

# Wood Burning (Stoves): the Challenges

Prof Paul S. Monks



AIR QUALITY EXPERT GROUP

## The Potential Air Quality Impacts from Biomass Combustion



Prepared for:

Department for Environment, Food and Rural Affairs;  
Scottish Government, Welsh Government; and  
Department of the Environment in Northern Ireland



Department  
for Environment  
Food & Rural Affairs

## Air Quality Expert Group

- The Air Quality Expert Group (AQEG) is an Expert Committee to Defra that provides independent scientific advice on air quality, in particular the air pollutants contained in the Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland and those covered by the EU Directives on Ambient Air Quality.
- Specifically AQEG gives advice on levels, sources and characteristics of air pollutants in the UK. It does not advise on health impacts or air quality standards.

# Motivations for report

- UK has ambitious climate change targets - 80% reduction in CO<sub>2</sub> emissions by 2050 compared to 1990 levels.
  - The heating sector poses challenges.
- Biomass combustion could contribute towards a shift to low carbon energy supplies.
- Government/EU incentives developed to encourage the move from fossil fuels to biomass in power generation and district heat/combined heat and power (CHP) sectors.
- Domestic burning of wood for local space heating is an increasing “lifestyle” choice – being seen as a low cost and green option with “feel good factor”.
- **But what about air quality impacts?**

# Key questions addressed in report

1. Do we understand the current range of, and likely changes in, source distributions from biomass burning?
2. Are biomass sources well represented within current and projected UK emission inventories?
3. Will the impact of future levels of biomass burning and policy developments lead to significant changes in ambient concentrations and population weighted mean exposures for NO<sub>x</sub> and PM<sub>10</sub>/PM<sub>2.5</sub>?
4. How strong is measurement evidence in relationship to pollution from biomass burning?
5. Are the risks well assessed with respect to the introduction of biomass-based heat provision and CHP systems into the urban environment within UK?

## Landscape



- Reduce the use of fossil fuels;
- Increase the use of renewable energy.

### → Return of wood burning.

UK (DECC):  
**Renewable  
heat incentive**

UK planning policy:  
**The Merton Rule  
(2003)**

EU forecasts = **57–110%** increase between 2010 and 2020.

# Wood Burning and Air Quality

- Wood smoke contains several pollutants:
  - **Particulate matter** (PM<sub>10</sub> and PM<sub>2.5</sub>),
  - **CO, NO<sub>2</sub>, VOCs, and climate gases** (e.g. methane and **black carbon**).



