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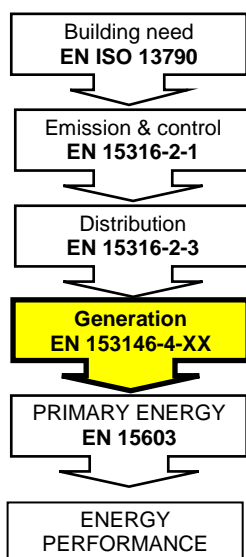


Figure 1: EN 15316 series

Information paper on EN 15316-4-7 Space heating generation systems - Biomass Combustion systems

Biomass combustion is one of the oldest heat generation techniques. The European market of biomass boilers <50 kW has increased to approximately 50% since 2001. The greatest increase of approximately 280% took place for wood chip boilers, although Logwood boilers constitute the most populous boiler type, with a total number of c.a. 187.000 in 2007.

This paper gives a short introduction to the CEN standard 15316-4-7 for calculation of boiler losses, fuel input and auxiliary energy consumption. All of the technologies contributing to the growth of the boiler market are taken into account in the standard. This paper contains explanations regarding the calculation method, with details on the input and output data and links with other CEN standards. This standard enables the integration of biomass boilers in the overall (i.e. holistic) energy evaluation of a building. Because of the CO₂ absorption during its growth, biomass fuels may have a very low primary energy conversion factor of < 0.5. Therefore the use of biomass boilers is an effective means for achieving low primary consumption and CO₂ emissions.

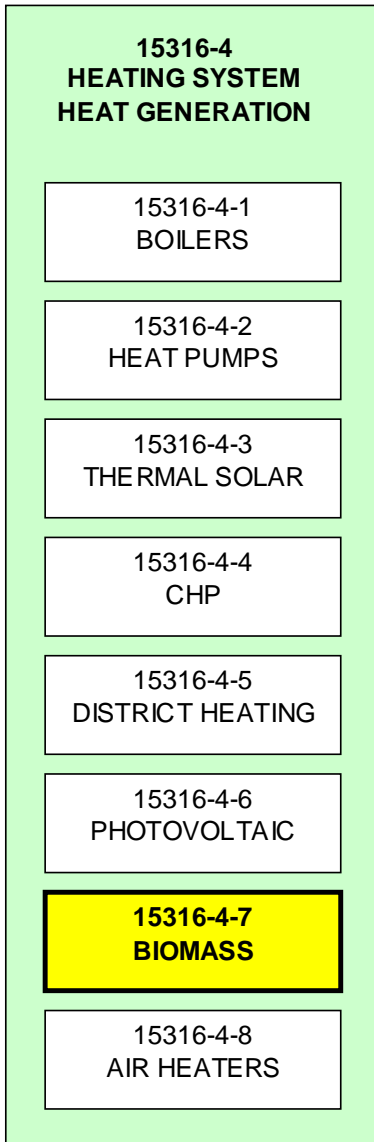
1 > Scope of standard

The standard provides calculation methods for the energy performance of heat generation of biomass combustion systems with respect to:

- > type of stocking device (automatic or by hand);
- > type of biomass fuel (pellets, chipped wood or log wood);
- > including control.

This standard is part of the EN 15316 series (see figure 1) for calculation of heating system energy requirements and efficiency. The required heat output, according to the distribution part EN-15316-2-3, must be available as an input for this standard.

The domestic hot water generation sub-system is treated in the standard EN 15316-3-3, although EN 15316-4-7 may be used to assess the heat generation for hot water production, when an indirectly heated storage system used heating boilers as a heat source. In this case, the required heat output for domestic hot water distribution (or storage) is taken into account as an input.



This standard is intended to calculate the in-use energy performance of a given boiler, either existing or new. Boiler sizing and the calculation of boiler operating conditions are not covered by this standard.

2 > Principle of the methods

The structure of this standards is very close to EN 15316-4-1 (combustion boilers - see information paper P102).

In general, the methods calculate fuel and auxiliary energy consumption of one or more boilers to match the attached distribution subsystem(s) heat demand. Boiler performance may also be given as an (annual) efficiency.

