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Lot 15

Solid fuel small combustion installations

Task 8: Policy Implementation

Final Report

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8. Task 8 – Scenario, Policy, Impact and Sensitivity Analysis

The objective of Task 8 is to analyse the results of the lot 15 preparatory study in the overall policy context of the EU.

Impact scenarios for the reference years 2010, 2015, 2020 and 2025 are developed to quantify the improvements that can be achieved through the implementation of different options versus a Business-As-Usual scenario.

This is followed by a brief policy analysis including an overview of the existing voluntary and mandatory programs existing in the EU and overseas that have been developed to promote the energy efficiency of solid fuel SCIs.

Finally, the main results of the study are evaluated using a sensitivity analysis to assess the error margins linked to the input data uncertainty.

It has to be kept in mind that the conclusions drawn here are preliminary and represent solely the view of the consortium and they do not reflect the opinion of the European Commission in any way. Unlike task 1-7 reports, which will serve as the baseline data for the future work (impact assessment, further discussions in the consultation forum, and development of implementing measures, if any) conducted by the European Commission, Task 8 provides as a summary of policy implications as seen by the consortium. Further, some elements of this task may be analysed again in a greater depth during the impact assessment.

8.1. SCENARIO ANALYSIS

Different scenarios are drawn up to illustrate quantitatively the improvements that can be achieved through the implementation of different sets of improvement options at EU level by 2020 versus a Business-As-Usual scenario (reference scenario).

For each of the Base Cases, the following scenarios are analysed:

- Business-as-Usual (BAU), assumes that continuity is maintained with the current situation and trends.
- Least Life Cycle Cost (LLCC) which assumes the future stock of solid fuel SCIs is continuously improved through the replacement (and stock growth) of older less efficient models with newer models that reduce the life cycle costs to consumers to the maximum as described in Task 7.
- Best Available Technology (BAT) which assumes the future stock of solid fuel SCIs is continuously improved through the replacement (and stock growth) of older less efficient models with newer models that represent the best available technology today regardless of the costs to consumers.

The following common assumptions apply to all the scenarios to simplify the analysis:

- In order to build realistic scenarios, an appropriate timeframe for manufacturers to redesign products needs to be considered (i.e. redesign cycle). A complete redesign cycle of a maximum of 4 years is considered in all scenarios.

In these scenario analyses, and for all base/product cases, the expected trends (2010-2025) on environmental impacts are presented in terms of three indicators:

- Total Energy Requirement (TER) during the whole life cycle of the installed base of SCIs (expressed in PJ/year)
- Particulate Matter (PM) during the whole life cycle of the installed base of SCIs (expressed in kt/year)
- Greenhouse gases emissions of the installed base over product life (in GWP100 – Global Warming Potential expressed in million ton CO2 equivalent)

The characteristics and market data (2007) for the Base/Product Cases are summarised in Task 2.

8.1.1. SALES AND STOCK DATA

To develop the scenarios, the sales/stock data for the reference years (2010 – 2025) are calculated based on the sales and stock data presented below.

→ SALES DATA

The sales of solid fuel SCIs for the years 2015 and 2025 were estimated on the basis of sales forecasts found in market studies.

Over the long term, it can be very difficult to predict the future sales of products. It is expected overall that solid fuel appliances have an upper limit of market penetration of heating devices as further increases in fuel demand would drive up the fuel prices, reducing a key incentives consumers have for using solid fuel heating[1]. Again, these long term projections are highly speculative, but remain the best available estimates. The reported growth was given in different reports from 2003 to 2007 and forecasts until 2011. The growth rates for many appliances were assumed to decrease over time reflecting the upper limit of market penetration of these appliances. Sales figures are shown in Table 8-1 below.

[1] The boiler and heating system market in the EU - BRG Consult, Kent UK, November 2006

Table 8-1: Sales data according to the different base cases (in thousand units)

Name	2010	2015	2020	2025
Open fireplace	748	748	748	748
Closed fireplace / Insert	851	996	1047	1074
Wood stove	396	464	487	500
Cooker	503	648	708	744
Slow heat release stove	301	366	445	541
Pellet stove	229	415	434	413
Conv. domestic boiler	163	87,4	49,6	28,2
Gas. DD domestic boiler	222	226	220	205
Retort boiler	3,9	3,5	3,1	2,7
Pellet boiler	45,7	70,9	68,5	59,2
Chip boiler	1,6	1,4	1,3	1,1

Overall, the direct heating market is expected to continue to grow at a steady rate[2] for the coming years while the boiler market is expected to contract slightly[1] [3].

Coal appliances are expected to steadily decline in sales on an overall European scale, however stability or even growth could be seen in the primary markets such as Poland, Czech Republic, Ireland and the UK.

➔ **STOCK DATA**

Based on the market trend analysis in Task 2 (see Task 2, § 2.3.5), the total market for different types of solid fuel SCIs for the years 2010, 2015, 2020 and 2025 was estimated. However, for the years 2015-2025, these figures are highly speculative, but remain the best available assumption for the long-term.

A narrower feature wise market distribution was estimated in Task 5 on the basis of assumptions and stakeholder feedback. These base cases have been used in this task to represent the potential savings available in the EU based on the policy scenarios proposed. Base case 4 (coal stove) is not considered as prescribed as a conclusion in Task 5 because it is a product specific to a narrow region of the EU and not ideal for consideration at the European level (see Task 5).

The stock was calculated with the following equation:

$$Stock(n) = stock(n-1) + sales(n) - sales(n-a)$$

where: 'a' is the average lifetime of the appliances as described in Task 2

'n' is the year for which the stock is being calculated

This means the stock of each year is equal to the stock of the year before, plus the sales of the current year, minus the sales of products that are at the end of their lifetime (that is, when they reach the average lifetime, they are discarded and are no longer part of the stock and hence subtracted). The sales for each year are based on market information compiled in Tasks 2. Since many appliances have average lifetimes

[2] Synthesis of results on sales of domestic heating appliances for wood in 2007, (French), Observ'ER report, Observatoire des energies renouvelables, December 2008

[3] The European markets for selected new heating technologies 2007 solid fuel/biomass boilers – Germany, BRG Consult, Kent UK, February 2007

which extend beyond the scope of the model (20 years), the following formula was used:

$$Stock(n)=stock(n-1)+sales(n)-stock(n-1)/a$$

This formula therefore assumes that a portion of the stock is discarded each year, and that portion is equal to the inverse of the lifetime. This gives the stock for the years 2010, 2015, 2020 and 2025 as presented in Table 8-2 below.

Table 8-2: Stock data according to the different base cases (in millions)

Name	2010	2015	2020	2025
Open fireplace	15,1	16,6	17,9	19,0
Closed fireplace / Insert	8,4	10,8	13,0	14,9
Wood stove	7,3	8,1	9,0	9,8
Cooker	6,1	7,4	8,8	10,1
Slow heat release stove	6,4	7,1	8,1	9,4
Pellet stove	1,1	2,3	3,3	4,0
Conv. domestic boiler	3,0	2,7	2,3	1,9
Gas. DD domestic boiler	1,6	2,2	2,7	2,9
Retort boiler	1,7	1,3	1,0	0,8
Pellet boiler	15,1	16,6	17,9	19,0
Chip boiler	8,4	10,8	13,0	14,9

➔ **PERFORMANCE DIFFERENCES BETWEEN STOCK AND SALES**

It is well recognised in the industry of direct heating appliances that there is a significant difference between the appliances being sold today and the appliances found in the stock. This is a result of the progress made in efficiency improvements and emissions controls, combined with the long lifetimes of products in this study. Older, less efficient products are still being used and are contributing a great deal of environmental impacts and emissions in the EU that must be taken into account. This could lead to an underestimate for the environmental impacts of the products in this study as all the base cases represent products currently sold on the market. Therefore, representing the stock has been done using accurate stock data compiled by the European Committee of Heating and Domestic Cooking Manufacturers (CEFACD) for the Lot 15 study. This information has been included in Table 8-3. Using this information, an estimate for how many older appliances are currently in use in the European stock has been made. For example, CEFACD has made a distinction between traditional closed fireplaces and modern closed fireplaces (also for wood stoves). This distinction allows the separation between stock and sales and allows for a more accurate picture of the environmental impacts associated with the stock to be estimated.

Table 8-3: Direct heating industry (CEFACD) compiled data for stock[4]

Name	Eff. Nom P. [NCV %]	Eco [mg/m³]	Epm [mg/m³]	Eogc [mg/m³]
Open Fireplaces	30	12500	2750	900
Traditional closed fireplaces	50	11750	750	500
Modern fireplace/insert	70	2000	120	200
Closed fireplace with boiler	65	10000	650	450
Traditional woodstove	50	11750	750	500
Modern woodstove	70	2000	110	180
Boiler stove	65	10000	650	450
Cooker	65	5000	350	300
Cooker with boiler	65	7500	400	350
Slow Heat Release Stove	75	2500	200	150
Pellet Stove	83	500	80	75
Pellet stove with boilers	85	500	80	75

Further to the information provided by CEFACD, the Austrian Bioenergy Centre provided historical data for testing of indirect boiler appliances over the past 20 years. This historical data has shown consistent improvement of boiler efficiencies, however is not consistent across each type of boiler.

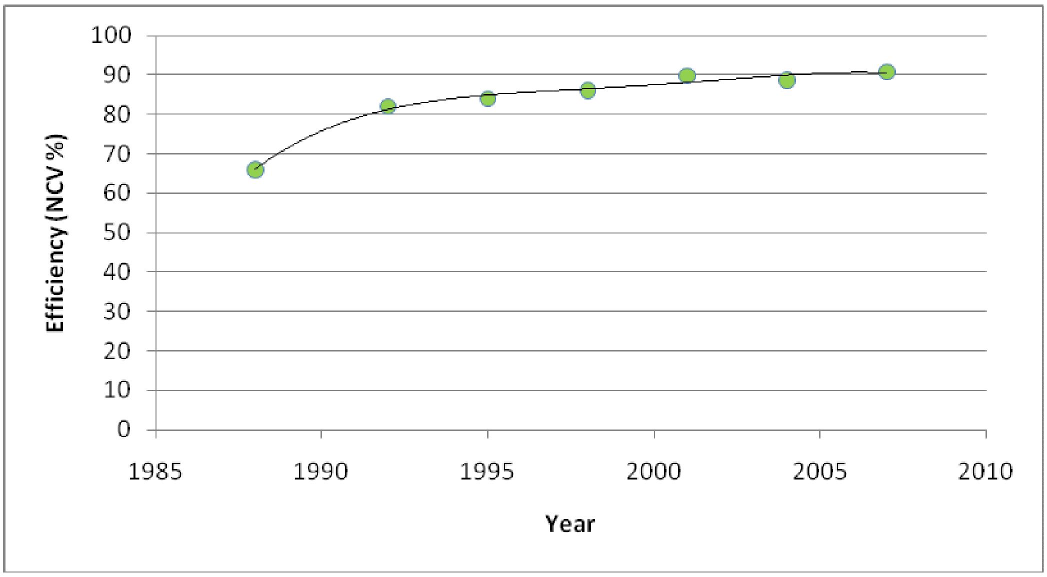

Figure 8-1: Historical efficiency of wood log boilers from the Austrian Bioenergy Centre[5]

This information therefore alludes to a quantification of the difference between stock and sales. It is different for each appliance type as the estimated improvement over each year must be considered along with the different life span of each type of

[4] CEFACD provided data through course of study regarding appliance efficiency and emissions

[5] Austrian Bioenergy Centre provided data for older appliances performance in Europe

appliance. This information, used with stock data presented in Task 2 (Table XX) gives an estimate for stock efficiency as presented in Table 8-4.

Table 8-4: Estimated stock efficiency for the base cases

NAME	**Base case efficiency**	**Estimated stock efficiency**[6]
	(% NCV)	(% NCV)
OPEN FIREPLACE	30	30
CLOSED FIREPLACE, INSERT	70	54
WOOD STOVE	70	54
COAL STOVE	70	54
COOKER	65	54
SHR STOVE	80	73
PELLET STOVE	86	78
DOM. CONV. BOILER	66	51
DOM. DD. GAS. BOILER	88	80
RETORT COAL BOILER	82	75
PELLET BOILER	88	80
NON DOMESTIC CHIP BOILER	88	80

It can be assumed that the stock has an associated real life efficiency which is lower than the test standard efficiency, however the real life efficiency has not been estimated here as it is not required for the policy analysis or regulations proposed in this task.

It must be noted that the stock of appliances (rather than current sales) in the EU is regarded to have the largest improvement potential, this has been confirmed by experts and industry.

→ SUMMARY OF SALES AND STOCK DATA

The market data presented above allows the calculation of the stock and sales data for each of the Base Cases as presented in Table 8-2. This data will be used in all scenario calculations and a linear interpolation will be made for the years in between the reference years.

Figure 8-2 gives the evolution of the years 2010 to 2025. Figure 8-3 and Figure 8-6 give the cumulative stock evolution for all base cases as a percentage of the total stock (split by direct and indirect heating appliances).

It should be noted that while the stock of open fireplaces continues to grow slightly over the time horizon, its significance in the market decreases due to the stronger growth of other appliances, namely pellet stoves and closed fireplace inserts.

[6] Stock efficiency weighting for direct heating appliances is based on CEFACD estimate for 'modern' versus 'traditional' appliances in the stock of Europe

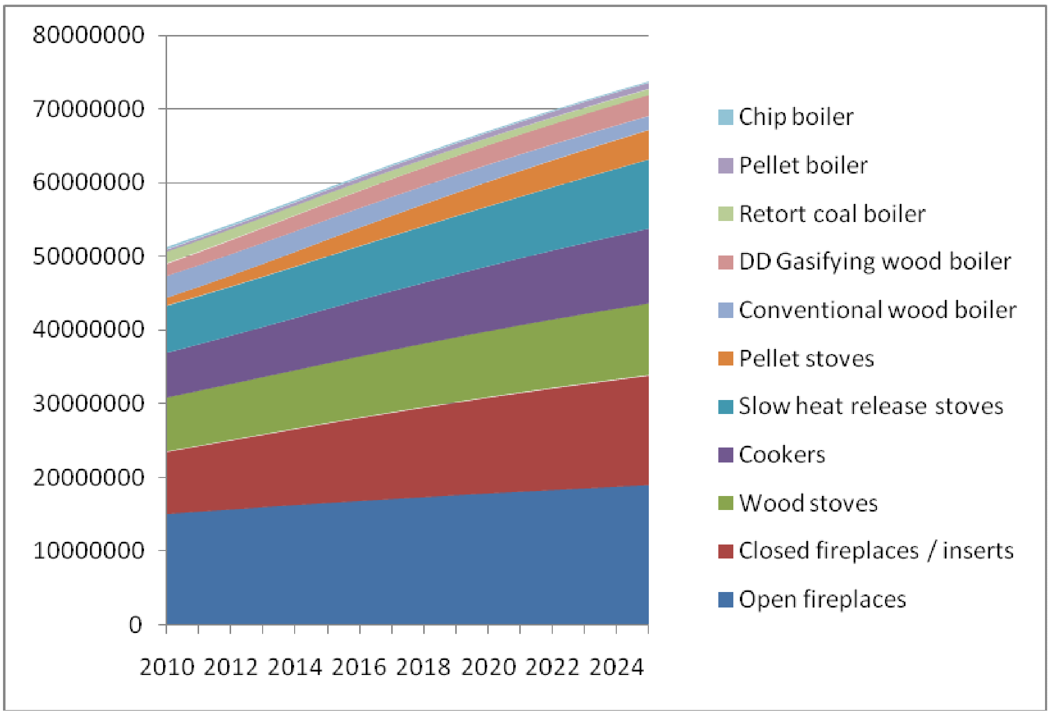

Figure 8-2: Stock evolution of solid fuel SCIs per Base Case (EU-27)

