Screening Framework for Air Quality Assessment of Multiple Biomass Boilers within a Site Boundary

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Final

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Foreword by the Irish Bioenergy Association

The Irish Bioenergy Association (IrBEA) commissioned Katestone Global to complete this report in response to the requirement for an EPA IPCC licence review for biomass heating system installations above 250kW at intensive agriculture EPA licensed facilities.

IrBEA promotes best practice across all aspects of the industry from biomass systems design and installation, quality fuel supply and environmental considerations. This three-part report (Technical description, Single boiler framework, Multiple boiler framework) is an example of the organisation working to address barriers to the deployment of renewable heat in Ireland.

This report provides a clear pathway for the installation of biomass heating systems, up to 1MW in size, on intensive agriculture licensed sites, without negatively impacting on local air quality. This is verified through the completion of the screening framework tool or a specific individual air modelling assessment depending on the individual site constraints. The framework also serves as a guide to other proposed installations where licencing is not required. Modern biomass boilers can be installed to dramatically reduce emissions of CO_2 and can do so without having any negative impacts on air quality.

During the course of completing this work, Katestone and IrBEA have consulted widely with industry and stakeholders in the development of this three-part report. This has resulted in Katestone Global developing a scientifically based solution to help resolve the issues identified without adversely impacting on air quality.

I would like to acknowledge the EPA engagement during this work and for their feedback and technical input to the various drafts presented during the review and approval process. I would like to pay tribute to Micheal Fogarty and his team at Katestone Global for their commitment and dedication when compiling this report.

IrBEA would like to express our sincere gratitude to the Sustainable Energy Authority of Ireland (SEAI), the Irish Farmers Association (IFA), the Wood Fuel Quality Assurance (WFQA) Scheme, Woodco, CHP Mechanical and Towards Zero Carbon for their sponsorship.

Seán Finan B.E C.Eng MIEI

IrBEA Chief Executive Officer

Sponsors:

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Glossary

Term	Definition
GJ	Grams per gigajoule
g/GJ	Gigajoule
g/s	grams per second
km	kilometre
kWh	Kilowatt hour
m	metre
m/s	metres per second
m^2	square metres
m^3	cubic metres
m^3/s	cubic metres per second
m^3/hr	cubic metres per hour
mg/Nm^3	Milligrams per normalised cubic meter
MW	Megawatts
MWth	Megawatts (thermal)
$\mu g/m^3$	micrograms per cubic meter
Abbreviations	**Definition**
AG4	Air Guidance 4
BAT	Best available techniques
CAFE	Cleaner Air for Europe
EPA	Environment Protection Agency
EF	Emission factor
ELV	Emission Limit Value
IrBEA	Irish Bioenergy Association
MCP	Medium Combustion Plant
SEAI	Sustainable Energy Authority of Ireland
SSRH	Support Scheme for Renewable Heat
STP	Standard temperature and pressure

1. INTRODUCTION

The heating requirement for a typical intensive pig or poultry housing unit is generally provided by one or more boilers with total thermal input ranging from 250 kW to 1 MW, which is small relative to typical industrial installations. Consequently, these small boilers represent a low risk of adverse air quality impacts. However, in general such boilers cannot be installed without some form of regulatory approval, which requires the applicant to demonstrate that the biomass boiler can be operated without causing adverse air quality impacts.

Katestone has developed a series of documents that describe and present a stepwise approach (Screening Framework) that can be adopted to assess whether proposed biomass boilers that meet certain requirements can be operated without causing adverse air quality impacts and, therefore, can be approved for installation. The titles of the documents in the series include:

- Biomass Boiler Air Quality Assessment Framework - Technical Description (Technical Description)
- Screening Framework for Air Quality Assessment of a Single Biomass Boiler within a Site Boundary (Single Boiler Screening Framework)
- Screening Framework for Air Quality Assessment of Multiple Biomass Boilers within a Site Boundary (Multiple Boiler Screening Framework)

The first document in the series provides a technical description of the principles that underpin the Screening Framework. It is titled *Screening Framework for the Air Quality Assessment of Biomass Boilers - Technical Description (D19011-29) Katestone Environmental Pty Ltd, January 2022*. It should be referred to if further information is required about the background and development of the Screening Framework and includes sections on:

- Regulations and guidance that underpin the Screening Framework
- The approach to the development of the Screening Framework
- The logical framework of the approach
- The data that underpins the Screening Framework.
- The data developed for use in the Screening Framework documents.

The second document in the series, the Single Boiler Screening Framework provides an air quality assessment framework for a single proposed biomass boiler within a site boundary. Its purpose is to provide a procedure that is quick and easy-to-apply to:

- Understand the information required to complete the stepwise approach.
- Determine whether a single proposed biomass boiler can be installed and operated without causing an adverse impact on air quality beyond the site boundary.
- Present the relevant information so that the regulator may confidently approve the boiler.

This is the third document of the series, the Multiple Boiler Screening Framework. It presents a similar air quality assessment framework to the Single Boiler Screening Framework to determine whether a number of proposed biomass boilers can be installed and operated without causing an adverse impact on air quality beyond the site boundary.

The Screening Framework adopts a number of conservative assumptions to ensure that boilers that are determined to be low risk under the requirements of the Screening Framework will not result in adverse air quality impacts.

The first set of steps of the Screening Framework requires the applicant to compile relevant operating parameters of the proposed boilers and information about the site on which they will operate. The second set of steps requires an applicant to answer a series of yes/no questions using the parameters that were compiled in the first set of steps. Finally, if the answers to all questions in the second set of steps results is 'yes', the proposed boilers can be installed and operated without causing an adverse impact on air quality beyond the site boundary. If the answer to **any** question in the second set of steps is 'no' it indicates a failure to meet the screening requirements. In this instance the proponent may opt to either redesign the biomass boilers or move to a higher level of air quality assessment using site specific dispersion modelling.

The Multiple Boiler Screening Framework will require the following information:

- The location of the site of the proposed boilers relative to urban centers
- The site's location relative to other sites that operate non-domestic boilers
- Boiler stack characteristics (for each onsite boiler) including:
  - Internal stack diameter
  - Stack temperature
  - Exit velocity
  - Stack height
  - Stack location
  - Emissions of NO_x
  - Emissions of particulate matter (dust)
- The operation of back-up boilers within the site boundary
- Operation of back-up gas heaters within the site boundary
- The moisture content of the fuel recommended by the boiler manufacturer for each boiler
- The thermal energy input and output specified by the manufacturer for each boiler
- The thermal efficiency of each boiler.
- Certification and laboratory testing reports issued to the boiler manufacturer that demonstrate that the boiler conforms with Eco-design Regulations.

This specific information is listed in the first table of the Screening Framework in Section 2 (Steps 1(a) to 1(s)). This information should be readily available from:

- Site Plans
- Population data published by the Central Statistics Office (CSO) (see Appendix A2)
- The Department of Housing, Planning and Local Government (see Appendix A3)
- The boiler manufacturer's technical and operational documents.

The information to be listed in Step 1(f) can be determined from compliance reports issued by the boiler manufacturer or from Section A5. The information to be listed in Step 1(l) and Step 1(m) of the Single Boiler Screening Framework can be determined from tables in Section A6 of Appendix A.

An overview of the information required for the Multiple Boiler Screening Framework is presented in Figure 1.

The last part of the Multiple Boiler Screening Framework is an assessment declaration and outcome statement that should be filled in and signed by the person that completed the Screening Framework.

