Nearly zero-energy buildings: Legislation alternatives for residential wood combustion and the impact on population exposure to fine particles

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Energy performance of buildings directive

- All new buildings need to be nearly zero-energy (nZEB) by the end of 2020
- \( nZEB = \) “very high energy performance, and the low amount of energy they require comes mostly from renewable sources”
- Member states can determine their own national legislation to achieve this goal in a cost-efficient way
Energy performance of houses measured by energy efficiency rate (E-value)

E-value = \( \frac{kW_{\text{purchased energy}}}{m^2} \times \text{energy coefficient} \)

Arbitrary coefficients, not comparable between countries

<table>
<thead>
<tr>
<th>Heating method</th>
<th>Energy coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil fuel boiler</td>
<td>1</td>
</tr>
<tr>
<td>Biofuel boiler or stove</td>
<td>0.5</td>
</tr>
<tr>
<td>Electric heating</td>
<td>1.7</td>
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<tr>
<td>District heating</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Proposed new value for detached houses up to 25% more stringent than the current one, depending on the size of the house
Finnish masonry heater

- Used mostly for supplementary heating
- ~90% of new detached houses include one
- Efficient combustion
The assignment

- Current Finnish legislation has a 2000 kWh/a maximum allowance of net heating energy from masonry heaters.
- If this is increased to 3000 or 4000 kWh/a in
  - All houses
  - Houses with electric heating

What is the impact on the population exposure to fine particles in Finland in 2050?

- Justification: wood is being viewed as carbon neutral
  => Increasing the use of wood could substitute for smaller savings in energy efficiency.
We assumed that people use their masonry heater according to the maximum limit in the E-value.

The construction of new detached houses:
- 11,500 houses built annually.
- Spatial allocation based on the locations of new detached houses from the last 10 years.
- Primary heating methods from the latest registered year.
Methods and assumptions

- Net heating energy converted to wood consumption using a coefficient of $1/0.6$
- $\text{PM}_{2.5}$ emission factor for masonry heaters 48 mg/MJ
- Three scenarios:
  - a) 2000 kWh/a in all houses (Baseline)
  - b) additional 2000 kWh/a in houses with electric heating
  - c) 4000 kWh/a in all houses.
• The dispersion of emissions modelled using source-receptor matrices
• Resulting annual average concentrations in a 1km x 1km grid
• Compared to population in each grid cell
Results: modelled PM$_{2.5}$ concentrations

- Concentrations mostly < 0.5 μg/m$^3$ in case a) and <1.3 μg/m$^3$ in case c)
- Currently measured background concentrations in Finland are typically 7 – 10 μg/m$^3$

![Map showing PM$_{2.5}$ concentrations for different scenarios](image)

- a) 2000 kWh/a in all houses
- b) Additional 2000 kWh/a in houses with electric heating
- c) 4000 kWh/a in all houses
Results: population exposure

- Total annual PM$_{2.5}$ emissions in the scenarios: a) 225t, b) 275t, c) 450t
  => Up to 5% of Finnish total RWC emissions in 2014
- Emissions in the outskirts of major population centers
  => 93% of population exposure in areas classified as urban
- Average annual PM$_{2.5}$ emission concentrations in these areas increase by 1-10%
- Currently exposure to fine particles in ambient air is estimated to cause ~1800 annual deaths in Finland
Observations

- The maximum allowance for a masonry heater’s net heating energy does not translate directly to the actual wood consumption
  - It could increase the number of houses where supplementary heating by wood combustion is necessary
- Efficiency of combustion appliances is increasing, but so is the popularity of stoves
- In addition to fine particle emissions, wood combustion also produces climate-warming gases and pollutants (e.g. black carbon)
  - Impact in the Arctic area especially strong because of deposition of particles to snow and ice
Even the use of modern, efficient stoves causes a notable increase in PM$_{2.5}$ concentrations in urban areas
=> Invariably results in detrimental heath effects
Increasing of residential wood combustion not justified on environmental grounds
Legislation should focus on improving energy efficiency of houses
Thank you

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