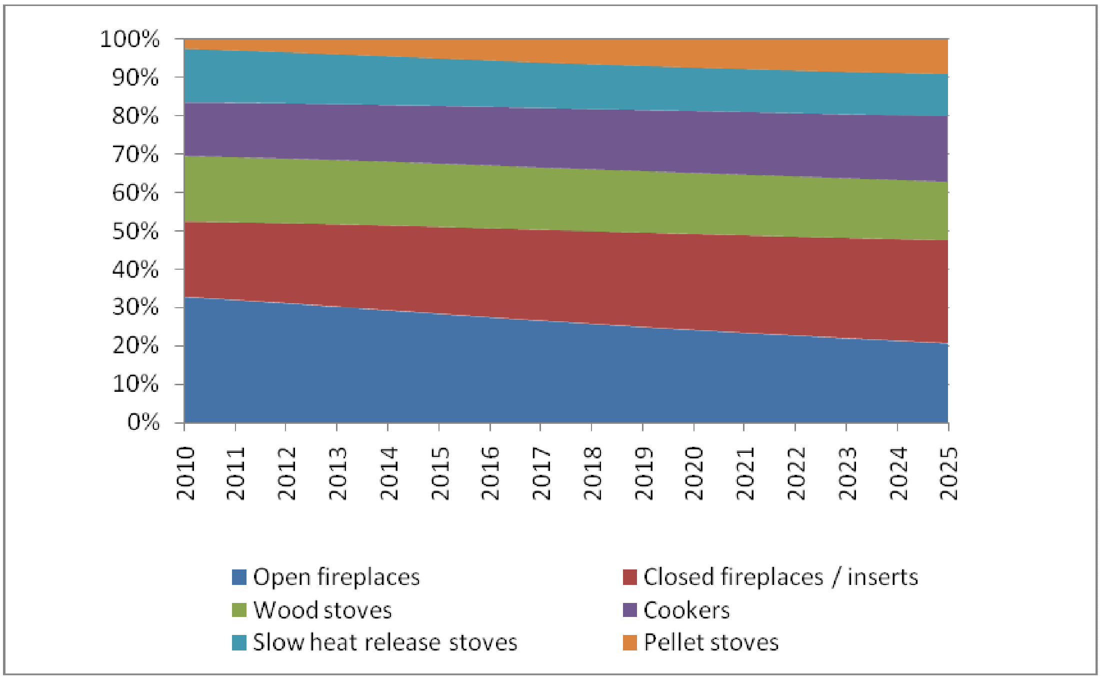

Figure 8-3: Estimate of significance of each of the direct heating base cases in term of stock (in % for EU-27)

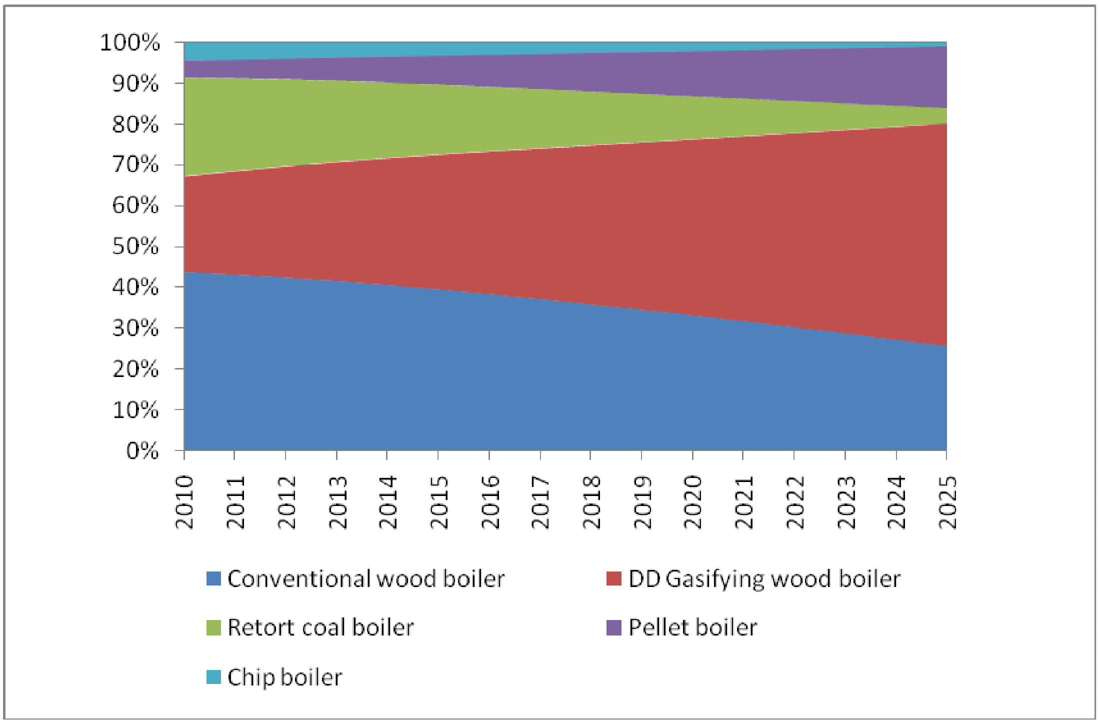

Figure 8-4: Estimate of significance of each of the indirect heating base cases in terms of stock (in % for EU27)

8.1.2. BUSINESS-AS-USUAL SCENARIO

The Business-as-usual scenario (BAU) assumes that continuity is maintained from the current situation and the market will continue to follow the current trends in terms of market development, technology development, and regulations. This is a rather difficult scenario to quantify because regulation changes are foreseen in several member states, technologies develop and markets change as a result of fuel prices. Nevertheless, the best estimates possible are made with information accumulated throughout the task documents.

In order to develop the BAU scenario, it was assumed that the future technical improvements of the solid fuel SCIs will lead to a slow and steady increase in appliance efficiency and which slowly replace the stock existing as older appliances are replaced. For simplification, it is represented in Figure 8-5 as 'new' stock and 'old' stock. The new stock is represented by base case appliances (base cases represent products sold on market today). The old stock represents appliances in the stock (or park) of products in use in the EU and have a lower efficiency as estimated in Table 8-4. By steadily increasing the amount of 'new' stock in the total stock, the effective environmental performance of the stock in the EU can be expected to improve. The steady increase in 'new' stock is based on current sales trends.

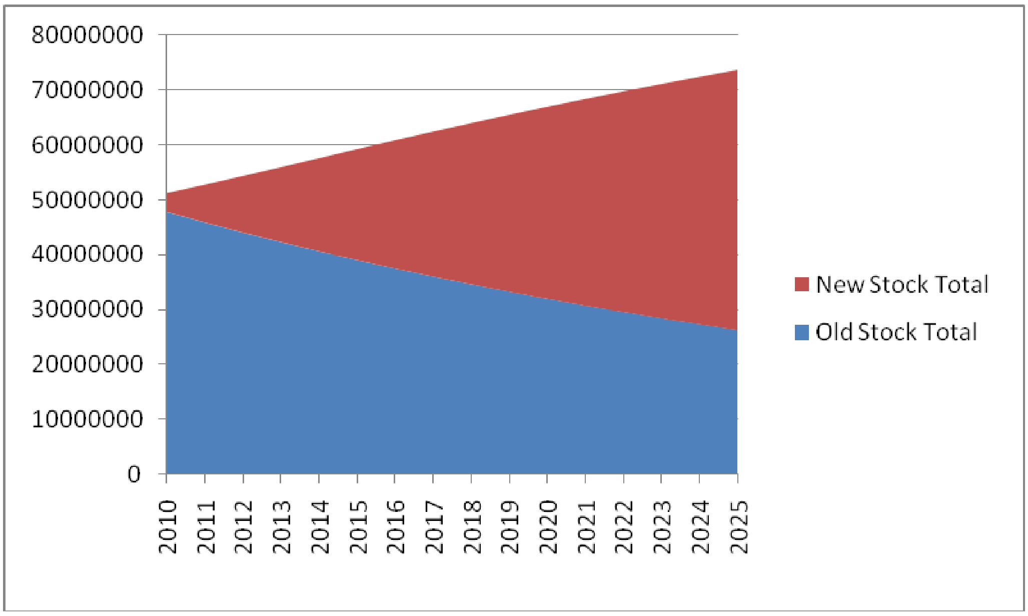

Figure 8-5: Stock evolution according to BAU for ‘old’ and ‘new’ appliances

As such, the BAU scenario represents a situation where the technical parameters of the products remain identical to the products installed in 2010 and where the sales and stock are the only parameters that will change over time. This scenario needs to be interpreted with care as solid fuel SCIs will not stop evolving in terms of technologies and performance. Moreover, in the absence of robust data to predict the future emissions profiles of solid fuel SCIs, such an approach allows limiting the number of “guesses” and provides a reasonable reference point for future comparison with alternative scenarios.

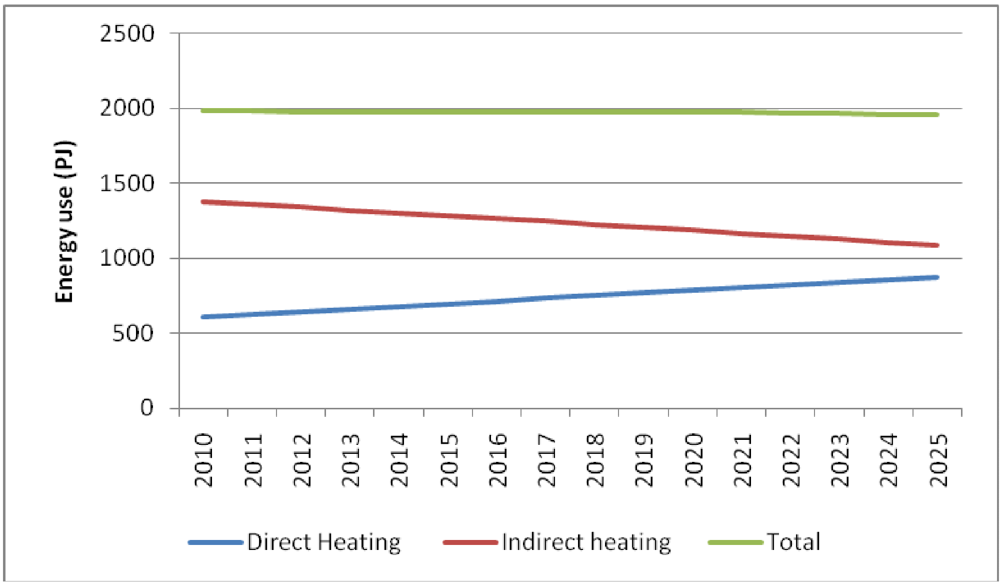

Figure 8-6: Environmental impacts – BAU scenario: Yearly energy use in petajoules (PJ)

Due to the growing market share and growing number of more sophisticated solid fuel SCIs), the BAU scenario clearly shows a stagnant energy use of solid fuel SCIs in the EU until 2025 while a steadily growing number of appliances come into use (Figure 8-2).

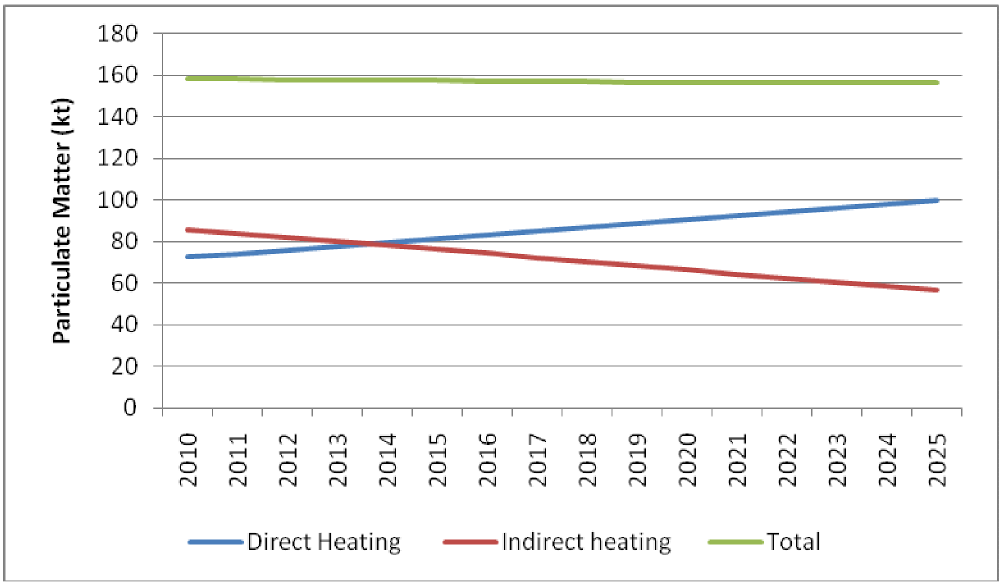

Figure 8-7: Environmental Impacts – BAU scenario : Yearly particulate matter in kilotonnes (kt)

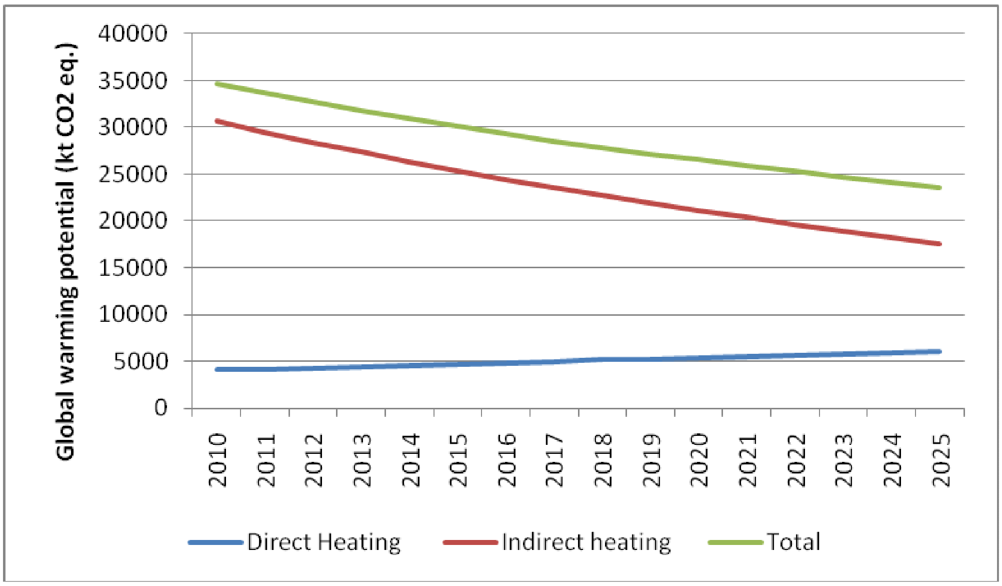

Figure 8-8: Environmental Impacts – BAU Scenario: Yearly greenhouse gases in megatonnes (Mt) of CO_2 eq.

The BAU scenario shows that for EU 27:

- Total Energy Requirement (TER) and particulate matter (PM) during the whole life cycle of all the installed SCIs is expected to remain stagnant for the next 15 year while improved efficiency in new appliances counterbalances the steady increase in SCI stock in use, while a portion of older appliances are steadily discarded.
- Global warming potential (GWP) steady decreases as the market for coal boilers is expected to shrink and the efficiency of coal boilers improves over the next years. Coal appliances are the only significant products when

considering GWP in this lot as all other product types have biomass derived fuels. Indeed, the direct heating curve in the figure above represents emissions from millions of biomass appliances, while the indirect heating curve almost exclusively represents the emissions from an approximate one million coal boiler appliances.

