 µg m^{-3} was exceeded.

Table 2-10: Measured benzene concentrations, 2012.

Site	Annual mean benzene concentration, µg m-3
Dublin Rathmines	1.2
Cork Old Station Road	0.6
Dublin Balbriggan	0.4
Westmeath Mullingar	0.4
Clare Shannon Town	0.4
Belfast Centre	0.6

2.5.7 Lead

Table 2-11 shows the annual mean lead concentrations measured at monitoring stations in 2012. The measured concentrations are all substantially less than the EU Directive limit of 0.5 µg m^{-3} (500 ng m^{-3}).

Table 2-11: Measured lead concentrations, 2012.

Site	Annual mean lead concentration ng m^{-3}
Dublin Rathmines	2.2
Dublin Winetavern St.	7.2
Cork Heatherton Park	20.3
Galway	8.1
Monaghan Kilkitt	5.5
Belfast Centre	4.2

2.5.8 Carbon monoxide

Table 2-12 shows the maximum 8-hour running mean and maximum hourly concentrations measured at monitoring sites in 2012. The maximum running mean concentrations are all substantially less than the EU Directive limit value and WHO guideline of 10 mg m^{-3}. The maximum hourly concentrations are all substantially less than the WHO guideline of 30 µg m^{-3}.

Table 2-12: Measured carbon monoxide concentrations, 2012.

Site	Maximum 8-hour running mean, mg m^{-3}	Maximum 1-hour mean, mg m^{-3}
Dublin Winetavern St.	1.4	2.1
Dublin Coleraine St.	3.5	3.8
Dublin Ringsend	2.1	3.4
Cork Old Station Road	2.2	3.7
Dublin Balbriggan	1.6	2.4
Westmeath Mullingar	0.8	1.4
Clare Shannon Town	0.9	1.5
Belfast Centre	1.9	2.7

2.6 Summary

Measured concentrations of sulphur dioxide, carbon monoxide, benzene and lead were generally substantially less than EU Directive limit values and WHO guidelines at monitoring sites in Ireland and Northern Ireland. These pollutants will therefore not be considered further in this study.

Measured nitrogen dioxide concentrations were generally less than the EU Directive limit values and WHO guidelines at monitoring sites in Ireland. The concentrations exceeded the EU directive limit values at several monitoring sites in Northern Ireland: however, these sites are all roadside, kerbside or urban centre sites that are likely to be affected by the emissions from road traffic. The concentrations were less than the EU limit values and WHO guidelines at the Derry Brooke Park urban background site.

Recent measurements of concentrations of particulate matter $PM_{2.5}$ were less than the EU Directive limit value at all sites. However, the WHO 24-hour guideline was exceeded at all sites.

Recent measurements of concentrations of particulate matter PM_{10} were less than the EU Directive annual limit value at all sites. The measured concentrations were also less than the EU Directive 24-hour limit value at all sites except Newry Canal Street in 2013. Ennis in Clare was just below the limit value in 2010. However, the WHO 24-hour guideline was exceeded at most sites.

Measured concentrations of benzo[a]pyrene have generally decreased from 2010 levels so that the EU target value was met at all sites in Ireland and Northern Ireland in the most recent reported year (2012 and 2013 respectively). However, concentrations at sites in Northern Ireland remain close to the target value and substantially above the UK air quality objective for polycyclic aromatic hydrocarbons.

The Ireland smoky coal ban was extended to cover Ennis in August 2011. There was a substantial reduction in annual mean $PM_{2.5}$ and PM_{10} concentrations at the Ennis monitoring site between 2010 and 2012.

The WHO 24-hour guidelines for $PM_{2.5}$ and PM_{10} were exceeded most frequently during the winter months when emissions from residential heating are likely to be highest. Measured benzo[a]pyrene concentrations were also substantially higher in the winter. However, high nitrogen dioxide concentrations at roadside sites in Northern Ireland also occurred most frequently in winter, which suggests that high winter concentrations generally may not be entirely related to higher emissions. Adverse dispersion conditions in winter, for example, may contribute to the high concentrations.

3 Significance and pollution intensity of residential heating and 'smoky' coal burning

Box 2: Summary of Section 3

Reported total NO_x emissions in Ireland are above the National Emission Ceiling (NEC) directive limit and if an upward trend is consolidated in future years, Ireland will need to consider additional measures to reduce NOx emissions in the residential sector where solid fuels emit approximately twice as much NOx per unit energy as other fuels. This issue does not arise in the case of Northern Ireland as UK emissions are below the specified NEC directive ceilings.

Analysis of the emission inventory indicates that PM_{10} and $PM_{2.5}$ emissions in Ireland decreased by approximately 12% between 2000 and 2013 with no clear discernible year on year trend, with emissions increasing in 2013 by 7% on the previous year. Coals (bituminous coal, anthracite & m,anufactured ovoids, lignite) make the single largest contribution to $PM_{10/2.5}$ emissions accounting for just half of all emissions in 2013. Coal fuels are the largest contributor to residential emissions at high emission density hotspots in much of the country. The decline in peat use (-27% over the period) is a significant part of the overall reduction. Much of the peat is burned in open countryside where the public health impacts of poor air quality are less likely to be significant: nevertheless, our analysis of data on the prevalence of the use of different residential fuels from Census 2011 indicates peat combustion is associated with elevated PM_{10} emission densities (emissions per unit area) in small areas, mainly throughout the Midlands (parts of Galway, Laois, Offaly, Kerry and North Tipperary) where peat bogs are a local and traditional source of fuel. The high emission densities could potentially result in significant impact on local air quality concentrations. There is a substantial contribution to emissions from biomass (10%), however, natural gas, kerosene and gas oil provide the major part of residential fuel use but do not contribute much to $PM_{2.5}$ emissions in Ireland.

Wood burning made the largest contribution to residential PM_{10} emissions in Northern Ireland in 2011 but wood use in Northern Ireland is highly uncertain and trends may reflect UK rather than Northern Ireland use. Coal, solid smokeless (low smoke) fuel and peat use also make large contributions to the total emissions. Emissions from petroleum coke continue to contribute to the inventory total. The UK NAEI provides maps of combined commercial, institutional and residential emissions for Northern Ireland at 1 km spatial resolution. The PM_{10} emission density is less than 0.2 tonne km^{-2} (2 kg ha^{-1}) throughout most of Northern Ireland with higher emission densities in, for example, west Belfast, Lisburn and Derry. Our analysis of 2011 Small Area census data indicates that emission densities are much higher in some small areas than shown in the NAEI 1 km maps. Solid fuel combustion is the main contributor to emissions in emission density hotspots throughout Northern Ireland.

Different emission factors have been used for residential solid fuel combustion in the emission inventories for Ireland and Northern Ireland reflecting different methodological approaches in the different jurisdictions. The inventories assume that the emission factor is directly related to fuel type alone: however, there are considerable differences in particulate matter emission factors between combustion appliance types using the same fuel. There is thus considerable uncertainty in the calculation of emissions, particularly at local level. The uncertainty might be reduced if more detailed information on the types of appliance was available.

Particulate matter emissions are projected to decrease in future, based on a range of assumed policy interventions, including a shift to cleaner energy sources driven, inter alia by climate policy. IIASA projections indicate that significant further reductions in emissions can be obtained as the result of technical measures to improve combustion performance, for example through the implementation of Eco-design standards. However, the success of the Ecodesign standards in the real world is vitally dependent on operator practice and the fuel type and quality. For example, a stove tested on 'smokeless (low smoke)' coal will have much higher real world emissions and lower energy efficiency when operated using regular bituminous (smoky) coal. To ensure the success of the Ecodesign standards, it will be important that Member States and regions take action to assure fuel quality and a concomitant shift to cleaner, less polluting solid fuels, where such fuels are used.

3.1 Introduction

This section considers the contribution from residential fuels to pollutant emissions in Ireland and Northern Ireland (including emission ceilings). It considers the numbers of households using different fuel types as their main source of heating. It includes a screening estimate of the emissions from Small Areas throughout Ireland and identifies potential emissions “hotspots” where the emissions per unit area are highest.

This section provides a short summary of the output from published dispersion modelling studies that estimate the contribution from residential heating to pollutant concentrations.

Air pollutant emission inventories are calculated by multiplying levels of activity by emission factors for each fuel. This section also includes a screening assessment to identify residential emission ‘hotspots’ where levels of air quality are likely to be elevated. The assessment is based on estimates of emissions from residential fuels for Ireland and for Northern Ireland using common UK emission factors and household heating data in the census data for each jurisdiction.

It is important to note that Ireland has adopted the revised EMEP/EEA guidebook 2013 for compiling national inventories in 2014. This results in significantly revised emission estimates for the residential sectors. However, these data were not available at the time of writing the Interim Report, but have been included for this final report. The updated estimates significantly improve the understanding of the emission trends for residential solid fuel emissions.

The European Commission has developed Ecodesign and labelling regulations for a variety of residential heating appliance types. This section includes a summary of the output from IIASA studies that consider the potential effect of the Ecodesign regulations on emissions from Ireland.

3.2 Pollutant emissions from residential activities

3.2.1 Particulate matter PM_{10}

Table 3-1 provides a summary of the emissions of particulate matter, PM_{10} from sources in Northern Ireland over the period 2000-2011 (UK National Atmospheric Emission Inventory). Table 3-1 shows the emissions categorised according to main emission sector in order to set residential emissions in the context of overall emissions. It also shows the residential emissions classified by fuel type in order to indicate the relative contributions from different fuels. The data shown in Table 3-1 are presented in Figure 3-1 and Figure 3-2.

Figure 3-1 shows that total PM_{10} emissions from Northern Ireland have decreased by approximately 40% since 2000. The emissions from the energy industries, mostly public power generation, have decreased substantially. Emissions from residential sources were the second largest contributor to emissions in 2011 with the “other” category, including commercial, institutional and agricultural sources providing the largest contribution.

Figure 3-2 shows that residential emissions decreased by approximately 50% between 2000 and 2005 but have remained at that level since then. The decline in peat emissions is a significant part of that reduction. Natural gas, LPG, fuel and gas oil have lower PM emissions than solid fuels (see Section 3.4) and do not contribute much to PM_{10} emissions in Northern Ireland. The emissions from anthracite have decreased substantially. The emissions from burning oil have not changed much since 2000. Wood burning made the largest contribution to emission in 2011 (however these estimates are highly uncertain as, in the absence of data for Northern Ireland, they assume similar growth as for the UK), with coal, solid smokeless (low smoke) fuel and peat also making large contributions. Emissions from petroleum coke continue to contribute to the inventory total.

Table 3-2 provides a summary of the emissions of particulate matter, PM_{10} from sources in Ireland over the period 2000-2013 (data for Northern Ireland for the same period are not available at the time of writing). The data was prepared for reporting under the Convention on Long Range Transport of Air Pollution (CLRTAP). Table 3-2 shows the emissions categorised according to main emission sector in order to set residential emissions in the context of overall emissions. It also shows the residential emissions classified by fuel type in order to assess the relative contributions from different fuels. The data shown in Table 3-2 are presented in Figure 3-3 and Figure 3-4.

Figure 3-3 shows that total PM_{10} emissions from Ireland have decreased by approximately 17% since 2000. The emissions from the energy industries, mostly public power generation, have decreased substantially. Emissions from residential sources were the second largest contributor (36%) to PM_{10} emissions in 2013 with the “energy industries” category, providing the smallest contribution.

Figure 3-4 shows that residential emissions of PM_{10} in Ireland decreased by approximately 12% between 2000 and 2013 with no clear discernible trend, (emissions increased between some years . The decline in peat use (about 27% over the period) and emissions is a significant part of that reduction. Solid 'coal' fuels (bituminous coal, manufactured fuels, lignite) make the single largest contribution to PM_{10} emissions accounting for half of all emissions in 2013. There is a substantial contribution to emissions from biomass (10%); however, natural gas, kerosene and gas oil provide the major part of residential fuel use but do not contribute much to PM_{10} emissions in Ireland.

Estimated total annual PM_{10} emissions per head of population in Ireland are higher than for Northern Ireland (approximately 5.6 and 2.9 kg respectively in 2011),.The contribution from residential heating is similarly higher in Ireland compared to Northern Ireland (1.9 kg vs 0.8 kg). This difference in the emissions per head of population from residential heating may be explained to some extent by differences in the emission factors used to calculate the emissions. Also, whilst, gaseous fuel use is relatively well-characterised for Northern Ireland, the use of solid fuel is much more uncertain and may account for the difference in the estimates between the jurisdictions; this matter is discussed in Section 3.6.

Coal fuels, peat and biomass make a substantial contribution to PM_{10} emissions in both Ireland and Northern Ireland. Note that the Northern Ireland inventory is a disaggregation of the UK inventory and, unless there is specific activity data available for Northern Ireland, some trends in emissions may reflect trends in energy use in the UK.

Table 3-1: Northern Ireland PM_{10} emissions 2000-2011, tonnes

Source	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Energy industries	760	1,023	396	413	315	295	292	251	223	113	71	54
Manufacturing industries and construction	724	652	542	502	518	651	636	654	552	501	577	514
Transport	1,222	1,211	1,250	1,276	1,234	1,217	1,200	1,146	1,108	1,071	1,037	892
Residential	3,187	2,781	2,523	2,142	1,778	1,537	1,454	1,385	1,513	1,472	1,570	1,536
Other+	3,038	2,940	2,972	2,980	2,948	2,745	2,660	2,491	2,407	2,214	2,186	2,282
Total	8,931	8,607	7,683	7,313	6,792	6,444	6,241	5,927	5,803	5,370	5,441	5,278
+Includes commercial, institutional and agricultural emissions												
Residential emissions by fuel type												
Anthracite	124	104	83	62	42	23	16	14	12	16	16	16
Burning oil	88	93	97	105	112	106	111	98	101	103	115	89
Coal	796	664	531	399	266	211	248	329	370	340	360	358
Coke	117	54	143	104	41	28	18	12	10	8	8	6
Fuel oil	0	0	0	0	0	0	0	0	0	0	0	0
Gas oil	5	6	8	7	7	6	7	7	7	6	7	6
LPG	4	4	3	3	2	2	2	2	3	2	3	2
Natural gas	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Peat	1218	1075	932	790	647	504	361	218	218	218	218	218
Petroleum coke	173	161	148	136	124	115	107	99	103	91	99	91
SSF	408	367	322	281	250	211	212	193	242	222	256	222
Wood	253	253	253	255	288	329	370	411	444	464	485	526
*Residential Total**	*3,186*	*2,781*	*2,520*	*2,142*	*1,779*	*1,535*	*1,452*	*1,383*	*1,510*	*1,470*	*1,567*	*1,534*
*Any mismatch with totals above due to rounding of emissions for individual fuels												

Figure 3-1: Northern Ireland PM_{10} emissions 2000-2011 by sector

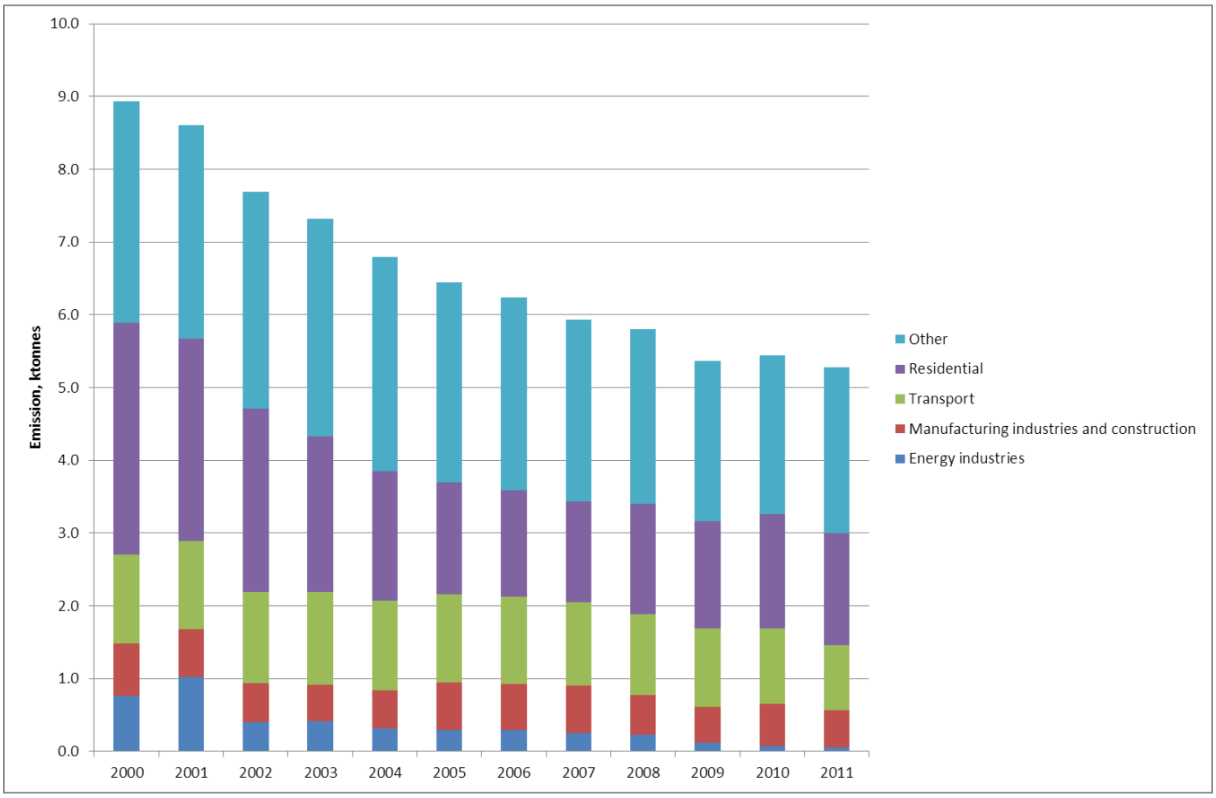


Figure 3-2: Northern Ireland PM_{10} emissions from residential sources 2000-2011 by fuel type

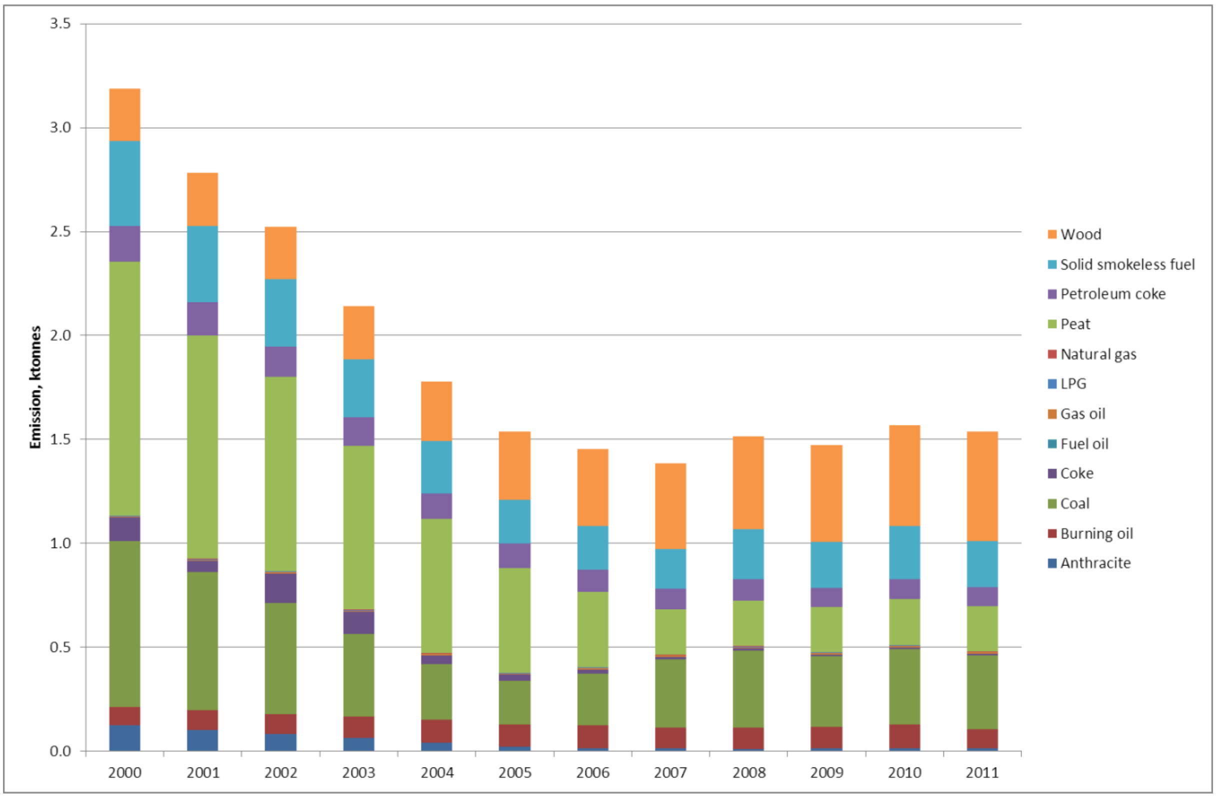


Table 3-2: Ireland PM_{10} emissions 2000-2013, tonnes

Source	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Energy industries	1796	2058	1710	1362	1487	1562	1392	1078	1017	799	717	612	709	627
Manufacturing industries and construction	2098	2226	2133	2361	2570	2906	2664	2598	2401	1958	2011	1776	1692	1692
Transport	3244	3082	2836	2717	2751	2531	2440	2408	2150	1895	1726	1603	1476	1455
Residential	10512	9931	9771	9180	8979	9379	9122	8937	9366	10058	9544	8764	8675	9284
Other[+]	13363	13421	13172	13320	13401	13234	12989	12894	13353	12833	12645	12647	12702	12595
Total	31014	30717	29622	28941	29187	29613	28607	27916	28287	27543	26643	25403	25254	25654
[+]Includes commercial, institutional and agricultural emissions														
Residential emissions by fuel type														
Bituminous Coal	3552	3069	2876	2823	2666	2761	2683	2405	2767	3123	3000	2565	2789	2926
Anthracite + Manufactured Ovoids	993	1,045	954	899	993	1,000	956	1,017	955	1,192	1,126	1,140	1,103	1,399
Lignite	288	350	432	312	248	398	62	99	165	201	176	178	202	293
Peat	5,059	4,864	4,910	4,572	4,505	4,619	4,796	4,589	4,731	4,596	4,289	4,081	3,629	3,686
Kerosene	45	51	53	57	62	63	63	63	70	73	80	64	54	56
LPG	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Gasoil / Diesel/ DERV	19	20	20	20	19	20	20	19	20	17	16	15	15	13
Petroleum Coke	4	5	4	4	2	3	2	3	2	1	1	1	1	1
Natural Gas	4	4	4	5	5	5	5	5	6	5	6	5	5	5
Biomass	547	523	518	488	478	507	534	738	650	850	851	716	878	905
*Residential Total**	*10512*	*9931*	*9771*	*9180*	*8979*	*9379*	*9122*	*8937*	*9366*	*10058*	*9544*	*8764*	*8675*	*9284*
*Any mismatch with totals above due to rounding of emissions for individual fuels														

Figure 3-3: Ireland PM_{10} emissions 2000-2013 by sector

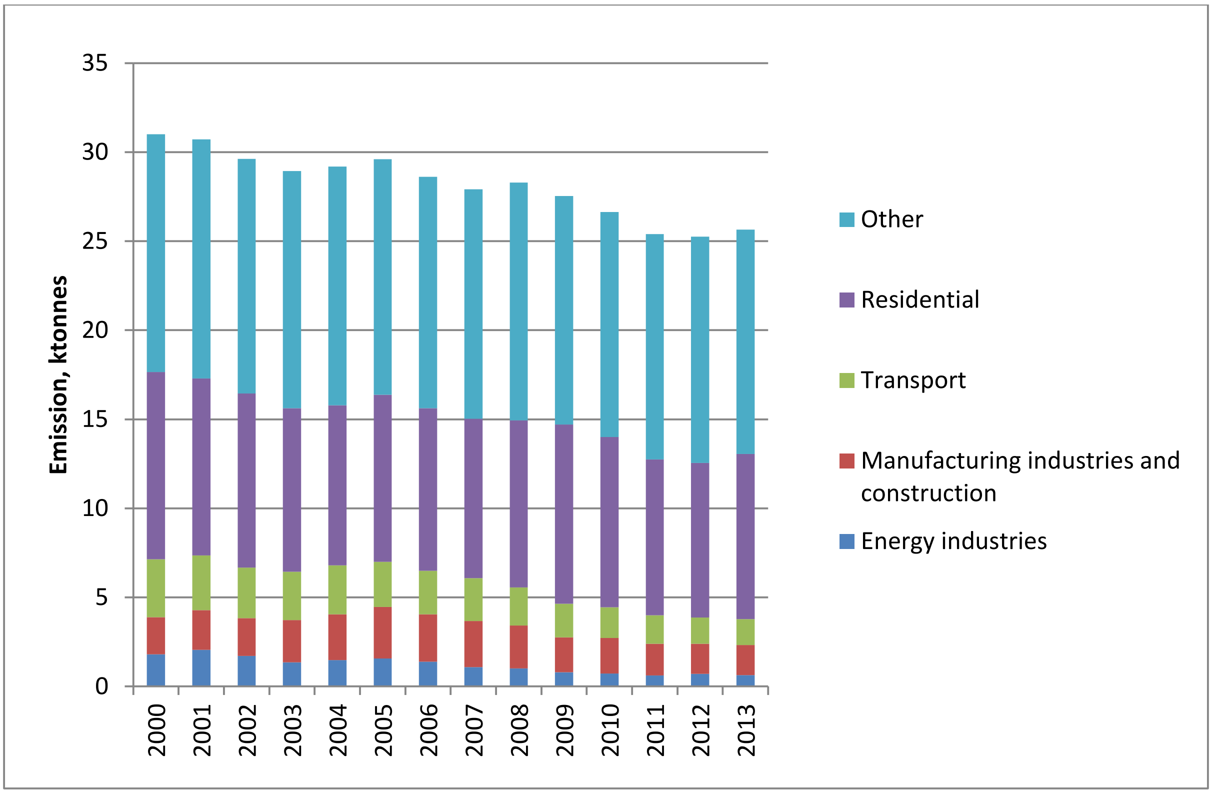
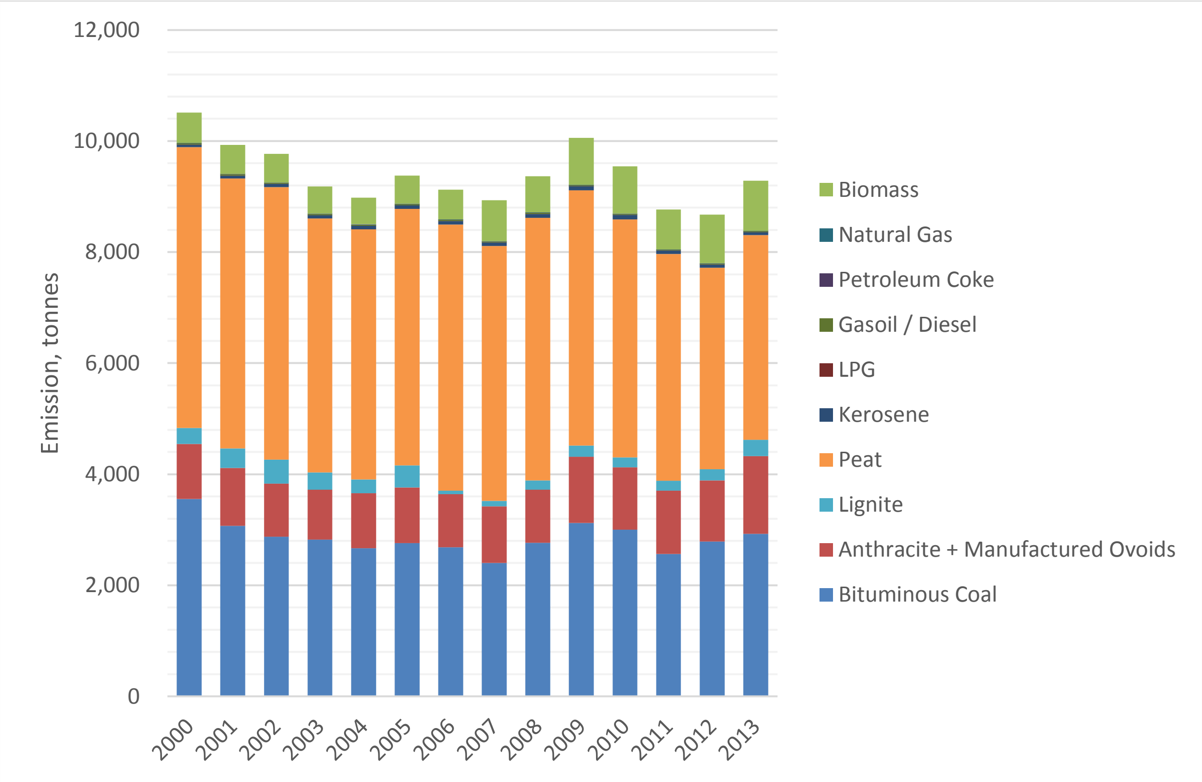


Figure 3-4: Ireland PM_{10} emissions from residential sources 2000-2013 by fuel type



3.2.2 Particulate matter $PM_{2.5}$

Table 3-3 provides a summary of the emissions of particulate matter, $PM_{2.5}$ from sources in Ireland over the period 2000-2013. The data was prepared for reporting under the Convention on Long Range Transport of Air pollution (CLRTAP) using the EMEP/EEA 2013 Guidebook. Table 3-3 shows the emissions categorised according to main emission sector in order to set residential emissions in the context of overall emissions. It also shows the residential emissions classified by fuel type in order to assess the relative contributions from different fuels. The data shown in Table 3-3 are presented in Figure 3-5 and Figure 3-6.

The emissions of particulate matter, PM_{10} include the $PM_{2.5}$ fraction, which makes up a substantial part of the PM_{10} in the emissions from most combustion sources. The EMEP/EEA Guidebook assumes very similar emission factors for $PM_{2.5}$ as for PM_{10} emissions for most residential combustion sources – the emission factors for $PM_{2.5}$ are slightly lower than for PM_{10}, indicating that most of the PM is emitted as $PM_{2.5}$. The emission inventories for residential PM_{10} and $PM_{2.5}$ are discussed further in Section 3.4 below.

As for PM_{10}, Residential $PM_{2.5}$ emissions in Ireland decreased by approximately 12% between 2000 and 2013 with no clear discernible year on year trend. The decline in peat use (-27% over the period) is a significant part of that reduction. Solid 'coal' fuels (bituminous coal, anthracite & manufactured ovoids, lignite) make the single largest contribution to residential $PM_{2.5}$ emissions accounting for half of all emissions in 2013. There is a substantial contribution to emissions from biomass (10%), however, natural gas, kerosene and gas oil provide the major part of residential fuel use but do not contribute much to $PM_{2.5}$ emissions in Ireland.

The UK National Atmospheric Emission Inventory does not report $PM_{2.5}$ emissions separately for Northern Ireland and so no $PM_{2.5}$ emissions are listed here.

Table 3-3: Ireland $PM_{2.5}$ emissions 2000-2013, tonnes

Source	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Energy industries	1290	1479	1213	956	1068	1109	989	754	699	537	485	402	457	401
Manufacturing industries and construction	2060	2182	2090	2295	2494	2821	2589	2524	2334	1911	1964	1734	1654	1655
Transport	3224	3064	2819	2701	2732	2513	2430	2399	2140	1886	1717	1594	1467	1447
Residential	10351	9779	9621	9040	8841	9235	8981	8797	9221	9901	9394	8627	8537	9137
Other+	3767	3770	3694	3815	3784	3770	3694	3654	3698	3380	3216	3190	3210	3210
Total	20691	20274	19437	18805	18920	19449	18683	18128	18093	17614	16776	15548	15325	15850
+Includes commercial, institutional and agricultural emissions														
Residential emissions by fuel type														
Bituminous Coal	3499	3023	2833	2781	2626	2720	2644	2369	2726	3077	2955	2527	2748	2883
Anthracite + Manufactured Ovoids	979	1030	939	886	979	986	942	1001	941	1175	1109	1123	1086	1379
Lignite	284	345	426	308	244	392	61	98	162	198	173	175	199	288
Peat	4984	4792	4838	4504	4438	4551	4724	4521	4661	4527	4225	4020	3575	3631
Kerosene	45	51	53	57	62	63	63	63	70	73	80	64	54	56
LPG	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Gasoil / Diesel	19	20	20	20	19	20	20	19	20	17	16	15	15	13
Petroleum Coke	4	5	4	4	2	3	2	3	2	1	1	1	1	1
Natural Gas	4	4	4	5	5	5	5	5	6	5	6	5	5	5
Biomass	532	509	504	475	465	494	520	719	633	827	828	697	855	881
*Residential Total**	10351	9779	9621	9040	8841	9235	8981	8797	9221	9901	9394	8627	8537	9137
*Any mismatch with totals above due to rounding of emissions for individual fuels														

Figure 3-5: Ireland $PM_{2.5}$ emissions 2000-2013 by sector

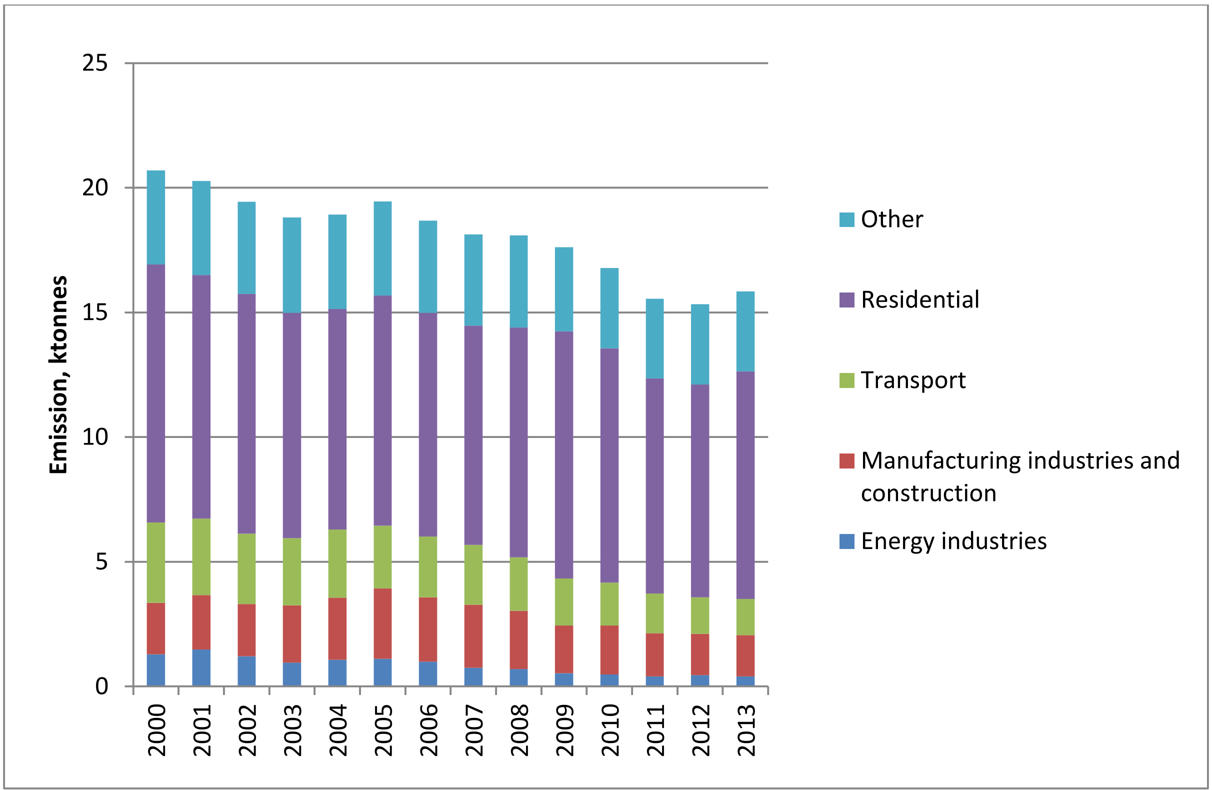
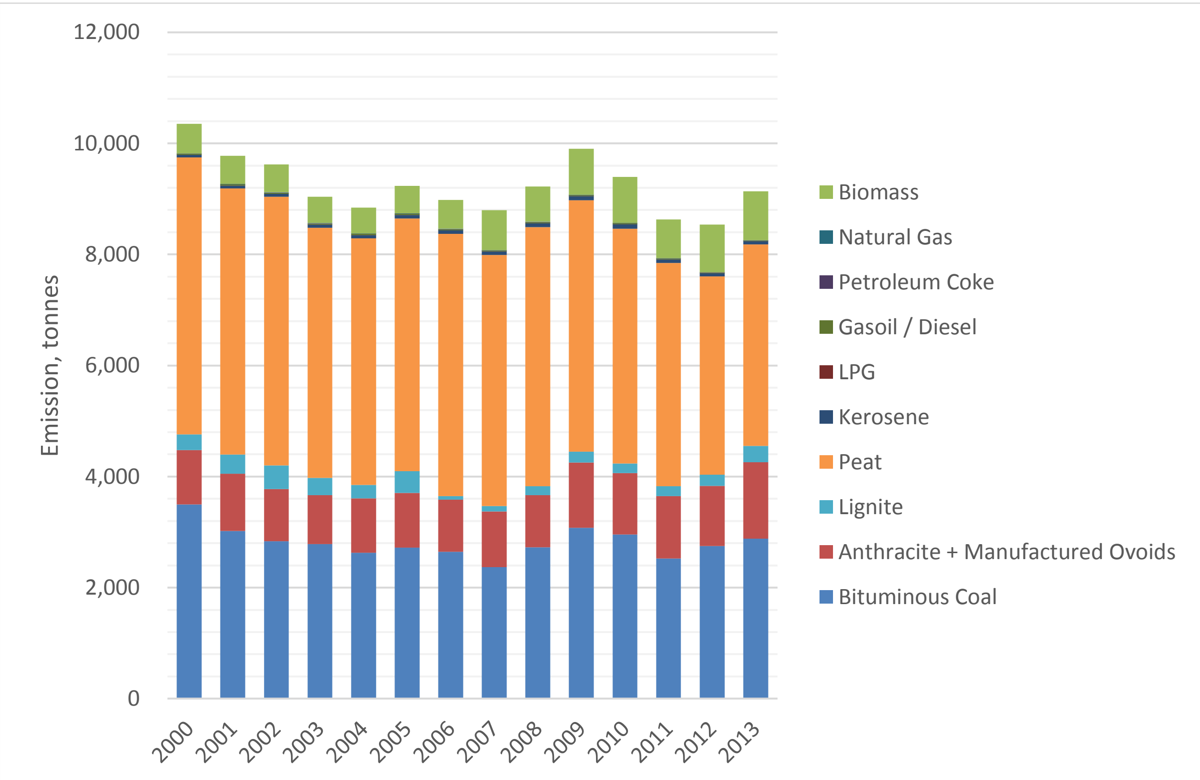


Figure 3-6: Ireland $PM_{2.5}$ emissions from residential sources 2000-2013 by fuel type



3.2.3 Benzo[a]pyrene

Table 3-4 provides a summary of the emissions of benzo[a]pyrene from sources in Ireland over the period 2000-2012. The data was prepared for reporting under the Convention on Long Range Transport of Air pollution (CLRTAP). Table 3-4 shows the emissions categorised according to main emission sector in order to set residential emissions in the context of overall emissions. It also shows the residential emissions classified by fuel type in order to assess the relative contributions from different fuels. The emissions from specific categories of residential fuel are also shown in Figure 3-7.

Total emissions of benzo[a]pyrene from Ireland have decreased by approximately 19% over the period 2000-2013. Residential combustion is by far the largest contributor to total benzo[a]pyrene emissions accounting for about 92% of all emissions in 2013.

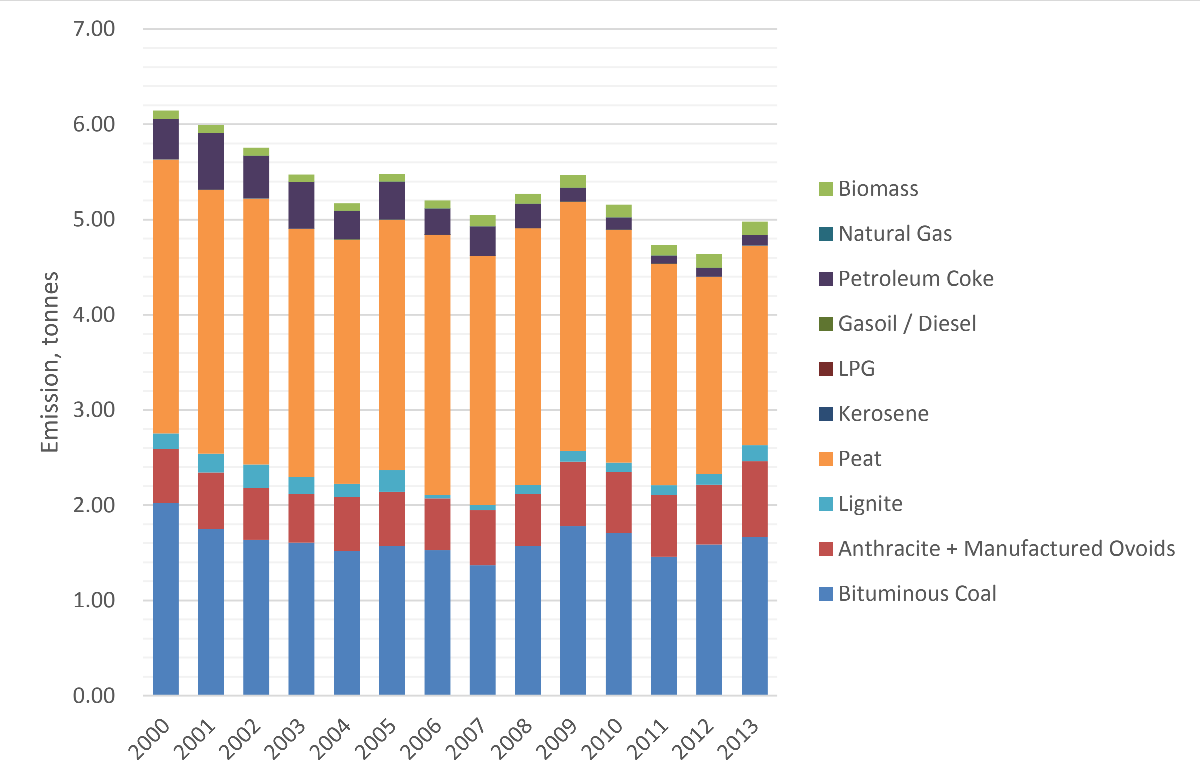
Figure 3-7 indicates that coal fuels (bituminous coal, anthracite & manufactured ovoids, lignite) and peat make the largest contribution to benzo[a]pyrene emissions constituting about 95% of all residential emissions (53% and 42% respectively in 2013), though only accounting for 18% of energy used in the sector. Oils (kerosene, gasoil) and gaseous fuels provide over 50% of residential energy use but are significantly cleaner as they contribute about 2% of the benzo[a]pyrene emission.

The UK National Atmospheric Emission Inventory does not report Benzo[a]pyrene emissions separately for Northern Ireland and so no Benzo[a]pyrene emissions are listed here.

Table 3-4: Benzo[a]pyrene emissions from Ireland, kg

Source	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Energy industries	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Manufacturing industries and construction	278	300	294	407	455	497	441	433	394	281	280	245	221	214
Transport	45	48	49	50	54	57	62	67	67	63	60	62	62	66
Residential	6146	5991	5754	5473	5169	5480	5201	5046	5272	5470	5158	4735	4634	4980
Other+	193	207	196	227	213	230	206	210	208	148	146	135	134	132
Total	6662	6546	6292	6157	5891	6265	5910	5757	5940	5962	5645	5176	5052	5393
+Includes commercial, institutional and agricultural emissions														
Residential emissions by fuel type														
Bituminous Coal	2022	1747	1637	1607	1518	1572	1528	1369	1575	1778	1708	1460	1588	1666
Anthracite + Manufactured Ovoids	566	595	543	512	566	570	544	579	544	679	641	649	628	797
Lignite	164	199	246	178	141	227	35	56	94	115	100	101	115	167
Peat	2880	2769	2796	2603	2565	2630	2730	2613	2693	2616	2441	2323	2066	2098
Kerosene	2	2	2	2	3	3	3	3	3	3	3	3	2	2
LPG	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Gasoil / Diesel	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Petroleum Coke	424	595	446	492	300	398	275	308	258	144	128	83	95	105
Natural Gas	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Biomass	87	83	82	78	76	81	85	118	103	135	135	114	140	144
Residential Total*	6146	5991	5754	5473	5169	5480	5201	5046	5272	5470	5158	4735	4634	4980
*Any mismatch with totals above due to rounding of emissions for individual fuels														

Figure 3-7: Ireland benzo[a]pyrene emissions from residential sources 2000-2013 by fuel type



3.3 National Emission Ceilings

National emission ceilings for four significant air pollutants are set out for all EU member states in the National Emission Ceilings (NEC) directive (2001/81/EC). The ceilings are to be achieved from 2010 for NO_x, SO_2, VOCs and ammonia.

In Ireland, national inventories indicate compliance with three of the 4 ceilings, but NO_x emissions continue to present a challenge. NO_x emissions declined sharply in recent years as a result of the economic recession, however, this downward trend has ceased with small increases in both 2012 and 2013 and it is anticipated that more significant increases may occur in future years, as economic activity increases. If so, Ireland will need to consider additional measures to reduce overall national NO_x emissions including in the residential sector where solid fuels emit approximately twice as much NO_x per unit energy as other fuels.

The UK ceilings have not been disaggregated and assigned to the Devolved Administrations, so compliance with the directive requirements does not arise for Northern Ireland. In any case, emissions in the UK for all pollutants are currently below the ceilings specified in the NEC directive.

3.4 Differences in residential emission inventories

Different methodological approaches are applied in the UK and Ireland to compile emission inventories for international reporting. The different approaches depend on the available data, for example, energy statistics, suitably disaggregated by region, fuel type and energy content. There is necessarily a degree of uncertainty associated with emissions inventory estimates and the particular methodological approach chosen is designed to utilise the best available data to provide an estimate that is transparent, complete, consistent, and accurate in the national context in which the inventory is compiled.

Generally, national emission inventory estimates are calculated multiplying the fuel consumption (activity data) for an activity by specific emission factors for each fuel type. Both Ireland and the United Kingdom adopt a 'Tier 1' approach to determine emissions for the residential sector. This is the lowest tier though it is the most commonly adopted approach across the EU, and is implemented because there is limited data to establish a more accurate inventory for the activity.

The emission inventory for Northern Ireland[17] is based on a "top down" disaggregation of the national UK inventory and sub-national activity statistics (where available). For many emission sources of AQ pollutants, the activity data available for Devolved Administration emissions are less detailed than for the UK as a whole, and for some sources data are not available at all. There is more uncertainty in the UK national statistics for residential and small-scale solid fuel and liquid fuel than for the metered energy flows (gas and electricity).

The disaggregation of the UK inventory data for the Devolved Administrations adopts percentage splits of the UK total for each of the constituent countries using available regional data (for example population, energy use where available). The Northern Ireland emissions are allocated according to information on heating systems in housing condition surveys, use of the metered energy and assumptions about smoke control areas.

As indicated earlier in this chapter, Ireland adopted the 2013 EMEP/EEA guidebook[18] emission factors for compiling national inventories in 2014. Table 3-5 summarises the emission factors in use in Ireland and UK Inventories in terms of heat input (fuel energy) and illustrates the differences in emission factors adopted by the inventories.

Prior to 2015, Ireland and UK emission inventories adopted significantly different emission factors from each other for several fuel types and consequently it is difficult to compare emissions across the jurisdictions. The emission factors used by Ireland for the inventory prior to 2015 for PM_{10} and $PM_{2.5}$ were obtained from the Co-ordinated European Programme on Particulate Matter Emission Inventories, Projections and Guidance (CEPMEIP) but they have now been updated using factors in the EMEP/EEA 2013 Guidebook.

Currently, EPA-commissioned research is ongoing into the emissions from various solid fuels typically used in Ireland with the aim of corroborating the emission factors in the EMEP/EEA 2013 Guidebook or providing more robust country-specific information on emissions.

Regional emission estimates for Northern Ireland are based on emission factors taken from the UK NAEI emission factor database[19]. The database provides emission factors in terms of emission per unit mass of fuel for solid and liquid fuels. The NAEI emission factors were converted to emission per unit energy content by dividing by the net calorific value from the Digest of UK Energy Statistics 2014[20].

The emissions factors for anthracite and solid smokeless (low smoke) fuels used in the Northern Ireland inventory are considerably lower than the EMEP/EEA Tier 1 emission factors for solid fuels. However, the EMEP/EEA guidebook does not take account of the lower emissions from anthracite and solid smokeless (low smoke) fuels, nor provide separate emission factors for these.

The emissions factors for benzo[a]pyrene in the Ireland inventory are taken from the NAEI and so the emission factors shown in Table 3-5 are similar, with most of the differences potentially explained by differences in the assumed calorific values of the fuels. However, differences in the emission factors for anthracite and solid smokeless (low smoke) fuels cannot be explained in this way.

The emission factor for benzo[a]pyrene in the UK NAEI for coal is substantially less than that given in the EMEP/EEA guidebook.

To allow comparison and develop comparable statistics between Ireland and Northern Ireland for screening purposes, the Ireland 2012 inventory has been recalculated to use emission factors from the Northern Ireland (UK) inventory[21] (Table 3-6). The main differences are in PM_{10} and $PM_{2.5}$ emission factors for coal, peat and biomass. The aggregated PM_{10} emission factors used in the UK NAEI for anthracite and solid smokeless (low smoke) fuels are similar to the factors used prior to 2015 in the

[17] Report available here : http://uk-air.defra.gov.uk/reports/cat07/1309111039_DA_AQPI_1990-2011_MainBody_Issue1.0.pdf
[18] http://www.eea.europa.eu/publications/emep-eea-guidebook-2013

[19] http://naei.defra.gov.uk/data/ef-all?q=11289

[21] This does not imply any shortcoming in either the UK or Ireland emission inventories or recommendations on emission factors for the national inventories; it reflects that Ireland national inventory can be more readily recalculated than the Northern Ireland inventory (which is a disaggregation of the United Kingdom inventory).

Ireland inventory however the UK NAEI emission factors for $PM_{2.5}$ for these fuels are higher than in the Ireland 2012 inventory.

Table 3-5*:* Comparison of current emission factors applied for residential sector

Fuel	PM_{10}, g/GJ net		$PM_{2.5}$, g/GJ net		Benzo[a]pyrene, mg/GJ net	
	NI UK	IRE EMEP/ EEA	NI UK	IRE EMEP /EEA	NI UK	IRE EMEP/ EEA
Coal	392	404	387	398	54.0	230
Anthracite & Ovoids	35 Anthracite 98 SSF	404	34 Anthracite 98 SSF	398	0.91 Anthracite 10.6 SSF	230
Lignite	N/A	404	N/A	398	N/A	230
Sod Peat	494 peat	404	481 peat	398	81.3 Peat	230
Peat Briquettes	494 peat	404	481 peat	398	81.3 Peat	230
Kerosene	3.2 burning oil	1.9	3.2 burning oil	1.9	0.110 gas oil	0.08
LPG	3.3	0.2	3.3	0.2	N/A	0.00056
Petcoke	102		101		1.01	
Natural gas	0.5	0.2	0.5	0.2	N/A	0.00056
Biomass	642 Wood	760	625 Wood	740	106 Wood	121
Gasoil	3.2	1.9	3.2	1.9	0.110	0.08

Table 3-6: Recalculated Ireland emission estimates 2011 for screening purposes

Fuel	Pollutant			Comment
	Recalculated			
	PM_{10}	$PM_{2.5}$	Benzo[a] pyrene	
	Tonne	Tonne	kg	
Coal	2483	2451	342	
Anthracite & Ovoids	187	187	16	Applies average of UK emission factors for anthracite and solid smokeless (low smoke) fuel
Coke	0	0	0	
Lignite	170	168	22	Applies UK emission factor for coal
Peat	4989	4858	822	
Kerosene	107	107	4	
LPG	0	0	0	
Gas oil	26	26	1	
Petcoke	36	36	0	Applies UK emission factor for solid smokeless (low smoke) fuel
Natural gas	5	13	0	
Biomass	604	588	100	
Residential Total	*8607*	*8433*	*1308*	

The recalculated PM_{10} emission for the residential sector in Ireland results in a higher per capita emission for residential emissions compared to Northern Ireland (1.9 kg vs 0.8 kg).

Note: While the recalculated emissions per capita in Northern Ireland are estimated to be lower than those for Ireland, the estimates are calculated based on the respective fuel consumption estimates (the UK sub-national estimates in the case of Northern Ireland), and the respective census data for central heating. Whilst, gaseous fuel use is relatively well-characterised for Northern Ireland, the use of solid fuel is much more uncertain and may account for the difference in the estimates between the jurisdictions. In addition, the Northern Ireland inventory uses NAEI emissions factors for anthracite and solid smokeless (low-smoke) fuels, which are lower than those set out in the EMEP/EEA guidebook used by Ireland.

3.5 Household emission density

3.5.1 Household fuel types

The 2011 censuses in Ireland and Northern Ireland provide information on the types of fuel used by households for central heating[22]. The censuses provide this data at Small Area level, typically tens of hectares: there are 18,488 Small Areas in Ireland and 4,537 in Northern Ireland.

Table 3-7 shows the numbers of households in Ireland categorised by fuel used for central heating. Ireland operates a Smoky Coal Ban in larger urban areas (further details are given in Section 6). Table 3-7 also shows the numbers of households within Smoky Coal Ban areas[23]. The census data do not distinguish between types of coal: it is assumed here that coal includes bituminous coal, anthracite and manufactured ovoids, coke, lignite and petroleum coke. Oil is the largest energy source for households

[22] http://www.cso.ie/en/census/census2011smallareapopulationstatisticssaps/
http://www.ninis2.nisra.gov.uk/public/Theme.aspx?themeNumber=136&themeName=Census+2011

[23] The Small Area boundaries do not always coincide exactly with the Smoky Coal Ban areas . The data shown are the total households in Small Areas that have their centroids in the Smoky Coal Ban areas.

in Ireland for central heating, although there is also substantial use of natural gas, particularly in the Smoky Coal Ban areas. Almost 90% of households that use natural gas are located in the Smoky Coal Ban areas and almost 60% of households in the ban areas use natural gas. Oil is also the largest energy source for households outside the ban areas but solid fuels (coal, peat and wood) are used by almost 20% of households outside the ban areas.

Note that Census data are for central heating, in many instances solid fuel appliances provide alternative or supplementary space heating of a single room rather than central heating so the incidence of solid fuel use may occur across a greater number of households than assumed here, based on the responses to the respective censuses.

Table 3-7: Number of households using each type of fuel for central heating in Ireland (2011)

Type of central heating	Number of households		Percentage of households		
	Ireland	Smoky coal ban areas	Ireland	Smoky coal ban areas	Outside ban areas
No Central Heating	26952	11325	1.6%	1.4%	1.9%
Oil (Central Heating)	711330	186549	43.1%	22.4%	64.1%
Natural Gas (Central Heating)	550215	488361	33.4%	58.7%	7.6%
Electricity (Central Heating)	140,419	100,953	8.5%	12.1%	4.8%
Coal (Central Heating)	79,145	19,982	4.8%	2.4%	7.2%
Peat (Central Heating)	78,638	3,048	4.8%	0.4%	9.2%
Liquid Petroleum Gas (Central Heating)	10,452	2,532	0.6%	0.3%	1.0%
Wood (Central Heating)	21,395	2,296	1.3%	0.3%	2.3%
Other	8,524	2,207	0.5%	0.3%	0.8%
Not Stated	22,338	14,020	1.4%	1.7%	1.0%
Total	1,649,408	831,273	100%	50.4%	49.6%

Table 3-8 shows the numbers of households in Northern Ireland categorised by fuel used for central heating. Combustion of certain fuels is restricted in Smoke Control Areas in Northern Ireland (further details in Section 6). Table 3-8 also shows the estimated numbers of households within Smoke Control Areas[24]. The majority of households in Northern Ireland use oil for central heating. Gas is also used for heating in a substantial number of households, particularly in Smoke Control Areas. Solid fuel is used for central heating by relatively few households, even outside the Smoke Control Areas. However, a substantial number of households outside the Smoke Control Areas reported that they used two or more types of central heating: it is possible that a substantial number of these households also use solid fuels.

[24] Note that the location of all Smoke Control Areas is not currently available in digitised form, the data are based on digitised information held by DoENI for some Smoke Control Areas and an assumption that all of Belfast City Council wards and selected other wards are wholly covered by Smoke Control Areas. Note that, where digitised mapping data for Smoke Control Areas are available, the Census Small Area boundaries do not always coincide exactly with the Smoke Control Areas. The data shown are the total households in Small Areas that have their centroids in the Smoke Control Areas.

Table 3-8: Number of households using each type of fuel for central heating in Northern Ireland (2011)

Type of central heating	Number of households		Percentage of households		
	Northern Ireland	Smoke control areas	Northern Ireland	Smoke control areas	Outside SCAs
No central heating	3,766	919	0.5%	0.5%	0.5%
Oil central heating	437,269	87,183	62.2%	49.1%	66.6%
Gas central heating	120,956	67,761	17.2%	38.2%	10.0%
Electric (including storage heaters) central heating	24,671	9,505	3.5%	5.4%	2.9%
Solid fuel (for example wood, coal) central heating	18,120	2,954	2.6%	1.7%	2.9%
Other central heating	4,083	785	0.6%	0.4%	0.6%
Two or more types of central heating	94,410	8,390	13.4%	4.7%	16.4%
Total	703,275	177,497	100%	25.2%	74.8%

Table 3-9 shows the annual residential emissions per household in Ireland, categorised by central heating fuel type, based on the emissions totals given in the **recalculated** national inventory (See Table 3-6) and the numbers of households shown in Table 3-7. Table 3-9 assumes that the households identified as using 'coal' for central heating use bituminous coal, anthracite, manufactured ovoids, lignite or petroleum coke but that bituminous coal is not consumed in those households inside the Smoky Coal Ban areas. It can be seen that emissions per household from non-bituminous coal (including 'low smoke' fuels)[25] inside Smoky Coal Ban areas are very much lower than corresponding emissions from coal outside these areas; peat and wood are estimated to produce the highest PM_{10} and $PM_{2.5}$ emissions per household: coal emissions per household are also substantial, particularly outside the Smoke Control Ban areas. Coal and peat are estimated to produce the highest emissions of benzo[a]pyrene per household outside the ban areas.

Table 3-9: Average emission per household in Ireland for households burning each fuel

Fuel	Area	Annual emission per household		
		PM_{10}, kg	$PM_{2.5}$, kg	B(a)P,g
Coal	Outside ban areas	46.9	46.4	6.26
"Non-bituminous Coal'	Inside ban areas	5.0	4.9	0.48
Peat	All	63.4	61.8	10.5
Wood	All	28.2	27.5	4.7
Oil	All	0.19	0.19	0.01
Natural gas	All	0.01	0.02	0.00

Table 3-10 shows the annual residential emissions of PM_{10} per household in Northern Ireland, categorised by central heating fuel type, based on the emissions totals shown in Table 3-1 and the numbers of households shown in Table 3-8. Table 3-10 assumes that bituminous coal, coke, solid smokeless (low smoke) fuel, peat, wood and petroleum coke are consumed outside the Smoke Control Areas and only solid smokeless (low smoke) fuel and anthracite are consumed in Smoke Control Areas. Table 3-10 also assumes (in the absence of specific information) that 50% of the heating demand for households using 2 or more types of central heating is provided by solid fuel. Households with solid fuel central heating produce the most emissions per household.

Note: While the calculated emissions per household for houses with solid fuel central heating in Northern Ireland are estimated to be lower than those for Ireland, the emissions per household are calculated based on the respective fuel consumption estimates (the UK sub-national emission inventory

[25] The traditional term is 'smokeless' coal but this fuel can still emit significant amounts of particulate matter in comparison to cleaner alternatives like gas or oil (see Table 3.5). Consideration is being given in Ireland to moving to the term 'low smoke'coal or solid fuel to better reflect this reality.

in the case of Northern Ireland), and the respective census data for central heating. Whilst, gaseous fuel use is relatively well-characterised for Northern Ireland, the use of solid fuel is much more uncertain and may account for the difference in the estimates between the jurisdictions.

Table 3-10: Average PM_{10} emission per household in Northern Ireland for households burning each fuel

Fuel	Location with respect to Smoke control Areas	PM_{10} Annual emission per household
Solid fuel	Outside	24.2
Solid fuel	Inside	3.7
Oil	All	0.21
Gas	All	0.02
2 or more types	Outside	12.3
2 or more types	Inside	2.0

3.5.2 Emission density

The ambient concentration of pollutants resulting from residential fuel consumption is related to the annual emission per unit area ("emission density"). This section provides estimates of local emission densities for Ireland and Northern Ireland.

Ireland prepares a spatial inventory of emissions at 50 x 50 km resolution as part of its submission under CLRTAP. However, this does not provide sufficient spatial resolution to be useful for this study; furthermore, it does not distinguish between fuel types.

The annual emission for PM_{10} was calculated for each Small Area in Ireland based on the numbers of households using each fuel for central heating taken from Census 2011 and the emissions per household shown in Table 3-9. The emissions density was then calculated by dividing the annual emission by the area (hectares) of the Small Area. Table 3-11 lists the top 40 Small Areas with the greatest PM_{10} emission density. It shows the population and area of the Small Area, the PM_{10} residential emission density and the percentage of the calculated emission from each fuel type. Figure 3-8 shows the location of each of the top 40 sites.

The top 40 sites are distributed throughout Ireland, with the greatest concentration of sites in the central area. All of the sites were outside the areas of the Smoky Coal Ban at the time of the census. Peat is the largest contributor to residential fuel emissions in the top 40 sites mainly in the Midlands (Laois, Offaly and Galway) and at least half of the sites in Kerry and North Tipperary where peat bogs are a local and traditional source of fuel – see Figure 3-9. Coal is the largest contributor to residential fuel emissions at hotspots in most of the rest of the country.

Figure 3-8: Location of potential residential PM_{10} hotspots in Ireland

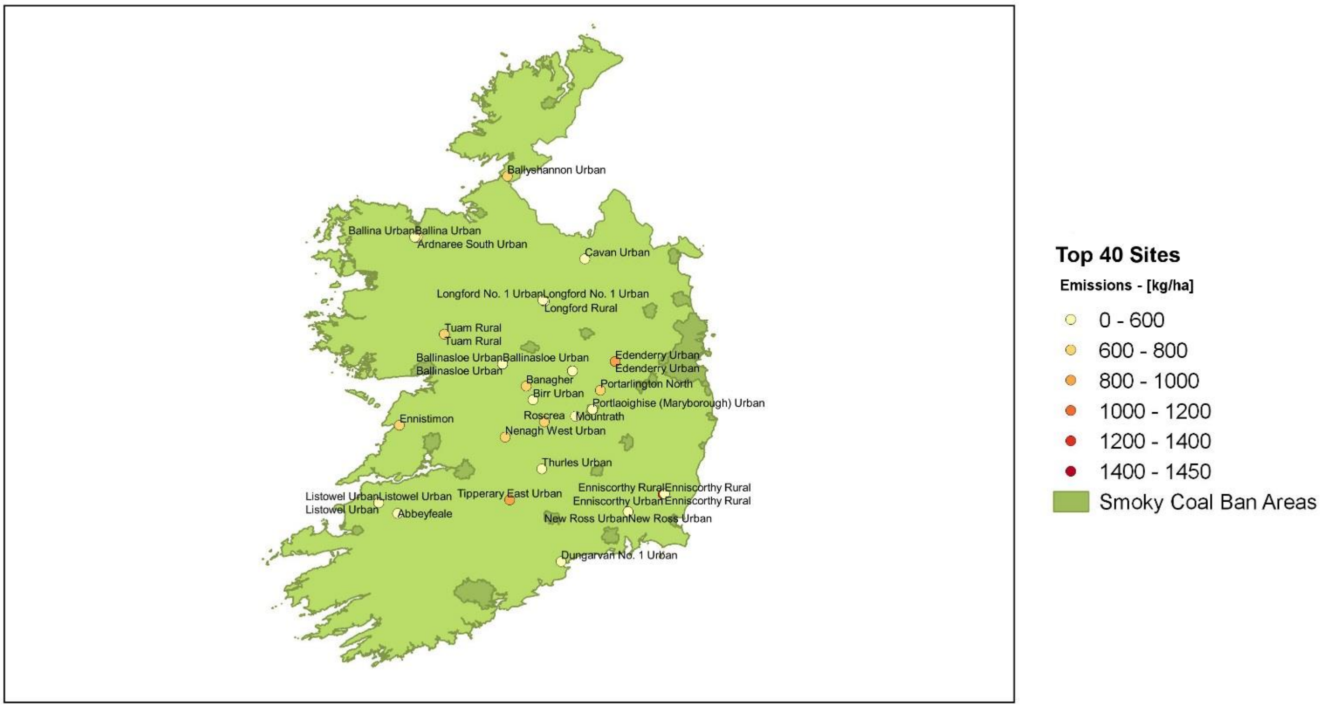
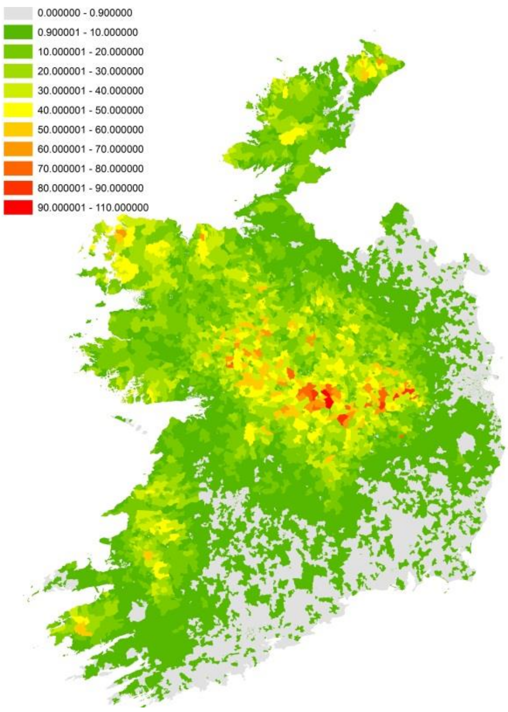


Figure 3-9: *Number of peat central heating systems per Small Area (Census 2011).*



The UK National Atmospheric Emission Inventory (NAEI) provides maps for 2012 commercial, institutional and residential combustion emissions (combined) for the whole of the UK at 1 km x 1 km spatial resolution. Figure 3-10 shows part of the map covering Northern Ireland for PM_{10} and $PM_{2.5}$

emissions[26]. The NAEI 1 x 1 km PM_{10} emission density is less than 0.2 tonne km^{-2} (2 kg ha^{-1}) throughout most of Northern Ireland with higher emission densities in, for example, west Belfast, Lisburn and Derry. The highest PM_{10} emission density shown in Figure 3-10 is 10 tonne km^{-2} (100 kg ha^{-1}). The $PM_{2.5}$ emission density shows a similar spatial pattern: the highest $PM_{2.5}$ emission density shown in Figure 3-10 is 9 tonne km^{-2} (90 kg ha^{-1}).

The PM_{10} emission density from residential sources has also been estimated for this study based on the 2011 Small Area census data for Northern Ireland. Table 3-12 lists the top 40 Small Areas with the greatest PM_{10} emission density. It shows the number of households and area of the Small Area, the PM_{10} residential emission density and the percentage of the calculated emission from each fuel type. Figure 3-11 shows the location of each of the top 40 sites.