**Uptake of wood  
burning**



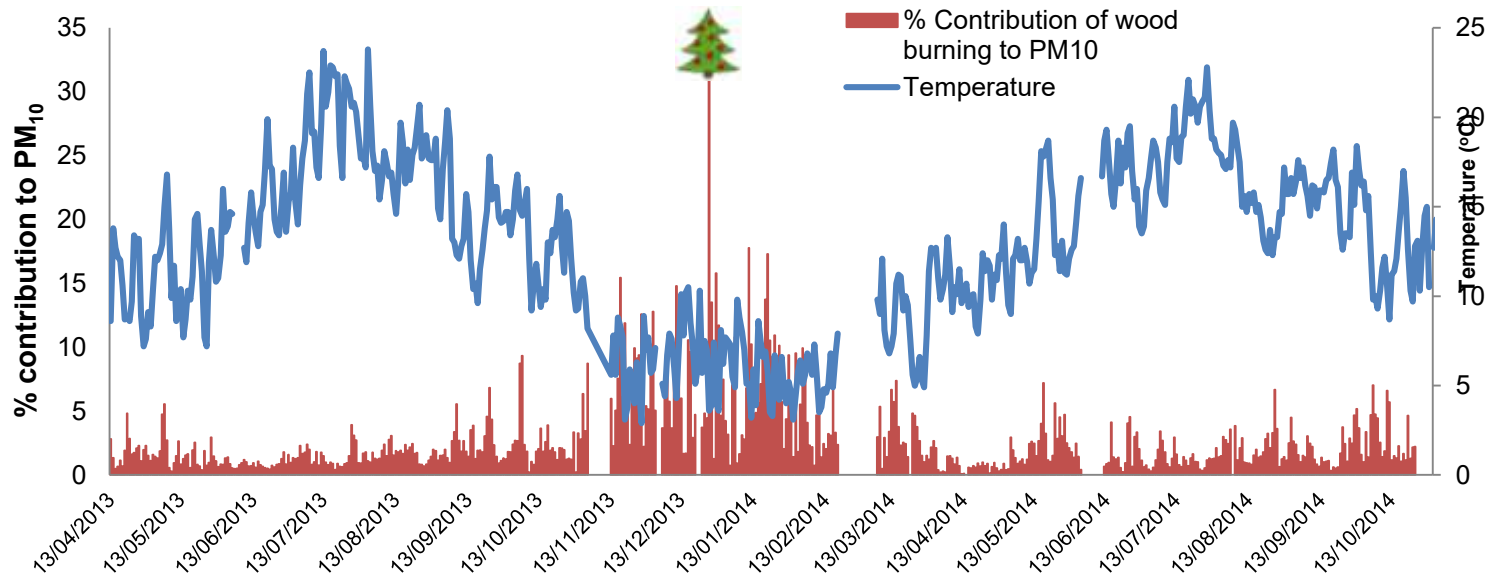
**Type of  
boilers/stove  
installed**



**Type of wood  
burned**



# Contribution of Wood Burning to Total PM<sub>10</sub> in Leicester



- Highest contribution observed during the winter:
  - The average contribution to PM<sub>10</sub> is **6.7%** (max 4.7 µg/m<sup>3</sup>) for **winter**, **3.7%** for **autumn** and **1.8%** for **spring/summer** combined.
- **Christmas day** particularly high contribution at **32%** high burning levels combined with low background of PM from other sources.

# Legislative context and emissions limits

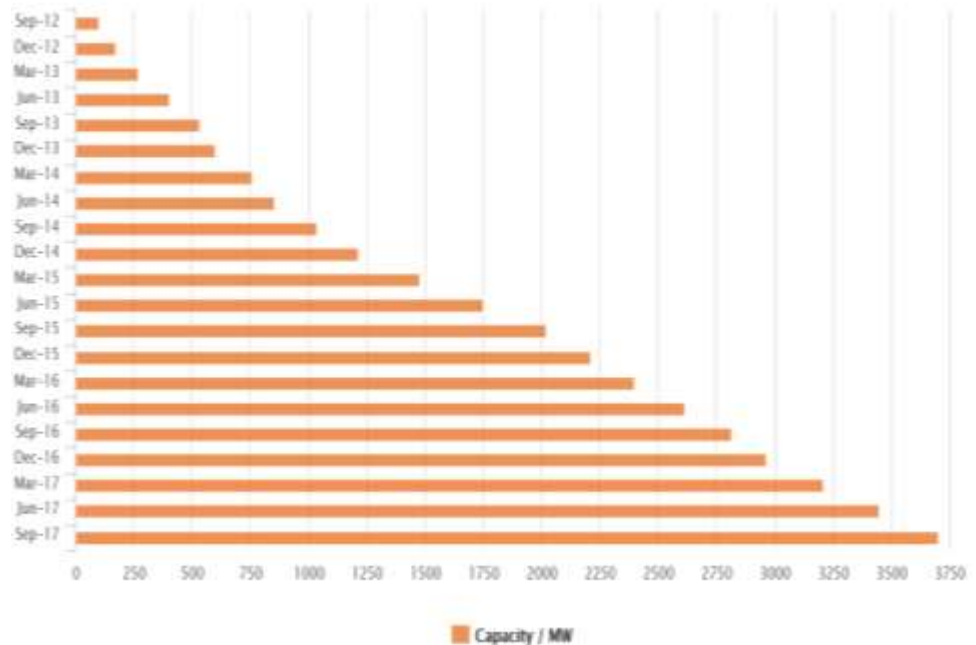
Type of plant	Incentive Scheme	Emissions Limits
Power generation	<ol style="list-style-type: none"><li>1. Renewables Obligations</li><li>2. EU Emissions Trading Scheme (EU-ETS)</li><li>3. Future EPS for CO<sub>2</sub></li></ol>	Industrial Emissions Directive
District heating and CHP	Renewable Heat Incentive (RHI)	<ol style="list-style-type: none"><li>1. Medium Combustion Plant Directive.</li><li>2. Limits imposed by RHI.</li></ol>
Domestic Boilers	RHI	<ol style="list-style-type: none"><li>1. Limits imposed by RHI.</li><li>2. Proposed Eco-design Directive.</li></ol>
Domestic Wood Burners	None	<ol style="list-style-type: none"><li>1. Appliance exemption within smokeless zones.</li><li>2. Proposed Eco-design Directive.</li></ol>