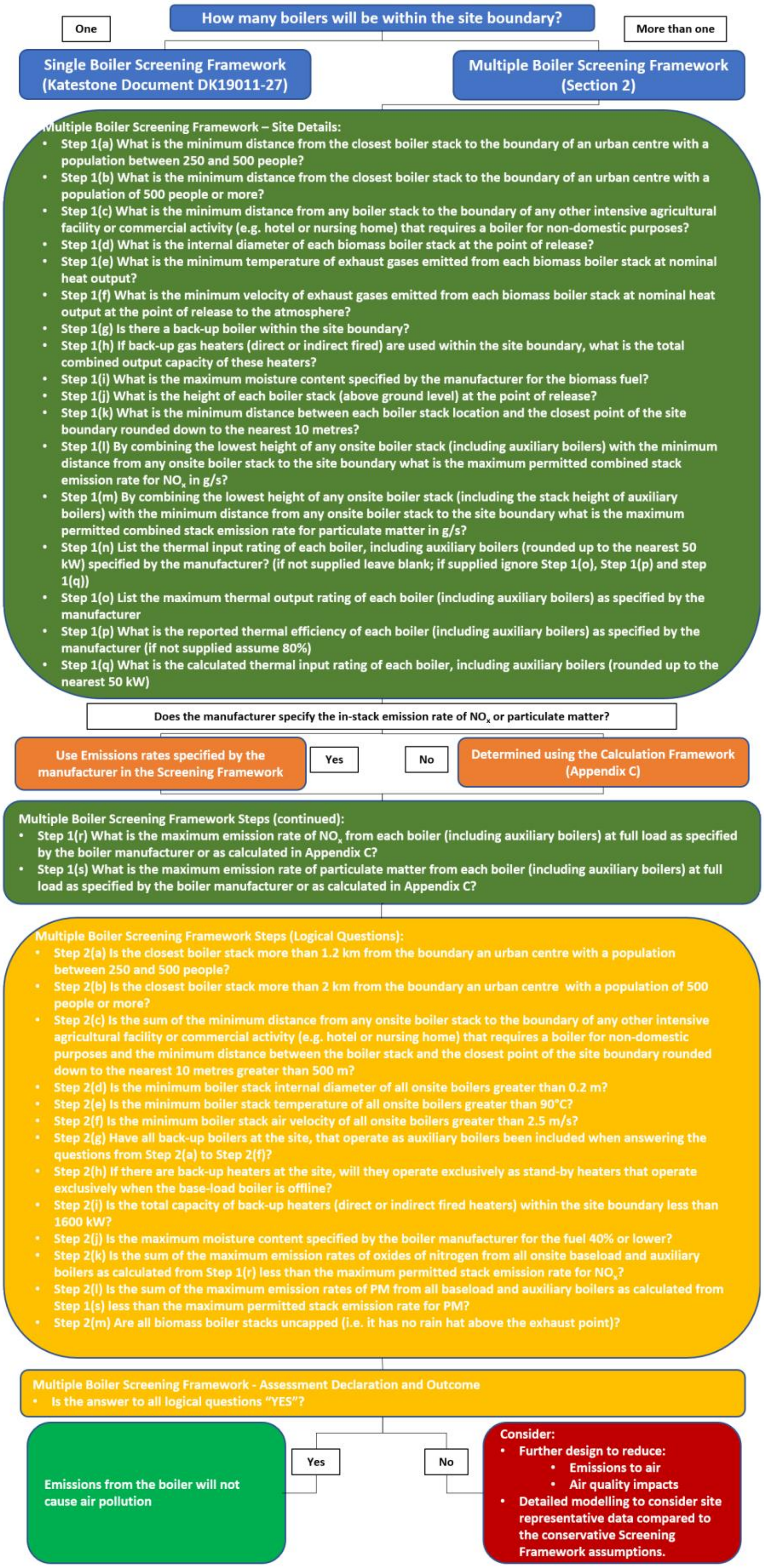


Figure 1 Overview of the information required for the Multiple Boiler Screening Framework

2. SCREENING FRAMEWORK – MULTIPLE BOILERS

2.1 Screening Framework

The following tables must be completed to determine if emissions from multiple boilers (including back-up boilers that operate in auxiliary mode) within a site boundary are compliant with air quality limits for particulate matter and oxides of nitrogen at the site boundary.

Step	Parameter	Value	Unit
Step 1(a)	What is the minimum distance from the closest boiler stack to the boundary of an urban centre with a population between 250 and 500 people?(see note 1)		km
Step 1(b)	What is the minimum distance from the closest boiler stack to the boundary of an urban centre with a population of 500 people or more? (see note 1)		km
Step 1(c)	What is the minimum distance from any boiler stack to the boundary of any other intensive agricultural facility or commercial activity (e.g. hotel or nursing home) that requires a boiler for non-domestic purposes? (see note 2)		m
Step 1(d)	What is the minimum internal diameter of any onsite boiler stack (including auxiliary boilers) at the point of release?		m
Step 1(e)	What is the minimum temperature of exhaust gases emitted from any onsite boiler stack (including auxiliary boilers) at nominal capacity? (see note 3)		°C
Step 1(f)	What is the minimum velocity of exhaust gases emitted from any onsite boiler stack (including auxiliary boilers) at the point of release to the atmosphere at nominal capacity? (see note 4)		m/s
Step 1(g)	Is there a back-up boiler within the site boundary? (see note 5)		yes/no
Step 1(h)	If back-up gas heaters (direct or indirect fired) are used within the site boundary, what is the total combined output capacity of these heaters? If there are no back-up gas heaters leave this blank. (see note 5)		kW
Step 1(i)	What is the maximum moisture content specified by the manufacturer for the biomass fuel for any onsite boiler (including auxiliary boilers)?		%
Step 1(j)	What is the lowest height of any onsite boiler stack (above ground level) at the point of release?		m
Step 1(k)	What is the minimum distance between any onsite boiler stack location (including auxiliary boilers) and the closest point of the site boundary rounded down to the nearest 10 metres?		m
Step 1(l)	By combining the lowest height of any onsite boiler stack (including auxiliary boilers) with the minimum distance from any onsite boiler stack to the site boundary what is the maximum permitted combined stack emission rate for NO_x in g/s? (see note 6)		g/s
Step 1(m)	By combining the lowest height of any onsite boiler stack (including the stack height of auxiliary boilers) with the minimum distance from any onsite boiler stack to the site boundary what is the maximum permitted combined stack emission rate for particulate matter in g/s?(see note 7)		g/s

Step	Parameter	Value				Unit
Step 1(n)	What is the thermal input rating of each boiler, including auxiliary boilers (rounded up to the nearest 50 kW) specified by the manufacturer? (if not supplied leave blank; if supplied ignore Step 1(o), Step 1(p) and step 1(q))	1		2		kW or MW
		3		4		
Step 1(o)	What is the maximum thermal output rating of each boiler (including auxiliary boilers) as specified by the manufacturer	1		2		kW or MW
		3		4		
Step 1(p)	What is the reported thermal efficiency of each boiler (including auxiliary boilers) as specified by the manufacturer (if not supplied assume 80%)	1		2		%
		3		4		
Step 1(q)	What is the calculated thermal input rating of each boiler, including auxiliary boilers (rounded up to the nearest 50 kW)(see note 8)	1		2		kW or MW
		3		4		
Step 1(r)	What is the maximum emission rate of NO_x from each boiler (including auxiliary boilers) at full load as specified by the boiler manufacturer or as calculated in Appendix C?(see note 9)	1		2		g/s
		3		4		
Step 1(s)	What is the maximum emission rate of particulate matter from each boiler (including auxiliary boilers) at full load as specified by the boiler manufacturer or as calculated in Appendix C?(see note 9)	1		2		g/s
		3		4		

Notes

[1] Section **A2** and Section **A3** of Appendix A provides methodologies to determine the population and to define the boundary of urban centres in Ireland for the purpose of the Screening Framework.

[2] Refer to Section **A4** of Appendix A for the definition of an *Intensive agricultural facility that requires a boiler for non-domestic purposes*

[3] The temperature measured at nominal heat output as part of Eco-design or EN 303-5:2013 compliance monitoring. The required values can be provided by the manufacturer of the biomass boiler.

[4] The exhaust velocity must be either determined as part of Eco-design or EN 303-5:2013 compliance monitoring or alternatively estimated in accordance with the methodology described in Annex E of EN ISO 16911-1. Section **A5** provides a further information on how to determine the minimum exhaust velocity.

[5] See definition of a back-up boiler in Section **A1** of Appendix A.

[6] The Screening Framework is underpinned by conservative dispersion modelling described in the Technical Description. Section **A6.1** of Appendix A describes an approach that can be adopted to determine the maximum permitted emission rate of oxides of nitrogen.

[7] The Screening Framework is underpinned by conservative dispersion modelling described in the Technical Description. Section **A6.2** of Appendix A describes an approach that can be adopted to determine the maximum permitted emission rate of particulate matter.

[8] If the thermal energy input of the boiler is not supplied it can be calculated by dividing the answer to Step 1(n) by the decimal answer to Step 1(o). The decimal answer to Step 1(o) is the percentage expressed as a fraction e.g. 90% = 0.9.

