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Analysis of proposed eco-design requirements for boilers and water heaters

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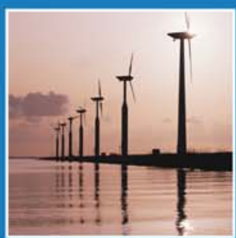

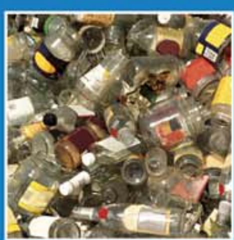
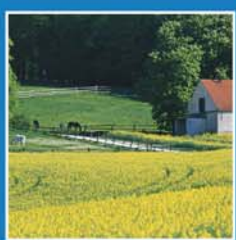
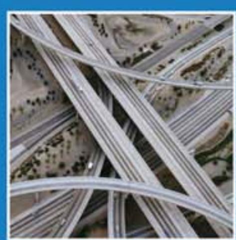

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Analysis of proposed eco-design requirements for boilers and water heaters

Contents

1 Executive summary 5

2 Introduction 7

3 Methodology 10

4 Data 12

5 Results 14

5.1 Results of calculations according to the space heat model 14

5.2 Calculations according to the hot water model 15

6 Analysis of the space heat model 16

7 Influence on the market 21

7.1 Which heating systems would be banned? 21

7.2 Adaptation of financial support programmes 22

7.3 Interrelations with 1. BImSchV 23

8 Overarching issues 24

9 Conclusion 26

10 Addendum: Brief comment on the latest developments 28

11 References 31

12 Appendix 33

Tables

Tab. 1: Versions of the WDs, Annex IV/V and of the Ecoboiler models taken as basis 8

Tab. 2: Required data and parameters for single / combi-boilers 11

Tab. 3: Overview of chosen examples for Blue Angel product groups 12

Tab. 4: Label classes, efficiency limits and product examples (VHK) 17

Tab. 5: Weighting of input parameters (for single / combi-boilers) 19

Tab. 6: Weighting of input parameters (for electric-driven heat pumps) 20

Tab. 7: Overview of the heating market in Germany 21

Tab. 8: NOx limits according to 1. BImSchV and WD of Lot 1 23

Tab. 9: Arguments for and against the enlarged product approach by VHK in Lot 1 and Lot 2 24

Tab. 10: Overview of ecodesign requirements for space heating according to the VHK Ecoboiler model and results of calculations of "Blue Angel" examples of CH-systems available in the German market 26

Tab. 11: Latest versions of the WD and of the Ecoboiler model (Lot 1) 28

Tab. 12: Net efficiency, market share and product examples (DG TREN) 30

Abbreviations

1. BImSchV	1. German Federal Immission Control Ordinance
approx.	approximately
BMU	German Federal Ministry for Environment
CH	Central Heating
CHP	Combined Heat and Power
COP	Coefficient Of Performance
DG TREN	Directorate-General for Energy and Transport
e.g.	for example
EHI	Association of the European Heating Industry
EPBD	Energy Performance of Buildings Directive
EU	European Union
EuP Directive	Energy using Products Directive
GCV	Gross Calorific Value
K	Kelvin
KfW	Kreditanstalt für Wiederaufbau
kW	kilowatt
LHV	Low Calorific Value
LT	low temperature
m^2	square metre
mg	milligram
No.	number
resp.	respectively
RT	Room Thermostat
TRV	Thermostatic Radiator Valve
UBA	German Federal Environment Agency
VHK	Van Holsteijn en Kemna
W	watt
WD	Working Document

1 Executive summary

In 2005, the European Union released the EuP Directive focusing on ecodesign requirements for energy-using products (2005/32/EC: EU Parliament and Council of the EU 2005). This directive, also called Ecodesign Directive, is a framework directive establishing a structure in which so-called implementing measures define specific requirements for placing products on the market and/or putting them into service within the internal European market. These requirements can be environmental performance standards (e.g. minimum energy efficiency or emission standards) and labelling or information requirements. Some existing European directives are already declared as being implementing measures of the Ecodesign Directive. Additionally, new implementing measures have been and will further be developed. Product-specific preparatory studies on behalf of the European Commission provide the basis for this.

The preparatory studies for **boilers (Lot 1)** and **water heaters (Lot 2)** have been conducted from February 2006 to October 2007 by Van Holsteijn en Kemna (VHK). Based on the preparatory studies, the EU Commission has released several working documents (WD) on possible ecodesign requirements for boilers and water heaters at the beginning of 2008.

Following these documents, boilers and water heaters comprise gas-fired, oil-fired and electric central heating (CH) (combi-) boilers / dedicated water heaters in combination with capturing solar thermal energy or ambient heat[1]. The requirements contain basically energy labelling measures, minimum efficiency performance standards and limits on NO_x emissions. An “Ecoboiler Model” resp. an “Eco Hot Water Model” has been elaborated within the preparatory studies. These models are a crucial part of the requirements and allow for calculation of the efficiencies of boilers and water heaters. Since the models have a high degree of complexity, the Federal Environment Agency (UBA) has asked Wuppertal Institute to analyse the spreadsheets and to carry out calculations for selected products.

The selection contains environmental-friendly boilers and water heaters which fulfil the award criteria of the “Blue Angel”, the German national voluntary environmental label, which sets environmentally related product obligations to manufacturers. Since the required input data of the spreadsheet is far more comprehensive than the selected award criteria of the “Blue Angel”, Wuppertal Institute has chosen specific products that are sold in the markets and fulfil the award criteria of the “Blue Angel” in order to perform the calculations.

The results of the calculation and the analysis of the Ecoboiler model reveal enormous differences concerning the energy label on boilers depending on the heating technology used. While a calculated electric brine/water heat pump obtains very good results,

[1] Please note: The scope of Lot 1 has been extended in the latest working document (cf. chapter 10).

calculated low temperature boilers perform rather bad. Condensing boilers are in between (cf. chapter 9).

Following the European Commission's suggestions for the implementation of the ecodesign requirements in 2011 resp. in 2013, a shift in market shares is expected depending on the heating technologies used. The enforced requirements on electric low-temperature boilers and condensing boilers will inter alia lead to some extent to the prohibition of many units which are available today. First of all low-temperature boilers will be in the border area of expiring energy label classes in 2011 and subsequently many condensing boilers will not be allowed to be sold in the internal market from 2013 onwards. Nevertheless, low-temperature boilers will not be completely squeezed out of the market since it will still be possible to sell heat pump or solar assisted low-temperature boilers.

The implementation of the ecodesign requirements will therefore lead to changes in the heating market in Germany. The share of the affected low-temperature boilers by the ban in 2013 amounts to approx. 25 % (152,000 units) of Germany's heating market today. In addition, condensing boilers would be banned to some extent.

Besides changes in market shares, several financial support programmes will have to be adjusted in Germany including inter alia the programmes "Energieeffizient Bauen", "Energieeffizient Sanieren" and the "Marktanreizprogramm" for renewable energies. Furthermore, the "1. BImSchV" in Germany will need to be revised, e.g. in the context of NOx limits.

A comprehensive approach has been chosen within Lot 1/2 taking into account the whole heating system (hybrids or stand-alones with/without solar and/or heat pumps), including e.g. heating system components like the control chain. This concept is called **"system approach"** or better **"enlarged product approach"**. It is in contrast to heating product approaches in other lots of the ecodesign directive process. There are arguments for and against the enlarged product approach. Advantages include e.g. the achievement of larger energy savings in comparison to component approach. One major disadvantage is the practical implementation which remains questionable.

In the beginning of June 2009, the European Commission has distributed a revised WD for possible measures on ecodesign and energy labelling for boilers. A new version of the Ecoboiler model has also been provided in addition to the WD (cf. chapter 10). Many changes have been made concerning both the WD and the Ecoboiler model. On the one hand, the Ecoboiler model has been simplified. However, due to missing input data needed for the new model calculation, but not yet available from the manufacturers, these latest version of the Ecoboiler model could not be analysed comprehensively. Nevertheless, Wuppertal Institute assumes that results in general will be comparable to calculations made applying the previous version of the Ecoboiler model.

2 Introduction

In 2005, the European Union released the EuP Directive focusing on ecodesign requirements for energy-using products (2005/32/EC: EU Parliament and Council of the EU 2005). This directive, also called Ecodesign Directive, is a framework directive establishing a structure in which so-called implementing measures define specific requirements for placing products on the market and/or putting them into service within the internal European market. These requirements can be environmental performance standards (e.g. minimum energy efficiency or emission standards) and labelling or information requirements. Some existing European directives are already declared as being implementing measures of the Ecodesign Directive. Additionally, new implementing measures have been and will further be developed. Product-specific preparatory studies on behalf of the European Commission provide the basis for this.

The preparatory studies for **boilers (Lot 1)** and **water heaters (Lot 2)** have been conducted from February 2006 to October 2007 by Van Holsteijn en Kemna (VHK). Based on the preparatory studies, the EU Commission has released a conjoint working document (WD) on possible ecodesign requirements for boilers and water heaters at the beginning of 2008 (WD-a 2008). The ecodesign requirements, which have been set down in the WD, contain basically compulsory energy labelling measures, minimum efficiency performance standards and limits on NO_x emissions. The requirements will be applied via CE-marking legislation. There are overlappings with other product groups: For instance, circulators, which contribute to the electric auxiliary energy of heating systems, are covered by Lot 11, and air conditioners and ventilation are covered by Lot 10. Furthermore there are overlappings with Energy Performance of Buildings Directive (EPBD).

In the scope of Lot 1/2 are boilers and water heaters including gas-fired, oil-fired and electric central heating (CH) (combi-) boilers / dedicated water heaters in combination with capturing solar thermal energy or ambient heat. Inter alia, boilers and water heaters using solid fuels as energy source (e.g. biomass or bio-oil), devices driven by district heating or CH-systems based on air heating are explicitly not included in the scope of Lot 1/2 (cf. Annex V 2008, 88). While combined heat and power (CHP) systems have not been covered by the first version of the suggested requirements (WD-a 2008), they have been included in WD 2009. An enlarged product approach has been chosen taking into account not only the boiler but also other heating components.

The “**Ecoboiler Model**” and the “**Eco Hot Water Model**” which have been developed within the preparatory studies of Lot 1/2 are intimately connected with the WD. The models contain the results of research of the preparatory studies in the form of spreadsheets which are distributed simultaneously. **Annex IV** (water heaters) resp. **Annex V** (boilers) of the WDs provided in 2008 (Annex IV 2008, Annex V 2008) are in line with these spreadsheets and have an identical structure. Due to the combination of text and spreadsheet, the policy makers and stakeholders are able to follow the calculation step-by-step. Influence on the result of different parameters can easily be judged. Furthermore, they are able to verify its robustness and applicability in a legal context.

During the consultation process, the draft version of the WDs including Annex IV/V and accompanied by the models have been and still are under consideration. Due to suggestions for improvement and questions raised by different stakeholders involved into the consultation process, the WD, appendices as well as the models still are subject to change. The EU Commission has released several improved versions. Tab. 1 shows the versions of Annex IV/V and of the models that have been basis for this analysis.

Tab. 1: Versions of the WDs, Annex IV/V and of the Ecoboiler models taken as basis

	WD	Annex IV/V	Ecoboiler Model
Boiler	Working document on possible Ecodesign En ergy labelling and Installation requirements for Boilers and Water Heaters, February 2008 (WD-a 2008)	Annex V, Revision draft Annex V d.d. 31.1.2008 on Ecodesign implementing measures for central-heating boilers and water heaters, Draft Version 1.1, 15th April 2008	Version 1.3beta, 9th June 2008 Please note: Revised version 1.3 (17th June 2008) has been taken into account but results are not presented within this short expertise since only minor changes have been made.
Water heaters	Working document on possible Ecodesign En ergy labelling and Installation requirements for Dedicated Water Heaters, June 2008 (WD-b 2008)	Annex IV on Ecodesign implementing measures for dedicated water heaters, Draft v2, 16th September 2008	Version 1, 15th July 2008 Please note: Draft VHK for dedicated water heaters, not approved by Commission

Temporarily, EU Commission has aimed for releasing a common WD on possible ecodesign, energy labelling and installation requirements for Lot 1 and Lot 2 since boilers and water heaters are related and often sold as packages (cf. WD-a 2008). Due to objections raised by EU Member States during the consultation process with regard to the approach towards boilers, EU Commission concentrated on possible ecodesign, energy labelling and installation requirements for water heaters first and issued a respective WD in June 2008 (cf. WD-b 2008). The document is accompanied by a revised draft spreadsheet for dedicated water heaters (15th July 2008, not approved by Commission). Furthermore, a new draft version of Annex IV on ecodesign implementing measures has been released on September 16th, 2008 (cf. Annex IV 2008). Due to the facts that only minor changes to the versions shown in Tab. 1 have been made concerning space heating and that calculation of water heaters have not been achievable due to missing data (cf. chapter 4), these revised versions have not been taken into account within this analysis.

