Review of Regulation 206/2012 and 626/2011

Air conditioners and comfort fans

Task 7 report

SCENARIOS

Final version

Date: May 2018

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Specific contract no.: No. ENER/C3/FV 2016-537/03/FWC 2015-619 LOT2/01/SI2.749247
Implements Framework Contract: № ENER/C3/2015-619 LOT 2

This study was ordered and paid for by the European Commission, Directorate-General for Energy.

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Abbreviations

BAT	Best Available Technology
BAU	Business as Usual
BC	Base cases
BEP	Break-Even Point
BNAT	Best Not yet Available Technology
COP	Coefficient of Performance for air conditioners in heating mode
ECC	Eurovent Certita Certification
$\eta_{s,c}$	Greek letter eta, denoted by s,c, means primary seasonal space cooling efficiency
$\eta_{s,h}$	Greek letter eta, denoted by s,h, means primary seasonal space heating efficiency
EER	Energy Efficiency Ratio for air conditioners in cooling mode
GWP	Global warming potential
LLCC	Least Life Cycle Cost
RRT	Round Robin Test
SEER	Seasonal Energy Efficiency Ratio for air conditioners, cooling mode
SCOP	Seasonal Coefficient of Performance for air conditioners, heating mode

Introduction to the task reports

This is the introduction to the Review of Regulation 206/2012 and 626/2011 for air conditioners and comfort fans. The report has been split into seven tasks, following the structure of the MEErP methodology. Each task report has been uploaded individually in the project's website. These task reports present the technical basis to define future ecodesign and energy labelling requirements based on the existing Regulation (EU) 206/2012 and 626/2011.

The task reports start with the definition of the scope for this review study (i.e. task 1), which assesses the current scope of the existing regulation in light of recent developments with relevant legislation, standardisation and voluntary agreements in the EU and abroad. Furthermore, assessing the possibility of merging implementing measures that cover the similar groups of products or extend the scope to include new product groups. The assessment results in a refined scope for this review study.

Following it is task 2, which updates the annual sales and stock of the products in scope according to recent and future market trends and estimates future stocks. Furthermore, it provides an update on the current development of low-GWP alternatives and sound pressure level.

Next task is task 3, which presents a detailed overview of use patterns of products in scope according to consumer use and technological developments. It also provides an analysis of other aspects that affect the energy consumption during the use of these products, such as component technologies. Furthermore, it also touches on aspects that are important for material and resource efficiency such as repair and maintenance, and it gives an overview of what happens to these products at their end of life.

Task 4 presents an analysis of current average technologies at product and component level, and it identifies the Best Available Technologies both at product and component level. An overview of the technical specifications as well as their overall energy consumption is provided when data is available. Finally, the chapter discusses possible design options to improve the resource efficiency.

Simplified tasks 5 & 6 report presents the base cases, which will be later used to define the current and future impact of the current air condition regulation if no action is taken. The report shows the base cases energy consumption at product category level and their life cycle costs. It also provides a high-level overview of the life cycle global warming potential of air conditioners and comfort fans giving an idea of the contribution of each life cycle stage to the overall environmental impact. Finally, it presents some identified design options which will be used to define reviewed ecodesign and energy labelling requirements.

Task 7 report presents the policy options for an amended ecodesign regulation on air conditioners and comfort fans. The options have been developed based on the work throughout this review study, dialogue with stakeholders and with the European Commission. The report presents an overview of the barriers and opportunities for the reviewed energy efficiency policy options, and the rationale for the new material/refrigerant efficiency policy options. This report will be the basis to calculate the estimated energy and material savings potentials by implementing these policy options, in comparison to no action (i.e. Business as Usual – BAU).

The task reports follow the MEErP methodology, with some adaptations which suit the study goals.

7 Introduction to Task 7

In task 7, a number of policy scenarios will be established based on the analyses and stakeholder consultations. Task 7 presents the ecodesign and energy labelling requirements, both for energy efficiency and for material efficiency. The focus will be on updating the existing regulations in terms of updating requirements and possible new requirements, e.g. energy efficiency, the use of low-GWP refrigerants, etc. Moreover, feasibility of policy options that address durability, reparability, disassembly and recyclability is analysed.

The scenarios together with a Business-As-Usual scenario is modelled for the period from 2015 until 2030, including sensitivity analyses.

