



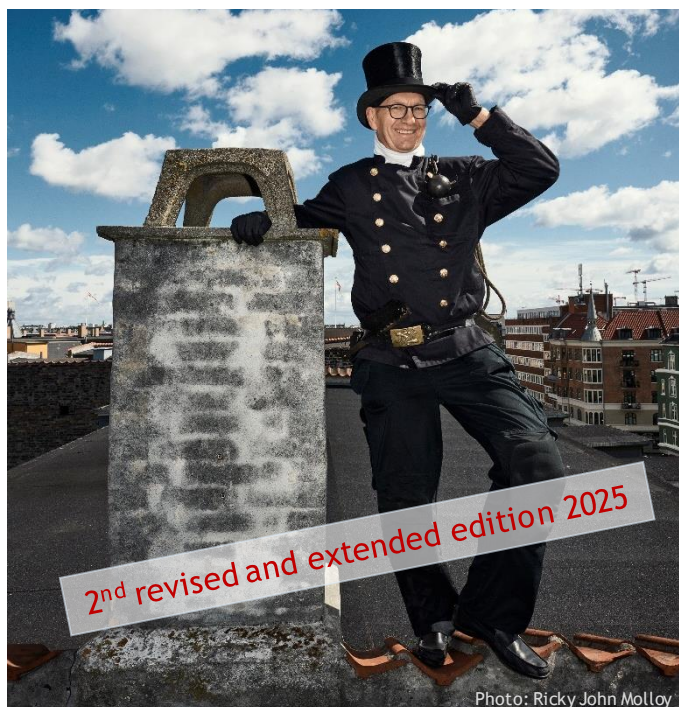
IEA Bioenergy
Technology Collaboration Programme

Inventory of National Strategies for Reducing the Impact on Air Quality from Residential Wood Combustion

(2nd revised and extended edition)

IEA Bioenergy: Task 32

May 2025





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Technology Collaboration Programme

Inventory of National Strategies for Reducing the Impact on Air Quality from Residential Wood Combustion (2nd edition 2025)

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Abbreviations and units

CO	Carbon monoxide
ESP	Electrostatic Precipitator
GHG	Greenhouse gas
LSH	Local Space Heater
NO _x	Nitrogen oxides
OGC	Organic Gaseous Carbon (i. e. volatile organic carbon, VOC)
PM	Particulate Matter
PM ₁₀	Particulate Matter having an aerodynamic diameter of up to 10 µm
QM	Quality Management
VAT	- Value Added Tax

Units:

m³_n Cubic meter, normalized to standard pressure and temperature (1,013 mbar and 0°C)

SUMMARY

Reduction of air pollution is a major societal goal, and great efforts are currently undertaken. Over the last 30 years, significant progress has been made, but wood combustion remains a significant source of air pollution in the member countries of IEA Bioenergy, particularly for carbon monoxide (CO) and particulate matter (PM)-emissions.

When wood combustion emissions originate from private households, problems are most difficult to solve. There are many influencing factors: the applied conversion technology is numerous, types of wood fuels are many, and wood fuel quality varies in many aspects. Additionally, user practice and operational skills are highly variable, but they play an enormous role in affecting emission levels. For these reasons, pollutant emissions are highest in the residential sector. Consequently, small scale biomass appliances form the main focus in this report. In this area, policy makers or institutions that are responsible for air quality control must coordinate an unmanageable number of options for remedial actions. For such a challenging task, it can be helpful to draw inspiration from success stories from other regions.

Therefore, this recently updated and extended report compiles national approaches concerning emission reduction strategies in the field of residential wood combustion in selected IEA-Bioenergy-member countries. The information presented was gathered in a structured manner through a detailed questionnaire. Where possible, the report also provides direct access to the original sources of information via active weblinks. Decision makers are thus enabled to easily trace back all information and to strengthen their own strategy.

Ten countries contributed to the compilation of information: Austria, Canada, Switzerland, Germany, Denmark, Italy, The Netherlands, Norway, Sweden and USA. The report is structured into three major parts. Part 1 briefly shows some simple statistics on the current status of wood combustion in selected countries, Part 2 forms the main part of the report, here extensive information of relevant measures is compiled for each of the selected countries. This is done in 16 sub-chapters, e. g. on stove replacement strategies, regional restrictions for furnaces, tightening of emission limits, inspections of stoves or boilers, quality labels, teaching and informing, etc. Finally, in Part 3, the effectiveness of measures for reducing wood-based pollutant emissions are briefly evaluated and prioritized by each involved expert.

Here are some selected highlights:

- National replacement schemes for old stoves were implemented in Germany and in Denmark. But there were many regional and temporal replacement schemes, sometimes also on municipal level.
- To ban wood fuel use is a widely used approach. Such restrictions are applied in all involved countries, either as temporary or as permanent bans. Mostly they are implemented regionally. Sometimes a wood fuel ban is depending on actual immission conditions. Or the ban is communicated as a temporary measure which is based on critical weather conditions, such as the ‘Stookwijzer’ in The Netherlands.
- Tightening of emission limits have a long history in several countries, typically they become stricter over time. For example, in the last years, Austria and Germany have introduced more stringent emission limits three times. The European limits (Ecodesign-directive) have finally forced other European countries to implement them, even Non-EU countries like Switzerland and Norway have followed. In the USA, the emission limits for certified stoves and for hydronic heaters were also tightened in two steps.
- Public incentives for investment for new appliances have been quite common over the past years. For stoves it seems crucial, that any scrappage bonus is designed in a way where a further use of the old stove is effectively disabled (e.g. in Canada or Denmark). For boilers, subsidies are mostly not conditional, except in Germany, where a long-term subsidy program has paved the way for an advanced state of technology by introducing strict ambitious emission classes or obligatory technical features. In the USA, also the measure of tax credits was introduced for purchase and installation of new wood stoves.

- Regular on-site inspections are common in most of the involved countries for both wood stoves and wood boilers. In most cases the chimney sweeps are involved, but mostly they only visit the site to ensure operational safety. But in Austria, Germany, Switzerland, and Denmark the stove itself is also regularly checked for functioning and damages. In Germany, the authorized district chimney sweep is also obliged to instruct the stove owner every 3 to 4 years on the proper operation. And he also tests fuel moisture, and for wood boilers he does full performance tests with recurring CO- and PM emission measurements.
- There are numerous labels for advanced stoves/boilers, most of which are based on the results of type tests carried out by certified bodies. Only the German “Blue Angel” is based on a dedicated real-life test protocol.
- Public information campaigns are manifold covering a range of interesting approaches. Apart from brochures and websites there are online-courses for stove users (Canada and Germany), citizen-science trailers which invite stove users to practically experience the correct operation (Austria), teaching videos about stove operation are available (Switzerland, Germany), or scientists lead discussion forums about wood stove technology and use (Norway). In Sweden all small-scale wood burning appliances are mapped to assess large emission reduction potentials. In the USA, much technical information is also made available via web-blogs.

1. INTRODUCTION, APPROACH AND GOAL

Reduction of air pollution is a major societal goal, and great reduction efforts are currently being undertaken. Over the last 30 years some progress has been made, improvements were mainly achieved in the area of gaseous emissions such as CO, NO_x and SO₂ (Figure 1), and to a lesser degree for particulate matter (PM) emissions such as total suspended particles (TSP) (Figure 2). For NO_x-emissions, the major source category is 'road transport', for SO_x-emissions, it is 'energy production and distribution', while for emissions of NH₃ 'agriculture' is mainly responsible and for NMVOC's it is 'industrial processes and product use' [1], [LINK](#). However, for CO and PM-emission, the major source category is 'commercial, institutional and households'. This is the field where wood combustion is a significant source of air pollution in the member countries of IEA Bioenergy.

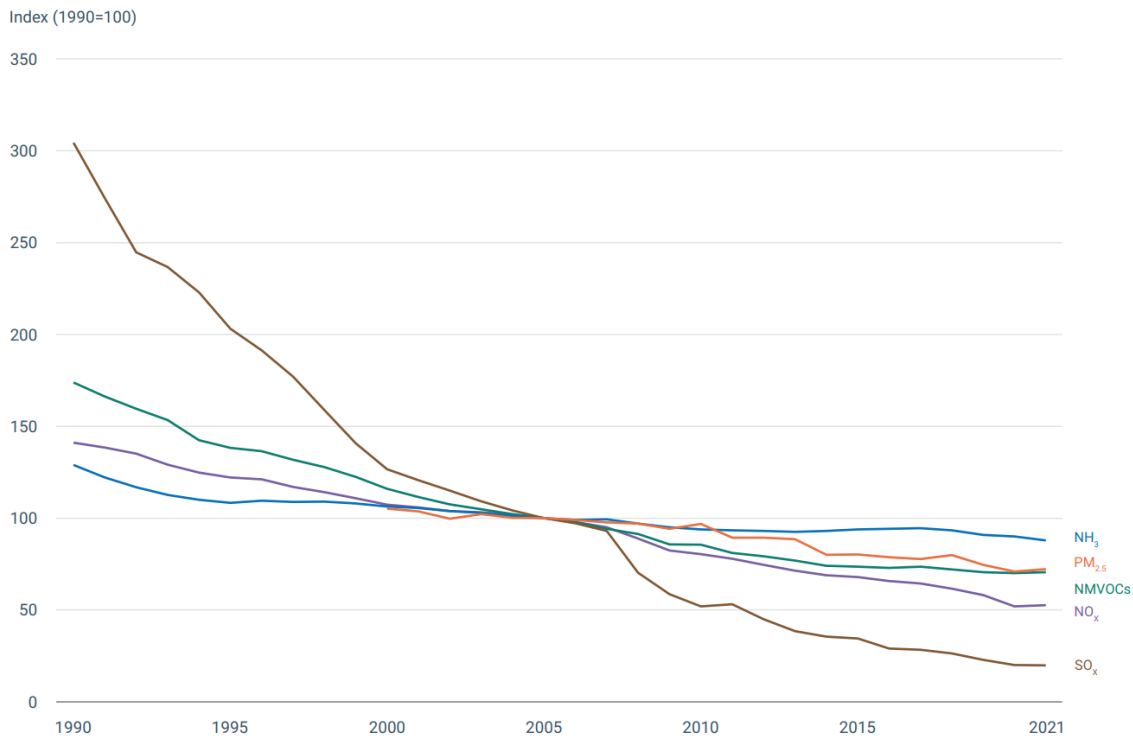


Figure 1: Emission trends for the main gaseous air pollutants in Europe (EU27). Source: European Union Emission Inventory Report 1990-2021 [1]: [LINK](#) [1]

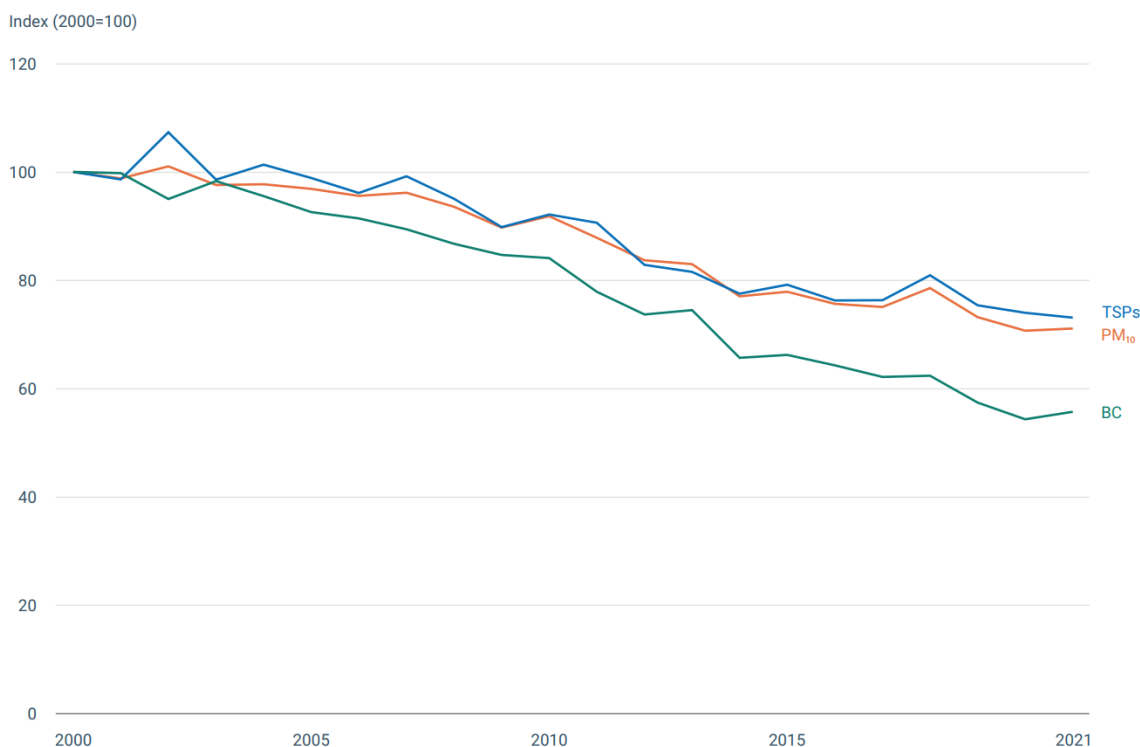


Figure 2: Emission trends for PM in Europe (EU27). Source: European Union Emission Inventory Report 1990-2021 [1]: [LINK](#) [1]

IEA Bioenergy, Task 32 "Combustion", is highly dedicated to contributing to further improvements in the reduction of pollutant emissions from wood combustion. Some recent efforts of the Task are the creation of

- “Technical guidelines for design of low emission stoves”, [LINK](#),
- A report on “Advanced test methods for firewood stoves”, [LINK](#),
- A report on the “Status of PM emission measurement methods and new developments”, [LINK](#),
- A report on “Aerosols from biomass combustion”, [LINK](#),
- A report on “Low emission operation of automatic wood boilers operated in cascades”, [LINK](#),
- A report on “Advanced test methods for pellet stoves”, [LINK](#),
- A report on “Low emission biomass combustion in automated boilers for heat and power”, [LINK](#),
- A report on “Residential biomass boiler systems - State-of-the-art and recent innovations”. To be published in May 2025, here: [LINK](#)

All documents can be downloaded on the IEA Bioenergy Task-32-Webpage, [LINK](#).

This report aims to further exchange information on national measures to reduce emissions from wood fuels by compiling detailed information on various approaches implemented in several IEA Bioenergy countries.

Scope and approach

Wood combustion takes place in a large power range from small-scale residential heating appliances up to district energy systems and industrial units with combined heat and power production. However, it's the residential scale appliances, mainly the stoves where contributions to air pollution are significant but and most difficult to prevent. A large problem is the high number of actors. But also the applied conversion technology is manifold while also wood fuels are inhomogeneous. Additionally, user practise and operational skills play an enormous role affecting the emission level in residential applications. For these and other reasons the pollutant emission level is highest in the residential sector. Consequently, these small biomass appliances form the focus of the report. Here, policy makers and institutions which are responsible for air quality control must coordinate an unmanageable number of options for remedial actions. For such a challenging task, it can be helpful to draw inspiration from success stories from other regions.

The information for this report was collected via an extensive questionnaire, where comprehensive answers were given and weblinks were provided. This questionnaire has been understood by each responding national expert differently. Thus, the collated country reports are somewhat heterogeneous as they are to a certain extent influenced by the personal background and experience of the involved persons. Therefore, this report should be treated as a starting point which can be built upon by further revisions and expansions in future. This 2nd edition is thus based on the initially published version dated October 2022.

Goal

It is the general goal of this report to provide structured knowledge about national approaches concerning emission reduction strategies in the field of wood combustion in selected IEA Bioenergy member countries and - where possible - to allow direct access to the original sources of information via active weblinks which might inspire decision makers in strengthening their own strategy. However, it was not the ambition to provide complete information. And the information collected is also not always fully updated. It is based on the subjective perception of the involved IEA Bioenergy experts and their network.

Ten countries contributed to the compilation of information: Austria, Canada, Switzerland, Germany, Denmark, Italy, The Netherlands, Norway, Sweden and the USA. All co-authors were inspired by the chance to look behind the curtains of other countries and to learn how others may have tackled the problem of emissions from wood fuel use.

Acknowledgements

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Practical advice: How to access a linked website in your language.

Sometimes a hyperlink in this report can lead you to a website in a non-English language. Then you can directly translate it into your language using your web-browser. To do so, please activate the respective function. For example, when using the Microsoft Edge browser: Right-click somewhere in the opened page and find "translation" in the pop-up context menu. Then choose your language.

Note: This function is not available when you have opened a pdf-document in the browser.

2. STATUS QUO OF WOOD COMBUSTION IN THE SELECTED COUNTRIES

The relevance of wood use for energy purposes can be read from the number of appliances in a country, as well as from the amount of fuel used. Estimates on both fields are compiled in the following two chapters. A short overview about differentiated approaches concerning emission limits is given in Chapter 2.3.

2.1 Number of appliances in the involved countries

From the data and the links provided in the questionnaire the number of appliances were calculated in relation to the population. Due to inconsistent data availability, this was only possible for residential room heaters (stoves). Figure 3 shows the calculated population related intensity of wood stoves in the selected countries. Here, the total number of all possible types of appliances is aggregated: room heaters, fireplaces, tiled stoves, masonry heaters, cooking stoves, pellet stoves and sauna stoves.

Norway shows the highest population related intensity of wood stoves among the involved countries. Statistically in Norway there is one stove per two persons (Figure 3), including also stoves in cabins. The prevalence of wood stoves is due to historical reasons with limited focus on district heating and water-based heating systems and is more than double of what is shown for Sweden. The intensity of stove availability in Sweden exceeds that of Germany, Denmark, and Italy by about 50 %. The data do not reveal any information about the frequency at which the stoves are used. Some estimates on this question might be drawn from the data given in Chapter 2.2 (Figure 5).

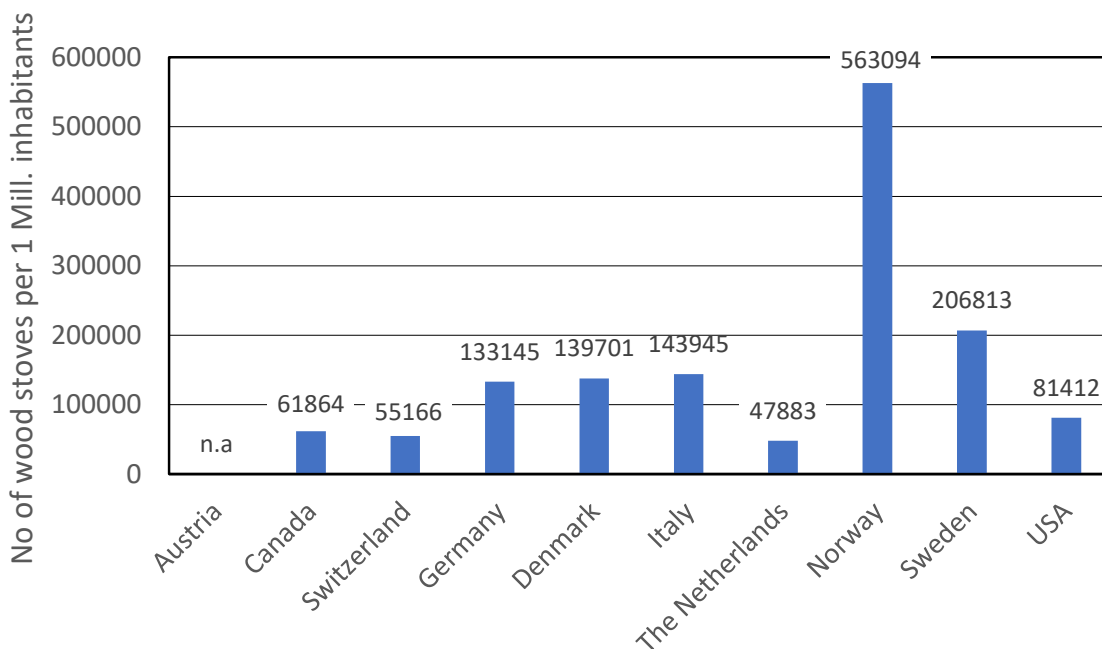


Figure 3: Population related intensity of wood stove availability in the participating countries, described as number of appliances per one million inhabitants. All numbers are based on residential wood burning appliances including pellets. Reference years: 2019, 2020, 2021 and 2023 (NO). Fireplaces are included (e.g. USA: 17.5 Mill), Population data from 2024. n.a.= not available

The number of stoves in a country related to the total population says something about how popular it is, and how affiliated the people are with burning wood. But there is no direct evidence about how likely it is that the population may be affected by neighbourly wood burning. This is probably better shown, when the number of stoves is related to the total land area of a country. Figure 4 shows these data for the participating countries. In this approach Germany, Italy and The Netherlands are highly in the focus. Their stove density is between 25 and 32 stoves per square kilometre. However, wood stoves are anything but evenly distributed, particularly when countries with a high range of local climates and wood availability are considered (e.g. USA). The value of such data for estimating the likelihood of hazards through wood smoke is thus very limited.

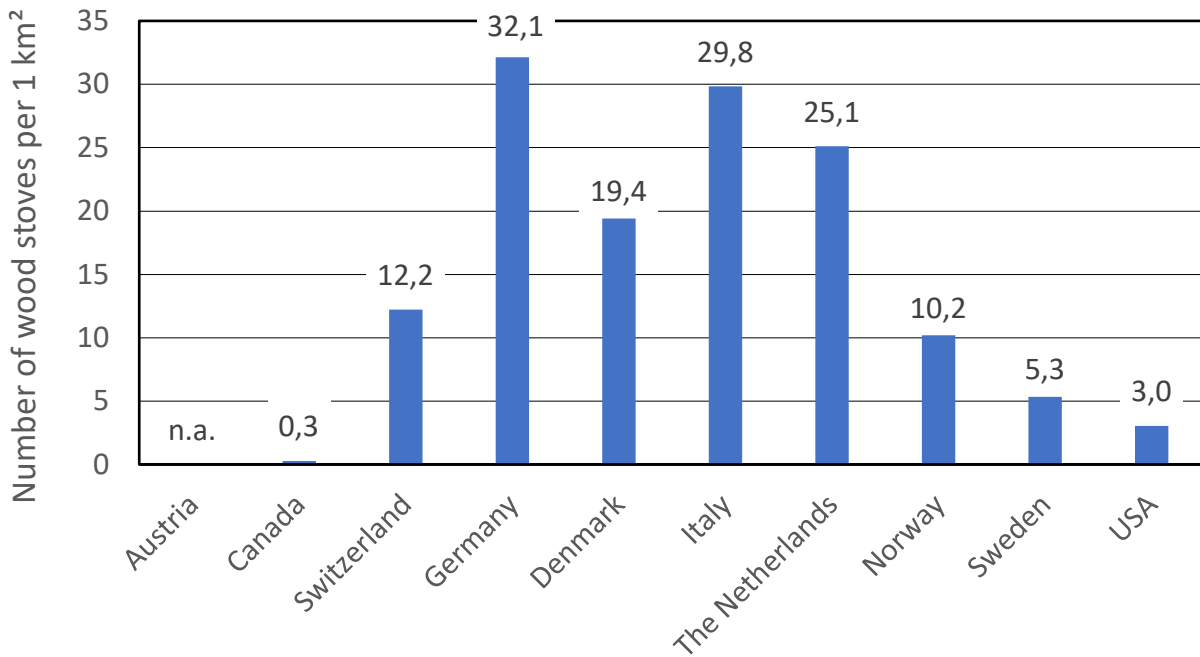


Figure 4: Area related intensity of wood stove availability in the participating countries, described as number of stoves per one square kilometer (km²) of land. All numbers are based on residential wood burning appliances including pellets. Reference years: 2019, 2020, 2021 and 2023 (NO). Fireplaces are included (e.g. USA: 17.5 Mill). Area data used: Country size without water areas. n.a.= not available

2.2 Amount of wood fuel used

The provided data does not allow a differentiated analysis on all wood fuels. But when regarding the log wood consumption only (Figure 5), it becomes clear that Austria's wood fuel consumption is highly dominated by the log wood fuel sector, where both, central heating boilers and individual log wood stoves strongly contribute. Log wood contribution is also quite strong in Norway.

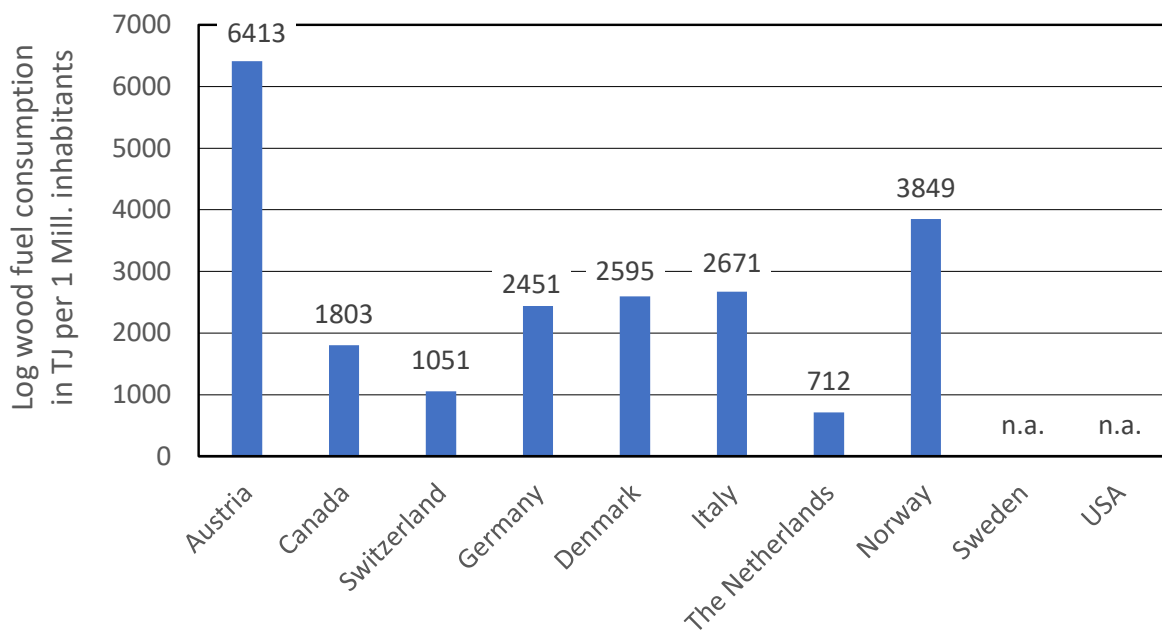


Figure 5: Log wood fuel consumption in involved countries, related to population. Reference years: 2019 or 2020. n.a.= not available

2.3 Current emission limits and further legal requirements in the countries

Europe. Here the harmonisation of emission limits is already quite advanced. This was achieved via several directives from the European Commission which are gradually transferred into national legislation.

In the residential sector the recently enforced European “Ecodesign directive” is the new landmark for minimum requirements. From January 2022 on the limits for Local Space Heaters (LSH) are given in the Ecodesign-Directive 2009/125/EG for space heaters, [LINK](#) [19]. The requirements are listed in Table 1. Most EU-Countries have transferred this regulation into national law, also the NON-EU-Country Switzerland follows these guidelines. Several countries even go beyond this requirement and are applying even stricter emission limits (e.g., for boiler inspections in practise), which requires approval by the EU commission to avoid market disturbance.

For wood boilers in central heating applications, another European regulation was established, the Ecodesign-Directive 2009/125/EG, [LINK](#) [20]. The requirements are listed in Table 1. It needs to be followed in the EU member countries and in associated member countries from January 2020 on and is applicable for appliances of up to 500 kW rated heat output. For larger plants, further regulation was established in the European Union by the MCP-Directive 2015/2193, the “Directive on the limitation of emissions of certain pollutants into the air from medium combustion plants”, [LINK](#) [21].

Table 1: Harmonized emission limits for small and medium scale wood combustion in the EU. Emission limit values in $\text{mg}/\text{m}^3_{\text{n}}$ are based on standard flue gas conditions at 1013 mbar and 0 °C, normalized to the respective reference oxygen content. OGC = Organic Gaseous Carbon

Parameter	Requirement
A) Solid fuel local space heaters (wood only)*, from 01.01.2022:	
Reference oxygen content for normalisation	13 %
Total PM emission [$\text{mg}/\text{m}^3_{\text{n}}$] (without condensables), i.e. using heated filter method)	50 for open fronted heaters 40 for closed fronted heaters, cookers 20 for pellet stoves
Alternatively: Total PM emission (incl. condensables), i.e. by sampling over the full burn cycle, a partial flue gas sample, using natural draft, from a diluted flue gas using a full flow dilution tunnel and a filter at ambient temperature)	6 g/kg for open fronted heaters 5 g/kg for closed fronted heaters, cookers 2.5 g/kg for pellet stoves
OGC emission [$\text{mg}/\text{m}^3_{\text{n}}$]	60 for all heaters and cookers for logs 20 for pellet stoves
CO emission [$\text{mg}/\text{m}^3_{\text{n}}$]	2000 for open fronted heaters 1500 for closed fronted heaters, cookers 300 for pellet stoves
NO _x emission [$\text{mg}/\text{m}^3_{\text{n}}$]	200
B) Wood boilers ($\leq 500 \text{ kW}$)**, from 01.01.2020:	
Reference oxygen content for normalisation	10 %
Total PM emission [$\text{mg}/\text{m}^3_{\text{n}}$] (without condensables, i.e. using heated filter method)	40 automatically stoked boilers 60 manually stoked boilers, both reported as "seasonal space heating emissions E _s **
OGC emission [$\text{mg}/\text{m}^3_{\text{n}}$]	20 automatically stoked boilers 30 manually stoked boilers, both reported as "seasonal space heating emissions E _s **
CO emission [$\text{mg}/\text{m}^3_{\text{n}}$]	500 automatically stoked boilers 700 manually stoked boilers, both reported as "seasonal space heating emissions E _s **
NO _x emission [$\text{mg}/\text{m}^3_{\text{n}}$]	200 automatically stoked boilers 350 manually stoked boilers, both reported as "seasonal space heating emissions E _s **

* European Ecodesign-Directive (Commission Regulation EU 2015/1185), dated April 24th, 2015, [LINK](#) [19]

** European Ecodesign-Directive (Commission Regulation EU 2015/1189), dated April 28th, 2015, [LINK](#) [20]

Canada. In North America the situation is quite different. In 2020, the US Environmental Protection Agency (EPA) has introduced New Source Performance Standards (NSPS) emission limits for particulate matter for new room heaters, residential hydronic heaters and forced air furnaces. Following the US EPA, Canada has updated its performance standard, CSA B415-1.22, and PM limits within the standard harmonising it with the US EPA NSPS 2020. This is shown in Table 2.

Table 2: Emission limits for residential wood combustion in Canada harmonised with the US EPA NSPS 2020

Parameter	Requirement
A) Wood stoves (both catalytic and non-catalytic)	
PM emission (g/h)	
- wood pellet stoves	2
- tested with crib wood	2
- tested with cord wood	2.5
B) Residential Hydronic Heater	
PM emission (lb/MMBtu heat output for each individual burn rate)	0.15
C) Residential Forced Air Furnace	
PM emission (lb/MMBtu heat output for each individual burn rate)	0.15

USA. Here, federal policy towards residential wood and pellet heating is not uniform, and it is spread across different agencies and departments. It relies on policies and goals of the Environmental Protection Agency (EPA), the US Department of Agriculture (USDA), the US Department of Energy (DOE), and the Internal Revenue Service (IRS) - with funding and direction from the US Congress. The EPA's mandate is to reduce wood smoke pollution; the USDA's mandate is to support the sustainable use of wood for energy, the DOE's mandate is to promote research and development on innovative and automated wood stove technology. The IRS implements tax credits for efficient wood and pellet stoves passed by Congress. There is some but not a lot of coordination between agencies.

The Environmental Protection Agency has taken the lead in instituting a process for reducing particulate wood smoke from residential wood burning appliances. Known as the New Source Performance Standards (NSPS), this action applies to wood stoves, pellet stoves, hydronic heater, and forced air furnaces. This measure was started in 2015, and continuing through 2015, with the following features and timelines:

- The first attempt by EPA to control emissions was in the 1988 and pertained only to residential wood stoves (this ruling was amended and update in 1998).
- In 2015, the EPA implemented revised standards for new residential heaters as well as standards for hydronic and forced-air heaters.
- EPA's mandatory smoke emission limit for wood stoves was 4.5 grams of smoke per hour (g/h) under Step 1 of the revised standards of performance for wood burning room heaters.
- In late 2018, the U.S. EPA proposed amendments to the NSPS (revising the standards issued in 2015). This amendment allows retailers additional time to sell current inventories of hydronic heaters and forced air furnaces that have not met current compliance requirements.
- Step 2 took effect on May 15, 2020, when the standard was lowered to 2.0 g/h.
- Heaters using the optional cord wood test method must meet a standard of 2.5 g/h.

It should be noted that several states have implemented emissions limits on their own:

- Washington State did so decades ago, pursuant to a state law requiring the Department of Ecology to establish its own or EPA's emissions standards on a statewide basis. The state adopted a standard of 2.5 g/hr for catalytic wood stoves and 4.5 g/hr for non-catalytic stoves.
- The U.S. Clean Air Act allows states to adopt emissions standards that are more stringent than the

current federal standard. However, this varies according to whether catalytic vs. non-catalytic stoves and other factors such as “cord wood test method” vs. other methods such as the “crib-wood” method are regarded.

Overview. Harmonisation is a common goal. In North America the EPA decisions for emission limits seem to have an orientating impact for Canadian policy, too, with some alignment happening. But differences to Europe remain large, either concerning the testing practise or the relevant emission parameters and their limits or units. In Europe, harmonisation has recently advanced largely, but non-European countries can deviate from the European Ecodesign requirements for residential heating. This is obviously also true for EU-member countries, in particular cases. An overview of such deviations is given in Table 3, which is based on the replies of the participating experts. Table 3 also shows the practice of regular field inspections concerning the actual level of air pollution. In the field of residential heating, this happens only in Germany and Austria, but inspections concerning security issues are quite common in all considered countries (see also Chapter 3.6). The obligatory use of a heat buffer storage can also be specified in national emission directives. Therefore, this is reflected in Table 3, too. It shows that an obligation for installing a heat buffer storage only exist in Germany and Austria.

Table 3: Emission regulations in the involved countries in relation to the respective European Ecodesign Directives and other relevant legal requirements in emission regulation

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
<i>For wood stoves (type testing):</i>										
Current national limits are stricter than Ecodesign?	no	n.a. ¹⁾	no	yes	no ⁹⁾	yes ⁶⁾	no	no	no	n.a. ¹⁾
<i>For wood boilers (type testing):</i>										
Current national limits are stricter than Ecodesign?	no	n.a. ¹⁾	no	yes	no	yes ⁶⁾	no	no	no	n.a. ¹⁾
<i>Field inspection of appliances (<100 kW):</i>										
Are emissions periodically checked in the field?	yes ³⁾	no	yes ¹¹⁾	yes ²⁾	no	yes ⁷⁾	no	no	no	no
<i>Other legal requirements for residential furnaces from emission directives:</i>										
Heat accumulator tank required for wood boilers?	yes ⁵⁾	no	yes ¹²⁾	yes ⁴⁾	no ¹⁰⁾	no ⁸⁾	no	no	no ¹³⁾	no

1) n.a. not applicable; units and measurement methods are not compatible to the European system (see Chapter 3.3).

2) applicable only for boilers ≥ 4 kW: CO and PM emissions are measured every 2 years (see Chapter 3.6).

3) applicable only for boilers and for CO emission limits, measured every 2 years (15 - 50 kW) or annually (>50 kW).

4) for log wood boilers 55 l volume per kW, for automatically charged boilers 20 l/kW. Automatic boilers: only relevant, if emission limits cannot be met at partial load during periodic field inspections.

5) valid for log wood boilers if emission limits are not met at partial load during type tests, but no obligatory buffer volume is then specified.

6) only in the Po-Region: Lombardy, Piedmont, Veneto and Emilia-Romagna. Recently, other regions with and without infringement procedures have also adopted more restrictive limits: Tuscany, Marche, Lazio, Campania, Sardinia and the province of Trento.

7) Applicable only for automatically charged LSHs and for all boilers for CO and NO_x emission when checking the energy efficiency of the system (based on UNI 10389-2, published in April 2022). Applicable for biomass heating systems of 35 to 150 kW only for PM emission limits (based on Decree 152/2006).

8) The accumulator tank, both for log wood boiler and automatically charged boilers is mandatory only for access to public incentives (Decree 199/2021, Annex IV).

9) In certain cases the Danish limits are different from Ecodesign.

10) A heat accumulator is one of more safety options as per EN 303-5 but not mandatory for emissions reasons.

11) residential boilers: Acceptance measurement of CO und TSP (measured in hot flue gas) und periodic CO measurement every 4 years, stoves: stoves are inspected every two years. There, combustion residues and the

condition of the installation are checked, and the operator is provided with information on how to use the installation properly and on how to use and store wood fuels.

¹²⁾ Hand-stoked boilers <500 kW: At least 12 litres of tank volume per litre of the thermal fuel storage bin volume. The volume must not be less than 55 litres per kW of rated heat output. Automatic boilers: at least 25 litres per kW of rated heat output. Pellet boilers <70 kW are excluded.

¹³⁾ only recommended

3. MEASURES AND ACTIONS

3.1 Replacement strategies and expiration dates for appliances

The preceding question to this chapter was:

“Is there any regional or national replacement schedule of older wood stoves or wood boilers, or does their permission expire at a fixed date or age?”

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	no	yes*	no	yes	yes	yes	no	no	no	yes

* Frequently combined with incentives

Chapter summary

Emission abatement through early replacement of older appliances is a strategy which has obviously been considered in many participating countries but was hardly enforced consistently. Two approaches are visible, the introduction of a scrapping bonus (i.e. voluntary replacement) and the replacement due to an expiring operating permit by age (i.e. legal obligation). Only the latter is considered in this chapter, while the subsidy-based approach is described in Chapters 3.2 and 3.4.

