Preparatory Study on

Eco-design of Water Heaters

Task 7 report (FINAL)

Policies, scenarios, impact & sensitivity analysis

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1 INTRODUCTION

This Task Report regards subtasks 7.1 to 7.4 as defined in the contract:

- Policies (subtask 7.1, Chapter 2 of this report)
- Scenarios (subtask 7.2, Chapter 3 of this report)
- Impact Analysis (subtask 7.3, Chapter 4 of this report)
- Sensitivity Analysis (subtask 7.4, Chapter 5 of this report)

Subtask 7.1 looks at suitable policy means to achieve the potential e.g. implementing LLCC as a minimum and BAT as a promotional target, using legislative or voluntary agreements, labelling and promotion.

Subtask 7.2 draws up scenarios for 2025 quantifying the improvements that can be achieved vs. a Business-as-Usual scenario and compares the outcomes with EU environmental targets, the societal costs if the environmental impact reduction would have to be achieved in another way, etc...

Subtask 7.3 presents an estimate of the impact on consumers (purchasing power, societal costs) and industry (employment, profitability, competitiveness, investment level, etc.), explicitly describing and taking into account the typical design cycle (platform change) in a product sector.

Finally, subtask 7.4 studies the robustness of the outcome in a sensitivity analysis of the main parameters (as described in Annex II of the Directive) .

2 POLICY RECOMMENDATIONS

2.1 Introduction

Subtask 7.1 looks at suitable policy means to achieve the potential e.g. implementing LLCC as a minimum and BAT as a promotional target, using legislative or voluntary agreements, labelling and promotion.

The subtask will make proposals for product classification, appropriate energy labelling classes and a feasible levels of (mandatory or voluntary) MEPS for energy and emissions in the use phase. For the Ecodesign measures relating to production, distribution and end-of-life, the policy analysis will recommend appropriate measures. With this work VHK will indicate how an implementing directive under 2005/32/EC is coherent and consistent with other policy measures (labelling, training) and especially the Energy Performance of Buildings Directive.

The underlying report will follow the three elements for market transformation: minimum requirements, incentives and information a.k.a "sticks, tambourines and carrots"[1].

2.2 Product definition

In this and the following paragraph we have listed the recommendations for product definition and classification. Where these recommendations could be used in future legislative texts, a first attempt at a legal format is used, but it is crude and far from complete. For instance, wherever it is referred to information "in the Annex", this annex still has to be constructed, mostly on the basis of the inputs from the preparatory sudy, but also additional information may be required.

Recommendations regarding the **product definition**:

- **Eco-design measures** proposed hereafter will relate to gas-fired, oil-fired and electric dedicated water heating systems (hereafter "Water Heaters") and systems that combine water heating with another functionality, notably space heating (hereafter "Combi")[2]. Whenever we refer to "Water Heaters" in general, it includes also "Combi" systems unless explicitly stated otherwise.
- A **Water Heater** is a device or set of devices that is equipped to transfer heat to cold drinking water from the grid thus producing Domestic Hot Water (DHW).
- A Water Heater shall comply with all the **safety, health and functional requirements** in current legislation, e.g. in the Gas Appliances Directive, etc. [to elaborate in legislation]

[1] Cit. A. Warren.

[2] Please note that the "Combi" is formally part of the Lot 1 preparatory study, but the functionality and the measures relating to the water heating function make them much more appropriate for inclusion in this Lot 2 on water heaters. With this approach, however, cross references to the Lot 1 study, in particular regarding the Task 1 to 4, are unavoidable.

- At least a Water Heater shall be capable of producing DHW at the **minimum flow rate, tapping volumes, tapping temperatures and timing** required for its size class (see classification), which implies that at the very least a flow rate of 2 litres (at a temperature increase of 45K) needs should be provided (equivalent to the smallest class; see product classification hereafter).
- The **DHW-distribution system and tapping devices**[3] shall not be part of the Water Heaters. For compliance assessment a reference distribution system and reference emitters shall be used, as defined in Annex. This reference system is in principle based on single piping (DHW circulation systems and their components are not included in the scope).
- In a Combi, typically based on indirect water heating through the means of CH-water and a heat exchanger between CH-water and DHW, a means for circulating the CH-water (hereafter "**CH-circulator**") may in exceptional cases not be part of a Combi. In case the CH-circulator is not part of the Combi system offered for CE-marking, the testing or assessment for CE-marking Eco-design criteria will occur with a reference CH-circulator as defined in annex (90 W circulator).
- Possible means for abducting flue gases (hereafter "**flue ducts**") and for introducing oxygen to the combustion process (hereafter "**combustion air inlet ducts**") may or may not be part of the Water Heater system, subject to specifications under e.g. the GAD. If no systems for flue gas abduction and/or combustion air introduction are part of the Water Heater system, reference systems will be used.
- Possible means for controlling the DHW-storage and/or supply tempertature process (hereafter "**DHW-controls**"), beyond those required to comply with the minimum safety requirements of current legislation[4], may or may not be part of the Water Heater offered for CE-marking[5]. A definition of DHW-controls is given in the Annex[6]. In case DHW-controls are not part of the Water Heater system offered for CE-marking, the testing or assessment for CE-marking Eco-design criteria will occur with a reference situation, assuming no particular controls (storage and supply temperatures at factory settings).
- If the Water Heater incorporates multiple heat generators and/or renewable energy sources (**heat pump, solar**) this will be included in the scope.but only if the systems are fully functional. In other words, if a system only contains part of the components this will not be taken into account. E.g. for systems equipped solar controls and/or a double coil tank that could "in principle" also be used for solar installations, but without the solar collector, the possible solar contribution will not be taken into account.
- If the Water Heater contains the means for **space heating** (hereafter "CH") the compliance with Ecodesign criteria shall be subject to a separate procedure of compliance testing on Eco-design measures for space heating, where part of the assessments of the space heating functions will be used as an input (see Annex)[7] for the validation of compliance testing as a water heater. A Water Heater with CH-function ("Combi") shall comply with both sets of requirements in principle. In case a system only complies with either the space heating related requirements or the water heating related requirements, there is a possibility for compensation indicated by the ratio between the net space heating load of the

[3] Kitchen and bathroom sink taps, bath taps, shower heads, etc.

[4] e.g. maximum thermostat

[5] e.g. external timer/ temperature controller

[6]

[7] In other words, the space heating compliance assessment has to be performed first.

CH-size class and the net water heating load of the HW-size class for which the manufacturer requests the CE-marking. [8]

- If a Water Heater contains the whole or part of the means required for **space cooling**[9], **ventilation**[10]**, air purification, humidification, de-humidification or any other functionality related to indoor air quality**, this extra functionality will not be part of the underlying compliance assessment. In due time, this functionality may –and probably shall—be part of a separate procedure of compliance testing on Eco-design measures (see Annex).
- If the Water Heater contains the whole or part of the means required for **other domestic heating functions, like cooking**[11], this extra functionality will not be part of the underlying compliance assessment. In due time, this functionality may –and probably shall—be part of a separate procedure of compliance testing on Eco-design measures, where part of the assessments of the space heating functions will be used as an input (see Annex)[12].
- The following Water Heaters are not included in the scope:
  - Water Heaters that produce a surplus of electricity, i.e. beyond what is needed for driving the electrical components within the system, are regulated in the CHP-Directive and in principle outside the scope of our assignment. However, if so desired CHP-systems could be included in the scope, but this would require e.g. an effort to synchronize the electricity credit values with the provisions of the CHP-Directive. (see Lot 1 study, Task 6 Report, par. 2.7.3).
  - Water Heaters using solid fuels, including biomass, as an energy source. For this group the Commission is engaged in a separate preparatory study for Eco-design measures.
  - Water Heaters driven by District Heating ("DH"). These are systems fuelled by waste heat from power plants, waste incineration plants, larger industrial installations, etc. [definition in Annex]
  - DHW-storage tanks without heat generation means.[13]

For all water heating systems not (yet) defined within the current scope, it is recommended to be coherent with the methodology in the underlying study (see Assessment Procedure).

2.3 Product classification

Recommendations regarding **product classification**:

- 9 size classes shall be used to distinguish Water Heater systems
- The familiar denomination S-M-L (small-medium-large) shall be used for the size classes, downwards extended to XS and XXS and upwards extended to XL, XXL, 3XL and 4XL.
- the size class qualification shall depend on
  - A minimum performance (flow rate, tapping volume, temperature and timing) as defined by the appropriate tapping pattern for the size class, and

[8] Typically the ratio of net heat loads of the same size class is 4/1 (CH/HW), but it depends on the size class.

[9] E.g. top cooling with cooling ceilings, fanned (hydronic) convectors or radiators, etc.

[10] E.g. ventilation based on mechanical extraction, combined with an air-based heat pump

[11] E.g. ranges, but also water beds deriving their heat from CH-system.

[12] In other words, the space heating compliance assessment has to be performed first.

[13] Please note that DHW-storage tanks with a fixed electrical resistance element (e.g. for a summer-mode) are included in the scope, even if they also contain a heat exchanger (coil) for e.g. a winter mode.

- A minimum energy efficiency and emission assessment as defined by the appropriate tapping pattern for the size class plus corrections (see assessment procedure)

▪ Whereby the load profile for which the energy efficiency and emission assessment during CE-marking should be performed is decided by the manufacturer.

▪ A manufacturer can decide to have one appliance tested for more than one load profiles, but this appliance should be brought on the market with different model denominations depending on the load profile for which it is tested. Also registration numbers for CE-marking will be differ, depending on the load profile.

▪ The size-class shall be clearly marked as a prominent part of label, fiche and any commercial communication describing the product during the purchase process.

As mentioned in the Eco-design directive all previous and current technology-dependent classifications will not be used for measures, i.e. there is no distinction between e.g. "*gas/oil/electric*" or "*storage/instantaneous*".

Table 2.1 . Overview of size classes

Size			Examples of applications
XXS	market share	**7.0%**	**small sink tap (no dishwash) [1 c]**
	Largest flow rate required (ΔT=45 K)	**2** ltr./ min.	single point only
	Largest tapping required	**2** ltr	(semi-) public toilets (if hot water needed)
	24 h net hot water demand	**2.1** kWh/ d	
	Nr. of cycles per 24 h	**18**	
XS	market share	**12,5%**	**average sink tap [1 b]**
	Largest flow rate required (ΔT=45 K)	**4** ltr./ min.	single point only
	Largest tapping required	**5** ltr	
	24 h net hot water demand	**2.1** kWh/ d	
	Nr. of cycles per 24 h	**16**	
S	market share	**24.0%**	**large sink tap/ small shower tap [1]**
	Largest flow rate required (ΔT=45 K)	**5** ltr./ min.	1 person household
	Largest tapping required	**9** ltr	student flat
	24 h net hot water demand	**2.1** kWh/ d	holiday home
	Nr. of cycles per 24 h	**11**	single point or small multi-point
M	market share	**52.7%**	**average shower tap [2]**
	Largest flow rate required (ΔT=45 K)	**6** ltr./min.	2-3 person household, showers
	Largest tapping required	**24** ltr.	multi-point
	24 h net hot water demand	**5.85** kWh/ d	larger holiday home
	Nr. of cycles per 24 h	**23**	
L	market share	**9.0%**	**bath tap [3]**
	Largest flow rate required (ΔT=45 K)	**10** ltr./ min.	4-5 person household with showers
	Largest tapping required	**62** ltr	and occasional bath
	24 h net hot water demand	**11.7** kWh/ d	small restaurants
	Nr. of cycles per 24 h	**24**	
XL	market share	**5.5%**	**large bath [4]**
	Largest flow rate required (ΔT=45 K)	**10** ltr./ min.	4-5 person household + daily bath
	Largest tapping required	**76** ltr	medium restaurants
	24 h net hot water demand	**19.1** kWh/ d	barber shop
	Nr. of cycles per 24 h	**30**	
XXL	market share	**8.8%**	**simulataneous bath+shower [5]**
	Largest flow rate required (ΔT=45 K)	**16** ltr./ min.	>4-5 person household, frequent bath
	Largest tapping required	**107** ltr	2-family household
	24 h net hot water demand	**24.5** kWh/ d	barber shop, large restaurants
	Nr. of cycles per 24 h	**30**	small public sauna or spa
3XL	market share	**<1%**	**multi-family (8 * M-class)**
	Largest flow rate required (ΔT=45 K)	**48** ltr./ min.	small hotels & campings
	Largest tapping required	**215** ltr	small collective shower facility
	24 h net hot water demand	**46.8** kWh/ d	also in cascades
	Nr. of cycles per 24 h	**23**	
4XL	market share	**<1%**	**collective hot water (16 * M-class)**
	Largest flow rate required (ΔT=45 K)	**96** ltr./ min.	larger multi-family, homes for elderly
	Largest tapping required	**430** ltr	swimming pool showers, hospitals, military, prisons
	24 h net hot water demand	**93.6** kWh/ a	hotels, car wash
	Nr. of cycles per 24 h	**23**	collective shower facilities (gym), also in cascades

2.4 Assessment procedure

Following directive 2005/32/EC the procedure for CE-marking (Art. 95 of The Treaty) applies.

As mentioned in the Task 1 report, the current EN test methods EN 13203-2 and prEN 50440 are largely sufficient –with some corrections for distribution losses and waste heat recovery as described later-- in describing energy efficiency and emissions of a Water Heater. The EN standards mentioned are formally only applicable to gas-fired water heaters (EN 13203-2) and electric storage water heaters (prEN 50440), but the principles are universal enough to declare the selected tapping patterns applicable to all types of Water Heaters. And we are confident that it must be possible to incorporate the tapping patterns in all relevant standards (e.g. for solar, heat pump water heaters, etc.)