The top 40 Northern Ireland sites are distributed throughout the province. Note that the absence of a complete mapping of the Smoke Control Areas means that some small areas may be incorrectly attributed to Smoke Control Areas (or outside Smoke Control Areas)[27]. Solid fuels provide the largest contribution to residential emissions in all the top 40 sites in Northern Ireland. The 2011 Northern Ireland census did not distinguish between types of solid fuel and so no distinction has been made in this analysis. The highest calculated PM_{10} emission density was 361 kg ha^{-1} for a 2.8 hectare area (Blackcave): this is substantially higher than the highest 1 km x 1 km emission density of 100 kg ha^{-1}.This comparison illustrates the localised nature of some of the pollution hotspots in Northern Ireland.

[26] http://naei.defra.gov.uk/data/map-uk-das?pollutant_id=122
[27] This assessment is based on digitised maps of the Smoke Control Areas provided by DOE. http://www.airqualityni.co.uk/laqm_sca.php?n_action=sca
Belfast City Council has indicated that the vast majority of the Greater Belfast area is under Smoke Control (although rural/sparsely inhabited areas on the periphery of Greater Belfast are not). The emission density will be lower than shown in Table 3.10 if the area is within a Smoke Control Area.

Table 3-11: The 40 Small Areas in Ireland with the highest estimated PM_{10} emission density

Small Area GEOGID	Area Name	County	Area, ha	In/Out SCB	Emission density kg/ha	Percentage of emissions by fuel type				
						oil	natural gas	coal	peat	wood
A187036013	Edenderry Urban	Offaly County	4.6	out	1430	0%	0%	7%	93%	0%
A247046003	Enniscorthy Urban	Wexford County	2.3	out	1211	0%	0%	99%	0%	1%
A217164004	Tipperary East Urban	South Tipperary	2.1	out	888	0%	0%	100%	0%	0%
A137043005	Longford No. 1 Urban	Longford County	3.0	out	886	0%	0%	60%	38%	2%
A187036012	Edenderry Urban	Offaly County	6.5	out	875	0%	0%	6%	94%	0%
A067017020	Ballinasloe Urban	Galway County	4.9	out	838	0%	0%	21%	79%	1%
A077128010	Listowel Urban	Kerry County	4.6	out	834	0%	0%	29%	70%	1%
A187087037	Tullamore Urban	Offaly County	7.1	out	803	0%	0%	6%	92%	2%
A187069005	Portarlington North	Offaly County	5.7	out	737	0%	0%	10%	89%	1%
A067017021	Ballinasloe Urban	Galway County	3.4	out	734	0%	0%	19%	80%	1%
A217152019	Roscrea	North Tipperary	5.0	out	731	0%	0%	22%	76%	2%
A067211004	Tuam Rural	Galway County	5.9	out	716	0%	0%	27%	72%	1%
A247045038	Enniscorthy Rural	Wexford County	3.4	out	684	0%	0%	100%	0%	0%
A067017010	Ballinasloe Urban	Galway County	5.1	out	683	0%	0%	11%	86%	3%
A157154002	Ardnaree South Urban	Mayo County	4.9	out	667	0%	0%	82%	17%	1%
A247091011	New Ross Urban	Wexford County	3.0	out	665	0%	0%	97%	3%	0%
A217136019	Nenagh West Urban	North Tipperary	2.5	out	630	0%	0%	88%	4%	7%
A247045039	Enniscorthy Rural	Wexford County	3.1	out	615	0%	0%	93%	3%	3%
A057012001	Ballyshannon Urban	Donegal County	2.5	out	609	0%	0%	95%	4%	0%
A037059012	Ennistimon	Clare County	3.7	out	606	0%	0%	93%	6%	1%
A187009006	Banagher	Offaly County	9.2	out	606	0%	0%	2%	98%	0%
A067211024	Tuam Rural	Galway County	4.7	out	605	0%	0%	20%	80%	0%
A137045004	Longford Rural	Longford County	3.0	out	598	0%	0%	70%	28%	2%
A247091016	New Ross Urban	Wexford County	4.4	out	595	0%	0%	97%	2%	0%
A247045029	Enniscorthy Rural	Wexford County	5.2	out	592	0%	0%	100%	0%	0%

Small Area GEOGID	Area Name	County	Area, ha	In/Out SCB	Emission density kg/ha	Percentage of emissions by fuel type				
						oil	natural gas	coal	peat	wood
A107073005	Mountrath	Laois County	3.5	out	589	0%	0%	21%	75%	4%
A077128001	Listowel Urban	Kerry County	3.4	out	584	0%	0%	19%	81%	0%
A127001003	Abbeyfeale	Limerick County	4.9	out	577	0%	0%	62%	38%	0%
A067017002	Ballinasloe Urban	Galway County	4.8	out	569	0%	0%	7%	92%	1%
A157016010	Ballina Urban	Mayo County	3.7	out	556	0%	0%	80%	19%	1%
A217162017	Thurles Urban	North Tipperary	4.4	out	548	0%	0%	63%	37%	0%
A157016009	Ballina Urban	Mayo County	3.7	out	546	0%	0%	78%	22%	0%
A027025006	Cavan Urban	Cavan County	3.8	out	538	0%	0%	94%	6%	0%
A077128006	Listowel Urban	Kerry County	6.4	out	535	0%	0%	46%	53%	0%
A187013015	Birr Urban	Offaly County	11.4	out	533	0%	0%	15%	84%	1%
A107080006	Portlaoighise (Maryborough) Urban	Laois County	2.4	in	532	0%	0%	5%	95%	0%
A187087028	Tullamore Urban	Offaly County	6.5	out	525	0%	0%	15%	84%	1%
A227032002	Dungarvan No. 1 Urban	Waterford County	2.5	out	515	1%	0%	99%	0%	0%
A137043013	Longford No. 1 Urban	Longford County	5.2	out	513	0%	0%	28%	24%	48%
A187087018	Tullamore Urban	Offaly County	6.6	out	508	0%	0%	15%	83%	2%

Table 3-12: The 40 Small Areas in Northern Ireland with the highest estimated PM_{10} emission density

Small Area	Name	Area, Hectares	In/Out SCA	Emission density, kg/ha	Percentage of emissions by type of central heating fuel			
					Gas	Oil	Solid fuel	Two fuel
N00003086	Blackcave	2.8	out	361	0%	1%	86%	13%
N00003085	Blackcave	3.0	out	281	0%	2%	77%	22%
N00002985	Erne	1.5	out	275	0%	2%	69%	29%
N00001980	Churchland	3.6	out	245	0%	2%	93%	6%
N00003186	Enagh_2_Limavady	5.1	out	229	0%	1%	83%	16%
N00002388	Woodville_1	2.1	out	223	0%	3%	51%	46%
N00003214	Greystone_Limavady	3.1	out	218	0%	1%	75%	24%
N00003213	Greystone_Limavady	2.9	out	197	0%	2%	59%	38%
N00003689	Bessbrook	3.9	out	197	0%	2%	60%	38%
N00002142	Oldtown	3.2	out	178	0%	3%	63%	34%
N00002874	Drumglass	4.8	out	169	0%	2%	59%	39%
N00001724	Northland	2.7	out	167	0%	3%	75%	22%
N00003310	Derryaghy_3	5.4	out	166	0%	2%	89%	10%
N00001742	Whitehead	2.6	out	151	0%	4%	56%	41%
N00002614	The Diamond	3.4	out	151	0%	4%	28%	68%
N00002578	Rosemount	3.9	out	149	0%	3%	50%	47%
N00002543	Kilfennan_2	3.8	out	149	0%	3%	13%	85%
N00002629	Westland	2.3	out	146	0%	4%	78%	18%
N00003507	Tonagh	3.7	out	141	0%	2%	88%	9%
N00000285	Loughries_2	6.6	out	141	0%	1%	91%	8%
N00002652	Ballymaglave_2	6.2	out	138	0%	2%	79%	19%
N00002773	Shimna	4.4	out	138	0%	2%	60%	38%
N00000546	Cullybackey	5.3	out	138	0%	2%	46%	52%
N00001985	Churchland	4.0	out	134	0%	2%	68%	30%
N00003713	Clonallan_1	7.4	out	133	0%	2%	34%	64%
N00003072	Antiville	2.4	out	128	0%	5%	47%	48%

Small Area	Name	Area, Hectares	In/Out SCA	Emission density, kg/ha	Percentage of emissions by type of central heating fuel			
					Gas	Oil	Solid fuel	Two fuel
N00002080	University	5.0	out	125	0%	3%	46%	51%
N00002631	Westland	2.0	out	124	0%	8%	29%	63%
N00002363	Tavanagh	5.4	out	124	0%	2%	76%	22%
N00002193	Ballybay	5.9	out	118	0%	2%	77%	21%
N00002081	University	3.9	out	118	0%	4%	64%	32%
N00004511	Sion Mills	2.9	out	118	0%	4%	35%	60%
N00003640	Dalriada	6.3	out	117	0%	2%	53%	45%
N00002606	Strand_1_Derry	5.0	out	115	0%	3%	84%	13%
N00003848	Seaview_2	6.3	out	115	0%	3%	53%	44%
N00002141	Oldtown	6.0	out	112	0%	2%	65%	33%
N00002873	Drumglass	4.9	out	112	0%	3%	36%	61%
N00002625	Victoria_Derry	6.6	out	110	0%	3%	47%	51%
N00004329	Whitehill	3.4	out	110	0%	3%	64%	32%
N00002390	Woodville_1	4.1	out	107	0%	5%	17%	79%

Figure 3-10: Disaggregated emission density maps for Northern Ireland (NAEI)

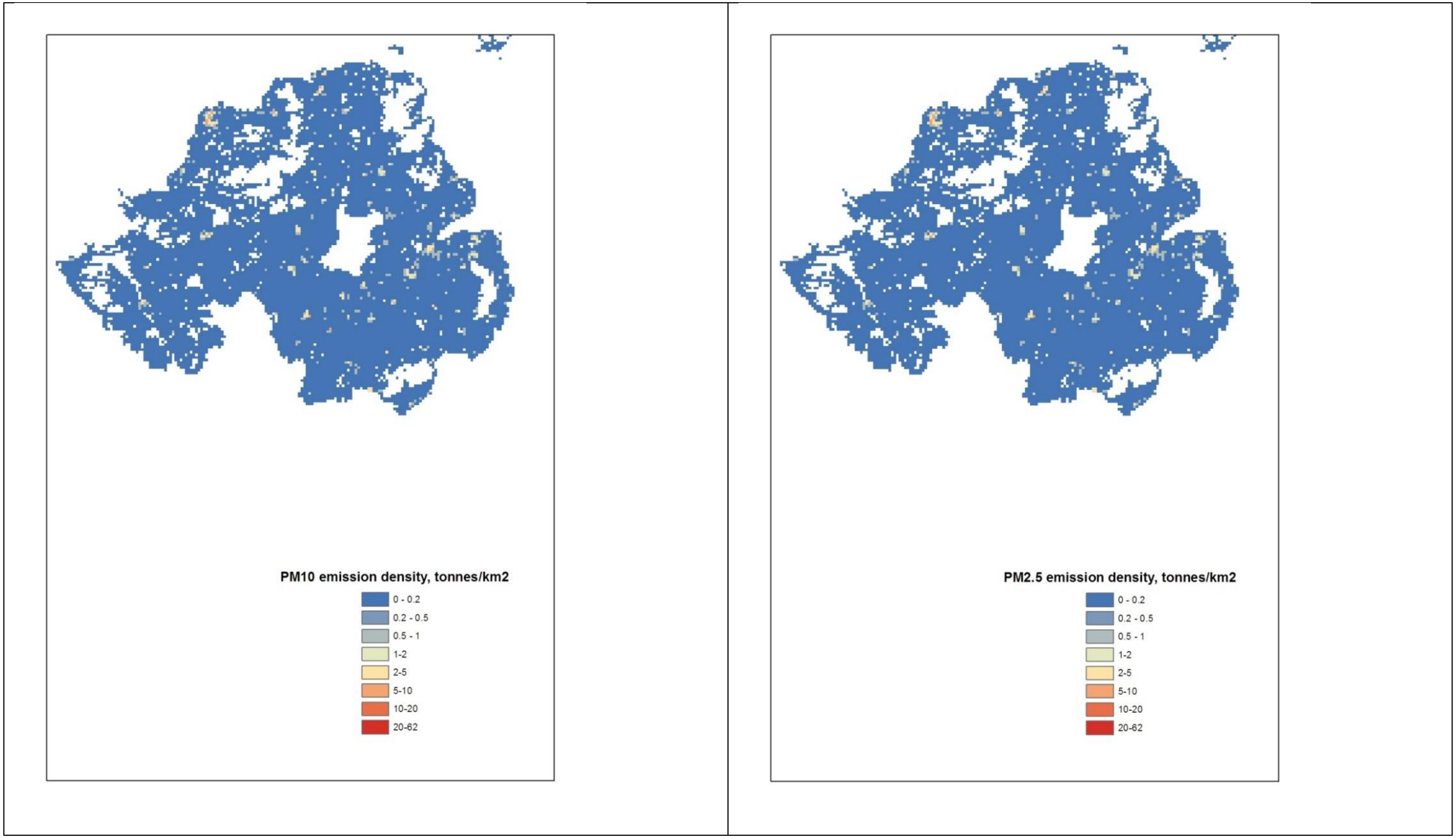
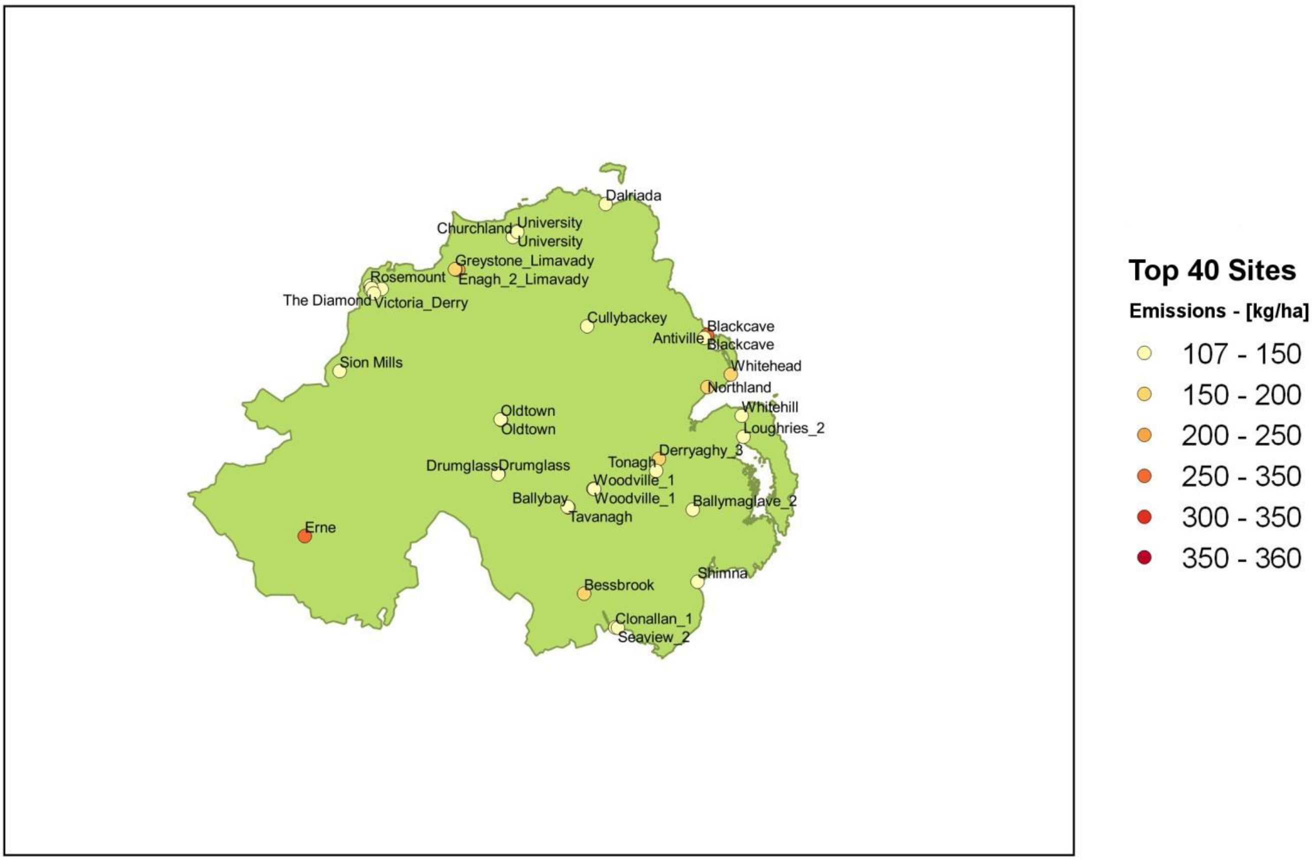


Figure 3-11: Location of potential residential PM_{10} hotspots in Northern Ireland



3.6 Modelling studies

Defra provides modelled estimates of the contribution from commercial, institutional and residential combustion to annual mean PM_{10} and $PM_{2.5}$ concentrations in Northern Ireland on a 1 km x 1 km grid. The estimated contributions are based on the output from the Pollution Climate Model (PCM). Figure 3-13 shows the modelled contributions to PM_{10} and $PM_{2.5}$ concentrations for 2012. The highest modelled concentrations are in the main towns and cities. The maximum predicted contributions from commercial, institutional and residential combustion are 4.2 µg m^{-3} for PM_{10} and 1.9 µg m^{-3} for $PM_{2.5}$. Residential combustion only contributes to part of the modelled concentration but is likely to be the main contributor in some locations.

The National Physical Laboratory (NPL) used the ADMS Urban dispersion model to estimate benzo[a]pyrene concentrations in Northern Ireland in 2008 at a spatial resolution of 1 km x 1 km. Figure 3-14 shows a map of the modelled contributions. Comparison with the predicted PM_{10} hotspots (Figure 3-11) indicates a similar geographic spread but note that this may occur because of similar assumptions in the attribution of fuel use (and hence emissions). The concentration is less than 0.4 ng m^{-3} across most of Northern Ireland with higher concentrations in the larger towns and cities. NPL identified 47 1-km squares where the modelled concentration exceeded the EU target value of 1 ng m^{-3}. Table 3-13 lists the towns and cities in which there were modelled exceedences. NPL assessed the proportion of the modelled concentration arising from commercial, institutional and residential combustion in each of the 47 squares: the contribution exceeded 90% in almost all of the squares.

In 2013-2014, additional PAH monitoring was carried out at a new site in Armagh city; the monitoring was undertaken to further validate the modelled results from the NPL research. The monitoring at Armagh showed that Benzo[a]pyrene levels were of a similar magnitude to levels at the other PAH monitoring sites in Northern Ireland.

Figure 3-12 shows the levels at all Northern Ireland monitoring sites, with the additional Armagh site levels, for comparison. The strongly seasonal trend in Benzo[a]pyrene concentrations is evident, with highest concentrations in the winter, providing evidence that residential heating is a key source of this pollutant.

Figure 3-12 : Mean monthly concentrations of Benzo[a]pyrene at monitoring sites in Northern Ireland, including short-term monitoring in Armagh city.

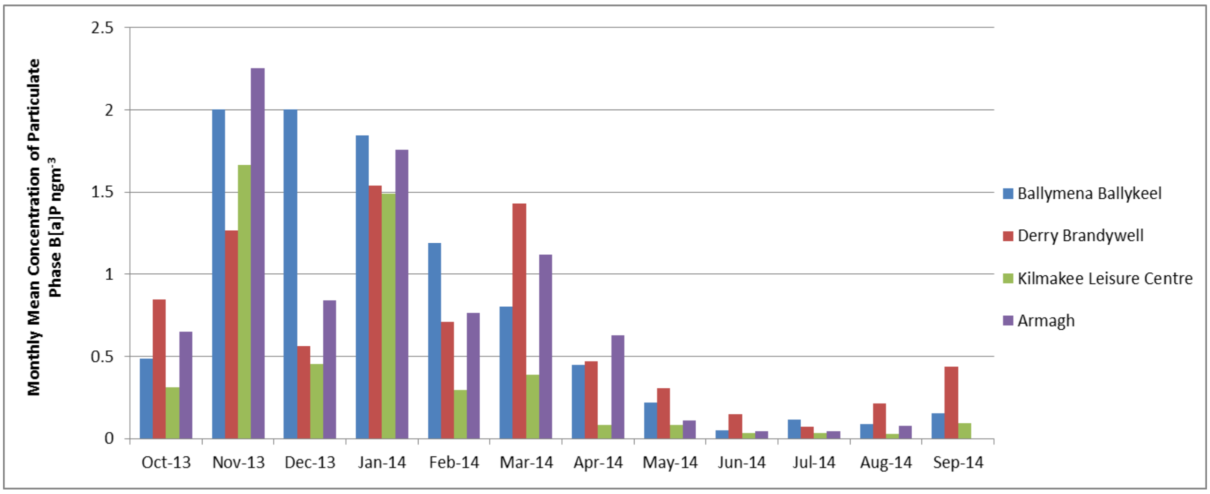
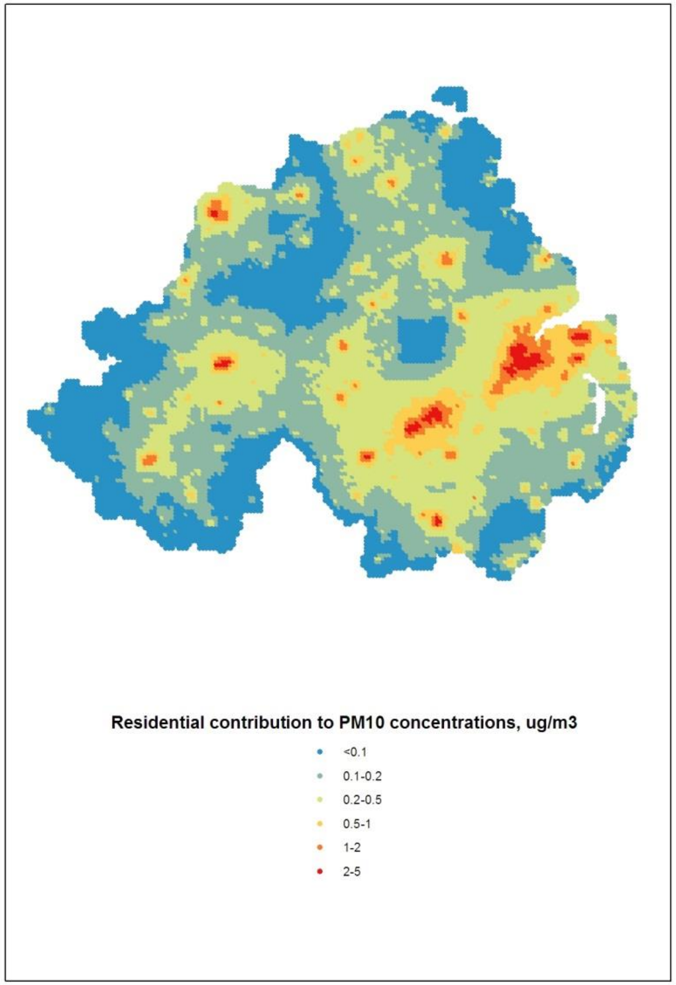


Table 3-13: Towns in Northern Ireland where the NPL model indicated that the EU target value for benzo[a]pyrene was exceeded

Towns with modelled exceedences of the EU target value for benzo[a]pyrene	
Armagh (2 squares)	Limavady
Ballymena	Lisburn (2 squares)
Ballymoney	Lurghan (3 squares)
Banbridge	Magharafelt
Belfast, Falls Road	Newcastle
Belfast, Lisburn Road	Newtownards
Belfast, Crumlin Road	Omagh (2 squares)
Carrickfergus (5 squares)	Portadown (3 squares)
Cookstown (2 squares)	Strabane (4 squares)
Derry (8 squares)	Warrenpoint
Dunmurry	
Enniskillen (2 squares)	
Larne (2 squares)	

Figure 3-13: Commercial, institutional and residential contribution to particulate matter concentrations in Northern Ireland (NAEI)



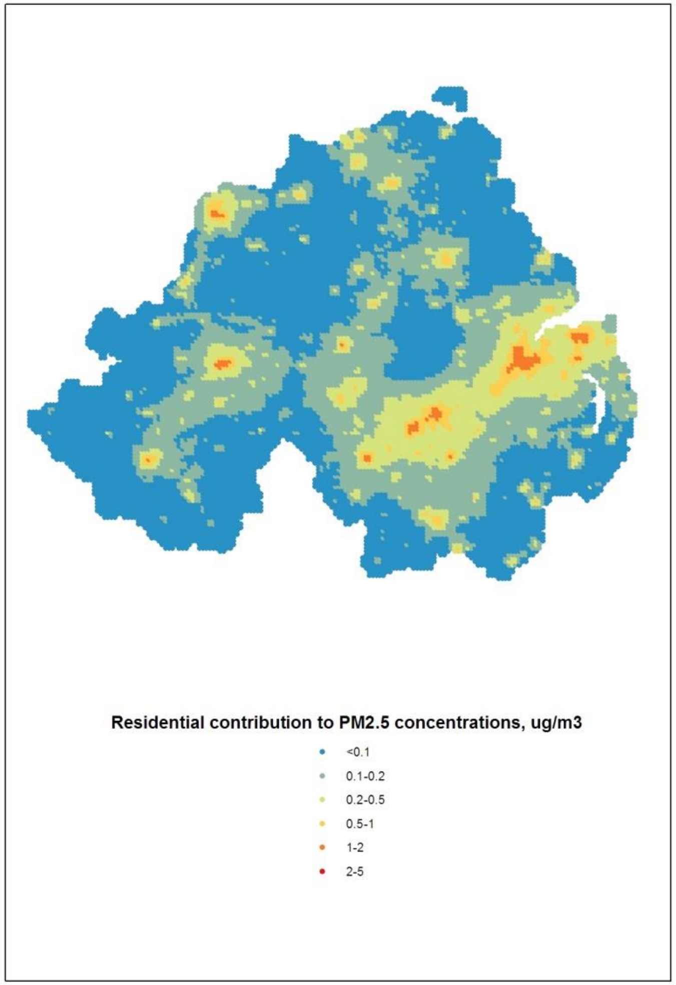
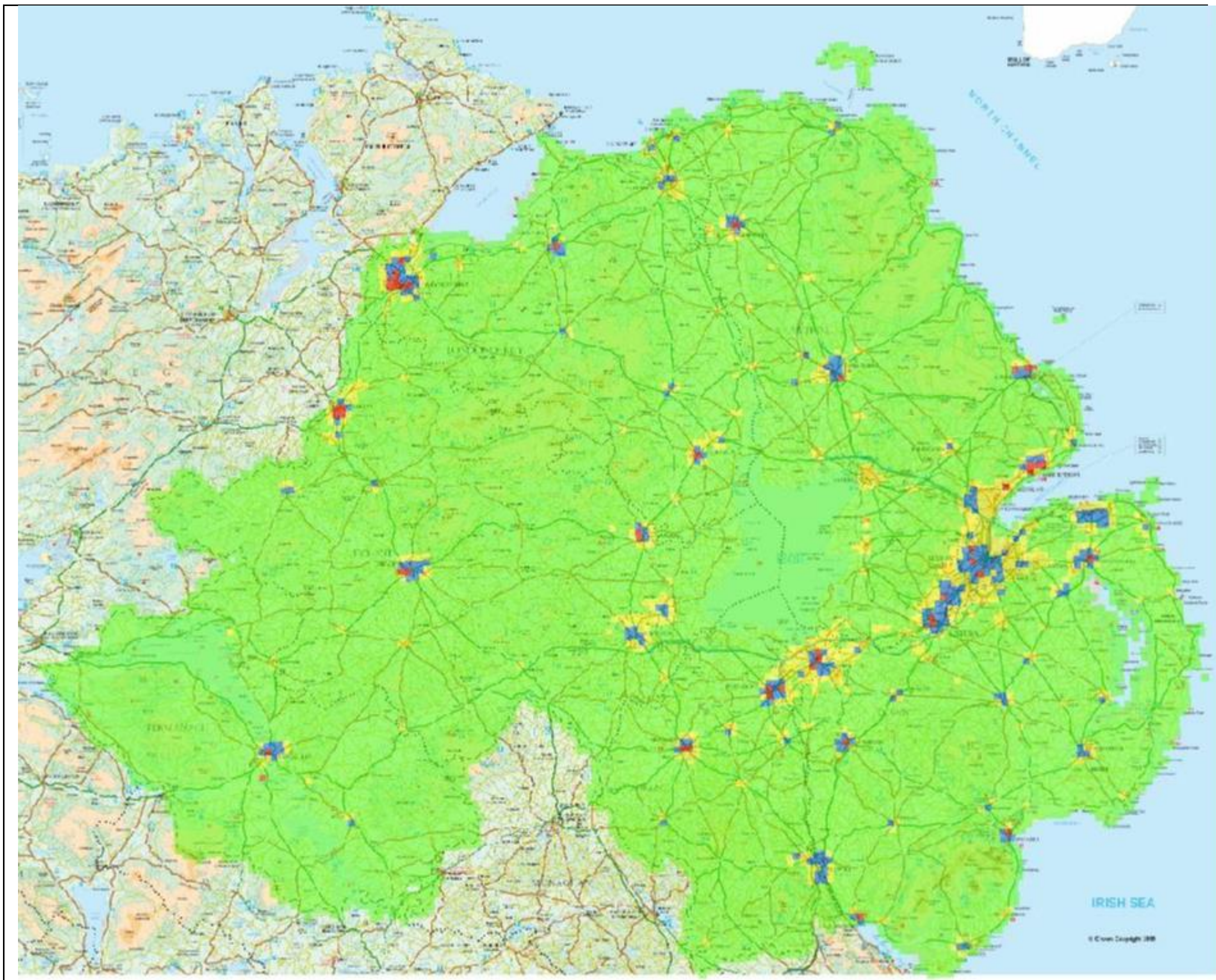


Figure 3-14: Modelled benzo[a]pyrene concentrations in Northern Ireland (NPL[28])



<0.4 ng m^{-3}
0.4-0.6 ng m^{-3}
0.6-1.0 ng m^{-3}
>1.0 ng m^{-3}

The EPA in Ireland is in the process of developing modelling capacity but does not currently carry out detailed modelling of air pollutant concentrations.

It is beyond the scope of this study to model the contribution made by the emissions from residential fuels to ambient concentrations in detail. A simple screening tool was developed for Local Air Quality Review and Assessment in the UK to identify areas where detailed assessment of residential emissions should be carried out[29]. The screening tool relates the contribution to PM_{10} concentrations from residential combustion to the emissions density: the annual mean concentration increases by approximately 4 µg m^{-3} for every 100 kg ha^{-1}. This suggests that the emissions from residential combustion in the identified top 40 sites in Ireland and in Northern Ireland (all of which have emission densities greater than 100 kg ha^{-1}, see Table 3-11 and Table 3-12) are likely to make a substantial local contribution (i.e. more than 4 µg m^{-3}) to PM_{10} concentrations.

[28] NPL Report AS66, Polycyclic Aromatic Hydrocarbons in Northern Ireland, Feb 2012 available here http://www.airqualityni.co.uk/documents/504120308_pah_in_ni_report_final_published_version_v2.pdf
[29] http://uk-air.defra.gov.uk/assets/documents/reports/cat18/0806261519_methods.pdf

3.7 Influence of combustion conditions on emissions

The emissions of particulate matter and benzo[a]pyrene from residential combustion appliances depend to a large extent on combustion conditions and hence on the design and operation of the appliance. A default tier 1 emission factor presumes a technology mix which may not be appropriate for Northern Ireland or Ireland. If data on the use of fuel in different technologies is available then it is possible to develop a more representative aggregated Tier 1 factor or a Tier 2 or Tier 3 inventory. Table 3-14 lists EMEP/EEA default Tier 2 emission factors for a range of appliance types which illustrates the variation in emission factors possible with different appliances (and fuels).

The dependence of the PM emissions on combustion conditions is particularly pronounced for solid fuel combustion: for example, the emission factors for wood pellet stoves and boilers are substantially lower than those for other appliance types and less than the emission factors used in the current Ireland and Northern Ireland inventories.

As noted earlier, there is considerable uncertainty associated with compiling an emissions inventory, and this is reflected to some degree in the range of emission factors used across different countries. The ‘pollution intensity’ of a heating fuel gives a measure of how much pollution is emitted for a given amount of heat produced and can be defined as the amount of pollution that is emitted to the atmosphere for a given amount of energy. The precise amount of pollution will depend on a range of factors, including the quality of the fuel and the efficiency of the combustion installation.

Clearly, assumptions in emission inventories about appliance technologies and, in particular, the relative use of fuel in technologies will influence the pollutant emission estimate for the residential sector. However, it is clear from Table 3-14 that the pollution intensity of solid fuels, regardless of combustion conditions, is significantly greater than either oil or gas.

Table 3-14: EMEP/EEA Tier 2 emission factors for residential combustion[30]

Source	Fuel	Pollutant				
		PM_{10}	$PM_{2.5}$	NOx	SOx / SO_2	B[a]P
Units		g/GJ	g/GJ	g/GJ	g/GJ	mg/GJ
Fireplaces, Saunas and Outdoor heaters	Solid fuel (not biomass)	330	330	60	500	100
Stoves	Solid fuel (not biomass)	450	450	100	900	250
Small (single household scale, capacity <=50 kWth) boilers	Solid fuel (not biomass)	225	201	158	900	270
Advanced coal combustion techniques <1MWth - Advanced stove	Coal fuels	240	220	150	450	150
Open fireplaces	Wood	840	820	50	11	121
Energy efficient stoves	Wood	380	370	80	11	121
Advanced / ecolabelled stoves and boilers	Wood	95	93	95	11	10
Pellet stoves and boilers	Wood	29	29	80	11	10
Conventional stoves	Wood and similar wood waste	760	740	50	11	121
Conventional boilers < 50 kWth	Wood and similar wood waste	480	470	80	11	121
Gaseous / liquid fuels						
Stoves, fireplaces, saunas and outdoor heaters	Natural gas	2.2	2.2	60	0.3	0.00056
Small (single household scale, capacity <=50 kWth) boilers	Natural gas	0.2	0.2	42	0.3	0.00056
Stoves	Gas oil	2.2	2.2	34	60	0.080
Small (single household scale, capacity <= 50 kWth) boilers	Gas oil	1.5	1.5	69	79	0.080

3.8 EU Eco-design requirements for residential heating

The European Commission is developing Ecodesign and labelling regulations for a variety of domestic heating appliance types. Regulations are in place for electrical, gas and oil-fired central heating boilers

[30] Available here http://www.eea.europa.eu/publications/emep-eea-guidebook-2013

and water heaters. There are proposals in development for solid fuel central heating boilers and for Local Space Heaters (roomheaters).

The proposed regulations include minimum requirements on the efficiencies and selected pollutant emission for new appliances. Note that a key focus of Ecodesign is to develop the single market and hence existing national requirements on new appliances will not be permitted following implementation of Ecodesign regulations – this would include Exemption arrangements for appliances used in Smoke Control Areas in Northern Ireland. Additional requirements on appliances (for example for environmental reasons) are permitted but only by application to the Commission. It is possible for Member States to introduce Ecodesign controls earlier than the Commission's deadline. Table 3-15 shows the emission limits for solid fuel central heating boilers. Table 3-16 shows the emission limits for local space heating products.

Table 3-15: EU Eco-design proposed emission limits for solid fuel small combustion installations, as of 1st January 2020[31]

Appliance	Pollutant	Emission limits (concentrations for a dry gas at 0°C, 101.3 kPa and 10% O_2)
Central heating boilers	Organic gaseous compounds (as C)	20 mg m^{-3} (manual appliance 30 mg m^{-3})
	Carbon monoxide:	500 mg m^{-3} (manual appliance 700 mg m^{-3})
	NOx (as NO_2) :	200 mg m^{-3} (fossil fuel 350 mg m^{-3})
	PM:	40 mg m^{-3} (manual appliance 60 mg m^{-3})

[31] COMMISSION REGULATION (EU) 2015/1189 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel boilers

Table 3-16: EU Eco-design proposed emission limits for local space heating products, as of 1st January 2022[32]

Appliance	Pollutant	Emission limits (concentrations for a dry gas at 0°C, 101.3 kPa and 13% O_2)
Solid fuel local space heaters (including open front local space heaters, closed fronted local space heaters and cookers)	NOx	200 mg m^{-3} (fossil fuel 300 mg m^{-3})
Open fronted local space heaters using solid fuel other than compresses wood in the form of pellets	PM	50 mg m^{-3} *
Closed fronted local space heaters using solid fuel other than compresses wood in the form of pellets and cookers	PM	40 mg m^{-3} *
Closed fronted solid fuel local space heaters using compressed wood in the form of pellets	PM	20 mg m^{-3} *
Open front local space heaters,	CO	2000 mg m^{-3}
Closed fronted local space heaters using solid fuel other than compressed wood in the form of pellets and cookers	CO	1500 mg m^{-3}
Closed fronted solid fuel local space heaters using compressed wood in form of pellets	CO	300 mg m^{-3}
Open fronted solid fuel local space heaters, closed fronted solid fuel local space heaters using solid fuel other than compressed wood in the form of pellets and cookers	OGC	120 mg m^{-3}
Closed fronted solid fuel local space heaters using compressed wood in form of pellets	OGC	60 mg m^{-3}

**When measured using the 'heated filter' method, other limits apply for the dilution tunnel and the electrostatic precipitator methods.*

In 2012 the International Institute for Applied Systems Analysis (IIASA) published an assessment of the potential for current and future emissions from small combustion sources, in the context of the baseline scenario developed for the review of the EU's Thematic Strategy[33]. The report highlighted the issue that whilst strict emission control legislation has been enforced in many other sectors, small residential combustion sources have not been subject to the same level of regulation and as a result without policy intervention the sector may become the primary source of PM emissions in the EU. The Eco-design directive provides an opportunity to regulate aspects of certain small combustion sources through the introduction of emission standards for new solid fuel stoves and boilers.

The review used the Greenhouse gas Air pollution INteractions and Synergies (GAINS) model to determine the impact of proposed Eco-design standards on emissions, air quality and environmental impacts, in the context of the TSAP revision, which estimates emissions for several small combustion interventions. Pollutant emissions in 2005 were used to determine the potential impact of the various scenarios. During 2005 one third of the total EU-27 emissions for PM fine particles ($PM_{2.5}$) and black carbon arose from small combustion sources using solid fuel.

Table 3-17 shows the emission projections for the domestic sector (includes residential, commercial, agricultural and other sources) for the base case, the maximum technically feasible reduction (MTFR) scenario and the Eco-design scenario for Ireland and for the UK. The projections show that $PM_{2.5}$ emissions decrease by 38% in Ireland between 2005 and 2030 for the baseline case and by 57% under

[32] COMMISSION REGULATION (EU) 2015/1185 of 24 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel local space heaters
[33] http://gains.iiasa.ac.at/images/stories/reports/TSAP/TSAP-SMALL%20SOURCES-20120612.pdf

the Eco-design scenario. Similarly the reductions in the UK as a whole are 23% for the baseline case and 54% for the Eco-design scenario. This suggests that the Eco-design measures will have an important effect on particulate emissions. The assessment assumed that the Eco-design measures would be implemented in 2016; in practice, the measures will come into force later which will delay the impact of the Eco-design measures.

Table 3-17: Projections for PM_{10} and $PM_{2.5}$ emissions arising from the domestic sector in Ireland and UK, under scenarios modelled in the IIASA study

Country	Scenario	Pollutant (kilotonnes)							
		$PM_{2.5}$				PM_{10}			
		2005	2020	2030	2050	2005	2020	2030	2050
Ireland	**Baseline (reported[34])**	4.9 (1.5)	3.5	3	3.7	5.2 (2.5)	3.8	3.1	3.9
	MTFR	-	2.9	2	2.2	-	3.1	2.1	2.3
	Eco-design	-	3.1	2.1	2.3	-	3.3	2.2	2.3
UK	**Baseline (reported)**	8.7 (13.1)	7.6	6.7	6.9	9.3 (13.3)	7.9	6.9	7.1
	MTFR	-	4.5	3.1	2.8	-	4.6	3.2	2.8
	Eco-design	-	6.6	4	3	-	6.8	4.1	3
Northern Ireland Calculated[35]	***Baseline (reported)***					*1.1 (1.5)*	*0.64*	*0.56*	*0.58*
	MTFR					-	*0.37*	*0.26*	*0.23*
	Eco-design					-	*0.55*	*0.33*	*0.24*

The proposed Eco-design measures for small combustion have required substantial negotiation, in part due to difficulty in reconciling different emission data from emission test methods. In addition, fuel quality and user (mis)behaviour can have a large influence on emissions from solid fuel appliances – in particular batch-fed, manually-controlled, natural draught appliances. 'Real life' emissions can be very different from a type-test under defined conditions in a test laboratory – consequently achieving emission reductions predicted by type-testing may be difficult. The IIASA study also highlighted the impact of operator practices and fuel on emission factors, stressing the potential for regional variation.

The IIASA assessment forecast that emission reductions can be achieved without the premature removal of less efficient appliances. Greater emission reductions can be achieved through the replacement of the existing appliance stock with more modern energy efficient models, with the following components, where applicable:

- Primary and secondary air distribution and control;
- Combustion chambers with lining;
- Fan assisted heat exchange;
- Advanced control loops;
- Catalytic afterburning;
- Boilers for indirect heating; and
- Automatic fuel feed and ash removal (pellet stoves and boilers).

[34] Figures in brackets are emissions reported for **residential** activity in national (and sub-national) emission inventories for 2005
[35] Calculated from ratio of UK and NI PM_{10} emission data for residential activity in 2011 or, for the baseline emission, 2005.

3.9 Summary

Reported NO_x emissions in Ireland are above the NEC directive limit and if an upward trend is consolidated in future years, Ireland may need to consider additional measures to reduce NO_x emissions in the residential sector where solid fuels emit approximately twice as much NO_x per unit energy as other fuels. This issue does not arise in the case of Northern Ireland as UK emissions are below the specified NEC directive ceilings.

Analysis of the emission inventory indicates that that PM_{10} and $PM_{2.5}$ emissions in Ireland decreased by approximately 12% between 2000 and 2013 with no clear discernible year on year trend. Coal fuels (bituminous coal, anthracite & manufactured ovoids, lignite) make the single largest contribution to $PM_{10/2.5}$ emissions accounting for about half of all emissions in 2013.. Coal fuels are the largest contributor to residential emissions at high emission density hotspots in much of the country. The decline in peat use (-27% over the period) is a significant part of the overall reduction since 2000. Much of the peat is burned in open countryside where the public health impacts of poor air quality is less likely to be significant: nevertheless, our analysis of data on the prevalence of the use of different residential fuels from Census 2011 indicates peat combustion is associated with elevated PM_{10} emission densities (emissions per unit area) in small areas, mainly throughout the Midlands (parts of Galway, Laois, Offaly, Kerry and North Tipperary) where peat bogs are a local and traditional source of fuel. The high emission densities could potentially result in significant impact on local air quality concentrations. There is a substantial contribution to emissions from biomass (10%), however, natural gas, kerosene and gas oil provide the major part of residential fuel use but do not contribute much to $PM_{2.5}$ emissions in Ireland.

Wood burning made the largest contribution to residential PM_{10} emissions in Northern Ireland in 2011 but this was due to an uncertain increase in wood use which could be reflective of UK rather than Northern Ireland use of this fuel. Coal, solid smokeless (low smoke) fuel and peat use also make large contributions to the total emissions. Emissions from petroleum coke continue to contribute to the inventory total. The UK NAEI provides maps of combined commercial, institutional and residential emissions for Northern Ireland at 1 km spatial resolution. The PM_{10} emission density is less than 0.2 tonne km^{-2} (2 kg ha^{-1}) throughout most of Northern Ireland with higher emission densities in, for example, west Belfast, Lisburn and Derry. However, our analysis of 2011 Small Area census data indicates that emission densities are much higher in some small areas than shown in the NAEI 1 km maps. Solid fuel combustion is the main contributor to emissions in emission density hotspots throughout Northern Ireland.

Different emission factors have been used for residential solid fuel combustion in the emission inventories for Ireland and Northern Ireland reflecting different methodological approaches. The inventories assume that the emission factor is directly related to fuel type alone: however, there are considerable differences in particulate matter emission factors between combustion appliance types using the same fuel. There is thus considerable uncertainty in the calculation of emissions, particularly at local level. The uncertainty might be reduced if more detailed information on the types of appliance was available. The Ireland 2013 emission inventory adopted updated emission factors but there remain differences in emission factors between emission inventories.

Particulate matter emissions are projected to decrease in future, based on a range of assumed policy interventions, including a shift to cleaner fuels and technologies. IIASA projections indicate that significant further reductions in emissions can be obtained as the result of technical measures to improve combustion performance, for example through the implementation of Eco-design standards. However, the success of the Ecodesign standards in the real world is vitally dependent on operator practice and the fuel type and quality. For example, a stove tested on 'smokeless (low smoke)' coal will have much higher real world emissions and lower energy efficiency when operated using regular bituminous (smoky) coal. To ensure the success of the Ecodesign standards, it will be important that Member States and regions take action to assure fuel quality and a concomitant shift to cleaner, less polluting solid fuels.

4 Air pollution and health

Box3: Summary of Section 4

The adverse health effects associated with air pollution exposure can range from increased severity of symptoms such as asthma, respiratory diseases and cardiovascular diseases, particularly in those with pre-existing conditions, to hospitalisation for these illnesses, right through to premature death.

The World Health Organisation (WHO) have recently published the Review of evidence on health aspects of air pollution - the REVIHAAP Project. Among the major findings are the following:

- There is additional support for the effects of short-term exposure to $PM_{2.5}$ on both mortality and morbidity, based on several multicity epidemiological studies;
- There is additional support for the effects of long-term exposures to $PM_{2.5}$ on mortality and morbidity, based on several studies of long-term exposure conducted on large cohorts in Europe and North America;
- An authoritative review of the evidence for cardiovascular effects, conducted by cardiologists, epidemiologists, toxicologists and other public health experts, concluded that long-term exposure to $PM_{2.5}$ is a cause of both cardiovascular mortality and morbidity;
- Significantly more insight has been gained into physiological effects and plausible biological mechanisms that link short- and long-term $PM_{2.5}$ exposure with mortality and morbidity, as observed in epidemiological, clinical and toxicological studies;
- There are additional studies linking long-term exposure to $PM_{2.5}$ to several new health outcomes; and
- There is emerging evidence that also suggests possible links between long-term $PM_{2.5}$ exposure and neurodevelopment and cognitive function, as well as other chronic disease conditions, such as diabetes.

The WHO International Agency for Research on Cancer (IARC) has classified air pollution as a carcinogen, particulate matter has also been classified as a carcinogen. The Committee on the Medical Effects of Air Pollutants (COMEAP) calculated that air pollution, as $PM_{2.5}$, for the UK in 2008 had a mortality burden equivalent to 29,000 deaths and an associated loss to the population of 340,000 life years. Similar calculations for Northern Ireland estimated 553 adult deaths attributable to $PM_{2.5}$ air pollution and 6,063 life years lost in 2010. Calculations completed in this study for Ireland based on PM_{10} data suggests that there were 1,148 deaths in 2011 with 13,566 years of life lost. These data are similar to those published recently by the European Environment Agency who estimated premature deaths attributable to $PM_{2.5}$ exposure in 2012 were 37,800 for UK and 1,200 for Ireland.

More recent data published on the health impact of ambient NO_2 pollution in London suggests that it is likely to be much higher than that of PM[36]. For example, in London the total mortality burden due to $PM_{2.5}$ in 2010 is estimated to be equivalent to 3,537 deaths while for NO_2 is estimated to be equivalent to 5,879 deaths (assuming the WHO value of up to a 30% overlap between the effects of $PM_{2.5}$ and NO_2). In the UK, recent estimates for NO_2 is an equivalent 23,500 deaths each year (based on 2010 data)[37]. The European Environment Agency recently[38] suggests that there are no deaths in Ireland due to the low levels of NO_2, though a separate number for Northern Ireland is not available. It is therefore reasonable based on this evidence that the mortality impact from both PM and NO_2 for the island of Ireland is estimated to be at least 1,700 deaths per year and possibly in excess of 2,000 deaths per year.

Although we know that mortality increases when air pollution increases, there are fewer examples of what happens when air pollution is reduced. However, there is evidence from national or regional scale air pollution reductions which resulted in changes in point and non-point source emissions and therefore ambient pollutant concentrations. Documented large scale air pollution reductions have been associated with a beneficial public health effect.

[36] REVIHAAP and Walton, H; Dajank,D., Beevers, S., Williams, M., Watkiss, P., and Hunt, A. (2015) Understanding the health impacts of air pollution in London. Report for Transport for London. Kings College London
[37] Defra (2015) Draft plans to improve air quality in the UK.
[38] European Environment Agency (2015) Air Quality in Europe – 2015 report

4.1 Historic overview of air pollution and health

The links between air pollution and adverse health effects are not new, Brimblecombe[39] references Swift in Dublin, recording that doctors advised their ill patients to move to the suburbs away from the foul air of the city'. Brimblecombe also refers to air pollution and health effects back as far as Roman times. He refers to numerous pollution events associated with coal burning, and he discusses policies introduced to reduce coal usage in the 15th to 19th centuries.

However, it was only really in the 20th century that scientific knowledge and understanding of air pollution developed. A number of well documented cases of severe air pollution, Donora in Pennsylvania 1948[40], London 1952[41] and also in Ireland, with 1982 Dublin Smog event[42]. Coal use was a factor in these events; in the case of London, coal use in industry, transport and heating and, in Dublin, coal for space heating.

All of these severe pollution episodes were shown to be associated with significant increases in mortality and/or morbidity. In the London episode of 1952, over 4000 excess deaths were recorded over the 2 week period of the air pollution. Others[43] now believe that the excess death toll was significantly higher than the official reports, and they estimate the excess deaths at about 12,000.

The events mentioned above were all very severe air pollution episodes. The question arises as to whether adverse effects of air pollution can be detected at low levels of pollution. From the 1980s onwards, various studies around the world have added to our knowledge in this respect. The Harvard Six Cities Study[44] was a publication that brought the issue of air pollution and health straight into the public eye. The study showed that people living in the city with the highest air pollution had the shortest life expectancy, and that those in the least polluted had the longest life expectancy. The big issue however, was that air pollution in all of these cities was within the USEPA guidelines in force at that time. The results from the "Air Pollution and Health—A European Approach" (APHEA) multi-city study in Europe[45] and the National Morbidity, Mortality, and Air Pollution Study (NNMAPS)[46] in the US show that adverse health effects are still detectable at low levels of air pollution, and that there is no threshold below which health impacts are not detected.

The adverse health effects associated with air pollution exposure can range from increased severity of symptoms such as asthma, respiratory diseases and cardiovascular diseases, particularly in those with pre-existing conditions, to hospitalisation for these illnesses, right through to premature death.

In recognition of the adverse health effects of ambient airborne pollution, the US EPA, and the European Commission have set air quality standards since the 1970s. The World Health Organisation (WHO) has also provided guidelines on air quality. These standards and guidelines have been periodically revised to reflect the evolving scientific understanding. In general, standards have tightened and the scope of the regulations has increased with time. Section 2 of this report provides a summary of European Union air quality standards and WHO guidelines.

4.2 Evidence of adverse health effects

There are now numerous studies which show a link between air pollution and adverse health effects, including mortality (Harvard six cities study, Pope and Dockery review[47], WHO report[48], and

[39] Peter Brimblecombe, The Big Smoke: A History of Air Pollution in London since Medieval Times
[40] Snyder, Lynne Page (1994). "'The Death-Dealing Smog Over Donora, Pennsylvania':Industrial Air Pollution, Public Health Policy, and the Politics of Expertise." Environmental History Review 18(1):117–139
[41] HMSO. 1954. Her Majesty`s Public Health Service. Mortality and Morbidity during the London Fog of December 1952. Public Health and Medical Subjects Report No. 95. London:Her Majesty's Stationery Office.
[42] Kelly I, Clancy L. Mortality in a general hospital and urban air pollution. Ir Med J 1984; 77: 322-324.
[43] Bell ML, Davis DL. 2001. Reassessment of the lethal London fog of 1952: novel Indicators of acute and chronic consequences of acute exposure to air pollution. Environ Health Perspect 109(suppl 3):389–394.
[44] Douglas W. Dockery, C. Arden Pope, Xiping Xu, John D. Spengler, James H. Ware, Martha E. Fay, Benjamin G. Ferris, and Frank E. Speizer An Association between Air Pollution and Mortality in Six U.S. Cities. NEJM Volume 329:1753-1759. 1993
[45] APHEA (Air Pollution and Health—A European Approach) Project. 1996. Short-term effects of air pollution on health: a European approach using epidemiological time series data. J EpidemiolComm Health 50(suppl 1):S3–S80.
[46] Jonathan M Samet, Scott L Zeger, Francesca Dominici, Frank Curriero, Ivan Coursac, Douglas W Dockery, Joel Schwartz, and Antonella Zanobetti. The National Morbidity, Mortality, and Air Pollution Study Part II: Morbidity and Mortality from Air Pollution in the United States. Health Effects Institute No. 94. June 2000
[47] Pope CA, Dockery DW. Health Effects of Fine Particulate Air Pollution: Lines that connect. J. Air & Waste Manage. Assoc. 56:709–742. 2006
[48] WHO. 2012. Health effects of black carbon. By Janssen N, Gerlofs-Nijland ME, Lanki T, Salonen RO, Cassee F, Hoek G, Fischer P, Brunekreef B, Krzyzanowski M. World Health Organization

COMEAP[49,50]). In Ireland, studies have shown that associations between air pollution and mortality at lower pollution levels are detectable in Ireland[51].

WHO have recently published the Review of evidence on health aspects of air pollution -the REVIHAAP Project[52]. REVIHAAP considers evidence primarily published since 2005. Among the major findings are the following:

- There is additional support for the effects of short-term exposure to $PM_{2.5}$ on both mortality and morbidity, based on several multicity epidemiological studies;
- There is additional support for the effects of long-term exposures to $PM_{2.5}$ on mortality and morbidity, based on several studies of long-term exposure conducted on large cohorts in Europe and North America;
- An authoritative review of the evidence for cardiovascular effects, conducted by cardiologists, epidemiologists, toxicologists and other public health experts, concluded that long-term exposure to $PM_{2.5}$ is a cause of both cardiovascular mortality and morbidity;
- Significantly more insight has been gained into physiological effects and plausible biological mechanisms that link short- and long-term $PM_{2.5}$ exposure with mortality and morbidity, as observed in epidemiological, clinical and toxicological studies;
- There are additional studies linking long-term exposure to $PM_{2.5}$ to several new health outcomes, including atherosclerosis, adverse birth outcomes and childhood respiratory disease; and
- There is emerging evidence that also suggests possible links between long-term $PM_{2.5}$ exposure and neurodevelopment and cognitive function, as well as other chronic disease conditions, such as diabetes.

The following paragraphs provide a short summary of some of the key publications cited by REVIHAAP.

A number of recent publications of cohort studies on long-term exposure to particulates report adverse health effects at low particulate pollution levels[53,54,55,56,57,58,59]. These studies refer to long term exposure to fine particulates, however there is also strong evidence of acute effects, or effects due to short term exposure to $PM_{2.5}$ and PM_{10} on mortality, morbidity and physiological endpoints[60,61]. A number of new multi-city studies[62] have also confirmed the previously reported small increases (0.4-1% per 10 μg m^{-3}) in daily mortality associated with $PM_{2.5}$ and PM_{10}. A study from Barcelona also found a significant association between daily mortality and $PM_{2.5}$. A key finding of this paper was that it showed the effects to differ for particles from different sources although residential fuel combustion was not identified as a separate source category.

[49] COMEAP (Committee on the Medical Effects of Air Pollutants). Cardiovascular Disease and Air Pollution: A Report by the Committee on the Medical Effects of Air Pollutant's Cardiovascular Sub-Group. 2006. London, UK: Department of Health, National Health Service.
[50] COMEAP 2010.The Mortality Effects of Long-Term Exposure to Particulate Air Pollution in the United Kingdom. Available from: http://www.comeap.org.uk/documents/reports/128-the-mortality-effects-of-long-term-exposure-to-particulate-air-pollution-in-the-uk.html
[51] P G Goodman , D Q Rich, A Zeka, L Clancy, D W Dockery Effect of Air Pollution Controls on Black Smoke and Sulphur Dioxide Concentrations across Ireland.. J. Air & Waste Manage. Assoc 2009: 59:207–213
[52] http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf?ua=1
[53] Beelen R, Hoek G, van den Brandt PA, Goldbohm RA, Fischer P, Schouten LJ, et al. 2008. Long-term effects of traffic-related air pollution on mortality in a Dutch cohort (NLCS-AIR study). 40 Environ Health Perspect 116:196–202.
[54] Crouse DL, Peters PA, van Donkelaar A, et al. Risk of nonaccidental and cardiovascular mortality in relation to long-term exposure to low concentrations of fine particulate matter: a Canadian national-level cohort study. Environ Health Perspect 2012;120:708-714.
[55] A.; Katsouyanni, K.; Korek, M.; Kramer, U.; Kuhlbusch, T.; Lanki, T.; Madsen, C.; Meliefste, K.; Molter, A.; Mosler, G.; Nieuwenhuijsen, M.; Oldenwening, M.; Pennanen, A.; Probst-Hensch, N.; Quass, U.; Raaschou-Nielsen, O.; Ranzi, A.; Stephanou, E.; Sugiri, D.; Udvardy, O.; Vaskovi, Filleul L, Rondeau V, Vandentorren S, Le Moual N, Cantagrel A, Annesi-Maesano I, et al. 2005. Twenty five year mortality and air pollution: results from the French PAARC survey. Occup 20 Environ Med 62:453–460.
[56] Miller KA, Siscovick DS, Sheppard L, Shepherd K, Sullivan JH, Anderson GL, Kaufman JD.Long-term exposure to air pollution and incidence of cardiovascular events in women. N Engl J Med. 2007 Feb 1;356(5):447-58
[57] Lipsett MJ, Ostro BD, Reynolds P, Goldberg D, Hertz A, et al. 2011. Long-term exposure to air pollution and cardiorespiratory disease in the California teachers study cohort.Am J RespirCrit Care Med 184:828-35.
[58] Malig BJ, Ostro BD. 2009. Coarse particles and mortality: evidence from a multi-city study in California. Occup Environ Med 66:832-9
[59] Ostro B, Lipsett M, Reynolds P, Goldberg D, Hertz A, Garcia C, et al. 2010. Long-term exposure to constituents of fine particulate air pollution and mortality: results from the California Teachers Study. Environ Health Perspect 118:363–369.
[60] Brook RD, Rajagopalan S, Pope CA 3rd, et al. 2010. Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association. Circulation 21:2331-78.
Breitner S, Stolzel M, Cyrys J et al. Short-Term Mortality Rates during a Decade of Improved Air Quality in Erfurt, Germany. Environ Health Perspect. 2009;117(3):448-454.
[61] Ruckerl, R., Schneider, A., Breitner, S., Cyrys, J., Peters, A., 2011. Health effects of particulate air pollution: A review of epidemiological evidence. Inhalation toxicology 23, 555-592.
[62] Susann Henschel, Richard Atkinson, Ariana Zeka, Alain Le Tertre, AntonisAnalitis, Klea Katsouyanni, Olivier Chanel, Mathilde Pascal, Bertil Forsberg, Sylvia Medina, Patrick G. Goodman Air pollution interventions and their impact on public health. International Journal of Public Health October 2012, Volume 57, Issue 5, pp 757-768

There is evidence of adverse health effects even in regions with relatively low annual averages of pollution, such as Canada[63] and cleaner cities in the U.S[64]. In general, most of the effects are observed from 0 to 5 days after exposures and are greatly increased when cumulative (e.g., 3 or 5 day moving averages) exposures are used as the exposure metric. A study in Dublin has made similar findings, with a strong cumulative aspect to the exposure, especially for respiratory mortality outcomes, with a more acute effect on cardiovascular outcomes.

Results from multi-city studies, support the view that there is no threshold or safe level of particulate matter below which health impacts do not occur. Additionally a recent study in Madrid found no evidence of a threshold, and reported that there was a linear association between $PM_{2.5}$ and hospital admissions for respiratory and cardiovascular disease (Linares, 2010).

In 2013, the WHO IARC have also classified air pollution as a carcinogen, particulate matter has also been classified as a carcinogen[65].

4.3 Particle size and composition

REVIHAAP considered the role of other fractions of metrics of particulate matter such as smaller fractions (ultrafines), black carbon and chemical constituents. Key findings were:

- Epidemiological and toxicological studies have shown PM mass ($PM_{2.5}$ and PM_{10}) comprises fractions with varying types and degrees of health effects, suggesting a role for both the chemical composition (such as transition metals and combustion-derived primary and secondary organic particles) and physical properties (size, particle number and surface area);
- The new evidence suggests that short-term exposures to coarse particles (including crustal material) are associated with adverse respiratory and cardiovascular effects on health, including premature mortality.
- There is increasing, though as yet limited, epidemiological evidence on the association between short-term exposures to ultrafine (smaller than 0.1 µm) particles and cardiorespiratory health, as well as the health of the central nervous system.
- New evidence links black carbon particles with cardiovascular health effects and premature mortality, for both short-term (24 hours) and long-term (annual) exposures.
- Epidemiological studies continue to report associations between sulphates or nitrates in secondary aerosols and human health.

4.3.1 Coarse Particulates

The particles in the range PM_{10}-$PM_{2.5}$ are often referred to as coarse particles. The published research in this area is not as comprehensive as it is with $PM_{2.5}$ or PM_{10}. REVIHAAP reported that new evidence suggests that short-term exposures to coarse particles (including crustal material) are associated with adverse respiratory and cardiovascular effects on health, including premature mortality. REVIHAAP cites a number of recent studies[66,67,68] that reported adverse health effects from exposure to coarse particulates, with cardiovascular effects reported and respiratory or total mortality. In general, the effect estimates for coarse PM were somewhat lower than for $PM_{2.5}$.

Ongoing research in Europe from the ESCAPE study[69] showed that for long-term exposure $PM_{2.5}$ and PM_{coarse} may not be highly correlated across the different regions of Europe as correlations ranged between 0.02 (Vorarlberg) to 0.81 (Paris). In addition the ESCAPE study showed that over all seasons, highest concentrations were observed in dry climates. Coarse particles in European urban areas often

[63] Burnett, RT, Stieb D, Brook JR, Cakmak S, Dales R. et al. 2004. Associations between short-term changes in nitrogen dioxide and mortality in Canadian cities. Arch Environ. Health 59: 228-236.
[64] Dominici F, Peng RD, Ebisu K, Zeger SL, Samet JM, Bell ML. 2007. Does the effect of PM10 on mortality depend on PM nickel and vanadium content? A reanalysis of the NMMAPS data. Environ Health Perspect 115:1701–1703.
[65] http://www.iarc.fr/en/media-centre/iarcnews/pdf/pr221_E.pdf
[66] Atkinson RW, Fuller GW, Anderson HR, Harrison RM, Armstrong B. 2010. Urban ambient particle metrics and health: a time-series analysis. Epidemiology 21:501-11.
[67] CHEN, S. S., TANG, C. S., JIN, H. F. & DU, J. B. 2011. Sulfur dioxide acts as a novel endogenous gaseous signaling molecule in the cardiovascular system. Chin Med J (Engl), 124, 1901-5.
[68] Mallone S, Stafoggia M, Faustini A, Gobbi GP, Marconi A, Forastiere F. 2011. Saharan Dust and Associations between Particulate Matter and Daily Mortality in Rome, Italy. Environ Health 15 Perspect 10: 1409-1414.
[69] Eftens, M.; Tsai, M.; Ampe, C.; Anwander, B.; Beelen, R.; Bellander, T.; Cesaroni, G.; Cirach, M.; 45 Cyrys, J.; de Hoogh, K.; De Nazelle, A.; de Vocht, F.; Declercq, C.; D÷del÷, A.; Eriksen, K.; Galassi, C.; Gražulevičien÷, R.; Grivas, G.; Heinrich, J.; Hoffmann, B.; Iakovides, M.; Ineichen, A.; Katsouyanni, K.; Korek, M.; Kramer, U.; Kuhlbusch, T.; Lanki, T.; Madsen, C.; Meliefste, K.; Molter, A.; Mosler, G.; Nieuwenhuijsen, M.; Oldenwening, M.; Pennanen, A.; Probst-Hensch, N.; Quass, U.; Raaschou-Nielsen, O.; Ranzi, A.; Stephanou, E.; Sugiri, D.; Udvardy, O.; Vaskovi, E.; Weinmayr, 50 G.; Bert Brunekreef, B.; Hoek, G. Variation of PM2.5, PM10, PM2.5 absorbance and PMcoarse 40 concentrations between and within 20 European study areas – results of the ESCAPE project. Atmos. Environ. 2012.

consist of re-suspended road particles containing a mixture of soil, tyre wear and brake wear. In addition, coarse particles can be transported regionally from desert areas.

Table 3-5 shows the emission factors in the national emission inventories currently applied to estimate emissions of PM_{10} and $PM_{2.5}$ from residential combustion. The coarse particle emission factor may be calculated as the difference between these emission factors. Particles in the range PM_{10}-$PM_{2.5}$ are generally considered to make up a relatively small part of particulate emissions from residential sources. However, the CEPMEIP emission factors (as adopted by Ireland prior to 2015) assume that coarse particles provide about 50% of the PM_{10} emission from residential combustion.

4.3.2 Ultrafine particles

Ultrafine particles are often defined as particles below an aerodynamic diameter of 100nm. There is very limited published research on the health effects of ultra-fine particles[70]. At these small particle sizes, mass is not a good metric to use, and particle number concentrations are more relevant. It is generally agreed that most of these ultrafine particles stem from combustion processes in urban settings. The link has been reported between ultrafine particles or total number concentrations and natural cause mortality from time series studies.

4.3.3 Secondary Particulates

Primary particles are those emitted directly to the air, such as particles emitted during combustion or abrasion, for example brake and tyre wear. Secondary particles are those formed from precursors by atmospheric processes and include sulphates and nitrates. Recent studies[71,72,73] from the Health Effects Institute (HEI) under their National Particle Components Toxicity (NPACT) initiative suggests sulphates from coal combustion are closely linked to cardiovascular effects associated with long term exposure to $PM_{2.5}$. However, the REVIHAAP review concluded that there are many components contributing to the health effects of $PM_{2.5}$ but not sufficient evidence to differentiate between these constituents (and their sources) that are more closely related to specific health outcomes. The HEI NPACT studies concluded that there was not compelling evidence that any specific source, component or size class of particulate matter may be excluded as a possible contributor to particulate matter toxicity.

4.3.4 Black Carbon

A recent WHO report that evaluated the evidence of health effects of exposure to Black Carbon, reports that in two pollutant models, the effects of Black Carbon was more robust than PM mass, and they concluded that there was sufficient evidence to show that there is an association between long term black carbon exposure and all cause and cardiopulmonary mortality.

It should be noted that this stronger, or more robust association of black carbon with the adverse health outcomes, may in part be due to the fact that the black carbon is acting as a marker for other harmful substances which are a by-product of combustion.

A review of Black Smoke exposure reported that fairly consistent associations between black smoke and morbidity and mortality are reported in the literature.

4.4 Polycyclic aromatic hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a group of hydrocarbons that are mainly formed by the incomplete combustion of organic materials. There are several hundred PAHs although benzo[a]pyrene is the most widely studied because it is the most significant contributor to the carcinogenic potency of ambient PAH mixtures. The main route to exposure is from inhalation of ambient or indoor air due to residential heating, cigarette smoke, coal and wood fires and vehicle exhaust. Chronic inhalation of Benzo[a]pyrene may cause a decrease in respiratory function, chest pain and irritation and cough. Benzo[a]pyrene is considered to be carcinogenic to humans[74]. REVIHAAP considered new evidence on health effects due to air emissions of PAHs. There is new

[70] Peters, A., Ruckerl, R., Cyrys, J., 2011. Lessons from air pollution epidemiology for studies of engineered nanomaterials.J.Occup.Environ.Med. 53, S8

[71] HEI NPACT Review panel (2013) Executive Summary. HEI's National Particle Component Toxicity (NAPCT) Initiative. Health Effects Institute, Boston, MA

[72] Vedel, S. et al (2013) National Particle Component Toxicity (NPACT) Initiative Report on Cardiovascular Effects Research Report 178 Health Effects Institute Boston, MA.

