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**BOILEFF**  
**Raising the efficiency of boiler installations**

**Work Package 5 – Field Testing**  
**D 5.1 - Summary report**

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## General

Insufficient installation of heating systems often leads to low efficiency of new boilers. Although test cases demonstrate that new boilers may achieve high efficiency, their real performance is often much lower.

BOILeff project was initiated to develop and to assess two new market approaches for improving the efficiency of boiler installations.

The first market approach is a high quality declaration (DHQUI). This declaration is included in the contract between installers and end consumers. It provides a checklist of quality criteria for a “high quality installation”. The second approach is a “performance guarantee (GPQU)”. The installer should be able to guarantee a certain efficiency of the boiler as a result of a “high quality installation”.

These two approaches are tested and evaluated by field tests under real conditions in work package 5. For the field tests, typical residential buildings with a heat load up to 20 to 25 kW have been taken into account. About 50 installations in Austria, Germany, Hungary, Spain and Greece were foreseen to participate in the field tests in the heating season 2008/2009. The deliverables of work package 5 are as follows:

- D5.1 – Summary report of field testing
- D5.2 – List of boiler owners and installers, that take part in the program
- D5.3 – List of boilers and consumed energy before the replacement
- D5.4 – Documentation of field test results

This deliverable summarizes the results of the field tests carried out in Austria, Germany, Hungary, Spain and Greece. For more detailed reference, each country has filled in spreadsheets (standard formats) for each test case, composing Deliverable 5.4. Furthermore the project partners developed national versions of their national field tests in order to analyse in depth the field tests in their countries case by case.

The comprehensive analysis of the field tests is carried-out in Deliverable 6.1 “Technical evaluation report”. The evaluation of the market success factors is performed in Deliverable 6.2 (Evaluation report on success factors for a broad market introduction of DHQUI and GPQU); updated “revised” versions of DHQUI and GPQU based on the experiences achieved in work package 5 are foreseen to be finalised within Deliverable 6.3. Lessons learnt related to the boiler and heating system will be communicated directly to the boiler industry (by Deliverable 6.4: Advise to the boiler industry).

## Field test results achieved in Austria

In total 78 costumers (boiler owners) and 36 innovative installers were interested in a participation in the “BOILeff” project in Austria. Finally 13 boiler owners and 12 installers participated in the field test (testing both DHQUI and GPQU).

Unfortunately in one single family house in Vienna the refurbishment of the heating system and the installation of the metering equipment could not be finished until March 2009. For this reason only 12 test cases were evaluated.

The typical business case of BOILeff installations includes the modernisation of old heating systems. Most of the boilers, which were replaced, were atmospheric gas boilers (see Fig.1) while condensing gas boilers were mostly used after the modernisation (see Fig.2).

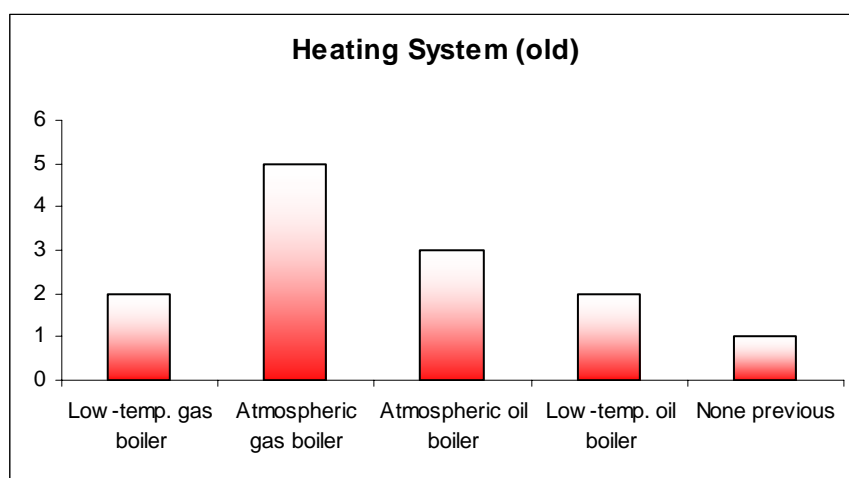


Figure 1: Type of boilers replaced

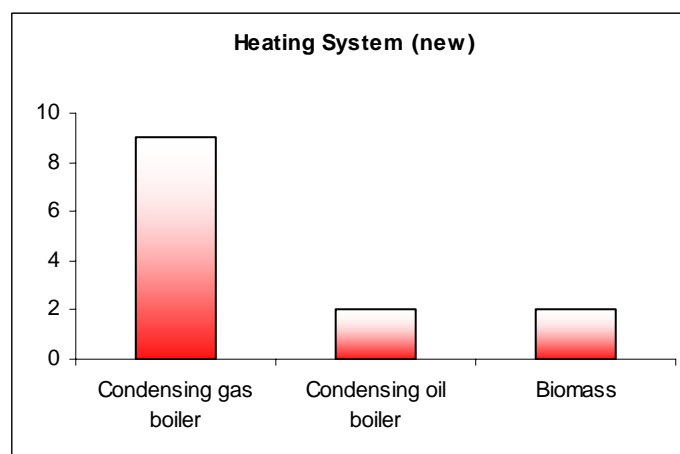


Figure 2: Type of boilers after replacement

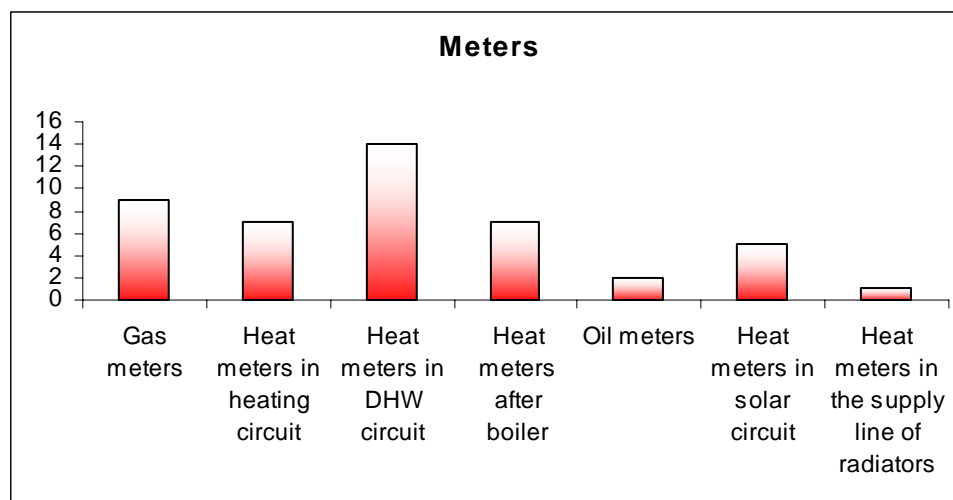
The evaluations of 12 Austrian test cases show a performance of gas condensing systems between 82.4% and 94.8% (HHV). The performance of the oil condensing systems varies between 84.2% and 85.9% (HHV). The pellets boiler shows an average performance of 90.6% (LHV) and the firewood fuelled boiler shows an average performance of 74.2% (LHV) (See Table 1).

