

Brief, January 2026

## Cost-Benefit: Electrostatic precipitators for wood boilers

Green Global Future has conducted a cost-benefit screening of the following scenario: *the ongoing revision of the Ecodesign regulations leads to an outcome where electrostatic precipitators will be a mandatory requirement for new log wood (with/without accumulation tank) and wood pellet boilers*. This work is funded by the Clean Air Fund.

Calculations are conducted for densely populated urban areas, smaller towns, and rural areas (below: *urban, towns, rural*), as the latter typically have more intense use of biomass than the former, in Denmark and Slovakia, two EU countries that have same size but quite different per-capita average income. The purpose of the cost-benefit screening is to illustrate consequences in both wealthier and less wealthy countries in the EU.

### COSTS: ELECTROSTATIC PRECIPITATORS

Table 1 shows the Gross National Product GNP of DK and SK underlining the different economic capacity whereas table 2 contains cost estimations regarding precipitators for wood boilers in the two member states.

**Table 1: GNP and average wages for Denmark and Slovakia**

	Denmark	Slovakia
<b>GNP per capita (2024)</b> <sup>1)</sup>	60,510 euro	19,130 euro
<b>Average wages</b> <sup>2)</sup>	70,000 euro	20,000 euro

1) [https://ec.europa.eu/eurostat/databrowser/view/sdg\\_08\\_10/default/table](https://ec.europa.eu/eurostat/databrowser/view/sdg_08_10/default/table)

2) [https://ec.europa.eu/eurostat/databrowser/view/nama\\_10\\_fte/default/table?lang=en](https://ec.europa.eu/eurostat/databrowser/view/nama_10_fte/default/table?lang=en)

**Table 2: Costs for electrostatic precipitators for small boilers**

	Denmark	Slovakia
<b>Estimated price of precipitator (mass production)</b>	1,000 euro <sup>1)</sup>	1,000 euro <sup>1)</sup>
<b>Estimated installation price of precipitator</b>	300 euro <sup>2)</sup>	90 euro <sup>7)</sup>
<b>Electricity costs per year</b> <sup>3)</sup>	Urban: 24 kWh	9 euro <sup>4)</sup>
	Towns: 36 kWh	13 euro <sup>4)</sup>
	Rural: 48 kWh	17 euro <sup>4)</sup>
<b>Extra maintenance costs per year (chimney sweep)</b>	70 euro <sup>5)</sup>	21 euro <sup>7)</sup>
<b>Total cost of ownership</b> <sup>6)</sup>	Urban	2,873 euro
	Towns	2,959 euro
	Rural	3,046 euro
<b>Ownership costs per year</b> <sup>6)</sup>	<b>Urban</b>	<b>144 euro</b>
	<b>Towns</b>	<b>148 euro</b>
	<b>Rural</b>	<b>152 euro</b>
		<b>80 euro</b>
		<b>82 euro</b>
		<b>84 euro</b>

1) The current market price (<https://peisogpipefag.no/products/esp-25?srltid=AfmBOorczmz-ESsZ1dvMLyl4xAhm-xqbwyPw-evctiTsA2d8V3fvM1VgM>) of an electrostatic precipitator being sold in very low quantities is 1,650 euro. If required by Ecodesign regulations, mass production is expected to reduce the price to max. 1,000 euro (confirmed by the producer *Exodraft* and by [https://cea-europe.org/wp-content/uploads/2024/11/CEA\\_Studie\\_20241125.pdf](https://cea-europe.org/wp-content/uploads/2024/11/CEA_Studie_20241125.pdf)).

2) Depending on the access to the chimney (assuming that the precipitator is easy to install c.f. <https://exodraft.dk/produkt/partikelprecipitator-esp-25/>).

3) Assuming that the precipitator (boiler) is used 800/1,200/1,600 hours/year in urban/towns/rural areas (in use 30W in average and no standby power use).

4) [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Electricity\\_price\\_statistics](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Electricity_price_statistics)

5) It is assumed that the house owner cleans the precipitator manually several times over the year when needed i.e., the chimney sweep mainly needs to control/service the precipitator once a year during the annual mandatory chimney inspection.