The task is concluded with a summary of the work undertaken in Task 7, with an overview of both positive and negative impacts related to each policy scenario as well as a set of recommendations.

This task report includes the following:

1. Overview of the barriers and opportunities for the suggested policy measures, focusing on ecodesign energy requirements and energy labelling.
2. Definition of proposed scope for ecodesign and energy labelling requirements.
3. Definition of policy measures for energy requirements, including timing and target levels.
4. Definition of material efficiency requirements, including the rationale for defining these requirements.
5. Scenario analyses presenting the effect of implementing the energy requirements.
6. Sensitivity analyses of the main parameters in the scenario analysis.

7.1 Policy analysis

According to MEErP and based on the results of the policy analysis, a (package of) policy instrument(s) should be selected and the impacts of the policy scenario(s) should be assessed on the energy system, the end-user and on industry in comparison with the impacts of the BAU scenario.

7.1.1 Stakeholder consultation

Stakeholders have been contacted and consulted from the very beginning of the study. Various industry stakeholders have supplied technical specifications of current average products, best available product on the market and best available technology (BAT). Consultation on material efficiency has also been carried out to assess the feasibility and needs for ecodesign policy interventions. Detailed market data and prices have been purchased from market intelligence company such as GfK[1] and BSRIA[2], and much of the analysis regarding efficiencies, sound power level, other technical parameters are based on the datasets from Eurovent Certita Certification (ECC[3]). The analysis of efficiencies is

[1] www.gfk.com
[2] https://www.bsria.co.uk
[3] http://www.eurovent-certification.com/. ECC is a certification company and includes a certification program for less than 12 kW air conditioners. ECC is the only public source in Europe to find technical information on a large number of products. The less than 12 kW certification program gathers 22 manufacturers, including all major brands; all their products have to be certified (this represented about 2200 models as per November

updated with datasets received from industry stakeholders after the second stakeholder meeting to make sure the result is based on sales weighted data to be more representative of the market.

After two stakeholder meetings, many industry stakeholders, NGOs, member states and consumer organisations have submitted comments and suggestions to the study, most of which have been taken into consideration or incorporated.

7.1.2 Barriers and opportunities for improvements

This subsection describes briefly the barriers and opportunities for improvements environmental impact, as well as opportunities for a revised Ecodesign measure.

Task 1 – 4 has shown that the current ecodesign and energy labelling regulations on air conditioners and comfort fans can be improved.

Scope coverage of current regulations for certain product group is blurry and to avoid loophole and ensure consistency with other regulations, the scope is recommended to extend to cover ventilation exhaust air conditioners and air to air heat pumps.

Low power modes power consumption and hours have been reviewed and it is shown that there is improvement potential to achieve lower power consumption in standby/off modes, thermostat-off mode and crankcase heater mode. The potential has not been realised by the industry due to the limited impact the consumption in each mode has on the overall efficiency calculation for SEER and SCOP. An opportunity for revised ecodesign measure is to propose to revise the weighting of the low power modes in the metrics, in order to create a greater incentive for manufacturers to reduce the power consumption. This is also identified as one of the improvement options to achieve higher efficiency in Task 6.

Assessment of existing average product and best available technology (BAT) shows that there is still potential for higher efficiency of heating and cooling for fixed air conditioners and of cooling by portable air conditioners. Least Life Cycle Cost (LLCC) assessment revealed that the LLCC option is close to the base case, as the LCC of a few different options are quite close to each other and the largest saving potential has already been achieved with current regulation due to the technology of inverter. The BNAT option shows the long-term potential, which is significant in comparison with LLCC option, although with the current cost for improvement, it is not the most economical option. However, this shows the level of achievable technology that could be used to set as a goal or a pulling force in the form of energy class scale.

To balance the energy efficiency and sound power level is crucial, for fixed air conditioners in the range of 6 – 12 kW capacity, there is a slight potential to lower the maximum sound power level requirement, whereas other air conditioners have no margin to achieve lower sound power at the same time achieve a higher minimum efficiency requirement as proposed.