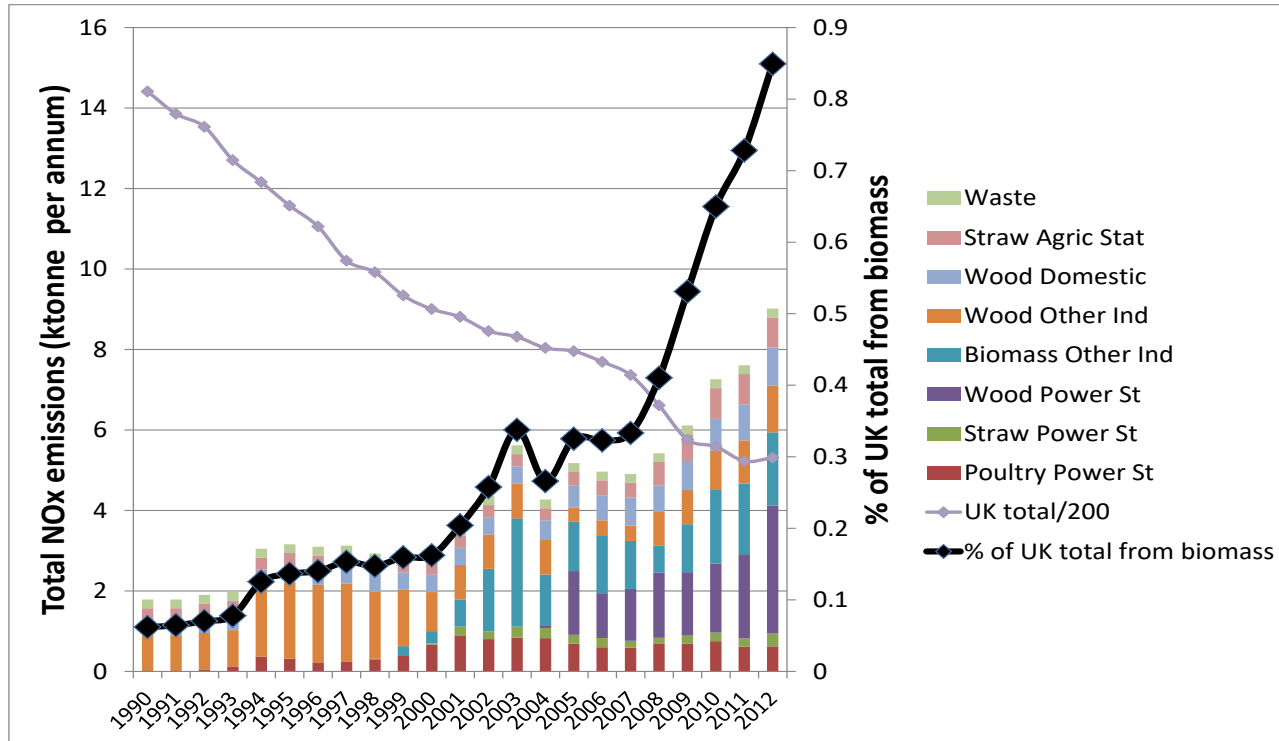
# Take up of the RHI (Ofgem)

- Non-domestic scheme dominates.
- 5 fold increase in non-domestic solid biomass boilers between March 2014 - Sept 2017.
- Mostly small commercial boilers
- < 200 kWth capacity.
- Total equivalent to capacity of large power station.

Non-Domestic RHI approved capacity – cumulative



# Estimated trends in primary emissions using NAEI data:NOx



\*percentage of total PM<sub>2.5</sub> emissions (2016 source: NAEI 2017)

# Primary Particulate Matter (PM<sub>2.5</sub>)

## SOURCES

**Domestic wood & coal burning**  **38%\***

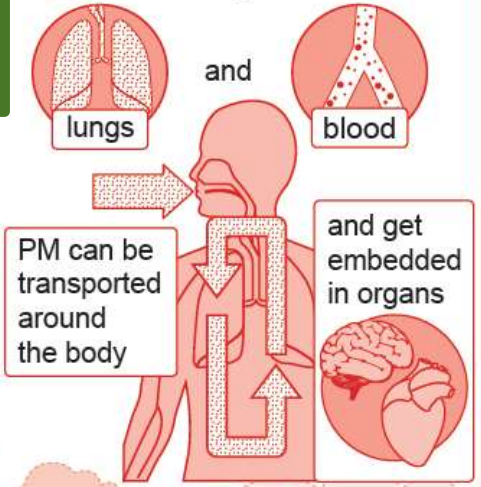
**Industrial combustion**  **16%\***

**Road transport**  **12%\***

**Use of solvents & industrial processes**  **13%\***

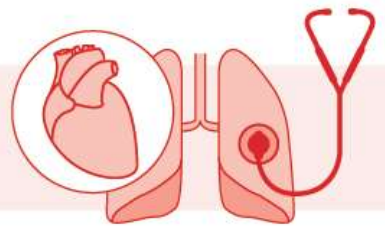
## IMPACTS

These tiny particles from smoke, soot and dust can get into the...



More likely to be affected are:

