



SOLID FUEL TRADE GROUP
— Warming Ireland's Homes —

Solid Fuel Trade Group Response to Consultation on the Development of a new Solid Fuel Regulation for Ireland March 2021

The Solid Fuel Trade Group (SFTG) represents a number of leading suppliers to the residential solid fuel market in Ireland. SFTG have played a key role in developing and supporting existing regulations and recommend the following actions:

- **Align Climate Change and Clean Air Policy, to prevent unintended deterioration of air quality**
- **Introduce an Appliance Upgrade Scheme, incentivising higher efficiency and lower emission appliance replacement.**
- **Ensure adequate resources committed to enforcement to ensure compliance with current regulation, through the Revenue Commissioners, Local Authorities and EPA.**
- **Ensure investment in home upgrades and retrofits is prioritised and targeted at those households which are in most need.**

The residential solid fuel market in Ireland has undergone significant change in the past 30 years. Use of coal has declined by 72%¹. Ireland now enjoys air quality standards that are amongst the best in Europe and is one of only four countries in Europe — the others being Estonia, Finland and Iceland — that had fine particulate matter (PM2.5) concentrations that were below the World Health Organization's (WHO) guideline values².

Approximately one in eight households or 600,000 people in Ireland depend on solid fuel as their primary form of home heat³. The majority of these homes are in rural areas and many are classified as “fuel poor”. This is because some do not have, nor can they afford to upgrade to, modern home-heating systems. Many others cannot, and never will, access the national gas network. These householders cannot make an easy consumer choice to switch their source of heat. They continue to rely on affordable solid fuel as a reliable source of heat and that right needs to be protected. Solid fuel offers an effective “pay as you go” solution to cash strapped households operating on a tight budget.

In addition to households that are entirely dependent on solid fuel there are hundreds of thousands more households that use solid fuel as a secondary source of heating. Reliability of supply and price are additional underestimated benefits of solid fuels. During power-cuts, when heating systems break down, or when home-heating oil cannot be delivered, households with a fireplace or stove can resort to solid fuel which is widely distributed to retail outlets and even delivered directly to homes across the country.

¹ SEAI Figures (see Appendix 1)

² Air quality in Europe – 2020 Report, EEA Report No 09/2020 (see Appendix 2)

³ CSO, 2016 Census (see Appendix 3)

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As climate change becomes more of a factor in our lives there is, understandably, great attention being given to high-tech heating systems, renewable energy and even the concept of bans on fossil fuels. At national government level these changes have already been reflected in the introduction of more stringent emissions standards and higher carbon taxes for solid fuel sold in Ireland.

While measures to protect the environment are necessary, the fact is that solid fuel emissions from households are a small and easy target. A target that puts the greatest burden on society's less well-off as well as those who are geographically more isolated. Solid fuel providers are already pulling their weight in working with the Government since 2002 to introduce solid fuel standards such as, low sulphur, smokeless coals and collecting carbon tax revenues.

While adapting to the pressures of climate change and air quality is a tough challenge for the solid fuel sector, it is one that the SFTG is playing a leading role in helping the Government to bring about.

The SFTG has proven itself in the facilitation of Government and EU climate change policies by entering into a voluntary agreement in 2002, later enshrined in law in 2011, agreeing to higher product standards and latterly by collecting carbon taxes for the Exchequer. Those higher product standards started with reducing the amount of sulphur in bituminous coal. A move to low-smoke fuels will be a serious challenge for many, particularly the "fuel poor" mentioned above. Fuel poverty is a very real concern as evidenced by the €200m that the Government provides each year to help vulnerable families heat their homes in the winter. Furthermore, a bituminous coal ban will not improve air quality as households will shift to more polluting unseasoned wood, sod turf and high sulphur non-compliant manufactured coal products.

Strong and consistent enforcement of existing environmental and tax regulation is essential if the solid fuel industry in Ireland is to continue to play its vital role in supporting households across the country.