[73] Lippmann, M. et al (2013) National Particle Component Toxicity (NPACT) Initiative: Integrated Epidemiologic and Toxicologic Studies of the Health Effects of Particulate Matter Components. Research Report 177 Health Effects Institute Boston, MA.

[74] Public Health England (2008) Polycyclic Aromatic Hydrocarbons (benzo[a]pyrene) A Toxicological Overview

evidence linking PAH exposure to cardiovascular end-points, but at present these effects of PAH exposure cannot be separated from the effects of particles.

4.5 Mortality attributable to air pollution

The WHO has published[75] estimates of total deaths attributed to ambient air pollution including 279,000 in European high income countries (in 2012). The WHO has also estimated[76] 17,700 deaths attributable to household air pollution in European high income countries (in 2012).

The European Environment Agency has published estimates of premature deaths attributable to $PM_{2.5}$ (and ozone) exposure[77]. An update by the European Environment Agency[78] recently estimated premature deaths attributable to $PM_{2.5}$ exposure in 2012 as 37,800 for UK and 1,200 for Republic of Ireland.

In England, the Public Health Outcomes Framework has included an air quality indicator which is the fraction of all cause adult mortality attributable to long term exposure to current levels of anthropogenic particulate air pollution. In 2010, COMEAP calculated that air pollution in 2008 had a mortality burden equivalent to "*nearly 29,000 deaths in the UK at typical ages and an associated loss of total population life of 340,000 life-years*". In 2014, similar mortality burden calculations were undertaken at a local authority level[79]. The fraction of mortality due to anthropogenic air pollution in Northern Ireland local authorities ranged from 5.2% in Belfast to 2.5% in Fermanagh with an average for Northern Ireland being 3.8% (see Table 4-1). There were 553 adult deaths attributable to air pollution and 6,063 life years lost in Northern Ireland in 2010.

There were 141 adult deaths attributable to air pollution and 1494 life years lost in the Belfast local authority area in 2010. The methodology assumes that the number of adult deaths and life years lost is proportional to the population-weighted annual average $PM_{2.5}$ concentration, 9.2 µg m^{-3} in Belfast. No calculation of the population-weighted $PM_{2.5}$ concentration attributable to residential combustion alone has been made. However, examination of Figure 3-13 suggests that the population-weighted contribution from commercial, institutional and residential combustion in Belfast is likely to be approximately1 µg m^{-3} and, as much of this is likely to be emitted by residential sources, perhaps 10-15% of the adult deaths in Belfast could be attributable to residential combustion. This equates to approximately 14 deaths per year in Belfast attributed to residential combustion emissions.

[75] Summary paper here : http://www.who.int/phe/health_topics/outdoorair/databases/AAP_BoD_results_March2014.pdf?ua=1
[76] Summary paper here : http://www.who.int/phe/health_topics/outdoorair/databases/HAP_BoD_results_March2014.pdf?ua=1
[77] Air quality in Europe – 2014 report available here http://www.eea.europa.eu/publications/air-quality-in-europe-2014
[78] European Environment Agency (2015) Air Quality in Europe – 2015 report.
[79] Gowers, A, Miller, B and Stedman JR (2014) Estimating local mortality burdens associated with particulate air pollution PHE,Oxon.

Table 4-1:Adult deaths attributable to $PM_{2.5}$ air pollution in Northern Ireland

Area	Fraction of deaths (%)	Deaths >25 years	Life years lost (YOLL)
Antrim	3.5	12	138
Ards	3.9	25	278
Armagh	3.3	15	164
Ballymena	3.5	18	202
Ballymoney	3.1	7	77
Banbridge	3.6	12	138
Belfast	5.2	141	1494
Carrickfergus	3.8	12	136
Castlereagh	4.5	28	295
Coleraine	3.1	15	170
Cookstown	3.1	8	90
Craigavon	4.1	27	327
Derry	3.5	26	339
Down	3.3	17	189
Dungannon	3.1	13	127
Fermanagh	2.5	12	126
Larne	3.6	10	115
Limavady	2.8	6	74
Lisburn	4.2	35	378
Magherafelt	3.0	8	89
Moyle	2.9	4	45
Newry/Mourne	3.3	22	249
Newtonabbey	4.0	28	292
North Down	4.4	34	331
Omagh	3.0	10	122
Strabane	2.6	7	82
Northern Ireland	**3.8**	**553**	**6,063**

Calculation of impact of air pollution in Ireland has been calculated (Table 4-2) using measured PM_{10} air quality concentrations. Rural background data (Kilkitt monitoring site) was used as the exposure of the rural population (although this is believed to be a very conservative estimate of the PM_{10} concentrations in rural areas). For PM_{10} concentrations in urban areas, the average of the measurements from the Zone D stations of the Irish EPA network excluding Kilkitt. The population data, stratified by urban/ rural dwelling, were combined with the concentration data to estimate population-weighted annual average concentrations of PM_{10}. A baseline impact assessment, based on data from 2011 was developed. The steps were as follows, using methods and formulae described by *Gowers et al* for UK Local Authority areas.

- From the population-weighted PM_{10} concentration, estimate a relative risk for mortality hazard in adults. Following COMEAP and others, a relative risk coefficient was applied.
- From the relative risk, the fraction of mortality attributable to the PM_{10} concentrations in each area was calculated.
- The attributable fractions to the number of deaths in those aged over 30 were applied in each area to estimate the number of attributable deaths.
- From the mortality data in 5-year age-groups, the remaining expectation of life in years at the birthday beginning each group were calculated.
- The deaths in each age-group by remaining life expectancy (adjusted for deaths taking place at all ages within each group) were used to estimate an equivalent number of years of life attributable. (The use of average age-specific life expectancies assumes that the impact on mortality applies across the whole population, not just high-risk or frail individuals.)

The estimates for Ireland and Northern Ireland are slightly different in the following respects:

1. Baseline years differ – Ireland estimates are for 2011 and Northern Ireland for 2010.
2. Age group - Ireland estimates are for adults >30 and Northern Ireland for adults >25.
3. Pollutant - Ireland estimates are for PM_{10} and Northern Ireland for $PM_{2.5}$.

This analysis suggests that for Ireland there were 1,148 deaths in 2011 with 13,566 years of life lost. These data are similar to those published recently by the European Environment Agency[80], who estimated premature deaths attributable to $PM_{2.5}$ exposure in 2012 are 1,200 for Ireland (37,800 for UK).

A further analysis undertaken in this study for Ireland estimated the change in attributable deaths and years of life that would follow reductions in the PM_{10} concentrations from the 2011 baseline (Table 4-3).

More recent data published on the health impact of ambient NO_2 pollution in London suggests that it is likely to be much higherthan that of PM[81]. For example, in London the total mortality burden due to anthropogenic $PM_{2.5}$ in 2010 is estimated to be equivalent to 3,537 deaths at typical ages while for NO_2 is estimated to be equivalent to 5,879 deaths at typical ages (assuming the WHO value of up to a 30% overlap between the effects of $PM_{2.5}$ and NO_2). In the UK, the total mortality burden from $PM_{2.5}$ is an estimated equivalent 29,000 deaths each year (based on 2008 data) while recent estimates for NO_2 is an equivalent 23,500 deaths each year (based on 2010 data)[82]. The 2015 EEA report suggests that there are no deaths in Ireland due to the low levels of $NO_{2,}$ though a separate number for Northern Ireland is not available. It is therefore reasonable, based on this evidence, to expect that the mortality impact from both PM and NO_2 for the island of Ireland is estimated to be at least 1,700 deaths per year and possibly in excess of 2,000 deaths per year.

[80] European Environment Agency (2015) Air Quality in Europe – 2015 report.
[81] REVIHAAP and r Walton, H; Dajank,D., Beevers, S., Williams, M., Watkiss, P., and Hunt, A. (2015) Understanding the health impacts of air pollution in London. Report for Transport for London. Kings College London
[82] Defra (2015) Draft plans to improve air quality in the UK.

Table 4-2: Adult deaths attributable to PM_{10} air pollution in Ireland

County	Deaths >30 years	Life years lost (YOLL)
Carlow	15	183
Cavan	21	202
Clare	29	333
Cork City	67	705
Rest of Cork	94	1,123
Donegal	39	457
Dublin City	191	2,173
Rest of Dublin	173	2,341
Galway	60	715
Kerry	43	478
Kildare	40	565
Kilkenny	23	266
Laois	18	204
Leitrim	10	100
Limerick	58	654
Longford	10	123
Louth	33	398
Mayo	39	402
Meath	35	433
Monaghan	15	181
North Tipperary	23	228
Offaly	18	223
Roscommon	18	192
Sligo	19	214
South Tipperary	24	271
Waterford	35	402
Ireland	**1,148**	**13,566**

Table 4-3: Estimates of gains from reduction in PM_{10} air pollution in Ireland

Reduction in PM_{10} concentration, %	Gain in deaths >30	Gain in life years
20	254	2997
30	79	4485
40	505	5966

4.6 Coal Combustion and Health effects

Ascribing adverse health effects to a very specific source of air pollution is not easy, as most pollution from various sources. Ireland is reported to have the third highest death rate from lung cancer in Western Europe[83], some of these deaths will be attributable to air pollution and there is a need to control air pollution to protect those with respiratory illness.

There is however clear evidence that particulates from coal burning play a role in causing excess mortality. Evidence has been found of an effect on total and cardiovascular mortality in Washington DC, and using selenium, an indicator for coal combustion, found an association with cardiovascular mortality and hospital admissions in New York. Health effects from coal burning can be very dependent on the source of the coal, and the associated chemical compositions[84].

The WHO report[85] on Black Carbon states that "*The burning of solid fuels, such as wood and coal, is usually not optimal, especially in small residential heaters, since there is, to a varying degree, incomplete smouldering combustion due to the relative shortage of oxygen. Subsequently, the aerodynamic diameter of emitted PM in flue gas becomes larger (150–600 nm) than in the case of diesel oil combustion in car engines, because in addition to thermochemically-formed (Elemental Carbon) EC, there are incompletely burnt tar-like organics attached to it*." Such fuel usage is often associated with being a less efficient form of energy, and in addition such combustion is also associated with much larger amounts of semi-volatile organics than the combustion of low-sulphur diesel oil. The WHO report also concludes that as a source of Black Carbon Particulates (BCP) vehicular traffic, especially diesel-powered, is a major source in urban areas, however, they also state that in some areas, the residential burning of wood or coal, and at least periodically open biomass burning, may be an even more important source of BCP. It has been concluded that there was no reason to consider PM from biomass burning to be less harmful than particles from other sources.

The recent WHO IARC report[86] gives particular attention to the issue of coal burning they state that "*given the technological challenges in burning coal cleanly in homes (including removal of toxins such as arsenic), policy on household fuel use should aim for the complete substitution of coal with cleaner fuels and should closely monitor levels and trends in the household use of coal*." Additionally they also highlight the cancer risks and state that "these cancer risks add weight to the urgency of ensuring a rapid transition by all households to technologies and fuels that deliver clean household air, and the need to focus attention on the importance of substituting coal"

A report to the executive board of the CLRTAP[87] highlights the importance of the contribution of residential heating using wood and coal to ambient air quality. The report concludes that policy-makers in regions with relatively high levels of air pollution need to consider incentives to switch from solid fuel for heating to other means of heating.

The WHO has published guidelines for indoor air quality on household fuel combustion[88]. The guidelines include a number of recommendations including:

- Set emission rate targets for $PM_{2.5}$ (and carbon monoxide) for fuel combustion
- unprocessed coal should not be used as a household fuel
- household use of kerosene (paraffin) is discouraged

It is important to recognise that these recommendations are particularly addressed towards improving indoor air quality in low and middle income countries where building construction requirements and combustion technologies differ markedly from western European countries. However, there is clear relevance for air quality in the desire to control emissions from residential heating and other activities.

4.7 Interventions

Although we know that mortality increases when air pollution increases, there are fewer examples of what happens when air pollution is reduced. There is some evidence from national or regional scale air

[83] Irish Lung Health Alliance http://www.lunghealth.ie/news.html
[84] Robert B Finkelman, William Orem,VincentCastranova,, Calin A Tatu, Harvey E Belkin, Baoshan Zheng, Harry E Lerch, Susan V Maharaj, Anne L BatesHealth impacts of coal and coal use: possible solutions. International Journal of Coal GeologyVolume 50, Issues 1–4, May 2002, Pages 425–443
[85] Nicole AH Janssen, Miriam E Gerlofs-Nijland, Timo Lanki, Raimo O Salonen, Flemming Cassee, Gerard Hoek, Paul Fischer, Bert Brunekreef and Michal Krzyzanowski Health impacts of black carbon available here http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2012/health-effects-of-black-carbon
[86] IARC REPORT http://www.iarc.fr/en/publications/books/sp161/index.php
[87] UNECE Executive Board to CLRTAP available here : http://www.unece.org/fileadmin/DAM/env/documents/2014/AIR/EB/ECE_EB_AIR_2014_6_E.pdf
[88] WHO guidelines available here : http://www.who.int/indoorair/guidelines/hhfc/en/

pollution reductions where either a policy was implemented to directly reduce air pollution concentrations and/or composition[89] or where a national political realignment, an employee strike at an industrial facility, or a large scale sporting event resulted in changes in point and non-point source emissions and therefore ambient pollutant concentrations[90,91,92,93]. Documented large scale air pollution reductions have been associated with a beneficial public health effect. This includes reductions in total and/or cause specific mortality rates, bronchitis prevalence, childhood hospital admissions for respiratory disease, asthma acute care events and hospital childhood asthma admissions. A recently published review of such interventions, whether planned or not, showed that in almost all cases the reduction in pollution was associated with reduced morbidity or mortality. Although not specifically relating to ambient pollution, similar consistent results were observed following workplace smoking bans[94,95]

One of the key papers in relation to intervention studies on residential air pollution relates to the Dublin smoky coal ban[96] where they report on both the reduction in pollution associated with the ban, and also the sustained reduction in mortality as well. Following the success of the Dublin smoky coal ban, this ban was extended to cover most of the other large urban areas in Ireland including Cork (1995), Arklow, Drogheda, Dundalk, Limerick and Wexford (1998) and Celbridge, Leixlip, Naas, Kildare and Waterford (2000). These smoky coal bans proved successful at reducing air pollution in all centres where they were implemented[97]. The success of the smoky coal bans at improving air quality in all cases has been documented. There were further extensions of the ban and also a change to the boundaries of some of the previous bans implemented in 2013.

In a reanalysis of the Dublin study by Health Effects Institute[98] looked at the health effects associated with the various bans. The re-analysis of the Dublin ban illustrated the challenges in determining and attributing health effects to particular causes when the health status of the population is rapidly changing as a result of many variables. For Dublin however respiratory mortality was still seen to drop by 17%, with the smoky coal ban, although the cardiovascular health outcome was not in evidence. Respiratory mortality was also seen to fall by 9% and 3% respectively with the 1995 (Cork) and 1998 (Limerick) bans. Reductions in hospital admissions of 4% and 3% for cardiovascular disease were seen with the 1995 and 1998 bans (there was a lack of complete data to study morbidity associated with the Dublin 1990 ban). Reductions in Asthma and COPD admissions were also reported in the new analysis. The reanalysis clearly shows health benefits associated with the various smoky coal bans.

REVIHAAP also cites three studies relating to measures related to residential wood burning. A programme to replace older, polluting wood stoves used for home heating with newer, more efficient models, to improve air quality in a rural community in Montana. The change-out programme was found to be effective in reducing ambient $PM_{2.5}$ concentrations. Children's respiratory health, as reported in surveys filled out by the parents, was somewhat improved. A separate study reported that $PM_{2.5}$ concentrations were reduced following the introduction of a regulation banning residential wood burning in some areas of San Joaquin Valley California when forecasts predict poor air quality. A further study reported a 4.8% reduction in the risk of mortality due to ischaemic heart disease and a 5.4% reduction in the risk due to cerebrovascular diseases after the intervention. A study of a wood heater replacement programme combined with community education campaigns and enforcement of environmental regulations, starting in 2001, to reduce ambient pollution from residential wood stoves in Launceston, Tasmania reported a decrease in mean daily wintertime concentrations of PM_{10} from 44 µg m^{-3} during 1994–2000 to 27 µg m^{-3} during 2001–2007. The period of improved air quality was associated with small non-significant reductions in annual mortality (males and females combined).

[89] Hedley, A.J.; Wong, C.-M.; Thuan, Q.T.; Ma, S.; Lam, T.-H.; Anderson, H.R.Cardiorespiratory and All-Cause Mortality after Restrictions on Sulphur Content of Fuel in Hong Kong: an Intervention Study; Lancet 2002, 360, 1646-1652
[90] Pope, C.A. III. Respiratory Disease Associated with Community Air Pollution and a Steel Mill, Utah Valley; Am. J. Public Health 1989, 79, 623-628.
[91] Pope, C.A. III; Rodermund, D.L.; Gee, M.M. Mortality Effects of a Copper Smelter Strike and Reduced Ambient Sulfate Particulate Matter Air Pollution; Environ. Health Perspect. 2007,115, 679-683.
[92] Friedman, M.S.; Powell, K.E.; Hutwagner, M.S.; Graham, L.M.; Teague, W.G. Impact of Changes in Transportation and Commuting Behaviors during the 1996 Summer Olympic Games in Atlanta on Air Quality and Childhood Asthma; JAMA 2001, 285, 897-905.
[93] Lee, J.T.; Son, J.Y.; Cho, Y.S. Benefits of Mitigated Ambient Air Quality Due toTransportation Control on Childhood Asthma Hospitalization during the 2002 Summer Asian games in Busan, Korea; J. Air & Waste Manage. Assoc. 2007, 57, 968-973.
[94] Goodman P, McCaffrey M, Agnew M, Paul G, Clancy L Effects of the Irish Smoking Ban on Respiratory Health of Bar Workers and Air Quality in Dublin Pubs..Am J RespirCrit Care Med Vol 175. pp 840–845, 2007
[95] Patrick G. Goodman, Sally Haw, Zubair Kabir, Luke Clancy. Are there health benefits associated with comprehensive smoke-free laws: a review,. IJPH (2009) 54:367–378
[96] Clancy L, Goodman P, Sinclair H, Dockery DW .Effect of air-pollution control on death rates in Dublin, Ireland: An intervention study.. The Lancet 2002; 360 October 19: 1210-1214
[97] EPA Report. Air Quality in Ireland 2011, Key Indicators of ambient air Quality.Available from www.epa.ie
[98] Dockery et al report Health Effects Institute study available here : http://pubs.healtheffects.org/getfile.php?u=931

A recent review of several studies[99] concluded that reducing air pollution levels does have positive health outcomes, the results are also remarkably similar to the improvements in health observed in non-smokers, where comprehensive workplace smoking bans have been adopted.

4.8 Summary

The adverse health effects associated with air pollution exposure can range from increased severity of symptoms such as asthma, respiratory diseases and cardiovascular diseases, particularly in those with pre-existing conditions, to hospitalisation for these illnesses and premature death.

The World Health Organisation (WHO) have recently published the Review of evidence on health aspects of air pollution - the REVIHAAP Project. The project considered evidence primarily published since 2005. Among the major findings are the following:

- There is additional support for the effects of short-term exposure to $PM_{2.5}$ on both mortality and morbidity, based on several multicity epidemiological studies;
- There is additional support for the effects of long-term exposures to $PM_{2.5}$ on mortality and morbidity, based on several studies of long-term exposure conducted on large cohorts in Europe and North America;
- An authoritative review of the evidence for cardiovascular effects, conducted by cardiologists, epidemiologists, toxicologists and other public health experts, concluded that long-term exposure to $PM_{2.5}$ is a cause of both cardiovascular mortality and morbidity;
- Significantly more insight has been gained into physiological effects and plausible biological mechanisms that link short- and long-term $PM_{2.5}$ exposure with mortality and morbidity, as observed in epidemiological, clinical and toxicological studies;
- There are additional studies linking long-term exposure to $PM_{2.5}$ to several new health outcomes, including atherosclerosis, adverse birth outcomes and childhood respiratory disease; and
- There is emerging evidence that also suggests possible links between long-term $PM_{2.5}$ exposure and neurodevelopment and cognitive function, as well as other chronic disease conditions, such as diabetes.

The WHO International Agency for Research on Cancer (IARC) has classified air pollution as a carcinogen, particulate matter has also been classified as a carcinogen.

The Committee on the Medical Effects of Air Pollutants (COMEAP) calculated that air pollution in the UK in 2008 had a mortality burden equivalent to 29,000 deaths and an associated loss to the population of 340,000 life years. Similar calculations for Northern Ireland indicate the average fraction of mortality due to anthropogenic air pollution in Northern Ireland local authorities has been estimated at 3.8%. There were 553 adult deaths attributable to anthropogenic air pollution, as $PM_{2.5}$, and 6,063 life years lost in Northern Ireland in 2010.

Calculations for Ireland undertaken in this study estimated that adult deaths attributable to air pollution, as PM_{10}, were 1,148 in 2011 and 13,566 years of life lost. The European Environment Agency (EEA) has published estimates of premature deaths attributable to $PM_{2.5}$ exposure. The study indicates best estimates for premature deaths in 2012 from $PM_{2.5}$ are 37,800 for UK and 1,200 for Ireland.

Recent estimates of impacts of NO_2 in the UK is an equivalent 23,500 deaths each year (based on 2010 data). The 2015 EEA report suggests that there are no deaths in Ireland due to the low levels of NO_2, though a separate number for Northern Ireland is not available. It is therefore reasonable based on this evidence that the mortality impact from both $PM_{2.5}$ and NO_2 for the island of Ireland is estimated to be at least 1,700 deaths per year and possibly in excess of 2,000 deaths per year.

Although we know that mortality increases when air pollution increases, there are fewer examples of what happens when air pollution is reduced. However, there is evidence from national or regional scale air pollution reductions which resulted in changes in point and non-point source emissions and therefore ambient pollutant concentrations. Documented large scale air pollution reductions have been associated with a beneficial public health effect.

[99] Henschel S et al Air pollution interventions and their impact on public health. International Journal of Public Health October 2012, Volume 57, Issue 5, pp 757-768

Analysis of the Dublin smoky coal ban illustrated the challenges in determining and attributing health effects to particular causes when the health status of the population is rapidly changing as a result of many variables. For Dublin however respiratory mortality was still seen to drop by 17%. Respiratory mortality was also seen to fall by 9% and 3% respectively with the 1995 (Cork) and 1998 (Limerick) bans. Reductions in hospital admissions of 4% and 3% for cardiovascular disease were seen with the 1995 and 1998 bans.

5 Residential Fuel Market

Box 4: Summary of Section 5

Energy use statistics for the residential sector in Ireland indicate that solid fossil fuel use fell by 23% between 2000 and 2012 although use of anthracite and ovoids (manufactured fuel) has increased by about 10% in the same period. Oil use increased by 6.5%. Natural gas use increased by 37% although much of that increase occurred before 2005. Electricity use increased by 27%, also with much of the increase before 2005. Renewable energy sources (biomass, solar and geothermal) have made a small but increasing contribution to residential energy requirements. The fuels with the highest particulate matter and benzo[a]pyrene emission factors per unit of energy (coal, peat and wood) provide up to 19% of the residential energy use. Oil, electricity and natural gas provide most of the energy.

Energy statistics available for Northern Ireland are less detailed. The UK publishes sub-national consumption of selected energy types including estimates of non-gas, non-electricity and non-road transport energy consumption. It is important to recognise also that some of the sub-national consumption statistics, for example for solid fuel use, are more uncertain than national estimates.

The majority of the energy supplied to Ireland and Northern Ireland is imported. Coal and oil can be supplied direct to ports in Ireland from many suppliers around the world and so there is some resilience to geopolitical change. All imported natural gas is currently piped from Scotland. The United Kingdom has substantial gas resources in the North Sea but these are not sufficient to meet UK demand so that the UK now imports substantial quantities of gas.

Relatively little peat and wood are imported and these fuels provide the most secure source of energy but supplies are limited. Policies that reduce the demand for fuels, for example those that encourage better insulation of homes or the use of solar or geothermal energy, will increase energy security.

Published estimates of the relative space heating costs in Ireland indicate that the lowest cost heating options all relate to high efficiency installations using gas and oil and modern high efficiency closed solid fuel stoves. It is important to note that the ranking is dependent on the efficiency of the appliance which particularly for standard (bituminous or 'smoky') coal is dependent on how well maintained (clean) the appliance is. oil-fired and LPG-fired non-condensing boilers are considerably more expensive heating options than the most efficient gas, coal, peat and wood burning appliances. Converting from coal, peat or wood heating to oil heating is likely to result in increased heating costs for many home owners and this may present a significant barrier to achieving emission reductions from residential heating.

Incremental benefits to air emissions are possible by changing from high emission fuels such as wood, peat, bituminous coal and lignite to petroleum coke, anthracite or manufactured low emission solid fuels, and these benefits can be delivered without the need for capital investment by the householder. More significant reductions would arise from changing to use of gaseous or liquid fuels but this would require capital investment. Electricity or non-biomass renewable technologies also provide potential to remove local emissions from replacement or partial substitution of solid fuel combustion-based heating.

5.1 Introduction

This section provides information about residential energy use in Ireland and Northern Ireland. It considers the primary production and importation of fuels and considers the potential effect of changes in residential energy use on energy security.

Consideration is given to the relative cost of fuels for space heating applications in order to assess the potential effect of changes in fuel use on household expenditure. Consideration is also given to the relative costs of fuels in Ireland and Northern Ireland.

Finally, consideration is given to the availability of natural gas to households throughout Ireland.

5.2 Residential energy use

Table 5-1 and Figure 5-1 show residential energy use categorized by fuel type for the period 2000-2012[100] for Ireland. Total residential energy use increased from 2000 levels until 2010 and has decreased slightly since then. Overall, fossil solid fuel use (bituminous coal, anthracite and manufactured ovoids, lignite and peat) fell by 23% between 2000 and 2012 but use of anthracite and manufactured ovoids increased in this period. Oil use (kerosene, gas oil/DERV) increased by 6.5%. Natural gas use increased by 37% although much of that increase occurred before 2005. Electricity use increased by 27%, also with much of the increase before 2005. Renewable energy sources (biomass, solar and geothermal) have made a small but increasing contribution to residential energy requirements.

Figure 5-2 shows the split between residential fuel usage in Ireland in 2012. The fuels with the highest particulate matter and benzo[a]pyrene emission factors per unit of energy (coal, peat and wood, which provides a substantial part of the renewable energy) provide up to 19% of the residential energy use. Oil, electricity and natural gas provide most of the energy. The energy statistics include an estimate of the contribution of non-traded solid fuels including wood and sod peat: this quantity is difficult to estimate, and while in overall energy consumption terms it is small, the associated emissions of air pollutants are significant.

The Northern Ireland government does not publish energy statistics in as much detail. The Department of Energy and Climate Change publishes UK sub-national consumption of selected energy types including estimates of non-gas, non-electricity and non-road transport energy consumption[101]. Sub-national residential energy consumption statistics for 2011 are available for electricity and certain fuels and are summarised in Table 5-2. The published subnational residential consumption statistics do not include estimates of natural gas use because of the market structure in Northern Ireland. It is important to recognise also that some of the sub-national consumption statistics, for example for solid fuel use, are modelled and are thus considered to be more uncertain than national estimates.

The Department of Enterprise, Trade and Investment, Northern Ireland, 2011 report "The Development of the Northern Ireland Renewable Heat Incentive" [102] provides estimates of Northern Ireland heat demand for 2011. These are shown in Table 5-3. The total heat demand in Northern Ireland was estimated in 2011 at 62,503 TJ[103] per year; this compares to 2,405,000 TJ per year in the UK as a whole and 232,000 TJ (heat consumption) per year in Ireland.

Comparing Table 5-2 and Table 5-3 we can see that the heat demand provided by oil is approximately 75% of the residential energy consumption attributed to oil. Similarly, the domestic heat demand provided by Economy 7 electricity is approximately 67% of the residential energy consumption.. The residential heat demand provided by coal in Table 5-3 is only 27% of the residential energy consumption: this does not take account of the contribution from manufactured solid fuels. Part of the

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[100] Data supplied by SEAI. Equivalent data is available from Eurostat http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database

[101] Department of Energy and Climate Change (213), UK sub-national consumption of other fuels for 2005 - 2011, Estimates of non-gas, non-electricity and non-road transport energy consumption available online at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/244782/uk_sub_national_consumption_of_other_fuels_2011.pdf (accessed 05 June 2014)

[102] Department of Enterprise, Trade and Investment, Northern Ireland, 2011, The Development of the Northern Ireland Renewable Heat Incentive July 2011 available online http://www.detini.gov.uk/the_development_of_the_northern_ireland_renewable_heat_incentive.pdf (accessed 12 May 2014)

discrepancy between these estimates can be explained by differences in the definitions of the various categories, by methodological differences and by the use of energy for other purposes than heating.

The main heating fuel in Northern Ireland is heating oil. Refined oil products account for around 77% of heat demand overall and 85-88% of the domestic heat demand. This is a very different situation in comparison to Great Britain where the natural gas market is prevalent and accounts for 68.8% of heating demand with heating oil only accounting for 10%. The natural gas market in Northern Ireland is still developing and therefore only accounts for 17% of overall demand and 9% of the domestic heat demand. The remaining heat demand in Northern Ireland is met by electricity or Economy 7[104] (1.2%), coal (3.2%) and renewables (1.7%).

Table 5-4 shows the residential energy consumption and heat demand per head of population based on population of 4.5 million in Ireland and 1.8 million in Northern Ireland. The consumption of oil per head is much higher in Northern Ireland. On the other hand the consumption of natural gas per head is higher in Ireland, reflecting to some extent the wider availability of gas supply. The consumption of electricity per head is similar although slightly higher in Ireland. The consumption of coal/solid fuel in both jurisdictions per head in energy terms is lower, however, relative to Great Britain and other similar EU countries it is relatively large and as seen from Chapter 3, is the predominant source of PM_{10}, $PM_{2.5}$ and Benzo[a]pyrene.

[104] Economy 7 is the name of a differential tariff provided by United Kingdom electricity suppliers that uses base load generation to provide cheap off-peak electricity during the night. Houses using the Economy 7 tariff require a special electricity meter which provides two different readings - one for electricity used during the day, priced higher, and the other for the night, priced lower. The night (off-peak) period lasts for a total of seven hours, hence the name.

Table 5-1: Residential energy use by fuel in Ireland, TJ (Source, SEAI).

Fuel/Energy	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Bituminous Coal	8,793	7,595	7,119	6,988	6,599	6,835	6,642	5,952	6,848	7,724	7,529	6,339	6,743	7,243
Anthracite + Manufactured Ovoids	2,459	2,587	2,360	2,225	2,459	2,476	2,367	2,516	2,365	2,952	2,787	2,822	2,718	3,464
Lignite	713	866	1,070	773	614	985	154	245	408	498	435	440	534	724
Peat	12,522	12,040	12,155	11,318	11,151	11,434	11,870	11,360	11,710	11,375	10,615	10,101	8,982	9,123
Kerosene	23,866	27,004	27,755	29,744	32,440	33,276	33,150	33,054	36,758	38,313	42,304	33,437	28,577	29,559
LPG	2,373	2,369	2,178	2,075	2,037	2,220	2,089	1,964	1,689	1,236	1,564	1,435	1,384	1,676
Gasoil / Diesel	10,221	10,351	10,394	10,394	10,004	10,719	10,266	9,748	10,547	8,946	8,606	8,101	7,722	6,740
Petroleum Coke	1,843	2,586	1,940	2,140	1,306	1,730	1,194	1,339	1,123	625	556	363	428	458
Natural Gas	18,366	20,171	19,910	22,565	25,168	25,405	26,464	24,825	28,003	26,155	29,715	23,834	25,141	25,381
Biomass	720	688	682	642	629	668	702	971	855	1,118	1,121	942	1,151	1,191
Solar	5	5	7	9	12	19	26	58	132	180	269	331	421	465
Geothermal	0	0	42	86	159	265	298	448	569	630	637	641	641	1,028
Electricity	22,954	24,225	23,689	25,082	26,450	27,047	29,103	29,032	30,698	29,249	30,771	29,825	29,239	28,617
Total	104,835	110,487	109,301	114,041	119,028	123,079	124,325	121,512	131,705	129,001	136,909	118,611	113,681	115,669
See also Appendix 1														

Figure 5-1: Residential energy trends in Ireland (2000-2012)

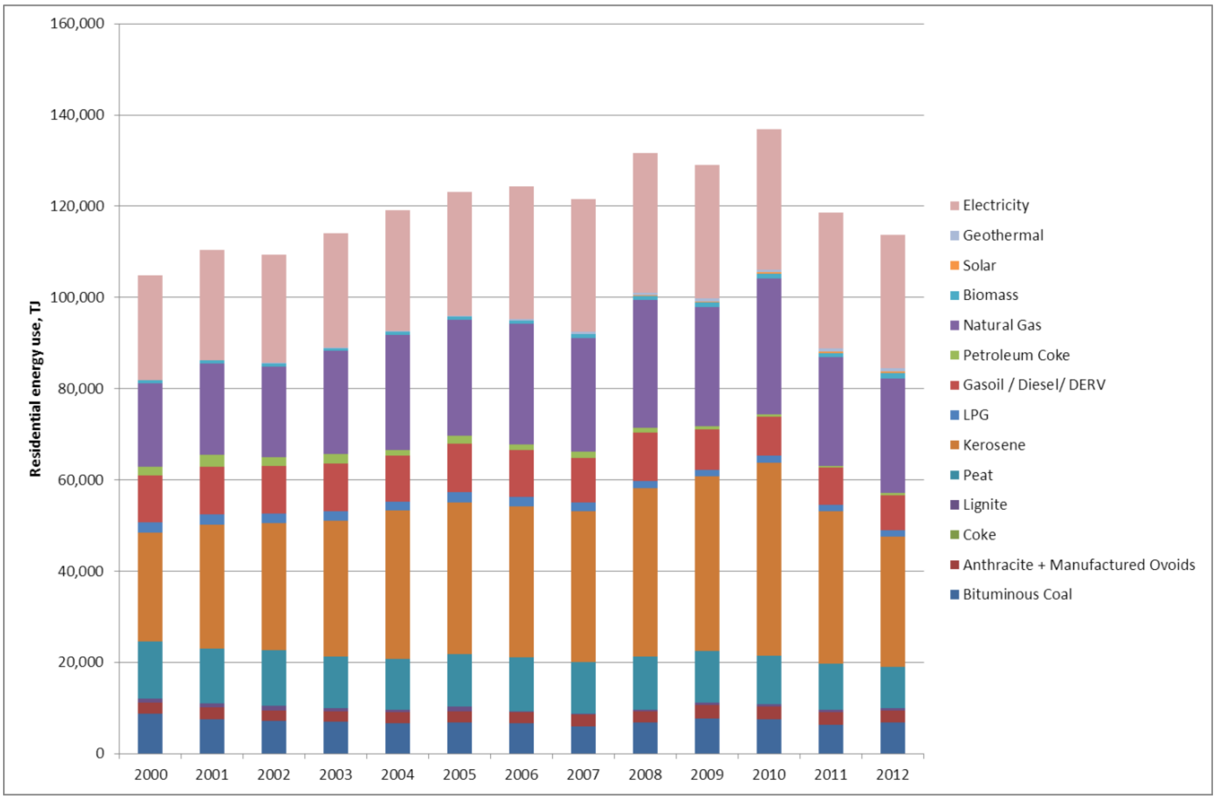

Figure 5-2 : Residential energy split in Ireland (2012)

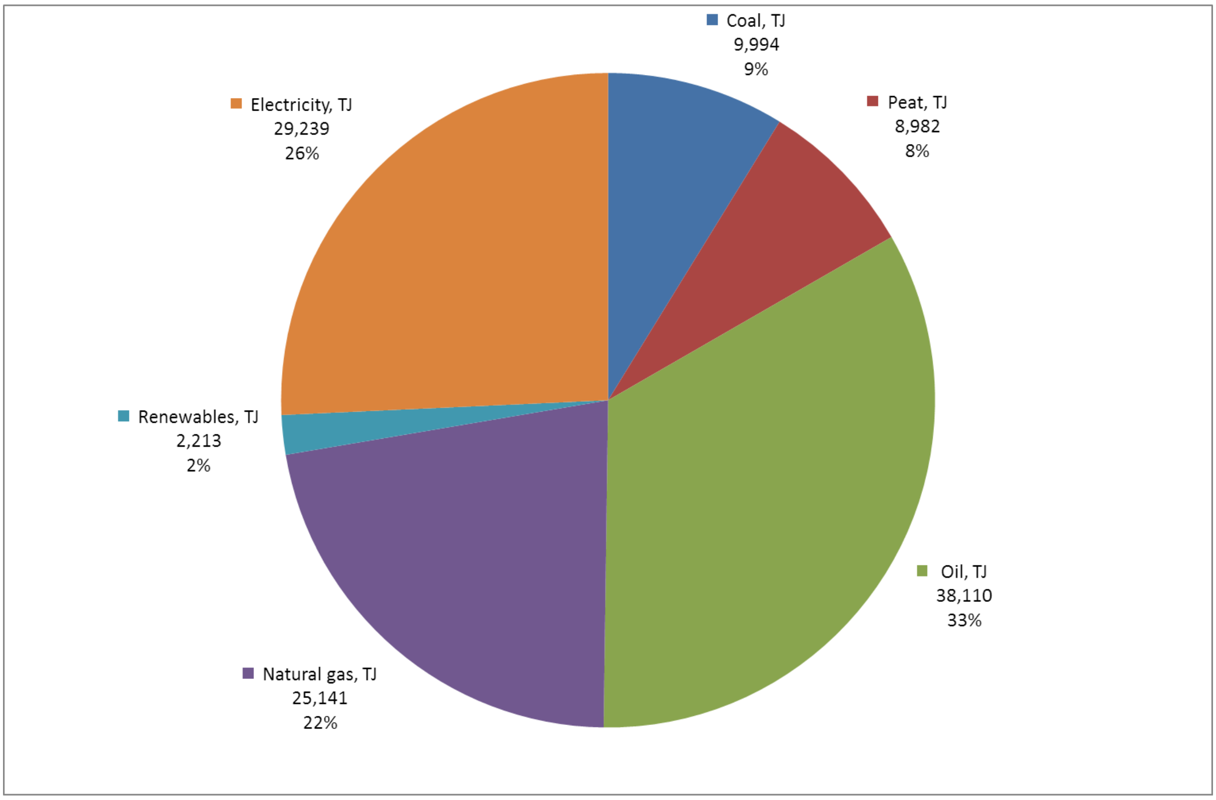

Table 5-2: Subnational residential energy statistics for Northern Ireland (2011)

Fuel/Energy Type	Consumption in reported units	Consumption TJ	Comment
Oil	1,062 ktoe	44,434	
Gas			No data
Economy 7 Electricity	260.3 GWh	937	
All electricity	2,826 GWh	10,174	
Renewable			No data
Coal	35.4 ktoe	1,482	
Manufactured solid fuel	75.6 ktoe	3,165	

Table 5-3: Heat Demand in Northern Ireland by Fuel Type (2011 estimate)

Fuel/Energy Type	Domestic (TJ)	Industrial, Commercial and Public (TJ)	Total (TJ)	% of Total
Oil	33,268	14,771	48,038	77
Gas	3,503	7,168	10,670	14
Economy 7 Electricity	634	148	781	1.2
Renewable	No information on split	No information on split	1,044	1.4
Coal	396	1,577	1,969	3.1
Total			62,503	

Table 5-4: Comparison of energy consumption per head of household

Fuel	Energy consumption, GJ per head of population		
	Republic of Ireland, residential consumption,2012	**Northern Ireland Domestic Heat Demand, 2011**	**Northern Ireland residential consumption, 2011**
Oil	8.1	18.5	24.7
Electricity	6.5	Not available	5.7
Natural gas	5.6	1.9	Not available
Coal(including anthracite, lignite and manufactured fuels)	2.2	0.2	2.6

5.3 Primary production and imports of fuels

5.3.1 Quantities

Details of primary fuel production and imports into Ireland are available from the Eurostat database[105]. Table 5-5 shows reported fuel production and imports for selected fuels. The production of natural gas has decreased substantially over the period 2000-2012 and been replaced largely by imports. Peat production is variable but has also decreased over the period, with a particularly sharp reduction in 2012. The production of solid biofuels in Ireland has increased over the period and has been supplemented further in recent years, from a very low base, by imported solid biofuels. Imports of bituminous coal have decreased while imports of non-aviation kerosene have increased.

The available data for Northern Ireland is more limited. The Department of Energy and Climate Change provides details of petroleum deliveries into Northern Ireland: not all of the delivered fuel is necessarily consumed in Northern Ireland. The Northern Ireland Annual Coal Inquiry collects information on all coal

105 http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database

and other solid fuels (includes bituminous coals, anthracite, lignite and manufactured solid fuels) shipped into Northern Ireland each year and the purpose for which it was imported: for domestic or industrial use, or for the generation of electricity. The information is obtained by surveying all coal importing ports in Northern Ireland annually. Some of the coal reported as intended for domestic consumption may be used for industrial purposes: some of the coal may be re-exported (including to Ireland) and not used in Northern Ireland. Table 5-6 shows the reported petroleum products and coal deliveries. Deliveries of burning oil and gas oil into Northern Ireland decreased by approximately 65% between 2004 and 2012 which may reflect wider penetration of the gas network. The imports of coal intended for domestic purposes greatly exceed the estimates for residential combustion of coal shown in Table 5-3 and Table 5-4: this suggests that a considerable part of the "domestic" coal is diverted to industrial use or re-export including to Ireland.

The remaining parts of this section describe the supply and import of specific fuel types and discuss the effect of policies that change how homes are heated on energy security.

Table 5-5: Primary production and imports of fuels to Ireland, TJ (Source SEAI)

	2000	2005	2007	2008	2009	2010	2011	2012
Primary production, TJ								
Natural gas	40193	19343	12979	14821	10676	9797	7159	7662
Solid biofuels (excluding charcoal)	4396	7536	7118	6824	7620	8248	8415	10048
Peat	59076	34332	26209	27214	23446	41073	31820	13188
Imports, TJ								
Anthracite	1340	1382	1256	1340	2010	1047	1382	1214
Bituminous Coal	68789	77205	60374	67324	54512	40444	59243	55433
Lignite/Brown Coal	754	1047	209	502	628	419	419	461
Liquified petroleum gas (LPG)	5066	4647	4857	5610	3433	3852	3140	2805
Non-aviation kerosene	14947	16329	20222	19259	22525	21269	26293	22064
Gas/diesel oil (without bio components)	88383	112457	115137	113881	101446	90058	85871	78126
Petroleum coke	9211	13314	12393	10844	5862	4145	3517	5234
Natural gas	103958	126274	164290	174757	169021	187862	165923	161024
Solid biofuels (excluding charcoal)	0	0	502	461	377	461	502	628

Table 5-6: Shipments of coal and petroleum products deliveries into Northern Ireland, TJ

Fuel	Use	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Coal	Domestic Use	18,633	17,788	13,348	10,872	14,496	12,714	14,134	14,587	13,952	10,812	12,140	13,046	10,449	20,355
	Industrial Use	5,708	4,017	7,127	7,218	5,859	5,104	6,010	4,983	10,238	5,738	5,194	9,030	10,510	10,872
	Generation of Electricity	46,568	48,924	36,965	32,948	33,975	29,505	34,488	23,616	22,529	15,342	23,496	17,758	30,834	31,619
	All Shipments	70,910	70,759	57,410	51,038	54,330	47,323	54,632	43,186	46,719	31,861	40,800	39,864	51,823	62,846
Burning oil	All					49,878	38,436	35,199	31,181	27,554	28,819	28,045	22,287	16,006	
Gas oil	All					22,819	17,106	14,236	15,870	16,726	14,215	22,911	9,536	8,814	
Assumes gross calorific values of 30.2, 46.2 and 45.3 GJ tonne for coal, burning oil and gas oil respectively based on Digest of UK Energy statistics															

5.3.2 Coal and coal products

Coal deposits in Ireland occur in four areas – the Leinster Coalfield straddling Counties Kilkenny, Laois and Carlow; the Slieve Ardagh Coalfield on the border of Counties Kilkenny and Tipperary; the Kanturk Coalfield in northwest County Cork and the Connaught Coalfield straddling Counties Leitrim, Roscommon, Sligo and Cavan. Most coal mining operations in Ireland started during the 18th century and were worked intermittently into the 20th century, some up until the 1990s[106]. There is currently no indigenous coal mining in Ireland. The largest share of Ireland's imports of coal comes from Columbia (42%[107]). Other major sources include South Africa, Poland, Asia, UK and Germany.

Arigna Fuels, Carrick-on-Shannon, Co. Roscommon is currently the only facility producing manufactured coal products on the island of Ireland.

Coal is imported into most parts of Ireland. The ports that are used for residential coal include:

Ireland:

- Foynes, Co. Limerick
- New Ross, Co. Wexford
- Cork
- Galway
- Dundalk, Co. Louth
- Sligo
- Greenore, Co. Louth

Northern Ireland:

- Derry (Lisahally)
- Belfast
- Larne
- Warrenpoint

The major importers of coal in Ireland and Northern Ireland are shown in Table 5-7.

Table 5-7: Main Importers of Coal in Ireland and Northern Ireland

Ireland Importers	Northern Ireland Importers
Bord na Mona	Capper Trading Ltd
Stafford Fuels	Hayes Fuels Ltd
Galtee Fuels	Kelly Fuels
	Lissan Group
	Fergusson coal

5.3.3 Oil products

There is no primary production of petroleum products in Ireland. Oil products are refined at the Whitegates refinery near Cork, Ireland's only refinery.

There is no primary production or refinery capacity in Northern Ireland and so all the petroleum products are imported.

There are eight ports in Ireland with oil terminals that can accept imported refined products for commercial distribution: Drogheda, Dublin, New Ross, Whitegate, Cork (Marina), Foynes, Limerick and

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[106] The Historic Mine Sites – Inventory and Risk Classification is a joint project carried out by the Geological Survey of Ireland and the Environmental Protection Agency. Available online at http://gis.epa.ie/ENVisionMines/reports/HMS-IRCNonTech.pdf
[107] Sustainable Energy Authority of Ireland, Energy Security in Ireland: A Statistical Overview 2011. Available online at http://www.seai.ie/Publications/Statistics_Publications/EPSSU_Publications/Energy_Security_in_Ireland/Energy_Security_in_Ireland_A_Statistical_Overview.pdf [Accessed 10 March 2014]

Galway. 45% of the transport and heating fuels used in Ireland are imported through Dublin Port. Domestic distribution is mainly by road[108]. There is a major oil terminal at Lisahally, Derry in Northern Ireland.

5.3.4 Gas

Production of natural gas from the Kinsale and satellite gas fields has declined in recent years. Further indigenous gas supplies were discovered at the Corrib field, located off the West Coast of Ireland. The Corrib field will be operated by Shell and is owned by a consortium including Shell, Statoil and Vermillion. The development of the field was substantially delayed by planning permission difficulties and the field does not yet contribute to the gas supply. It is predicted that the Corrib gas field will initially meet approximately 40% and, at peak flow, 60% of annual demand in Ireland.

There is no natural gas production in Northern Ireland. There has been some geological investigation into the potential for gas production from hydraulic fracturing in Fermanagh, but there has been substantial opposition to any development.

Natural gas is imported into Ireland from Great Britain via two interconnector pipelines that link Scotland with the north of Dublin.

Gas is imported to Northern Ireland from Great Britain via an interconnector pipeline that links Scotland with Islandmagee, near Larne in Co. Antrim. The Northern Ireland and Ireland gas distribution grids are connected by the South-North gas transmission pipeline which was constructed in 2006.

5.3.5 Wood and wood products

Wood is generally supplied for residential combustion in the form of wood pellets, wood chips, wood briquettes or as firewood logs.

SEAI[109] has identified two major producers of wood pellets on the island of Ireland. D Pellet Ltd is based in County Kilkenny and uses forest thinnings as the raw material source. Balcas Ltd is located in Enniskillen, Northern Ireland and uses sawmill by-product as the source material for pellets. Both companies produce bulk and bagged pellets that are available through distributors and agents on an island wide basis.

SEAI has identified 38 suppliers of wood fuels in Ireland:

- 12 can supply bulk pellets
- 12 can supply bulk bagged pellets
- 16 can supply bagged pellets
- 18 can supply wood chips
- 8 can supply wood briquettes
- 17 can supply firewood logs, including kiln-dried wood logs.

5.3.6 Peat

Bord na Móna is the largest producer of peat in Ireland. The main output from Bord na Móna is milled peat extracted from raised bogs in the Irish Midlands. Most of this output is used to supply three power stations for electricity generation. Bord na Móna also produces peat briquettes from the milled peat for supply to the residential heating market. The peat briquettes are marketed throughout the whole of Ireland though are not classified as authorised fuels for use in Smoke Control Areas in Northern Ireland.

An estimated 300 contractors harvest sod turf for residential heating.[110] Sod peat represents 60-70% of the residential peat market. In October 2015 Bord na Móna published its Sustainability 2030 report[111], which outlined its strategy to replace large scale peat production with alternative energy sources, including biomass, wind and solar by 2030.

5.3.7 Energy security

The majority of the energy supplied to Ireland and Northern Ireland is imported. Coal and oil can be supplied direct to ports in Ireland from many suppliers around the world and so there is some resilience

[108] http://www.iea.org/publications/freepublications/publication/ireland_2011.pdf
[109] http://www.seai.ie/Renewables/Bioenergy/Sources/Wood_Energy_and_Supply_Chain/Wood_Chips/
[110] http://www.epagma.eu/_SiteNote/WWW/GetFile.aspx?uri=%2Fdefault%2Fhome%2Fnews-publications%2Fnews%2FFiles%2FMainBloc%2FCountry%20reports%20all%20121010_371eb97a-5d9b-4f29-820c-65e1da1f4114.pdf
[111] http://www.bordnamona.ie/wp-content/uploads/2011/06/Sustainability_Statement_2015.pdf

to geopolitical change. All imported natural gas is currently piped from Scotland. The United Kingdom has substantial gas resources in the North Sea but these are not sufficient to meet UK demand so that the UK imports substantial quantities of gas from Norway (pipeline) and from the Middle East (LNG). The security of supply to Ireland is thus dependent on the availability of gas from the United Kingdom. The development of the Corrib gas field and the Shannon LNG terminal will, when complete, increase the security of gas supply to Ireland.

Peat and wood biomass are mostly produced in Ireland and relatively little is imported. These fuels provide the most secure source of energy but supplies are limited and their use has significant environmental impact.

Policies that result in the replacement of coal with heating oil may be considered to have a relatively neutral effect on energy security because both these fuels can be imported from around the world.

Policies that reduce the demand for fuels, for example those that encourage better insulation of homes or the use of solar or geothermal energy, will increase energy security.

5.4 Fuel costs

SEAI publish data on the delivered energy costs for a range of fuels used for residential space heating. SEAI also provide estimates of typical seasonal efficiencies for various types of space heating appliance[112]. The delivered energy costs and seasonal efficiency estimates have been combined in Table 5-8 provide an estimate of the relative space heating costs for relevant fuel/appliance combinations in Ireland.

Note: *The costs for coal are based on a unit purchase of one tonne of fuel and so may underestimate actual cost to the consumer, who may more typically purchase coal in smaller quantities, for example, 10kg, 20kg or 40 kg bags. Costs do not include purchase and installation costs of the heating appliance or associated equipment.*

Based on these assumptions, the lowest calculated cost heating options shown in Table 5-8 all relate to high efficiency installations using gas, oil and high efficiency closed solid fuel stoves. It is important to note that the ranking is dependent on the efficiency of the appliance which particularly for standard (bituminous or 'smoky') coal is dependent on how clean the appliance is. SEAI[113] recommend that for stoves using bituminous coal, cleaning should be carried out *twice weekly* '*particularly if bituminous (i.e. non smokeless (low smoke)) coal is used. This type of coal produces a lot of slag deposits when burnt. These can stick to the boiler surfaces and reduce efficiency'*

The most expensive heating options all relate to the least efficient heating option, that is, an 'open fire' reflecting the fact that most of the heat (~75%) is lost through the chimney.

Table 5-8 indicates that heating using natural gas in a modern condensing gas boiler is the least cost option. The ease of operation of gas heating and control in addition to its low cost makes it an attractive option where it is available.. Solid fuel stoves generally need manual stoking and although mineral fuels have relatively long refuel intervals, wood log-burning stoves can have very short refuelling intervals (as low as 45 minutes) which is a considerable inconvenience compared to automatic boilers.

Heating using open fires with all fuels results in higher costs than the condensing gas boiler. The decorative effect of open fires is often perceived as attractive to house owners but has significantly more potential for impact on outdoor (and indoor) air quality when in use than other technologies.

The use of bulk wood pellet boilers results in similar running costs to condensing gas boilers but purchase costs tend to be higher.

Conventional oil-fired and LPG-fired boilers are considerably more expensive heating fuels than the most efficient gas, coal, peat and wood burning appliances. Converting from coal, peat or wood heating to oil heating is likely to result in increased heating costs for many home owners. However, the cost of fuel is less marked when upgrading to a modern condensing oil boiler.

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[112] http://www.seai.ie/Publications/Statistics_Publications/Fuel_Cost_Comparison/Domestic-Fuel-Cost-Comparisons.pdf

[113] Efficient Home Heating; your options. SEAI. http://www.seai.ie/Publications/Your_Home_Publications_/Energy_Efficiency/Efficient_Home_Heating_guide.pdf

Table 5-8: SEAI Costs[114] of heating with various technologies in Ireland

Appliance	Fuel	Delivered energy cost		Seasonal Efficiency rating		Useful Energy cost, c/MJ		
		c/MJ	c/kWh	High	Low	High efficiency	Low efficiency	Average
Condensing boiler	Natural gas Band D2	1.87	6.73	97	85	1.9	2.2	2.06
Flueless gas	Natural gas Band D2	1.87	6.73	90	90	2.1	2.1	2.08
Stove/Closed room heater with back boiler	Standard coal	1.47	5.30	85	60	1.7	2.5	2.09
Stove/Closed room heater with back boiler	Premium coal	1.48	5.31	85	60	1.7	2.5	2.10
Stove/Closed room heater with back boiler	Ovoids	1.51	5.44	85	60	1.8	2.5	2.15
Condensing boiler	Kerosene	1.98	7.12	97	85	2.0	2.3	2.18
Stove/Closed room heater with back boiler	Standard anthracite	1.61	5.79	85	65	1.9	2.5	2.18
Condensing boiler	Gas oil	2.04	7.33	97	85	2.1	2.4	2.25
Stove/Closed room heater with back boiler	Grade A anthracite	1.69	6.09	85	65	2.0	2.6	2.30
Stove/Closed room heater no back boiler	Standard anthracite	1.61	5.79	80	60	2.0	2.7	2.35
Biomass boiler	Wood pellets bulk	1.68	6.03	87	60	1.9	2.8	2.36
Stove/Closed room heater no back boiler	Standard coal	1.47	5.30	80	50	1.8	2.9	2.39
Stove/Closed room heater no back boiler	Premium coal	1.48	5.31	80	50	1.8	3.0	2.40
Stove/Closed room heater no back boiler	Ovoids	1.51	5.44	80	50	1.9	3.0	2.46
Stove/Closed room heater no back boiler	Grade A anthracite	1.69	6.09	80	60	2.1	2.8	2.47
Stove/Closed room heater with back boiler	Natural gas Band D2	1.87	6.73	85	60	2.2	3.1	2.66
Stove/Closed room heater no back boiler	Natural gas Band D2	1.87	6.73	75	65	2.5	2.9	2.68
Gas fired boiler	Natural gas Band D2	1.87	6.73	75	65	2.5	2.9	2.68
Stove/Closed room heater with back boiler	Peat briquettes baled	1.91	6.87	85	60	2.2	3.2	2.71
Stove/Closed room heater with back boiler	Lignite nuggets	1.91	6.87	85	60	2.2	3.2	2.71
Electric storage heater	Night rate	2.63	9.45	90	90	2.9	2.9	2.92
Biomass boiler	Wood pellets bagged	2.08	7.48	87	60	2.4	3.5	2.93
Oil fired boiler	Kerosene	1.98	7.12	75	60	2.6	3.3	2.97
Condensing boiler	Bulk LPG	2.76	9.94	97	85	2.8	3.2	3.05
Biomass boiler	Wood pellets briquette	2.18	7.84	87	60	2.5	3.6	3.07
Flueless gas	Bulk LPG	2.76	9.94	90	90	3.1	3.1	3.07
Stove/Closed room heater no back boiler	Lignite nuggets	1.91	6.87	80	50	2.4	3.8	3.10
Oil fired boiler	Gas oil	2.04	7.33	75	55	2.7	3.7	3.21
Open fire with high output back boiler	Standard coal	1.47	5.30	50	35	2.9	4.2	3.58
Open fire with high output back boiler	Premium coal	1.48	5.31	50	35	3.0	4.2	3.58
Open fire with high output back boiler	Standard anthracite	1.61	5.79	50	40	3.2	4.0	3.62
Open fire with high output back boiler	Ovoids	1.51	5.44	50	35	3.0	4.3	3.67
Open fire with high output back boiler	Grade A anthracite	1.69	6.09	50	40	3.4	4.2	3.81
Stove/Closed room heater no back boiler	Peat briquettes baled	1.91	6.87	55	45	3.5	4.2	3.86
Gas fired boiler	Bulk LPG	2.76	9.94	75	65	3.7	4.2	3.96
Open fire with high output back boiler	Peat briquettes baled	1.91	6.87	50	35	3.8	5.5	4.63

[114] SEAI fuel comparison : http://www.seai.ie/Publications/Statistics_Publications/Fuel_Cost_Comparison/Domestic-Fuel-Cost-Comparisons.pdf

Appliance	Fuel	Delivered energy cost		Seasonal Efficiency rating		Useful Energy cost, c/MJ		
		c/MJ	c/kWh	High	Low	High efficiency	Low efficiency	Average
Open fire with high output back boiler	Lignite nuggets	1.91	6.87	50	35	3.8	5.5	4.63
Electric fire	Electricity band DD	5.67	20.40	100	100	5.7	5.7	5.67
Open Fire	Standard anthracite	1.61	5.79	30	25	5.4	6.4	5.90
Open Fire	Standard coal	1.47	5.30	30	20	4.9	7.4	6.13
Open Fire	Premium coal	1.48	5.31	30	20	4.9	7.4	6.15
Open Fire	Grade A anthracite	1.69	6.09	30	25	5.6	6.8	6.20
Open Fire	Ovoids	1.51	5.44	30	20	5.0	7.6	6.30
Open Fire	Natural gas Band D2	1.87	6.73	30	20	6.2	9.3	7.79
Open Fire	Lignite nuggets	1.91	6.87	30	20	6.4	9.5	7.95
Open Fire	Peat briquettes baled	1.91	6.87	30	20	6.4	9.5	7.95

Note: The costs consider only the economic and do not consider the wider external costs, e.g. health costs caused by air pollution. For coal, costs are based on a unit purchase of one tonne of fuel and so may underestimate actual cost to the consumer, who may more typically purchase coal in smaller quantities, for example, 10kg, 20kg or 40 kg bags.

Table 5-9: Carbon tax per tonne of solid fuels in Ireland

Solid Fuel Type	Rate of Tax May 1st 2014
Coal	€ 52.67
Peat briquettes	€ 36.67
Milled peat	€ 17.99
Other peat	€ 27.25

Table 5-10 summarises the price range for fuels determined in this study across a total of 22 retail outlets in Northern Ireland. This in turn represents a mix of rural and urban locations and also a geographical spread (North/South/East/West). Table 5-10 also shows the SEAI reported delivered costs in Ireland. Costs are reported in euros to allow comparison: however the relative costs will change with the exchange rate. The costs for peat and solid fuels are similar between the two countries. Natural gas, heating oil and day rate electricity cost less in Northern Ireland. In consequence, converting to a modern condensing gas or oil boiler is more attractive in Northern Ireland.

Table 5-10: Comparison of fuel prices in Northern Ireland and Ireland

Fuel Type	Unit	Price range (per unit/per weight)	
		Northern Ireland	Ireland
Turf	per bag	€3.74 - 6.01	
Peat briquettes	per bale	€4.06 - 5.61	€4.3
Lignite briquettes	per bale	€4.31 - 7.44	
Standard coal	per tonne	€274.55 - 490.72	€389
Premium coal	per tonne	€406.33 - 447.58	€409
Anthracite	per tonne	€517.60 (only 1 piece of data)	€476
Smokeless (low smoke) ovoids	per tonne	€374.75 - 422.58	€451
Slack	per tonne	€280.19 - 374.75	
Doubles	per tonne	€343.98 - 450.30	
Firelogs/heatlogs	per bag	€2.50 - 5.37	
Wood logs	per bag	€3.74 - 5.31	
Natural gas	kWh	€0.057-0.058[115]	€0.072 Band D2
Heating oil	Litre	€0.63-0.82[116]	€0.97-1.00
Electricity	kWh	€0.15-0.19[117]	€0.18-0.64
Electricity night rate	kWh	€0.11[118]	€0.10

Notes:

1: Prices are expressed in Euros based on exchange rates of 1.25 euro/£

2: prices are inclusive of VAT at 13.5% and 5% in Ireland and Northern Ireland respectively

5.5 Availability of natural gas

Most fuels can be delivered throughout Ireland to residential properties by road. However, natural gas is not available to many households because the gas network does not extend to their houses. Table 5-11 shows the numbers of households using gas for central heating in each of the counties of Ireland and the Local Government Districts in Northern Ireland, based on the 2011 census data. More than 45% of households use natural gas in Cork City, Limerick City, Waterford City, Fingal, South Dublin, Dun Laoghaire-Rathdown, Dublin City and Belfast City. On the other hand, 3% or less of households in Donegal, Kerry, Leitrim, Longford, Mayo, Sligo or Wexford County in Ireland and Armagh, Banbridge and Craigavon, Causeway Coast and Glens, Newry, Mourne and Down, Mid-Ulster and Fermanagh and Omagh. In these districts, the likely use of gas is LPG rather than natural gas. The extension of the Northern Ireland gas network to the west of Northern Ireland has been announced[119] however, extensions to the natural gas network will necessarily be to major centres of population where population density and industry can justify the investment in transmission infrastructure.

[115] http://www.consumercouncil.org.uk/filestore/documents/Gas_Price_Comparison_Table.pdf , 8/8/2014

[116] Based on http://www.consumercouncil.org.uk/energy/home-heating-oil/oil-price-archive/31st-july-2014 8/8/2014

[117] http://www.consumercouncil.org.uk/filestore/documents/Electricity_Price_Comparison_Table.pdf 8/8/2014

[118] http://powerni.co.uk/my-home/products-and-prices/tariff-rates/ standard night rate

[119] Information here :
http://www.detini.gov.uk/deti__equality_impact_assessment_extension_of_the_gas_network_to_the_wes_____2_.pdf?rev=0

Table 5-11: Proportion of households using gas for central heating

County/District	Number of households with gas central heating	Total households	Percentage of households with gas central heating
Carlow County	4573	19365	24%
Cavan County	1801	25720	7%
Clare County	4926	42534	12%
Cork County	36467	140445	26%
Cork City	30735	47110	65%
Donegal County	558	57721	1%
Galway County	2462	60350	4%
Unallocated	3	614	0%
Galway City	4300	27697	16%
Kerry County	943	52922	2%
Kildare County	26786	70504	38%
Kilkenny County	7111	33583	21%
Laois County	6954	27916	25%
Leitrim County	177	12228	1%
Limerick County	8538	47121	18%
Limerick City	11093	22300	50%
Longford County	258	14410	2%
Louth County	17280	43897	39%
Mayo County	683	47778	1%
Meath County	20893	61922	34%
Monaghan County	1101	21176	5%
Offaly County	2056	26543	8%
Roscommon County	872	23601	4%
Sligo County	601	24428	2%
North Tipperary	1029	25611	4%
South Tipperary	5800	32664	18%
Waterford County	1475	24040	6%
Waterford City	11220	18199	62%
Westmeath County	3007	30624	10%
Wexford County	449	52345	1%
Wicklow County	16274	47579	34%
Fingal	65238	92951	70%
South Dublin	65273	89877	73%
Dun Laoghaire-Rathdown	55526	75786	73%
Dublin City	133753	207847	64%
Total Ireland	***550215***	***1649408***	***33%***
Antrim and Newtownabbey	10516	54035	19%
North Down and Ards	15405	64605	24%
Armagh, Banbridge and Craigavon	1897	75506	3%
Mid and East Antrim	7916	54314	15%
Causeway Coast and Glens	1752	53722	3%
Newry, Mourne and Down	1759	61998	3%
Belfast	67731	141567	48%
Lisburn and Castlereagh	10371	52648	20%
Mid Ulster	357	47772	1%
Derry and Strabane	2884	55596	5%
Fermanagh and Omagh	368	41512	1%
Total Northern Ireland	***120956***	***703275***	***17%***

5.6 Barriers to uptake of lower emission fuels

Table 5-12 ranks fuels in terms of emissions (based on the Tier 1 emission factors used for the screening assessment). In general, to reduce emissions then it is necessary to use fuels with a lower emission factor.

Table 5-12 indicates that incremental benefits are possible by changing from high emission fuels such as wood, peat, bituminous coal and lignite to petroleum coke, anthracite or manufactured low emission solid fuels, and these benefits can be delivered without the need for capital investment by the householder. More significant reductions would arise from changing to use of gaseous or liquid fuels but this would require investment on behalf of the householder. Electricity is not included but clearly would have no emissions at the point of use. Non-biomass renewable technologies also provide potential to remove local emissions from replacement or partial substitution of combustion-based heating.

Note that the emission factors in Table 5-12 provide a simple ranking of emission intensity as they do not reflect differences in technology (for example lower emissions from use of solid fuels in modern appliances). In general use of modern automatic solid fuel appliances can be expected to reduce PM_{10} emissions to a level similar to, or below anthracite in Table 5-12. For example, the Renewable Heat Incentive in Great Britain sets a requirement for PM emissions from biomass boilers of 30 g/GJ. Emission criteria for a 6kW output stove for use in a Smoke Control Area is 7 g/hr which is equivalent to an emission factor of about 250 g/GJ (note that the value of the calculated emission limit factor will depend on appliance efficiency). Recently exempted stoves for use in Smoke Control Areas typically have emission levels in the range of approximately 50-200 g/GJ.

Table 5-12: **Indicative emission intensity (factors used for screening assessment)**

Fuel	PM_{10}, g/GJ net	$PM_{2.5}$, g/GJ net	Benzo[a]pyrene, mg/GJ net
Biomass	642	625	106
Peat	494	481	81.3
Coal	392	387	54
Lignite	392	387	54
Petcoke	102	101	1.01
Anthracite & Ovoids	66.5	66	5.6
LPG	3.3	3.3	-
Kerosene	3.2	3.2	0.11
Gasoil	3.2	3.2	0.11
Natural gas	0.5	0.5	-

Availability of lower emission fuels may be a barrier however only natural gas is constrained to a grid supply – other fuels such as wood pellets, LPG, oil are all readily transported but they do require suitable storage at the dwelling.

In practical terms, a solid fuel appliance is not suitable for burning liquid or gaseous fuels so would need replacement with the associated cost of the appliance(s) and installation. Availability of natural gas may be key as the running cost of the other fuel/technology combinations are in many cases less attractive than for solid fuel technologies.

It is possible to use manufactured solid fuels on open fireplaces which use coal or peat although some fuels (for example anthracite) can be difficult to light and petroleum coke if used by itself can destroy grates due to its higher burning temperature and high sulphur content. For closed appliances, it is usually possible to substitute fuels if the appliance is designed to burn different fuel types however the emissions benefits may be limited.

For automatic central heating then gas, oil and modern biomass appliances offer convenience, efficiency and air quality emission benefits when compared to older solid fuel systems and wood log roomheaters with boilers. However, even modern biomass appliances have PM emissions orders of magnitude higher than gas fired appliances.

Table 5-8 indicates that running costs are often higher than a solid fuel roomheater with boiler which would also seem an inconvenient option for central heating in a home.

