UNIVERSITY OF LEICESTER

Air Quality Expert Group

Wood Burning (Stoves): the Challenges

Prof Paul S. Monks

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.

UNIVERSITY OF LEICESTER

Motivations for report

- UK has ambitious climate change targets - 80% reduction in CO_2 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 NOx and PM_{10}/$PM_{2.5}$?
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

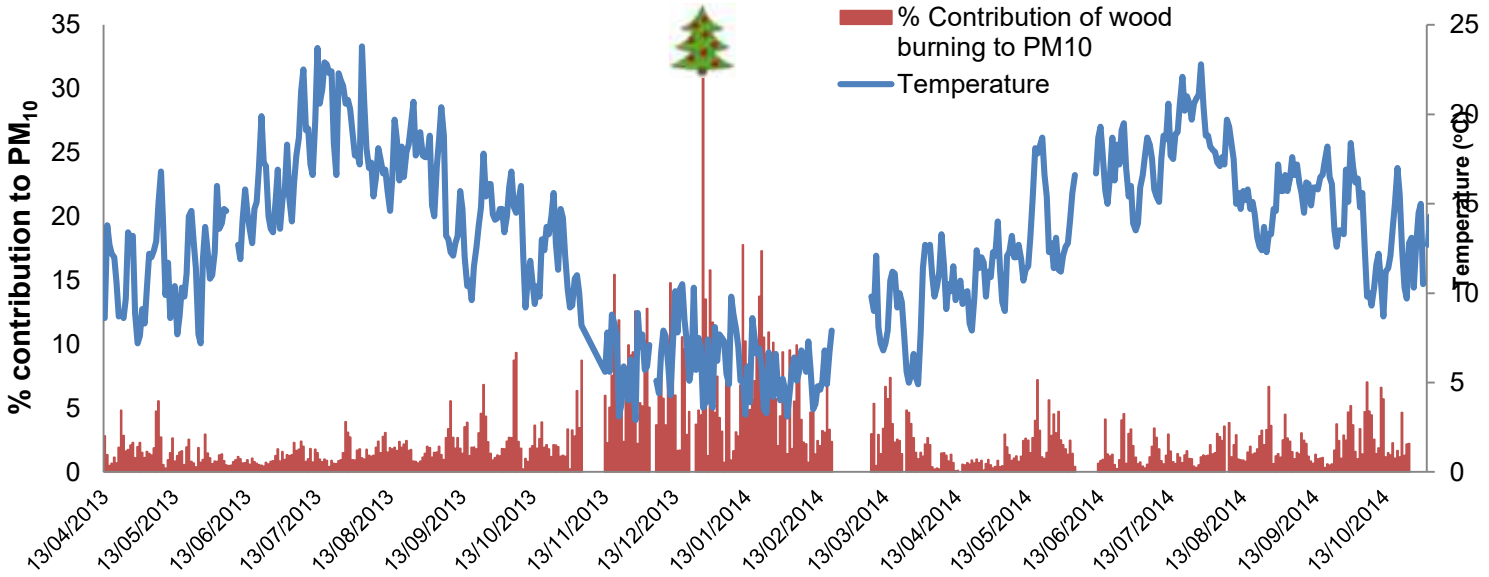
- Wood smoke contains several pollutants:
  - **Particulate matter** (PM_{10} and $PM_{2.5}$),
  - **CO, NO_2, VOCs,** and **climate gases** (e.g. **methane** and **black carbon**).

Uptake of wood burning

Type of boilers/stove installed

Type of wood burned

Contribution of Wood Burning to Total PM_{10} in Leicester



- Highest contribution observed during the winter:
  - The average contribution to PM_{10} is **6.7%** (max 4.7 µg/m^3) 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.