Obligatory stove replacement was reported from regions in Canada, from Germany, from Denmark, and from Italy. The approaches are quite different, in Italy and Canada they are introduced on regional or sometimes even municipal levels, while in Germany and Denmark the replacement follows a nationwide legislation. In all cases, they are based on the existence and results from type testing certificates. In Germany, a continued stove operation becomes critical for three different age classes which shall be replaced if they are older than 1975, 1985, 1995 and 2010, while in Denmark the replacement is triggered by the change of ownership plus the fact that a stove was built before 2003. A similar process is applied in regions of the USA, where replacement on uncertified stoves is required upon change of house ownership or major refurbishment of a building. Also in Italy the replacement of a stove or a boiler is enforced stepwise, here the continued operation is only allowed when in two steps a more ambitious emission class is achieved, from 2018 and from 2020 onward.

For wood boilers, replacement requirements are only known from Germany and Denmark. In Germany, all boilers that are older than 1995, 2006 and 2010 need to prove for CO- and PM-emissions (determined in field measurements) that they can meet the stepwise tightened emission limits, or otherwise they shall be retrofitted with ESP's or be replaced or shut down. In Denmark, there have been subsidy schemes to scrap old log wood boilers and in September 2022 a scrapping scheme for wood pellet boilers was introduced.

Replacement strategies are not always motivated by emission abatement goals, but they can also be targeted at more independence from fossil fuels. This is for example partly true for some Canadian regions and for Austria, where legal restrictions apply.

For wood stoves, early replacement via incentives was reported from several regions in Canada, several municipalities in Germany, several regions in Italy, but no such nationwide incentive program was mentioned. However, in Germany, a compulsory replacement of stoves reaching a certain age was established by law, which is executed in several stages of a given timeline.

A key requirement for high impact on cleaner air seems to be that the old appliance can never anymore be operated elsewhere. Most replacement programs have therefore implemented a proof of disposal.

Austria

The implementation of a replacement schedule or expiration date of old wood stoves or boilers was discussed several times but did not get enough political support.

But there is a strong movement towards replacement of fossil fuel boilers. Since the participation of the green party in 2020 the Austrian government is taking big efforts on the decarbonisation of the heating sector. Therefore, ambitious expiration dates for fossil fuel heating systems have been set and a generous funding programme supports the changeout of such heating systems against renewable alternatives, [LINK](#) [180].

Canada

General. In Canada, clean air legislation is managed between multiple government jurisdictions where the federal government's role in addressing air quality issues is largely defined through non-regulatory instruments, while provinces and territories are responsible for regulating pollution from industry and business activities. Municipal governments may implement stringent policies and regulations depending on local circumstances and concerns. Regulations related to air emissions from wood combustion differ significantly between provinces and territories.

- For residential wood burning appliances, most jurisdictions require these appliances to meet certification requirements set by CSA B415.1 or US EPA Residential Wood Heaters 40 CFR Part 60.
- For Small-Size Biomass Combustors (SSBC), there are no common size thresholds or emission limits and custom permitting conditions.

Examples of replacement programs. There are several examples from the few Canadian jurisdictions implementing replacement programs:

- Province of Quebec - Quebec City: [6]
- Province of Ontario - Ottawa City Exchange Program: [LINK](#) [7]
- Province of British Columbia - Several cities in BC offer wood stove exchange programs which are listed here: [LINK](#) [8]. A detailed example of a wood stove exchange program and then evaluation reports are found here: [LINK](#) [9].

A relevant regulation in the province of British Columbia (BC) is the Solid Fuel Burning Domestic Appliance Regulation, published under the Environmental Management Act and last amended in November 2, 2019 by B.C. Reg. 218/2016. ([LINK](#) [10])

Metro Vancouver has delegated authority to manage air quality and to control air pollution under the BC Environmental Management Act, including the development of regulations. Regulatory activity relates to emissions control, therefore the removal/replacement of appliances is not required under regional regulations. The Residential Indoor Wood Burning Emission Regulation Bylaw (Bylaw 1303) restricts the use of appliances that do not meet emissions criteria in urban areas after 2025, but does not require the removal of non-compliant appliances [11]. Quebec City has a new municipal by-law (RVQ 2954), come into effect on April 19, 2021, that regulates the use of wood-burning appliances.

Appliances concerned. Many of the exchange programs target uncertified residential wood burning appliances, such as wood stoves, wood burning inserts and fireplaces with no CSA B415 or US EPA NSPS certification. For example, City of Ottawa and Quebec City exchange programs apply to wood stoves, masonry wood inserts, factory-built wood fireplaces (slow combustion), wood furnaces or wood boilers that are not certified to the CSAB415.1 or EPA emissions standard. In British Columbia (BC), the province run replacement is applied to outdoor wood boilers and there is no regulatory requirement for other old appliances to be replaced or phased out.

The Changez d'Air program in the Province of Quebec (see above) ran in 450 cities and replaced old wood burning appliances (4500+) with wood burning devices (81 %), gas devices (13 %) and wood pellet devices (6 %).

Dates of expiration. The dates are varying. The permission to use uncertified outdoor wood boilers in BC will expire in 2026. Quebec's Changez 'Air program ran through 2012 and 2013. Quebec City program is introduced in 2021.

Metro Vancouver's wood stove exchange program has been operating since 2009 and continues to operate currently. Metro Vancouver has received approximately \$341,000 since 2009 for the wood stove exchange program.

Possible exceptions. There are hardly any exceptions. In few jurisdictions, like in BC, boilers with no near neighbours are exempted.

Switzerland

There is no national replacement schedule for older wood stoves or wood boilers (<70 kW) and there are also no such schedules by the cantons. However, Switzerland is federally organized with legal competences reaching down to the community level. Therefore, local rules cannot be excluded.

On the national level the replacement or shutdown of devices, especially old boilers, which often exhibit high emissions, is enforced with changes in the Swiss Ordinance on Air Pollution Control (OAPC, [LINK](#) [16]), which is periodically updated. For wood combustion appliances, an important update was introduced in 2018 with the following regulations which may enforce a replacement:

- Introduction of mandatory emission measurement every 4 years for wood boilers <70 kW
- Introduction of a mandatory regular inspection of wood stoves every 2 years
- Tightening of emissions limit values for field measurements for CO from 4000 mg/m³_n to 1000 mg/m³_n (at 13 % O₂)
- Introduction of mandatory heat accumulators for boilers 70 - 500 kW (from 2022 on also for boilers >500 kW) with capacity of at least 25 l per kW.

On the state level, several cantons (Aargau, Bern, Basel, Fribourg, Geneva, Glarus, Grisons, Schaffhausen, Thurgau, Ticino, Vaud, Valais, Zurich) have introduced cantonal action plans for cleaner ambient air. In these plans, several regulations were introduced which are not included or are stricter than in the national emission regulations (see Chapter 3.2).

Germany

The relevant regulation which enforces the replacement of appliances is the First Ordinance on the Implementation of the Federal Immission Control Act, "1. BImSchV", dated January 26th, 2010, [LINK](#) [4]).

For stoves. The relevant section is Section 26 of 1. BImSchV, [LINK](#) [4], titled "Transitional arrangement for space heaters for solid fuels: Space heaters for solid fuels which were constructed and in operation prior to 22 March 2010 may only be further operated if the following limit values (type testing results) are not exceeded (at 13 % O₂):

- Particulate matter: 0.15 g/m³_n,
- CO 4 g/m³_n.

The documentation of compliance with the limit values may be provided by submitting a test bench certificate of the manufacturer, or by a measurement carried out by a chimney sweep at the site of the user. This is done using a modified emission testing device (30 min PM sampling). The chimney sweep shall follow measurement instructions described in the national VDI-Standard 4207, Part 2 [2].

The replacement obligation for stoves, which fail to meet the above requirement is enforced for all appliances except

- Non-commercial cooking stoves, baking ovens <15 kW,
- Open-hearth fireplaces,
- Masonry heaters,
- Space heaters in residential units heated exclusively via this installation,
- Space heaters that were manufactured or constructed prior to 1950.

Should it not be possible to provide documentation of compliance with the limit values, existing space heaters shall be decommissioned, on the following dates depending on the date on the type plate:

<u>Date on the type plate</u>	<u>Date of retrofitting or decommissioning</u>
up to Dec 1974	Dec 2014
Jan 1975 up to Dec 1984	Dec 2017
Jan 1985 up to Dec 1994	Dec 2020
Jan 1995 up to Mar 2010	Dec 2024

Possible exceptions for stoves: Should it not be possible to provide documentation of compliance with the limit values, existing space heaters shall be retrofitted with a device to reduce particulate matter emissions in accordance with the state-of-the-art, which is described in a National VDI-Standard 3670 [3].

For boilers. The relevant section is Section 25 of 1.BImSchV, [LINK](#) [4], titled “Transitional arrangements for firing installations for solid fuels, excepting space heaters”. Existing biomass boilers (i. e. before 2010), may only continue to be operated if the limit values of Stage 1 (Chapter 3.3), depending on the date of their construction, are complied with.

Should it not be possible to prove compliance with the limit values (Stage 1) during regular emission inspections by chimney sweeps, existing boilers shall be decommissioned, on the following dates depending on the date on the type plate:

<u>Date on the type plate</u>	<u>Date of compliance with the limits of Stage 1</u>
up to Dec 1994	Jan 2015
from Jan 1995 up to Dec 2004	Jan 2019
Jan 2005 up to Mar 2010	Jan 2025

There are no exceptions for boilers. Retrofitting of ESP’s or catalysts may be required to meet the stricter requirements of Stage 2; their effectiveness will be proven during follow-up periodic emission inspections by chimney sweeps.

Denmark

The Danish Change of Ownership Order (BEK no. 1449, [LINK](#) [159]) entered into force on 1st of August 2021 and requires that wood stoves and fireplace inserts produced before 1 January 2003 must be replaced or scrapped in connection with property purchases. In this connection, all property buyers must report information whether there is a fuel combustion installation subject to the Change of Ownership Order on the property and if so, report the age of the wood stove or fireplace insert in connection with the land registration process and subsequently in the Danish Environmental Protection Agency’s internal case processing system. This regulation applies to wood-burning stoves and fireplace inserts up to 1 MW. At present it is not possible to be exempted from the scheme, even if a particle filter is fitted.

Chimney sweeps report that the scheme has proven very efficient as they experience significantly increased activities both, in shutting down fireplaces, and in approving newly mounted stoves and inserts. Stove manufacturers report very high annual sales which partly has to do with this regulation and partly with the general European energy situation in recent years, probably mainly volatile natural gas prices due to the war in Ukraine.

Due to this busyness, there have been shortages in the supply of stoves and inserts and the EPA has temporarily been able to provide a 12-month dispensation for the mandatory stove exchange on top of the 12-month notice that is already a part of the scheme. In November 2023, the EPA announced the deadline for application of a dispensation to be on the 31st of December 2023. [LINK](#) [232]. Both the sales of new and thus much more efficient units and the shutdown of fireplaces undoubtedly contribute to the significantly decreasing consumption of firewood that has been reported by the national energy statistics.

Regarding central heating boilers, there have from 2008-2014 been subsidy schemes to scrap old log wood boilers (from before 1980), and from December 2022 an existing scrapping scheme for oil boilers and

natural gas boilers was modified to include wood pellet boilers to facilitate a change for heat pumps, [LINK](#) [233].

Italy

Regulation. The regulation for implementing a replacement scheme is the “Po basin Agreement for the implementation of joint measures to improve the quality of air”, signed in Bologna, during the G7 Environment on 9 June 2017, by the Minister of Environment and the Presidents of the Lombardy, Piedmont, Veneto, and Emilia-Romagna regions. These are the 4 Po-Regions of Italy. In 2022 and 2024, other regions (Tuscany, Trentino-Alto Adige, Umbria, Lazio, Campania and Puglia) received funding from the Ministry of the Environment (MASE) to implement regional programs for the replacement of obsolete biomass heating systems, like the one in force in the Po-Regions.

Appliances concerned. These are those wood heating appliances which are mentioned in the Ministerial Decree n. 186/2017 [12]. This decree has decided about the assignation of the number of “Stars” which each appliance can receive, depending on the emission level as reported in the certificate of the type testing. The corresponding emission and efficiency thresholds which need to be met in order to receive either <3, 3, 4 or 5 stars are described in Chapter 3.3. The characterized appliances are

- Open/closed fronted heaters, stoves, cookers (EN 13229)
- Slow heat realising appl. (EN 15250)
- Pellets appliances (insert and stoves, EN 14785)
- Wood boilers (manually stocked, EN 303-5)
- Pellets and wood chip boilers (automatically stocked, EN 303-5)

The replacement is applied up to 35 kW heating power. The emission values are those of the type tests, referred to nominal power output (13 % O₂).

Expiration dates. In the 4 regions which have signed the “Po basin agreement”, two deadlines are effective,

from 15.10.2018:

- Only appliances with more than “2 Stars” can continue to be in operation,
- Only appliances with more than “3 Stars” can be installed,

from 01.01.2020:

- Only appl. with more than “3 Stars” can continue to be in operation,
- Only appl. with more than “4 Stars” can be installed.

Exemptions. Exemptions are only possible if the heating appliance is the unique source of heat of the building.

If the appliance was installed more than 15 years ago, it is very likely that it cannot be classified based on “Stars” performance ranking. Besides, it is very likely that an appliance installed more than 10 years ago has less than 3 Stars. According to AIEL estimates, in the four regions about 40 % of the appliances in operation need to be replaced. These 4 regions consume 50 % of the primary energy destined for production of heat and sanitary water in the residential sector in Italy.

The Netherlands

There is no replacement strategy in The Netherlands where wood stoves or wood boilers need to comply with a certain minimum quality. Some municipalities however have 100 % bans for wood stoves after a certain deadline, see below.

Norway

There is no such replacement strategy in Norway, but there is a strong focus on the need for replacing old wood stoves with modern clean-burning ones.

Sweden

Schemes for fading out old stoves by introducing scrapping premium for boiler stoves made before 2007 and smaller than 500 kW, has been discussed on governmental level in Sweden but so far has nothing been decided. New stoves and boilers have, since January 2020, to follow the Ecodesign directive. However, as a stove and boiler has expected lifespans of an average of 30 years there is a slow exchange of old units and also a relatively large second-hand market.

The idea of a scrapping premium is thus meant to compensate for potential second-hand value. But due to that, the effect on emissions in the countryside is less severe, it is also suggested that the scrapping premium should only be valid for units replaced within urban areas. These schemes are still just suggestions and not ratified in Sweden.

USA

Several regional and/or local jurisdictions specify that out of compliance wood stoves must be replaced upon sale of a home, or upon major remodelling. For example, in Laguna Beach, California, a city-wide ordinance requires a retro-fit of all wood burning fireplaces to meet EPA Phase II emission limits when homeowners conduct major residential remodelling or demolition, [LINK](#) [229]. Essentially all in-place appliances are “grandfathered-in” so that homeowners are exempt from the new rules and may operate their wood burning appliances according to previous rules. New EPA certified wood stoves have enhanced features to limit particulate emissions. These include either secondary air recirculation features designed to promote more complete combustion, or catalytic elements designed to absorb particulate matter. In general, wood stoves with adjustable burn rates (vs. single burn rates, which are designed so the owner cannot adjust the airflow) are treated equally.

On February 3, 2015, the U.S. Environmental Protection Agency (EPA) had updated its clean air standards for residential wood heaters. The specifications are compiled in Chapter 3.3.

Forbids sale and/or installation of uncertified stoves. Two states, and several urban areas and counties do not allow old uncertified stoves to be sold or installed off the second-hand market. Where change-out programs occur, banning the future installation of old stoves is a keyway to preserve air quality gains. Some examples of such measures are listed below.

- Washington: Since 1992, has forbidden sale and installation of wood stoves or inserts that are not certified to the stricter Washington state emission standards, [LINK](#) [201]
- Oregon: Forbids sale and installation of wood stoves or inserts that are not certified. Oregon began certifying stoves in 1984 and the EPA in 1988, [LINK](#) [202].
- Colorado: prohibit people from selling new or used wood-burning devices unless they meet current (Step 2) EPA certification and emissions performance requirements, [LINK](#) [203]
- Denver-Metro area, Colorado: Prohibits sale and installation of new or used uncertified wood burning appliances
- Fairbanks non-attainment area, Alaska: rules prohibit a person from selling, leasing, or conveying a wood stove or pellet stove with emission limit more than 2.0 grams per hour. [LINK](#) [204]
- Summit County, Colorado: Forbids the installation of a non-certified wood stove in a new home or as a replacement unit for an existing non-certified stove.
- San Joaquin Valley, California: Forbids sale and installation of non-certified stoves.
- Town of Mammoth Lakes, California: Uncertified stoves prohibited from being installed in the town. No more than one EPA-certified wood stove can be installed in new single-family detached dwellings. [LINK](#) [205]

Stove removal. Uncertified stoves must be removed upon sale of home. Some examples of such measures are listed below.

- Oregon: Uncertified stoves must be removed when a home is sold, [LINK](#) [202]
- Marin County, California: Non-certified stoves must be removed upon a home's remodel, [LINK](#) [205]

Fairbanks non-attainment area, [LINK](#) [204] There are several active wood stove change-out programs in the USA. Figure 6 shows a map of activities of individual U.S. states, [LINK](#) [206].

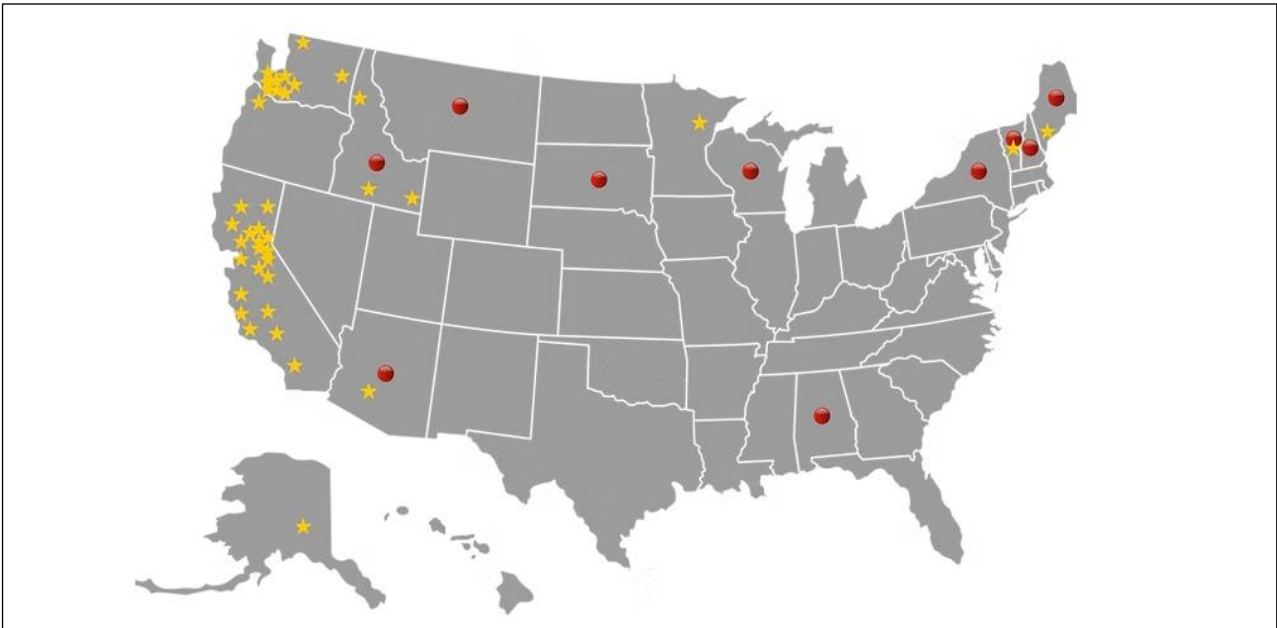


Figure 6: February 2024 map of active wood stove change-out programs (yellow stars) and incentives (red circles)

Certain areas (primarily at the county and municipality level) have implemented successful wood stove changeout programs. Examples include:

- *Portola, California.* This community received a \$2.48 million EPA grant to cover the purchase cost of new EPA-certified appliances, when used to replace older wood stoves. Installation costs were covered by the City of Portola. The program was structured into 2 geographic zones (the City of Portola, and the outlying areas), and included additional incentives for low-income households. This successful program had a 5-year duration (2016-2021) and was motivated in part by its rural, forested location as well as lack of natural gas access.
- *Washington County, Oregon.* This program was motivated by winter air inversions and provided rebates of between \$1,500 and \$3,500 when residents replaced a non-EPA-certified wood stove with a cleaner device. Funds were provided by 9 different partners.
- *Libby, Montana.* In this remote Montana community, a “two-pronged” approach was used for facilitating wood stove change-outs. In Phase 1, low-income households were identified and offered EPA-certified stoves at no cost. Phase 2 focused on other households and businesses that did not qualify for Phase 1. A key part of this effort involved local fairs and outreach activities to build awareness within the community.
- *Other California.* Households using highly polluting, uncertified wood stoves or wood inserts or utilizing a fireplace as a primary heat source are eligible for an incentive towards replacing their old, uncertified device with a cleaner, more efficient heating device. The incentive amount will be determined by each District in coordination with CAPCOA, [LINK](#) [208]. In order to determine if a device is uncertified and qualifies for this program, the users have to check the own model against the U.S. EPA current and historical list of certified wood heaters. If the stove’s manufacturer and model is not on the current and historical lists, the stove is considered uncertified. Additional methods to check eligibility are found in the Program Guidelines, [LINK](#) [207].

Changeout program success stories are also displayed on a website, where differentiated information is accessible for either policy makers or for homeowners, [LINK](#) [209]. Policy makers are advised about the do’s and don’t’s (checklist for best practices) and homeowners can find information about benefits of relevant programs.

3.2 Regional restrictions (bans) for biomass fuels

The preceding question to this chapter was:

“Are or were there any regional bans for the use of wood stoves or wood boilers?”

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
for wood stoves	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
for wood boilers	yes	no	yes	yes	yes	yes	yes	no	no	yes

Chapter summary

Wood fuel restrictions to improve air quality are a widely used concept, they are applied in all involved countries, mainly for wood stoves. To ban the use of a wood stove is always a decision of a region or a municipality, never it is a nationwide measure in any of the participating countries. There can be temporary or permanent wood fuel bans.

Temporary bans are in most cases triggered by incidents such as the exceedance of a certain immission concentration. In Austria, for example, the province of Styria has banned the use of wood stoves in the City of Graz when PM₁₀ concentration is higher than 75 µg/m³ over 3 days. Or in Germany (City of Stuttgart) the so-called “comfort stoves” cannot be used anymore if the weather forecast is unfavourable and a PM₁₀-immission limit of 50 µg/m³ is exceeded as daily mean value. Also, in the Norwegian City of Bergen, a ban for certain room heaters was implemented in 2021, it applies for wood stoves which are older than 1998, and for all open fireplaces. In the Italian Po-Regions, there are temporary bans when one of two “PM alert” levels is reached: Level 1: 4 consecutive days with PM₁₀ >50 µg/m³_n and Level 2: 10 consecutive days with PM₁₀ >50 µg/m³_n. A temporary ban can also be firmly anchored in the annual calendar, this happens in the Canadian City of Vancouver where seasonal restrictions were introduced which are not directly connected to any immission measurement: Here wood combustion is not allowed over the summer season from May 15 to September 15. In The Netherlands, a digital tool (Stookwijzer) was implemented to inform customers using colour codes yellow, orange and red if adverse weather conditions exist for burning wood in a certain area (grid of 1 x 1 km). In an increasing number of municipalities, the tool is now used to forbid burning wood in all stoves and fireplaces in case of code red (max. wind of 2 Bft and/or already high ambient concentrations of pollutants). Users can install the app on their phone, consult the webpage or subscribe to an email distribution list.

Another group of restrictions are permanent bans of wood fuels. They can be caused by exceeded immission levels. In Switzerland, for example, a ban for wood fuels exists in the Canton of Geneva, where new wood stoves are not anymore permitted in zones with high air pollution. In the Netherlands, the municipality of Utrecht forbids all domestic wood fuel use after 2030. In the USA there are municipalities that ban the use of so-called uncertified stoves, or that ban the installation of a new appliance, particularly fireplaces are often excluded.

But often there are exemptions from a fuel ban. Examples of such exemptions are for example (a) installations that are the sole source of heat for a residential unit, (b) systems with which the obligation for renewable heat is fulfilled, (c) pellet stoves, (d) historical stoves, (e) stoves with baking device, (f) exemptions based on the existence of a retrofitted PM reduction device (particle separator), and others.

Wood fuel bans can be implemented in many ways. The most common and the quickest way is the direct creation of a municipal directive, which directly addresses certain appliances and their use. But there are indirect ways of influencing wood fuel use, too. Such ways are for example a preventive ban of wood stoves implemented in a development plan of a municipality. Another possibility is to ban wood fuels via municipal statutes which require house builders to purchase a certain form of energy, e. g. district heating as compulsory energy source. Also land sale contracts between a municipality and the new landowner can introduce a wood fuel ban if the use of certain forms of energy becomes inherent, and the agreement is then also legally binding by being documented in the land register.

Austria

Ban for stove users. The province of Styria has implemented a legislation that bans the use of wood stoves as secondary heating if ambient fine particle (PM₁₀) levels are high in the city and region of Graz, [LINK](#) [182]. This is because the region of Graz is facing significant air quality problems (PM and NO_x), mainly due to its disadvantageous geographical location, that prevents air exchange in winter. The temporary ban in case of high ambient particle levels, is one of the measures which have been implemented to improve the air quality situation in this region. The following frame conditions apply:

- The ban is only put into force if the PM₁₀ concentration in ambient air exceeds 75 µg/m³ on three consecutive days.
- The ban is only valid for secondary heating systems. Not for wood stoves which are operated as main heating systems.
- Tiled stoves are generally excluded from this ban.

Ban for wood boilers. In areas with air quality issues, like the urban areas Graz and Vienna but also other areas with high ambient pollutant concentrations, the installation of wood heating appliances or heating plants can be restricted directly because of environmental impact assessments or indirectly via mandatory connection to the district heating grid.

In declared areas where ambient air pollutant levels are exceeded, new biomass combustion plants often do not obtain a building permission during the mandatory environmental impact assessment. Either the applications are fully rejected or the requirements for flue gas cleaning are so high that an economic operation is impossible.

In several urban areas (e.g. Graz and Vienna) large district-heating(DH)-networks were built and constantly extended in the last decades. In some municipalities compulsory connection to the district heating grids was implemented in such DH service areas. This indirect ban usually does not only apply to biomass-based heating systems but to all individual heating technologies. In some regions only manually fired (logwood) appliances are restricted. In such cases, pellet or wood chip boilers can be installed.

Coal ban for heating. The federal law prohibiting the installation of coal boilers (and of heating oil boilers) in all new buildings since 1.1.2020. Existing heating systems are not affected by this law. However, in another law an expiration date of 1.1.2035 was set which is valid for all fossil fuel boilers operating with solid or liquid fuels. These bans are part of an ambitious target for climate neutrality for 2040, they are not motivated by PM emission reduction aims.

Canada

There is no universal ban on wood appliance use in Canada, however, jurisdictions can decide to implement partial or full restrictions on the installation of new appliances, or usage of wood burning appliances.

Regional wood fuel restrictions. Metro Vancouver (MV) introduced seasonal restrictions for a use of wood heating appliances, it prohibits their use in the warmer months (May 15 to September 15), with some defined allowable uses. This “Seasonal and Unauthorized Discharge Prohibitions” came into effect on May 15, 2021 (By-law 1303, [LINK](#) [17]).

Furthermore, the regulation in Vancouver will also restrict the use of unregistered appliances in most urban areas of the region after 2025. Appliances typically need to meet emissions criteria (defined in By-law 1303) to be eligible for registration, with some exceptions for defined circumstances. The restriction mentioned above is part of a suite of actions that are being phased in between 2020 and 2025. By-Law-1303 also provides exemptions from the seasonal restrictions in cases where a wood burning appliance provides the sole source of heat in a residence, for off-grid homes that are in rural areas, as well as during an emergency (e.g. a power outage lasting more than three hours).

Another regional regulation was issued by the City of Montréal (By-Law 15-069: [LINK](#) [18]), it became effective from October 1, 2018. It introduces a flexible ban of wood fuels during a smog warning on the territory of Montréal, then this ban applies to any solid fuel-burning appliance, except devices used for cooking food or for commercial purposes. The curtailment is announced via the weather websites (Environnement Canada et MétéoMédia).

A second part of Montreal's regulation prohibits the use of any solid fuel-burning device or fireplace, unless it is recognized by a certification process (CSA/B415.1 or US/EPA), establishing that it has an emission rate no greater than 2.5 g/h of particles into the atmosphere. Montreal's By-law 15-069 [18] authorizes the exceptional use of any solid fuel-burning device (compliant or not) during electricity outages of more than three hours.

Regional coal fuel restrictions. Manitoba government enacted a legislation which bans petroleum coke and coal for space heating. The legislation came into effect on January 1st, 2014.

Switzerland

The cantonal action plans for cleaner ambient air differ from canton-to-canton (Aargau, Bern, Basel, Fribourg, Geneva, Glarus, Grisons, Schaffhausen, Thurgau, Ticino, Vaud, Valais, Zurich), consequently only some noticeable specifics can be mentioned here.

Regional wood fuel bans. A ban for wood fuels exists in the canton Geneva. There, an installation of new devices is not permitted in zones with high air pollution, e.g. where limit values for PM in the ambient air are exceeded. Therefore, new wood heating devices are not allowed for the city centre of Geneva, and the area around the Geneva airport, while the ban does not affect existing devices. No exceptions from this rule are known. Further fuel bans in other regions may be possible or upcoming, as Switzerland is federally organized with far-reaching legal competences down to the community level.

On the regional level several cantons have introduced cantonal action plans for cleaner ambient air with regulations that are not included or stricter than the national regulations. In certain cases, these regulations can hamper or prevent an economically feasible project or plant operation. The execution of tightened emission limit values or restrictions for combustion devices applies to zones where concentrations of PM and/or NO_x as precursor of ozone are exceeding the respective limit values of the Swiss Ordinance on Air Pollution Control (OAPC) ([LINK](#) [16]).

Regional fuel quality restrictions. There are regional restrictions concerning maximum moisture content in the fuel. For example in canton Zürich, moisture content is limited to max. 20 % in log wood and 30 % in wood chips for devices <70 kW, this is checked in case of complaints or exceeding of the emission limits. Concerning coal fuel for heating, only coal briquettes or coke with a sulphur content not exceeding 1 % may be used in combustion installations having a rated thermal input of less than 1 MW.

Operational limitations for boilers. In Swiss regions also the total number of starts per year can be limited. This is the case for example in the central cantons Zurich, St. Gallen and Aargau, where a maximum of 1,000 starts per year and facility is permissible for appliances up to 100 kW and 500 starts per year and facility >100 kW. Now this is not enforced and only controlled when the emission limit values cannot be met or there are complaints from neighbours. Furthermore, since the number of installations with two-boilers or with a boiler-cascade (3 or more boilers) is rapidly growing and to meet the requirement of 500 start per facility and year is not possible here, a new evaluation scheme for defining a new number of allowed starts is being in discussion between the cantons and the Suisse Wood Combustion Association.

Regional emission limits. Indirectly the PM-emissions from boilers may also be affected by the introduction of a NO_x-limit value for heating plants <10 MW. In the Swiss Ordinance on Air Pollution Control (OAPC) ([LINK](#) [16]) there are only NO_x-limit values for boilers/plants >10 MW, or for boilers/plants with NO_x-emissions >2500 g/h. Two examples for tightened NO_x limit values are (a) Canton Grisons:

General NO-limit value of 250 mg/m³_n for heating plants >3 MW, and (b) Canton Zurich: NO_x-limit value of 150 mg/m³_n for heating plants with NO_x-emissions >1,500 g/h.

Furthermore, the regional tightening of TSP emission limits (measured in the hot flue gas) has been an applied measure. For example, the regional introduction of a TSP limit of 20 mg/m³_n instead of 50 mg/m³_n for devices from 70-500 kW was decided in several regions where a cantonal action plan is in force.

Regional monitoring requirements. Regional pressure can also be imposed by introducing a mandatory continuous monitoring of emissions for heating plants. This was for example, the case in Canton Zurich for heating plants >70 kW which burn wood residues from the wood-processing industry and woodworking businesses.

Retrofitting deadlines. On Cantonal level, in some cases the retrofitting deadlines for existing devices were shortened when certain new requirements are not met (e. g. exceedance of emission limit values, heat accumulator requirements, etc.).

Germany

Examples for wood fuel bans. In many areas the use of wood fuel is restricted or was banned in the past. Some examples for regional fuel bans are:

- *Munich.* The city wanted to achieve an early replacement or shutdown of older stoves which had been erected before Oct. 1999. Older stoves in the city area needed to be retrofit with dust precipitator. This was only true for those stoves which could not provide a certificate of compliance with the requirements of 1.BImSchV (Stage 2) [4], which at that time was not yet legally binding. A subsidy payment for replacement was given (in 2015), see Chapter 3.4.
- *Aachen.* It was required a new stove would prematurely comply with the limit values of 1.BImSchV (Stage 2) [4] already from Oct. 2010 on. Also older stoves could only be further used if stricter requirements were met (PM: 0.075 g/m³_n; CO: 2 g/m³_n). A subsidy payment for replacement was given (see Chapter 3.4)
- *Berlin.* New zoning maps now display “air priority zones“ where wood fuels can only be applied if emissions are “comparable to oil and gas appliances”.
- *Esslingen.* A new zoning map of 1999 introduced a fundamental ban of wood furnaces. But exemptions for the newest state of stove technology were possible. These exemptions were defined for those stoves which prematurely complied with today’s requirements of 1.BImSchV (Stage 2).

In Germany, a municipality may decide to influence the use of wood fuels by banning their combustion. This may be the case, for example, in a health resort area. Then a municipality can decide to ban the use of certain fuels.

Records on wood fuel bans. During the last decade a total number of 1400 cases with fuel restrictions was listed in Germany by a an initiative named “Free heat” ([LINK](#) [13]) which was fighting against such wood fuel bans; but the correctness or relevance of this number cannot be approved easily. In the meanwhile the map with the regional wood fuel bans was deleted from the website. However, this number is today completely outdated anyway, because numerous municipalities had withdrawn their fuel bans and stove restrictions as soon as the stricter emission limits of the 1. BImSchV (Stage 2) [4] became effective in 2015.

Means to express permanent fuel bans. There are five possibilities for of such incineration bans in Germany.

- *Development plans.* In a development plan, a municipality can permit only certain fuels or generally restrict the use of fuels by specifications in the Building Code for an area. This could then allow only one specific type of energy supply, which can for example be covered almost exclusively by a municipal supplier. For example, this would be the case with district heating.

- *Fuel ordinances.* In each Federal state, where an immission control law applies (currently these are: Bavaria, Berlin and Brandenburg), regulations can be made by the municipalities, which may decide for additional tightening of limit values for emissions or even prohibit the use of certain combustion plants.
- *Clean air plans.* An air pollution control plan is based on the German Federal Immission Control Act. It requires the responsible authorities to reduce air pollution. These clean air plans in turn require measures to be taken by the regional authorities, e. g. by introducing a regional ban for wood appliances in development plans (see above) or by banning certain solid fuels completely.
- *Statutes.* Every municipality or local authority has the right to oblige energy consumers to purchase a certain form of energy by statute, e. g. district heating as compulsory energy source. Thus, the restriction of wood heating appliances is indirectly hidden in a statute. Apart from air quality issues, municipalities can also justify this decision by claiming a higher climate-friendliness.
- *Land sale contracts.* In purchase contracts for real estate concluded between a municipality and the new landowner a use of a certain form of energy can be inherent. The agreement made in the purchase contract is then also registered in the land register of the municipality and thus becomes legally binding.

Temporary wood fuel bans. In the City of Stuttgart, the instrument of a temporary ban for operating an existing residential wood stove was introduced, it was imposed for all so-called “comfort stoves” by the environmental protection office of the City. Comfort stoves are space heaters for wood fuels that supplement an existing heating system but do not cover the basic heat requirement. The latest ban period was started in Nov. 16th, 2021. The ban was justified by the latest weather forecast and a high risk of exceeding the PM₁₀-immission limit of 50 µg/m³ as daily mean value. Exemptions from the temporary fuel ban in Stuttgart were (a) installations that are the sole source of heat for a residential unit, (b) systems with which the obligation for renewable heat is fulfilled in accordance the State’s Renewable Heat Act for buildings, (c) stoves with baking device, d) pellet stoves, e) room heaters for solid fuels which were built after Dec. 2014 (fulfilling 1. BImSchV (Stage 2) [4]). Individual exemptions could also be granted upon application if an appliance was retrofitted with a downstream PM-reduction device (particle separator), [LINK](#) [14]. The regulation expired in April 15th, 2022, due to good progress concerning air pollution development.

Restrictions concerning the frequency of use. Only for one stove type such restrictions were ever defined in Germany, for open fireplaces. Such appliances may only be operated “occasionally” (as defined in 1. BImSchV [4]). An operation of 8 days per month, each for 5 hours, and max. 30 days per year is regarded as lawful in Germany (Oberverwaltungsgericht Rheinland-Pfalz in 1991, Az.: 7 B 10342/91).

Denmark

Section 17 of the Statutory Order on stoves, [LINK](#) [167], allows municipalities to lay down rules on pollution control measures for solid fuel combustion plants. Some municipalities have an ordinance regulating the use of stoves and boilers. A regulation on wood combustion describes the requirements that the municipality imposes on pollution from combustion plants connected in the whole municipality or in specific areas. The municipality must advertise the regulation in public media so that it is available to affected citizens and businesses.

