



# Mapping emissions from residential wood combustion in Denmark

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Real-world emissions from residential wood combustion

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# Outline

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# Introduction (1)

- › **DCE, AU is responsible for preparing the national inventory of emissions to air in accordance with international obligations**
- › **The national emission inventories are reported annually to EU and UN**
- › **The national emission inventory covers 5 sectors:**
  - › **Energy**
  - › **Industrial processes**
  - › **Agriculture**
  - › **Land use**
  - › **Waste**
- › **Energy covers all combustion, including residential wood combustion (RWC) in stoves and boilers**

## Introduction (2)

- › RWC is a major source to air pollution in Denmark
- › Especially for PM, dioxin and PAH, but also for some metals
- › The inventories are subject to large uncertainties

	Share of national emission in 2013
SO <sub>2</sub>	2,5 %
NO <sub>x</sub>	1,9 %
NMVOG	9,2 %
CH <sub>4</sub>	1,3 %
CO	22,9 %
PM <sub>2.5</sub>	60,1 %
HCB	5,7 %
PCDD/F	49,7 %

	Share of national emission in 2013
As	4,1 %
Cd	69,8 %
Cr	48,3 %
Cu	2,9 %
Hg	4,9 %
Pb	7,3 %
Zn	28,6 %
PAH	66,5 %



# Emission calculation methodology for RWC

- › **Denmark is obligated to follow international guidelines for calculation and reporting of emissions**
  - › EMEP/EEA 2013 Guidebook
  - › IPCC 2006 Guidelines
- › **It is recommended to use well-documented national data if available**
- › **Emission calculation methodology**
  - › **Emission = wood consumption \* emission factor**



# Wood consumption

- › Emissions calculations are based on the wood consumption included in the official national energy statistics published annually by the Danish energy agency (DEA)
- › DEA carries out biennial surveys of RWC which form the basis for the statistics
- › Denmark is obligated to use the national energy statistics for the national emission inventory
- › In 2013 wood consumption in households was 21.9 PJ wood and 9.2 PJ wood pellets, corresponding approximately 1.4 mio. tonnes and 0.6 mio. tonnes



# Appliance stock

- > **The inventory include**
  - > **4 types of wood stoves,**
  - > **fireplaces,**
  - > **4 types of wood boilers, and**
  - > **wood pellet boilers**
  
- > **In 2015 the categories will be adjusted to take into account the updated wood stove act**
  
- > **It is assumed that Denmark has**
  - > **750 000 wood stoves**
  - > **~ 16 000 fireplaces, and**
  - > **~ 46 000 wood boilers**



# Appliance stock in 2013

			Stock in 2013	Wood consumption TJ
<b>STOVES</b>	Old stove	Stove pre-1990	157.500	2.683
	New stove	Stove with DS mark 1990-2005	292.500	6.757
	Modern stove	Stove conforming with Danish legislation (2008)	120.000	2.586
	Eco labelled / new advanced stove		180.000	3.879
	Other stove	Fireplaces etc.	16.210	249
<b>BOILERS</b>	Old boilers with accumulation tank	pre-1980	3.611	505
	Old boilers without accumulation tank		2.856	345
	New boilers with accumulation tank	post-1980	27.172	3.410
	New boilers without accumulation tank		12.999	1.591
	Pellet boilers/stoves			9.185