Purchase and installation costs, appliance size and fuel storage are also factors. A solid fuel roomheater is generally much lower in cost than an automatic boiler.

5.7 Summary

Energy use statistics for Ireland residential sector indicate that solid fossil fuel use fell by 23% between 2000 and 2012 although use of anthracite and ovoids (manufactured fuel) has increased by about 10% in the same period. Oil use increased by 6.5%. Natural gas use increased by 37% although much of that increase occurred before 2005. Electricity use increased by 27%, also with much of the increase before 2005. Renewable energy sources (biomass, solar and geothermal) have made a small but increasing contribution to residential energy requirements. The fuels with the highest particulate matter and benzo[a]pyrene emission factors per unit of energy (coal, peat and wood) provide up to 19% of the residential energy use but are responsible for ~60% of all $PM_{2.5}$ emissions. Oil, electricity and natural gas provide most of the energy.

Energy statistics available for Northern Ireland are less detailed. The UK publishes sub-national consumption of selected energy types including estimates of non-gas, non-electricity and non-road transport energy consumption. It is important to recognise also that some of the sub-national consumption statistics, for example for solid fuel use, are more uncertain than national estimates.

The majority of the energy supplied to Ireland and Northern Ireland is imported. Coal and oil are supplied direct to ports in Ireland from many suppliers around the world and so there is some resilience to geopolitical change. All imported natural gas is currently piped from Scotland. The United Kingdom has substantial gas resources in the North Sea but these are not sufficient to meet UK demand so that the UK now imports substantial quantities of gas.

Relatively little peat and wood are imported and these fuels provide the most secure source of energy but supplies are limited, and harvest and use causes significant environmental damage. Policies that reduce the demand for fuels, for example those that encourage better insulation of homes or the use of solar or geothermal energy, will increase energy security.

Published estimates of the relative space heating costs in Ireland indicate that the lowest cost heating options all relate to high efficiency installations using, gas, oil and high efficiency closed solid fuel stoves. It is important to note that the ranking in Table 5-8 is dependent on the efficiency of the appliance which particularly for standard (bituminous or 'smoky') coal is dependent on how well maintained (clean) the appliance is.

Oil and LPG-fired non-condensing boilers are considerably more expensive heating options than the most efficient gas, coal, peat and wood burning appliances. Converting from coal, peat or wood heating to oil heating is likely to result in increased heating costs for many home owners and this may present a significant barrier to achieving emission reductions from residential heating.

Incremental benefits to air emissions are possible by changing from high emission fuels such as wood, peat, bituminous coal and lignite to petroleum coke, anthracite or manufactured low emission solid fuels, and these benefits can be delivered without the need for capital investment by the householder. More significant reductions would arise from changing to use of gaseous or liquid fuels but this would require capital investment on behalf of the householder. Electricity or non-biomass renewable technologies also provide potential to remove local emissions from replacement or partial substitution of combustion-based heating.

6 Smoke Control Legislation and Enforcement

Box 5: Summary of Section 6

Air quality legislation derived from EU Air Quality Directives is implemented in both Ireland and Northern Ireland (Section 2). In addition, Ireland and Northern Ireland have long-established but different legislative instruments to mitigate public health impacts from use of solid fuels – the smoky coal ban areas in Ireland and measures including powers to create smoke control areas in Northern Ireland. Ireland has progressively extended the smoky coal ban areas and regulations on solid fuel supply.

Local Authorities (LA) are key to implementation of the legislative controls in both jurisdictions. Whilst few Smoke Control Orders have been made in recent years in Northern Ireland, Ireland has extended the coverage of the smoky coal bans and implemented solid fuel labelling requirements.

Supervision in Ireland includes LA inspection plans developed with the Environmental Protection Agency's (EPA) Office of Environmental Enforcement working through the Network for Ireland's Environmental Compliance & Enforcement (NIECE) to improve the overall level of compliance with the Regulations.

The EPA provides Local Authorities with guidance on the development and implementation of LA inspection plans under the European Union Recommendations for minimum criteria for environmental inspections (RMCEI). Enforcement activities are linked to the inspection and enforcement plans of the EPA and LA. The EPA has developed a web portal to allow LA to upload and update their inspection plans.

Enforcement statistics for Ireland indicate increased inspections and enforcement notices by regulatory authorities in the period prior to the updated 2012 Regulations.

Enforcement statistics are not available for Northern Ireland however contact with LA would suggest that current compliance with requirements in designated SCAs is high. Where there are non-compliances these are reportedly individual cases.

In Northern Ireland LAs, smoke control and air quality typically forms part of a suite of duties for those staff within local authorities with responsibility for environmental protection. There are very few, if any, instances where there are dedicated staff available purely for air quality regulatory functions.

6.1 Ireland

6.1.1 Air Pollution Act 1987 (as amended)

The primary legislation in Ireland for the prevention and control of air pollution is the Air Pollution Act, 1987 (No. 6 of 1987[120]). This act provides a statutory framework for the control of air quality and has not been amended significantly since its introduction.

In accordance with the Air Pollution Act 1987 (as amended), Local Authorities (LAs) may take whatever measures they consider necessary to prevent or limit air pollution in their area and the operators of certain industrial plants, specified in the Act, must obtain an air pollution licence from the relevant Local Authority.

The Local Authority plays an integral role in preventing and combating air pollution. This includes:

- dealing with complaints with regard to air pollution;
- enforcing the ban on the marketing, distribution, sale and burning of specified fuel (bituminous coal) in specified (ban) areas;
- organising and conducting research into the causes, extent and prevention of air pollution;
- assessing compliance with the relevant legislation; licensing certain categories of industry; establishing and running educational programmes about air pollution and its prevention;
- monitoring of emissions or the ambient air within their functional area;

The current legislative controls on coal in Ireland are implemented through regulations made under the 1987 Act.

6.1.2 Marketing, Sale, distribution and burning of specified fuels regulations

6.1.2.1 Development and extent of smoky coal ban areas

In the 1980s, the greater Dublin area was frequently subjected to episodes of smog, largely attributed to the burning of solid fuels (mainly bituminous coal) in domestic fireplaces. One major contributory factor was Government policy in response to the fuel crises of 1970 which in the 1980s required new houses to be fitted with open fires and provided incentives to existing households to convert from oil fired heating to systems burning solid fuels[121]. This led to an increase in the quantity of solid fuel (mainly bituminous coal) utilised for domestic heating, which in turn gave rise to repeated incidences of extremely high concentrations of black smoke during the winter months.

[120] Available online at http://www.irishstatutebook.ie/1987/en/act/pub/0006/print.html
[121] Dublin Regional Air Quality Management Plan. 2009-2012 (page 16) available online at http://www.dublincity.ie/WaterWasteEnvironment/AirQualityMonitoringandNoiseControl/Documents/Dublin_Regional_Air_Quality_Management__Plan_2009_2012.pdf

Figure 6-1: Smoky Chimney, Ireland, Bray (Zone C), 2012

Photo with kind permission of Des Cannon.

In early 1982, the daily concentration of black smoke exceeded 1,700 µg m^{-3}, which was almost seven times higher than the contemporary EEC limit (250µg m^{-3} over three days).

The consumption of bituminous coal had been identified as the key cause of severe air pollution problems in urban areas, resulting in high winter mortality rates[122]. To address the air pollution challenges and to bring Ireland into compliance with EU air quality standards, the Air Pollution (Marketing, Sale and Distribution of Fuel) Regulations (S.1. No. 123 of 1990[123]) were introduced in Dublin in September 1990. These regulations (often referred to as the smoky coal ban) prohibited the marketing sale and distribution of bituminous or smoky coal.

Subsequent regulations limited the sulphur content of all solid fuel for sale in the Dublin area to 2%[124]. The smoky coal ban led to an immediate, dramatic, and sustained reduction in smoke levels. These levels subsequently reduced pollutant levels from being close to or exceeding legal limit values to a point that was almost one tenth of the contemporary EEC limit (250µg m^{-3} over three days).

The Ireland regulatory provisions prohibit the burning of specified fuels[125] within specified areas[126]. The fuel characteristics and specified areas are defined in S.I. No. 326/2012 - Air Pollution Act (Marketing, Sale, Distribution and Burning of Specified Fuels) Regulations 2012.

The ban is now in force in 27 cities and towns, and has resulted in a reduction in levels of sulphur dioxide and smoke in these areas. Furthermore, the monitoring of PM indicates lower concentrations in regions where the ban has been enforced.

A Voluntary Agreement between the Solid Fuel Trade Group (SFTG) and the Minister for the Environment, Community and Local Government, signed in 2002, required that coal imported by SFTG members would have a sulphur content of equal to or less than 0.7%. The main provision of this voluntary agreement was placed on a statutory footing in 2011, when the Air Pollution Act, 1987 (Marketing, Sale and Distribution of Fuels) (Amendment) Regulations 2011 (S.I. No. 270 of 2011) were

[122] Environment, Community and Local Government (2012) Delivering Cleaner Air: Smoky Coal Ban Regulations – Review and Public Consultation [online]. Available from: http://www.environ.ie/en/Publications/Environment/Atmosphere/FileDownLoad,29914,en.pdf [Accessed 12 March 2014].

[123] http://www.irishstatutebook.ie/1990/en/si/0123.html

[124] The sulphur limit was originally set at 1.5% in the 1990 Regulations (Regulation 3 of S.I. No. 123 of 1990) though revised in 1992 (S.I. No. 274/1992) to 2% to allow the inclusion of petcoke in blends.

[125] Specified Fuel means-
(a) any bituminous coal,
(b) any admixture of solid fuel containing bituminous coal,
(c) any manufactured fuel containing bituminous coal where such manufactured fuel contains more than 14% volatile matter by weight on a dry ash-free basis save where such fuel has a smoke emission rate of not more than 10 grams per hour, or
(d) any solid fuel having a sulphur content greater than 2% by weight on a dry ash-free basis.

[126] "Specified Area" means an area listed under Schedule 1 or Schedule 2 of S.I. No. 326 of 2012, Air Pollution Act (Marketing, Sale, Distribution and Burning of Specified Fuels) Regulations 2012 available online at http://www.irishstatutebook.ie/2012/en/si/0326.html

introduced by the Minister, following the introduction of the carbon tax, in order to consolidate and safeguard the improvements to air quality brought about by the agreement. The Regulations were consolidated in 2012 (S.I. No. 326 of 2012). The Regulations require that bituminous coal placed on the market for residential use does not have a sulphur content greater than 0.7%. All coal bagging operators supplying bituminous coal to the residential market are required to demonstrate product compliance in an annual audit and to be registered with the EPA. Certain solid fuel suppliers are also required to be registered with the EPA namely wholesalers, distributors and persons for whom more than 50% of their annual turnover is in bituminous coal. Retailers trading in bituminous coal are required to hold a record showing the EPA registration number of the company that supplied their product.

6.1.2.2 2012 review and amendments

In 2012 the Department of the Environment, Community and Local Government (DECLG) released a report[127] detailing the outcome of a review of the 'smoky' coal ban regulations. The assessment aimed to determine the suitability of the ban in limiting the impacts on air quality arising from the use of residential fuels, in the context of any changes that occurred in the 20 years following the introduction of the regulations.

The review noted that despite the success of the ban in larger cities, the regulations had been less effective in smaller towns, as residents could easily purchase bituminous coal outside of the ban area, with suppliers often being established close to the border. Furthermore the review considered the impact the economic downturn has had on the consumption of solid fuels, with the first significant increase in 'smoky' coal use following the introduction of the ban reported by Dublin City Council in 2012.

Several changes were introduced following the review, including the extension of the ban to all towns with greater than 15,000 residents - so as to align with the national EPA zones for air quality management under the CAFÉ directive - and the inclusion of a prohibition on the burning or use of bituminous or smoky coal to complement the ban on sale. The realigned ban areas provide for coverage of the whole urban area as well as a 'buffer' zone so as not to facilitate the sale for coal in the immediate environs of the ban areas.

Levels of air pollutants, including PM_{10} and PAH, continue to be of concern outside ban areas due to the use of solid fuels during the winter heating season.

Table 6-1: Urban Areas where Smoky Coal Ban Applies

Urban Area	Year Smoky Coal Ban Introduced
Dublin	1990
Cork	1995
Arklow, Drogheda, Dundalk, Limerick and Wexford	1998
Waterford, Celbridge, Leixlip, Galway and Naas	2000
Bray, Kilkenny, Sligo and Tralee	2003
Athlone, Carlow, Clonmel and Ennis.	2011
Greystones, Letterkenny, Mullingar, Navan, Newbridge, Portlaoise and Wicklow Town[128]	2013

[127] Delivering Cleaner Air, consultation document on review of the 'smoky' coal regulations, available here http://www.environ.ie/en/Environment/Atmosphere/AirQuality/SmokyCoalBan/

[128] Wicklow has a population less than 15,000 (approx. 13,500 incl. Rathnew) but was added on the basis of representations received from local political representatives and the local authority.

6.1.3 Solid Fuel Regulations

6.1.3.1 Overview of solid fuel regulations

The SFR (S.I. No. 326 of 2012[129]) consolidate and update the existing provisions of the *Air Pollution Act (Marketing, Sale and Distribution of Fuels) Regulations 1998-2011* into a single piece of legislation, replacing and revoking the pre-existing regulations.

The main legislative provisions of the SFR are:

- a ban on marketing, sale and distribution inside specified areas of specified fuel :

  (a) any bituminous coal,

  (b) any admixture of solid fuel containing bituminous coal,

  (c) any manufactured fuel containing bituminous coal where such manufactured fuel contains more than 14% volatile matter by weight on a dry ash-free basis save where such fuel has a smoke emission rate of not more than 10 grams per hour, or

  (d) any solid fuel having a sulphur content greater than 2% by weight on a dry ash-free basis.
- a ban on the residential burning or use of specified fuel inside specified areas
- the requirement to sell smokeless (low smoke) coal in sealed bags with a printed notice
- restrictions on storage and transport of specified fuel inside specified areas
- restriction on sulphur content of solid fuel inside a specified area (<2% by weight) and for bituminous coal outside specified areas (<0.7% by weight)

The SFR require that bags of solid fuel sold in specified areas where the ban applies must be sealed and have a printed notice in accordance with Schedule 3 of the SFR. The SFR require that all bituminous (smoky) coal supplied for residential heating outside specified areas must have sulphur content not greater than 0.7% by weight and, if sold in a bag, then the bag must be sealed.

The SFR introduced for the first time in 2012 a ban on the burning of specified fuels in private dwellings within specified areas to complement the existing ban on the marketing, sale and distribution.

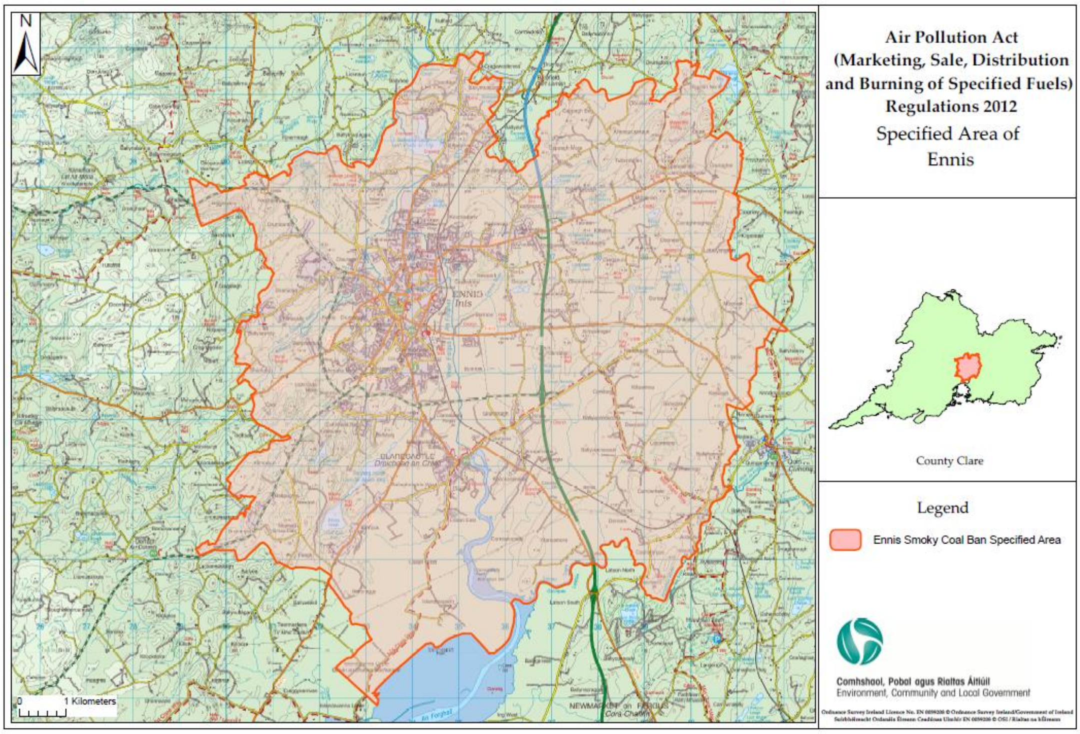
Since the 1st May 2013 the ban on the marketing, sale, distribution and burning of specified bituminous fuels applies in specified areas of Greystones, Letterkenny, Mullingar, Navan, Newbridge, Portlaoise and Wicklow-Rathnew.

The SFR make revisions to many long established boundaries that rationalise existing specified areas to account for residential development outside the original ban area boundaries. The realigned ban areas provide for coverage of the whole urban area as well as a 'buffer' zone so as not to facilitate the sale of coal in the immediate environs of the ban areas. The approach in Northern Ireland (see 6.2) is to prohibit smoke emissions in Smoke Control Areas (SCAs) and this is regulated through a wide range of pre-authorised fuels and appliances. In contrast, the focus of the SFR is on bituminous fuels so that other solid fuels like peat briquettes or biomass (logs, wood chip etc) are not affected.

Specified areas where the ban on the Marketing, Sale, Distribution and Burning of Specified Fuels are defined in Schedule 1 and Schedule 2 of the SFR. Detailed mapping[130] of the specified areas are available on the DoECLG website[131]. An example of the ban area of Ennis introduced in 2011 is shown in Figure 6-2.

[129] http://www.environ.ie/en/Legislation/Environment/Atmosphere/FileDownLoad,31033,en.pdf
[130] Available in Adobe pdf and ESRI shapefile
[131] Details of ban areas are provided here http://www.environ.ie/en/Environment/Atmosphere/AirQuality/SmokyCoalBan/#maps

Figure 6-2 : Ennis Smoky Coal Ban Area.



6.1.4 Enforcement of Solid Fuel Regulations

The SFR are enforced by the LA within its functional area. LA implement the SFR by raising awareness of regulatory requirements, undertaking inspections of solid fuel suppliers/households and prosecuting offenders as appropriate. Inspections must be carried out by an authorised officer. A LA may initiate legal proceedings under Section 13 of the Air Pollution Act 1987 (as amended). LA also enforce the Environmental Protection Agency Act (Registration of Coal Baggers and Solid Fuel Suppliers) Regulations 2012) (S.I. No. 454 of 2012)[132]. The Environment (Miscellaneous Provisions) Act 2011 introduced fixed payment notices (FPN) (or 'on the spot fines') for certain offences relating to the supply and sale of solid fuel. Revised FPN offence provisions have been drafted to reflect the consolidated Regulations. The Environment (Miscellaneous Provisions) Bill 2014 was published in September and, once enacted, will give effect to the revised FPN offence provisions. The specific offence, reference to the regulation breached and value of associated FPN is shown in Appendix 2.

Irish LAs use a number of approaches to implement the SFR which are shown in Table 6-2.

[132]Available online at http://www.irishstatutebook.ie/pdf/2012/en.si.2012.0454.pdf

Table 6-2: Local Authority Enforcement Approaches

Action	Description
Communication & Awareness	Effective communication and awareness of the requirements of the SFR is the first step in a LA enforcement strategy. The aim of this step is to ensure that suppliers of solid fuel and householders are aware of the requirements of the regulations, how to comply and penalties for non-compliances.
Pre-Inspection Awareness Visit	This step may be appropriate for a newly established supplier of solid fuel or a supplier located in areas where the SFR recently came into force. The aim of this step is to provide the supplier with information on the SFR and compliance requirements. In carrying out this step, the authorised officer has made the decision not to carry out a formal inspection but rather to communicate the requirements of the SFR to the retailer.
Announced Inspection	This is a formal inspection carried out by an authorised officer where advanced notice is given to the premises. Where non-compliances are detected, the authorised officer collects evidence; a fixed payment notice may be issued.
Unannounced Inspection	This is a formal inspection carried out by an authorised officer where no advanced notice is given to the premises. Where non-compliances are detected, the authorised officer collects evidence; a fixed payment notice may be issued.
Mystery Shopper	Mystery shopping is an enforcement approach used to establish compliance with the SFR. The mystery shopper's identity and purpose is not known by the establishment being evaluated. Mystery shoppers perform specific tasks such as purchasing a product and asking questions. Where non-compliances are detected, the authorised officer collects evidence; a fixed payment notice may be issued.
Internet Surveillance	This approach is applicable to online suppliers and involves enforcement officers undertaking periodic online surveillance targeting discussion forums, buy and sell sites, etc.
Covert Inspection	Covert inspections or "covert surveillance" is carried out by authorised officers when it is beneficial not to disclose their identity. Examples include authorised officers visiting a premises and attempting to purchase smoky coal for use in an area covered by the ban (mystery shopper), ordering smoky coal from a mobile supplier in order to establish if smoky coal is being supplied in an area covered by the ban, surveillance of mobile suppliers etc.
Overt Inspection	Overt inspections include visiting retailer premises and vehicle checkpoints. During overt inspections, enforcement staff are clearly visible through the use of marked vehicles, branded visible clothing etc. Examples of overt actions include: inspections at retail premises, vehicle checkpoints including multi agency enforcement actions.
Follow-up Inspection	A follow-up inspection is carried out by an authorised officer in order to ensure that non-compliances have been addressed and rectified.
Leaflet Drop to Residential Area	This step is targeted at householders in areas where the smoky coal ban applies and where it is suspected that some householders may be burning smoky coal. It aims to raise awareness in a specific area.
Letter to Householder	When a specific householder is suspected of being in breach of the SFR a letter explaining the regulations is sent to the householder. The aim of this letter is to make the householder aware that the LA is actively enforcing the SFR and that non-compliances are liable to prosecution.

The EPA's Office of Environmental Enforcement (OEE) has been working with LA, through the Network for Ireland's Environmental Compliance & Enforcement (NIECE) to improve the overall level of compliance with the Regulations. The EPA collates data on the enforcement activities[133] of LA under the SFR. The number of inspections carried out and warning letters issued by LA from 2009 to 2012 are shown in Table 6-3.

Table 6-3: Local Authority SFR Enforcement Statistics 2009 to 2012

Enforcement of the Smoky Coal Regulations	2009	2010	2011	2012
Total number of inspections	275	381	688	567
Warning letters under smoky coal regulations	14	5	56	331

The EPA provides Local Authorities with guidance on the development and implementation of LA inspection plans under Recommendations for minimum criteria for environmental inspections (RMCEI). Enforcement activities are linked to the inspection and enforcement plans of the EPA and LA. The EPA, through the NIECE, has guided the development and implementation of LA inspection plans under RMCEI. The EPA has developed a web portal (https://www.niece.ie/) to allow LA to upload and update their inspection plans.

SWiFT 7[134] is a fuel certification scheme devised by NSAI in collaboration with a range of regulatory and industry stakeholders that supports the regulatory requirements which are set out under Regulation 7 of the SFR. It provides a methodology whereby coal, which is compliant with the requirements of the regulations, can be verified as having suitable provenance and identified to the regulatory authorities as meeting legislative requirements.

Bituminous coal product must be certified as compliant with the SFR by annual audit. Companies marketing certified fuels should use the logo (Figure 6-3), which is a mark of quality to give the consumer confidence that smoky coal purchased and burned meets minimum environmental quality standards. SWiFT 7 was revised in 2015 to extend its scope to include low smoke solid fuels and biomass blended fuels. Suppliers of coal are required to register with the EPA, and the EPA registration number is contained within the SWiFT logo.

Figure 6-3: Logo Identifying Compliance with SWiFT 7

During 2012 the EPA carried out random testing to verify the sulphur content of bituminous coal.

[133] Dr. Ian Marnane, Environmental Protection Agency, Personal communication, 13 September 2013

[134] SWiFT 7:2015. *Verification of environmental parameters for certain solid fuels supplied to the residential market in Ireland*. NSAI, Glasnevin, Dublin.

6.2 Northern Ireland

6.2.1 Clean Air (Northern Ireland) Order 1981

Clean Air legislation was first introduced in Northern Ireland under the Clean Air Act (Northern Ireland) 1964 to deal with smog and the high levels of smoke in towns and cities. The legislation was subsequently repealed and updated by the Clean Air (Northern Ireland) Order 1981. Under this legislation, district councils may, by Order, declare all or part of their district a smoke control area. The effect of a Smoke Control Order is to limit the emission of smoke from chimneys in the area and, when initially enacted provide support to enable change to less polluting technologies. Details of SCA are held by Local Authorities although summary notices are also published in the (Belfast) Gazette.

In smoke control areas, residents are required to use "authorised" smokeless (low smoke) fuels or install an "exempted fireplace[135]". Northern Ireland has declared over 120 smoke control areas since 1966 across 16 councils.

The following are local authorities that contain Smoke Control Areas:

- Newry Mourne and Down District Council
- Armagh Banbridge and Craigavon District Council
- Lisburn and Castlereagh City Council
- Ards and North Down Borough Council
- Belfast City Council
- Antrim and Newtownabbey Borough Council
- Mid and East Antrim Borough Council
- Causeway Coast and Glens Borough Council
- Derry City and Strabane District Council

In SCAs residents must only use 'exempted' fireplaces, which have been tested to ensure they do not emit a substantial quantity of smoke using specified fuels, or they may use 'authorised' smokeless (low smoke) fuels. A list of the permitted fireplaces and fuels are provided in legislative instruments – currently the 'Smoke Control Areas (Exempted Fireplaces) (No. 2) Regulations (Northern Ireland) 2013' and 'Smoke Control Areas (Authorised Fuels) Regulations (Northern Ireland) 2013', respectively.

Authorised fuels include the following general fuel types :

- anthracite;
- semi-anthracite;
- gas;
- low volatile steam coals;

Note that bituminous coal, wood and peat are not Authorised fuels so cannot be used in an SCA unless in an Exempted appliance. Oil is not an Authorised fuel but appliances designed to burn liquid fuels are Exempted appliances.

In addition to the 'generic' fuel types, specific fuel products can be Authorised. These are manufactured fuels assessed by testing to BS3841 on a 'standard' open fireplace for particulate emission over a series of burn cycles. The required emission limit is <5 g/h smoke and there is also a limit on sulphur content (maximum sulphur content is 2% on a dry basis although a manufacturer can declare a lower sulphur content as part of their quality plan).

Residential appliances are assessed against particulate emission criteria detailed in Table 6-4. These are based on limits defined in BS PD 6434:1969 and also provided on the Clean Air Act website[136]. There are different emission limits applied for larger appliances.

[135] Smoke Control Areas (Exempted Fireplaces) Regulations (Northern Ireland) 2013 available online at http://www.legislation.gov.uk/nisr/2013/198/pdfs/nisr_20130198_en.pdf
[136] Availalble here : http://smokecontrol.defra.gov.uk/ and here http://www.doeni.gov.uk/index/protect_the_environment/local_environmental_issues/air_and_environmental_quality/smoke_control.htm

Table 6-4: Particulate emission limits for Exempted appliances <45 kW output

Output, kW	x	3	6	9	12	30	45
Emission limit, g/h	5+(x/3)	6	7	8	9	15	20

Assessment of fuels and appliances is currently undertaken by Ricardo-AEA on behalf of Defra and the Devolved Administrations. Recommendations are made to Defra and the Devolved Administrations to include in updated legislation which provides the Authorisation or Exemption.

The majority of Smoke Control Areas (SCAs) within Northern Ireland were declared relatively soon after the introduction of the primary legislation. The fact that the intervention was coupled with grant aid assistance to help homeowners install an exempted appliance in instances where properties did not currently have the same, coupled with an active communication and education programme at that time, and subsequent follow on enforcement where necessary assisted in ensuring high levels of compliance and the removal of non-Authorised fuels from use within the designated SCAs

The level of detail within currently available digitised data does not however provide full details of the geographical spread of SCAs across Northern Ireland. Nor does it provide detail with regards to the nature of the SCAs currently declared[137], for example conditions on permitted fuels and any relaxations for specific premises.

6.2.2 The Sulphur Content of Solid Fuel Regulations (Northern Ireland) 1998

The regulations prohibit retail sale or delivery of solid fuel with a sulphur content of more than 2% on a dry basis for any solid fuel.

6.2.3 Current Compliance levels and resourcing within SCAs

Discussions with relevant staff within local authorities suggests that current compliance with requirements in designated SCAs is considered high. Where there are non-compliances these are generally individual cases.

In terms of current resource levels, air quality typically forms part of a suite of duties for those staff within local authorities with responsibility for environmental protection. There are very few, if any, instances where there are dedicated staff available purely for Smoke Control or indeed air quality regulatory functions.

A survey of local authorities has been conducted in order to provide further data regarding current compliance levels as well as current capacity. The data is currently being analysed and will provide further insight once available.

6.2.4 Current priorities

Discussions with local authority staff responsible for air quality within local authorities in Northern Ireland suggests that they take the view that air pollution as a result specifically from coal burning has largely been addressed, primarily through the interventions introduced through clean air legislation in the 1980s. This would also appear to be borne out by an analysis of the air quality management areas declared within Northern Ireland as discussed in Section 2. Although a number of air quality management areas in Northern Ireland have beem declared for residential emissions, the main focus has been transport emissions. Current concerns and priorities are focused around specific pollutants – particularly fine particles ($PM_{2.5}$) and PAH's - and actions needed for compliance with EU Directives. It is acknowledged that residential solid fuel use (including coal, peat, wood and manufactured smokeless (low smoke) fuels) contributes to the levels of all of these pollutants.

6.3 Summary

Air quality legislation derived from EU Air Quality Directives is implemented in both Ireland and Northern Ireland (see Section 2). In addition, Ireland and Northern Ireland have long-established but different

[137] The provisions within the legislation and associated guidance allow flexibility in the use of SCAs. in terms of their scope and application.

legislative instruments to mitigate public health impacts from use of solid fuels – the smoky coal ban areas in Ireland and measures including powers to create smoke control areas in Northern Ireland. Ireland has progressively extended the smoky coal ban areas and regulations on solid fuel supply.

Local Authorities (LA) are key to implementation of the legislative controls in both jurisdictions. Whilst few Smoke Control Orders have been made in recent years in Northern Ireland, Ireland has extended the coverage of the smoky coal bans and implemented solid fuel labelling requirements.

Supervision in Ireland includes LA inspection plans developed with the Environmental Protection Agency's (EPA) Office of Environmental Enforcement working through the Network for Ireland's Environmental Compliance & Enforcement (NIECE) to improve the overall level of compliance with the Regulations.

The EPA provides Local Authorities with guidance on the development and implementation of LA inspection plans under the European Union Recommendations for minimum criteria for environmental inspections (RMCEI). Enforcement activities are linked to the inspection and enforcement plans of the EPA and LA. The EPA has developed a web portal to allow LA to upload and update their inspection plans

Enforcement statistics for Ireland indicate increased inspections and enforcement notices by regulatory authorities in the period prior to the updated 2012 Regulations.

Enforcement statistics are not available for Northern Ireland however contact with LA would suggest that current compliance with requirements in designated SCAs is high. Where there are non-compliances these are reportedly individual cases.

In Northern Ireland LAs, smoke control and air quality typically forms part of a suite of duties for those staff within local authorities with responsibility for environmental protection. There are very few, if any, instances where there are dedicated staff available purely for air quality regulatory functions.

7 Climate change tensions and synergies

Box 6: Summary of Section 7

Natural gas has the lowest emission factor for both carbon and the key air quality pollutants so changing heating fuels from liquid or solid fuels to natural gas reduces emissions of both carbon dioxide and particulate matter.

Gas oil and kerosene also have lower emission factors for both emissions than solid fuels. Consequently, a change from solid fuel to liquid fuels can also reduce emissions of particulate matter and greenhouse gases.

Solid biomass is considered to be ‘carbon neutral’. This means that the CO_2 emissions from the combustion of biomass are assumed not to result in any net increase in CO_2 to the atmosphere, though biomass does result high emissions of black carbon, which is a short lived climate pollutant. From an air quality perspective, biomass can result in high emissions to the atmosphere. Biomass heating is a well-established technology which can be readily applied and because it is considered carbon neutral, it is consequently very attractive for climate policy developers. Consequently, converting from fossil fuels to solid biomass can be considered to have a positive effect on climate change: however, the emission of particulate matter will potentially contribute to a deterioration in local air quality.

The emissions of particulate matter from biomass combustion depend substantially on the design and operation of the combustion appliance. Modern biomass pellet boilers, for example, have substantially lower particulate matter emission factors than older models and so the impact on air quality can be reduced, though the resultant PM emissions would still be orders of magnitude higher than for a gas fired boiler.

Biomass stoves are increasingly marketed as ‘green’ technology due to the low carbon emission but can have substantial PM emissions. Use of a modern wood log stove to replace an open fireplace burning coal or other solid fuels is likely to be beneficial for air quality emissions but is unlikely to be the least-polluting option. Widespread use of wood log stoves to replace or partially-substitute appliances using cleaner fuels could have a negative impact on air quality.

Some forms of renewable energy such as solar thermal or geothermal emit neither carbon dioxide nor particulate matter. Adapting households to these forms of heating would therefore reduce emissions of both carbon dioxide and air pollutants. Prioritising replacement of solid fuel use in areas of poorer air quality due to residential fuel emissions may provide more effective reductions.

Electric heating does not produce carbon dioxide or particulate emissions at the point of use, and not at all where the electricity is generated by non-combustion means (wind, solar). Consequently, converting residential heating from solid fuel heating to electric will reduce emissions and can have a beneficial effect on local air quality but may not necessarily reduce national carbon dioxide or air pollutant emissions such as NOx unless it is generated without fossil fuel combustion.

Electric-powered heat pumps typically have Seasonal Performance Factors of around 3 when they are used in conjunction with low temperature systems such as underfloor heating. Seasonal Performance Factor is defined as the ratio of heat output from the heat pump and the electricity supplied to the heat pump over the heating season. Conversion to heat pumps may be beneficial in terms of both local air quality and climate change, particularly if the electricity is generated without fossil fuel combustion.

Measures to reduce heat losses from homes such as insulation and draught-proofing reduce fuel use so that these measures reduce emissions of both carbon dioxide and air quality pollutants.

7.1 Air Pollution and Climate Tensions and Synergies.

Ireland and the United Kingdom continue to develop measures to reduce greenhouse gas emissions in order to meet their international obligations relating to climate change. Reducing emissions of greenhouse gases from residential combustion can make a significant contribution to the required reduction but it is important that this is done in a way that is consistent with obligations and policy objectives to reduce air pollution.

Both the UK and Ireland are members of the Climate and Clean Air Coalition (CCAC[138]) which seeks to bring coherence between clean air and climate policy, by highlighting the health benefits of reducing certain air pollutants, in addition to the benefits to climate policy. It aims to do this by raising awareness of the health and climate impacts, promote best mitigation practice and support the development of specific new national and regional actions, particularly in developing countries where the most significant impacts occur.

The air pollutants are known as short-lived climate pollutants (SLCPs), and include black carbon (soot) and ozone. Black carbon is very fine particulate matter with significant health impacts which is a constituent of residential solid fuel emissions. While the main focus of the CCAC is on developing countries, national measures taken to reduce SLCPs reduce public health impacts and climate impacts.

Table 7-1 shows the carbon dioxide (ktonnes carbon dioxide) and/or total greenhouse gas emissions (ktonnes carbon dioxide equivalent) from fuel combustion in 2011 in Ireland[139] and Northern Ireland[140]. Carbon dioxide makes up almost all of the total greenhouse gas emissions from fuel combustion. Residential combustion contributed 18% of carbon dioxide emissions from fuel combustion in Ireland and 22% of greenhouse gas emissions from fuel combustion in Northern Ireland. Solid fuel contributed 31% of residential combustion emissions in Ireland while providing 17 % of delivered energy.

Table 7-1: Greenhouse gas emissions, 2011

	Ireland		Northern Ireland
	ktonne CO_2	ktonne CO_2 eq	ktonne CO_2 eq
Total energy	36,371	36,939	13,696
Energy industries	11,798	11,941	3,737
Manufacturing and construction	4,175	4,196	1,909
Transport	11,162	11,290	4,048
Other (including residential)	9,235	9,482	4,002
Residential	6,432	n/a	3,016
Residential liquid fuel	3,106	n/a	n/a
Residential solidfuel	1,966	n/a	n/a
Residential gaseous fuel	1,359	n/a	n/a
Residential biomass fuel	116	n/a	n/a

Table 7-2 shows the emission factors for a range of residential fuels for carbon emissions and $PM_{2.5}$ emissions in the Ireland Greenhouse Gas Inventory and Air Pollutant Inventory respectively.

[138] http://www.ccacoalition.org/
[139] http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/8108.php
[140] http://naei.defra.gov.uk/reports/reports?report_id=799

Table 7-2: Emission factors of carbon and $PM_{2.5}$ used in Ireland inventories

Fuel	Carbon emission factor, tonnes C/TJ net	PM_{10} emission factor, kg/TJ net	$PM_{2.5}$ emission factor, kg/TJ net	Benzo[a]pyrene emission factor, kg/TJ net
Gas oil	19.99	5	5	0.109
Kerosene	19.47	5	5	0.109
Anthracite	26.80	60	30	48.1
Bituminous coal	25.00	60	30	55.7
Lignite	27.60	60	30	52
Peat	29.86	120	60	55.7
Peat briquettes	26.96	120	60	55.7
Sod peat	28.36	120	60	55.7
Natural gas	15.55	0.2	0.2	0.001
Solid biomass	30.00	285	270	86.7

Natural gas has the lowest emission factor for both carbon and the key air quality pollutants so changing heating fuels from liquid or solid fuels to natural gas reduces emissions of both greenhouse gases and particulate matter.

Gas oil and kerosene also have lower emission factors for both emissions than solid fuels. Consequently, a change from solid fuel to liquid fuels will also reduce emissions of particulate matter and greenhouse gases.

Solid biomass has the highest emissions of both carbon dioxide, PM and Benzo[a]pyrene. However, solid biomass is considered to be carbon neutral, the CO_2 emissions do not count towards the country total reported to the Intergovernmental Panel on Climate Change (IPCC). Consequently, converting from fossil fuels to solid biomass can be considered to have a positive effect on climate change: however, the high emissions of particulate matter will potentially contribute to a deterioration in local air quality. Biomass heating is a well-established technology which can be readily applied and because it is considered carbon neutral it is very attractive for climate policy developers. However, section 9 describes impacts on air quality in Italy of a rapid change to biomass.

The emissions of particulate matter from biomass combustion depend substantially on the design and operation of the combustion appliance. Modern biomass pellet boilers, for example, have substantially lower particulate matter emission factors and so the impact on air quality can be ameliorated. In the Renewable Heat Incentive (RHI) scheme for England, Scotland and Wales, PM and NOx emission criteria (30 g/GJ for PM) are applied for biomass boilers in recognition of the potential impact on incentivised growth in biomass use. The emission criteria were selected to ensure availability of compliant boilers and control potential air quality impacts. Similarly, emission criteria are under consideration in the phase II review of the Northern Ireland RHI scheme for non-domestic heating. The Northern Ireland RHI for domestic heating includes provision for inclusion of emission certificates from April 2016.

In Ireland a national Bioenergy Plan was agreed by Government in 2014. The Plan proposes to introduce an Exchequer-funded RHI in 2016 subject to State Aid approval from the European Commission and further Government approval for the scheme. The scheme will be aimed at larger commercial and industrial installations outside of the Emissions Trading System to adopt renewable heating solutions.

Biomass stoves are increasingly marketed as 'green' technology due to the low carbon emission. Use of a modern wood log stove to replace an open fireplace burning coal or other solid fuels is likely to be beneficial for air quality emissions but is unlikely to be the least-polluting option. Widespread use of wood log stoves to replace or partially-substitute appliances using cleaner fuels could have a negative impact on air quality.

Some forms of renewable energy such as solar thermal or geothermal emit neither carbon dioxide nor particulate matter. Adapting households to these forms of heating would therefore reduce emissions of both carbon dioxide and air pollutants. Prioritising replacement of solid fuel use in areas of poorer air quality due to residential fuel emissions may provide more effective reductions.

Electric heating does not produce carbon dioxide or particulate emissions directly. However, both these substances are emitted from fossil fuel power stations. However, such power stations are regulated and particulate matter emissions from regulated facilities are tightly controlled and so contribute little to air pollution. However, the carbon dioxide emitted contributes to national totals. Typically electricity generated from coal contributes 69 tonnes carbon per TJ: gas-fired power stations contribute around 29 tonnes carbon per TJ delivered. Consequently, converting residential heating to electric can have a beneficial effect on local air quality but may not necessarily reduce national carbon dioxide emissions unless it is generated without fossil fuel combustion (e.g. wind turbines or hydroelectric power).

Electric-powered heat pumps typically have Seasonal Performance Factors of around 3 when they are used in conjunction with low temperature systems such as underfloor heating. Seasonal Performance Factor is defined as the ratio of heat output from the heat pump and the electricity supplied to the heat pump over the heating season. Conversion to heat pumps may be beneficial in terms of both local air quality and climate change, particularly if the electricity is generated without fossil fuel combustion.

Measures to reduce heat losses from homes such as insulation and draught-proofing reduce fuel use so that these measures reduce emissions of both carbon dioxide and air quality pollutants.

8 Fuel poverty[141], Residential Heating, and Air Pollution

Box 7: Summary of Section 8

The pathways by which fuel poverty affects health are complex and range from direct effects like thermal stress on the body from colder indoor temperatures, or poor air quality from poor quality fuels, to indirect effects where those experiencing fuel poverty cut back on spending across other areas such as food, clothing or transport which contributes to social exclusion. Fuel poverty arises from a wide range of complex and inter-related factors including the level of energy demand or need; the available income; and the price of fuel. None of these factors is uniquely or exclusively responsible for fuel poverty. Price sensitive households may assume that the lowest price option is the best, regardless of energy content or fuel quality, however, poor quality solid fuels can contain high levels of contaminants like sulphur, moisture or ash, which will reduce the heat available for delivery into the home and increase air pollution.

Excess Winter Mortality provides a statistical measure of the increased number of deaths in winter and is used as a measure of fuel poverty. However, there were fewer than ten Excess Winter Deaths in some of the counties and administrative districts and it is not possible to place a robust interpretation on statistics derived from small sample numbers.

Air pollution contributes to premature mortality and may also be a significant contributor to Excess Winter Mortality, as figures for the fraction of mortality due to particulate air pollution in Northern Ireland local authorities are comparable with the Excess Winter Death fraction. Excess Winter Mortality is relatively high in Coleraine, Armagh, Banbridge and Derry in Northern Ireland and Dun Laoghaire Rathdown, Kildare, Offaly, Westmeath, Clare, South Tipperary and Waterford City in Ireland.

The top 40 emission density hotspots in Ireland were compared with their Haase-Pratschke Deprivation category. Small Areas were categorised as very disadvantaged or disadvantaged. It is concluded that almost all of the identified residential pollution hot spots in Ireland are in deprived or very deprived areas. These areas predominantly use coal or peat for heating with little use of oil or gas and thus the potential exists for impacts on air quality to elevate mortality and add to deprivation in these areas.

Fuel poverty is widespread throughout Northern Ireland with a substantial proportion of fuel-poor households in each of the Local Government Districts. The lowest proportion of fuel-poor households is in Belfast and the highest proportion in Ballymoney, Coleraine, Cookstown, Fermanagh, Larne, Moyle, Omagh and Strabane. The Local Government District level data does not provide sufficient detail to allow an assessment of the relationship between fuel poverty and emissions density.

[141] The broader term ‘energy poverty’ is used in the Warmer Homes strategy in Ireland, to capture for example electricity used for home heating or indeed lighting needs. For the purposes of this report the term ‘fuel poverty’ is used

8.1 Introduction

The concept of fuel poverty was developed almost 30 years ago, as a consequence of a series of energy shocks that exposed households to increasing fuel prices. Fuel poverty continues to be a significant social concern; and is defined as the ability to adequately to heat the home that can arise from a myriad of factors including from the inefficient use of energy in the residential sector[142]. The main indicator for fuel poverty is the number of additional deaths in the winter period over and above the rest of the year and this number is often attributed exclusively to fuel poverty. However, other factors including air pollution contribute to premature mortality and in the same order of magnitude (see 8.2 below).

A wide range of complex and inter-related factors contribute to fuel poverty in households, including the

- level of energy demand or need,
- available income and,
- price of fuel.

None of these factors is uniquely or exclusively responsible for fuel poverty. For example, household income may be low, but if the energy need is low, for example, because of good levels of house insulation, then the amount of fuel required for adequate home heating may be affordable. Similarly the price of the fuel will also be a factor. However, different fuels contain different amounts of energy and can be used in different appliances with different efficiencies and so deliver greater or lesser levels of heat to the home for the same amount of fuel.

As an example of the complexity, solid fuels are generally sold by weight rather than by energy content. A price sensitive household may assume that the lowest price option is the best, regardless of energy content or fuel quality. However, poor quality solid fuels can contain high levels of contaminants like sulphur, moisture or ash, which will reduce the heat available for delivery into the home, and can also contribute to air pollution. So the lowest price option may not be the cheapest option for providing heat to the home, and, in addition, can contribute to elevated levels of air pollution.

The pathways by which fuel poverty affects health are complex. McAvoy[143] grouped the effects into direct and indirect effects:

Direct effects

- Colder indoor temperatures place a 'thermal stress' on the body, affecting the immune system and the blood and cardiovascular system
- Cold damp houses harbour mould and dust mites which aggravate respiratory and allergic conditions
- Living in damp, cold housing has negative effects on mental health

Indirect effects

- In order to adequately heat their homes, householders experiencing fuel poverty cut-back on spending across other areas such as food, clothing and transport which further contributes to social exclusion
- Fuel-poor households tend to accumulate debt ultimately leading to disconnection from mainstream fuel and electricity supplies which drives them further into poverty and social exclusion
- Fuel-poor households are associated with 'spatial shrink' where fewer rooms are occupied in the winter months. Spatial shrink is associated with further deterioration in overall housing condition and contributes to overcrowding.

These factors contribute to an increase in the number of people that die in the winter. The Excess Winter Mortality provides a statistical measure of the increased number of deaths in winter. It has been

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[142] -Healy, J.D. and Clinch, J.P., 2002. Fuel poverty, thermal comfort and occupancy: results of a national household survey in Ireland. Applied Energy 73, 329-343.
[143] McAvoy, H., 2007. All-Ireland policy paper on fuel poverty and health. Institute of Public Health in Ireland. Dublin.

suggested that Excess Winter Mortality (EWM) is a relevant metric for measuring fuel (energy) poverty in terms of its impacts on human health due to the strong link between ill health and housing for elderly groups in the United Kingdom and Ireland[144]. Section 8.2 provides a summary of the Excess Winter Mortality in Local Government Districts in Northern Ireland and Ireland.

However, it should be noted that various factors contribute to Excess Winter Mortality other than fuel poverty-not the least of which is air pollution. Other metrics have been developed to quantify fuel poverty more directly. Sections 8.3 and 8.4 present recent estimates of fuel poverty in Ireland and Northern Ireland.

8.2 Excess Winter Mortality

The Excess Winter Mortality is calculated in Northern Ireland from the number of recorded deaths in the period December-March minus the average of the number of deaths in the preceding period August-November and the following period April-July. NISRA publish Excess Winter Mortality Statistics for the five Health and Social Care Trusts in Northern Ireland[145]. NISRA also publish statistics from the Registrar General's annual report which give monthly deaths by Administrative Area[146]. Table 8-1 shows the Excess Winter Mortality calculated from the Registrar General's statistics for the winter 2011/12. It also shows the Excess Winter Deaths as a percentage of the total annualised non-winter deaths, i.e the number of deaths that would have occurred if there was no winter.

The Central Statistics Office in Ireland publishes Vital Statistics[147] which provide statistics on the number of deaths in each quarter by county of residence. Table 8-2 shows the numbers of deaths in the quarters July-September 2012, October-December 2012, January-March 2013 and April-July 2013.

Table 8-2 also shows estimated Excess Winter Deaths based on the January-March quarter compared with the previous July-September and following April-July quarters.

There were fewer than ten Excess Winter Deaths in some of the counties and administrative districts. It is not possible to place a robust interpretation on statistics derived from small sample numbers. Excess Winter Mortality Statistics derived for smaller areas would be less reliable. Nevertheless, it can be seen that the excess Winter Mortality is relatively high in Coleraine, Armagh, Banbridge and Derry in Northern Ireland and Dun Laoghaire Rathdown, Kildare, Offaly, Westmeath, Clare, South Tipperary and Waterford City in Ireland.

The Excess Winter Mortality statistics are affected by factors other than fuel poverty. Air pollution does contribute to premature mortality during the whole year (see Chapter 4) but may contribute more significantly during the winter periods due to additional emissions from sources like home heating and meterological conditions (e.g. inversions) which may exacerbate exposure by trapping and accumulate pollutants in the atmosphere. Gowers, Miller and Stedman estimated that the fraction of mortality due to anthropogenic particulate air pollution in Northern Ireland local authorities ranged from 5.2% in Belfast to 2.5% in Fermanagh with an average for Northern Ireland being 3.8%. These figures are comparable with the Excess Winter Death fraction shown in Table 8-1 so it is concluded that it is likely that air pollution is potentially a significant contributor to Excess Winter Mortality.

144 Wilkinson, P., Landon, M., Armstrong, B., Stevenson, S., Pattenden, S., McKee, M., Fletcher, T., 2001. Cold comfort: the social and environmental determinants of excess winter deaths in England, 1986-96. The Joseph Rowntree Foundation. Policy Press, Southampton. Available online.
145 http://www.nisra.gov.uk/demography/default.asp32.htm

146 http://www.nisra.gov.uk/demography/default.asp10.htm
147 http://www.cso.ie/en/media/csoie/releasespublications/documents/vitalstats/2013/vstats_q12013.pdf

Table 8-1: Excess winter mortality in Northern Ireland Administrative Areas

District	Recorded deaths			Excess winter deaths 2011/12	Percentage of annualised deaths
	December -March 2011/12	August-November 2011	April-July 2012		
Belfast HSC Trust	**1,230**	**1,060**	**1,141**	**129.5**	**3.9%**
Belfast	*997*	*852*	*946*	*98*	*3.6%*
Castlereagh	*233*	*208*	*195*	*31.5*	*5.2%*
Northern HSC Trust	**1,281**	**1,135**	**1,205**	**111**	**3.2%**
Antrim	*128*	*120*	*132*	*2*	*0.5%*
Ballymena	*197*	*156*	*184*	*27*	*5.3%*
Ballymoney	*72*	*72*	*57*	*7.5*	*3.9%*
Carrickfergus	*118*	*116*	*102*	*9*	*2.8%*
Coleraine	*189*	*142*	*170*	*33*	*7.1%*
Cookstown	*86*	*78*	*85*	*4.5*	*1.8%*
Larne	*110*	*96*	*96*	*14*	*4.9%*
Magherafelt	*93*	*92*	*82*	*6*	*2.3%*
Moyle	*57*	*50*	*54*	*5*	*3.2%*
Newtownabbey	*231*	*213*	*243*	*3*	*0.4%*
South Eastern HSC Trust	**999**	**937**	**890**	**85.5**	**3.1%**
Ards	*225*	*226*	*207*	*8.5*	*1.3%*
Down	*192*	*177*	*180*	*13.5*	*2.5%*
Lisburn	*306*	*286*	*281*	*22.5*	*2.6%*
North Down	*276*	*248*	*222*	*41*	*5.8%*
Southern HSC Trust	**925**	**748**	**881**	**110.5**	**4.5%**
Armagh	*186*	*128*	*162*	*41*	*9.4%*
Banbridge	*128*	*97*	*85*	*37*	*13.6%*
Craigavon	*223*	*202*	*238*	*3*	*0.5%*
Dungannon	*145*	*125*	*148*	*8.5*	*2.1%*
Newry & Mourne	*243*	*196*	*248*	*21*	*3.2%*
Western HSC Trust	**757**	**661**	**735**	**59**	**2.8%**
Fermanagh	*162*	*160*	*165*	*-0.5*	*-0.1%*
Limavady	*72*	*69*	*83*	*-4*	*-1.8%*
Derry	*301*	*236*	*255*	*55.5*	*7.5%*
Omagh	*124*	*109*	*125*	*7*	*2.0%*
Strabane	*98*	*87*	*107*	*1*	*0.3%*
Northern Ireland	***5,192***	***4,541***	***4,852***	***495.5***	***3.5%***

Table 8-2: Excess winter mortality in Ireland

County/City	Recorded deaths				Excess winter deaths	Percentage of annualised deaths
	July-September 2012	October-December 2012	January-March 2013	April-July 2013		
Carlow	65	85	88	116	-2.5	-0.7%
Dublin City	1065	957	1130	1021	87	2.1%
South Dublin	240	218	251	284	-11	-1.0%
Fingal	250	266	300	260	45	4.4%
Dun Laoghaire Rathdown	311	352	436	339	111	8.5%
Kildare	204	230	275	216	65	7.7%
Kilkenny	135	133	176	182	17.5	2.8%
Laois	88	127	127	113	26.5	6.6%
Longford	63	72	90	80	18.5	6.5%
Louth	176	178	216	185	35.5	4.9%
Meath	202	200	250	221	38.5	4.6%
Offaly	89	104	158	116	55.5	13.5%
Westmeath	137	134	202	159	54	9.1%
Wexford	254	208	279	257	23.5	2.3%
Wicklow	177	206	236	197	49	6.6%
Clare	165	165	223	177	52	7.6%
Cork City	293	245	343	275	59	5.2%
Cork County	507	563	658	637	86	3.8%
Kerry	262	251	320	331	23.5	2.0%
Limerick City	125	129	159	146	23.5	4.3%
Limerick County	205	230	217	212	8.5	1.0%
North Tipperary	126	132	158	141	24.5	4.6%
South Tipperary	131	146	213	199	48	7.3%
Waterford City	64	61	96	81	23.5	8.1%
Waterford County	119	119	124	117	6	1.3%
Galway City	65	64	65	89	-12	-3.9%
Galway County	300	313	349	319	39.5	3.2%
Leitrim	59	59	66	56	8.5	3.7%
Mayo	247	248	313	322	28.5	2.5%
Roscommon	98	146	121	150	-3	-0.6%
Sligo	98	105	144	115	37.5	8.8%
Cavan	131	129	134	132	2.5	0.5%
Donegal	264	277	319	307	33.5	2.9%
Monaghan	96	102	111	92	17	4.5%
Ireland	***6811***	***6954***	***8347***	***7644***	***1119.5***	***3.9%***

8.3 Fuel poverty in Ireland

The strategic policy to address fuel poverty in Ireland is set out in the Warmer Homes, *A strategy for affordable energy in Ireland*[148], which uses the broader term energy poverty which is defined as follows:

[148] http://www.dcenr.gov.ie/Energy/Energy+Efficiency+and+Affordability+Division/Affordable+Energy.htm

a household is considered to be energy poor if it is unable to attain an acceptable standard of warmth and energy services in the home at an affordable cost. The measurement of fuel poverty in Ireland has been attempted by several methods. Scott et al[149] considered two measures. That is,

- an expenditure measure, in which households are classified as fuel-poor if they spend more than 10% of net income excluding housing costs on energy in the home
- a subjective measure, in which the occupants' own assessments of their conditions are used

Scott et al estimated using the expenditure method that 15.9% of households in Ireland were fuel-poor in 2005 and 19.4% were fuel-poor in 2008.

The Household Budget Survey 2009-2010 (CSO, 2012) report[150] contains information on the weekly net disposable income, housing costs and heating and lighting costs classified by gross income deciles. Table 8-3 provides a summary of these costs and shows the fuel and light costs as a percentage of the net disposable income excluding housing costs for each decile. Table 8-3 suggests that more than 20% of households might be considered fuel-poor in Ireland by this definition. However, simply comparing average energy use with income by decile conceals the wide variation in energy use within each decile. Improved estimates could be obtained by detailed analysis of anonymised microdata from the Household Budget Survey.

Table 8-3: Proportion of net income spent on fuel in Ireland by gross income decile

Gross income decile	Net disposable income, € per week	Housing costs, €	Fuel and light costs, €	%Fuel and light of net disposable income excluding housing costs
0-10%	188.91	71.98	24.59	21.0%
10-20%	300.98	78.82	25.17	11.3%
20-30%	431.28	91.65	31.61	9.3%
30-40%	549.2	110.08	34.35	7.8%
40-50%	669.46	120.29	36.29	6.6%
50-60%	802.56	143.33	37.37	5.7%
60-70%	972.03	161.91	39.8	4.9%
70-80%	1183.82	191.83	38.51	3.9%
80-90%	1472.64	195.27	39.1	3.1%
90-100%	2289.38	312.8	46.73	2.4%

The Survey on Income and Living Conditions (SILC) in Ireland is an annual household survey conducted by the Central Statistics Office (CSO) and covers a broad range of topics in relation to income and living conditions. It is the official source of data on household and individual income and also provides a number of key national poverty indicators, such as the 'at risk of poverty' rate, the consistent poverty rate and rates of enforced deprivation[151]. The Survey includes information on the percentage of individuals unable to afford to keep the home adequately warm (Table 8-4).The percentage unable to keep the home warm has increased substantially since 2006.

[149] https://www.esri.ie/UserFiles/publications/20081110114951/WP262.pdf

[150] http://www.cso.ie/en/media/csoie/releasespublications/documents/housing/2010/0910first.pdf

[151] http://www.cso.ie/px/pxeirestat/Database/eirestat/Survey%20on%20Income%20and%20Living%20Conditions%20(SILC)/Survey%20on%20Income%20and%20Living%20Conditions%20(SILC)_statbank.asp?sp=Survey on Income and Living Conditions (SILC)

Table 8-4: Percentage of individuals in Ireland unable to keep the home adequately warm, 2006-2012

Year	Percentage of individuals unable to keep the home adequately warm
2006	3.8
2007	3.5
2008	3.7
2009	4.1
2010	6.8
2011	6.8
2012	8.5

The general trend that is observed among fuel-poor households in Ireland is that vulnerability is strongly linked to low income, unemployment, single-person households and households headed by a pensioner. For example, approximately 25% of households headed by an unemployed person are unable to heat their home adequately, compared to 13% headed by an employed person. A similar behaviour is observed for lone-parents, with one fifth of households being unable to afford adequate heating. However, low-income continues to be the levering factor to determine energy poverty. In Ireland, when annual household income falls below €30,000, the risk of fuel poverty rises exponentially[152].

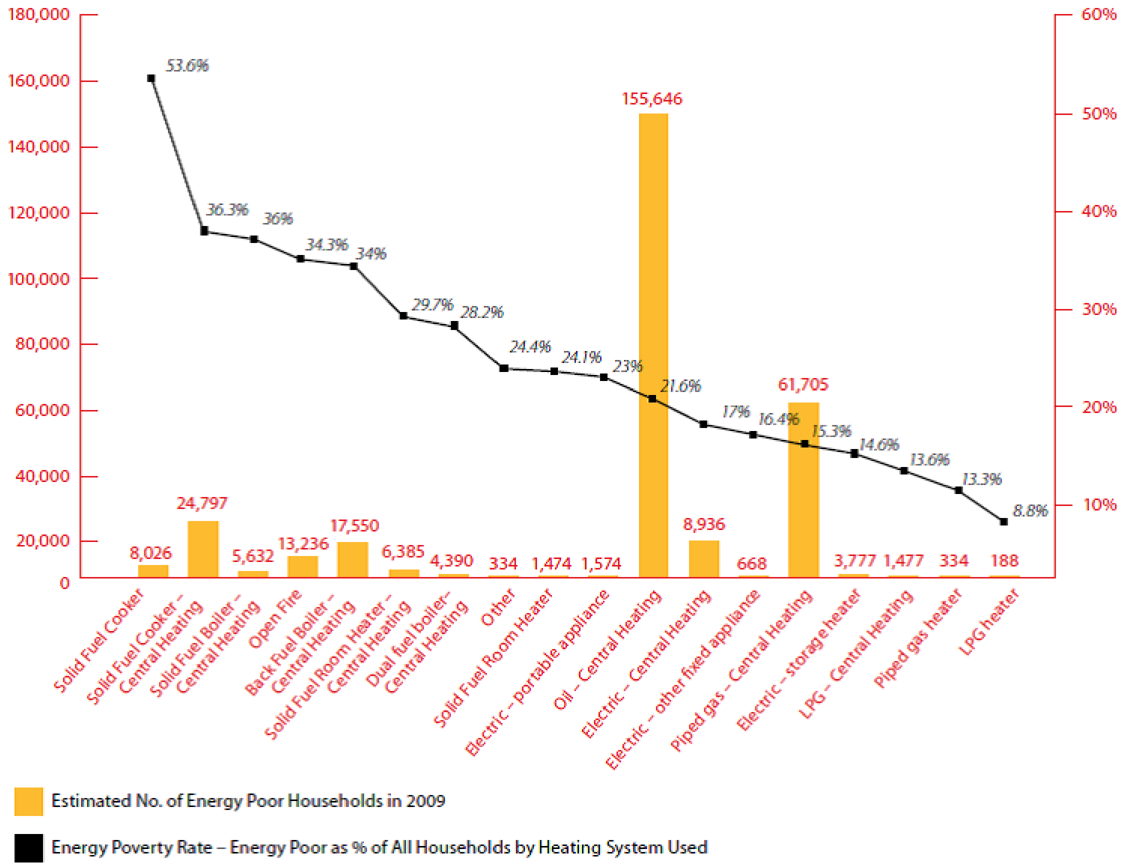
A study conducted in 2004 presented[153] a more detailed picture on fuel poverty in Ireland. The investigations found that 40% of the fuel-poor households had annual incomes of less than €8,888 (IR£7000), 33% of these living on social welfare. The highest prevalence of fuel poverty was found in households with a long-term ill or disabled head (44.8%), followed by an unemployed (30.5%) and retired heads (22%). Separated, divorced or widowed household heads are found more likely to suffer fuel poverty (29%) than married or co-habiting counterparts (11.8%), this fact being related to subsistence based on a sole income. Regarding the age of the dwelling, the largest number of fuel-poor homes (19%) are old (pre 1940), followed by households built between 1940 and 1980 (17%). Remarkably high rates of fuel poverty are found in tenant households, but especially those who rent from a local authority, where one-in-three such households are unable to adequately heat their home, compared with just one-in-ten owner-occupier (mortgaged) households. The highest incidence of fuel poverty (7.8%) is found in small towns with (<10,000). High fuel poverty levels are also found in urbanised and very rural areas, with lower incidences for large towns or other major cities.

Haase[154] considered the potential for mapping fuel poverty in Ireland. He suggested that the Irish deprivation index may be strongly correlated with an optimal estimate of the risk of fuel poverty at the aggregate level, which would considerably simplify the implementation of government policies which attempt to target fuel poverty through area based initiatives. The Pobal interactive mapping tool[155] provides values of the Haase-Pratschke Deprivation Index for each Small Area in Ireland. Each Small Area is categorised on the scale extremely disadvantaged/very disadvantaged/disadvantaged/marginally below average/marginally above average/affluent/very affluent/extremely affluent.

Table 8-5 lists the top 40 emission density hotspots in Ireland identified in Section 3 and their Haase-Pratschke Deprivation category. Twenty four of the Small Areas were categorised as very disadvantaged: sixteen of the Small Areas were categorised as disadvantaged. It is concluded that the identified residential pollution hot spots are in deprived or very deprived areas. These areas predominantly use coal or peat for heating with little use of oil or gas. The Warmer Homes strategy highlighted the correlation between fuel poverty and use of solid fuels (Figure 8-1) and the analysis here indicates a potential link to poor air quality. Poor air quality further adds to the deprivation and health impacts in these areas though it is not captured by the formal deprivation index.

[152] (McAvoy, 2007)
[153] -Healy, J.D. and Clinch, J.P., 2004. Quantifying the severity of fuel poverty, its relationship with poor housing and reasons for non-investment in energy saving measures in Ireland. Energy Policy 32, 207-220.
[154] Haase, T., 2011. Mapping Fuel Poverty in the Ireland. A report to Energy Action Ltd. Trutz Haase – Social & Economic Consultant, Dublin.
[155] http://maps.pobal.ie/#/Map

Figure 8-1: Energy Poverty Rates by type of heating system



Source: CSO, Household Budget Survey 2004-05 and analysis of movements in energy prices and incomes between 2004/05 and 2009

Table 8-5: Deprivation in the top 40 emission density hotspots in Ireland

Small Area GEOGID	Area EDName	County	Deprivation score	Percentage of emissions by fuel type				
				oil	natural gas	coal	peat	wood
A027025006	Cavan Urban	Cavan County	Very disadvantaged	0%	0%	94%	6%	0%
A037059012	Ennistimon	Clare County	Very disadvantaged	0%	0%	93%	6%	1%
A057012001	Ballyshannon Urban	Donegal County	Very disadvantaged	0%	0%	95%	4%	0%
A067017002	Ballinasloe Urban	Galway County	Disadvantaged	0%	0%	7%	92%	1%
A067017010	Ballinasloe Urban	Galway County	Very disadvantaged	0%	0%	11%	86%	3%
A067017020	Ballinasloe Urban	Galway County	Very disadvantaged	0%	0%	21%	79%	1%
A067017021	Ballinasloe Urban	Galway County	Very disadvantaged	0%	0%	19%	80%	1%
A067211004	Tuam Rural	Galway County	Very disadvantaged	0%	0%	27%	72%	1%
A067211024	Tuam Rural	Galway County	Very disadvantaged	0%	0%	20%	80%	0%
A077128001	Listowel Urban	Kerry County	Very disadvantaged	0%	0%	19%	81%	0%
A077128006	Listowel Urban	Kerry County	Disadvantaged	0%	0%	46%	53%	0%
A077128010	Listowel Urban	Kerry County	Very disadvantaged	0%	0%	29%	70%	1%
A107073005	Mountrath	Laois County	Very disadvantaged	0%	0%	21%	75%	4%
A107080006	Portlaoighise (Maryborough) Urban	Laois County	Very disadvantaged	0%	0%	5%	95%	0%
A127001003	Abbeyfeale	Limerick County	Very disadvantaged	0%	0%	62%	38%	0%
A137043005	Longford No. 1 Urban	Longford County	Very disadvantaged	0%	0%	60%	38%	2%
A137043013	Longford No. 1 Urban	Longford County	Disadvantaged	0%	0%	28%	24%	48%

Small Area GEOGID	Area EDName	County	Deprivation score	Percentage of emissions by fuel type				
				oil	natural gas	coal	peat	wood
A137045004	Longford Rural	Longford County	Very disadvantaged	0%	0%	70%	28%	2%
A157016009	Ballina Urban	Mayo County	Very disadvantaged	0%	0%	78%	22%	0%
A157016010	Ballina Urban	Mayo County	Very disadvantaged	0%	0%	80%	19%	1%
A157154002	Ardnaree South Urban	Mayo County	Disadvantaged	0%	0%	82%	17%	1%
A187009006	Banagher	Offaly County	Disadvantaged	0%	0%	2%	98%	0%
A187013015	Birr Urban	Offaly County	Disadvantaged	0%	0%	15%	84%	1%
A187036012	Edenderry Urban	Offaly County	Very disadvantaged	0%	0%	6%	94%	0%
A187036013	Edenderry Urban	Offaly County	Very disadvantaged	0%	0%	7%	93%	0%
A187069005	Portarlington North	Offaly County	Disadvantaged	0%	0%	10%	89%	1%
A187087018	Tullamore Urban	Offaly County	Very disadvantaged	0%	0%	15%	83%	2%
A187087028	Tullamore Urban	Offaly County	Disadvantaged	0%	0%	15%	84%	1%
A187087037	Tullamore Urban	Offaly County	Disadvantaged	0%	0%	6%	92%	2%
A217136019	Nenagh West Urban	North Tipperary	Very disadvantaged	0%	0%	88%	4%	7%
A217152019	Roscrea	North Tipperary	Disadvantaged	0%	0%	22%	76%	2%
A217162017	Thurles Urban	North Tipperary	Disadvantaged	0%	0%	63%	37%	0%
A217164004	Tipperary East Urban	South Tipperary	Disadvantaged	0%	0%	100%	0%	0%
A227032002	Dungarvan No. 1 Urban	Waterford County	Disadvantaged	1%	0%	99%	0%	0%
A247045029	Enniscorthy Rural	Wexford County	Very disadvantaged	0%	0%	100%	0%	0%

Small Area GEOGID	Area EDName	County	Deprivation score	Percentage of emissions by fuel type				
				oil	natural gas	coal	peat	wood
A247045038	Enniscorthy Rural	Wexford County	Disadvantaged	0%	0%	100%	0%	0%
A247045039	Enniscorthy Rural	Wexford County	Very disadvantaged	0%	0%	93%	3%	3%
A247046003	Enniscorthy Urban	Wexford County	Very disadvantaged	0%	0%	99%	0%	1%
A247091011	New Ross Urban	Wexford County	Disadvantaged	0%	0%	97%	3%	0%
A247091016	New Ross Urban	Wexford County	Disadvantaged	0%	0%	97%	2%	0%

8.4 Fuel poverty in Northern Ireland

The definition of fuel poverty in Northern Ireland is based on the definition as set out in the UK fuel poverty strategy. A household is considered to be in fuel poverty if, in order to maintain a satisfactory level of heating (21°C in the main living area and 18°C in other occupied rooms), it is required to spend in excess of 10 per cent of its household income on all fuel use. Fuel poverty assesses the ability to meet all domestic energy costs including space and water heating, cooking, lights and appliances. Fuel poverty is assessed in Northern Ireland using computer models developed by the Building Research Establishment. The calculation has three components: energy prices, fuel consumption and income.