- **Align Climate Change and Clean Air Policy, to prevent unintended deterioration of air quality**

Fuel Poverty in Ireland

The issue of fuel poverty must be front and centre of any debate on the regulation of solid fuel. Fuel poverty occurs when a household needs to spend more than 10% of its income on energy in order to maintain an acceptable level of heat throughout the home⁴.

According to a Pre Budget submission (June 2018) by St. Vincent de Paul (SVP), in 2017:

- 48% went without heating due to cost
- 1 in 4 experience energy poverty

⁴ Department of Communications Energy and Natural Resources 'A Strategy for Warmer Homes in Ireland' Reference Indecon 2009

- SVP spent €4.3m on fuel and electricity supports

According to the Institute of Public Health (IPH) in Ireland, fuel poverty has a detrimental effect on health in a number of ways:

- Cold indoor temperatures place a ‘thermal stress’ on the body
- Cold damp houses aggravate respiratory and allergic conditions
- Living in cold damp housing has a negative effect on mental health
- Households experiencing fuel poverty cut back on spending in other important areas such as food, clothing and transport, which further contributes to poor health and social exclusion
- Households experiencing fuel poverty tend to occupy fewer rooms in the house, resulting in overcrowding and deterioration in the overall condition of housing. This is called ‘spatial shrink’

The IPH clearly states that fuel poverty remains a very important public health issue on the island of Ireland. Fuel poverty is unacceptably high and contributes to the social exclusion experienced by the unemployed, the old, the disabled and lone-parent families. It also contributes to significant ill-health. The IPH estimates that the island of Ireland has among the highest levels of excess winter mortality, with 2,800 excess deaths over the winter months.

According to the SILC, 29% of people living in consistent poverty are unable to afford to keep their house adequately warm⁵. Recent weather events have served as a stark reminder of the stress many households continue to face being able to meet their utility costs.

In the SVP Submission to the Commission for the Regulation of Utilities, July 2020, it notes that the ESRI estimated that in 2019, one in six households (17.4 per cent or approximately 302,000 households) in Ireland were defined as “energy poor”, spending more than 10 per cent of their income on energy, with older people living alone and lone parents significantly more likely to fall into this category.

In the SVP Pre-Budget Submission 2021, Investing to Save, Building an Equal Society After Covid-19, the society expressed concern that as we emerge from Covid-19, a significant proportion of households will be in energy debt. Energy usage during the restrictions has increased as people are at home more, and many households will experience bill shocks at a time when they are on a reduced income.

Environmental Impact

There have been a series of legislative initiatives targeted at the residential use of solid fuels:

- Air Pollution Act, 1987 (Marketing, Sale and Distribution of Fuels) Regulations, 1990 (S.I. No. 123 of 1990).
- Air Pollution Act, 1987 (Marketing, Sale and Distribution of Fuels) Regulations, 1998.
- Air Pollution Act (Marketing, Sale, Distribution and Burning of Specified Fuels) Regulations 2012.
- Air Pollution Act (Marketing, Sale and Distribution of Specified Fuel Regulations 2020)

⁵ CSO (2018) Survey of Income and Living Conditions 2016, Table 7c.

The solid fuel industry has been supportive of many of these initiatives and of efforts to encourage safe and appropriate use of solid fuels.

Carbon tax was introduced as a 'disincentive' to use fuels with higher CO₂ outputs. The tax is calculated based on the Carbon Content of the fuel. The well intentioned policy was intended to reduce the output of CO₂ to atmosphere. Fossil fuels are taxed, but renewable fuel (Wood) is exempt.

In theory, and from the narrow perspective of CO₂, the Policy, and associated tax are to be applauded, but there are other unintended consequences when air quality is analysed.

The WHO has set guidelines for PM₁₀, PM_{2.5}, PAH, NO_x and SO_x. While these guidelines have not yet been incorporated into Irish legislation, they provide a useful reference for the EPA to report against.

As stated in the introduction, Ireland has fine particulate matter (PM_{2.5}) concentrations that were below the World Health Organization's (WHO) guideline values. Any significant shift could be a concern as the studies referenced below note that wood emits substantially more PM_{2.5} and PAH than fossil fuels, including coal, per unit of heat. However these studies do not differentiate between seasoned wood and unseasoned wood.