8.1.3. LLCC SCENARIO

The LLCC scenario represents a situation where the solid fuel SCIs achieve reductions in energy requirements which are similar to the ones identified by the LLCC points in Task 7.

The market penetration of solid fuel SCIs with these different performance levels was calculated based on the estimates on the share of sales of each of these types of products for each year in question.

The calculation method and total stock volume is the same as the BAU scenario, the only difference is the performance of the appliances and how the stock is subdivided. The rate of adoption was based on the redesign cycle of 4 years whereby at 4 years 50% of the market sales are represented by the LLCC product (the remaining 50% being represented by the BC). A second tier 2 years after the primary tier sees 100% of the market being represented by the LLCC product.

This scenario represents a significant market transformation. The assumption is fundamentally that 6 years after regulations come into force, all appliances on the market are represented by the LLCC appliance highlighted in Task 7.

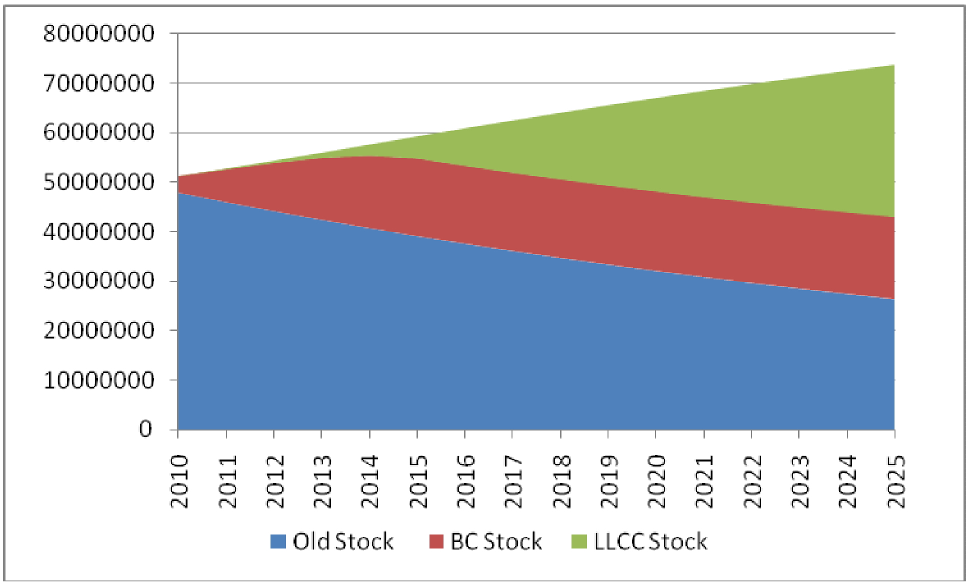

Figure 8-9: Significance of each of the Base Cases and improved LLCC scenario in term of stock (EU-27)

The analysis of the environmental impacts of solid fuel SCIs through EcoReport with the LLCC stock and sales configuration, shows that the penetration of improved solid fuel SCIs could reduce the environmental impacts of solid fuel SCIs compared to the 2025 BAU situation.

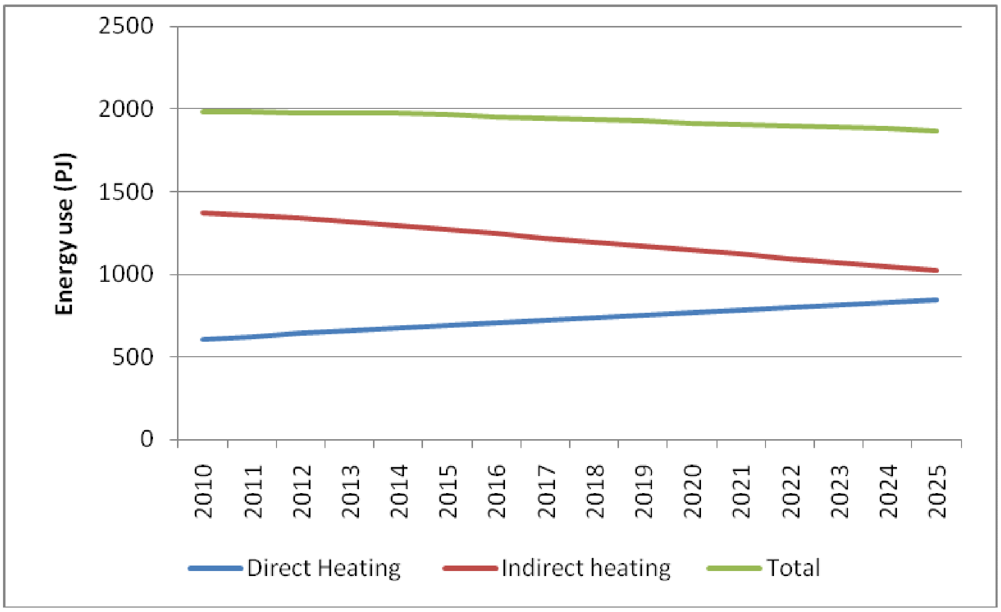

Figure 8-10: Environmental impacts – LLCC scenario: Yearly energy use in petajoules (PJ)

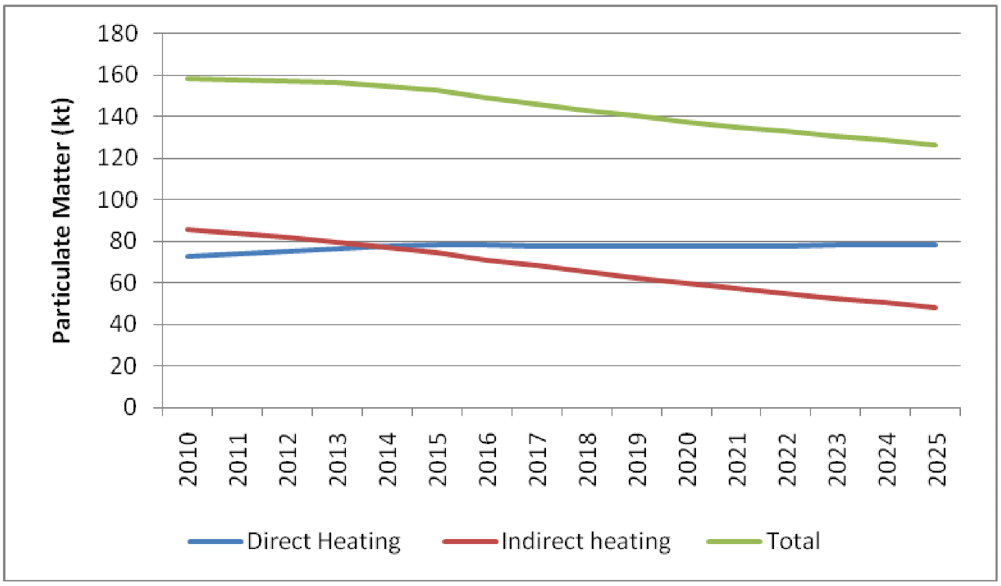

Figure 8-11: Environmental impacts – LLCC scenario: Yearly particulate matter in kilotonnes (kt)

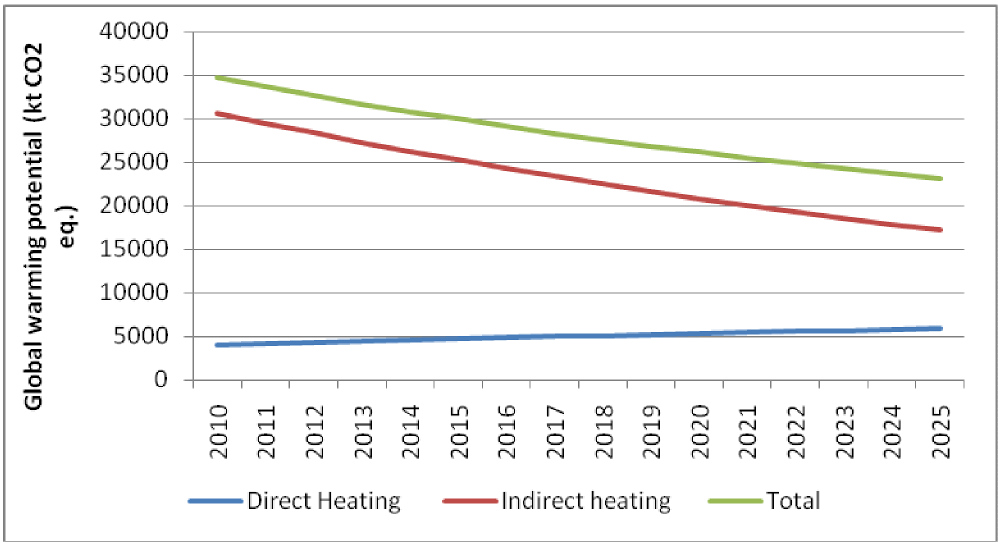

Figure 8-12: Environmental Impacts - LLCC Scenario: Yearly greenhouse gases in megatonnes (Mt) of CO_2 eq.

The LLCC scenario shows that for the total stock of solid fuel SCIs in EU 27:

- TER during the whole life cycle of the installed base of solid fuel SCIs can be decreased approximately 6% between now and 2025 despite a significant expected increase in the number of appliances in use in the EU over the same time frame.
- Particulate matter follows the same trend as energy use and can be reduced by 32 kt per year by 2025
- Greenhouse gases emissions show few significant changes compared to BAU. Indeed as most appliances in this lot are carbon neutral, improvements to them makes very little difference on the carbon footprint. This analysis does consider the contribution of GHG other than CO2 including CO from appliances and includes all aspects of the SCIs lifecycle.

Table 8-5: Environmental Impact reduction potential of LLCC compared to BAU

Impact reduction potential compared to BAU (absolute and percent)	2015		2020		2025	
Total TER (PJ /year)	15,9	0,8%	59,6	3,0%	88,3	4,5%
Total PM (kt/year)	4,9	3,1%	19,0	12,0%	29,8	18,8%
Total GWP (Mt CO_2-eq/year)	0,1	0,3%	0,4	1,0%	0,5	1,5%

8.1.4. BAT SCENARIO

The BAT scenario investigates the effects of further improvement (the starting point is therefore the products as described in LLCC scenario) through the implementation of further measures. These measures include improvements to appliances which require a net increase in the life cycle costs for the consumer.

The sales and stock distribution for the BAT scenario were calculated based on the same adoption schedule as that of the LLCC scenario. It assumes 50% adoption of BAT technologies (as described in Task 7) after a 4 year first tier adoption, and then followed by 100% adoption after 2 additional years.

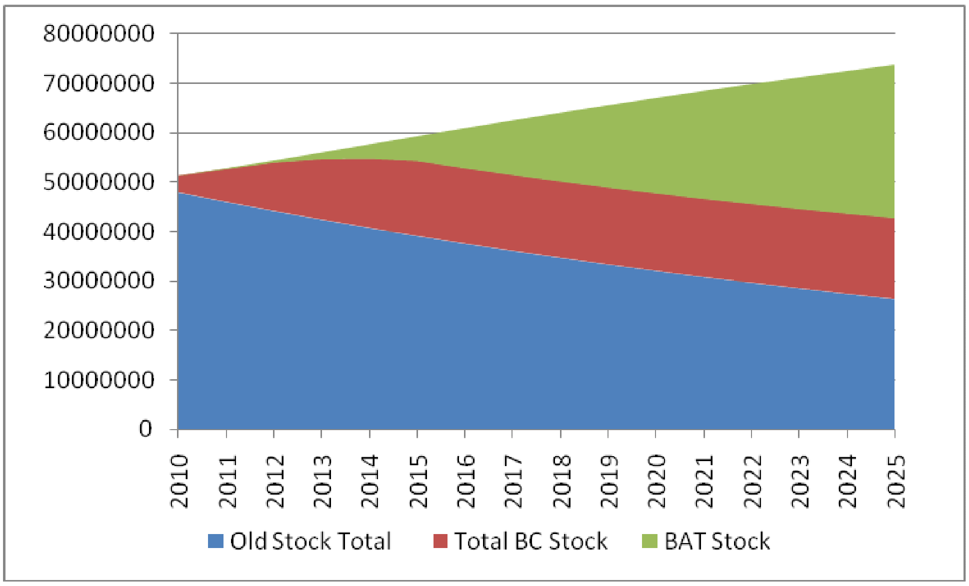

Figure 8-13: Significance of each of the Base Cases and improved BAT scenario in term of stock (EU-27)

As would be expected, the BAT scenario calculated shows that the penetration of measures can achieve even greater reductions of the environmental impacts of solid fuel SCIs then the BAT scenario, compared to the BAU scenario. Again it should be kept in mind that the reductions shown below are achieved despite a growing market.

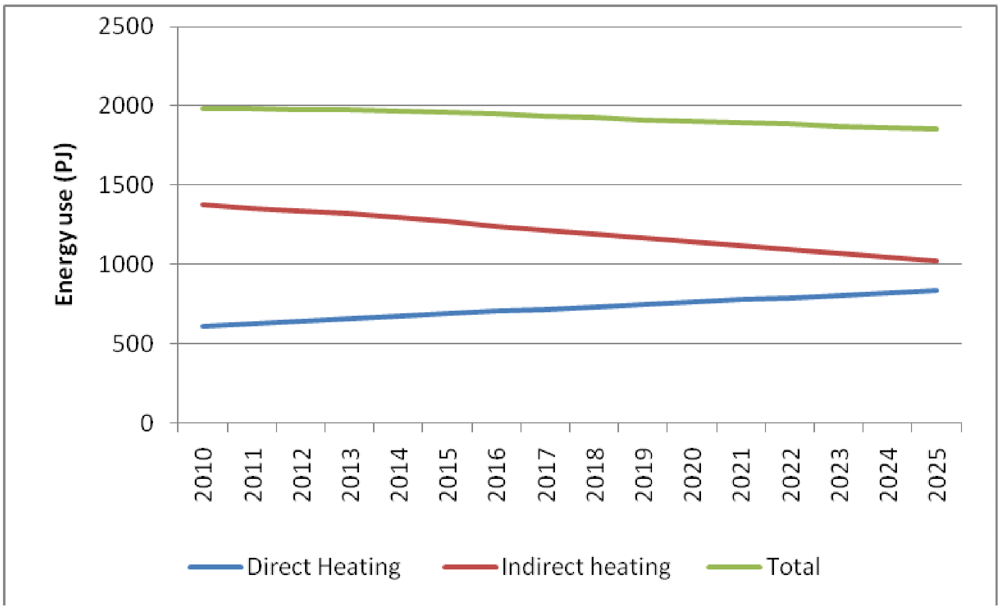

Figure 8-14: Environmental impacts – BAT scenario: Yearly energy use in petajoules (PJ)

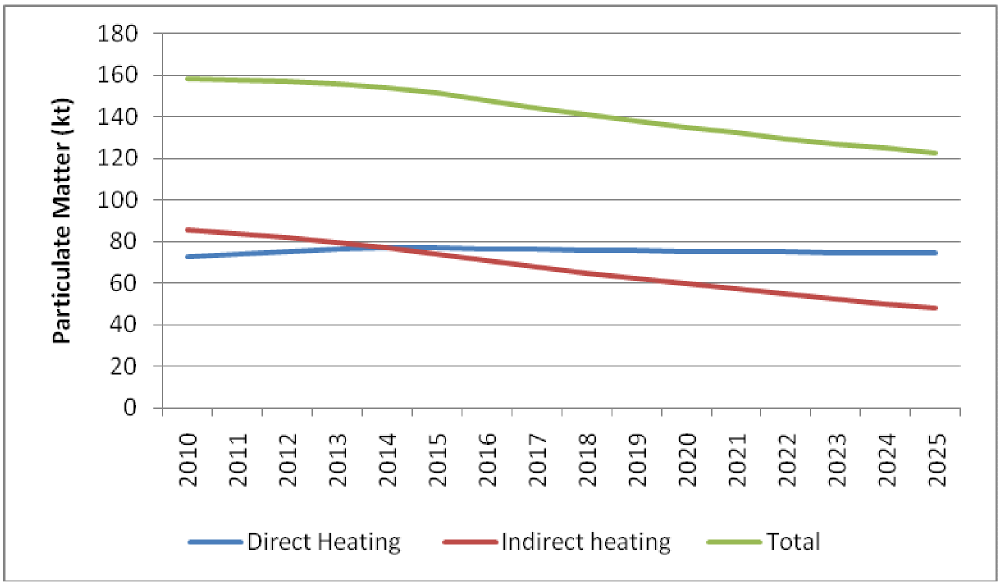

Figure 8-15: Environmental impacts – BAT scenario: Yearly particulate matter in kilotonnes (kt)