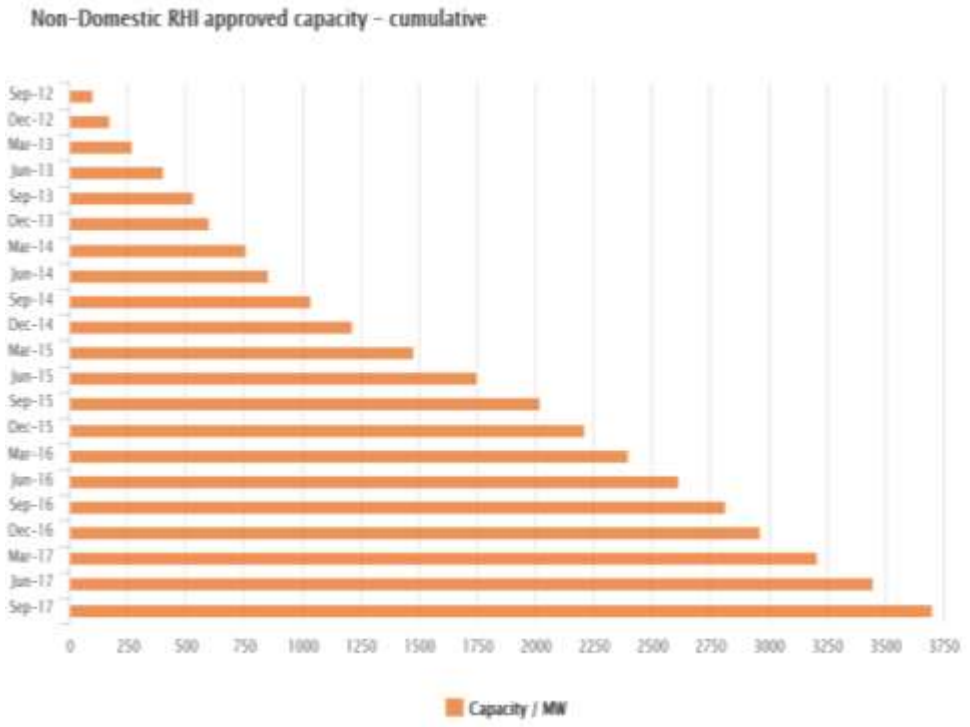
Cordell et al, AENV, 2016

Legislative context and emissions limits

Type of plant	Incentive Scheme	Emissions Limits
Power generation	1. Renewables Obligations 2. EU Emissions Trading Scheme (EU-ETS) 3. Future EPS for CO_2	Industrial Emissions Directive
District heating and CHP	Renewable Heat Incentive (RHI)	1. Medium Combustion Plant Directive. 2. Limits imposed by RHI.
Domestic Boilers	RHI	1. Limits imposed by RHI. 2. Proposed Eco-design Directive.
Domestic Wood Burners	None	1. Appliance exemption within smokeless zones. 2. Proposed Eco-design Directive.

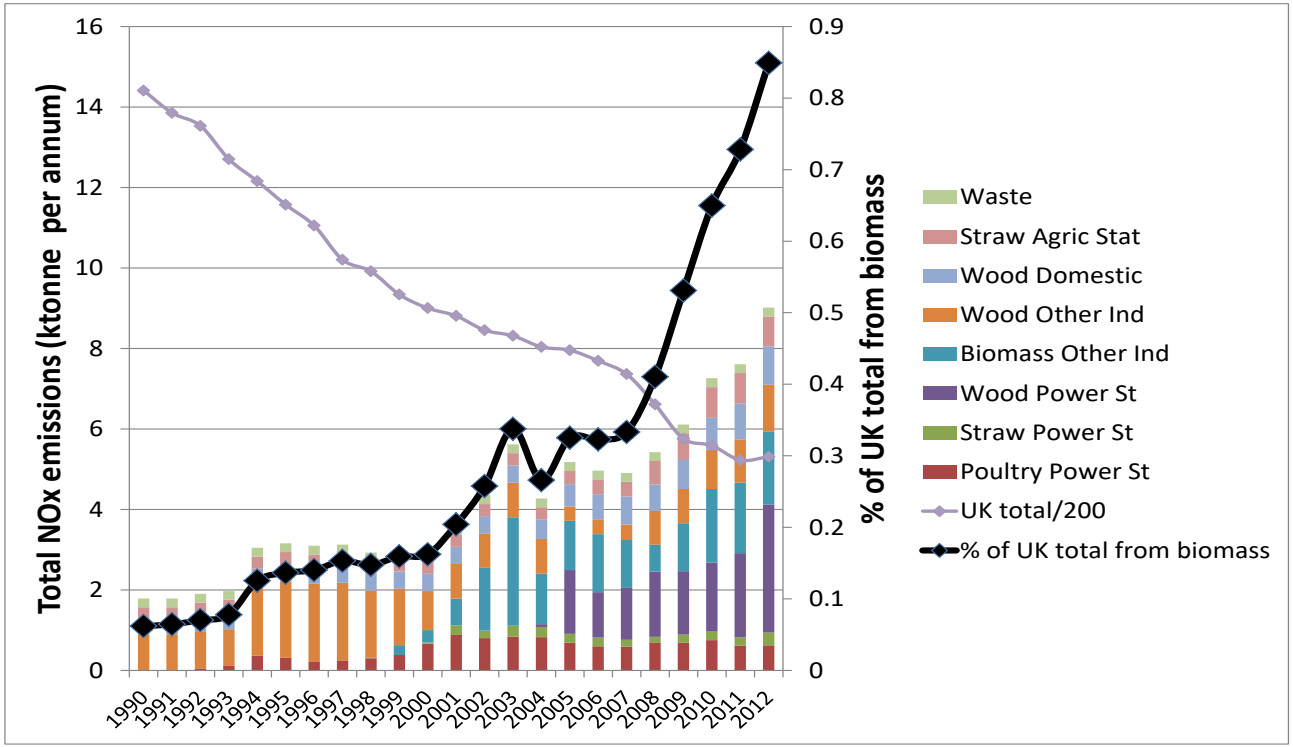
Take up of the RHI (Ofgem)