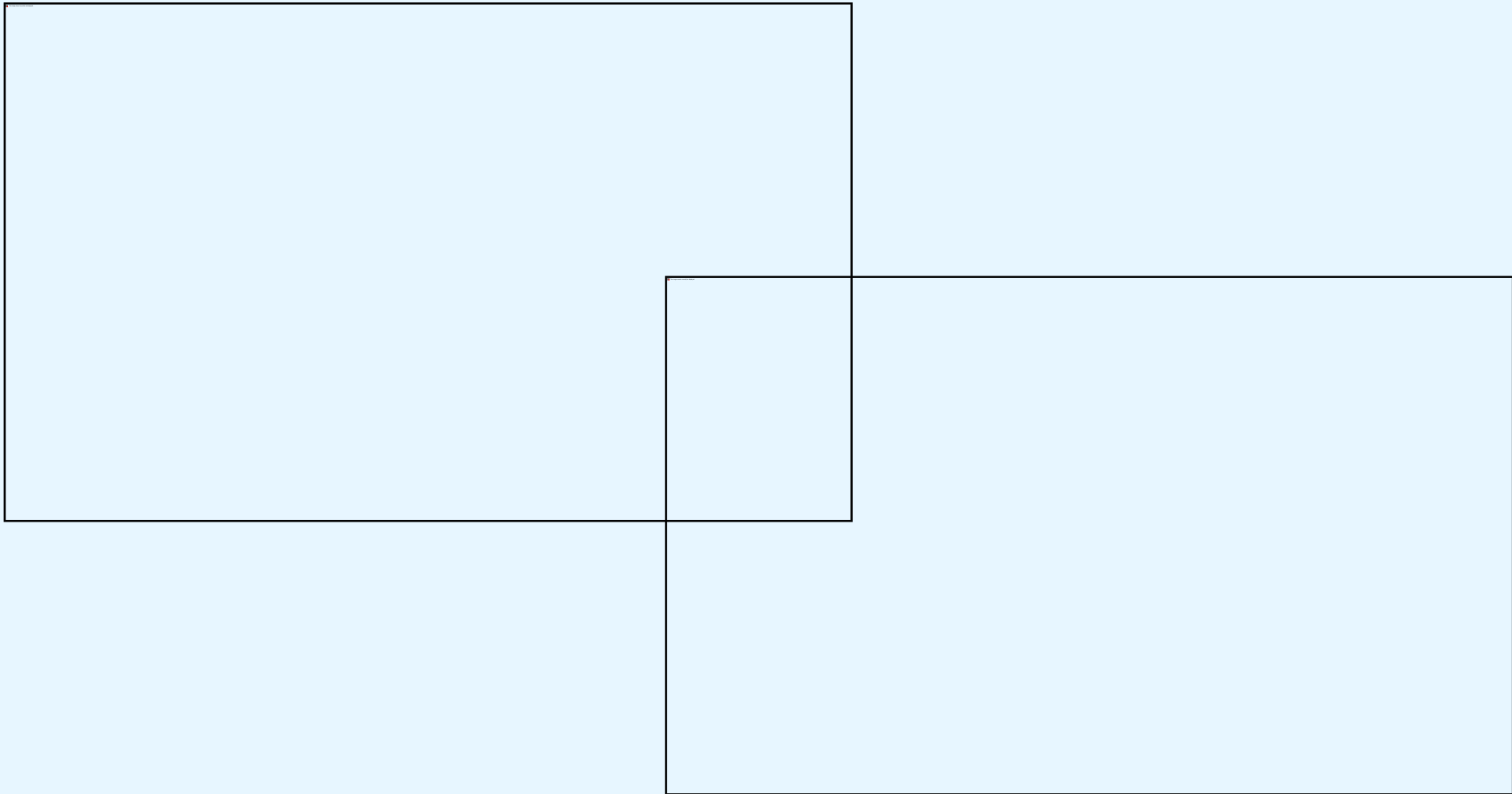
# Emission factors

- › Emission factors (EF) are associated with large uncertainties and mainly based on international guidelines (EMEP/EEA)
- › Most EFs decrease for newer technologies

Emission factor (g/GJ)	NO <sub>x</sub>	NMVOC	CH <sub>4</sub>	CO	PM <sub>2.5</sub>	BC	PCDD/F	Benzo(a) pyrene
Old stove	50	1200	430	8000	<b>930</b>	93	800	121
New stove	50	600	215	4000	<b>740</b>	74	800	121
Modern stove	80	350	125	4000	<b>514</b>	82	250	61
Eco labelled / new advanced stove	95	175	2	1117	<b>206</b>	58	100	10
Other stove	50	600	430	4000	<b>740</b>	74	800	121
Old boilers with accumulation tank	80	350	211	4000	<b>900</b>	144	550	121
Old boilers without accumulation tank	80	350	256	4000	<b>1800</b>	288	550	121
New boilers with accumulation tank	95	175	50	1117	<b>206</b>	58	100	10
New boilers without accumulation tank	95	350	50	2234	<b>413</b>	116	200	20
Pellet boilers/stoves	80	10	3	300	<b>29</b>	4	100	10