The results of the most recent assessment are presented in the Northern Ireland Housing Executive House Condition Survey 2011 report[156]. According to NIHE figures, fuel poverty in Northern Ireland has been changing in the recent years (34% in 2006, 44% in 2009, 42% in 2011), mainly due to significant increases in the fuel prices and a continued dependence on oil, electricity and solid fuel for heating. Of the total households in Northern Ireland, 42% spend more than 10% of their income on fuel (these are classified as being in fuel poverty), 15% spend more than 15% (severe fuel poverty) and 6% spend more than 20% (extreme fuel poverty). Other key findings were:

- Low income remains the most significant cause of fuel poverty, with 79% of households with annual incomes of less than £10,000 being fuel-poor.
- The age of dwellings is determinant for fuel poverty, with almost two-thirds (69%) of fuel-poor households living in older (pre 1919) buildings.
- Fuel poverty is extensive in rural isolated areas, where 50% of households are fuel-poor.
- As for age, 66% of the households headed by an older person (>75 years) were fuel-poor in 2011.
- Fuel poverty is deemed higher in households whose heads are unemployed (55%) or retired (62%).
- Households with solid fuel (59%) were more likely to be in fuel poverty than households with electric (46%) central heating, oil (44%) or gas (34%) central heating.

Several policies implemented in the past decade aimed to alleviate fuel poverty through increasing incomes, reducing fuel prices and improving energy efficiency of the housing stock have not produced the desired results[157]. Between 2001 and 2009, the number of households in fuel poverty in Northern Ireland reported in the House Condition Survey increased by 81%. This has been produced by a dramatic increase in energy prices, especially for home heating (72% between 2008 and 2010), a fall in incomes as a consequence of the current recession and a poorly-targeted fuel poverty remediation programme[158].

An example of the inaccurate policy alleviation is the Winter Fuel Payment (WFP) which is awarded to pensioners as a supplementary payment for winter fuel bills. This policy missed the 51% of the fuel-poor households in Northern Ireland that are not headed by a pensioner. Furthermore, WFP does not differentiate between pensioners who are fuel-poor and those who are not[159].

BRE have modelled fuel poverty at District Council level as part of the House Condition Survey 2011. Table 8-6 shows the percent of fuel-poor households in each of the Local Government Districts. Fuel poverty is widespread throughout Northern Ireland with a substantial proportion of fuel-poor households in each of the Local Government Districts. The lowest proportion of fuel-poor households is in Belfast and the highest proportion in Ballymoney, Coleraine, Cookstown, Fermanagh, Larne, Moyle, Omagh and Strabane. The Local Government District level data does not provide sufficient detail to allow an assessment of the relationship between fuel poverty and emissions density: more detailed data at Small Area level would allow such an assessment to be made.

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[156] http://www.nihe.gov.uk/index/corporate/housing_research/house_condition_survey.htm

[157] Boardman, B., 2010. Fixing fuel poverty: Challenges and solutions. London: Earthscan.
[158] Liddell, C., Morris, C., McKenzie, P., Rae, G., 2011. Defining fuel poverty in Northern Ireland: A preliminary review. Coleraine. University of Ulster.
[159] Walker, R., McKenzie, P., Liddell, C., Morris, C., 2012. Area-based targeting of fuel poverty in Northern Ireland: An evidenced-based approach. Applied Geography 34, 639-649.

The Affordable Warmth Scheme was launched in Septmber 2014 and will actively target Northern Ireland households considered to be most at risk of fuel poverty[160].

Table 8-6: Fuel Poverty in Northern Ireland

Local Government District	Number of Households	Percent of Fuel-poor Households
Antrim	19,709	38 - 42%
Ards	30,964	38 - 42%
Armagh	21,216	43 - 46%
Ballymena	20,270	47 - 51%
Ballymoney	11,424	52 - 56%
Banbridge	17,975	38 - 42%
Belfast	151,567	32 - 37%
Carrickfergus	13,234	43 - 46%
Castlereagh	27,254	38 - 42%
Coleraine	23,332	52 - 56%
Cookstown	10,543	52 - 56%
Craigavon	35,297	38 - 42%
Derry	40,468	47 - 51%
Down	25,745	43 - 46%
Dungannon	16,560	47 - 51%
Fermanagh	18,840	52 - 56%
Larne	10,859	52 - 56%
Limavady	12,007	47 - 51%
Lisburn	44,913	38 - 42%
Magherafelt	12,282	47 - 51%
Moyle	6,560	52 - 56%
Newry and Mourne	34,406	43 - 46%
Newtownabbey	33,371	38 - 42%
North Down	32,679	38 - 42%
Omagh	15,059	52 - 56%
Strabane	14,708	52 - 56%

8.5 Additional obstacles for reducing fuel poverty.

The prevalence of fuel poverty in Ireland continues to be a concern. The current cases of fuel poverty in the island remain unsolved due to a number of factors, apart from income and household structure. The profile of households in Ireland[161] is particularly sensitive to changes in fuel prices; a 15% price rise would increase the number of fuel-poor households from 15.9% in 2005 to 20.4% (28%) when using the 10% expenditure measure for defining fuel poverty. This fact along with income availability is strongly related to the choice of fuels. The highest income households in Ireland are more likely to use gas or oil as their primary fuel, whereas the lower quartiles tend to use coal where permitted. For example, between 2002 and 2006 the price of natural gas increased 70% in Ireland and 124% in Northern Ireland, while the price of anthracite increased only 22% and 17% respectively.

Fuel poverty is aggravated by the use of inefficient heating systems in many fuel-poor homes. Households are often unable or unwilling to upgrade to more efficient heating systems because there

[160] See http://www.nidirect.gov.uk/affordable-warmth-grant-scheme
[161] Scott, S., Lyons, S., Keane, C., McCarthy, D., Tol, R.S.J., 2008. Fuel poverty in Ireland: extent, affected groups and policy issues. Working Paper No. 262. ESRI.

is a lack of appropriate incentives and because they have difficulty in accessing credit on acceptable terms.

One approach to alleviating energy poverty has been to adopt social and fuel pricing policies. Addressing fuel poverty through subsidies to energy costs or fuel payments has demonstrated to be an ineffective because extra income may not be used by households for covering their unmet energy services or for improving the energy efficiency of their dwellings. Subsidising fuel costs may remove the incentive to upgrade the efficiency of heating systems[162].

[162] -Ürge-Vorsatz, D. and Herrero, S.T., 2012. Building synergies between climate change mitigation and energy poverty alleviation. Energy Policy 49, 83-90.

9 Measures to address air quality impacts of residential solid fuel heating in EU Member States

Box 8: Summary of Section 9

The analysis focused on the effectiveness of Member States' policy packs submitted in support of Time Extension Notices under the Air Quality Directive in the control of PM_{10} emissions from residential or small-scale combustion and the associated abatement costs. In general, it was clearly evidenced that the respective policy packs resulted in an improvement in air quality. However, control costs were computed exclusively for the use of solid mineral fuels and biomass, no costs related to the transition from these fuels to gaseous options (natural gas, LPG) were considered. Most of the studied Member States (except Spain) show a predominant use of wood as the preferred substitution fuel. This was seen by stakeholders as an attractive fuel alternative that also helps address climate change obligations.

After the introduction of a coal ban in Italy, a notable increase in the annual emissions of $PM_{2.5}$ (*ca.* 20% in comparison to 2002 levels) took place, which can be attributed to the immediate transition to biomass. Emissions of $PM_{2.5}$ continued to grow to reach almost a 70% increase on 2002 levels by 2010. These increases can be attributed almost exclusively to the use of wood, that is the increase in particulate emission was entirely due to growth in biomass use. However, if gas had been an option to replace coal rather than wood then emissions would have decreased.

In Germany, there have been localised bans on use of solid mineral fuels but the impacts are not evident in national energy data or $PM_{2.5}$ emissions, which have increased as biomass and solid mineral fuel use has grown.

In Poland, a solid mineral fuel ban is proposed for Krakow but has only recently been agreed. It is notable that wood is also banned, that there is a transition period and, a commitment from the local government to support equipment replacement to ensure effective implementation of the fuel ban.

9.1 Basis of review

Consideration of policy levers in Ireland and Northern Ireland for the control of emissions to air from residential combustion entails a review of such policy elsewhere in Europe. An assessment of the impact of these policies and the methods of their implementation was undertaken to identify best practice.

The combustion of solid fuels such as hard, bituminous and brown coal is known to be an important source of particulate matter (PM) that is emitted to the atmosphere, having a direct and well-known impact on human health[163]. While the use of solid fuels in power generation and industrial processes is more or less characterised and controlled, emissions controls on residential solid fuel use (mainly heating and cooking) are more limited[164].

Aiming to control the levels of exposure of the population to air pollution, the European legislative framework through Directive 2008/50/EC defines a series of limit values (LVs) that should not be exceeded; Member States should submit a detailed program of control strategies directed to reduce problematic air quality levels and assure future compliance. Reports by Member States submitted to the European Commission include controls on the use of solid fuels in the residential sector across Europe. This section provides analysis of the most relevant control policies, actions and measures carried out by Member States on the use of solid fuels in the residential sector.

9.2 Studied locations

In order to acquire a complete perspective on the types of actions that the different European Member States are undertaking to reduce the residential combustion of solid fuels, an analysis was conducted of the plans that were submitted to the European Commission for time extensions for compliance with the air quality directive. Applications for time extensions have been submitted for controlling either PM_{10} or NO_2 from many sectors, including domestic heating.

[163] Brandt, C., Kunde, R., Dobmeier, B., Schnelle-Kreis, J., Orasche, J., Schmoeckel, G., Diemer, J., Zimmermann, R., Gadener, M., 2011. Ambient PM10 concentrations from wood combustion – Emission modelling and dispersion calculation for the city area of Augsburg, Germany. Atmospheric Environment 45, 3466-3474.
[164] Fenger, J., 2009. Air pollution in the last 50 years – From local to global. Atmospheric Environment 43 (1), 13-22.

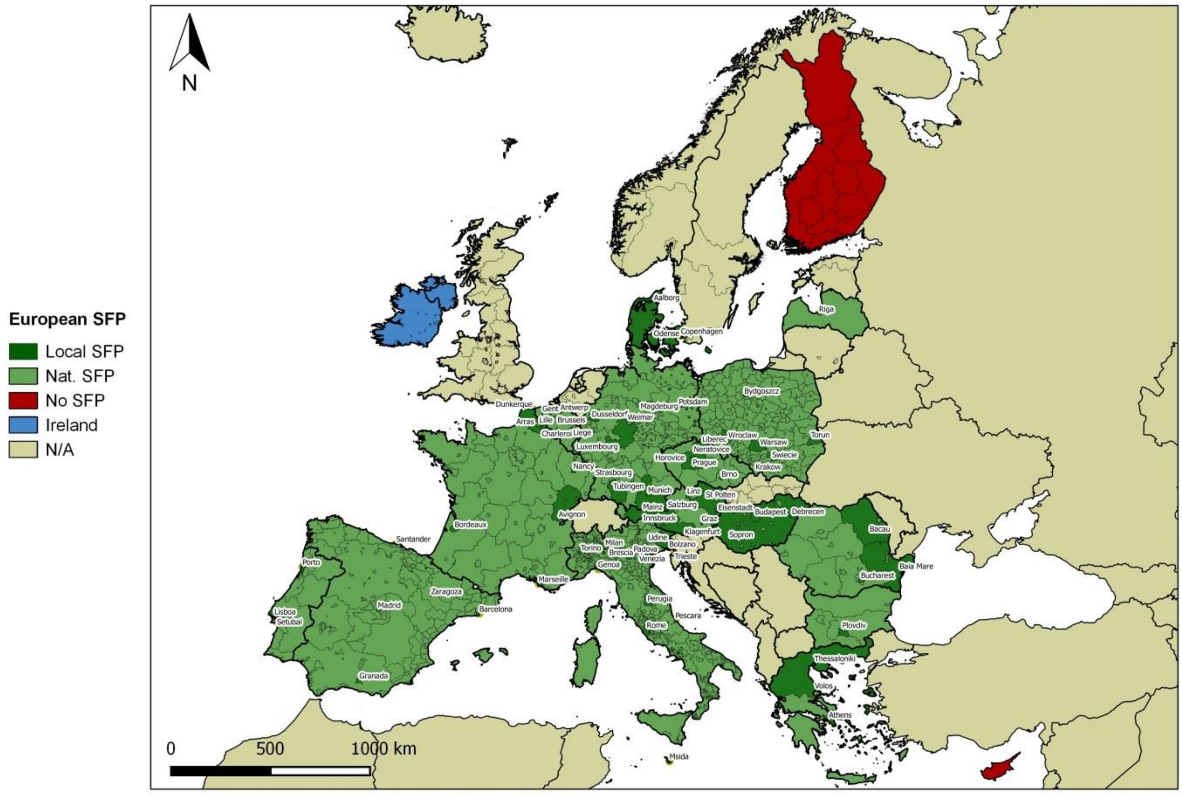

Figure 9-1: Map of the analysed air quality management areas and EU Member States.

Member States with their respective Air Quality Management (AQM) areas, in which there are policies directed to controlling the use of solid (mineral) fuels in the domestic sector, are shown in Figure 9-1 (abbreviated as SFP, solid fuel policies). A detailed list of each of these AQM areas - grouped by Member State and differentiating between local (cities) and regional (regions) administrative units - is given below.

- **Austria (AT).**
  - ***Cities:*** Eisenstadt, Kittsee, Illmitz, Klagenfurt, Wolfsberg, Villach, Amstetten, St. Pölten, Linz, Wels, Enns-Kristein, Salzburg, Graz, Innsbruck.
  - ***Regions:*** Wiener Umland Süd, Wiener Umland Nord, Oberösterreich, Voralberg.

- **Belgium (BE).**
  - ***Cities:*** Antwerp (city and port), Gent (city and port), Brussels, Liege, Engis, Charleroi.
  - ***Regions:*** Brussels, Franders and Wallonia.

- **Bulgaria (BG).**
  - **Cities:** Plovdiv.

- **Czech Republic (CZ).**
  - ***Cities:*** Prague, Neratovice, Hořovice, Mladá Boleslav, Liberec, Česká Lípa, Dobruška, Brno.
  - ***Regions:*** Bohemia, Moravia.

- **Denmark (DK).**
  - ***Cities:*** Copenhagen, Odense, Aalborg.

- **France (FR).**

- o ***Cities:*** Avignon, Trois Vallees, Marseille, Nancy, Strasbourg, Bordeaux, Valenciennes, Dunkerque, Lille, Arras, Bethune-Lens-Douai.
- o ***Regions:*** Alsace, Aquitaine, Bourgogne, Haute-Normandie, Ile-de-France, Nord Pas de Calais, Provence-Alpes-Cote d'Azur, Rhone-Alpes.

- **Germany (DE).**
  - ***Cities:*** Dusseldorf, Wuppertal, Magdeburg, Weimar, Munich, Tubingen, Potsdam, Mainz.
  - ***Regions:*** Nordrhein-Westfalen, Sachsen-Anhalt, Thüringen, Bayern, Baden-Wurttemberg, Brandenburg, Rheinland-Pfalz.

- **Greece (EL).**
  - ***Cities:*** Athens, Thessaloniki, Volos.
  - ***Regions:*** Northern and Southern Greece.

- **Hungary (HU).**
  - ***Cities:*** Budapest, Debrecen, Sopron.

- **Italy (IT).**
  - ***Cities:*** Rome, Frosinone, Cassino, Ferentino, Latina, Milan, Bergamo, Brescia, Torino, Bolzano, Genoa, Sarzana, La Spezia, Busalla, Gorziana, Pordenone, Trieste, Udine, Venezia, Padova, Treviso, Pescara, Perugia, Terni.
  - ***Regions:*** Friuli-Venezia Giulia, Lazio, Liguria, Lombardia, Abruzzo, Piedmont, Trento, Veneto, Autonomous Province of Bolzano, Aosta Valley, Umbria.

- **Latvia (LV).**
  - ***Cities:*** Riga.

- **Luxembourg (LU).**
  - ***Cities:*** Luxembourg.

- **Malta (MT).**
  - ***Cities:*** Msida.

- **Poland (PL).**
  - **Cities:** Bydgoszcz, Świecie, Toruń, Włocławek, Jelenia Gora, Wrocław, Zgorzelec, Gorzów, Warsaw, Radom, Krakow.
  - **Regions:** Kuyavia-Pomerania, Lower Silesia, Mazovia, Lesser Poland.

- **Portugal (PT).**
  - ***Cities:*** Lisbon, Porto, Setubal.
  - ***Regions:*** Northern and Southern Portugal.

- **Romania (RO).**
  - ***Cities:*** Bacău, Bucharest, Baia Mare.

- **Spain (ES).**
  - ***Cities:*** Madrid, Barcelona, Zaragoza, Santa Cruz de Tenerife, Santander, Granada.
  - ***Regions:*** Cantabria, Catalonia, Madrid.

Other Member States analysed in the study: Cyprus (CY), Finland (FI). In these member states, no measures for the abatement of emissions from the combustion of solid fuels in the residential sector were provided.

Member States not analysed in the study : Croatia (HR), Estonia (EE), Ireland (IE), Lithuania (LT), Netherlands (NL), Slovakia (SK), Slovenia (SI), Sweden (SE) and United Kingdom (GB).

In every case, the analysis of policies and measures was carried out taking into consideration the time span between **2002** and **2010**. 2002 was chosen as having a representative state of the air quality situation before the introduction of Directive 2008/50/EC. In the same way, 2010 was deemed as having representative air quality after the enforcement of the Directive, and being adequately “recent” to assess the impact of short- and medium-term control measures as well as the onset of long-term strategies.

9.3 Activities: consumption of solid fuels in the domestic sector in Europe.

For integrated assessment purposes, the first step towards analysing the effects of policy should be the characterisation of the **activities** (i.e. fuel consumption) on which measure packs will concentrate. In this respect, annual consumption of solid fuels for the domestic sector[165] were obtained from the Centre on Emission Inventories and Projections (CEIP)[166] for 2002 and 2010. Figure 9-2 shows these consumptions referred to the population in each of the AQM areas of the European Union, expressed in petajoules per year and inhabitant [PJ/yr·hab]. As can be seen, countries such as Finland, Greece, Portugal, Spain, Sweden and the United Kingdom register decreases in the consumption of solid fuels for domestic heating in most of their AQM areas.

The most notable reductions are experienced however, in countries of the former Eastern Bloc, namely Bulgaria, the Czech Republic, Estonia, Hungary, Lithuania, Romania and Slovakia. In the case of the Czech Republic, reductions of 35% were achieved in Brno and České Budějovice, while for Bulgaria, reductions in North and South-west Bulgaria rise to over 79%. Hungary also registered high reductions in consumptions, of up to 74% while Lithuania reduced even more its use of solid fuels (90%). Countries like France, Ireland and Italy achieved marginal reductions in their solid fuel consumptions (below 5%).

On the other hand, countries like Latvia and Poland showed an increased in their consumptions of solid fuels. For some locations in Poland such as Warsaw, Krakow, Łodź, Lublin and Białystok, consumptions increased by a maximum of 52%. Moreover, fuel consumptions in Poland are the highest amongst its European counterparts: 18 PJ/yr·hab for Lesser Poland (Małopolska) and 13 PJ/yr·hab for Mazovia. In the case of Latvia, total emissions are more modest, having an annual consumption below 0.7 PJ/yr·hab, which is an increase of 37% when compared to 2002 figures.

[165] Code N09 1 A b i according to the NFR09 / Guidelines 2009. Accessible here.
[166] CEIP – Centre on Emission Inventories and Projections. Accessible here.

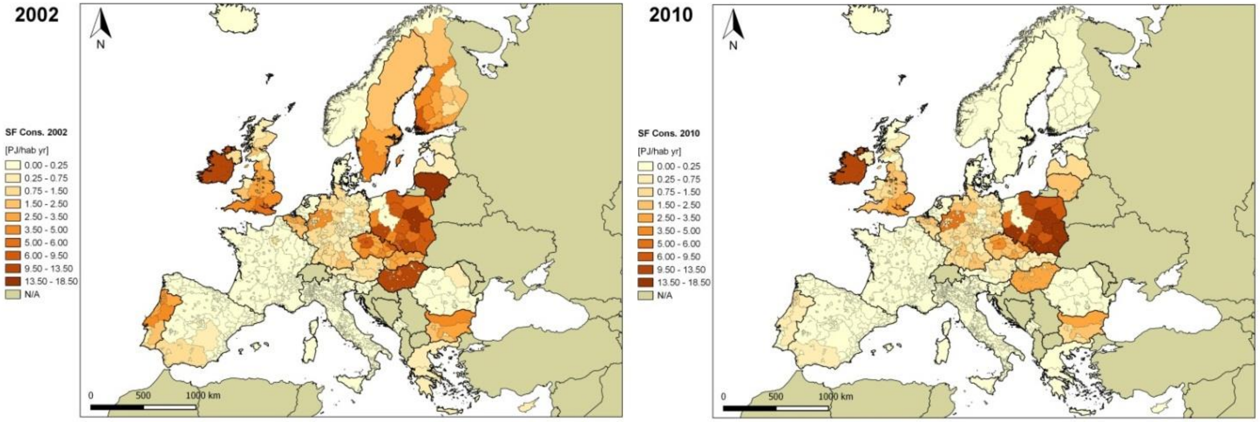

Figure 9-2 : Solid fuel consumptions per capita (domestic sector) in the EU/EEA AQM areas in 2002 and 2010.

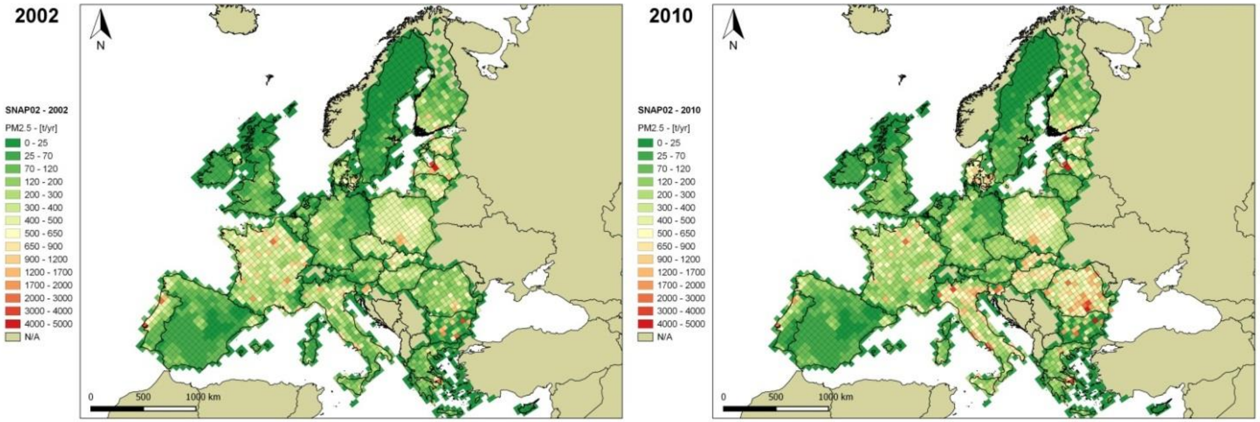

Figure 9-3 : Emissions of $PM_{2.5}$ of stationary domestic sources (SNAP02) in 2002 and 2010 according to EMEP.

9.4 Emissions: solid fuel burning in the domestic sector in Europe.

Annual emissions data of $PM_{2.5}$ [t/yr] were taken from the Centre on Emission Inventories and Projections (CEIP) and intersected with the EMEP 50×50 km^2 grid to produce Figure 9.3. The most notable example of $PM_{2.5}$ hotspots are seen in Lisbon, Paris, Milan, Bucharest, Riga, Tallinn, Athens and Sofia.

It should be noted that the emissions presented in Figure 9-3 are those **of domestic stationary sources** (i.e. boilers), regardless of their working fuel. Determining the emissions due to solid fuel burning only were broadly estimated in Table 9-1which contains the 2010 $PM_{2.5}$ emissions for SNAP02 ($E_{SF\text{-}SNAP02}$) for France, Germany, Italy, Poland, and Spain as well as the emissions produced only by the combustion of solid fuels in the residential sector ($E_{SF\text{-}SNAP02,PM2.5}$). These data were obtained from the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model of the International Institute of Applied Systems and Analysis (IIASA)[167], which is the reference integrated assessment model in Europe.

Table 9-1: Contribution of solid fuel combustion to the total SNAP02 in 2010.

Country	$E_{SNAP02,PM2.5}$ – [t/yr]	$E_{SF\text{-}SNAP02,PM2.5}$ – [t/yr]	$\%_{SF\text{-}SNAP02,PM2.5}$
France (FR)	105,667	37,878	35.85%
Germany (DE)	59,718	20,320	34.03%
Italy (IT)	45,391	23,694	52.07%
Poland (PL)	56,317	34,680	61.58%
Spain (ES)	17,801	3,330	18.71%

According to the data in Table 9-1, the contribution of solid fuel combustion to the total emissions of the domestic sector (SNAP02) is highly variable across countries. The lowest contribution is observed for Spain (18.71%), while the highest share corresponds to Poland (61.58%). These values are in concordance with the per capita consumptions shown in Figure 9-2, which assign the highest consumptions to Poland whereas France and Spain exhibit a low presence of solid fuels in the domestic sector.

9.5 Emission control strategies: solid fuel combustion in Europe.

The complete set of measures are summarised in Table 9-2and described in detail in Appendix 3. Most of the measures are directed towards the controlling the equipment in which combustion is usually carried out: boilers, stoves and fireplaces. The most common measure for reducing PM_{10} emissions due to domestic heating seems to be the gradual migration of heating equipment to clean and efficient alternatives, namely retrofitting. The exact definition of “clean and efficient alternatives” cannot be generalised across Member States, since every location has a predominant heating fuel (Table 9-2) which in many cases may not be solid fuels (e.g. Spain). What remains clear is that for those locations where solid fuels are the predominant heating fuel in the domestic sector (e.g. Latvia, Poland), retrofitting will bring about a change in the fuel composition as well. Although technical, this measure involves in many cases incentivising change through economic or fiscal instruments (i.e. subventions) that encourage change among users. The level of enforcement of this measure has not been stated, so it is unclear whether solid fuel users would change on good will or as a result of a legal instrument. An additional related measure (applied in 51 AQM areas) is the implementation of district heating networks,

[167] The model is available for online consultations at IIASA. Accessible here.

which seek to substitute individual, single-house devices with communal equipment with higher capacities and efficiencies (and emission control). The third most popular measure throughout European AQM areas involves changing the fuel feedstock used at home for heating purposes. In most cases, changing the usual fuel feedstock will necessarily involve changing the equipment in which combustion takes place – for example, changing coal for natural gas means changing boilers as well. Without further details, this measure might presumably involve funding from public or private institutions for changing combustion equipment.

Table 9-2: Summary of measures for mitigating the use of solid fuels in the residential sector across EU Member States

Category of policy/measure	Concerned pollutants	Enforcing countries	Measures (code)	No. AQMa	Type(s)
Group of policies and actions controlling EQUIPMENT					
Incentives for the renovation of residential (domestic/communal) combustion equipment	PM_{10}	AT, BE, CZ, DK, ES, FR, HU, IT, LV, PL, RO	AT03, BE05, CZ01, DK02, ES01, ES02, FR03, HU02, IT01, LV01, PL02, RO01	90	A,B
Technical control of the emission levels of residential combustion equipment	NO_x, PM_{10}	BE, DK, EL	BE07, DK01, EL03	8	B
Technical certification of residential combustion equipment	NO_x	AT, DE, FR, PT	AT08, DE05, FR04, PT01, PT02	29	B
Incentives for the development of novel technologies for wood-burning equipment	PM_{10}	AT, DK, IT	AT07, DK03, IT04	5	A,B
Gradual migration from individual heating to district heating networks	PM_{10}	AT, BG, CZ, DE, HU, IT, LU, PL	AT02, BG01, CZ02, DE04, HU01, IT03, LU02, PL01	51	B
Adoption of regular maintenance programs for residential combustion equipment	PM_{10}	BE, FR	BE06, FR01	26	B
Adoption of legal instruments to control the emissions of residential equipment	PM_{10}	AT, BE, LV	AT01, AT05, AT09, BE02, LV02	32	D
Group of policies and actions controlling FUELS					
Change of usual fuel feedstock for residential Combustion	NO_x, PM_{10}	ES, EL, FR, MT, PL, RO	EL01, EL02, FR05, FR07, MT01, PL03, RO02	34	A,B
Technical standardization of fuel compositions and finishing	PM_{10}	BE, DE, LV	BE08, DE03, LV03	13	B
Ban on the use of solid fuels for residential Combustion	NO_x, PM_{10}	DE, IT, PL	DE01, IT02, PL04	25	B
Limitations in the chemical contents of fuel Feedstock	NO_x, PM_{10}	FR, LU	FR04, LU01, RO03	19	B
Group of policies and actions controlling USERS					
Awareness campaigns on efficient domestic consumption and fuels	NO_x, PM_{10}	AT, BE, BG, DK	AT06, BE01, BE03, BE07, BG02, DK04	30	C
Ban on open-air wood burning practices	NO_x, PM_{10}	AT, FR, HU	AT04, FR02, HU03	24	B
OTHER control policies and actions					
Increasing knowledge on emission sources and patterns	NO_x, PM_{10}	BE, DE, HU	BE04, DE02, HU04	4	B
Source apportionment studies on particulate matter (characterization)	PM_{10}	ES	ES03	1	B
Management practices for vegetal refuse and gardening waste	PM_{10}	FR	FR06	12	B
Establishment of atmospheric protected urban zones	PM_{10}	ES	ES04	2	B

9.6 Measures by reduction time scale.

Apart from the nature of measures under a decision-making point of view, these can also be classified in terms of the temporal horizon in which they occur. To this respect, Member States have labelled measures as short term (ST), medium term (MT) or long term (LT). Figure 9-4 illustrates the apportionment of measures according to their respective time scales, where it can be seen that most of them are intended to produce results in the long term. These actions are related to the substitution of traditional solid-fuel burning equipment (e.g. fireplaces) and in the implementation of correct maintenance and emission control procedures over the short term. In general, long term actions tend to focus on the development of infrastructure (e.g. new gas supply infrastructure) and on the assimilation of information and concepts by the general public.

Figure 9-4 : Share of measures by reduction time scale across Member States.

ST: short term, MT: medium term, LT: long term.

9.7 Detailed analysis of measure packs in four Member States.

For the purposes of this study, to determine if policy measures in Europe could be applied on an all-island basis, a detailed assessment of policy in France Germany, Italy and Spain was carried out.

Control strategies are classified according to their sector, device and target fuel (activity type), as can be seen in Table 9-3for the four studied Member States. Control strategies focus on technical measures that seek to renovate (New), improve (Improvement) or modify (Modification) the existing heating installations. Most of these measures are of an end-of-pipe nature and do not account for any contributions in the total abatement of emissions due to the non-technical part of the measure (e.g. the awareness of end-users on energy savings). As a consequence, any real abatement is likely to be higher than the figures given in this report. Additionally, the existence of some control strategies for a given set of fuels in any Member State clearly reflects usual fuel-mixes (e.g. the exclusive use of derived coal by Italy). Data are available for the three selected years, with the exception of two cases.

Table 9-3*: Availability of solid mineral fuel control strategies in the domestic sector for the studied Member States.*

Fuel	Device	Action	DE	ES	FR	IT
Wood	Fireplaces	Improvement	•••	•••	•••	•••
		New	•••	•••	-	•••
	Single House Boilers	Improvement	•••	•••	•••	•••
		New	•••	••	••	•••
		Pellets	-	-	-	•••
	Heating stoves	Improvement	•••	•••	•••	•••
		New	-	•••	•••	•••
		Pellets	-	-	-	•••
Brown Coal	Single House Boilers	Modification	•••	-	•••	-
		New	•••	-	-	-
	Heating stoves	Improvement	•••	•••	•••	•••
		New	-	•••	•••	•••
Derived Coal	Heating stoves	Improvement	-	-	-	•••
		New	-	-	-	•••
Hard Coal	Single House Boilers	Modification	•••	-	•••	•••
		New	•••	-	-	-
	Heating stoves	Improvement	•••	•••	•••	•••
		New	-	•••	-	•••

• Available in 2000, • Available in 2005, • Available in 2010.

9.8 Detailed analysis of relevant measures within the NSMC project.

Some of the Member State actions are of relevance in the policy making context for the NSMC project. These actions are of special interest because of their potential applicability and effectiveness within the regulatory framework under an all-island perspective.

9.8.1 Fuel bans.

The prohibition on the use of solid mineral fuels has been implemented to date in particular locations of four Member States: Germany, Italy, Poland and Spain. Although the modalities and features of these fuel bans change from country to country, in general this measure seeks to forbid the use of solid mineral fuels (especially coal) for domestic heating purposes and foster the transition to cleaner alternatives like natural gas. The implementation of these solid mineral fuel bans required a previous policy making process and the approval of a supporting regulatory framework.

9.8.1.1 Italy.

The prohibition of solid mineral fuels in Italy was effectively introduced as a measure titled: *"Ban on the use of fuel oil and other fuels in the civil ambit"*. In general, the measure focused on the establishment of new restrictions on the use of some fuels (especially solid mineral fuels) in combustion plants of the residential sector installed in municipalities and urban clusters labelled as "critical", and has been applied extensively by the regions of Lombardy and Piedmont.

The measure is circumscribed within a decree of the President of the Council of Ministers of March, 2002, which established the need to set out in law the characteristics of fuels that are relevant to air pollution as well as the technological characteristics of the combustion plants. The decree seeks to establish which fuels could be used in each type of combustion plant. Additionally, part of this decree (Articles 8 and 9) gave powers to the Italian Regions to ban the use of solid mineral fuels in heating plants that are not part of an industrial production cycle if it were necessary to meet air quality standards. Most of the provisions specified in this decree have been incorporated into the legislative decree n. 152/2006 which has been in force since 2010.

This decree prohibits the use of coal, coke and fuel oil in heating equipment that is not part of an industrial production cycle and/or power plants with a rated thermal input equal or greater than 3 MW. Any of these plants intended for civil use needs to obtain a special permit from the local competent authorities in order to continue operations using solid mineral fuels.

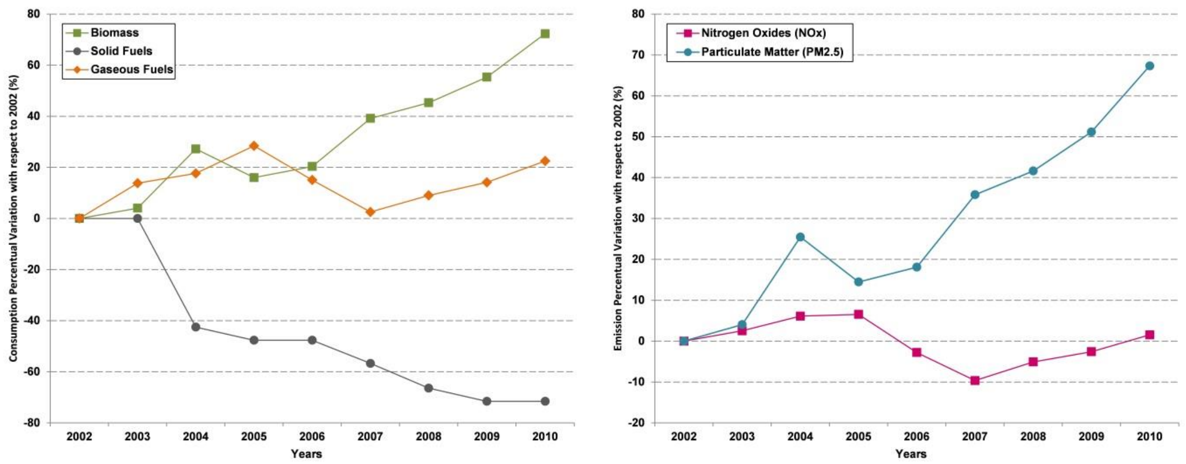

Figure 9-5 : Consumption of SF (left) and emissions of NO_x/$PM_{2.5}$ (right).

Domestic sector - Italy.

The effects of the ban on the use of solid mineral fuels have been evidenced by activity data in the National Italian Emission Inventory, where the use of coal and coke in the residential, commercial and institutional sectors decreased from approximately 700 TJ in 2002 to 125 TJ in 2012 (Figure 9-5). The most recent version of the Italian Energetic Balance[168] reports a net consumption of 4 kt of solid mineral fuels in the residential sector during 2012. Most of these reductions were produced by the dismantling of several communal plants in apartment buildings in cities like Rome, Milan and Turin. The alternative fuel that has replaced coal has been solid biomass (wood), whose use has not been limited at the national level and whose consumption has been increasing constantly in recent years. A proof of this is the sharp increase in the consumption of wood in 2010 with respect to the previous year (40%) and a more consistent increase in the latest two years (65%).

After the introduction of the coal ban a notable increase in the emissions of $PM_{2.5}$ (*ca.* 20% in comparison to 2002 levels) took place, which can be attributed to the immediate transition to biomass. Emissions of $PM_{2.5}$ continued to grow to reach almost a 70% increase on 2002 levels by 2010. These increases can be attributed almost exclusively to the use of wood due to the sizeable difference in emission factors for $PM_{2.5}$ (0.39 kt/PJ) when compared, for example, with those of natural gas (0.001 kt/PJ), that is there was very little increase in particulate emission due to any additional gas use. However, if gas had been used to replace coal rather than wood then emissions would have decreased.

9.8.1.2 Germany.

The German regulatory framework for emissions was first introduced in the year 1988, when the available technology for a cleaner combustion of fuels in the residential sector was still limited. As a consequence, a series of regulations have been implemented since year 2007 that condition the use of solid fuels in the residential sector to the existence of a monitoring and reporting routine for the installations that consume them (all of them with a rated thermal input of less than 1 MW). These limitations are described in the 1st Ordinance for the Implementation of the Federal Immission Control Act (1. Bundes-Immissionsschutzverordnung - BlmSchV), which sets the national emission LV for small combustion plants, regardless of their fuel. Specifically, the new regulations focus on controlling the emissions of carbon monoxide (CO) and particulate matter ($PM_{2.5}$ – representing 90% of the total particle mass). Additional regulations require owners to use dry wood in the form of pellets, after previous standardization and adhering to an energetic efficiency labelling programme ("Blue Angel"). Any installations that do not comply with the new regulations should be substituted within the stipulated transition period[169].

The fuel ban framework of Germany is not as consistent and widespread as that of Italy, basically due to its Federal administrative structure which gives each Land (autonomous region) the prerogative to determine independent environmental policies. To date, 20 cities in Germany have recently introduced ban practices on solid mineral fuels in the residential sector or are planning to do so. Among these cities are Freiburg, Mühlacker, Pfinztal, Walzbachtal, Munich, Berlin, Cologne, Langenfeld, Mönchengladbach, Münster, Mainz, Jena, Mühlhausen, Weimar, and the Ruhr area. Furthermore, some cities have adopted more stringent LVs than those contemplated by the BlmSchV (e.g. Aachen, Munich and Berlin).

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[168] Bilancio Energetico Nazionale. Accessible here.
[169] Behnke, A., 2007. Domestic heating – PM-Emissions and reduction measures in Germany. Dustconf 2007 International Conference. Maastricht, the Netherlands. April 23-24.

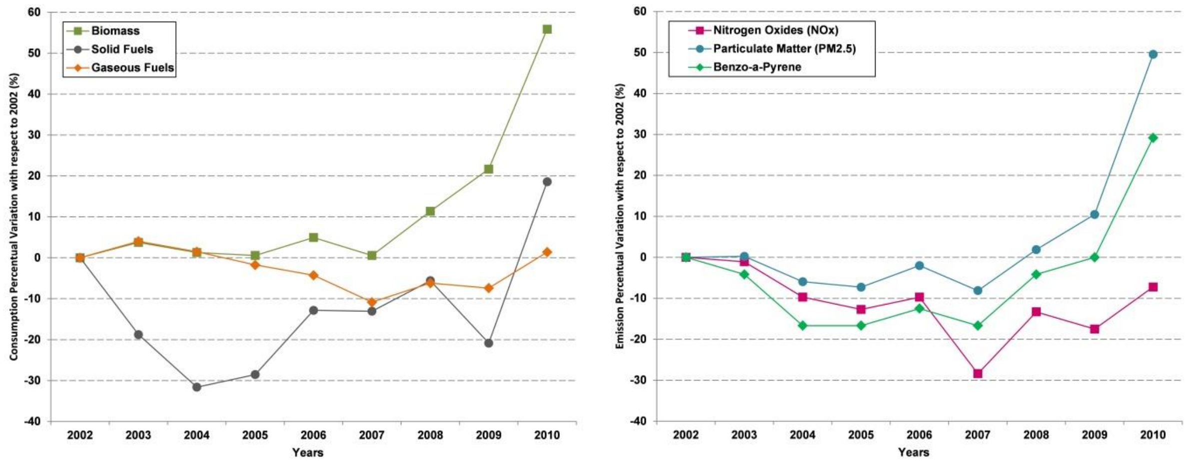


Figure 9-6 : Consumption of SF (left) and emissions of NO_x/$PM_{2.5}$ (right).

Domestic sector - Germany.

In this respect, it is worth noting that the oldest fuel ban in Germany dates to 2011, and because of this recent introduction, the effects of the measure are not evident in the emission trends shown in Figure 9-6. Although a decrease in the use of solid mineral fuels is witnessed in the first years of the study period (2002-2004), this trend reverts after that year and consistently increases until reaching 2010 with a net increase of 20% with respect to 2002. Conversely, a very dramatic increase in the use of biomass as fuel took place during the same period (reaching 55% in 2010). In Germany, the use of wood as a fuel in domestic heating appliances is of great importance due to high prices for fossil fuels such as natural gas and heating oil, which are inevitably imported. There are over 15 million fireplaces and stoves in Germany and emissions of particulate matter attributable to wood-fired heating installations are comparable to those from engines of cars, trucks and motorcycles on the national scale.

This is evidenced by the almost identical shape of the $PM_{2.5}$ emission trend and its wood consumption counterpart. A similar pattern is found for benzo[a]pyrene which is a compound emitted by both solid mineral fuel and biomass-burning devices. In general, it can be said that in the German case, the emissions of the domestic heating sector have increased and that the use of solid mineral fuels continues to be customary despite the fact that many AQM areas pledged to implement bans on their use.

9.8.1.3 Spain.

The case of Spain is very particular, when compared to that of Italy or Germany due to the fact that the use of solid mineral fuels in the residential sector is more or less marginal at the national scale (Table 9-1). For the past 30 years, the use of solid mineral fuels in Spain (basically brown and hard coal) was fostered by extensive public funding by the Spanish Ministry of Industry, Energy and Commerce, something that was particularly relevant for power generation, which produced about one fifth of the total power in 2012 from solid-fuel sources[170]. This funding aimed to continue developing the national coal mining industry, which is concentrated in the northern provinces of León, Asturias and in the region of Andorra de Aragón (province of Teruel). In these locations, the use of solid mineral fuels for residential heating continues to be much extended, as well as in other cities such as Ponferrada (León) or Puertollano (Castilla-La Mancha). The residual use of solid mineral fuels for domestic heating dramatically decreased since the onset of the latest economic crisis (2009), basically due to a decision of the Spanish Government to gradually reduce public subventions for solid mineral fuel use. This decrease had already been produced by an unfavourable policy towards solid mineral fuels taking place since the past mandate (2006-2012) following the National Emissions Ceiling Directive[171]. This Directive

[170] Club Español de la Energía (ENERCLUB). Accessible here.
[171] Instituto para la Reestructuración de la Minería del Carbón y Desarrollo de las Comarcas Mineras (IRMC), 2006. Plan Nacional de Reserva Estratégica de Carbón 2006-2012 y Nuevo Modelo de Desarrollo Integral y Sostenible de las Comarcas Mineras. Ministerio de Industria, Energía y Turismo. Available online.

limits the national emissions of air pollutants including sulphur dioxide. Spanish coal varieties are particularly rich in sulphur. Data are still unavailable on the residential fuel transitions that took place in the country but coal became more expensive than gaseous fuels.

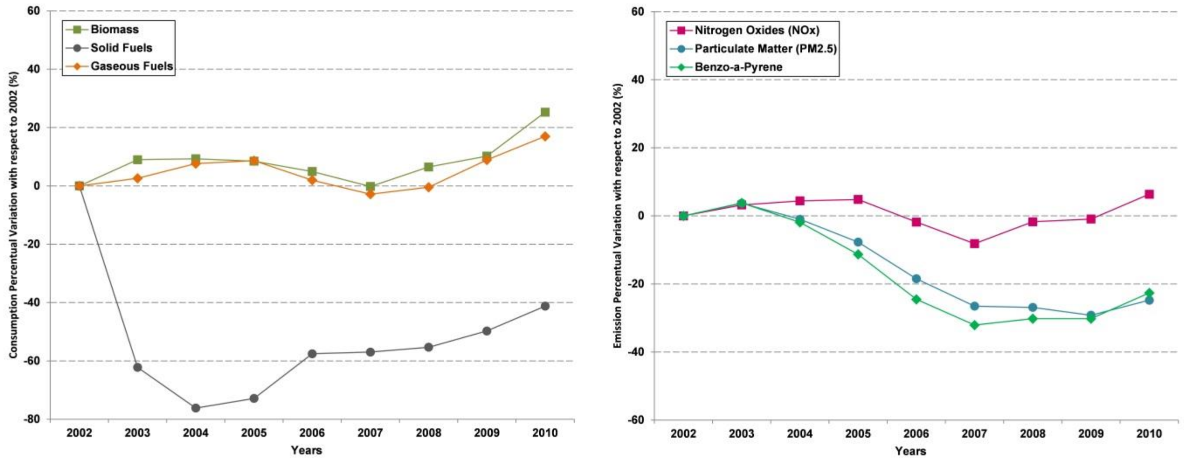
9.8.1.4 Poland

For the last 50 years, the city of Krakow and the surrounding region of Lesser Poland have had the reputation of being one of the most polluted regions in Europe (with 120 days above the PM_{10} limit value in 2012)[172]. The city itself is heavily affected by several phases of anthropogenic emissions and drastic changes of air quality[173]. Furthermore, the contribution of household heating to the total emissions of particulate matter (PM_{10}) was considerably higher than anywhere else in Europe (almost 42%), and strongly affecting the composition of particles in the region[174,175,176]. This is certainly in agreement with the per capita consumption values that are shown in Figure 9-2, in which Poland is the country with highest consumption and highest increases between 2002 and 2010.

As a consequence, in 2013 the Law on Environmental Protection of the Regional Parliament was passed, which explicitly defined the types and qualities of fuels allowed for heating purposes in the area. A transitional period of five years has been give since the approval of the law and its full enforcement to allow users to install new heating devices and to let coal mining companies plan their future stocks. The final approval of the law faced numerous obstacles, most of them related to the rise in heating costs and a potential decrease in coal mining and stove production. The main concern of the public was the need for a general substitution of heating equipment in the region.

In the interim, coal, wood and heavy fuel oil stoves will not be permissible in new buildings and residents with existing stoves will have to replace them with acceptable installations. In the future, Krakow expects to use gas, electricity or light fuel oil as energy sources for residential heating, and the local authorities have committed to fund the replacement of existing furnaces. In a parallel decision, the City Council adopted a subsidy programme to protect its poorest residents from the increased costs associated with cleaner fuels and the installation of new devices.

In general, this measure seeks to be a definitive step in improving the general air quality levels of the city and to comply with European legislation and time extensions. It is expected that the fuel ban in Krakow will be adopted by other cities in Poland with similar problems such as Gliwice or Katowice.



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[172] Krakowski Alarm Smogowy (KAS), 2013. The air in Krakow: problem, impacts, reasons, solutions. Krakow, Poland. Available online.
[173] Oudinet, J.P., Méline, J., Chełmicki, W., Sanak, M., Dutsch-Wicherek, M., Besancenot, J.P., Wicherek, S., Laferrière, B.J., Gilg, J.P., Geroyannis, H., Szczeklil, A., Krzemień, K., 2006. Towards a multidisciplinary and integrated strategy in the assessment of adverse health effects related to air pollution: The case study of Cracow (Poland) and asthma. Environmental Pollution 143 (2), 278-284.
[174] Viana, M., Kuhlbusch, T.A.J., Querol, X., Alastuey, A., Harrison, R.M., Hopke, P.K., Winiwarter, W., Vallius, M., Szidat, S., Prévôt, Hueglin, C., Bloemen, H., Wåhlin, P., Vecchi, R., Miranda, A.I., Kasper-Giebl, A., Maenhaut, W., Hitzenberger, R., 2008. Source apportionment of particulate matter in Europe: A review of methods and results. Journal of Aerosol Science 39, 827-849.
[175] Belis, C.A., Karagulian, F., Larsen, B.R., Hopke, P.K., 2009. Critical review and meta-analysis of ambient particulate matter source apportionment using receptor models in Europe. Atmospheric Environment 69, 94-108.
[176] Smolak, M., 2013. Ban on solid fuels in Kraków. Client Earth. Presentation of December 16th, 2013. Available online.

Figure 9-7 : Consumption of SF (left) and emissions of $NO_x/PM_{2.5}$ (right).

Domestic sector - France.

9.8.2 Transitions to cleaner fuels.

The term "transitions to cleaner fuels" describes a group of measures that basically aims to switch heating fuels from coal to more efficient alternatives such as natural gas, or low-carbon varieties such as biomass. Unlike the fuel bans, measures classified as transitions do not take place as a result of a prohibiting regulation but rather as the consequence of a series of fostering actions, most of them economic or fiscal. This section contains examples of measures that achieved transitions to cleaner fuels in two Member States: France and Spain.

9.8.2.1 France.

The general use of solid mineral fuels in France (not only in the domestic sector) has been gradually replaced by other alternatives, namely wood and natural gas. Coal mining activities in France ceased in 2004, and the state-owned coal company Charbonnages de France ceased to exist at the end of 2007. These facts rendered the use of solid mineral fuels an expensive and less-viable alternative, since future coal reserves would inevitably be imported. In Figure 9-7, a drop in the consumption of solid mineral fuels (60%) is observed the very first year, suggesting an effect comparable to that of the fuel ban in Italy[177] however consumption has risen in subsequent years.

This drop in consumption can be explained by the fact that solid mineral fuels ceased to be supplied from local sources, which in turn decreased demand. It should also be noted that in 2002 consumption of solid mineral fuel/coal in France was already quite low (6.09 PJ) compared to the consumption of gaseous fuels in that same year (278 PJ) so these changes are deemed marginal, although an overall decrease is nonetheless observed.

The aforementioned provided an adequate set of conditions to introduce the use of other fuels through a series of air quality plans at national, regional and local scale. The best-known plan applied by the National Government was the "Plan Particules", which in its domestic sector section contemplates a set of measures not intended to abate the emissions of solid mineral fuel boilers (practically absent in France) but to control that of wood-burning systems, which account for almost 40% of the national $PM_{2.5}$ emissions. Three types of concrete measures will aid the transition to be completed: (i) the conditioning of subvention and fiscal aids to those users that demonstrate an effective transition towards less PM-emitting equipment, (ii) the establishment of a series of regulations for domestic equipment (following the German example already discussed), and (iii) raising enough awareness among users of the high emissive nature of wood burning. Any changes in technologies will be coordinated by the national energy entity (ADEME – Agence de l'Environnement et de la Maitrisse de l'Energie).

The important contribution of wood in the national domestic fuel mix in France did not result in a sizeable reduction (about 20%) in the $PM_{2.5}$ emissions within the period between 2002 and 2010. This fact is further confirmed by the emission trend of benzo[a]pyrene. As for gaseous fuels (basically natural gas), these have not been the obvious alternative to solid mineral fuels or wood, since the increase is not substantial in the studied period.

9.8.2.2 Spain.

It has been made clear in the previous sections that the already-low consumption of solid mineral fuels in the residential sector in Spain experienced an important decrease due to the control measures undertaken to limit the sulphur content in fuels (e.g. coals) and to the suspension of public funding for the consumption of coal and the development of coal-mining regions. In order to accelerate the transition to cleaner fuels, local and regional authorities in almost every autonomous community of Spain offered

[177] Lahlou, S., 2013. National report on the French Energy regime. D13 from the BARENERGY project. EDF. Available online.

funding for switching from old communal, coal and diesel-burning boilers which were usually installed in apartment buildings, to natural gas single-house condensing boilers.

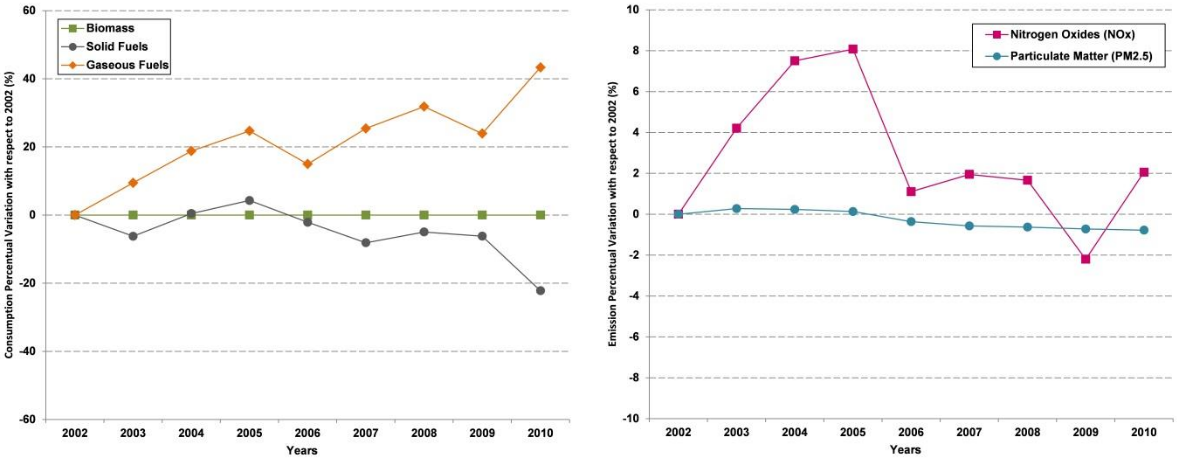

Figure 9-8 : Consumption of SF (left) and emissions of NO_x/$PM_{2.5}$ (right)

Domestic sector - Spain.

In the Autonomous Community of Madrid, a boiler renovation plan was implemented along with boiler manufacturers, trade unions and financial institutions ("Plan Renove de Calderas"). In the period between 2009 and 2012, 48,710 boilers were substituted using a total budget of 12.3 million euros (M€). This program achieved the almost-total decommission of coal-fired boilers in the region, remaining only around 200 of them.

The annual consumptions of fuels in the residential sector are depicted in Figure 9-8. As it can be seen from this figure, there is a clear favourable trend towards the use of gaseous fuels, whereas the consumption of biomass remains unchanged, suggesting a poor penetration in the national fuel mix. There is a clear decreasing trend in the use of solid fuels as well, which has been justified by the disinterest of the Spanish public administrations to continue funding due to compliance issues with the National Emission Ceilings Directive and the lack of financial resources caused by the current economic crisis. As a result, there is a low overall reduction in the emissions of $PM_{2.5}$, basically produced by the poor contribution of biomass use (highly emissive) and by the decreasing trend in the use of solid mineral fuels.

9.9 Policy efficiency and abatement costs.

In order to complement the analysis on the adequateness or viability of a given set of measures intended to mitigate the use of solid mineral fuels in the residential sector, a general outlook on the control abatement costs per Member State is given. Due to the fact that the total costs will depend heavily on the extent to which an activity is subject to a control measure, the analysis of the unit costs per activity levels is first addressed for all Member States that claimed to be implementing control policies on the consumption of solid mineral fuels in the domestic sector. Afterwards, a detailed analysis of the efficiency of the respective policy packs, as well as their associated abatement costs in the four chosen member states is given (France, Germany, Italy and Spain), including the use of biomass.

In every case, these unit costs per activity levels were taken from the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model of the International Institute of Applied Systems and Analysis (IIASA). The unit costs considered by GAINS represent end-of-pipe emission control measures that do not change activity levels (e.g. energy consumption) as well as structural measures (e.g. energy conservation) that deliver the same energy service with different inputs[178].

9.9.1 Policy efficiency and abatement costs in France.

The evaluation of the effectiveness of solid mineral fuel policy packs in France is depicted in Figure 9-9. As it can be seen, adopting control strategies clearly brings about a benefit in the emissions of $PM_{2.5}$ for each year, being especially high in 2000 (312 vs.16 kt/yr). Lower abatements were registered in 2005 and 2010, yet the difference between unabated and controlled emissions is sizeable. The total abatement costs of implementing these measures are high, accumulating over 1,056 M€ in the period of ten years that was studied. A breakdown of the controlled emissions and the abatement costs by equipment and fuel type is shown in Figure 9-9.

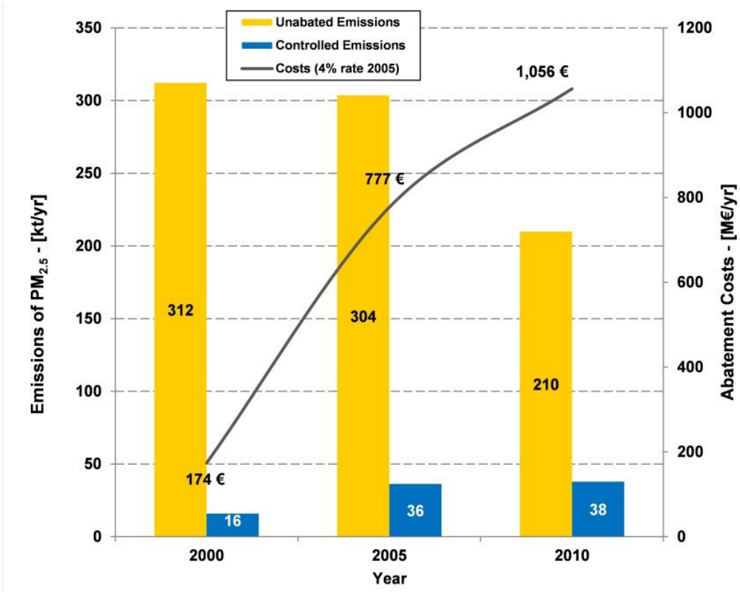

Figure 9-9 : Emissions reduction in the domestic sector due to solid-fuel and costs. France

The increase in controlled emissions that is noticed from 2000 to 2010 is caused by an increase in the use of controlled heating stoves. In general, most of the costs will be allocated to control heating stoves (either through their improvement or substitution), most of which will naturally be fuelled with biomass as well, summing up to 993 M€ in the ten year period. Slight increases were observed in the use of coal, whose almost negligible use led to a marginal increase in costs.

9.9.2 Policy efficiency and abatement costs in Germany.

The case of Germany differs from the previous French case in that the emissions of $PM_{2.5}$ are initially lower, so the net abatement is lower too (40 vs. 12 kt/yr in 2000) as shown in Figure 9-10. As a consequence, the total costs in the ten year period equal 403 M€ and attaining total abatement rates of 66%, suggesting an overall improvement in the contribution of solid mineral fuels in the domestic sector. The breakdown of emissions according to equipment type and fuels is presented for Germany in Figure 9-10.

[178] Amann, M., Bertok, I., Borken-Kleefeld, J., Cofala, J., Heyes, C., Höglund-Isaksson, L., Klimont, Z., Nguyen, B., Posch, M., Rafaj, P., Sandler, R., Schöpp, W., Wagner, F., Winiwarter, W., 2011. Cost-effective control of air quality and greenhouse gases in Europe: Modeling and policy applications. Environmental Modelling & Software 26, 1489-1501.

Between one third and half of the measures concentrated on changes to single-house boilers, followed by heating stoves. Most of the emissions under control focus on wood (401 M€ - 99% of the total abatement costs), whose sharp rise is responsible for most of the $PM_{2.5}$ related emissions. Abatement costs for solid mineral fuels (hard and brown coal) are very low, which suggest that such fuels are a minor part of the national energy mix in the domestic heating sector.

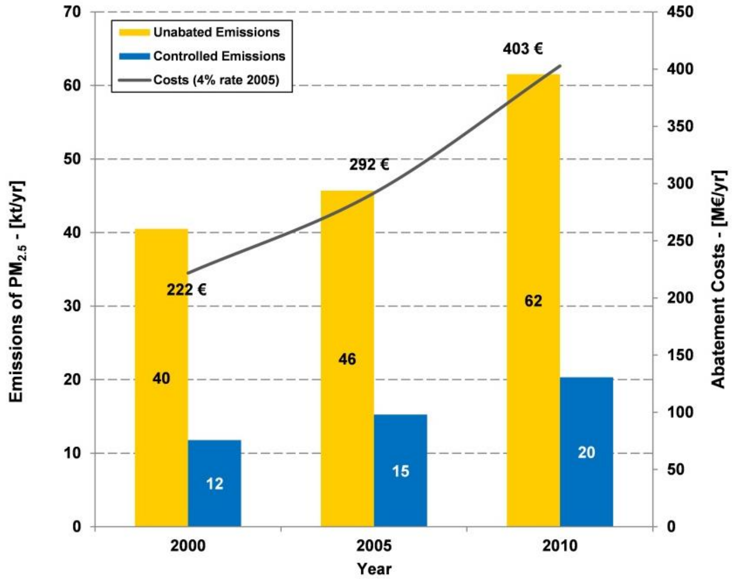

Figure 9-10 : Emissions reduction in the domestic sector due to solid mineral fuel and costs. Germany

9.9.3 Policy efficiency and abatement costs in Italy.

In Italy an 85% of reduction in $PM_{2.5}$ emission is indicated through the studied policy packs in 2010 with a total cost of 547 M€. The comparison of unabated and controlled emissions, as well as costs for Italy are presented in Figure 9-11. Like the previous two examples, most of the control costs are on measures affecting the consumption of wood, whose costs in Italy (and in the rest of the studied countries) is quite high: 19.88 €/GJ for heating stoves. This figure is particularly relevant because most of the control policies in Italy are focused on heating stoves. The sharp rise in emissions observed from 2002-2010 is produced by the consistent increase in the consumption of wood in Italy[179].

[179] D'Elia, I. and Peschi, E., 2013. Lo scenario emissivo nazionale nella negoziazione internazionale. Agenzia Nazionale per le Nuove Technologie, l'Energia e lo Sviluppo Economico Sostenible (ENEA). RT/2013/10/ENEA. Rome, Italy.

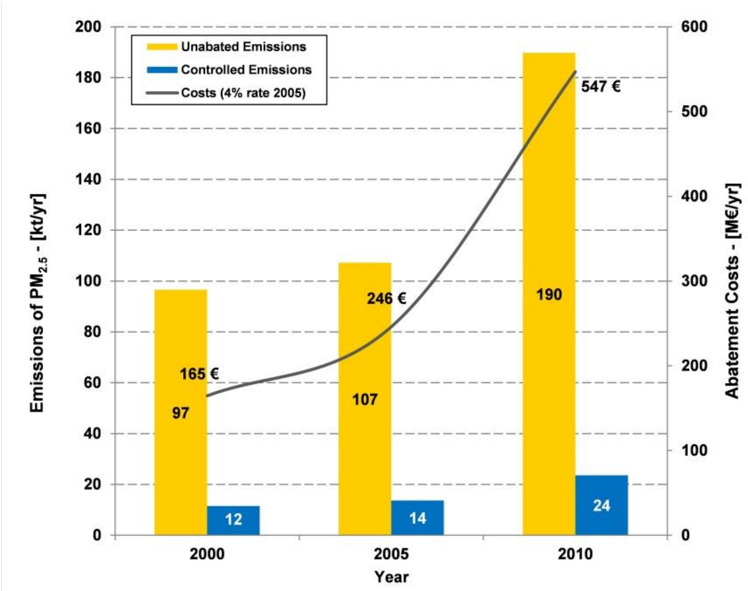

Figure 9-11 : Emissions reduction in the domestic sector due to solid fuel and costs. Italy

9.9.4 Policy efficiency and abatement costs in Spain.

The Spanish case is the least costly of the four cases, due to the fact that the consumption of solid mineral fuels in the residential sector was already very low. The net emission reductions are as high as 96% in 2010, but the costs (due to the already-low consumptions) are kept down: 114 M€ (Figure 9-12). The breakdown of the controlled emissions shows that actions were concentrated on single-house boilers and heating stoves, while the main fuel that is being regulated in this case is wood (as with the rest of the Member States). Almost all control measure spend were applied to measures addressing switch to biomass with the single-house boilers and heating stoves account for 85% of the total control.

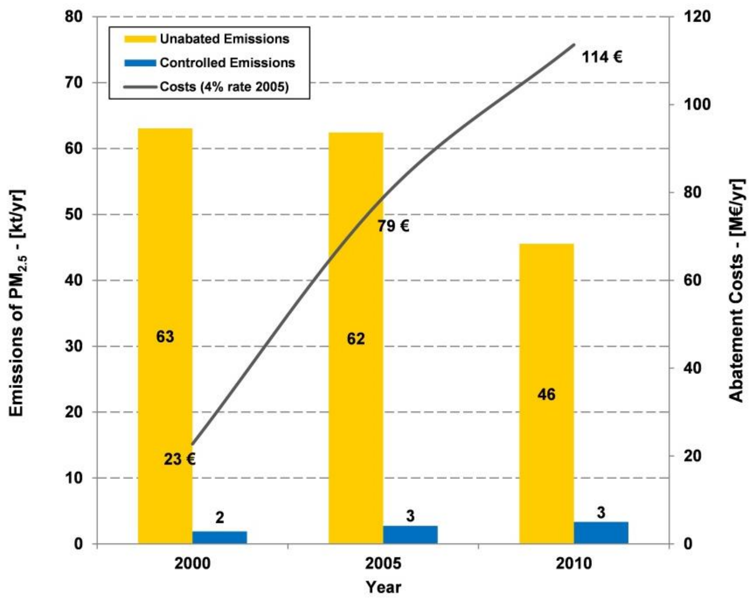

Figure 9-12 : Emissions reduction in the domestic sector due to solid mineral fuel and costs Spain

9.10 Summary

The analysis focused on the effectiveness of the claimed policy packs in the control of $PM_{2.5}$ emissions and the associated abatement costs. In general, it was clearly evidenced that the respective policy packs resulted in an improvement in air quality. However, it should be clearly noted that control costs were computed exclusively for the use of solid mineral fuels and biomass, yet no costs related to the transition from these fuels to gaseous options (natural gas, LPG) were able to be considered. Most of the studied Member States (except Spain) show a predominant use of wood as the substitution fuel. This was seen by stakeholders as an attractive fuel alternative that also tackles climate change.