The Danish EPA hosts a (not updated) web-list of examples concerning individual rules created by Danish municipalities on log wood combustion, [LINK](#) [160]. Some of these municipal regulations have been updated to e.g. match changes in national regulation but the core content remains the same. When the above rules are not followed, there can be a shutdown by the municipality. More information on this is given in Chapter 3.7.

At least one of the municipalities, Lejre Municipality, has put a ban on residential wood combustion into the local planning regulation for two new development areas: New houses cannot be built with chimneys. A complaint by the local chimney sweep, and the national chimney sweeps association has been rejected by the planning complaints authority.

On the Danish website, also an example of how densely populated areas deal with the problem comes from Sweden, from Malmö (see below, Chapter “Sweden” or follow this [LINK](#) [161]).

In 2023, an announcement on municipal regulations for the replacement or scrapping of older wood stoves and fireplace inserts in areas with collective heat supply came into force, allowing municipalities with collective heat supply to set requirements about replacement or scrapping of wood-burning stoves and fireplace inserts installed before 1 June 2008, [LINK](#) [234].

This order has quickly found traction and several municipalities - amongst these the largest cities, Odense, Aarhus and Copenhagen - have adopted bans on wood stoves and inserts in specific areas, Aarhus at the time of writing probably being the most significant with a view to ban 6,000 out of 19,000 stoves in the municipality, [LINK](#) [235]. Chimney sweeps report that this has already had a significant effect on their work load. Also in less densely populated municipalities there is a political majority for abolishing old stoves and inserts in areas with district heating supply, an example being Furesø Municipality, [LINK](#) [236].

Italy

In Italy a ban on the use of wood fuel is only known for the municipality of Milan, in the Lombardia Region. Milan is an air pollution area with still about 80 days where PM₁₀ and NO_x-limits are exceeded during winter. In November 2020 the Lombardia Region was condemned by the European Court of Justice for exceeding the PM₁₀ and NO_x-Limits. Therefore, a new “Air quality regulation” has been approved with the City Council Resolution n. 56 of 11/19/2020. The regulation prohibits new installations of biomass heating plants up to 3 MW, including also those that are using heating oil and biodiesel. Furthermore, from 01.10.2023 all biomass heating biomass plants which were installed more than 10 years ago cannot continue to be in operation, [LINK](#) [15]. However, a ruling by the Council of State - Section 4, no. 09669/2022, annulled art. 3 of the Regulation on air quality concerning “Civil heating systems”. The reason is that these bans are “technical rules” that must be mandatorily notified to the European Commission, as they affect the free movement of goods in the Union. The Municipality of Milan is currently modifying the regulation, the new version will be published within the first months of 2025.

Temporary bans. In the Po-Regions there are two “PM alert” levels: Level 1: 4 consecutive days with PM₁₀ > 50 µg/m³, and Level 2: 10 consecutive days with PM₁₀ > 50 µg/m³. Then these “emergency measures” apply in the Po-Regions regions:

- With level 1 only 4-Stars biomass domestic heating systems (see Chapter 3.3) can be operated, the others are shut down, except in those cases where the system is the unique source of heat of the building.
- With level 2 only 5-Stars biomass domestic heating systems (see Chapter 3.3) can be operated, the others are shut down, except in those cases where the system is the unique source of heat of the building.

The Netherlands

There are cases of wood fuel bans in The Netherlands, mainly for boilers and central heating. Since 2020 the city of Nijmegen forbids new biomass boilers. However, this decision was not dominated by air pollution considerations, but rather by doubts about the short-term climate impact (carbon debt), fear of biodiversity loss and avoidance of deforestation. After 2030, the domestic use of wood fuels will be completely banned in the municipality of Utrecht.

Similar news comes from the municipality of Waddinxveen, where all new biomass boilers above 130 kW are prohibited since 2021. The exact motivation of this ban is unknown, but it is likely to be driven by air quality concerns.

A strong recommendation for not-using a wood stove was created by the Dutch ‘Stookwijzer’ (Heating alarm), which triggers at adverse weather conditions, [LINK](#) [104]. The ‘Stookwijzer’ tries to discourage stove users via an app, website and via email distribution list. In an increasing number of municipalities,

temporary wood fuel bans are installed in case of a 'red' situation. More information is presented in Chapter 3.13. Wood boilers are not affected.

Norway

In Bergen (city) a ban for using certain room heaters was implemented, it was effective from January 2021 to February 2023. It was applied for wood stoves which were older than 1998, and for all open fireplaces. The reason for this measure was that there was a too high air pollution level in the City of Bergen, especially for PM_{2.5}. The ban was applied to all old wood stoves except antique stoves (older than 1940) if they were installed in buildings of historical/preservation value. It was applied to all older closed-fireplaces, and to all open fireplaces. It did not apply to soapstone and tiled stoves which have a large ability to store heat (slow heat releasing appliances). The ban was applied to all building categories. Fines were introduced for those users that did not follow the rules. No compensation was paid, but there has been a wreckage or replacement subsidy (5,000 kroner per unit), it was stopped when the budget was used. Generally, also any removal of a wood stove shall always be indicated to the municipality. If the stove is then replaced, the new stove must be registered by the user; this is done online.

Sweden

The municipality (290 in Sweden) is responsible for the local air quality in the municipality, or a municipal board can influence the presence of wood burning equipment through what is allowed in building permit applications (PBL). They can also set rules for wood burning in local regulations. It can for example deal with temporary bans on small-scale burning with certain solid fuels in a specified area, if necessary to prevent inconvenience to human health in the municipality.

If necessary, the municipality may, through its supervision, demand that individual property owners take measures to limit disturbances from wood burning (Environmental Code, Chapter 26, Section 9). Thus, the bans are case specific and origins from complaining neighbours. The Swedish Environmental Protection Agency has collected such court cases and the verdict in court in the document "Praxis vedeldning" (Firing practise): [LINK](#) [100].

An example of how to deal with wood smoke problems in densely populated areas comes from Sweden, from Malmö, where the municipality has introduced special restrictions on solid fuel firing. On the one hand, the City has limited the possibility of installing new heating systems using solid fuels, while on the other hand special zones have been introduced, where "cosy" firing with solid fuel may only take place in winter (Oct. 1st till Mar. 31st) and not more often than 2 times a week, [LINK](#) [161].

USA

Ban on the use of uncertified stoves. Forbidding the use of old, uncertified stoves is rare in the US and likely only used after years of offering funding to change out old stoves. But some examples for such actions which are mostly related to the stove quality can still be mentioned:

- Tacoma-Pierce County, Washington: As of October 2015, it is illegal to purchase or operate an uncertified wood stove in the Tacoma-Pierce County Smoke Reduction Zone.
- Marin County, California: The county forbids the use of non-certified appliances since July 2008 and forbids installation of non-certified stoves in new construction or remodels.

Ban of installations of wood-burning fireplaces. Some examples are mentioned below:

- Denver Metro area: The installation of fireplaces is not allowed unless they are equipped with an EPA Phase II wood or pellet burning insert, or electric or gas log.
- California Bay Area: Forbids installing fireplaces or stoves in new constructions.
- New York City: Bans new constructions of fireplaces. In 1968, NYC required that wood burning appliances shall not be installed in confined spaces or alcoves. The minimum size of the space or room in which the appliance is located shall be three hundred cubic feet. There shall be at least one openable window serving such space or room. Wood burning appliances shall not be installed in any garage.

Forbids sale of new, uncertified wood or pellet stoves. At the federal level, the EPA forbids the manufacturer, advertising and sale of residential wood heaters that do not pass emission regulations and become certified. Consumers rarely have to worry about this, as new uncertified stoves should not be on the market. One big exception is that some companies openly ignore EPA regulations and continue making and selling outdoor wood boilers for the residential market and the EPA has been ineffectual at enforcing its rules with these companies for many years.

A useful compilation of legislative actions and bans is given on the website of the Alliance for Green Heat, under the header “Policy”, [LINK](#) [206]. Ordinances and regulations for wood-burning appliances are compiled on a useful EPA-Website, [LINK](#) [210].

Restricts installations of outdoor wood boilers (hydronic wood heaters). Many states and counties restrict the installation of outdoor wood boilers by limiting the kinds that be installed, like New York, or limiting where they can be installed, like in Vermont, where you have to have a 100 foot set-back from your property line, for example. The State of Wisconsin assembled a list of municipalities that restrict outdoor boilers that is nine pages long. Connecticut, Indiana, Maine, Massachusetts, Pennsylvania and Utah also have property line setbacks and most also have minimum stack height regulations.

3.3 Tightening of general emission limits for biomass combustion and further requirements

The preceding question to this chapter was:

“Was there a tightening of emission limits for biomass burning appliances since 2010?”

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Chapter summary

In all participating countries the instrument of tightening emission limits was an issue in the past. In almost all cases the emission limits refer to type testing results and not to measurements in the field. Quite often the tightening happened in a stepwise approach. In Austria, for example, there have been 3 different periods of emission tightening, 1995, 2011 and 2015. Also in Germany there were three key dates, 1988, 2010 and 2015, when step by step emission limits became more ambitious. Also in the US, a two-step approach was introduced, with a 5-year transition period for stoves to meet the requirements of the Step-2 emission limits which entered into force in 2020. In Denmark, the first tightening happened in 2008. In Italy, the introduction of emission limits happened in 2006 and limits were tightened in 2017 nationwide, while in the Po-Region of Italy an even stricter regime for pollutant emissions from stoves was implemented. In The Netherlands, Norway and Sweden, the introduction of the European Ecodesign rules for both, wood fuel boilers (in 2020) and wood stoves (in 2022) were taken as an occasion for directly replacing the national law by the harmonized European scheme. This European harmonisation process is also expected to trigger more adaptations in other surrounding countries. But among the involved EU-countries of this survey, surprisingly not all seem to have yet fully implemented the harmonized European rules. In some countries national rules still apply, sometimes this is legitimated by the fact that they are generally (e.g. in Germany) or regionally (e.g. in Italy) stricter than the European limit values. However, non-EU countries, such as Switzerland and Norway, have already fully implemented the EU-regulations.

It can be foreseen, that European harmonisation will remain incomplete, this is because the test methods and the reported units for air pollutant emission will continue to be incompatible. Norway and Denmark will continue to apply PM-measurements from diluted flue gas, reported in g/kg fuel input, and the Austrian law refers the emissions measurement to mg/MJ fuel input. This makes it difficult if not practically impossible to convert and to compare their results to most commonly used concentration units

of the other countries, where emission measurements are usually reported in mg/m³n. An overview of the harmonized European requirement is given in Chapter 2.3 (Table 1).

Even more complicated is the comparison between Europe and North American countries. In Canada, the tightening of emission limits is also a well-known concept for reduction of wood-fuel-based emissions, but the rules are already very heterogeneous within the Country itself, because the Canadian provinces and territories are autonomous in establishing individual clean air acts. Furthermore, there is once again an even higher discrepancy of emission measurement standards as well as the reported parameters and units between North America and Europe.

Austria

Emission legislation is under provincial law, however since the first implementation of emission thresholds the Austrian provinces and the federal government use a form of agreement defined in the Austrian constitutional law (article 15a-agreement) to harmonize legal requirements among the nine provinces. This means that a 15a-agreement between the federal government and the 9 provinces defines the legal requirements. All 9 provinces implement the content of the agreement in their provincial legislation.

There have been several phases of tightening of emission limits in Austria over the last years. This is shown in Table 4. Those emission requirements are all relevant for type tests only, but CO-emission limits are examined in boiler inspections, too (Chapter 3.6). Further tightening of emission limits may be required to achieve conformity with Ecodesign requirements (see Chapter 2.3).

Table 4: Tightening of emission limits for wood stoves and boilers in Austria since 2011

Year	1995 till 2011	2011 till 2015	from 2015
Regulation	Vereinbarung Art. 15a B-VG über Schutzmaßnahmen betreffend Kleinf Feuerungen	Vereinbarung Art. 15a B-VG über das Inverkehrbringen von Kleinf Feuerungen und Überprüfung von Feuerungsanlagen und Blockheizkraftwerken	Vereinbarung Art. 15a B-VG über das Inverkehrbringen von Kleinf Feuerungen und Überprüfung von Feuerungsanlagen und Blockheizkraftwerken, LINK
A) Solid fuel local space heaters:			
Total PM emission (<u>without condensables</u>), in mg/MJ	60	Manually fired: 60 Pellet stoves: 50	Manually fired: 35 Pellet stoves: 25
OGC emission in mg/MJ	Manually fired: 80 Automatically fired: 40	Manually fired: 80 Pellet stoves: 30	Manually fired: 50 Pellet stoves: 30
CO emission in mg/MJ	Manually fired: 1100 Automatically 500	Manually fired: 1100 Pellet stoves: 500	Manually fired: 1100 Pellet stoves: 500
NO _x emission in mg/MJ	150	150	100
B) Wood boilers:			
Nominal power range	≤ 350 kW	≤ 400 kW	≤ 400 kW
Total PM emission (<u>without condensables</u>), in mg/MJ	60	Manually fired: 50 Automatically: 40	Manually fired: 30 Automatically: 20
OGC emission in mg/MJ	Manually fired: 80 Automatically fired: 40	Manually fired: 50 Automatically: 30	Manually fired: 30 Automatically: 20
CO emission in mg/MJ	Manually fired: 1100 Automatically: 500	Manually fired: 500 Automatically: 250	Manually fired: 500 Automatically: 250
NO _x emission in mg/MJ	150 mg/MJ	150 mg/MJ	100 mg/MJ

Canada

Emission limits. Most provincial, territorial and municipal governments in Canada require retail sales of new appliances to be in compliance with the emission limits set by the US EPA and/or the CSA B415.1 [82] standards. The US EPA NSPS 2020 emission limits came into effect in May 2020. Draft CSA B415.1-2021

performance standard, which is currently under public review, proposes to harmonize PM emission limits with those in the US/EPA NSPS 2020 for wood burning appliances. The emission limits set in the NSPS 2020 are stricter than those in the previous rulings. All emission limits are related to results from type tests.

Metro Vancouver (MV) is considering amendments to the “Boilers and Process Heaters Emissions Regulation” (Bylaw No. 1087, 2008). Currently all biomass boilers and process heaters less than 50 MW capacity are required to register. The current by-law includes emissions limits for PM, CO and VOCs. Subject to direction from the MV Board, MV staff will consult with stakeholders regarding revision of emissions limits and other requirements to ensure attainment of Canadian Ambient Air Quality Standards (CAAQS) for PM_{2.5} and NO₂.

Regional regulations. The majority of provinces and territories in Canada have Clean Air Acts. In regulating residential wood burning appliances, certification requirements are the most commonly chosen regulatory element. Rules and regulations for small-sized biomass combustion system (SSBCs) vary between provinces and territories, and, between municipalities in the same province/territory, with different size thresholds, emission limits and permitting conditions/requirements. A few provinces have regulations specific to SSBCs (Provinces of Quebec, Ontario and British Columbia). Regulated SSBCs in Canada are most commonly divided into two ranges, SSBCs less than 3 MW output capacity and greater than 3 MW output capacity (Table 5).

Table 5: Summary of regulatory instruments pertaining to wood burning in Canada

Jurisdiction	Federal	BC	Metro Vancouver	Alberta	Saskatchewan	Manitoba	Ontario	Québec	Montreal	New Brunswick	Nova Scotia	P.E.I.	Newfoundland & L.	Nunavut	NWT	Yukon
Environmental acts / general legislation ¹	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Regulations on SSBCs		✓	✓				✓	✓							✦	
Emission limits		✓	✓				✓	✓							✦	
Certification requirement ²		✓					✓	✓	✓	✓	✓		✓			✓
Emission dispersion modelling		✓	✓				✓									
Fuel restrictions or specifications		✓	✓				✓				✓	✓	✓			
Testing and monitoring		✓	✓				✓	✓							✦	
Ambient air quality standards	✓								✓	✓		✓			✦	
Curtailed / no burn days		✓							✓							

¹ General environmental legislation for wood/solid fuel burning not specific to SSBCs

² Including through building codes

✦ regulation in preparation

Switzerland

There was a nation-wide update of the Swiss Ordinance on Air Pollution Control (OAPC) ([LINK \[16\]](#)) in 2012 and 2018. On the regional level, several cantons (Aargau, Bern, Basel, Fribourg, Geneva, Glarus, Grisons, Schaffhausen, Thurgau, Ticino, Vaud, Valais, Zurich) have also introduced cantonal action plans for cleaner ambient air. In these plans several regulations were introduced which are not included or are stricter than in the national emission regulations (see Chapter 3.2)

For stoves. In 2018 field measurements for wood boilers <70 kW and inspections for space heaters were introduced. Space heaters are inspected every two years and the combustion residues and the condition of the installation are checked and the operator is provided with information on how to use the installation properly and on how to use and store wood fuels. For wood boilers <70 kW an acceptance measurement of CO und TSP (measured in hot flue gas) in the field and periodic CO field-measurement every 4 years are carried out. The new emission limits for CO are 2,500 mg/m³ instead of 4,000 mg/m³ (13 % O₂).

In the OAPC the emission limit values are implemented for the “placing on the market”. These emission limit values have to be fulfilled in type tests. From January 2020 (wood boilers) 2022 (space heaters) the limits are harmonized with Ecodesign-Directive 2009/125/EG, [LINK](#) [19] and the old emission limits expire. The limits that expired in January 2022 are listed in Table 6.

Table 6: Emission limit values for placing space heaters on the Swiss market (at 13 % O₂).

	OAPC-2018 Appendix 4 [16] (until Dec. 2021)		European Ecodesign Directive 2009/125/EG (from Jan. 2022) [19]	
	CO [mg/m ³ _n]	TPM [mg/m ³ _n]	CO [mg/m ³ _n]	TPM [mg/m ³ _n]
Residential cookers	3,000	90	1,500	40
Central heating cookers	3,000	120	1,500	40
Fire places	1,500	75	1,500	40
Pellet space heaters	500	40	300	20
Storage heaters	1,500	75	1,500	40

For boilers. In 2018 field measurements were introduced for boilers <70 kW. Acceptance measurements are required for CO und TPM (measured in hot flue gas). During later use the CO Emissions are measured every 4 years. In field measurements lower emission limits for CO (1,000 mg/m³ for automatic boilers and 2500 mg/m³ for hand stoked boilers) instead of 4,000 mg/m³ (13 % O₂) are in place. TPM-field-measurements (measured in hot flue gas) were newly introduced at the level of 50 mg/m³_n (for automatic boilers) and 100 mg/m³_n (for hand stoked boilers) (13 % O₂), before 2018 there was no limit value.

Emission limits also need to be met during type tests. Since January 2020 the limits are harmonized with Ecodesign-Directive 2009/125/EG for solid fuel boilers, [LINK](#) [20] and the old emission limits have expired. The old and new limits are listed in Table 7. The limits apply for type tests, but not for field inspections (see above).

Table 7: Type test emission limit values for boilers in Switzerland (at 13 % O₂)

	OAPC-Appendix 4 [16] (until Dec. 2019)		European Ecodesign Directive (from Jan. 2020) [20]	
	CO [mg/m ³ _n]	TPM [mg/m ³ _n]	CO [mg/m ³ _n]	TPM [mg/m ³ _n]
Log wood boiler (<350 kW)	800	50	509	44
Automatic wood chip boiler (<350 kW)	400	60	364	29
Pellet boiler (<70 kW)	300	40	364	29

For large combustion plants. There was also a change of emission limit values for larger plants in the range of 70-500 kW. In 2012 compared to 2008 the TPM emissions level was reduced from 150 mg/m³_n to 50 mg/m³_n (at 13 % O₂, measured in hot flue gas). The CO-emission level was reduced from 1,000 mg/m³ to 500 mg/m³_n.

Heat accumulator tanks. Furthermore, in 2018 a requirement for a heat accumulator tank was introduced. Hand-stoked boilers with a rated heat output of up to 500 kW must be fitted with a heat storage tank having a volume of at least 12 litres per litre of the thermal fuel storage bin in the boiler and the volume shall not be less than 55 litres per kW of rated heat output. Automatic boilers with a rated

heat output of up to 500 kW (and from 2022 also boilers >500 kW) must be fitted with a heat accumulator with a volume of at least 25 litres per kW of rated heat output. The foregoing does not apply to wood pellet boilers with a rated thermal input of up to 70 kW.

Dust removal system. Requirements for such systems were introduced. In the case an electrostatic precipitator (ESP) for installations with a rated thermal input of more than 70 kW, uptime of the dust removal system must normally amount to at least 90 %. Uptime is determined on the basis of the installation's operating hours.

Germany

For stoves. Before 2010 there were no Federal emission limits for wood stoves below 15 kW. With the revised 1.BImSchV-legislation starting in 2010 ([LINK](#) [4]), limits were introduced already for new wood stoves from 4 kW or higher. Older stoves then needed to fulfil the previous limits for appliances of 15 kW or higher, i. e. 150 mg PM/m³_n and 4,000 mg CO/m³_n (at 13 % O₂).

In 2015 the stage-2-emission limits of 1.BImSchV for stoves came into power, according to the decided graduated scheme. The stage-2 requirements introduced a decline of PM emission limits for close fronted heaters by a factor of 47 % (from 75 to 40 mg/m³_n) and for pellet stoves by 40 % from 50 to 30 mg/m³_n. A similar tightening happened also for CO: minus 37.5 %, from 2,000 to 1,250 mg/m³_n (for close fronted heaters) or 400 to 250 mg/m³_n (for pellet stoves). These limits apply only for type tests. For stoves no onsite emission inspections are performed.

For boilers. Before the revised 1.BImSchV-legislation starting in 2010 ([LINK](#) [4]) the PM emission limits for boilers of 15 to 50 kW nominal heating power were at 150 mg/m³_n (13 % O₂), no limits were defined for appliances below 15 kW nominal heating power output. In 2010, limits were introduced for the whole power range of new wood boilers (from 4 kW to 500 kW), PM was then limited to 100 mg/m³ and in 2015 to 20 mg/m³. For CO the decline was from 4,000 mg (before 2010) to 1,000 mg/m³ and in 2015 to 400 mg/m³_n (all at 13 % O₂). This means a stepwise tightening of minus 33 % (Stage 1) and another 80 % (Stage 2) for PM. For CO, the tightening was in a magnitude of minus 75 % (Stage 1) and another minus 60 % (Stage 2). These revised limits apply only for field performance during furnace inspections by chimney sweeps (every 2 years, see Chapter 3.6). There were no major changes for 500 to 1000 kW, thus from 2015 onward their PM- and CO-limits do not differ from smaller units anymore.

Heat accumulator tanks. Precise requirements for heat accumulator tanks of hand charged boilers were first introduced in 2010. They shall be fitted with a heat storage tank having a water volume of at least 12 litres per litre of the fuel storage bin in the boiler. And the volume of the buffer storage tank shall not be smaller than 55 litres per kW of the rated heating power output. For automatic boilers (up to 1000 kW) the required minimum storage volume is 20 litres per kW of rated heat output. There are cases of exemptions from this requirement (e.g. when the emission limits can also be met during partial load operation in the field, or when the appliance provides only base load in a system, or when it can only operate at full load). To receive public subsidies the heat storage tank for automatic boilers shall be higher than 20 l/kW (see Chapter 3.4).

Denmark

Emission limits for wood combustion appliances (wood stoves and boilers below 1 MW) were for the first time introduced in 2008. Before 2008, emission limits for type testing according to EN 303-5 applied.

Wood stoves. Here the particulate matter (PM)-emission as reported in a type testing certificate had to be either

- 10 g/kg and a maximum emission of 20 g/kg in a full testing cycle
- or alternatively 75 mg/m³_n at 13 % O₂-concentration.

From January 2022, the harmonized limits in the Ecodesign-Directive ([LINK](#) [19]) are also followed, this can be read from the "Wood Stove Ordinance", [LINK](#) [167], where the emission requirements are shown in Appendix 6. In special cases, for instance if a stove that was installed before 2022 has to be re-installed, if

a stove is over 50 kW capacity, if it is a sauna stove or if a stove is not assembled at a factory, Appendix 1 of the ordinance applies (Details in §4.1-4.).

Wood boilers. Here, the type testing certificates (according to EN 303-5) had to prove conformity for 3 emission parameters, carbon-monoxide (CO); organic gaseous carbon (OGC) and particulate matter (PM) which were introduced in 2008. These (today outdated) limits were as follows (in mg/m³_n at 10 % O₂):

Manual fuel charging:

- < 50 kW: CO: 5000; OGC: 150; PM: 150
- > 50-150 kW: CO: 2000; OGC: 100; PM: 150
- > 150-300 kW: CO: 1200; OGC: 100; PM: 150

Automatically charged biomass boilers:

- < 50 kW: CO: 3000; OGC: 100; PM: 150
- > 50-150 kW: CO: 2500; OGC: 80; PM: 150
- > 150-300 kW: CO: 1200; OGC: 80; PM: 150

From January 2020 on, the harmonized limits in the Ecodesign Directive, [LINK](#) [20], are also applicable in Denmark for biomass boilers of up to 500 kW rated heat output. Furthermore, the Danish “Wood Stove Ordinance” sets requirements for medium sized combustion plants, from 0.5 -1 MW_{th}.

Italy

National restrictions. In 2017 the National Decree 152/2006 - Consolidate Environmental Text, was updated by the Ministerial decree 183/2017 for the implementation of EU directive 2015/2193 (Medium Combustion Plants). This decree refers to heating plants with a nominal heating power of more than 35 kW. The new emission limits for biomass plant are significantly more restrictive than before, they address the civil biomass plant up to 3 MW and the industrial plant (process heat) up to 1 MW, which are heating plants that are not subject to the authorization for atmospheric emissions. For instance, before the changes the limit value for dust emission in civil biomass heating plant (0,15-3 MW) was 150 mg/m³_n (6 % O₂), now it is 50 mg/m³_n (6 % O₂). These biomass plants > 35 kW are subject to annual field verification of compliance with the limit values.

Regional restrictions. Starting from 2018, the Po-Regions (Lombardia, Piemonte, Veneto, Emilia-Romagna) introduced the “Po basin agreement” with restrictions for domestic heating appliances and boilers up to 35 kW. In this agreement the rules are given for assignation of the number of classes (“Stars”) that each appliance will be allocated to according to Table 8, depending on results reported in the certificate of type testing, measured at nominal power output. From January 2020 on, only appliances with more than “4-Stars” can be installed. A replacement schedule for older installations is shown in Chapter 3.2. Only pellets of A1-quality (according to ISO 17225-2) shall be used in the residential pellets appliances in the four regions.

Before the introduction of the Po basin agreement (2018) a wood/pellet domestic appliance and boiler to be installed in Italy had to have the CE marking and therefore had to be certified based on European technical standards (EN 13240, EN 13229, EN 12815, EN 15250, EN 14785 and EN 303-5).

Other Italian regions with higher air pollution have oriented their regional restrictions for domestic biomass appliances (≤ 35 kW) based on the Stars performance classification, i.e. Tuscany, Marche, Lazio Campania Regions.

The Italian biomass association AIEL has developed an interactive map showing the Italian regions that have introduces specific restriction for the use of biomass for domestic heating purposes. For each region the adopted legislative measures are listed and continuously updated, [LINK](#).

Apart from the above deviation the harmonized limits in the Ecodesign-Directive ([LINK](#) [19]) are also applicable in Italy from 2022 on for local space heaters. And for biomass boilers another Ecodesign-Directive ([LINK](#) [20]) applies since 2020 for biomass boilers up to 500 kW rated heat output.

Table 8: Emission limits of appliances for receiving the obligatory “Stars”-classification according to the Po basin agreement as required from 1.1.2020. Emission values are from type testing, given for 13 % O₂.

	3 Stars	4 Stars	5 Stars
Total PM emission [mg/m ³ n] (heated filter method)	40 heaters, stoves, cookers, tiled stoves 30 pellets appliances (insert&stoves) 30 wood boilers (manually stocked) 20 pellets/chips (automatically stoked)	30 heaters, stoves, cookers, tiled stoves 20 pellets appliances (insert&stoves) 20 wood boilers (manually stocked) 15 pellets/chips (automatically stoked)	25 heaters, stoves, cookers, tiled stoves 15 pellets appliances (insert&stoves) 15 wood boilers (manually stocked) 10 pellets/chips (automatically stoked)
OGC emission [mg/m ³ n]	100 heaters, stoves, cookers, tiled stoves 50 pellets appliances (insert&stoves) 15 wood boilers (manually stocked) 15 pellets/chips (automatically stoked)	70 heaters, stoves, cookers, tiled stoves 35 pellets appliances (insert&stoves) 10 wood boilers (manually stocked) 10 pellets/chips (automatically stoked)	35 heaters, stoves, cookers, tiled stoves 10 pellets appliances (insert&stoves) 5 wood boilers (manually stocked) 5 pellets/chips (automatically stoked)
CO emission [mg/m ³ n]	1500 heaters, stoves, cookers 1250 slow heat releasing appl. 364 pellets appliances (insert&stoves) 364 wood boilers (manually stocked) 250 pellets/chips (automatically stoked)	1250 heaters, stoves, cookers 1000 slow heat releasing appl. 250 pellets appliances (insert&stoves) 200 wood boilers (manually stocked) 100 pellets/chips (automatically stoked)	650 heaters, stoves, cookers 650 slow heat releasing appl. 250 pellets appliances (insert&stoves) 30 wood boilers (manually stocked) 25 pellets/chips (automatically stoked)
NO _x emission [mg/m ³ n]	200 heaters, stoves, cookers, tiled stoves 200 pellets appliances (insert&stoves) 150 wood boilers (manually stocked) 145 pellets/chips (automatically stoked)	160 heaters, stoves, cookers, tiled stoves 160 pellets appliances (insert&stoves) 150 wood boilers (manually stocked) 130 pellets/chips (automatically stoked)	100 heaters, stoves, cookers, tiled stove 100 pellets appliances (insert&stoves) 150 wood boilers (manually stocked) 120 pellets/chips (automatically stoked)
Minimum efficiency (%), (based on <i>net</i> calorific value)	75 heaters, stoves, cookers, tiled stoves 85 pellets appliances (insert&stoves) 85 wood boilers (manually stocked) 90 pellets/chips (automatically stoked)	77 heaters, stoves, cookers, tiled stoves 87 pellets appliances (insert&stoves) 87 wood boilers (manually stocked) 91 pellets/chips (automatically stoked)	85 heaters, stoves, cookers, tiled stoves 88 pellets appliances (insert&stoves) 88 wood boilers (manually stocked) 92 pellets/chips (automatically stoked)

The Netherlands

The emission limits for biomass boilers that are used commercially were tightened in 2024. Residential boilers or stoves only need to comply with Ecodesign limits since 2022, before that no limits applied. Certain indirect restrictions were imposed by a subsidy scheme for wood boilers and pellet stoves where the requirements were based on the German emission ordinance (1.BImSchV [4]). This subsidy scheme is already abandoned. Another already abandoned subsidy scheme for residential boilers had used the existing limits for boilers that are used in companies under the ‘Activiteitenbesluit’ (38 mg/m³n dust, 750 mg/m³n CO, 300 mg/m³n NO_x @ 6 % O₂). All requirements are based on type test results.

For stoves there are no formal national limits other than the compulsory Ecodesign limits. Further tightened emission limits for boilers up to 10 MW were introduced in 2024, as shown in Table 9.

Table 9: Recently tightened emission limits for boilers up to 10 MW in The Netherlands (Besluit Activiteiten Leefomgeving, all figures at 6 % O₂)

	< 1 MW	1 .. 5 MW	>5 .. 10 MW
NO _x	300	145	100
SO ₂	200	100	60
Dust	40	5	5
NH ₃	10	10	10

Norway

In Norway the European Ecodesign requirements are introduced from 2022 for residential heating. Larger combustion plants, from 1 MW, follow the requirements of the European Medium scale combustion directive (MCPD), with a special tightening for new plants in operation after 19 December 2021. There is also a tightening of limits for old plants above 5 MW from 2025 and for plants from 1 to 5 MW from 2030. The European Ecodesign directive comes into play for heaters and boiler below 1 MW.

In Norway, emission limits for wood stoves can either be declared in mg/m³ according to the standards for the European Ecodesign directive or in g/kg according to the Norwegian test standard. Before the introduction of the Ecodesign requirements there were no CO-, NO_x- or OGC-emission limits. Conformity is only proven during type approval measurements, there is no field performance testing.

Sweden

There was a tightening of emission limits for wood combustion in Sweden via the Swedish building regulations BBR (2011:6) and then in the amendment to these in 2017 (BFS 2017:5) and 2019 (BFS 2019:2). In the Swedish National Board of Housing rules for constructions, the emission limits from 2011 were updated in 2017 (in so called BFS's). For stoves limiting values for OGC were cancelled and only values for CO were implemented in order to comply with EU standards.

For wood boilers (≤ 500 kW), the requirements of PM and CO emissions were added in the amendment of BFS 2017, while limits for OGC were reduced. All emission limits refer to type test measurements.

Finally, since January 2020 the requirements are following the European EcoDesign requirements. But there is a difference in how the efficiency is calculated.

USA

Area of residential wood stoves. On February 3, 2015, the U.S. Environmental Protection Agency (EPA) had updated its clean air standards for residential wood heaters. Allowable PM_{2.5} emission limits have generally been reduced from 4.5 to 2.5 g per hour. The specifications are compiled in Table 10.

Table 10: Emissions limits for new wood stoves and pellet stoves, [LINK](#) [200]

Step	PM limit	Compliance deadline
Step 1: For all stoves without current EPA certification	4.5 grams per hour of operation for catalytic and non-catalytic stoves Limit is for crib testing. If tested with cordwood, emissions test method must be approved, and stoves must meet crib wood limit	60 days after final rule is published in the Federal Register
Step 2: All wood stoves and pellet stoves	2.0 grams per hour for catalytic and non-catalytic stoves, if emissions are tested using cribs Alternative limit: 2.5 grams per hour, if tested with cord wood; method must be approved	5 years after the effective date of the final rule

Area of wood boilers. In the early 2000s, outdoor wood boilers (OWBs) became popular for residential heating in the United States. These systems were mostly hydronic, heating buildings ranging from 1,800 to 20,000 square feet in size and had little in the way of pollution controls. Most are sized between about 100,000 and 3 million BTUs per hour. Thus, when used in residential neighbourhoods, smoky conditions were common. An extreme case was Fairbanks, Alaska, where OWB use was common, combined with very cold winter temperatures and also an air temperature inversion, which caused smoke to stagnate, with little dispersion, [LINK](#) [211]. OWBs have also been common in the northeastern part of the country. NESCAUM (Northeast States Consortium on Air Use Management) has estimated that OWBs typically emit at least 20 times more emissions than most EPA-Certified stoves, [LINK](#) [212]. Also contributing to high emissions is the fact that many OWBs operate yearround (providing hot water to homes even in summer), are cyclic in operation, and have large, inefficient fireboxes coupled with short stack heights.

The US EPA implemented a voluntary program in 2007, designed to encourage manufacturers to produce cleaner models for retail sale. Here, a voluntary limit of 0.6 pounds of particulate per 1 million BTUs of energy output was implemented. However, even with these emission limits, it is estimated that OWBs could meet the emission limits while generating up to 12 times the level of emissions required of indoor wood stoves.

Corrective measures have included limits on use (i.e. shorter heating season or burn times), zoning requirements (i.e. a mandatory setback distance from property lines), increasing minimum required stack heights, and/or required changeouts for more efficient OWBs when selling property.

Today’s final rule builds on the voluntary program. The new emissions limits for these heaters were introduced in two steps. Step 1 is identical to the current qualifying level for EPA’s voluntary Hydronic Heater Program: After December 31, 2015, heaters sold at retail had to meet the Step 1 emissions limit in the final rule. In Step 2 (from 2020), hydronic heaters had to meet stronger emissions limits. The specifications are compiled in Table 11.

Table 11: Emissions limits and compliance deadlines for hydronic heaters, [LINK](#) [212]

Step	PM limit	Compliance deadline
Step 1	0.32 pounds per million Btu heat output (weighted average), with a cap of 18 grams per hour for individual test runs. Limit is for crib testing. If tested with cordwood, emissions test method must be approved, and stoves must meet crib wood limit.	60 days after final rule is published in the Federal Register
Step 2	0.10 pounds per million Btu heat output for each burn rate Alternative limit: 0.15 pounds per million Btu heat output for each burn rate. If tested with cordwood; method must be approved.	5 years after the final rule is published (2020)

General. All these emission reductions have been national measures, through the US Environmental Protection Agency (EPA). But regional and/or municipal restrictions have also been implemented in air-quality vulnerable areas. In other cases (for example Colorado), emissions limits are more restrictive depending on elevation. Here, emissions limits are less stringent at elevations 7,000 feet or greater above sea level.

There are several approved methods for certifying wood heaters in the US:

- EPA method 28R- uses “crib wood” (a grade of dimension lumber nailed together in a specified configuration). This method uses a dilution tunnel for accurate measurement of particulate matter and requires at least one complete burn cycle at each of the 4 burning rates. In addition to particulate matter testing, heat output and overall efficiency must be quantified.
- American Society for Testing and Materials (ASTM) E2779-10 is approved for testing wood pellet heating systems and employs the same emissions sampling as for EPA method 28R. At least one burn cycle is required for each of 3 burn rates: maximum, medium, and minimum.
- EPA ALT-140 is an approved alternative test method for certifying wood heating appliances using cordwood (i.e. firewood). This method uses the same emissions limits as EPA method 28R, however requires 3 burn cycles at each of 4 burn rates (start-up, high-fire, maintenance-fire, and low burn).

A key feature of these methods is that they require a certain number of test burns (i.e. replications) at several different parts of the burn cycle (start-up, high-fire, and/or low fire). This is presumably an attempt to be thorough and provide valid statistical results based on more than a single sample.