In a report by UCC on the SAPPHERE Project (Source Apportionment of Particulate Matter in Urban and Residential Areas of Ireland) the very detailed analysis clearly indicates that in the towns (Killarney, Birr and Enniscorthy) where the study was conducted, wood had higher PM_{2.5} readings than coal. The results included both bituminous coal and smokeless coal as the analysis cannot differentiate between the two. Equally, the analysis could not differentiate between unseasoned and seasoned wood. With sod peat and wood burning bigger contributors to PM_{2.5} in these towns further disincentives to the use coal could in fact create much more serious air quality issues.

The message is clear – while there is a benefit in terms of CO₂ output, from switching fuel source from fossil to wood, there is a consequent increase in emissions to air of PM_{2.5} and PAH. The report, "A study of emissions from domestic solid fuel stove combustion in Ireland" (Appendix 4), showed that wood logs generated the most amount of PM and CO₂ emissions and the results suggested that if domestic combustion of bituminous coal and peat were 100% substituted with unprocessed biomass fuels, as is being proposed by some groups, it could lead to significant increases in particulate air pollution. The report also highlights the importance of how solid fuels are used and the importance of appliances.

One strategy that all agree on is 'improved appliance efficiency'. The Eco Design Directive will be a major step on this journey when it is introduced in Jan 2022. Many stove manufacturers have already upgraded their appliances to this standard.

Government Policy should aim to incentivise the upgrading of appliances. Stoves can increase the efficiency of fuel use by a factor of three. SEAI produce figures which demonstrate that the efficiency of an open fire averages 25%, whilst the efficiency of stoves averages 65% and can reach 80%, with high efficiency stoves. Solid fuel stoves require a minimum 75% efficiency to meet the requirements of Ecodesign.

The Stove Industry Alliance (SIA) states that independent tests confirm Ecodesign appliances produce 90% less particulate emissions than an open fire and 80% less than a stove that is 10 or more years old. In order to meet Ecodesign, manufacturers must provide evidence, through independent testing, that their stove achieves lower emission across four tests. These four tests assess levels of particulate matter (PM), organic gaseous compounds (OGC), carbon monoxide (CO) and nitrogen oxides (NOx).

There is currently no incentive to upgrade solid fuel appliances, and the benefits of a scheme would be manifold, and include:

1. Benefit to Air Quality, through reduced fuel consumption, and increased efficiency of burning leading to reduced PM_{2.5}, and PAH emissions
2. Reduced CO₂ emissions due to greater useable heat output from reduced fuel use.
3. Reduction in Fuel Poverty, as increased fuel use efficiency, reduces the household expenditure required to heat the home

To improve efficiency and reduce CO₂, PM_{2.5}, PAH's and other emissions:

- **Introduce an Appliance Upgrade Scheme, incentivising higher efficiency and lower emission appliance replacement.**

Taxation on Solid Fuels

A balanced discussion on regulation of solid fuels in Ireland must include reference to solid fuel carbon taxes, VAT and the border with Northern Ireland.

As expected, an additional carbon tax levy of €6 per tonne was confirmed in October 2020 but its application to solid fuels was deferred to May this year. This means an increase of €0.72 on a bag of coal / smokeless fuel. In July 2020 Minister Eamon Ryan confirmed that the programme for Government commits to increasing carbon tax to €100 per tonne by 2030, through annual increases of €7.50 per annum to 2029 and €6.50 in 2030. The Minister intends to offset, in part, these price rises through increases in the winter fuel allowance as well as additional funding for the warmer homes schemes. Though there will be additional funding for home retrofits (see below), the scale and cost of the challenge will ensure that many households will continue to rely on solid fuel as both a primary and an important secondary heating source.