Step	Parameter	Value	Unit
[9] It is essential that the **maximum emission rate** and not the maximum concentration of NO_x and particulate matter is presented here. If the maximum emission rates of NO_x and particulate matter are not explicitly stated by the boiler manufacturer, Appendix C provides two methodologies that can be adopted to determine emission rates of PM and NO_x. Equation 2 presented in Section **C2** of Appendix C describes a methodology that can be adopted if the boiler manual specifies emissions of NO_x and particulate matter as grams per gigajoule (g/GJ) and Section **C6** describes a calculation framework if this value is not provided but the boiler is compliant with the requirements of Ecodesign the Ecodesign Directive (Step 6 of **Table C2** for NO_x and Step 7 of **Table C2** for particulate matter			

Step	Question	Yes/No
Step 2(a)	Is the closest boiler stack more than 1.2 km from the boundary an urban centre with a population between 250 and 500 people?	
Step 2(b)	Is the closest boiler stack more than 2 km from the boundary an urban centre with a population of 500 people or more?	
Step 2(c)	Is the sum of the minimum distance from any onsite boiler stack to the boundary of any other intensive agricultural facility or commercial activity (e.g. hotel or nursing home) that requires a boiler for non-domestic purposes and the minimum distance between the boiler stack and the closest point of the site boundary rounded down to the nearest 10 metres greater than 500 m? (see note 1)	
Step 2(d)	Is the minimum internal diameter of all onsite boilers greater than 0.2 m?	
Step 2(e)	Is the minimum boiler stack temperature of all onsite boilers greater than 90°C?	
Step 2(f)	Is the minimum boiler stack air velocity of all onsite boilers greater than 2.5 m/s?	
Step 2(g)	Have all back-up boilers at the site, that operate as auxiliary boilers been included when answering the questions from Step 2(a) to Step 2(f)? (see note 2)	
Step 2(h)	If there are back-up heaters at the site, will they operate exclusively as stand-by heaters that operate exclusively when the base-load boiler(s) and or/auxiliary boiler(s) are offline is offline? (see note 2)	
Step 2(i)	Is the total capacity of back-up heaters (direct or indirect fired heaters) within the site boundary less than 1,600 kW?	
Step 2(j)	Is the maximum moisture content specified by the boiler manufacturer for the fuel 40% or lower?	
Step 2(k)	Is the sum of the maximum emission rates of NO_x from all onsite baseload and auxiliary boilers as calculated from Step 1(r) less than the maximum permitted stack emission rate for NO_x (see note 3)	
Step 2(l)	Is the sum of the maximum emission rates of PM from all baseload and auxiliary boilers as calculated from Step 1(s) less than the maximum permitted stack emission rate for PM (see note 4)	
Step 2(m)	Are all biomass boiler stacks uncapped (i.e. it has no rain hat above the exhaust point)?	

[1] Is the value specified in Step 1(c) + the value specified in step 1(k) greater than 500 m.

[2] See boiler definitions in Section **A1** of Appendix A

[3] If the sum of the values specified in Step 1(r) is less than the value specified in Step 1(l) the answer to this question is ‘yes’

[4] Is the sum of the values specified in Step 1(s) is less than the value specified in Step 1(m) the answer to this question is ‘yes’

2.2 Screening Framework - Assessment Declaration and Outcome

If the answers to all questions in the second table in Section 2.1 of the Screening Framework is 'yes', the boiler will not result in adverse air quality impacts.

Question	Yes/No
Based on the answer to the questions in the second table of the Screening Framework, has the Screening Framework demonstrated that the boiler will not result in adverse air quality impacts? A yes answer is required to demonstrate compliance with relevant air quality standards.	

If the answer to the question in the table above is 'YES" based on the information supplied and assessed, emissions from the boiler will not cause air pollution. There is no need to consider:

- Further design to reduce:
  - Emissions to air
  - Air quality impacts
- Detailed modelling to consider site representative data compared to the conservative Screening Framework assumptions.

Question	Are these document included with the application - Yes/No
The Screening Framework is applicable to all biomass boilers that comply with the requirements of the Ecodesign Regulations. The following supporting documents are to be included with this application: • Ecodesign compliance certificate • Ecodesign emissions compliance testing reports	

I hereby declare that the information provided for this Screening Framework is true and correct. I also understand that any wilful dishonesty may render the outcome of the Screening Framework void.

Signed: ………………………………...

Date: …………………………………...

APPENDIX A – RELEVANT INFORMATION

A1 TYPE OF BOILER OR HEATER BASED ON MODE OF OPERATION

The heating requirements of intensive agricultural housing units are generally met using boilers or heaters. Boilers heat water that is transported in pipes to a radiator that increases the temperature of the housing unit. Heaters can be direct fired or in-direct fired. Direct fired heaters (e.g. brooders in poultry houses) exhaust the heated products of combustion directly into the living area to increase the temperature of the housing unit. In-direct fired heaters utilise various mechanisms to transfer the heat of combustion to the living area (e.g. radiators) to increase the temperature of the housing unit while the products of combustion are exhausted directly to the atmosphere.

Most intensive agricultural sites operate with two types of boilers or heaters, namely:

- Baseload boilers or heaters, which are single or multiple boilers or heaters that are used to meet the thermal requirements in production houses.
- Back-up boilers or heaters, which are generally single boilers or multiple boilers/heaters that operate intermittently to meet the thermal requirements in production houses including:
    - Standby boilers or heaters that operate when baseload boiler(s) are offline (e.g. during scheduled servicing or maintenance).
    - Auxiliary boilers or heaters that can work concurrently with the baseload boiler at certain times to achieve the peak demand / system load.

The Multiple Boiler Screening Framework is relevant to the assessment of baseload and standby auxiliary boilers. A detailed dispersion modelling assessment is required if back-up gas heaters operate as auxiliary heaters.

A2 POPULATION CENTRES

The census of population is a detailed count of every person living in Ireland on a particular date. It takes place every 5 years and is carried out by the Central Statistics Office (CSO).

The last census carries out in Ireland was in 2016. Information from this census is publicly available and must be used to determine the population of villages/towns within 2 km of the site boundary. Information on CSO's website is available in graphical or tabulated format.

The information is available through the CSO census homepage (https://www.cso.ie/en/census/). Population information can be taken from the mapping section on the CSO homepage as follows:

- Go the to census mapping webpage (http://census.cso.ie/sapmap/)
- Agree to the terms and conditions of use
- Click on the *Census 2016 Boundaries* button[1] to reveal a pop-out that lists the *Census 2016 Boundaries* as a list of tick-box options on the right-hand side of the webpage
- Scroll down and highlight the *Settlements* Option
- Close the *Census 2016 Boundaries* window by clicking the x in the top right-hand side of the window
- Zoom and pan to the area where the propose boiler will be installed
- Point the cursor to any settlements within 2 km of the proposed site boundary and click with the left mouse button (or touch the settlement if using a touch screen) to reveal a pop-out containing relevant population data for that settlement
- Use the data to answer the relevant questions on the Screening Framework.

A3 BOUNDARY OF POPULATION CENTRES

The Screening Framework requires a set definition of the boundary of a population centre for the purpose of determining a setback distance between the site boundary and a population centre.

In the Republic of Ireland, land boundaries of counties and their constituent denominations, such as baronies, parishes, townlands and towns are defined as administrative boundaries under Local Government legislation. The Screening Framework utilises the *"administrative boundary – towns"* to define the extent of populated places.

This information is available from the Department of Housing, Planning and Local Government (DHPLG) from its *myplan website* (https://viewer.myplan.ie/). Site boundary information can be taken from the mapping section on DHPLG's *myplan website* as follows:

- Go to the *myplan.ie* website
- Agree to the terms and conditions of use
- On the left-hand side of the webpage, click the *Layer List* button
- In the *Layer List* window check the box *Administrative Boundaries*
- Click the arrow to the left of the *Administrative Boundaries* check box to reveal the sublist

[1] There are five (5) buttons on the top left corner of the screen. The "Census 2016 Boundaries" button is the leftmost of the 5 buttons. The "Census 2016 Boundaries" button has a 3-d illustration of a yellow square above a blue square above a red square).

- Check the box beside *Towns*
- Close the *Layer List* window by clicking the x in the top right-hand side of the window
- Zoom and pan to the area where the propose boiler will be installed
- Determine the distance between the site boundary and the *Towns* boundary to answer the relevant questions on the Screening Framework.

A4 INTENSIVE AGRICULTURAL FACILITY THAT REQUIRES A BOILER FOR NON-DOMESTIC PURPOSES

The Screening Framework requires a set definition for an *intensive agricultural facility that requires a boiler for non-domestic purposes.*

Farm developments may require planning permission; however, some agricultural developments are exempt from the need for planning permission. Department of Environment and Local Government advice[2] states:

> *Categories of exempted development are set out in planning law. Much agricultural development, especially uses of land for agricultural purposes, is exempted. In other cases certain thresholds exist, these may include size or height. Where these thresholds are exceeded, the exemptions no longer apply. The purpose of exemption is to avoid controls on developments of a minor nature*
>
> ……………….
>
> *The provision of the following types of agricultural buildings and structures is exempted development:*
>
> > ………………..
> >
> > *Type 2*
> >
> > *A roofed structure housing pigs, mink or poultry provided that its floor area does not exceed 75 square metres and that the total floor area of all Type 2 structures within the farmyard complex (or 100 metres of it) does not exceed 100 square metres. In addition boundary fencing of a mink holding must be escape-proof for mink;*
> >
> > ………………..

The Screening Framework defines an *intensive agricultural facility that requires a boiler for non-domestic purposes* as a Type 2 facility that legally meets the requirements for planning permissions.

In Ireland, local authorities/county councils publish planning information on their websites. The websites contain planning maps that provide details including:

- Planning applications for all *Type 2* buildings and structures that require planning permission
- The extent of the boundaries of the sites for which a planning application has been submitted.