The Regulatory Committee will decide on final regulations of Lot 1/2 on the basis of the WD and it is expected that regulations will be enacted in the course of 2009 or 2010.

Since the models have a high degree of complexity, contain many calculation steps and comprise a broad variety of parameters, the spreadsheets are not very transparent and assessable. UBA has asked Wuppertal Institute to analyse the spreadsheets and to carry out calculations for selected systems in order to support the evaluation of the

WD including the appendices and the accompanied spreadsheets. Furthermore, UBA has asked for outlining shortcomings, analysing the applied system approach and for estimating economic impacts. The short expertise has been conducted in the framework of task 14 of the project “Materialeffizienz und Ressourcenschonung” (FKZ 3707 93 300) on behalf of the German Federal Ministry for Environment (BMU) and UBA.

3 Methodology

Wuppertal Institute has been instructed to perform calculation for selected environmental-friendly boilers and water heaters which fulfil the award criteria of the "Blue Angel" - the German national voluntary environmental label, which sets environmentally related product obligations to manufacturers. The following Blue Angel product groups have been selected by UBA:

- **RAL-UZ 39** - Special gas boilers
- **RAL-UZ 40** - Combined water heaters and circulating water heaters for the use of natural gas
- **RAL-UZ 46** - Combined oil-burners and boiler units
- **RAL-UZ 61** - Low-emission and energy-saving gas-fired calorific value heating devices
- **RAL-UZ 112** - Wood-pellet boilers (optional, if possible)
- **RAL-UZ 118** - Energy-efficient heat pumps using absorption and adsorption technology or operating by use of combustion engine-driven compressors
- **RAL-UZ 121** - Energy-efficient heat pumps using an electrically powered compressor

Besides products awarded with the Blue Angel ecolabel, Wuppertal Institute has been asked to perform calculations for **two instantaneous water heaters** with different water heating loads (XXS, M), as well as for **gas-fired and electric heat pumps** fulfilling EU environmental requirements according to 2007/742/EC (optional, if possible).

The comparison of the award criteria of the Blue Angel with the required input data of the Ecoboiler model reveals that the calculations are not possible just on the basis of Blue Angel criteria since the spreadsheets require a more comprehensive data basis. Depending on the features of the CH-system a limited part of the input fields of the Ecoboiler model has to be filled out (cf. Annex V 2008, 13). In Tab. 2, input fields are exemplarily shown for a single conventional gas- or oil-fired boiler resp. combi-boiler, which have to be filled out in order to carry out a calculation in the context of RAL-UZ 39, RAL-UZ 40, RAL-UZ 46, RAL-UZ 61.

Tab. 2: Required data and parameters for single / combi-boilers

CH-system	Section	Parameter no. and description according to Annex V
Single conventional gas- or oil-fired boiler (sections 1-10) and combi-boiler (1-14)	1	1.1 Manufacturer; 1.2 Model; 1.3 Date; 1.4 ID
	2	2.1 Space heating load
	3	3.1 *Qb8060* nominal heat (pref column only); 3.2 Turndown ratio *turndown* (pref column only); 3.3 Two-stage burner *twostage* ? (pref column only); 3.4 Combi compensation *combicomp* ? (pref column only)
	4	4.1 *η8060* (pref column only); 4.2 *η8060min* (pref column only); 4.3 η*5030* (pref column only); 4.4 *η5030min* (pref column only)
	5	5.1 *p_bstby* standby heat loss % of Qb8060; 5.2 *Pign p*ilotflame power in kW (pref column only)
	6	6.1 *airfuelmix*; 6.2 *Fueldewpoint dpt*
	7	7.1* Combustion *airintake*; 7.2 Designated in-/outdoors *boilpos* ?; 7.3 Env. Volume *volumeb*; 7.4 Noise (*noiseh*)
	8	8.1 Boiler (empty) *massb*; 8.2 Water content *massw*
	9	9.1 Pump hrs after off *tpmp*; 9.2 Pmp hr/d setback *pmpsb*; 9.3 El. pump Pboff *elpmp*; 9.4 El. at Pboff *elstby*; 9.5 El. at Pbnom *elmaxon*; 9.6 El. at Pbmin *elminon*; 9.7 Variable speed pump *varsp*; 9.8 Pump configuration *pmpconfig*; 9.9 If no pump: pressure drop boiler *pdrop*
	10	10.1 Automatic timer *autotimer* ?; 10.2 *Optimiser*? [option eliminated. no saving]; 10.3 Valve control *Vcontrol*; 10.4 Temperature control *Tcontrol*; 10.5 Setting: *Cgrad, Cpar, CL*
	11	11.1 Water heating load
	12	12.1 Fuel consumption (in GCV) *Qfuel*; 12.2 Electricity consumption *Qelec*
	13	13.1 smart control factor *dhwsmart*; 13.2 noise (*noisew*)
	14	14.1 combustion efficiency *ηcomb*; 14.2 avg. flue gas temp. at tapping *Tflue*

Source: Wuppertal Institute based on Ecoboiler model and Annex V 2008, Abbreviations and explanations thereof see Annex V.

4 Data

The award criteria of the Blue Angel scheme are not sufficient to provide enough information and data for the Ecoboiler model. Therefore, one concrete example for each Blue Angel product group has been chosen by Wuppertal Institute in order to perform the calculations.

For instance, RAL-UZ 39 does not contain enough quantitative requirements to provide the necessary information inputs to enable the performance of a calculation, particularly in the field of technical specifications. Therefore, a specific boiler has been chosen carrying the Blue Angel ecolabel RAL-UZ 39. In Tab. 3 comments are stated including contradictories and problems which Wuppertal Institute encountered prior to the calculations. The concrete examples have been chosen by the degree of data availability and on the basis of findings and ratings of foundations. In some cases, manufacturers could not provide data on specific parameters. In these cases, assumptions have been made by Wuppertal Institute in order to ensure feasibility of the calculation.

Tab. 3: Overview of chosen examples for Blue Angel product groups

Blue Angel **product group** *(resp. other criteria)*	**Example Number** *(real models available at present at the market stand behind the examples)*	**Description**
RAL-UZ 39	Example 1	Gas-fired low-temperature boiler
RAL-UZ 40	Example 2	Standard gas-fired boiler
RAL-UZ 46	----	No calculation carried out.
RAL-UZ 61	Example 3	Gas-fired condensing boiler
RAL-UZ 112	----	Calculation has not been possible due to limited scope of Lot 1/2 (cf. chapter 3).
RAL-UZ 118	----	Calculation has not been possible due to missing data on the part of manufacturers (cf. chapter 3).
RAL-UZ 121	Example 4	Electric heat pump (In 2008, no heat pump has been awarded with RAL-UZ 121. Therefore, the top performer of an evaluation has been used as basis for the calculation.)
Instant. water heaters (XXS, M)	----	Calculation has not been possible due to missing data on the part of manufacturers (cf. chapter 3).
2007/742/EC	----	No calculation carried out.

Data gaps have occurred during data search. UBA had asked Wuppertal Institute to carry out all calculations not only for boilers but for combi-boilers featuring space heating of a building as well as sanitary hot water heating. However, Wuppertal Institute has faced **insufficient data especially in the context of water heaters.** According to Annex V, the energy consumption of a dedicated water heater or a CH-combi, incorporating a space heating and water heating function, has to be reported by the manufacturer using a given test standard with predefined tapping patterns (cf. Annex V 2008, 26-27). The measured fossil-fuel resp. electricity consumption in kilowatt hours a day is fed into the mathematical model (parameter no. 12.1 [Qfuel] resp. parameter no. 12.2 [Qelec]). Since data on the energy consumption of water heaters (parameter no. 12.1 and 12.2 values are the essential part for calculation) have not been measured and reported by manufacturers yet the energy efficiency of water heaters could not be specified.

A similar problem has occurred in the context of heat pump assisted water heating. The manufacturers are asked to indicate the energy consumption of the back-up heater for two different load patterns (parameter no. 18.3 [Qelecmin] resp. parameter no. 18.6 [Qelecmax]). Since these values also have not been available yet, energy efficiency of the water heating function of the heat pump (Example 4) could not be determined.

Besides data gaps with respect to the water heating function, the following remarks have to be stated:

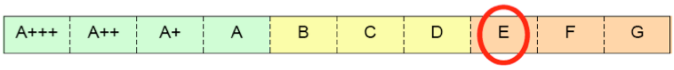
- It has not been possible to carry out calculations for wood-pellet boilers due to the restricted scope of this analysis. The Ecoboiler model would have to be adopted to boilers and water heaters using biomass since they are not in the scope of Lot 1/2 (cf. Annex V 2008, 88).
- Due to the fact that no heat pump is carrying the Blue Angel label in the context of RAL-UZ 118 and that Wuppertal Institute has been facing data gaps in the context of heat pumps using absorption and adsorption technology or operating by use of combustion engine-driven compressors, calculation has not been performed. Nevertheless, it has been possible to carry out a broad classification of gas-fired heat pumps (cf. chapter 5).
- Due to missing data on energy consumption of water heaters, calculation has not been possible in the context of instantaneous water heaters (XXS, M).

5 Results

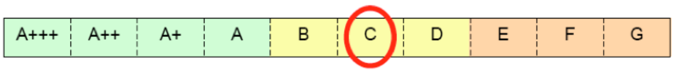
5.1 Results of calculations according to the space heat model

In this chapter the results of the calculations of the selected CH-systems are presented. A comprehensive overview of the calculations including the input mask as well as a documentation is attached in the appendix.

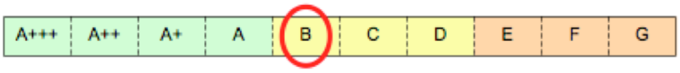
- **Example 1 (RAL-UZ 39)** is a gas-fired low-temperature boiler with integrated heat exchanger for hot water production in combination with an external hot water tank. The boiler is the successor of a model which was carrying the Blue Angel in 2007. The two boilers are identical in construction. The unit has an atmospheric gas burner with one stage and has a nominal power of 38.4 kW. The efficiency at nominal power and flow 80°C / return 60°C is approx. 82 %. A circulating pump is not integrated, thus a reference pump of the Ecoboiler model is used leading to comparatively high electric energy consumption (cf. Annex V 2008, 30-31). Wuppertal Institute assumed an installed thermostatic radiator valve (TRV) with p-band 2K and a boiler temperature control by a weather sensor and room thermostat (RT). According to the calculation, the boiler has an efficiency of 55 % leading to energy label class “E” of the proposed labelling (WD-a 2008) in the context of space heating.



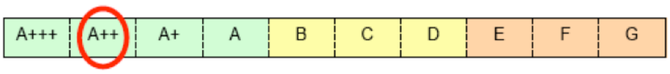
- **Example 2 (RAL-UZ 40)** is a standard gas-fired, wall-mounted boiler with integrated heat exchanger for hot water production in combination with an external hot water tank. The unit has an atmospheric water-cooled burner with electronic ignition. Furthermore, an ionisation detector is used for flame monitoring. The boiler modulates between minimal heat input of 9.3 kW and nominal heat input of 17.5 kW. The efficiency at nominal power ranges from approx. 81 % to 87 % referring to the gross calorific value (GCV). A circulating pump is integrated and the boiler has an electric power consumption of 110 W at nominal power. Wuppertal Institute assumed an installed TRV with p-band 2K and a boiler temperature control by weather sensor and RT. The boiler has an efficiency of approx. 66 % leading to energy label class “C” of the proposed labelling (WD-a 2008).