those already suffering from lung and heart conditions



Original design by Deira Digital Comms

# Updated primary emissions based on DECC usage survey.

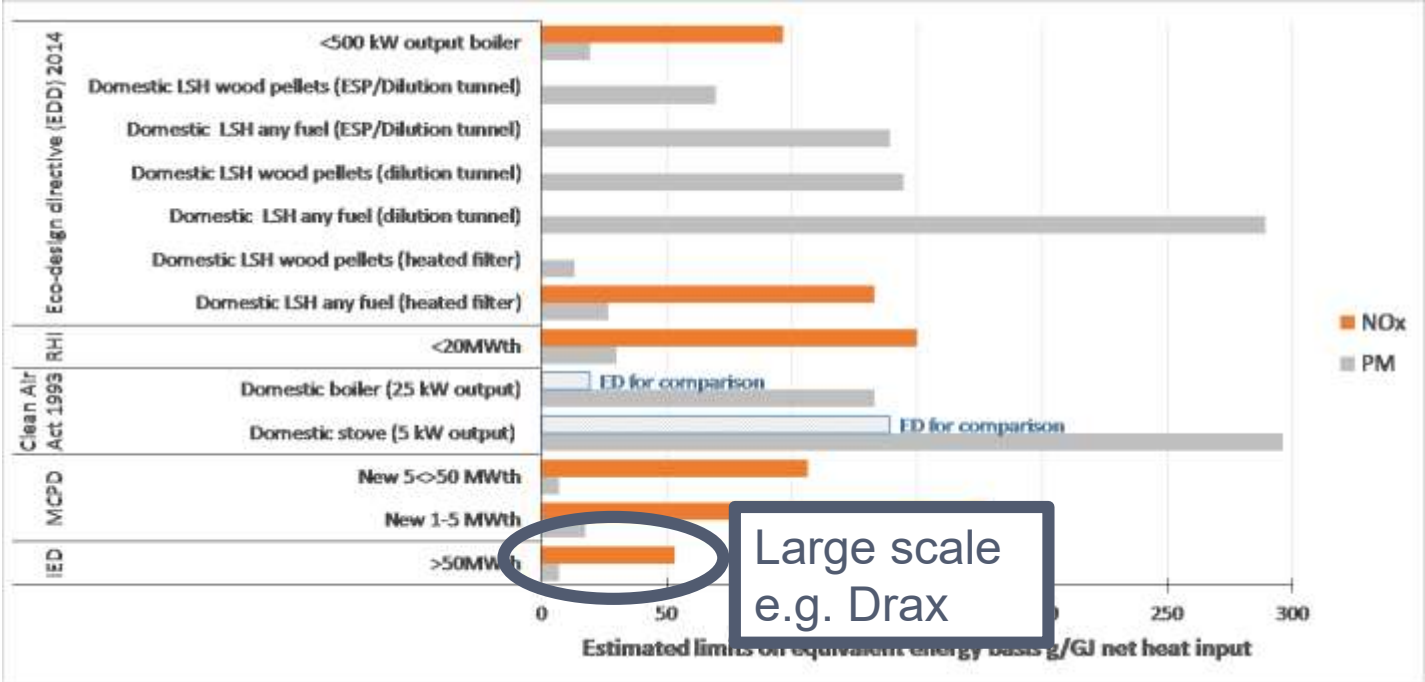


**NECD?**

# Small scale domestic sources

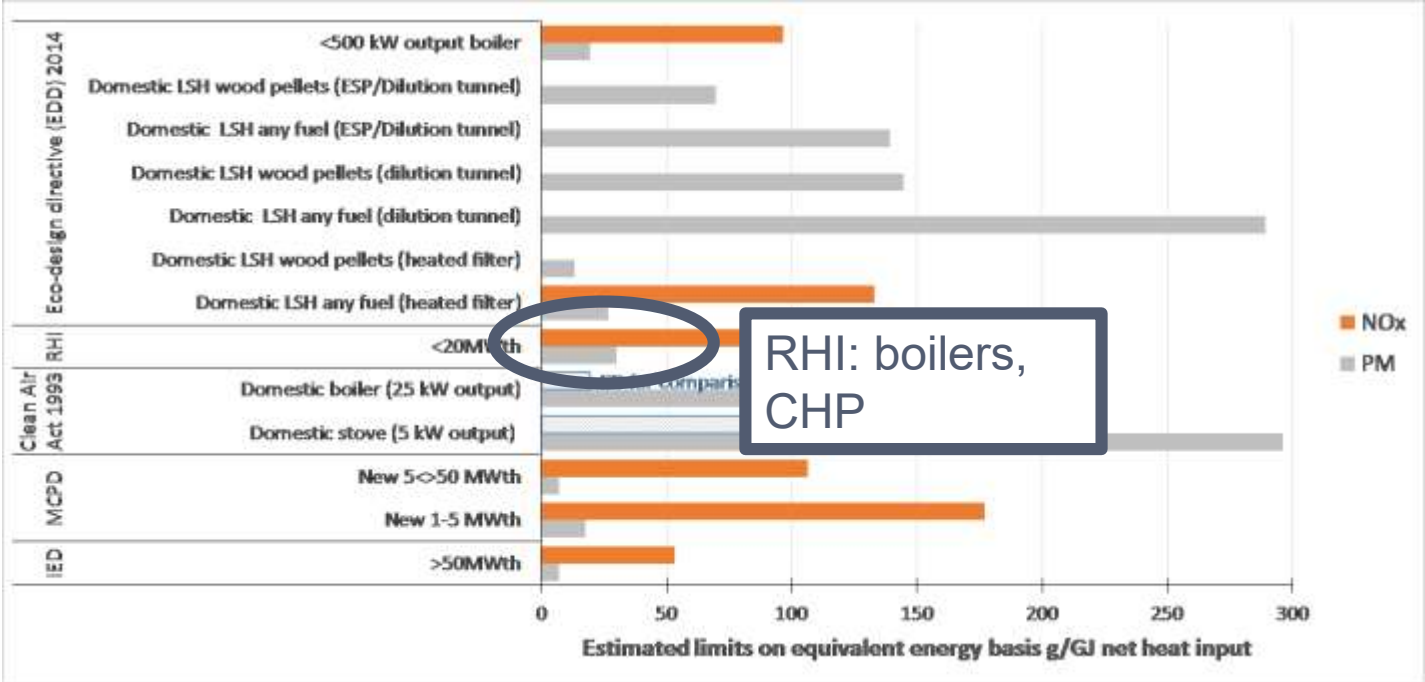
- Stove Industry Alliance estimate around 150,000 units installed per year (based on 2009).
  - Lack of available PM control systems for domestic stoves, particularly those with retro-fit options.
  - Emissions will be seasonal
- Recent survey on domestic wood use by DECC (Walters, 2016) estimated that **7.5 % of the population uses wood as heating on average 22 hours per week**. The main wood devices were **logwood in stoves or open fires**.