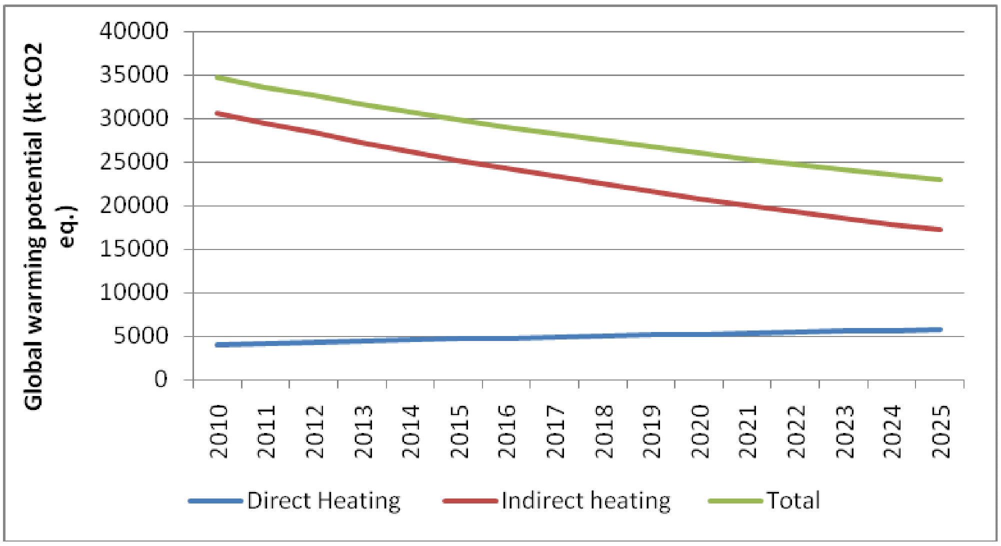

Figure 8-16: Environmental Impacts - BAT Scenario: Yearly greenhouse gases in megatonnes (Mt) of CO_2 eq.

The BAT scenario indicates that for the total stock of solid fuel SCIs in EU 27:

- Total Energy Requirement (TER) during the whole life cycle of the installed base of appliances can be reduced by 7% between now and 2025. This is not significantly different than the LLCC scenario and is expected as described in Task 7; the LLCC and BAT scenarios have few differences.
- Particulate matter emissions during the whole life cycle of the installed base of appliances can be reduced by 32kt per year. This is not significantly different than the improvements of the LLCC scenario.

- Greenhouse gases emissions of the installed base over product life was not observed to differ between the BAT scenario, the LLCC scenario and the BAU scenario

Details on the improvement potential of BAT compared to the BAU scenario for different environmental indicators are summarised in Table 8-6.

Table 8-6: Environmental impact reduction potential of BAT compared to BAU

Impact reduction potential compared to BAU (absolute and percent)	**2015**		**2020**		**2025**	
Total TER (PJ /year)	20,8	1,0%	71,6	3,6%	105,5	5,3%
Total PM (kt/year)	6,1	3,9%	21,7	13,7%	33,6	21,3%
Total GWP (Mt CO2-eq/year)	0,1	0,4%	0,5	1,4%	0,7	2,0%

8.1.5. Summary of Scenarios

The following graphs summarise the energy consumption and environmental impacts avoided over the life time of solid fuel SCI products based relative to BAU scenarios for the LLCC and BAT scenario.

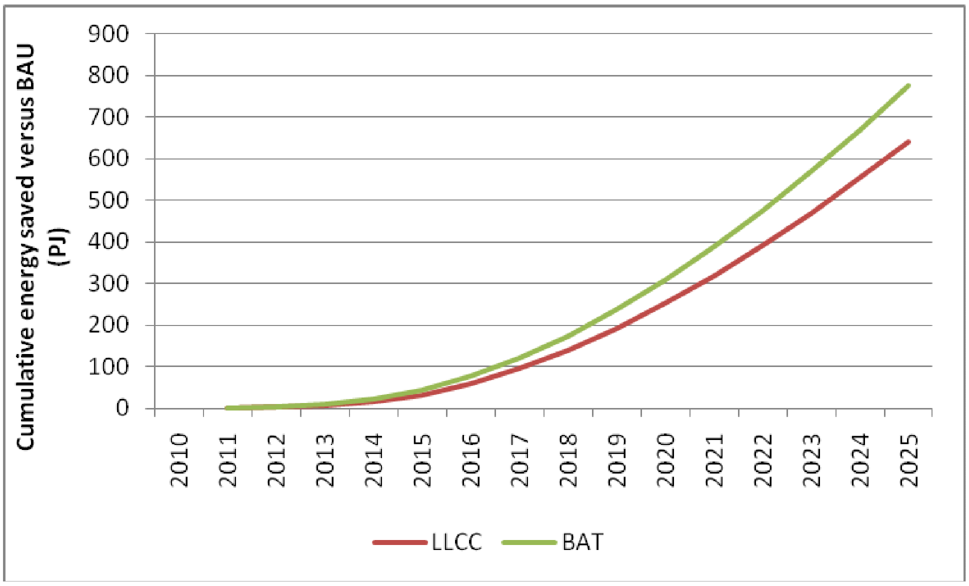

Figure 8-17: Cumulative energy use avoided for the LLCC and BAT scenarios versus BAU scenario (PJ)

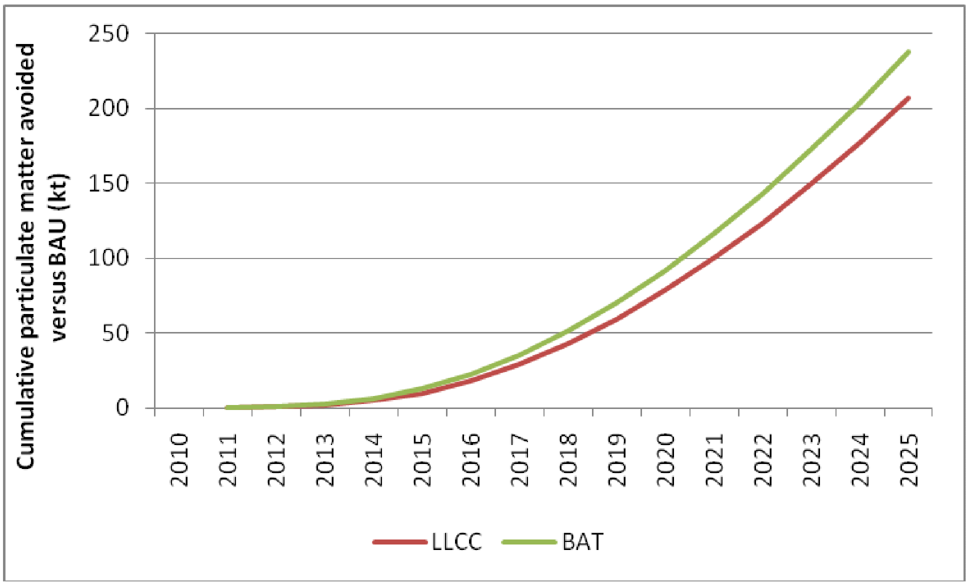

Figure 8-18: Cumulative particulate matter avoided for the LLCC and BAT scenarios versus BAU scenario (PJ)

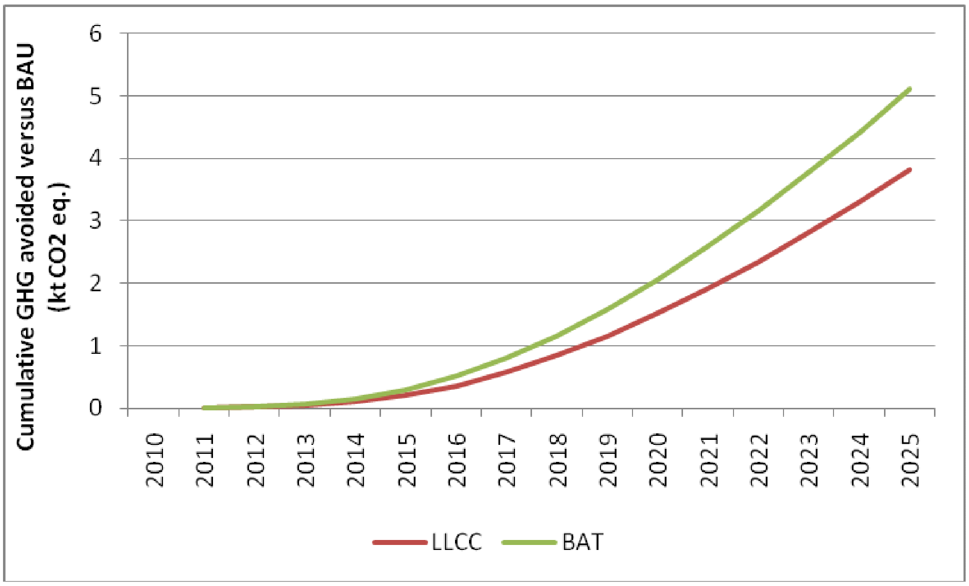

Figure 8-19: Cumulative GHG avoided for the LLCC and BAT scenarios versus the BAU scenario (kt CO2 eq.)

Overall, there are few differences between the LLCC and BAT scenarios and this is observed in the results shown above. Both scenarios provide significant savings of energy and PM compared to the BAU scenario.

There is little difference in GHG emissions avoided between the scenarios analysed, as the order of magnitude of GHG savings is in kt of CO2 eq. while the total emissions are in Mt of CO2 eq.

8.2. POLICY ANALYSIS

The policy options presented in this section give mechanisms for discussion which could achieve the scenarios analysed in the previous section.

8.2.1. ENERGY LABELS

➔ DIRECT HEATING APPLIANCES

Energy labelling could provide strong incentives for a voluntary shift in the market. Comparative energy labelling promotes the introduction of energy efficient equipment on the market. Firstly, it helps buyers identify energy efficient products without detailed technical knowledge. Secondly, it stimulates innovation and creates a challenge for manufacturers who seek to differentiate themselves from competitors on the basis of energy efficiency. An A to G class could be defined on the basis of the test efficiency value of the SCI.

A potential weak point for creating an energy label for solid fuel SCIs is that some of them are not directly sold to the end-user (no buying decision). Indeed, some solid fuel SCIs are provided by homebuilders. However, it is most likely that home builders will want to carry a good image of their company to their customers therefore choosing higher efficiency class products rather than low efficiency class products. Combining minimum efficiency requirements through progressive, staged banning of products within certain classes (ie ban products labelled as G efficiency) would be a solution to this potential weakness.

It is recommended that the direct heating appliances are labelled but on a different labelling scheme to indirect heating appliances. This is because the functional unit of the two types of appliances is different. Direct heating appliance supply radiant and convective heat while also improving the aesthetic and ambient atmosphere of a room. Indirect heating products supply hot water to the hydronic system. The effects of the respective systems interacting with the product types are different. There will be a need to ensure that labelling is clear so that consumers are aware that the direct heating label is not comparable to an indirect heating appliance label. This can be achieved graphically and through textual information on the label.

The label of products is necessarily dependent on the fuel type used and this must be identified on the label.

- **Energy label for direct heating appliances**

A mandatory energy label is proposed in this section and is applicable to open fireplaces, closed fireplaces and inserts, freestanding roomheaters and stoves, cookers, slow heat release stoves, kachelofens, pellets stoves and similar appliances with boiler components as per their respective standard allows.

Classifications for each appliance type have been given based on an analysis of the technical characteristics of the appliances and the market of each appliance type and the market as a whole as well.

Pellet fuels consume more energy during the processing stage of their lifecycle and therefore justify a shift in the class limits to properly reflecting the energy consumption difference of the production phase of the fuel lifecycles[7]. This class limit shift is countered by the typically higher efficiency of pellet burning products on the market today and hence is a reasonable shift from the product perspective.

Slow heat release stoves also provide a different function (heat retention and release over long periods) and use fundamentally different phenomena to transfer the heat and therefore can justify another scale.

Products which operate in a regime where condensation is a possibility should be considered in the grading scheme so as to encourage their development but should be marked as such to allow simple understanding that these products are highly efficient but require extra caution.

Existing guidelines which could be helpful for establishing class limits include:

- For closed fireplaces, inserts and freestanding roomheaters, class G matches the minimum requirements of EN13240
- For cookers the lowest class should be the minimum requirement of EN12815 (60%)
- For slow heat release stoves the minimum requirement of SHR appliances covered EN 15250 (70%).
- For pellet stoves, the minimum efficiency requirement of EN14785 (75%)
- Class C or D approximately matches the base case nominal test efficiency (Task 5) which is expected to approximately represent typical current market products.
- Class A for all appliances represent a BAT efficiency as discussed in Task 6. This means only the best appliances on the market will receive A classification. It also represents the point where condensation becomes restrictive for most appliance types, and acknowledges that efficiency improvements beyond this point are technically and economically difficult.
- Class limits for open fireplaces should be null and explained in the following section, except for open fireplaces with boilers.
- Water heating functionalities (tested under the respective standards) of roomheater appliances are to be included as per the respective standard describes.
- Boilers with roomheating functions (as per EN12809) are given in "indirect heating section" of this document.

The class limits have been proposed to be a balance between two important characteristics, consistency and label effectiveness. Consistency requires that the label be equally classified for all appliances so that an A appliance of cookers can be

[7] This refers to Task 5 Table 5-19 where the energy consumption of fuel was 1262 and 1067 MJ per GJ respectively for pellets and wood logs. This is not to be confused with the GWP indicators given subsequently in this document as 11 and 6 kg CO2 eq. per GJ of space heat.

considered equivalent to an A appliance of pellets stoves. This tends to make the class limits for each appliance the same. This is contrasted by a need for each appliance type to be challenged by its own class limits, to create a market transformation. This tends to make each product's class limit specific to itself. There should be a compromise between these two objectives.

Another issue to consider is the precision of testing and the distinction of class limits. For example, the criteria for classification of appliance class limits are possibly at 4% for some efficiency bands which requires low measurement uncertainties to ensure effective classification. It is foreseeable that retesting an appliance could result in its reclassification as subsequent test result variations can be more than the efficiency bands suggested. If an appliance is tested more than once, it is proposed that the results of all the valid tests be averaged to determine the final appliance classification.

With proper implementation, labelling schemes such as this one have shown to improve the average efficiency of appliances on the market significantly. Washing machines have seen an average efficiency increase of 20% over 8 years, while refrigerators and freezers have seen an average efficiency increase of 60% over 13 years[8]. Analysis has shown that the market tends to quickly adapt to the label criteria and sales become heavily weighted towards A and B appliances. A market transformation of this nature for the direct heating appliances in this study would eventually meet the BAT or LLCC scenario predictions presented in the previous section, however may not meet the timelines proposed in the scenarios as labelling market transformation programs tend to only show significant results several years after their initial implementation. Further measures may be required to accelerate this and have been proposed in the following sections as complimentary policy options.