- **Example 3 (RAL-UZ 61)** is a gas-fired, wall-mounted condensing boiler. Hot water production is possible with the integrated plate heat exchanger using the concept of an instantaneous water heater. Even though the boiler is capable of hot water production the efficiency of the water heater could not be determined due to missing data on energy consumption (cf. chapter 3). The boiler modulates between minimal heat input of 4.7 kW and nominal heat input of 21.3 kW. A circulating pump is integrated with an electric power consumption between 42 W and 85 W at nominal power. The boiler control system offers night setback and has a function to adjust the pump hours after burner-turn-off. Wuppertal Institute assumed an installed TRV with p-band 2K and a temperature control by weather sensor and RT. With these inputs and further data the boiler has an efficiency of approx. 73 % leading to energy label class "B" of the proposed labelling (WD-a 2008).



- Example 4 is an electric brine/water heat pump. It has a nominal power of 9.9 kW. The nominal coefficient of performance (COP) amounts to 3.6. A hot water tank with a capacity of 175 litre is integrated in the heat pump. Although the heat pump is capable of hot water production, the efficiency of the water heater could not be determined due to missing data on energy consumption (cf. chapter 3). Wuppertal Institute assumed an installed TRV with p-band 2K and a boiler temperature control by weather sensor and RT. The heat pump gains a good energy label class of the proposed labelling (WD-a 2008), more precisely "A++" with an efficiency of approx. 108 %.



5.2 Calculations according to the hot water model

The examination of the hot water model has not been possible due to data gaps. Against this background it has not been possible to state weak points and shortcomings within the model for hot water and to evaluate the suggestions of ITG Dresden.

6 Analysis of the space heat model

The analysis of selected examples shows enormous differences concerning the energy label on space heat depending on the heating technology used, whereas the fuel type used has only minor impact on the space heating efficiency. The efficiency of oil-fired boilers is a little bit below those fired with gas since oil-fired boilers require additional parts for the atomization of oil leading to a higher auxiliary energy consumption.

- **Low-temperature boiler** - The low-temperature boiler of example 1 would achieve an energy label class “E” of the proposed labelling (WD-a 2008). In order to classify the boiler as “E” the manufacturer would have to integrate an efficient circulating pump. Energy label “C” would be possible to achieve but requires changes in boiler design. Example 2 would get the energy label class “C”. According to VHK, low-temperature boilers are in the range of the classes C and D. Therefore, the findings are in line with VHK predictions. However, example 1 has a comparatively poor label class. Energy efficiency of gas-fired low-temperature boilers is below efficiency of condensing boilers since latent heat of the vaporization of the water of the condensate is not used.
- **Condensing boiler** - The analysed condensing boiler (example 3) would get the energy label class “B” with a space heating efficiency of 72 %. The efficiency of the boiler could be raised to 76 % with relatively simple changes, e.g. with a revised setting of the control (Cgrad). Due to these simple changes, the boiler would be above the minimum efficiency performance standard of 76 % proposed for 2013 (cf. WD-a 2008, 12). But in order to classify the boiler with an “A” the manufacturer would have to change basic features of the boiler, e.g. a better valve control setting. According to VHK, efficient condensing boilers will not be banned by ecodesign requirements by 2013. Very good condensing boilers would reach energy label class “A”.
- **Heat pump** - Heat pumps would gain very good energy label classes within the Ecoboiler model, particularly in comparison to condensing boilers. The analysed heat pump (example 4) is a comparatively good heat pump and it would get the energy label “A++”. According to VHK, best heat pumps would reach energy label class “A+++” and very inefficient ones would be labelled as low as class “B”. According to Vaillant, brine/water-heat pumps gain label classes in the region of “A++”. Water/water-heat pumps perform poorer inter alia due to larger dimensioned pumps and air/water-heat pumps are in the range of proposed energy label class “A”. Gas-fired heat pumps (or absorption heat pumps) would have even better energy label classes than electric heat pumps. According to VHK, gas-fired heat pumps gain label classes “A++” resp. “A+++” (cf. Tab. 4). Manufacturers, such as Robur, confirm this classification (cf. Robur 2008, 5).

In order to verify plausibility of the results the findings have been compared to calculations of selected CH-systems made by Vaillant. Moreover, additional explanations of

VHK have been taken into account. They include the classification of typical boilers depending on the label class which has been presented at the final stakeholder meeting on September 11th, 2007. The VHK classification is illustrated in Tab. 4.

Tab. 4: Label classes, efficiency limits and product examples (VHK)

Class	Limit	Examples	
A+++	>120%	Vertical el. GSHP	Best Gas Abs. HP
A++	>104%	Gas-fired Abs. HP	Hor. El. GSHP
A+	>88%	Best condens+ solar	Vent. Air HP
A	>80%	Best condens	Outside Air HP
B	>72%	Avg. Condens	Outside Air HP
C	>64%	Best LT	Low Condens
D	>56%	Avg. LT	Best atmo. + solar
E	>48%	Low-end LT	Best atmo.
F	>40%	Avg. atmospheric	Electric res. + solar
G	≤40%	Low-end atmospheric	Electric resistance

Source: VHK 2007

According to WD-a 2008[2], energy efficiency of smaller CH-boilers (up to XL) shall be at least 56 % at the beginning of 2011, so that classes E, F and G will be banned (cf. WD-a 2008, 9). These requirements will have the effect that electric resistance CH-boilers and inefficient low-temperature CH / combi-boilers will be banned. The more inefficient representatives of the low-temperature boilers will be banned starting 2011, e.g. boilers featuring a comparatively low efficiency, those without integrated smart-controlled pump as well as those with a poor boiler temperature control system. Ecodesign requirements shall be tightened at the beginning of 2013. According to the proposal, efficiency of smaller CH-boilers shall be at least 76 % in 2013 and the classes B (in parts), C, D, E, F and G will be banned (cf. WD-a 2008, 9). These ecodesign requirements will lead to a ban on low-condensing boilers, which are in the range of energy classes C and D. Nevertheless, low-condensing boilers will not be completely squeezed out of the market since it will still be possible to sell heat pump or solar assisted low-temperature boilers. A boiler gains approx. one energy label class if it is combined with an average two-panel five square meter solar system. Improvement of more than one energy label class is also possible with a larger solar system. The more ambitious requirements starting 2013 would also lead to a ban on condensing boilers whose efficiency is below 76 %. Against this background, first of all low-temperature boilers will be in the border area of expiring energy label classes in 2011 and subsequently condensing boilers will be in the border area of expiring energy label classes in 2013. Even though oil-fired boilers perform worse in regard to energy efficiency they will not be banned completely. Manufacturers are free to compensate efficiency reductions due to oil-furnace by means of modifications of boiler design.

The calculations of the examples have been used to rate the weighting of input parameters of the Ecoboiler model. UBA has asked for a feedback on the impact of the individual components such as circulation pump, system control and hydraulic controls on the final result. Tab. 5 resp. 6 show the weighting of the input parameters of the spreadsheet for single / combi-boilers. The main adjustment screws are shown in the left column. They include e.g. the specific efficiencies (as expected) and pump configurations. Furthermore, the controllers play a decisive role in the context of weighting of input parameters, particularly time, temperature and hydraulic controls have a major impact.

[2] Please note: Ecodesign requirements have been revised in WD 2009 but these changes have not been considered.

Tab. 5: Weighting of input parameters (for single / combi-boilers)

Great impact (several percent on final result)	**Medium impact** (approx. 1-2 % on final result)	**Little impact** (less than 1 % on final result)
4.1 η8060 (efficiency at nominal power and 80/60 °C)	2.1 Space heating load (identifier of space heating load pattern)	3.2 Turndown ratio turndown (of the boiler)
4.2 η8060min (efficiency at minimal power and 80/60 °C)	3.1 Qb8060 nominal heat input in kW	3.3 Two-stage burner twostage ?
4.3 η5030 (efficiency at nominal power and 50/30 °C)	5.2 Pign pilotflame power in kW	3.4 Combi compensation combicomp ? (Does product comply with 'combicomp' definiton?)
4.4 η5030min (efficiency at minimal power and 50/30 °C)	6.2 Fueldewpoint dpt (gas, oil, LPG)	5.1 p_bstby standby heat loss % of Qb8060 (Standby heat loss as % of Qb8060)
9.1 Pump hrs after off tpmp	7.2 Designated in-/outdoors boilpos?	6.1 airfuelmix (type of air-fuel mixing technology)
9.8 Pump configuration pmpconfig (integrated, internal only, none)	9.4 El. at Pboff elstby (electric power consumption of boiler at burner off (no purge)	7.1 Combustion airintake (Method of combustion air intake of the burners)
10.1 Automatic timer autotimer? (identifier of usage of automatic timer)	9.6 El. at Pbmin elminon (electric power consumption at minimal boiler power Pbmin)	7.3 Env. Volume volumeb (Boiler volume)
10.3 Valve control Vcontrol (all components of hydraulic system)	11.1 Water heating load (identifier of water heating load pattern)	7.4 Noise (noiseh) (noise level of boiler measured as sound power at nominal load)
10.4 Temperature control Tcontrol (controls for adjustment of boiler temperature)		8.1 Boiler (empty) massb (boiler mass (empty))
10.5 Setting: Cgrad, Cpar, CL (slope, parallel shift of heating curve and CL refers to system feed temperature)		8.2 Water content massw (water content of boiler heat exchanger)
12.1 Fuel consumption (in GCV) Qfuel (fuel consumption of water heating test in kWh/day)		9.2 Pmp hr/d setback pmpsb (control of the circulator pump with a night-setback option)
12.2 Electricity consumption Qelec (electricity consumption of water heating test in kWh/day)		9.3 El. pump Pboff elpmp (Nominal pump power)
13.1 smart control factor dhwsmart (Does WH comply with definition smart control?)		9.5 El. at Pbnom elmaxon (Electricity consumption at nominal CH-boiler power)
		9.7 Variable speed pump varsp
		9.9 If no pump: pressure drop boiler pdrop
		10.2 Optimiser? [option eliminated. no saving]
		13.2 noise (noisew) (of water h.)
		14.1 combustion efficiency ηcomb (of water heater)
		14.2 avg. flue gas temp. at tapping Tflue

Please note: Parameters 9.1 – 9.8 are mutually dependent and weighting may vary depending on particular pump configuration. Source: Wuppertal Institute based on calculations within Ecoboiler model, for abbreviations and explanations thereof see Annex V 2008.

Tab. 6: Weighting of input parameters (for electric-driven heat pumps)

Great impact (several percent on final result)	**Medium impact** (approx. 1-2 % on final result)	**Little impact** (less than 1 % on final result)
2.1 Space heating load (identifier of space heating load pattern)	7.2 Designated in-/outdoors boil-pos?	7.1 Combustion airintake (Method of combustion air intake of the burners)
9.1 Pump hrs after off tpmp	9.4 El. at Pboff elstby (electric power consumption of boiler at burner off (no purge)	8.1 Boiler (empty) massb (boiler mass (empty))
9.8 Pump configuration pmpcon-fig (integrated, internal only, none)	16.1 Nominal Power Phpnom	8.2 Water content massw (water content of boiler heat exchanger)
10.1 Automatic timer autotimer? (identifier of usage of automatic timer)	16.7 Auxiliary el. consumption hpaux	9.2 Pmp hr/d setback pmpsb (control of the circulator pump with a night-setback option)
10.3 Valve control Vcontrol (all components of hydraulic system)	16.9 Tank ref. heat loss Pstbyhpw	9.3 El. pump Pboff elpmp (Nomi-nal pump power)
10.4 Temperature control Tcon-trol (controls for adjustment of boiler temperature)	16.11 Use (also) vent. exhaust air ventmix ?	9.7 Variable speed pump varsp
10.5 Setting: Cgrad, Cpar, CL (slope, parallel shift of heating curve and CL refers to system feed temperature)	16.13 Test points for heat pumps	16.2 turndownhp (Turndown ratio of heat pump)
11.1 Water heating load (identifier of water heating load pattern)		16.6 Maximum sink temperature Tsnkmax
12.1 Fuel consumption (in GCV) Qfuel (fuel consumption of water heating test in kWh/day)		16.8 Tank volume nominal Vhp
12.2 Electricity consumption Qelec (electricity consumption of water heating test in kWh/day)		16.10 Tank hot water capacity V40hp
16.3 HPtype, Tsrc/Tsnk (Heat pump type)		
16.4 Nominal COP COPnom		
16.5 50 % load COP correct COP50		
17+18 (Sections) Back-up heater		

Please note: Parameters 9.1 – 9.8 are mutually depend and weighting may vary depending on particular pump configuration. Source: Wuppertal Institute based on calculations within Ecoboiler model, for abbre-viations and explanations thereof see Annex V 2008.