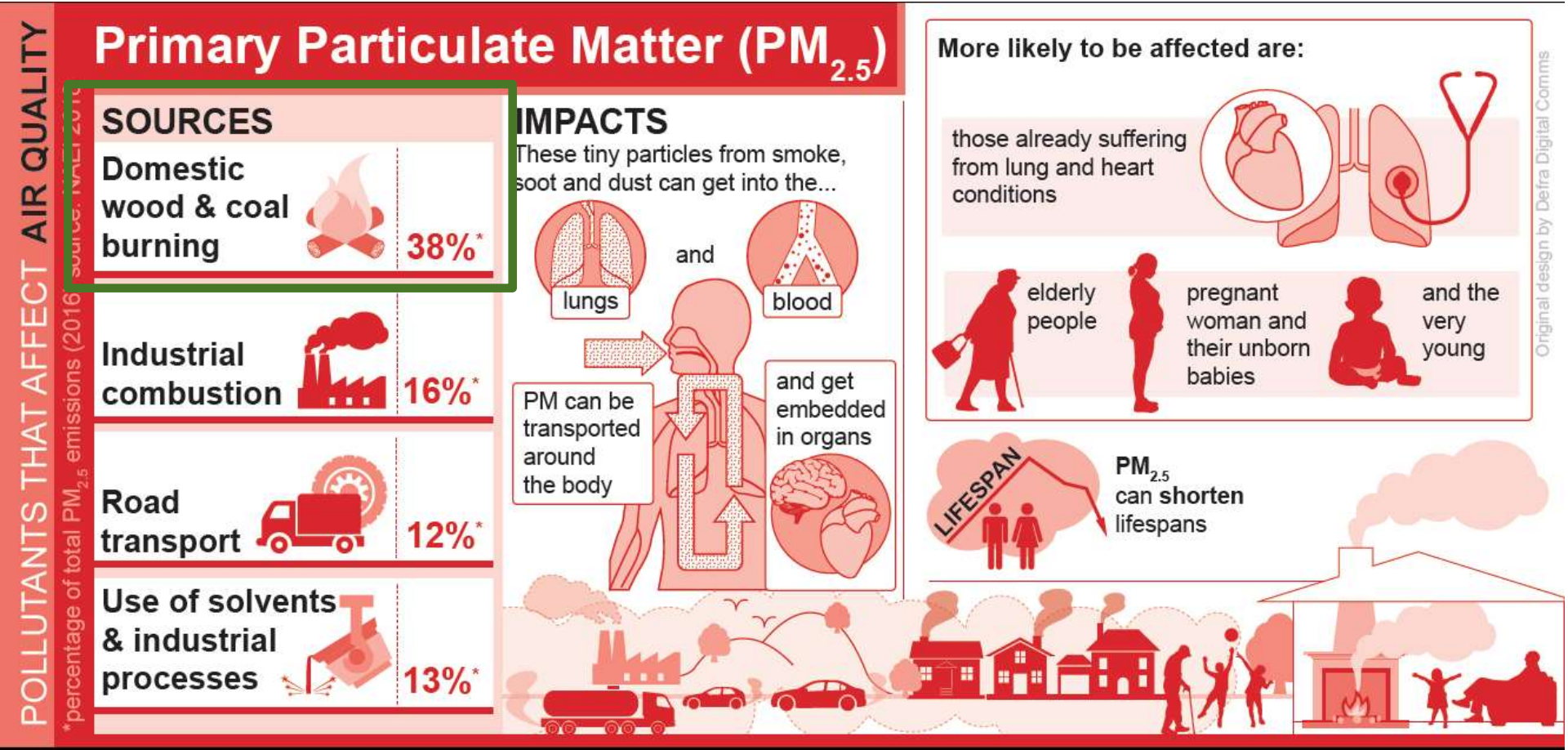
- Non-domestic scheme dominates.
- 5 fold increase in non-domestic solid biomass boilers between March 2014 - Sept 2017.
- Mostly small commercial boilers
- < 200 kWth capacity.
- Total equivalent to capacity of large power station.