- **Mandatory Global Warming Potential Information**

The intended fuel type for each appliance could be clearly given on the energy label and an indication of the global warming potential for the fuel could be given in [kg of CO2 equivalent per GJ of space heat]. This will allow consumers to see the distinct difference between renewable biomass fuels and non-renewable coal based fuels.

Renewable fuels consistently have a lifecycle global warming potential near 10 kg/GJ while non-renewable fuels have showed lifecycle global warming potentials around 160kg/GJ.

The fuel global warming potential [GWP_{fuel}] given in (kg of CO2 eq. per GJ) as given in Task 5:

- Wood: 6
- Pellets: 11
- Coal: 109

The appliance efficiency should be given in percent for nominal test power. The global warming potential for the product can therefore be approximated (in kg of CO2 eq. per GJ of space heat) by:

[8] Paolo Bertoldi, Bogdan Atanasiu, Electricity Consumption and Efficiency Trends in the Enlarged European Union, Institute for Environment and Sustainability and the Joint Research Centre, 2007

$$GWP_{product} = \frac{[GWP_{fuel}]}{[Efficiency]} x\ 100$$

Typical roomheater products would therefore have the global warming numbers on their label (given as an example for understanding, not indicative) as given in Table 8-7.

Table 8-7: Typical estimated global warming potential of appliances for different fuels

Appliance Type	Efficiency	Wood	Coal	Pellets
	(% NCV)			
Open fireplaces	30	20.1	363.5	-
Closed fireplaces/ inserts	70	8.6	156	-
Freestanding roomheaters	70	8.6	156	-
Cookers	65	9.2	168	-
Slow heat release appliances	80	7.5	-	-
Pellet stoves	86	-	-	12.8

Above all, roomheaters under Eco-design should be designed with a specific fuel type in mind (not universal fuels) so that the designer may optimise the performance of the appliance to the intended fuel type. This can be communicated to the consumer and will help to ensure that operating conditions are always closest to that which the designer intended.

An example label showing two appliances, one with coal and the other with wood is given in Figure 8-20.

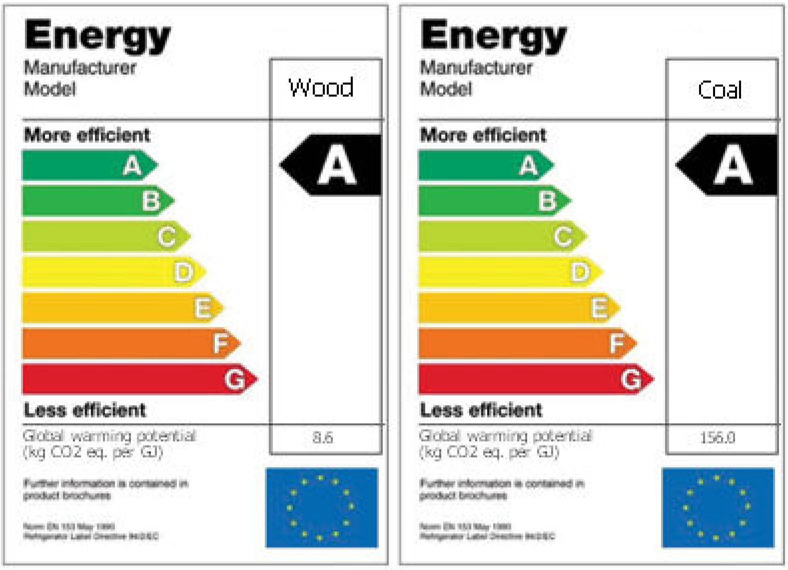

Figure 8-20: Example labels showing global warming potential differences

The impacts of this labelling proposal are difficult to predict. Above all, the coal stove was excluded from the scenario analysis because it was found to represent a narrow portion of the overall European market. Labelling of this nature would influence consumers who are considering coal stoves to choose appliances with a different fuel. There are always other factors which strongly influence consumers' decisions and in this case, availability and cost of fuel would be key factors. This label would have an influence on those factors and thus could be an important addition to the overall labelling scheme for direct heating appliances, however it is very difficult to predict how much impact it will have and as such was not included in the scenarios in the previous section. Nevertheless, informing the consumers about how much environmental impacts their decisions have will help to ensure that environmentally sensitive choices are possible.

- **Open fireplace label**

Appliances operating without doors (or normally operated with open doors) and without water heating components should not be classified according to the roomheater efficiency labelling scheme. It is proposed for these appliances to have a clear and strong note declaring:

"THIS APPLIANCE HAS LIMITED EFFECTIVENESS AS A HEATING DEVICE AND SHOULD BE USED FOR DECORATION OR AMBIANCE ONLY. IT IS INHERENTLY INEFFICIENT FOR SPACE HEATING".

A possible layout is given below in Figure 8-21 for products under EN 13229 with 'open fire doors' and 'functional modifications' with no boiler or water heating functions.

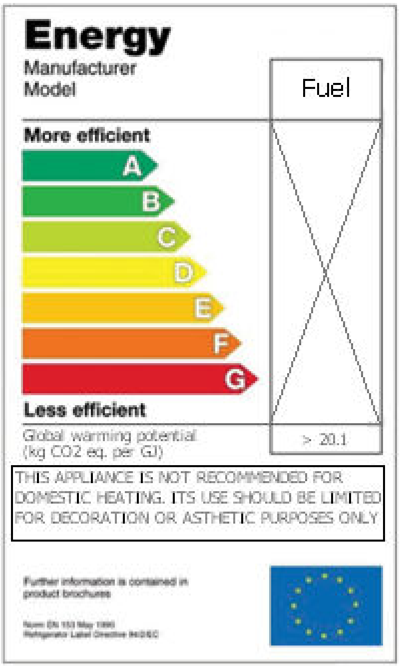

Figure 8-21: Possible label for open fireplaces without boilers

This is in accordance with the conclusions of Task 5 that product improvements to this product type are not an effective area for the EcoDesign Directive to be implemented. A classification of these appliances based on efficiency would not provide much improvement to this product type. Rather, in the sample labelling scheme shown in Figure 8-21, consumers will clearly understand that products in this category perform much worse, and as such, the label discourages consumers from using this product for heating.

The global warming potential indicator should be indicated and typically will be 2 or 3 times higher than equivalent closed door appliances, again showing to consumers the higher impacts of using these product types.

Again it is difficult to predict the impact that this labelling mechanism will have as it is oriented towards changing the product type which a consumer purchases. It was not modelled in the scenario analysis because its impacts are difficult to predict and other factors such as personal preference, fuel availability and cost again are very important. This labelling proposal will at least ensure that consumers are capable of making environmentally sensitive choices.

➔ INDIRECT HEATING APPLIANCES

The labelling of boilers in the EU is an on-going Eco-design initiative under Lot 1 and has made progress on many aspects. A proposed labelling scheme and working document have been made available as a result of the continuing work in the consultation forum shown in Figure 8-22.

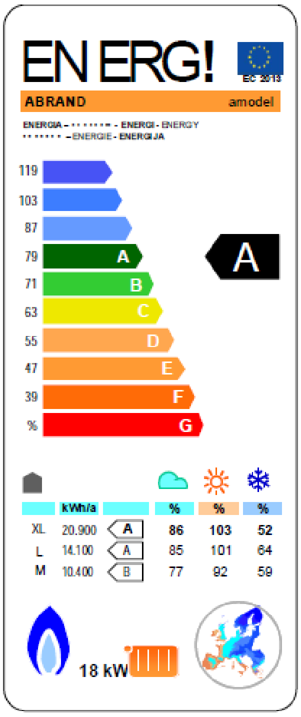

Figure 8-22: Proposed energy label layout for Lot 1 boiler products

The class limits for boilers in Lot 1 <70kW expressed as seasonal efficiency (as defined in Lot 1 working documents) is given in Table 8-8.

Table 8-8: Class limits for Lot 1 boilers based on net seasonal efficiency

Class label	Seasonal Efficiency (NCV)
A+++	119
A++	103
A+	87
A	79
B	71
C	64
D	56
E	48
F	40
G	34

Wood log boilers

Wood log boilers can be integrated into the Lot 1 work as a renewable energy heat generator. The sales and application of these products are consistent with the work which has been ongoing thus far.

An adjusted scale or correction factor is necessary to properly accommodate domestic wood log boilers to the Lot 1 work. This is because condensing heat exchangers pose extra challenges to solid fuel boilers, and the fuel itself is renewable and if managed sustainably poses few net environmental impacts throughout its lifecycle.

Wood boiler modulation

Furthermore, as highlighted in Task 7, a key improvement options for solid fuel boilers is the ability to modulate. Boilers unable to modulate must be incorporated into the method, however must also be done so in a fashion that discourages their application through the resulting class they are assigned. Measures should be implemented to ensure that boiler modulation capabilities are included in products from the very beginning of design phase. While the BIN method inherently gives appliances which modulate well better seasonal efficiencies and hence better classification, it must be adapted to the technical constraints of wood combustion to properly address or penalise appliances which do not modulate as well as they could. This is a key issue to be addressed for solid fuel wood boilers. Wood boiler modulation should not be considered an equivalent technology to gas boiler modulation as it is much more difficult to achieve effective wood boiler modulation.

Combinations in Lot 1

The method used in Lot 1 allows for combinations of appliances, for example, a wood appliance to supplement a gas fired appliance. In these cases wood fired appliances should be given firing priority over fossil fuel appliances and heat pumps. This is because when available, wood fuel is more ‘renewable’ and has fewer impacts than the above listed heat generators. Solar heat generators should be given ‘firing’ priority over wood boilers as the availability of wood is typically higher than solar and hence solar should be used when it is available.

Pellet boilers

Pellet boilers can be integrated into the Lot 1 work as a renewable energy heat generator. The sales and application of these products are consistent with the work which has been ongoing thus far. An adjusted scale or correction factor is necessary to properly accommodate pellet boilers to the Lot 1 work. Condensing heat exchangers pose extra challenges to solid fuel boilers, while the fuel itself is renewable and if managed sustainably poses few net environmental impacts throughout its lifecycle.

Pellet boiler modulation

Furthermore, as highlighted in Task 7, a key improvement options for solid fuel boilers is the ability to modulate. Boilers unable to modulate must be incorporated into the method, however must also be done so in a fashion that discourages their application through the resulting class they are assigned. Pellet boilers typically have more modulation capabilities than wood boilers.

- Combination in Lot 1

The method used in Lot 1 allows for combinations of appliances, for example, a pellet appliance to supplement a gas fired appliance. In these cases pellet fired appliances should be given firing priority over fossil fuel appliances and heat pumps. This is because when available, wood fuel is more 'renewable' and has fewer impacts than the other fuel types. Solar heat generators should be given priority over pellet boilers as the availability of wood is more reliable than solar.

- **Boilers with space heating function (appliances under EN 12809)**

Although these products were not considered to have a significant enough market presence on a EU wide basis for representation as a base case, it is possible that they could be included and integrated into the Lot 1 labelling. This integration will be much more time consuming and complicated due to the nature of these products and may not be justified based on the reduced potential benefit due to the narrow market of these appliances. The following analysis is a proposal for labelling these products for informational purposes only. This issue is important to consider because neglecting to label these product types could easily provide a 'loop-hole' for manufacturers wishing to evade labelling mechanisms.

The problem is that the BIN method used in Lot 1 cannot easily integrate all the functional benefits of boilers with roomheating functionality. This problem mainly revolves around how to interpret the seasonal efficiency of an appliance tested under EN12809. Also, heating demand does not necessarily drive the operation of manually fuelled appliances, which are fired only when the consumer decides to fire them (and on a typically more intermittent basis - often they are not the only heat source in the house and are used to supplement other heating systems which do operate based on heating demand).

- Seasonal efficiency of boiler appliances with roomheater function

The Lot 1 BIN method requires a seasonal efficiency be calculated for labelling. While this is applicable for appliances whose primary intent is to heat water based on a predictable demand, appliances under EN 12809 are operated in a fundamentally different manner than those for which the BIN method was originally designed.

It is therefore proposed that the seasonal efficiency be calculated in a fundamentally different manner. In principle the calculation is a weighted average of two separate heating processes, the direct portion and the indirect portion. The distinction of these two portions of heating may not always be available and this must be considered before implementing this labelling scheme on these product types.

- The hot water heating portion should be subjected to the regular seasonal efficiency calculation BIN method (including losses in the water system). The 'hot water heating portion' of the appliance's heat balance is defined as Pw/P of Annex A.6.2.4 of EN12809:2001.
- It is proposed that the nominal appliance efficiency according EN 12809 be used as the classification criteria against the existing class limits for the direct heating portion of the appliance's heat balance. The 'direct heating portion' of the appliance's heat balance is defined as equal to Psh/P of Annex A.6.2.4 of EN12809:2001.

The weighted average of the above two calculations gives a single efficiency against which the appliance can be classified using the existing class limits.

The total energy use of these appliances is not based on heating seasons or heating demand, but rather based on what consumers choose to burn in the appliance. It is therefore proposed, based on Table 3-27 in Task 3 that these appliances are fired an estimated 337 hours per year and therefore consume an amount of energy corresponding to their nominal efficiency (EN 12809 – not seasonal efficiency) and nominal power. It should be noted this yearly use was developed in general for appliances in the EU and not specifically for this product type, and therefore refinement of this number could be considered.

- Combinations in Lot 1

The method used in Lot 1 allows for combinations of appliances, for example, a wood appliance to supplement a gas fired appliance. In these cases wood fired appliances should be given firing priority over fossil fuel appliances and heat pumps. This is because when available, wood fuel is more 'renewable' and has fewer impacts than the above listed heat generators. Solar heat generators should be given 'firing' priority over wood boilers as the availability of wood is more reliable than solar.

Coal appliances should get lower priority than gas or oil as the fuel contains more sulphur, heavy metals and carbon than gas or oil.

- Applicability

This calculation is no doubt more complicated and will require more care during implementation of the final labelling measures. The key point a policy maker should consider when implementing the above calculation method is whether the market size and demographics justify the extra calculation, legislative and enforcement efforts.

These products tend to be specific to the United Kingdom and Ireland and are therefore recommended to be left for the respective national bodies where these products are of concern. The information provided in this analysis is therefore for informational purposes only and is given for assistance when considering whether to include these products in the Lot 1 label.

Non renewable (coal) fuel boilers

These appliances have demonstrated a sufficient market influence for a labelling scheme to be effective, however it is questionable whether it is directly applicable for incorporation to the Lot 1 scheme. These types of boilers are less frequently used for domestic use and are therefore not applicable to incorporation to the Lot 1 labelling scheme which was designed for domestic purposes.

If it is deemed worthwhile to incorporate these products into the Lot 1 labelling scheme despite these recommendations, no correction factor is proposed. It should be noted that despite this proposal for a correction factor, BAT technologies in this field should be considered for class A classification as they can be a good alternative to other fuel types for heating and often represent the only choice consumers have.

The BIN method again does not properly reflect the operation of these appliances and should be adapted if these appliances are labelled according to the Lot 1 scheme. Manually fuelled appliances are operated only when the consumer fires them and are typically fired in batches. This requires adjustments to the method of calculating seasonal efficiency.

Fuel types are not defined enough for product classifications to be further broken down at a EU level.

It is recommended that these products be subject to emission limit values (ELVs) and minimum efficiency performance (MEPs) as proposed in the following sections.

- **Chip boilers**

These appliances do not have enough market influence for a labelling scheme to be effective. These types of boilers are not always used for domestic use and are therefore not applicable to incorporation to the Lot 1 labelling scheme which was designed for domestic purposes.