In principle the tapping patterns could also be used for the testing of emissions of NOx, CO, CH4, CxHy, Sox, PM, etc. for fossil-fuel fired Water Heaters. However, at the current state of affairs of standards and empirical test results this is not the case. Some standards just give NOx and CO-testing at steady state operation. Apart from NOx testing, where the current test at steady state efficiency do give a reasonable impression of real-life emissions, none of the other impact parameters can now be tested adequately.

In the long run the emission measurements should be incorporated into the test procedures and EN standards and sufficient empirical data should be gathered to set appropriate emission limit values for at least the carbon-related emissions (CO, CH4, CxHy), and assess the relevance of any limit values for the other emissions. For the time being we propose a transitory regime, whereby only emission limit values are proposed for NOx, based on the harmonized standards.

For the assessment of energy efficiency testing we recommend to organise compliance assessment for a Water Heater consisting of

- A series of tests according to harmonized European test standards
- Assessments to be made by the test institute / notified body
- A mathematical validation method that performs a (minor) correction above test results and other assessment as an input to calculate energy efficiency, carbon and NOx emissions of the Water Heater. For CO-emissions the steady state emissions do not represent realistic values in practice but could be used to set very preliminary targets.

For energy efficiency and NOx-emissions of dedicated Water Heaters we expected that the regime can be final for size-classes up to and including XXL. Some updating of values in due time (e.g. after 4-6 years) may be needed.

For energy efficiency of the 3XL and 4XL sizes no tapping patterns are defined. Here we propose 8 times tapping pattern nr. 2 of prEN13203-2 (in terms of flow rates and tapping volumes, with the same frequency) or 16 times tapping pattern nr. 2 for sizes 3XL and 4XL respectively. **<u>For other emissions besides NOx it</u>** is expected that standards-development will take another 4-6 years.

For Combi appliances (see Lot 1), especially in the smaller size classes (<XXL), we anticipate some changes in 4-6 years when the space heating function can be tested dynamically, which will influence the credits for combining the function.

2.4.1 Required Tests

The following is a list of parameters that come out of EN-standard test procedures and that are recommended to be used for the compliance assessment

- Energy consumption (electric and fossil fuel) with selected tapping pattern:
    - prEN 50440 (1c and 1b voor XXS, XS-size),
    - prEN 13203-2 (patterns 1-2-3-4-5 for S-M-L-XL-XXL size) or
    - a derived tapping pattern (8*M or 16*M) or steady state efficiency for 3XL and 4XL
- Solar systems: Collector loop loss UL, tank heat loss coefficient UA, tank volume, etc.. If no standard is yet available: Further validation with mathematical model otherwise emulation/tapping pattern test.
- Heat Pump (if no standard is yet available): Efficiency tests at the Tsink and Tsource indicated for the various types. If no standard is yet available: Further validation with mathematical model; otherwise emulation/tapping pattern test.
- For fossil-fuel fired water heaters: NOx and CO emissions (steady state testing at nominal capacity)
- Special test procedures apply for Water Heaters with "smart control", i.e. that have sensors and logic to recognize tapping patterns and consumer habits to regulate the storage and supply temperature. In principle, these water heaters shall be tested with the factory setting temperatures (i.e.) and the smart-control-bonus can be established separately[14]. This avoids very long testing (some types measure patterns up to 2 weeks before the smart control is applied) and possible fraud, e.g. appliances recognizing that they go through EN test procedure.
- Noise (NF and EN, but choice to be made)

An overview of parameters and standards can be found in the Annex.

Please note that fuel input and thereby energy efficiency values for fossil fuel should be assessed in terms of GCV (<u>Gross Calorific Value</u>). For electric power inputs as a part of the overall energy efficiency values a <u>primary energy conversion factor</u> 2,5 (1 kWhe = 2,5 kWhprim) will be used.

For a significant part of the Water Heater systems (all gas- and oil-fired dedicated water heaters and combi-s) **<u>Third Party Testing</u>** is current practice, involving specialized test institutes and Notified Bodies. If not for any other reason, the safety issues involved with the fossil fuels make Third Party testing indispensable.

Furthermore, the outcome of many tests is highly susceptible to fuel quality, ambient parameters and the overall quality of the test institutes. Given the fact that the Eco-design measures are an important competitive item in the sector and in the interest of a "level-playing-field" we therefore propose to extend current practice of Third Party Testing to <u>all</u> Water Heaters.

Apart from Third Party testing, we recommend to create **<u>Market Surveillance</u>** at EU-level by an independent body performing 100-150 random spot checks annually. Costs could be limited (ca. € 1 mln. /yr.) and it would avoid discussions on the neutrality of the surveillance. As one CE-marking conformity test usually covers between 10 and 20 models, the 100-150 spot checks could cover around 1000-2000 models. [more information in the chapter on impact assessment]

[14] The exact procedure to be determined in the consultation process

2.4.2 *Other assessments*

Apart from the tests according to harmonized standards, a number of relatively simple assessments and measurements will be required. These basis of these assessments is on one hand a series of simple tests to identify certain features (weight, envelope volume) and descriptions of these features. These will be incorporated in the legislation.

- Product envelope (in m3)
- Product weight (in kg)
- Room air intake (e.g. from type declaration)
- For Combi: water content (in ltr., in case)
- For Combi: Type of air-fuel mixer and/or air factor
- System of DHW-storage and -supply temperature control, included in the package (if any): None (fixed temperatures), timer control (no reheat during 23.00 and 7.00h), smart control.
- In case of the use of a refrigerant, e.g. for a heat-pump based Water Heater system, the type of refrigerant should be assessed (self declaration)

2.4.3 *Validation of test results*

For performance

The test house/ notified body checks whether the Water Heater meets the definition and the minimum performance requirements for the size-class for which CE-marking is requested.

For energy/carbon

The results from the generic tests and the other assessments above feed into a mathematical model that will result in a single Index ("E-index) that is indicative of the main environmental impacts: the use of energy resources and the carbon (CO_2) emissions.

This calculation is specific for the size class for which CE-marking is requested and uses the specific Load Profile. A description of the model and calculation procedure can be found in the Annex.

For NOx (acidification)

The test institute reports the NOx emissions during steady state, according to the indicated test method and certifies whether the NOx-emissions meet the target values (see next paragraph). The unit is ppm (parts per million) at 3% O_2.

For CO (carbon/ toxicity)

The test institute reports the CO emissions during steady state, according to the indicated test method and certifies whether the CO emissions meet the target values (see next paragraph).. The unit is ppm (parts per million) at 3% O_2.

For refrigerant

The test institute reports the nature and quantity of the refrigerant contained in the Water Heater system and certifies whether the GWP (Global Warming Potential) meets the target values (see next paragraph).

2.5 Targets

2.5.1 Target levels

LLCC- (Least Life Cycle Costs) and BAT levels that have been identified in Task 6 are given in the table below:

Table 2.2. LLCC-target efficiencies

	BaseCase	LLCC Task 6	BAT Task 6	LLCC harmonised
XXS	27%	25-30%	34%	24%
XS	27%	25-30%	34%	27%
S	23%	30-33%	36-40%	30%
M	35%	38-45%	>45-50%	44%
L	37%	50-55%	>60 %	50%
XL	37%	55-60%	>70%	58%
XXL	34%	60%	>75%	68%
3XL	52%	72%	>75%	74%
4XL	49%	90%	>90%	92%
weighted avg.	**34%**	**52%**		**51%**

As mentioned in Task 6, these values indicate a range, the exact values are to be established in conjunction with a coherent methodology (see labelling table page 20).

This is the rationale for the column "LLCC harmonised" which follows a mathematical pattern with ever increasing class-widths and an extra jump between S and M and between 3XL and 4XL. The reasons for the increasing class-widths are technical, e.g. with increasing load the fixed part of the losses becomes relatively smaller and also tank losses do not increase linearly with size. The reasons for the extra jumps are mainly economical: For the smallest loads (XXS-XS-S) solutions requiring chimneys and or ducts are very often not economical or not saving energy (pilot flame, atmospheric). Also the societal gain from forcing these classes to their ultimate LLCC limit is very small. For the largest class (4XL, 16 times the M-size) the load makes all sorts of renewables economical (heat pump, solar. etc.). Apparently the largest concessions between the Task 6 outcomes and the proposes "harmonised LLCC" are in the middle (L to 3XL). However, this is also the area where the uncertainties in LCC-calculations are highest. For instance, the 57% efficiency in the XL-class is for a high-quality air-source heat pump, substituted "like-for-like". However, in a situation where this level is compulsory, there will also be a large share where there is no substitution "like-for-like". For that reason we propose the next lower level and a review when enough experience has been gained. But the ultimate decision is of course up to the Commission and Consultation Forum. In terms of overall efficiency gain, as is shown in the last row of the table, the difference is around 1%.

In combination with the LLCC target also the following emission limit values are deemed feasible:[15]

- NOx emission limit value (long term): 20 ppm (for gas- and oil-fired products; whereby this requirement will be annulled in case of multi-valent systems involving renewable energy sources). This would bring the EU up to speed with the most stringent legislation outside the EU (California).
- CO emission limit value (preliminary): 400 ppm (for gas- and oil-fired products). This is purely a precaution until realistic test standards are in place. Note that there is a trade-off technically between CO and NOx emission-levels.

These values are identical to values current applied in California and are deemed possible also for the European industry after a transition period.

For emissions of CO, CH4, CxHy and PM (Particulate Matter) the final LLCC emission limit values can as yet not be established as no appropriate test procedures –and thereby no data from water heaters—are available. It is recommended that the Commission issues a mandate to CEN to develop the appropriate standards (see also Assessment Procedure).

2.5.2 Environmental impacts at LLCC target levels.

The following tables from Task 6 give the expected energy savings at target levels. Table 2.3 applies to the LLCC-level, yielding an average saving of 35-40% with respect of the Base Case. Table 2.4 relates to the BAT level, yielding savings of 60-70%.

Table 2.3. Annual Energy Consumption

Energy in kWh/a					Savings vs. Base Case in kWh/a and %			
	Base Case	LLCC	% syst.eff.	BAT	LLCC	%	BAT	%
XXS	1757	1681	27%	1349	76	4%	408	23%
XS	1762	1513	30%	1133	249	14%	629	36%
S	2159	1530	30%	1293	629	29%	866	40%
M	3906	3015	43%	2289	891	23%	1617	41%
L	7375	5032	51%	4014	2343	32%	3361	46%
XL	11566	7334	57%	5903	4232	37%	5663	49%
XXL	16277	8949	60%	7182	7328	45%	9095	56%
3XL	19746	14175	72%	12076	5571	28%	7670	39%
4XL	41668	22839	90%	22327	18829	45%	19341	46%

Estimated overall energy saving at LLCC level: ca. 30-40% (between M and L).
Estimated overall energy saving at BAT level: ca. 60% (between M and L)

In Task 6 BAT (Best Available Technology) or BNAT (Best Not yet Available Technology) levels over 90%. However, these savings apply to the larger size classes (XXL, 3XL, 4XL) and require ground source heat pump technology sometimes with an add-on benefit of solar installations, which would have several drawbacks for application in mandatory measures

[15] Please note that the ELVs are linked to the LLCC target level , at which they will incur little extra costs (e.g. € 10, - higher production costs). However, if the political discussion would lead to lower Index values for energy/ carbon, then also the value for NOx has to be revised (lower).

- It cannot be universally applied. 'Geothermal' or 'vertical' ground-source heat pumps require special permissions from the waterworks and/or the commune, etc.
- Specialist installers and special equipment are necessary and (as yet) not abundant
- The efficiency of the heat pump is highly dependent on the lay-out and installation.
- Often a heat pump is a base-load device with considerable penalties in efficiency during part load and/or at high sink temperatures , which means that a hybrid device (e.g. with a conventional product) may often be a good solution
- Ground (or water/brine) source heat pumps are difficult to apply in e.g. existing apartments and with small heat loads. For apartments(S and possibly M) we assume the BAT implies a small air-based heat pump, but with typically a much lower efficiency (COP 2,5-3,3) than ground source heat pumps.
- The energetic benefits are highly dependent on the climate, especially with air-based heat pumps and of course with solar energy.
- As a result of the above, the pay-back time will vary widely per country and circumstance. Our analysis in Task 6 shows e.g. payback times of 20 years (LCC slightly higher than the Base Case), but it could easily be half or double that amount depending on the circumstances.
- The current heat pumps are mostly electric, which means that on a hypothetical full EU heat pump strategy would lead to increased emissions of everything else besides CO2: more acidification, more VOCs, more heavy metals, etc. . See for instance the scenario analysis in the eco-design study for boilers, where –due to the higher load—heat pumps do become more economical sooner (i.e. at LLCC level). This causes a surge in e.g. NOx-emissions, which takes some 10-15 years to remedy through higher efficiency and NOx-targets.
- Many heat pumps are reversible, which means that they can supply both cooling and heating. If they are attached to a CH-system the (active) cooling options will be limited (only top-cooling), but still this could lead to a summer operation that would be detrimental to the saving and mitigation effort.

All in all, the heat pump technologies represent an interesting option with a large saving potential and should be promoted whenever and wherever possible (with emphasis on possible). As such they should therefore have their place in the highest ranks of a labelling scheme. However, the uncertainties (and the costs) of the option should be taken into account. Regarding the solar-assisted water heaters our technical and economical analysis indicates economical benefits of a magnitude that are generally too small to make them qualify as LLCC-target, unless perhaps employed in larger installations and at mass volume collector prices.

2.5.3 Life Cycle Costs at LLCC and BAT levels

The table below from Task 6 gives the Life Cycle Costs at LLCC and BAT levels. It shows savings at LLCC level of up to 13-17% for the smaller size classes (up to L) and up to 42% for the largest sizes. The savings at BAT level indicate that the BAT-solutions do not save as much money as LLCC-solutions but are still more economical than the Base Case.