The planning information published by county councils can be used to complete relevant questions the Screening Framework related to facilities within 500 metres of the boundary of the proposed development.

[2] https://www.housing.gov.ie/sites/default/files/migrated-files/en/Publications/DevelopmentandHousing/Planning/FileDownLoad,1587,en.pdf

A5 DETERMINATION OF MINIMUM EXHAUST VELOCITY AT NOMINAL CAPACITY

The velocity of air from the stack at the point of discharge is dependent on the air flowrate through the stack and the area of the stack at the point of discharge. It is common for the stack diameter to be tapered at the top to reduce the stack area at the point of discharge to achieve a higher exhaust velocity.

The exhaust velocity is calculated by dividing the exhaust air flowrate (not corrected to standard temperature, pressure or oxygen concentration) by the area of the stack at the point of discharge.

The exhaust velocity can be determined using two approaches namely:

- Approach 1 - Using the actual exhaust air flowrate (m^3/s) divided by the area of the stack at the point of discharge
- Approach 2 - Using a theoretical air flowrate (m^3/s) divided by the area of the stack at the point of discharge.

If adopting Approach 1, the exhaust air flowrate (m^3/s) should be measured at the nominal heat output as part of Eco-design or EN 303-5:2013 compliance monitoring. This should be available from the boiler manufacturer.

If adopting Approach 2, the theoretical exhaust air flowrate (m^3/s) at nominal heat output should be determined in accordance with an EPA approved approach. The EPA requires gas velocity and volumetric flowrate to be determined in accordance with the following ISO standard:

> "Stationary source emissions – Manual and automatic determination of velocity and volume flow rates in ducts -ISO EN 16911-1:2013".

Annex E of EN ISO 16911-1 (Annex E) describes a procedure for the calculation of the dry stoichiometric gas flow rate. EPA published Air Guidance Note 10 (AG10) in April 2020 that aims to provide clarification of the requirements of Annex E.

The stoichiometric flue gas volume at STP and 0% O_2 can be calculated using thermal input of the biomass boiler and a fuel factor:

$$F = S \times Q \qquad \textit{(Equation 1)}$$

Where:

F is the stoichiometric flowrate of air with dimensions of volume per time e.g. cubic metres per hour (Nm^3/h).

S is the fuel factor, which is the volume of flue gas generated at standard reference conditions (0% O_2, 0 °C and 101.325 kPa) per unit of thermal energy input. It has units of Nm^3/GJ.

Q is the maximum rate of thermal energy input of the boiler with units of GJ/s or GW or similar.

Annex E lists fuel factors that are related to the moisture content of biomass. The fuel factors increase as the moisture content increases. Table E.3 of Annex E presents fuel factors for biomass with mass fractions of moisture ranging from 20% to 60% in increments of 10%. An uncertainty value is presented for each increment to account for a variation in moisture content of ± 10% around each increment.

The moisture content of biomass used in biomass boilers can vary considerably. In general, manufacturers specify and require the fuel moisture content to be less than 40% for biomass boilers with thermal inputs less than 1 MW for efficient operation. A condition of this Screening Framework is that the biomass fuel that is used contains less than 40% moisture.

The vast majority of biomass boilers with thermal capacity up to 1 MW that will be installed and operated in accordance with the requirements of the Support Scheme for Renewable Heat (SSRH) scheme. SSRH requires compliance audits including fuel certification and documentation. SSRH imposes ongoing obligations to use fuel that is certified to meet the requirements and specifications of manufacturers. At all times, records must be maintained to demonstrate compliance to the fuel requirements and specifications of the boiler manufacturer.

A conservative approach has been adopted for the calculation of the stoichiometric exhaust air flowrate to determine the minimum exhaust velocity. The conservative approach assumes that biomass combusted in a biomass boiler with a thermal capacity of 1 MW will have the moisture content of 20%, which results in the lowest air flowrate that can be calculated using the data in Annex E. Also, the maximum uncertainty value for moisture content of -2.8% has been applied in the calculation of the stoichiometric exhaust air flowrate from biomass with 20% moisture content.

The fuel factor, S, specified in Annex E for biomass with a moisture content of 20% is 0.26 m^3/MJ. The uncertainty specified for the fuel factor is ± 2.8% caused by deviations in fuel moisture content of ±10% around reported value of 20%. The fuel factor adopted for the calculation of the stoichiometric exhaust air flowrate for the purpose of calculating emission rates using Equation 1 is, therefore, 0.253 m^3/MJ, which assumes the worst-case volume of exhaust air for biomass with a moisture content of 20% using the approach described in Annex E.

The stoichiometric exhaust air flowrate at 0% O_2 needs to be adjusted to stack conditions to determine the actual exhaust air flowrate at the stack conditions. The Screening Framework specifies that the minimum stack temperature is 90°C. A review of Eco-design or EN 303-5:2013 compliance monitoring reports for a range of commercially available biomass boilers typically used at intensive agricultural facilities indicates that, at nominal operational capacity, the range of measured concentrations of oxygen was between 6% and 9%. To determine a conservative estimate of exhaust velocity the stoichiometric exhaust air flowrate at 0% O_2 was converted to an air flowrate at 6% O_2, which is more representative of actual likely stack conditions

Once the exhaust air flowrate (at 90°C and a concentration of O2 of 6%) is calculated, the exhaust velocity can be calculated as described in Approach 1 and Approach 2 above (volumetric flowrate divided by the stack area at the point of exhaustion). Exhaust velocities calculated in accordance with EN 303-5:2013 and assuming in-stack conditions of 90°C and a concentration of O_2 of 6% for a range of internal stack diameters (at the point of exhaustion) are presented in Table A1. The exhaust velocities highlighted in italics in Table A1 are insufficient to meet the requirements of the framework. In such instances, the stack can be tapered at the point of release to the atmosphere to a point that achieves a velocity of 2.5 m/s.

Table A1 **Exhaust velocities calculated in accordance with EN 303-5:2013 and assuming in-stack conditions of 90°C and a concentration of O_2 of 6% for a range of internal stack diameters (at the point of exhaustion)**

Thermal Output	**Internal diameter at point of exhaustion (m)**				
	0.20	**0.25**	**0.30**	**0.35**	**0.4**
kW	**Stack velocity at point of exhaustion (m/s)**				
50	*0.7*	*0.5*	*0.3*	*0.2*	*0.2*
100	*1.5*	*1.0*	*0.7*	*0.5*	*0.4*
150	*2.2*	*1.4*	*1.0*	*0.7*	*0.6*
200	3.0	*1.9*	*1.3*	*1.0*	*0.7*
250	3.7	*2.4*	*1.7*	*1.2*	*0.9*
300	4.5	2.9	*2.0*	*1.5*	*1.1*
350	5.2	3.4	*2.3*	*1.7*	*1.3*
400	6.0	3.8	2.7	*2.0*	*1.5*
450	6.7	4.3	3.0	*2.2*	*1.7*
500	7.5	4.8	3.3	*2.4*	*1.9*
550	8.2	5.3	3.7	2.7	*2.1*
600	9.0	5.7	4.0	2.9	*2.2*
650	9.7	6.2	4.3	3.2	*2.4*
700	11.2	7.2	5.0	3.7	2.8
750	12.0	7.7	5.3	3.9	3.0
800	12.8	8.2	5.7	4.2	3.2
850	13.6	8.7	6.1	4.5	3.4
900	14.4	9.2	6.4	4.7	3.6
950	15.2	9.8	6.8	5.0	3.8
1000	16.0	10.3	7.1	5.2	4.0

A6 DETERMINATION OF MAXIMUM ALLOWABLE EMISSION RATES

A6.1 Oxides of Nitrogen (NO_x)

The data for assessing NO_x emissions associated with biomass boilers is presented in this section. The data is presented in tables that state the maximum permitted emission rate of NO_x based on the distance of the stack from the site boundary for various stack heights. The distance refers to the minimum distance between the location of the stack and any point on the site boundary. The maximum emission rates of NO_x are presented in Table A2.