It is recommended that these products be subject to emission limit values (ELVs) and minimum efficiency performance standards (MEPS) as proposed in the following sections.

- **Impacts**

The proposed labelling schemes discussed above promote the highest efficiency appliances as well as introduce extra incentives (A+ - A+++ classification) for manufacturers to work towards overcoming the technical and financial challenges posed by operation in the condensing regime for solid fuel boilers. These are in line with the BAT and LLCC scenarios discussed in the previous section. The impacts of the proposed labelling scheme can reach the ambitions of the BAT or LLCC scenarios however would require extra measures and incentives to meet the timeframes proposed in these scenarios.

8.2.2. EMISSION LIMIT VALUES (ELVS)

The values discussed below are suggested for informational purposes however are not necessary to achieve the impact savings proposed, as the other measures proposed in this document (labelling and MEPS) could achieve similar emission reductions with less legislation. This is because, in general as efficiency of appliances increase, emissions decrease.

- **CO and VOC (OGC)**

CO and VOC (OGC) values have been proposed for limits. The measurement methods are established and reliable enough across the EU to provide a comparable and repeatable basis for testing and regulating emissions.

- **NOx emissions**

It is accepted that NOx emissions from solid fuel combustion are exclusively the result of fuel derived nitrogen and therefore not possible to limit through product improvements. NOx emissions are not relevant for regulation for any appliance discussed in this study as was elaborated in Task 4.

Particulate matter

A harmonised testing standard for particulate emissions levels is not sufficiently accepted by industry and experts yet for solid fuel SCIs. As a result, emission limits have been included based on the DIN+ measurement method to allow for short term progress to be made, while in the long term, a harmonised standard should be developed. This study makes no endorsement or suggestion for which measurement method should be adopted. As a result of this, current legislation targets could focus on efficiency, CO, and OGC as these can be tested and measured across product groups in a consistent and repeatable fashion.

It is generally accepted that for solid fuel SCI appliances, an increase in combustion efficiency will result in a general decrease in particulate emissions. In the case of particulate matter, efficiency increases necessarily reduces the organic component of particulate emissions. This ensures that efficiency improvements improve particulate matter emissions at least to the point where only inorganic fuel based particulates remain.

➔ ELVs AND PROPOSED TIME FRAMES

Proposed ELVs for direct heating appliances are given in Table 8-9 and Table 8-10 with associated time frames for implementation. Particulate matter is a very important emission with significant impact on air quality and human health. There is recognition within the industry that emissions must be limited however there is considerable variability in the current (national) emission test methods, particularly for residential appliances. The lack of a harmonised measurement standard in the EU means that regulation of PM emission across EU-27 is not currently possible. Nevertheless proposed values here can be used as a guide.

Tier 1 ELVs are proposed for implementation upon adoption on the measures.

Table 8-9: Proposed ELV values for tier 1 upon adoption

Tier 1 - Immediate	Respective standard	CO	OGC	PM *
		mg/m3 @ 13% O2	mg/m3 @ 13% O2	mg/m3 @ 13% O2
Closed fireplaces/ inserts**	EN 13229	3750	180	75
Freestanding roomheaters	EN 13240	3750	180	75
Cookers	EN 12815	3750	180	100
Slow heat release appliances	EN 15250	3750	180	75
Pellet stoves	EN 14785	500	120	50
Boilers with roomheating function	EN12809	3750	180	75
Boilers	EN 303-5	Class 3	Class 3	Class 3

* - given based on DIN+ method as an example for guidance but not indicative nor intended to endorse DIN+ method. Numbers should be reviewed and revised upon completion of a harmonised particulate measurement method for all of EU. Comparative testing indicates that DIN+ concentrations may capture only 5% of the particulate determined by other methods.
** - includes open door (or no door) appliances with boiler add-ons

Tier 1 ELVs are based on the following:

- CO for closed fireplaces, inserts, freestanding roomheaters, cookers, SHR stoves are based former class 1 lower CO emission limits of EN 13240 (0.3% vol) and current Swedish legislation limits
- OGC for closed fireplaces, inserts, freestanding roomheaters, cookers, SHR stoves are based on former Nordic Eco-label
- PM for closed fireplaces, inserts, freestanding roomheaters, SHR stoves are based on current Danish legislation. Cooker OGC is based on industry proposal.
- CO, OGC and PM for pellet stoves and boilers is based on current Danish legislation

No ELV proposition has been made for open fireplaces.

Table 8-10 shows proposed Tier 2 ELV values. These values are proposed to be implemented 4 years after adoption of measures.

Table 8-10: Proposed ELV values for tier 2 approximately four years after adoption

Tier 2 – After four years	Respective standard	CO	OGC	PM *
		mg/m3 @ 13% O2	mg/m3 @ 13% O2	mg/m3 @ 13% O2
Closed fireplaces/ inserts	EN 13229	1250	100	37.5
Freestanding roomheaters	EN 13240	1250	100	37.5
Cookers	EN 12815	1500	100	37.5
Slow heat release appliances	EN 15250	1250	100	37.5
Pellet stoves	EN 14785	250	100	20
Boilers with roomheating function with closed doors	EN12809	1250	100	37.5
Boilers	EN 303-5	Class 4 or 5**	Class 4 or 5**	Class 4 or 5**

* - given based on DIN+ method as an example for guidance but not indicative nor intended to endorse DIN+ method. Numbers should be reviewed and revised upon completion of a harmonised particulate measurement method for the entire EU.
** - dependent on future amendments to standard

Tier 2 ELVs are based on the following:

- CO and OGC for closed fireplaces, inserts, freestanding roomheaters, cookers, SHR stoves are based on CEFACD industry association proposal and are also equivalent to new German emission requirements for CO (see Task 1).
- PM for closed fireplaces, inserts, freestanding roomheaters, SHR stoves are based on current Nordic Eco-label.
- CO, OGC and PM for pellet stoves is based on industry association proposal

No ELV proposition has been made for open fireplaces.

ELV targets could be met implicitly by meeting MEPs targets. In general, as found in Task 7, improved efficiency reduces emissions across all significant indicators. ELV targets have been presented here for informational purposes, but the MEPs proposed in the following section combined with the labelling criteria in the previous section could accomplish the ELV goals in similar time frames with less policy intervention. The overall impacts associated with the above ELV proposals may not be significantly different than what the other mechanisms proposed in this document can accomplish.

8.2.3. Minimum Efficiency Performance Standards (MEPS)

Some member states are preparing mandatory legislation i.e. Minimum Energy Performance Standards (MEPS) for solid fuel SCIs (see Task 1). MEPS are designed to accelerate the elimination of less efficient appliances on the market rather than to promote the most efficient. As these regulations are still under development no comparison with the different performance levels defined by the LLCC and BAT scenarios is provided here.

Minimum efficiency performance requirements can be adopted and it is possible to correlate them with the labelling schemes.

➔ **DIRECT HEATING APPLIANCES**

For direct heating appliances, the following MEPS are recommended:

- All products sold should have a nominal test efficiency performance higher than class G lower class limits however they are best defined.
- Subsequent class removal can be considered 2 or 4 years after the implementation of the first MEPS.

A clear long term schedule for MEPs should be provided to all stakeholders to help ensure acceptance and timely adoption of the regulations. Open fireplaces with back-boilers have been included in this proposed scheme and will see the most difficulty in meeting these MEPS.

The impacts associated with this mechanism will help to ensure that the timeframes proposed in the BAT and LLCC scenarios could be met. By removing the worst products on the market, one accelerates the market transformation posed by the labelling efforts discussed in the previous section.

➔ **INDIRECT HEATING APPLIANCES**

For indirect heating appliances covered under EN 303-5, a class 2 efficiency is recommended to be the minimum efficiency upon adoption of measures.

Two years after adoption, class 3 efficiency as defined in EN 303-5 is proposed for the minimum efficiency performance level. This efficiency class level is consistent with the ELV proposed for immediate adoption (which are also based on EN 303-5 class 3).

Four years after adoption, class 4 or 5 efficiency as yet to be defined in EN303-5 is proposed for the minimum efficiency performance level. Adjustments of class limits is foreseen in EN303-5 and related adjustments to MEPs and labelling class limits can follow as seen appropriate at the time.

The impacts associated with this proposed mechanism will help to ensure that the timeframes in the BAT and LLCC scenarios could be met. By removing the worst products on the market, one accelerates the market transformation posed by the labelling efforts discussed in the previous section. MEPS related to the labelling initiative of Lot 1 have not been discussed here. If they are considered it should be noted that the impacts for each product type should be individually analysed to be certain that it is reasonable.

8.3. IMPACT ANALYSIS

8.3.1. IMPACT ON THE CONSUMERS

➔ **IMPACTS ON HEALTH**

PM in general raises issues in terms of public health in the EU, not only from a health point of view, but also from an economic as well as a societal point of view. Fossil fuel in households, together with transport, is the major contributor in terms of PM air pollution, so solid fuel small heating appliances covered by lot 15 can contribute to substantial PM emissions reduction.

PM air pollution is pointed out as being responsible of an average 8.6 months life loss for every person in the EU. Studies have highlighted the fact that PM pollution can cause cardiovascular and respiratory diseases[9]. Even short-term exposure to higher PM concentrations increases the risk of emergency hospital admissions for cardiovascular and respiratory causes. PM defines a heterogeneous group in terms of size, composition and origin. When inhaled, the coarse fraction PM10 reach the upper part of the airways and lung, while fine particles PM2.5 are more dangerous and penetrate more deeply and may reach the alveolar region. Heating appliances typically are large emitters in terms of PM2.5. This differs from one country to another, with lower values for low density countries and higher values for countries with a high density of population such as the Netherlands and Belgium.

Current policies to reduce emissions of air pollutant by 2010 are expected to save 2.3 months of life for an average EU citizen. This is the equivalent of preventing 80 000 premature deaths and saving over 1 million years of life in the EU.

Long-term exposure to PM is particularly damaging to human health and reduces life expectancy, and needs to be tackled as a priority. On top of the burden in terms of public health, this also has a financial cost. For the EU, a range of 58-161 billion Euros could be saved if deaths from PM pollution were reduced. Additionally, 29 billion Euros need not be spent on diseases attributed to PM. This represents a total cost of 87-190 billion Euros[10]. The wide range is due to difficulties to model their impacts, their distribution, etc. Comparable figures in a different study gave 80 billion dollars (around 55 million Euros) for the cost of pollution in China in 2004[11]. This cost is mainly imputable to particle matter.

➔ FINANCIAL IMPACTS ON CONSUMERS

Due to growing environmental concern and a general awareness from the consumer's point of view that often, the purchase of a more effective solid fuel small heating appliances will bring benefits over the long time, more and more consumers are ready to buy more efficient appliances, even with a higher purchasing price. Lifecycle cost calculations in Task 7 confirmed the existing improvement potentials as economically feasible for the manufacturer with a cost advantage for the consumer from the LLCC point of view. Savings for the consumer, in case ambitious requirements are set, can possibly reach a few thousand Euros.

➔ IMPACTS ON CONVENIENCE

With the outlined measures and scenarios, no impact on convenience for the user is identified.

For high efficiency appliances, constraints on condensation in the chimney become restrictive. Upgrading a chimney or flue system often is a financial barrier to the level

[9] Polichetti G et al (2009) Effects of particulate matter (PM_{10}, $PM_{2.5}$ and PM_1) on the cardiovascular system.

[10] World health organisation (2005) European Union can save up to €161 billion a year by reducing air-pollution deaths

[11] Taylor J(2006) Press article in PM "Pollution cost China $80b in 2004: report"

of efficiency of an appliance can achieve. Any implementing measures should account for the extra costs associated with upgrading chimney systems for consumers who wish to switch to a very high efficiency appliance.

➔ Impacts on safety

It must be noted that direct heating appliances typically depend on relative buoyant forces to drive the draught of the appliances and ensure effective removal of combustion flue gases. As the efficiency of direct heating appliances increases (indicatively beyond 80%) the lower flue temperatures reduces the strength of the flue draught and therefore introduces the possibility of backdraught in the chimney and flue system. This is a safety concern as it becomes possible for the appliance to inadvertently emit CO emissions into the room it heats.

CO is a serious safety concern in the case of solid fuel appliances. It can accumulate without colour, odour, taste or irritation, and hence is undetectable for humans. It can affect health at concentrations above 100ppm and ultimately can cause death.

A properly designed and installed chimney can help reduce the chances of backdraught in highly efficient appliances. This is often costly and significantly changes the life cycle costs of improved appliance performance. High efficient solid fuel combustion appliances are more likely to introduce potentially damaging condensation into the chimney and flue system of the consumer's dwelling. Appliances sold which operate at efficiencies where condensation is a concern (typically at or above 80% NCV for properly seasoned wood fuels in direct heating appliances) should only be sold to informed consumers who understand that their chimney may require significant upgrading and that this upgrading should only be done by a certified and trained technician.

Condensation heat exchangers were identified as a key improvement option in Task 7 for indirect heating appliances. Products with these design components also require properly designed and installed chimneys to accommodate condensation.

8.3.2. Impact on the industry

The goal of this section is to identify the potential impacts to setting eco-design requirements on manufacturers. Some identified impacts include:

➔ Redesign/Adaptation

As for the adaptation to the eco-design requirements, the capital investment needed by the manufacturer to upgrade or redesign his products and his production lines, happening before the production line capital costs have fully been recovered can imply conversion costs that otherwise would not be required. However, redesign through component level modification does not always require upgrading the production platform.

Furthermore, worse performing products tend to be older and therefore have had a longer time for the manufacturer to recovery and profit from the initial development costs. As it is these products that Eco-design requirements should target, the amortisation period for the development costs of products is not as significant as the redesign time itself when considering time frames for the Eco design requirements.

Innovative manufacturers will capitalise their former and current R&D efforts, benefiting from harmonised rule-making and their competitiveness could be increased.

➔ **INSTALLERS TRAINING**

As for installers, appliances become more efficient and present a higher degree of complexity, further training is needed in order to cope with the higher degree of complexity to tune the chimney and the water flowing, pumping, etc. Otherwise, the benefits due to increased efficiency would be overshadowed by the losses due to improper installation. Properly trained and certified technicians are required for upgrading or installing solid fuel heating systems with high efficiencies, as pointed out before, the installation into the dwelling is as influential on the system efficiency as the product itself. The training and certifying of the personnel should be charged with sizing and installing a heating system for safety reasons and for system optimisation reasons.

➔ **FUEL SUPPLY**

For fuel supply, as the pellets market grows, so do the concerns regarding the industry, i.e. especially concerning the supply, such as the volume and the origin of the pellets.

The wood pellet industry is experiencing an enormous growth as recorded by the last Pellets Industry Forum. The professionalisation of the sector, an increased number of actors across the world and a recent EU norm for wood pellets expected to go into effect as of 2010, are displaying an interest in the industry as a source of market opportunities.

Therefore, the status of pellets is currently shifting from by-product to a simple product. This will have impacts over the value chain of the industry.

Pellets are regarded as an energy source that can contribute to the renewable energy targets set by the EU Renewable Energy Directive. Currently, the growing demand is heterogeneous at MS level and the situation of national markets is at different stages of development. These factors may trigger situations concerning the security of the supply that in turn can undermine the benefits of wood pellets use.

An increase in the demand of wood pellets will not be decoupled of an increase in the raw material necessary to its production. If wood pellets were made mainly from residual wood, then the raw material could be seen as an input from a waste stream and the impacts linked to its production will be reduced significantly. Since other sources must be taped to overcome an increase in the demand, the use of SRC (short rotation coppice) or agricultural biomass for pellet production is becoming necessary. The consequent environmental impacts linked to the production, commercialisation and use of these raw materials is more important and has to be acknowledged and tackled.