After the introduction of the coal ban in Italy, a notable increase in the emissions of $PM_{2.5}$ (*ca.* 20% in comparison to 2002 levels) took place, which can be attributed to the immediate transition to biomass. Emissions of $PM_{2.5}$ continued to grow to reach almost a 70% increase on 2002 levels by 2010. These increases can be attributed almost exclusively to the use of wood due to the sizeable difference in emission factors for $PM_{2.5}$ (0.39 kt/PJ) when compared, for example, with those of natural gas (0.001 kt/PJ), that is the increase in particulate emission was entirely due to additional biomass use. However, if gas had been an option to replace coal rather than wood then emissions would have decreased.

In Germany, there have been localised bans on use of solid mineral fuels but the impacts are not evident in national energy data or $PM_{2.5}$ emissions, which have increased as biomass and solid mineral fuel use has grown.

In Poland, the solid mineral fuel ban had not been in effect during the study period but it is notable that wood is not being adopted as a replacement fuel, that there is a transition period and, a commitment from the local government to support equipment replacement to ensure effective implementation of the fuel ban.

10 Policy Measures and Consultation

Box 9: Summary of Section 10

Clean air policy is typically wide in scope and often involves a range of measures to ensure efficient emission reduction and public health improvements whilst minimising fuel poverty. It is clear from the evidence presented in this report that a range of measures is likely to be most effective in improving public health, for example a smoky coal ban/smoke control area is implemented alongside policies on energy efficiency, fiscal measures to promote the uptake of low emission fuels supplemented by information, communication and profile raising of the issue.

10.1 Introduction

Current policy and measures to reduce emissions from solid fuel burning have been shown to be effective where they have been implemented, both in Smoke Control Areas in Northern Ireland and in the smoky coal ban areas in Ireland.

However, it is clear that in some areas, exceedances of Target Values and Daily Alert Values occur in Northern Ireland and exceedances of the WHO guideline values occur in both Ireland and Northern Ireland. The EPA has found evidence that air pollution in smaller urban areas outside smoky coal bans is higher than in larger cities where SCBs apply.

There is now very strong evidence that particulates and other pollutants, even at low levels, are damaging to human health and are disproportionately emitted from solid fuel combustion. There is therefore a need to establish whether the current policy mix of instruments is fit for purpose and to re-examine additional measures and policies that could assist in reducing these emissions.

The preceding chapters in this report presented an evidence base to describe the issue. In order to inform policy making this chapter sets out a range of the available policy measures to reduce emissions from residential fuel combustion, and then presents (i) the findings of a consultation undertaken to seek views from key stakeholders, and (ii) and an analysis of the evidence base and potential future measures with promise.

To establish the most appropriate measures an understanding of the criteria to assess them is required. Access to information is needed to estimate:

a) a means of monitoring progress;
b) funding allocated to each measure (Euros/£ per year);
c) total estimated costs (Euro/£);
d) the reduction potential from implementation date to the end policy assessment date.

The criteria to judge the success of a measure include

a) Effectiveness of the measure to reduce emissions
b) The ease of implementation, which impacts of the timescale and cost for the delivery of the measure
c) Resource requirements which impact on the cost of the measure
d) Impacts on other fuels markets, supply and wider industry and also fuel poverty across both jurisdictions.

Effectiveness: the impact that a measure is able to deliver to improve air quality can be estimated using dispersion modelling prior to implementation. This does rely on the availability of robust emissions data and monitoring data.

Ease of implementation: characteristics are: *Applicability*: a measure should contribute towards the strategic objectives to improve air quality and have the capacity to address non compliances (e.g. could it reduce particulate matter if particulate matter exceedance is the problem?); *Appropriateness*: effective measures are balanced and provide overall benefit in both environmental and economic terms; *Attractiveness:* (acceptability to the public) - competent authorities usually prepare an environmental and economic case for the measure, and associated public information, in sufficient detail that the effectiveness of the measure and its health and other benefits can be seen to justify any costs of the measure; *Affordability:* appropriate budgets need to be available for the measures to be implemented; and *Achievability*: key implementation issues including enforcement powers and other practical considerations are understood and in place.

Resource requirements: evidence-based characteristics that might be used to assess the resource requirements and the critical path of measures include whether it is clear: Who/which organisation is responsible for initiating the measure, for delegating actions to others and for terminating the actions; What the actions are that need to be taken to reduce emissions or to provide information and recommendations; When the actions will be initiated or terminated (for example when measured or forecast concentrations exceed information or alert values); Where will the measures be applied; and why the measures are needed (e.g. to provide the public with information; to reduce emissions etc.)

Impacts: on fuel market, supply, fuel industry, fuel poverty.
The sorts of evidence that is needed for assessing the more promising measures include:

1. Source apportionments that are sufficient for directing a measure where it is most required, e.g. if highest contributions to air quality pollutant levels are fromparticular fuels or technologies, then most first stage measures should be targeting emission reduction from this source?
2. Descriptions of the extent to which a measure can be applied – and whether the measure is likely to encounter any legal and acceptability barriers. For example, if particular fuels are to be banned then appropriate supply of substitute fuel should be available in the marketplace.
3. Information related to the transferability of a measure – whether it was found to be transferable over a wide spatial scale; transferability depends on neighbouring and wider geographical area but also on the temporal dimension of the measure. In particular, the fuel market would need to be sufficiently adaptable to deliver if the measure is to reach a wide spatial area.
4. Measures of cost effectiveness – and how commercially viable the measure is; the operating life of a measure within a sector will influence costs as well as overall effectiveness. Understanding of how the measure would impact on the cost of the fuel market and industry is required to predict the impact on fuel price and any consequence to fuel poverty.
5. Indications of whether the effect of the measure can be (and have been) monitored. For example, has an actual impact of the measure been found on air quality - has there been a % emission reduction of pollutant and/or reduction in ambient air concentration (the % reduction required to meet a limit value).
6. The overall environmental and social acceptability of the measures is understood, and the measure should not exacerbate social inequality (e.g. the measure should not increase fuel poverty)

10.2 Policy and Measures with potential for Ireland and Northern Ireland

A recent WHO report[180] identified coal and wood as an important source of ambient (outdoor) air pollution, which can also cause substantial indoor air pollution through either direct exposure or infiltration from outside, and is linked to serious health effects such as respiratory and cardiovascular mortality and morbidity. The report indicates the following policy options for control of solid fuel in Europe and North America:

- Emission limits, typically on PM but also efficiency and other pollutants :
  Regulatory
  Voluntary certification

[180] Chafe, Z et al Residential Heating with wood and coal : Health Impacts and policy options in Europe and North America, WHO, 2015, ISBN 978 92 890 50760

- Fuel Switching to cleaner fuels. The report cites schemes for changing from older appliances to cleaner, more efficient appliances
- 'No burn' days, temporary mandatory or voluntary restrictions triggered by poor air quality – may be in defined areas :
  Regulatory
  Voluntary
- Scrappage schemes, or regulations to remove or make inoperable inefficient, 'dirty' heaters on the sale of a house with limits on types of replacement device that can be used
- Incentives
- Education

There are a variety of policy measures that can be implemented to give effect to a shift from the use of high emission solid fuel whilst also limiting reliance on non-renewable energy sources and improving energy efficiency. Some of these have already been implemented or are scheduled for introduction by both Ireland and Northern Ireland, whilst some are still to be explored.

10.2.1 Regulatory framework development

10.2.1.1 Gaps and knowledge networks

Clean air legislation derived from EU Air Quality Directives is implemented in both Ireland and Northern Ireland. However, Ireland and Northern Ireland have long-established but different legislative instruments to mitigate public health impacts from use of solid fuels – the smoky coal ban areas in Ireland and measures including powers to create smoke control areas in Northern Ireland. In both Ireland and Northern Ireland, the main legislative provisions in relation to the regulation of emissions from residential solid fuel use are implemented by the local authorities.

There may be opportunities to improve legislation for example to address anomalies or gaps in the legislation which limit implementation or effectiveness. Other non-legislative actions may improve implementation.

For example, in both jurisdictions, networks of local authorities exist to promote consistent national and regional implementation and enforcement. In Ireland, the Local Authority Implementation Group (LAIG) was established with the aim of facilitating and enhancing implementation and enforcement activities by local authorities and the EPA. It generally meets twice per year to provide a forum exchange of information and intelligence. In Northern Ireland a similar network, the Pollution Group (a sub-group of the Chief Environmental Health Officers Group of district councils), meets regularly to promote better enforcement of a range of environment legislation.

Many of the enforcement staff in both jurisdictions are members of the Environmental Health Association of Ireland, an all island body set up to educate, advise and promote awareness of environmental health issues among the public and professionals. Consideration could be given to establishing liaison between the two groups to provide for an exchange of information regarding the relevant legislation to improve implementation and enforcement with a view to promoting better environmental and health outcomes.

10.2.2 Regulatory framework: different approaches and technical standards

The respective approaches to address residential emissions in the respective jurisdictions have evolved over different timeframes and were influenced by a range of specific national and regional circumstances. The respective approaches share the same general approaches but also have important differences for example in relation to geographic scope, range of fuels addressed, the estimation methodologies applied and the technical standards applied.

For example, the smoke emission rate applying to Authorised fuels in SCAs is 5 grams/hr, whereas the corresponding rate is 10 grams/hr in SCBs which,applies only to manufactured fuels containing bituminous (smoky) coal. On the other hand, the maximum sulphur content of bituminous (smoky) coal in Ireland is 0.7% whereas the corresponding figure in Northern Ireland is 2% as is the case for manufactured solid fuels in both jurisdictions.

Consideration could be given to examining the different approaches in the respective jurisdictions to assess their relative merits and technical standards

10.2.3 Encouraging Fuel Switching

10.2.3.1 Access to natural gas network

The expansion of the natural gas networks can provide access to cleaner burning fuel in areas that would typically be reliant on solid fuels. In Ireland and Northern Ireland the gas grid could be extended more widely to smaller population centres and those currently off the network. In addition this would widen the potential for the transmission of some renewable fuels, such as bio-gas, via the gas network. Due to the shared border between Northern Ireland and Ireland it may be possible to extend the cross border gas network, providing easier access to the more remote regions in each area. Such extensions have to be economic otherwise the network costs will push the final retail gas tariff higher than consumers will find acceptable, so switching from oil or coal may not happen.

10.2.3.2 Fuel type restrictions

Arguably the most effective and administratively straightforward means for the transition from high emissions residential solid fuels has been the prevention of the combustion of 'smoky coal' through the implementation and enforcement of Smoky Coal Bans in Ireland and the prevention of the combustion of smoky fuels in general (including 'smoky coal', wood and peat etc.) in Smoke Control Areas in Northern Ireland. At present 27 cities and towns in Ireland and 16 Local Authorities in Northern Ireland are subject to these regulations, and pollutant levels suggest that their implementation and enforcement can have a marked effect. Therefore the expansion of the areas covered by these bans is likely to further this improvement, whilst also limiting the potential for consumers to purchase 'smoky coal' in adjacent areas that are exempt from the bans.

The NPL report considered a range of scenarios to address residential PAH emissions in Northern Ireland, and included a cost benefit analysis of introducing a Northern Ireland-wide smoke control area. The report concluded that this would not be cost effective but recommended that (i) smoke control areas ought to be effectively enforced and that (ii) the areas covered by smoke control legislation should be examined further.

The Environmental Protection Agency has had similar considerations in Ireland to address the problem of air pollution from home heating, particularly in smaller urban areas. The EPA[181] is supportive of longer term progress towards a nationwide ban on coal for residential heating, in line with the WHO approach, and recommended consultation with the authorities in Northern Ireland to investigate the possibilities of developing an all-island policy on residential emissions given the related issues arising.

Further consideration could be given to assessing the relative merits of the different approaches in the respective jurisdictions and potential synergies that might arise to facilitate a wider transition to cleaner residential fuels, including for example measures for more practicable and effective implementation and enforcement. A particular benefit for low income households may be a less costly transition to cleaner fuels because householders may be able to retain existing heating equipment and be in a position to purchase fuel on an 'as needed' basis.

10.2.3.3 Fuel Pricing

Tax incentives may be used as a driver to encourage homeowners to opt for cleaner liquid or gas fuels, or alternatively take advantage of grants for the installation of renewable energy sources, such as those imposed by the Solid Fuel Carbon Tax Regulations in Ireland.

There are solid fuel products emerging onto the residential fuel market which blend mineral (fossil) fuels with biomass to produce lower carbon, 'low smoke' solid fuels. Under the current arrangements for the Solid Fuel Carbon Tax in Ireland, these products pay the same rate of carbon tax as traditional solid fossil fuels. Relief from the carbon tax of the biomass element of these 'low smoke' fuels could help to promote these fuels which would lead to a reduction of air pollution, where higher emission fuels are displaced. Consideration could be given to introducing carbon tax relief for low smoke biomass blended fuels.

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[181] EPA submission on Delivering Cleaner Air consultation.
http://www.environ.ie/en/Publications/Environment/Atmosphere/FileDownLoad,29914,en.pdf

10.2.4 Fuel Efficiency

Fuel efficiency provides benefits for carbon emission targets as well as air quality. There are also benefits to the home owner or tenant from reduced expenditure on fuel. The refurbishment of existing housing stocks and the use of building regulations to ensure new-builds and potentially existing buildings meet high energy efficiency standards can provide both a reduction in GHG emissions and limit the need for domestic heating through the minimisation of potential heat loss. Methods of improving the energy efficiency of homes include:

- Insulation, including solid wall, cavity wall or loft insulation;
- Draught proofing; and
- Double/triple glazing.

Community schemes such as combined heat and power (CHP) / district heating programmes or geothermal schemes can also provide effective alternatives to the household consumption of solid fuel.

Both the UK (NI) and Ireland Governments have taken strides to address the issue of energy efficiency in homes through a number of policies and incentives, including:

1) UK
   a) **The Green Deal**, which was launched in autumn 2012. The scheme is financed by the private sector and allows homeowners to undertake refurbishments with no up-front costs. However the scheme is only available to households in England, Scotland and Wales, therefore excluding Northern Ireland.
   Proposals for a derivative of this scheme – "the green new deal" was previously developed for Northern Ireland but subsequently not supported by the Executive.

2) Ireland
   a) The Better Energy Homes scheme, which was launched in May 2011 and provides grants to homeowners for the installation of the following:
      i) Roof insulation;
      ii) Wall insulation;
      iii) Boiler and heating control upgrades; and
      iv) Solar panels.
      v) The grants are only applicable to homes built prior to 2006 and in contrast to the RHPP grants must be approved prior to works commencing[182].

   b) The Better Energy Warmer Homes Scheme (BEWH), which is administered by the Sustainable Energy Authority of Ireland (SEAI) and provides funding specifically for at-risk groups, including the elderly and vulnerable, to improve the energy efficiency of their homes. The properties must be occupier owned non-Local Authority and have been constructed prior to 2006. Measures include the following and are provided at no cost to the household[183]:
      i) Attic insulation;
      ii) Draught proofing;
      iii) Lagging jackets;
      iv) Low energy light bulbs;
      v) Cavity wall insulation; and
      vi) Energy advice.

[182] http://www.seai.ie/Grants/Better_energy_homes/
[183] http://www.seai.ie/Grants/Warmer_Homes_Scheme/About_the_BEWH.html

10.2.5 Reduce Energy Demand

10.2.5.1 Fuel poverty strategies

There are a number of ways to define the term 'fuel poverty', including as a percentage, where a household is deemed to be fuel-poor if more than 10% of its income is spent on fuel to maintain suitable heating levels, or within the context of the poverty line, where a household is seen to be in fuel poverty if it is pushed below the poverty line in order to pay for energy[184].

Schemes to address those households in or at risk of fuel poverty have been established in both Ireland and Northern Ireland. These typically involve grants for those that meet the criteria, which can be spent on improvements to the home to improve energy efficiency. Those currently available include:

1) Northern Ireland
   a) The Warm Home Discount Scheme, which is provided by the Department for Social Development and offers a £140 discount on electricity bills to eligible applicants[185].

2) Ireland
   a) The Better Energy Warmer Homes**[186]** scheme delivers a range of energy efficiency measures to low income households who meet defined eligibility criteria and who are vulnerable to energy poverty. The scheme is managed by the SEAI and delivered through a range of Community Based Organisations (CBOs), augmented by a panel of private contractors in order to ensure national coverage. Recipients of the scheme do not receive grants but have measures installed free of charge. Homeowners register their interest in the scheme and are placed on the SEAI waiting list. Since the commencement of the scheme in 2000, over 105,000 homes around the country have received energy efficiency measures under the Warmer Homes scheme, with a total spend of over €116 million.

10.2.5.2 Smart metering

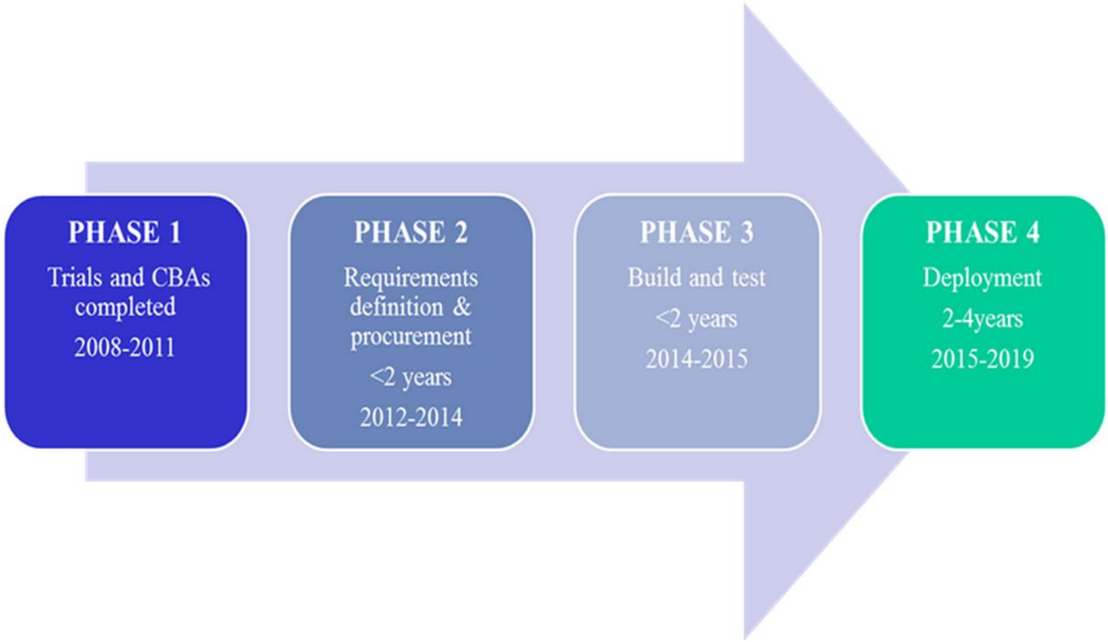
Smart meters are a state-of-the-art alternative to the electro-mechanical and diaphragm meters, which provide up-to-date data on the usage of gas and/or electricity to the user and provider whilst allowing bi-directional communication between the supplier and consumer. This allows the consumer to be fully aware of their usage and the associated costs, encouraging a reduction in consumption thus improving energy efficiency. Discretionary energy usage can also be moved away from peak periods during the day, reducing the overall energy bills and allowing for the Peak Flow Management of electricity use.

Smart meters have been embraced by numerous countries within the EU and both Northern Ireland and Ireland are making headway in establishing their use.

In Ireland the Smart Metering Programme Phase 1 was established by the Commission for Energy Regulation (CER) in late 2007 with the aim of rolling out a universal National Smart Metering Programme. Between 2008 and 2011 a number of smart-metering trials were run for residential and small-to-medium (SME) business consumers and a cost-benefit analysis for the national rollout completed, the findings of which were published by CER in 2011[187]. CER are currently undertaking stakeholder engagement and consultation with the aim of establishing a smart meter solution, under Phase 2. Full deployment has been planned for between 2015 and 2019 under Phase 4 (see Figure 10-1)[188].

[184] https://www.gov.uk/government/collections/fuel-poverty-statistics
[185] https://www.gov.uk/the-warm-home-discount-scheme
[186] http://www.dcenr.gov.ie/Energy/Energy+Efficiency+and+Affordability+Division/Better+Energy.htm
[187] http://www.dcenr.gov.ie/NR/rdonlyres/B18E125F-66B1-4715-9B72-70F0284AEE42/0/2013_0206_NEEAP_PublishedversionforWeb.pdf
[188] http://www.cer.ie/electricity-gas/smart-metering

Figure 10-1: Deployment phases of smart metering in Ireland



Similarly the objective in the UK is for all homes and small businesses to be fitted with smart meters by 2020, with energy suppliers required to take all reasonable steps to install them. All homes fitted with a smart meter will have the option on an in-home display (IHD) allowing the residents to monitor their energy consumption and the cost of their electricity and gas. It is anticipated most smart meters will be fitted between 2015 and 2020 with the programme hoped to provide £6.2 billion net benefits to the UK[189].

Once smart metering has been rolled out throughout Ireland and Northern Ireland homeowners will have greater control over their energy consumption. However it is important to note that the meters only monitor consumption of electricity and natural gas. Therefore measures to ensure homeowners do not opt for hard fuels in order to minimise their 'monitored' energy use must also be considered.

10.2.6 Ecodesign Regulation - Emissions standard for solid fuel boilers and stoves

As set out in section 3.7 the EU has developed new regulations which set ambitious emissions standards for residential solid fuel boilers and stoves. The regulations were established under the single market provision of the TFEU so the emissions standards will provide commons standards for such products for sale across the EU from 2022. However, Member States may introduce the Ecodesign standards ahead of 2022 if they wish, and some MSs have already achieved these standards.

The Ecodesign standards will provide a measure of regulation of emissions from such products in Ireland where currently no national legislative emission standards apply.

Consideration could be given to introducing the Ecodesign standards in advance of 2022.

10.2.7 Sources of renewable energy

Advances in technology have made it possible for residential homes to be retrofitted with renewable sources of energy, allowing residents to benefit directly whilst also lessening the burden on national energy consumption. Such technologies include:

- Solar panels;
- Heat pumps;
- Small scale wind turbines[190] and;

[189] https://www.gov.uk/government/policies/helping-households-to-cut-their-energy-bills/supporting-pages/smart-meters
[190] https://www.gov.uk/green-deal-energy-saving-measures/overview

- Biomass boilers

Schemes to educate homeowners on the potential for renewable technologies and provide financial incentives to encourage their uptake within the housing market have already been introduced in both Northern Ireland and Ireland, including:

1) Northern Ireland:
   a) Feed-in Tariffs, which allow homeowners to generate their own electricity through the use of small-scale renewables, which can either be used by the home-owner or sold back to the energy supplier[191] at a premium rate.

   b) Renewable Heat Incentive Northern Ireland (RHI), the first phase of which provides financial support for the installation of renewable heat technologies at non-domestic premises, including small businesses, hospitals, schools and district heating schemes. Financial support is provided for the lifetime of the installation, up to a maximum of 20 years, and is applicable to the technologies listed in the Department of Enterprise, Trade and Investment (DETI) also recent launched support for domestic properties.

Table 10-1: Technology tariffs under the Northern Ireland RHI

Technology	Size range	NI RHI tariff (pence per kWh)	Length of tariff
Biogas injection	Biomethane all scales, biogas combustion less than 200kWth	3.2	20 years
Biomass boilers	Less than 20kWth	6.6	20 years
	20kWth and above, up to but not including 100kWth	6.3	20 years
	100kWth and above, up to but not including 1000kWth	1.5	20 years
Ground source heat pump	Less than 20kWth	8.9	20 years
	20kWth and above, up to but not including 100kWth	4.5	20 years
	100kWth and above	1.5	20 years
Solar thermal	Below 200kWth	9.0	20 years

   c) The Renewable Heat Premium Payment (RHPP) scheme which is provided by the Department of Enterprise, Trade and Investment (DETI) in Northern Ireland and offers a similar service to the RHI. RHPP is designed to enable the heating of homes by renewable sources, and is solely available to domestic properties in Northern Ireland. The programme allows residents to apply for a voucher once one of the designated renewable technologies has been fitted to their property, which can then be exchanged for grant money[192]. RHPP recipients are being transferred across to RHI since the scheme was opened to domestic properties from 15 December 2014. The technologies and applicable value of the grants are illustrated in Table 10-2.

[191] https://www.gov.uk/feed-in-tariffs
[192] http://www.nidirect.gov.uk/renewable-heat-premium-payment-rhpp.htm

Table 10-2: Technologies and grants available under the RHPP scheme in Northern Ireland

Technology	Voucher value (£)
Air source heat pumps	1,700
Biomass boiler	2,500
Ground source or water source heat pump	3,500
Solar thermal hot water	320

2) Ireland
   a) Better Energy Homes is a government scheme that provides a financial incentive to private homeowners who wish to improve the energy performance of their homes. Fixed grants are provided towards the cost of a range of measures including attic insulation, wall insulation, heating systems upgrades, solar thermal panels and accompanying BER. Better Energy Homes is a demand-led programme. Since commencement in March 2009 to end March 2014, the scheme has delivered energy efficiency measures to over 156,000 homes, supported by grants of over €163million.

10.2.8 Scrappage schemes

Schemes to encourage the replacement of old, less efficient boilers have been introduced in both regions, under the 'Grant to replace your boiler' scheme in Northern Ireland[193] and under the 'Better Energy Homes' programme in Ireland[194].

Under the 'Grant to replace your boiler' initiative homeowners can apply for a grant of up to £1,000 for a new boiler if the household income is below £40,000 and their current boiler is older than 15 years. The criteria for the grant payable are listed in Table 10-3.

Table 10-3: Amount of grant payable under the 'Grant to replace your boiler' scheme in Northern Ireland

Household income	Grant	Amount of the grant if control measures are installed
<£20,000	£700	£1,000
£20,000 - £40,000	£400	£500

The grants can be used for the following:

- The replacement of an inefficient boiler with a condensing oil or gas boiler;
- A switch from an oil to a gas boiler; or
- A switch to a wood-pellet boiler.

However grants are not applicable for the following appliance categories:

- Economy 7 heating;
- Stoves used exclusively for cooking;
- Back boilers; or
- Room heaters.

Similarly under the 'Better Energy Homes' scheme a grant of €560 is available for the upgrade of a homeowners' heating control system with a gas or oil boiler.

193 http://www.nidirect.gov.uk/grant-to-replace-your-boiler
194 http://www.seai.ie/Power_of_One/Heat_Your_Home_For_Less/Replacing_Your_Boiler/

However there may be potential to improve these schemes through incentivising a switch to fuels that result in lower GHG emissions, whilst also emitting lower pollutant concentrations, including bio-fuels and LPG. Early adoption of the Ecodesign requirements would also encourage more rapid replacemnt of existing stock.

10.2.9 EU LIFE funding for air quality research projects.

The EU LIFE Programme[195] provides EU funding for a range of research related to the environment. The current programme should promote, inter alia, local and regional energy projects addressing, air quality targeting in particular emission of particulate matter (PM) in 'hotspot' areas with continued high use of coal and biomass fired heating installations.

Consideration could be given to seeking EU LIFE funding for appropriate projects in relation to high PM and other emissions from residential solid fuels.

10.3 Consultation on residential heating

10.3.1 Consultation focus

Following identification of measures, a questionnaire was developed (Appendix 4) to establish the views of key stakeholders to selected themes and potential measures. The different key stakeholders included Government and Agencies, Local Authorities, Industry, NGOs /Institutes and International contacts. The Consultation sought views on whether current measures for air pollution and residential air pollution were adequate and to highlight areas for improvement. In addition stakeholders were asked for views across a range of themes agreed with the project steering board:

1) Measures
    a) Priority fuels for promotion in residential heating
    b) Priority for actions to reduce emissions from residential solid fuel
    c) Policies to encourage uptake of measures
    d) Other policy options
    e) Building regulation changes
    f) Other clean air measures
2) Voluntary incentives
    a) Is use of voluntary measures appropriate
    b) Are there other non-regulatory measures
    c) Any examples
3) Impact of Measures
    a) Application of WHO or other guidance
    b) Fuel poverty mitigation
4) Communications
    a) Public awareness of air pollution from residential heating
    b) Raising public awareness of air pollution from residential heating
    c) Public awareness of existing controls/legislation
    d) Raising public awareness of existing controls
    e) Key messages of awareness campaigns

    In addition, stakeholders were invited to comment further on any areas not sufficiently covered.

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[195] http://ec.europa.eu/environment/life/publications/lifepublications/lifefocus/documents/airquality.pdf

10.3.2 Stakeholder consultation

The study's aim was to consider what further clean air measures are feasible and cost-effective to reduce air pollution levels from residential emissions, so as to address current exceedances and move towards the WHO health based standards in line with the commitment in the EU's 7th Environmental Action Programme. Given the current economic backdrop and the constraints on public finances, it is critically important that any measures considered can deliver emission reductions in a cost-effective way, which does not present an undue burden for public finances. Measures should also be aligned with, and promote other policy objectives including, for example, the reduction of fuel poverty.

The questionnaire (Appendix 4) was designed to engage with key expert stakeholders with a range of expertise from key stakeholder groups: Government and Agencies, Local authorities, Health/impacts, Fuel poverty, Fuel market/policy, Industry, Fuel statistics and technical standards, NGOs /Institutes and International contacts.

In order to anonymise the responses they were grouped into:

- Government /Local Authorities
- Health / Social Impacts
- Industry
- NGO/Institutions
- International

The number of respondents from Northern Ireland was much lower than Ireland (Figure 10-2). Some industries operate in both Ireland and Northern Ireland but allocation has been according to the address provided in the questionnaire response. In some sectors, for example local authorities, there was a joint response from Northern Ireland and individual responses from Ireland, which accounts for some of the difference in the number of respondents. Where possible, this has been taken into account when summarising the responses. The relatively small number of respondents from Northern Ireland needs to be considered e.g. where no comment has been reported - this may be in part due to the small number of respondents.

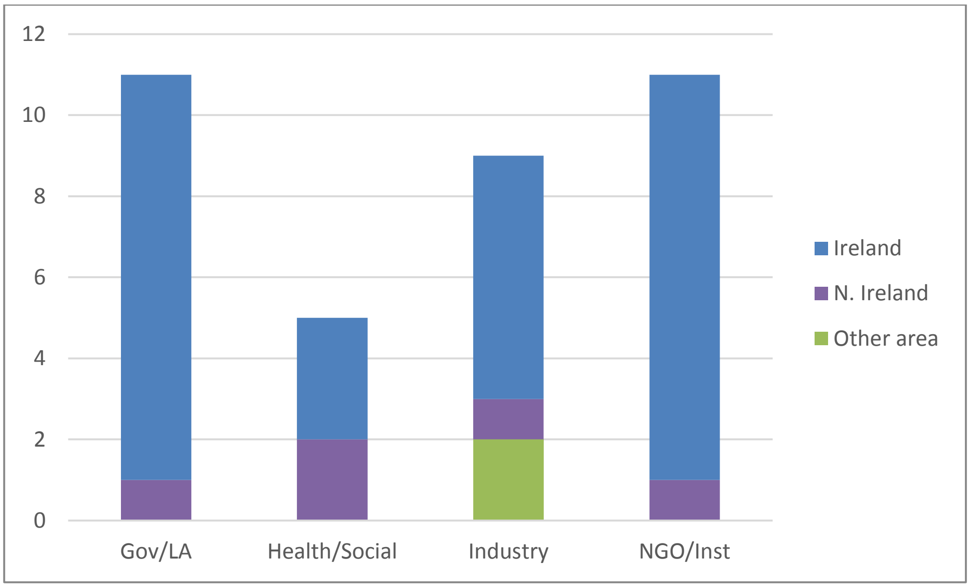

Figure 10-2: Distribution of respondents

The responses to the questionnaire are summarised in Table 10-4. More detail of the responses is provided at Appendix 5.

Responses to the questions can occasionally be contradictory, a respondent may indicate that the current legislation is fit for purpose and then go on to make suggestions for improvement e.g. most industry respondents consider the smoke control areas and smoky coal bans are adequate, but they are in favour of a harmonised standards across the whole island and suggest regulation of fuel at all steps of the distribution chain to eliminate smoky coal.

Recurring themes included the need to base change or advice on sound evidence, and that air quality monitoring should be sufficient to demonstrate the scale of improvements the measures have delivered.

Communication aimed at all parties, individuals, politicians, industry and regulators is seen as key to making a change.

Table 10-4 Summary of key messages from consultation

Key messages identified and supported by all parties:	Response by group and jurisdiction	Ireland	Northern Ireland	Comments
Harmonise regulations (and tax) across all the island – focus on all fuels	LA	yes	Yes	Parties in both jurisdictions supported harmonising the regulations. LA in Northern Ireland suggested that mandatory standards across Europe would be beneficial. Most Ireland respondents thought it would be good to have an all-island SCB. In Northern Ireland it was generally suggested the areas should be larger but without reference to an all-island approach.
	H&S	yes	Yes	
	Ind.	yes	Yes	
	NGO	yes	Yes	
Create a traceable supply chain - a 'level playing field' for all suppliers	LA	Yes	n/c	Comments related to a 'level playing field' came from the LA. Industry suggesting legislation, and enforcement, to cover the supply chain. (NGO – increase accountability)
	H&S	n/c	Voluntary	
	Ind.	Yes	n/c	
	NGO	yes	n/c	
• Register operators in the supply chain, and support with education	LA	Yes	-	All groups suggested registration of suppliers and vendors in some form.
	H&S	n/c	Voluntary	
	Ind.	Yes	n/c	
	NGO	yes	n/c	
• Test fuel when it is imported into the country to ban the import of 'Smoky Coal'	LA	Require a workable test	-	This was identified as a workable solution – cross-border. There are problems enforcing the current legislation. Voluntary disclosure of test result by industry was proposed. Industry feel that LA should enforce regulations.
	H&S	n/c	Yes	
	Ind.	Require a workable test	n/c	
	NGO	Ban import	n/c	
Incentivise replacing open fires with cleaner, more efficient heating systems	LA	Yes	n/c	Insulation to improve energy efficiency was a general recommendation. Replacing open fires with stoves (or other efficient options) was recommended by most sectors, as was an approval scheme for stoves. Industry also recommended a register of authorised installers and service engineers.
	H&S	n/c	n/c	
	Ind.	Yes	Yes	
	NGO	Yes	yes	
Inform people about the true cost of using different types of fuel (heat vs. cost)	LA	Yes	yes	All respondents indicated that good clear factual guidance was required. The specific issue of heat vs. cost was raised by every class. Many indicated it required good clear package labelling.
	H&S	Yes	Yes	
	Ind.	Yes	Yes	

Key messages identified and supported by all parties:	Response by group and jurisdiction			Comments
	NGO	Yes	yes	
Provide good information based on facts		Ireland	Northern Ireland	All respondents indicated that good clear factual guidance was required. There were a range of different suggestions.
	LA	Yes	yes	
	H&S	Yes	Yes	
	Ind.	Yes	yes	
	NGO	Yes	yes	
Include all/more fuels and air pollutants		Ireland	Northern Ireland	There are a range of views most indicate a decision should be based on evidence, and the evidence indoor/outdoor needs improving. LA/Ind./NGO in Ireland indicated that monitoring needed to be improved.
	LA	Yes	n/c	
	H&S	Renewable	yes	
	Ind.	Yes	yes	
	NGO	Whole energy	yes	

n/c – no comment. Note in Northern Ireland this will be influenced by the small sample size

10.4 Policy and Measure Assessment

10.4.1 Introduction

As previously described in section 10.1 in general terms, development of options for policy and measures must be underpinned with evidence of their performance. An evidence-based process to assess which measures would be most effective (and under which conditions) can be helpful in assessing their potential impact. The assessment provides practical information on:

1) The effectiveness of measures for improving air quality - judged in terms of pollutant concentration improvement and, to eliminate the impact of meteorological factors, in terms of emissions reduction;
2) The utility of the measures and their ease of implementation (administrative practicability and logistical effectiveness); and finally
3) The resource requirements to implement the measures and, where available, cost data.

To assess policy and measures for air quality management purposes a number of criteria need to be examined and data for these collated. These include:

a) administration levels for the measure: local, regional and national;
b) type of measure: economic/fiscal; technical; education/information; etc.;
c) timescale for implementation: short; medium (about a year); long term;
d) source sector for the measure: transport; industry including heat and power; agriculture; commercial and residential etc.;
e) spatial scale of the sources affected: local; agglomeration; national etc.;
f) regulatory or non-regulatory measures;
g) differing geography, topography, meteorology, and natural/anthropogenic source mix etc.

10.4.2 Assessment approach

It is clear that air pollution has substantial health impacts in both jurisdictions, and that residential solid fuel use is a key contribution to total emissions and reducing air pollution levels in the ambient air has positive health outcomes. A qualitative assessment of policy measures on residential solid fuel use has been undertaken using Multi Criteria Assessment (MCA) methodologies to assess which policy measures may provide scope for intervention.

10.4.3 Policy Measure Screening Assessment

An assessment of each measure was undertaken based on either evidence from the research reported in earlier chapters of this document or from professional judgement informed as appropriate by the responses to the stakeholder consultation. The assessment was against the following criteria

1. Effective – What potential has the measure to reduce PM/other pollutants (scale 1-5 with 1=low,5-high)
2. Administrative efficiency – has the measure the potential to be implemented on a national/regional scale rather than the local scale (scale 1-3, 1=no, 2-4= to a varying degree, 5=yes)
3. Deliverable – Are systems in place e.g. legislation or can systems be put in place to enable the measure to be implemented (scale 1-3, 1=no, 2-4= to a varying degree, 5=yes)
4. Cost effectiveness- how costly is the measure in comparison to other available measures. (scale 1-5, 1=high, 2-4= medium, 5=low)
5. Achievable - can the measure be successfully implemented and enforced, are there barriers to its implementation, e.g. would it command community support (scale 1-3, 1=no, 2-4= to a varying degree, 5=yes)
6. Timescale for impact – How quickly will the impact be realised following measure implementation (scale 1-5, 1=slow, 5 = immediate)
7. Impact on other pollutants – Would the measure have a positive impact on other pollutant levels e.g. carbon dioxide (CO_2) (scale 1-3, 1=no, 2= maybe, 3=yes)
8. Coherence with wider government policies – does the measure have synergies with wider government e.g. energy poverty, energy security, health and wellness promotion. (scale 1-3, 1=no, 2-4= to a varying degree, 5=yes).

The results of the assessment are presented in Table 10-5 below. It should be noted that the measures were assessed on the basis of expert judgement on the *potential* for these measures to deliver emission reductions. The ranking of particular measures will vary depending on a range of assumptions and expert judgement.

Table10-5: Assessment for measures potential.

Policy Measure Category	Detail of Policy Measure	Effective	Administrative efficiency	Deliverable	Affordable	Achievable	Timescale for impact	Impact on other pollutant	Coherence with wider policy	Total score
Legislation	Expand the geographic area covered by Smoke control area or Smoky coal ban	5	3	5	4	4	4	4	5	**34**
Promote cleaner fuels	Lower emission solid fuels through price incentives	4	5	5	3	3	4	4	5	**33**
Legislation	Improve enforcement of existing regulations	3	3	3	5	4	4	2	5	**29**
Energy efficiency	Reduce energy use and increase energy efficiency e.g smart metering	1	4	4	4	5	5	1	5	**29**
Legislation	Improve regulation of solid fuels (e.g. on sales)	5	4	3	2	3	3	4	4	**28**
Promote cleaner fuels	Increase cleaner fuel types e.g gas or renewables	5	3	4	2	4	1	4	4	**27**
Energy efficiency	Increase fuel efficiency	2	4	3	3	5	4	2	4	**27**
Research & Development	EU LIFE funding for air quality research projects	1	4	5	5	5	1	1	4	**26**
Communication and Education	Increase public knowledge	1	4	4	4	5	2	1	4	**25**

Policy Measure Category	Detail of Policy Measure	Effective	Administrative efficiency	Deliverable	Affordable	Achievable	Timescale for impact	Impact on other pollutant	Coherence with wider policy	Total score
Schemes/ Incentives	Incentives for energy efficiency	1	3	5	3	5	3	1	4	**25**
Schemes/ Incentives	Fuel switching schemes e.g. RHI	2	3	5	2	4	2	2	4	**24**
Schemes/ Incentives	Voluntary schemes/codes of practice	1	4	4	4	4	2	1	3	**23**
Technical Standards	Harmonise technical standards of solid fuels	2	4	2	3	3	3	2	3	**22**
Schemes/ Incentives	Scrappage schemes	2	2	4	1	3	1	2	2	**17**
Schemes/ Incentives	Building regulation amendments e.g. no chimney policy	2	2	3	3	1	1	2	1	**15**

10.4.4 Results of policy assessment

The expansion of the existing smoke control areas and smoky coal ban areas appears to be the most attractive way to reduce emissions. It is evidently simpler to expand an existing policy measure which the policy community and stakeholders are familiar with, and systems are in place to enforce the measure to ensure the emission reduction is delivered. This measure targets high pollution hotspots, many of which are in smaller urban areas, outside SCAs/SCBs, as indicated by the analysis presented in Chapter 4... The fuel market is already set up to deliver cleaner fuels to existing designated areas and with adequate time the barriers to expansion should be surmountable. Concern from the consultation did arise on the possible impact on fuel poverty if such designations were expanded. However, no evidence has emerged during the consultation, to indicate that the recent smoky coal bans increased fuel poverty in areas where they were introduced, though clearly fuel poverty is an important consideration.

In addition, the promotion of low emission solid fuels through price incentives was assessed as being potentially attractive for policy. Effectiveness was deemed to be high as the uptake of cleaner fuels is likely to be high if adequate price differentials are put in place to encourage consumers to switch to cleaner fuels. Concern over who pays for any price differentials put on fuels needs to be understood so that consumers can switch while either maintaining or lowering their fuel bills. Where adequate price differentials between fuels are not in place the policy measure is by necessity likely to be less effective. Generally, such fiscal measures are typically easier and less costly to implement as unlike expanded legislation enforcement costs are typically less, though there may be a cost to the exchequer in term of revenue foregone.

Increased alternative fuels such as gas or renewables is also attractive, though while these are potentially effective they can be costly to implement, though the payback with lower energy bills needs to be accounted for. There is also the perception and in many cases the reality that renewables are seen as a secondary energy supply to supplement either gas, oil or solid fuel.

The least attractive measures include scrappage schemes and changes to building regulations such as introducing a no chimney policy. The time required to see the impact of these schemes is over the longer term and they can be particularly costly to introduce. Feedback from the consultation did not support changes to the building regulations regarding the introduction of a no chimney policy citing interruptions in electricity supply where open fires/wood burners would be the sole supply of heat. However, consideration of these schemes should be examined now where a particular measure is potentially effective. For example, building regulations could include an early adoption of the Ecodesign standards prior to the implementation date of 2022. In addition the existing scrappage schemes in place provides an incentive for efficient boiler installations in households of low income.

It was suggested during the consultation that a traceable fuel supply chain be established which one commentator stated would create a level playing field. To do this a register of operators could be developed and information should be publicised on what this signalled to the marketplace. The quality of fuel could form part of this system with fuels tested on import with a certification of standards.

11 Conclusions and next steps

The World Health Organisation (WHO) has recently published the Review of evidence on health aspects of air pollution - the REVIHAAP Project. Among the major findings are the following:

- additional support for the effects of short-term exposure to $PM_{2.5}$ on both mortality and morbidity;
- additional support for the effects of long-term exposures to $PM_{2.5}$ on mortality and morbidity;
- long-term exposure to $PM_{2.5}$ is a cause of both cardiovascular mortality and morbidity;
- Significantly more insight has been gained into physiological effects and plausible biological mechanisms that link short- and long-term $PM_{2.5}$ exposure with mortality and morbidity;
- additional studies link long-term exposure to $PM_{2.5}$ to several new health outcomes; and
- There is emerging evidence that also suggests possible links between long-term $PM_{2.5}$ exposure and neurodevelopment and cognitive function, as well as other chronic disease conditions, such as diabetes.

The WHO International Agency for Research on Cancer (IARC) has classified air pollution as a carcinogen, particulate matter has also been classified as a carcinogen.

Recent measurements of concentrations of $PM_{2.5}$ were less than the EU Directive limit value at all sites. However, the WHO 24-hour guideline was exceeded at all sites in Northern Ireland and most sites in Ireland. Measured concentrations of benzo[a]pyrene have generally decreased from 2010 levels so that the EU target value was met at all sites in Ireland and Northern Ireland in the most recent reported year (2012 and 2013 respectively). However, concentrations at sites in Northern Ireland remain close to the target value and substantially above the UK objective for polycyclic aromatic hydrocarbons.

The WHO 24-hour guidelines for $PM_{2.5}$ and PM_{10} were exceeded most frequently during the winter months. Measured benzo[a]pyrene concentrations were also substantially higher in the winter. However, high winter concentrations may also be related to other factors affecting dispersion of emissions.

Analysis of the emission inventory indicates that coal makes the single largest contribution to residential emissions of PM_{10}, $PM_{2.5}$ and benzo[a]pyrene emissions in Ireland. Coal fuels (bituminous coal, anthracite & manufactured ovoids and lignite) are the largest contributor to residential emissions at high emission density hotspots in much of the country. The decline in peat use (-27% over the period) is a significant part of the overall reduction in emissions though is still a significant source. Much of the peat is burned in open countryside where the public health impacts of poor air quality is less likely to be significant. There is a substantial contribution to emissions from biomass (10%), however, natural gas, kerosene and gas oil provide the major part of residential fuel use but do not contribute much to emissions in Ireland. Wood burning made the largest contribution to residential PM_{10} emissions in Northern Ireland in 2011 but wood use in Northern Ireland is highly uncertain. Coal, solid smokeless (low smoke) fuel and peat use also make large contributions to the total emissions. Emissions from petroleum coke continue to contribute to emissions in Northern Ireland.

Analysis of 2011 Small Area census data indicates that emission densities may be much higher in some small areas than shown in the NAEI 1 km maps.

Air pollution (as $PM_{2.5}$) is estimated to have had a mortality burden equivalent to 553 adult deaths and 6,063 life years lost in Northern Ireland in 2010. Similar calculations have been completed for Ireland based on PM_{10} which suggests that there were 1,148 deaths in Ireland in 2011 with 13,566 years of life lost. These data are similar to those published recently by the European Environment Agency who estimated premature deaths attributable to $PM_{2.5}$ exposure in 2012 were 1,200 for Ireland.

More recent data published on the health impact of ambient NO_2 pollution in the UK suggest a similar level of deaths per year as estimated from PM. However, a recent report from the European Environment Agency suggests that there are no deaths in Ireland due to NO_2 as levels are low, though a separate number for Northern Ireland is not available. It is therefore reasonable based on this evidence that the mortality impact from both $PM_{2.5}$ and NO_2 for the island of Ireland is estimated to be at least 1,700 deaths per year and possibly in excess of 2,000 deaths per year.

Ireland and Northern Ireland have long-established but different legislative instruments to mitigate public health impacts from use of solid fuels – the smoky coal ban areas in Ireland and measures including powers to create smoke control areas in Northern Ireland.

There are air quality and climate co-benefits of reducing energy use from residential energy use.

The pathways by which fuel poverty affects health are complex. Excess Winter Mortality provides a statistical measure of the increased number of deaths in winter and is used as a measure of fuel poverty. However, there were fewer than ten Excess Winter Deaths in some of the counties and districts and it is not possible to place a robust interpretation on statistics derived from small sample numbers.

Fuel poverty arises from a wide range of complex and inter-related factors including the level of energy demand or need; the available income; and the price of fuel. None of these factors is uniquely or exclusively responsible for fuel poverty.

However, almost all of the identified residential pollution hot spots in Ireland are in deprived or very deprived areas. These areas predominantly use coal or peat for heating with little use of oil or gas and thus the potential exists for impacts on air quality to elevate mortality and add to deprivation in these areas.

Fuel poverty is widespread throughout Northern Ireland with a substantial proportion of fuel-poor households in each of the Local Government Districts. However, the Local Government District level data does not provide sufficient detail to allow an assessment of the relationship between fuel poverty and emissions density.

An analysis of policy measures to reduce the combustion of high polluting residential fuels across Europe indicated that where a coal ban was made wood was the dominant substituted fuel. Subsequent emissions of particulate matter did not significantly decrease although in some cities a coal and wood ban has been implemented.

Clean air policy is typically wide in scope and often involves a range of measures to ensure efficient emission reduction and public health improvements whilst minimising fuel poverty. It is clear from the evidence presented in this report that a range of measures is likely to be most effective in improving public health, for example a smoky coal ban/smoke control area is implemented alongside policies on energy efficiency, fiscal measures to promote the uptake of low emission fuels supplemented by information, communication and profile raising of the issue.

Recommended polices for both Governments to consider include the expansion of the existing smoke control areas and smoky coal bans which appear to be the most attractive to reduce emissions. It is evidently simpler to expand an existing policy measure which the community is familiar with and systems are in place to enforce the measure to ensure the emission reduction is delivered. This measure targets high pollution hotspots and therefore does not unduly penalise the populations where air quality is good.

In addition, the promotion of low emission solid fuels through price incentives was assessed as being potentially attractive for policy and it is therefore a recommendation that this is considered by both jurisdictions. Effectiveness was deemed to be high as the uptake of cleaner fuels is likely to be high if adequate price differentials are put in place to encourage consumers to switch to cleaner fuels. It is recommended that the above policies are considered alongside the provision of information, communication and profile raising of the issue to support the implementation of these policies.

Reported total NO_x emissions in Ireland are above the EU National Emission Ceiling (NEC) directive limit and if an upward trend is consolidated in future years, Ireland should consider additional measures to reduce NOx emissions in the residential sector where solid fuels emit approximately twice as much NOx per unit energy as other fuels. This issue does not arise in the case of Northern Ireland as UK emissions are below the specified NEC directive ceilings.

It is recognised that this evidence review and policy recommendations has focussed, deliberately, on one emission source – residential solid fuel. Poor air quality is most often derived from many sources of emission. A further recommendation to Governments across all Ireland therefore is that while focus should be rightly be targeted on key sources of emission, it is acknowledged that in some areas of both jurisdictions other pollution sources will be relevant. In the interests of improving public health, all key sources of emission should be tackled in where relevant in pollutant hotspot areas. A range of measures to reduce emissions from residential solid fuel combustion together with a similarly effective approach for other sources of pollution will result in the best outcome to reduce the *ca.* 2,000 deaths each year across the island of Ireland.

Appendices

Appendix 1: Residential Fuel Use in Ireland

Appendix 2 - Fixed Penalty Notices in Ireland

Appendix 3 - Solid fuel measures applied by EU Member States

Appendix 4 - Questionnaire on North South Ministerial Council Study on Residential Solid Fuels

Appendix 5 – Questionnaire Responses

Appendix 1 - Residential Fuel Use in Ireland

	Units are ktoe (Tones of Oil Equivalent)																						
Residential	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Coal Total	**626**	**699**	**476**	**476**	**338**	**246**	**368**	**278**	**320**	**263**	**286**	**264**	**252**	**239**	**231**	**246**	**219**	**208**	**230**	**267**	**254**	**230**	**242**
Bituminous Coal	608	573	322	339	253	178	280	222	240	197	210	181	170	167	158	163	159	142	164	185	177	152	165
Anthracite + M'factured Ovoids	0	93	129	116	65	47	69	38	57	47	59	62	56	53	59	59	57	60	56	70	67	67	65
Coke	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lignite	18	33	26	21	20	21	19	18	23	19	17	21	26	18	15	24	4	6	10	12	10	11	12
Peat Total	**725**	**622**	**645**	**612**	**611**	**606**	**484**	**462**	**464**	**324**	**299**	**288**	**290**	**270**	**266**	**273**	**284**	**271**	**280**	**272**	**254**	**241**	**215**
Milled Peat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sod Peat	570	465	494	452	470	486	365	356	346	206	179	179	178	177	177	183	196	186	174	169	165	163	128
Briquettes	155	156	151	160	142	120	119	106	118	118	120	109	113	93	89	90	88	85	106	103	88	79	87
Oil Total	**389**	**417**	**399**	**413**	**535**	**647**	**665**	**721**	**785**	**926**	**915**	**1,011**	**1,010**	**1,059**	**1,094**	**1,145**	**1,115**	**1,101**	**1,197**	**1,173**	**1,263**	**1,035**	**910**
Kerosene	105	114	106	122	206	283	364	395	467	595	570	645	663	710	775	795	792	789	878	915	1,010	799	683
LPG	69	70	65	64	65	60	56	54	55	55	57	57	52	50	49	53	50	47	40	30	37	34	33
Gasoil / Diesel/ DERV	197	204	207	207	236	270	218	225	223	236	244	247	248	248	239	256	245	233	252	214	202	194	185
Petroleum Coke	19	29	22	19	29	33	27	47	40	39	44	62	46	51	31	41	29	32	27	15	13	9	10
Natural Gas	117	161	187	217	239	252	303	286	339	387	439	482	476	539	601	607	632	593	669	625	710	569	600
Renewables Total	**45**	**40**	**32**	**33**	**32**	**30**	**27**	**24**	**25**	**18**	**17**	**17**	**17**	**18**	**19**	**23**	**25**	**35**	**37**	**47**	**49**	**47**	**53**
Hydro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biomass	45	40	32	33	32	30	27	24	25	18	17	16	16	15	15	16	17	23	20	27	27	22	28
Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	5	7	9	10
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	6	7	11	14	15	15	15	15
Non-Renewable (wastes)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity	**356**	**374**	**396**	**403**	**415**	**427**	**449**	**458**	**474**	**517**	**548**	**579**	**566**	**599**	**632**	**646**	**695**	**693**	**733**	**699**	**735**	**712**	**698**
Combustible Fuels Total	1,902	1,939	1,739	1,751	1,755	1,780	1,847	1,771	1,933	1,917	1,956	2,060	2,044	2,122	2,207	2,287	2,267	2,197	2,396	2,363	2,507	2,098	1,995
Fossil Fuels Total	1,857	1,899	1,707	1,718	1,723	1,750	1,820	1,747	1,908	1,899	1,938	2,044	2,027	2,107	2,192	2,271	2,250	2,174	2,375	2,337	2,481	2,075	1,967
Total	**2,258**	**2,313**	**2,135**	**2,154**	**2,170**	**2,207**	**2,296**	**2,229**	**2,407**	**2,434**	**2,504**	**2,639**	**2,611**	**2,724**	**2,843**	**2,940**	**2,969**	**2,902**	**3,146**	**3,082**	**3,265**	**2,834**	**2,718**

Appendix 2 - Fixed Penalty Notices in Ireland

Fixed Payment Notices for Certain Offences Relating to Solid Fuel Regulations (Ireland)

Where the relevant offence consists of:	FPN
placing on the market, on sale or distributing specified fuel within a specified area; or [Regulation 5 (1) of S.I. No. 326 of 2012]	€1,000
transporting specified fuel within a specified area in a vehicle that is simultaneously being used for the sale or distribution of any other fuels; [Regulation 5 (4)(b) of S.I. No. 326 of 2012]	€500
placing on the market, on sale or distributing within a specified area any solid fuel in an unsealed bag; [Regulation 5 (2)(a) of S.I. No. 326 of 2012]	€500
placing on the market, on sale or distributing within a specified area any solid fuel in a bag without a printed notice in the required form on such bag; [Regulation 5 (2)(b) of S.I. No. 326 of 2012]	€500
placing on the market, on sale or distributing outside specified areas bituminous coal in an unsealed bag; [Regulation 7 (1)(c) of S.I. No. 326 of 2012]	€500
failure by the owner of any vehicle which is used for the transport of specified fuel within a specified area to retain on the vehicle a statement with the required information; [Regulation 5 (5) of S.I. No. 326 of 2012]	€250
failure by a person or body placing bituminous coal on sale to hold a record showing that the product has a sulphur content no greater than 0.7%. [Regulation 7 (1) (d) of S.I. No. 326 of 2012]	€250

FPN are issued in the form set out in the Air Pollution Act (Fixed Payment Notices) Regulations 2011 (S.I. No. 713 of 2011[196]).

[196] http://www.irishstatutebook.ie/pdf/2011/en.si.2011.0713.pdf

Appendix 3 - Solid fuel measures applied by EU Member States

Detailed actions for controlling solid fuel combustion at the domestic sector across Member States.

AUSTRIA

Measure code: AT01

- **Title:** Clean air act for boiler systems.
- **Description:** The clean air act for the emission of boiler systems limits the emission values of plants with a thermal input below 50 MW.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** National.
- **Locations:** AT0101, AT0102, AT0103, AT0201, AT0202, AT0203, AT0702, AT0703, AT0705, AT0708, AT0709, AT0801, AT0804.

Measure code: AT02

- **Title:** Actions to increase the use of district heating.
- **Description:** This action seeks to promote communal heating within the local district through the construction and maintenance of decentralized biomass plants.
- **Controlled pollutants:** PM_{10}, NO_2.
- **Administrative level:** Local.
- **Type of measure:** Economical/Fiscal and Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** AT0201, AT0202, AT0203, AT0114A, AT0220A, AT0057A, AT0158A, AT0065, AT0066A, AT0059A, AT0140A, AT0227A, AT0215A, AT0236A, AT0067A, AT0149A, AT0501, AT0502.

Measure code: AT03

- **Title:** Stove substitution initiatives.
- **Description:** This measure seeks to incentivise the replacement of old individual stoves that use solid fuels by modern heating systems through a series of subsidies and information campaigns.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Regional/Local.
- **Type of measure:** Economical/Fiscal and Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** AT0201, AT0202, AT0203, AT0114A, AT0220A, AT0057A, AT0158A, AT0065, AT0066A, AT0059A, AT0140A, AT0227A, AT0215A, AT0236A, AT0067A, AT0149A, AT4001, AT4002, AT0402, AT0403, AT0501, AT0502.

Measure code: AT04

- **Title:** Prohibition of burning of biogenic materials in the open air.
- **Description:** The measure involves implementing a year-round ban on burning biogenic materials in the open, either for cooking or for forestry operations.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Other.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** National.
- **Locations:** AT0201, AT0202, AT0203.

Measure code: AT05

- **Title:** National Austrian pack of actions for particulate matter – boiler section.
- **Description:** Increased control of heating systems.
- **Controlled pollutants:** PM_{10}.

- **Administrative level:** Regional.
- **Type of measure:** Economic/Fiscal.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Agglomeration.
- **Locations:** AT0114A, AT0220A, AT0057A, AT0158A, AT0065, AT0066A, AT0059A, AT0140A, AT0227A, AT0215A, AT0236A, AT0067A, AT0149A, AT4001, AT4002, AT0402, AT0403.

Measure code: AT06

- **Title:** National Austrian pack of actions for particulate matter – boiler section.
- **Description:** The measure concentrates in providing relevant information under a series of campaigns on correct heating practices.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Regional.
- **Type of measure:** Educational/Informative.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Agglomeration.
- **Locations:** AT0114A, AT0220A, AT0057A, AT0158A, AT0065, AT0066A, AT0059A, AT0140A, AT0227A, AT0215A, AT0236A, AT0067A, AT0149A, AT4001, AT4002, AT0402, AT0403.

Measure code: AT07

- **Title:** Controlled burning of biomass outside combustion devices.
- **Description:** The measure involves controlling the burning of biomass (wood, gardening waste, bush cuttings) outside of combustion plants by spreading concepts of optimal management.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local/Regional.
- **Type of measure:** Economical/Fiscal and Educational/Informative.
- **Time scale of reduction:** Short term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** AT0801, AT0804.

Measure code: AT08

- **Title:** Technical and organizational measures for controlling air pollution from domestic heating devices.
- **Description:** This measure concentrates a series of organizational measures in combustion plants and domestic heating systems that include the mandatory installation of particulate filters for greater biomass heating boilers, to promote biomass district heating systems, the increased control of permissible fuels and information campaigns.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local/Regional.
- **Type of measure:** Economical/Fiscal and Educational/Informative.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Local/Agglomeration.
- **Locations:** AT0801, AT0804.

Measure code: AT09

- **Title:** Amendment of combustion law.
- **Description:** The measure seeks to reduce NO_x emissions of incineration of biomass power plants of less than 10 MW. This also includes reducing the emission limit values for incinerations of solid fuels.
- **Controlled pollutants:** NO_2.
- **Administrative level:** National.
- **Type of measure:** Other.
- **Time scale of reduction:** Short term.
- **Spatial scale of the sources affected:** Local/Agglomeration.
- **Locations:** AT03E01.

BELGIUM

Measure Code: BE01

- **Title:** Awareness on domestic energy consumption.
- **Description:** The measure intends to educate the general public on the most relevant issues concerning energy consumption at home under the “energivores” programme.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Educational/Informative.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** National.
- **Locations:** BEF01S, BEF02S, BEF03S, BEF04A, BEF05S, BEF06S, BEB10A, BEW11S, BEW12S, BEW13S, BEW14S.

Measure Code: BE02

- **Title:** Legal instrument on energy performance of new heating.
- **Description:** Within the framework of Directive 1992/42/CE, national energy administrations should collaborate with gas suppliers aiming to implement a system of performance control on domestic heating appliances focusing on CO, PM and NO_x for boilers and fireplaces.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Economic/Fiscal and Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** National.
- **Locations:** BEF01S, BEF02S, BEF03S, BEF04A, BEF05S, BEF06S, BEB10A, BEW11S, BEW12S, BEW13S, BEW14S.

Measure Code: BE03

- **Title:** Establishment of a public information check-point about energy saving.
- **Description:** This action consists in the establishment of a government-supported check-point (Guichet de l’Energie) to provide information to the general public on efficient heating practices and clean fuels.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Regional.
- **Type of measure:** Educational/Informative.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Regional.
- **Locations:** BEB10A.

Measure Code: BE04

- **Title:** Better knowledge of the energy situation in the residential sector.
- **Description:** The measure aims to achieve a better understanding of the most relevant aspects on energy consumption in the residential sector: fuel sources, technologies, potential abatement measures. The action is circumscribed within a wider set of actions directed to the improvement of energy consumptions aiming to achieve a 16% reduction per habitant.
- **Controlled pollutants:** PM_{10}, NO_2.
- **Administrative level:** Regional.
- **Type of measure:** Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Regional.
- **Locations:** BEB10A.

Measure Code: BE05

- **Title:** Primes for the private housing sector to switch to instantaneous gas heating and thermal regulation.
- **Description:** The measure focuses on allocating economic incentives for proprietors and developers to switch to gas heating alternatives and to allow their equipment to be regularly inspected and controlled. The measure focuses on allocating economic incentives for proprietors and developers to switch to gas heating alternatives and to allow their equipment to be regularly inspected and controlled. The action is circumscribed within a wider set of actions

directed to the improvement of energy consumptions aiming to achieve a 16% reduction per habitant.

- **Controlled pollutants:** PM_{10}, NO_2.
- **Administrative level:** Regional.
- **Type of measure:** Economic/Fiscal.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Regional.
- **Locations:** BEB10A.

Measure Code: BE06

- **Title:** Maintenance and service programmes for residential heating and hot water consumptions.
- **Description:** This programme follows a decision of the Flemish Government for conducting inspection and maintenance campaigns of heating appliances in buildings and homes, as well as determining minimum yields for heaters with problematic pollutants.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Regional.
- **Type of measure:** Economic/Fiscal.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Regional.
- **Locations:** BEF01S, BEF02A, BEF03S, BEF04A, BEF05S, BEF06S.

Measure Code: BE07

- **Title:** Smoke nuisance control and reduction.
- **Description:** This initiative is a consequence of the interest of the Flemish Government to avoid causing smoke nuisance produced by domestic combustion activities during conditions of no wind and fog. It involves designing wood stoves and fireplaces that do not produce odour nuisance caused by soot and smoke, and a ban on using wood stoves in conditions of no wind and fog (except for premises with wood burning as the only form of heating).
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Regional.
- **Type of measure:** Technical.
- **Time scale of reduction:** Short term.
- **Spatial scale of the sources affected:** Regional.
- **Locations:** BEF01S, BEF02A, BEF03S, BEF04A, BEF05S, BEF06S.

Measure Code: BE08

- **Title:** Awareness campaigns on the correct use of stoves and against open fires. Changes in residential heating behaviour.
- **Description:** The action seeks to increase awareness on the correct use of stoves by making a set of information brochures available ("smarter burning") as well as familiarising people on the problems associated with open fires in the household.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Regional.
- **Type of measure:** Educational/Informative.
- **Time scale of reduction:** Short term.
- **Spatial scale of the sources affected:** Regional.
- **Locations:** BEF01S, BEF02A, BEF03S, BEF04A, BEF05S, BEF06S, BEW11S, BEW12S, BEW13S, BEW14S.

Measure Code: BE09

- **Title:** Standardization of household solid fuels and their composition.
- **Description:** This decision seeks the elaboration of a national standard for determining the supply state of household solid fuels (e.g. pellets), their finishing and composition, favouring high-quality fuels.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Technical.
- **Time scale of reduction:** Medium term.

- **Spatial scale of the sources affected:** Regional.
- **Locations:** BEF01S, BEF02A, BEF03S, BEF04A, BEF05S, BEF06S, BEW11S, BEW12S, BEW13S, BEW14S.

BULGARIA

Measure Code: BG01

- **Title:** Implementation of district heating strategies for the residential sector.
- **Description:** This action involves studying implementation options of district heating for the residential sector.
- **Controlled pollutants:** NO_2.
- **Administrative level:** Local.
- **Type of measure:** Technical.
- **Time scale of the reduction:** Medium term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** BG0002PV.

Measure Code: BG02

- **Title:** Information campaign to limit the use of primitive solid fuel heating stoves with low thermal efficiency.
- **Description:** The measure contemplates launching an information awareness campaign to avoid and limit the use of primitive stoves for heating.
- **Controlled pollutants:** NO_2.
- **Administrative level:** Local.
- **Type of measure:** Educational/Informative.
- **Time scale of the reduction:** Short/Medium term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** BG0002PV.

CZECH REPUBLIC

Measure Code: CZ01

- **Title:** Conversion of heating systems and prevention on switching back to solid fuels in households.
- **Description:** The measure intends to prevent users from switching back to solid fuels because of their lower market prices through the renovation of heating systems and economic support. In the case of Prague, it also contemplates reinforcing a grant program for the conversion of heating systems already in place which will involve information campaigns and the engagement of financial institutions.
- **Controlled pollutants:** PM_{10}, NO_2.
- **Administrative level:** Local/Regional.
- **Type of measure:** Economic/Fiscal, Technical, Educational/Informative.
- **Time scale of the reduction:** Medium term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** CZ010-1, CZ010-2, CZ010-3, CZ0622, CZ0622, CZ0622.

Measure Code: CZ02

- **Title:** Fostering gasification and district heating strategies.
- **Description:** This action contemplates fostering new strategies to implement environmentally friendly energy networks that rely on gasification plants and district heating facilities.
- **Controlled pollutants:** PM_{10}, NO_2.
- **Administrative level:** Local.
- **Type of measure:** Technical.
- **Time scale of the reduction:** Long term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** CZ0202, CZ05-1-1, CZ0502, CZ053-1, CZ0622, CZ0622, CZ0622, CZ0642-1.

DENMARK

Measure code: DK01

- **Title:** Restriction of particle pollution from wood-burning stoves and boilers.
- **Description:** The initiative seeks to control air pollution from wood burning stoves and boilers below 300 kWth, which resulted in a Statutory Order that has been in force since June, 2008.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** National.
- **Location:** DKA9.

Measure code: DK02

- **Title:** Subsidies for phasing out less central heating boilers for solid fuels.
- **Description:** This measure contemplates subsidising the gradual substitution of central heating boilers who use solid fuels dating back to 1980.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Economic/Fiscal.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** National.
- **Location:** DKA9.