## Calculation and Metering Method used

For the field test of the “Guaranteed Performance Quality” (GPQU), the installer guarantees high efficiency of the new high-quality heating system. For the calculation of the efficiency and the energy savings compared to the old heating system, two methods were developed:

- The first one is called “Finger Print Method” and is based on a theoretical model taking into account data of the building resp. flat and its inhabitants (heat load, indoor temperature, hot water demand etc.), of the heating system (including the boiler itself as well as pipes, armatures etc.), and of the site specific climate parameters. A more detailed description of the Finger Print Method is given in Deliverable 4.2 of the BOILeff project (<http://www.energyagency.at/BOILeff>).
- The second one is a more simple approach. In principle, it is an empirical formula that emerges from metering results. With this method the resulting efficiency only depends on few parameters: type of fuel, location of the boiler inside or outside the heated area and whether there is a bypass valve or not (see also Deliverable 4.2).

The field tests were carried out in the heating season 2008/2009. Every heating system was equipped with additional test equipment (following Deliverable 4.1)<sup>1</sup> as follows: heat meter placed in the heating circuit, heat meter placed in the domestic hot water circuit, and additional heat meters if necessary (e.g. for solar thermal systems or in case of an additional heating circuit), oil meter (gas metering is provided by the standard gas meters of the gas utility companies.) - (See Figure 3).



**Figure 3:** Meters used in the Austrian field tests

The metering results of BOILeff installations show excellent performance compared to efficiencies of standard systems. The BOILeff systems achieve efficiency improvements – compared to standard systems (stock) – for gas systems of 13%, for oil systems of 10%, for the pellets system of 17%, and for the firewood system of 7%<sup>2</sup>.

<sup>1</sup> Deliverable 4.1: Summary report on the measurements of boiler efficiency”; see [www.energyagency.at/boileff](http://www.energyagency.at/boileff)

<sup>2</sup> Seasonal efficiencies of standard installations in Austria are: gas - 76% (HHV), oil - 75% (HHV), pellets - 74% (LHV), firewood - 67% (LHV) [Source: Zach F., Analysis of energy savings of heating systems in the Austrian building sector, diploma thesis, Vienna, June 2008].

Further details concerning metering concepts and details of each field test is available in the Austrian national field test reports ([1], [2]).

## Results

When comparing the achieved efficiencies (see Table 1 and Figure 4) with the guaranteed efficiencies based on the GPQU the following conclusions can be drawn:

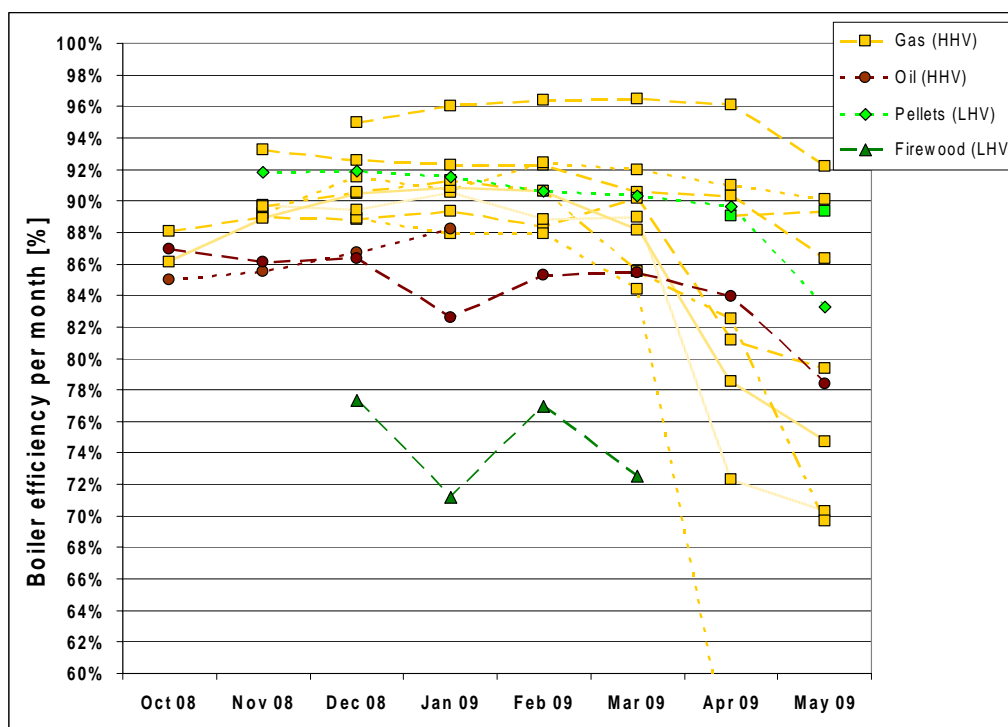
- Four systems (three from eight gas systems; one biomass system) show higher efficiencies than calculated; one gas system does not show a deviation at all.
- Four gas systems and one biomass system show a negative deviation (compared to the calculated value) not larger than 3%.
- The two oil systems have a negative deviation from the calculated values of 1.5% and 6.7%, respectively.