7 Influence on the market

7.1 Which heating systems would be banned?

The implementation of the ecodesign requirements stated in WD-a 2008[3] would have an effect on market shares of the different heating technologies. The enforced requirements on electric driven water heaters and (combi-) boilers, low-temperature boilers and condensing boilers to some extent would lead to the prohibition of many units which are available today. In Germany approx. 17 Mio. CH-systems with an average lifetime of 24 years are installed (Kleemann 2006). The actual market of boilers in Germany in 2007 is shown in Tab. 7. Since there are hardly any electric driven (combi-) boilers sold in Germany today, their market share is negligible. The share of the affected low-temperature boilers by the ban in 2013 amounts to approx. 25 % (152,000 units) of Germany's heating market today. In addition, condensing boilers would be banned to some extent. The share of the banned condensing boilers could not be quantified within this short expertise because it requires a comprehensive analysis of the energy efficiency of the existing condensing boiler market.

Tab. 7: Overview of the heating market in Germany

Type of heating system	Number of sold units in 2008	Market share (in %)
Biomass	35,112	5.7
Heat pumps	62,216	10.1
Oil boilers (LT)	46,200	7.5
Oil condensing boilers	58,520	9.5
Gas boilers (LT)	14,784	2.4
Gas condensing boilers	308,000	50
Combi-boiler (LT, gas is predominant)	91,168	14.8
Total market	**616,000 units**	**100 %**
Thermal solar systems	approx. 200,000 (2 Mio. m^2)	

Source: BDH 2009

Banned units have to be substituted by efficient systems. Especially, instead of low-temperature heating systems condensing boilers will probably be installed to an even larger extent than in today's market. Condensing boilers have a lower flue gas temperature since they incorporate an additional heat exchanger achieving an extra energy efficiency by recycling the hot exhaust to pre-heat the cold water coming in. The

[3] Please note: Ecodesign requirements have been revised in WD 2009 but these changes have not been considered.

lower flue gas temperature leads to condensation of the humidity in the chimney. Therefore, changes of the physical structure of the chimney are necessary when switching from conventional to condensing boilers leading to additional costs. But in terms of life cycle costs there are also savings due to a reduction of fuel consumption. Therefore, a substitution of low-temperature boilers by condensing boilers leads to higher investment costs in the first place, but also to savings in the long run. In order to estimate the net cost impact, which could be a net cost saving impact, annual energy cost savings would have to be calculated, which would require a sophisticated calculation and a comprehensive analysis of the energy efficiency of the existing condensing boiler market, which both has not been possible in the course of this short study.

7.2 Adaptation of financial support programmes

Several financial support programmes would have to be adjusted in Germany due to the ban on certain system technologies. Particularly, funding of the replacement of conventional boilers by condensing boilers could become obsolete. In particular, the following nationwide programmes would have to be revised:

- "Energieeffizient Bauen" (KfW, programme no. 153, 154)
- "Energieeffizient Sanieren" (KfW, programme no. 151, 152)
- "Wohnraum Modernisieren" (KfW, programme no. 141, 143)

Please note: Financial support programmes of KfW have recently been revised (1st April 2009) and former programmes, e.g. "CO_2- Gebäudesanierungsprogramm" and "Ökologisch Bauen", have been restructured and renamed.

Furthermore, funding of renewable energies will have to be revised to some extent. This includes the funding of air/water heat pumps which have comparatively poor energy label classes, e.g. within the framework of the "Marktanreizprogramm zur Förderung erneuerbarer Energien", as well as the energy efficiency bonuses with the "Marktanreizprogramm" (cf. also Pehnt et al. 2009). Furthermore, adjustments of the German Renewable Energies Heat Act (EEWärmeG) might be necessary. For instance, one could consider an alignment of the methods for evaluating heat pumps.

Besides these nationwide programmes, several programmes of the different states ("Länder") as well as those of municipal energy suppliers need to be revised.

7.3 Interrelations with 1. BImSchV

There are interactions between the introduction of energy efficiency requirements in the context of Lot 1/2[4] and the "1. BImSchV" (ordinance on small and medium size combustion installations Erste Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes; Kleinfeuerungsanlagenverordnung) in Germany. According to 1. BImSchV, new heating systems up to a nominal heat output of 120 kW and using water as heat transfer medium need to fulfil the criteria in the context of NOx-emissions stated in the following Tab. (§7 1. BImSchV):

Tab. 8: NOx limits according to 1. BImSchV and WD of Lot 1

WD of Lot 1		1. BImSchV
from 01/01/2013	**35 mg/kWh** for gas-fired boilers up to 70 kW[1] without renewable input **70 mg/kWh** for oil-fired boilers up to 70 kW[1] without renewable input **70 mg/kWh** for gas-fired boilers with renew-able input[3] (includes all "larger" boilers[2]) **105 mg/kWh** oil-fired boilers with renewable input[3] (includes all "larger" boilers[2])	**60 mg/kWh** for gas-fired boilers up to 120 kW **80 mg/kWh** for gas-fired boilers from 120 kW to 400 kW **120 mg/kWh** for gas-fired boilers above 400 kW **110 mg/kWh** for oil-fired boilers up to 120 kW **120 mg/kWh** for oil-fired boiler from 120 kW to 400 kW **185 mg/kWh** for oil-fired boilers above 400 kW
Comments: [1] Smaller boilers include size classes up to XL. [2] Larger boilers include size classes XXL and above. [3] Includes products with at least 30 % renewable input. Please note: a) A mistake (kW instead of kWh) which has been made within WD-b 2008 (p.9) is corrected within this table. b) The lot 1 WD 2009 includes different NOx limits.		

Source: WD-b 2008; 1. BImSchV (Draft)

The comparison of the limits stated in 1. BImSchV as well as those stated in the WD-b 2008 reveals that NOx-limits of the WD are slightly more sophisticated. The limits of the 1. BImSchV will be superseded by those of the implementing measure.

Besides NOx emissions, 1. BImSchV will be affected by a possible EuP Lot 1 regulation in terms of the overall efficiency with respect to realistic conditions. According to 1. BImSchV, new heating systems and those replaced by new ones featuring a nominal heat output of more than 400 kW and using water as heat transfer medium need to have a "Normnutzungsgrad" of at least 91 %. The Normnutzungsgrad has to be measured according to DIN 4702, supplementary sheet 8. This requirement will be superseded by the implementing measure.

4 Please note: Requirements have been revised in WD 2009 but these changes have not been considered.

8 Overarching issues

In the context of the scope of Lot 1/2, it is important to consider that the WD-a 2008 and WD-b 2008[5] of the EU Commission suggest that boilers and water heaters should be part of a well-designed system. A comprehensive approach has been chosen taking into account the whole heating system (hybrids or stand-alones with/without solar and/or heat pumps), thereby including heating system components like the complete control chain (boiler temperature controller, room thermostats, valve controllers) and even a service contract whereby the manufacturer guarantees hydraulic balancing of the system and correct initial controller settings. This concept can be called **"system approach"** or better **"enlarged product approach"**, and is in contrast to heating product approaches in other lots of the ecodesign directive process (e.g. Lot 15 on solid fuels).

There are arguments for and against the enlarged product approach listed in the table below.

Tab. 9: Arguments for and against the enlarged product approach by VHK in Lot 1 and Lot 2

Pro	Contra
- Consideration of total heating system including all components and reward of well-matched components. - More transparency for customers and installers: System approach helps customers / installers to select a well-balanced overall system including components which have a good match. - Achievement of larger energy savings in comparison to component approach. - More freedom for boiler manufacturers to achieve requirements due to free choice of efficient components.	- Bundling is confusing for customers, e.g. if the very same hot water tank has different energy labels depending on the boiler it is sold with. - Implementation remains questionable. - It is unclear how to deal with replacement of single components. - Stronger cooperation of manufacturers of boilers and components is necessary.

The enlarged product approach is a promising way of increasing energy efficiency not only of the boiler itself but of the total heating system. Rewarding a system which consists of well-matched components sets incentives to increase energy efficiency beyond the efficiency of the boiler itself. Due to the enlarged product approach, combinations of components, which are individually excellent but perform badly in combination are avoided. Compatibility is taken into account within this approach since a good communication between the different system components has to be guaranteed.

Nevertheless, it remains open if the enlarged product approach will be feasible in practice. Especially the labelling and CE-marking of a bundle of components is challenging

5 Please note: Requirements have been revised in WD 2009 but these changes have not been considered.

in implementation. For example, in practice, distribution of boilers and water heaters can be either the distribution of a complete package (maybe even including solar thermal collectors, storages, circulators, etc.) from manufacturers directly to installers, or the delivery of components to installers via the wholesaler where installers choose components and bundle them to a package for their clients, thereby, e.g., bundling components from different manufacturers. While in the first case, the enlarged product approach will result in one single label and CE-mark for a specific package sold, in the second case, several packages could be bundled with one specific boiler available at the wholesaler, and it remains unclear, how the labelling and CE-marking could work in this case.

A compromise and a way out of this dilemma could be to reward, if a single boiler or water heater generally provides the possibility to be combined with other components to an efficient heating or water heating system. One requirement for this ability could be the implementation of unified and open plug and play protocols that allow communication between heating system components of different manufacturers (e.g. www.opentherm.org). This would leave the opportunity open for future system improvement by adding (then compatible) new energy-efficient solutions to an existing system. The existence of such an interface should be rewarded with additional points in the scheme.

9 Conclusion

The analysis of the Ecoboiler model (Version 1.3beta, 9th June 2008)[6] reveals enormous differences concerning the energy label on space heating systems depending on the heating technology used. The following table summarises the results of the calculations of selected CH-systems. Furthermore, provisional energy label classes and the proposed minimum standards are presented, which will be introduced in 2011 resp. 2013.

Tab. 10: Overview of ecodesign requirements for space heating according to the VHK Ecoboiler model and results of calculations of "Blue Angel" examples of CH-systems available in the German market

Minimum standards: (for smaller CH-boiler *)	Energy label:	Results of calculations of examples:
	A+++	
	A++	Heat pump
	A+	
	A	
starting 2013 (< 70 kW): **> 76 % (B to G banned)**	B	**Condensing boiler** (RAL-UZ-61)
	C	**Low-temperature boiler** (RAL-UZ-40)
	D	
starting 2011: **> 56 % (E to G banned)**	E	**Low-temperature boiler** (RAL-UZ-39)
	F	
	G	

** Abstracted from the WD, Reference: WD-a 2008, 9*

Source: Wuppertal Institute based on calculations within Ecoboiler model.
The arrows show theoretical technical improvement potentials of the respective boilers requiring changes in boiler design / boiler features.

6 Please note: Ecoboiler model has been revised 2009 but these changes have not been considered.

Based on the proposal WD-a 2008 for the energy efficiency rating scale, low-temperature boilers will be banned in 2011 to some extent. In 2013, low-temperature boilers without renewable energies will be banned completely. The share of affected low-temperature boilers amounts to approx. 30 % of Germany's heating market today. In addition, inefficient condensing boiler systems will be banned in 2013.

Manufacturers will have to re-design inefficient condensing boilers starting with the main adjustment possibilities shown in Tab. 5 resp. 6.