UNIVERSITY OF LEICESTER

Estimated trends in primary emissions using NAEI data:NOx

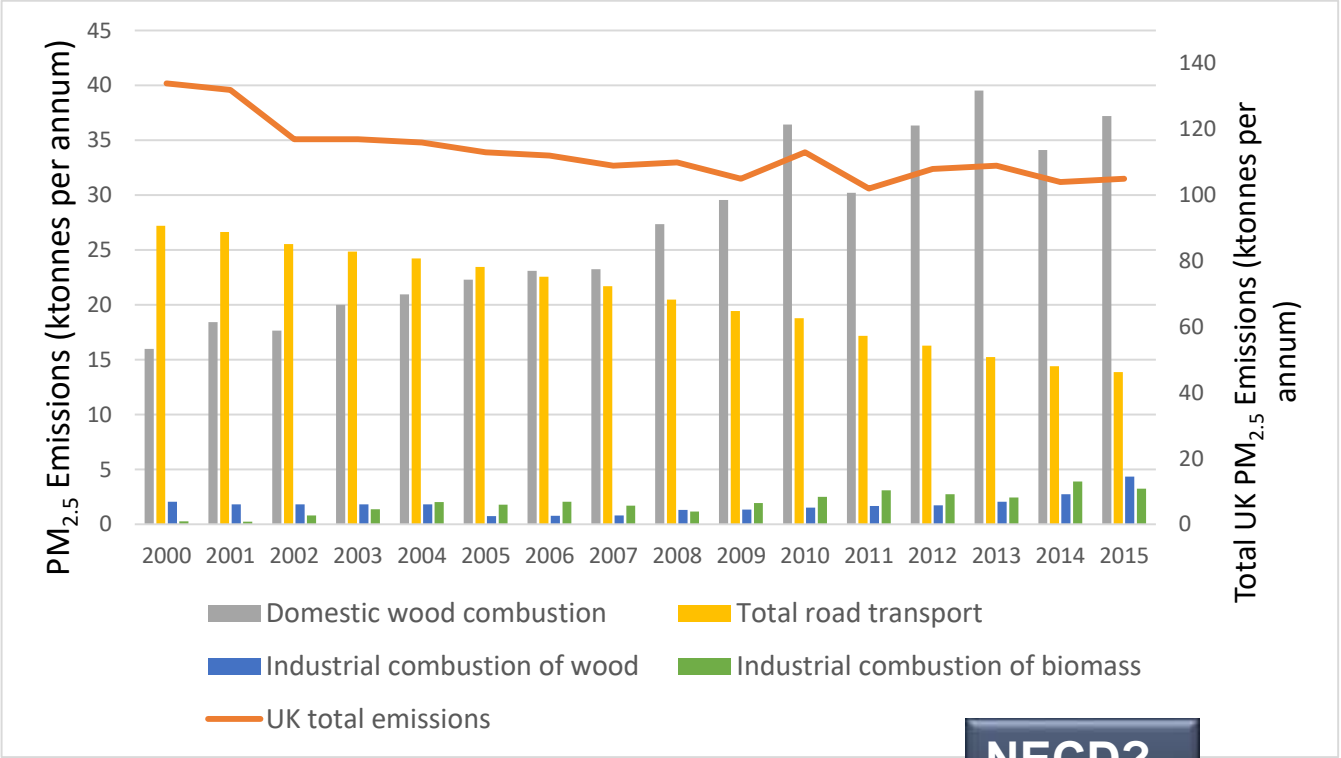




report preparation

UNIVERSITY OF LEICESTER

Updated primary emissions based on DECC usage survey.



NECD?