Measure code: DK03

- **Title:** Cleaner wood burning.
- **Description:** The action has been endowed with a 10 million DKK budget for the development and testing of technologies that can reduce the emissions of particles from wood burning stoves.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Economic/Fiscal.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** National.
- **Location:** DKA9.

Measure code: DK04

- **Title:** Information on correct burning.
- **Description:** The Danish Environmental Protection Energy has through several heating seasons been running information campaigns to orientate the people on the correct use of wood burning stoves.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Educational/Informative.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** National.
- **Location:** DKA9.

FRANCE

Measure Code: FR01

- **Title:** Surveillance and maintenance programme for domestic boilers.
- **Description:** The action involves characterising typical domestic boilers and to propose actions aimed to the reduction of emissions through correct maintenance practices.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local.
- **Type of measure:** Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Local/Regional.
- **Locations:** FR01N00002, FR30A00001, FR16A00001, FR16A00002, FR16N00001, FR31A00001, FR31N00003, FR03A00001, FR03A00002, FR24A00001, FR04A00001,

FR15A00001, FR20A00001, FR20N00001, FR06A00001, FR10A00001, FR11A00001, FR11N00002, FR28A00001.

Measure Code: FR02

- **Title:** Prohibition on open-air wood-burning.
- **Description:** The action will prohibit burning wood in open-air fires at residential areas. Regulations to this respect will be decided according to the sanitary regulations of every department.
- **Controlled pollutants:** PM_{10}, NO_2.
- **Administrative level:** Local/Regional.
- **Type of measure:** Economic/Fiscal and Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Local/Regional.
- **Locations:** FR01N00002, FR30A00001, FR16A00001, FR16A00002, FR16N00001, FR31A00001, FR31N00003, FR03A00001, FR03A00002, FR24A00001, FR04A00001, FR15A00001, FR20A00001, FR20N00001, FR06A00001, FR10A00001, FR11A00001, FR11N00002, FR28A00001, FR04A01.

Measure Code: FR03

- **Title:** Incitement to limit the use of wood as fuel only to high-performance installations.
- **Description:** This measure includes promoting efficient heating technologies which use wood as feedstock, while prohibiting its use elsewhere.
- **Controlled pollutants:** PM_{10}, NO_2.
- **Administrative level:** Local.
- **Type of measure:** Economic/Fiscal and Educational/Informative.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Local/Regional.
- **Locations:** FR01N00002, FR30A00001, FR16A00001, FR16A00002, FR16N00001, FR31A00001, FR31N00003, FR03A00001, FR03A00002, FR24A00001, FR04A00001, FR15A00001, FR20A00001, FR20N00001, FR06A00001, FR10A00001, FR11A00001, FR11N00002, FR28A00001, FR26N10, FR11A01, FR03A02.

Measure Code: FR04

- **Title:** Requirement of eco-labelling in wood-burning devices and feedstock.
- **Description:** This action is directed towards the compulsory inclusion of eco-labels in wood-burning devices (Flamme-Verte label) and feedstock (NF label) that might produce high-performance combustion of wood.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local/Regional.
- **Type of measure:** Other.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Local/Regional.
- **Locations:** FR01N00002, FR30A00001, FR16A00001, FR16A00002, FR16N00001, FR31A00001, FR31N00003, FR03A00001, FR03A00002, FR24A00001, FR04A00001, FR15A00001, FR20A00001, FR20N00001, FR06A00001, FR10A00001, FR11A00001, FR11N00002, FR28A00001.

Measure Code: FR05

- **Title:** Development of strategies for the use of biomass as fuel feedstock.
- **Description:** This action intends to launch several project tenders for the development and implementation of comprehensive strategies for the application of biomass as fuel.
- **Controlled pollutants:** PM_{10}, NO_2.
- **Administrative scale:** Local.
- **Type of measure:** Technical.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** National.
- **Locations:** FR01N00002, FR30A00001, FR16A00001, FR16A00002, FR16N00001, FR31A00001, FR31N00003, FR03A00001, FR03A00002, FR24A00001, FR04A00001, FR15A00001, FR20A00001, FR20N00001, FR06A00001, FR10A00001, FR11A00001, FR11N00002, FR28A00001, FR04A01.

Measure Code: FR06

- **Title:** Vegetal refuse management.
- **Description:** The action seeks to ban the burning of vegetal refuse at domestic and residential entourages under any circumstances.
- **Controlled pollutants:** PM_{10}.
- **Administrative scale:** Local/Regional.
- **Type of measure:** Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** National.
- **Locations:** FR03A00001, FR03A00002, FR24A00001, FR04A00001, FR15A00001, FR20A00001, FR20N00001, FR06A00001, FR10A00001, FR11A00001, FR11N00002, FR28A00001.

Measure Code: FR07

- **Title:** Fostering general change from solid fuels to less-polluting options for residential combustion equipment.
- **Description:** Fuel substitution for residential combustion equipment under local/municipal supervision and control.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local/Regional.
- **Type of measure:** Economic/Fiscal, Technical and Educational/Informative.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** Local.
- **Location:** FR16A02, FR25A01, FR31A01.

GERMANY

Measure code: DE01

- **Title:** Ban on the use of solid fuels in the residential sector.
- **Description:** The measure intends to prohibit the combustion of any form of solid fuel, including green/compostable waste in the residential sector.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local.
- **Type of measure:** Other.
- **Time scale of reduction:** Short term.
- **Spatial scale of the sources affected:** Regional.
- **Locations:** DESTE07, DETHWE01.

Measure code: DE02

- **Title:** Increasing knowledge on unknown emission sources related to heating.
- **Description:** This action seeks to investigate the existence of unidentified sources that are actually being used for heating purposes (fireplaces, stoves, boilers) in order to quantify their contribution to the local air quality picture.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Regional.
- **Type of measure:** Other.
- **Time scale of reduction:** Long/Medium term.
- **Spatial scale of the sources affected:** Regional.
- **Locations:** DENWE41, DENWE43.

Measure code: DE03

- **Title:** Improving the quality of fuels and feedstock.
- **Description:** The given action aims to improve the quality (chemical composition, finishing) of fuels across emission sectors, including the residential sector.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Economic/Fiscal and Technical.
- **Time scale of reduction:** Short/Medium/Long term.

- **Spatial scale of the sources affected:** Local/Zone/Agglomeration/National.
- **Locations:** DEBYE02, DEBYE03.

Measure code: DE04

- **Title:** Expansion of district heating.
- **Description:** The action will encourage a successive optimization of the district heating network and the promotion of connection to it from family homes at competitive costs.
- **Controlled pollutants:** PM_{10}, NO_2.
- **Administrative level:** National.
- **Type of measure:** Economic/Fiscal and Technical.
- **Time scale of reduction:** Short/Medium/Long term.
- **Spatial scale of the sources affected:** Local/Zone/Agglomeration/National.
- **Locations:** DEBWE44, DEBWE45, DEBWE46, DEBWE48, DERPE05.

Measure code: DE05

- **Title:** Implementation of normalized evaluation standards for small combustion devices and fireplaces.
- **Description:** Action directed towards a standardised evaluation of small combustion devices and fireplaces.
- **Administrative level:** Local.
- **Type of measure:** Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Agglomeration/National.
- **Locations:** DEBBE04, DEBBE05.

GREECE

Measure Code: EL01

- **Title:** Extension of the natural gas supply network within the urban tissue.
- **Description:** This measure concerns the extension of the supply network for natural gas in the urban tissue (major cities and Northern Greece) as well as enforcing users to change diesel boilers to natural gas alternatives within the domestic and services sector.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Economic/Fiscal and Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** National.
- **Locations:** EL0001, EL0003, EL0004.

Measure Code: EL02

- **Title:** Construction of a natural gas supply network (Southern Greece).
- **Description:** This measure aims to install and maintain a supply network for natural gas in the region of Southern Greece, which ultimately seeks to enforce users to change diesel boilers to natural gas alternatives within the domestic and services sector.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Economic/Fiscal and Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** National.
- **Locations:** EL0002.

Measure Code: EL03

- **Title:** Controls in the emissions of fixed combustion sources.
- **Description:** The measure considers the establishment of limit values under the appropriate legislative framework for fixed combustion sources. It is especially directed to boilers used in the domestic and services sector for heating and hot water for sanitary.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Technical.

- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** EL0002.

HUNGARY

Measure Code: HU01

- **Title:** Strategies for supporting the competitiveness of district heating and heating facilities modernization programmes.
- **Description:** The measure contemplates reducing taxation of more efficient heating systems and favours the installation of district heating systems at densely-populated urban centres.
- **Controlled pollutants:** PM_{10}, NO_2.
- **Administrative level:** Local.
- **Type of measure:** Economic/Fiscal.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** HU0001, HU0009.

Measure Code: HU02

- **Title:** Modernisation of residential heating installations and fuel switch.
- **Description:** This action is directed to substituting old solid fuel fired modules that remain operative for natural gas options.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local.
- **Type of measure:** Technical.
- **Time scale of reduction:** Medium/Long term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** HU0001, HU0011.

Measure Code: HU03

- **Title:** Regulation of household combustion activities.
- **Description:** The action will concentrate the attention of policy makers to the reinforcement of sanctions on uncontrolled combustion activities taking place at the domestic environment (waste burning, exterior fireplaces, etc.).
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local.
- **Type of measure:** Technical.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** HU0009.

Measure Code: HU04

- **Title:** Monitoring emissions of domestic heating equipment.
- **Description:** The measure will include the implementation of a set of monitoring and control practices of emissions of domestic heating equipment.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local.
- **Type of measure:** Technical.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** HU0009.

ITALY

Measure code: IT01

- **Title:** Heating systems migration.
- **Description:** Sustain the migration of heating systems from solid fuels, mineral oil to methane, GPL or other low emissions media. The program contemplates a mandatory check of heating systems with a power of less than 35 kW under a program of self-certification. In some regions,

this measure includes the development of a programme intended to extend the use of natural gas on domestic heating boilers.

- **Controlled pollutants:** PM_{10}, NO_2.
- **Administrative level:** Local.
- **Type of measure:** Technical.
- **Time scale of reduction:** Short term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** IE06E01, I06E02, I06E03, I06E04, I12Ef1, I12Ef2, I12Ef3, I07E01, I07E02, I07E03, I13E02, I13E03, I10E01, I10E02.

Measure code: IT02

- **Title:** Ban on the use of solid fuels and fuel oil in the residential sector.
- **Description:** The measure considers the restriction on the use of certain fuels in combustion plants for civil use installed in a group of municipalities classified as "critical areas". In particular, the use of solid fuels such as clusters of brown coal, stem coal, metallurgical coal, anthracite and/or its mixtures as well as heavy oil fuels. It is especially directed to installations with a capacity of less than 1.5 MW.
- **Controlled pollutants:** PM_{10}, NO_2.
- **Administrative level:** Regional.
- **Type of measure:** Technical.
- **Time scale of reduction:** Short/Medium term.
- **Spatial scale of the sources affected:** National.
- **Locations:** I03E01, I03E02, I03E03, I03E04, I03E05, I03E06, I03E07, I03E08, I08E01, I08E02, I01E03, I01E04, I01E05, I01E06, I05E02, I05E03, I04E01, I04E12, I04E13, I04E14, I02E01, I02E02.

Measure code: IT03

- **Title:** Implementation of district heating.
- **Description:** The action will involve financing the construction of district heating systems that are for different residential areas, accompanied by a series of eco-building practices.
- **Controlled pollutants:** NO_2.
- **Administrative level:** Regional.
- **Type of measure:** Economic/Fiscal and Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** National.
- **Locations:** I03E01, I03E02, I03E03, I03E04, I03E05, I03E06, I03E07, I03E08.

Measure code: IT04

- **Title:** Improving wood burning.
- **Description:** The action considers incentivising the substitution and/or redesigning of typical fireplaces at home that use wood as fuel for efficient equipment.
- **Administrative level:** Local.
- **Type of measure:** Economic/Fiscal.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** Regional.
- **Locations:** I13E02, I13E03.

LATVIA

Measure Code: LV01

- **Title:** Switching to low-emission stationary combustion sources.
- **Description:** The action consists in replacing inefficient and outdated combustion plants for individual heating with modern and more environmental friendly options.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local.
- **Type of measure:** Economic/Fiscal and Technical.
- **Time scale of reduction:** Short/Medium term.
- **Spatial scale of the sources affected:** Local/Regional.
- **Locations:** LV0001.

Measure Code: LV02

- **Title:** Establishment of PM-emission limits for domestic heating equipment.
- **Description:** This action seeks to implement stricter PM-emission limits for typical residential combustion devices.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Technical.
- **Time scale of reduction:** Short term.
- **Spatial scale of the sources affected:** National.
- **Locations:** LV0001.

Measure Code: LV03

- **Title:** Regulations for fuel quality.
- **Description:** The present measure seeks to regulate the composition and finishing of fuels, paying special attention to those used in the residential sector.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Other.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** National.
- **Locations:** LV0001.
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LUXEMBOURG

Measure Code: LU01

- **Title:** Regulation of wood firing.
- **Description:** The action seeks to reduce emissions from the rising number of wood-fired heating systems within the city, seeking appropriate regulatory mechanisms to lower air pollution from wood firing.
- **Controlled pollutants:** NO_2.
- **Administrative level:** National.
- **Type of measure:** Other.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** National.
- **Locations:** LCPU.

Measure Code: LU02

- **Title:** Migrating to district heating.
- **Description:** Further connection of urbanised areas to the local heat network as well as the planned utilisation of heat from the waste incineration plant in Leudelange will contribute to a more sustainable use of energy resources.
- **Controlled pollutants:** NO_2.
- **Administrative level:** National.
- **Type of measure:** Other.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** National.
- **Locations:** LCPU.
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MALTA

Measure Code: MT01

- **Title:** Extending the use of LPG.
- **Description:** This measure contemplates the introduction/extension of LPG as a fuel for cooking and domestic heating instead of conventional solid fuel plants.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** National.
- **Type of measure:** Economic/Fiscal.
- **Time scale of reduction:** Short/Medium term.

- **Spatial scale of the sources affected:** National.
- **Locations:** MT0001.

POLAND

Measure Code: PL01

- **Title:** Developing connections to a district heating network.
- **Description:** The measure seeks to connect individual energy users to a central district heating network for the supply of thermal energy.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local.
- **Type of measure:** Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Regional.
- **Locations:** Kp05Bydg, Kp06Swiec, Kp05TOR, KpWLO, LuGorzSC, MzWar, MzRad, Mp07MKR.

Measure Code: PL02

- **Title:** Replacement of old boilers and furnaces.
- **Description:** This action seeks to dismantle old boilers, stoves and furnaces in homes, usually coal-burning, for cleaner options through the combination of economic incentives and information campaigns.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local/Regional.
- **Type of measure:** Economic/Fiscal, Technical, Educational/Informative.
- **Time scale of reduction:** Medium/Long term.
- **Spatial scale of the sources affected:** Local/Regional.
- **Locations:** Kp05Bydg, Kp05TOR, KpWLOP, Ds05Jeg, DsLub1, DsWro1, DsZgo1, LuGorzSC, MzCIES, MzWar, MzRad, Mp07MKR.

Measure Code: PL03

- **Title:** Favouring low-emission fuels for residential boilers.
- **Description:** The action concentrates on favouring low-emission fuels, such as natural gas, as preferred fuels to be used at the residential sector.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local/Regional.
- **Type of measure:** Economic/Fiscal, Technical, Educational/Informative.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** Kp06Swiec, LuGorzSC, MzWar, MzRad, Mp07MKR.

Measure Code: PL04

- **Title:** Solid fuel ban in the city of Krakow.
- **Description:** This action seeks to ban the use of solid fuels in the city of Krakow for residential purposes, specifically focusing on coal and wood.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local/Regional.
- **Type of measure:** Technical, Other.
- **Time scale of reduction:** Short term.
- **Spatial scale of the sources affected:** Local/Regional.
- **Locations:** Mp07MKR.

PORTUGAL

Measure Code: PT01

- **Title:** Fireplace certification.
- **Description:** Through the certification of fireplaces, contribute to enhance indoor and outdoor air quality. The plan seeks to develop reference standards for the certification of equipment and a compulsory or incentivised periodic check program.

- **Controlled pollutants:** NO_2.
- **Administrative level:** National.
- **Type of measure:** Technical.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** National.
- **Locations:** PT01028, PT01049, PT01026, PT01030, PT01041, PT3001.

Measure Code: PT02

- **Title:** Certification of residential combustion equipment.
- **Description:** The measure aims to create a set of standards for the certification of residential combustion equipment (boilers) under a compulsory or incentivised period check scheme.
- **Controlled pollutants:** NO_2.
- **Administrative level:** National.
- **Type of measure:** Technical.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** National.
- **Locations:** PT01028, PT01049, PT01026, PT01030, PT01041, PT3001.

ROMANIA

Measure Code: RO01

- **Title:** Incentivising change to efficient domestic heating alternatives.
- **Description:** The Green House program (Programul Casa Verde) is developed to replace or supplement traditional heating systems with solar energy or other intelligent systems.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local.
- **Type of measure:** Technical.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** RO0199.

Measure Code: RO02

- **Title:** Extension of the natural gas supply network.
- **Description:** The action focuses on extending coverage in Bucharest to connect all residents to the natural gas distribution system.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local.
- **Type of measure:** Economic/Fiscal and Technical.
- **Time scale of reduction:** Long term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** RO0801.

Measure Code: RO03

- **Title:** Reduction of the use of wood as heating fuel in the domestic sector.
- **Description:** This measure seeks to control the use of wood as a heating fuel in the domestic heating through the introduction of a series of regulations at the local Council level.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local.
- **Type of measure:** Other.
- **Time scale of reduction:** Short term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** RO0602.

SPAIN

Measure Code: ES01

- **Title:** Fostering general change from solid fuels to less-polluting options for residential combustion equipment.

- **Description:** Fuel substitution for residential combustion equipment under local/municipal supervision and control.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Local. Regional.
- **Type of measure:** Economic/Fiscal, Technical, and Educational/Informative.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** Local.
- **Locations:** ES0505, ES0601, ES0602.

Measure Code: ES02

- **Title:** Renovation plan for domestic boilers and heaters.
- **Description:** Plan to be implemented at the municipalities with environmental conservation areas (Barcelona) or generally (Madrid). This includes actions aimed to the renovation of boilers and domestic equipment. Special focus is being made on domestic boilers with a nominal thermal capacity less or equal than 70 kW, which can either be individual (home use) or communal (building use). Usual change from diesel/coal-fuelled boilers to natural gas.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Regional.
- **Type of measure:** Economic/Fiscal.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** Zone.
- **Locations:** ES0901, ES0902, ES1301, ES1308, ES1309.

Measure Code: ES03

- **Title:** Study of particulate matter.
- **Description:** Characterization of particulate matter in order to determine the sources of pollution and correctly direct actions. The study should be particularly focused on organic carbon fractions that might suggest combustion of biomass, peat or carbon.
- **Controlled pollutants:** PM_{10}.
- **Administrative level:** Regional.
- **Type of measure:** Other.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** Zone.
- **Locations:** ES0705.

Measure Code: ES04

- **Title:** Creation of atmosphere-protected urban zones.
- **Description:** When focused on the residential sector, the plan intends to differentiate zones within a city on which conventional gasoil and coal boilers are to be banned and regulate the introduction of biomass as feedstock.
- **Controlled pollutants:** NO_2.
- **Administrative level:** Regional.
- **Type of measure:** Technical.
- **Time scale of reduction:** Medium term.
- **Spatial scale of the sources affected:** Zone.
- **Locations:** ES0901, ES0902.

Air quality: PM_{10} levels and trends in Europe.

The discussion presented in Section 9 concentrated on the causes of **air pollution** under an integrated assessment framework, namely human activities, emission of pollutants and related abatement measures. As the most logical step, this section is dedicated to the description of the air quality situation in Europe produced by the concerning pollutant: **particulate matter** (in this case, **PM_{10}**). In order to conduct this analysis, air quality observations were drawn from European databases for the period comprised between 2002 and 2010. The most notable of these databases is the European Environment Agency's AirBase[197], which provides hourly observations for many years and the most relevant pollutants across Europe. In the previous sections a direct reference to the domestic sector was made in every case, using specific sector-data when possible. This however, will not be possible in this section due to the fact that the air quality levels resulting at a given location have been produced by the emission of very many sources (in urban centres the main contribution would be road traffic) and by imported parcels through atmospheric dispersion of air pollutants emitted afar. Unless an air quality model is effectively carried out, it is impossible to isolate the contribution of the domestic sector to the total air quality levels relying only on observations. As a result, analysis in this section will rely solely on qualitative appraisals.

Member States are required to submit a PM_{10} time extension whenever they register repeated **violations** of the **LV** for PM_{10}. Figure A3-1 depicts the **maximum number of days** in which the daily mean concentration of PM_{10} was above the limit value in a given AQM area (some AQM areas have several monitoring locations in place) in 2002 and 2010. A quick inspection of this figure suggests that many urban locations experienced increases in the number of days above LV (Paris, Rome, Sofia, Bucharest, Lisbon and Berlin). Since we are not isolating the effect of road traffic in these locations, this fact might be caused by the classical dieselisation paradigm that was so extensive in many European locations, aimed to reduce the emissions of greenhouse gases and caused by the constantly-increasing fuel prices which in turn increased PM_{10} and NO_x (Vedrenne et al., 2014). Analysis should concentrate however, on those AQM areas in which road traffic does not have a considerable influence and/or on those in which the per capita consumption of solid fuels was very high (Figure A3-2). For example, noticeable **reductions** were achieved in Portugal (Norte-Litoral), Spain (Castilla-La Mancha, Montes de Toledo, Andalusia and Lugo), Greece, Germany (Nordhessen, Niedersachsen and Vogtland) and France (Aquitaine). On the other hand, sizeable **increases** where evidenced in Poland (Krakow, Łodź and Lublin), Italy (Modena and Abruzzi) and Bulgaria (South-East Bulgaria and Sofia). The reason for Hungary and Romania going from no exceedances in 2002 to considerable levels in 2010 is the installation of new monitoring locations in the respective AQM areas, therefore registering exceedances. Particularly in the case of Bulgaria, Poland, Portugal and Spain, the observed changes in 2010 with respect to 2002 may be to a large extent caused by an increased consumption of solid fuels or by the policy packs that have been discussed in section 4. In order to have a more accurate perspective of the benefits of controlling solid fuels through policy making in Europe between 2002 and 2010, a detailed analysis was carried out for different **urban and rural background** monitoring locations in France, Germany, Italy and Spain, to minimise the influence of road traffic.

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[197] EEA AirBase. Accessible online.

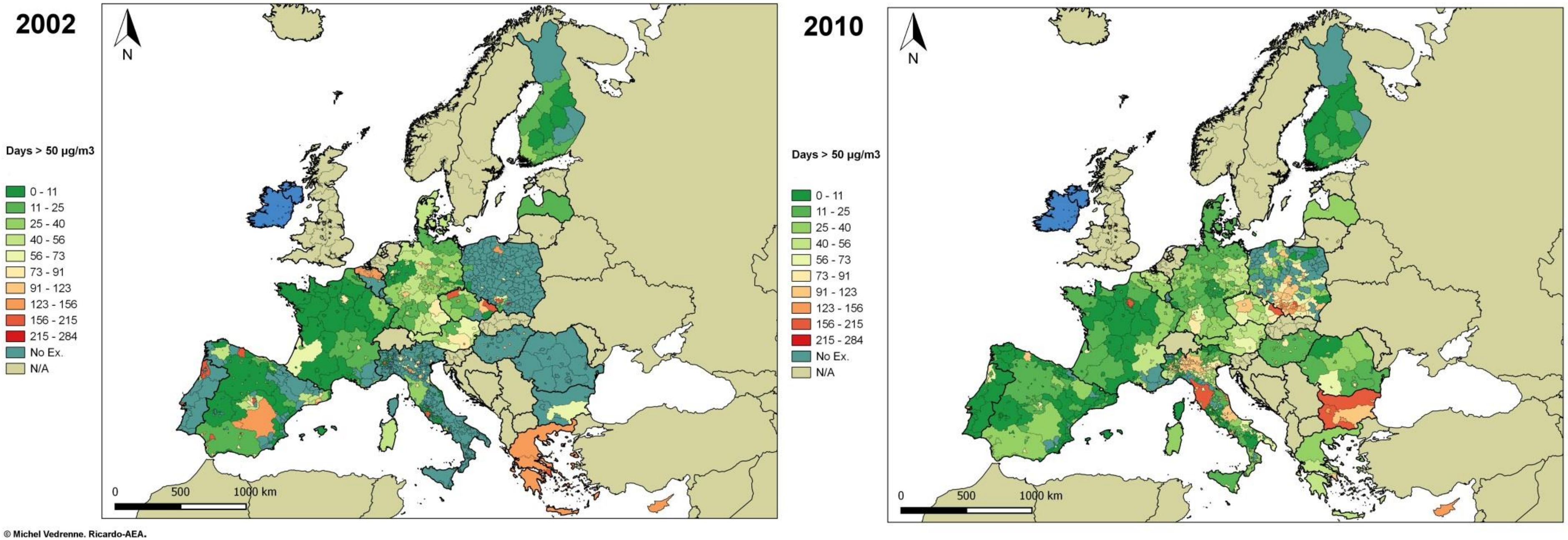

Figure A3-1. ***Number of days above PM_{10} LV (50 µg*** m^{-3}***) in the EU AQM areas in 2002 and 2010***

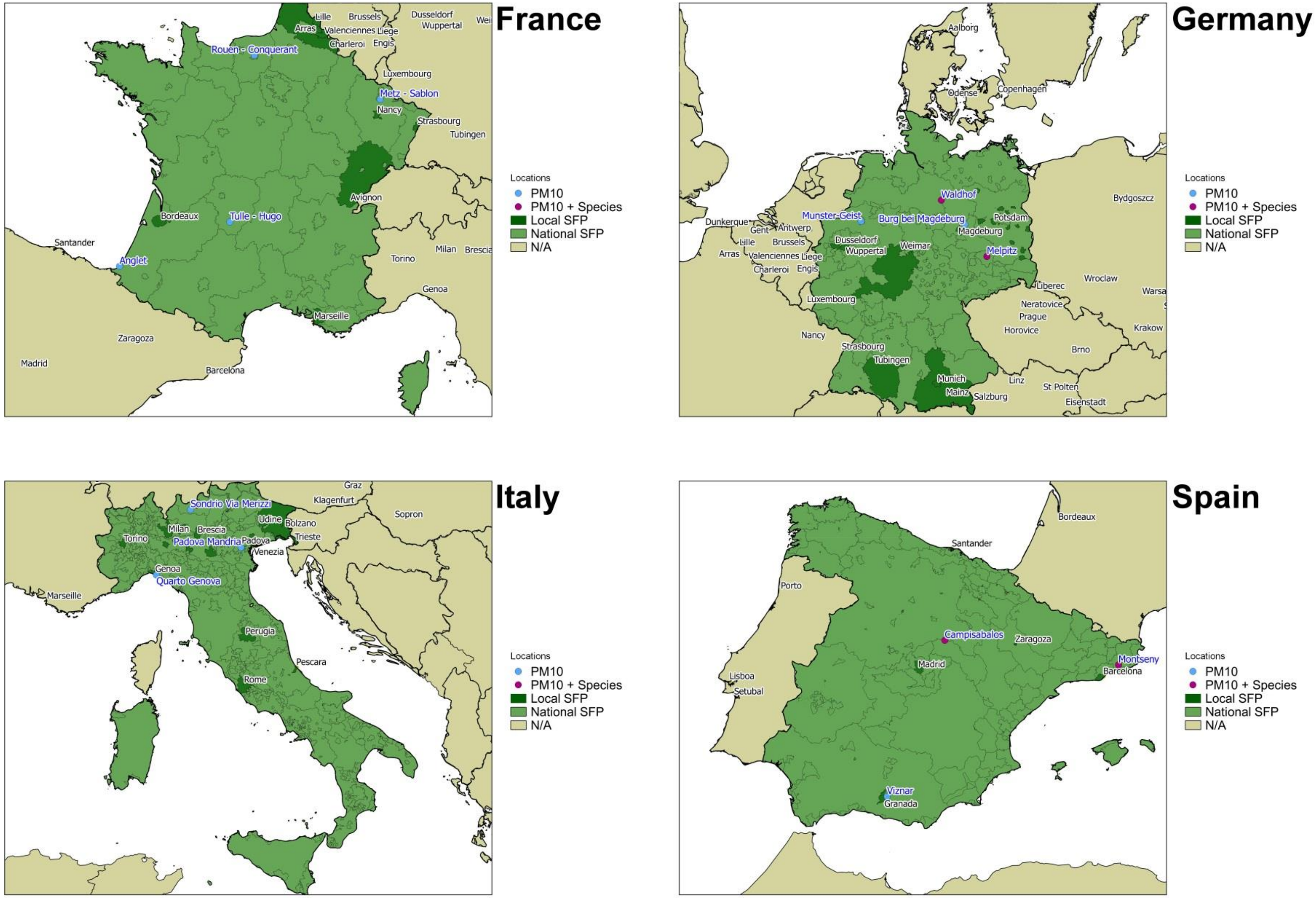

Figure A3-2. ***Selected monitoring locations and AQM areas in France, Germany, Italy and Spain.***

PM_{10} levels and trends in France.

In order to elucidate the contribution of solid fuel combustion to the air quality levels, four urban and rural background locations were selected throughout France. Data from most of these stations participated in a source-apportionment study of particulate matter published by Belis et al., (2009), which will be useful for inferring the influence of source types in the observed PM_{10} levels. The exact location of these stations is shown in Figure A3-2, as well as their location relative to the selected solid fuel-controlling AQM areas in France. With the data obtained from AirBase, the maximum 36th daily concentration value (percentile 90.4) of PM_{10} was calculated in order to derive a policy relevant indicator that is intimately related to human health protection. The resulting trends for the four monitoring locations are shown in Figure A3-3. In general, it can be seen that the overall trend in the four locations lies always below the PM_{10} LV, except for the first three years registered in **Anglet**. Moreover, there is not a clear decreasing tendency for these stations, which could be well explained by either the absence of proximal domestic heating sources (the observed high consumption of fuelwood would probably produce consistent increases in PM_{10} levels). Since the exact contribution of domestic sources at these locations cannot be allocated, no conclusive results were whatsoever obtained from analysing air quality levels in France with the selected group of stations.

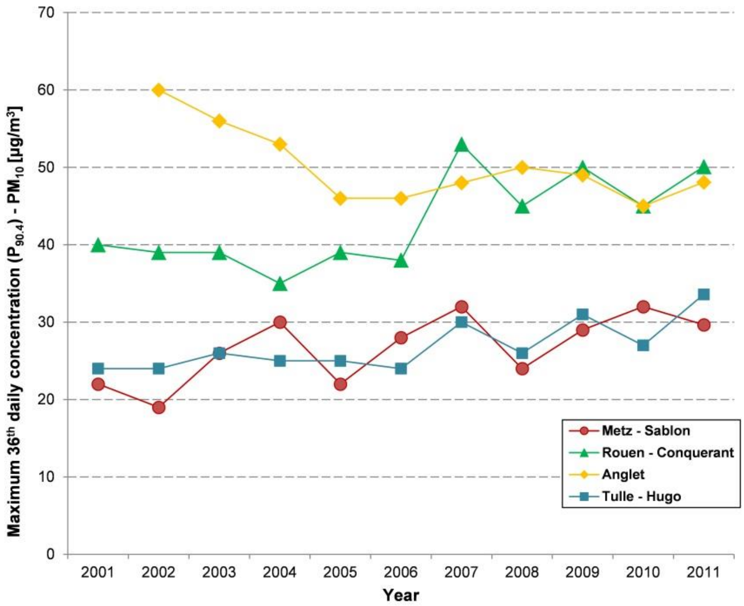

Figure A3-3. ***PM_{10} maximum 36th daily value ($P_{90.4}$) for the selected monitoring locations.*** ***France***

PM_{10} levels and trends in Germany.

As with France, four urban and rural background monitoring sites were selected to assess possible decreases in air quality levels due to solid fuel combustion controls in Germany. Of the selected stations, two are EMEP supersites that have information on PM_{10} concentrations and on their speciation as well (Figure A3-2). Particularly, the stations of **Münster** and **Burg bei Magdeburg** were selected because the exact contribution of the residential sector has been reported at the local air quality plan documents (1% and 8% respectively) and because their respective regions reported to implement fuel bans. The analysis of Figure A3-4 shows the evolution of percentile 90.4 for the German selected sites, revealing mixed behaviours. For instance, **Münster** exhibits a clear decreasing trend in the contribution of PM_{10} of the residential sector to the total air quality levels (yet in every year exhibiting values below LV). The case of **Burg bei Magdeburg** shows some anomalies towards the end of the period of interest (above LV), while at its beginning a decreasing trend was experienced as well.

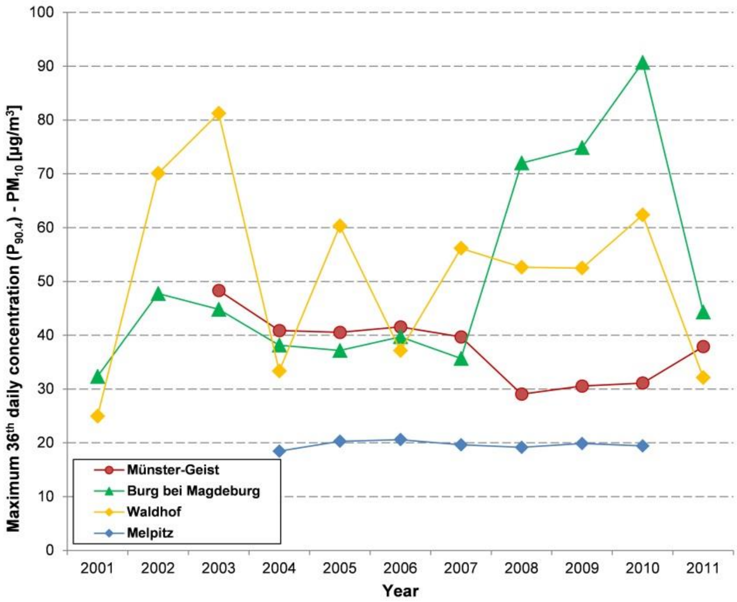

Figure A3-4. ***PM_{10} maximum 36th daily value ($P_{90.4}$) for the selected monitoring locations. Germany***

The EMEP stations of **Waldhof** and **Melpitz**, from which PM_{10} speciation profiles were obtained, show different trends. The PM_{10} values that **Waldhof** registered are extreme and divergent, exhibiting a modest increasing trend in the period between 2006 and 2010. **Melpitz** however, seems to be representative of the rural background of these region of Germany, due to the virtually unchanging trend exhibited. The only conclusive data that can be obtained from the inspection of these trends are the effective reduction of PM_{10} contributions of the domestic sector in **Münster** and the representativeness of the urban background in **Melpitz**. As with the French case, a further inspection in other locations might be adequate.

PM_{10} levels and trends in Italy.

The selection of monitoring locations in Italy was made preferring urban and rural background monitoring locations and focusing on the northern regions of the country, whose wetter climates might limit **particle resuspension** phenomena wherever traffic becomes a strong influence (Figure A3-2). The resulting trends in PM_{10} percentile 90.4 can be seen in Figure A3-5 for the three selected locations.

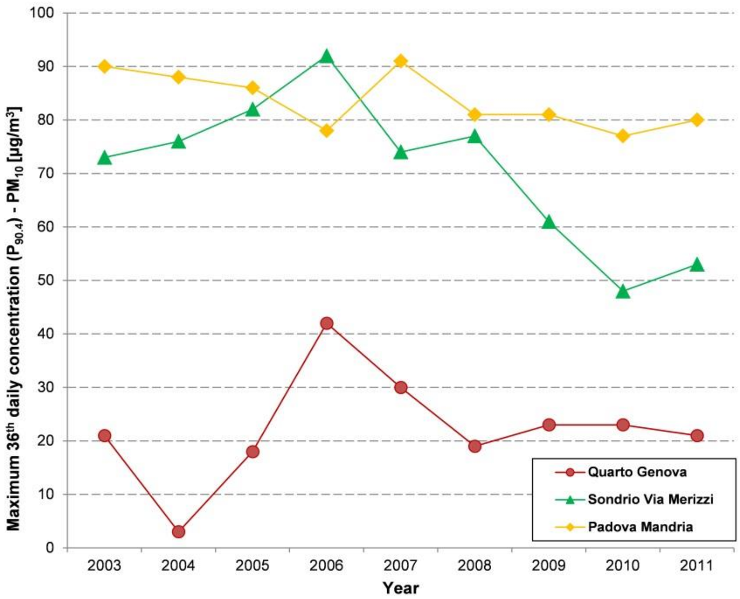

Figure A3-5. ***36th daily PM_{10} maximum value ($P_{90.4}$) for the selected monitoring locations. Italy***

The rural background location of **Sondrio Via Merizzi** is the only one of the three sites that clearly exhibits a decreasing trend in PM_{10} levels (approx. 20 µg m^{-3}). Despite the decreasing trend, observations continue to be above LV. Due to its location in a rural and residential area, it can be said that the contribution of the domestic sector would play a heavier role, thus improving air quality levels due to policy making (i.e. the Italian fuel ban). The case of **Padova Mandria** also exhibits a decreasing trend in PM_{10} levels, although not as dramatic as that of **Sondrio** (10 µg m^{-3}). Being above the LV, the contribution of the residential sector to the observed PM_{10} levels remains unclear due to the fact that the monitoring site is classified as urban background and could be more exposed to other sources as well. Finally, the monitoring site of **Quarto Genova** exhibits an overall even trend with some anomalies in the first years of the study period.

As with the German stations of Burg bei Magdeburg and Waldhof and from the trends reported by this station, no self-standing conclusions can be drawn on the effectiveness of the solid fuel controlling measures. In general the potential effectiveness of the Italian policy pack on PM_{10} at the residential sector could be confirmed by analysing other monitoring locations with similar characteristics to **Sondrio**. It would also be very useful to conduct source apportionment studies with speciation data (currently only available the EMEP stations of Ispra and Montelibretti). Additionally, interesting conclusions on the actual contribution of the residential sector, and particularly the combustion of solid fuels for heating, to the total PM_{10} could be obtained from a comprehensive air quality modelling study.

PM_{10} level and trends in Spain.

Spain is a country with a little dependence on the use of solid fuels generally (and particularly negligible for domestic heating). Additionally, Spain is reputed for experiencing particle resuspension phenomena at urban monitoring sites, so in order to minimize this affectation, only three EMEP monitoring locations were selected for analysis (Campisábalos, Montseny and Víznar), having speciation data available for the first two (Amato et al., 2012). These stations are of particular importance due to their reputed good characterisation of the background concentrations adjacent to analysed AQM areas (Madrid, Barcelona, Granada), as shown in Figure B2.

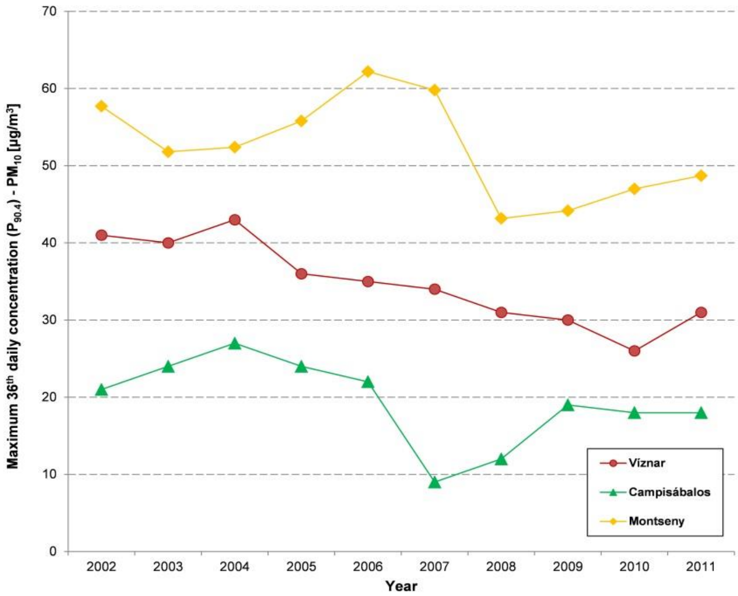

Figure A3-6. ***PM_{10} maximum 36^{th} daily value ($P_{90.4}$) for the selected monitoring locations. Spain***

The air quality observations obtained for these three locations can be seen in Figure A3-6. The general trend for the three locations is clearly decreasing, being more dramatic for **Montseny** and **Víznar** (approx. 10 µg m^{-3}) than for **Campisábalos** (2 µg m^{-3}). At this point, it is not possible to affirm whether these decreases are solely due to solid fuel restrictions from the domestic sector or to a more generalised policy that also affected their use at larger point sources (power plants and factories). Further insights on the nature of the contributing source are given in the following sections.

PM_{10} source apportionment.

The analysis that has been carried out previously has focused on the temporal evolution of PM_{10} concentrations in a number of locations in four Member States. Except for a couple of these locations (Münster and Sondrio Via Merizzi), no self-standing conclusions were obtained on the actual effect of solid fuel policy packs in the domestic sector. To gain further insight on the magnitude of these control strategies, source apportionment studies provide useful information.

To this respect, detailed measurements of concrete species (markers) inform on the **provenance** of a given amount of fraction of the total PM_{10} mass. This section relies on a series of European studies carried out at several locations throughout the continent and reported in Viana et al., (2008) and Belis et al., (2009). Additionally, source apportionment studies were carried out for one station in **Germany** (Melpitz) and one more in **Spain** (Campisábalos), taken from different observation campaigns that took place in the studied period. The classification criteria for these studies were taken according to what is recommended by Karanasiou et al., (2011).

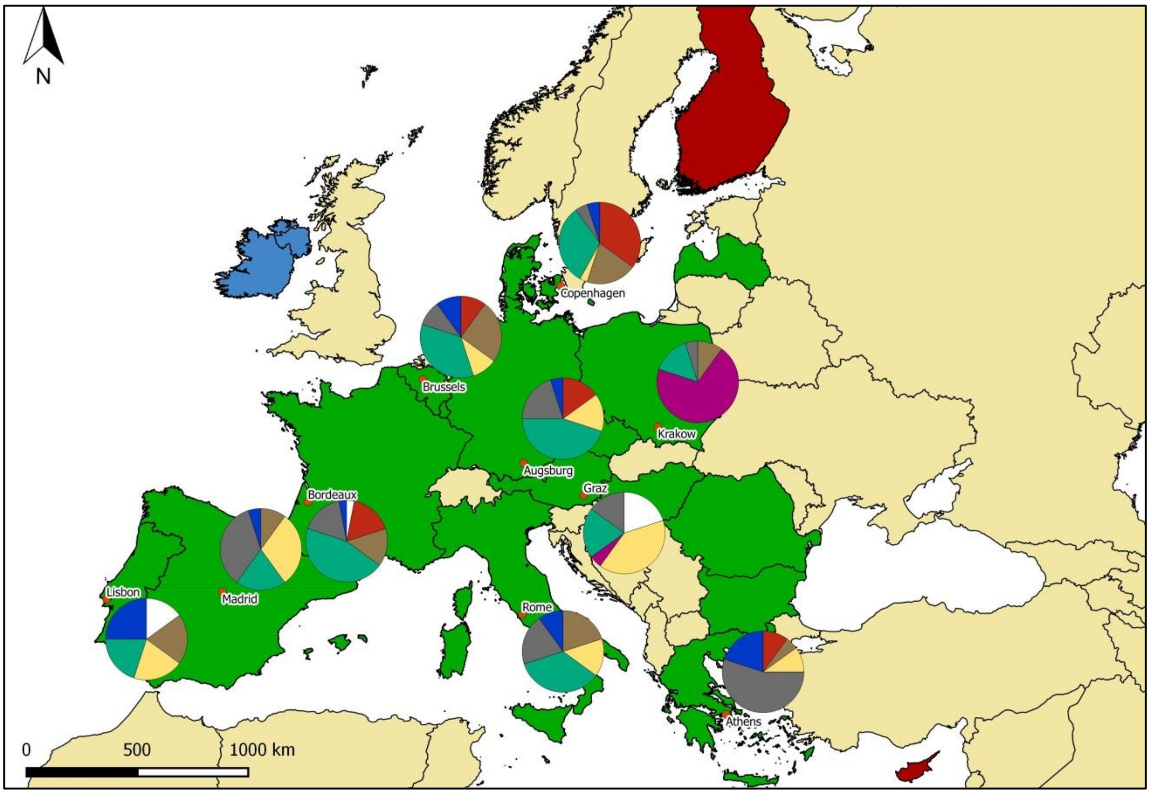

Figure A3-7. ***Representative PM_{10} source apportionment in ten representative locations.***
■-industrial, ■-residential, ■-traffic, ■-mineral, ■-biomass, ■-sea salt, ■-secondary inorganic aerosol, □-other

The importance of solid fuel controlling actions at the residential sector for PM_{10} will be greater for those locations in which a higher component of the residential and **biomass-burning** fractions. As it can be seen in Figure A3-7, sites like Augsburg (DE), Athens (EL), Bordeaux (FR), Brussels (BE), Copenhaguen (DK), and Graz (AT) have an important component of the before mentioned fractions of interest, being in some cases of determining importance (in Copenhagen it accounts for approximately 35%). In this line, locations whose composition of particles does not exhibit any of these fractions – Madrid (ES), Lisbon (PT), Rome (IT) – are unlikely to experience deep changes in its PM_{10} levels due to the actions limiting the combustion of solid fuels in the residential sector. The location with the highest component of **residential origin** is Krakow (PL), with more than 70% and no contributions from biomass burning. This might be an indicative that the primary energy sources of the residential sector are solid fuels (e.g. coal or lignite). A very small contribution is also observed in Graz (AT), of about 5%. Finally, it can be seen that in general the share of the residential and biomass sector in the total particulate matter composition tends to be higher for Northern European locations, while the share of **traffic sources** is greater in those locations that are eminently urban (i.e. Madrid, and Athens).

PM_{10} source apportionment in Germany.

As it was already stated, a source apportionment study was carried out for **Melpitz** which is an EMEP station located in Eastern Germany (Figure A3-2). It is reputed to be representative of the background concentrations of the urban and industrial zones of East Germany. The data on speciation were obtained from the Chemical Coordinating Centre (CCC)[198] of EMEP-NILU and contrasted with the PM_{10} hourly concentrations of AirBase. For the concrete case of Melpitz, speciation data on elemental carbon (EC), organic carbon (OC), calcium (Ca^{++}), magnesium (Mg^{++}), ammonium ($NH4^{+}$), nitrate ($NO3^{-}$), sodium (Na^{+}), chlorides (Cl^{-}), sulphate ($SO4^{=}$) and potassium (K^{+}) were obtained and apportioned into the respective fraction according to what is recommended in Karanasiou et al., (2012).

The mass of each of the before mentioned species measured in the Melpitz site from 2004 to 2010 is shown in Figure A3-8 as well as the translation of those species into sources. As it can be seen, the share of residential sources (named coal in the graph) is kept almost constant throughout the studied years. While the mineral and residential sources are almost unchangeable, the main concerning issue is to correctly apportion the total mass of organic carbon between the traffic and the residential sector. There is an additional issue that concerns the unidentified fraction of PM_{10} (N/Id), which introduces a great amount of uncertainty because its real composition might clearly offset the apportion categories in Figure A3-8. The constant pattern observed for residential combustion in this site can be partially explained by the steady consumption of gaseous fuels in Germany, and by the almost-negligible contribution of solid fuels to the national energy mix. The consumption of biomass in Germany is also consistent, as evidenced by the presence of biomass-related fractions in the mass of total PM_{10} (<2%).

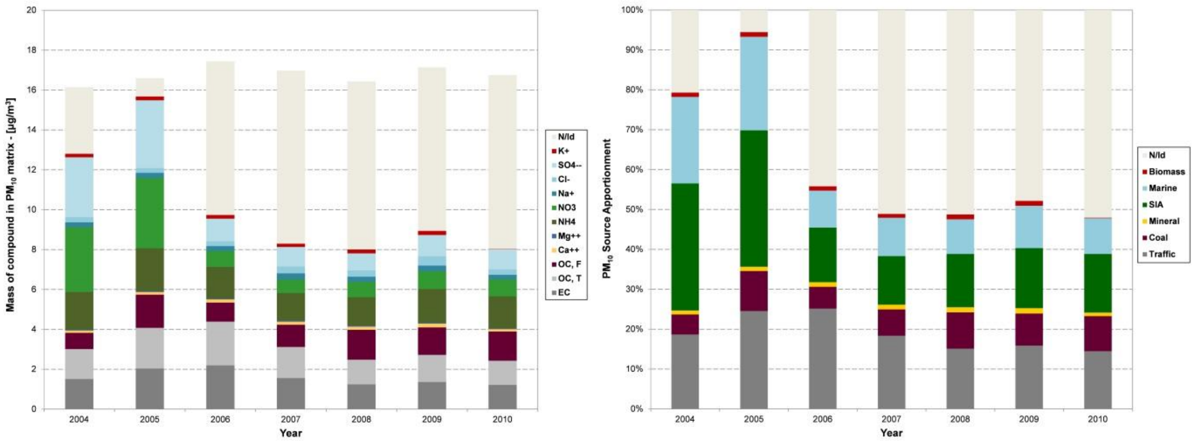

Figure A3-8. ***PM_{10} components (left) and source apportionment (right) for Melpitz.***
Germany

PM_{10} source apportionment in Spain.

In a similar way to the analysis carried out for Melpitz (Germany), a PM_{10} source apportionment was carried out with measurements for different species carried out in Campisábalos (Spain) (Figure A3-2). As it was already discussed, Campisábalos is a rural background station that belongs to the EMEP network and is used to characterise background concentrations of the urban agglomerations in central Spain (mainly Madrid). As in the previous example, speciation data were obtained from the Chemical Coordinating Centre (CCC) of EMEP-NILU and contrasted with the PM_{10} hourly concentrations of AirBase. The available data were measurements of iron (Fe), elemental carbon (EC), organic carbon (OC), arsenic (As), calcium (Ca^{++}), ammonium ($NH4^{+}$), nitrate ($NO3^{-}$), sodium (Na^{+}), chlorides (Cl^{-}), sulphate ($SO4^{=}$) and potassium (K+) and grouped in source categories according to Karanasiou et al., (2012).

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[198] World Data Centre for Aerosols. Accessible here.

The resulting masses of each of the species and the categories into which these are grouped are shown in Figure A3-9. Unlike Melpitz, the results of Campisábalos show an every time lower contribution of the residential sector (“coal”), and a higher contribution of road traffic. Despite the problem in correctly apportioning organic carbon among the traffic and residential sectors, the anomalies that are directly imputed to the residential sector in this case were very evident. Additionally, the presence of arsenic as a typical marker for residential combustion clearly showed a **decreasing trend**. This finds its explanation in the reduction in the emissions of coal (Figure A3-9) and in the **overall decrease of PM_{10}** emissions at this same location.

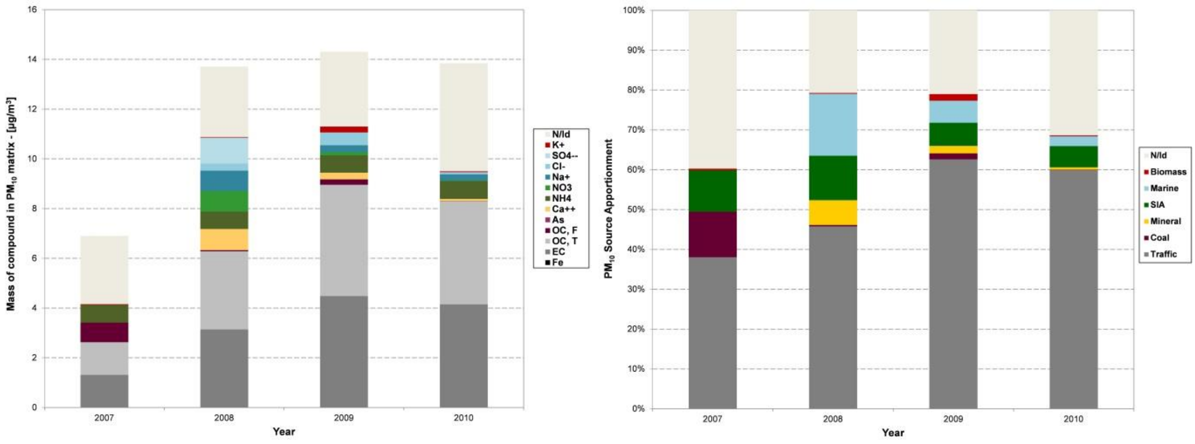


Figure A3-9. ***PM_{10} components (left) and source apportionment (right) for Campisábalos.*** ***Spain***

Fuel type	Measure	AT	BE	BG	CZ	DE	DK	EL	ES	FR	HU	IT	LV	LU	MT	PL	PT	RO
Control Costs for Particulate Matter (PM) – €/GJ																		
Fuel wood	Fireplace, improvement	3.25	-	-	3.25	3.25	3.25	-	3.25	3.25	-	-	3.25	-	-	3.25	3.25	-
Fuel wood	Fireplace, new	24.68	-	-	-	24.68	-	-	24.68	-	-	-	-	-	-	-	24.68	-
Fuel wood	Boilers, pellets	0.19	-	-	0.19	0.19	-	-	0.19	-	-	-	-	-	-	0.19	-	-
Fuel wood	S. house boiler, improvement	1.21	-	1.21	1.21	1.21	-	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
Fuel wood	S. house boiler, new	1.98	-	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	1.98	-	1.98
Fuel wood	S. house boiler, pellets	2.49	-	-	2.50	-	2.49	-	-	-	2.50	2.49	-	-	-	2.49	-	-
Fuel wood	Stove, improvement	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58
Fuel wood	Stove, new	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88	19.88
Fuel wood	Stove, pellets	-	-	-	21.53	-	-	-	-	-	21.53	21.53	-	-	-	21.53	-	-
Hard coal	S. house boiler, new				0.26	0.26	-	-	-	-	0.26	-	-	-	-	-	-	-
Hard coal	Stove, improvement	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	-	2.58	2.58	2.58	-	2.58	2.58
Hard coal	Stove, new	19.88	19.88	-	19.88	19.88	19.88	-	19.88	19.88	19.88	-	-	19.88	-	-	19.88	-

Coke	Stove, improvement	-	-	-	2.58	-	-	-	-	-	2.58	2.58	-	-	-	-	-	-
Coke	Stove, new	-	19.88	-	19.88	-	-	-	-	-	19.88	19.88	-	-	-	-	-	-
Lignite	S. house boiler, new	-	-	-	0.49	-	-	-	-	-	-	-	-	-	-	-	-	-
Lignite	Stove, improvement	-	-	-	3.09	-	-	-	-	-	-	-	-	-	-	-	-	-
Lignite	Stove, new	-	-	-	23.85	-	-	-	-	-	-	-	-	-	-	-	-	-
Diesel	Boilers, good housekeeping	-	-	-	0.01	0.24	0.17	0.17	0.17	0.30	0.01	0.18	0.01	0.18	-	-	0.18	0.01
Fuel oil	Boilers, good housekeeping	-	0.17	-	0.01	0.17	0.17	0.17	0.17	0.30	0.01	0.18	0.01	-	0.01	-	0.18	0.01

Table A1. ***Unit costs per activity levels for particulate matter (PM) according to GAINS across Member States.***

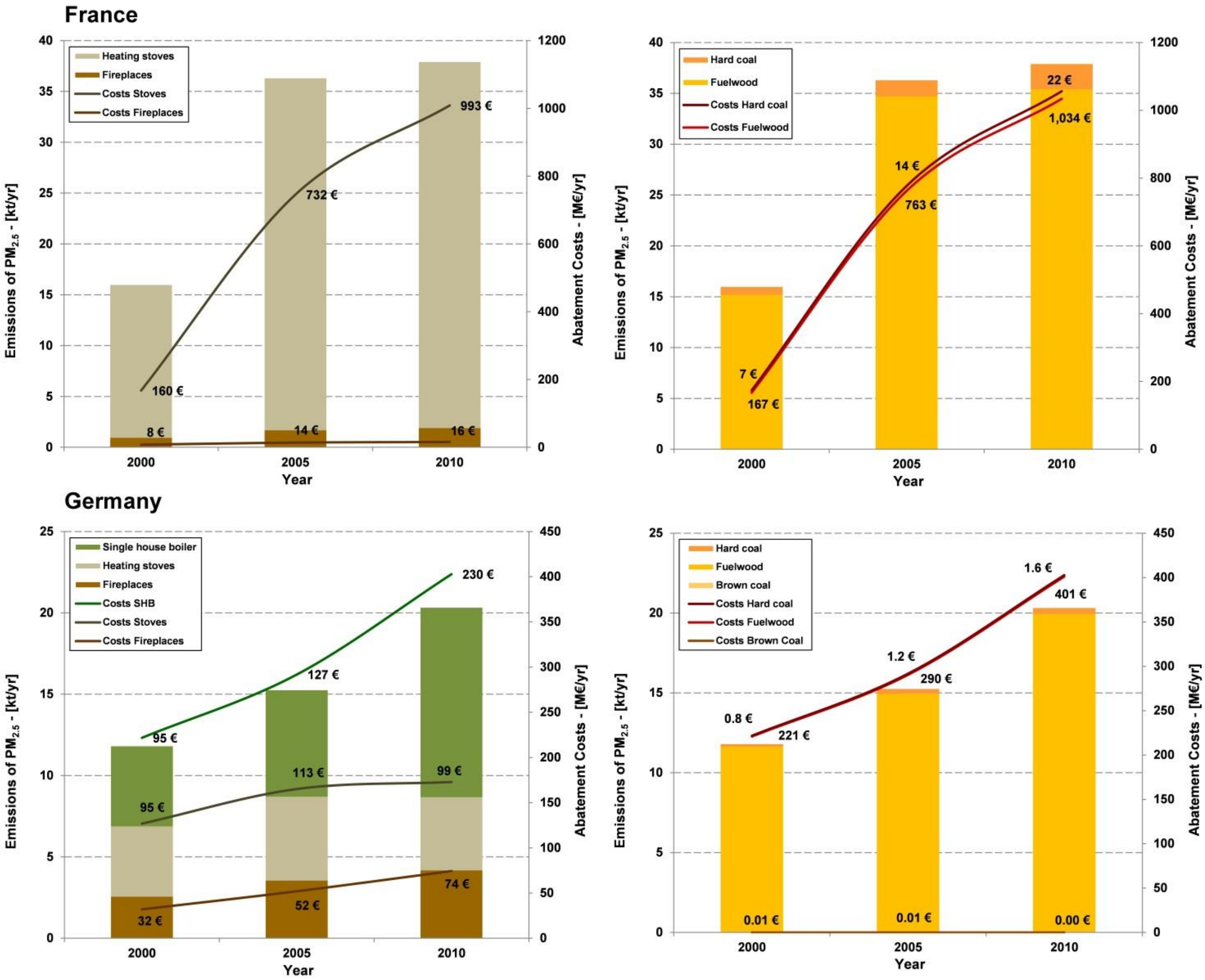


Figure B10a*. **Breakdown of controlled emissions and costs by equipment and fuel type.***

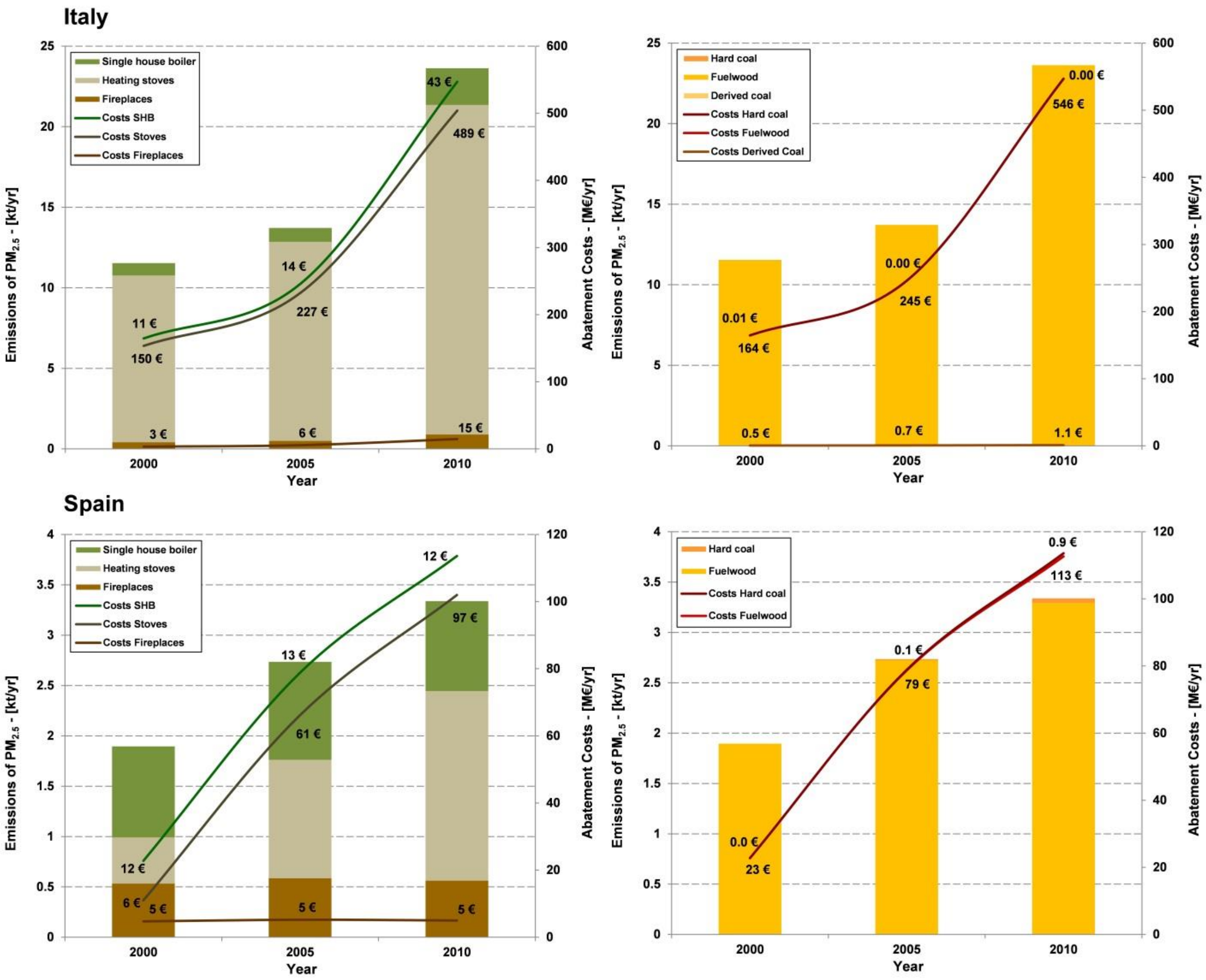


Figure B10b. ***Breakdown of controlled emissions and costs by equipment and fuel type.***

Appendix 4 - Questionnaire on North South Ministerial Council Study on Residential Solid Fuels

Information on the questionnaire on North South Ministerial Council Study on Residential Solid Fuels

Air quality legislation derived from EU Air Quality Directives is implemented in both the Republic of Ireland and Northern Ireland. In addition, the Republic of Ireland and Northern Ireland have long-established but different legislative instruments which operate in certain urban areas and seek to address public health impacts from residential use of solid fuels. These are the 'Smoky' Coal Ban areas (SCBs) in the Republic of Ireland and Smoke Control Areas (SCAs) in Northern Ireland.

However, as elaborated in the Interim Report, elevated levels of air pollution from residential solid fuel use persist in both jurisdictions in exceedance of WHO health based standards, and in exceedance of EU and national standards for Northern Ireland. The WHO 24-hour guidelines for $PM_{2.5}$ and PM_{10} were exceeded most frequently during the winter months when emissions from residential heating are likely to be highest. Measured benzo[a]pyrene concentrations were also substantially higher in the winter. Adverse atmospheric dispersion conditions in winter, for example, may also contribute to the high air quality concentrations.

The European Environment Agency (EEA) has published estimates of premature deaths attributable to $PM_{2.5}$ exposure. This indicates best estimates for premature deaths in 2011 from $PM_{2.5}$ are 39,450 for the UK and 1,229 for the Republic of Ireland. According to a report by Public Health England, the average fraction of mortality due to anthropogenic air pollution in Northern Ireland local authorities has been estimated at 3.8%. An estimated 553 adult deaths were attributable to anthropogenic air pollution (and 6,063 life years lost) in Northern Ireland in 2010. EPA estimates for the Republic of Ireland indicate that residential solid fuel is the predominant source of $PM_{2.5.}$

CURRENT AND POTENTIAL FUTURE MEASURES

Local Authorities (LAs) are key to implementation of legislative controls in both jurisdictions. 126 SCAs have been declared across 16 LAs in Northern Ireland since the late 1960s, although few have been made in recent years. The Republic of Ireland has, in recent years, extended the coverage of the SCBs to 26 urban areas and implemented national sulphur standards for coal.

However, legislation should not be considered the only or exclusive option for achieving policy aims. Fiscal measures or voluntary agreements (or codes of practice) with industry and/or other stakeholders may provide complementary approaches to support achievement of overall clean air objectives.

Fiscal measures can be used to encourage behavioural change which could lead to a reduction in air pollution from the residential heating sector. These can be designed to act either as incentives or disincentives. Incentives could include, for example, lowering of levies/tax on cleaner fuels or grant assistance for cleaner/renewable heating technology. Penalties could include, for example, increased levies/tax on the most polluting fuel products or heating technologies. Fiscal measures generally apply at the *point of purchase* – this is an important point to note as where they apply to on-going expenditure (e.g. fuels) they can affect emissions from all sources (new and existing), whereas when they apply to capital expenditure (installations), they do not affect the majority of existing sources.

In addition, voluntary agreements with relevant trade groups could be used, for example, to promote cleaner fuels and/or harmonised standards. There could also be targeted support to protect households at risk of fuel poverty during a transition to cleaner fuels and heating technologies.

STAKEHOLDER CONSULTATION AIMS AND OBJECTIVES

The study's aim is to consider what further clean air measures are feasible and cost-effective to reduce air pollution levels from residential emissions, so as to address current exceedances and move towards the WHO health based standards in line with the commitment in the EU's 7th Environmental Action Programme. Given the current economic backdrop and the constraints on public finances, it is critically important that any measures considered can deliver emission reductions in a cost-effective way, which does not present an undue burden for public finances. Measures should also be aligned with, and promote other policy objectives including, for example, the reduction of fuel poverty.

Questionnaire on the air quality impact of residential solid fuel in Northern Ireland and the Republic of Ireland

The questionnaire is designed to engage with you as a key expert stakeholder so that the analysis for the final report will benefit from the range of expertise in the different key stakeholder groups. It is designed to cover the range of relevant issues, and it is recognised that not all stakeholders will have views on all the questions posed. When answering the questions, unless otherwise specified, please indicate if your response relates to (i) The Republic of Ireland (ii) Northern Ireland or (iii) to both jurisdictions. Feel free to elaborate and include quantitative information if available to support your answers.

Your feedback will be analysed following pre-set criteria. The results will be published in form of examples of best practices for reducing emissions from residential fuels. In the publication, no reference to the personal identity of the respondent will be given.

For each issue in the questionnaire we invite you to summarise your experiences (positive or negative), to mention any problems that you may have encountered and, possibly, ideas for solving such problems. For clarifying the issue and pointing out relevant aspects, a few introductory remarks have been given for each issue.

To allow inclusion of your comments in the report, we would prefer to receive the filled-in questionnaire in electronic format by email by 19 June 2015. Please send it to beth.conlan@ricardo-aea.com at Ricardo-AEA (with a copy to barry.mcauley@doeni.gov.uk and micheal.young@environ.ie), where the results will be processed.