# Comparison of PM and NOx emissions limits for different scales of combustion devices based on g/GJ net heat input



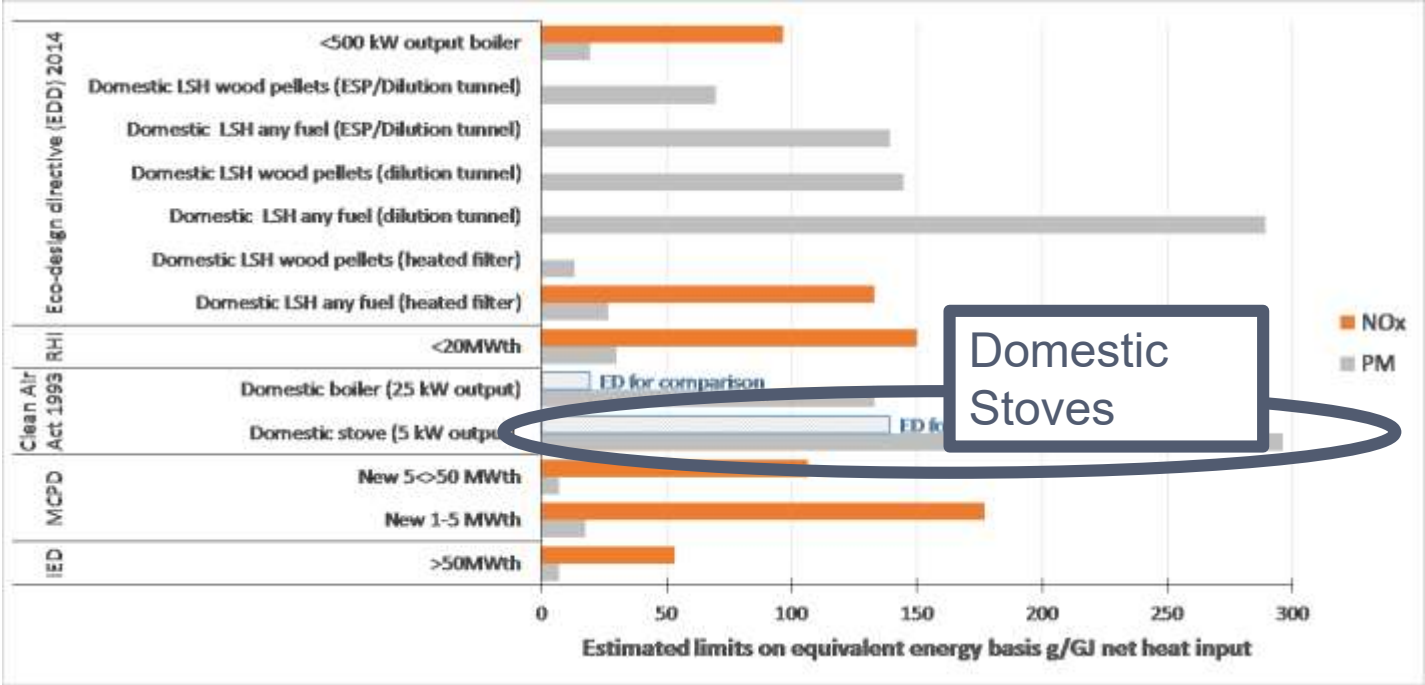
Large scale  
e.g. Drax

# Comparison of PM and NOx emissions limits for different scales of combustion devices based on g/GJ net heat input



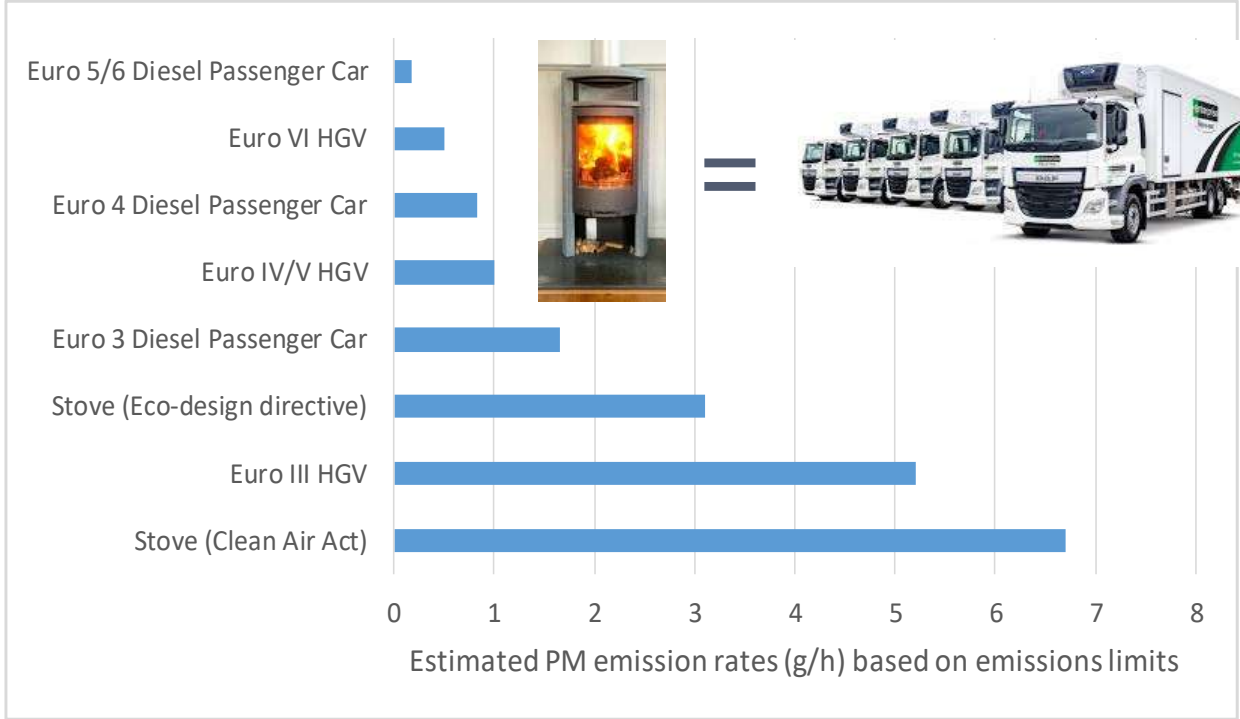