Table A2 Maximum emission rate of NO_x (g/s) depending on stack height and the minimum distance between the stack and the site boundary

Minimum distance between boiler stack and site boundary (m)[1]	Stack Height (m)						
	4 m	5 m	6 m	7 m	8 m	9 m	10 m
	Maximum emission rate of oxides of nitrogen (g/s)						
10 m	0.014	0.022	0.039	0.09	0.17	0.23	0.30
20 m	0.014	0.022	0.039	0.09	0.17	0.23	0.30
30 m	0.020	0.028	0.042	0.09	0.17	0.23	0.30
40 m	0.030	0.036	0.050	0.09	0.17	0.23	0.30
50 m	0.035	0.041	0.051	0.09	0.17	0.23	0.30
60 m	0.037	0.042	0.052	0.09	0.17	0.23	0.30
70 m	0.042	0.049	0.060	0.09	0.17	0.23	0.30
80 m	0.044	0.051	0.060	0.09	0.19	0.24	0.30
90 m	0.049	0.057	0.067	0.10	0.19	0.26	0.31
100 m	0.054	0.064	0.079	0.12	0.22	0.28	0.33
110 m	0.057	0.067	0.086	0.13	0.23	0.29	0.35
120 m	0.064	0.076	0.097	0.14	0.23	0.29	0.35
130 m	0.073	0.086	0.11	0.16	0.24	0.29	0.35
140 m	0.078	0.092	0.12	0.17	0.25	0.29	0.35
150 m	0.087	0.103	0.13	0.21	0.26	0.30	0.35
160 m	0.096	0.113	0.14	0.22	0.27	0.31	0.36
170 m	0.104	0.122	0.15	0.22	0.28	0.31	0.36
180 m	0.115	0.135	0.17	0.23	0.28	0.33	0.37
190 m	0.123	0.145	0.18	0.24	0.29	0.34	0.38
200 m	0.126	0.151	0.18	0.24	0.30	0.35	0.39
210 m	0.139	0.165	0.20	0.25	0.30	0.35	0.40
220 m	0.142	0.172	0.21	0.26	0.31	0.36	0.41
230 m	0.149	0.184	0.22	0.27	0.32	0.37	0.43
240 m	0.155	0.192	0.23	0.28	0.33	0.37	0.44
250 m	0.155	0.196	0.23	0.28	0.33	0.38	0.44
260 m	0.163	0.207	0.25	0.29	0.34	0.39	0.45
270 m	0.170	0.215	0.25	0.30	0.35	0.40	0.46
280 m	0.171	0.217	0.26	0.30	0.36	0.41	0.46
290 m	0.177	0.223	0.26	0.31	0.36	0.42	0.47
300 m	0.180	0.229	0.27	0.32	0.37	0.43	0.48
310 m	0.185	0.233	0.28	0.32	0.38	0.43	0.48
320 m	0.190	0.239	0.29	0.33	0.39	0.44	0.50

Minimum distance between boiler stack and site boundary (m)[1]	Stack Height (m)						
	4 m	5 m	6 m	7 m	8 m	9 m	10 m
	Maximum emission rate of oxides of nitrogen (g/s)						
330 m	0.196	0.244	0.29	0.34	0.40	0.46	0.51
340 m	0.198	0.247	0.30	0.35	0.40	0.46	0.52
350 m [2]	0.205	0.252	0.31	0.35	0.41	0.47	0.53

[1] Stack within 10 m of the site boundary should adopt the values specified for 10 m

[2] Stacks located more than 350 m from the site should adopt the values specified for 350 m

A6.2 Particulate Matter

The data for assessing particulate matter emissions associated with biomass boilers is presented in this section. The data is presented in tables that state the maximum permitted emission rate of particulate matter based on the distance of the stack from the site boundary for various stack heights. The distance refers to the minimum distance between the location of the stack and any point on the site boundary. The maximum emission rates of particulate matter are presented in Table A3.

Table A3 **Maximum emission rate of particulate matter (g/s) depending on stack height and the minimum distance between the stack and the site boundary**

Minimum distance between boiler stack and site boundary (m)[1]	Stack Height (m)						
	4 m	5 m	6 m	7 m	8 m	9 m	10 m
	Maximum emission rate of Particulate Matter (g/s)						
10 m	0.002	0.003	0.005	0.014	0.029	0.038	0.049
20 m	0.002	0.003	0.005	0.014	0.029	0.038	0.049
30 m	0.003	0.004	0.006	0.014	0.029	0.038	0.049
40 m	0.004	0.006	0.007	0.015	0.029	0.038	0.049
50 m	0.005	0.006	0.008	0.015	0.029	0.038	0.049
60 m	0.006	0.008	0.010	0.017	0.029	0.038	0.049
70 m	0.007	0.009	0.012	0.018	0.029	0.039	0.049
80 m	0.009	0.010	0.013	0.019	0.031	0.040	0.050
90 m	0.010	0.012	0.016	0.023	0.034	0.043	0.052
100 m	0.012	0.014	0.017	0.023	0.035	0.047	0.054
110 m	0.013	0.016	0.020	0.026	0.039	0.049	0.058
120 m	0.015	0.017	0.022	0.030	0.041	0.054	0.063
130 m	0.016	0.019	0.024	0.032	0.043	0.057	0.065
140 m	0.019	0.022	0.028	0.035	0.046	0.058	0.071
150 m	0.021	0.024	0.030	0.037	0.047	0.058	0.073
160 m	0.023	0.027	0.033	0.040	0.049	0.061	0.074
170 m	0.025	0.029	0.034	0.043	0.052	0.064	0.074
180 m	0.028	0.032	0.036	0.046	0.054	0.065	0.075
190 m	0.030	0.034	0.039	0.048	0.057	0.066	0.078
200 m	0.032	0.036	0.041	0.049	0.059	0.069	0.081
210 m	0.034	0.038	0.043	0.051	0.062	0.072	0.083
220 m	0.038	0.042	0.048	0.053	0.066	0.075	0.087
230 m	0.040	0.045	0.050	0.057	0.069	0.077	0.089
240 m	0.042	0.046	0.052	0.058	0.070	0.081	0.094
250 m	0.045	0.049	0.054	0.060	0.071	0.084	0.095
260 m	0.047	0.051	0.057	0.062	0.074	0.087	0.098
270 m	0.049	0.053	0.060	0.065	0.076	0.090	0.100
280 m	0.052	0.055	0.062	0.068	0.076	0.090	0.103
290 m	0.053	0.058	0.064	0.070	0.079	0.094	0.107
300 m	0.055	0.060	0.067	0.073	0.081	0.096	0.109
310 m	0.056	0.062	0.069	0.076	0.083	0.098	0.112

Minimum distance between boiler stack and site boundary (m)[1]	Stack Height (m)						
	4 m	5 m	6 m	7 m	8 m	9 m	10 m
	Maximum emission rate of Particulate Matter (g/s)						
320 m	0.060	0.066	0.072	0.080	0.086	0.100	0.116
330 m	0.062	0.068	0.074	0.083	0.091	0.103	0.117
340 m	0.064	0.069	0.076	0.085	0.092	0.106	0.121
350 m [2]	0.065	0.071	0.079	0.088	0.094	0.107	0.125

[1] Stack within 10 m of the site boundary should adopt the values specified for 10 m

[2] Stacks located more than 350 m from the site should adopt the values specified for 350 m

APPENDIX B - WORKED EXAMPLE

B1 APPLICATION INFORMATION

A poultry farmer (applicant) is seeking approval from EPA to replace a 500 kW natural gas boiler with two 260 kW biomass boilers for baseload and one 250 kW backup boiler that will operate as an auxiliary boiler. The boiler stacks will be located 53 metres, 56 metres and 60 m from the nearest point on the boundary of the site. The manufacturer provided the following specifications:

- The 260 kW boilers:
  - Stack Diameter: 0.3 metres
  - Minimum operational stack temperature: 112 °C
  - Minimum operational stack exit velocity: 5.3 m/s
  - Maximum emission rate of particulate matter: 0.013 g/s
  - Maximum emission rate of oxides of nitrogen: 0.0416 g/s
  - The boiler stack is 9.0 m above ground level.
  - Certified fuel moisture content requirements: 35%.
- The 250 kW auxiliary boiler:
  - Stack Diameter: 0.3 metres
  - Minimum operational stack temperature: 115 °C
  - Minimum operational stack exit velocity: 5.1 m/s
  - Maximum emission rate of particulate matter: 0.011 g/s
  - Maximum emission rate of oxides of nitrogen: 0.0341 g/s
  - The boiler stack that is 9.0 m above ground level.
  - Certified fuel moisture content requirements: 35%.

The farm is in rural Monaghan. It is surrounded by farmland and some isolated rural houses. The centre of the nearest village is Smithborough located 2.7 km from the boundary of the site.

The closest intensive agricultural shed (pig or poultry) is a poultry farm that is 1.5 km from the boundary of the site. Information relating to nearby agricultural activities can be found on Monaghan County Council's planning website, which shows the following details about the nearby poultry farm:

- This poultry farm houses 39,000 broilers and was approved in 2017.
- The boundary of the site containing the closest intensive agricultural shed is 50 m closer to the applicant's farm than the intensive agricultural shed.