Wood pellet production in the UK is an example of the pressure exerted to the industry by the growing demand. The main raw material in this industry is saw dust (produced as a by-product, from a sawmilling operation or the manufacture of wooden structures) but the increased demand for raw material has caused wood pellet manufacturers to start drying and pulverising whole tree trunks, to ensure sufficient raw material[12].

Plantation forests will become the most probable scenario for supplying the increasing demand of this raw material. Fast-growing eucalyptus plantations projects in Australia have been reported to appear in order to respond to the increasing demand. In the US, the forest-products industry from a North-Eastern state, Maine, looks this as an emerging opportunity and developers are already planning and building manufacturing plants that together could produce 1 million tons or more of wood pellets a year[13]. The environmental impacts of these plantations are linked to unsustainable land use and carbon costs derived from the transport of these materials from locations overseas.

Other environmental impacts, linked to the production and commercialisation of wood pellets from SRC, are generated mainly during the planting, farming and chipping, generally done with fossil fuel powered machinery. Crops also require herbicides during establishment, fertilizer throughout growth, and occasional pesticide treatment. These chemicals require substantial amounts of energy and potential fossil fuel usage through manufacture.

➔ **TESTING**

As appliance efficiency increases, appliances tend to become more sophisticated and it is foreseeable that testing requirements also become more extensive, and therefore more expensive. This is particularly true for indirect heating appliances where boiler testing may require multiple test points such as full load, part load, and different operational water temperatures.

This impact could be significant on manufacturers, especially SMES who develop products and would then be required to pay testing facilities for (possibly several) tests to characterise their product. This introduction of these extra costs is undesirable to many stakeholders but is integral to the eco-design measurements proposed here. Testing requirements should therefore be made in consideration of the testing and measurement costs which must be shouldered by product developers and should be a compromise between thoroughness of product performance evaluation and cost effectiveness.

8.3.3. PRODUCT DESIGN CYCLES AND TECHNOLOGY INNOVATION

Given the innovation in solid fuel SCIs and the estimated redesign cycle of 4 years, it is important to provide clear long term (4 years) targets for all stakeholders, particularly for manufacturers to predetermine a date for a new specification levels.

Immediate labelling of products could begin market transformations without imposing restrictive measures against manufacturers.

[12] Pellets@las (2009); English Handbook for wood pellet combustion.

[13] http://news.mongabay.com/bioenergy/2007/04/us-wood-pellet-industry-eyes-exports-to.html

8.4. SENSITIVITY ANALYSIS OF THE MAIN PARAMETERS

The robustness of the outcomes of the study depends on the underlying assumptions. These assumptions were already mentioned throughout of the study. The most critical aspects and assumptions are tested under this section, related to:

- The economic data, primarily the fuel tariff which has an influence on the LCC
- The assumptions on the typical use pattern as defined in Task 3
- The emissions and efficiency of each appliance

8.4.1. ASSUMPTIONS ON THE FUEL PRICE

This section investigates how variations in the price of different fuels, due to differences in national tariffs or price changes in the world market, will influence the point of LLCC.

In order to test the model, the lowest and highest fuel prices reported by any MS, from Table 2-25 in Task 2, were taken to find the average difference and define a possible variation in the fuel price. Table 8-11 presents the fuels under study and the selected variation.

Table 8-11: Selected variation in the fuel price

Retail prices [€/GJ, net basis]				
Fuel type	**EU Average**	**Minimum**	**Maximum**	**Variation**
Forest residues	4.0	2.79	7.13	30%
Firewood logs	6.5	0.81	23.18	30%
Refined wood fuels	10.0	4.57	22.65	20%
Coal	8.0	1.29	20.8	40%

In general, the testing supported the assumptions for the selection of the LLCC, as it proved to be the best option in terms of life cycle cost for the majority of pellets, chips and wood fuelled appliances, regardless of the change in fuel prices. There are certain cases, such as the downdraught gasifying boiler where variations in the wood price have a different impact on the life cycle cost of the options that make the LLCC more or less costly than the base case.

In the BC3, wood stoves, a variation in the fuel price affects the life cycle cost of the base case and the BAT (considered to be the LLCC) in a different proportion. As presented in Figure 8-23 , if the average price of wood increases more than 15%, the BAT offers more opportunities of savings as it is less costly than the base case. On the contrary, at the actual average value and lower fuel prices, the BAT is slightly more costly than the base case. However, both curves are very close to each other and in the extreme projected decrease or increase in fuel prices the maximum difference found is 3%. Generally, as fuel prices increase, more efficient products become cheaper than their respective alternatives.

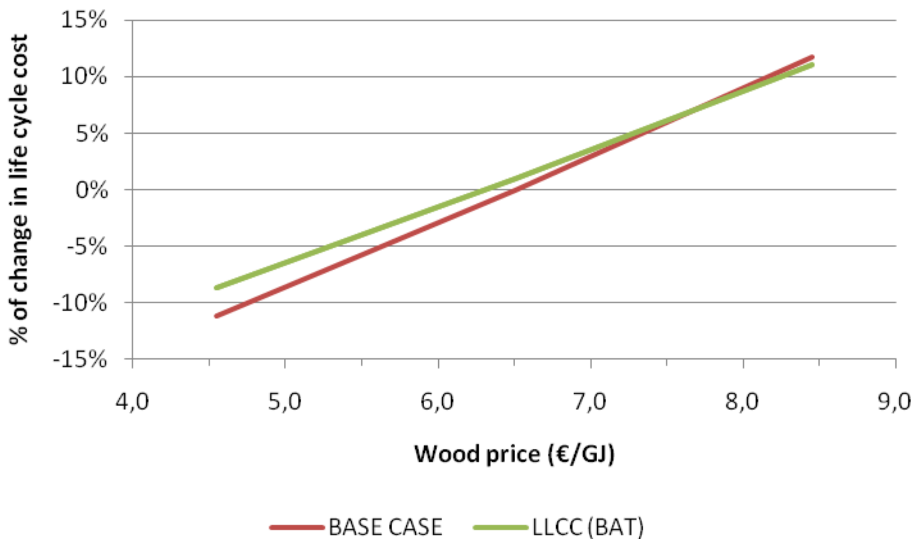

Figure 8-23: BC3 – Wood stoves life cycle costs versus wood prices

Another appliance that displays effects in the life cycle cost of the selected options due to a variation in fuel prices is the DD gasifying food boiler. As presented in Figure 8-24, the BAT and LLCC are affected in the same proportion by the change in fuel, whereas the base case is more or less costly than the other two, depending on the price of fuel. For lower wood prices, LLCC is always less costly followed by the base case, leaving the BAT as the more expensive option. For increased wood prices (higher than 15% of the average price) the BAT becomes less expensive than the base case, and the LLCC remains as the less costly option. Again, higher fuel prices will make the BAT more attractive.

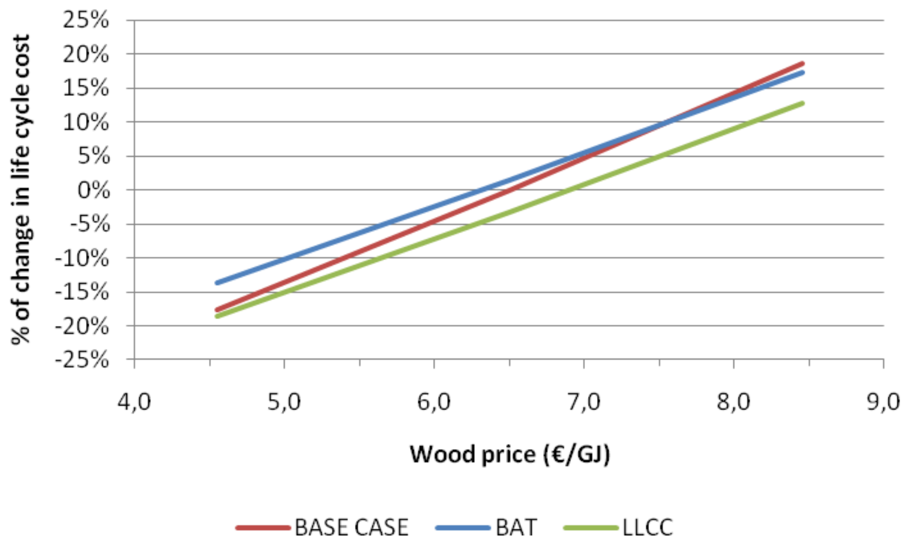

Figure 8-24: BC 9 – DD gasifying boiler life cycle costs versus wood prices

The pellets stove base case (considered also to be the LLCC option) is always less costly than the BAT regardless the variation in the fuel price. The difference in both curves, showed in Figure 8-25, is due the capital cost of the appliance which is not compensated for by fuel savings.

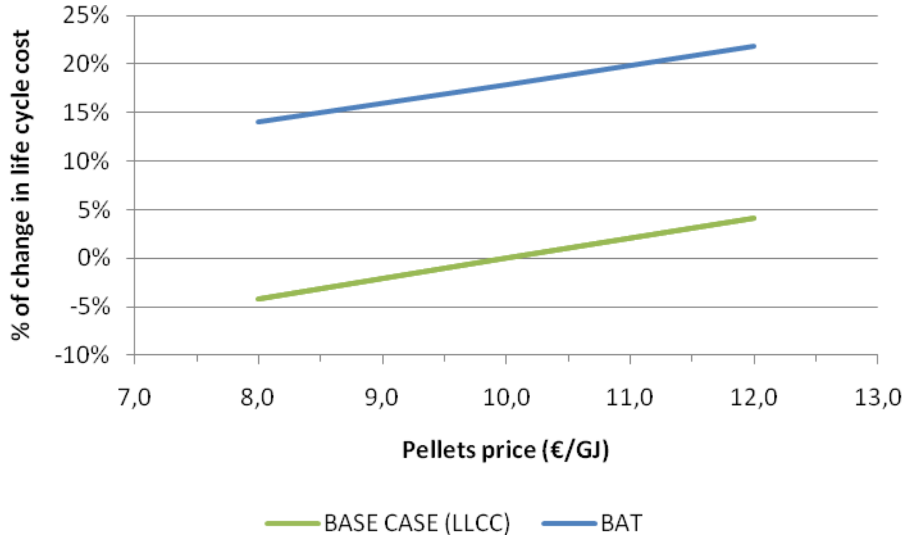

Figure 8-25: BC 7- Pellet stove life cycle costs versus pellet prices

The pellet boiler LLCC life cycle cost is less costly than the other options, base case and BAT, regardless the variation in the fuel price. However, again the BAT becomes less expensive with increases in the fuel price as presented in Figure 8-26.

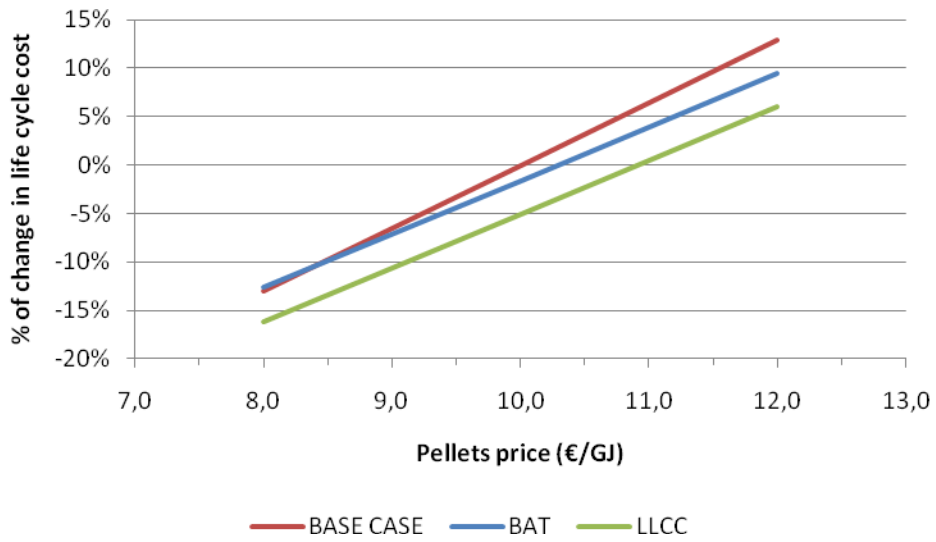

Figure 8-26: BC 11 – Pellet boiler life cycle costs versus pellet prices

8.4.2. ASSUMPTIONS ON THE USE PATTERN

In order to test the assumptions on the use pattern, the time of use was varied by ±80% in every base case. In general, a variation in the time of use didn't affect considerably the selection of the LLCC option. For most of the appliances fuelled by wood, pellets and chips, the LLCC has a better performance (is less costly) than the base case or the BAT. An increase of the use in hours/y represents some savings potential in BAT's as is the case in wood pellets, presented in Figure 8-27.

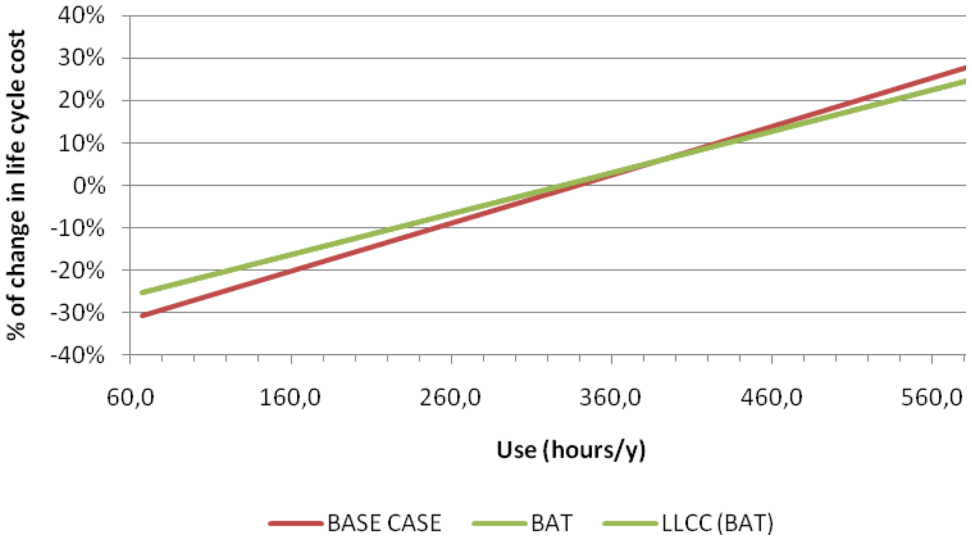

Figure 8-27: BC 3 – Wood stove life cycle costs versus hours of use per year

In the conventional wood boiler, an increase or decrease in the time of use has an important effect in the base case, as it is much less efficient than the BAT. The latter is always a better option regardless of changes in time of use as presented in Figure 8-28.