The calculation period can be divided into a number of calculation steps (e.g. months, weeks, bins, operation modes as defined in EN ISO 13790)

The methods take into account boiler and accumulator storage heat losses, and/or recovery due to the following physical factors:

- > flue gas losses (boiler on for boilers stocking by hand);
- > draught losses (boiler off);
- > envelope losses (boiler on and off);
- > auxiliary energy use (standby/electronics, ignition, charge, pump, fan);
- > auxiliary energy recovery.

The common input data is the heat required by the attached distribution sub-system(s). The additional load for a domestic hot water distribution subsystem may be taken into account when using a single generator for both services.

Other input data is required to characterize:

- > type and characteristics of the heat generator(s);
- > location of the heat generator(s);
- > operating conditions (time schedule, water temperature, etc.);
- > type and characteristics of the accumulator storage system(s);
- > control strategy (on/off, multistage, modulating, cascading, etc.).

The basic outputs are:

- > fuel consumption;
- > auxiliary energy consumption;

which are used as an input in EN 15603 to calculate primary energy required by the heating system.

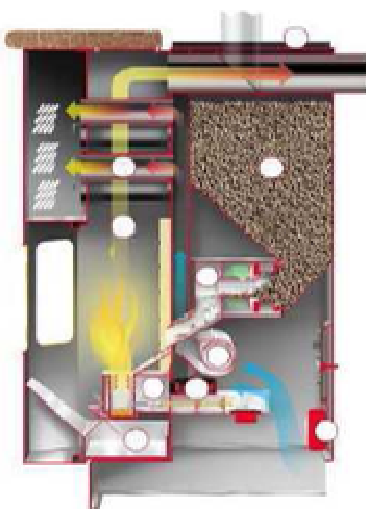
Other output information is available:

- > generation and accumulator storage total heat loss (flue gas, draught and envelope losses);
- > recoverable generation and accumulator storage heat losses (explicit or already taken into account as a reduction of losses);
- > seasonal generation efficiency.

The performance calculation methods for biomass combustion systems differ with respect to:

- > type of stocking device (automatic or by hand);
- > type of biomass fuel (pellets, chipped wood or log wood).

These two methods are described below.



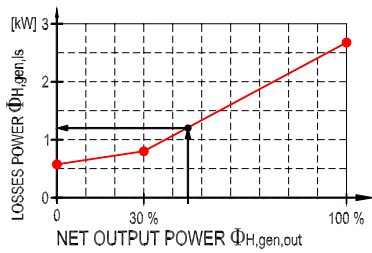


Fig.2: CASE SPECIFIC METHOD
Graph showing the basic linear relationship between output load $\Phi_{H,gen,out}$ and losses power $\Phi_{H,gen,ls}$. Interpolation is here made between part load and full load.

- 100 % full load
- 30 % part load
- 0 % stand by

Applying the methods, the following types of data may be used:

- > data declared by the boiler manufacturer;
- > on site measurements;
- > tabulated default data.

3 > Boiler with automatic stocking

The calculation method for biomass boilers with automatic stocking (method (1)) is comparable to the methods used for automatically fired boilers using oil or gas (clause 5.3 of EN 15316-4-1).

For the calculation period, power and losses of full load, part load and standby are calculated from net efficiency data, adjusted by interpolation for real operating conditions. Real losses are interpolated between these different load situations as shown in figure 2 "case specific method". A similar interpolation is performed to calculate auxiliary energy.

Full load and part load test data are generally available for new or recent boilers, but not for existing old boilers.

Standby-losses and auxiliary power consumption data are partly available from different producers of new boilers, but not for existing old boilers.

Default data shall be given in a national annex to complete missing data for new boilers, and to allow the use of this method for existing boilers, since the required values are not easy to obtain by direct measurement. Additional boiler input parameters are:

- > correction factor of full-load efficiency;
- > correction factor of intermediate load efficiency.

No procedure to determine these data is given. They should be given in a national annex. Default values for these factors are given in annex A.

Input data for actual operating conditions are:

- > net heat output to the heat distribution sub-system(s);
- > average water temperature in the boiler;
- > boiler room temperature;
- > temperature reduction factor depending on the location of the generator.

These data should come from calculations according to other parts of EN 15316, or from default values.

Annex A of the standard contains a complete set of default parameters that can be used as a reference and template to develop a national annex.

4 > Boiler stocking by hand

Two performance calculation methods for boilers with stocking by hand are described.