6) Assuming that the lifetime of the precipitator is 20 years: <https://www.epa.gov/sites/default/files/2020-07/documents/cs6ch3.pdf>

7) Assumed 30 % of the price in Denmark since average salary in Slovakia is around 30 % of the average salary in Denmark.

The average annual gross salaries in Denmark and Slovakia are approximately €70,000 and €20,000, respectively. This means that the annual cost of electrostatic precipitators (as shown in Table 2) represents only about 0.2–0.4% of these incomes - and is already offset by savings on alternative fuels such as gas or oil. Furthermore, the inflation in Denmark is around 2 % and the inflation in Slovakia is around 4.5 %. As a result, making electrostatic precipitators mandatory for new wood boilers would not pose a general financial burden. However, in less affluent EU countries some households require financial support to afford the upfront cost of installation of precipitators. Some member states already have provisions to support schemes for domestic heating.

## Benefits: electrostatic precipitators

Over its lifetime, a well-maintained, high-quality electrostatic precipitator is assumed to remove at least 70% of fine particles. The calculation below assumes use of dry wood and proper boiler operation, which is why it is essential to include this information on the product label. However, if these conditions are not met e.g., using improper fuel or poor boiler management - air pollution increases significantly. In such cases, the benefits of precipitators would be greater than those calculated, as more particles would be removed.

Table 3a-3c presents the health benefits (benefits for society) per GJ of heating, using a wood pellet boiler and a log wood boiler with/without accumulation tank (acc. tank), resulting from reduced fine particle (PM<sub>2.5</sub>) emissions from wood boilers through the use of precipitators. The health benefits are underestimated, as electrostatic precipitators also remove ultrafine particles, larger particles, and harmful substances such as dioxins, Polycyclic Aromatic Hydrocarbons, and heavy metals attached to the particles. However, only the benefits from reducing fine particles (PM<sub>2.5</sub>) are included, since there are currently no externality values for other particle sizes, and the extent to which the precipitator removes particle-sorbed dioxins, PAHs, and heavy metals is unknown.

**Table 3a: Small wood pellet boiler: Health benefits of electrostatic precipitators per GJ of house heating**

		Denmark	Slovakia	
<b>Health cost per kg of PM<sub>2.5</sub></b> <sup>1)</sup>	Urban: > 3,000 citizens/km <sup>2</sup>	325 euro	338 euro <sup>5)</sup>	
	Towns: 1,500-3,000 citizens/km <sup>2</sup>	213 euro	303 euro <sup>5)</sup>	
	Rural: < 100 citizens/km <sup>2</sup>	149 euro	283 euro <sup>4)</sup>	
<b>Emissions from a new boiler <u>without</u> precipitator</b>	PM <sub>2.5</sub> emission <sup>2)</sup>	0.055 kg		
	Health costs (euro)	Urban	18	19
		Towns	12	17
		Rural	8	16
<b>Emissions from a new boiler <u>with</u> precipitator</b>	PM <sub>2.5</sub> emission <sup>3)</sup>	0.016 kg		
	Health costs (euro)	Urban	5	6
		Towns	4	5
		Rural	2	5
<b>Health benefits (avoided costs) of precipitators (euro)</b>	<b>Urban</b>	<b>13</b>	<b>13</b>	
	<b>Towns</b>	<b>8</b>	<b>12</b>	
	<b>Rural</b>	<b>6</b>	<b>11</b>	

1) [https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Notater\\_2023/N2023\\_54.pdf](https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Notater_2023/N2023_54.pdf) (Multiplying with 1.09 to get 2025 prices).

2) Assuming 85% energy efficiency and using emission factors of <https://dce2.au.dk/pub/SR435.pdf> (Ecodesign wood pellet boilers = 47 g/GJ).

3) Assuming an average fine particle removal of 70% over the lifetime by the precipitator.

4) Assuming that the rural PM<sub>2.5</sub> emission from boilers in Slovakia has a cost being 1.9 higher than rural boilers in Denmark due to the much higher regional population density in central Europe <https://www.eionet.europa.eu/etcs/etc-atni/products/etc-atni-reports/etc-atni-report-04-2020-costs-of-air-pollution-from-european-industrial-facilities-200820132017>

5) Assuming that the cost increase from rural areas to more densely populated areas (towns and urban) in Slovakia are 31% of corresponding cost increase in Denmark since the Slovakian GNP is 31% of the Danish GNP (table 1).