**Table 1:** Seasonal efficiencies of the Austrian field test<sup>3</sup> (Source: Austrian Energy Agency)

Nr.	Type of building	Fuel	Location	Heat load of the building/flat [kW]	Type of installed boiler	Guaranteed efficiency by "Finger Print Method" [%]	Measured efficiency [%]
1	flat	gas	Vienna	13.1	Wall mounted condensing boiler	88.1	86.7
2	flat	gas	Vienna	4.9	Wall mounted condensing boiler	87.8	87.8
3	single family house	gas	Vienna	11.4	Wall mounted condensing boiler	92.2	N.A.
4	single family house	gas	Maria Enzersdorf (Lower Austria)	4.7	Floor mounted condensing boiler	85.4	82.4
5	small multi family house	gas and solar	Neupurkersdorf (Lower Austria)	22.0	Floor mounted condensing boiler	93.4	94.8
6	single family house	gas	Herzogenburg (Lower Austria)	5.8	Wall mounted condensing boiler	85.3	87.5
7	single family house	gas and solar	Herzogenburg (Lower Austria)	11.2	Wall mounted condensing boiler	89.7	91.3
8	single family house	biomass and solar	Klosterneuburg (Lower Austria)	4.2	Floor mounted wood gas boiler	75.2	74.2
9	single family house	gas and solar	Linz (Upper Austria)	7.5	Wall mounted condensing boiler	89.6	88.8
10	single family house	oil	Pucking (Upper Austria)	9.8	Floor mounted condensing boiler	90.9	84.2
11	single family house	gas	Pucking (Upper Austria)	12.0	Floor mounted condensing boiler	92.3	89.8
12	single family house	oil	Schwanenstadt (Upper Austria)	8.3	Floor mounted condensing boiler	87.4	85.9
13	single family house	biomass and solar	Seekirchen am Wallersee (Salzburg)	11.0	Floor mounted pellets boiler	89.0	90.6

Taking into account technical reasons (the return temperature of the heating circuit was sometimes too high to enable the condensation) why one of 12 systems shows a deviation of 6.7%, it can be concluded that guarantees with a security band of three percentage points can be issued by installers when the installations are based on the DHQUI in Austria.

<sup>3</sup> The calculated and measured efficiencies of gas and oil fuelled systems are based on the higher heating value (HHV), those of biomass fuelled boilers are based on the lower heating value (LHV) because the condensing technology has not been deployed successfully in biomass boiler systems up to now.



**Figure 4:** Monthly efficiencies of 12 Austrian BOILeff installations including eight gas condensing systems (dashed orange lines)<sup>4</sup>, two oil condensing systems (dashed brown lines), one pellets system (dashed light green line) and one firewood system (dashed dark green line) (Source: Austrian Energy Agency)

Further results referring to the metered monthly efficiencies of the systems are:

- The efficiencies of systems with integrated solar systems (test cases 5, 7, 13) decline only by 2.6 to 7.4 % in the summer months (compared to monovalent gas heating system quite small deviations).
- In case of the firewood boiler (test case 8) no decline of the efficiency occurs because since beginning of April 09 no heating supply (low energy house standard) was necessary and the domestic hot water demand is completely supplied by the solar system.
- The efficiency of one floor mounted gas condensing system with an internal hot water storage tank (test case 4) dropped deeply in April and May (lower than 60%) because the heating was switched off and the domestic hot water demand was extremely low.

<sup>4</sup> The efficiency of one gas condensing system dropped deeply in April and May (lower than 60%) because there was no more heating in this building and the domestic hot water demand was extremely low, too.

## Conclusions

The BOILeff installations lead to energy savings between 829 and 20,414 kWh/a. The high energy savings in test cases 5 and 8 were also achieved by the insulation of the building during the replacement of the heating system. Furthermore the changing of the energy carrier from gas resp. oil to biomass in test cases 8 and 13 lead to the high CO<sub>2</sub>eq savings. On average, the implemented highly efficient BOILeff installations lead to energy savings of 7,984 kWh/a and CO<sub>2</sub>eq savings of 3,035 kg/a per test case.

In total, the 12 Austrian test cases lead to energy savings of 95,808 kWh/a and a reduction of green house gases of 36.4 t/a.

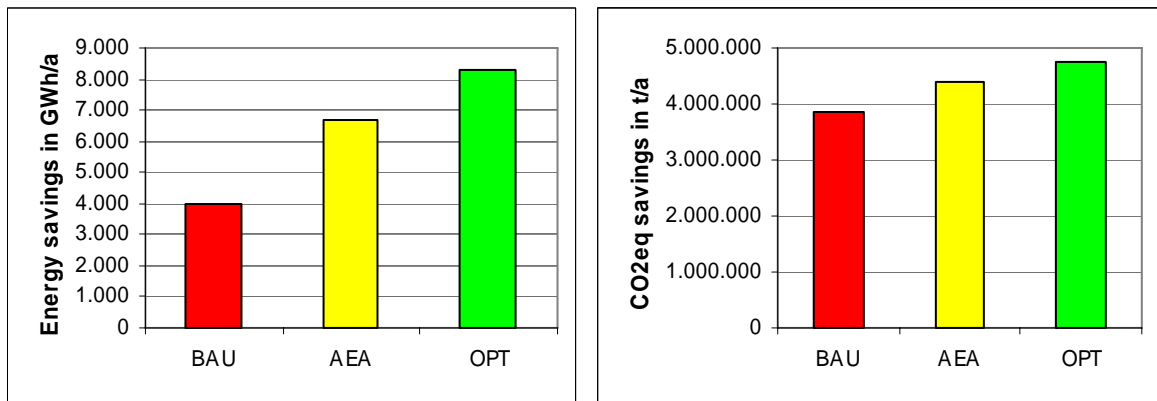
Nr.	Heat degree days of the climate region [20/12]		Total useful floor-space of heated area [m <sup>2</sup> ]	Emitters	Climate corrected energy consumption [kWh/a]		Energy savings [kWh/a]	CO <sub>2</sub> eq savings [kg/a]
	Average	2008/09			Old system	New system		
1	3,048	2,895	134	Radiators and floor heating	40,294	29,494	10,800	2,733
2	3,048	2,895	75	Radiators	13,259	7,433	5,826	1,474
3	3,048	2,895	298	Floor heating	44,684	N.A.	N.A.	N.A.
4	3,355	3,181	127	Radiators	13,824	11,487	2,337	591
5	3,355	3,181	407	Radiators and floor heating	57,000	37,043	19,957	8,868
6	3,355	3,181	99	Radiators	15,773	14,944	829	210
7	3,355	3,181	149	Radiators and floor heating	26,319	18,854	7,465	1,889
8	3,048	2,895	125	Floor heating	25,502	5,088	20,414	6,371
9	3,267	3,312	171	Radiators and floor heating	18,418	16,058	2,360	597
10	3,267	3,312	195	Radiators and floor heating	28,392	22,425	5,967	1,909
11	3,267	3,312	195	Radiators and floor heating	39,204	26,467	12,737	5,849
12	3,267	3,312	129	Radiators	33,480	27,348	6,132	1,962
13	3,371	3,316	181	Radiators	13,013	12,028	985	3,972

**Table 2:** Achieved climate-corrected<sup>5</sup> energy and CO<sub>2</sub>eq savings by the highly efficient BOILeff installations (Source: Austrian Energy Agency)

Presently, the total energy demand for heating and domestic hot water amounts to 62,545 GWh/a in Austria. Taking into account that new heating systems follow BOILeff quality criteria (DHQUI) energy savings between 2,700 and 4,300 GWh/a can be achieved compared to a business as usual (BAU) scenario; representing a saving potential between 4.3 and 6.9% (see Figure 5).