Heat pumps gain very good energy label classes and will hardly not be affected by the requirements proposed in the WD.

Substitution of banned system technologies by more energy-efficient technology requires higher investment costs. Particularly, additional initial investment costs are substantial when switching from conventional to condensing boilers. However, the net cost impact including energy cost savings might be a cost reduction. For a detailed estimate for Germany, additional data would be needed.

Against the background that ecodesign requirements will lead to a shift in market shares, funding programmes need to be revised. Especially, revision of nationwide KfW programmes and the "Marktanreizprogramm" will become necessary.

The question, if and how far an enlarged product approach is feasible, cannot be finally judged. There are relevant arguments for as well as against the enlarged product approach. However, the requirement to implement a unified open interface that allows communication between all components even from different manufacturers and that provides the basis for possible optimisations of the heating system performance could open up a new perspective.

10 Addendum: Brief comment on the latest developments

In the beginning of June 2009, the European Commission has distributed an revised WD (WD 2009) for possible measures on ecodesign and energy labelling for boilers. A new version of the Ecoboiler model has also been provided in addition to the WD (cf. Tab. 11).

Tab. 11: Latest versions of the WD and of the Ecoboiler model (Lot 1)

	WD	Ecoboiler Model
Boilers	Working documents for possible measures on ecodesign and energy labelling for boilers, 3rd June 2009 (WD 2009)	Latest version of the Ecoboiler model has been released on 3rd June 2009

The revised WD 2009 contains several changes which have been made due to comments that the European Commission has received from the stakeholders and Member States. Inter alia, the new WD comprises following modifications (cf. WD 2009, 1):

- The scope of the WD has been extended. It includes combi-boilers, micro-cogeneration and cylinders as well as fossil fuelled boilers, electric central heating, heat pumps and solar heating.
- The WD addresses boilers and combi-boilers up to 400 kW.
- Ecoboiler model has been simplified and the quantity of required input-data in order to perform calculations has been reduced.
- Testing points have been revised.
- Third party testing is the norm.
- NOx emissions limits have been revised and extended to CHP-installations taking into account stirling motors.
- Co-firing of renewable energy is addressed by a provision.
- The influence of controls on energy efficiency has been revised.
- Certain characteristics for replacing small boilers in apartment blocks have been addressed

The Association of the European Heating Industry (EHI) raises concerns against the latest WD, especially against the complexity of the approach (cf. EHI 2009). Furthermore, the EHI states several key concerns. For instance, EHI states that for domestic boilers up to 70 kW it is impossible to assess the latest Ecoboiler model due to missing input-data. EHI argues that required input-data is not in-line with any EC approval scheme and not defined by any European Harmonized Standard and that new tests have to be made in order to be able to state e.g. “eta1” for boilers or “COP1” for heat pumps (cf. EHI 2009).

Also Wuppertal Institute identified data gaps. For instance, data gaps exist in connection with “COP1” to “COP5” in the context of heat pumps. Due to the changes in the model and the testing conditions, it has not been possible to make further calculations within the limited frame of this study. Nevertheless, Wuppertal Institute assumes that results of the latest Ecoboiler model will not vary tremendously from the results of the calculations presented above. A slide of the presentation held by DG TREN on 24th / 25th of June 2009 supports this assumption which provides an overview of product examples and the corresponding net efficiency (cf. Tab. 12).

In addition, first results of calculation concerning heat pumps which have been carried out by the manufacturer “Stiebel Eltron” indicate that heat pumps obtain also good energy labelling classes with the latest Ecoboiler model.

The Federal environment agency and other stakeholders raise concerns in relation to the exclusion of biofuels when, at the same time including CHP-installations into the scope. The exemption for biofuel might be used to circumvent the emission requirements of the ordinance.

At the same time the requirements for NO_x emissions relate to stirling motors and are probably not achievable by internal combustion engines. They should hence be adapted to the state of the art of this well established technology.

Tab. 12: Net efficiency, market share and product examples (DG TREN)

Examples		
vertical ground-source + gas fired heat pumps	market share **net efficiency > 119%**	<1%
best air-based electric heat pump + average horizontal GSHP	market share **net efficiency > 103%**	<1%
best solar assisted + micro CHP	market share **net efficiency > 87%**	2%
best condensing	market share **net efficiency > 79%**	8%
average condensing	market share **net efficiency > 71%**	10%
best Low Temperature	market share **net efficiency > 64%**	12%
average Low Temperature	market share **net efficiency > 56%**	15%
low-end Low Temperature (TODAY'S AVERAGE)	market share **net efficiency > 48%**	30%
average atmospheric	market share **net efficiency > 40%**	15%
low-end atmospheric +electric resistance	market share **net efficiency < 40%**	6%

Source: European Commission 2009

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12 Appendix

Example 1: Gas-fired low-temperature boiler (RAL-UZ 39)

Version 1.3beta, 9 june 2008

ANNEX B: DATA REPORT

DATA REPORT CH-BOILERS & WATER HEATERS

1,1	Manufacturer	
1,2	Model	

2,1	**SPACE HEATING LOAD**	6 -XL		11,1	**WATER HEATING LOAD**	0 -none	
	BOILER(S)	*pref*	*nopref*		**WATER HEATER** (gas/oil/elec)		
3,1	**Qb8060** nominal heat input in kW	38,4	0	12,1	Fuel consumption (in GCV) **Qfuel**	kWh/d	0
3,2	Turndown ratio **turndown**	100,00%	0,00%	12,2	Electricity consumption **Qelec**	kWhe/d	0
3,3	Two-stage burner **twostage** ?	0 -no	0 -no				
3,4	Combi compensation **combicomp** ?	0 -no		13,1	smart control factor **dhwsmart**	0 -no	
				13,2	noise (**noisew**)	dB-A	43
4,1	**η8060**	82,43%	80,00%				
4,2	**η8060min**	82,43%	80,00%	14,1	combustion efficiency **ηcomb**	%	90%
4,3	**η5030**	83,42%	80,00%	14,2	avg. flue gas temp. at tapping **Tflue**	oC	120
4,4	**η5030min**	83,42%	80,00%		elec yes or no?	0 -no	
					SOLAR ASSIST		
5,1	**p_bstby** standby heat loss **% of Qb8060**	1,20%	1,00%	15,1	Collector aperture area **Asol**	m2	0,00
5,2	**Pign** pilotflame power in kW	0	0	15,2	Zero-loss collector efficiency **η0**	-	0,85
				15,3	First-order loss coefficient **a_1**	W/(m²K)	3,37
6,1	**airfuelmix**	1 -atmospheric		15,4	Second-order loss coefficient **a_2**	W/(m²K²)	0,01
6,2	**Fueldewpoint dpt**	1 -gas		15,5	Incidence angle modifier **IAM**	-	0,97
				15,6	**Solar part of** tank volume **vsol**	ltr	300
7.1*	Combustion **airintake**	1 -room sealed		15,7	UA-value of heatexchanger **UAsol**	W/K	1800
7.2*	Designated in-/outdoors **boilpos**?	1 -indoors		15,8	Collector loop pipe lenght, **Lpipesol**	m	6
7.3*	Env. Volume **volumeb**	m3	0,43	15,9	Coll. loop loss per m pipe **Upipesol_m**	W/(m.K)	0,3
7,4	Noise (**noiseh**)	dB-A	45	15,1	Tank heat loss coeff **UA**	W/K	1,7
				15,11	Solar pump power **solaux**	W	80
8,1	Boiler (empty) **massb**	kg	204	15,12	Tank position **solpos**	1 -indoors	
8,2	Water content **massw**	kg	18	15,13	Usage sol **usesol** (HW, CH or both)	3 -both HW & CH	
9,1	Pump hrs after off **tpmp**	h	24		**BACK-UP HEATER**		
9,2	Pmp hr/d setback **pmpsb**	0 -no		17,1	**ELBU** el. back-up space heating?	0 -no	
9,3	El. pump Pboff **elpmp**	kW	0		*hot water back-up additional data*		
9,4	El. at Pboff **elstby**	kW	0,005	18,1	Waterloadmin	4 -M	
9,5	El. at Pbnom **elmaxon**	kW	0	18,2	**Qfuelmin**	kWh	10
9,6	El. at Pbmin **elminon**	kW	0	18,3	**Qelecmin**	kWhel	0,5
9,7	Variable speed pump **varsp**	0 -no		18,4	Waterloadmax	5 -L	
9,8	Pump configuration **pmpconfig**	3 -none		18,5	**Qfuelmax**	kWh	20
9,9	If no pump: pressure drop boiler **pdrop**	mbar	44	18,6	**Qelecmax**	kWhel	1
	CONTROLLERS				**HEAT PUMP**		
10,1	Automatic timer **autotimer**?	1 -yes		16,1	Nominal Power **Phpnom**	kW	0
10,2	Optimiser? [option eliminated, no saving]	0 -no		16,2	**turndownhp**	%	100%
10,3	Valve control **Vcontrol**	2 -RTV 2K		16,3	**HPtype** (Tsrc/Tsnk)	3 -El. air/ water	
10,4	Temperature control **Tcontrol**	4 -weather c. BT+RT		16,4	Nominal COP **COPnom**		3,7
10,5	Setting **Cgrad** 1,5 **Cpar** 0	**CL**	15	16,5	50%. load COP correct **COP50**	%	125%
				16,6	Maximum sink temperature **Tsnkmax**	oC	50
				16,7	Auxiliary el. consumption **hpaux**	W	151
				16,8	Tank volume nominal **Vhp**	ltr	125
				16,9	Tank ref. heat loss **Pstbyhpw**	W	60
				16,1	Tank hot water capacity **V40hp**	frac. Vhp	1,9
				16,11	Use (also) vent. exhaust air **ventmix** ?	0 -no	
				16,12	Usage hp **usehp** (HW, CH or both)	3 -both HW & CH	
				16,13	Testpoints (table left)		

	hp	Pcor			COPcor		
16.13T	oC	35	45	55	35	45	55
16.13a	-7	0,71	0,68	0,66	0,86	0,71	0,56
16.13b	2	0,87	0,85	0,83	1,10	0,89	0,67
16.13c	7	1,03	1,00	0,97	1,23	1,00	0,76
16.13d	20	1,34	1,29	1,25	1,70	1,28	0,86
16.13e							

	OUTPUT: SPACE HEATING ENERGY				**OUTPUT: WATER HEATING ENERGY**		
A.1	Space heat load	kWh/a	18.836	B.1	Water heat net load	kWh/a	0
A.2	Space heat primary energy use	kWh/a	34.229	B.2	Water heat primary energy use.	kWh/a	0
A.3	Space heat efficiency	55,0%		B.3	Water heat energy eff.	0,0%	
A.4	Energy label Space Heat	E		B.4	Energy label Water Heating	none	

Example 1: Gas-fired low-temperature boiler (RAL-UZ 39)