Table 2.4. Life Cycle Costs

Life Cycle Costs in Euro				Savings vs. Base Case in Euro and %			
	Base Case	LLCC	BAT	LLCC	%	BAT	%
XXS	1824	1819	1595	5	0,3%	229	13%
XS	1961	1689	2532	272	13,9%		
S	2167	1800	1893	367	16,9%	274	13%
M	4274	3392	5195	882	20,6%		
L	9001	6341	8053	2660	29,6%	948	11%
XL	11786	8636	10177	3450	26,7%	1609	14%
XXL	15901	10293	12960	5608	35,3%	2941	18%
3XL	25028	18969	25896	6059	24,2%		
4XL	49043	28553	46892	20490	41,8%	2151	4%

2.6 Incentives

2.6.1 Introduction

The LLCC-targets above constitute the "sticks" part of a balanced strategy of "sticks, carrots and tambourines". And, as will be indicated in the paragraph on Alternative Scenario's, "sticks only" will not be enough to realize the full saving/ mitigation potential.

In general the aims of financial incentives ('carrots') like subsidies, tax deductions, low-interest loans are :

- To address the problem of "affordability" of Eco-design measures for low-income groups
- To smoothen the transition process towards mandatory LLCC targets, showing that the government is not just asking sacrifices from the market actors (manufacturers, consumers, etc.) but is also serious in contributing its share in the effort.
- To reach environmental and energy saving goals that go beyond the LLCC targets (27% saving) but that promote a move towards BAT-solutions (50-60% saving).

Of these three, the criterion of **"affordability" i**s also the only one explicitly addressed in the 2005/32/EC directive. Only in case the water heater is a gas-fired Combi there is the chimney and early replacement problem, i.e. if the appliance has to be condensing and the collective chimney of certain apartment buildings cannot accommodate a mixed use (see report on Lot 1).

The other two aims of financial incentives can be handled at Member State level (subsidiarity principle) and the following just gives some indications.

2.6.2 Other Financial Incentives

As mentioned, generic incentive programs can smoothen the implementation process towards the LLCC-targets and help to reach national goals beyond the LLCC targets. Although this is typically a matter that does not needs to be treated at an EU-level, the preparatory study can provide information on the subject.

In that sense, the Task 1 and Task 2 report are the most important, providing an overview of measures in each Member State and supplying information on the sales and the price levels per Member State.

In general one can say that –in water heating-- most financial incentives have been focused on solar installations, whereas the other "more normal" improvement options and heat pumps for water heating have addressed more modestly. This is probably due to the lack of an objective yardstick for the efficiency of water heaters and might change with EU-wide labelling.

In the context of emission trading there appeared to be a consensus that a price of € 20,-/ tCO_2 is reasonable for carbon saving. An M-size water heater uses around 12 tCO_2 over its product life (Base Case, see task 5) and a 35 % saving (LLCC-target) would imply a saving of 4 tCO_2. In that case a subsidy of € 80,- would be a minimum. But for larger water heater systems this would be significantly higher: € 250,- for L-class, € 400,- for XL-class, etc..

Compared to whitegoods the subsidy level of € 150,- is also modest. Member States have given subsidies up to € 100,- or more for the most efficient refrigerators and freezers, despite the fact that the carbon saving involved is only a fraction (<20%) than that of water heaters.

Compared to cars, the subsidies on water heaters are extremely low. With past and current schemes for cars there have been take-back subsidies of around € 1000,- when purchasing efficient cars (label A or B) . The carbon saving from such an exercise is limited to on average around 8-9 tCO_2 over the life time of the car, e.g. going from an average stock-average of 160-170 gCO_2/km to around 100-110 gCO_2/km. At an optimistic 150.000 km over the car product life this 60 gCO_2/km saving results in the 9 tCO_2 mentioned. At € 20/ tCO_2 this should have resulted in € 180,- subsidy, but of course there are some lateral effects (lower NOx, SOx, PM, etc.), which –by the way— are not very different from those of water heaters.

We believe the labelling of cars, and the fact that it is a high-interest product considerably better known to the public, may have something to do with it. This allows for instance to introduce a sort of "bonus/ malus" arrangement, whereby the subsidies for the more efficient cars can be financed by extra road tax or extra levies on the least efficient cars.

The introduction of a **labelling program** as part of the Eco-design measures could therefore be of crucial importance, because it would identify not only the best products, but –for the first time-- also the worst products on the market. Especially in the transition period this would allow the application of a similar "bonus/ malus" subsidy/tax system as with cars.

2.7 Information: EPB & Labelling

Apart from minimum targets and financial incentives, promotional and educational activities at Member State level would usually accompany the introduction and implementation of the new legislation. At EU-level we recommend measures that would create the right conditions and tools for such information activities, notably

- Labelling, which can also be an important tool for the financial incentives
- Coherence with other legislation for energy saving and emission mitigation, especially the efforts in the field of EPBD (Energy Performance of Buildings).

2.8 Labelling

Labelling of domestic water heaters has been on the agenda of the Energy Labelling directive 92/75/EC for the last 15 years, without a resulting directive. Presumably, e.g. using the new standards and insights from the underlying study, this process could be finalized under the 92/75/EC directive. But still, even at an optimistic estimate of lead times we would have to wait at least two years before issuing an EU- labelling directive for water heaters and another 3-5 years before this legislation is implemented at national level.

In that context, we would recommend to investigate whether the labelling process – which we think is crucial for a responsible transition to the LLCC target level – could be implemented sooner through a specific Eco-design measure, e.g. running in parallel – but preceding in time-- the 92/75/EC procedure.

In that sense, it is recommended to include mandatory labelling as an Eco-design measure and VHK has discussed several options with the expert group in order to be able to give the Commission a detailed advice in the matter.

2.8.1 Labelling: Good Practice

In general a label, and more specifically a label for the Water Heater, has to meet a series of demands both on the lay-out and the content, notably its should be

- Recognisable and coherent across products (redundant style characteristics, like A-G and recognisable colour-scheme)
- Attractive *("rainbow")* and conspicuous *(bright colours)*, instil confidence *(EU flag and some legal small print)*,
- Avoid (technical) texts, but use symbols, icons, well-known classifications, etc.. Technical information should be on the "fiche" as much as possible.
- Performance indications should be based on the function that the consumer wants (e.g. "hot water" at a certain temperature, flow rate, etc.), not on the technology involved (e.g. "electric storage water heater").
- Any other label-information on the product besides energy/environment should be very limited, e.g. to the main performance characteristic. "More information" isn't "Better information". Furthermore, a label isn't the only source of information on the product. For more extended information there is the "fiche", the nameplate and any other information that a manufacturer wants to put in its brochure, internet-site, etc..
- Give consumers the correct impression of energy efficiency and environmental benefits available, within that function
- Give a complete impression of where a specific product is placed in the total field. For instance, if an extra class exists better than A (A+ or A++) this should be instantly clear to the consumer by adding the extra bars above the "A"
- Easy to understand for lay-men,
- Acceptable to experts (scientifically sound)
- Give a fair and "level" playing field for the manufacturers.
- Be exact, without overstating exactness when it isn't there. E.g. for "solar" and "heat pumps" the class-widths can/should be much bigger because of uncertainty in yield → double class-widths for A+ to A+++.
- Based on a correct understanding of the test tolerances involved. For fossil-fuel fired boilers round robin tests (with the same product) tolerances of ±2-2,5% at

full-load and ±4% at part-load are shown. To this, production tolerances must be added. In other words, for gas-appliances at least a class-width of 6-7% should apply to avoid products jumping two classes at spot checks. For electric water heaters tolerances may be similar, but if the efficiency is measured in primary energy (and not electric kWh) then also the class widths can be a factor 2,5 smaller, i.e. a smallest class-width of at least 3% on primary energy efficiency would apply for the smallest size-classes where electric single point water heaters are found (XXS-XS).

- Be robust in a court of law, founded on clear rules and test procedures. In the past there have been court-cases for fraud against white-good manufacturers, who allegedly claimed much too high efficiency classes. In the following court case it was clear that judges were baffled by the phenomenon of tolerances, which has been seriously detrimental to the credibility of those labelling schemes, especially when used for public subsidies ("tax payer's money"). In the future this should be avoided at all costs.
- Be ambitious, whereas at the same time leave enough room to differentiate between existing products and thereby also trigger improvement in the lower-end products.
- Should stimulate innovation, i.e. rewarding the most advanced technology.
- Reward (the use of) renewables, but with factual information and subject to the same validation as conventional products (Let the figures speak for themselves).
- In the case of multi-function appliances, where the water heating function is combined with other functions (space heating, cooking, etc.) the label should be able to accommodate classifications per function. This is especially so, if the consumer has a choice between a multi-function appliance and dedicated products.
- Also in the case of multi-function appliances the user should at least optically be given an idea of the relative environmental impact of each function. For instance, for existing dwellings the hot water function of a combi constitutes only a quarter or one-fifth of the impact of the space heating. For new dwellings the impacts can be about equal. A compromise is a ratio 1:3 between water and space heating.
- Being index in the context of 2005/32/EC it should be able –probably in the long run—not to take into account only energy efficiency but eventually also other eco-aspects (NOx, CO, noise, GWP refrigerant) and not just energy and carbon.
- Should help to enforce LLCC-targets, e.g. the target level should preferably be identical to a class limit (e.g. between B and A).
- Should be coherent with, and possibly applicable in other existing and future legislation, notably the EPBD.
- Should be useable in incentive-schemes: Subsidies, loans, tax-deductions, but also schemes like the "white certificates" and –as far as renewables are a part— "green certificates".

2.8.2 Label design

Based on the above the proposal for a design of the label was made. Figure 2 shows the label for an Energy-index ('E') of a dedicated Water Heater and for a combi- system.

The (water heating part) of the label is based on the outcomes of the Assessment Procedure, i.e.

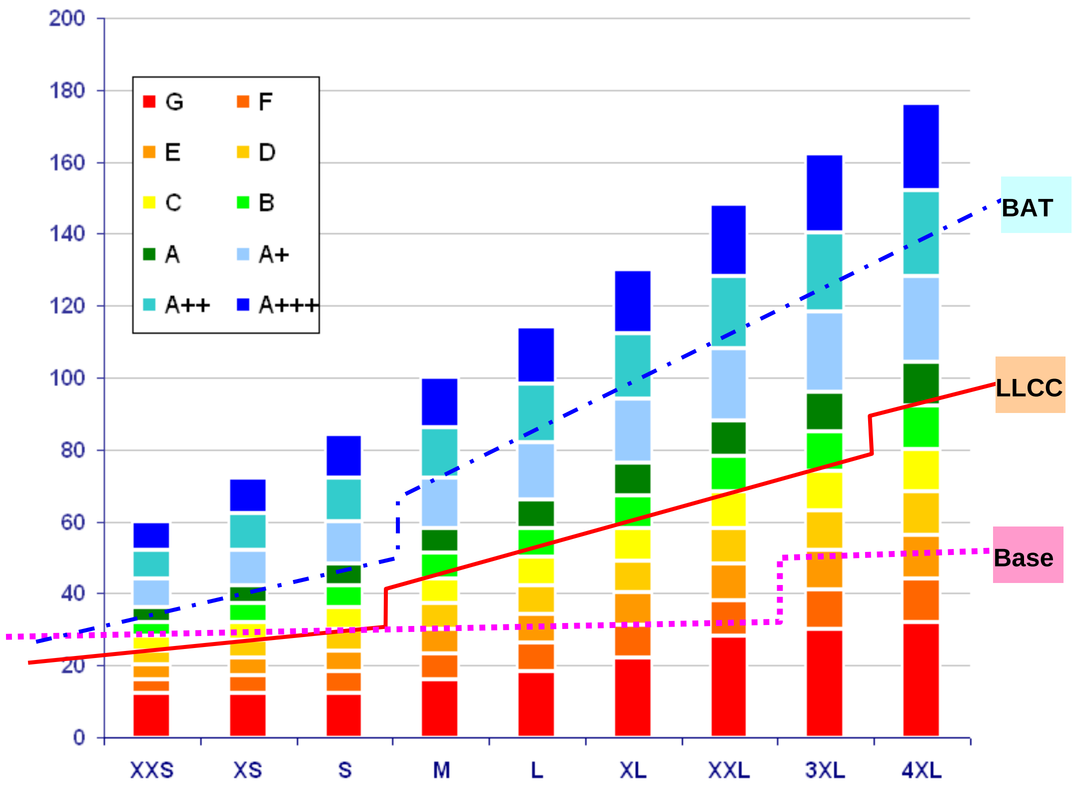
- Energy efficiency[16], as a measure for energy resources use and carbon emissions is the main parameter. The lower efficiency class-limits vary per size class, as given in the table below.
- The table is based on class-widths 4, 5, 6, 7, 8, 9, 10, 11 and 12 % points for classes XXS-XS-S-M-L-XL-XXL-3XL-4XL.
- Furthermore, the table is based on start values of 12, 12, 12, 16, 18, 22, 28, 30, 32 for the F/G class limit.

[16] The CH System Efficiency is based on the ratio between the actual CH- system and a 100% efficient CH-system ('ideal '). However, following the recommendations by prof. Oschatz we propose to use the Net Efficiency values (ratio between energy input and net heat load of the dwelling/ building)

Table 2.5. Lower efficiency class limits (except for G, where it is the highest class limit)

	XXS	XS	S	M	L	XL	XXL	3XL	4XL
A+++	52	62	72	86	98	112	128	140	152
A++	44	52	60	72	82	94	108	118	128
A+	36	42	48	58	66	76	88	96	104
A	32	37	42	51	58	67	78	85	92
B	28	32	36	44	50	58	68	74	80
C	24	27	30	37	42	49	58	63	68
D	20	22	24	30	34	40	48	52	56
E	16	17	18	23	26	31	38	41	44
F	12	12	12	16	18	22	28	30	32
G (startvalue)	**12**	**12**	**12**	**16**	**18**	**22**	**28**	**30**	**32**
class widths	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Base Case Task 6	27	27	23	26	33	30	30	52	49

Base Case ▪▪▪▪▪▪▪▪ **LLCC** —— **BAT** – –



2.8.3 Fiche

Apart from the label there will also be a “fiche”, which contains all the technical information and test results. The correct format for the fiche has to be elaborated in the process leading up to the legislation.