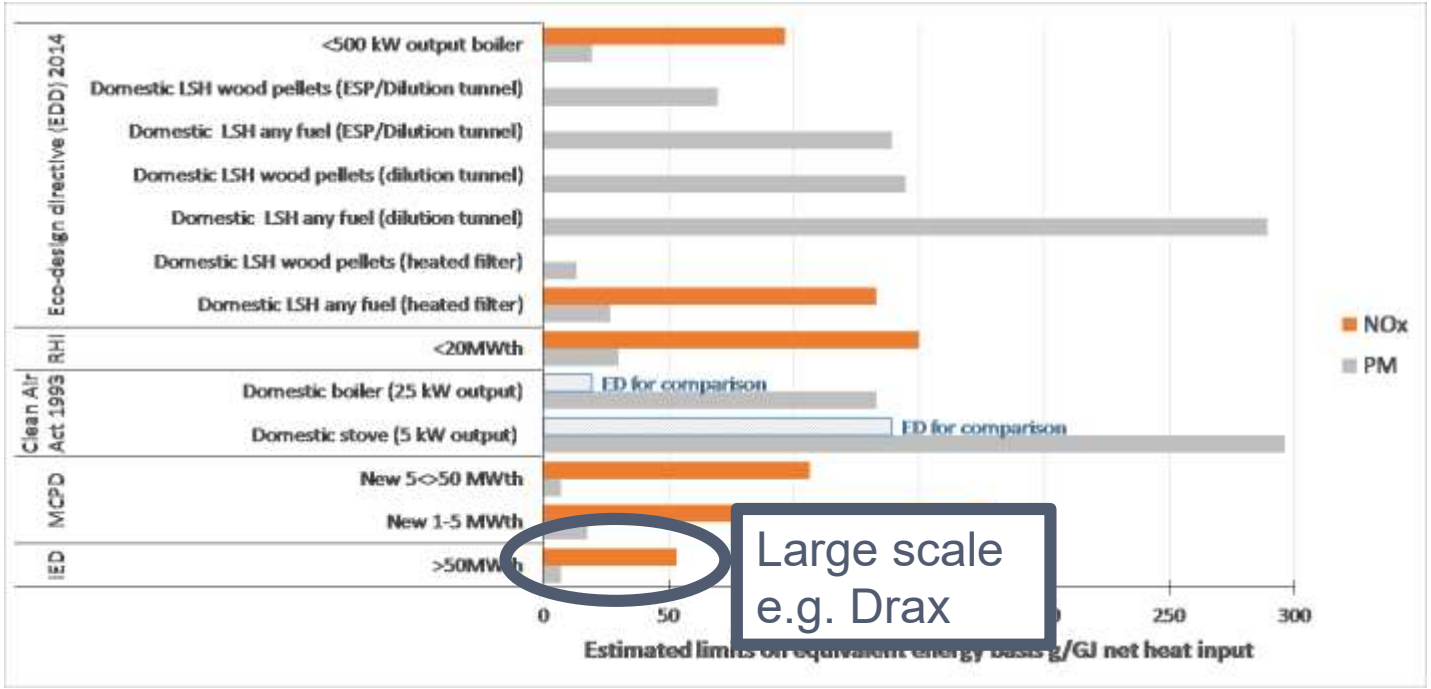
UNIVERSITY OF LEICESTER

Small scale domestic sources

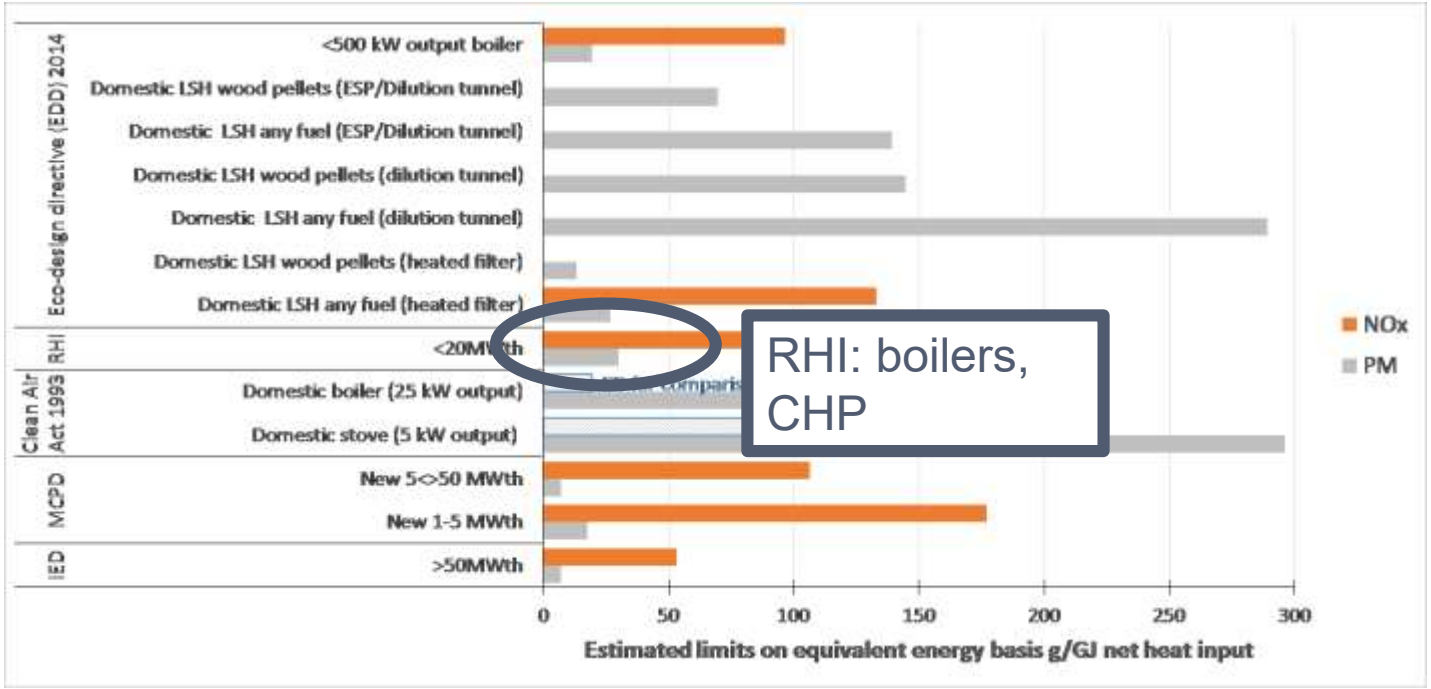
- Stove Industry Alliance estimate around 150,000 units installed per year (based on 2009).
- Lack of available PM control systems for domestic stoves, particularly those with retro-fit options.
- Emissions will be seasonal