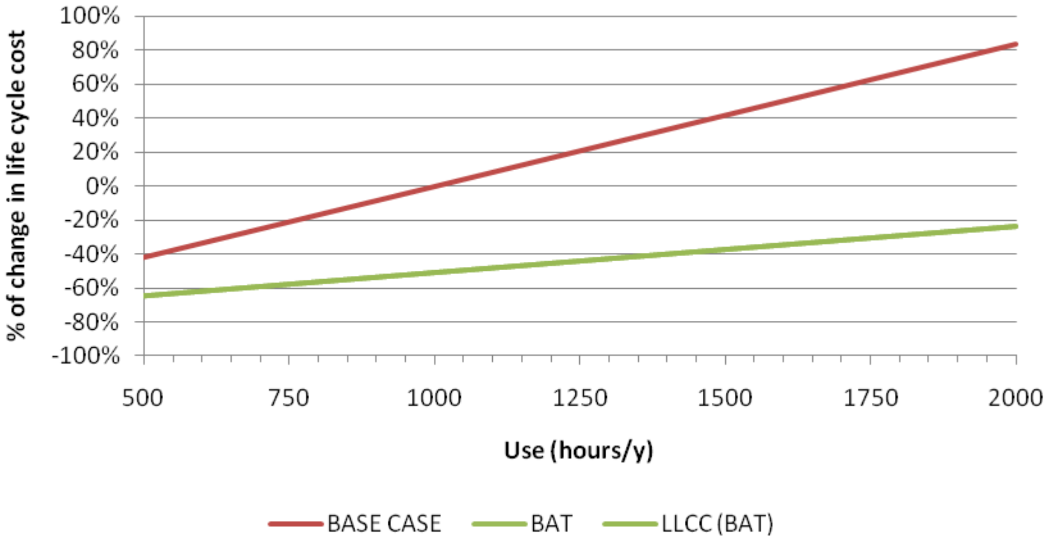

Figure 8-28: BC 8 – Conventional wood boiler life cycle costs versus hours of use per year

An increase in the time of use represents more savings in the BAT and the LLCC compared to the base case, as presented in Figure 8-29 for the pellet boilers.

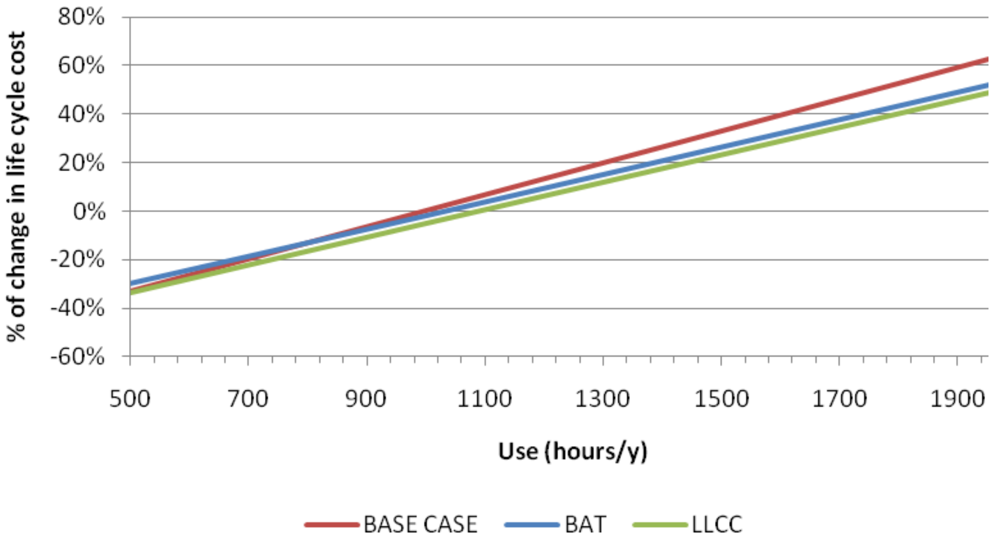

Figure 8-29: BC 11 – Pellet boiler life cycle costs versus hours of use per year

In general as the time of use increases, the BAT and LLCC appliances become less and less costly on a LCC basis. The less an appliance is used, the less time it has to recovery its capital costs in efficiency savings.

8.4.3. ASSUMPTIONS ON THE APPLIANCE EFFICIENCY

Assumptions of appliance efficiency for representing the base cases, the stock, the BATs and the component improvement options were unavoidable throughout the study. The market of SCIs has a wide variety of appliances and this made it very difficult to represent the entire market with just a few base cases and improvement options. The efficiencies and emissions of these appliances therefore represent a very wide range of appliances and not all stakeholders agreed to the numbers chosen for this representation. It is known that the results of the study are very sensitive to the assumptions related to efficiency and emissions. While emissions are equally important here, they have no direct financial consequences on the life cycle costs and hence will not be analysed. It is however understood that the emissions assumptions can vary as much as the efficiency assumptions and can have impacts as relevant as those of the efficiency.

In general, the efficiency was found to profoundly affect the life cycle costs for all appliances. The lines in Figure 8-30 show how sensitive the life cycle cost results are to efficiency. In this figure the capital cost separates the two scenarios. The slope shows how the efficiency varies the LCC. While it may appear that the base case scenario would be a lower cost option for consumers if one was to continued the analysis and increase the base case efficiency (extending the red line lower towards the right and underneath the green line), one must keep in mind that the product capital costs will tend to rise as product performance increases. This invalidates the perception that the base case is lower life cycle option.

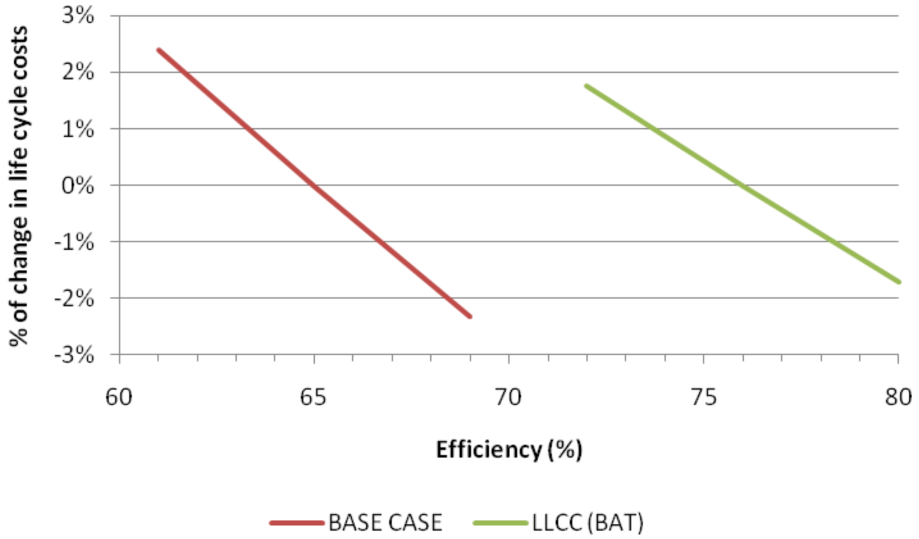

Figure 8-30: BC 3 – Wood stove life cycle cost changes versus real life efficiency for LLCC and BAT improvement option

Figure 8-31 shows a similar pattern again. Fundamentally the efficiency of an appliance is directly linked to its life cycle cost through the increased consumption of fuel.

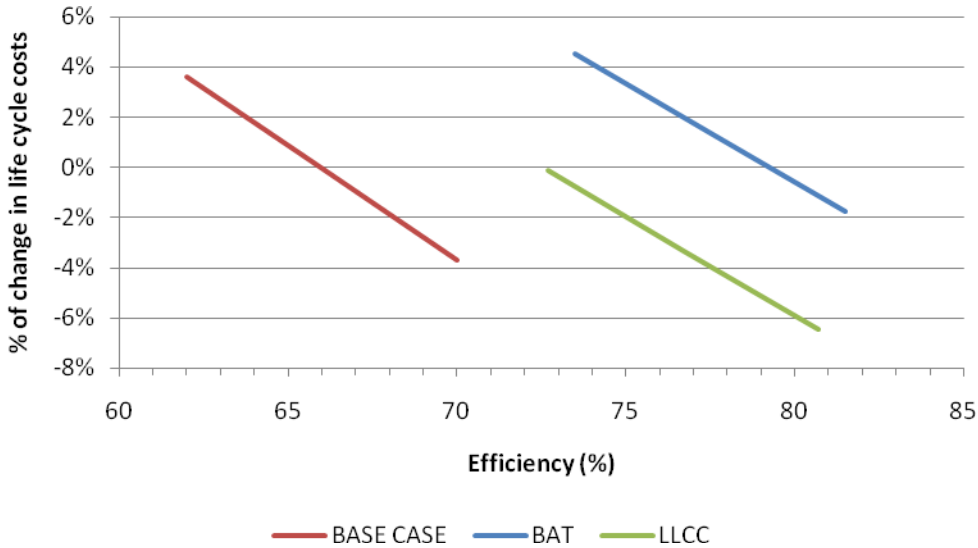

Figure 8-31: Wood boiler life cycle cost changes versus real life efficiency for LLCC and BAT improvement option

As the above graphs have shown efficiency is a key component to the validity of results in this study. In determining the LLCC or BAT scenarios compared to the BC, appliances efficiency must be considered relative to each other and relative to their respective capital costs. The capital costs therefore make up another important dimension for the sensitivity analysis.

8.4.4. ASSUMPTIONS ON THE CAPITAL COSTS

The differences in capital costs between base cases and their respective BAT / LLCC is a key component for analysis. Cost savings through increased efficiency must always offset incremental capital costs of high performing appliances. The analysis below demonstrates how the assumptions in the study affect the outcomes.

In Figure 8-32, the variation in life cycle cost versus capital cost is plotted and shows parallel lines. This is the case for every base case, LLCC and BAT. This is because the capital cost has directly linear affect on the LCC of a product.

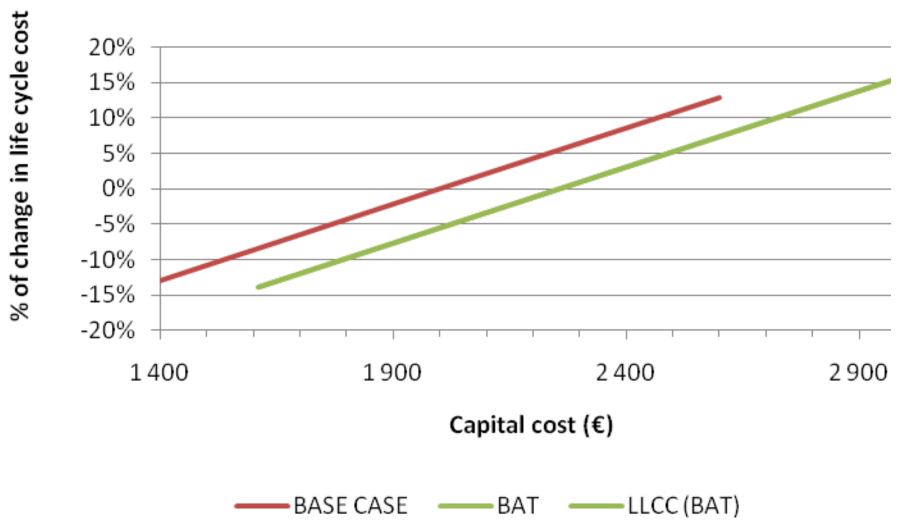

Figure 8-32: BC 3 – Wood stove life cycle costs versus capital cost

Figure 8-33 shows the same pattern for the downdraught gasifying boiler base case and its respective options.

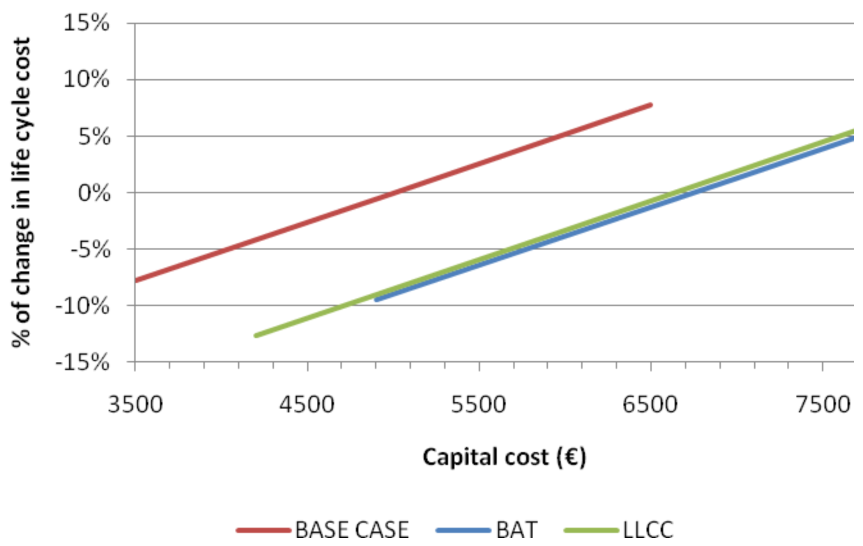

Figure 8-33: BC 9 – Downdraught gasifying boiler life cycle costs versus capital cost

The capital cost of an appliance therefore moves the LCC in the same proportion every time.

8.4.5. FUEL QUALITY

As highlighted in Task 4 of this study, the fuel quality is of utmost importance when analysing the variability of performance and costs of products in Lot 15. Task 4 documented the wide range of fuel variation in terms of technical characteristics of the chemistry of the fuel. It should be recognised in this study that the fuel assumptions of the base cases made were based on several scientifically supported analyses, but were far from an exhaustive and comprehensive review of all fuel types available or in use in the EU.

The nature of solid fuel is fundamentally very variable and hence difficult to characterise into a few parameters which could be varied and examined relative to base case results. It is only possible to discuss the importance of this parameter and understand that appliance performance can be limited by the fuel quality used. Fuel quality therefore has a significant effect on the efficiency, lifetime and life cycle costs of products.

8.5. CONCLUSIONS

With market transformation programs, approximately 5% of the yearly energy demand can be saved between 2010 and 2025 based on LLCC and BAT scenarios. This can accumulate to over 700 PJ of energy over the 15 year time horizon. Approximately 200 kt of particulate matter cumulative can be saved on the same time horizon based on LLCC scenarios and BAU.

A labelling scheme is proposed for direct heating appliances could classify appliances between A and G. ELV are proposed which match labelling classification limits. Products less than G lower class limits are recommended for removal from market upon adoption of the label. Subsequent staged removal of other product classes are suggested also. Overall, technologies operating in the more difficult 'condensing regime' are given A or higher classes, promoting their adoption and acknowledging the special difficulties this poses.

Products related to Lot 1 (wood boilers and pellet boilers, possibly coal fuelled appliances) are recommended to be integrated to the Lot 1 labelling scheme. Other solid fuel boiler types are not recommended to be integrated to the Lot 1 labelling scheme as they are not primarily intended for domestic use and are not recommended for labelling at all. Care should be given to ensure the functionality and mode of operation of each appliance type is properly considered when integrating new product types into the existing Lot 1 labelling scheme. ELVs and MEPs are recommended and proposals are based on EN 303-5 class limits and include products not covered by the proposed labelling scheme.

In general the ELVs proposed could be accomplished equally well with less policy intervention through the labelling scheme and MEPs proposed. Emissions have a significant impact on the health of the population. The ELVs are proposed as an optional implementing measure are can be implemented as an extension to the MEPs if deemed necessary. Particulate matter emission limits are proposed based on a temporary measurement method, which can be used until a harmonised measurement standard is agreed upon.

The LLCC and BAT scenarios are not significantly different from each other because, in general, as an appliance's efficiency increases, its life cycle costs decrease. Both scenarios represent a significant shift in the sales. Indeed, the average appliance sold on the market goes from approximately class D to become class B or better for the direct heating label and for indirect heating appliances from class C or D to better than class A for the Lot 1 label after approximately four years of adoption. A change this significant will require a great deal of effort and collaboration between industry, government and technical experts.

Fundamentally, as the life time of these products is very long, market transformation programs such as labelling and ELV / MEPs take a long time to transform the stock (or park) of products in use. The time frame for transforming the stock of products extends beyond the time horizon of this study (15 years). Incentives or programs to encourage old appliances to be replaced may be more effective overall in reducing the energy consumption and emissions of these products in The EU however this is not the scope of the Eco-design directive.

The sensitivity analysis allows identifying the factors that could influence the various assumptions made on the improvement potential of the Base Cases. Some factors have a foreseeable effect such as the impact of the fuel rate on the LCC. The assumptions on the appliance efficiency and the use pattern are the most sensitive. Overall, the conclusions of the study are within the range of acceptability of accuracy in the sensitivity analysis.