# Wood consumption and PM<sub>2.5</sub> emission



# Mapping of emissions from RWC (1)

- › Denmark is obligated to report the national emissions of air pollution, spatially distributed on a grid with a resolution of 50km x 50km
  - › From 2017 the resolution is increased to  $0.1^{\circ} \times 0.1^{\circ}$  (~10km x 10 km)
- › Gridded emissions of high resolution (1km x 1 km) has been prepared for Denmark since 2010
- › The gridded emissions is used as input in air quality modelling
- › The gridding methodology is continuously improved as new spatial data become available



# Mapping of emissions from RWC (2)

- › **Based on the Building and dwelling register (BBR), a distribution key is prepared for mapping of RWC emissions**
- › **The distribution key include the share of the national total emission to be allocated to each 1km x 1km grid cell**

# Distribution key

## > Addresses with RWC is identified based on

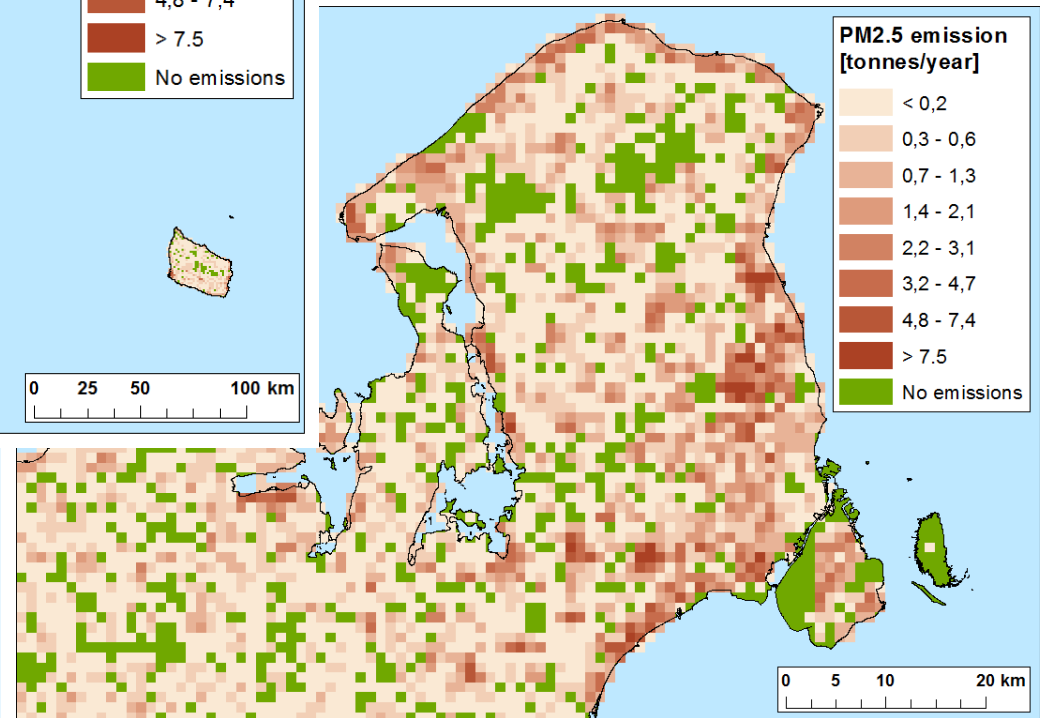
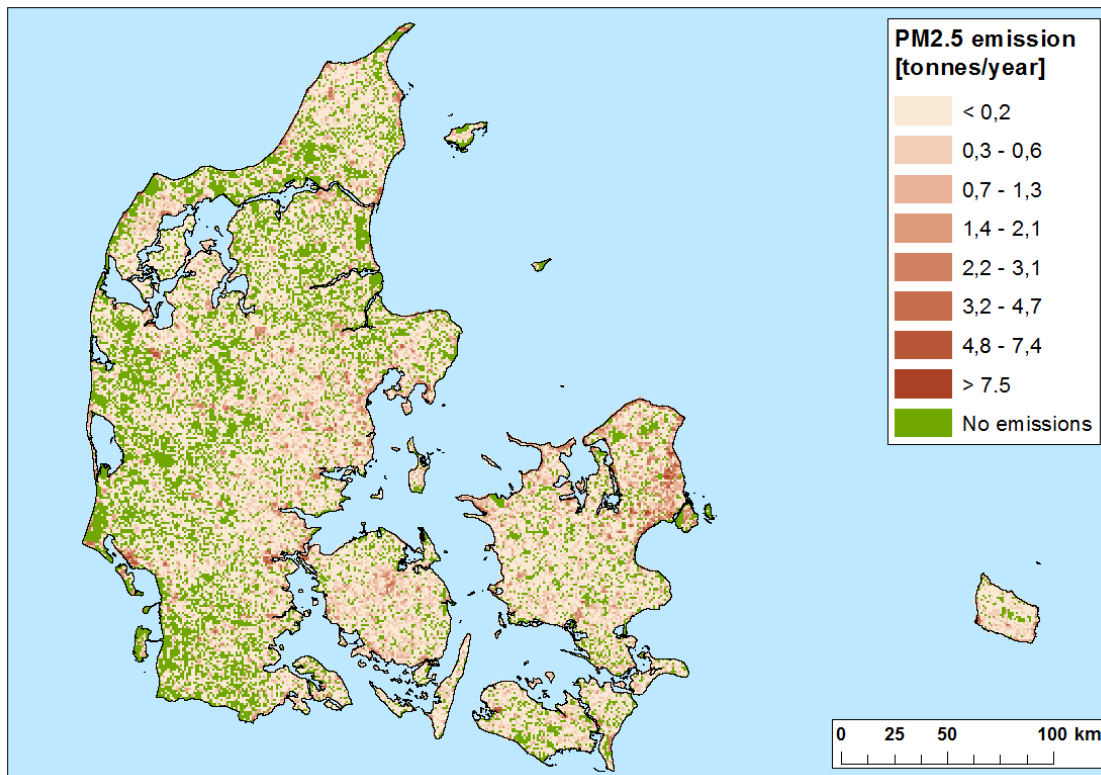
- > Building type
- > Heating installation
- > Fuel
- > Supplementary heating