RHI: boilers, CHP

# Comparison of PM and NOx emissions limits for different





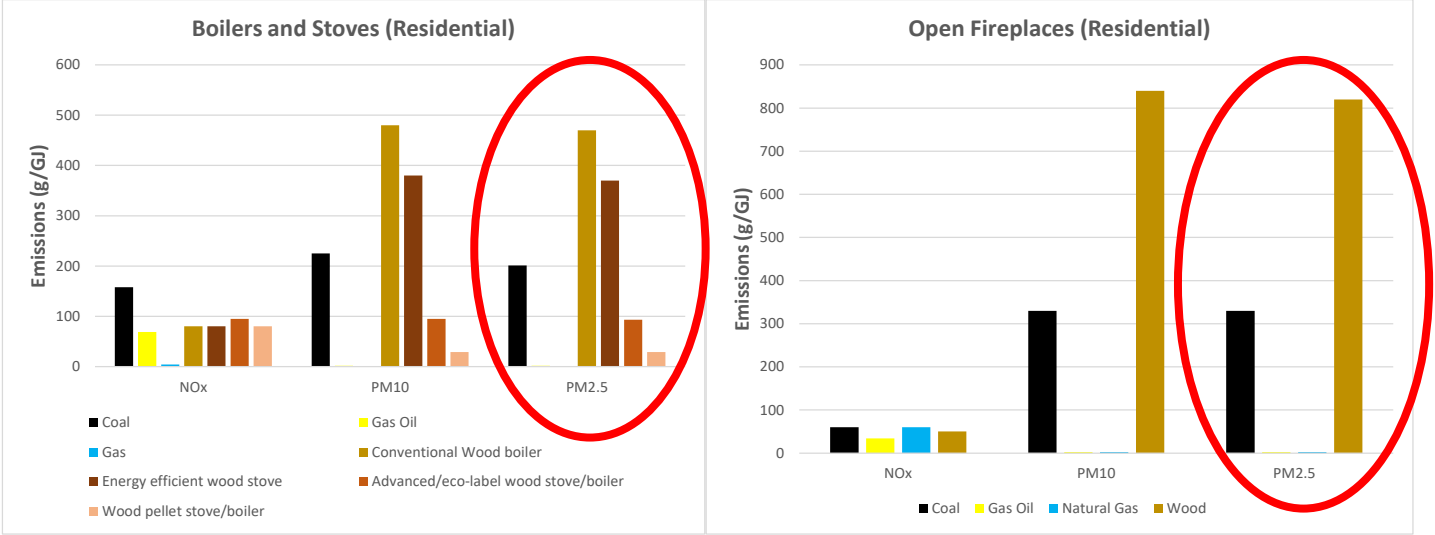
# Estimated PM emission rates from a 5 kW stove compared to typical exhaust PM emissions from vehicles based on EU emissions limits (g/h)