3.4 Public financial support schemes

The preceding question to this chapter was:

“Is or was there any subsidy or financial incentive for installing an appliance? (can be municipal, regional, or national subsidy)”

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
for wood stoves	yes*	yes	no	yes	yes**	yes	yes*	yes	yes	yes***
for wood boilers or heating plants	yes	yes	yes	yes	no	yes	yes	yes	yes	(yes)

* only for pellet stoves, **only scrappage bonus, ***tax credits for log wood and pellet stoves with efficiency $\geq 75\%$

Chapter summary

This question about financial incentives was motivated by the assumption that subsidies can be a powerful vehicle to implement new technological benchmarks, because they can be coupled with special requirements that aim at better performance and higher emission standards. And the questionnaire shows that public subsidies are generally quite common in wood combustion. This is particularly true for central heating boilers, while in Europe for wood stoves public incentives are never broadly or steadily available, except in Italy (National programme “Conto Termico”: about 30-40 % of the investment costs for stoves). But apart from Italy, previously known subsidies for stoves were mostly only regionally offered or they were available for only a short period of time due to budget limitations. Previous short-term subsidy examples for stoves were reported from Austria (500 € per unit, but only for pellet stoves), from some Canadian regions (e. g. Northern Territories for log wood and pellet stoves: 50 % of cost but max. \$1,000 per unit), from Germany (e. g. in the Cities of Aachen and Munich with 25 or 30 % of eligible costs for stove replacement, max. 250 or 300 €), from The Netherlands (only for pellet stoves, 50 € per kW, but minimum 500 €) and from Norway (about 400 € per unit if it was built before 1998). And in Denmark there were a number of replacement schemes for stoves that were built before 1995. In most cases the programs were designed in a way which would guarantee that the old stove could not be used anymore or be sold for usage elsewhere. Currently all these programs are expired.

In opposition to Europe, nationwide public incentives for stoves were recently introduced in the USA via an income tax credit of 26 %, based on the full cost of a unit (purchase and installation). Here, too, the aim was to have an impact on stove quality by requiring certified stove quality and a minimum efficiency level.

In most cases the subsidy was justified by the assumption that a stove replacement would in any case lead to a cleaner combustion, because a new stove from the market was assumed to be technologically more advanced, compared to the one replaced. In Canada there were also cases where wood stoves (mainly pellet stoves) were subsidized to reduce direct electrical heating. Subsidies for stoves can also be aiming at a full removal instead of a replacement, then the subsidy is a scrappage bonus. But examples of such programmes can hardly be found, it was only reported from the German City of Aachen where a 50 € bonus was paid for an immediate stove shutdown.

For wood fuel boilers, subsidy programs are quite common, all countries except Denmark had previously introduced such instruments, and more often than for stoves such programs are nationwide. However, in many such subsidy programs the motivation was to replace fossil fuel or electricity rather than to improve air quality. Only few countries have used the funding to enforce advanced technology. The most ambitious funding program is known from Germany (the “MAP”, today revised as “BEG”), where one particular goal was to pave the way for new advanced wood combustion standards by introducing strict new emission classes and technological features which became eligible for an even higher bonus payment. This program can be seen as the main trigger for the development of low-cost ESP’s for small appliances and for today’s broad availability of condensing wood fuel boilers in Central Europe. Furthermore, the steady and long-term countrywide MAP/BEG-funding also created an advanced heat buffer storage industry and stimulated

industries to develop hybrid systems with wood and solar or heat pump energy use via defining particular requirements for bonus funding in this area.

Also in other countries, subsidies for boilers are sometimes coupled to special conditions. Quite often the funding is based on the existence of a quality label, this is e. g. true for Austria (Austrian ecolabel UZ-37), for Canada (CSA-B415.1-10 or US EPA 40CFR Part 60 AAA standard) or for Switzerland (label of “Holzenergie Schweiz”). But the label requirements did not aim at ambitiously defining a new technological standard.

In Switzerland the funding of larger boilers (>70 kW) mostly requires that the planning process is assisted by a quality assurance scheme, the QM Holzheizwerke®. For smaller boilers, funding requirements mostly require a quality label of the installed device.

In general, it seems that the setting of new technological standards through ambitious subsidy programmes is more sustainable if the funding is organised on a nationwide basis. Countries with highly decentralised decision-making structures in the field of environmental protection (e.g. Canada, Switzerland) will achieve less of a subsidy-induced impact on the state of technology if bonus-related specifications that go beyond official requirements are not coordinated across all regions.

Austria

For stoves. There was a national annual subsidy programme in the years from 2008 to 2020, the „Förderaktion Holzheizungen“ which had been funded by the Austrian Climate and Energy Fund (Österreichischer Klima- und Energiefond). The funding was limited to pellet stoves to support the market implementation and penetration of automated direct heating appliances. An investment into a pellet stove received a subsidy of 500 €. The steering effect concerning emission reduction was achieved by the exclusive eligibility of pellet appliances, but also by the fact, that only eco-labelled pellet stoves could receive the subsidy (Austrian ecolabel UZ-37, see Chapter 3.12).

For boilers. A similar action as for stoves was launched for boilers by the Austrian Climate and Energy Fund, too, It ran under the title “Förderaktion Holzheizungen“ (Funding action wood heating). A total subsidy of 2000 € was paid for the replacement of a fossil fuel boiler by a pellet or wood chip boiler. 800 € were paid if the replaced appliance was minimum 15 years old. Sometimes there were also additional subsidies on provincial and/or community level.

In 2021, the “Oil and Gas Escape Bonus (“Raus aus Öl und Gas Bonus”) was created by the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK). The bonus is a maximum payment of 7,500 € or 50 % of the total eligible costs, provided that a fossil heating system is replaced. [LINK](#) [181]. The measure focusses on fossil fuel reduction, a steering effect concerning emission reduction can be seen in the fact that the boiler shall carry the ecolabel UZ37 (see Chapter 3.12).

There are additional subsidies on provincial and/or community level. An updated document provides an overview of the current (2022) funding options for wood heating systems in Austria (community funding programmes not included): [LINK](#) [183].

In Austria, funding priority is given to the connection to district heating. If district heating is not available, highly efficient and clean biomass boilers or heat pumps are funded with the same amount.

Canada

There was a Federal subsidy program, the ecoENERGY Retrofit-Homes program (April 2007 to March 2012), which provided grants up to \$5,000 to help homeowners. Replacement of wood-burning system or appliance (both indoor and outdoor) was incentivised as long as the appliance was certified to either standard: CAN/CSA-B415.1 or the United States Environmental Protection Agency (EPA) 40 CFR Part 60. This is also typical for programs which are published on district level.

For stoves. On district level there are several other programs, which are also considering wood stoves. In the *Northwest Territories* The Arctic Energy Alliance (AEA) provides rebates for the purchase of new, more energy efficient models of products, [LINK](#) [42]. Log wood stoves and pellet stoves receive 50 % of purchase cost (up to \$1,000), while combinations of boilers and water heaters receive \$1,250. In *Nova Scotia* a heating system rebate program offers rebates between \$150 and \$2,500, to upgrade to an efficient home heating system, including wood heating equipment. Homeowners using electricity for heating receive low interest financing to help install wood heating equipment, among other Energy Star® certified heating equipment. In *Yukon* the Good Energy Program offers between \$300 and \$800 rebate, depending on the appliance type, [LINK](#) [43]. *Nunavatsiavut communities* offers a complete cost covered program for certain income levels, wood stoves are eligible, [LINK](#) [44]. *Prince Edwards Island* has an equipment upgrade rebate for biomass heating devices; biomass stoves certified to EPA or CSA B415.1-10 [82] can receive up to \$1,000 under regular rebate, or up to \$1,800 under low-income rebate, and for boilers up to \$2,000/\$3,500, [LINK](#) [45]. In *New Brunswick* a rebate program is combined with other home improvements, rebate amounts for pellet stove and for wood or pellet boiler or furnace range from \$500 to \$700 (depending on performance), [LINK](#) [46]. Eligible wood/pellet equipment in New Brunswick must meet either the CSA-B415.1-10 or the US EPA 40CFR Part 60 AAA standard, and a reference to a US database is given for finding suitable appliances, [LINK](#) [47]. In *Quebec* financial assistance is provided under the “Chauffez Vert” program for replacement of an oil or propane central heating system with a system powered by an eligible renewable energy. E. g. the replacement of a heating oil system in a single-family house will be awarded with \$1,275, in a semi-detached or row home \$875, in a mobile home \$1,075, in a duplex or triplex \$875 per eligible unit; in residential buildings with multiple units \$550 per unit.

For boilers. At federal level, various programs have existed that have helped with the installation of small biomass boilers as a replacement for fossil fuels. The Bioheat Stream under the Clean Energy for Remote and rural communities (CERCC) Program aims to reduce the heavy reliance on diesel, fuel oil and propane mainly for heating needs. The total funding allocation for the Bioheat Stream was \$55 million and came into effect in April 2018 and ends March 2024. Feasibility studies and/or installation of proven biomass combustion heating systems, district heating and combined heat and power systems are eligible. The expected range of funding is up to \$ 5 million per project, [LINK](#) [48].

In the *Northwest Territories* eligible communities, commercial businesses, non-profit organizations and NWT residents are eligible for up to \$20,000 in rebate funding while businesses, community governments, indigenous governments and non-profit organizations are eligible for up to \$50,000. Eligible wood heating technologies include wood pellet boilers/furnaces for space heating and EPA certified wood boilers/-furnaces, [LINK](#) [49]. *Prince Edwards Island* as part of its Equipment Upgrade Rebate offers rebates for the installation of Energy Star® certified heating equipment, and biomass heating devices. The biomass boilers and furnaces are eligible up to \$2,000 under regular rebate, and up to \$3,500 under low-income rebate, while the equipment must be certified to US EPA or CSA B415.1 [82] standards, [LINK](#) [45]. In *Quebec* the bioenergy program, administered by the Ministry of Energy and Natural Resources and financed by the Green Fund, aims to reduce greenhouse gas emissions and the consumption of fossil fuels by financing energy conversion projects to bioenergy. The financial assistance program was relaunched on June 29, 2017, it is offered to businesses, institutions and municipalities [LINK](#) [50].

Switzerland

For stoves. There was no subsidy program for wood stoves in Switzerland.

For boilers and heating plants. Support was or is available via the following Swiss programs.

- *Foundation of Climate Protection and Carbon Offset "KliK"*. Since 2013 the KliK-Program provides support for wood boilers of all sizes throughout entire Switzerland. The funding is CHF 100 per t fossil CO_{2,eq} replaced. It is a specific program for medium-sized and smaller heating networks. For example when 100,000 m³n gas are replaced with wood a yearly subsidy of 20,000 CHF is paid until 2030.
- *Building Program (Gebäudeprogramm)*. This program from the Swiss Federation and the Cantons runs since 2015 in entire Switzerland. It applies to wood boilers of all sizes and provides minimum subsidy

rates, either as a single fixed payment per installation or depending on the installed thermal power. For example, automatic wood-fired systems up to 70 kW are subsidized with at least CHF 3,000 per system and a performance-based component of CHF 50 per kW of thermal output. The Building Program is executed differently from canton-to-canton. In canton Berne for wood combustion >70 kW the new system must cover 100 % of the heat demand. Then the subsidy is limited to 35% of the system costs. In the canton of Zurich only wood heating plants >300 kW are subsidized when an oil or gas heating system is replaced.

- *Energy Future Switzerland (Energiezukunft Schweiz, EZS)*. This program runs since 2020 in entire Switzerland and it applies to wood boilers of all sizes. The funding is CHF 1.80 per litre of heating oil or cubic metre of natural gas which is replaced by wood. With a correct dimensioning of the wood boiler/heating plant, this corresponds to around CHF 360 per kW rated thermal input.
- *Myclimate*. The program runs since 2020 in entire Switzerland and applies to pellet boilers of 70 kW and below. Funding amounts, conditions and requirements are the same as for the “EZS”-program.
- *Investment Contribution Program*. Such contribution is given by the Swiss Federal Office of Energy (SFOE) for combined heat and power plants (CHP), it runs since 2018, when it replaced the system of the cost-covering feed-in subsidy of the electricity produced by wood based CHP. The investment contribution is limited to 20 % of the eligible investment costs and a maximum of 100 % of the non-amortisable additional costs. From 2023 on the max. 20 % will be increased to max. 60 % of the eligible investment costs.

Stimulation for the use of advanced and clean boilers. In the “*Building Program*” most cantons only support projects with wood heating plants >70 kW or even larger (e.g. canton Zurich). To ensure a high quality, most cantons request that the planning process is assisted by QM Holzheizwerke®, [LINK](#) [51], a quality management system for automated wood heating plants. The focus of QM Holzheizwerke® is an optimized design, planning and execution of the heat generation system and the thermal network. The quality goals are a reliable low-maintenance operation, high efficiency and low distribution losses, low emissions in all operating conditions, precise control and sustainable economic efficiency.

In “*Energy Future Switzerland*” all boilers with a maximum heating power of 70 kW (pellet, log wood or wood chips) must be planned as a central heating system and a performance guarantee must be presented, which confirms that of the boiler product is in accordance with the targets of the Swiss Federal Office of Energy and its program “EnergieSchweiz”. Furthermore, the quality label for wood boilers from Swiss association on wood energy (“Holzenergie Schweiz”) must be presented (see Chapter 3.12). Boilers which are larger than 70 kW have to undergo the review process of QM Holzheizwerke® during the planning process.

In the “*Investment Contribution-Program*” a subsidy is only possible for large plants and as the actual technical standard of new plants in Switzerland is very high, only clean and advanced technology is used.

Germany

For log wood stoves. In the early 2010s there were temporary campaigns combined with subsidy programs aiming at a replacement of older wood stoves by providing incentives for more advanced appliances. This happened in several German cities.

- *City of Aachen*. They implemented the short term program “AltbauPlus” (from Dec 2010 till Dec 2011), [LINK](#) [34]. There was a 50 € subsidy for immediate shutdown, or, 25 % of eligible costs as subsidy for replacement (max. 250 €), or 50 % of eligible costs for retrofit PM-reducing devices (max. 500 €). These devices (ESP’s or combustion air control devices) were listed in a continuously updated document. Further requirements were that the owner had to sign a written commitment that of the old appliance would not be sold, and the consultancy and approval of the responsible chimney sweep was required.
- *City of Munich*. The Munich program was in power from Oct 2014 until around 2017, it ended when the total budget of 100,000 € was utilized, [LINK](#) [35]. There was a subsidy of 30 % of eligible costs or max. 300 € for each replacement of an older log wood stove. Total eligible costs included the acquisition and installation costs. It was required that the new stove would prematurely comply with the limit values of stage 2 of the 1. BImSchV [4] as proven by a type test certificate provided by the manufacturer.

Also, a letter of commitment was needed, declaring that the owner would not resell the new stove. And the consultancy and approval of the responsible district chimney sweep was needed. The program was meant to shorten the designated transition period from older to new devices (i. e. time until legal operating permit expires, see Chapter 3.1), in order to create an immediate benefit for air quality.

- *State of Rhineland-Palatinate*. The program “1000 Efficient Stoves for Rhineland-Palatinate” was launched, starting from 30.08.2017, [LINK1](#) and [LINK2](#) [36]. The program expired automatically when 500,000 € had been spent. The subsidy paid was differentiated: for replacement by a new log wood stove having $\geq 82\%$ efficiency: 300 €, for $\geq 85\%$ efficiency: 500 €, for replacement by a new pellet stove $\geq 92\%$ efficiency: 500 €, for replacement by a new wood stove with water jacket (log wood or pellets) $\geq 85\%$ efficiency: 800 € subsidy. Replacement happened for room heaters built between 01/01/1985 and 01/01/1995 which did not meet the emission requirements of Stage 2 of 1. BImSchV [4]. More than 1,400 units were subsidized.

For pellet stoves. Pellet stoves with water jacket for central heating purposes are until to date continuously being funded over the last 1.7 decades in Germany. They are mostly treated as boilers (see section below: funding for boilers).

For wood boilers. On Federal level the German Market Incentive Programme for Renewable Heating (MAP), [LINK](#) [61] has set new benchmarks for boiler technology over the past years. In 2020, this program was replaced by “Federal support scheme for efficient buildings” (BEG), [LINK](#) [37], with revision in Dec. 2023, [LINK](#). For many years (till Dec. 2019) special advanced boilers received the funding according to the MAP [61] as listed in Table 12.

Table 12: Subsidy for wood fuel boilers in Germany until Dec. 2019 ([LINK](#) [61]), before replacement by BEG-program

Boilers from 5 to 100 kW	In existing buildings	In new buildings
Log wood boilers	5,250 € (condensing boiler) or 3,000 € (with secondary particle removal device)	3,500 € (condensing boiler) or 2,000 € (with secondary particle removal device)
Wood chip boiler	5,250 € (condensing boiler or with secondary particle removal device)	3,500 € (condensing boiler or with secondary particle removal device)
Pellet boiler with <u>new</u> buffer tank	5,250 € (condensing boiler or with secondary particle removal device)	3,500 € (condensing boiler or with secondary particle removal device)
Pellet boiler without new buffer tank	4,500 € (condensing boiler or with secondary particle removal device)	3,000 € (condensing boiler or with secondary particle removal device)
Pellet stove with water jacket	3,000 € (with secondary particle removal device)	2,000 € (with secondary particle removal device)

A bonus system for ESP’s and for condensing boiler technology was introduced already in 2008. At that time only one boiler manufacturer was offering an integrated condensing unit in a residential pellet boiler and one manufacturer offered a retrofit condenser for different boiler types. In the meantime, the total number of such boiler manufacturers grew rapidly, in 2019 there were already 12 such manufacturers. Furthermore, in 2008 ESP’s for residential boilers had only been available as retrofit units by two manufacturers. Since then, a minimum number of 10 manufacturers now appear, of which 8 apply boiler-integrated ESP’s (in 2019). This development was clearly triggered by the specific requirements for the MAP subsidy.

In the funding scheme, particularly ambitious emission limits (@ 13% O₂) were also defined for a boiler to become eligible. They were: CO-emissions of 200 mg/m³_n at nominal heat output, 250 mg/m³_n at partial load operation; PM emissions for log wood boilers of 15 mg/m³_n, for all others 20 mg/m³_n; boiler

efficiency of $\geq 89\%$, but for pellet stoves with water jackets $\geq 90\%$. All these requirements were proven by boiler type testing certificate, according to EN 303-5. The heat buffer storage tank requirement was ≥ 30 litres per kW of nominal heating power for wood chip boilers, ≥ 55 litres per kW for wood log boilers. All appliances that comply with these requirements are listed in regularly updated documents ([LINK1](#) [38], [LINK2](#) [39]).

Amendment of boiler subsidy program in 2021. On Federal level the above MAP programme for renewable heating (MAP) was replaced by the “Federal support scheme for efficient buildings” (BEG), the first version started in Jan 2021, [LINK](#) [40] and was amended in 2023, [LINK](#) [40]. It became more attractive and was simplified, while additional technological improvements were awarded. And there is an extra innovation bonus given to the above flat rates if ultra-low PM-emissions are attested for the boiler (i.e. $\leq 2.5 \text{ mg/m}^3_{\text{n}} @ 13\% \text{ O}_2$). This needs to be proven by type testing certificate. Boilers that qualify for this new innovation bonus, are listed in a continuously updated document (the “positive-list”), [LINK](#) [41]. The other requirements as mentioned above remained also valid. But additionally, a heat storage tank is now required for eligible pellet boilers, too (30 litres per kW).

Denmark

Wood stoves. There was no direct subsidy scheme for installing a wood stove in Denmark. But the fact that biomass for heating purposes is exempted from energy tax is a general driver (see Chapter 3.5).

However, a number of scrapping schemes have existed. Here it has been possible to receive a scrapping bonus for replacing an older wood stove. This happened most recently in 2019/2020, where DKK 42 million (€ 5.6 million) had been allocated for scrapping allowances for wood stoves that were older than 1995. The scrapping bonus would apply either for replacing the old stove or closing the fireplace completely.

Wood boilers. There have not been any subsidy schemes for wood boilers since the 1990’ies. But the fact that biomass for heating purposes is exempted from energy tax has also here been an efficient driver to replace fossil fuel boilers with biomass boilers (see Chapter 3.5).

Italy

For stoves and boilers. There are funding programs which equally apply for local space heaters (LSH) and for wood boilers. The details are listed in the following.

- *National programme “Conto Termico”.* The Conto Termico subsidy program, [LINK](#) [52], provides incentives of up to 65 % of the investment costs for replacing an existing biomass heating plants of up to 2 MW power. The incentive is calculated using an algorithm based on power output and climate zone, that is renewable heat produced by the appliance during its technical life. For local space heaters (LSH) it covers in average 30-40 % of the investment costs for installing the heating plant. For boilers up to 35 kW it covers up to 30-35 % of investment costs, for larger boilers in average about 35-40 %. The incentive is paid directly to the beneficiary in one (up to € 5,000), two or five annual shares of the same amount. The program has an annual budget of 500 Mill. € (cumulative annual expenditure) which are always spent until funds are exhausted. There are minimum performance requirements from official type testing which are listed in the table below.

Table 13: Minimum performance requirements for receiving subsidies for wood fuel appliances in Italy, up to 12 June 2022.

Type of appliance	Certification	PM $\text{mg/m}^3_{\text{n}} @ 13\% \text{ O}_2$	CO $\text{g/m}^3_{\text{n}} @ 13\% \text{ O}_2$	Efficiency $\text{mg/m}^3_{\text{n}} @ 13\% \text{ O}_2$
Wood-LSH’s	EN 13240 EN 13229	40	1,5	>85%
Pellet-LSH’s	EN 14785	30	0,36	
log wood and wood chip boilers	EN 303-5 Class 5	30	0,36	87+log(Pn) >89% (>100 kW)
Pellet boilers		20	0,25	

The Legislative Decree 199/2021, which implemented RED II, introduced new requirements for access to Conto Termico starting from 13 June 2022, [LINK](#).

The following are the new requirements: In the case of replacement of an existing biomass heating plant, a new biomass heating appliances with at least 4-stars is required. In the case of a new installation or a replacement of an existing coal-fired or heating oil heating plant, a new biomass heating appliances with at least 5-stars is required. Only certified pellets can be used, or a quality better or equal to that used in the certification of the appliance. There is an “PM emission bonus” too, for instance in the case of pellet boilers the granted bonus is +20 % of the incentive if the PM-emission is in the range of 15-20 mg; if the PM-emission is ≤ 15 mg the bonus is +50 % of the incentive. For manually stocked boilers a heat storage tank is mandatory, having a volume which is calculated based on the formula in the European boiler standard EN 303-5 [53]; there the required storage volume is determined according to the nominal and partial boiler load, the burning duration and the heat load of the building. For automatically stoked wood chip boilers a puffer tank of at least 20 l/kW is mandatory. For pellet boilers it is mandatory that the puffer tank and the appropriate volume shall be dimensioned by the planner. The actual Conto Termico (2.0) will be converted in 2025 into the 3.0-version, nevertheless, as mentioned above, a tightening of performance requirements has already entered into force, in application of Annex IV to decree 199/2021 (Implementation of Directive (EU) 2018/2001 of the European Parliament and of the Council, of 11 December 2018, on the promotion of the use of energy from renewable)..

- *National programme: “Fiscal deduction”*. This incentive is applicable to log wood and pellet appliances and to woody biomass boilers up to 500 kW which are certified in accordance with the respective European standards, [LINK](#) [54]. Besides, starting from 13 June 2022, when the installation replaces an existing biomass appliance the new appliance must be at least rated 4-Stars, in all other cases 5-Stars. These are the new environmental requirements (see Chapter 3.3). The subsidy program is extended from year to year.
- *Regional programmes*. There are also some regional programs (i.e. Po Regions) where incentives are given for replacing stoves that are rated less than 3- or 4-Stars. These programmes started within 2021 and will be extended up to 2025. Po-Regions and other Italian regions have already activated this measure, starting from July 2021, [LINK](#) [55].

The Netherlands

For stoves. Only for pellet stoves there was the ISDE subsidy programme between 2016-2019 (4 years), where a new stove received substantial subsidy. The funding was 50 € per kW, with a minimum of 500 € for pellet stoves that was used as room heater only. If a pellet stove also had a water jacket for delivery of heat to other rooms the minimum funding was 1,400 € (or 50 € per kW). The sole requirement was that the supplier could show that the stove would comply with Ecodesign limits (see Chapter 2.3). In the initial concept an additional requirement was planned to be incorporated, namely that only certified installers should be involved, to guarantee proper installations, but this was considered too complex to implement. The attractive funding had raised enormous interest, and new actors started to sell pellet stoves. In practise, however the installation quality was in many cases inappropriate, and largely due to the several bad examples the public perception became quite negative. As a result, the program was stopped again in 2020.

For boilers. For biomass boilers up to 500 kW, there was the ISDE subsidy programme between 2016 and 2019 that stimulated investments. Irrespective of the type of boiler (hand fired, automatic fired, type of fuel, all biomass boilers that complied with the then existing limits for boilers used in companies under the ‘Activiteitenbesluit’ (38 mg/m³_n dust, 750 mg/m³_n CO, 300 mg/m³_n NO_x @ 6 % O₂) could receive this subsidy. This stimulation for the use of advanced and clean boilers was enforced by the fact that a whitelist of those boilers was prepared that had demonstrated ability to meet these emission limits and were thus eligible for the subsidy.

This ISDE investment subsidy decreased over time, in 2019 it was 70 € per kW with a minimum of 1,250 € per installation. The programme was then completely stopped in 2020 after the public debate increased on the envisaged effects on air pollution and doubts about short term CO₂-neutrality. For larger industrially used biomass boilers, the SDE subsidy scheme provided operational support, similar to a

contract for difference. Due to the same public opposition against biomass combustion, this subsidy scheme was completely abolished for application of biomass boilers in case of low temperature heat combustion (< 100°C feed temperature).

Norway

For wood stoves. There was a governmental subsidy program financed by ENOVA for replacement of stoves which were older than 1998 by a new burning appliance which fulfils the current market requirements. There were also city or county programs in some cities and densely populated areas. Enova no longer provides financial support (only in an initial phase to provide market introduction support for new technologies). The usual amount of funding (governmental or regional) was about 400 € per unit.

For wood boilers. The Enova program currently includes a subsidy scheme for water based central heating units with wood fuel. The subsidy for Wood or pellet stoves with water jacket is at 10,000 NOK (about 1,000 €). [LINK](#) [147]. This is also true for residential biomass boilers. The funding requirement is that the appliance shall be new (from factory) and will become newly installed, a replacement of an older unit is thus not eligible. All units must be approved for use in Norway.

Sweden

From 2001 to 2006 the conversion of oil boilers or electricity heating to other types of sustainable residential heating of houses was supported by the Swedish Energy Agency. This included the change to biomass but also to heat pumps or to district heating. It was a 30 % investment aid on the labour and material costs for the installation. The focus was set on chancing to renewable energy, not to reduce emissions.

USA

A variety of tax credits are available for purchase and installation of new wood stoves. Most of these are available at the Federal level. Biomass stoves are defined as appliances that “burn biomass fuel to heat a home or heat water”.

Beginning in 2021, consumers buying qualifying wood or pellet appliances (or larger residential biomass heating systems) are entitled to an income tax credit on 26 % of the full cost (purchase and installation) of the unit. The credit remained at 26 % through 2021 and 2022, but then it was reduced to 22 % in 2023. This provision is part of the Biomass Thermal Utilization (BTU) Act, [LINK](#) [213]. To claim the tax credit, installed biomass systems must have a Thermal Efficiency Rating of at least 75%. The credit is uncapped and based on the full cost (purchase and installation) of the unit. It must be for the year the product installation is completed, [LINK](#) [214].

From 2023 through 2032, a tax credit of \$2,000 annually is offered. It is based on 30 percent of the purchase price for qualifying wood stoves and installation costs are eligible. This new tax credit, which was part of the “Inflation Reduction Act”, has the following additional features, [LINK](#) [215]; [LINK](#) [216]:

- can be used for more than one appliance, purchased sequentially
- is a lifetime credit
- purchase and installation costs of certain accessories (such as chimneys and vents) do count towards the credit
- does not phase out for higher income earners (i.e. no income restrictions)
- is available for both wood stoves and pellet stoves
- is closely associated with heat pump tax credit
- is available only for EPA certified and/or high efficiency units (thermal efficiency rating of at least 75 %)

A list of the qualifying wood stoves can be found here: [LINK](#) [217].

3.5 Other indirect regulatory measures

Indirect regulatory measures have non-monetary impacts which are effective via changing the legal framework conditions towards or against wood energy use or towards certain wood energy technologies. The preceding questions to this chapter were:

A) *“Is solid fuel combustion affected through any (upcoming) building standards?”*

NOTE: Chimney regulations are addressed in Chapter 3.8

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	yes	yes	yes	yes	no	yes	no	yes	no	No

B) *“Is solid fuel combustion directly or indirectly affected by taxation and fees?”*

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	yes	no	no	yes	yes	yes	no	no	no	yes

C) *“Is solid fuel combustion restricted when a certain level of population density is exceeded?”*

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	no	no	no	no	no	no	no	no	no	no

D) *“If applicable: Is there a penalty for using solid fuels in households?”*

Country	AT	CA	DE	DK	IT	NL	NO	SE	USA
Answer	no	no	no	no	yes	no	no	no	no

Chapter summary

Building standards can have various impacts on residential wood fuel use and this was confirmed by most of the participating countries. A core element of the building is the chimney, which can even be a mandatory component, depending on the building’s energy standard (e. g. in Austria and Norway). But a chimney can also become problematic if advanced efficiency standards need to be met; then the heat losses during standstill phases are contrary to the objectives. In Europe, the national energy acts for buildings follow an EU-directive on energy performance of buildings, and this more and more intensifies the incentive to avoid a chimney at all as its existence can mean to become downgraded in the energy consumption certificate, which is today generally required, also for older buildings. Direct requirements concerning the chimney itself (e. g. height, position) are covered in Chapter 3.8.

Apart from insulation and efficiency requirements, building standards can also include renewable energy obligations. This, for example, is true in Germany and in Italy. The German regulation describes an obligation for using renewable energies in space heating of new buildings, which can be fulfilled by a minimum of 50 % heat provision through an automatically fed wood boiler, but not by wood stoves or log wood boilers. In Italy, there is also a 50 % obligation of renewables, and this refers both to boilers and stoves. Only in the Italian Po-Regions, a deviation from this regulation was made possible because this region suffers from wood smoke.

Taxation is also a wide field of activities for influencing bioenergy applications through specific wood-fuel based regulations, e.g. in the USA tax credits are even granted to stimulate the purchase of a new stove. However, there is no known tax that would aim to penalise or avert emission-related burdens. This is

probably because taxation (e.g. of a stove or chimney system) is hardly the responsibility of the regions or municipalities that bear the actual burden of excessive pollutant emissions. Taxation is rather used as a method to push forward the use of wood fuels, e. g. in Germany, where the VAT on log wood and forest wood chips remains reduced at 5.5 % or 7 %, and in Italy firewood and wood chips are at a VAT level of 10 % instead of 22 %.

But also, the exemption of biomass fuels from existing CO₂-taxation schemes is influencing wood fuel applications by introducing a competitive advantage. However, such efforts have never shown any aspect which would directly aim at pollutant emission reductions. Also, no municipal fees were found which could be air quality related.

From the answers collected, it also became clear that there isn't an emission regulation which directly applies differentiated emission limits or would allow certain maximum emission mass flows by population density (e. g. via an emission cadastre). However, regions with high population densities are generally more likely forced to launch preventive or limiting measures concerning wood fuel applications. Such measures are described in Chapter 3.2. An approach, that comes a bit closer to a spatially differentiated emission control strategy comes from Canada, where a guidance manual for managing air emissions from small solid biomass combustors is proposed for jurisdictions to use a stepped or tiered approach to manage air emissions.

Austria

Building standards. Solid fuel combustion is not directly affected by changes in the new building standards, but there are indirect effects. In the new building standards of several provinces the mandatory requirement of a chimney system in every new building was omitted. Thereby, many new buildings in these provinces do not have a built-in chimney anymore. This makes the later installation of combustion appliances difficult or at least more expensive.

Taxation. Austria is implanting a carbon tax in July 2022. The tax will start at 30 €/t of CO₂ and increase annually until 2025 (2023: 35 €/t, 2024: 45 €/t, 2025: 55 €/t). The CO₂-taxation pathway on fossil fuels is almost the same as in Germany.

Canada

Building standards. In Canada, the energy efficiency of buildings is characterized according to a National Energy Code for Buildings (NECB) [LINK](#), [56], which applies to commercial and institutional buildings, and to the National Building Code (NBC), [LINK](#) [57], which applies to small buildings and houses. These are key components of the model code system that define the minimum energy efficiency requirements for the construction of new buildings. Both NECB and provincial/territorial building codes specify for solid-fuel-burning space-heating equipment to meet the EPA 40 CFR, Part 60, Subpart AAA or CSA B415.1 [82].

Population density. In the recently published Guidance manual for Managing Air Emissions from Small Solid Biomass Combustors (SSBC), by CCME [58], it is proposed for jurisdictions to use a stepped or tiered approach to manage air emissions (Table 14). This tiered approach reflects current Canadian realities, in which some jurisdictions have fairly sophisticated regulatory frameworks and others have no regulation at all or deal with new installations on a case-by-case basis. The Tier 1 requirements cover a basic level of regulation across all types of SSBCs. While Tiers 2 and 3 are for specific air sheds or jurisdictions.

Table 14: CCME recommended tiered approach to manage air emissions from small solid biomass combustors in Canadian jurisdictions, [LINK](#) [58]

Levels	Typical situation
Tier 1	<ul style="list-style-type: none"> - Minimal exposure of population to particulate matter (PM) - Jurisdictions currently without regulations for SSBCs - Rural areas or areas with low population density - No public concern about using wood fuels
Tier 2	<ul style="list-style-type: none"> - Areas with medium population density - Jurisdictions with basic regulations for SSBCs in place - Areas where there is some public concern about using wood fuels - Buildings close to SSBCs can be protected by increasing stack height
Tier 3	<ul style="list-style-type: none"> - Exposure of large population to SSBC emissions - Urban areas or areas with high population densities - Areas with poor air quality - Areas with existing elevated public concern about using wood fuel

Switzerland

Building standards. The stack height is regulated in the Swiss Ordinance on Air Pollution Control (OAPC) ([LINK](#) [16]), depending on the mass flow of the flue gas. Depending on the location and/or the size of the combustion device the process of attaining a building permit for the chimney can be limited and/or complicated (e.g. in case of buildings under monument conservation or protected landscapes).

Taxation and fees. Since 2008 there is a CO₂ act in Switzerland:

- Anyone who imports "extra-light" heating oil with a Sulphur content of more than 0.1 percent (% mass) or produces or extracts it domestically pays an incentive tax to the Swiss Confederation.
- Anyone who uses fuels of fossil origin (heating oil, coal, gas) must pay an incentive tax to the Confederation on the basis of the CO₂ act and in accordance with the CO₂ ordinance of 30 November 2012.
- Energy-intensive companies with emissions of more than 100 tons of CO₂ per year can be exempted from the levy, if they commit to a CO₂ reduction target and proof the committed targets by an independent reporting.

CO₂ tax for coal is collected by the customs when coal is imported. But in Switzerland there is no coal production and only a very limited utilization. In 2020 the CO₂ tax was 120 CHF per ton CO₂. There is also the Mineral Oil Tax which taxes the users who must pay a tax of 0.3 Rp/l for "extra-light" heating oil.

Population density. There is no direct differentiation of measures according to population density. But most of the cantons have cantonal Action Plans where "action regions ("Massnahmegebiete") are defined. In the actual Action Plans in most of the densely populated cantons (e.g. Zurich, Basel) the entire cantonal areas are defined as action region. In such regions emission limit values are stricter than in the OAPC and there are often additional regulations (e.g. number of starts are limited, stricter regulations on the allowed fuel, see Chapter 3.2).

Germany

Insulation standards. Standards for insulation of buildings were constantly tightened in Germany over the last years. This development has influenced the framework conditions for biomass heating systems. In new buildings, the integration of a chimney is often not anymore considered because of the heat losses during standstill phases which hinder the fulfilment of building efficiency targets. Furthermore, an extremely low energy consuming building, e.g. the "3-litre-house" (i.e. 30 kWh/m² or annually 3 litres of heating oil per m³) or the "Passive House Standard (15 kWh/m²) would require very low heating power output which is

currently not broadly available with stoves or boilers, or it may require the use of appliances which have to operate in partial load.

Energy consumption certificate. The German Energy Act for Buildings (Gebäudeenergiegesetz 2020, GEG, [LINK](#) [59]) describes the energy performance certificate for buildings which had become compulsory in 2009 according to the EU-directive on energy performance of buildings, [LINK](#) [60]. Since 2014, this specific certificate (8 classes, from A+ to G) needs to be presented to potential tenants or buyers for each building. On the real estate market this regulation stimulates competition towards higher efficiencies, and often the existence of an additional chimney for a wood stove is then seen as a disadvantage due to the chance for becoming downgraded in the certificate.

Renewable energy obligation. The above mentioned GEG ([LINK](#) [59]) also describes an obligation for the use of renewable energies in space heating of new buildings. By using biomass fuels, this obligation can be fulfilled. But this is only true if automatic boilers are applied, including pellet stoves with water jackets. Contributions from log wood stoves or log wood boilers are not considered. A minimum of 50 % contribution from biomass is required if the biomass option is chosen.

Taxation and fees. Taxes that are introduced to place an additional burden of fuel use due to higher pollutant emission do not exist. There is rather an opposite situation, as some wood fuels benefit from the existing taxation.

- There is a reduced Value Added Tax (VAT) rate for log wood fuels. The rate is 5.5 % or 7 %, depending on the taxation status of the forestry enterprise,
- For wood pellets the VAT rate is the usual 19 %
- For wood chips the VAT rate is either 7 % or 19 %, depending on the raw material used.

Being a renewable energy source, wood fuels are also exempted from both, energy tax and CO₂-tax.