2.8.4 Coherence with EPBD and other legislation

As mentioned before, the mathematical validation in the Assessment Procedure is fully in line with the harmonised standards that are being prepared for a harmonised EPB approach. VHK has derived the common denominators from these standards (prEN 51316 series, etc.) and used them in the mathematical model. Only in some instances, e.g. where the standards left gaps, we have gone beyond what was in the standards. For instance we have anticipated that certain items like “summer comfort” that are in some new standards but not the older ones would be implemented throughout all standards. Also 3XL and 4XL performance classes introduced in the study, are not in EN standards.

The result is a mathematical model of water heating that is reasonably robust.

At this point, the question arises whether it would not be timely to “hand back” this mathematical model to CEN and now ask them to continue their work on this harmonised basis. The reason why we are proposing this, is because it appears that also the harmonisation work inside the EPB seems to be in a transitory phase: In three years time a large number of pre-standards have been produced that more or less contain all the know-how on installations that is in the national standards. However, this has as yet not resulted in a single harmonised system where all Member States agree on. In fact, several Member States in the so-called Paragraph 13 committee have proclaimed that they will (continue to) use their own national standards. Although they are of course perfectly in their right, it is no exactly what is in the spirit of the EPBD. In such a situation an outside influence, like the Eco-design legislation may help.

In that context we recommend not just to incorporate the bare minimum text required in the legislation concerning Eco-design measures, but also to include an Informative Annex that explains the modelling that is behind the measures. As it is then incorporated in legislation, it can easily be used as a reference for the EPB harmonisation.

In the same spirit it is recommended to expand on the general model in an Explanatory Memorandum that could incorporate not just the EU-average climate and building data, but also the national data that have been used and that will show policy makers in the Member States how such a single harmonised model would work out for their particular national circumstances.

2.8.5 Related Eco-design projects/ products

Apart from the EPBD we recommend that the mathematical model, expanded where necessary, shall be used a basis for preparatory studies and possibly measures for related products: Solid fuel s, Local Heaters, Space cooling, ventilation systems, etc..

Apart from the EPBD, we recommend that also Eco-design measures on a component level should benefit from the model, notably

- Indirect cylinders, other storage tanks (also for solar/ HP/etc.)
- Air/fuel mixers

- Solar collectors
- Heat pump components (compressor, controls, evaporator, condenser, etc.)

In particular the above components could each be subject to a separate A-G energy labelling system that of course has to be consistent with the overall water heater labelling scheme. Minimum targets can be considered in a preparatory study.

Less important (and perhaps more difficult to do) but worth considering:

- CPU (SMPS-level mandatory)
- Fans (e.g. permanent magnet DC fans mandatory)
- Fuel "transport" and preparation: Gas valves, oil pumps

The preparatory study for the components could be treated in one single study, because commercial and technical parameters are linked to the water heater.

- Task 1 (standards) would be unique, but still should always be seen as coherent with s
- Task 2 numbers commercial identical to water heaters.
- Task 3 (dwellings and infrastructure) → water heaters
- Task 4 (technical analysis)→ unique, but always linked to water heater
- Task 5 (BaseCase) → already given: pump 90 W + 1000 l/h, on/off thermostat, TRV 2K
- Task 6 (design options) → unique
- Task 7→ impact is already given in Integrated Model.

2.9 Timing

The following gives an overview:

- Labelling in place Jan. 2009 at the latest (part test, part model).
- MS promotion from Jan. 2009 (concurs with EPBD certificates and standards)
- Staged introduction of minimum standards (3 tiers):
- Jan. 2009/ 2011/ 2013 (31.12.2012)
- Minimum standards energy/carbon (system efficiency) and NOx. Preliminary standard for CO.
- Introduction of new test/emulation standard for CO, CxHy, PM, CH4 Jan. 2013
- Revision of labelling classes etc., completed Jan. 2013.
- Also minimum standards for CO, CxHy, PM, CH4 based on new standard, starting 2013.

2.10 Alternative policies

During the study in the past 18 months we have been confronted with several alternatives to the scenario we have recommended in the previous chapters. Here we would like to briefly present these alternatives and the reasons why we do not recommend them.

2.10.1 Minimum Targets Only

This scenario is based on an opinion that lateral policy measures are superfluous, because the minimum standard will in itself push away the bad solutions. No labelling, no promotion, no MS subsidies or other incentives, but just "tough" legislation. The expected effect of such a strategy is that it provokes defensive behaviour, delaying tactics, lack of understanding. It may create protests from consumer associations and those defending a real or perceived disadvantage for the lower income groups. And ultimately it will result in the realisation of only a part of the saving potential.

Keywords for a successful market transformation and transition are "trust", "responsibility" and "commitment" from all stakeholders. And a strategy of "mandatory targets only" may well be perceived as the opposite.

2.10.2 Labelling and Promotion Only

Alternatively, it could be decided that there is no need to set a mandatory minimum limit for energy efficiency and emissions: just labelling, subsidies and promotion (e.g. directly and through the EPBD) would be sufficient in this strategy.

What could be the effect of such a strategy can be seen e.g. from Switzerland, which has been highly successful in approaching home owners with its Minergie-approach. A high percentage of these home-owners and especially private builders have invested in insulation, heat pumps, etc.. At the same time however, this strategy has almost completely failed with regards to buildings where the home-owner (landlord, property manager, developer) is not the one paying the energy bill. For this considerable group the absolute height of the investment (the price of the installation) has been and still is the one and only selection criterion. And there has been no government willing to subsidize all the extra costs of an efficient installation over the very cheapest installation. As a consequence, the cheapest is always chosen. This is of course done at the expense of the –very often economically disadvantaged—families renting the apartments that have to pay the energy bill. There is of course the hope that energy certification and other measures (lower "all-in" rent) will convince the property owners that an efficient installation will also be to their benefit, but that is just hope....

Another segment of the building market where just "carrots and tambourines" can count on limited success is the segment of (semi-)public buildings, especially those at the local and regional level. Some of the oldest and most inefficient water heating installations around can be found in hospitals, homes for the elderly, sports facilities, prison buildings, etc.. Often the reason is that the budgets are very limited, tied to very specific cost items and items like a new water heating installation are not explicitly budgeted, but have to come from a total annual budget. This means that a new water heater has to be weighed against e.g. postponing the building of a new wing for the school, a new operating room in a hospital, etc.. And the current political reality is that the new, better almost never wins, so the investment is postponed until the is really beyond repair and the new will be the cheapest option available.

2.10.3 EPB Only

It has been claimed in the very beginning of the study that we don't need EU-wide measures because we have the EPBD and other promotional instruments on a national scale that will promote the introduction of the best water heater solutions in situations (and countries) where this is most appropriate. This is a tempting thought. And there is certainly some truth in it, because for new housing and renovations this will certainly be a big influence. However, it is not certain what this will mean for the biggest water heater market: i.e. the existing buildings. They represent 70% of the market in unit sales and even if the EU succeeds in finding common grounds also for regulating the existing buildings, it will never be as ambitious as for new houses. And even for new houses there is always a competition between building technologies, where for most contractors there is a higher profit margin in building more insulated walls than just buying a better (which is just a profit for the installer). Another consequence of national EPB standards regulating the market is the fact that currently most EPBs are different. This means that for each EU Member State the manufacturer has to develop a specific commercial strategy and most likely country-specific products. The production-series of the latter will be lower than for products that can be sold EU-wide and therefore the prices will be higher. This isn't to the advantage of the consumer, the manufacturer or ultimately the environment. In short, such a strategy is in contrast with the EU strategy for the development of an EU-market. Instead, the EU should strive for harmonised EPB standards that in each MS are in line with Eco-design measures for water heaters and vice versa.

The authors believe that any of the above strategies will lead to limited saving considerably lower than the economical potential. Furthermore, it has to be considered that –at least in part—some of these strategies are irreversible. Once a policy maker has gone down the path of "simplification", "just sticks", "just carrots" or "just tambourines" it will provoke a series of events and behaviours of stakeholders that will have a lasting effect in the future. Also in this sense we recommend the balanced approach in the previous paragraphs.

3 SCENARIOS

3.1 Introduction

Subtask 7.2 (Scenario Analysis) draws up the scenarios for 1990-2020 on the basis of policy measures indicated in Subtask 7.1. To this end, VHK extends the Analyses and Models in the previous Task Reports to make projections for 2010 and 2020 and a comparison with a Business-as-Usual (BaU) reference scenario.

Furthermore, VHK uses the ECOHOTWATER model for the environmental impacts and the Life Cycle Cost evaluation.

Subtask 7.2 comprises the following scenario's:

- **BaU** (Business-as-Usual) : Based on BRG sales projections in Task 2 report, trends in Task 3 report regarding the load, BaseCase (2005 sales) figures from the Task 5 report
- **Slow:** Implementation of targets 31.12.2014 and after that no improvement beyond LLCC level
- **Realistic** scenario: Staged introduction minimum targets. Final tier 31.12.2012. Labelling per 1.1.2009. Support by labelling, EPBD, ESD, financial incentives, green/white certificates, promotion etc. boosts efficiency by 3% annually over the 2009-2018 period. After that, the market is expected to stabilize.
- **Ambitious** scenario Measures as above. Efficiency-increase 5% annually 2009-2018. Continued efforts will lead to further increase of 2% annually also after 2018.
- **Amb + ER**: "Ambitious" plus Early Replacement of 3 mln. water heaters annually starting 2013.
- **NOx 20 ppm**: As "Amb+ER" plus emission limit value of 20 ppm for fossil-fuel fired water heaters not utilizing at least 10% renewables.
- **Freeze_2005**: Theoretical reference scenario. No technology change and technology market share changes since 2005. Only replacement effect.

Please note, that this subtask is based on modelling with the ECOHOTWATER model and the WH STOCK model, which are both added as separate "deliverables" for this subtask. (MS Excel files)

The underlying Word-report shows the highlights regarding the inputs and the conclusions. Numerical tables of the scenario outcomes are given in the Annex.

3.2 Base Case (avg. sales 2005)

The table on the next page summarizes the findings from the Task 5 report. It gives the 2005 sales figure **[part A]**, of 17,2 mln. units/a, subdivided by technology and by size-class.

The net load (60% of the tapping pattern) applicable to each size class, multiplied by the sales, is given in **[part B]**. This amounts to a total of 31.717 GWh/a for the BaseCase. For the scenario analysis especially the weighted average load per technology is important, because it will be used throughout the analysis.

[Part C] gives the estimated efficiencies, from the BaseCase with some minor correction (e.g. we have assumed that a significant portion of GIWH still uses pilot flames)

Table 3.1 . Calculation of annual primary energy consumption Base Case (avg. EU-25, sold in 2005)

A. Total sales EU-25 in '000 units in the year 2005

in '000 units	XXS	XS	S	M	L	XL	XXL	3XL	4XL	Total
COMBI				4619	130	73	40			4862
CYL				422,5	373,5	370,5	268,5	112	66	1613
SOL				100	149					249
GSWH				112	54	33	35			234
ESWH	964	482	482	1785	542	473	1179			5907
GIWH		133	133	*1418*	*165*					1849
EIWH H	224	1499	55	250						2028
EIWH E	49	43	41	268						401
Total	1237	2157	711	8975	1414	950	1523	112	66	**17143**

B. Net load in GWh/a (60% of tapping pattern * no. of units)

Net load kWh/a.unit	*461*	*461*	*461*	*1284*	*2559*	*4188*	*5387*	*10268*	*20537*		
total net load in GWh/a	**XXS**	**XS**	**S**	**M**	**L**	**XL**	**XXL**	**3XL**	**4XL**	**Total GWh/a**	**Average kWh/a**
COMBI			0	5.931	333	306	215			6.785	1395
CYL				542	956	1.552	1.446	1.150	1.355	7.002	4341
SOL				128	381					510	2047
GSWH				144	138	138	189			609	2601
ESWH	444	222	222	2.292	1.387	1.981	6.351			12.900	2184
GIWH		61	61	1.821	422					2.366	1279
EIWH	125	712	44	665						1.547	763
Total GWh/a	570	995	328	11.523	3.617	3.977	8.202	1.150	1.355	**31.717**	**1850**

C. Efficiency in % (primary energy, Gross Calorific Value)

in %	XXS	XS	S	M	L	XL	XXL	3XL	4XL	weight avg.*
COMBI			25%	38%	48%	52%	55%			40%
CYL				33%	42%	47%	50%	52%	49%	47%
SOL				50%	60%					57%
GSWH				17%	29%	37%	41%			32%
ESWH	25%	23%	21%	27%	27%	29%	30%			29%
GIWH		12%	25%	37%	44%					37%
EIWH	31%	30%	32%	35%						32%

D. Energy consumption in GWh/a (net load/ efficiency)

Sales	XXS	XS	S	M	L	XL	XXL	3XL	4XL	Total
COMBI			0	15.607	693	588	392			17.280
CYL				1.644	2.276	3.301	2.893	2.212	2.766	15.092
SOL				257	635					892
GSWH				846	477	374	460			2.156
ESWH	1.778	966	1.058	8.489	5.137	6.831	21.171			45.429
GIWH		511	245	4.921	960					6.637
EIWH	408	2.364	140	1.900						4.812
Total	**2.186**	**3.841**	**1.443**	**33.664**	**10.177**	**11.094**	**24.915**	**2.212**	**2.766**	**92.298**
Efficiency aggreg.	26%	26%	23%	34%	36%	36%	33%	52%	49%	34%

**=weighted for total net load in GWh/a, so taking into account both sales and load*

E. Energy consumption at LLCC targets (in MWh/a)

target	24%	27%	30%	44%	50%	58%	68%	74%	92%	**51%**
energy in GWh/a	2.374	3.686	1.093	26.189	7.234	6.856	12.061	1.554	1.473	**62.521**

[Part D] calculates the annual energy consumption of Water Heaters sold in 2005 from the above. In total this amounts to 92 TWh/a of primary energy. The overall efficiency is 32-33%.