B2 SCREENING FRAMEWORK - WORKED EXAMPLE

B2.1 Tables

Step	Parameter	Value	Unit
Step 1(a)	What is the minimum distance from the closest boiler stack to the boundary of an urban centre with a population between 250 and 500 people?(see note 1)	*2.5 km from the site boundary to the boundary of Smithborough (population 395) according to DHPLG's myplan website*	km
Step 1(b)	What is the minimum distance from the closest boiler stack to the boundary of an urban centre with a population of 500 people or more? (see note 1)	*7.1 km from the site boundary to the boundary of Monaghan Town (population 7,678) according to DHPLG's myplan website*	km
Step 1(c)	What is the minimum distance from any boiler stack to the boundary of any other intensive agricultural facility or commercial activity (e.g. hotel or nursing home) that requires a boiler for non-domestic purposes? (see note 2)	*Approximately 1.4 km*	m
Step 1(d)	What is the minimum internal diameter of any onsite boiler stack (including auxiliary boilers) at the point of release?	*0.3*	m
Step 1(e)	What is the minimum temperature of exhaust gases emitted from any onsite boiler stack (including auxiliary boilers) at nominal capacity? (see note 3)	*112*	°C
Step 1(f)	What is the minimum velocity of exhaust gases emitted from any onsite boiler stack (including auxiliary boilers) at the point of release to the atmosphere at nominal capacity? (see note 4)	*5.1*	m/s
Step 1(g)	Is there a back-up boiler within the site boundary? (see note 5)	*Yes*	yes/no
Step 1(h)	If back-up gas heaters (direct or indirect fired) are used within the site boundary, what is the total combined output capacity of these heaters? If there are no back-up gas heaters leave this blank. (see note 5)	*35%*	%
Step 1(i)	What is the maximum moisture content specified by the manufacturer for the biomass fuel for any onsite boiler (including auxiliary boilers)?	*9.0*	m
Step 1(j)	What is the lowest height of any onsite boiler stack (above ground level) at the point of release?	*50*	m

Step	Parameter	Value				Unit
Step 1(k)	What is the minimum distance between any onsite boiler stack location (including auxiliary boilers) and the closest point of the site boundary rounded down to the nearest 10 metres?	*0.23 g/s*				g/s
Step 1(l)	By combining the lowest height of any onsite boiler stack (including auxiliary boilers) with the minimum distance from any onsite boiler stack to the site boundary what is the maximum permitted combined stack emission rate for NO_x in g/s? (see note 6)	*0.038 g/s*				g/s
Step 1(m)	By combining the lowest height of any onsite boiler stack (including the stack height of auxiliary boilers) with the minimum distance from any onsite boiler stack to the site boundary what is the maximum permitted combined stack emission rate for particulate matter in g/s?(see note 7)	1		2		kW or MW
	What is the thermal input rating of each boiler, including auxiliary boilers (rounded up to the nearest 50 kW) specified by the manufacturer? (if not supplied leave blank; if supplied ignore Step 1(o), Step 1(p) and step 1(q))	3		4		
Step 1(n)	What is the thermal output rating of each boiler (including auxiliary boilers) as specified by the manufacturer	1	*260*	2	*260*	kW or MW
	What is the maximum thermal output rating of each boiler (including auxiliary boilers) as specified by the manufacturer	3	*220*	4		
Step 1(o)	What is the reported thermal efficiency of each boiler (including auxiliary boilers) as specified by the manufacturer (if not supplied assume 80%)	1	*90%*	2	*90%*	%
	What is the reported thermal efficiency of each boiler (including auxiliary boilers) as specified by the manufacturer (if not supplied assume 80%)	3	*90%*	4		
Step 1(p)	What is the calculated thermal input rating of each boiler, including auxiliary boilers (rounded up to the nearest 50 kW)(see note 6)	1	*300*	2	*300*	kW or MW
	What is the calculated thermal input rating of each boiler, including auxiliary boilers (rounded up to the nearest 50 kW)(see note 8)	3	*250*	4		
Step 1(q)	What is the maximum emission rate of NO_x from each boiler (including auxiliary boilers) at full load as specified by the boiler manufacturer or as calculated in Appendix C?(see note 7)	1	*0.0416*	2	*0.0416*	g/s
	What is the maximum emission rate of NO_x from each boiler (including auxiliary boilers) at full load as specified by the boiler manufacturer or as calculated in Appendix C?(see note 9)	3	*0.0341*	4		
Step 1(r)	What is the maximum emission rate of particulate matter from each boiler (including auxiliary boilers) at full load as specified by the boiler manufacturer or as calculated in Appendix C?(see note 7)	1	*0.013*	2	*0.013*	g/s
		3	*0.011*	4		
Notes						

Step	Parameter	Value	Unit
[1] Section **A2** and Section **A3** of Appendix A provides methodologies to determine the population and to define the boundary of urban centres in Ireland for the purpose of the Screening Framework. [2] Refer to Section **A4** of Appendix A for the definition of an *Intensive agricultural facility that requires a boiler for non-domestic purposes* [3] See definition of a back-up boiler in Section **A1** of Appendix A. [4] The Screening Framework is underpinned by conservative dispersion modelling described in the Technical Description. Section **A6.1** of Appendix A describes an approach that can be adopted to determine the maximum permitted emission rate of oxides of nitrogen. [5] The Screening Framework is underpinned by conservative dispersion modelling described in the Technical Description. Section **A6.2** of Appendix A describes an approach that can be adopted to determine the maximum permitted emission rate of particulate matter. [6] If the thermal energy input of the boiler is not supplied it can be calculated by dividing the answer to Step 1(n) by the decimal answer to Step 1(o). The decimal answer to Step 1(o) is the percentage expressed as a fraction e.g. 90% = 0.9. [7] It is essential that the **maximum emission rate** and not the maximum concentration of NO_x and particulate matter is presented here. If the maximum emission rates of NO_x and particulate matter are not explicitly stated by the boiler manufacturer, Appendix C provides two methodologies that can be adopted to determine emission rates of PM and NO_x. Equation 1 presented in Section **C2** of Appendix C describes a methodology that can be adopted if the boiler manual specifies emissions of NO_x and particulate matter as grams per gigajoule (g/GJ) and Section **C6** describes a calculation framework that can be adopted if the boiler manual specifies the maximum in-stack concentration of NO_x (the value entered in Step 11 of **Table C2**) and particulate matter (the value entered in Step 12 of **Table C2**).			

Step	Question	Yes/No
Step 2(a)	Is the boundary of the site located in a rural area more than 1.2 km from the nearest house of an urban centre with a population between 250 and 500 people?	*Yes*
Step 2(b)	Is the boundary of the site located in a rural area more than 2 km from the nearest house of an urban centre with a population of 500 people or more?	*Yes*
Step 2(c)	Is the sum of the minimum distance from any onsite boiler stack to the boundary of any other intensive agricultural facility or commercial activity (e.g. hotel or nursing home) that requires a boiler for non-domestic purposes and the minimum distance between the boiler stack and the closest point of the site boundary rounded down to the nearest 10 metres greater than 500 m? (see note 1)	*Yes*
Step 2(d)	Is the internal diameter of all onsite boilers greater than 0.2 m?	*Yes*
Step 2(e)	Is the minimum boiler stack temperature of all onsite boilers greater than 90°C?	*Yes*
Step 2(f)	Is the minimum boiler stack air velocity of all onsite boilers greater than 2.5 m/s?	*Yes*
Step 2(g)	Have all back-up boilers at the site, that operate as auxiliary boilers been included when answering the questions from Step 2(a) to Step 2(f)? (see note 2)	*Yes*
Step 2(h)	Is the maximum moisture content specified by the boiler manufacturer for the fuel 40% or lower?	*Yes*
Step 2(i)	Is the sum of the maximum emission rates of oxides of nitrogen from all onsite boilers (including auxiliary boilers) as specified by the boiler manufacturer or as calculated in Appendix C less than the maximum permitted stack emission rate for NO_x (see note 3)	*Yes (0.1173 g/s of emission vs 0.23 g/s)*
Step 2(j)	Is the sum of the maximum emission rates of PM from all boilers (including auxiliary boilers) as specified by the boiler manufacturer or as calculated in Appendix C less than the maximum permitted stack emission rate for PM (see note 4)	*Yes (0.037 g/s of emission vs 0.038 g/s)*

[1] Is the value specified in Step 1(c) + the value specified in step 1(j) greater than 500 m.

[2] See boiler definitions in Section **A1** of Appendix A

[3] If the sum of the values specified in Step 1(q) is less than the value specified in Step 1(k) the answer to this question is 'yes'

[4] Is the sum of the values specified in Step 1(r) is less than the value specified in Step 1(l) the answer to this question is 'yes'

B2.2 Screening Framework - Assessment Declaration and Outcome

If the answers to all questions in the second table in Section 2.1 of the Screening Framework is 'yes', the boiler will not result in adverse air quality impacts.