The possible savings in greenhouse gases are between 3.85 and 4.74 mio t. Compared to the BAU scenario 0.6 mio t (AEA scenario) and 0.9 mio t (OPT scenario) can be realised (see Figure 5). Space heating contributes significantly – with about 14.2 mio t CO<sub>2</sub>eq or 15.6% – to the total green house gas emissions of about 91.1 mio t. For this reason policy measures aiming to improve heating systems are strongly recommended and these measures will pay-off in significant reductions of greenhouse gases.

<sup>5</sup> The metered energy consumption has been taken into correlation to the specific heat degree days in the metering season and recalculated in relation to average heat degree days of the climate region.



**Figure 5:** Energy savings (left side) and reduction of CO<sub>2</sub>eq per year in Austria based on three scenarios:

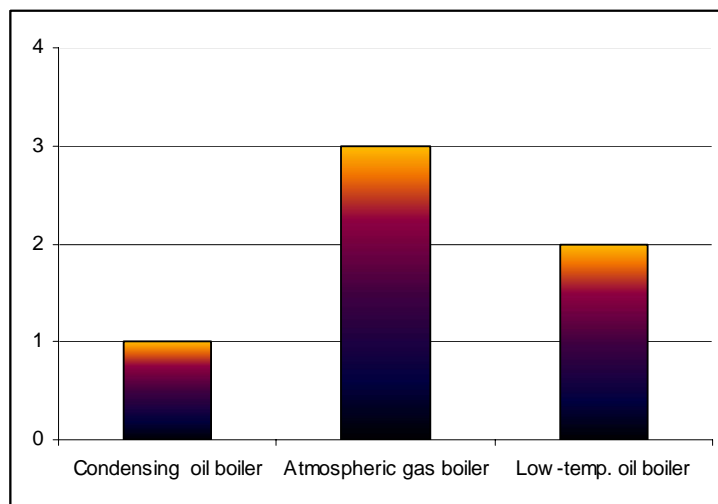
- BAU – business as usual: The present stock will be replaced by new standard heating systems
- OPT(imum) scenario: The present stock will be replaced by new highly efficient BOILeff installations
- AEA scenario: The present stock will only be replaced partly by highly efficient BOILeff systems taking into account appropriate building categories, principal agent problems, fuel switch etc., the other part will be replaced by new standard heating systems

Beside of the implementation of DHQUI and GPQU by Austrian installers, some provinces of Austria consider to use the declaration of high quality installation (DHQUI) as additional subsidy criteria when launching boiler exchange programs.

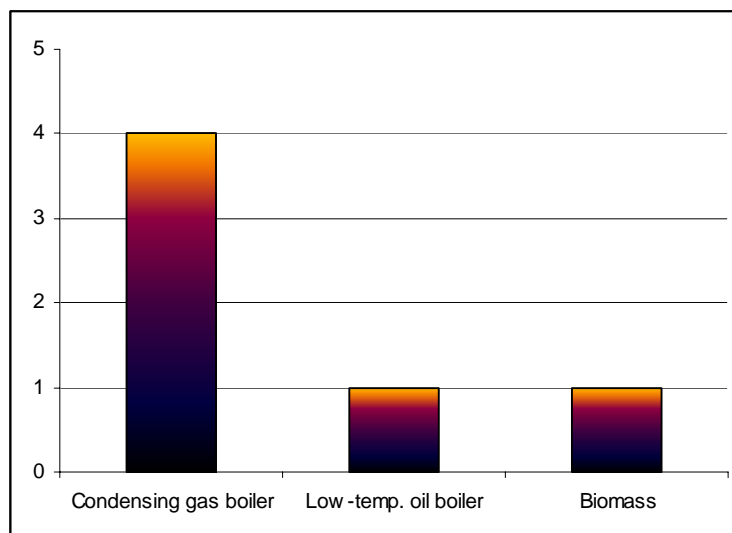
## Field test results achieved in Germany

In Germany, 18 boiler owners and 40 installers were interested in participating in the “BOILeff” project. Finally six boiler owners and three installers participated in the field tests.

For the field test, typical residential buildings with a heat load up to 30 kW were taken into account. The German field test includes six installations, and was carried out in the heating season 2008/2009. Originally, two further field tests had been planned. In one case, the boiler installation and the installation of the necessary oil meter were delayed. In another case (with pellet boiler), the measurements could not be carried out – despite of available measuring components, due to time constraints of the installers.



**Figure 6:** Type of boilers replaced



**Figure 7:** Type of boilers after replacement

### ***Calculation and Metering Method used***

For the calculation of the efficiency and the energy savings compared to the old heating system, an overall accounting method was implemented. This method takes into account measured input and output data of all components of the heating system, data of the building

rsp. flat, the heat load of the building and site specific climate parameters. For the field test, every heating system was equipped with additional test equipment as follows:

sector	Installed measuring equipment
energy-input	gas meter <sup>6</sup> , wood: firewood, wood pellets (journal)
energy-output	Heat meter placed in the heating circuit, heat meter placed in the domestic hot water circuit (... alternatively a water meter). Additional heat meters if necessary (e.g. for solar thermal systems or in case of an additional heating circuit).

The measuring period started in October 2008 and was finished in June 2009. Due to the higher amount of time and effort needed in the selection and preparation phase for the test projects, individual measurements could not start before December 2008. In the case of test case No.2 (see Table 3), the scheduled installation was delayed (partly due to supply shortfalls on the part of the manufacturers), so that meter reading could only start in April 2009 after the measuring technology had been installed. In five test cases (No. 1-4 and No. 6; see Table 3) additional electricity meters for measuring the auxiliary energy were installed.

The concrete measuring schemes applied fulfil the requirements of the measuring concept developed for the BOILeff project; for detailed information (see Deliverable D 4.1 and the national summary report of Wuppertal Institute ([3]).

Table 3 gives a summary of achieved results of the field tests in Germany. A comparison with the guaranteed efficiency, calculated according to GPQU (Deliverable 4.2) was done in four cases. In one heating system with different energy inputs from different energy sources (fossil, solar, biomass) at the same time and in a multi-family building, the efficiency calculations using the "Finger Print Method" produced no suitable results.

## Results

The next two tables show the results both in terms of achieved seasonal efficiencies and achieved in energy/CO<sub>2</sub>eq savings.