To be able to better compare single and double duct air conditioners with others, it is suggested to split double duct air conditioners in two distinct categories, fix and portable products; indeed, fix double duct air conditioners in fact compete with split air conditioners, while portable double duct compete with single duct air conditioners. In addition, for portable air conditioners and heat pumps, there should be a seasonal performance metrics,

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2016); representativeness is believed to be high: about 80 % of products sold in Europe according to the Preparatory study.

and there should be a test method that includes the infiltration air flow in the measurement. This would ensure better consumer understanding of the energy label which does not make a distinction between single/double duct air conditioners and others, and reports a more realistic performance at the same discourage consumers to use thermodynamic heating with single duct products. More details in section 7.1.5.

7.1.3 Policy options

There are several product policy instruments available, which could be used to regulate air conditioners and comfort fans. Given that there are already ecodesign and energy labelling regulation for these products, the focus of policy options is easily identified. The basic types of policy instruments as presented below:

1) **No action option – Business as usual (BAU)**, the current regulations are to be retained as they are. The first overall decision to be made is whether there is a need for further EU intervention. This BAU scenario will be used as reference for comparison with other policy scenarios.
2) **Ecodesign requirements** (under the Ecodesign Directive (2009/125/EC)): This means mandatory minimum requirements would be introduced for a set of parameters, the manufacturers would bear the responsibility for their products to be compliant when placed on the market and the Member States would verify compliance via market surveillance activities. This acts as a "push" instrument for products to achieve better performance because all appliances will have a minimum level of energy efficiency performance regulated by the implementing measure. Since there is already Ecodesign regulation No 206/2012 for air conditioners and comfort fans, this policy option will be analysed in one or more scenarios with newly proposed requirements in this review study.
3) **Energy labelling** (under the Energy Labelling Regulation (2017/1369/EU)[4]): This implies mandatory labelling of the product for a set of parameters. Manufacturers are responsible for labelling their products and it is also enforced by Member State market surveillance. This acts as a "pull" instrument because the consumers will choose the products they want to purchase which can pull the market towards higher energy performance. Since there is already Energy Labelling regulation No 626/2011, this policy option will be analysed in one or more scenarios with newly proposed requirements and energy class scale.
4) **Self-regulation** as an alternative to Ecodesign requirements: The Ecodesign Directive (2009/125/EC) recognizes self-regulation by industry as an alternative to binding legislation. Self-regulation, which can be based on voluntary agreements, is a valid alternative as long as it delivers the policy objectives set out in the legislation faster and in a less costly manner than mandatory requirements. The directive gives specific requirements for self-regulative measures. This option was already discarded since preparatory study as there have been established ecodesign and energy labelling regulations since.
5) **Voluntary labelling** implies manufacturers can choose whether to label their products. In the case of ENERGY STAR[5] and Ecolabel[6], the specifications are established through regulations, ensuring that the labelled product belongs to the

[4] Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU
[5] Regulation (EC) No 106/2008 of the European Parliament and of the Council of 15 January 2008 on a Community energy-efficiency labelling programme for office equipment (recast version)
[6] Regulation (EC) No 66/2010 of the European Parliament and of the Council of 25 November 2009 on the EU Ecolabel

upper segment of the market in terms of energy consumption and other environmental aspects. Member States are responsible for market surveillance. The US ENERGY STAR covers air conditioners, but it is not in scope of the EU-US ENERGY STAR agreement (covers only office equipment). However, EU Regulation 66/2010/EC[7] for EU Ecolabel already covers air conditioners under heat pumps[8], therefore this policy option will not be further analysed in detail.

In conclusion, policy options 1, 2 and 3 will be analysed further in the later sections of this task.

7.1.4 Recommended policy measures

In this section, policy measures assessed in previous section as feasible options are selected for further analysis, including timing and target levels. In the following subsection, the discussions include whether there should be revised ecodesign requirements, such as minimum (or maximum) requirements, and whether it should be complemented with revised energy labelling schemes, needs for new standards to be developed as well as the existing measurement standards that could be used and lastly possibility of setting material efficiency requirements and information requirements on installation of the product or other user information.

7.1.4.1 Ecodesign requirements

LLCC identified in the Task 6 and used for setting the immediate minimum requirement for ecodesign.

For portable air conditioners, it is also recommended to set minimum ecodesign requirements based on seasonal performance metrics (SEER and SCOP) for portable air conditioners as well using the proposed metrics as transitional method.