➢ 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

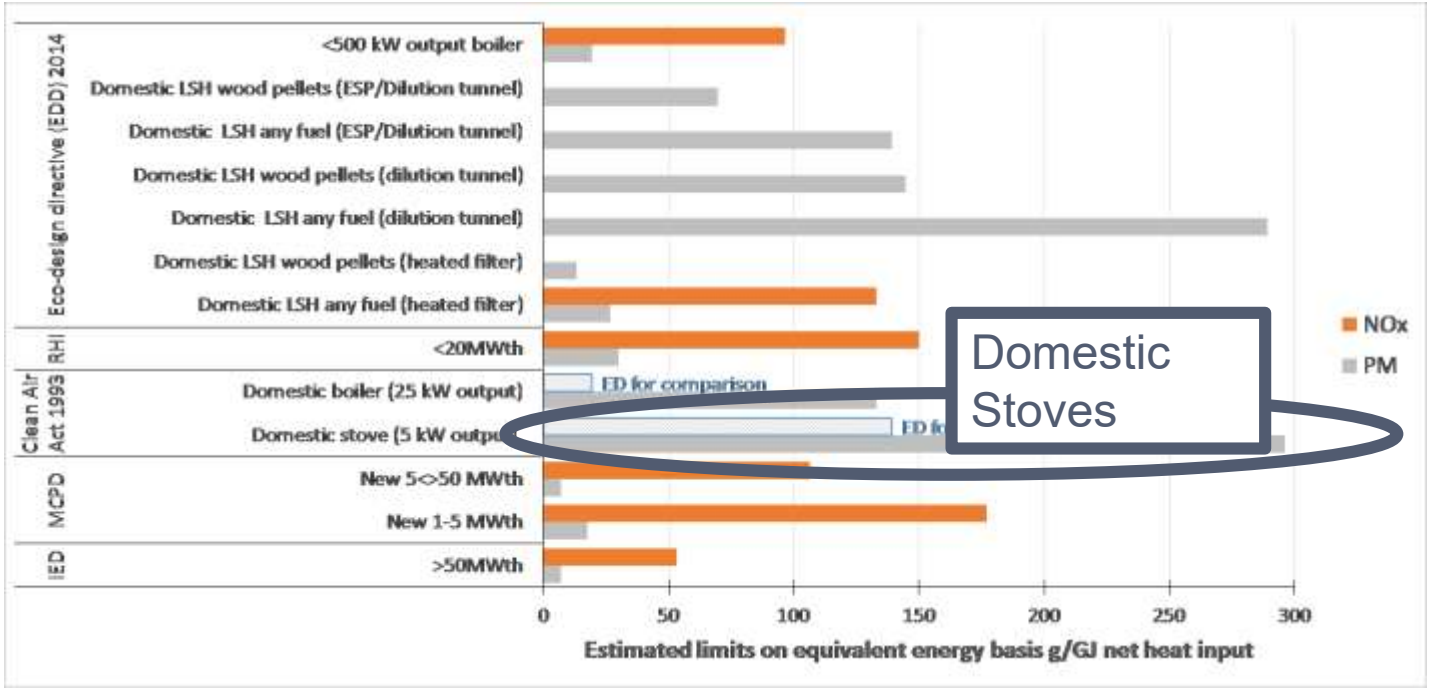


Comparison of PM and NOx emissions limits for different scales of combustion devices based on g/GJ net heat input