Penalties. Such penalties are only possible if illegal fuels (e.g. waste, paper, bark briquettes) are used. (See Chapter 3.6)

Denmark

Biomass for heating purposes is exempted from energy tax. This has been an efficient driver to replace fossil fuel boilers by biomass boilers, both for domestic heating and in district heating schemes over a long period of time (more than 25 years). While energy taxes, carbon taxes, NO_x-taxes and sulphur taxes apply to fossil fuels, the energy tax exemption and low sulphur tax for biomass have paved the way for low operational costs which has more than levelled the extra investment cost in biomass combustion equipment.

Italy

Renewable energy obligation. In Italy for getting the permission for a new building or the permission to implement a major renovation of an old building, it is mandatory to cover minimum 60 % of the energy consumption (heating, cooling, sanitary water) by renewable energy resource (RES). In the case of bivalent heating systems (presence of both one or more biomass appliances and a fossil source appliance for covering the building's thermal needs) and in the presence of a centralized boiler or biomass appliances with water jacket, the maximum contribution attributable to the biomass (RES) is 90 %. But on the other hand, in the presence of air biomass room heaters, the accepted contribution is maximum 30 %. And in the case of a manually stocked log wood appliance the maximum is 50 % (source: UNI/TS 11300).

The biomass primary energy conversion factor is 80%, it means that 80% of energy produced with wood is considered renewable. This gives an important advantage to wood as renewable resource. Nevertheless, in the Po-Regions regions a deviation from this regulation was introduced: In those areas of this regions which suffer from wood smoke, wood fuel cannot be considered as renewable energy source which could help to comply with the 60 % RES-obligation.

Taxation and fees. Several years ago, the Italian government increased the VAT for wood pellets, from 10 % to 22 %. For firewood and wood chips the VAT is still 10 % and no increase is currently planned.

Population density. Emission regulations do not directly differentiate according to population density, but indirectly there is an interconnection to the level of PM concentration in the air. In the Po-Regions regions there are two “PM alert” level: Level 1: 4 consecutive days with $PM_{10} > 50 \mu\text{g}/\text{m}^3$, and Level 2: 10 consecutive days with $PM_{10} > 50 \mu\text{g}/\text{m}^3$. Then the “emergency measures” as described in Chapter 3.2 apply in the Po-Regions regions.

Threat of penalty. There is a penalty when the biomass appliances with less than 4- or 5-Stars rating, is used during PM alert (see above), or if a 3-Stars appliance is still operated in the Po-Regions. Naturally, the penalty is only applicable if there is an on-site inspection by the competent authorities, therefore such penalties are very difficult to implement. Nevertheless, the Po-Regions have already intensified the registration and on-site inspections.

The Netherlands

In neither of the mentioned fields of indirect regulatory measures any steering effects for wood fuel use can be mentioned for The Netherlands.

Norway

An indirect impact is given by the fact that the erecting of a chimney is not mandatory in passive houses. Thus, the opportunities for residential wood heating will gradually slowly decline in the future.

There can also be specific regional restrictions for wood combustion in some cities or densely populated areas during certain climatic conditions in wintertime. This is related especially to $PM_{2.5}$ emissions, where levels exceeding a certain health impacting limit may cause local authorities to restrict the level of wood firing for a short period.

Sweden

In neither of the mentioned fields of indirect regulatory measures any steering effects for wood fuel use can be mentioned for Sweden.

USA

Taxation plays a certain role to encourage investments into newer wood stoves, this is done through tax credits for purchase and installation (see Chapter 3.4). Apart from this, no other indirect regulatory measures or any steering effects on wood fuel use can be mentioned for the USA.

3.6 Inspections of boilers, stoves, fuel or ash

The preceding question to this chapter was:

“Does a system of regular on-site inspections for wood combustion appliances exist?”

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
for wood stoves	yes	yes*	yes	yes	yes	yes	no	yes	yes**	no
for residential wood boilers	yes	yes*	yes	yes	yes	yes	no	yes	yes**	no

*not on regular basis **only for safety issues

Chapter summary

All involved countries except The Netherlands reported that mostly recurring on-site inspections for residential wood combustion appliances exist, this is true for both, wood stoves and wood boilers. In most cases the chimney sweeps are involved, but sometimes also specially trained and certified chimney technicians are mandated (Canada), or regional inspectors of heating plants for municipalities with more than 40,000 citizens become active (Italy). The inspections are mostly on a recurring basis, in Canada they are irregular and only purpose driven. In all other reported cases the chimney sweeps becomes active at a frequency of least once a year (Austria for stoves and Denmark), between 1 and 3 years (Austria for boilers, depending on size), every second year (Switzerland for stoves and boilers >70 kW, and Germany for boilers), every 3 years (Sweden), every 3.5 years (Germany for stoves), every 4 years (Switzerland, for boilers <70 kW) or depending on frequency of use (Norway). Additionally, the chimney sweeps are also doing the recurrent sweeping which usually happens much more frequently.

In all cases a main purpose for the inspections is to guarantee operational safety. But in several countries further goals shall also be achieved. In Austria, Germany, Switzerland, and Denmark the stove is also regularly checked for functioning and damages which will impact the combustion quality (e. g. worn out air sealings or door closure mechanisms, broken refractory linings), in Austria even a direct air tightness test is planned for the future. Additionally, in Switzerland, also the ash is looked at, to see if there were evidence for any illegal fuel use which would require an ash sample to be sent for analysis to an accredited test laboratory. In Germany, a very comprehensive national standard and checklist was elaborated to describe and harmonize all aspects of this inspection task. Furthermore, the authorized district chimney sweep in Germany has the obligation to instruct the stove owner every 3.5 years on the proper stove use according to the guidelines in the above-mentioned national standard.

Performance tests by on-site measurements are less common during the inspections. This is particularly true for stoves, where a recurrent emission test is performed in none of the involved countries. Only in Germany, at least the wood storage is regularly tested at the site for excessive fuel moisture content which shall be below $M=20\%$, this is done by using a rapid testing device. And in Germany, on-site measurements for CO and PM emissions can also be performed for stoves, but they are not recurrent and they are mainly to assign the stove to an advanced emission class in order to avoid a shutdown according to age, if scheduled. In Denmark an actual emission test of a stove is also possible if there is evidence for low performance as presumed after visual stove inspections. In Italy an on-site measuring routine of the chimney draught is applicable from April 2022.

Recurrent on-site emission measurements are only performed for residential boilers. Currently this happens only in Austria, Switzerland, Germany, and Italy. In Austria only CO-emissions are measured (annually or every 2 or 3 years, depending on nominal power). In Switzerland for boilers <70 kW CO-emission testing is applied whereas for boilers of 70-500 kW, CO and PM measurements are carried out recurrently. These measurements are performed by accredited measurement companies every 2 years (boilers of 70-500 kW) or every 4 years (boilers <70 kW).

The most comprehensive emission inspection infrastructure was built in Germany, where both PM- and CO-emissions are tested at all existing wood boilers which are larger than 4 kW, this happens every second

year. This infrastructure includes specially trained district chimney sweeps, the purchase and use of several type approved measuring devices which all have to undergo frequent inspections, the establishment of numerous national technical standards for all infrastructural elements and a dense network of about 20,000 chimney sweeps of which about 7,500 are “authorized district chimney sweeps” having a particular status of being a representative of the authorities, which means that the sweep is legally entitled to enter private homes.

There is also some movement to change the system of emission inspections in some countries. In Denmark, a previously existing scheme for annual boiler emission tests was abolished around 10 years ago as it proved too costly, both for owners and for the administration. In Italy, however, an on-site measuring of efficiency, draught and flue gas emissions (CO and NO_x) is currently being prepared and it shall become applicable for pellet stoves and all for wood boilers.

Austria

For stoves. The inspections are performed by the chimney sweeps. They are compulsory and happen usually once a year, however the respective legislation is on provincial level, so minor deviations in different provinces are possible. Chimney cleaning intervals are shorter, typically 2 or 3 cleanings per year, they are compulsory, too.

During inspections usually just operational safety is looked at, and the appliance is cleaned. For combustion appliances with external air supply (room air independent) a regular inspection of air tightness is also foreseen. There are inspection guidelines, but no details on the execution of inspections is given. Usually only reference to “suitable state-of-the-art methods” is made.

If complaints are submitted to the responsible body (usually the major or the district administration department) a mandatory inspection is one of the options to be decided. If the performance does not comply with existing requirements the responsible body has to set a deadline for the owner of the heating system until all deficiencies must be remedied. If this is not done a full operation ban is possible as final consequence.

For boilers. All wood boilers are being inspected on routine basis. Usually, regular inspections are performed by maintenance staff of the boiler manufacturers. Additionally, some chimney sweeps or testing companies are also offering this service.

The detailed inspection plan is defined in provincial law - therefore 9 different regulations are in force in Austria. However, the provincial legal implementation is based on an agreement of all provinces with the federal government (so called article 15a-agreement, defined in the Austrian constitution). Such agreements define the minimum requirements, each province must implement. Further or stricter requirements are possible as long as they do not contradict the minimum requirements of the 15a-agreement, which can be accessed here: [LINK \[184\]](#). These minimum inspection requirements for solid fuel boilers are:

- up to 15 kW: 3 years (only safety inspection)
- 15 - 50 kW: 2 years (safety and environment)
- above 50 kW: every year (safety and environment)

“Safety inspection” means mainly tightness of appliance and flue gas system, visual inspection of technical failures. An “environmental inspection” usually means that a CO measurement in the flue gas is performed. Such a test can only be performed by registered companies with measurement equipment fulfilling specific requirements.

Inspections can also be triggered by complaints from third parties. In such as case the procedure is the same as for stoves (see above).

For larger plants. Plants having a capacity of 0.1 to 50 MW fuel energy input are inspected more intensively, the inspections are performed by external experts as defined in the respective law. Inspection frequency depends on capacity and application (e.g. fuel, use of heat, etc.), but usually this happens at least once per year. The set of evaluated parameters is defined in the respective law. At least CO, dust or PM₁₀, and NO_x are included. In some cases, additionally a continuous monitoring of specific parameters (e.g. flue gas composition) may be required ([LINK1](#) [185], [LINK2](#) [186]).

Canada

Regular inspections of wood burning appliances are not required by most jurisdictions. But there can be purpose driven inspections.

A chimney technician may be trained and certified from a recognized organization such as WETT inc (Wood Energy Technology Transfer inc.), or the CSIA (Chimney Safety Institute of America). Inspection by WETT certified inspector may be required for the purposes of insurance, pre-purchase home inspection, system performance issues and where there are visible signs of damage.

Several rebate programs (such as those offered by City of Ottawa, Quebec City, New Brunswick) have specific language with regards to installation by WET certified professional: “All wood/pellet systems must be installed by a WETT certified professional that has either “Technician” or “Sweep” certification. Alternatively, an installation can occur by a non-WETT certified installer; however, the entire system must be subsequently inspected and approved by a WETT certified inspector. The invoice or receipt from the in-staller should have the name of the WETT certified individual or company.”

Example for Metro Vancouver. In the region the purpose driven inspections are performed by Environmental Regulation & Enforcement Officers. As for the Seasonal Prohibitions for wood heating in Vancouver from May 15 - Sep 15 (see Chapter 3.2) such inspections may be performed as a follow-up to complaints that are logged with Metro Vancouver (e.g. from May 15 until June 15, 2021, 36 complaints were logged). During the actual burning season which begins after Sep 15, a more proactive model directed at visible emission sources (chimneys) will commence inspecting as often as possible for conformance with Best Burning Practices, to assist with appliance registration, or both.

When inspecting for conformance with Best Burning Practices, the correct fuel use, moisture content of fuel and ash quality/creosote build-up are checked. When inspecting to assist with residential wood burning appliance registration the owner/operator’s name and contact information, including appliance address, appliance make and model and any additional information evidencing that the appliance meets reference emission standards are recorded. In all inspections visually driven tools are applied, such as a camera, clipboard, inspection form, writing instrument, and moisture meter.

Inspections may be triggered by air quality complaints lodged against a residential address where it is suspected that a wood burning appliance is being used incorrectly. Inspections may also be driven by visual observation from Metro Vancouver staff. This opens formal communication channels that include an escalating series of educational and advisory letters, and depending on the severity of the situation, may lead up to the potential issuance of a Notice of Bylaw Violation and/or a potential Municipal Ticket Information.

Example for Ville de Montréal. In enforcing the Bylaw 15-069 [18], Ville de Montréal established a follow-up of complaints and cases, which can be reported by calling 311 call line. Total of 9 inspectors enforce the Bylaw 15-069, and one technical agent conduct the case following. In cases of non-compliance, the City sends notices of infraction and may prosecute offenders. The City also ensures that devices and fireplaces are in its database by doing street checkups during winter usage.

Guidelines for inspections. For the actual performance of the inspections there are no standardized or harmonized implementation rules. But the inspecting staff is trained to check conformity with all relevant requirements which are mentioned in the standards. The installation standards are CAN/CSA-B365 (Installation Code for Solid-Fuel-Burning Appliances and Equipment) and CSA B366.1 (Solid Fuel Fired

Central Heating Appliances). The performance standards are CSA B415.1-10 [82] (Performance testing of solid-fuel-burning heating appliances) and US/EPA Code of Federal Regulations, Title 40, Part 60, Subpart AAA - (Standards of Performance for New Residential Wood Heaters). Additionally, for boilers it is a requirement to be stamped with the appropriate ASME Code product certification mark and registered with the National Board. Here the pollutant emission is not in the focus but rather boiler safety issues.

Switzerland

For stoves. In Switzerland stove inspections are performed by chimney sweeps and accredited measurement companies. This happens every 2 years. The parameters which are checked are the fuel used, the combustion residues and the condition of the installation. This is done by visual inspection according to the guidelines of the Swiss Association of Chimney Sweeps. When the combustion residues (i.e. the ash) show evidence that a non-authorized fuel was used, an ash sample is collected and sent for analysis to an accredited laboratory. The inspections can also be triggered by complaints of neighbours (odour nuisance or excessive visible dust pollution).

For boilers. Boiler inspections are only performed accredited measurement companies. For boilers <70 kW there is an acceptance measurement of CO and TSP (in the hot flue gas) and then periodic CO measurements every 4 years. For boilers 70-500 kW the compliance with emission limit values is checked every 2 years with measurements of CO and TSP. Compliance is checked with the CO emission limits by on-site measurement. During the course of this measurement also a visual inspection of the combustion residues (i.e. the ash) and of the wood fuel is carried out, this is done by visual inspection. Also these inspections can be triggered by complaints of neighbours (odour nuisance or excessive visible dust pollution). The same procedure is applied for large biomass boilers and CHP's, however, for large boilers >500 kW, depending on the size and wood fuel used, also additional components (e.g. NO_x, VOC, SO₂, NH₃, Pb, Zn, ...) have to be measured.

Measurements have to be conducted according to the emission measurement guidelines from the Federal Office for the Environment (i.e. for wood burning devices <70 kW: [LINK](#) [171], for wood burning devices >70 kW: [LINK](#) [172]). For wood burning devices <70 kW certain instructions be followed, for manually stoked boilers and stoves (manually stoked and automatic) the measurement procedure shall start 15 minutes after the cold start and for automatic boilers 15 min after the start of the fuel feeding. For stoves the measurement shall last at least over 15 min and for boilers over 30 min, however it can be split into 2 x 15 min. Boilers have to be set on "automatic" mode.

For wood burning devices >70 kW the emission limits according to the OAPC apply in principle to all normal operating conditions. However, during acceptance and control measurements not all possible operating conditions can be investigated. Therefore the measurements have to be conducted for the most common operating conditions. Consequently, mostly only the operating conditions at full load (>70 %) and part load (30 to 50 %) are measured. 3 x 15 min measurements are carried out from which 2 x 30 min mean values are calculated. The highest of the two 30 min mean values is used to check the compliance with the emission limit values.

For all devices, requirements exist concerning the measurement point (minimum distance between measurement opening and exit of the combustion device and other devices (e.g. ESP's or flue gas ventilators) or bends of the flue gas duct). Only measurement devices which are listed by the Suisse Federal Institute of Metrology (METAS) are allowed. TSP must be measured gravimetrically in the hot flue gas according to EN 13284-1.

Germany

Inspections for stoves. In Germany, stove inspections are performed by the "authorized chimney sweep" of the district, who is in a more elevated position compared to the staff or to a freelancer chimney sweep. The inspection happens twice in a 7-years-period. Compared to this inspection, the actual sweeping of the chimney is done by a regular chimney sweep, it happens between 2 or 4 times per year, depending on the frequency of use, which is estimated by the chimney sweep. The parameters and aspects that are looked after during stove inspections are:

- Conformity of appliance with European law (e.g. CE-certificate, Ü-certificate)
- Conformity of any existing ESP with European law (e.g. CE-certificate, Ü-certificate), if applicable
- Technical state and existence of obvious deficiencies of the appliance
- Admissibility of the fuels applied and their suitability according to the manufacturer's specifications (visual inspection)
- Moisture content of fuel is directly determined by onsite-measurement and is judged in relation to the requirements (except wood pellets)
- general suitability of physical fuel properties, existence of illegal or foreign materials and suitability of storage facility
- safety issues and relevant damages
- For open fireplaces: It is checked if the appliance is only used "occasionally", as it is written in the legislation (i.e. max 8 days per month for 5 hours and max. 30 days per year, see Chapter 3.2).

Fuel moisture content of wood logs is determined using measurement devices which have been certified according to VDI-Standard 4206, Part 4. The on-site measurement performance is described in VDI-Standard 4207-2 [29]: Three wood logs are sampled from the storage pile and they are each freshly split in 2 halves, before each log shall be tested by insertion of the sensor needles into the freshly split surface at three different spots (see image).



Stove inspections on complaints. Complaints about a stove or boiler operation can be directed to the environmental office of the district administration. This administration can then commission the authorized district chimney sweep to perform an unscheduled inspection of a stove or a boiler (following the above checklist). In some cases, this forced inspection can also include an extra emission measurement. In case of any irregularity or illegal operation (e. g. waste incineration), there is the possibility of a penalty. In repeated cases, a stove or boiler can also be shut down (see Chapter 3.7).

Standardized user instructions for stoves. If a new stove was installed or the stove has changed the user becomes instructed by the authorized district chimney sweep on the proper operation of the stove, on proper fuel storage and on all particularities concerning wood fuel handling. The content of these instructions for stove owners is provided in detail by the VDI-Standard 4207-2 [29]. The following details on information to be provided during the instruction of a stove owner are addressed in the standard:

Combustion process:

- Phases of combustion process: drying, devolatilization, gasification, combustion
- Endothermic and exothermic processes

Heating up

- Clean the grate
- Open air dampers
- Load fuel and use kindling
- Start the fire using the top-down method, if possible
- i.e. "Candle effect"
- Use fire starters (paraffin impregnated wool balls)
- High temperatures should be reached fast in the appliance

Refuelling:

- Pay attention to maximum fuel charge
- Pay attention to fuel moisture content
- Do not use small wood pieces or too chunky pieces to maintain the fire
- Place the split logs with the split face towards the fire bed
- Do not use unsplit rolls, if possible
- Pay attention to adequate distance from fire bed walls or internals, where applicable

Operation:

- Control thermal output via the fuel rate
- Do not force continuous operation through throttling the air supply
- Control interventions after ignition and during the burnout phase
- Follow manufacturer's instructions
- Combustion grate openings should always be covered by embers or fuel

- Maloperation results in smoke nuisance and poor efficiency along with increased deposits in the fireplace and the flue system (causing nuisances to the neighbourhood)

Fuel preparation:

- Match fuel size to stove
- Split large wood pieces if in doubt
- Large wood pieces are more problematic than small ones in the combustion process
- Split rolls at least once

Drying time

- Under favourable conditions soft wood may already be used after summer drying
- Hard wood should be allowed dry for two summer periods, if necessary
- Drying time depends on wood length
- Split wood dries faster
- Wood is hygroscopic

Storage:

- Outdoors, preferably on the south side, covered airy location, protected against rain and soil moisture
- Pay attention to appropriate distance from building walls and to spacing between stack rolls
- Take only dry wood into the building
- At unfavourable storage conditions wood may uptake moisture again

Handling of solid fuels:

- Use untreated wood only
- Make sure that wood is free from contaminants
- Do not use demolition wood or disposable wooden pallets unless their origin is free from doubt
- Make sure to use the right pellet class
- Industrial pellets are not suited for residential heating

Fireplace cleaning:

- Empty the ash pan regularly
- Keep grate openings clear
- Periodically clean the flue pipe and fireplace as necessary
- Check air inlets and air supply ducting for cleanliness and clean, if necessary

Maintenance:

- Check combustion air controls for proper functioning
- Check mechanically operated grates for smooth running
- Repair or replace damaged fire box internals
- Replace or supplement gaskets, if required
- Check proper function of throttling dampers, if installed
- Check combustion controls, if installed (automated stoves)

Fuel misuse:

- Only use suitable and authorized fuel
- Do not use compressed paper, carton and bark
- Do not use waste or refuse: "Refuse in the heater equates toxics in the garden"

Ash removal:

- Check ash pan for ash level prior to building the fire and empty, if necessary
- Do not spread the ash in the garden, but fill it in a non-combustible container and dispose it with the household waste after interim storage (ash normally has elevated pollutant concentrations)

Inspections for residential boilers. These inspections are performed every two years by the authorized chimney sweep of the district, who shall follow the technical rules described in VDI-Standard 4207-2 [29]. The actual sweeping of the chimney for a boiler happens twice per year. The parameters and aspects that are looked after during boiler inspections are:

- Conformity of appliance with European law (e.g. CE-certificate, Ü-certificate)
- Technical state and existence of obvious deficiencies of the appliance
- Existence of proper heat storage tank at the required volume
- Admissibility of the fuels applied and their suitability according to the manufacturer's specifications (visual inspection). Wood pellets shall be of A1 quality according to ISO 17225-2, supplier declarations or package labels are checked.
- Moisture content of fuel is determined and judged in relation to the requirements (this applies only for log wood and wood chips, not for pellets)
- General suitability of physical fuel properties, existence of illegal or foreign materials and suitability of storage facility

- Determination of CO-concentration in flue gas and accordance of results with emission limits. Measurements are performed at nominal heat load over 15 minutes.
- Determination of PM-concentration in flue gas and accordance of results with emission limits. Measurements are performed at nominal heat load over 15 minutes.
- The required emission measurements (CO and PM) are performed with all suitable fuels as declared by manufacturer (e.g. pellets & log wood).

Testing devices for flue gas measurement. Measuring equipment for boiler inspections by chimney sweeps require a certificate according to VDI-Standard 4206, Part 1 [26] (for CO-emission), and Part 2 [27] (for total particulate matter emission). Currently 5 testing devices are listed as being suitable for determining both, PM- and CO/O₂-concentration (Figure 7). PM is determined as total dust. During the type testing, the devices are evaluated towards a gravimetric reference measuring system which applies the heated filter method, following VDI Standard 2066, Part 1 [25].

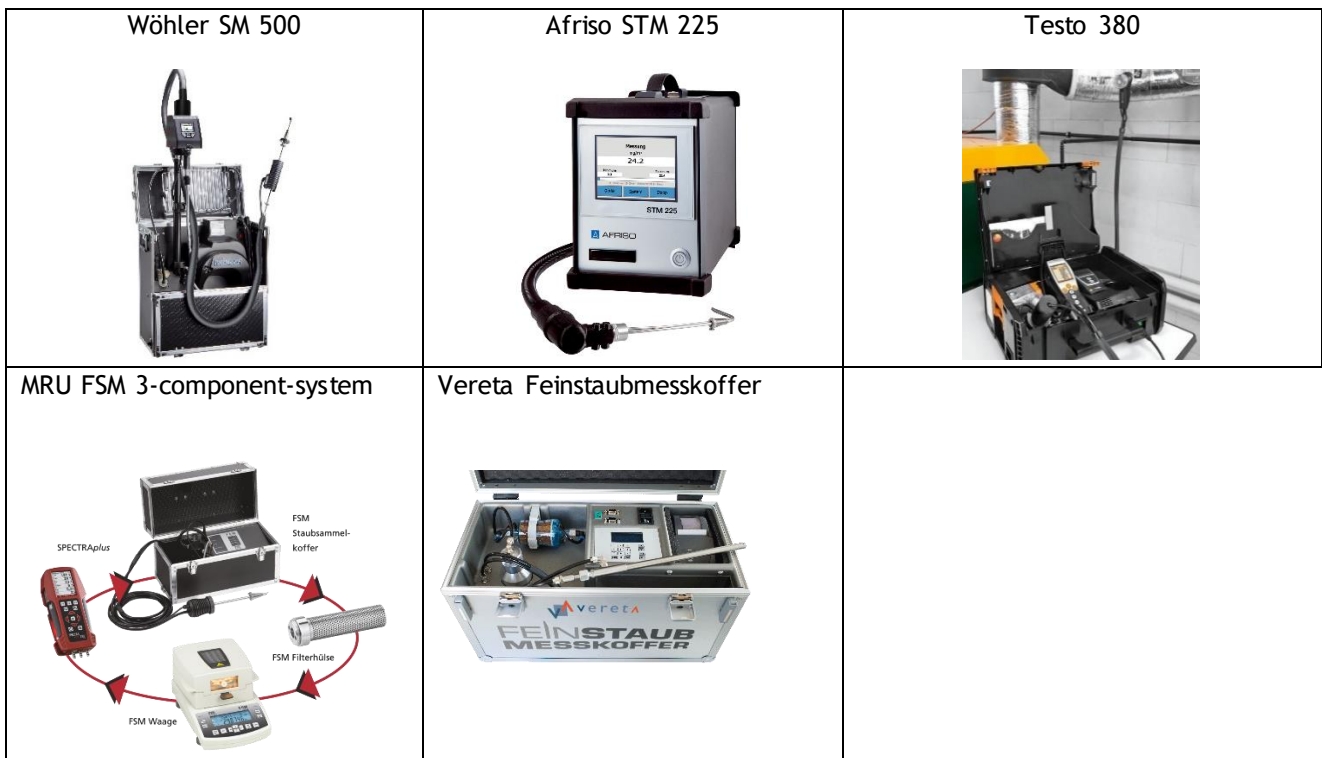


Figure 7: Approved measurement devices for on-site emission inspections by authorized chimney sweep in Germany [32]

When used for regular inspections the applied devices (Figure 7) shall undergo a routine checking for functioning and accuracy every 6 months. Bodies which perform the routine tests need to comply with requirements described in a specific national Standard (VDI 4208-2 [31]), where all details concerning required test gases, reference test systems, testing environment, qualification of personnel, documentation are specified. Also the operating chimney sweep him-/herself needs to be qualified for this function. Requirements for his/her qualification are described in the national VDI Standard 4208-1 [30].

Performing flue gas inspections. During the inspections, the flue gas sampling is performed over 15 minutes at nominal heat load. For wood chip boilers, the fuel which is then used shall be the lowest fuel quality as specified by the boiler manufacturer (A1, A2 or B, according to ISO 17225-4), unless the operator certifies by signature that the existing fuel at the site represents his usual fuel for the installation. The flue gas sampling port shall be located at a distance of roughly twice the diameter of the flue connector from the flue outlet, where possible. The probe position shall be at the core flow which shall be located by using a temperature sensor. All the details for the repeated on-site inspections are specified in the VDI-Standard 4207, Part 2 [29].

Testing devices and performance of wood chip moisture determination.

Measurement devices for proving conformity with moisture requirements in the national emission regulation (1. BImSchV [4]) require a certificate according to VDI-Standard 4206, Part 4 [28]. An example of such an approved device is given in the figure on the right (by Wöhler, HF550/FW550 [33]). With the availability of the mentioned standard for testing devices it is foreseen that wood chips shall be tested in the future, too, as it is already the case for inspections at wood log stoves (see above). Particularly, this applies to automatic boilers which are not capable of using wet fuel (i.e. >20 % moisture content), according to manufacturer's declaration.



Procedure for failure at boiler inspections. If a boiler does not pass the scheduled inspection measurement, a follow-up measurement becomes mandatory within 6 weeks. During this time, the appliance should receive servicing, be repaired or more suitable fuel shall be procured. If then the appliance fails again during the repeated measurement, notice is given to the environmental office of the district administration. This office will then decide whether a third measurement shall be performed. In final consequence, a replacement or a shutdown of the appliance may become decreed (see Chapter 3.7).

Determining illegal fuel origin. If there is evidence of any illegal fuel composition (e. g. by finding larger quantities of metal in the ash or plastic and textiles or carton/paper in the fuel), the authorized chimney sweep may collect samples from the combustion residues for analysis. The ash is then sieved (<2 mm) and the fine fraction becomes analysed for heavy metal content. Reference values (in mg/kg) are: As 30, Pb 200, Cd 10, Cr 400, Cu 600, Ni 200, Zn 2000, Cl 2000, Ti 1000 (VDI-Standard 4207, Part 2 [29]). If thus, evidence of illegal fuel use is confirmed this becomes documented in the measurement protocol which is then submitted to the respective authority.

Inspections at large scale biomass furnaces or CHP'S. The authorized chimney sweep can perform the flue gas inspection for wood furnaces up to 1,000 kW nominal heating power. Beyond this boundary an accredited measurement institute shall be assigned. The frequency of inspections then changes from every second year to every third year.

Denmark

For wood stoves. The local chimney sweep inspects the stove and chimney at least once a year. Depending on an individual assessment and subsequent agreement with the owner, the chimney sweep can decide for more frequent inspections. The local chimney sweep involves all aspects of the installation and operation. He is also the one to approve the type test certificate and the installation in the first place. Main indicators at the inspection would be ash quality and potential soot formation in the chimney. In case these indicators would be suspicious, he would dig deeper and potentially involve monitoring such as emission testing. If fire hazards are found, the chimney sweep is obliged to inform authorities. The inspections are not introducing any routine measurements but are mainly based on visual inspection of the stove and of the remains after sweeping the chimney.

Complaints can trigger an unannounced visit from the municipality in which the chimney sweep would take part. Such inspections would include ignition of the fireplace and assessment of the combustion quality. A ministerial order - Order no. 541 of 22/05/2017, normally called the "Chimney Sweep Ordinance" - regulates the work of the chimney sweeps. It is not very technical, [LINK](#) [164].

For wood boilers. Historically, Denmark had a scheme for annual boiler inspections. The scheme was abolished around 10 years ago as it proved too costly, both for owners and for the administration. Subsequently the chimney sweeps carry out annual inspections of the chimney only. The aspects and the extent of the inspections are basically the same as explained above for wood stoves, but additionally there can be energy balance calculations made if suspicious indicators are found. No routine measurements are applied, just visual inspection of the stove and of the remains after sweeping.

Also for wood boilers, complaints can trigger an unannounced visit from the municipality in which the chimney sweep would take part. Such inspections would include ignition of the boiler and an assessment

of the combustion quality. The same ministerial ordinance as mentioned above for stoves regulates this involvement of the chimney sweeps, [LINK](#) [164].

Italy

Inspected objects and intensity. The frequency of inspections of “heating plants” (residential stoves and boilers up to 3 MW) of buildings are established by qualified installer and maintenance technicians. They must define and declare in writing to the user which are the control and maintenance operations that the system installed and maintained by them is required (art. 7 of D.P.R. 74/2013 - Regulation defining the general criteria for the operation, management, control, maintenance, and inspection of heating plants). All heating systems must have a system booklet and must be registered in the “Regional Informatic Registry of Heating Plants” by qualified installers and maintenance technicians. All the control reports carried out on the heating systems must be uploaded to the cadastre.

Every year, the public control authority (usually regions, provinces or municipalities with more than 40,000 inhabitants) carry out random checks on registered plants. Every year a sample of heating plants registered is inspected. The system is not yet fully established, currently in average only 10 % of all room heaters (<35 kW) have been registered in the regional registries by the installers or maintainers.

Aspects checked. The aspects that are looked after are safety issues (conformity with the installation national standard, i.e. fire safety, ventilation openings, etc.) and maintenance issues (visual inspection of the system, cleaning the system including the chimney system). For biomass heating systems the cleaning of the chimney is mandatory: the shorter period between 2 years or 4 t of fuel used or in the case of inactivity of more than 2 years, before ignition (source: UNI 10683 [24]). Furthermore, it is recorded whether the appliance is properly registered and whether it has a proof concerning the minimum performance criteria. This proof is usually provided by the manufacturer to the end user via the “Environmental Certificate”, which shows how many “Stars” it had received in the classification (see Chapter 3.3). The certificate was issued by a notified body, based on type test results.

Upcoming changes. In April 2022 the new national standard, for the on-site measuring of efficiency, draught, and flue gas emissions (CO and NO_x) has been published. For log wood room heaters only the measurement of draught will be applicable, while for pellet stoves and all type of biomass boilers will become completely applicable. This standard also describes the procedures and minimum requirements of rapid devices for the on-site measuring of moisture content in log wood and wood chips. With the new standard it is now also possible for biomass appliances and boilers to carry out the “Energy efficiency report” by qualified installers and maintenance technicians. The frequency of on-site checks and the limit values to be respected will be defined shortly in a specific decree under development at the Ministry. At this time (December 2024), a draft of the decree has been sent to the conference of the regions for a technical consultation. The publication of the decree is expected within the first half of 2025.

Procedure upon complaints. Complaints are reported quite often in winter. Before the publication of the Italian standard (UNI 10389-2 [23]) it was difficult for inspectors to check the appliance and the appropriate quality of wood. With the new technical standard, it is expected that the inspections will become more effective. Sanctions of the responsible person for the appliance can only become effective after a series of cases with non-compliance (i. e. use of contaminated wood). Also, for plants >35 kW an on-site checking of emission level can be decided directly by the authority and the responsible plant owner, or the operator can become sanctioned.

Guidelines for inspection. The inspecting staff will check conformity with the national installation standard for biomass appliances up to 35 kW (UNI 10683:2022 [24]).

Inspection of boilers >35 kW. For inspections at larger appliances >35 kW an on-site emission measurement is mandatory. This on-site measurement shall be performed by a testing service provider which complies with ISO 17025 [22].

Larger plants. The above-mentioned inspection rules apply for boilers up to 3 MW (for space heating purposes) and for boilers up to 1 MW in the case of industrial heating plants (process heat). For larger plants, a specific emission authorisation is needed. Then, all monitoring requirements for the plants are established in the permission document. Plants with more than 5 MW heating power require continuous emission monitoring.

The Netherlands

There are no regular or purpose driven inspections of residential wood burning appliance in The Netherlands.

Norway

For stoves and boilers. To ensure a secure operation and a correct installation, wood stoves and residential wood boilers are inspected. This is done by the chimney sweeps in combination their regular visit for sweeping. A testing for flue gas emissions or for ash quality is not performed. The inspection intervals are irregular, depending on the intensity of use. This intensity is estimated during the chimney sweeping. Inspection intervals can be several years. The inspection is done visually and by using chimney sweeping equipment. In principle the inspections could also be triggered by complaints, but this hardly happens in practise. The owner has a general obligation to operate the appliance correctly and to carry out maintenance to ensure good performance and safety. There are several requirements connected to correct installation/safety, relevant documents are issued by the Ministry of Justice and Public Security: [LINK1](#) [148], or by the Norwegian Chimney Sweeps Association, [LINK2](#) [149].

Large scale boilers. Here the inspections are done by an accredited control institution, e. g. Norsk Energi. This happens after being installed or when changes or repairs are carried out that require control. This applies especially to plants producing hot water with a temperature above 110 °C or an overpressure above 0.5 bar, and to plants with steam production. It is the plant owner that is responsible for ensuring that inspections are timely carried out by an accredited institution according to rules and regulations. Authorities can also initiate a plant inspection to control that the owner confirms with rules and regulations. The main focus is set on safety issues, not on emissions.

Sweden

Stoves and boilers are inspected by chimney sweeps in Sweden. This happens every 3 years. The focus is set on safety issues. But they can also be triggered by occasional complaints, e. g. if a neighbour has reported excessive emissions to the local environmental office.

During the inspections a visual control of the unit is performed. But also a camera can be led through the chimney. There are no regular inspections to prove conformity with emission limits from a residential wood burning appliance. The instructions for performing these inspections are compiled in a specific document, [LINK](#) [101].

USA

It appears that there are few, if any requirements for in-home inspections after purchase. Rather, consumers are required to purchase certified stoves from the retailers/manufacturers, who likely will have only certified stoves for sale. In other words, the burden is on the manufacturers to design stoves that meet emissions requirements.

3.7 Possible forced shutdown of appliances

The preceding question to this chapter was:

“Are there ways to enforce a full shutdown of a wood burning appliance?”

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	yes	yes	yes	yes	yes	yes	no	yes	yes	no

Chapter summary

All involved countries except The Netherlands, have established routines which will finally allow a forced shutdown of a wood heating appliance if necessary. The pathway to such a shutdown is often similar. If it is for safety reasons the shutdown happens quickest. In all other cases the authorities will set deadlines for the remediation of deficiencies. But in order to identify any deficiencies there must first be evidence. Such evidence can be a complaint from the public, e. g. from the neighbourhood. In countries where recurrent emission testing is part of the onsite inspection routine, such evidence can also be that the appliance fails to comply with the legal emission limits. Furthermore, a non-compliance with emission requirements can also simply be determined via the age of the appliance which can justify the requirement of a replacement (e. g. in Denmark or Germany, for older wood stoves).

More reasons for non-compliance can be the use of illegal fuel or too wet fuel, as determined during recurrent fuel inspections (in Germany) or during ash inspections (in Switzerland), but such incompliances will in most cases not lead to a shutdown but rather to a fine. This is usually also true if a stove is illegally operated during an alert situation or during a temporary ban of wood stove use, as described in Chapter 3.2.

In case of a forced shutdown, cases were reported where the chimney was made unusable. But there also are examples where the stove owner can demand to leave the whole installation in a usable state where the rejected stove can remain in place for the case of emergency or in a catastrophe, this is for example a usual procedure in Germany.