Method (1) (see chapter 7.3 case specific boiler efficiency method) is based on data related to the test procedures according to EN 303-5. However, supplementary data are needed in order to take into account the specific operation conditions during the heating period. This method is comparable to that used for boilers with automatic stocking (see above), and with the method defined in clause 5.3 of EN 15316-4-1.

Method (2) (see chapter 7.4 boiler cycling method) explicitly distinguishes losses which occur during boiler cycling. Some of the parameters can be measured on site. This method is comparable with that defined in clause 5.4 of EN 15316-4-1.

The second method (2) performs an analysis of boiler losses.

	fluegas losses	envelope losses	asch losses
boiler heating up	X	X	
boiler heating operation	X	X	X
boiler cooling down		X	X
boiler in fired bed operation		X	
boiler in non operation			

Figure 3: Specific losses at different situations

The calculation interval is divided into five situations (see figure 3), with specific loss calculations for each situation:

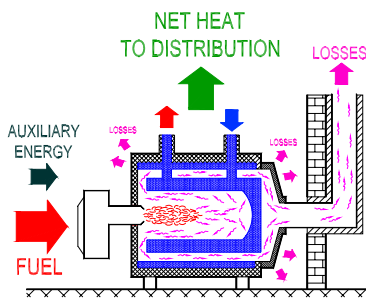
- > boiler heating up;
- > boiler heating operation;
- > boiler cooling down;
- > boiler in fire bed operation;
- > boiler in non operation.

For each calculation interval the time is calculated depending on the system heat demand. For each situation the losses are calculated using boiler characterization data.

Fuel requirement is obtained according to combustion power and calculated total operation time.

Basic single stage boiler characterization input parameters (see figure 4) are:

- > maximum combustion power of the generator (test conditions);
- > heat loss factors at test conditions for flue gas losses, draught losses and envelope losses depending on the different situations;
- > average boiler water temperature at test conditions for boiler on;
- > average boiler temperature at test conditions for boiler off;
- > temperature of test room;
- > electrical power consumption of auxiliary appliances (before the generator, typically burner auxiliaries) and related recovery factor;
- > electrical power consumption of auxiliary appliances (after the generator, typically primary pump and accumulator storage) and related recovery factor.



Generation subsystem basic energy balance

Fuel input $E_{H,gen,in}$
 = net heat to distribution $Q_{H,gen,out}$
 - recovered auxiliary energy $Q_{H,gen,aux,rvd}$
 + losses $Q_{H,gen,ls}$

$$E_{H,gen,in} = Q_{H,gen,out} - Q_{H,gen,aux,rvd} + Q_{H,gen,ls}$$

Figure 4: Energy balance

Annex A to 15316-4-7 provides examples of default values.

Actual operating conditions input data:

- > net heat output to the heat distribution sub-system(s);
- > average water temperature in the boiler;
- > boiler room temperature;
- > reduction factor taking into account recovery of heat losses through the generator envelope, depending on location of the generator.

These data should come from calculations according to other parts of EN 15316, or from default values.

Annex A of the standard contains a complete set of default parameters for this method. It can be used as a reference and template to develop a national annex.

5 > FAQ

Why two methods?

No single method provides a correct solution for all cases. A simplistic method may not be able to show the effect of improvements, whilst a detailed method may be unnecessarily time consuming.

Method (1): Boilers with automatic stocking operate similarly to boilers for liquid and gaseous fuels. For simplification of calculations, there are also default values given for hand-stocked boilers.

Method (2): The boiler cycling method is good practice for existing boilers.

Are national annexes always required?

Case specific and boiler cycling methods have annexes (annex A and B) where default values are given. If dedicated national values are required, they have to be written in a national annex .

Where do the methods come from?

The methods for boilers with both automatic stocking and stocking by hand are based on Austrian knowledge.

What was the aim in developing the two methods?

Method (1): The case specific method is intended to use boiler efficiency data, if possible.

Method (2): The boiler cycling method is intended to deal with existing boilers, to keep a connection with directly measurable parameters.

6 > References

1. EN 303-5 Heating boilers for solid fuels
2. EN 15316-4-1 Space heating systems - Combustion systems (boilers)
3. EN 15316-4-7 Space heating systems - Biomass combustion system
4. EN15316-2-3 Heating distribution subsystem
5. EN15316-3-3 Domestic hot water generation subsystem

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