➢ **Please use the white cells of the tables for filling in your replies.**

Respondent (for internal use only)	
Name	
Address	
Telephone	
Email address	
Organisation	

1 Legislative and Regulatory Measures	
Introductory remarks: Air quality legislation derived from EU Air Quality Directives is implemented in both the Republic of Ireland and Northern Ireland (Section 6 of the report). In addition, the Republic of Ireland and Northern Ireland have long-established but different legislative instruments to mitigate public health impacts from use of solid fuels – the smoky coal ban areas in the Republic of Ireland and measures including powers to create smoke control areas in Northern Ireland	
1a. Do you consider that the current legislation to limit air pollution from household emissions is fit for purpose?	□ Yes □ No □ Don't know

1 Legislative and Regulatory Measures	
If *No*, what gaps exist in the legislation? Please elaborate	
1b. Is the geographic area covered by Smoke Control Areas and Smoky Coal bans under the current legislation adequate?	□ Yes □ No □ Don't know
If *No*, where should they be extended? Please elaborate	
1c. Could the regulation of solid fuel (for example on sales) be improved to enhance the effectiveness of the current regulations?	□ Yes □ No □ Don't know
If *Yes*, how could this occur? Please describe.	
1d. Could the regulation of home heating appliances be improved to enhance the effectiveness of the current regulations?	□ Yes □ No □ Don't know
If *Yes*, how could this be improved? For example, would introduction of the EU Ecodesign space heating emission standards ahead of the mandatory 2022 deadline provide beneficial reductions from new installations? Please elaborate	
1e. Do you consider that enforcement of the existing regulations is effective?	□ Yes □ No □ Don't know
If *No*, what do you consider are the problems with enforcement and how could they be addressed? Would stronger cross agency co-operation be helpful?	
1f. A range of different technical standards exists for residential solid fuels in Northern Ireland and the Republic of Ireland, for example, in relation to sulphur content, petcoke content and smoke emissions rates. Do you think that harmonisation of technical standards could be of benefit?	□ Yes □ No □ Don't know
If *Yes*, please indicate which standards would benefit from harmonisation and why.	
1g. Different approaches are used to compile solid fuel statistics and emission inventories in Ireland and Northern Ireland. Are there areas where improvements could be made to increase the robustness of the estimates?	□ Yes □ No □ Don't know
If *Yes*, please specify	
1d. What impacts do you think any changes to the legislation as you may have proposed above would have on: fuel cost; industry; employment; fuel poverty; public finances?	

2. Measures	
Introductory remarks: There are various policy measures to reduce emissions from residential solid fuel burning, some of which are already in place and others which have been introduced in other European Countries.	
2a What fuels do you think should be promoted in the residential heating sector? Please rank in terms of preference with **1 being highest and 10 being lowest**	
Anthracite	
Bituminous coal	
Electricity	
Gas	
Manufactured solid fuels (e.g. authorised solid fuels, ovoids)	
Oil	
Peat Briquettes	
Petroleum Coke	
Sod Peat	
Renewable fuels	
Wood	
Are there any other fuels to add? If so, please specify.	
2b. Please rank the following policy measures to reduce emissions from residential solid fuel in order of preference with **1 being highest and 5 being lowest**.	
Increase Fuel Efficiency – e.g boiler upgrade	
Increase use of Cleaner Fuel Types e.g.– expansion of natural gas or renewables	
Increase Fuel type restrictions e.g. Smoky coal bans/Smoke Control Areas – expand geographically and/or to additional fuels/ control at import/ point of sale/point of use	
Increase Fuel Pricing e.g. carbon tax in Ireland	
Reduce Energy Use and increase Energy Efficiency measures e.g smart metering	

2. Measures	
Please provide the rationale for your preference.	
2c What schemes would you prefer to be put in place to encourage the uptake of the above policy measures? Please rank in order of preference with **1 being highest and 3 being lowest**	
Introduce Scrappage schemes e.g. for Central heating boiler	
Fuel switching incentive e.g. renewable heat incentive	
Incentive for energy efficiency e.g. insulation at discounted rates	
Would you consider any other incentive scheme to encourage the uptake of these measures of benefit? If so, please describe.	
2d. Are there further cost-effective measures for residential solid fuels which could contribute to current and/or future EU and international obligations for air pollutants (e.g. for $PM_{2.5}$, SO_2, NO_x) for 2020 under the Gothenburg Protocol and for 2030 under the EU Clean Air Package? • Are there specific areas where further research would be of value? • Are there national/EU/international research funding programmes which might be considered?	
2e.For new housing stock or significant alterations, could the building code (Building Regulations) be used to reduce residential emissions? • Could there be a 'no chimney' policy in areas with natural gas network or with minimum densities or scale? • Would different Building Regulations for differing densities of housing be appropriate? • Would different Building Regulations for areas with on/off natural gas grid be appropriate? • Should any preference for biomass combustion under building regulations be associated with a corresponding emission standard for air pollution?	
2f. Are there clean air measures that could be taken that align with overall climate policy aims to transition to a low carbon economy which could reduce cost? Please elaborate	
2g. Are there any other measures which Government should be considering to reduce emissions from residential solid fuel burning? Please provide details.	

3. Voluntary Incentives	
Introductory remarks: Voluntary measures that the solid fuel industry could take to reduce air pollution from the residential heating sector may be very cost-effective and effectively complement regulatory measures to reduce the health impacts of solid fuel use on the population.	
•	
3a. Do you think that a voluntary scheme / code of practice / industry-regulator agreement within the fuel industry could be effective?	□ Yes □ No □ Don't know
If Yes, please elaborate.	
Are there specific areas that such a scheme or code of practice would most effectively address, for example, fuel quality standards, statistical reporting, assisting LA enforcement?	□ Yes □ No □ Don't know
If *Yes*, please provide details. What impacts do you think such measures would have on: fuel cost; industry; employment?	
Are there other non-regulatory measures which could lead to a reduction in air pollution from the residential heating sector?	□ Yes □ No □ Don't know
If *Yes*, please provide details and What impacts do you think such measures would have on: fuel cost; industry; employment; fuel poverty	
•	
Are there any examples of successful best-practice solid fuel measures / interventions used elsewhere that could be used here?	□ Yes □ No □ Don't know
If *Yes*, please provide details	

4. Impact of Measures
Introductory remarks: The impact of emissions from residential solid fuel to health is important. Similarly, fuel poverty is a health issue in society. Addressing the latest evidence on the health impact of air pollutants should be considered in policy making, whilst simultaneously, setting policy to lower fuel poverty is a key aim.
4a. How should new and/or emerging evidence on the health impacts of air pollution or international best practice guidance from residential solid fuels be considered? Specifically, • How should relevant WHO or other international best practice guidance for Europe be addressed? • Are there specific fuels or activities for which action should be prioritised? • Are there measures taken internationally in relation to reducing air pollution from home heating which could be effectively applied here? • Is indoor air pollution an important consideration in assessing the impact of residential solid fuels?

4. Impact of Measures
4b. The incidence of fuel poverty and the use of solid fuel are highly correlated; are there measures that could be taken to address fuel poverty and at the same time lower emissions from residential heating? • Are cheaper fuels, regardless of quality, a solution to fuel poverty? • Could improvements in energy efficiency along with lower emissions be made by incentivising certain fuels, heating devices etc? • Would increased use of gas (where available) for heating help address fuel poverty and reduce emissions? If so, should increased use of gas be incentivised for those houses that can avail of it?
4c. Please add any other information you have on the impact of measures on health and fuel poverty.

5. Communications	
Introductory remarks: Communication and education has an important role to play in raising public awareness about health, air quality, and fuel efficiency/costs and the role that the residential heating sector plays in this. Education and awareness strategies could be used to highlight to households the availability of cleaner fuels alternatives, and their cost-effectiveness. Such strategies could also highlight the negative health impacts of air pollution which is produced from burning solid fuels, especially poorer quality fuels, and the cost savings associated with burning cleaner fuels. There are several ways of delivering information and awareness, for example, via the internet, advertising, reports, industry activity, product labelling.	
5a. On a scale of 1 to 10 how aware do you think the general public is of the problem of air pollution from the residential heating sector, with **1 being lowest and 10 being highest?**	
5b. Can you suggest any ways in which awareness might be improved?	□ Yes □ No □ Don't know
If *Yes*, please describe	
5c. Is there sufficient awareness of the specific areas to which current Smoky Coal Ban / Smoke Control regulations apply?	□ Yes □ No □ Don't know
If *No,* how could this be addressed (e.g. internet etc.)?	
5d. On a scale of 1 to 10 how aware do you think the public is of relative air pollution impacts and energy efficiencies/values for different types of solid fuels, with **1 being lowest and 10 being highest**?	
5e. Can you suggest any ways in which awareness might be improved?	□ Yes □ No □ Don't know
If *Yes*, please describe	
•	
5f. Which, in your view, would be more effective: an awareness campaign with the primary emphasis on environmental considerations, health considerations or cost considerations?	

5. Communications

6. Any other issues
Please provide any other comments on issues not sufficiently covered.

Thank you very much for your cooperation!

Appendix 5 - Questionnaire on North South Ministerial Council Study on Residential Solid Fuels

Questionnaire responses

Table A5.1 : Summary of consultation responses

	No of questionnaires returned	Assigned group in analysis	No of questionnaires returned
Government and Agencies.	1	Gov/LA	10
Local authorities	9		
Health/impacts	3	Health / Social Impacts	5
Fuel poverty	2		
Fuel market/policy	0		
Industry	9	Industry	9
Fuel statistics and technical standards	1	NGO/Inst	10
NGOs /Institutes	9		
International Contacts.	1	International	1
Number of questionnaire returned	35		
Response without a questionnaire	2		

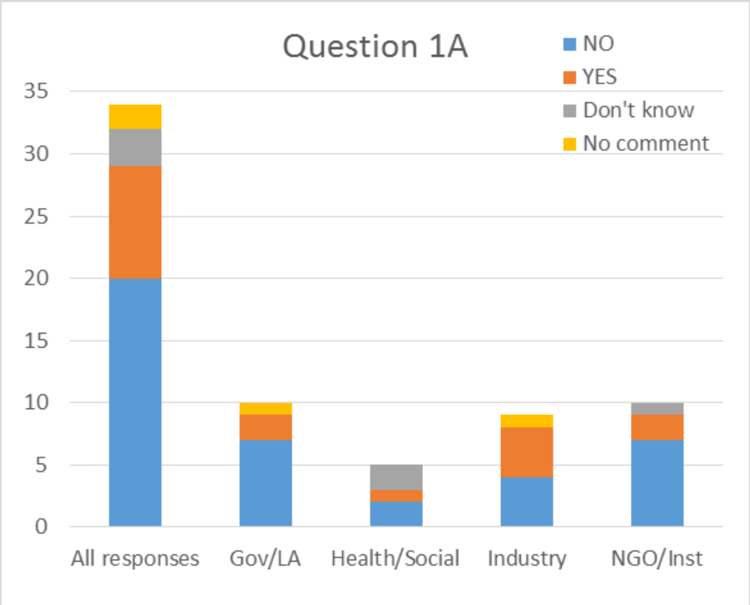
Note: Some respondents only answered questions when they had an opinion. In the following summaries responses have been classed as 'No Comment' when they have expressed a view on some of the question in the section but not the specific question and not included where there was not response for the section.

Legislative and Regulatory Measures (Q1)

Key messages from questionnaire responses

- Harmonise regulations (and tax) across all the island
  - Create a level playing field for all retailers, remove the advantages of non-compliance
- Focus legislation on all fuels
- Enforce regulations – create regulations that can be enforced
- Test fuel when it is imported into the country to remove ‘Smoky Coal’ from the 'Black Market
- Registration scheme for operators in the distribution chain
- Registration scheme for appliance installers and service agents
- Carbon Tax to widen differential between clean and dirty fuels
- There should be an all-island Smoky Coal Ban, or do not allow storage of smoky coal within the SCB area
- Additional Smoke Control Areas, review of coverage (Northern Ireland)
- Solid fuels could be regulated so that customers receive statutory protections comparable to those for gas and electricity customers
- Provide clear harmonised standard test method for the measuring of appliance smoke emissions.
- Estimates based on the use of emission factors and census data have to be backed-up with ambient measurements and source apportionment studies.
- Health and health/cost together were identified as the key messages in public awareness campaigns.

1a. Do you consider that the current legislation to limit air pollution from household emissions is fit for purpose?



The general view is that the current legislation is not fit for purpose by all respondent groups except for the industry section where half the respondents consider legislation fit for purpose.

Legislation is focussed only on "smoky coal" – legislation should include all (solid) fuels.

Enforcement:

- there are currently errors in the legislation which prevent enforcement action.
- There are limited enforcement options - the ability to seize product or apply on the spot fines may allow more rapid enforcement actions.
- enforcement of the ban on the burning of specified fuels in private dwellings within specified areas is unworkable.
- there are not workable specifications for analysis of samples.
- greater enforcement and monitoring of air quality is vital

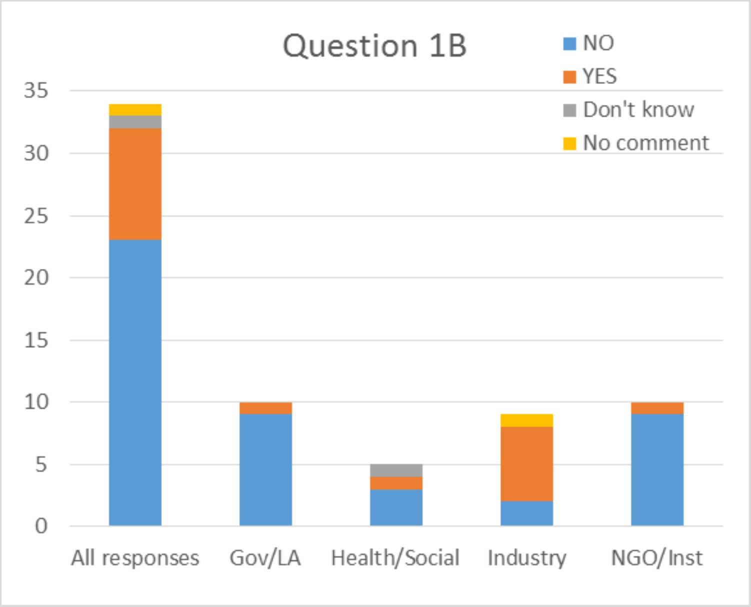
Control of the distribution chain:

- Make it a legal requirement to register the **full distribution chain** annually, include transport of fuel.
- There are contrasting views on the regulatory body one to have a registration system across all-island and others to transfer the registration to Local Authorities

Other comments:

- Use building regulations to ban/phase out of open fireplaces and improve supervision of solid fuel appliances.
- Use a Carbon Tax to widen differential between clean and dirty fuels.
- Home Renovation Schemes to enable retrofitting of cleaner systems.

1b. Is the geographic area covered by Smoke Control Areas and Smoky Coal bans under the current legislation adequate?



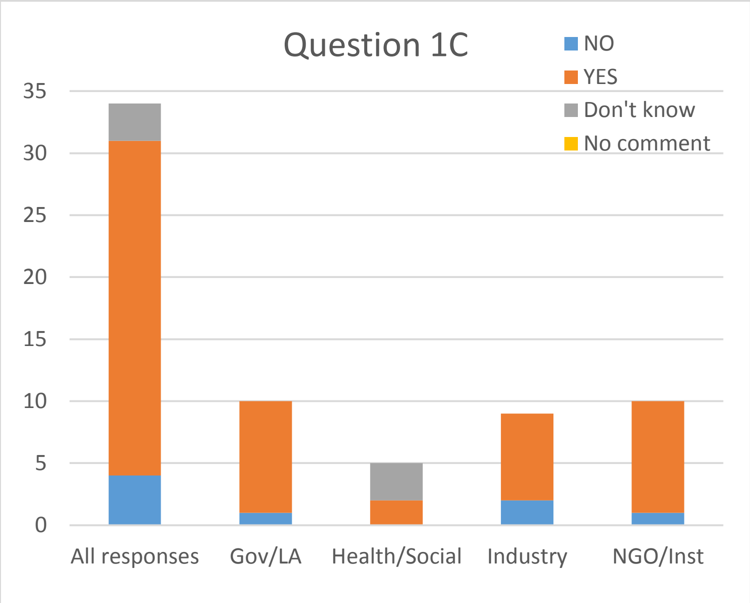
The general responses is for an all-island Smoky Coal Ban. If not an all-island ban, define larger smoke control areas. This would simplify enforcement and stop coal sales from smoky areas into Smoky Coal Ban areas. It would:

- require harmonised regulations and would allow for a more centralised enforcement,
- provide everyone with same protection against pollutants,
- be easier to deal with those in the industry who purposely circumvent the legislation.

Smoke Control Areas should be extended to include those areas that exceed WHO guidelines in relation to $PM_{2.5}$ and PM_{10}. An LA commented on boundary changes (in Northern Ireland) requiring review of geographic coverage.

An all Island ban on importation of bituminous coal is desirable but not practical e.g. power stations such as at Moneypoint in Co Clare uses coal in generation of electricity.

1c. Could the regulation of solid fuel (for example on sales) be improved to enhance the effectiveness of the current regulations?

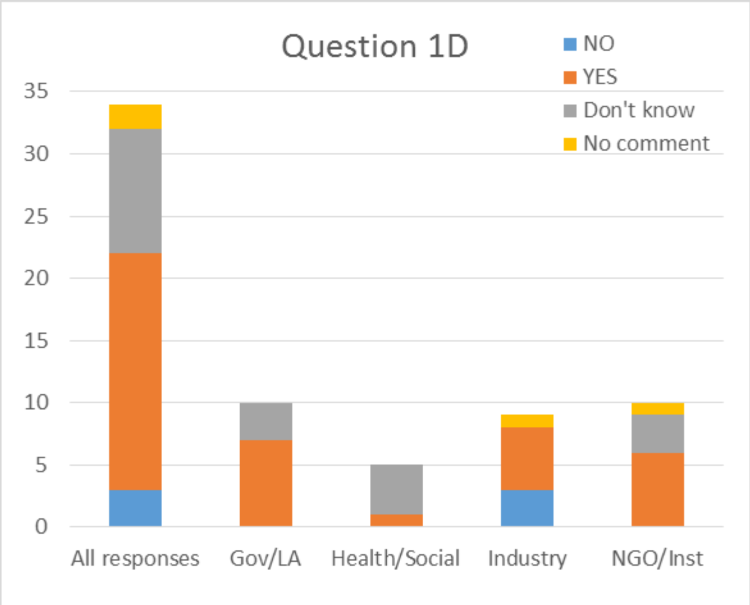


Do not allow storage of smoky coal within the SCB area.

- Strict and comprehensive control on imports would allow for better control of fuels subsequently marketed in Ireland.
- Incentivise the use of smokeless (low smoke) coal
- A ban itself is not adequate
- Appropriate regulation is required for all fuels
- Greater monitoring and accountability for those selling fuels

Solid fuels could be regulated so that solid fuel customers receive statutory protections comparable to those enjoyed by gas and electricity customers

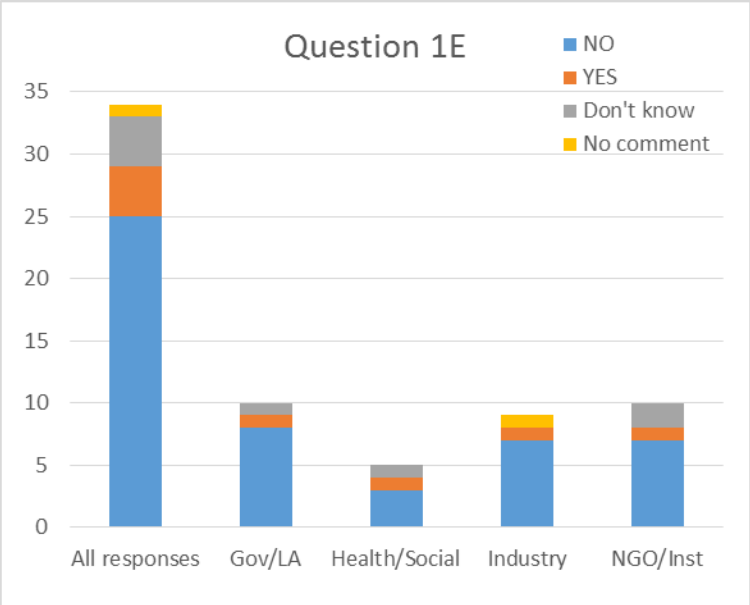
1d. Could the regulation of home heating appliances be improved to enhance the effectiveness of the current regulations?



The supplementary question directed the consultees toward the possibility of introducing Ecodesign requirements early. Comments included:

- Key to success is Communications - getting the Public and Trade to buy in to improvements including the Eco Design Directive
- Provide clear harmonised standard test method for the measuring of appliance smoke emissions.
- The 2022 deadline is too far removed and should be brought forward but see contrary comments below as well
- Early introduction of the Eco Design Directive would not be beneficial:
  - appliance designers and manufacturers will need time to ensure their products are capable of meeting the new legislation.
  - The transition should be orderly so as to allow solid fuel appliance suppliers to change their business models.
- If gas is available it should be used (to replace solid fuel)

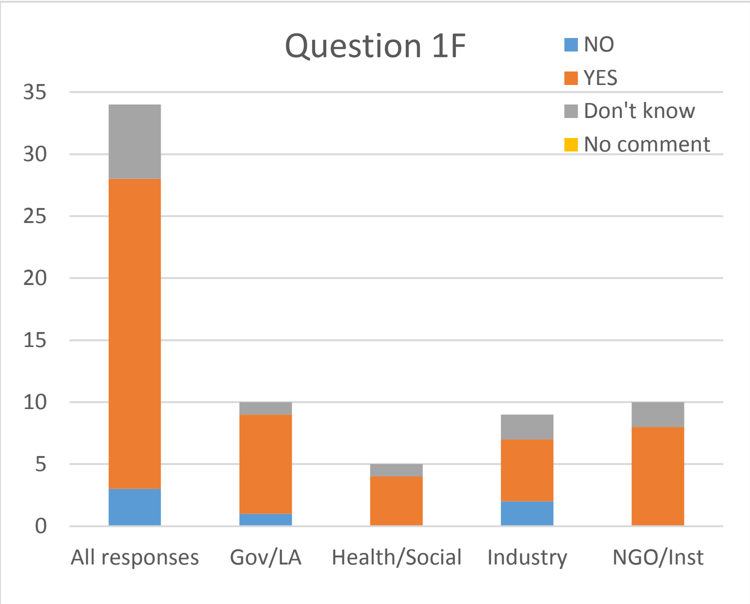
1e. Do you consider that enforcement of the existing regulations is effective?



What do you consider are the problems with enforcement and how could they be addressed?

- There is a need for a multi strand approach starting with a public awareness campaign but which also has greater resource to enforce regulations
- Recognise that the market has changed fundamentally since 1990 and that a whole island integrated approach across local authority boundaries is required
- Lack of Resources, regulations difficult to apply.
  - Heating season pressure on resources
  - Entry powers to private homes, power to seize material, not available
  - Absence of lab facilities (could redefining 'Specified Fuel' remove need for laboratory)
  - Inspection at point of entry to the island, could provide better coverage for less cost.
- Lack of traceability of coal bags
  - Development of a distinctive logo / brand to signify authorised compliant products
  - Develop a register of all operators in the fuel business
- Ignorance of regulations
- Need for cross-border co-operation

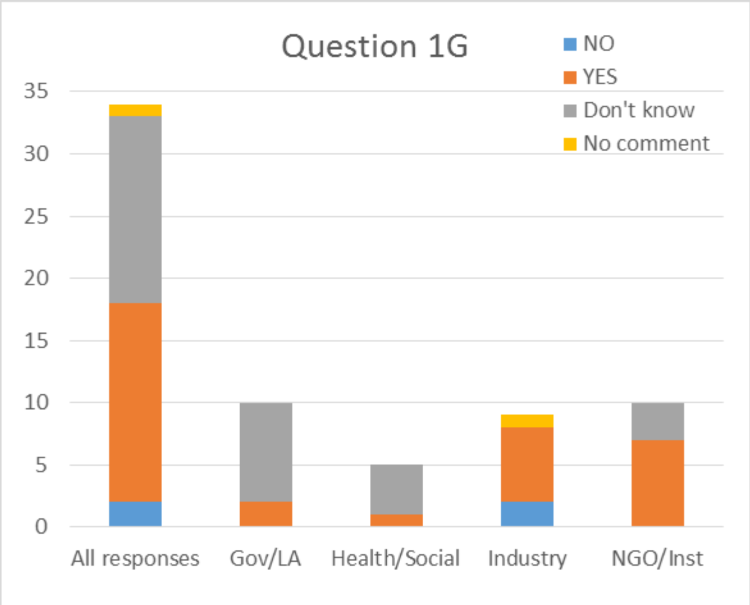
1f. A range of different technical standards exists for residential solid fuels in Northern Ireland and Ireland, for example, in relation to sulphur content, petcoke content and smoke emissions rates. Do you think that harmonisation of technical standards could be of benefit?



For positive answers, consultees were asked to indicate which standards would benefit from harmonisation and why.

- Common standards create a level playing field for enforcement and control
- Harmonise standards to maximise public health
- Prioritise disparity in smoke emission rate standards
- Similar sulphur content for all-island
- Harmonise incentives to achieve standards
- Harmonise testing methods
- Harmonise new standards for traceability - Packaging, Labelling, Transporting
- Even the forthcoming regulation as part of the Eco Design Directive will have three different and distinct standards for the determination of conformance

1g. Different approaches are used to compile solid fuel statistics and emission inventories in Ireland and Northern Ireland. Are there areas where improvements could be made to increase the robustness of the estimates?



Clarifications provided where answers were 'Yes'.

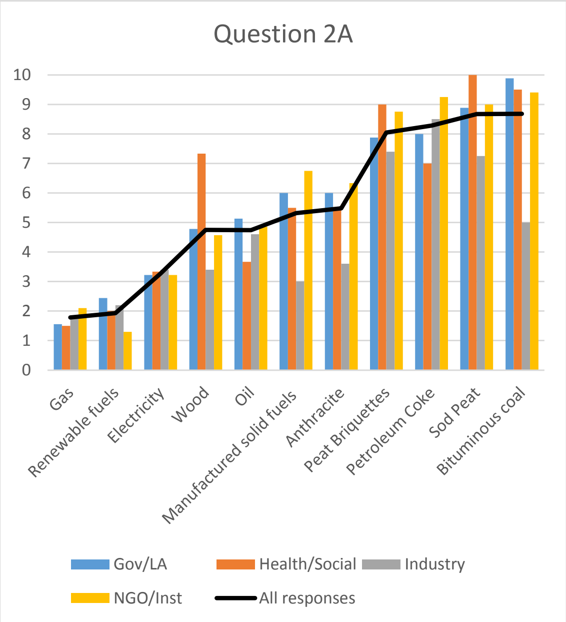
- There are significant gaps in the data collected, and its interpretation. This leads to many incorrect conclusions, whether in the calculation of mortality figures, or in the attribution of emissions to source. Harmonisation of approaches on gathering data is required for direct comparisons.
- Estimates based on the use of emission factors and census data have to be backed-up with ambient measurements and source apportionment studies.
- Data collection is vital to effective policy making, harmonising across jurisdictions makes most sense. The data sets in the possession of suppliers, would be very helpful in understanding consumption, payment and geographic patterns. Such information when produced in an aggregate fashion creates a clearer and broader picture of consumer behaviour.

1h. What impacts do you think any changes to the legislation as you may have proposed above would have on: fuel cost; industry; employment; fuel poverty; public finances?

- A level playing field for all retailers, remove the advantages of non-compliance
- Industry will produce more smokeless (low smoke) fuel, bringing costs down and employment up. If required quickly it would benefit from financial support.
- Costs of capturing reliable real time based air quality measurement, and accurate source attribution
- Restrictions, bans or additional taxes on these solid fuels will directly increase fuel poverty.
- Cross-border fuel marketing will be impacted which will have an impact on tax take.
- Communication and enforcement of current legislation would reduce the perceived air quality issues.
- Align the emissions factors of residential solid fuels in terms of absolute and relative emissions by fuel type

Measures (Q2)

2a What fuels do you think should be promoted in the residential heating sector? Please rank in terms of preference with 1 being highest and 10 being lowest

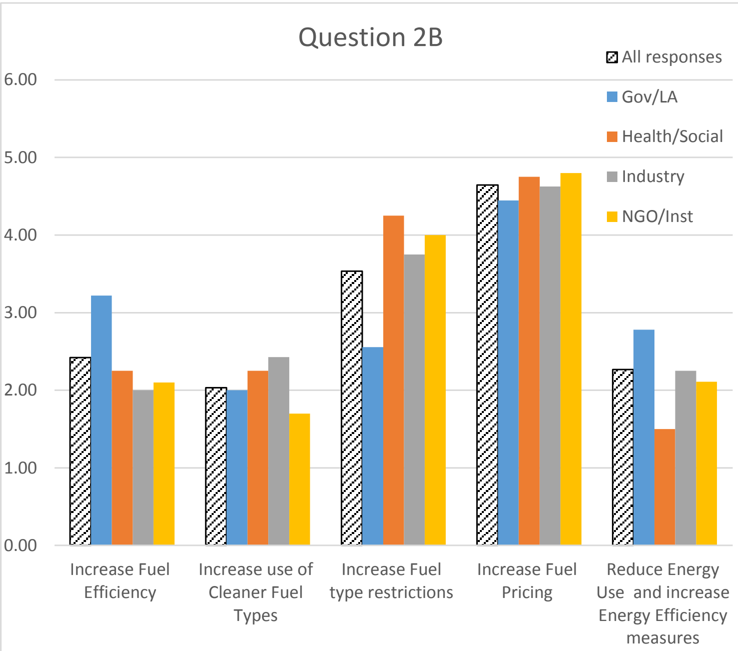


- The responses were broadly similar and fuels fall into 3 categories this was similar across all respondents:
  - Gas, Renewable, Electricity (preferred)
  - Wood, Oil, Smokeless (low smoke) fuel
  - Peat, Coke, Bituminous coal (least preferred).
- Need to take into account 'it's not what you burn it's the way that you burn it'.
- This question was not answered by 4 of the respondents from the Industry sector. It was considered that the:
  - Question is too subjective
  - scope of this question was too confined
  - ranking too simplistic

One respondent from the industry sector suggested that criteria need to be identified before ranking should be attempted. One could rank against many criteria including:

- Access and availability.
- Cost per unit of heat – affordability.
- Energy Security – Both geographic area, and political stability.
- CO_2 Emission Profile.
- Emissions impacting Air Quality.
- Performance of Fuel
- Capital cost of fuel choice
- Tradition
- Appliance type

2b. Please rank the following policy measures to reduce emissions from residential solid fuel in order of preference with 1 being highest and 5 being lowest.



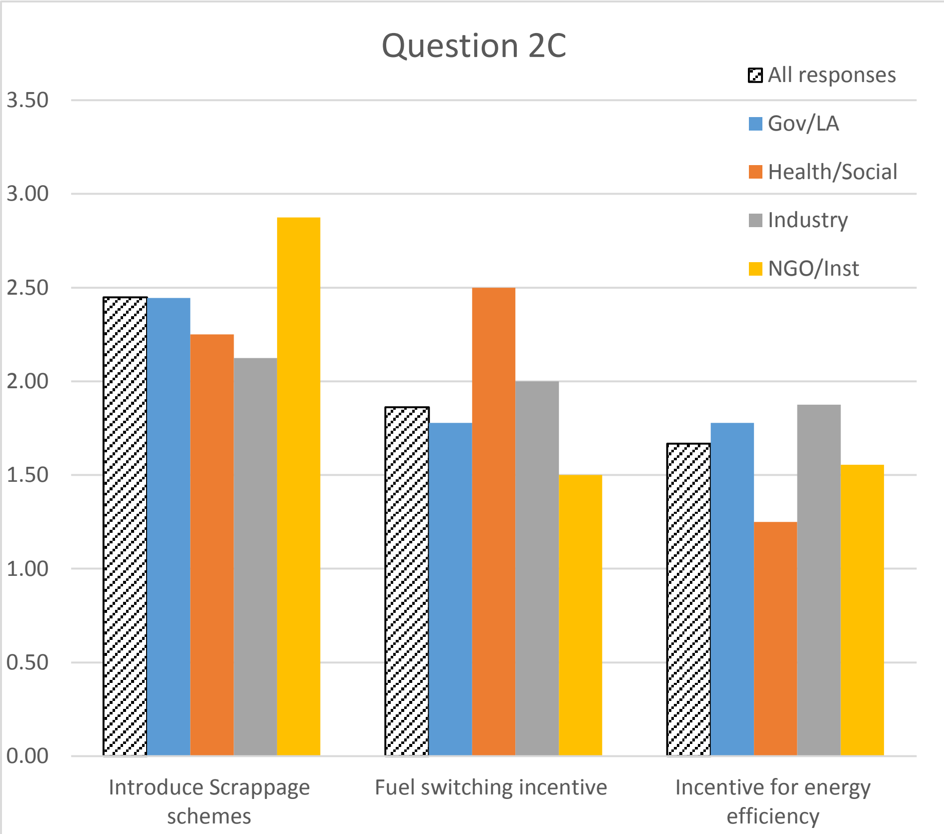
The importance of avoiding Winter Mortality from hypothermia was raised, solid fuel (used in room heating) is not susceptible to **power supply interruptions,** unlike most alternatives

One consultee commented that the move to renewables is inevitable so should be encouraged and implement some transitionary measures in the meantime.

Many comments were provided and the following summarises a broad range of commentary:

- Behaviour:
  - Behaviour is largely driven by perceived benefits
  - A carrot as opposed to a stick approach is needed.
- Reduce Energy Use and Increase Energy Efficiency
  - Smart metering roll-out will contribute towards energy efficiency
  - Reducing energy consumption through improved home energy efficiency should be the first priority of energy policy.
- Increase Fuel Efficiency
  - Upgrade open fire to a closed stove
  - Combined standard for efficiency and fuel emissions from appliances
- Cleaner Fuel Types
  - Switch to smokeless (low smoke) solid fuels. Either island wide or in both jurisdictions at a time of their choosing
  - Incentive a fuel switch from solid fuel to natural gas in gas areas.
  - Wider consumer access to natural gas and renewable options.
  - Using intrinsically cleaner fuels more efficiently is a more sustainable approach
- Cost measures
  - There is insufficient evidence to justify banning or increasing tax on specific fuels.
  - Tax increases would exacerbate the already significant fuel poverty issue.
  - Tax increases will be resisted and illegal sellers will flourish.
  - Polluter pays principle i.e. make the market self-regulatory.
  - Measures have to be cost effective for existing households based on their current means of heating

2c What schemes would you prefer to be put in place to encourage the uptake of the above policy measures? Please rank in order of preference with 1 being highest and 3 being lowest



- **Incentives to replace open fireplaces with high efficiency stoves** - this is classed in Energy efficiency and Scrappage schemes by different groups.
    - Link grants to operating cleanliness of the appliance throughout its entire cycle
    - Coupled with education/awareness programmes
    - Home Renovation Incentive
    - Pay as you Save schemes.
    - A requirement whereby local authorities must phase out open grate solid fuel heating for social housing and regulation of the private rented sector.

- **Fuel switching incentive** e.g. renewable heat incentive.
    - Beneficial across the range of biomass, geothermal and heat pump technologies as well as heat from renewable electricity.
    - Introduce a smoky coal ban either island-wide or in both jurisdictions at a time of their choosing. This will incentivise the uptake of smokeless (low smoke) solid fuel at no cost to the consumer.
    - Fuel switching generally incurs a significant capital cost and does not help people in fuel poverty
    - Provide information on solid fuel and peat packaging including cost/kwhr

- **Incentive for Energy Efficiency.**
    - Current grants need to be maintained.
    - Recommendation that funding should come from General Taxation.
    - Instead of an administratively cumbersome and costly incentive scheme offer free energy efficiency upgrades to the most disadvantaged.

- **Communication**
    - Consumer research presented by SEAI7 that there is a need for the communication of relevant information as well as grant supports and finance.

- It is a well-established fact that end users will respond to an opportunity to **increase efficiency and reduce their fuel costs**, the facts need good communication.

- **Other Incentive Scheme**
  - Upgrading home insulation. This has been successful in Northern Ireland in the past.
  - Free or subsidised energy audits
  - Introduce more district heating systems where fuel use and emissions can be better managed
  - Measures suggest consumer choice – this is not the experience of people in fuel poverty.

2d. Are there further cost-effective measures for residential solid fuels which could contribute to current and/or future EU and international obligations for air pollutants (e.g. for $PM_{2.5}$, SO_2, NO_x) for 2020 under the Gothenburg Protocol and for 2030 under the EU Clean Air Package?

Are there national/EU/international research funding programmes which might be considered?

There are a number of funding programmes under the overall INTEREG 2014-2020 fund which could be considered. Ireland/Northern Ireland could apply to for funding on the health related aspects associated with solid fuels

Are there specific areas where further research would be of value?

- The messaging around residential solid fuel regulation is critically important.
- It is necessary to have strong evidence-based analysis surrounding options and the reasons for change– so not just air pollution, but also health, climate, employment, energy imports, fuel poverty, efficiency etc. etc.
- The air monitoring scheme operated at present is inadequate.
- Need the modelling and policy analysis to show that any measures to be introduced will reduce air pollutants in Ireland
- This requires direction from Government on the research agenda as well as the development of certain residential data sets.
- Additional research is required into the health impacts of the exposure of individuals to pollutants from residential solid fuel burning both indoors and out.

Other measures

Consider after treatment systems such as those used in vehicles for particulates, scrubber systems

2e.For new housing stock or significant alterations, could the building code (Building Regulations) be used to reduce residential emissions?

Would different Building Regulations for differing densities of housing be appropriate?

Would different Building Regulations for areas on/off natural gas grid be appropriate?

- Building Regulations need a root and branch review.
- It would be difficult to enforce
- Can be tailored to geographic location
- Little effect on improving existing house stock
- Required for the private rented sector
- An increase in the insulation and energy efficiency standards required by the Building Regulations should be the first step before any of the others is considered.

Could there be a 'no chimney' policy in areas with natural gas network or with minimum densities or scale?

- Should be implemented in areas with a natural gas
- Extreme given the stated good quality of Irish air
- 'No chimney' policy a step too far but different level of building regulations in some areas may be appropriate.
- Not compatible with the increased use of higher efficiency solid fuel heating appliances
- Experience in UK has proven that many customers in homes built without a chimney are keen to erect a prefabricated flue system to provide opportunity to install a wood burning appliance and thereby offer an alternative heat source in the event of power cuts.
- Negative aesthetic implications.

Should any preference for biomass combustion under building regulations be associated with a corresponding emission standard for air pollution?

- It would be useful to produce a biomass emission standard.
- We see no reason to impose further restrictions beyond what will be demanded of a biomass heating appliance which will satisfy the requirements of the Ecodesign Directive.

2f. Are there clean air measures that could be taken that align with overall climate policy aims to transition to a low carbon economy which could reduce cost? Please elaborate

A range of comments:

Appliance lead strategy based on the Ecodesign Directive, supported by Government incentives for the fuel poor and a strong communication strategy.

It is clear that domestic coal burning will have to be phased out if the 80% reduction in CO_2 emissions by 2050 is going to be achieved.

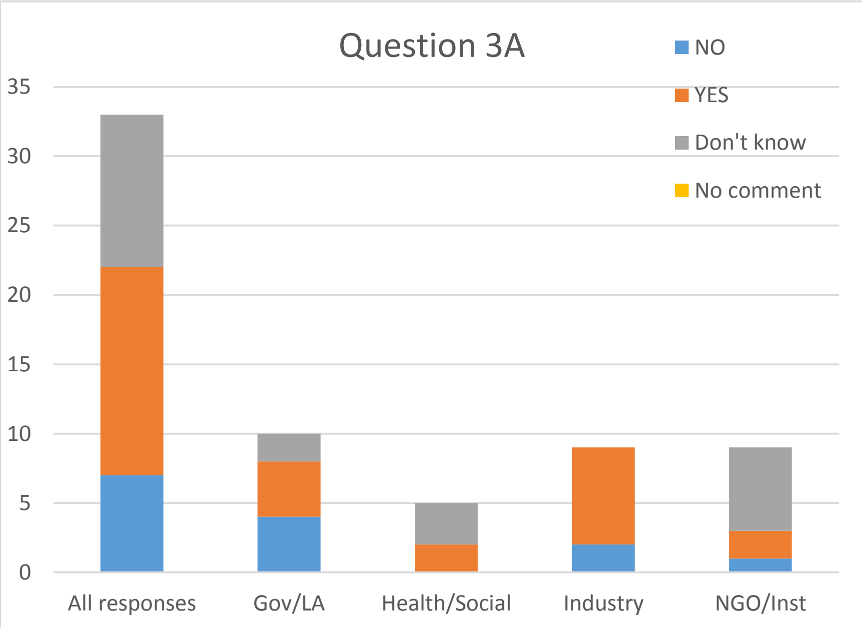
- Clean-air policy in cities (similar to London)
- Carbon tax
- An all Island ban on importation and sale of bituminous coal
- Eliminate the price differential between bituminous coal and low smoke fuels
- The development of district heating systems, particularly those that use natural gas, wind, solar, PV, geothermal and / or renewable fuels should be promoted and incentivised.
- Transition to clean burning technology, as legislated for in The Ecodesign Directive regulations in 2022,
- Policy that encourages the upgrading of appliances to higher efficiency appliances will deliver a dual dividend, of reduced fuel consumption, and reduction in emissions. The combined impact aligns clean air policy with overall climate policy
- There always has to be a balance on the reduction of CO_2 versus the increase in NOx and other pollutants.
- Energy efficiency measures

2g. Are there any other measures which Government should be considering to reduce emissions from residential solid fuel burning? Please provide details.

- Power to implement regulation e.g. entry powers to residential properties
- Standards for stoves (e.g. DEFRA UK)
- A national PR campaign to win the hearts and minds of the fuel users.
- Promote electrification of heat.
- The transition to a smokeless (low smoke) fuel country coupled with stricter import controls.
- Harmonisation of standards, particularly between Ireland and Northern Ireland,
- Review the current 'smokeless (low smoke)' definition
- Financial incentives, such as grants and tax refunds
- Take the brakes off the uptake of household renewable generation, for instance each household in NI is limited to 4Kw generation because of infrastructure constraints.
- Promote community energy advisors who would have access to ‘hard to reach’ households

Voluntary Incentives (Q3)

3a. Do you think that a voluntary scheme / code of practice / industry-regulator agreement within the fuel industry could be effective?



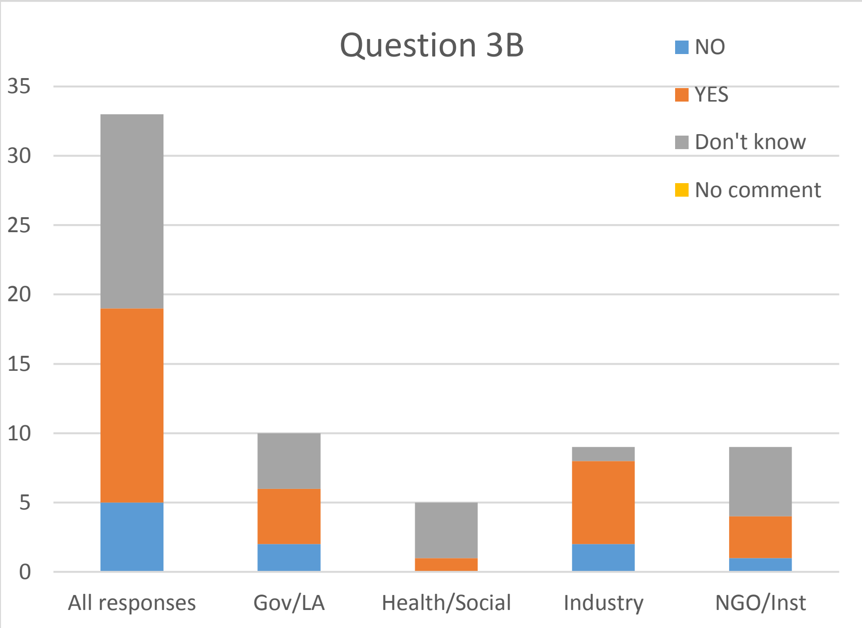
Yes

- A voluntary code of practice may have a value in providing a focus and clear position and raising awareness on these issues but measures to monitor and promote accountability may also be necessary
- There was concern that all sectors of the distribution chain would not support.
- The current SFTG agreement works well, industry would support exploring another VA, If there was enough support to produce a positive change
- For traceability of coal stocks e.g. using bar codes on labels, standardisation of package colouring for different types of coal e.g. all anthracite in orange bags
- OFTEC are motivated and the industry has said it would fund some initiatives, such as a registration scheme for oil and solid fuel technicians.
- The trade could assist in a move to lowering emissions from solid fuel burning by undertaking to educate the end-consumer on the efficiencies and savings related to the burning of smokeless (low smoke) fuels in homes.

No

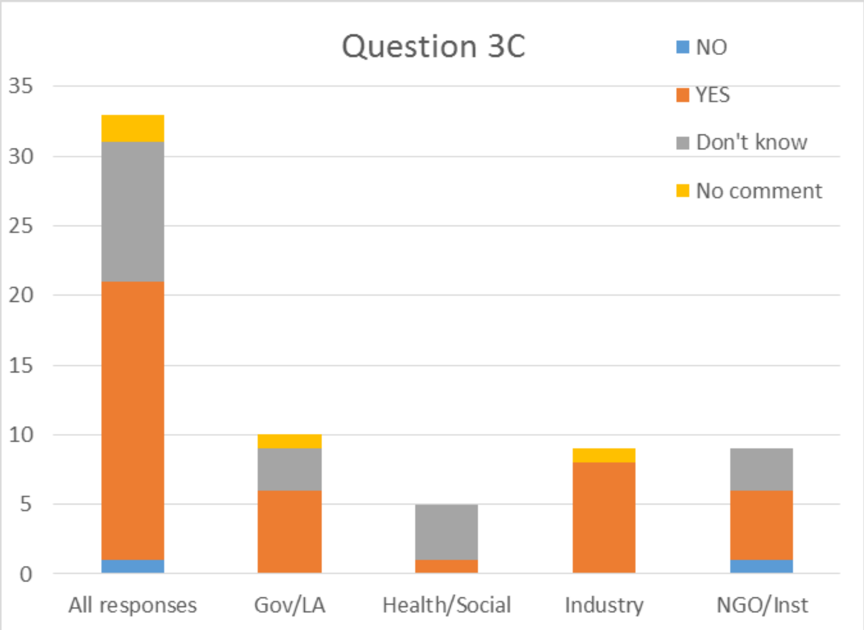
- Industry have, for example, been aware of the issue with bituminous coal for many years and could have agreed to voluntary scheme or code of practice to terminate/restrict supply before now.
- Voluntary systems do not work
- A voluntary code amongst such a large and diverse group of suppliers with many small retailers will be hard to monitor and by definition operates without regulation.

3b Are there specific areas that such a scheme or code of practice would most effectively address, for example, fuel quality standards, statistical reporting, assisting LA enforcement?



- More reporting would help to understand usage patterns and where such usage may be more harmful to the environment.
- An Appliance-led Strategy has environmental benefits, additionally, there are benefits as follows:
  - Reduced Fuel Costs, and consequent alleviation of Fuel Poverty
  - Economic activity and job creation generated by the supply of new appliances (Both Manufacture and Installation)
  - Sustained employment in the solid fuel industry
  - Tax revenue for Government through stimulatory effect of installation programme, and preservation of rural employment in fuel supply industry.
- A voluntary scheme to clearly mark product with heat content to allow the consumer to make a more informed choice.
- Industry reflection on the statistical evidence may promote new products, efficiencies etc which may benefit both environment and employment
- Education:
  - Better awareness will lead to better decisions by home owners.
  - Encourage burning of Authorised Smokeless (low smoke) Fuels in urban locations where air quality is an issue.
- The impacts of measures require proper analysis, not opinion.
- A pilot project could lead to real examples of how to better manage heating needs Changes to fuels to encourage for example the reduction of particulates may impact other emission like NOx

3c. Are there other non-regulatory measures which could lead to a reduction in air pollution from the residential heating sector?



- Winter fuel allowance to apply ONLY to smokeless (low smoke) fuels.
- Incentivise timber industry to develop suitable wood fuel
- Eliminate the price deferential between bituminous and low smoke fuel,
- A voluntary moratorium on the importation of dirtier fuels for a trial period of say, one year, to allow for analysis of air pollution and medical data trends.
- Promote installation of higher efficiency Stoves
- Expansion of schemes such as Warm Homes etc

Education and advice.

- Education programmes should be championed by Governments.
- A transparent information campaign, To help educate individual decision makers to make informed choices
- The relevance of the efficiency of appliances appears to be poorly understood
- Public awareness campaign on impacts of burning unclean fuels or household waste
- Communication to the public around the issue of emissions and best fuel choices would help people make better choices

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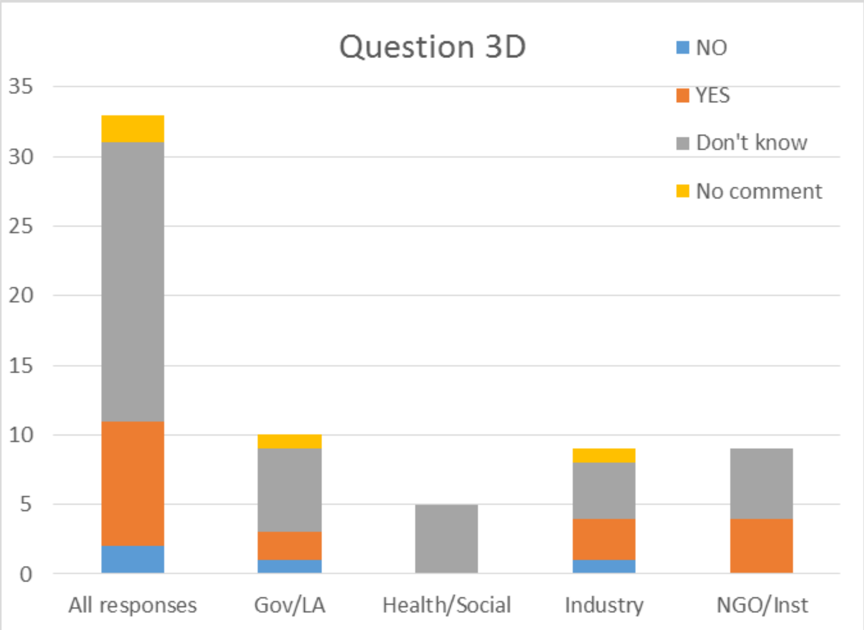
3d. Are there any examples of successful best-practice solid fuel measures / interventions used elsewhere that could be used here?



- District heating schemes as in Sweden and Spain.
- How people on continent cut, split & season their wood for 2 year period prior to use.
- RHI (Renewables Heat Incentive) and Green Deal - UK Government only entertain wood burning appliances which is too restrictive.
- Washington State/Canada border an international approach to wood burning
    - High temperature wood burning is promoted in enclosed systems.
    - A solid fuel burning fee is paid on the sale/resale of solid fuel burning device. Funds are used by the Department of Ecology to educate wood stove dealers

Impact of Measures (Q4)

4a. How should new and/or emerging evidence on the health impacts of air pollution or international best practice guidance from residential solid fuels be considered? Specifically,

How should relevant WHO or other international best practice guidance for Europe be addressed?

- Ireland is starting from a position of strength
- Reducing CO_2 and improving air quality should be managed together
- Upgrade appliances and reduce fuel demand

Are there specific fuels or activities for which action should be prioritised?

- Prevention of burning municipal solid waste in domestic stoves
- The prohibition of smoky coal and an all-island approach is key.

Are there measures taken internationally in relation to reducing air pollution from home heating which could be effectively applied here?

- Promote district heating
- Wider coal bans. In USA there are no-smoke nights: wood-burning is banned in towns when the dispersion of emissions is expected to be limited.

Is indoor air pollution an important consideration in assessing the impact of residential solid fuels?

- Respondents indicated that reports showed internal air quality to be good and bad. A review of the research, and possible new research may be required to clarify this issue.
- There is evidence that indoor air quality can become a problem under more recent building regulations, with minimal ventilation giving rise to increased levels of moisture. etc. However, appropriately maintained solid fuel appliance and flus improve air circulation and ventilation.

4b. The incidence of fuel poverty and the use of solid fuel are highly correlated; are there measures that could be taken to address fuel poverty and at the same time lower emissions from residential heating?

- *Are cheaper fuels, regardless of quality, a solution to fuel poverty?*
- *Could improvements in energy efficiency along with lower emissions be made by incentivising certain fuels, heating devices etc?*
- *Would increased use of gas (where available) for heating help address fuel poverty and reduce emissions? If so, should increased use of gas be incentivised for those houses that can avail of it?*

- Cheaper fuels, regardless of quality, are not an answer to fuel poverty. The switch to manufactured smokeless (low smoke) fuels would not increase fuel poverty as the cost per kWh of useful heat is comparable.
- Incentivised energy efficiency and transfer to cleaner fuels is a better solution for air pollution and fuel poverty
- A move to gas would be beneficial as it is cheaper and produces less emissions than coal or oil.
- More funding for heating grants, insulation grants of older properties

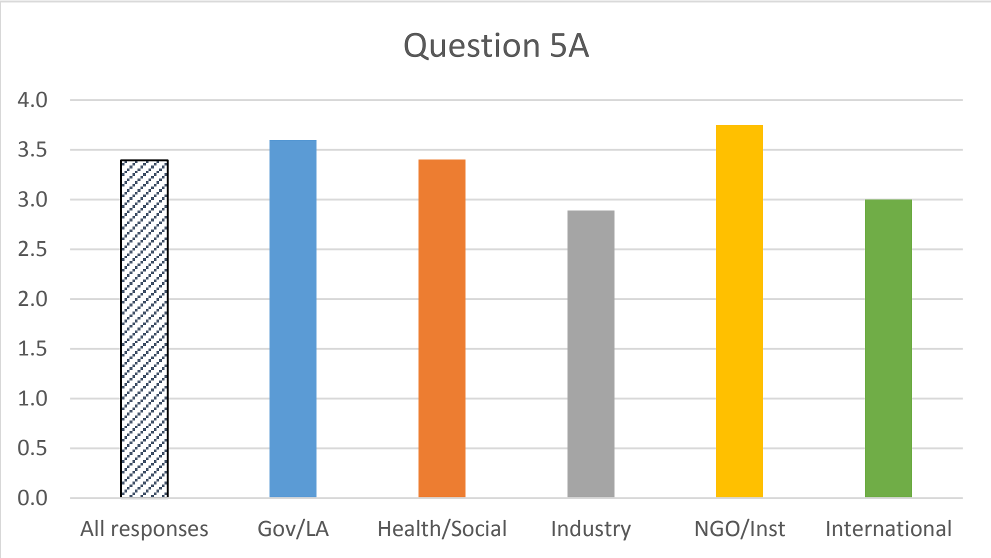
4c. Please add any other information you have on the impact of measures on health and fuel poverty.

- With the increase in energy/oil prices in Northern Ireland, there has been a marked increase in the number of homes who are starting to use open fires again. The lack of availability of gas and the availability of smoky coal contribute to this.
- For some households, solid fuel may be the only heating option as they can neither afford an oil conversion nor the cost of regularly filling the tank.
- Energy security is important for Ireland. Solid Fuel sourcing is geographically dispersed, and additionally it is easily stored in bulk, or at any level within the distribution chain.
- Because of the inherent conflict between many of these factors we recommend that a Health Impact Assessment is carried out by an independent agency to assess the impact of any proposed measures. This is particularly important given the Health Impact of previous domestic heating policy initiatives which caused adverse impacts in the 1980's.
- Many primarily local authority (LA) or privately rented accommodation (PRA) households have open fires and therefore continue to have a need for solid fuel. These should be prioritised for improvements.

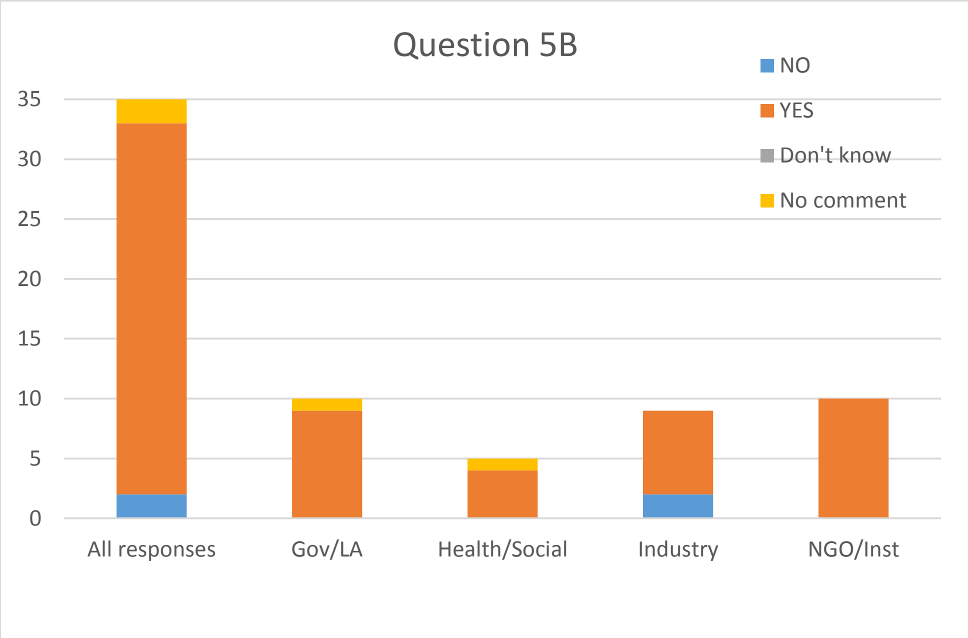
Communications (Q5)

5a. On a scale of 1 to 10 how aware do you think the general public is of the problem of air pollution from the residential heating sector, with 1 being lowest and 10 being highest?

No sector thought the general public had a good awareness of the air pollution problem.



5b. Can you suggest any ways in which awareness might be improved?



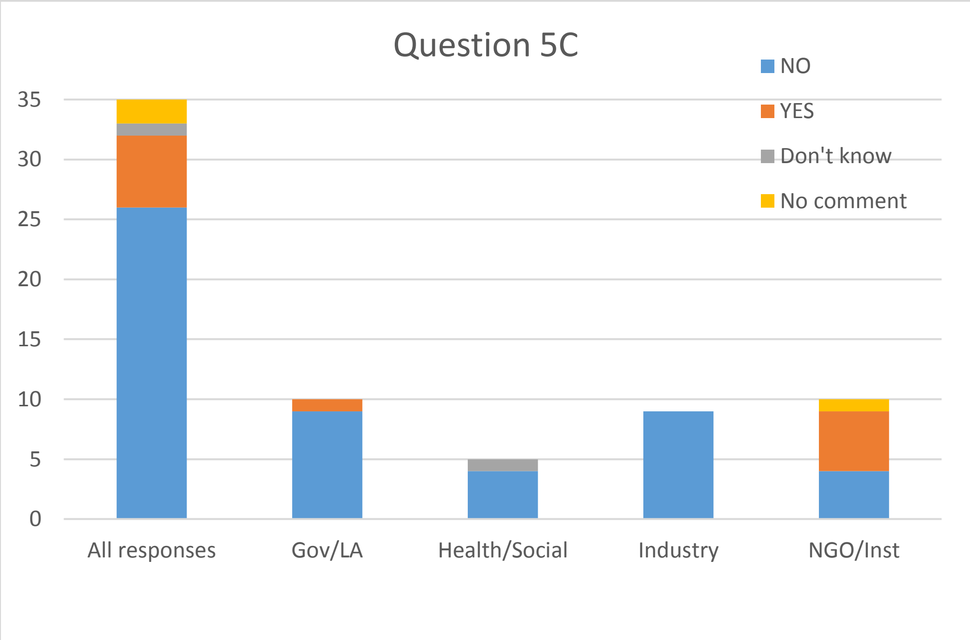
All but 4 respondents suggested a way to improve awareness. These included:

- Raise awareness of civil society and policy makers
    - Public awareness campaign on health impacts of air pollution along the lines of the campaign currently run by the State with respect to carbon monoxide poisoning.
    - Public awareness campaigns on simple and cost-neutral transmission to cleaner solid fuels and the efficiencies of modern closed appliances.
    - Similar campaigns aimed at county council and national politicians to ensure proper awareness by those in a position to make regulatory change.
    - Simplification of the current SEAI domestic fuel cost comparison as a means to enabling informed decisions by the householder
- Increase awareness through television campaigns, education at primary school level, more documentaries on the effects of solid fuels on our health.
- Media campaigns have their place but are 'remote' should include mail shot and door step all suppliers / retailers.
- Public awareness campaign supported by the State that goes beyond the traditional media outlets:
    - Working in the schools through the Green Schools initiative is very important
    - Healthy Ireland framework

- The Department of Environment and Department of Education to get together alongside experts to produce digestible information for householders on air pollution, climate change and clean air.

There may also be the '*resistance to authority*' or *'government apathy'* dimension in a person's reluctance to heed advice from local or national authorities

5c. Is there sufficient awareness of the specific areas to which current Smoky Coal Ban / Smoke Control regulations apply?



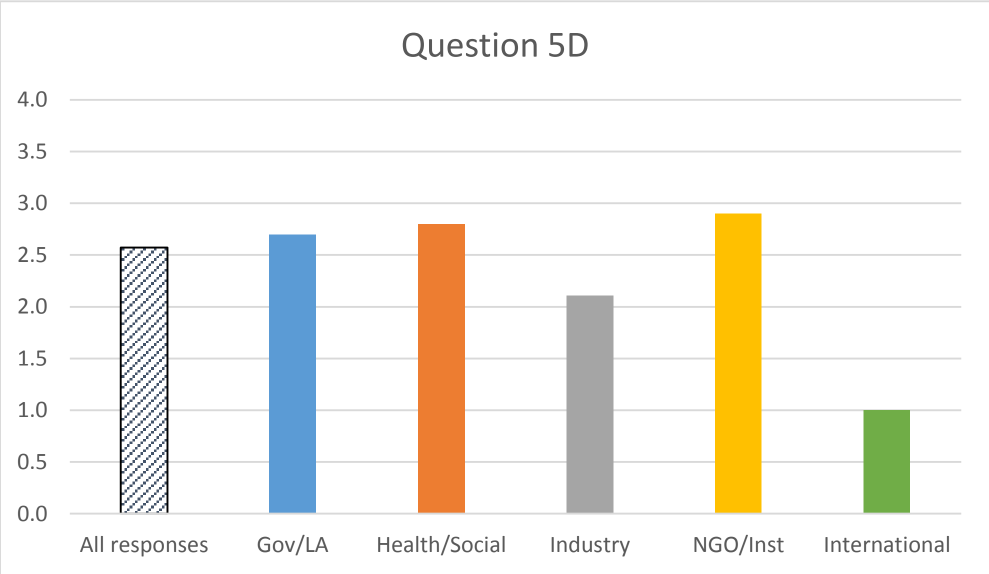
28/34 respondents said NO, 5 of the NGO's considered there was sufficient awareness.

- Regular and continual reminders are required.
- An all-island ban on smoky coal would address confusion and lack of awareness around this issue.
- Maps of smoky areas positioned in prominent places in public building and on local authority websites. Information provided in local newspapers etc.
- Local Authorities have a responsibility to inform and enforce.
- A wide reaching awareness campaign. All community and voluntary and charitable groups could play a significant role in widening the availability of information. Social media in general is largely underutilised.
- Part of a package of environmental information given to residents on moving into a new dwelling.
- Some years ago it was commonly known that specific Councils had a ban on the use of smoky coal, and there was a marked decrease in the smoking chimneys in areas where the ban was being enforced. In recent times this has significantly changed. As oil has become more and more expensive, so people have looked for cheaper and more easily budgeted for methods to heat their homes

5d. On a scale of 1 to 10 how aware do you think the public is of relative air pollution impacts and energy efficiencies/values for different types of solid fuels, with 1 being lowest and 10 being highest?

The message has become lost in the fuel poverty debate as there is a lot of information on the health impacts of living in a cold, damp home and on the whole area of heat or eat

Average rank for each sector

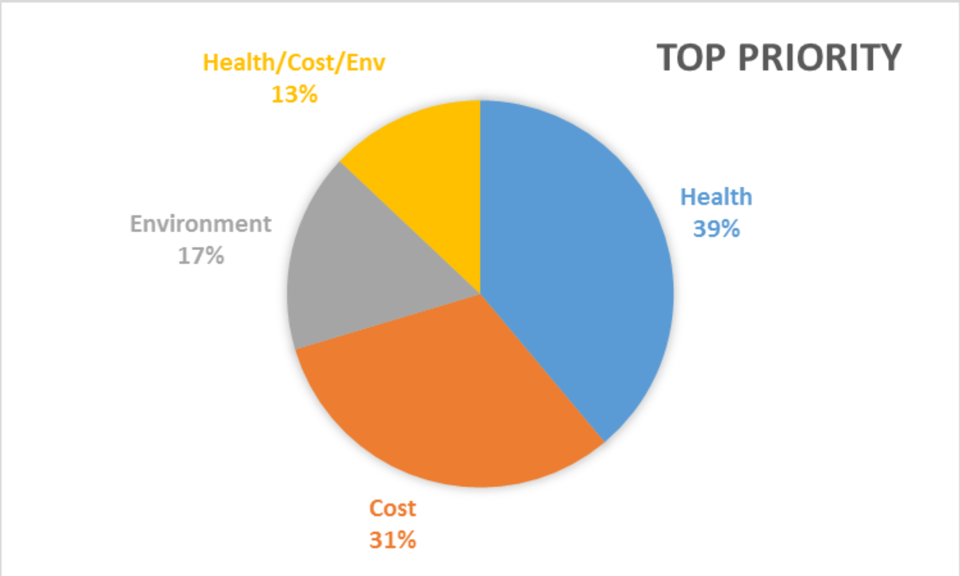


5e. Can you suggest any ways in which awareness might be improved?

- All but 3 respondents suggested a way to improve awareness. These included:

- **<u>Product labelling</u>**
    - Information provided on labelling/packaging. Include this in Green Schools Projects.
    - A rating scale similar to white goods for the different products outlining / combining heat production and emissions data. (include air pollution ranking)
    - **A traffic light system for fuel** (as with food) or coloured bags
- **<u>Communication</u>**
    - A national PR campaign across all media
    - Public awareness need to be repeated not just a one off
    - Awareness could be raised about the impact of specific fuels in relation to energy efficiency
    - consumer friendly information
    - Advertising of impact of future Ecodesign standard
    - Ireland needs high quality real-time data about the actual air pollutants and their concentration levels.
    - An information network between GPs and hospitals etc regarding respiratory problems.
- Awareness must focus on personal health – who is aware that mercury, selenium, arsenic is emitted when coal is burned?

5f. Which, in your view, would be more effective: an awareness campaign with the primary emphasis on environmental considerations, health considerations or cost considerations?



- Health and health/cost together were identified as the key to awareness campaigns.
- There was also a view that - All three strands are totally intertwined and that there are different audiences for different messages:
    - Environmental considerations will appeal to younger audiences, e.g. school children,
    - Health may be aimed at older generations or indeed localised to people already in the health services but,
    - Cost is universal for those who are paying for energy.

- Alternatively - The focus should be on Sustainability issues:
  Security of Supply, Competitiveness (cost) & Environment

Any other issues (Q6)

- One recommendation (NGO): RoI should move toward a Clean Air Act (for national rather than local control) with legislation based on high quality air monitoring measurements to validate the emission inventories approach. A comprehensive, long-term public education programme devised by experts (jointly funded by Department of Environment and Department of Education) would be needed to accompany the introduction of the Act. It should start at School level and go on to life-long learning initiatives on air pollution, climate change and clean air. The role of the EPA would need to be substantially increased if these recommendations are accepted.

- The relative impact of vehicle emissions on air quality needs to be effectively evaluated to enable priorities to be established for air quality improvement.

- The use of an emission inventory approach (based on laboratory combustion experiments) is not sufficient to provide a satisfactory assessment of the contribution of solid fuel burning to ambient PM levels. Measurements of air quality and source apportionment studies are also needed.

- The burning of domestic waste in residential fireplaces, stoves and ranges does occur to varying extents and should not be overlooked as a contributor to air pollution, particularly the burning of plastics. Similar to the burning of bituminous coal in specified areas, the burning of domestic waste is hard to detect and enforce but occurs countywide, not in a concentrated area. This may be a good topic for an awareness campaign.

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