Austria

Depending on the size of the plant and the respective law the main steps to a forced shutdown are:

- Confirmation of non-compliance with regulatory requirements by the respective expert (as defined in the law)
- Immediate shutdown in case of imminent danger (e. g. safety issues)
- In all other cases the authority sets a deadline for the remediation of deficiencies to the operator or the operating company.
- If the non-compliance is not remedied within the set deadline, another deadline can be set, or a shutdown can be forced.

The shutdown execution depends on the type of application. For residential applications the building authority (usually the major or the district administrative authority) bears the responsibility to act in case of continuous non-compliance with legal requirements. For commercial applications, the respective trade authority initiates the procedure.

The authorities can also impose financial penalties.

Canada

The requirements for forced shutdown are that (a) the appliance does not meet safe operational requirements, (b) it causes significant air quality impacts or (c) there is a loss of enjoyment of property.

In case of air/health/economic impacts, a pollution abatement order or Ministerial Orders can be issued. For example, in Metro Vancouver the District Director may take steps to address activities that are causing pollution or are likely to cause pollution in the region, under Metro Vancouver’s Air Quality Management

Bylaw (Bylaw 1082). Orders, prosecution or administrative penalties could be applied, but these are rare for domestic appliances. Incompliance with Ministerial Order leads to fines.

Switzerland

A shutdown of an appliance is possible if the retrofitting mandated by the authorities is not carried out within the pre-scribed deadline. If, for example, the periodic measurement to check compliance with emission limits fails, the emission limit values authorities grant a deadline to make adjustments and then a second measurement is carried out. If the measured values again exceed the emission limit values, a retrofitting is mandated by the authorities (e. g. heat storage tank, dust removal device) which must be carried out within a certain deadline. Depending on which pollutant and/or how much the emission limit value was exceeded, the retrofitting deadlines can be only a few months up to several years. The plant operator covers all costs for the additional measurements and the retrofitting up to all consequences coming along with the worst-case scenario which could be a forced shutdown.

Germany

For a wood stove, a shutdown can become obligatory if an old or unsuitable appliance was not replaced or retrofitted with ESP. The shutdown happens after the transition period described in Chapter 3.1. For wood boilers, a shutdown can be mandated when regular flue gas inspection measurements (Chapter 3.6) have shown incompliance with emission limits in Chapter 3.3.

In case of a forced shutdown, appliance owners and/or operators are forced to undersign a document, saying that they have taken notice of the shutdown. This declaration is then sent to the authorized district chimney sweep. An example of such declaration is given here: [LINK \[62\]](#). In case of a stove, the owner can then decide to leave the appliance in an operative state for an emergency case (“catastrophe”). If the stove would then be used, the district chimney sweep needs to be informed. The chimney of the building will continue to become inspected once a year. Also, the usual stove inspection routine (twice in 7 years) will still be performed, and the respective service fees need to be paid to the chimney sweep.

If the chimney sweep recognizes that the stove is still used after the shutdown, a penalty can be enforced by the regional authority.

Denmark

Safety issues. Municipalities have options to regulate wood combustion. The forced shutdown option is mostly related to fire risks. In case of a chimney fire, the chimney sweep must submit a recommendation to the municipality as to whether a ban should be imposed on continued use of the flue gas system. The chimney sweep must provide the police with all information for use in a possible investigation of the case. The municipality may issue an order to the owner or user that the combustion plant and flue gas systems may not be used until compliance with the executive order is given. If continued use of the flue system constitutes a predominant danger of fire, the municipal council may, pursuant to section 18 of the Building Act, issue an immediate order that the owner or user may not use the flue gas system.

Emission issues. Regional operational restrictions can be set by the Danish municipalities (see Chapter 3.2). In rare cases a municipality can actively ban the stove use of an individual owner directly. As an example of a real case, such a ban could be formulated like this: “Prohibition of the operation of the combustion plant during easterly winds, or when it is completely windless and when the trail of smoke at the same time visibly and persistently sinks into the immediate area due to meteorological conditions”, [LINK \[162\]](#). Two further anonymized case stories are available for download on the above website (in Danish language).

Italy

The shutdown of a biomass heating system can take place either for safety reasons (detected during periodic checks and maintenance) or for non-compliance with the minimum environmental performance required or - in the case of systems with higher thermal power (>35 kW) - non-compliance with the emission limit values prescribed by national or regional legislation.

A shutdown of a wood heating appliance (up to 500 kW) can happen in the Po-Regions and in those Italian regions which had regulated the installation and operation of biomass appliances with reference to Decree 186/2017 (Stars). If the minimum performance requirements (on-paper, that is the Environmental Certificate) does not meet the requirements of the regional regulation, the inspector (public authorities) can order the shutdown of the appliance, with a deadline. The inspector issues an official report to the end-user, together with the sanction. In some cases, if the appliance has an electronic part, the inspector puts the electronic part out of service to avoid further use.

The Netherlands

A forced shutdown of individual residential wood burning appliance is complex in the Netherlands. This is for several reasons. Firstly, there are no formal emission limits for devices in the field, only a law article that states that 'no nuisance to neighbouring civilians is allowed'. For this, the designated authorities need to prove that the suspected device causes nuisance in the direct surroundings. As there are no proper methods to independently verify this, and it is not allowed to enter homes without permission or a legal warrant to inspect the situation, this is difficult to prove. In case of complaints from neighbouring homes, mediation is often attempted in such cases.

To tackle this problem, TNO has worked on the development of a method that should be instrumental to independently assess if nuisance is caused by a suspected stove based on correlation of certain components measured in ambient air.

Until such method is available, an increasing number of municipalities decide to use general bans (for example a total ban for all wood stoves by 2030 in Utrecht, or conditional temporary bans for all wood stoves in case of adverse weather conditions (as indicated by a 'code red' in the 'Stookwijzer'). Fines may be imposed in case stoves are still operated under such conditions.

Norway

A shutdown of stoves, boilers and larger plants can happen if they do not fulfil safety regulations or when local air pollution levels are too high, which typically happens when a larger number of wood stoves is operated in an area. A shutdown is also possible when emission limits for larger plants are repeatedly exceeded. In this case, fines can be imposed for larger plants, however, there is recurrent reporting but no recurrent inspections for emissions from wood combustion plants in Norway. Fines can also be imposed for wood stoves that were not replaced in time or are operated illegally, e. g. according to the municipal regulation that was imposed for a time period in the City of Bergen (see 3.2).

Sweden

Anyone who fires with firewood or other fuels is responsible for reducing the emissions of air pollution and other disturbances to the environment as far as it is not unreasonable. This is shown in the second chapter of the Swedish Environmental Code.

The municipality is responsible for the local air quality. It can

- influence the presence of wood burning equipment through what is allowed in building permit applications (PBL) (see Chapter 3.2).
- state rules for wood burning in local regulations (Section 40 of the Ordinance [1998: 899] on environmentally hazardous activities and health protection). This may, for example, be a temporary ban on small-scale heating with certain solid fuels in a specified area, if this is necessary to prevent inconvenience to human health in the municipality.
- if necessary, the municipality may, through its supervision, require individual property owners to take measures to limit disturbances from wood burning (The Swedish Environmental Code, Chapter 26, Section 9).

There may be sanctions, depending on the severity of the situation.

USA

Forced shutdowns are generally not happening, since older appliances are grandfathered-in to the latest EPA rules. However, in some cases (for example when a home is sold or in some cases remodelled), residents may be required to remove out-of-compliance stoves. These regulations are usually local, county, or state (but not national) jurisdictions.

3.8 Impact through regulations for chimneys

The preceding questions to this chapter were:

A) *“Is there any regulation concerning the required minimum chimney height or position to the roof ridge for residential heating?”* NOTE: Building regulations are addressed in Chapter 3.5.

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

B) *“Are there any requirements for auxiliary chimney ventilation devices?”*

Country	AT	CD	CH	DE	DK	IT	NL	NO	SE	USA
Answer	no	no	no	no	no	yes	yes	no	no	no

C) *“Are there any requirements for rain protection of chimneys?”*

Country	AT	CD	CH	DE	DK	IT	NL	NO	SE	USA
Answer	no	no	no	no	no	yes	no	yes	no	no

Chapter summary

Apart from building regulations (Chapter 3.5), chimney requirements (position, length, materials, fixtures) could become effective to improve or to suppress the use of wood burning appliances. Chimney related policy can thus become a tool for indirect enforcement of a more advanced state of the art for appliances or abatement technologies.

Almost all involved countries have reported that there are rules for chimney design (e. g. height and position) and some examples are mentioned in this chapter. But as long as the chimney rules remain unchanged, these rules do not have any direct impact on the situation of residential wood fuel appliances. Only when the standards for chimney design change, e. g. when new requirements for determining the minimum height of a chimney outlet are introduced, chances are given that indirectly this will also affect wood heating appliances. In Germany, for example, the new emission ordinance has changed and tightened the rules for determining the required chimney height and position for new buildings. Such changes can have consequences for existing wood heating installations. While old chimneys can usually still be used, any stove or boiler replacement could be regarded as a refurbishment of the whole heating system, and this would normally mean that the newest chimney rules shall be fulfilled with the consequence of additional costs. For old chimneys, this can mean that if sufficient dilution of pollutants cannot be guaranteed without restructuring the chimney, a stove replacement shall then guarantee that the pollutant mass flow will stay below a critical level when it arrives at the neighbour’s skylight. This can mean that new stove requirements need to be defined for such replacement (e. g. automatic air control, ESP, an ambitious stove quality label, etc.). Such rules are currently being elaborated in Germany. Thus, chances are given that the changing of chimney rules might become a trailblazer for advanced performance characteristics of wood stoves.

Requirements for auxiliary chimney ventilation devices hardly exist. But in some cases, they can be suggested by the chimney sweep for improved chimney draught.

Rain caps on chimney tops can be seen as obstacles which disturb the upward movements of the flue gases and will thus lead to reduced dilution of pollutants upon arrival at a neighbouring building. Nevertheless, rain protections on chimney tops are quite common. Sometimes they can be avoided if the chimney base is connected to the sewer. Generally, they are allowed, with exceptions in Switzerland. But little attention is paid to their design and functioning. A technical optimisation of rain protection devices for chimneys would be helpful, but this would not influence the release of pollutants to the emission but could rather reduce health related problems in the direct neighbourhood.

Austria

Chimney requirements. The requirements are defined in 9 provincial building regulations. This often leads to slightly different requirements in each province. Most provinces, however, have implemented the requirements elaborated by the Austrian Institute of Construction Engineering, [LINK](#) [187]. They are:

- For gabled roofs: Minimum chimney height above ridge: 40 cm (exemption if chimney distance to ridge is large: 100 cm above roof area (measured in 90° angle to the roof)).
- For flat roofs: Minimum chimney height above attic: 40 cm, or minimum 100 cm above roof surface area

Chimney ventilation. There are no mandatory requirements, only the general requirement that the safe transport of flue gases must be ensured.

Rain caps. There are no specific requirements, only the general requirement that the entry of precipitation into the building structure must be avoided by suitable measures. In the case of a chimney this can be done by rain protection on the rooftop or via connection of the chimney base to the sewer.

Canada

The Canadian building code and many provincial and territorial building codes require minimum chimney heights. For example, according to the Ontario Building Code (1992), “A chimney flue shall extend not less than

- 900 mm above the highest point at which the chimney comes in contact with the roof, and
- 600 mm above the highest roof surface or structure within 3 m of the chimney.”

For example, Metro Vancouver’s Bylaw 1087 - the Boilers and Process Heaters Emission Regulation for biomass fired heaters and boilers below 50 MW_{th} output capacity requires that the chimney outlet of the plant must be at least 20 meters above ground level. In the province of British Columbia, the “Solid Fuel Burning Domestic Appliance Regulation” has standards pertaining to the installation of outdoor wood boilers that would apply to some Small-Size Biomass Combustors (SSBC). A pellet-fuelled outdoor boiler must be installed at least 10 metres setback from the property lines of the parcel of land it is installed on. Any other outdoor boiler must be set back 40 metres.

Switzerland

Chimney height and position. The stack height is regulated in the OAPC ([LINK](#) [16]) and in the enforcement guide “Minimum height of chimneys above roof”. For wood combustion units <70 kW particular requirements apply: The chimney outlet must overtop the highest part of the building (e. g. roof ridge) by at least 0.5 m and for flat roofs by at least 1.5 m (accessible flat roofs by at least 2 m from the roof surface). If the chimney outlets of small wood-burning installations are closer than 10 m from higher neighbouring buildings, the neighbouring buildings are decisive for the minimum height.

Chimneys must always be arranged in such a way that the exhaust gases do not lead to excessive emissions in the vicinity of skylights, air inlets, etc. and do not lead to excessive emissions. The cross-section of the chimney must comply with the rules of technology and must not be too large. If it is technically feasible the exit velocity of the flue gases at the chimney outlet must be at least 6 m/s.

Rain caps. Chimney cowls and attachments that prevent the free vertical flow are not permitted. Exceptions are possible but they must be well justified.

Germany

Chimney height and position. The technical rules for appropriate chimney heights were recently changed in the amendment of emission ordinance “1. BImSchV”, [LINK](#) [5]), which makes reference to a newly revised VDI-Standard 3781-4 [63]. This standard describes new requirements for determining the minimum height of a chimney outlet. In the new emission ordinance, the rules now became stricter. From January 2022, chimneys for new combustion plants must be designed in a way that the outlet of the chimney is located close to the ridge and it shall overtop the ridge by minimum 40 cm. “Close to the ridge” is understood to mean (a) that the horizontal distance of the outlet opening from the ridge is smaller than the horizontal distance to the eaves, and (b) that the vertical distance of the outlet opening from the ridge is greater than the horizontal distance from the ridge. Neighbouring buildings also have an impact, e.g. with an appliance of max. 50 kW heating power the required height of a chimney outlet shall be at least 1 meter higher than the tops of any vents, windows or doors of a neighbour building which is located within a 15 m radius.

Primarily, these new rules affect all new installations from the day of enforcement in January 2022. They are a significant new burden for wood stoves and boilers because the individual realisation of an appropriate chimney height may become impossible or too costly, particularly for a wood stove. Currently, the emission ordinance “1. BImSchV”, [LINK](#) [5], refrains from demanding these new requirements for older buildings, too. Many appliances would otherwise have to be shut down as chimney adaptations are sometimes impossible. It was also decided, that in those cases where stoves or boilers are being replaced, the old chimney rules can still apply although such replacements are usually regarded as a refurbishment of the given heating system, and this would normally mean that the newest chimney rules would need to be respected. Stove- and chimney sweep associations claim that several millions of existing chimneys for wood combustion appliances would not anymore meet the revised requirements, if the rules of VDI-Standard 3781-4 should in the future become obligatory for older buildings, too.

Rain caps. They are not forbidden, but the VDI-Standard 3781-4 for chimneys [63] requires that an obstruction of the free flow of exhaust fumes shall be avoided, and this shall be checked in each individual case. Nevertheless, rain caps above chimney outlets are quite common in Germany

Denmark

Chimney height and position. Relevant requirements for chimney dimensioning were defined for residential combustion plants of 30 kW rated heating power and below. Such exhaust systems that are established or substantially modified must:

- in the case of flat roofs with roof slopes of up to and including 5°, open at least 1 meter above the roof surface,
- in the case of roof slopes from 5° up to and including 20°, open at least 40 cm above the ridge or be at least 1 meter from the roof surface, and
- in the case of roof slopes of more than 20°, open at least 40 cm above the ridge or have a horizontal distance to the roof surface of at least 2.3 m.

The outlet on flue systems that are established or substantially altered must, within a distance (radius) of 15 meters, protrude at least 1 meter above the upper edges of ventilation inlets, windows, or doors.

In addition, the guidance text of the Building Regulations states that a chimney should be higher than the highest point of the building. Here it also appears that when determining the extractor height, especially for stoves and other plants for solid fuels, the spreading conditions should be taken into account, i.e. turbulence from building and planting, distance to and the height of surrounding houses as well as the prevailing wind direction in relation to the neighbours, [LINK](#) [165].

Chimney ventilation. There are no mandatory requirements, however, in case of poor draught detected at an inspection, the chimney sweep can suggest installation of mechanical draught improvement.

Rain caps. Most chimneys have a cover; however, this is mainly to avoid blockage from birds building nests. The chimney sweep does not mind open tops.

Italy

Chimney height and position. The installer shall install the biomass appliance (up to 35 kW) in accordance with the national standard UNI 10683:2022 and at the end of installation he must deliver the “Declaration of conformity” of the heating plant to end-user. The same document must be delivered to the municipality. The minimum height of the chimney is calculated based on the position of the chimney (distance from the ridge) and the slope of the roof (§ 8.9). For example, with slopes in the range 48-70%, the height of the chimney, or the outlet height, cannot be less than 1300 mm.

Chimney ventilation. The requirements are defined by the national standard UNI 10683:2022 (§ 8.8). Static draft activators can be installed in compliance with the following requirements: (i) they shall not obstruct the flow of flue gas, (ii) they shall not reduce the cross section of the chimney, and in case of malfunction (iii) they shall not limit the natural draft of the chimney.

Rain caps. The requirements are defined by the national standard UNI 10683:2022. The installation of a chimney ventilation pot is not mandatory, nevertheless when it is not installed, the chimney shall be suitable for wet operation (Class W) and must be equipped with an inspection point at the base and a liquid discharge system.

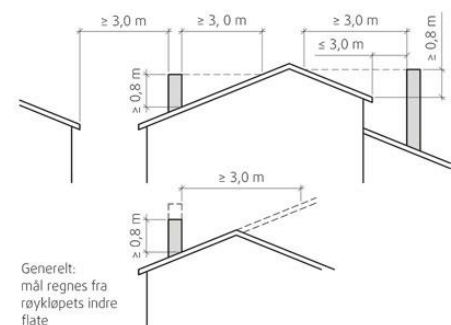
The Netherlands

Chimney height and position. For these requirements there is a national building regulation and the National Standard NEN 2757.

Chimney ventilation. For these requirements there is a national building regulation and the National Standard NEN 1087.

Norway

The chimney outlet should be at least 0.8 m above the highest point of the roof at the chimney and should have a horizontal distance to the roof surface of at least 3.0 m, for the sake of fire safety in case of chimney fire (see figure). The distance can be calculated from the inner surface of the smoke outlet. When the chimney is close to the ridge, the chimney outlet should have at least 3.0 m horizontal distance to the extension of the roof surface so as not to get too close to the ridge. Nevertheless, it is sufficient that the chimney mouth is at least 0.8 m above the ridge. If the chimney is located less than 3.0 m from another building's roof, wooden wall or opening in a brick wall, the chimney outlet should be at least 0.8 m above the highest point of the neighbouring roof, [LINK](#) [151]. More details on the regulation are found here: [LINK](#) [152].



Source: [LINK](#)

Rain caps and ventilators. There is no regulation for rain caps on the chimneys, but they are recommended. There are no requirements for auxiliary chimney ventilation devices.

Sweden

Chimney height and position. According to the Swedish building regulations BFS 2011:6 the chimney height shall be sufficient to perform a good chimney draught and to protect neighbours from the emissions.

USA

Chimney height and position. For residential wood heating, chimneys should extend at least 3 feet above the point of exit to the outdoors (i.e. the roofline). Chimneys should also be located less than 10 feet horizontally from the highest point of the roof (Purdue extension). Other sources indicate the importance of a “3-2-10” rule. Here “3” indicates that chimneys must extend a minimum of 3 feet above the roof. Here “2” indicates that chimneys should be 2 feet higher than any point within 10 feet horizontally from the chimney (i.e. steeper roof pitches would require longer chimneys). Here “10” refers once again, for the need for a 10 foot horizontal distance just mentioned, [LINK](#) [218], [LINK](#) [219].

The above information seems to have broad applications to U.S. locations. But local codes may specify additional restrictions. An example for such locally applied building codes specifying technical requirements for properly designing masonry fireplaces and chimneys is available from the state of Washington, [LINK](#) [220].

Chimney ventilation. There are no mandatory requirements.

Rain caps. No specific requirements were found. However many sources highly encourage rain caps on chimneys, not only to assist with clean combustion on rainy days, but to prevent small animals, birds, and/or other debris from falling into the chimney, creating a nuisance and potentially a chimney fire hazard.

3.9 Particle precipitation devices in residential sector

The preceding question to this chapter was:

“Are there any measures to enhance their availability/dissemination in the residential sector?”

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	no	no	yes	yes	no	no	no	no	no	no

Chapter summary

Measures to enhance the dissemination of ESPs in the residential sector were only reported from Switzerland and Germany.

In Switzerland, there is no subsidy on a national level, but still there has been regional support for the implementation of ESPs in residential wood heating systems, typically a minimum efficiency of 60 % was required for the subsidy. Furthermore, there were three pilot projects where several houses with wood stoves or wood boilers were equipped with ESPs and a performance monitoring in cooperation with research facilities was carried out.

In Germany, there were no general subsidies for ESPs on stoves, too. But for boilers that are equipped with a dust precipitator there has been a particular long-term subsidy on federal level (see Chapter 3.4). Currently the subsidy program does not anymore address precipitators directly, but such devices are now indirectly supported by an elevated subsidy rate for boilers, given that they can meet the ultra-low PM emission requirement of max 2.5 mg/m³_n as proven in the type testing report.

An obstacle for introducing new filters or ESPs into the market is seen in the fact that they are treated as components of buildings, but they are not listed on the European Building Products list, which means that conformity with common market rules cannot simply be declared by a CE-certificate on the product. Therefore, a filter manufacturer needs to pass a time-consuming and costly individual process of approval before market release. Consequently, filters and ESPs have become more and more integrated into new furnaces, rather than being sold as retrofit devices. In Germany, wood stoves which want to become marketed with the new environmental certificate “Blue Angel” will usually require an ESP to meet the ambitious PM-emission requirement of the label.

Austria

There are no measures to enhance the dissemination of precipitators in the residential sector in Austria.

Canada

There are no measures currently available to enhance the dissemination of precipitators in the residential sector in Canada.

Switzerland

Currently there is no subsidy on a national level. But presumably there was regional fundings for the implementation of ESPs in residential wood heating systems in the cantons Grisons and Lucerne. And currently there is a subsidy for ESPs in canton Thurgau and Grisons. The canton Thurgau subsidises the replacement of an oil or gas heating system with a wood-fired central heating system with CHF 7,000 (single and multi-family houses). If then an ESP with an efficiency of at least 60 % is also installed, an additional CHF 1,000 is granted. The canton Grisons subsidises the installation of an ESP with up to 3,000 CHF depending on the installed combustion technology.

Sources from authorities and from the association of wood energy Switzerland claim that there were three pilot projects, one several years ago in the region of Lucerne and Central Switzerland, one in the region Misox in the canton Grisons and one in the village Sass Fee in canton Valais where several houses with wood stoves or wood boilers were equipped with ESPs and a performance monitoring in cooperation with research facilities was carried out. The measures and subsidies of the pilot project Misox are implemented in the actual action plan of the region Misox.

Germany

For stoves there are no general ESP-subsidies available. Only in selected cases (municipalities) short term programs had been effective to promote retrofitting of ESPs in combination with wood stoves (e.g. 500 € subsidy in City of Aachen, see Chapter 3.4).

For boilers that are equipped with a dust precipitator there was a particular long-term subsidy on federal level (see Chapter 3.4). The program has now expired; it was replaced by a new program (BEG, [LINK](#) [37]) where precipitators are not particularly addressed anymore. Such devices are now indirectly supported by an elevated subsidy rate (+5 percentage points of the total investment), given that the boiler has proven to meet an ultra-low PM emission requirement of max 2.5 mg/m³_n (at 13 % O₂) during type testing.

An obstacle for introducing new filters or ESPs into the market is seen in the fact that they are treated as components of buildings, but they are not listed on the European Building Products list, which means that conformity with common market rules cannot simply be declared by a CE-certificate on the product. Therefore, a filter manufacturer needs to pass a time-consuming and costly individual process of approving on national level for the German market (performed by the German Institute of Construction Technology). Consequently, filters and ESPs are becoming more and more integrated into new appliances. Thus they become a functional element of new boilers instead of being available as separate retrofit products.

For ESPs which are used to become retrofitted or combined with wood stoves, a new environmental label was recently published (Blauer Engel, [LINK](#) [64]). Such labelled products are, however, currently not yet available on the market.

Denmark

There are no measures to enhance the dissemination of precipitators in the residential sector in Denmark.

Italy

There are no measures to enhance the dissemination of precipitators in the residential sector in Italy. At the moment (December 2022) there is only an obligation to install a particulate matter abatement system

(including an ESP filter) for biomass boilers >15 kW in the Lombardy Region in the case of replacing a natural gas/oil heating system (Annex 1 - D.G.R. 5360/2021, Lombardia Region, [LINK](#)).

The Netherlands

There are no measures yet to enhance the dissemination of precipitators in the residential sector in The Netherlands.

Norway

There are no measures to enhance the dissemination of precipitators in the residential sector in Norway.

Sweden

There are no measures to enhance the dissemination of precipitators in the residential sector in Sweden.

USA

There are no measures to enhance the dissemination of precipitators in the residential sector in the USA.

3.10 Catalyst application in residential sector

The preceding question to this chapter was:

“Are there any measures to enhance catalyst availability/dissemination in the residential sector?”

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	no	no	no	no	no	no	no	no	no	no

Chapter summary

No measures to enhance catalyst dissemination in the residential sector were reported. But it can be expected that the creation of new and ambitious environmental labels such as the German environmental certificate “Blue Angel” (see Chapter 3.12) might create some pressure to integrate a catalyst into wood stoves, particularly because some interesting progress was recently reported for catalysts on wood stoves. For today’s central boilers, however, the current level of pollutant emissions in Europe does not call for any catalyst integration.

The question concerning catalysts was inspired by the situation in the USA, where log wood stoves are more than elsewhere equipped with catalysts. The United States Environmental Protection Agency mentions catalytic combustors in documents for choosing the right wood-burning stove, [LINK](#) [221].

All involved countries:

From none of the countries any measures to enhance the dissemination of catalysts in the residential wood combustion sector were reported.

3.11 Fuel certificates or labels

The preceding question to this chapter was:

“Are there any fuel certificates used or obligatory?”

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	yes	no	yes	yes	no	yes	no	yes	no	yes

Chapter summary

Many countries or organisations have established fuel certificates (labels) or standards. Mostly, the basic requirements are directly drawn from the international standards of the ISO 17225 series. From the questionnaires, a legal obligation to meet the respective fuel requirements of a standard (or label) was only read for Switzerland, Germany and Italy, and this applies only for wood pellets. The legal obligation comes from the fact that reference to the standard is made in the respective law. E.g. in Germany and in many Italian regions only A1-quality of the ISO pellet standard may legally be used in residential furnaces, while in Switzerland A1- and A2-quality are both permitted. Since 2022 there are also requirements for wood briquettes. Existing briquette fuel labels such as EN_{plus} “A1-quality” can be officially declared to reflect the legal requirement in a national legislation. This is the case in Germany, where the label itself serves as proof of conformity.

In other countries, there seem to be no legal obligations to use one of the quality classes from the international pellet standard ISO 17225-2 or to refer to any label. Then the purchase of such certified fuel is voluntary. For all wood fuels except wood pellets this is true in all involved countries, including Switzerland and Germany.

To address a particular quality class of a standard or a label can be a measure to restrict the range of raw materials used for fuel production. For example, if it is a requirement to use only A1-quality from the ISO 17225-2-pellet standard, pellets from short rotation poplar would automatically be excluded from use in stoves and residential boilers due to high ash content. Thus, critical fuel properties are avoided.

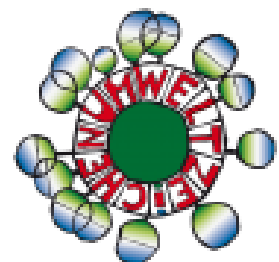
Apart from wood pellets, labels were also created for wood briquettes. These labels are applied in most involved countries, but without being legally binding. Fuel labels for trade were also created for wood chips, this is the case in Austria, Switzerland, Germany, Italy and Norway. For log wood there are only few labels (in Italy and Norway), which are used on voluntary basis.

Apart from the USA, where the national PFI-label is widely referenced, the European EN_{plus} label for wood pellets (or the equivalent Canadian CAN_{plus}-label) is widely used in international trade. Other regional labels are usually designed as an add-on, which can additionally address sustainability issues or the obligatory use of renewable energy for production, as in the case for the Austrian “Umweltzeichen”. Or they aim at using an already established and recognized label such as the Nordic Swan (e. g. in Sweden). In terms of pollutant emissions, they can mostly be seen as compatible to the ISO-standard 17225-2 for wood pellets, because the technical requirements of “Class-A”-Quality of the Standard are mostly met.

Austria

For wood chips and pellets and briquettes. The Austrian Ecolabel (Österreichisches Umweltzeichen, UZ 38) is applied for “Biomass-based fuels”, in particular for wood chips and for wood pellets and briquettes, [LINK](#) [188]. Reference is made to the requirements which are defined in the international ISO standards for pellets, briquettes and wood chips (ISO 17225 ff). However, two particularities are mentioned:

- Only renewable energy sources may be used for drying the raw materials.
- The proportion of wood, wood fibres or wood chips used must come 100 % from sustainable forestry.



Source:
www.umweltzeichen.at

The requirement of using only natural and untreated raw materials can be proven by an EOX-content analysis (extractable organically bound halogens); the limit value in the fuel shall be not higher than 3 mg/kg. A direct access to the guideline and requirements is found here: [LINK](#) [189].

Legal requirements are based on “standardised biomass-based fuels” which comply with existing national standards (e. g. for log wood, wood chips, wood pellets and briquettes). If non-standardised biomass-based fuels are used, different (usually stricter) emission requirements can be applied.

Canada

ISO solid biofuel quality standards are adopted by CSA (CAN/CSA-ISO 17225 Part 1 to 7 for wood pellets, briquettes, wood chips, non-woody pellets, non-woody briquettes, firewood) and are implemented in voluntary basis. A number of Canadian wood pellet producers are third party certified to the EN_{plus} or CAN_{plus} certification regime. CAN_{plus} is equivalent to EN_{plus}. Reference is sometimes also made to PFI wood pellet specifications, [LINK](#) [65], e.g. in Ontario’s A-14 Guideline.

Switzerland

Wood pellets. For wood pellets, the Swiss Ordinance on Air Pollution Control (OAPC, [LINK](#) [16]) only allows the sale, distribution and use of pellets that meet the requirements of the international standard for pellets ISO 17225-2 [68] for A1-and A2 quality. EN_{plus}-certificate is also widely used in Switzerland. The EN_{plus} certification is a voluntary certification that controls and certifies pellet producers and pellet suppliers. This certification goes beyond the ISO 17225-2. For wood briquettes the OAPC only allows the briquettes with A1 and A2 quality according to ISO 17225-3.

Wood chips. For wood chips there are no legal requirements or labels, however the classification of fuels and particle sizes of QM Holzheizwerke® ([LINK](#), [51]) for wood-fired heating plants is widely used. This classification is based on the specifications of ISO 17225-1 [67]. The classification of particle sizes is supplemented with the S-classes of ISO 17225-4 [70].

Germany

Wood briquettes and wood logs. DIN_{plus} and EN_{plus} certificates are also issued for wood briquettes. Their use is voluntary. No certificates or labels are yet available for trade of wood logs. But there is a German initiative which aims at preparing a label for natural untreated log wood. The specific requirements are however not yet published.

Wood pellets. According to an official document which interprets the German emission ordinance, the A1-pellet-quality class from the old European pellet standard EN 14961-2, which was later replaced by ISO 17225-2 [68], is legally required for small scale appliances. Well-known and largely used fuel certificates are DIN_{plus} and EN_{plus}. From the EN_{plus} quality labels, only the A1-class is legally accepted in small scale appliances, A2-quality is excluded. During regular boiler inspections at end user site, the supplier declarations or package labels are checked every 2 years by the chimney sweep (see Chapter 3.6).

Wood chips. A national EN_{plus}-certificate for wood chips was created in 2016. Requirements are shown in Table 15. The use is voluntary, no legal obligations are connected to it. 15 wood chip producers are currently listed as EN_{plus} wood chip suppliers ([LINK](#) [72]).

Table 15: Requirements for wood chips according to the German EN_{plus}-certificate, [LINK](#) [66]. Differences to the ISO-Standard 17225-4 (June 2021 [70]) are marked in green.

Parameter	Unit	EN _{plus} A1	EN _{plus} A2	EN _{plus} B
Moisture content (as received)	%	≥ 8 to ≤ 25 ISO: ≤ 25	≤ 35 ISO: >25 and ≤ 55	to be reported
Ash content (dry)	%	≤ 1.0 ISO: ≤ 1.5	≤ 1.5	≤ 3.0
Calorific value (as received)	kWh/kg	to be stated		
Particle size class ^{a)}		P31s or P45s		
Coarse fraction ^{b)}	%	≤ 6 in P31s (> 45 mm) and ≤ 10 in P45s (> 63 mm)		
Fines (< 3.15 mm)	%	≤ 5 ISO ≤ 10	≤ 8 ISO ≤ 10	≤ 10
Maximum length ^{c)}	mm	for P31s: 120 for P45s: 150 ISO: 200	for p31s: 150 ISO: 120 for P45s: 200	for P31s: 150 ISO: 120 for P45s: 200

^{a)} Main fraction ≥ 60 %. Main fractions are in P31s: 3,15 - 31,5 mm, in P45s: 3.15 - 45 mm

^{b)} Max. cross section in P31s: 4 cm², in P45s: 6 cm² (not defined in ISO 17225-4)

^{c)} In a sample of 10 litres there may be 2 pieces with a cross sectional area of < 0.5 cm²

Denmark

Only clean biomass fuels can be converted in normal combustion plants that are not rated for waste incineration. The array of allowed solid biofuels are the ones mentioned in Appendix 1 of the Ordinance no. 1224 of 04/10/2023 on biomass waste, [LINK](#) [166].

No fuel certificates apply for small scale combustion systems. Proprietary standards still prevail in Denmark and quality is maintained largely by the above-mentioned ordinance and by experience and trust between the user and the supplier. An industry sustainability scheme has recently been elevated to law and updated in May 2024, [LINK](#) [237]. Especially due to ILUC and IFUC reporting, fuel importers are required to perform sustainability reporting.

Italy

Wood logs. The “Biomassplus-label” is a voluntary certification scheme for firewood (“legna da ardere”). The general requirements for wood fuels are published in the handbook for the general part ([LINK](#) [73]), it specifies sustainability criteria (traceability according to EN 15234-5 and GHG calculation -70 % relative to natural gas). Further details on actual fuel requirements are published in the handbook of special requirements for log wood, [LINK](#) [74]. Regulatory reference is the ISO 17225-5 [71]. Four quality classes are indicated: A1+, A1, A2 and B. To guarantee the quality class, the manufacturer must demonstrate that they are equipped with adequate equipment and facilities.

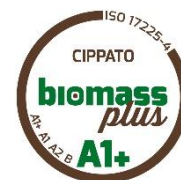


Wood briquettes. Also, for briquettes there is voluntary certification scheme, the Biomassplus-wood briquette (“bricchette”). Concerning the general requirements, the same reference as mentioned above for log wood applies. Further details on fuel requirements are published in the handbook on special requirements for wood briquettes, [LINK](#) [75]. Regulatory reference is the ISO 17225-3 [69]. Three quality classes are indicated: A1, A2 and B.



Wood pellets. For wood pellets the widely used European EN_{plus}-certificate is referenced in Italy. Since 2018, in the Po-Regions, and more recently also in other Italian regions with higher PM pollution (Tuscany, Marche, Lazio and Campania), only pellets of A1-quality (according to ISO 17225-2 [68]) shall be used in the residential pellet appliances up to 35 kW.

Wood chips. For wood chips, too, there is voluntary certification scheme, the Biomass-plus-wood chips (“cippato”). Concerning the general requirements, the same reference as above mentioned for log wood and briquettes applies. Further details on fuel requirements are published in the handbook on special requirements for wood briquettes, [LINK](#) [76]. Regulatory reference is the ISO 17225-4 [70]. Five quality classes are indicated: A1+, A1+ “calibrated wood chips”, A1, A2, B1. To guarantee the quality class, the manufacturer must demonstrate that they are equipped with adequate equipment and facilities.



The Netherlands

Beyond the existing European EN_{plus} certificates for pellets and briquettes, there are no national fuel certificates used in the Netherlands.

Norway

Wood logs. In trade, the use of a certificate is not obligatory. Reference is sometimes voluntarily made to the Norwegian standard NS 4414, [LINK](#) [153] and ISO 17225-5 [71].

Wood chips. In trade, the use of a certificate is not obligatory. But when quality specifications are made by a plant operator, reference is sometimes made to ISO 17225-4 [70].

Wood pellets. There is no obligation to use standardized wood pellet fuel. Plant operators, however, sometimes refer to the Norwegian standard ISO 17225-2[68] or to EN_{plus} Standards.

Wood briquettes. There is no obligation to use standard wood briquettes. Reference is sometimes made to the Norwegian standard ISO 17225-3 [69] or to the Nordic Swan label, the requirements for the Nordic swan label are defined in a criteria document, [LINK](#) [102].

Sweden

Beyond the existing European EN_{plus} certificates for pellets and briquettes, there is also a voluntary labelling scheme for solid fuels and fire lighting material in Sweden, the Nordic Swan. Requirements and procedure are defined in a criteria document, [LINK](#) [102]. Concerning material composition, reference is made to EN ISO 17225 parts 1-5 for wood fuels, while fire lighting products must comply with requirements in the European Standard EN 1860-3:2003. For pellets and briquettes the requirements of the A1-class are defined. For wood chips the A1 or the A2-class are required. A number of 49 ecolabelled fuel products from 6 companies are available, [LINK](#) [103].