**Table 3b: Small log wood boiler (no acc. tank): Health benefits of precipitators per GJ of house heating**

		Denmark	Slovakia	
<b>Health cost per kg of PM<sub>2.5</sub></b> <sup>1)</sup>	Urban: > 3,000 citizens/km <sup>2</sup>	325 euro	338 euro <sup>5)</sup>	
	Towns: 1,500-3,000 citizens/km <sup>2</sup>	213 euro	303 euro <sup>5)</sup>	
	Rural: < 100 citizens/km <sup>2</sup>	149 euro	283 euro <sup>4)</sup>	
<b>Emissions from a new boiler <u>without</u> precipitator</b>	PM <sub>2.5</sub> emission <sup>2)</sup>		0.367 kg	
	Health costs (euro)	Urban	119	124
		Towns	78	111
		Rural	55	104
<b>Emissions from a new boiler <u>with</u> precipitator</b>	PM <sub>2.5</sub> emission <sup>3)</sup>		0.110 kg	
	Health costs (euro)	Urban	36	37
		Towns	23	33
		Rural	16	31
<b>Health benefits (avoided costs) of precipitators (euro)</b>	<b>Urban</b>	<b>83</b>	<b>87</b>	
	<b>Towns</b>	<b>55</b>	<b>78</b>	
	<b>Rural</b>	<b>39</b>	<b>73</b>	

- 1) [https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Notater\\_2023/N2023\\_54.pdf](https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Notater_2023/N2023_54.pdf) (Multiplying with 1.09 to get 2025 prices).
- 2) Assuming 85% energy efficiency. Using emission factors of <https://dce2.au.dk/pub/SR435.pdf> (Ecodesign log wood boilers without acc. tank = 312 g/GJ).
- 3) Assuming an average fine particle removal of 70% over the lifetime by the precipitator.
- 4) Assuming that the rural PM<sub>2.5</sub> emission from boilers in Slovakia has a cost being 1.9 higher than rural boilers in Denmark due to the much higher regional population density in central Europe <https://www.eionet.europa.eu/etcs/etc-atni/products/etc-atni-reports/etc-atni-report-04-2020-costs-of-air-pollution-from-european-industrial-facilities-200820132017>
- 5) Assuming that the cost increase from rural areas to more densely populated areas (towns and urban) in Slovakia are 31% of corresponding cost increase in Denmark since the Slovakian GNP is 31% of the Danish GNP (table 1).

**Table 3c: Small log wood boiler (acc. tank): Health benefits of precipitators per GJ of house heating**

		Denmark	Slovakia	
<b>Health cost per kg of PM<sub>2.5</sub></b> <sup>1)</sup>	Urban: > 3,000 citizens/km <sup>2</sup>	325 euro	338 euro <sup>5)</sup>	
	Towns: 1,500-3,000 citizens/km <sup>2</sup>	213 euro	303 euro <sup>5)</sup>	
	Rural: < 100 citizens/km <sup>2</sup>	149 euro	283 euro <sup>4)</sup>	
<b>Emissions from a new boiler <u>without</u> precipitator</b>	PM <sub>2.5</sub> emission <sup>2)</sup>		0.070 kg	
	Health costs (euro)	Urban	23	24
		Towns	15	21
		Rural	10	20
<b>Emissions from a new boiler <u>with</u> precipitator</b>	PM <sub>2.5</sub> emission <sup>3)</sup>		0.021 kg	
	Health costs (euro)	Urban	7	7
		Towns	4	6
		Rural	3	6
<b>Health benefits (avoided costs) of precipitators (euro) per GJ</b>	<b>Urban</b>	<b>16</b>	<b>17</b>	
	<b>Towns</b>	<b>10</b>	<b>15</b>	
	<b>Rural</b>	<b>7</b>	<b>14</b>	