Solid fuel tax treatment now varies substantially between the United Kingdom and the ROI market. In the United Kingdom there is no carbon tax, as residential solid fuel was specifically excluded from the chancellors Finance Act in 2000. In Ireland the impact of Carbon Tax is an increase of €3.53 on a 40kg bag of coal and €0.77 on a bale of peat briquettes (from May 21). A further difference occurs with VAT which is levied at 13.5% on solid fuel in ROI, and at 5% in the United Kingdom.

Enforcement of Tax Rules

With such a significant difference in tax treatment of solid fuel between the UK and Ireland, there is increasing evidence of operators based in the market, supplying solid fuel that does not comply with the operable tax code.



European Union Single Market constraints preclude the use of any cross-border movement controls in the administration of Solid Fuel Carbon Tax. Therefore, Revenue has no authority to stop vehicles and physically inspect loads of such fuel. Similarly, the transport or possession of solid fuels that originated in Northern Ireland are not, in themselves, Revenue offences and Revenue's officers have no authority to challenge such transportation or possession. It is important to note that liability to Solid Fuel Carbon Tax does not arise on the physical presence of the goods in the State, but on first supply in the State by the supplier who is obliged to register with Revenue, make a return and pay the tax. This return must be made one month after the two-month accounting period provided for in law.

The collection of solid fuel carbon tax is heavily reliant on the regulatory regime covering the marketing, sale, distribution and burning of solid fuels in the State. This regulatory regime is operated by the Department of Environment, Climate and Communications, and is enforced by local authorities.

However given the scale and growth in illicit trade it is clear that there is continued and widespread ignorance and / or deliberate evasion of the rules. Irish consumers order solid fuel online from NI based businesses and courier companies deliver the fuel without charging carbon tax. Some Irish based businesses sell solid fuel to NI based businesses, do not charge carbon tax, the product is collected but never leaves the jurisdiction. SFTG cannot find any evidence of prosecutions in this area and as such rogue operators continue to profit from the price gap created by carbon tax in Ireland.

It is clear, given the amount of non-compliant fuel that reaches households in Ireland that increased resources are required to augment the current activities of the Revenue Commissioners, and the Local Authorities, to ensure that the solid fuel market is uniformly regulated for all suppliers. A dysfunctional market is of no benefit to legitimate suppliers, Government, or the environment.

The issue of untaxed solid fuel is a serious threat to the industry. The Sale of Illicit Goods Bill proposed an approach to tackling the illicit trade in tobacco, alcohol and fuel products. However this Bill did not receive the necessary support. The issue is raised time and again by public and industry representatives but as yet an effective mechanism to curtail this activity has yet to be found. With rising carbon taxes and higher VAT in Ireland and no equivalent taxes and lower VAT in N Ireland this problem is likely to get worse. Every effort must be made to bring a workable solution to this problem.

Growth in more polluting solid fuels

Consumers have obviously become very aware of the increasing cost of compliant fuels and have acted as predicted by the economists – they have looked for cheaper alternatives. In many areas sod turf has been the beneficiary with turf now being delivered to households in towns and cities across the country. Theoretically, sod turf is liable to carbon tax but there is no practical way to collect it and Revenue will confirm carbon tax receipted is negligible. It is difficult to get accurate figures for sod turf production and usage but SEAI (Appendix 1) estimates that the market for sod turf is almost twice as big as the market for peat briquettes and 25% bigger than the market for bituminous coal.

Used in a stove, sod turf emits about 750 grammes of CO₂ per kW of emitted heat (depending on moisture content) compared to 405 grammes of CO₂ for a smokeless fuel in the same appliance. Therefore, the switch back to turf is driving up both CO₂ and smoke emissions. Existing users should be entitled to cut and use turf for themselves but a policy that drives more people to use turf and increase overall emissions from the sector is counterproductive and needs to be changed. Increased emissions from sod turf usage more than offset any reduction in emissions from coal use since the introduction of carbon tax.

Another beneficiary of current taxation and regulation strategy is wood. Wood usage is increasing rapidly driven by:

- Cost – cheap unseasoned (wet) wood is sold throughout the country with little or no controls.
- Renewable – as unseasoned wood is a renewable fuel, it certainly saves on CO₂ emissions but as mentioned above and in Appendix 4 its emission profile is higher than coal.