The LLCC target level is given in **[Part E]** and amounts to 51% efficiency on average.

3.3 BaU-scenario

Table 3.2 gives the relevant data for the Business-as-Usual (BaU) scenario. It is based on the Task 2 and Task 5 reports and it is the starting point of the scenario analysis.

The WH_STOCK model takes into account the following effects in the BaU scenario:

- Negative effects 2005-2020: Increase in number of households (10-12%), increase comfort (8-10%; e.g. more and longer showers), increase in ownership (number of water heaters per households; currently 1,32and rising)
- Positive effects 2005-2020: Average efficiency increase through water heater park replacement in line with trend (5-7%)
- Overall effect 2005-2020: Ca. 18% increase.

In the WH_STOCK model these effects are calculated throughout the whole period (1990-2020) in the following ways:

- The **load effect** (more comfort) is controlled by a load factor ("LoadCor"), which is set at -0,5% annually. The pivot-point for this load factor is the "net load" value for the base year 2005 [see worksheet STOCK 1YR in model].
- The **efficiency effect** is given in Table 3.2, which is equivalent to worksheet STOCK 5YR. These values are used as anchor points for the respective years in the STOCK 1YR worksheet. The values are based on the following considerations:
  - The base year 2005 , where it is derived from the Base Case values as shown in Table 3.1 [from worksheet BASE CASE in spreadsheet]
  - Post-2005, where we assumed that most of the sales increase in absolute numbers came from LT combi-boilers, thus arriving at 36% efficiency for sales 2020 (from 34% in 2005).
  - Pre-2005, where we assumed an ever lower share of combi-boilers and a higher share of electric storage water heaters. Also efficiency levels per technology were adjusted as shown in Table 3.2.

- The **growth effect** of increasing number of households and ownership comes from the unit sales projections by BRG Consult in Task 2. But we did calibrate the "ProductLife" parameter and individual sales slightly to match sales and park data. Graph 3.1 gives the unit sales projections (from Task 2).

Please note that the efficiency figures in Table 3.2 [and worksheet STOCK 5YR] are averages per technology family, weighted for the loads and sales in the various size classes as indicated in Table 3.1 . In the worksheet STOCK 1YR , which is the actual stock model, there is no longer a differentiation between technology families but aggregate (average) efficiency figures are used, weighted for the sales of the technologies.

Table 3.2. BaU scenario data

year-->	1990	1995	2000	2005	2010	2015	2020
COMBI	2341	2873	4125	4865	4987	5484	5981
CYL	1577	1729	1635	1683	1846	1951	2056
SOL		103	170	249	543	730	916
GSWH	250	261	291	234	208	167	126
ESWH	5629	5450	5652	5905	5973	6134	6295
GIWH	2308	1929	1972	1849	1734	1615	1495
EIWH	1619	1970	2303	2430	2406	2458	2509
TOTAL *(incl. el. showers)*	**13724**	**14315**	**16147**	**17216**	**17698**	**18473**	**19248**
Weighted efficiency (for load and sales)							
COMBI	34%	35%	36%	40%	41%	42%	44%
CYL	42%	43%	44%	47%	47%	48%	49%
SOL	56%	56%	56%	57%	56%	56%	56%
GSWH	34%	35%	36%	32%	38%	39%	40%
ESWH	26%	26%	26%	29%	27%	28%	29%
GIWH	30%	30%	33%	37%	36%	38%	39%
EIWH	28%	29%	30%	32%	33%	33%	33%
Average net load in kWh/a							
COMBI	1395	1395	1395	1395	1395	1395	1395
CYL	4341	4341	4341	4341	4341	4341	4341
SOL	2047	2047	2047	2047	2047	2047	2047
GSWH	2601	2601	2601	2601	2601	2601	2601
ESWH	2184	2184	2184	2184	2184	2184	2184
GIWH	1279	1279	1279	1279	1279	1279	1279
EIWH	763	763	763	763	763	763	763
	1850	**1850**	**1850**	**1850**	**1850**	**1850**	**1850**
TWh primary/a							
COMBI	9,6	11,5	16,0	**17,1**	17,0	18,2	19,0
CYL	16,3	17,5	16,1	**15,5**	17,0	17,6	18,2
SOL	0,0	0,4	0,6	**0,9**	2,0	2,7	3,3
GSWH	1,9	1,9	2,1	**1,9**	1,4	1,1	0,8
ESWH	47,3	45,8	47,5	**45,2**	48,3	47,8	47,4
GIWH	9,8	8,2	7,6	**6,3**	6,2	5,5	4,9
EIWH	4,4	5,2	5,9	**5,7**	5,6	5,7	5,8
	89	**90**	**96**	**93**	**97**	**99**	**99**
Total in PJ	**322**	**325**	**345**	**334**	**351**	**355**	**358**
avg. kWh/a.unit	6511	6316	5934	**5386**	5507	5342	5167
avg. efficiency	28%	29%	31%	**34%**	34%	35%	36%

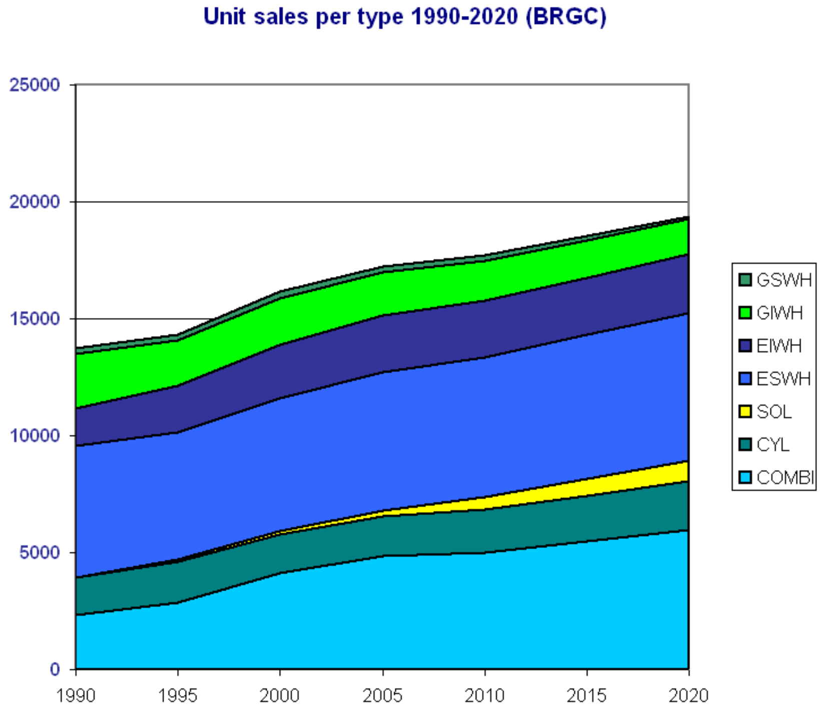


Fig. 3.1. Unit sales projections 1990-2025 BRG Consult (1990-2025)

3.4 WH_STOCK Model

3.4.1 Energy

All alternative scenarios in the WH_STOCK model are treated in the worksheet "STOCK 1YR". This sheet covers BRG **sales data** 1990-2020 for the BaU, as discussed in the previous paragraph, but also forward projections to 2025 and backward projections for 1970-1990 based on the extrapolation of 1990-2020 trends[17].

From the accumulation of historical sales data over the Product Life the **park data ("stock")** are built, indicating the number of water heaters installed in a particular year.

For most scenarios this is pretty straightforward. Only in an Early Replacement scenario "Amb+ER", there are extra sales due to an extra replacement of the oldest products on the market (15 years old in the model). The gain of this scenario comes from the difference in efficiency between the old and the new appliances. The relevant parameter is **"ER"** with a default setting of 0,2 years[18], which amounts to ca. 3 mln. extra water heaters sold annually.

Similarly to the park data, the **efficiency data** are given for each individual year . How this works for the BaU data 1990-2020 has been explained in the previous paragraph. Also here we made backward projections up to 2025 and backwards projections 1970-1990 for the BaU scenario.

[17] Note that when opening the WH_Stock model the columns 1970-1989 are hidden. Unhide to check if required.

[18] This means the model takes 20% of the sales of 15 years ago

Until 2009, the year in which the labeling and other lateral measures are introduced, the BaU-scenario applies to all alternative scenarios, except the "Freeze_2005" scenario, which freezes its efficiency numbers from 2005 onwards (but maintains BaU sales data). From 2008 the efficiency data start to differ between the scenarios. And for the "Amb+ER"scenario even the sales data start to differ, as ecplained before. We will discuss this later, after we have treated the general principles.

Once we have the efficiency data as well as the average **"net load"** (in kWh/a, see previous paragraphs), we can calculate the average **annual unit energy consumption** of a water heater sold in a particular year (in kWh/a).

Multiplying the unit energy consumption with the EU-sales in that year gives the total **sales energy consumption** of those sales (in TWh/a)

Accumulating the year energy consumptions over a number of years equal to the product life, we find the **stock energy consumption** of all water heaters in operation in a particular year. This is the base figure from which most impacts are derived and we therefore introduce at this point two correction factors:

- First there is what we call a **single-point correction**, which is due to the fact that the ownership rate is 132%, which means that in a number of households (max. 32%) the average heat load per household of 60 litres is divided over two or more (mostly single point) water heaters. In those cases, typically with single-point water heaters for all tapping points or one small single-point water heater in the smaller classes (XXS-XS-S) in the kitchen and a medium size (M) water for the bathroom, the net load per water heater is overestimated. By how much is difficult to say, but if we assume that all water heaters in the XXS-XS-S classes are "extra", then the net load would diminish by around 6-7%. Hence, we use a fixed correction factor of 0,93.

- Then there is the **correction for secondary dwellings**. Task 3 shows that 20% of the dwelling stock is made up by secondary dwellings, i.e. mostly used during weekends and/or holidays. The water heaters in these dwellings will be used at an estimated 20% of the normal rate, which means that the calculated stock energy consumption has to be corrected by around 16%. Hence we will use a correction factor of 0,84.

From the corrected stock energy consumption in TWh/a we now derive:

- Energy consumption in PJ/a (conversion 1 TWh= 3,6 PJ)

- Carbon emission in Mt CO2 equivalent/a, using a multiplier based on electricity and gas shares (see below) and the values from the EcoReport.

- Acidification emissions (e.g. NOx, SO2) in kt SOx equivalent/a, using a multiplier based on electricity and gas shares (see below) and the values from the EcoReport. For the "NOx 20 ppm" scenario we use half the values (EcoReport uses around 40 ppm) for the gas share starting from 2013 , with a linear extrapolation from the "old"2009 values.

- Energy expenditure in € bln./a in the "ECONOMICS" section, using an average energy price in €/kWh (see below).

3.4.2 Economics

In the **"Economics"** section of the spreadsheet, we try to calculate the total expenditure of EU-25 water heater users, i.e. the energy expenditure, maintenance costs and the purchase costs (=price + installation) for the EU in a particular year. The input values and methodology is the same as is used for the LCC-calculations in Tasks 5 and 6, but the difference is that we are using aggregated data.

In that sense, the **average energy price** in €/ kWh primary energy is built from

- Electricity, gas- and oil rates per kWh primary energy (!) in the base-year
- Annual (long-term) price rate increase of the individual energy sources
- Relative share of electricity, gas and oil employed for water heaters

The data for the two first sets of inputs can be found in the Task 5 report. The outcome for 2005 --for instance-- is tan aggregated energy rate for water heaters of € 0,053/ kWh. The average water heater energy price increase is around 4,4 %/a (over 6% for fuel, 2% for electric).

The last set of data, i.e. the relative share of electricity vs. gas [19], was estimated from the relative market share of technologies as given by BRG consult, but also taken into account that electric water heaters will the primary choice for secondary homes. In that sense an electricity share of 45% was estimated for 2005, coming down from ca. 60% in 1990 and going towards around 40% in 2010. After 2010 we assumed a constant share of 40%.

From the Task 5 Report we found for the aggregated **purchase price** € 575,- in the base year 2005 (product + installation, consumer price incl. VAT) at an aggregated efficiency level of 34%. The relevant parameter in the spreadsheet is "BasePrice". Using the Task 6 report we could also make an estimate that every 1% efficiency improvement resulted in a price increase (parameter "PriceInc") of € 22,-/%. With these two parameters we calculated the purchase costs in a particular year.

Finally, the **maintenance costs** were derived from the BaseCase with an (extra correction) of 2% in other years, because the average inflation rate in 1990-2005 was much higher than today.

From the above three data –and of course the sales, stock and energy consumption data—it was possible to make an estimate of the **total EU monetary expenditure on water heaters.**

Finally, as the customary unit is 2005 Euro, we had to correct the findings for inflation (2%) to find the **corrected EU expenditure.**

3.4.3 Accuracy

The model constitutes the best effort of the authors, based on the data available. Model outcomes, especially regarding carbon emissions, have been checked against the results of the preparatory study on the eco-design central-heating boilers (Lot 1) and the totals given by the latest outcomes of the EU GreenHouse Gas (GHG) Inventory 2005, issued by the European Environmental Agency (EEA, May 2007). ECCP figures were also taken into account, but here it was found that carbon emissions of electric water heaters were underestimated, mainly due to lack of data. Gas-fired water heaters were estimated roughly correct for 1990, but underestimated in the 2010 baseline.

Having said all that, it is unrealistic to expect a higher accuracy than ±5-10% from the model outcomes, especially for the projections of the monetary expenditure.