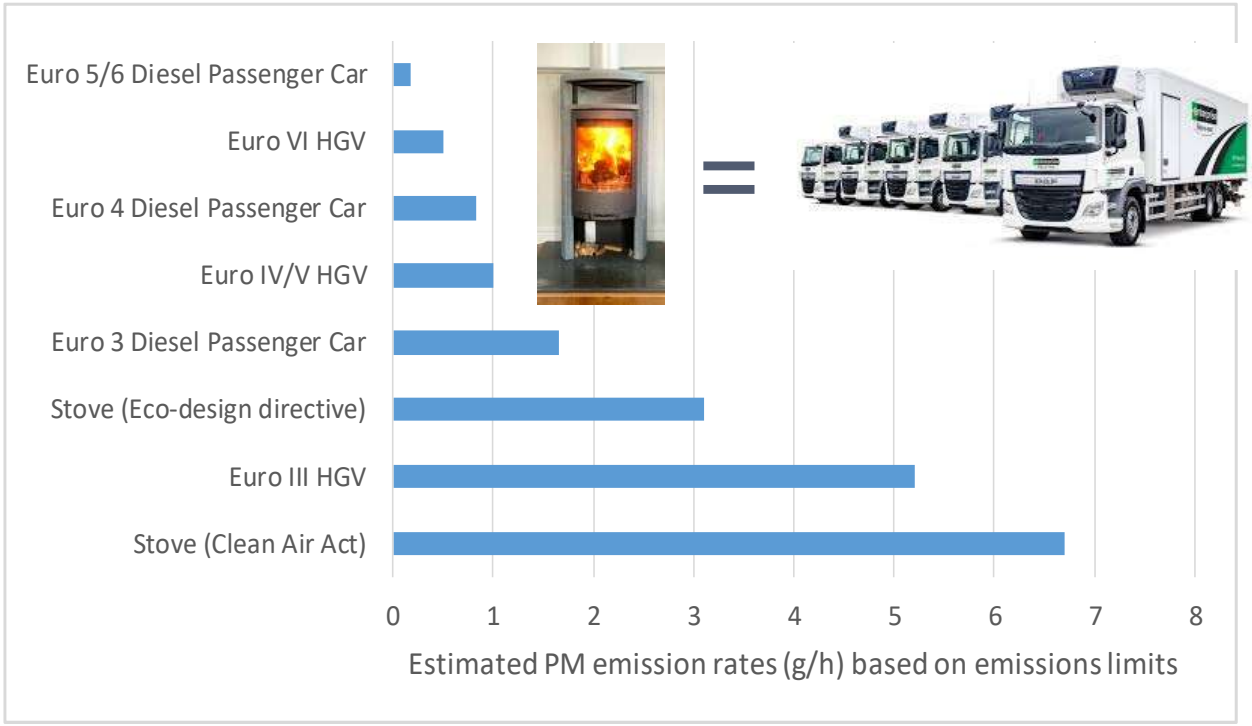
UNIVERSITY OF LEICESTER

Comparison of PM and NOx emissions limits for different



UNIVERSITY OF LEICESTER

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

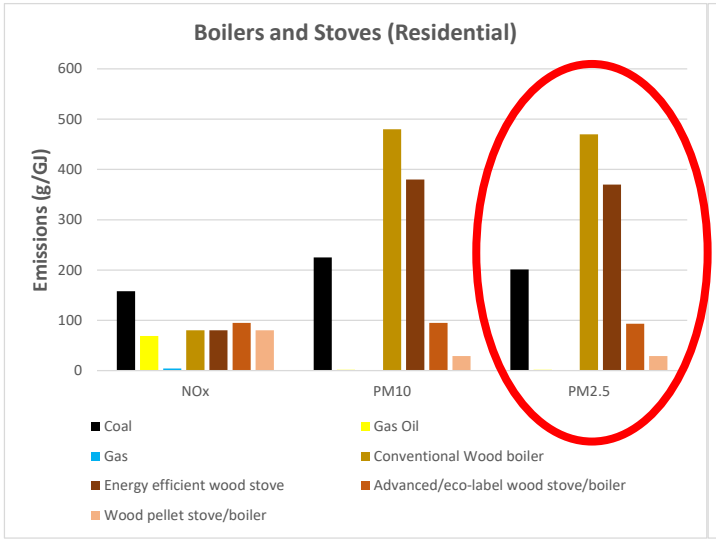


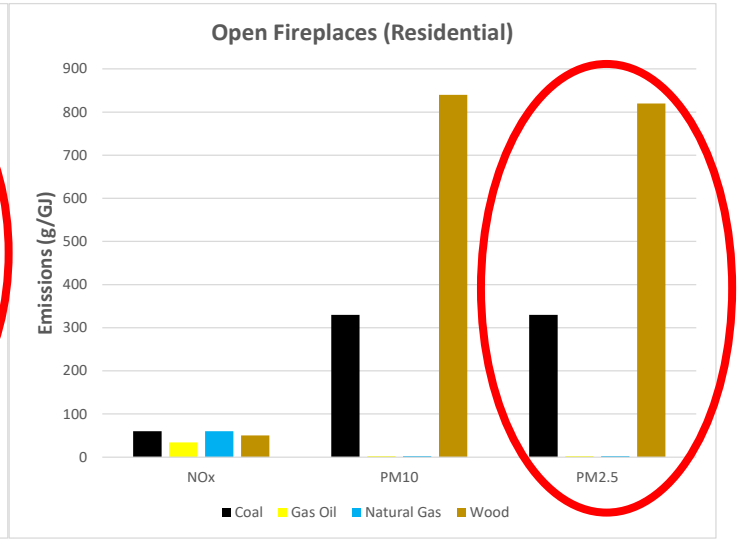
UNIVERSITY OF LEICESTER

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.

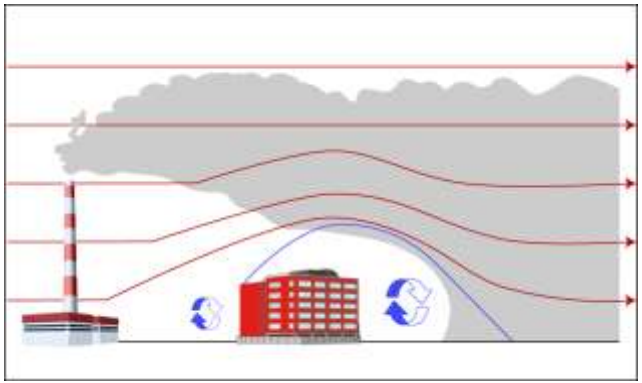
Comparison of emissions factors for combustion of fuels (EMEP/EEA, 2013)





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 eve is stipulated.
- Downwash therefore expected to be significant.