From this, it is absolutely clear that a policy that reduces current legitimate fuels usage (by making them unaffordable) and drives up usage of turf and unseasoned wood, is going to lead to further deterioration in air quality.

Another effect of carbon tax and poor enforcement of existing product standards has been to create a growing market for environmentally inferior high sulphur ovoids. Sulphur limits in Ireland are 0.7% for bituminous coal and 2.0% for manufactured ovoids. Both SFTG and a number of Local Authorities have evidence of widespread availability of low cost, non-compliant ovoids with sulphur limits as high as 5.0%.

As they are cheap to manufacture, they undercut legitimate low sulphur products and are attractive to consumers regardless of the long term damage to appliances and the environment. A lack of enforcement by local authorities – mainly due to lack of resources – has allowed this market to grow and encouraged new players to get involved many avoiding paying carbon tax and VAT altogether. Control is challenging as there is no way to visually differentiate high sulphur ovoids from low sulphur ones and, at present, all product testing for legal purposes, has to be done in the UK.

Enforcement of Product Standards

The enforcement of regulations, from carbon tax to product standards, effectively rests with the local authorities throughout the country. Repeated and regular breaches of existing regulations can be summarised as follows:

Coal Bagging Registration – there have been instances of companies who have operated while not adequately registered as required and administered by the EPA.

Product compliance – nationwide availability of high sulphur non-compliant ovoids. Both industry representatives and local authorities have identified persistent problems but efforts to stop the sale of these illegal products have been completely ineffective. Ovoids, manufactured using bituminous coal, are available for sale in the UK and cannot be differentiated from low smoke ovoids without specific tests which are difficult and expensive to administer.

SEAI, Residential Fuel Use

Appendix I

Residential Final Energy use (ktoe)	1990	2000	2005	2010	2015	2016
Coal	626	206	246	254	206	179
Bituminous Coal	608	210	163	177	126	101
Anthracite + Manufactured Ovoids	0	59	59	67	68	69
Coke	0	0	0	0	0	0
Lignite	18	17	24	10	13	9
Peat	725	299	273	254	201	197
Milled Peat	0	0	0	0	0	0
Sod Peat	570	179	183	165	128	128
Briquettes	155	120	90	88	73	69
Oil	389	915	1,145	1,263	956	1,005
Crude	0	0	0	0	0	0
Refinery Gas	0	0	0	0	0	0
Gasoline	0	0	0	0	0	0
Kerosene	105	570	795	1,010	775	815
Jet Kerosene	0	0	0	0	0	0
Fuel Oil	0	0	0	0	0	0
LPG	69	57	53	37	37	39
Gasoil / Diesel/ DERV	197	244	256	202	138	145
Petroleum Coke	19	44	41	13	7	6
Naphtha	0	0	0	0	0	0
Bitumen	0	0	0	0	0	0
White Spirit	0	0	0	0	0	0
Lubricants	0	0	0	0	0	0
Natural Gas	117	439	607	710	555	563
Renewables	45	17	23	54	76	83
Hydro	0	0	0	0	0	0
Wind	0	0	0	0	0	0
Biomass	45	17	16	27	32	33
Landfill Gas	0	0	0	0	0	0
Biogas	0	0	0	0	0	0
Wastes	0	0	0	0	0	0
Solar	0	0	0	7	13	14
Geothermal	0	0	6	20	31	37
Non-Renewable (Wastes)	0	0	0	0	0	0
Electricity	356	548	646	735	678	677
Total	2,238	2,504	2,940	3,270	2,672	2,704

Update for 2019

2019	Units = ktoe	NACE (Rev 2)	Coal	Bituminous Coal	Anthracite + Manufactured Ovoids	Lignite \ Brown Coal Briquettes	Peat	Sod Peat	Briquettes	Biomass
Residential			175	59	110	5	183	128	58	25