**Table 3:** Seasonal Efficiencies of the German Field tests

Nr.	Type of building	Fuel	Location	Heat load of the building/flat [kW]	Type of installed boiler	Guaranteed efficiency by "Finger Print Method" [%]	Measured efficiency [%]
1	Single family house	gas	Wuppertal	11.5	Condensing boiler	85.0	78.1
2	Single family house	Gas/solar/firewood	Ennepetal	14.2	Condensing boiler	87.6	77.3
3	Multi family house	oil	Neuss	24	Low-temperature boiler	--	80.5
4	Single family house	gas	Wuppertal	24.2	Condensing boiler	87.6	(60.1) (failure)
5	Single family house	Gas/solar/firewood	Ennepetal	9.3	Condensing boiler	89.0	89.0
6	Single family house	Wood (pellets & firewood)	Wuppertal	29	Duo boiler – firewood	--	56.0

**Table 4:** Achieved climate-corrected energy consumption and CO<sub>2</sub> reduction

<sup>6</sup> Gas metering is provided by the standard gas meters of the gas utility companies.

Nr.	Heat degree days of the climate region [G15:Essen] 2008/09	Total useful floor-space of heated area [m <sup>2</sup> ]	Climate corrected energy consumption [kWh/a]		Energy savings [kWh/a]	CO <sub>2</sub> reduction [kg/a]
			Old system	New system		
1	2081	134	29.071	26.998	2.073	436
2	2081	75	35.348	25.763	5.369	3.181
3	2081	298	51.568	49.830	1.738	511
4	2081	127	26.507	26.969	N. A.	1.477
5	2081	407	24.272	20.958	3.094	1.094
6	2081	99	51.844	49.089	2.755	13.930

## Conclusions

The present DHQUI quality recommendations and the „Guaranteed Performance Quality” are in principle applicable for the modernization of existing systems as well as for heating systems in new buildings.

Relevant positive experiences made by the participating installers with first successfully implemented projects can be viewed as an “important amplifier” for the further dissemination of this integrated installation and modernization approach in Germany.

However, looking at the results obtained in practice and presented in table 3, it appears that the introduction of both the DHQUI and the GPQU in Germany will not be an easy task. Neither of these concepts may ‘sell itself’ in the market. It turned out to be a difficult task to find installers interested to participate in the field test, which caused the delay in implementation mentioned above. The business rationale for adopting additional work and costs in a boiler market dominated by price seemed not obvious to many contractors contacted.

Even some of the three relatively innovative installers who finally participated seemed to have difficulties implementing the DHQUI and GPQU concepts. The large deviation between the guaranteed GPQU values and the measured values, which are 7 and 10 percentage points worse than the reference value for test cases no. 1 and 2 can only be explained, if the DHQUI requirements were not completely fulfilled. The authors estimate that particularly the steps of hydraulic optimization and optimal setting of the control device were not sufficiently carried out.

In test case no. 4, the heat meter was installed too close to a bend in the circuit, so it was unable to function as planned. The resulting value for the measured energy efficiency must, therefore, be discarded. The very low value for the combined firewood and wood pellet boiler in test case no. 6 must also be treated with caution; there is a large uncertainty in the heat content of the firewood used.

On the other hand, there are two test cases (no. 3 and 5), which achieved quite high measured values and in the case no. 5 match the reference value. It seems that the DHQUI requirements were fulfilled in these cases, which was confirmed by an inspection.

Therefore, the difference in measured energy efficiency values between test cases 3 and 5 on the one hand, and test cases 1 and 2 on the other hand, seem to support the result that the DHQUI will lead to considerable energy savings from an improved installation and operation of central heating systems. However, it also seems to indicate that even well-skilled German installers experience difficulties in implementing DHQUI and GPQU concepts.

An important basic precondition for successful acquisition and market success is thus a further training for installers with practical orientation. In the following, Wuppertal Institute offers some considerations on how this could be structured and organized in Germany. Furthermore, the incentives for the installers must be enhanced, e.g., by requiring DHQUI in connection with financial support programs available in Germany, and by an independent control of the quality and, if possible, of the efficiency of installation by random checks..

As a conclusion regarding the training, it can be stated that the training should best take place with a team of specialist engineers / technical instructors and an experienced practitioner (unity of theory and practice). Besides the theory, practical skills should always be trained in conjunction with a “learning by doing” mode (solving of an exemplary heat load calculation, appointments on site and checking of a modernized system).

This can take place through the well-proven Optimus training concept of the proKlima energy-Fonds Hannover ([www.proklima-hannover.de](http://www.proklima-hannover.de) or [www.proklima-projekte.de](http://www.proklima-projekte.de)). Financial incentives of the respective local / regional energy providers could also be helpful for a limited number of starting projects.

Through the ZVSH-/FdZ heating check, which has now been implemented nationwide, an evaluation tool for the “inspection of heating systems“ compliant to the EPBD (Energy Performance of Buildings Directive, article 8), is now available in Germany. The heating check could be used as an important “door-opener function” for a possibly following (DHQUI-) BOILeff refurbishment of the heating system. The pursuing service “Guaranteed Performance Quality - GPQU” needs an even longer lead time, since the single installer will offer these ambitious services only after he has made his own experiences with high quality installations and the establishment of an equally qualified and interest-independent “trust fund for guaranteed quality”.

Against the background of an upcoming automatic capture of energy consumption (“smart metering”) by the energy supplier at the customer’s home, also a targeted energy monitoring could be implemented by the technical trade / energy service provider for the plant-sided equipment of the boilers with measuring systems for energy input and heat dissipation (incl. auxiliary energy capture) as a possible range of services offered in the future.

## Field test results achieved in Greece

In Greece, focus was given to the development and the spread of DHQUI (work package 3). RAE managed to gather more than 200 signed DHQUI forms, by over 10 boiler installers and associations, from all over Greece. Specifically, 12 installers took part in the implementation of the DHQUI, while more than 26 installers showed interest for further collaboration. More than 20 customers have received the declaration and from now on, boiler installers will inform their customers about the DHQUI approach.

Copies of the signed forms are available and data are used for a statistical analysis.

### ***Results of DHQUI Field tests***

In more details, regarding heat production and heat generation, 25% of boilers are not designed according to the needs of the customer. Only 20% of the users can change the heating curve independently, in order to optimize the facility. Regarding monitoring, only 10% of hydraulic circle are equipped with identification labels and temperature indicators on flow pipe and return pipe. Finally, fuel flow meters and counters of operating hours are installed in 45% of the test cases.

As for heat distribution, in 30% of the test cases not all pipelines, armatures, storage and hot water tanks are insulated against heat loss.

Also, only 30% of all necessary armatures and gauge connections are installed to carry out a hydraulic balance of the facility.