Source: Ecolabelling Sweden AB

USA

No labels for log wood or wood chips are found in the USA. But for wood pellets there is the Pellet Fuels Institute (PFI) standards program. The PFI Standards Program is a third-party accredited program that enables consumers to easily identify PFI graded fuel pellets which are consistent and reliable, from producers whose facilities are subject to regular third-party inspection and lab testing.



Source: <https://www.pelletheat.org/pfi-standards>

Three pellet grades are listed: PFI premium, PFI standard, and PFI utility, with each grade having different allowed levels of ash content. Typically, premium pellets have less than 1 % ash, standard less than 2 %, and utility less than 6 % ash content, [LINK](#) [222]

No label requirements are known for U.S. briquette production.

3.12 Stove or boiler certificates or labels

The preceding question to this chapter was:

“Are there any stove or boiler certificates used, referenced or obligatory?”

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	yes	yes	yes	yes	yes	yes	no*	yes	yes	yes

* only certificates for installers and trade persons

Chapter summary

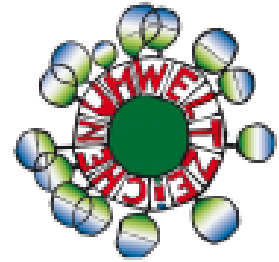
Apart from legal emission requirements, technological improvements and lower emission can also be enforced via quality labels for products. In almost all involved countries such labels are intensively used. Among the involved ten countries ten different labels can be counted, four of them were created only in Germany. All of them are dealing with wood stoves. Most labels are based on existing standards, i. e. the results concerning emissions and efficiency as reported in the type test certificate is usually the main basis. In four out of ten described stove labels the emission limits were tightened compared to the minimum legal requirements. This is true for the Austrian “Umweltzeichen”, the German “Blue Angel”, the Italian “ariaPulita” and the Scandinavian “Nordic Swan”. The German DIN_{plus}-label, too, was over many years stricter than the emission legislation at that time. When it became obvious that the DIN_{plus} label had gradually defined a new state of technology, the label requirements were eventually converted into the revised German legislation, starting from 2015.

Via new labels, new technical features and stove characteristics can be pushed into the market. This is the intention of the German TÜV-Süd certificate, which describes a significant number of supplemental tests. For example, it is checked which mode of ignition is the least polluting one (e. g. bottom-up or top-down ignition). And also the stand-still heat losses are assessed, they shall not exceed 7 m³/hr at a differential chimney pressure of 5 Pa. The intention here is that thus an automatic air control system shall become inevitable, and it then shall then be in line with the new national standard for automatic combustion air controls (DIN_{spec} 18843-1).

But among all labels for log wood stoves the most ambitious one is clearly the German Blue Angel label for room heaters, launched in 2020. This is true for several reasons: One is that the label requires the stove to prove its performance during a unique real-life reflecting testing procedure which is not based on the existing European type testing protocol but is for example demanding the measurement of the cold starting batch within a measured cycle of 7 consecutive batches. Furthermore, the emission requirements are extremely strict, consequently an ESP and/or a catalyst will usually need to be implemented. Also, an automated combustion air control is required to avoid too much user influence and maloperation. Any external (retrofit) precipitator will have to prove a precipitation efficiency of 75 % by mass and 90 % by particle number. Again, the goal is here to define a new standard, which can one day become the benchmark. Several stoves types were already awarded the label.

Austria

For stoves. The Austrian Ecolabel for wood fired heating systems (Österreichisches Umweltzeichen, UZ 37) is also applied for stoves. A direct access to the Guideline and requirements is found here: [LINK](#) [190].



Source:
www.umweltzeichen.at

Selected requirements are¹:

- for manually operated stoves (logwood or briquettes):
CO: 650 mg/MJ, NO_x: 120 mg/MJ, OGC: 45 mg/MJ, dust: 30 mg/MJ
- For pellet stoves:
CO (NL): 115 mg/MJ (nominal load), CO (PL): 230 mg/MJ (part load - 30 % of NL), NO_x: 100 mg/MJ, OGC (NL): 5 mg/MJ, OGC (PL): 9 mg/MJ, dust: 15 mg/MJ

For boilers. The above mentioned Austrian Ecolabel is also relevant for residential heating boilers, [LINK](#) [190]. The main requirements in the label guideline are given in Table 16.

Table 16: Emission limits of the Austrian Ecolabel UZ37 for residential wood boilers in Austria

Parameter (all values in mg/MJ) ¹	Pellets	Wood chips	Logwood
CO (nominal load)	45	120	180
CO (part load, 30 %)	100	200	500*
NO _x	100	100	100
OGC (nominal load)	3	4	15
OGC (part load)	3	6	-
Dust	15	20	20

* for logwood boilers partial load is defined at 50 % of nominal load

Usually, the ecolabel is mandatory if any public subsidy programmes (either federal, provincial, or municipal level) exist. In its current fossil fuel changeout campaign the Austrian government gives financial support only to ecolabelled products, [LINK](#) [192]. Manufacturers must pre-register their products which meet the requirements. All eligible products are listed in a public database, [LINK](#) [193].

Canada

For stoves. Most jurisdictions require residential indoor wood burning appliances to be certified to CSA B415.1 [82] or US Code of Federal Regulations, Title 40, Part 60, Subpart AAA. Test protocols, such as fuel types and qualities, how to load fuel into appliances, burnout rates and methods to capture and measure PM for the CSA B415.1 standard and the US EPA Wood Heater Rule are the same. Both standards use dilution tunnels and employ US EPA Method 5G, 5H or G1. PM emission results from these two standards can therefore be considered comparable.

Test methods referred in the CSA B415.1 or US EPA standards for wood burning appliances (such as stoves, boilers and furnaces) are E2515-17 [77], E2558-13 [78], E2618-13 [79], E2817-11 [80] and E3053-17 [81]. During certification tests, both CSA B415 and US EPA standards require emission test runs in four different burn rate categories (Average kg/hr, dry basis): Category 1: <0.80, Category 2: 0.80 to 1.25, Category 3: 1.25 to 1.90 and Category 4: Maximum burn rate.

CSA B415.1 and US EPA require clear labelling on the appliances. The labelling as defined in CSA B415.1 [82] for room heaters comprises:

¹ To convert from mg/MJ to mg/m³_n (@13 % O₂): divide by 0.65 (for rough estimations).

- the average particulate emission rate in g/h and g/MJ_{net} (output).
- the average efficiency of the appliance, expressed as a percentage.
- the minimum energy output rate from a test used in determining the average emission rate.
- the maximum energy output rate from a test used in determining the average emission rate.
- the average electrical power consumption in kW.
- the average electrical power production in kW (if applicable).

For boilers and forced air furnaces. Hydronic heaters (boilers) are required to be certified to CSA B415.1 [82] or US Code of Federal Regulations, Title 40, Part 60, Subpart AAA. The currently revised version of CSA B415.1-2021, proposes to recognise the Class 5 certification for boilers as defined in the European Standard EN 303-5:2021. Jurisdictions may require wood chip/wood pellet/hog fuel boilers to be field tested to confirm their compliance.

The obligatory labelling as defined in CSA B415.1 [82] for boilers and forced-air furnaces comprises:

- the average particulate emission rate in g/MJ_{net}, based on the amount of delivered energy.
- the average delivered efficiency of the appliance, expressed as a percentage.
- the minimum delivered energy output rate from a test used in determining the average emission rate.
- the maximum delivered energy output rate from a test used in determining the average emission rate.
- the average overall efficiency of the appliance, expressed as a percentage.
- the minimum overall energy output rate.
- the maximum overall energy output rate.
- the average electrical power consumption in kW.
- the average electrical power production in kW (if applicable).

Switzerland

For stoves. The association Wood Energy Switzerland assigns a quality label for wood stoves (no specific name). The certificate is awarded upon fulfilment of requirements on emissions, efficiency and safety, these requirements are tested according to the usual European type testing standards. Emission requirements are mostly the same as in the German Emission Ordinance 1. BImSchV [LINK](#) [5] [4], except that in Switzerland pellet stoves may have higher PM emissions of 40 mg/m³_n (@13 % O₂), this is described in the rules for compliance, [LINK](#) [85]. Concerning efficiency, the Swiss certificate defines stricter requirements than the above-mentioned German law, except for pellet stoves.



Source: Holzenergie Schweiz

All certified stoves (including pellet stoves) are listed on the association's a website [LINK](#) [83]. The corresponding test reports with the detailed results can be obtained from the stove manufacturer or from the association. Those manufacturers who create individual slow heat releasing appliances based on a certified calculation method can also receive the quality label of Wood Energy Switzerland. In no case it is legally required that the stove carries this label.

For boilers. The association Wood Energy Switzerland also assigns a quality label for wood boilers. The certificate is awarded upon fulfilment of requirements on emissions, efficiency and safety, which are proven during the usual European type testing procedure (EN 303-5 [86]). Emission requirements are stricter than in the European Ecodesign Directive (see Chapter 2.3). According to the rules of compliance, [LINK](#) [85] the CO limits (@13 % O₂) for log wood-, wood chips- or pellet boilers are at 400, 200 and 150 mg/m³_n, respectively, and for OGC they are at 20, 15 and 10 mg/m³_n and for PM emission they are consistently at 40 mg/m³_n. The awarded boilers are listed on the website, [LINK](#) [84]. The certificate is important for subsidies; boilers shall carry the label when seeking financial support via one of the programs "myclimate" or "Energy Future Switzerland" (see Chapter 3.4), this is relevant when a fossil fuel fired boiler <70 kW becomes replaced by a wood fired boiler.

Germany

Several certificates were or are currently created for wood stove technology in Germany. Two of them are based on results from existing European type testing procedures (DIN_{plus}, HKI_{Cert}), while a third one uses a unique and ambitious test protocol which aims at reflecting real life operational conditions (“Blue Angel”). Furthermore, a fourth certification was recently launched, it also aims at better performance throughout the useful life of a stove (TÜV-Süd certificate). These four approaches are described in the following.

DIN_{plus}-label for stoves. The first stove certificate in Germany was launched in 2011, the DIN_{plus} certificate. It is widely used for stoves. There is an individual certification scheme for each of 5 different space heater types: Stoves according to EN 13240 (room heaters, [LINK](#)), EN 13229 (inset appliances, [LINK](#)), EN 15250 (slow heat release appliances, [LINK](#)), EN 12815 (cooking stoves, [LINK](#)) and EN 14785 (pellet stoves, [LINK](#)). DIN_{plus}-stoves have to fulfil the emission requirements (at 13 % O₂-content) for CO ≤ 1250 mg/m³_n, for NO_x ≤ 200 mg/m³_n, for OGC ≤ 120 mg/m³_n and for Total PM ≤ 40 mg/m³_n.



Source: DinCertco

Before 2016, several German municipalities had based possible exemptions from their existing ban for wood stoves on the existence of the DIN_{plus}-label for the desired stove. But currently there is no such obligation anymore, due to the tightening of general emission limits. This is because the DIN_{plus}-limitations for PM and CO became the new legal requirement for newly sold appliances. From 2015 on this was introduced with the new German emission ordinance 1. BImSchV, [LINK](#) [4]. The other two emission parameters (NO_x and OGC) are in the future also legally regarded by the EU-Ecodesign directive (EU 2015/1185 [19]) which became effective from January 2022. In this directive, NO_x limits are the same as for DIN_{plus}, while OGC-limits became tightened by Ecodesign to a level of 60 mg/m³.

“Blue Angel” label for room heaters. This label is only applicable to room heaters for wood logs. It was launched in 2020. It is presumably the most ambitious certificate in the area. This is true for three reasons: (a) the label requires the stove to prove its performance during a unique and real-life reflecting testing procedure which is not based on the existing European type testing protocol. Nevertheless (b) the emission requirements are extremely strict (see below), and (c) the label requires that the room heaters are equipped with an automated air control to avoid too much user influence and maloperation.



In application for room heaters
Source: RAL gGmbH

According to the award criteria (download page: [LINK](#) [87]), a Blue-Angel-room-heater shall meet ambitious requirements for total PM by mass (heated filter method) of 15 mg/m³_n, for CO of 500 mg/m³_n, for OGC of 70 mg/m³_n and for NO_x of 180 mg/m³_n (all at 13 % O₂). These emission limits are particularly strict when knowing that the specific test protocol differs in several ways from the usual European type testing procedure, e. g. it also includes the stiring phase. An additional measurement of the particle number concentrations is also obligatory. Recently (in version 8, dated 01/2024) also a limit value for particle number concentration was introduced at a level of 3 x 10⁶ particles per cm³. Furthermore, an emission control technology such as a dust precipitator and a catalyst are practically unavoidable due to the strict requirements. If the stove is combined with an external (retrofit) precipitator, a minimum precipitation efficiency of 75 % by mass and 90 % by particle number shall be verified. Additionally, an automatic regulation of air supply is required. Minimum efficiency of fuel conversion is 75 % at nominal and at partial load.

There are further requirements listed in the award criteria [LINK](#) [87].

- a user monitor or interface (to indicate when intervention from operator is needed),
- a high air tightness (i. e. proven in a mechanical stress test according to EN 16510-1),
- min. 10 years of spare part availability,
- the creation of a quick user guide (i. e. two pages guide on fuel, ignition, air control, stoking, cleaning/maintenance),

- the elaboration of more detailed operational instructions,
- a requirement for improved recycling of materials.

Concerning the novel test protocol for the Blue Angel stove award, the procedure is challenging. An initial cold starting batch is included in the measurement cycle, it is directly combined with a second heating-up batch to become one gravimetric PM-sampling period. Then three consecutive batches are performed and measured (30 min PM sampling each) at full load, followed by two more consecutive batches at partial load. Finally, from the total of 6 PM-measurements the average is calculated. A real or simulated natural chimney draught is realized with ambient temperature between 15 and 30 °C at the installation site and a chimney height of 4 m, draft in cold stage shall be <2 Pa.

The total number of products that have so far received the “Blue Angel” certificate is six (Aug. 2024). They are listed on the official website, [LINK](#) [88]. The Blue Angel stakeholders are governmental. They actively promote the label as a suitable way to highlight those stoves which might be exempted from regional bans of cities and municipalities for conventional log wood stoves.

HKl_{cert}-Label for stoves. The HKl_{cert} label was launched in 2015 by the German stove industry association (HKI). It is issued for appliances according to EN 13240 (room heaters), EN 13229 (inset appliances) and EN 15250 (slow heat release appliances). According to the award criteria ([LINK](#) [90]) the existing emission limits for CO and PM as specified by German law (1. BImSchV) shall be met. For NO_x and OGC the limits of Ecodesign directive (EU 2015/1185) apply. Efficiency requirements are slightly more demanding than in the German law.



Source: HKI

Concerning the testing procedure, the regular type testing protocol shall be applied, but it is based on the European Standard of EN 16510-1 [91] which is now finally approved by EU. The intention of the certificate launched in 2015 was an early introduction the testing routine requirements of the long time pending draft standard prEN 16510-1 to current products. Furthermore the label aims at ensuring better conformity between stoves as tested in type testing to those stoves that are finally sold to the market. This is enforced via leakage tests and self-monitoring of production by the manufacturer.

TÜV-Süd-certificate for stoves. This certificate was recently published (in 2021) by TÜV-Süd, in collaboration with the German stove industry association HKI, [LINK](#) [92]. No known products have yet been certified (Feb 2022). The certificate applies to three different types of stoves: room heaters (EN 13240), inset appliances (EN 13229) and slow heat release appliances (EN 15250).



Source: TÜV Süd

In the TÜV-Süd-certificate, most aspects of the testing procedure follow the usual European type testing protocol, but the published award criteria (download page: [LINK](#) [92]) also describe a significant number of supplemental tests that need to be performed: It is checked which mode of ignition (i.e. cold start) is the least polluting one and whether the manufacturer has suggested the best option (1); tests are also done on reduced load (2) and the tightness of stove and leakage air is assessed before and after heating and after an endurance test (3) of 6,000 door closures applied on the door mechanism. Aspects (2) and (3) also described in the European test standard EN 16510-1 [91]. Furthermore, the stand-still heat losses are tested, they shall not exceed 7 m³/hr at a differential chimney pressure of 5 Pa. Usually such loss prevention is guaranteed by the existence of an automatic air control system which is also generally required for TÜV-Süd certificate, and which shall be in line with the new national standard DIN_{spec} 18843-1 [94]. Alternatively, the stove could also be equipped with an ESP having a minimum precipitation efficiency of 50 %, as tested according to the National test standard DIN_{spec} 33999 [93]. For receiving the label inspections are made the manufacturing site to prove conformity of current stove production with the originally tested stove. This happens at least once a year.

Blue Angel label for particle precipitators. Another “Blue Angel” label was created for retrofit particle precipitators. It was launched in Jan 2022. The certificate aims to label all precipitators which shall become combined with all those stove types, for which a specific Blue Angel award has not yet been released, as it is currently only the case for room heaters according to EN 13240 (see Blue Angel description above). In consequence, newly installed stove insets or slow heat releasing appliances, which can’t directly receive the Blue Angel award will automatically achieve a Blue-Angel-status if they are equipped with such a dust precipitator.



In application for particle precipitators
Source: RAL gGmbH

According to the award criteria ([LINK](#) [89]), a Blue-Angel-dust-precipitator shall meet ambitious requirements. The minimum precipitation efficiency for total PM by mass (heated filter method) shall be 65 %, while for particle number concentration it is even at 90 %. All requirements need to be met at the same time. The test procedure differs from the German DIN_{spec} 33999 [93] for ESP’s, as the cold start phase (first 2 batches) of the applied stove shall also be measured and in the final evaluation those results shall be weighted at 1/3, while the measurements for nominal load operation are weighted at 2/3 in the calculation. At nominal load the PM concentration during test shall be between 100 and 200 mg/m³_n (@13 % O₂).

To date (Aug 2024) no precipitators have yet received the award. The stakeholders of the label promote the use of the precipitators in regions where a newly installed log wood stove generally needs to carry the Blue Angel award.

Certificates for boilers. No national certificate exists for boilers. Labeling follows the European rules of Ecodesign.

Denmark

For wood stoves. According to the Ordinance no. 199 of 04/02/2022, the so-called “Wood Stove Ordinance”, [LINK](#) [167], a test certificate is mandatory for market release in Denmark for wood stoves and fireplace inserts installed before 1 January 2022. No specific name applies, but the test should be performed by an approved institute and follow the specifications in the order and upon installation, the local chimney sweep should approve the certificate along with the inspection of the entire installation. The regulation is based on the Ecodesign scheme for Local Space Heaters, [LINK](#) [19], see Chapter 2.3. The emission requirements are shown in Appendix 6 of the wood stove ordinance, [LINK](#) [167]. In special cases, for instance if a stove has to be re-installed or if it is over 50 kW capacity, Appendix 1 of the ordinance applies.

In Denmark, stoves can also receive the Nordic Swan eco label. The requirements are listed below (see chapter for Sweden below).

For wood boilers. Boilers with a capacity below 1 MW_{th} are also regulated by the above mentioned “Wood Stove Ordinance”, [LINK](#) [167], and the same rules as described above apply. Emission requirements are here shown in Appendix 2 of the mentioned the regulation. The Danish Technological Institute keeps a list of approved boilers, [LINK](#) [168].

Italy

For stoves and boilers. The label *ariaPulita*TM is issued for wood stoves and boilers. The requirements are explained in the rules of compliance, [LINK](#) [98]. They follow the Ministerial Decree n. 186/2017, that has classified the appliances based on number of “Stars”, which characterize the level of pollutants emissions and efficiency (see Chapter 3.3). The *ariaPulita*TM-label is a voluntary certification scheme for biomass local space heaters and for boilers up to a nominal heating power of 35 kW. All classified products are listed in a searchable database, [LINK](#) [99].



Source: www.certificazioneariapulita.it

The Netherlands

For stoves. There is no national label for the stove itself, but for the installer and salesperson there is a voluntary training available to become a certified installer or salesperson, including training material and examination. The installer can be certified on the quality of installation, while salespersons can be certified on the quality of their sales advice. Both trainings aim to prevent suboptimal installations of stoves, flue gas channels and chimneys. The certificate is currently not compulsory but is offered on a voluntary basis by the NHK (the Dutch association of stove suppliers).

For boilers. There is also a voluntary quality scheme in place for installers of biomass boilers (with training material and examination), it is part of the EU RED Annex 4, however in practise this is hardly used.

Norway

In Norway the Nordic swan label is voluntarily used for wood stoves (see chapter for Sweden below), with a PM emission limit that is lower than the PM emission limit of 10 g/kg dry fuel that is obligatory according to the Norwegian test standards NS 3058 and 3059.

Sweden

All new equipment has by law to fulfill CE marking and type approval. Apart from the CE mark, that characterizes conformity with European product rules, there is no other governmentally or legally binding certification scheme for wood stoves or boilers.

For stoves. Some stove manufactures have chosen also to add the voluntary Nordic Ecolabel, “the Swan”. The award criteria can be downloaded: [LINK](#) [139]. This Ecolabel does not only claim that the stove has a high efficiency and produces low emissions of environmentally hazardous substances. It also claims that the stove is manufactured without unnecessary toxins and metals and with a low environmental impact.



Source: www.wikipedia.org

Moreover the idea behind the Nordic Swan is also to impact the development and thus the requirements are always pushed in that way that only the best performers of the market (kind of BAT) are able to meet them and will thereby serve as good examples. The label is also applicable for pellet stoves. CO emissions are determined during the procedures of European test protocols EN 13240, EN 13229, EN 15250 and EN14795, while PM emissions are determined according to the procedure in the Norwegian Standards NS 3058 and NS 3059. Log wood stoves need to meet stricter requirements than in the current European Ecodesign Directive, e.g. for manually operated stoves, the CO requirement is 1,250 mg/m³n @13 % O₂ (Ecodesign: 1,500 mg/m³n) and for PM emission it is 2 g/h (Ecodesign: 5 g/h).

USA

For Stoves: the voluntary hangtag program. A voluntary hangtag had marked units that had met the standards before the May 2020 date, thereby accelerating the emissions reductions efforts. In order to receive a hangtag, wood stove models must be tested by an EPA-approved laboratory (as per the 2015 NSPS specifications). A key variable was whether standardized tests are performed with crib wood, cord wood, or wood pellets. For models to qualify for a hangtag, the following particulate matter emission levels were required, [LINK](#) [223]:

- Wood and wood pellet stoves (2.0 g/hr),
- Hydronic heaters (0.10 lbs/mmBTU for each test burn),
- Forced air furnace (0.15 lbs/mmBTU for each test burn).

Compliance was aimed primarily at wood stove manufacturers, producing new stoves for retail sale. For cordwood testing (an alternative procedure to the above), wood heaters that meet the following emissions standards may display the voluntary hangtag:

- Wood and wood pellet stoves: 2.5 g/hr,
- Hydronic heaters: 0.15 lbs/mmBtu for each burn rate,
- Forced-air furnaces: hangtag is not available because these appliances already test with cord wood (CSA B415.1-10).

Hangtags must include the following information, [LINK \[224\]](#), [LINK \[226\]](#):

- **Efficiency.** Weighted average efficiency calculated using the higher heating value of fuel (HHV) from the test report submitted to EPA by an EPA-accredited lab. Lower Heating Value (LHV) efficiency and other efficiency measures are not acceptable.
- **Smoke emissions.** Weighted average particulate matter emissions (in grams per hour for wood/pellet stoves, or pounds per million BTU heat output for each burn category for hydronic heaters and forced-air furnaces.
- **Heating area.** The size of the area that the device can heat as specified in owner's manual.
- **Fuel tested.** Wood pellet: ground wood or biomass that is compressed into a pellet; Crib wood: '2 x 4' or '4 x 4' cut lumber that is stapled together; Cord wood: typical firewood used in homes, this test is considered a better measure to reflect how a heater will perform in residential settings, [LINK \[225\]](#).



Test method differences (crib wood vs. cord wood) are discussed on an EPA web page, [LINK \[225\]](#).

Source:
www.epa.gov/burnwise/wood-stove-label-and-hang-tag

3.13 Specific information campaigns on clean use of wood fuels

There were two preceding questions to this chapter:

A) *“Are there any relevant public campaigns concerning correct use of wood fuel in residential heating?”*

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

B) *“Are there any relevant campaigns to defame wood fuel use in residential heating (with the aim to reduce air pollution from wood fuels, but not raise questions about sustainability issues)?”*

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	no	yes	no	no	yes	yes	yes	yes	no	no

Chapter summary

In all involved countries there are relevant public campaigns concerning correct use of wood fuels in residential heating. Most common is the creation of brochures and information websites (all countries). In many cases the wood fuel associations are involved and provide own web-links and brochures. But also, environmental agencies or Ministries of Environment can be the driving forces behind the created information packages. Sometimes also governmental research institutes are contractors or creators of brochures.

But to reach more stove users, the campaigns often go beyond brochures and websites. In Canada, for example, an online course for stove users is offered, it can be accessed without any restrictions. In Austria end-user training events were developed in the “Clean Air” project series, where a citizen-science trailer is inviting stove operators to test their wood heating habits. In Germany, a voluntary training course for stove users is currently being elaborated, which shall be held in presence (working title “Stove d licence”). But also a commercial online-training course is now available which ends with an examination and a certificate. The creating company now expands its business by creating customised training courses for stove industry to enable them to pass these on to their new customers with every sale. Teaching videos about correct ignition of a stove were elaborated for example in Switzerland, and a similar video publication, which also involves celebrities, is known from Denmark. A video series about the impact of several maloperations of a stove on PM-emission was elaborated in Germany, to serve as cautionary example. In Italy, apart from a video on the five golden rules of good wood combustion, the wood fuel association also launched an information campaign via local TV, radio, and social networks. The Netherlands have created the ‘Stookwijzer’ which was implemented to spread the information about unfavourable weather conditions for wood heaters, and it is the aim to discourage stove users to use their appliance; this happens via an app, website and via email distribution list. In Norway, the Norwegian Research Organisation SINTEF is active in a campaign on correct combustion; videos and websites are created but also the scientists are leading discussions forums and participate in online-workshops about wood stove technology. Webinars on correct wood heating are also regularly offered by the Bavarian research centre TFZ in Germany. In the USA, much technical information is also made available via web-blogs. In Sweden, instruction videos on how to fire correctly are broadly available. Some videos are embedded into municipalities webpages, generally wood fuel-based information is provided by almost every Swedish municipality; this is due to the fact that they are responsible for local air quality.

In Sweden also all small-scale wood burning appliances are mapped. This is to assess large emission reduction potentials that are collectively required to meet the specifications in the environmental quality goal. From this mapping, proposals were elaborated on how to avoid an impact on the air quality of small-scale wood burning in a most economically efficient way.

Austria

Information activities. The Ministry for climate action, environment, energy, mobility, innovation and technology and the Environment Agency Austria are operating a website with information about the correct use of heating technologies; [LINK](#) [194]. Another programme, where the avoidance of pollutant emissions is not the main focus, is also run by the same ministry, it provides more general information on heating with biomass on a dedicated website, [LINK](#) [195]. The same is true for a “wood heat” information website by the Austrian biomass association where information on several current topics (e.g. sustainability, emissions, etc.) is provided, [LINK](#) [197].

Brochures. An informative two page leaflet “Heating properly” (“Richtig einheizen”) was produced and released by the Austrian biomass association, [LINK](#) [197].

Demonstration actions. In the province of Styria end user training events were developed and investigated in the frame of the “Clean Air” project series. In these events, a citizen science trailer is inviting end users to test their wood heating habits. Therefore, three wood stoves equipped with measurement equipment are used to compare emissions and efficiency of different kinds of operation. After these workshops the participants are invited to continue their participation by documenting their heating habits using an app which was developed within the clean air project. This firemonitor® app collects some basic information (including fotos) on the real-life operation of wood stoves in the households. The project is explained in a short video (in German only): [LINK](#).

General. There are no systematic campaigns in Austria. Now and then the topics emissions and sustainability of energetic use are discussed in the media, but usually without a bigger public response.

Canada

Public campaign and videos. National efforts are made to increase public awareness and education. Some relevant publications and media can be mentioned:

- “Guide to Residential Wood Heating (2018)” by Canada Mortgage and Housing Corporation (CMHC) and Natural Resources Canada: [LINK](#) [106].
- “Wood smoke“, informational webpage, Health Canada, [LINK](#) [107]
- Metro Vancouver has a video about best burning practices, which is on Metro Vancouver’s website (metrovancover.org) and Vimeo channel: Best Burning Practices - Residential Wood Burning on Vimeo. This has also been shared through Metro Vancouver’s social media channels.

City of Montreal had a campaign promoting its By-law 15-069 when it was launched in 2015. Many platforms were used to disseminate key messages to the public. Among the initiatives were selective posting of an information letter, of a declaration form as well as of an explanatory brochure to some 50,000 residents presumed to own a solid fuel device; the use of social media; advertising broadcast on the radio, the Web and in print media; broadcast of bulletins on Métrovision and the Ministère des Transports du Québec (MTQ) screens; and dissemination of a newsletter.

Online course. The Fraser Basin region of British Columbia has a Wood Smoke Information Resources Portal, which offers wood smoke education via online course (Figure 8), videos series on cleaner burning, and resident tip sheets, [LINK](#) [108].

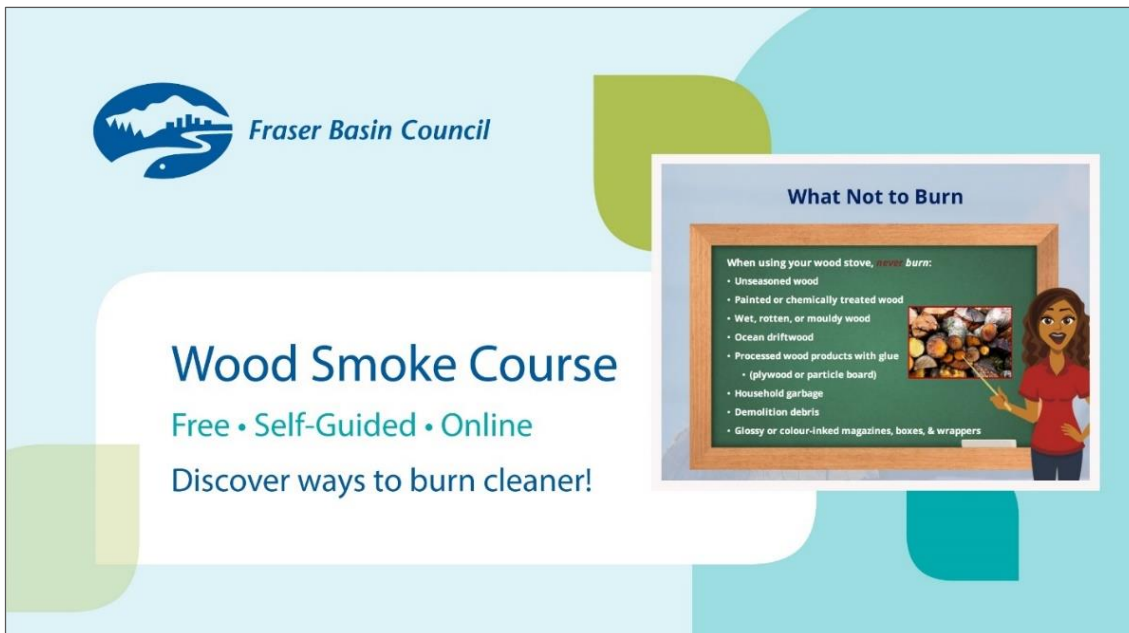


Figure 8: The Fraser Basin Wood Smoke Course, [LINK](#) [108]

Information packages. There are several fact sheets related to wood burning, e.g.:

- “Wood Burning Smoke”, Government of Alberta, [LINK](#) [109].
- “Prohibited Debris: Before You Burn... Learn!”, Government of Alberta, [LINK](#) [110].
- Residential Wood Pellet Heating | A Practical Guide for Homeowners by Arctic Energy Alliance, [LINK](#) [111].
- Wood smoke brochure by City of Whitehorse, Yukon, [LINK](#) [112].

Switzerland

Information campaign. There are several examples for country wide actions:

- Wood Energy Switzerland: Brochure and video about how to best start a fire in wood stoves and wood boilers and how to operate wood heating systems (including information of different wood fuel types), [LINK](#) [113]
- “FairFeuern” has created an information webpage and Brochure, [LINK](#) [114], on residential wood heating. “FairFeuern” is an information platform jointly provided by the environmental agencies of the eastern Swiss cantons of Appenzell Innerrhoden, Appenzell Ausserrhoden, Glarus, Graubünden, St. Gallen, Schaffhausen, Thurgau, Zurich and the Principality of Liechtenstein. Partners are also the municipal emission control offices of the city of Zurich and the city of St. Gallen, [LINK](#) to website [115].

Further examples for cantonal or regional actions are:

- Canton Basel-Land: Information about best practices (wood storage, how to start the fire, what to do with the ash) of wood use in wood stoves, [LINK](#).

Defaming of wood fuel. There are no systematic campaigns to defame wood fuels in Switzerland. But individual negative comments occasionally appear in the media, often from directly affected persons and frequently during the cold period of the year, when air pollution is locally increased. In addition, a few individuals as e.g. the known meteorologist Jörg Kachelmann repeatedly publishes comments on the negative effect of wood burning in newspapers and blogs.

Germany

Information packages. Several brochures and handbooks on correct residential heating with wood are available (all in German language):

- Informative guidebook for stove users “Clean heating with room heaters”, by TFZ, [LINK](#) [116],
- Demonstration videos illustrating the impact of poor stove operation on PM emissions, [LINK](#) [117], (several YouTube-videos to be accessed via to TFZ webpage),
- Information from German Stove Association on correct heating, the HKI-Website, [LINK](#) [118]
- Brochure by German Federal Agency on Renewable Raw Materials (FNR) on the correct use of log wood stoves, [LINK](#) [119],
- Handbook on wood heating, edited by TFZ and published by German Federal Agency of Renewable Raw Materials (FNR): [LINK](#) [121],
- Brochure by State Environmental Office of Bavaria (LfU) on clean operation of room heaters for log wood, [LINK](#) [122],
- Brochure by State Environmental Office of Bavaria (LfU) on central heating boilers for wood fuels, [LINK](#) [123],
- Guidebook on correct and clean heating with wood, by Federal Environmental Office (UBA), [LINK](#) [124],
- LUBW brochure about what you should know when purchasing and operating a wood stove, [LINK](#) [125].

Training course for wood stove users. A current activity aims at introducing a comprehensive voluntary training course for stove users (working title “Stove licence”), under the auspices of the Federal Office of Environment (UBA). The preparatory project will terminate in 2024. But over the last years the Bavarian Research Centre TFZ has offered several webinars on stove-related questions and on correct log wood stove operation.

In Germany, there is also an independent commercial organisation, the ‘Ofenakademie’ (Stove Academy) which now offers a two-hour online training course for users of room heaters, the course ends with an examination and a certificate, [LINK](#) [120] (Figure 9). According to the company, until now (Jan 2025), 33,000 users are already registered, their registration fees are mostly sponsored by municipalities, NGO’s or stove manufacturers. The further approach of the ‘Stove Academy’ is now to acquire customers from the stove industry, that have the Academy create customised training courses for the respective stove type to enable the industry to pass these on to the respective new customers together with the operating instructions with every sale.

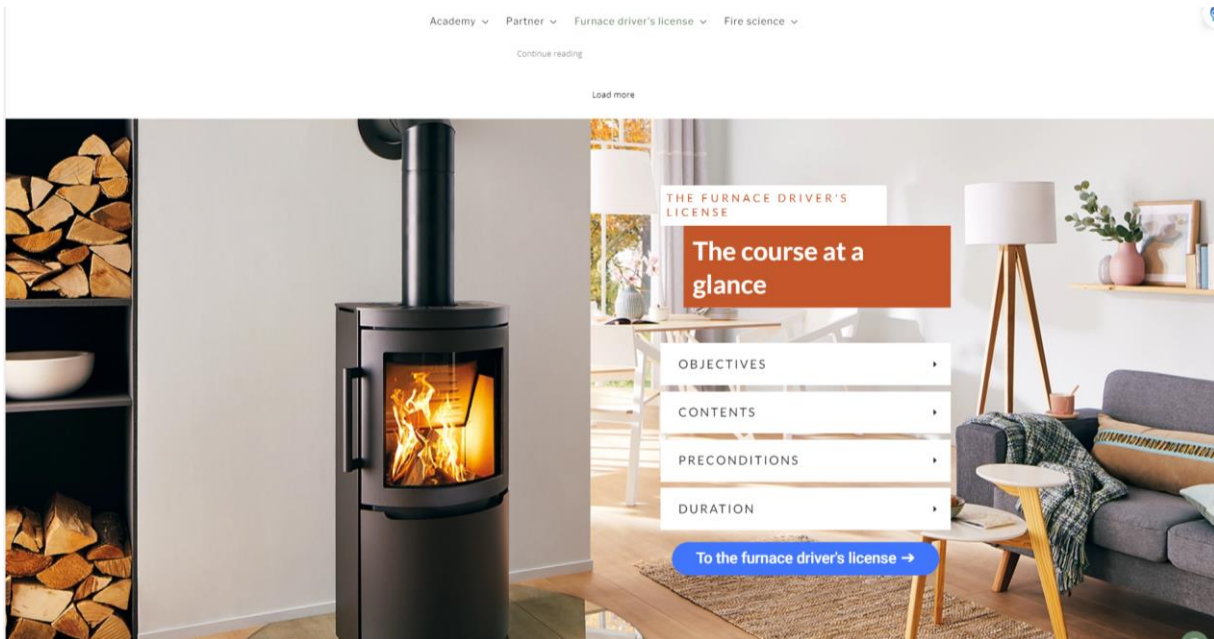


Figure 9: The online training course for log wood stoves by 'Stove Academy', Source: www.ofenakademie.de (This webpage was automatically translated from German language).