Last Updated : 8th November 2020

2019 provisional data

2019 provisional data based on 2018 breakdown

2018 data

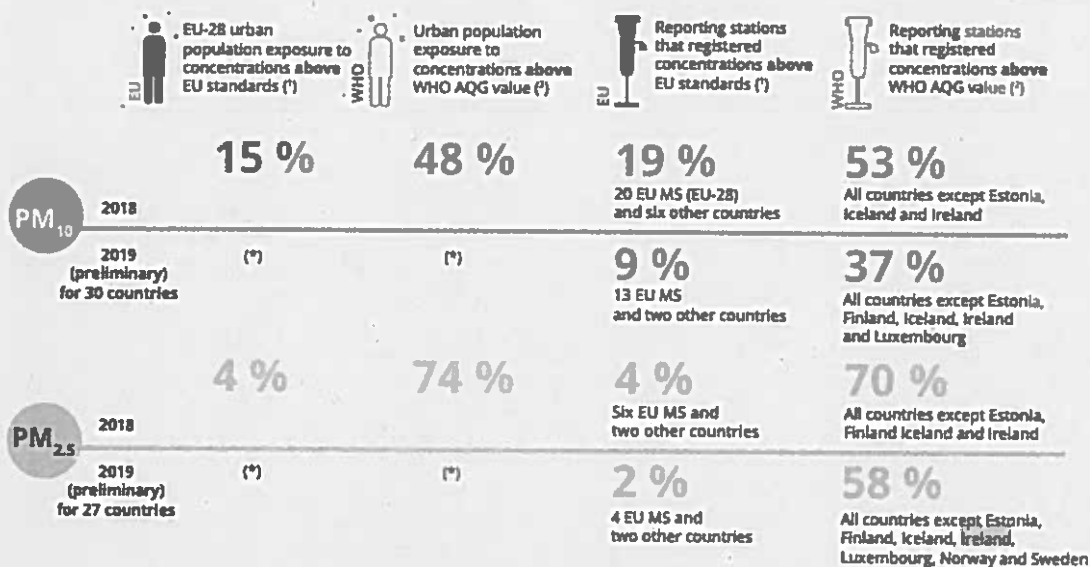
Sod peat is estimated due to new legislation and the methodology is under review

Coal - SEAI carry out a monthly sample survey of large solid fuel distributors and importers. An additional estimate is made to cover the smaller units not surveyed. SEAI worked with the CSO in 2009 to develop this estimation technique, which uses data from the CSO trade statistics. Prior to 2009, data was based on estimates by industry experts.

Peat - Industry experts provided an estimate for consumption of sod peat in the residential sector up to 2011. This estimate was no longer available from 2012. For sod peat consumption in 2012, a 20% decrease was applied to the 2011 estimate. Since then, in the absence of further data, the figure has been assumed to have remained constant. In 2015, SEAI consulted with industry experts, and it was decided that there was no basis to amend the figure further. In 2011, sod peat was estimated to account for 67% of residential peat use, the remainder being from peat briquettes for which Bord na Móna provides an estimate.

Biomass - SEAI carry out a sample survey of known wood fuel suppliers. However, there is a very poor response rate to this survey. The market changes frequently and not all suppliers are covered. An estimate is included for untraded firewood. Since 1995, this has been assumed to have followed the same annual trend as coal and peat consumption. In 1995, all wood use was untraded and was estimated as 30 ktoe. By 2016, it was assumed that untraded wood use had dropped to 9 ktoe accounted for 32% of wood energy. The previous "Energy in the Residential Sector, 2013 Report" contains a more detailed description of the methodology for estimating wood use.

Figure ES.1 Key numbers



Press release 23 November 2020 Brussels

Marked improvement in Europe's air quality over past decade, fewer deaths linked to pollution

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Better air quality has led to a significant reduction of premature deaths over the past decade in Europe. However, the European Environment Agency's (EEA) latest official data show that almost all Europeans still suffer from air pollution, leading to about 400,000 premature deaths across the continent.