# Fuel switching

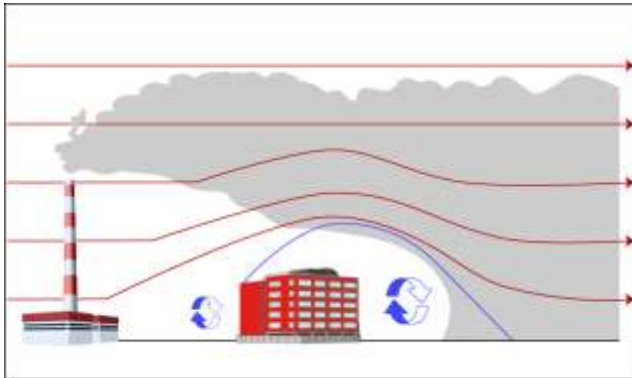
- The net benefits or dis-benefits from using **biomass** as a fuel depend on **what fuel it replaces**.
- In **power gen** it is likely to replace coal and is subject to limits imposed by IED. The **net change** in emissions **likely to be small**.
- In the district heating and **domestic sectors** biomass could replace **coal, oil, gas** and hence net change in emissions could vary.
- Conversely, stoves could replace **open fire burning**.
- Currently we do not capture this information on a local level – only through national fuel supply information.

# Comparison of emissions factors for combustion of fuels (EMEP/EEA, 2013)



# Influence of dispersion

- Larger plant likely emitted from taller chimney stacks than domestic devices
  - More effective dispersion reducing ground level concentrations.
- Domestic emission flue height covered by Building Regs but usually 0.6 m above roof eave is stipulated.
- Downwash therefore expected to be significant.





ELSEVIER

Contents lists available at ScienceDirect

# Science of the Total Environment

journal homepage: [www.elsevier.com/locate/scitotenv](http://www.elsevier.com/locate/scitotenv)



## Impact of the wood combustion in an open fireplace on the air quality of a living room: Estimation of the respirable fraction



A. Castro<sup>a</sup>, A.I. Calvo<sup>a,\*</sup>, C. Blanco-Alegre<sup>a</sup>, F. Oduber<sup>a</sup>, C. Alves<sup>b</sup>, E. Coz<sup>c</sup>, F. Amato<sup>d</sup>, X. Querol<sup>d</sup>, R. Fraile<sup>a</sup>

<sup>a</sup> Department of Physics, IMARENAB University of León, 24071 León, Spain

<sup>b</sup> Centre for Environmental and Marine Studies (CESAM), Department of Environment and Planning, University of Aveiro, Aveiro 3810-193, Portugal

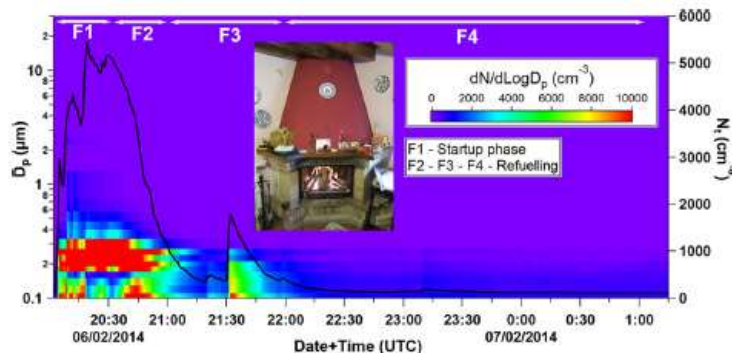
<sup>c</sup> Centre for Energy, Environment and Technology Research (CIEMAT), Department of the Environment, 28040, Madrid, Spain

<sup>d</sup> Institute of Environmental Assessment and Water Research, Spanish Research Council (IDAEA-CSIC), 08034 Barcelona, Spain

### HIGHLIGHTS

- Combustion in the fireplace emissions up to indoor concentrations of 5500 fine particles  $\text{cm}^{-3}$
- The ignition and first refueling emit more and larger particles than later refueling.
- Incorrect cleaning of the fireplace can be as polluting as the refueling processes.
- The ash removal process can be very dangerous at the pulmonary level.

### GRAPHICAL ABSTRACT



# Since AQEG report Defra have been identifying ways to minimise impacts:

- Introduction of the Ecodesign Ready Scheme.
- Launch of the Ready to Burn woodfuel scheme.
- Development of key messages for reducing smoke for consumers by chimney sweep organisations.
- Publication of a practical guide to encourage better burning practices.
- Liaison with local councils to get their assistance in raising awareness.
- Publication of consultation on the air quality strategy

Key messages for smoke reduction:

<https://goo.gl/7N7eYz>

Defra practical guide: [https://uk-air.defra.gov.uk/library/reports?report\\_id=948](https://uk-air.defra.gov.uk/library/reports?report_id=948)

## What is the problem?

Many of us enjoy the appeal and comfort of a woodburning stove or open fire and for some people it has once again become an important part of home heating.

### Facts & Figures

Ready to Burn fuel after you receive fuel for each day.

A big seasoned log with 50% moisture is full water. A fire of water burning wet wood means that much of the heat generated is used to boil off excess water. Seasoning logs has to be passed by your chimney on to a water heating or central heating system.

Seasoned wet wood creates more smoke and creosote which are not good for those breathing them in. Appliances are also generally shorter when burning wet wood and you will have to log and burn more wood to keep your warm.

Wet wood should be seasoned or dried for up to 2 years or less (dried in a controlled temperature indoors one is get it to 20% moisture content or less).