Defaming of wood fuel. Defaming activities are also observed in Germany, although an organisational structure is not easily visible. Often, they do not directly criticize pollutant emissions but are addressing sustainability issues and sometimes they generally deny the CO₂-mitigation effect of wood combustion. For example, it has become obvious, that the group around the journalist Jörg Kachelmann is always quickly reacting when there is a wood energy related report on the media (TV, radio, newspaper), this happens via X or in any specific discussion forums which are opened by the media themselves. It can be assumed that the Kachelmann team searches for relevant publications, where he and his followers can place an initial comment to lead the opinion throughout the subsequent discussion on the platforms.

Denmark

Public campaigns. Numerous campaigns have over the years informed the public about the advantages of biomass and of the correct use of wood fuel - mainly targeted at combustion in wood stoves. Some campaigns have accompanied scrapping schemes that also could be seen as campaigns themselves.

A former campaign named "Stop smoking for wood stoves" that was promoted by the EPA and the chimney sweeps. The campaign was web-based and includes videos on correct ignition with celebrities as well as with a chimney sweep and can to some extent still be seen at the YouTube channel of the Danish EPA, [LINK](#) [169]. It provided instructions on a lot of topics around wood combustion, such as fuel choice, air supply, visual control of combustion quality, FAQ's etc. Reference is also made to the Swiss research concerning correct ignition from the top, [LINK](#) [170]. The campaign has been evaluated in 2016, [LINK](#) [238].

The most recent campaign is "Fire correctly" which can be seen at the of the Danish EPA, [LINK](#) [239]. The campaign is a collaboration between the EPA and the Chimney Sweep Association and includes pamphlets for wood burning stoves and boilers on correct ignition techniques and good advice for reducing particle emissions.

Brochures. Support on specific information towards proper wood fuel use also comes from the Danish Chimney Sweep Association, they release information leaflets and are involved with the EPA, [LINK](#) [178]. A brochure on the topics can be seen in this [LINK](#) [178].

Wood combustion defaming campaign. There is a strong and persisting defaming campaign going on in Denmark involving NGO's, local and national politicians and journalists/media - even large newspapers

and TV stations. Some NGOs work to reduce or end all (residential) wood combustion. Some do it in order to avoid PM emissions. Especially "Green Transition Denmark" (formerly known as the Eco Council) works to reduce air pollution, [LINK1](#) [174] and [LINK2](#) [175]. The work includes loud discussions with for instance the chimney sweep association, who cannot recognise the results and consequences reported by the NGO.

Italy

Public campaign. Several campaigns for clean wood combustion can be mentioned:

- The Italian wood energy association AIEL developed a comprehensive website oriented to end-users for promoting the correct use of wood fuels, this also includes the domestic scale, [LINK](#) [126].
- The European Life-project prepAIR developed an information campaign oriented to domestic biomass heating, [LINK](#) [127], for the campaign, several materials were elaborated, e.g. leaflets and a YouTube-video addressing the 5 golden rules of good wood combustion.
- With AIEL the municipality of Feltre developed an information campaign oriented to end-users within the project "Feltre Rinnova". The info-campaign applied local TV, Radio and social networks. For the inauguration of the campaign, a public event was organized in the meeting room of the local hospital and a very famous testimonial (opinion leader on environmental issues) was invited. About 500 citizens attended the event, [LINK](#) [128].
- In 2023, the Veneto Region implemented a portal to raise awareness among citizens about the correct use of woody biomass, [LINK](#) [129].
- In 2024, the Piedmont Region launched an information and awareness campaign to use adequate quality wood for heating and to consciously manage wood-fired systems to achieve energy efficiency and protect air quality, [LINK](#) [130].
- In 2024, the autonomous province of Bolzano (South Tyrol) has launched a communication and awareness project for the correct use of wood in domestic systems. Chimney sweeps are actively involved in the project and, in addition to the usual cleaning and maintenance work, they will have the task of carrying out personalized consultations and performing a simplified check-up of the systems, [LINK](#) [131].

Brochures. Brochures that were developed during previously mentioned activities are:

- Brochure by AIEL on correct residential heating, [LINK](#) [132]
- European Life-project prepAIR-brochure on domestic biomass heating, [LINK](#) [133]

Teaching courses. Wood heating instruction events were also held by AIEL for end users within the above-mentioned project "Feltre Rinnova". The content was on the importance of adequate firewood quality, how to recognise a modern wood stove, how to correctly use the wood stove (ignition and operation), the importance of correct installation and maintenance, and on security aspects (fire- and CO-risk).

Defaming of wood fuel. Almost every autumn an info campaign to defame the use of wood fuels is organised. Some years ago an important association of fossil fuels commissioned a scientific study to highlight the high dust emission of wood appliances in comparison to natural gas and LPG boilers. They published the results in the most important national newspapers. [LINK](#) [191].

The Netherlands

Media actions. A specific media action that was initiated by the NL Ministry of Environment is the 'Stookwijzer' (stook = Dutch word for heating). This tool informs stove operators if adverse weather conditions exist in a specific region for using a woodstove, based on expected windspeed and modelled air quality indices and temperature inversion. The result is a colour yellow, orange or red. This is decided by the national health agency (RIVM) in conjunction with the national meteorological agency (KNMI), for the current weather conditions for using a stove (see [LINK](#) [104]). In case of a 'code red', the lighting of a wood stove it is strongly discouraged, this is communicated using the app, a website and newsletter [105].

Public campaign. To reduce air pollution from wood stoves and other sources, the national government, provinces and municipalities have joined the public campaign for the ‘Schone Lucht Akkoord’. As part of this action, a set of actions have been recently initiated (see also section 9 of this document, [LINK](#) [199]):

- Public information material is prepared in standard format that can be used by municipalities and provinces (ongoing).
- Health effects of wood smoke are incorporated in general information about the energy transition, and actively communicated (ongoing).
- The ISDE subsidy on pellet stoves and biomass boilers up to 500 kW has stopped as of Jan 1st, 2020
- It has been attempted to use Ecodesign limits in the Netherlands earlier than 2022, however the EC had prohibited this.
- The Netherlands lobbies at the EC for further tightening of Ecodesign limits (ongoing action).
- By providing a toolkit, municipalities are assisted to take adequate measures in communication in case of nuisance from wood smoke, and enforcement of adequate measures.
- It is currently very difficult to assess a case of excessive pollution from wood smoke in case a wood stove user is suspected from causing excessive pollution in an area. As a result, it is difficult for municipalities to take measures to enforce optimal user behaviour. An independent measurement method is therefore being developed to enable independent assessment in case of complaints.
- The ‘Stookwijzer’ (see above) is set up to actively provide information on bad local weather conditions for wood stove use, supported by a specific website, and to collect complaints from local areas on nuisance from wood smoke, in order to forward these to the local municipalities.
- Local municipalities act upon the complaints received from the ‘Stookwijzer’
- The feasibility of additional measures is investigated, following the German system for improving the quality of wood stoves, installations and consumer behaviour (ongoing).
- Several municipalities are using the Stookwijzer to impose a temporary ban for burning wood in case of code red.
-

The Dutch association of wood stove suppliers (NHK) provides public information on clean combustion on their website (brochures and in-formation materials, video training material), [LINK](#) [142].

Norway

There is an information campaign on wood fuel use led by SINTEF, the Norwegian Research Organisation. The focus is set on wood stoves and wood burning. Several videos and illustration provide information on correct combustion (in English and Norwegian language), [LINK](#) [154]. The website also hosts a blog (<https://blog.sintef.com/?s=wood+stove>) where SINTEF-scientists are involved in discussions about wood stove technology.

In Norway, wood energy is also questioned and criticized, such activities are often launched by individuals. An interesting debate about usefulness of small scale appliances was held online on the platform “Innoasis Science Talks”, titled “Should we ban wood stoves” The full video of the event (in English language) is available online: [LINK](#) [155]. More videos are available, e.g. a short clip about how to interpret the flames in a log wood stove, [LINK](#) (on YouTube).

Sweden

Public campaign. The Swedish Environmental Protection Agency (Naturvårdsverket) did in 2017 carry out a campaign called “Light it from the top”, which was directed towards 79 Swedish municipalities. The participating municipalities helped distributing information materials to house owners with wood boilers or stoves. The brochure used can be downloaded, [LINK](#) [134].

Instruction videos on how to fire correctly in order to avoid emissions and maintain high efficiency were also produced. Some were embedded into municipality’s webpages or linked to The Swedish Environmental Protection Agency’s webpage where the material can be viewed today ([LINK1](#) and [LINK2](#) to the videos, in Swedish language).

Almost every municipality provides some kind of information on their webpages concerning wood heating. This is mainly because they are responsible for local air quality. Many such webpages also link to The

Swedish Environmental Protection Agency and their material, [LINK](#) [135]. Examples of municipal web pages: [LINK1](#), [LINK2](#))

Brochures. Several brochures on wood heating are available:

- From the Swedish Civil Contingencies Agency, [LINK](#) [136]
- Swedish Stove Heating Association, [LINK](#) [137]

Emission mapping. In 2017, the Swedish Environmental Protection Agency was commissioned by the Swedish government - after consultation with the Swedish Metrological Institute - to map emissions from small-scale wood burning and to assess large emission reduction potentials that are collectively required to meet the specifications in the environmental quality goal “Fresh Air”. The assignment was extended and expanded by also developing proposals for milestones to avoid an impact on the air quality of small-scale wood burning and to review the possibility of reducing the impact on the air quality of small-scale wood with economic instruments. The results are reported in the report "Mapping and analysis of emissions from wood burning", [LINK](#) [138].

USA

Much of the technical information on wood stove use and emissions is generated through University Extension Service offices.

The “Alliance for Green Heat“, a non-profit organization, promotes modern wood and pellet heating systems as a low-carbon, sustainable and affordable energy solution. Their mission is to: “promote cleaner and more efficient wood and pellet heating”. While their primary focus is on the technology and the regulatory environment around combustion, the sustainable supply and use of firewood and pellets is also paramount to their mission, [LINK](#) [227].

The “Wood Heat Organization Inc.“ is a “non-profit, non-governmental agency dedicated to the responsible use of wood as a home heating fuel“, [LINK](#) [228].

There are also many online wood heating-related blogs providing useful information from users (however potentially unsubstantiated, unverified, and/or not peer-reviewed).

3.14 Activities of fuel-, stove- and boiler industry towards lower emissions

The preceding questions to this chapter was

“Are there any mentionable activities of associations, industry groups or individual players?”

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Chapter summary

Activities of the stove and boiler industry are mostly coordinated by the involved associations in the country. Their core activity towards the higher performance of biomass appliances is to provide an information platform, e. g. via organising events, maintaining websites, publishing brochures and more. Often these associations become active partners in temporary research projects or are sometimes even funding or coordinating them. This is true for Austria, Canada, Switzerland, Germany, and others.

Stove and boiler associations are sometimes also developers of training courses. For example, in The Netherlands voluntary trainings are available for installers and for salesperson to become certified, and in Canada the association helped in organizing “Train-the-Trainer”-courses for safe installation of wood burning appliances. In Canada the industry association was also involved in a wood stove changeout

program across the country, providing public education workshops on health, safety issues related to wood burning and better burning practices. In Germany, some manufacturers are having customised training courses for their individual stove types created. This is then done by a commercial company which is also involved in selling access to general online training courses for private stove operators as a result of sponsoring by municipalities or NGO's.

In many cases stove and boiler associations are also involved in developing labels, or they are even the creators and sometimes owners of such labels. This is for example true in Switzerland (label of the Association for Wood Energy Switzerland, for stoves and boilers), in Italy (ariaPulita-Label for stoves) and in Germany (HKI_{cert}-label and TÜV-Süd-label, both are for stoves).

National and international standardisation is also a usual and permanent involvement of all stove and boiler associations and often also of individual industry representatives. In Germany, for example, the stove industry association was the authorized institution in the creation of four new national standards (Technical Specifications) for automatic air control variants for log wood stoves that were published in 2021.

Austria

In Austria, several industry associations are supporting the development of biomass combustion technology. Most of their activities are linked to information exchange: They provide relevant information on their websites, prepare different types of publications on specific topics and organize information events. These active associations are:

- The Austrian biomass association (website: [LINK](#)), which maintains a specific online information package which also includes information that specifically aiming to improve stove user operation (see links in Chapter 3.13).
- The Austrian pellet association, ProPellets (website: [LINK](#)).
- The Austrian tiled stove association (website: [LINK](#)).
- Working group on district heating (part of Austrian biomass association) (website: [LINK](#)).
- Association of Austrian boiler manufacturers (website: [LINK](#)), where apart of biomass also gas/oil, heat pump, solar thermal installations are covered)

Canada

Heart, Patio & Barbeque Association of Canada (HPBAC) is an industry association representing companies that produce, sell, or service appliances and accessories in the hearth and barbecue industries in Canada, [LINK](#). HPBAC has been an active participant in many programs aimed at educating the public about better burning practices and the replacement of uncertified wood burning appliances with new technology, certified appliances. Several Canadian wood appliance manufacturers and test labs are active members of the CSA B415. 1 Technical Committee. Below are examples of programs and initiatives by HPBAC:

- *Burn it Smart*. This program, which ran from 2002 through 2010, included regional wood stove changeouts programs across Canada which provided public education workshops on health, safety issues related to wood burning and better burning practices. HPBAC's regional chapters administered several of the programs and provided assistance to other program administrators. Following the cancelation of the national program, HPBAC continued to organize workshops in Indigenous communities, including in the Far North, with funding provided by NRCan.
- *WETT Train the Trainer and WETT Training*. HPBAC helped to facilitate WETT training sessions in indigenous communities in Northern Ontario to enable safe installation of wood burning appliances by community members. The next phase of the program was a fully funded change-out in remote communities.
- *Research on GHG Remission reduction*. HPBAC commissioned and funded a research project by Dr. James E. Houck in 2018 on Climate Change Benefit from the Replacement of Older Conventional Cordwood Stoves with U.S. EPA Certified Cordwood Stoves. The study quantified the reduction of GHG emissions when an uncertified appliance is replaced with a certified appliance (U.S. EPA NSPS as of 2012) based on average amount of wood fuel burned for household use and using air emission

data from in situ testing sponsored by the U.S. EPA, U.S. Department of Energy, Environment Canada, HPBA and several local and state environmental and energy agencies.

Stove user specific information distributed by HPBAC is given on their website, [LINK](#) [140]. Few of Canadian manufacturers are also regular participants to US DOE's wood stove design challenges.

Switzerland

Several activities of the Swiss industry can be mentioned:

- *Technology development.* The Swiss industry was active in the development of low emission technologies for wood combustion as e.g. innovative combustion systems, control technologies and electrostatic precipitators. The technology development of the industry is assisted by public funded research (see Chapter 3.15).
- *Stove operation.* The industry was involved in the development of documents on best practise to start and operate wood combustion devices described in Chapter 3.13.
- *Labelling of appliances.* For wood stoves and boilers, the Swiss association on wood energy ("Holzenergie Schweiz") is active in quality control by a quality label: Details of the Swiss labelling are described in Chapter 3.12.

Germany

The creation of new technical Standards for automatic stove control was initiated by several advanced industry partners in collaboration with TFZ. Four different national "Technical Specifications" (Parts 1 to 4) on automatic air control variants for log wood stoves were recently published in 2021:

- DIN/TS 18843-1:2021-08: Residential solid fuel burning appliances – Combustion air devices - Control units for residential appliances – Part 1: Electrically powered, temperature-controlled combustion air devices
- DIN/TS 18843-2:2021-08 Residential solid fuel burning appliances – Combustion air devices - Control units for residential appliances - Part 2: Mechanically controlled combustion air devices without auxiliary power
- DIN/TS 18843-3:2021-08 Residential solid fuel burning appliances – Combustion air devices - Control units for residential appliances - Part 3: Electrically powered, flue gas component-controlled combustion air devices
- DIN/TS 18843-4:2021-08: Residential solid fuel burning appliances – Combustion air devices - Control units for residential appliances - Part 4: Additional functions of combustion air devices

The German Stove Association HKI is promoting a new label for space heaters, which shall also require a proof of conformity with one or several of the above standards on combustion air control. The details to this activity and the specific requirements are mentioned in Chapter 3.12 on certificates and labels

Stove industry (represented by the European Fireplace Association EFA and by HKI) also aims at a wide introduction of a so-called "Quick User Guide" (QUG) to become an essential part of a stove-specific user instruction which is required for each new stove. Meanwhile, the most advanced approach to the requirements of a quick user guide was made by the initiators of the "Blue Angel" certificate for low wood stoves (see Chapter 3.12).

In Germany, some individual stove manufacturers are recently also active in online training courses for stove operation. Via a recently founded commercial company, named the 'Stove Academy', [LINK](#) [120] which offers general online stove-training courses (see Chapter 3.13), customised training courses for the respective stove types are created in order to pass them on to new customers with every sale.

Denmark

The Danish Association of suppliers of fireplaces and wood stoves, DAPO, provides relevant information as to avoid emissions when using wood as a fuel. They reflect the public campaigns and promote both cleaner stoves, better chimneys and better (drier) fuel, [LINK](#) [176]. But when looking at the designs of new products from various suppliers, it is clear that wide stoves and much glass are still popular features. Improvements towards lower emissions are competing with design priorities.

The biomass boiler manufacturers seem much less organised and have probably always been. Several of newly checked manufacturers now claim to provide sustainable boilers, however, none of them speak about emissions directly. After observing the list of approved biomass boilers at the DTI over many years (see Chapter 3.11) it is obvious that they have been interested in improving efficiencies as the level has been increasing. Further support towards emission abatement comes from the emerging Danish industry for retrofit ESP's (Electrostatic precipitators), which are also applied for wood stoves, [LINK](#) [177].

Stove industry can also make use of the label "Nordic Swan" which is described in chapter 3.12. Swan-labelled wood stoves can be found here: [LINK](#) [179]. It shows that only two Danish manufacturers currently have chosen to swan-label their products.

Italy

The Italian wood energy industry, represented by its association AIEL, has developed a web-portal, [LINK](#) [132], with parts dedicated to the domestic wood heating (Chapter 3.13).

AIEL also developed the certification scheme "ariaPulita", [LINK](#) [98], which is mentioned in Chapter 3.12. In 2022 ariaPulita aims to include a market surveillance and a mandatory Quick User Guide for wood appliances, the version which was developed by the European project "beReal", [LINK](#) [141].

The Netherlands

The Dutch association of wood stove suppliers, the NHK ([LINK](#) [142]) provides public information such as leaflets ([LINK](#)) or informative videos ([LINK](#)) on their website. The association represents the long-term stakes of the stove manufacturing and distribution sector which try to make the use of wood stoves more sustainable and accepted. A higher technological standard is promoted by informing the general audience on the difference in emissions between high quality stoves that comply with the European Ecodesign requirements and other stoves that don't. Furthermore, for the installer and salesperson there are voluntary trainings available to become a certified installer or a certified salesperson, including training material and final examination. This training is compulsory to become a member of the NHK as an installer. The installer can be certified on the quality of installation while a salesperson can be certified on the quality of his/her sales advice. Both trainings aim to prevent suboptimal installations of stoves, flue gas ducts and chimneys. More information on the certification scheme is found here: [LINK](#) [142].

In the recent past the NHK initiated a deposit refund scheme for customers that would return their old stove when purchasing a new stove that meets Ecodesign criteria. This was done to prevent these old stoves from entering a second life in the second-hand market. After the budget ended, the programme stopped. It is estimated that approximately 10 % of old stoves re-enter into the market.

Norway

Stove manufacturers that are organised in the Norwegian Bioenergy Association (Nobio) or the industry association 'Norsk Varme' constantly focus on improvements and meeting future requirements. Furthermore, stricter emission and efficiency requirements are voluntarily followed by seeking the award of the Nordic Swan Ecolabel (see 3.12).

Sweden

The Swedish stove manufacturers sometimes decide to voluntarily meet stricter emission and efficiency requirements by seeking the award of the Nordic Swan Ecolabel. Details to the specific requirements of this label are mentioned in Chapter 3.12 on certificates and labels.

USA

Industry is actively supporting the activities mentioned in Chapter 3.14.

3.15 R&D activities

The preceding questions to this chapter was

“Are there any relevant national public R&D approaches or programs towards cleaner wood combustion?”

Country	AT	CA	CH	DE	DK	IT	NL	NO	SE	USA
Answer	yes	yes	yes	yes	no	--	no	yes	--	--

Chapter summary

National public R&D approaches towards cleaner wood combustion are manifold and can hardly be displayed comprehensively. In this chapter only some highlights or research “hotspots” from the perception of the involved experts are mentioned. The compilation of answers shows that both, R&D activities for better technology and better products are happening while at the same time researchers are also involved in developing strategies or concepts for teaching, demonstration and knowledge-creation that aims at the end user. And finally, the fundamental knowledge about wood related emissions and health problems is also being created, mostly to become used by politics and NGO’s.

Austria

Some examples of currently relevant research topics are listed in the following.

- New Stoves 2020: Which are the most promising technological trends for logwood stoves and how can the development be supported.
- Stove Testing 2020: Development of a testing procedure for logwood stoves, which better reflects real-life operation than the current testing standard.
- Future logwood stoves: Development of innovative stove concepts including integrated secondary emission abatement technologies.
- Clean Air Projects: Investigation of measures reducing emission from biomass combustion (e. g. system changeout, user training, filters, etc.). In the follow-up project, an end-user training was developed and conducted in several workshops, [LINK](#) [198].

Canada

Several R&D funded research projects have been funded by federal government programs, such as Natural Resources Canada Panel on Energy Research and Development Program (NRCan - PERD), Environment and Climate Change Canada (ECCC) and Health Canada. Most of the research over the years related to performance and characterisation of emission profiles from wood burning appliances in support of development of standards, test methods, policies and regulations. Below is a summary of a new multi-year, multi-phase R&D project led by Environment Canada and Climate Change and Health Canada. The project aims to develop emission factors that are reflective of the Canadian residential wood combustion by accurate measurements using current combustion technology and operational conditions representative of users burning practices along with parameters that impact the efficiency of combustion of firewood. The experimental study is designed to assess the impacts of set of parameters (mandatory) and their interactions on each pollutant emissions and emission factors to the highest possible resolution. Mandatory parameters include appliance types, fuel types, moisture content and outside ambient air temperature. Pollutants targeted by the study include GHG emissions (CO₂, CH₄, N₂O, CO, non-methane VOCs), speciated PAHs, NO_x, SO_x, TPM, PM₁₀, PM_{2.5}, black and/or elemental carbon, organic carbon, speciated VOCs. It is expected that the knowledge from this research project will allow policy makers to better understand the potential for GHG, air pollutant and short-lived climate pollutants mitigation and assess it against potential negative impacts to air quality. At the time of writing this survey, this project was ongoing. Another worthwhile research activity, which is currently ongoing, has a similar goal to the aforementioned residential study and aims to develop Canadian emission factors for automatically fed wood combustion systems. These systems are typically used in commercial and institutional sector and in remote and rural communities.

Switzerland

Substantial R&D activities on clean wood combustion is conducted in Switzerland since 1985. Main research groups on wood combustion and related topics (e.g. particle removal) are:

- Ökozentrum Langenbruck (www.oekozentrum.ch)
- Verenum Research (www.verenum.ch)
- University of Applied Sciences and Arts Northwestern Switzerland (www.fhnw.ch)
- Lucerne University of Applied Sciences and Arts (www.hslu.ch)
- University of Applied Sciences and Arts Western Switzerland (www.heig-vd.ch)

From 2013 to 2020, the Swiss government supported the coordinated energy research in the "Swiss Competence Centers for Research in Energy" (SCCER) including an activity on biomass conducted in the "SCCER Biosweet", [LINK](#).

The results from Swiss research on biomass combustion are documented in the proceedings of the symposium on wood energy ("Holzenergie-Symposium"), which is held since 1990 on behalf of the Swiss Federal Office of Energy. The proceedings are available via the following [LINK](#) [144]. In addition, final reports of research projects funded by the Swiss Federal Office of Energy are available on the following website: [LINK](#) [145].

Germany

During the last three decades the Federal Agency of Renewable Raw Materials (FNR) and the Ministry of Agriculture have launched several dedicated calls for development of advanced wood combustion technologies for space heating appliances. One of the recent calls was titled "Clean combustion of solid biofuels in small-scale combustion plants with very low pollutant emissions", dated September 2019, it was open until June 2020, and several new projects being executed since then. Apart from this dedicated program (and other previous dedicated calls), the general long term funding program of FNR was always open for support to new technical solutions towards clean wood combustion: [LINK](#) [143].

Further relevant national funding can also be granted by the Ministry of Economy within the Program "Energetic use of biogenic residuals and waste material" in the 7th Energy research program. More support to R&D activities concerning PM reduction was also granted by Governments of the 16 German States (without depending on specific research calls).

Denmark

There are no dedicated R&D programmes, but some institutes do perform R&D projects and apart from EC funding they have the option of receiving funding from Danish funds including the DEA demonstration and development programme (EUDP, [LINK](#)) and, potentially the Green Demonstration and Development Programme (GUDP, [LINK](#)), now managed by the Danish Agricultural Agency. Many wood-fuel related research projects are carried out by the Danish Technological Institute (DTI), [LINK](#).

Italy

No specific activities were here reported.

The Netherlands

A research project was initiated by RIVM in 2023 to investigate the health impacts of inhaling wood smoke in real lung tissue. At the time of publication of this report, the research was still ongoing.

Norway

The Research council of Norway continuously allocates funding for knowledge building and innovation projects in the residential wood combustion area. An interesting brochure on research achievements made by CFD-based stove optimisation or other means is available here: [LINK](#) [156]. An ongoing knowledge building project, SusWoodStoves [LINK](#) [230], has e.g. resulted in a vision for sustainable wood stoves, and the project has contributed to a new IEA Bioenergy factsheet on residential solid biofuels combustion, also showing the continuous improvement over time, [LINK](#) [231].

Sweden

R&D activities focusing on clean wood combustion technology are scarce, but aspects concerning clean air and impact of particles can be included in general research programs.

USA

No specific activities were here reported.

3.16 Other actions or suggestions

In this chapter the national experts could feed-in some further ideas or experience, which are deemed helpful for emission abatement. Suggestions were made by Switzerland and Germany.

Switzerland

Quality assurance measures. A national quality control and quality management (QM) system can be effective in assuring a high performance of a biomass energy solution. It was implemented in Switzerland under the name "QM Holzheizwerke®" and it is run since the 1990's. The quality management system is in power for the planning and erection of automated biomass heating systems, [LINK](#) [157]. The QM system was further developed and jointly implemented by a multi-national group from Switzerland, Austria and Southern Germany. It is widely applied to guarantee optimum plant planning and high quality with respect to efficiency, environment, and economy. While QM Holzheizwerke focuses on medium and large-scale applications, a supplementary system was established for applications from 70 kW up to 500 kW with a limited complexity and introduced as "QMmini", [LINK](#) [157]. An additional focus is given on the quality management during plant planning and operation of thermal networks and introduced as "QM Fernwärme" (i.e. QM District Heating), [LINK](#) [158].

Germany

Market surveillance. In Europe there is a growing consciousness about the significance of a powerful market surveillance for stoves and boilers. The aim is to disclose cases where appliances which are sold on the market do not comply with the technical state as given during the type testing, either because the technical layout may have changed over the years or due to irregularities during the type testing procedure. First action groups are now being discussed in Germany and anonymous test of marketed stoves were recently commissioned by regional authorities (unpublished). But a more intensive focus is required, not only on small scale heating appliances but also on fuels and their compliance with certificate requirements.

4. EFFECTIVENESS OF MEASURES TO REDUCE WOOD BASED POLLUTANT EMISSIONS

The following collection of statements and judgements refer to the 15 focus areas as presented in Chapter 3. The involved IEA Bioenergy experts were asked which of the described actions they deemed most effective. They were asked to highlight a maximum 3 focus areas, but the interpretation of this requirement was quite flexible. The answers reflect the personal perception and subjective judgement of the involved national expert and his or her supporters.

Austria

Replacement strategies and expiration dates (3.1). They are particularly effective if a specific group of appliances shall be taken out of the market. While Austria has no experiences with expiration dates for old biomass combustion technology, currently a big replacement programme for fossil fuel heating systems is in place. This programme defined expiration dates for all types of fossil fuel heating systems and applications: In a first step fossil fuel heating systems were forbidden for new buildings, then also for existing buildings and systems expiration dates were defined. It is important that such replacement programmes are accompanied by public financial support schemes (see 3.4).

Public financial support schemes (3.4). In Austria, public financial support for modern clean wood combustion technologies has a long and successful history. Beside the general support of modern wood combustion such programmes can define specific quality requirements for the products eligible for funding. In Austria this has been done by only supporting automated combustion appliances (no logwood stoves) which were awarded with the Austrian ecolabel (Umweltzeichen UZ37, Chapter 3.12).

Regular on-site inspections, combined with information (3.6 + 3.13). Regular on-site inspections are very effective for identifying critical appliances in terms of safety, efficiency or emissions. The biggest advantage of such programmes is the inspection in real-life situations. Thereby, the real fuel quality and the current technical condition of the appliance are considered. Of course, nationwide regular on-site inspection programmes require significant personal and financial resources. In Austria chimney sweeps are taking over an important part of the inspection programme which turned out as very effective as they can combine the regular sweeping of chimneys with inspections of the connected heating appliances.

Ideally, regular inspections are combined with information or user training campaigns. For example, chimney sweeps could offer best practice trainings for logwood stoves or give boiler users general tips on efficiency measures (see 3.13).

Canada

Regular inspections (3.6 + 3.8). The inclusion of regular inspection and maintenance of wood burning appliances by certified "WETT" professionals is important. Based on the positive experiences in Europe, this is expected to improve user's knowledge and behaviour about how to operate and maintain an appliance. It can ensure regular maintenance of appliance and chimney, lead to purchase of better-quality fuel, and increase confidence among the regulators.

Certificates or labels for fuels, stoves or boiler (3.11 and 3.12). Certification and labelling, similar to ENERGY Star and ENERGUIDE that are applied to common appliances, are important. These two measures combined is expected to be valuable marketing tool as they are rigorous processes, well recognised and accepted by public, and apply strict efficiency requirements. They can also be beneficial for consumers and manufacturers to distinguish high performing wood burning appliances from those low efficiency ones. The certification can also be extended to fuels and fuel producers, such as firewood, wood pellets and wood chips. It is the opinion of the Canadian author of this survey, that supportive government policies and program are needed to establish and implement fuel certification mechanisms until the market becomes self-sustaining.

Activities of fuel-, stove- and boiler industry towards lower emissions (3.14). Here the automatic air control of stoves to minimise user interference shall be accentuated. One of the main challenges with wood stoves is that their performance is highly dependent on user behaviour. Minimising the need for user

interference by automation and smart controls can lead to significant improvements towards efficient and clean burning.

Switzerland

Tightening of general emission limits for biomass combustion and further requirements (3.3). For boilers from 70 to 500 kW the lowering of the emission limits for TSP (measured in hot flue gas) in the cantonal action plans down to 20 mg/m³ was effective. To safely meet these requirements, the use of particle precipitators will in many cases be necessary. Furthermore, also the tightened CO and TSP emission limits for stoves and boilers (in field measurements and type tests), as introduced in the new OAPC 2018 was successful. This was also true for boilers <70 kW, where the introduction of regular field measurements of CO-emission every 4 years was introduced in the OAPC 2018 and for wood stoves a regular inspection (every 2 years) of the proper condition and status of the entire installation was introduced in the new OAPC 2018. Also, the introduction of the heat accumulator obligation in the OAPC 2018 for boilers from 70 to 500 kW (and from 2022 also for boilers >500 kW) is regarded effective and useful.

Public financial support schemes (3.4). New financial support schemes for wood heating were introduced in the last couple of years or the funding amount was upscaled. In some of the programs, quality requirements of wood boilers and heating plants are demanded, this has a positive long impact on the state of technology.

Inspections of boilers, stoves, fuel or ash (3.6). The regular stove inspection (condition of the entire installation, ash and wood fuel) every 2 years together with the information given to the operators for an optimum operation will lead to a reduction of inappropriate operation and consequently to reduced pollutant emissions.

Germany

Inspections of boilers, stoves, fuel or ash (3.6). In Germany there are 7,500 chimney sweeping businesses with around 20,000 employees for around 14 million heating systems requiring sweeping and inspection. The “Authorized District Chimney Sweep who conducts the inspection is a highly skilled and well-trained specialist on air quality and combustion safety issues for appliances up to 1 MW (for wood fuels) and 10 MW for oil/gas fuels. Having this particular status of being a representative of the authorities, he or she is legally entitled to enter private homes and to perform inspections and tests according to comprehensive National Standards. And these inspections can have legal consequences for the user. The chimney sweep infrastructure constitutes a key requirement for enforcing technical innovations, new rules and legal changes in the field of wood combustion as it reaches out to the end user.

Tightening of general emission limits for biomass combustion (3.3). In an infrastructure, where local inspections of appliances (e. g. by chimney sweeps in Germany) can identify any non-conformity with legal requirements, the tightening of emission limits can be very effective. But also, if even more advanced emission limits are defined as requirement for receiving public subsidies (see section 3.4) this can also create massive market pressure to improve the technology. As a result, the state of technology will gradually improve, and today’s advanced technological state can tomorrow become legally prescribed.

Stove or boiler certificates or labels (3.12). If certificates and labels clearly enable to identify the most advanced and cleanest technology in a real-life operation, they will become highly respected. However, the reputation of previously issued stove and boiler labels has been low, as critical operational phases had always been excluded from the conformity tests. Emission requirements were also quite unambitious in order to avoid too costly components for primary or secondary emission abatement. But in today’s “Blue Angel”-Certificate for log wood stoves in Germany, the emission requirements are drastically tightened, while at the same time also the testing procedure was defined closer to real-life operational conditions. Thus, the environmental value of a product with this new label is quite high. And there is an awareness in Germany that regional bans can be imposed on wood-burning stoves, which would not be enforced if a new stove is labelled with the Blue Angel certificate.

Denmark

Scrapping schemes in combination with campaigns have proven to be very efficient in terms of making consumers either abolish their fireplace or buy a much more efficient stove (or potentially light less fires). Chimney sweeps have reported that especially in town and cities, many consumers have to a very high extent shut down their fireplaces and furthermore that the recent municipal initiatives on banning wood stoves in areas supplied by district heating have started to kick in. This development goes hand in hand with energy improvements in the residential sector such as exchange of windows and better insulation. And, furthermore, even before the municipal bans, it would often take place in areas supplied by district heating. Both, shutting down fireplaces and exchanging old stoves by new ones, will reduce the firewood consumption. The campaigns, schemes and orders have had a clear impact on the consumption of firewood that according to the national statistics from the Danish Energy Agency has been reduced from 24,5 PJ in 2015 over 16,5 PJ in 2019 to 13.8 PJ in 2022 (up again to 15,7 PJ in 2023) and it is likely that at least a part of the remaining combustion takes place in new stoves at much higher efficiencies and with significantly lower emissions than before.

Italy

Replacement strategies, regional restrictions, and public financial support (3.1, 3.2, 3.3 and 3.4). In Italy about 90 % of PM₁₀-emissions in winter are produced by domestic wood combustion in local space heaters. Some millions of wood appliances are still in operation that are incompatible with the process of improving air quality, this is particularly true in the Po-Regions. During the last 12 years with the incentive to accelerate the technological turnover (Conto Termico) we were able to replace 500.000 obsolete domestic biomass appliances. This measure is important, but it is not sufficient to achieve a concrete PM emission reduction in short-term.

A tightening of emission limits for biomass combustion, both for domestic and industrial plants, is important. But the “Stars” performance classification (see 3.3) implemented in Italy is based on type test data at nominal power output, therefore it not always sure - especially in the case of wood appliances - that the replacement produces a significant reduction of PM and OGC emission. The incentives (public subsidy) should only be given to appliances tested with methods that reflect real operating conditions.

Inspections of boilers, stoves, fuel or ash (3.6). In the case of domestic appliances, it is essential to intensify the on-site inspections, introducing standards for on-site measuring of efficiency and CO, also for local space heaters. It is also very important to qualify the installers and service personnel of biomass plants, developing specific courses and quality marks. The quality of the installation and maintenance of the systems are essential to ensure high efficiency of the systems and to minimize of harmful emissions.

Stove or boiler certificates or labels (3.12) combined with specific information campaigns on clean use of wood fuels (3.13). Local space heaters and boilers certificates/labels are important, but they should be based on tests which reflect as much as possible the real operating condition (“beReal”-cycle). Each local space heater should be accompanied by a Quick User Guide, this should be mandatory for the manufacturers. There is scientific evidence on the PM- and OGC-reducing effect of such a Quick User Guide, [LINK](#) [141]..

In combination with the suggested replacement measures it is essential to implement an information campaign including specific training courses for end-users of local space heaters, with priority to manually stoked appliances. Without a strong collaboration with end-users it is very difficult to reach concrete results in short-term.

The Netherlands

Three fields of action have proven to be effective in The Netherlands:

- The ‘Stookwijzer’-campaign, as it has a permanent character and creates general awareness (see description in Chapter 3.13).

- Bans on using woodstove were installed in a number of municipalities, either conditional based on the Stookwijzer, or unconditional after a certain time (in Utrecht after 2030). The media attention that was attracted also created awareness elsewhere.
- The voluntary certification scheme for installers helps in avoiding wrong installations. This should be given a compulsory character. We saw in the market that when a subsidy came in place on pellet boilers, many new actors started to install pellet boilers without having a certificate (they were no members of the NHK, the Dutch association of wood stove suppliers). This resulted in many bad installations and a negative image of domestic wood stoves.
- A deposit refund scheme to avoid that old stoves re-enter the market. It also creates an incentive for customers to consider buying a new stove.

Norway

The key towards cleaner wood combustion is seen in three focus areas:

- continuous technology development,
- secondary emission reduction measures,
- user education (correct stove selection and operation).

Sweden

Further governmental focus on policies and legislation promoting exchange of older units towards new units complying with the Ecodesign requirements, e.g. such as smart scrapping schemes.

Continue with recurring information campaigns on correct firing using the municipalities obligations to secure local air quality.

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