UNIVERSITY OF LEICESTER

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: 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

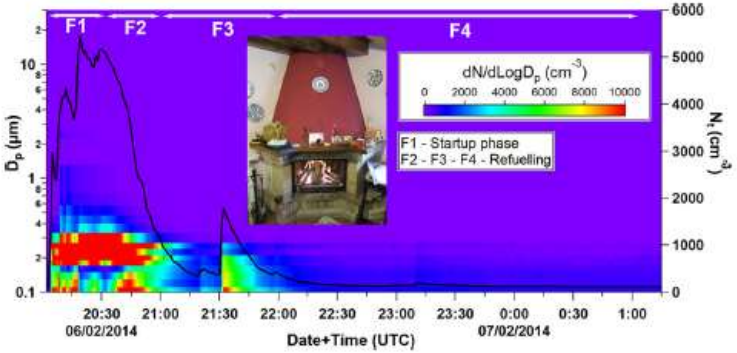
A. Castro [a], A.I. Calvo [a,*], C. Blanco-Alegre [a], F. Oduber [a], C. Alves [b], E. Coz [c], F. Amato [d], X. Querol [d], R. Fraile [a]

[a] Department of Physics, IMARENAB University of León, 24071 León, Spain
[b] Centre for Environmental and Marine Studies (CESAM), Department of Environment and Planning, University of Aveiro, Aveiro 3810-193, Portugal
[c] Centre for Energy, Environment and Technology Research (CIEMAT), Department of the Environment, 28040, Madrid, Spain
[d] 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 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

Relative $PM_{2.5}$ emissions in your home from domestic heating methods

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

Relative emissions from different solid fuels

-sulphur
ufactured
lid fuel

Dry wood

LESS DIRTY

0 g/MWh

Electric heating

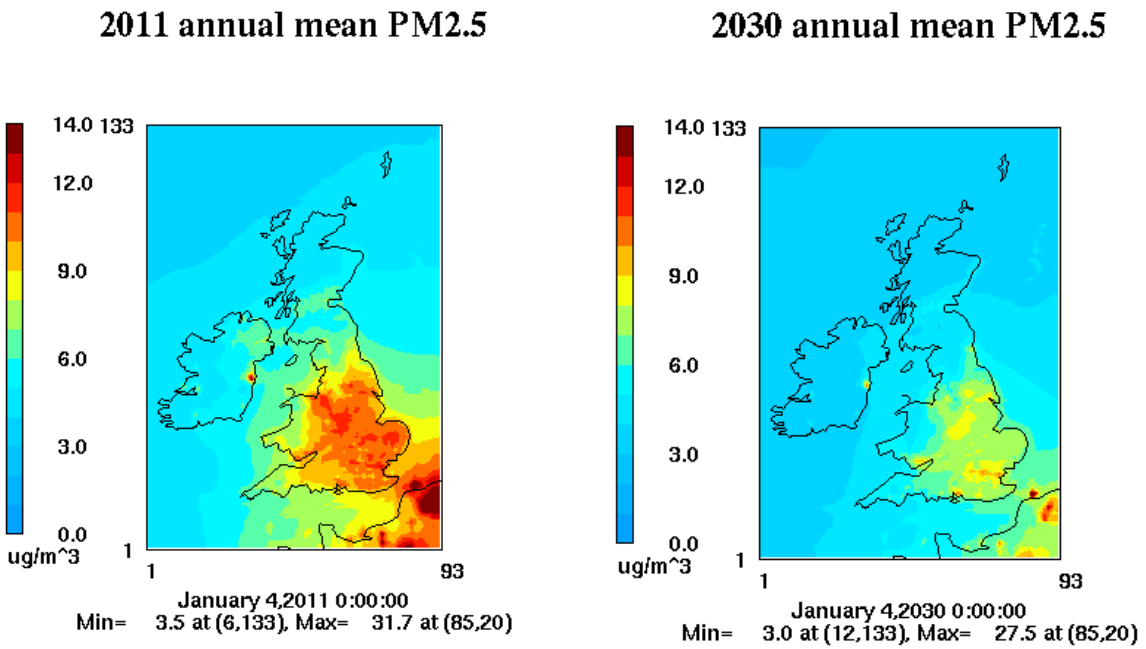
CLEAN

Smoke plumes are not to scal
small combustion tables). The
an advanced / ecolabelled sto

2016 Guidebook (1A4 -
Ecodesign stove: wood in
(≤50 kWth) boiler.

Modelling the future
Annual mean UK concentrations of $PM_{2.5}$

(Williams, Beevers, Kitwiroon 2018)



Urban Wood Burning

Challenges

- Biomass open burning and stoves are a significant challenge with respect to (local) air quality (38% of $PM_{2.5}$ 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