### Less or equal to 20% Moisture Content

### More Information:

For official info: [www.readytoburn.org](http://www.readytoburn.org) has further benefits of switching to Ready to Burn wood fuel products.

Ready to Burn is a Woodsure scheme and [www.woodsure.co.uk](http://www.woodsure.co.uk) has a list of wood fuel producers who have achieved Ready to Burn status.

woodsure is made together with Ready to Burn.

RETAS and DEFRA support the Ready to Burn Scheme.

[www.readytoburn.org](http://www.readytoburn.org) [www.woodsure.co.uk](http://www.woodsure.co.uk)  
tel: 01848 278188

**woodsure**  
wood fuel assured

### Choose the right appliance

Woodburning stoves produce much less smoke than open fires. If you are thinking of buying a stove then consider purchasing one that has been approved for use in smoke control areas by DEFRA, or an Ecodesign Ready stove. These have been tested to high standards to demonstrate low smoke emissions. Stoves which have not undergone these tests do not carry this assurance.

### Maintain your open fire/stove

Be considerate towards your neighbours when lighting bonfires, outdoor burners and BBQs and always take care not to cause a smoke nuisance. Dispose of garden waste through your Local Council's deposit scheme.

### Open fires and wood-burning stoves

A practical guide

### Know the law in Smoke Control Areas

**The law in Smoke Control Areas**  
Many urban areas are smoke control areas. It means that you can only use authorised smokeless fuels.

**What you can do**

By following these simple steps, you will reduce the harmful health effects that are caused by burning smoke, including breathing problems such as asthma attacks.

**What you can do to help reduce the harmful effects from smoke:**

- Think if you have to burn
- Burn seasoned wood (including Ready to Burn)
- Maintain chimneys and sweep chimneys.

## Relative PM<sub>2.5</sub> emissions in your home from domestic heating methods

### Relative emissions from different solid fuels



Low-sulphur  
manufactured  
solid fuel

Dry wood

LESS DIRTY

0 g/MWh



Electric  
heating

CLEAN

## Clean Air Strategy (Consultation)

- New powers for local government
- Ensuring only the cleanest stoves can be bought and installed
- Ensuring only the cleanest fuels are available for sale
- Voluntary Industry Initiatives

Smoke plumes are not to scale (small combustion tables). The image shows an advanced / ecolabelled stove.

2016 Guidebook (1A4 - Ecodesign stove, wood in (<50 kWth) boiler.

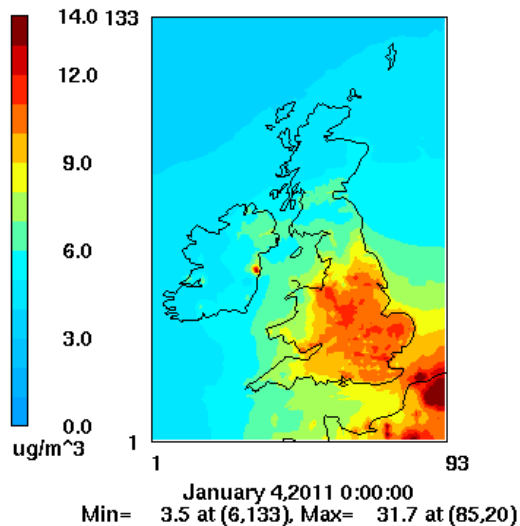


# Modelling the future

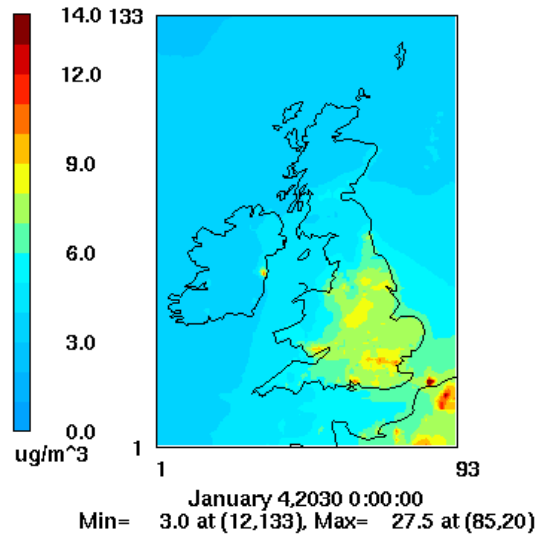
## Annual mean UK concentrations of PM<sub>2.5</sub>

(Williams, Beevers, Kitwiroon 2018)

2011 annual mean PM<sub>2.5</sub>



2030 annual mean PM<sub>2.5</sub>



Urban Wood Burning



# Challenges

- Biomass open burning and stoves are a significant challenge with respect to (local) air quality (38% of PM<sub>2.5</sub> 2018 NAEI)
- Stove/(open fire) operation
  - Type of Fuel (incl. treated wood)
  - Wet/Dry
  - Operation (air)
  - Flue
- Stove turnover/replacement
- Chimney/Dispersion
- Indoor exposure
- Estimating impact and number in official statistics