Required parameters	Input data	Reference / comment
1.1 Manufacturer		Manufacturer information[1]
1.2 Model		Manufacturer information[1]
1.3 Date	10.10.2008	
1.4 ID		Manufacturer information[1]
2.1 Space heating load	XL	Assumption - The CH-system will be declared "XL" by the manufacturer within the framework of CE-marking.
3.1 Qb8060 nominal heat input in kW	38,4 kW	Manufacturer information[1]
3.2 Turndown ratio turndown	100 %	Manufacturer information[2] - Boiler has a fixed power output.
3.3 Two-stage burner twostage ?	No	Manufacturer information[2] - CH-system is not a multi-stage boiler.
3.4 Combi compensation combicomp ?	No	Assumption - Storage tank is not included in the space heating test.
4.1 η8060	82.43 %	Manufacturer information[2] - The manufacturer information of 91.5 % based on the lower heat-ing value (LHV) has been converted to gross calorific value (GCV).
4.2 η8060min	82.43 %	The efficiency also amounts to 82.43 % since the boiler has a fixed power output.
4.3 η5030	83.42 %	Manufacturer information[2] - The manufacturer information of 92.6 % based on the lower heat-ing value (LHV) has been converted to gross calorific value (GCV).
4.4 η5030min	83.42 %	The efficiency also amounts to 83.42 % since the boiler has a fixed power output.
5.1 p_bstby standby heat loss % of Qb8060	1.20 %	Manufacturer information[2]
5.2 Pign pilotflame power in kW	0 kW	Manufacturer information[2] - Electronic ignition.
6.1 airfuelmix	atmospheric	Manufacturer information[2] - No pre-mix fan pre-sent.
6.2 Fueldewpoint dpt	gas	Manufacturer information[1] - Natural gas Erdgas E resp. LL.
7.1 Combustion airintake	room sealed	Manufacturer information[1]
7.2 Designated in-/outdoors boilpos?	indoors	Manufacturer information[1]
7.3 Env. Volume volumeb	0.43 m^3	Manufacturer information[1]
7.4 Noise (noiseh)	45 db-A	Assumption - Manufacturer information has not been available.
8.1 Boiler (empty) massb	204 kg	Manufacturer information[1]
8.2 Water content massw	18 kg	Manufacturer information[2]
9.1 Pump hrs after off tpmp	24 h	Fixed parameter "24h" since there is no inte-grated pump (cf. Annex V 2008, 31).
9.2 Pmp hr/d setback pmpsb	No	Fixed parameter "no" since there is no integrated pump (cf. Annex V 2008, 31).
9.3 El. pump Pboff elpmp	0 W	Fixed parameter "0 W" since there is no inte-grated pump (cf. Annex V 2008, 30).
9.4 El. at Pboff elstby	5 W	Assumption - Manufacturer information has not been available.
9.5 El. at Pbnom elmaxon	0 W	Fixed parameter "0 W" since there is no inte-

		grated pump (cf. Annex V 2008, 30).
9.6 El. at Pbmin elminon	0 W	Fixed parameter “0 W” since there is no integrated pump (cf. Annex V 2008, 30).
9.7 Variable speed pump varsp	No	Fixed parameter “no” since there is no integrated pump (cf. Annex V 2008, 31)
9.8 Pump configuration pmpconfig	none	Manufacturer information[2] – No integrated pump.
9.9 If no pump: pressure drop boiler pdrop	44 mbar	Manufacturer information[2]
10.1 Automatic timer autotimer?	Yes	Manufacturer information[1]
10.2 Optimiser? [option eliminated. no saving]	---	---
10.3 Valve control Vcontrol	TRV 2K	Assumption – Hydraulic controls are i.a. based on Thermostatic Radiator Valve (TRV) with p-band 2K meaning that TRV cannot be pre-adjusted to a range smaller than 2K (cf. Annex V 2008, 11).
10.4 Temperature control Tcontrol	weather c. BT+RT	Assumption – Boiler temperature is controlled by an outdoor temperature sensor and by room thermostat for a part of the boiler temperature range (cf. Annex V 2008, 10).
10.5 Setting: Cgrad, Cpar, CL	Cgrad: 1,5 Cpar: 0 CL: 15	Cgrad: Manufacturer information[2] Cpar: Manufacturer information[2] CL: Assumption

[1] Technical specifications by manufacturer

[2] Verbal information by manufacturer (Information received via telephone conversations)

***Comments*:**

The pump of this boiler is not integrated in the boiler. Therefore, reference values of an average pump that are included in the spreadsheets are used in order to perform the calculations. Within the model it is assumed that the pump runtime after boiler off is 24 hours, that the pump has a specific power output and that no night-setback is possible. These default-values have a great influence on the results leading to a loss of several percent in the context of overall efficiency.

Nevertheless, it is possible to control an external pump with the existing control system of the boiler according to the manufacturer. However, the configuration of the function “pump hours after burner-off” (parameter 9.1) with the boiler control system is not possible. These issues have not been taken into account in the Ecoboiler model as a matter-of-fact since default values are used.

Example 2: Standard gas-fired boiler (RAL-UZ 40)

Version 1.3beta, 9 june 2008

ANNEX B: DATA REPORT

DATA REPORT CH-BOILERS & WATER HEATERS

1,1	Manufacturer		
1,2	Model		

		pref	nopref
2,1	**SPACE HEATING LOAD**	5 -L	
	BOILER(S)	*pref*	*nopref*
3,1	**Qb8060** nominal heat input in kW	17,5	0
3,2	Turndown ratio **turndown**	53,00%	0,00%
3,3	Two-stage burner **twostage** ?	0 -no	0 -no
3,4	Combi compensation **combicomp** ?	0 -no	
4,1	**η8060**	81,35%	80,00%
4,2	**η8060min**	80,72%	80,00%
4,3	**η5030**	86,40%	80,00%
4,4	**η5030min**	86,85%	80,00%
5,1	**p_bstby s**tandby heat loss **% of Qb8060**	0,80%	1,00%
5,2	**Pign p**ilotflame power in kW	0	0
6,1	**airfuelmix**	1 -atmospheric	
6,2	**Fueldewpoint dpt**	1 -gas	
7.1*	Combustion **airintake**	1 -room sealed	
7.2*	Designated in-/outdoors **boilpos**?	1 -indoors	
7.3*	Env. Volume **volumeb**	m3	0,13
7,4	Noise (**noiseh**)	dB-A	45
8,1	Boiler (empty) **massb**	kg	32
8,2	Water content **massw**	kg	10
9,1	Pump hrs after off **tpmp**	h	0,05
9,2	Pmp hr/d setback **pmpsb**	1 -yes	
9,3	El. pump Pboff **elpmp**	kW	0,11
9,4	El. at Pboff **elstby**	kW	0,005
9,5	El. at Pbnom **elmaxon**	kW	0,11
9,6	El. at Pbmin **elminon**	kW	0,05
9,7	Variable speed pump **varsp**	1 -yes	
9,8	Pump configuration **pmpconfig**	1 -integrated	
9,9	If no pump: pressure drop boiler **pdrop**	mbar	100

CONTROLLERS

10,1	Automatic timer **autotimer**?					1 -yes	
10,2	Optimiser? [option eliminated. no saving]					0 -no	
10,3	Valve control **Vcontrol**					2 -RTV 2K	
10,4	Temperature control **Tcontrol**					4 -weather c. BT+RT	
10,5	Setting **Cgrad**	1	**Cpar**	0		**CL**	10

	hp	Pcor			COPcor		
16.13T	oC	35	45	55	35	45	55
16.13a	-7	0,71	0,68	0,66	0,86	0,71	0,56
16.13b	2	0,87	0,85	0,83	1,10	0,89	0,67
16.13c	7	1,03	1,00	0,97	1,23	1,00	0,76
16.13d	20	1,34	1,29	1,25	1,70	1,28	0,86
16.13e							

OUTPUT: SPACE HEATING ENERGY

A.1	Space heat load	kWh/a	10.515
A.2	Space heat primary energy use	kWh/a	15.823
A.3	Space heat efficiency	66,5%	
A.4	Energy label Space Heat	C	

11,1	**WATER HEATING LOAD**	0 -none	
	WATER HEATER (gas/oil/elec)		
12,1	Fuel consumption (in GCV) **Qfuel**	kWh/d	0
12,2	Electricity consumption **Qelec**	kWhe/d	0
13,1	smart control factor **dhwsmart**	1 -yes	
13,2	noise (**noisew**)	dB-A	45
14,1	combustion efficiency **ηcomb**	%	100%
14,2	avg. flue gas temp. at tapping **Tflue**	oC	57
	elec yes or no?	0 -no	
	SOLAR ASSIST		
15,1	Collector aperture area **Asol**	m2	0,00
15,2	Zero-loss collector efficiency **η0**	-	0,85
15,3	First-order loss coefficient **a_1**	W/(m²K)	3,37
15,4	Second-order loss coefficient **a_2**	W/(m²K²)	0,01
15,5	Incidence angle modifier **IAM**	-	0,97
15,6	**Solar part of** tank volume **vsol**	ltr	300
15,7	UA-value of heatexchanger **UAsol**	W/K	1800
15,8	Collector loop pipe lenght, **Lpipesol**	m	6
15,9	Coll. loop loss per m pipe **Upipesol_m**	W/(m.K)	0,3
15,1	Tank heat loss coeff **UA**	W/K	1,7
15,11	Solar pump power **solaux**	W	80
15,12	Tank position **solpos**	1 -indoors	
15,13	Usage sol **usesol** (HW, CH or both)	3 -both HW & CH	
	BACK-UP HEATER		
17,1	**ELBU** el. back-up space heating?	0 -no	
	hot water back-up additional data		
18,1	Waterloadmin	4 -M	
18,2	**Qfuelmin**	kWh	10
18,3	**Qelecmin**	kWhel	0,5
18,4	Waterloadmax	5 -L	
18,5	**Qfuelmax**	kWh	20
18,6	**Qelecmax**	kWhel	1
	HEAT PUMP		
16,1	Nominal Power **Phpnom**	kW	0
16,2	**turndownhp**	%	100%
16,3	**HPtype** (Tsrc/Tsnk)	3 -El. air/ water	
16,4	Nominal COP **COPnom**		3,7
16,5	50%. load COP correct **COP50**	%	125%
16,6	Maximum sink temperature **Tsnkmax**	oC	50
16,7	Auxiliary el. consumption **hpaux**	W	151
16,8	Tank volume nominal **Vhp**	ltr	125
16,9	Tank ref. heat loss **Pstbyhpw**	W	60
16,1	Tank hot water capacity **V40hp**	frac. Vhp	1,9
16,11	Use (also) vent. exhaust air **ventmix** ?	0 -no	
16,12	Usage hp **usehp** (HW, CH or both)	3 -both HW & CH	
16,13	Testpoints (table left)		

OUTPUT: WATER HEATING ENERGY

B.1	Water heat net load	kWh/a	0
B.2	Water heat primary energy use.	kWh/a	0
B.3	Water heat energy eff.	0,0%	
B.4	Energy label Water Heating	none	

Example 2: Standard gas-fired boiler (RAL-UZ 40)

Required parameters	Input data	Reference / comment
1.1 Manufacturer		Manufacturer information[1]
1.2 Model		Manufacturer information[1]
1.3 Date	12.10.2008	Manufacturer information
1.4 ID		Manufacturer information[1]
2.1 Space heating load	L	Assumption - The CH-system will be declared “L” by the manufacturer within the framework of CE-marking.
3.1 Qb8060 nominal heat input in kW	17,5 kW	Manufacturer information[1]
3.2 Turndown ratio turndown	53 %	Manufacturer information[1] - Boiler modulates between 9.3 kW and 17.5 kW
3.3 Two-stage burner twostage ?	No	Manufacturer information[2] - Step-less modulating boiler.
3.4 Combi compensation combicomp ?	No	Assumption - Storage tank is not included in the space heating test.
4.1 η8060	81.35 %	Manufacturer information[1] / Assumption – According to manufacturer information the efficiency amounts to 90.3 - 95.9 % based on the lower heating value (LHV). Wuppertal Institute has taken the lower value of 90.3 % as basis and assumed that it has been measured at a system feed temperature of 80°C and a system return temperature of 60°C. Furthermore, the LHV has been converted to gross calorific value (GCV).
4.2 η8060min	80.72 %	Manufacturer information[1] / Assumption – According to manufacturer information the efficiency at 30 % part load amounts to 89.6 – 96.4 % based on the lower heating value (LHV). Since the efficiency at minimal power has not been available, Wuppertal Institute took the lower part load value of 96.4 % for the efficiency at minimal power as basis and assumed that it has been measured at a system feed temperature of 80°C and a system return temperature of 60°C. Furthermore, the LHV has been converted to gross calorific value (GCV).
4.3 η5030	86.40 %	Manufacturer information[1] / Assumption – According to manufacturer information the efficiency amounts to 90.3 - 95.9 % based on the lower heating value (LHV). Wuppertal Institute has taken the upper value of 95.9 % as basis and assumed that it has been measured at a system feed temperature of 50°C and a system return temperature of 30°C. Furthermore, the LHV has been converted to gross calorific value (GCV).
4.4 η5030min	86.85 %	Manufacturer information[1] / Assumption – According to manufacturer information the efficiency at 30 % part load amounts to 89.6 – 96.4 % based on the lower heating value (LHV). Since the efficiency at minimal power has not been available, Wuppertal Institute took the upper part load value of 96.4 % for the efficiency at minimal power as basis and assumed that it has been measured at a system feed temperature of 50°C and a system return temperature of