As for heat dissipation, in no case each room is equipped with an individual control (thermostatic valves). Only in 35% of the test cases, there is one individual control for the flat/house. Finally, in half of the houses, the temperature is adjusted at 60 °C for panels and at 45 °C for floor heating. The circulation pumps are adjusted to the optimal level only in 40% of houses.

Regarding domestic hot water, the temperature level of the storage water is adjusted at 52-55% only in 30% of the houses (usually higher). Only in five houses out of a hundred the hot water storage tank is not integrated.

Finally, only in 10% of houses, the adjustment of the room temperature is done by thermostatic valves and only in 4 out of 10 houses, there is hydraulic balance of heat distribution and dissipation.

Regarding WP5 and the field tests, the task was not completed, for the reasons mentioned below.

### ***Conclusions***

The implementation of the EPBD has only just started in Greece. In fact, the law implementing the directive entered in force only in January 2009 whereas several supporting documents towards its implementation are unfortunately still missing.

This gap in the legislation strongly hinders the possibility of performing measurements for WP4/WP5. Regardless of our numerous efforts, installers do not want to undertake the responsibility of signing any document/certificate, unless they are legally covered by their technical federations, which in turn await for the implementation of the directive and the

issuance of its supportive documents (in the form of ministerial decisions) in order to guide their members.

As a result of the meetings held with various associations of boiler installers (ESTIA, PROMITHEAS etc), it has been made clear that Greek boiler installers do not want to commit themselves in participating in WP5. The process of installing or substituting a boiler in Greece involves several specializations of technicians, which do not collaborate with each other. For example, the engineer does not ask the customers about their needs and generally he designs the system based on experience. There is little communication between the engineer and the installer. Responsible for the installation are both the boiler installer and the hydraulic fitter. There is no substantial collaboration between the involved parts. The maintenance of the boiler is usually carried out by someone else, different from the first installer or plumber. Not all technicians are certified to do the job, and it was very difficult to forward the tool of WP4 developed by the project.

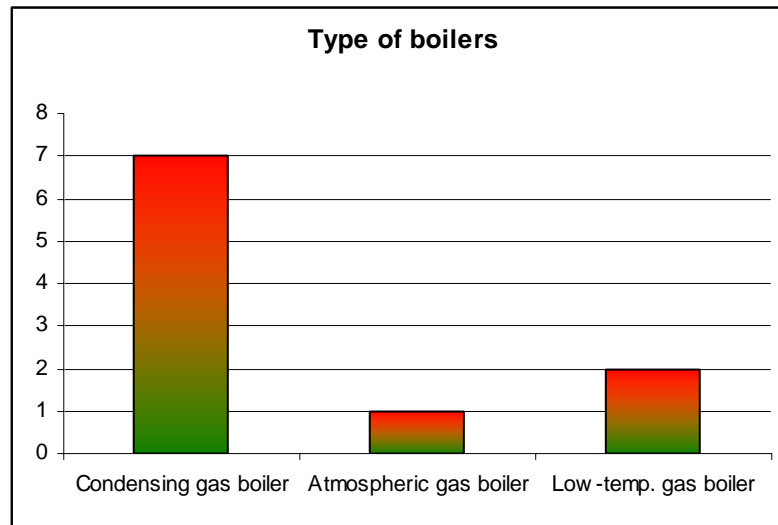
The lack of legislative framework in Greece and of necessary controlling mechanism makes the boiler installers not to take responsibility for any guarantee regarding the efficiency of the boiler and the heating system. This implies that it does not exist the necessary framework that would protect both installers and boiler owners in case of a field test.

Over 100 installers were contacted by telephone and were informed about the project. The installers could potentially participate in the BOILeff project, if the appropriated conditions existed. However, they did not want to commit themselves regarding any guarantee to be given and they did not want to undertake the extra cost which is needed for the installation of the meters.

In conclusion, at project level we believe that RAE has made what is possible to inform the most important stakeholders about the targets of the BOILEFF project and the contents of DHQUI and GPQU. Nevertheless, the realization of the results of WP4 – i.e. the GPQU approach – is unfortunately premature for the Greek market.

## Field test results achieved in Hungary

In total more than 20 costumers and 10 installers were interested in participating in the "BOILeff" project. Finally 20 boiler owners and 10 installers participated in the field test.



**Figure 8:** Type of boilers used in the Hungarian field tests

### ***Calculation and Metering Method used***

Measurement concept applied in BOILEFF is based on direct boiler and seasonal efficiency determination method (see Deliverable 4.1). Direct means measurement and comparison of useful energy with energy content of consumed fuel and auxiliary energy.

For this purpose following quantities shall be measured and stored for investigated period or season:

- Fuel consumption
- Electrical (auxiliary) energy consumption
- Useful heat supply by heating and by hot water supply side.

Seasonal efficiency can be determined from these data:

$$\eta_{\text{seasonal}} = \frac{\dot{Q}_{\text{Heating}} + \dot{Q}_{\text{HotWater}}}{\dot{Q}_{\text{Firing}} + \dot{Q}_{\text{Electricity}}}$$

Advantage of this process is that all major and minor effects are taken into account in the efficiency. From the viewpoint of Guaranteed Performance Quality (GPQU) it is the best way to apply.

Fuel in each case was natural gas supplied by Hungarian gas supply network:

Data of natural gas: Lower heating value: LHV = 34 MJ/m<sub>3</sub>  
 Higher heating value: HHV = 37,4 MJ/m<sub>3</sub>  
 Specific CO<sub>2</sub> emission: 1,97506 kg/m<sub>3</sub>

Fuel consumption was measured by means of installed fuel-gas meters. Electricity consumption was measured by means of electricity meter installed into electrical connection of boilers.

## Conclusions

The seasonal efficiencies varied in the range of 82,59% to 103,36% (LHV) or 75,08% - 93,97% (HHV) (see Table 5).

**Table 5:** Seasonal Efficiencies of the Hungarian Field tests

Nr.	Type of building	Fuel	Location	Heat load of the building/flat [kW]	Type of installed boiler	Seasonal Efficiency (based on LHV) [%]	Seasonal Efficiency (based on HHV) [%]	Guaranteed efficiency by "Finger Print Method" [%]
1	Detached House	gas	Godollo	20	Condensing boiler	103.36	93.97	91,1
2	Detached House	gas	Kalocsa	23.4	Condensing boiler	100.02	90.93	87,6
3	Detached House	gas	Budapest	15	Condensing boiler	98.43	89.48	86,3
4	Office	gas	Veresegyhaz	40	Condensing boiler	95.87	87.15	86,3
5	Detached House	gas	Zalaszentivan	16.21	Condensing boiler	93.22	84.74	86,3
6	Detached House	gas	Godollo	12	Condensing boiler	89.92	81.75	86,3
7	Detached House	gas	Budapest	20	Condensing boiler	88.04	80.04	85,0
8	Detached House	gas	Solymar	24	Low temperature boiler	85.2	77.45	N.A.
9	Detached House	gas	Budapest	12	Low temperature boiler	83.71	76.10	N.A.
10	Detached House	gas	Budapest	35	Atmospheric boiler	82.59	75.08	N.A.