## > Weighting factors are applied for

- > Primary vs. supplementary RWC
- > Stoves vs. boilers
- > Building types

	Technology	Building group	Weighting factor
Primary RWC	Stove	Single-family house	0.8
	Stove	Holiday house	0.2
	Stove	Apartment building	0.8
	Boiler	Single-family house	1
	Boiler	Holiday house	0.8
	Boiler	Apartment building	1
Supplementary RWC	Stove	Single-family house	0.4
	Stove	Holiday house	0.2
	Stove	Apartment building	0.08

# Gridded PM<sub>2.5</sub> emissions





# Uncertainties

- › **Mapping is associated with large uncertainties**
- › **Errors in registrations in BBR**
  - › **Number of appliances in Denmark**
  - › **Location of appliances**
- › **No information on technology and age of appliances**
- › **No information on wood consumption per appliance**
- › **Fuels (wood, wet , waste etc.)**
- › **User behaviour (top-down, insufficient air supply etc.)**
- › **Annual variations (temperature, new occupants etc.)**



# Summary

- › **Large uncertainties on all parameters**
- › **Regardless of effort RWC will always be an activity with significant uncertainties**
- › **A considerable improvement would be a national register based on information from the chimney sweepers**
  - › **Would reduce the uncertainty of total number, age distribution, and location of stoves and boilers**





› **Thank you for your attention**