[19] Oil share negligible (set at 2% throughout)

3.5 Alternative Scenarios

The graphs in this section give the outcomes of the calculations for alternative scenarios (alternative to BaU). Numerical tables of the scenarios can be found in the Annex. Discussion of the main results is given below, whereby we use the annual carbon emissions in Mt CO2 equivalent (hereafter "Mt") as a main yardstick.

3.5.1 Freeze_2005

The **"Freeze_2005"** scenario is a theoretical reference, which freezes the efficiency numbers from the year 2005 for all future sales. There is still an efficiency improvement through park replacement (= historical improvements) for which it uses the BaU sales data, but no continuation of existing trends in technologies and market shifts. The comparison between the "BaU" and "Freeze_2005" shows projections of carbon and energy if e.g. all current measures and efforts for efficiency improvement would have stopped in 2005. The difference with BaU is small, around 10 Mt CO2 in 2025. A possible explanation is the impression that, apart from promoting solar water heating, the measures regarding improving the average conventional water heater have been very limited and therefore efficiencies in the 2025-park are projected to be only slightly worse than with BaU.

3.5.2 Slow

In the "Slow" scenario, the minimum target level is introduced 2 years later than in the "Realistic" scenario, i.e. by 31.12.2004 following a linear extrapolation from 2009 BaU data. Furthermore, after 2015 there is no efficiency improvement because there are no lateral measures. The effect in 2025 is a saving of 69 Mt with respect of BaU, which is a difference of 36 Mt with the Realistic scenario (150 vs. 186 Mt CO2= 24% more). Energy and acidification scenarios predict similar results. Consumer expenditure is projected to be € 10 bln. more in 2025 than with the "Realistic" scenario, but still € 23 bln. less than with Bau in that same year.

3.5.3 Realistic

In the Realistic scenario not only it is assumed between 2009 and 2013 the efficiency will move from the BaU level to the LLCC-target level, but also that starting 2012 there will be an additional efficiency improvement of 3% (parameter "RealGrow") until 2018, after which the market will stabilize (parameter "RealGrow2"=0%). This extra grow is due to lateral measures and account for the difference with the "Slow" scenario mentioned above. The 2025 carbon saving in 2025 is 105 Mt, which constitutes a saving of 40% with respect of BaU. (see chapter on impact analysis for more evaluation).

3.5.4 Ambitious

In the Ambitious scenario is similar to the Realistic scenario, but the additional efficiency improvement in 2012-2018 is 5% annually (parameter "AmbGrow"). After 2018 the improvement continues albeit at a lower level of 2% (parameter "AmbGrow2"). In 2025 the saving is 128 Mt with respect of BaU and 23 Mt with respect of the Realistic scenario.

3.5.5 Amb + ER

The most ambitious carbon saving scenario enhances the Ambitious scenario by adding also an Early Replacement strategy whereby starting 2013 around 3 mln. water heaters extra are sold (16-17% sales increase) as replacement sales (e.g. sales schemes where old water heater is recollected).

3.5.6 NOx 20 ppm

This scenario builds on the "Amb+ER" scenario in a sense that it also introduces an emission limit value of 20 ppm for gas-fired appliances. Because only roughly half of the water heaters are gas-fired, the extra effect of this saving may be slightly disappointing, because in 2025 only some 10 kt SO2 equivalent (14 kt NOx) is saved with respect of "Amb + ER". The reason is, that in fact most acidification emissions (SO2, NOx) come from the power plants driving the electric water heaters. The share of gas-fired heaters in the total is relatively small and therefore also the savings are small. Having said that, the EcoReport emission value (from the GEWIS data base) are very optimistic for water heaters: ca. 40 ppm. In reality these mostly atmospheric appliances might have emissions 2 to 3 times higher and thereby also the saving could be 2 to 3 times higher.

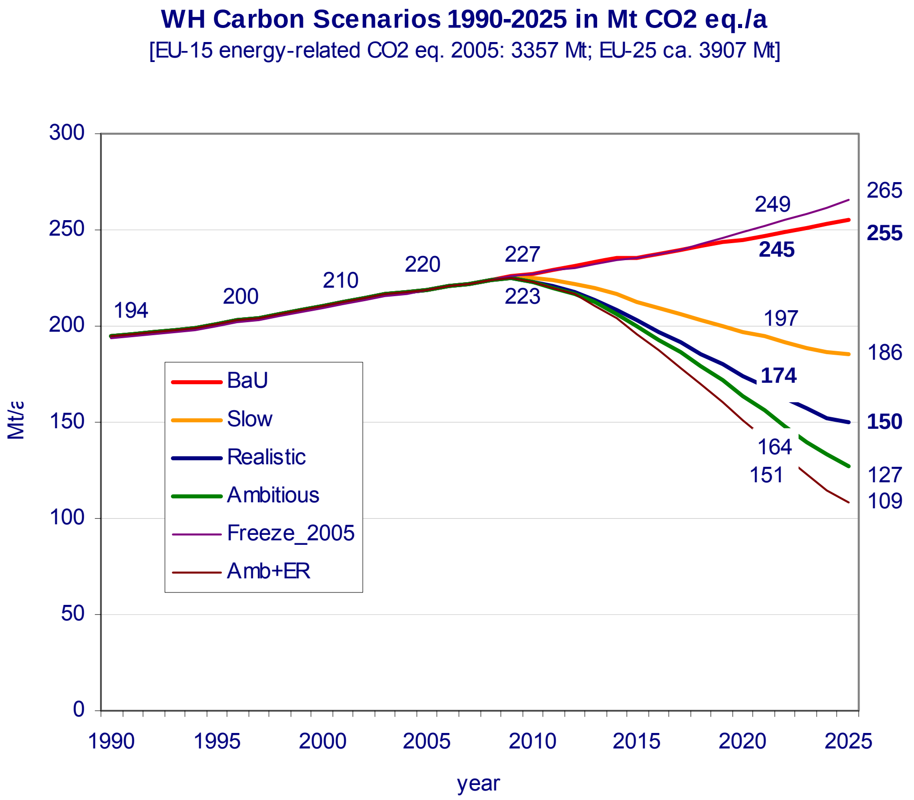


Fig. 3.2. Carbon scenarios for Water Heating. In a "Realistic" scenario the saving vs. Business-as-Usual is 245-174= 71 Mt CO2 equivalent in 2020. In 2025 this saving is projected to be 105 Mt. The most ambitious scenario, involving Early Replacement (Amb+ER), can be ca. 145 Mt.

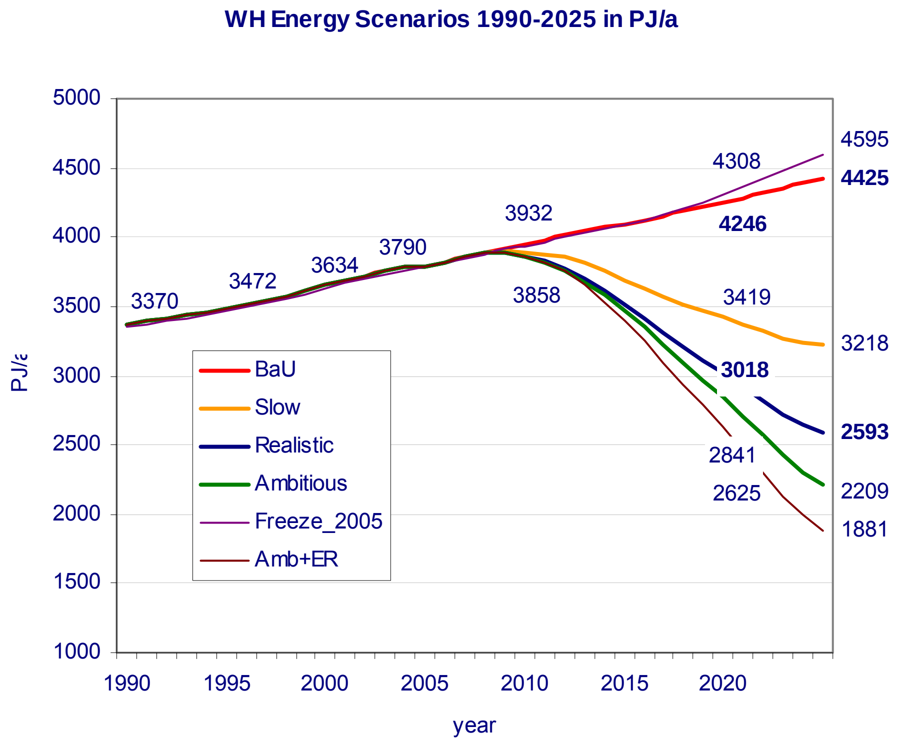


Fig. 3.3. Energy scenarios for Water Heating. In a realistic scenario the saving vs. Business-as-Usual is 1267 PJ/a in 2020. In 2025 this saving is projected to be 1883 PJ/a. Conversion to mtoe: 1 mtoe = 41,87 - 44 PJ (depending on Net Calorific Value - Gross Calorific Value as a base; the study uses GCV).

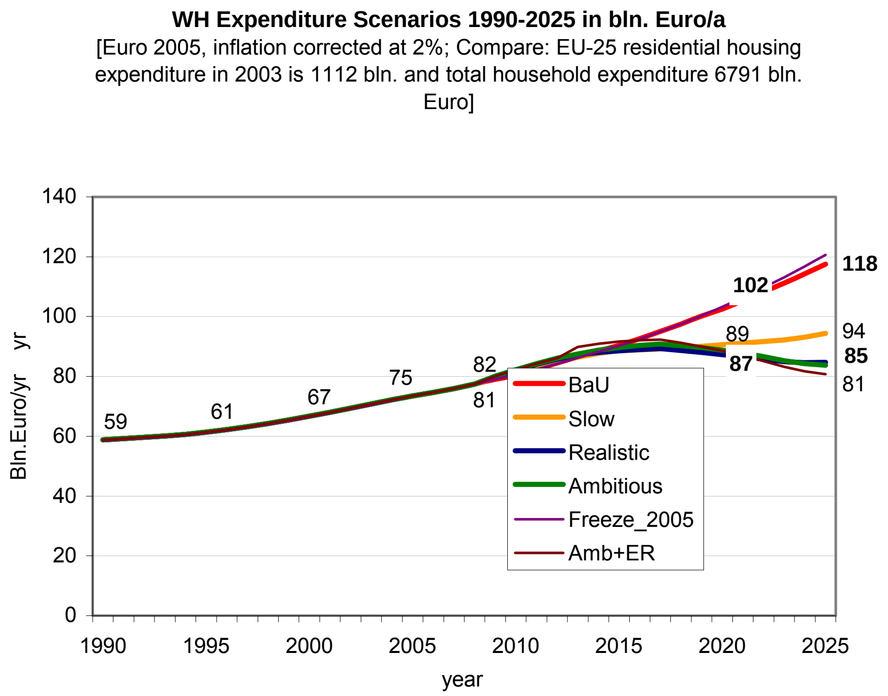


Fig. 3.4. Expenditure scenarios for Water Heating. In a realistic scenario the saving vs. Business-as-Usual is € 15 bln. in 2020. In 2025 this saving is projected to be € 33 bln. (consumer rates). Based on € 0,053 per kWh primary in the 2005-mix, as well as 6% fuel price and 2% electricity price increase per year.

WH Acidification Scenarios 1990-2025 in kt SOx eq./a

[EU-15 total in 2005: 10.945 kt SOx equivalent, from 9015 kt Nox (*0,7) and 4635 kt SO2]]

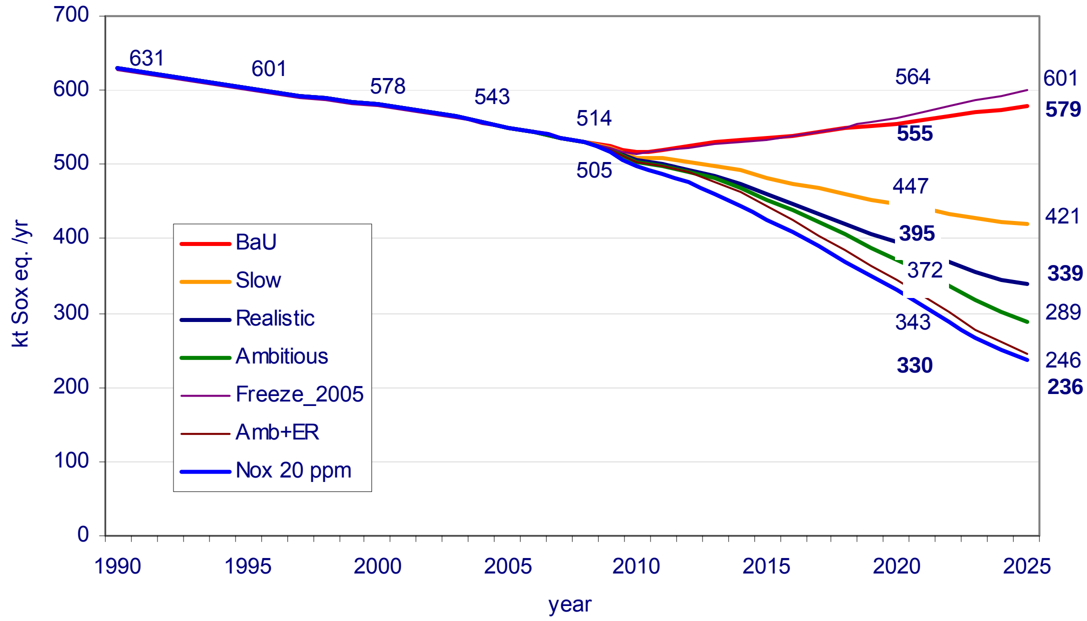


Fig. 3.5. Acidification-related emissions scenarios for Water Heating.

4 IMPACT ANALYSIS

4.1 Introduction

Subtask 7.3 makes an estimate of the impact on consumers and industry, explicitly describing and taking into account the typical design cycle (platform change) in a product sector.