These efficiencies in cases 1 to 5 aligned with expected GPQU values, but in cases 6 and 7 not. For low temperature type boilers (cases 8 to 10) no parameters are available to perform an efficiency (GPQU-)calculation. Reasons for lower values (cases 6 and 7) are assumed that not all the suggested actions of DHQUI were performed during the installation. Furthermore, the temperature level of the flow temperature in some cases is seen as possible reason that condensation was not achieved or only in small scale during the heating season. At this stage, the efficiency (GPQU-)calculation does not take into account the flow temperature level, which has significant effect on boiler efficiency.<sup>7</sup>

Fuel gas savings varied from 216 m<sup>3</sup> to 1.226 m<sup>3</sup> at certain sites. Total gas savings at 10 installation places was 5.427 m<sup>3</sup> comparing with fuel consumption in preliminary heating season. The relative fuel gas savings vary in the range between 6% and 28%. The average savings ratio is 16%.

<sup>7</sup> An updated version of the efficiency (GPQU-) calculation – taking into account the heat dissipation system – will be performed in Work Package 6.

**Table 6:** Achieved climate-corrected energy and CO<sub>2</sub> saving

Nr.	Heat degree days of the climate region [20/12]		Total useful floor-space of heated area [m <sup>2</sup> ]	Emitters	Energy savings (based on LHV) [kWh]		CO <sub>2</sub> emission savings [kg/year]	
	Average	2008/09				Climate corrected		Climate corrected
1	3301	3065	250	Floor heating	11,577	12,371	2,421	2,587
2	3301	3065	200	Floor heating	5,879	6,283	1,230	1,314
3	3301	3065	160	Combined	8,244	8,810	1,724	1,842
4	3301	3065	600	Combined	3,555	3,789	743	794
5	3301	3065	132.21	Combined	4,221	4,511	883	943
6	3301	3065	200	Radiators	5,191	5,547	1,085	1,160
7	3301	3065	282	Combined	3,160	3,377	661	706
8	3301	3065	113	Radiators	2,012	2,150	421	450
9	3301	3065	82	Radiators	2,285	2,442	478	511
10	3301	3065	212	Radiators	5,128	5,480	1072	1146

The energy savings at 10 installation sites based on LHV amounted to 51.253 kWh (based on HHV 56.378 kWh). CO<sub>2</sub> emission reduction varies in the range of 421 to 2.421 kg/year. Total saving is 10.718 kg/year.

Both heating season 2007/2008 and 2008/2009 was 7.7% warmer than average. Climate-correction calculation was performed to average year according to heat degree days written in the national report. The climate-corrected energy savings at the 10 Hungarian installation sites (based on LHV) were 54.769 kWh (and on HHV 60.246 kWh). The CO<sub>2</sub> emission savings vary in the range from 450 to 2.587 kg/year. The total savings is 11.453 kg/year.

A further analysis included the electrical energy consumption as part of the total energy input; the values are in the range between 0.37% and 3.57%. The average value is 1.38%. It shows the importance of hydraulic balance and application of pumps with low energy consumption.

The results of measurements proved also the viability of applied DHQI and GPQI methods at 10 selected installations.

## Field test results achieved in Spain

BOILeff project provoked a great interest among installers and other agents of the sector. More than 20 installers have been interested in taking part but only 7 of them have been able to participate in the field tests. These installers have presented a total of 14 installations (see Figure 9) (customers) located in Catalunya and Madrid (two different regions of Spain).

10 of the realized field tests are completely new installations and only 4 are replacements. In these 4 replacements only the boiler has been changed, the rest of the heating system (heat emitters, pipelines ...) remains the same. The power of the installed boilers (see Figure 10) ranges between 21.6 kW (the smallest one) up to 250 kW (the biggest one) in a multifamily building.