Question	Yes/No
Based on the answer to the questions in the second table of the Screening Framework, has the Screening Framework demonstrated that the boiler will not result in adverse air quality impacts? A yes answer is required to demonstrate compliance with relevant air quality standards.	*Yes*

If the answer to the question in the table above is 'YES" based on the information supplied and assessed, emissions from the boiler will not cause air pollution. There is no need to consider:

- Further design to reduce:
  - Emissions to air
  - Air quality impacts
- Detailed modelling to consider site representative data compared to the conservative Screening Framework assumptions.

I hereby declare that the information provided for this Screening Framework is true and correct. I also understand that any wilful dishonesty may render the outcome of the Screening Framework void.

Signed: ………… *John Doe*……………………...

Date: ……………*01/02/2021* …………………...

APPENDIX C CALCULATION OF EMISSION RATE

C1 OVERVIEW

A fundamental part of the Screening Framework is the maximum mass emission rate of particulate matter or oxides of nitrogen, which should be specified in grams per second (g/s).

Mass emission rates are rarely explicitly provided by boiler manufacturers. However, in many instances, the technical specifications that boiler manufacturers supply include parameters that can be used to calculate the mass emission rate, such as:

1) Maximum thermal energy input of the boiler in GJ or kWh.
2) Maximum emission rate of an air pollutant per unit of thermal energy input, which may be reported in units such as: grams per gigajoule (g/GJ) or grams per kWh (g/kWh).
3) Maximum concentration of an air contaminants in the exhaust stream, which may include reference conditions such as:
    - STP, standard temperature of 0°C and pressure 101.3kPa, which is usually denoted as normal cubic metres (Nm^3).
    - Moisture of 0%, which is also referred to as “dry”.
    - Exhaust oxygen content such as: 5% O_2 or 7% O_2.

This chapter specifies methodologies to calculate mass emission rates of air contaminants from typical technical specifications that are provided by boiler manufacturers.

C2 MAXIMUM EMISSION RATE

The maximum emission rate of an air contaminant can be calculated using equations 2 and 3.

Equation 2:

$$E = Q \times EF_i \qquad \textit{(Equation 2)}$$

Where:

E is the emission rate in units of grams per second (g/s).

Q is the maximum energy input of the boiler with units of GJ or kWh or similar.

EF_i is an emission factor for pollutant i with dimensions of mass per energy input.

Equation 3:

$$E = F \times C_i \div 1000 \qquad \textit{(Equation 3)}$$

Where:

E is the emission rate in units of grams per second (g/s).

F is the maximum volumetric flowrate of air with dimensions of volume per time e.g. cubic metres per hour (Nm^3/h) at STP and a defined concentration of oxygen.

C_i is the maximum concentration of pollutant i in the boiler exhaust with units of milligrams per cubic metre (mg/Nm^3) or similar at STP and a defined concentration of oxygen.

When Equation 3 is used, it is important to ensure that there is consistency in reference conditions between the concentration and the volumetric flowrate of air. Reference conditions are commonly as follows:

- 0°C, 20°C or 25°C
- 101.3 kPa
- Dry
- The oxygen reference concentration for the maximum pollutant concentration should be consistent with the oxygen reference concentration for the volumetric flowrate of air.

The division by 1000 in Equation 3 is to convert milligrams to grams.

Commission Regulation (EU) 2015/1189 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament (Ecodesign and Energy Labelling – Framework Directives) and of the Council with regard to ecodesign requirements for solid fuel boilers specifies the emission limit values (ELVs) for automatically stoked solid fuel boilers as follows:

- 40 mg/Nm^3 for particulate matter
- 200 mg/Nm^3 for NOx.

The ELVs refer to concentrations of these air contaminants reported for dry exit flue gas, calculated at a standard temperature and pressure (273.15 K, 101.3 kPa) and a standardised O_2 content of 10%. Biomass boilers that comply with the Ecodesign Directive must demonstrate that these emission limits can be achieved under standardised testing.

When determining the maximum emission rate in accordance with Equation 3, these limits must be adopted as the maximum concentration of pollutant to determine the worst case emission rate. The requirement of Commission Regulation (EU) 2015/1189 is to report the concentration of these air contaminants at 10% oxygen. As a consequence, the maximum volumetric flowrate of air in Equation 3 should also be referenced to 10% oxygen.

C3 VOLUMETRIC FLOWRATE OF AIR AT REFERENCE CONDITIONS

In the absence of air flow measurements (F in Equation 3), a theoretical volumetric flowrate of air can be calculated as the stoichiometric flue gas volume (Nm^3/s) per unit of biomass combusted (GJ/s). The stoichiometric flue gas volume is the volume of gas that would be produced if combustion resulted in complete oxidation with no excess air.

The EPA requires gas velocity and volumetric flowrate to be determined in accordance with the following ISO standard:

> "Stationary source emissions – Manual and automatic determination of velocity and volume flow rates in ducts -ISO EN 16911-1:2013".

Annex E of EN ISO 16911-1 (Annex E) describes a procedure for the calculation of the dry stoichiometric gas flow rate. EPA published Air Guidance Note 10 (AG10) in April 2020 that aims to provide clarification of the requirements of Annex E. The methods in Annex E and AG10 can be used to determine the theoretical air flowrates from the combustion of biomass required for the calculation of emission rates of particulate matter and NO_x.

The stoichiometric flue gas volume at STP and 0% O_2 can be calculated using thermal input of the biomass boiler and a fuel factor:

$$F = S \times Q \qquad \text{(Equation 4)}$$

Where:

F is the stoichiometric flowrate of air with dimensions of volume per time e.g. cubic metres per hour (Nm^3/h).

S is the fuel factor, which is the volume of flue gas generated at standard reference conditions (0% O_2, 0 °C and 101.325 kPa) per unit of thermal energy input. It has units of Nm^3/GJ.

Q is the maximum rate of thermal energy input of the boiler with units of GJ/s or GW or similar.

Annex E lists fuel factors that are related to the moisture content of biomass. The fuel factors increase as the moisture content increases. Table E.3 of Annex E presents fuel factors for biomass with mass fractions of moisture ranging from 20% to 60% in increments of 10%. An uncertainty value is presented for each increment to account for a variation in moisture content of ± 10% around each increment d.

The moisture content of biomass used in biomass boilers can vary considerably. In general, manufacturers specify and require the fuel moisture content to be less than 40% for biomass boilers with thermal inputs less than 1 MW for efficient operation. A condition of this Screening Framework is that biomass fuel used is less than 40% moisture content. The vast majority of biomass boilers with thermal capacity up to 1 MW that will be installed and operated in accordance with the requirements of the Support Scheme for Renewable Heat (SSRH) scheme. SSRH requires compliance audits including fuel certification and documentation. SSRH imposes ongoing obligations to use fuel that is certified to meet the requirements and specifications of manufacturers. At all times records must be maintained to demonstrate compliance to the fuel requirements and specifications of the boiler manufacturer.

A conservative approach has been adopted for the calculation of the stoichiometric exhaust air flowrate. The conservative approach assumes that biomass combusted in a biomass boiler with a thermal capacity of 1 MW will have the maximum moisture content of 40% permitted under the SSRH scheme. Also, the maximum uncertainty value for moisture content of +10% has been applied in the calculation of the stoichiometric exhaust air flowrate from biomass with 40% moisture content.

The fuel factor, S, specified in Annex E for biomass with a moisture content of 40% is 0.276 m^3/MJ. The uncertainty specified for the fuel factor is ± 5% caused by deviations in fuel moisture content of ±10% around reported value of 40%. The fuel factor adopted for the calculation of the stoichiometric exhaust air flowrate for the purpose of calculating emission rates using Equation 3 is therefore 0.29 m^3/MJ which assumes the worst-case volume of exhaust air for biomass with a moisture content of 40% using the approach described in Annex E.

C4 OXYGEN CONCENTRATION

Exhaust air from a boiler contains oxygen that has not reacted with the fuel as part of the combustion process. Environmental regulations and manufacturers specifications for exhaust concentrations of air pollutants are normalised to standard oxygen concentrations to correct for excess dilution. When calculating an emission rate of an air contaminant it is important that the concentration (C_i) and air flowrate (F) in Equation 3 are at the same reference conditions for oxygen (EPA, 2018).

To adjust an air flowrate to a reference oxygen level, the adjusted air flowrate, F_o, is determined by:

$$F_o = F \times \frac{21 - [R]}{21 - [N]} \qquad \textit{(Equation 5)}$$

Where:

F is the air flowrate at reference level of O_2 (m^3) (The reference level of O_2 is the level of O_2 the manufacturer reports the in-stack concentration of an air contaminant at. It should be reported at STP, dry conditions)

[N] is the reference level of O_2 (%)

[R] = is the level of O_2 assumed for the exhaust air flowrate in Equation 4 (%).

It is conservatively assumed that [R] in Equation 5 is 0%.

C5 VOLUMETRIC AIR FLOWRATE CONVERSION TABLES

Theoretical normalised (STP, dry) volumetric flowrates of air are presented in Table C1 for a range of thermal inputs and an oxygen reference level of 10%. The values calculated in these tables are based on the calculations in the previous sections of this appendix.