The impact analysis has played a role throughout Tasks 1 to 4 and it has been discussed with expert group.

This chapter merely highlights the outcomes.

4.2 Economic impacts at LLCC-target levels:

- Purchase price (product + installation) will rise from € 575 to € 949 (+€ 374) .
- LCC will drop almost 15%, e.g. from ca. € 4.600 to € 3.900 per system M-size.
- Simple payback period 7,5 years on average. Discounted Payback period 6-7 years (M-class).

4.3 Technology impacts at LLCC-target levels:

- No fuel technology bans apply. The table on the next page gives an overview of the design options and base case options from the Task 6 report, but now ranked in the labeling classes from Chapter 2. **This overview is an illustration. It is by no means prescriptive and by no means complete: in reality all families cover a wide range of index and size-classes. But still, it gives a first impression of possible impacts.**
- In the smallest size-classes (XXS-XS-S) the table shows top-scores for electronic ally controlled EIWHs (electric instantaneous water heaters). ESWHs (electric storage water heaters) with smart control and good insulation can come close. Lowest scores are for GIWHs (gas instantaneous) with a pilot flame. Room-sealed GIWHs with waterturbine-ignition or electronic ignition may have high score e.g. in the S-size, but with a considerable price penalty.
- In the M-L-XL size the gas appliances are dominant in the mid/high section. Devices are electronic GIWHs, smart control and room-sealed GSWHs (gas storage), gas-fired (condensing) combi's and s with indirect cylinders. Note that a smart control may be at least as important as being condensing or non-condensing. Known solar-assisted gas-fired water heaters will have the best efficiency of the "gas-family". The very best –not yet available—in the larger size would be a Gas absorption heat pump.
- Conventional electric devices without renewables (ESWHs, EIWHs) are in the lowest efficiency-classes. For the M-class, some electric devices can "survive" the LLCC target level if they are solar-assisted. For the L and XL overall this will not be the case. The strongest competitor for the gas appliances, with the highest efficiency, will be electric (ventilation) air-based water heaters where we believe considerable cost-reductions are possible at volume production.

Table 4.1 . Illustration of some technologies: Indicative index and size classes

Class	XXS	XS	S	M	L	XL	XXL	3XL	4XL
A+++	52	62	72	86	98	112	128	140	152
				AHP 3,5	AHP 3,5	AHP 3,8	GSHP	GSHP	GSHP
A++	44	52	60	72	82	94	108	118	128
				AHP 3	AHP 3	AHP 3,3	AHP 3,6		GSHP
A+	36	42	48	58	66	76	88	96	104
	EIWH E 8	EIWH E 8			COMB Scd	GAHP 1,4	GAHP 1,4	AHP 3,6	GSHP
A	32	37	42	51	58	67	78	85	92
	EIWH H 8	EIWH H 8		AHP 2,5 COMB Scd GIWH 21 E	GIWH 40 I	COMBI Scd SOLGAS 6	SOLGAS 10	GAHP 1,4 SOLGAS 25	AHP 3,6 SOLGAS 50
B	28	32	36	44	50	58	68	74	80
	BC	BC	GIWH 18E	SOLES 3 COMB LT	SOLGAS 3 COMB LT		SOLGAS 6		
C	24	27	30	37	42	49	58	63	68
	ESWH 10	ESWH 20	GIWH 18 I BC EIWH 18E ESWH 30sc	EIWH 23E	GSWH sm	GSWH sm SOLEI 6 CYL 150	COMB cd CYL 250 SOLEI 10		
D	20	22	24	30	34	40	48	52	56
			EIWH 18H	BC	SOLEI 3			SOLEI 25	
E	16	17	18	23	26	31	38	41	44
			ESWH 30	ESWH 80	BC GSWH P	GSWH P	SOLEI 6 GSWH P	GSWH P	GSWH P
F	12	12	12	16	18	22	28	30	32
			GIWH 18 P	GSWH 80 P	ESWH 80	BC ESWH 150	BC ESWH 250	BC	BC
G	<12	<12	<12	16	18	22	28	30	32
				GIWH 21 P					

Legend: Blue cells= electric; Green cells=gas-fired; White cells=BaseCase (mixed); **BC**=Base Case; **GIWH**=Gas Instantaneous + value (kW) + letter (P=pilot flame; I=water-tubine ignition; E=electronic); **GSWH**=Gas Storage + value (ltr. Tank)+ letter (P=pilot flame; sm=electronic, smart control); **ESWH**=electric storage + value(ltr. Tank)+ letter (sc=smart control; no letter=standard); **EIWH**=electric instantaneous + value (kW) + letter (H=hydraulic control; E= electronic); **SOLES**= solar-assisted electric storage + value (collector area); **SOLEI**= solar assisted electric instan-Taneous + value (collector area); **SOLGAS**=solar assisted gas-fired + value (collector area); **CYL**= LT and indirect cylinder + value (ltr. Tank); **COMB LT**= instantaneous LT gas combi-; **COMB cd**= condensing gas with small smart control storage; **AHP**= electric (ventilation) air heat pump + value (COP); **GAHP**=Gas-fired absorption heat pump + value (COP); **GSHP**= electric ground source heat pump (water/water).

- The large sizes XXL, 3XL and 4XL represent the collective residential water heaters and the large non-residential water heating installations (hospitals, swimming pools, sports facilities, etc.). These sectors are currently dominated by the large storage water heaters and indirect cylinders (>250 litre tanks) as stand alone or in cascades. Yet, these current solutions have moderate scores and with the implementation of the minimum LLCC target at A-level, the table shows that the use of renewables (solar+gas, heat pumps) will become a necessity. The highest score is for the vertical ground source heat pumps with COPs of 4-5 upwards. Followed by gas-fired heat pumps and solar installations with fossil-fuel fired back-up.

4.4 Stakeholder impacts at LLCC targets

Positive impacts on stakeholders:

- Innovative manufacturers can capitalize on current and past R&D efforts, profit from a more unified internal market and harmonized rule-making. They can increase their global competitiveness, because the quality of their leading-edge technology can now be "proven" with objective yardsticks and compliance with tough rule-making ,
- Installers, where especially the small installer will benefit from the shift of the system design towards manufacturers, enabling them to play their role, for intermediaries (whole-sellers, etc.) because of higher income but also because again the shift of system-design responsibility will save on costs for technical know-how and stock,
- Low-income groups in rented apartments and houses who can expect a noticeable drop in housing costs,
- Medium- and high-income groups –who would have chosen the most economical and –in part—the most ecological system anyway—the options become more transparent and the chances increase on proper installations (and thereby realizing the projected saving also in practice),
- For builders and specifiers the same applies: options become more transparent and the chances of proper installations increase.
- For building inspectors and other local housing organizations compliance checks will become simpler (especially also with labeling and integration with the EPBD requirements),
- Central governments in Member States –especially NMS—will have a robust handle in realizing environmental targets and a robust basis for market surveillance.
- The EU as a whole will have an instrument for targets relating to trade (internal market and global competitiveness), environment (Kyoto, Gothenburg, etc.), energy and security of supply as well as the on innovation (Lisbon).

Negative stakeholder impacts or at least for those that will perceive the targets as a "mixed blessing" in the short term:

- Utilities and tax offices will see their revenues from energy sales to the residential sector drop by 7-8% and their income from the tertiary sector drop by around 5%. This will take place over a long period (2009-2025) and is usually compensated by energy rate increases and/or an increase in energy demand from other products/ sectors in that same period. Furthermore, both utilities and governments have long recognized energy saving ("negawatts") to be A Good Thing. And pushing for high energy volume sales is not the most advantageous strategy. In fact, utilities may become one of the strongest advocates of the most efficient heating water heaters, especially if it is linked to lateral measures like the "white certificates" or the "green certificates".

- Manufacturers and OEMs, who derive their competitive edge from local regulations and circumstances and are (no longer) equipped to innovate. For these groups R&D support on a national scale may be adequate.
- Some test houses that derive their competitive edge solely from knowledge of the local circumstances and rule-making, may experience harmonized measures as a threat. On the other hand, the increased necessity of testing for CE-marking and market surveillance will also create new opportunities.
- Water heating installations are usually the last item in the building process and it is tempting to cut some budgetary corners with a cheap installation to stay within budget. For those builders and contractors that are engaged in this practice, it will become impossible at least below a certain minimum level. On the long run, helped by information campaign and an adequate transition period, this 'problem' will solve itself. This budget-item will be easily explainable to clients and there is a level playing field for all builders.
- The extra construction costs (=price increase) of new dwellings and buildings will be between 0,1 and 0,4% of the total. However, if the building has to meet the EPB standards anyway, this is not really an extra cost but rather a part of the minimum EPB requirements for the building as a whole. For private house purchaser the price increase is not believed to be disruptive for obtaining financing, especially as more and more financial institutions look at sustainability issues, energy certificates, etc. as a factor in the value of real estate and an extra argument to facilitate loans.
- For landlords having to replace the water heating system(s) in a collective apartment building or a commercial office building the investment costs will go up, while the economical benefits (lower running costs) will go to the tenants especially if --as is the case in most countries—the maximum annual increase of the rent is state-regulated. On the other hand, there are several trends whereby the governments (and building corporations) are looking no more at just the rent of the apartment and social housing, but at the total housing costs (rent+energy+other) and allowing special provisions.
- Some insulation manufacturers and suppliers of other installation components may not be entirely happy in the beginning. Minimum targets and labeling for CH- systems will clearly put in evidence the energy saving effect of efficient s vis-à-vis other saving measures . And because the builder can "spend his/her money only once", they may fear that the builder may save on insulation measures and low-E windows. We expect that this fear will be short-lived, because experience from countries where e.g. condensing water heaters are the standard product (NL, UK) shows that all building measures, including insulation, benefit from a heightened awareness of the saving potential in the building sector.
- With the need of Third Party testing, the testing costs will go up. However, the effect will be very limited and the experts have indicated that this is an acceptable price to pay for a "level playing field", especially for SMEs that might find themselves in a disadvantage if the system would rely solely on self-declaration. Testing costs of a full tapping pattern test are around € 2.500,- to € 3000,- . For solar-assisted and heat pump installations it would be some 50% more. For gas-fired water heater manufacturers, where external testing is already mandatory, these costs constitute less than 3-4% of R&D costs. The R&D costs in turn are around 3-4% of the product price, so the overall effect on the price will be negligible (around 0,1-0,2% more).

5 SENSITIVITY ANALYSIS

Subtask 7.4 studies the robustness of the outcome in a sensitivity analysis of the main parameters, changing energy prices, interest rates, etc.. (as described in Annex II of the Directive) . For this we have used the ECOHOTWATER model, which differentiates climate, building and environmental parameters for 25 EU Member States. The results from this analysis are discussed in paragraph 7.2.

But basically, the sensitivity analysis has played a role from the very beginning of the study and has been a guiding principle throughout much of the Tasks 1 to 4. This is discussed in paragraph 5.3

The sensitivity analysis is conducted for six countries, representing a range in climates, energy costs and general costs (country price multiplier).

Table 5-1: Countries included in sensitivity analysis

	Climate	Energy costs		Country price multiplier
		Gas	Electric	
Malta	warmest		low	low 0.8
Estonia	cold	lowest	lowest	very low 0.7
Italy	warm	high	high	low 0.85
Finland	coldest			very high 1.55
Denmark	northern sea	highest	highest	highest 2.2
Poland	land	low		lowest 0.5

5.1 Sensitivity LLCC-targets

The graph below shows the Life Cycle Cost curves for the design options identified in Task 6 for the M-size. The LLCC-efficiency target is at around 38 to 44% .

- The first conclusion is that the absolute value of the LLCC point varies by 135% of the minimum: from € 2826,- for Poland (low energy prices and labour costs) to € 3832,- for Denmark (high energy prices, high labour costs).
- The second conclusion is that the shape of the curves are largely identical, i.e. the design options with lowest costs are the same for these countries. The largest deviations can be found with solar-assisted and heat pump solutions. Especially the ground source heat pump is sensitive to local prices.