- 1) [https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Notater\\_2023/N2023\\_54.pdf](https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Notater_2023/N2023_54.pdf) (Multiplying with 1.09 to get 2025 prices).
- 2) Assuming 85% energy efficiency and using emission factors of <https://dce2.au.dk/pub/SR435.pdf> (Ecodesign log wood boilers with acc. tank = 60 g/GJ).
- 3) Assuming an average fine particle removal of 70% over the lifetime by the precipitator.
- 4) Assuming that the rural PM<sub>2.5</sub> emission from boilers in Slovakia has a cost being 1.9 higher than rural boilers in Denmark due to the much higher regional population density in central Europe <https://www.eionet.europa.eu/etcs/etc-atni/products/etc-atni-reports/etc-atni-report-04-2020-costs-of-air-pollution-from-european-industrial-facilities-200820132017>
- 5) Assuming that the cost increase from rural areas to more densely populated areas (towns and urban) in Slovakia are 31% of corresponding cost increase in Denmark since the Slovakian GNP is 31% of the Danish GNP (table 1).

## Cost-benefit: electrostatic precipitators for wood boilers

Table 4 provides a cost-benefit analysis comparing the annual ownership costs per household with the health benefits gained from reducing fine particle pollution using electrostatic precipitators.

**Table 4: Cost-benefit analysis per household of requiring electrostatic precipitators (per year)**

		Denmark	Slovakia
<b>Boiler contribution to house heating <sup>1)</sup></b>	Urban	57 GJ (16 MWh)	
	Towns	72 GJ (20 MWh)	
	Rural	86 GJ (24 MWh)	
<b>Wood pellet boiler: Health (euro per year) benefits of precipitators <sup>2)</sup></b>	Urban	741	741
	Towns	576	864
	Rural	516	946
<b>Log wood boiler (no accumulation tank): Health benefits (euro per year) of precipitators <sup>2)</sup></b>	Urban	4,731	4,959
	Towns	3,960	5,616
	Rural	3,268	6,278
<b>Log wood boiler (with accumulation tank): Health benefits (euro per year) of precipitators <sup>2)</sup></b>	Urban	912	969
	Towns	720	1,080
	Rural	602	1,204
<b>Ownership costs in euro per year <sup>3)</sup></b>	Urban	144	80
	Towns	148	82
	Rural	152	84
<b>Wood pellet boiler: benefit to cost ratio</b>	<b>Urban</b>	<b>5,0</b>	<b>9,3</b>
	<b>Towns</b>	<b>4,0</b>	<b>10,2</b>
	<b>Rural</b>	<b>3,2</b>	<b>11,1</b>
<b>Log wood boiler (no acc. tank): benefit to cost ratio</b>	<b>Urban</b>	<b>32,9</b>	<b>62,1</b>
	<b>Towns</b>	<b>26,8</b>	<b>68,5</b>
	<b>Rural</b>	<b>21,5</b>	<b>74,6</b>
<b>Log wood boiler (acc. tank): benefit to cost ratio</b>	<b>Urban</b>	<b>6,3</b>	<b>12,1</b>
	<b>Towns</b>	<b>4,9</b>	<b>13,2</b>
	<b>Rural</b>	<b>4,0</b>	<b>14,3</b>

1) Assuming 800/1,200/1,600 hours of precipitator (boiler) use a year in urban/towns/rural areas and a typical new boiler (15-20 kW).

2) Calculated from health benefits due to less pollution for boilers with precipitators in table 3a-3c (e.g. 57GJ · 13€/GJ = 741€).

3) From annual costs calculations (table 2).

Mandating the use of precipitators for small new wood boilers would be highly beneficial to society by reducing the health burden of air pollution, with benefits far outweighing the costs (benefit to cost ratio > 1). Electrostatic precipitators will also reduce climate impacts from wood boilers due to reduced emission of black carbon particles. For larger installations, the filter will be relatively cheaper (per MW of boiler installation) due to economics of scale i.e., an even better investment for society.

Nevertheless, heat pumps generate much less air and climate pollution compared to the best wood boilers with electrostatic precipitators - even when the electricity for heat pumps is produced from coal. Therefore, energy renovation and the use of heat pumps should always take precedence over wood burning in stoves and boilers.

## Further information

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