The data can be used to determine the emission rates of PM and NO_x for boilers when the manufacturers specify the thermal input rating of the boiler.

Table C1 Theoretical volumetric flowrates of post combustion air, normalised to STP for boilers with rated thermal inputs between 50 kW and 1000 kW with flue gas oxygen concentration of 1%

Thermal Input	Energy Input	Oxygen Concentration
		10%
kW	GJ/s	m^3/s
50	0.00005	0.03
100	0.00010	0.06
150	0.00015	0.08
200	0.00020	0.11
250	0.00025	0.14
300	0.00030	0.17
350	0.00035	0.19
400	0.00040	0.22
450	0.00045	0.25
500	0.00050	0.28
550	0.00055	0.30
600	0.00060	0.33
650	0.00065	0.36
700	0.00070	0.39
750	0.00075	0.42
800	0.00080	0.44
850	0.00085	0.47
900	0.00090	0.50
950	0.00095	0.53
1000	0.00100	0.55

C6 CALCULATION FRAMEWORK

This section describes a calculation framework that provides a step-by-step procedure to determine the emission rate of PM or NO_x based on the data provided by the manufacturer including:

- Thermal input rating of the boiler
- The concentration of NO_x or PM referenced to a concentration of oxygen.

The values determined from the calculation framework can be used as input to the Screening Framework – Single Boilers Step 1(r) and Step 1(s).

The Calculation Framework is presented in Table C2.

Table C2 Calculation Framework

Step	Parameter	Value	Unit
1	What is the thermal output rating of the boiler as specified by the manufacturer		kW
2	What is the reported thermal efficiency of the boiler as specified by the manufacturer (if not supplied assume 80%)		%
3	What is the thermal input rating of the boiler as specified by the manufacturer (rounded up to the nearest 50 kW) – If not supplied leave blank and go to Step 4		kW
4	What is the calculated thermal input rating of the boiler (rounded up to the nearest 50 kW) (see note 1)		kW
5	What is the theoretical volumetric flowrate of air (read from **Table** C1) based on the thermal input in Step 3 or Step 4		Nm^3/s
6	What is the maximum emission rate of NO_x for this boiler(see note 2)		g/s
7	What is the maximum emission rate of PM for this boiler[3](see note 3)		g/s

Notes

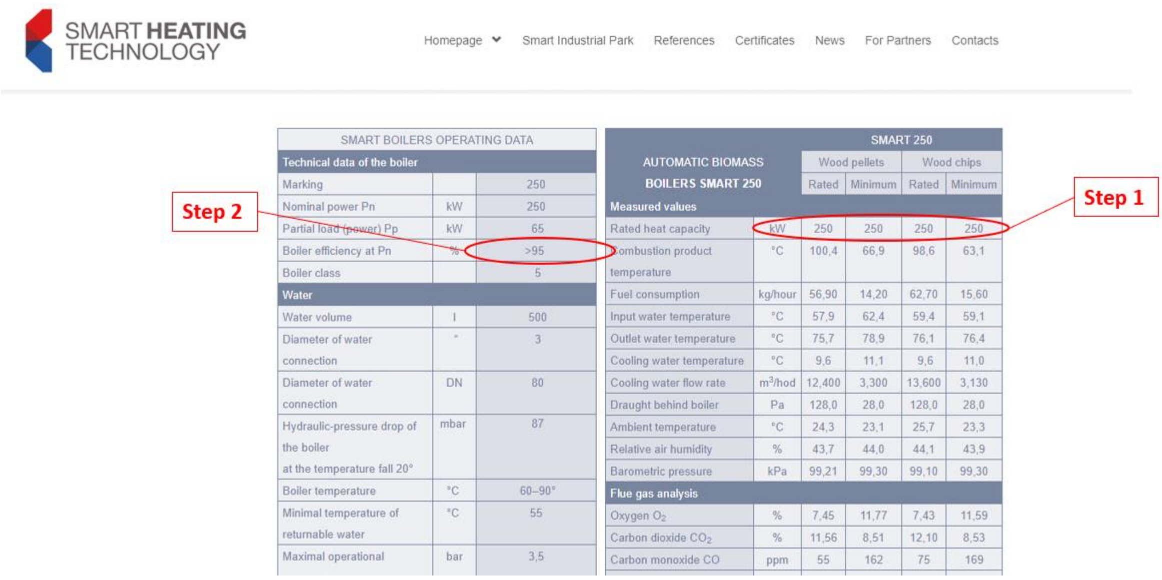
[1] If the thermal input of the boiler is not supplied (Step3) it can be calculated by dividing the answer to Step 1 by the decimal answer to Step 2. The decimal answer to Step 2 is the percentage expressed as a fraction e.g. 90% = 0.9.

[2] Calculated as the product of the value entered for Step 5 x 200 divided by 1000 (Step 5 x 200)/1000

[3] Calculated as the product of the value entered for Step 5 x 40 divided by 1000 (Step 5 x 40)/1000

C7 EXAMPLE

A worked example of the calculation framework is provided in Table C3. The data used to complete Table C3 was sourced from the Smart Heating Technology website for a SMART 250 kW boiler (http://www.smartheating.cz/en/smart-250-kw/). The location of the data entered to Table 7 on the Smart Heating website is presented in Figure C2 as an example of how to locate relevant data from technical specifications typically provided by manufacturers.


SMART HEATING TECHNOLOGY

Homepage | Smart Industrial Park | References | Certificates | News | For Partners | Contacts

SMART BOILERS OPERATING DATA		
Technical data of the boiler		
Marking		250
Nominal power Pn	kW	250
Partial load (power) Pp	kW	65
Boiler efficiency at Pn	%	>95
Boiler class		5
Water		
Water volume	l	500
Diameter of water connection	"	3
Diameter of water connection	DN	80
Hydraulic-pressure drop of the boiler at the temperature fall 20°	mbar	87
Boiler temperature	°C	60–90°
Minimal temperature of returnable water	°C	55
Maximal operational	bar	3,5

AUTOMATIC BIOMASS BOILERS SMART 250		SMART 250			
		Wood pellets		Wood chips	
		Rated	Minimum	Rated	Minimum
Measured values					
Rated heat capacity	kW	250	250	250	250
Combustion product temperature	°C	100,4	66,9	98,6	63,1
Fuel consumption	kg/hour	56,90	14,20	62,70	15,60
Input water temperature	°C	57,9	62,4	59,4	59,1
Outlet water temperature	°C	75,7	78,9	76,1	76,4
Cooling water temperature	°C	9,6	11,1	9,6	11,0
Cooling water flow rate	m^3/hod	12,400	3,300	13,600	3,130
Draught behind boiler	Pa	128,0	28,0	128,0	28,0
Ambient temperature	°C	24,3	23,1	25,7	23,3
Relative air humidity	%	43,7	44,0	44,1	43,9
Barometric pressure	kPa	99,21	99,30	99,10	99,30
Flue gas analysis					
Oxygen O_2	%	7,45	11,77	7,43	11,59
Carbon dioxide CO_2	%	11,56	8,51	12,10	8,53
Carbon monoxide CO	ppm	55	162	75	169

Figure C2 Screenshot of the Smart Heating Technology webpage (http://www.smartheating.cz/en/smart-250-kw/) that illustrates the typical format of manufacturer data required for the calculation of emission rates and the location of the data required to complete the calculation framework

Table C3 Worked example of the calculation framework

Step	Parameter	Value	Unit
1	What is the thermal output rating of the boiler as specified by the manufacturer	*250*	kW
2	What is the reported thermal efficiency of the boiler as specified by the manufacturer (if not supplied assume 80%)	*95*	%
3	What is the thermal input rating of the boiler as specified by the manufacturer (rounded up to the nearest 50 kW) – If not supplied leave blank and go to Step 4		kW
4	What is the calculated thermal input rating of the boiler (rounded up to the nearest 50 kW) (see note 1)	*263.2*	kW
5	What is the theoretical volumetric flowrate of air (read from **Table** C1) based on the thermal input in Step 3 or Step 4		Nm^3/s
6	What is the maximum emission rate of NO_x for this boiler(see note 2)	*0.034*	g/s
7	What is the maximum emission rate of PM for this boiler[3](see note 3)	*0.0068*	g/s

Notes

[1] If the thermal input of the boiler is not supplied (Step3) it can be calculated by dividing the answer to Step 1 by the decimal answer to Step 2. The decimal answer to Step 2 is the percentage expressed as a fraction e.g. 90% = 0.9.

[2] Calculated as the product of the value entered for Step 5 x 200 divided by 1000 (Step 5 x 200)/1000

[3] Calculated as the product of the value entered for Step 5 x 40 divided by 1000 (Step 5 x 40)/1000