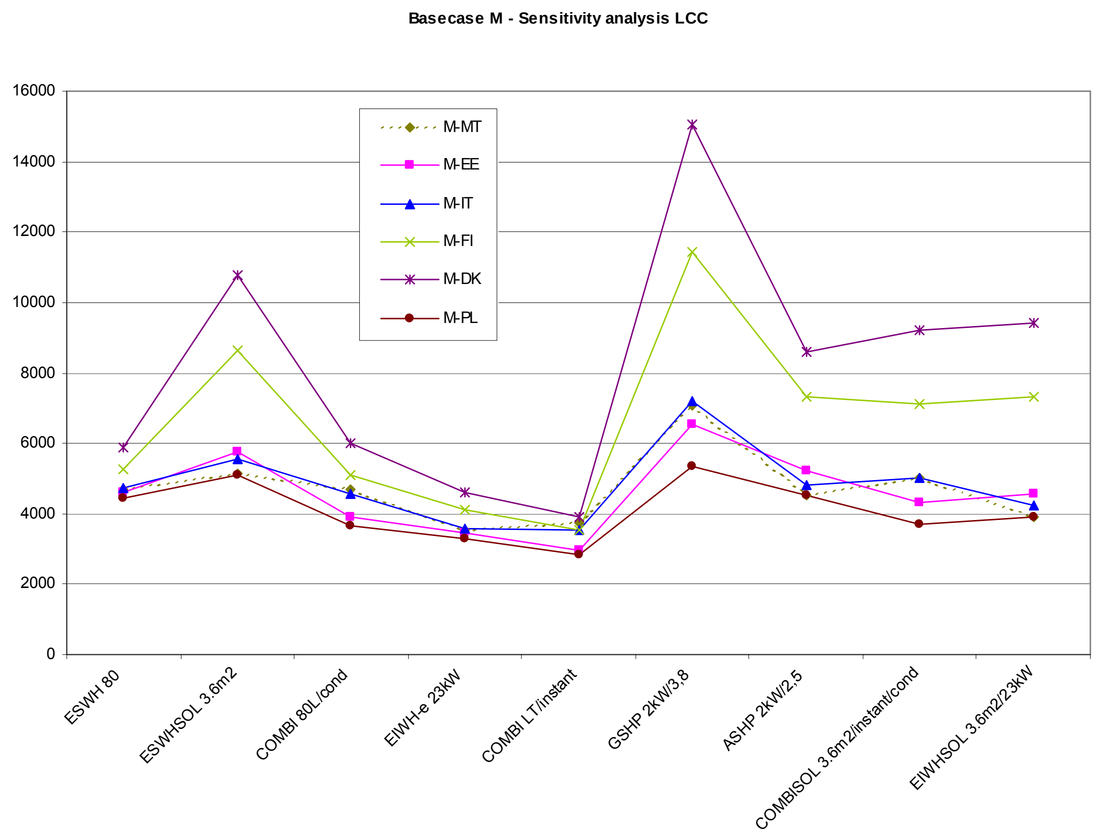


Figure 5-1: Water heater LCC in various countries

Table 5-2 : Overview LLCC's for nine options in six selected countries

LCC	ESWH 80	ESWHSOL 3.6m2	COMBI 80L/cond	EIWH-e 23kW	COMBI LT/instant	GSHP 2kW/3,8	ASHP 2kW/2,5	COMBISOL 3.6m2/ instant/cond	EIWHSOL 3.6m2/23k W
MT	4679	5155	4701	3525	3728	7088	4528	5017	3900
EE	4594	5762	3908	3448	2952	6547	5231	4314	4554
IT	4722	5554	4554	3563	3525	7209	4806	5022	4217
FI	5245	8625	5112	4096	3525	11418	7330	7116	7339
DK	5880	10784	5988	4592	3917	15054	8584	9210	9438
PL	4422	5096	3650	3296	2845	5360	4512	3684	3907

- Purchase prices are based on worst-case scenario, i.e. countries where condensing water heaters are currently a niche market. For more competitive condensing markets the price increase will be considerably less and payback times considerably more favorable.
- Energy rates are based on average long-term annual price increases over the period 2000-2006 (5-6% for gas, 8-9% for oil, 1,5-2% for electric). If we take the most recent annual price increases as an input --between 1.1.2005 and 1.1.2006-- the annual price increase is more than double (16% for gas, 32% for heating oil, 4,6% for electricity), which would more than half the pay-back times.
- Doubling inflation (now set at 2%) to 4% will also reduce the pay-back time, but will in practice be counterbalanced by an increase in interest rates (now set at 4%) which will offset this effect.
- Combining the effects above, the discounted payback time for LLCC-targets would drop from an average 6-7 years to around 1,5-2 years.
- The next step in design improvement -after the LLCC-point- will most likely require at least heat pump technology (electric or gas-fired) possibly with add-on

solar assistance and will show a wider spread because the technology is more climate-dependent.

As an illustration of that last point the graph below shows the efficiency of three renewable options in the L-size for selected EU Member States. Please note that the air-based heat pump (AHP) mainly uses ventilation air (20 oC) and for that reason the differences are small. For the solar-assisted gas-fired water heater (GIWHSOL) the variation is between 58% (DK, FIN, EE) and 78% (MT). For the electric solar-assisted water heater the range varies between 32% and 41%.

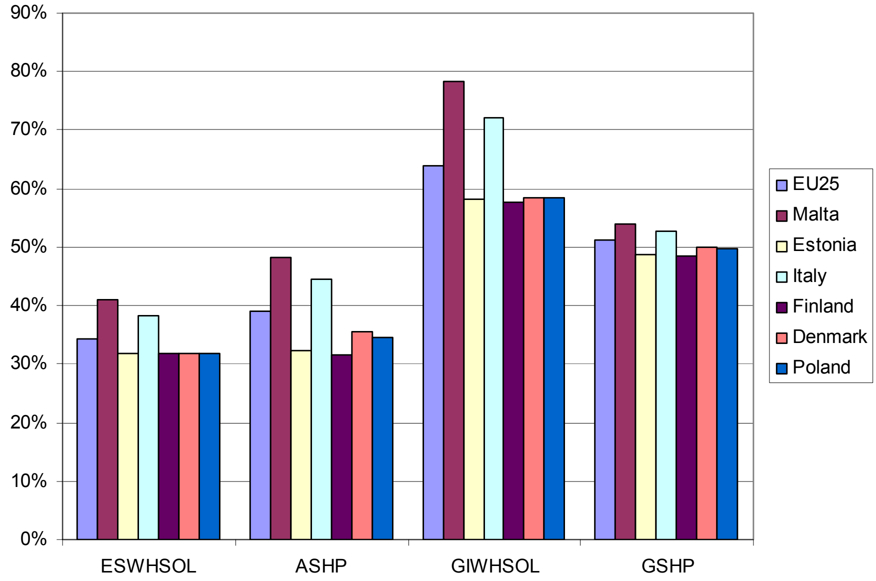


Figure 5-2: System efficiencies of renewable options for six countries

This Task Report shows only a limited number of sensitivity analysis options. The ECOHOTWATER model, which is a deliverable of this study, includes the climate data of all EU-25 capitals and therefore allows a much wider array of options for sensitivity analysis.

ANNEX

Scenario Tables

WH_STOCK

Table A1. WH STOCK Environmental

	1990	1995	2000	2005	2010	2013	2015	2020	2025
net load (kWh/a)	1716	1760	1804	1850	1897	1925	1945	1994	2044
sales (000)	13724	14315	16147	17216	17698	18163	18473	19248	20023
park (000)	218348	227821	241222	258744	277051	287882	294211	307249	319370
Extra ER sales 2013 onwards						3083	3229	3443	3540
Efficiency									
Freeze_2005	28%	29%	31%	34%	34%	34%	34%	34%	34%
BaU	28%	29%	31%	34%	34%	34%	35%	36%	37%
Slow	28%	29%	31%	34%	39%	46%	51%	51%	51%
Realistic	28%	29%	31%	34%	42%	54%	60%	66%	66%
Ambitious	28%	29%	31%	34%	43%	56%	66%	82%	92%
kWh/a.unit									
Freeze_2005	6039	6316	5934	5386	5522	5605	5661	5804	5951
BaU	6511	6316	5934	5386	5507	5626	5342	5167	5524
Slow	6511	6316	5934	5386	4900	4193	3833	3930	4029
Realistic	6511	6316	5934	5386	4534	3583	3256	3033	3110
Ambitious	6511	6316	5934	5386	4449	3455	2958	2439	2228
TWh primary/a									
Freeze_2005	83	90	96	93	98	102	105	112	119
BaU	89	90	96	93	97	102	99	99	111
Slow	89	90	96	93	87	76	71	76	81
Realistic	89	90	96	93	80	65	60	58	62
Ambitious	89	90	96	93	79	63	55	47	45
	89	90	96	93	79	54	46	36	39
Sales year energy									
Without correction									
Freeze_2005	931	965	1010	1053	1092	1119	1135	1197	1276
BaU	936	970	1015	1053	1095	1124	1135	1179	1229
Slow	936	970	1015	1053	1082	1059	1025	950	894
Realistic	936	970	1015	1053	1074	1028	977	838	720
Ambitious	936	970	1015	1053	1072	1021	963	789	614
Amb+ER	936	970	1015	1053	1072	1014	942	729	522
Stock energy in TWh/a									
WITH CORRECTION									
Freeze_2005	3352	3472	3634	3790	3932	4029	4085	4308	4595
BaU	3370	3491	3653	3790	3943	4048	4087	4246	4425
Slow	3370	3491	3653	3790	3894	3813	3690	3419	3218
Realistic	3370	3491	3653	3790	3865	3701	3518	3018	2593
Ambitious	3370	3491	3653	3790	3858	3676	3466	2841	2209
Amb+ER	3370	3491	3653	3790	3858	3652	3392	2625	1881
CO2 in Mt (1 PJ= 0,0577 Mt)									
Freeze_2005	193	200	210	219	227	232	236	249	265
BaU	194	201	211	219	228	234	236	245	255
Slow	194	201	211	219	225	220	213	197	186
Realistic	194	201	211	219	223	214	203	174	150
Ambitious	194	201	211	219	223	212	200	164	127
Amb+ER	194	201	211	219	223	211	196	151	109
Acidification (in kt Sox equivalent; gas 60 mg/kWh; oil 310 mg/kWh)									
Freeze_2005	628	601	578	549	514	527	534	564	601
BaU	631	604	581	549	516	530	535	555	579
Slow	631	604	581	549	509	499	483	447	421
Realistic	631	604	581	549	506	484	460	395	339
Ambitious	631	604	581	549	505	481	453	372	289
Amb+ER	631	604	581	549	505	478	444	343	246
Nox 20 ppm	631	604	581	549	497	459	427	330	236

Table A2. WH STOCK Economics

		1990	1995	2000	2005	2010	2013	2015	2020	2025
Oil share		2%	2%	2%	2%	2%	2%	2%	2%	2%
Oil price		0,019	0,028	0,041	0,061	0,090	0,115	0,134	0,199	0,295
Gas price		0,021	0,027	0,036	0,047	0,062	0,073	0,081	0,106	0,140
El price		0,045	0,049	0,054	0,060	0,066	0,070	0,073	0,081	0,089
Maintenance		22	25	27	30	33	35	37	40	45
Share electricity										
Freeze_2005		60,0%	55,0%	50,0%	45,0%	40,0%	40,0%	40,0%	40,0%	40,0%
BaU		60,0%	55,0%	50,0%	45,0%	40,0%	40,0%	40,0%	40,0%	40,0%
Slow		60,0%	55,0%	50,0%	45,0%	40,0%	40,0%	40,0%	40,0%	40,0%
Realistic		60,0%	55,0%	50,0%	45,0%	40,0%	40,0%	40,0%	40,0%	40,0%
Ambitious		60,0%	55,0%	50,0%	45,0%	40,0%	40,0%	40,0%	40,0%	40,0%
Amb+ER		60,0%	55,0%	50,0%	45,0%	40,0%	40,0%	40,0%	40,0%	40,0%
Avg. Fuel price										
Freeze_2005		0,04	0,04	0,05	0,053	0,06	0,07	0,08	0,10	0,12
BaU		0,04	0,04	0,05	0,05	0,06	0,07	0,08	0,10	0,12
Slow		0,04	0,04	0,05	0,05	0,06	0,07	0,08	0,10	0,12
Realistic		0,04	0,04	0,05	0,05	0,06	0,07	0,08	0,10	0,12
Ambitious		0,04	0,04	0,05	0,05	0,06	0,07	0,08	0,10	0,12
Amb+ER		0,04	0,04	0,05	0,05	0,06	0,07	0,08	0,10	0,12
Avg. Price (incl. install)										
Freeze_2005		443	463	504	574	574	574	574	574	574
BaU		443	463	504	574	557	571	580	606	632
Slow		443	463	504	574	670	828	934	934	934
Realistic		443	463	504	574	738	1000	1132	1264	1264
Ambitious		443	463	504	574	756	1044	1264	1616	1836
Amb+ER		443	463	504	574	756	1044	1264	1616	1836
Avg. Energy costs Eur/a.unit (not corrected)										
Freeze_2005		212	248	268	285	353	405	445	565	722
BaU		228	248	268	285	352	406	419	503	671
Slow		228	248	268	285	313	303	301	382	489
Realistic		228	248	268	285	290	259	256	295	377
Ambitious		228	248	268	285	284	250	232	237	270
Total purchase costs EU per annum										
Freeze_2005	mln. Eur	6.085	6.623	8.140	9.881	10.157	10.424	10.602	11.047	11.492
BaU		6.085	6.623	8.140	9.881	9.863	10.372	10.718	11.663	12.659
Slow		6.085	6.623	8.140	9.881	11.853	15.047	17.259	17.983	18.707
Realistic		6.085	6.623	8.140	9.881	13.069	18.168	20.916	24.334	25.314
Ambitious		6.085	6.623	8.140	9.881	13.381	18.967	23.355	31.110	36.767
							22.186	27.437	36.675	43.267
Total running costs (energy+maint)										
Freeze_2005	mln. Eur	37.457	43.532	52.094	63.567	78.942	90.947	99.852	128.798	169.177
BaU		37.634	43.731	52.322	63.567	79.142	91.342	99.905	127.117	163.421
Slow		37.634	43.731	52.322	63.567	78.260	86.616	91.243	104.782	122.723
Realistic		37.634	43.731	52.322	63.567	77.749	84.374	87.484	93.938	101.653
Ambitious		37.634	43.731	52.322	63.567	77.628	83.876	86.354	89.171	88.728
Amb+ER		37.634	43.731	52.322	63.567	77.628	83.396	84.749	83.338	77.653
Total consumer expenditure										
Freeze_2005	**mln. Eur**	43.542	50.155	60.234	73.448	89.099	101.371	110.454	139.845	180.669
BaU		43.719	50.354	60.462	73.448	89.005	101.714	110.624	138.781	176.079
Slow		43.719	50.354	60.462	73.448	90.114	101.663	108.501	122.765	141.430
Realistic		43.719	50.354	60.462	73.448	90.818	102.541	108.400	118.272	126.967
Ambitious		43.719	50.354	60.462	73.448	91.009	102.843	109.709	120.281	125.495
Amb+ER		43.719	50.354	60.462	73.448	91.009	105.582	112.186	120.012	120.920
Consumer expenditure corrected for inflation (EU 2005)										
Freeze_2005	**bln. Eur**	59	61	67	73	81	86	90	103	121
BaU		59	61	67	73	80	87	90	102	118
Slow		59	61	67	73	81	86	89	91	94
Realistic		59	61	67	73	82	87	89	87	85
Ambitious		59	61	67	73	82	87	90	89	84
Amb+ER		59	61	67	73	82	90	92	89	81