The EEA's 'Air quality in Europe – 2020 report' shows that six Member States exceeded the European Union's limit value for fine particulate matter (PM_{2.5}) in 2018: Bulgaria, Croatia, Czechia, Italy, Poland, and Romania. Only four countries in Europe — Estonia, Finland, Iceland and Ireland — had fine particulate matter concentrations that were below the World Health Organization's (WHO) stricter guideline values. The EEA report notes that there remains a gap between EU's legal air quality limits and WHO guidelines, an issue that the European Commission seeks to address with a revision of the EU standards under the Zero Pollution Action Plan.

Central Heating by Fuel Type (CSO)

Appendix 3

Table 16: Central heating by fuel type

Fuel Type %	Household Budget Survey						Census	
	1987	1995	2000	2005	2010	2015	2011	2016
Oil	12%	25%	39%	46%	41%	38%	44%	41%
Natural Gas	4%	14%	25%	28%	39%	35%	34%	34%
Electricity	1%	2%	4%	3%	5%	5%	9%	9%
Solid Fuel	31%	21%	9%	8%	4%	5%	11%	13%
Other Central Heating	4%	6%	7%	8%	6%	11%	1%	1%
No Central Heating	48%	32%	17%	10%	3%	6%	2%	1%

Source: CSO

Table 16 shows fuel used for central heating from 1987 to 2016 using a combination of data from the CSO Household Budget Survey (HBS) and from the 2011 and 2016 censuses. Census 2011 was the first census to include questions on the type of household heating. The HBS is based on a sub-sample of the population, whereas the census surveys the full population. The HBS is scaled up to the national level based on the most recent census, which for the 2010 HBS was the 2006 census. There were some differences between the HBS and the census results, particularly for solid fuel and electricity; the reasons for this are not clear. Nevertheless, the broad historical trends across the full time period can be inferred, for example, the widespread adoption of oil and gas central heating systems from the 1990s onwards.

A Study of Emissions from Domestic Solid Fuel Stove Combustion in Ireland Appendix 4