		30°C. Furthermore, the LHV has been converted to gross calorific value (GCV).
5.1 p_bstby standby heat loss % of Qb8060	0.8 %	Assumption – The standby heat loss at 50 °C as % of Qb8060 amounts to 0.8 %.
5.2 Pign pilotflame power in kW	0 kW	Manufacturer information[1] - Electronic ignition.
6.1 airfuelmix	atmospheric	Manufacturer information[1]
6.2 Fueldewpoint dpt	gas	Manufacturer information[1]
7.1 Combustion airintake	room sealed	Assumption
7.2 Designated in-/outdoors boilpos?	indoors	Manufacturer information[1]
7.3 Env. Volume volumeb	0,13 m^3	Manufacturer information[1]
7.4 Noise (noiseh)	45 db-A	Assumption - Manufacturer information has not been available.
8.1 Boiler (empty) massb	32 kg	Manufacturer information[1]
8.2 Water content massw	10 kg	Manufacturer information[1]
9.1 Pump hrs after off tpmp	0.05	Assumption – Manufacturer information has not been available.
9.2 Pmp hr/d setback pmpsb	Yes	Manufacturer information[1]
9.3 El. pump Pboff elpmp	110 W	Manufacturer information[1] – Three-stage pump with 45W, 75W, 110W
9.4 El. at Pboff elstby	5 W	Assumption - Manufacturer information has not been available.
9.5 El. at Pbnom elmaxon	110 W	Manufacturer information[1]
9.6 El. at Pbmin elminon	50 W	Assumption - Manufacturer information has not been available.
9.7 Variable speed pump varsp	Yes	Manufacturer information[1] – Three-stage pump with 45W, 75W, 110W
9.8 Pump configuration pmpconfig	integrated	Manufacturer information[1] – Grundfos UP 15-60 AO
10.1 Automatic timer autotimer?	Yes	Manufacturer information[1]
10.2 Optimiser? [option eliminated. no saving]	---	---
10.3 Valve control Vcontrol	TRV 2K	Assumption – Hydraulic controls are i.a. based on Thermostatic Radiator Valve (TRV) with p-band 2K meaning that TRV cannot be pre-adjusted to a range smaller than 2K (cf. Annex V 2008, 11).
10.4 Temperature control Tcontrol	weather c. BT+RT	Assumption – Boiler temperature is controlled by an outdoor temperature sensor and by room thermostat for a part of the boiler temperature range (cf. Annex V 2008, 10).
10.5 Setting: Cgrad, Cpar, CL	Cgrad: 1 Cpar: 0 CL: 10	Cgrad: Assumption Cpar: Assumption CL: Assumption

[1] Technical specifications by manufacturer

Example 3: Gas-fired condensing boiler (RAL-UZ 61)

Version 1.3beta, 9 june 2008

ANNEX B: DATA REPORT

DATA REPORT CH-BOILERS & WATER HEATERS

1,1	Manufacturer	
1,2	Model	

2,1	**SPACE HEATING LOAD**	5 -L	
	BOILER(S)	*pref*	*nopref*
3,1	**Qb8060** nominal heat input in kW	21,3	0
3,2	Turndown ratio **turndown**	22,07%	0,00%
3,3	Two-stage burner **twostage** ?	0 -no	0 -no
3,4	Combi compensation **combicomp** ?	0 -no	
4,1	**η8060**	87,39%	80,00%
4,2	**η8060min**	91,53%	80,00%
4,3	**η5030**	96,04%	80,00%
4,4	**η5030min**	96,67%	80,00%
5,1	**p_bstby** standby heat loss **% of Qb8060**	0,60%	1,00%
5,2	**Pign** pilotflame power in kW	0	0
6,1	**airfuelmix**	3 -ionisation	
6,2	**Fueldewpoint dpt**	1 -gas	
7.1*	Combustion **airintake**	1 -room sealed	
7.2*	Designated in-/outdoors **boilpos**?	1 -indoors	
7.3*	Env. Volume **volumeb**	m3	0,15
7,4	Noise (**noiseh**)	dB-A	49
8,1	Boiler (empty) **massb**	kg	53
8,2	Water content **massw**	kg	2,7
9,1	Pump hrs after off **tpmp**	h	0,03
9,2	Pmp hr/d setback **pmpsb**	1 -yes	
9,3	El. pump Pboff **elpmp**	kW	0,085
9,4	El. at Pboff **elstby**	kW	0,005
9,5	El. at Pbnom **elmaxon**	kW	0,125
9,6	El. at Pbmin **elminon**	kW	0,082
9,7	Variable speed pump **varsp**	1 -yes	
9,8	Pump configuration **pmpconfig**	1 -integrated	
9,9	If no pump: pressure drop boiler **pdrop**	mbar	50
	CONTROLLERS		
10,1	Automatic timer **autotimer**?	1 -yes	
10,2	Optimiser? [option eliminated, no saving]	0 -no	
10,3	Valve control **Vcontrol**	2 -RTV 2K	
10,4	Temperature control **Tcontrol**	4 -weather c. BT+RT	
10,5	Setting **Cgrad** 1,5 **Cpar** 0	**CL**	15

	hp	Pcor			COPcor		
16.13T	oC	35	45	55	35	45	55
16.13a	-7	0,71	0,68	0,66	0,86	0,71	0,56
16.13b	2	0,87	0,85	0,83	1,10	0,89	0,67
16.13c	7	1,03	1,00	0,97	1,23	1,00	0,76
16.13d	20	1,34	1,29	1,25	1,70	1,28	0,86
16.13e							

11,1	**WATER HEATING LOAD**	5 -L	
	WATER HEATER (gas/oil/elec)		
12,1	Fuel consumption (in GCV) **Qfuel**	kWh/d	25
12,2	Electricity consumption **Qelec**	kWhe/d	0,1
13,1	smart control factor **dhwsmart**	1 -yes	
13,2	noise (**noisew**)	dB-A	49
14,1	combustion efficiency **ηcomb**	%	100%
14,2	avg. flue gas temp. at tapping **Tflue**	oC	57
	elec yes or no?	0 -no	
	SOLAR ASSIST		
15,1	Collector aperture area **Asol**	m2	0,00
15,2	Zero-loss collector efficiency **η0**	-	0,85
15,3	First-order loss coefficient **a_1**	W/(m²K)	3,37
15,4	Second-order loss coefficient **a_2**	W/(m²K²)	0,01
15,5	Incidence angle modifier **IAM**	-	0,97
15,6	**Solar part of** tank volume **vsol**	ltr	300
15,7	UA-value of heatexchanger **UAsol**	W/K	1800
15,8	Collector loop pipe lenght, **Lpipesol**	m	6
15,9	Coll. loop loss per m pipe **Upipesol_m**	W/(m.K)	0,3
15,1	Tank heat loss coeff **UA**	W/K	1,7
15,11	Solar pump power **solaux**	W	80
15,12	Tank position **solpos**	1 -indoors	
15,13	Usage sol **usesol** (HW, CH or both)	3 -both HW & CH	
	BACK-UP HEATER		
17,1	**ELBU** el. back-up space heating?	0 -no	
	hot water back-up additional data		
18,1	Waterloadmin	4 -M	
18,2	**Qfuelmin**	kWh	10
18,3	**Qelecmin**	kWhel	0,5
18,4	Waterloadmax	5 -L	
18,5	**Qfuelmax**	kWh	20
18,6	**Qelecmax**	kWhel	1
	HEAT PUMP		
16,1	Nominal Power **Phpnom**	kW	0
16,2	**turndownhp**	%	100%
16,3	**HPtype** (Tsrc/Tsnk)	3 -El. air/ water	
16,4	Nominal COP **COPnom**		3,7
16,5	50% load COP correct **COP50**	%	125%
16,6	Maximum sink temperature **Tsnkmax**	oC	50
16,7	Auxiliary el. consumption **hpaux**	W	151
16,8	Tank volume nominal **Vhp**	ltr	125
16,9	Tank ref. heat loss **Pstbyhpw**	W	60
16,1	Tank hot water capacity **V40hp**	frac. Vhp	1,9
16,11	Use (also) vent. exhaust air **ventmix** ?	0 -no	
16,12	Usage hp **usehp** (HW, CH or both)	3 -both HW & CH	
16,13	Testpoints (table left)		

OUTPUT: SPACE HEATING ENERGY

A.1	Space heat load	kWh/a	10.515
A.2	Space heat primary energy use	kWh/a	14.498
A.3	Space heat efficiency	72,5%	
A.4	Energy label Space Heat	B	

OUTPUT: WATER HEATING ENERGY

B.1	Water heat net load	kWh/a	2.559
B.2	Water heat primary energy use	kWh/a	4.884
B.3	Water heat energy eff.	52,4%	
B.4	Energy label Water Heating	B	

Example 3: Gas-fired condensing boiler (RAL-UZ 61)

Required parameters	Input data	Reference / comment
1.1 Manufacturer		Manufacturer information[1]
1.2 Model		Manufacturer information[1]
1.3 Date	08.10.2008	Manufacturer information
1.4 ID		Manufacturer information[1]
2.1 Space heating load	L	Assumption - The CH-system will be declared "L" by the manufacturer within the framework of CE-marking.
3.1 Qb8060 nominal heat input in kW	21.3 kW	Manufacturer information[2] – Nominal heat input at 80/60 amounts to 21.3 kW.
3.2 Turndown ratio turndown	22.07 %	Manufacturer information[2] - Nominal heat input varies between 4.7 kW and 21.3 kW.
3.3 Two-stage burner twostage ?	No	Manufacturer information[2]
3.4 Combi compensation combicomp ?	No	Assumption - Storage tank is not included in the space heating test.
4.1 η8060	87,39 %	Manufacturer information[2] - The manufacturer information of 97 % based on the lower heating value (LHV) has been converted to gross calorific value (GCV).
4.2 η8060min	91,53 %	Manufacturer information[2] / assumption - The manufacturer information of 101.6 % at 30 % part load has been taken as basis and this lower heating value (LHV) has been converted to gross calorific value (GCV).
4.3 η5030	96,04 %	Manufacturer information[2] / assumption - According to manufacturer information the efficiency at 50/30 amounts to 106.6 - 103.3 % based on the lower heating value (LHV). Wuppertal Institute has taken the lower value of 103.3 % as basis and has converted the value to gross calorific value (GCV).
4.4 η5030min	96,67 %	Manufacturer information[2] / assumption - According to manufacturer information the efficiency at 50/30 amounts to 106.6 - 103.3 % based on the lower heating value (LHV). Wuppertal Institute has taken the upper value of 106.6 % as basis and has converted the value to gross calorific value (GCV).
5.1 p_bstby standby heat loss % of Qb8060	0.60 %	Manufacturer information[2]
5.2 Pign pilotflame power in kW	0 kW	Manufacturer information[2] - Electronic ignition.
6.1 airfuelmix	ionisation	Manufacturer information[2]
6.2 Fueldewpoint dpt	gas	Manufacturer information[1]
7.1 Combustion airintake	room sealed	Manufacturer information[1]
7.2 Designated in-/outdoors boilpos?	indoors	Manufacturer information[1]
7.3 Env. Volume volumeb	0.15 m^3	Manufacturer information[1]
7.4 Noise (noiseh)	49 db-A	Manufacturer information[2]
8.1 Boiler (empty) massb	53 kg	Manufacturer information[1]
8.2 Water content massw	2.7 kg	Manufacturer information[2]
9.1 Pump hrs after off tpmp	0.03 h	Manufacturer information[2] – 2 Minutes according to manufacturer.