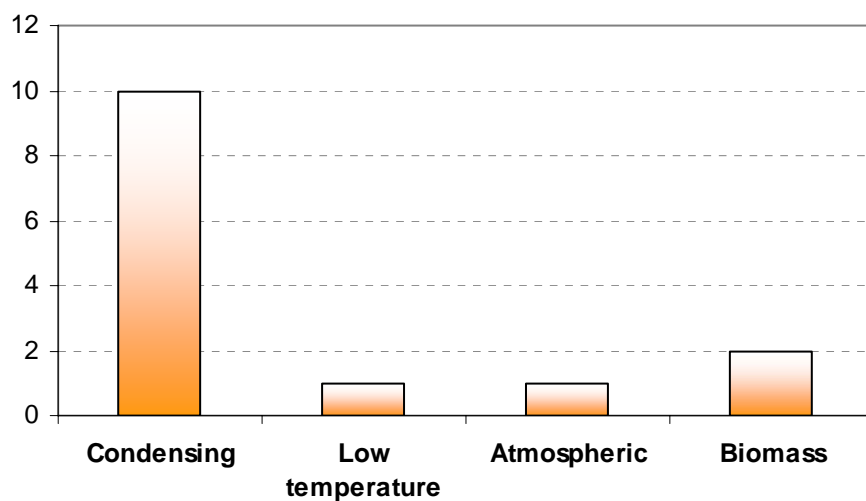


Figure 9: Types of boilers installed in Spain

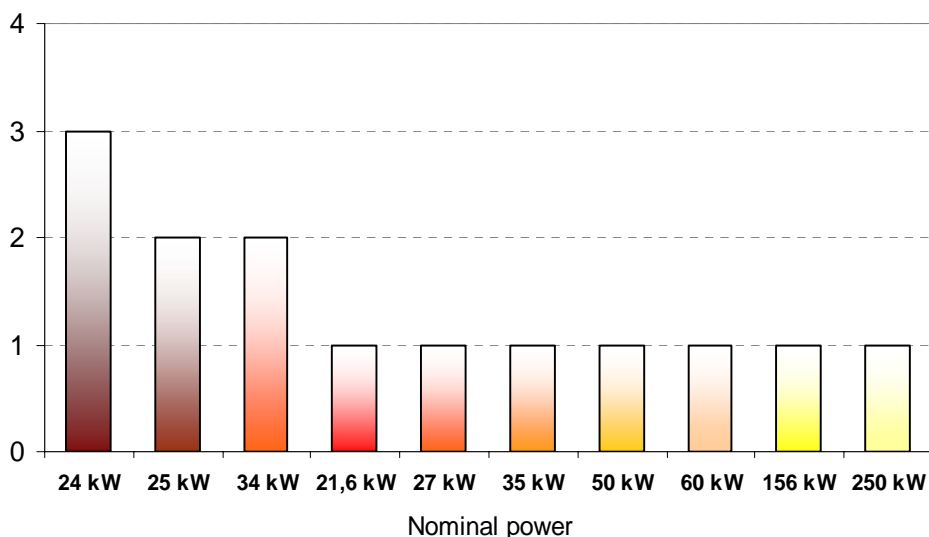


Figure 10: Nominal power of the installed boilers

## Calculation and Metering Method used

Due to the lack of heat meters in BOILeff installations we haven't been able to calculate the boiler performances and, since the majority of facilities were new, it has not been possible to compare the consumptions of this heating season with others from previous seasons. So, the energy and CO<sub>2</sub> savings have been estimated based on the standard and BOILeff boiler performances found during the BOILeff Project. The following data sets were used:

- Standard oil boiler (installed during the last 10 years): 77% (HHV)
- Standard natural gas boiler (installed during the last 10 years): 81% (HHV)
- Standard pellet boiler: 74% (LHV)
- BOILeff oil boiler: 87% (HHV)
- BOILeff natural gas boiler: 90% (HHV)
- BOILeff pellet boiler: 90% (LHV)

As a consequence, to estimate the energy and CO<sub>2</sub> savings Crever considered the performance of a BOILeff installation and of a standard one. Based on the energy consumption the energy savings were calculated. In two cases Crever obtained the BOILeff boiler performances directly, the energy savings have been calculated in these cases as the difference between the BOILeff performance and the standard one multiplied by the energy consumption.

This estimation has been possible in 65 % of the studied cases, because information of the fuel consumption during the heating season 2008-09 was available, in the other cases this information could not be gained.

## Results

Table 7 summarizes the field test results in Spain.

Table 7: Spanish field tests

Nr.	Type of building	Fuel	Location	Heat load of the building/flat [kW]	Type of installed boiler	Heat degree days 2008/2009 HD <sub>15</sub>	Total useful floor-space of heated area [m <sup>2</sup> ]	Emitters
1	single family house (new installation)	Propane	Barcelona	19	Condensing boiler	1110	115	Surface/ floor heating
2	single family house (new installation)	gas	Barcelona	20	Condensing boiler	782	140	Surface/ floor heating
3	single family house (new installation)	gas	Barcelona	17.85	Condensing boiler	686	210	Surface/ floor heating
4	single family house (new installation)	Pellets	Tarragona	24	Atmospheric boiler	825	238	Surface/ floor heating
5	single family house (new installation)	Gasoil	Tarragona	22	Atmospheric boiler	825	214	Surface/ floor heating
6	single family house (new installation)	Pellets	Tarragona	20	Atmospheric boiler	825	200	Surface/ floor heating
7	single family house (new installation)	Gas	Lleida	29	Condensing boiler	1254	198	Surface/ floor heating
8	Flat	Gas	Lleida	20	Condensing boiler	1228	95	Radiators
9	single family house (new installation)	Gas	Barcelona	34	Condensing boiler	1356	190	Surface/ floor heating
10	single family house (new installation)	Gasoil	Barcelona	34	Low-temperature boiler	1356	200	Surface/ floor heating
11	single family house	Gas	Madrid	51	Condensing boiler	1033	408	Radiators

	(new installation)							
12	single family house	Gas	Madrid	40.11	Condensing boiler	1033	260.4	Radiators
13	Multi family house	Gas	Madrid	150	Condensing boiler	1033	1170	Radiators
14	Multi family house	Gas	Madrid	250	Condensing boiler	1033	1900	Radiators

## Conclusions

Spanish field tests have been mainly focused on the Declaration of High Quality (DHQUI) and all participant installers are conscious that in order to reduce the energy consumption in the domestic sector it is necessary to increase the efficiency of the installations. This increase can only be achieved in high quality facilities. For this reason, the participating facilities are better, in quality and efficiency, than what can be found in the Spanish sector. The presence of a great number of facilities with floor heating (9 out of 14) is an indicative of the effort realized by installers as well as by final users to achieve energy savings and also to increase comfort.

In 7 of the presented facilities, and in fulfilment of the new Technical Code of the Buildings (RD 314/2006 (BOE 28/03/06)), there are solar thermal installations for domestic hot water (DHW). In addition, in 3 of these facilities the solar thermal plant is also for heating, which is not fixed or obligatory by the legislation and has been realized in a voluntary way by installers and consumers made aware of the importance of energy savings and the integration of renewable energies in the domestic sector. Another example of this integration of renewable energies can be found in the two facilities that have biomass boilers, where the CO<sub>2</sub> emissions can be considered neutral.

Though the quality of the evaluated facilities is over the average, there are still some aspects that can be improved. These aspects include the circulating pumps because in most of cases the installed ones are not low energy consumption pumps. Another aspect that can be improved is the insulation of the pipelines, only 50 % of the facilities have a thickness of insulation greater than 2/3 of the diameter of the pipeline. Despite the facilities fulfil the regulation of insulation it is important to emphasize that a better insulation could help to avoid unnecessary losses and to increase the efficiency of the system.

Considering the Contract for Guaranteed Performance Quality (GPQU), it is necessary to mention the initial rejection of some installers to sign a document that could compromise them in a future. Nevertheless, we came to a consensus to fix a performance value for the heating systems that has been guaranteed for 2 years, in 13 of the facilities. URC Crever concludes that it is necessary to give more information to the installers on how to calculate the performance of the system. This information could also be complemented with some other information concerning the calculation of thermal loads of buildings and the use of heat meters.

To sum up it can be concluded that the developed DHQUI and GPQU documents have shown to be of a great interest for end consumers as well as for installers because they are seen as a useful tool to differentiate between high and low quality installations. With the use of these documents, installers will have an opportunity to differentiate their quality installations from cheap and low quality ones. This fact will help them to be more visible in the market and to increase the number of high quality installations that will achieve a better performance and therefore energy savings.

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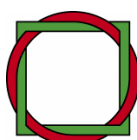
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## Project partners:



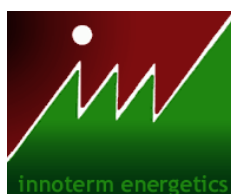
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