<p>A study of emissions from domestic solid fuel stove combustion in Ireland</p> <p>Anna Trubetskaya,^{1,2} Churshui Lin,^{1,3} Jurgita Ovadnevaite,^{4,5,6} Darius Caburnis,^{1,4} Colin O'Dowd,^{1,4} JJ Lashy,¹ Rory F.D. Monaghan,^{1,4} Robert Johnson,⁸ Peter Layden,⁸ and William Smith⁶</p> <p>¹Department of Chemical Sciences, University of Limerick, Limerick, Ireland ²State Key Laboratory of Loess and Quaternary Geology, Key Laboratory of Aerosol Chemistry and Physics, Institute of Earth Environment, Chinese Academy of Sciences, Xi'an 710061, China ³CAS Center for Excellence in Quaternary Science and Global Change, Chinese Academy of Sciences, Xi'an 710061, China ⁴School of Physics and Centre for Climate and Air Pollution Studies, Ryan Institute, National University of Ireland Galway, University Road, Galway, Ireland ⁵MaREI, the SFI Research Centre for Energy, Climate and Marine, Galway, Ireland ⁶School of Engineering and Ryan Institute, National University of Ireland Galway, Galway, Ireland ⁸Arup Facilities, Arup Curragh-on-Shannon Co. Roscommon, Ireland ⁹Department of Mechanical Engineering, University College Dublin, Dublin, Ireland</p> <p>E-mail: anna.trubetskaya@ul.ie; jurgita.ovadnevaite@nuigalway.ie; william.smith@ucd.ie</p>	<p>4 Discussion</p> <p>This study showed that wood logs generated the most amount of PM and CO₂ emissions, whereas TUS briquettes and Ecobrite produced low PM emissions than other solid fuels, as shown in Section 3.3 and in the supplemental material (Figure S-5). The PM emission factors for solid fuels ranged from 0.2 to 108.2 g GJ⁻¹ wet depending on the stove type, air supply and method of PM determination. In general, the literature reports a range of values for PM emission factors for wood, woodchips and pellets made from triticale and miscanthus burning varying from 3 to 170 g GJ⁻¹ wet.⁴⁴⁻⁴⁶ Thus, the present PM emission factors for wood logs burning using both ACSM and gravimetric methods were in the range of previously calculated PM emission factors (34.8 to 108.2 g GJ⁻¹)⁴⁵. In the present study, Ecobrite and TUS briquettes generated the lowest PM emission factors (8.0 to 18.7 g GJ⁻¹), lower than PM emission factors reported (31.5-88.1 g GJ⁻¹) for smokeless fuel in the literature^{28,47}. The Ricardo report estimates that the total annual mass of PM_{2.5} emissions from residential burning of smoky coal in Ireland are 2451 tonnes (31% of total PM emissions), peat 4836 tonnes (62% of total PM emissions) and biomass 588 tonnes (7% of total PM emissions)⁴⁷. However, uncertainty surrounds the reporting of biomass fuel consumption, which may be 20% to 200% higher, when non-traded wood is included^{4,48}.</p> <p>Burning of these products account for over 83% of the total residential particulate PM_{2.5} emissions for the whole of Ireland. If, as proposed, domestic combustion of smoky coal and peat were 100% substituted with unprocessed biomass fuels, our results suggest that this</p>
<p>could lead to significant increases in particulate air pollution. As noted in Section 3.4, the absolute level of PM emissions determined for a particular test depends on the measurement method employed. Cooling and dilution of the flue gas prior to sampling ensure that condensable organic compounds (COC) are included in the PM measurements, and therefore tends to yield a higher PM EF than samples taken from the hot, raw flue gas. The measurement equipment required, however, is substantially more expensive, more delicate, and more cumbersome than the hot filter system, and requires significant technical expertise for set up and operation. The associated dilution system is prone to blockage (particularly during the PM-intensive ignition / light-up phases) and introduces significant uncertainty regarding the instantaneous dilution ratio - which is central to the calculation of PM emissions. Moreover, the literature suggests the PM EF is directly affected by the level of dilution employed^{49,50}. The hot-filter method, in contrast, is relatively simple and robust, and captures PM from all stages of the combustion process - including the all-important ignition and light-off phases. However, it does not capture volatile organic matter that condense at a temperature lower than that of the filter itself, and may therefore underestimate PM emissions for fuels with a high volatile content.</p> <p>Based on the data in chapter 3.3, the average PM_{2.5} emissions arising from domestic solid fuel combustion across the whole of Ireland in 2011 were 320 g GJ⁻¹. Our results suggest that, if torrefied fuels were substituted for smoky coal, peat and un-processed wood fuels, the reduction in PM_{2.5} emissions would be in the region of 63%. This is supported by previous results describing benefits of torrefaction pretreatment leading to reduced formation of PM emissions⁴⁷. The decrease in PM emissions caused by torrefaction is likely a culmination of different effects such as pre-treatment, physical structure of briquettes, elemental composition, and reduction of moisture content, as previously reported^{31,20}.</p> <p>When compared with Ecobrite, smoky coal had similar values for elemental composition and calorific values, as shown in Table 2. However, smoky coal showed greater PM emission factors than the burning of smokeless coal has generated. Thus, the results indicated that</p>	<p>could occur.</p> <p>5 Conclusion</p> <p>The novelty of the present work derives from the use of dual measurement methods to determine PM emission factors from domestic stoves. These emission factors depend on user behaviour, on stove-specific features, and on the type of measurement method used. Organic aerosols were the dominant constituent of PM emissions observed in our tests, regardless of the compositional differences between the fuels. However, black carbon constituted up to 20% of PM emitted by firelighters, and firelighters also displayed a PM emission factor far higher than any of the fuels studied. These findings will be explored further in a forthcoming paper. This study also suggests that thermally pretreating biomass using torrefaction can significantly reduce emissions compared to wood logs, peat, and smoky coal. A countrywide switch to 1) Erndraigh approved stoves and 2) lower emitting solid fuels, could have a significant impact on air pollution reduction in Ireland. However, individual users will continue to exert a substantial, uncontrollable influence on the absolute level of PM emission from seasonally-controlled domestic stoves.</p>