9.2 Pmp hr/d setback pmpsb	Yes	Manufacturer information[2]
9.3 El. pump Pboff elpmp	85 W	Manufacturer information[2] – Pump power is 42 to 85 W.
9.4 El. at Pboff elstby	5 W	Assumption - Manufacturer information has not been available.
9.5 El. at Pbnom elmaxon	125 W	Manufacturer information[2]
9.6 El. at Pbmin elminon	82 W	Manufacturer information[2] / assumption
9.7 Variable speed pump varsp	Yes	Manufacturer information[2]
9.8 Pump configuration pmpconfig	integrated	Manufacturer information[2]
10.1 Automatic timer autotimer?	Yes	Manufacturer information[1]
10.2 Optimiser? [option eliminated. no saving]	---	---
10.3 Valve control Vcontrol	TRV 2K	Assumption – Hydraulic controls are i.a. based on Thermostatic Radiator Valve (TRV) with p-band 2K meaning that TRV cannot be pre-adjusted to a range smaller than 2K (cf. Annex V 2008, 11).
10.4 Temperature control Tcontrol	weather c. BT+RT	Assumption – Boiler temperature is controlled by an outdoor temperature sensor and by room thermostat for a part of the boiler temperature range (cf. Annex V 2008, 10).
10.5 Setting: Cgrad, Cpar, CL	Cgrad: 1,5 Cpar: 0 CL: 15	Cgrad: Manufacturer information[2] Cpar: Manufacturer information[2] CL: Assumption
11.1 Water heating load	L	Assumption - The integrated water heater of will be declared “L” by the manufacturer within the framework of CE-marking.
12.1 Fuel consumption (in GCV) Qfuel		Data has not been available.
12.2 Electricity consumption Qelec		Data has not been available
13.1 smart control factor dhwsmart	Yes	Assumption – The water heater meets the de-mands (cf. Annex V 2008, 74)
13.2 noise (noisew)	49 db-A	Manufacturer information[1]
14.1 combustion efficiency ηcomb	100 %	Assumption – Measurement is described on page 72 in Annex V 2008.
14.2 avg. flue gas temp. at tapping Tflue	57 °C	Manufacturer information[2]

[1] Technical specifications by manufacturer, [2] Verbal information by manufacturer (Information received via telephone conversations)

Comment

The boiler has an integrated heat exchanger for hot water heating. A switching valve is integrated in the system feed flow line which redirects the water to the heat exchanger if required.

Example 4: Electric brine/water heat pump

Version 1.3beta, 9 june 2008

ANNEX B: DATA REPORT

DATA REPORT CH-BOILERS & WATER HEATERS

1,1	Manufacturer		1.3 Date	
1,2	Model		1.4 ID	

2,1	**SPACE HEATING LOAD**	4 -M	
	BOILER(S)	*pref*	*nopref*
3,1	**Qb8060** nominal heat input in kW	0	0
3,2	Turndown ratio **turndown**	15,00%	0,00%
3,3	Two-stage burner **twostage** ?	0 -no	0 -no
3,4	Combi compensation **combicomp** ?	0 -no	
4,1	**η8060**	89,00%	80,00%
4,2	**η8060min**	89,00%	80,00%
4,3	**η5030**	97,00%	80,00%
4,4	**η5030min**	97,00%	80,00%
5,1	**p_bstby** standby heat loss **% of Qb8060**	0,80%	1,00%
5,2	**Pign** pilotflame power in kW	0	0
6,1	**airfuelmix**	4 -next gen. O2	
6,2	**Fueldewpoint dpt**	1 -gas	
7.1*	Combustion **airintake**	3 -none (electric)	
7.2*	Designated in-/outdoors **boilpos**?	1 -indoors	
7.3*	Env. Volume **volumeb**	m3	0,7
7,4	Noise (**noiseh**)	dB-A	47
8,1	Boiler (empty) **massb**	kg	217
8,2	Water content **massw**	kg	10
9,1	Pump hrs after off **tpmp**	h	24
9,2	Pmp hr/d setback **pmpsb**	0 -no	
9,3	El. pump Pboff **elpmp**	kW	0,093
9,4	El. at Pboff **elstby**	kW	0,008
9,5	El. at Pbnom **elmaxon**	kW	0,07
9,6	El. at Pbmin **elminon**	kW	0,05
9,7	Variable speed pump **varsp**	0 -no	
9,8	Pump configuration **pmpconfig**	1 -integrated	
9,9	If no pump: pressure drop boiler **pdrop**	mbar	100
	CONTROLLERS		
10,1	Automatic timer **autotimer**?	0 -no	
10,2	Optimiser? [option eliminated. no saving]	0 -no	
10,3	Valve control **Vcontrol**	2 -RTV 2K	
10,4	Temperature control **Tcontrol**	4 -weather c. BT+RT	
10,5	Setting **Cgrad** 0,3 **Cpar** 0	**CL**	15

	hp	Pcor			COPcor		
16.13T	oC	35	45		35	45	
16.13a	-5	0,92	0,86		1,15	0,88	
16.13b	0	1,07	1,00		1,32	1,00	
16.13c	5	1,22	1,14		1,49	1,12	
16.13d							
16.13e							

11,1	**WATER HEATING LOAD**	4 -M	
	WATER HEATER (gas/oil/elec)		
12,1	Fuel consumption (in GCV) **Qfuel**	kWh/d	0
12,2	Electricity consumption **Qelec**	kWhe/d	0
13,1	smart control factor **dhwsmart**	0 -no	
13,2	noise (**noisew**)	dB-A	43
14,1	combustion efficiency **ηcomb**	%	90%
14,2	avg. flue gas temp. at tapping **Tflue**	oC	120
	elec yes or no?	0 -no	
	SOLAR ASSIST		
15,1	Collector aperture area **Asol**	m2	0,00
15,2	Zero-loss collector efficiency **η0**	-	0,85
15,3	First-order loss coefficient **a_1**	W/(m²K)	3,37
15,4	Second-order loss coefficient **a_2**	W/(m²K²)	0,01
15,5	Incidence angle modifier **IAM**	-	0,97
15,6	**Solar part of** tank volume **vsol**	ltr	300
15,7	UA-value of heatexchanger **UAsol**	W/K	1800
15,8	Collector loop pipe lenght. **Lpipesol**	m	6
15,9	Coll. loop loss per m pipe **Upipesol_m**	W/(m.K)	0,3
15,1	Tank heat loss coeff **UA**	W/K	1,7
15,11	Solar pump power **solaux**	W	80
15,12	Tank position **solpos**	1 -indoors	
15,13	Usage sol **usesol** (HW, CH or both)	3 -both HW & CH	
	BACK-UP HEATER		
17,1	**ELBU** el. back-up space heating?	1 -yes	
	hot water back-up additional data		
18,1	Waterloadmin	4 -M	
18,2	**Qfuelmin**	kWh	0
18,3	**Qelecmin**	kWhel	2
18,4	Waterloadmax	5 -L	
18,5	**Qfuelmax**	kWh	0
18,6	**Qelecmax**	kWhel	6
	HEAT PUMP		
16,1	Nominal Power **Phpnom**	kW	9,9
16,2	**turndownhp**	%	100%
16,3	**HPtype** (Tsrc/Tsnk)	1 -El. brine/ water	
16,4	Nominal COP **COPnom**		3,6
16,5	50%. load COP correct **COP50**	%	89%
16,6	Maximum sink temperature **Tsnkmax**	oC	62
16,7	Auxiliary el. consumption **hpaux**	W	151
16,8	Tank volume nominal **Vhp**	ltr	175
16,9	Tank ref. heat loss **Pstbyhpw**	W	43
16,1	Tank hot water capacity **V40hp**	frac. Vhp	1,9
16,11	Use (also) vent. exhaust air **ventmix** ?	0 -no	
16,12	Usage hp **usehp** (HW, CH or both)	3 -both HW & CH	
16,13	Testpoints (table left)		

	OUTPUT: SPACE HEATING ENERGY		
A.1	Space heat load	kWh/a	7.480
A.2	Space heat primary energy use	kWh/a	6.942
A.3	Space heat efficiency	107,7%	
A.4	Energy label Space Heat	A++	

	OUTPUT: WATER HEATING ENERGY		
B.1	Water heat net load	kWh/a	1.284
B.2	Water heat primary energy use.	kWh/a	2.722
B.3	Water heat energy eff.	47,1%	
B.4	Energy label Water Heating	B	

Electric brine/water heat pump

Required parameters	Input data	Reference / comment
1.1 Manufacturer		Manufacturer information[1]
1.2 Model		Manufacturer information[1]
1.3 Date	19.10.2008	
1.4 ID		Manufacturer information[1]
2.1 Space heating load	M	Assumption - The CH-systems will be declared "M" by the manufacturer within the framework of CE-marking.
7.1 Combustion airintake	None (electric)	Manufacturer information[1]
7.2 Designated in-/outdoors boilpos?	Indoors	Manufacturer information[1]
8.1 Boiler (empty) massb	217 kg	Manufacturer information[1]
8.2 Water content massw	10 kg	Assumption
9.1 Pump hrs after off tpmp	24 h	Manufacturer information[2]
9.2 Pmp hr/d setback pmpsb	No	Manufacturer information[2]
9.3 El. pump Pboff elpmp	93 W	Manufacturer information[1]
9.4 El. at Pboff elstby	8 W	Assumption
9.7 Variable speed pump varsp	No	Manufacturer information[2]
9.8 Pump configuration pmpconfig	Integrated	Manufacturer information[1]
10.1 Automatic timer autotimer?	No	Manufacturer information[1]
10.2 Optimiser? [option eliminated. no saving]	---	---
10.3 Valve control Vcontrol	TRV 2K	Assumption – Hydraulic controls are i.a. based on Thermostatic Radiator Valve (TRV) with p-band 2K meaning that TRV cannot be pre-adjusted to a range smaller than 2K (cf. Annex V 2008, 11).
10.4 Temperature control Tcontrol	Weather c. BT + RT	Assumption – Heat pump temperature is con-trolled by an outdoor temperature sensor and by room thermostat for a part of its temperature range (cf. Annex V 2008, 10).
10.5 Setting: Cgrad, Cpar, CL	Cgrad: 0.3 Cpar: 0 CL: 15	Cgrad: Manufacturer information[1] Cpar: Manufacturer information[1] CL: Assumption
11.1 Water heating load	M	Assumption - The integrated water heater of will be declared "M" by the manufacturer within the framework of CE-marking.
12.1 Fuel consumption (in GCV) Qfuel		Data has not been available.
12.2 Electricity consumption Qelec		Data has not been available.
16.1 Nominal Power Phpnom	9.9 kW	Manufacturer information[2]
16.2 turndownhp	100 %	Manufacturer information[1] – Heat pump operates only at fixed stage.
16.3 HPtype (Tsrc/Tsnk)	El. Brine/water	Manufacturer information[1]
16.4 Nominal COP COPnom	3.6	Manufacturer information[2]
16.5 50%. load COP correct COP50	89 %	Manufacturer information[2] / assumption
16.6 Maximum sink temperature Tsnkmax	62 °C	Manufacturer information[2]
16.7 Auxiliary el. consumption hpaux	151 W	Manufacturer information[2]

16.8 Tank volume nominal Vhp	175 ltr	Manufacturer information[1]
16.9 Tank ref. heat loss Pstbyhpw	43 W	Manufacturer information[3]
16.10 Tank hot water capacity V40hp	1.9	Assumption
16.11 Use (also) vent. exhaust air ventmix ?	No	Fixed parameter (cf. Annex V 2008, 28)
16.12 Usage hp usehp (HW, CH or both)	Both HW & CH	Manufacturer information[1]
16.13 Testpoints	default test points	Heat pump default testpoints of COP and Pnom forvarious Tsrc/Tsnk from prEN 15316-4-2.
17.1 ELBU el. back-up space heating?	Yes	Manufacturer information[1]
18.1 Waterloadmin	M	
18.2 Qfuelmin		Data has not been available.
18.3 Qelecmin		Data has not been available.
18.4 Waterloadmax	M	
18.5 Qfuelmax		Data has not been available.
18.6 Qelecmax		Data has not been available.

[1] Technical specifications by manufacturer, [2] Verbal information by manufacturer (Information received via telephone conversations)

[3] Stiftung Warentest 2007: test Spezial Energie, Sonderheft. 58-63