It is proposed the following ecodesign requirements and timing:

- Tier 1: from 2021, minimum efficiency requirement with one tier based on BC:
    - LLCC for BC 1 (BC): SEER= 6.0, SCOP= 4.0, LCC = 3521€
    - LLCC for BC 2 ((10% UA cond): SEER= 5.5, SCOP= 3.9, LCC = 6391€
    - LLCC for BC 3 (HE1): SEER= 2.3, LCC = 602€, 9 years of payback time

See proposed ecodesign minimum efficiency requirements summarised in the table below.

Table 1: Proposed minimum efficiency requirements for air conditioners in a potential revised ecodesign regulation

	Tier 1, January 2023	
	SEER	**SCOP**
Other than portable, < 6 kW	6	4
Other than portable, 6 – 12 kW	5.5	3.9
Portable	2.3	-

As seen in the table, it is the opinion of the study team that no SCOP minimum requirement should be proposed for single and double duct air conditioners at this time. It is proposed to start the development of a new standard in line with EN14825 plus infiltrations (with default values if required). With this potential new standard in place, double duct products will have to be improved to stay on the market to compete with performance of other products. It is proposed that the single ducts would not be allowed to operate in

[7] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:027:0001:0019:en:PDF
[8] http://ec.europa.eu/environment/ecolabel/eu-ecolabel-products-and-services.html

thermodynamic heating mode. Once performances of new double duct products for new standard are known, then it can be evaluated how far their performances should be increased.

It is however proposed to add ecodesign information requirement of SCOP derived using the proposed metrics if the single and double duct air conditioners have heating function. This means that existing requirements in the current regulation No 206/2012 for COP should still apply beside the added information requirement.

Lastly, infiltration measurement should be proposed in the future mandate for standards.

Requirements for minimum energy efficiency

	Air conditioners, except double and single duct air conditioners		Double duct air conditioners		Single duct air conditioners	
	SEER	SCOP (heating season: Average)	EER_{rated}	COP_{rated}	EER_{rated}	COP_{rated}
If GWP of refrigerant > 150 for < 6 kW	4,60	3,80	2,60	2,60	2,60	2,04
If GWP of refrigerant ≤ 150 for < 6 kW	4,14	3,42	2,34	2,34	2,34	1,84
If GWP of refrigerant > 150 for 6-12 kW	4,30	3,80	2,60	2,60	2,60	2,04
If GWP of refrigerant ≤ 150 for 6-12 kW	3,87	3,42	2,34	2,34	2,34	1,84

Figure 1: Current minimum efficiency requirement set by Regulation 206/2012

As a comparison with current requirement shown in figure above, the proposed SEER requirement for air conditioners other than portables is quite much more ambitious, while the proposed SCOP requirement is not increased significantly from the current requirement level, in order to ensure competitiveness with other heating products. For portable air conditioners, the minimum requirement set for SEER of 2.3 is equal to EER of 2.93 (35°/35°).

7.1.4.2 Energy labelling requirements

BAT and BNAT identified in Task 6 are used for proposing energy efficiency classes, with BNAT as the top level at energy class A. BNAT for different base case is derived with simulation of improvement options, it could mean that it has higher performance than the best available product (BAT) on the market. In light of how quickly air conditioners have populated the current A+++ even though it is not yet introduced by the regulation, it is proposed that Energy Class A should have a relatively high threshold level. This is however in line with the Commission's goal with the revised energy labelling scheme that the upper class (A) shall be empty at the time when the regulation comes into force, therefore the best available product on the market when the revised regulation is adopted should only be able to achieve energy class B.

It is proposed that the following efficiency levels are used for the top energy efficiency class of a revised energy labelling regulation:

- BNAT for BC 1 (all improvement options): SEER= 11.4, SCOP = 5.9, LCC= 4469 €, 25 years of payback time
- BNAT for BC 2 (all improvement options): SEER= 10.6, SCOP = 5.5, LCC= 8667, 32 years of payback time
- BNAT for BC 3 (all improvement options with R290): SEER= 4.3, LCC= 798€, 28 years of payback time

Energy efficiency classes for air conditioners, except double ducts and single ducts

Energy Efficiency Class	SEER	SCOP
A+++	SEER ≥ 8,50	SCOP ≥ 5,10
A++	6,10 ≤ SEER < 8,50	4,60 ≤ SCOP < 5,10
A+	5,60 ≤ SEER < 6,10	4,00 ≤ SCOP < 4,60
A	5,10 ≤ SEER < 5,60	3,40 ≤ SCOP < 4,00
B	4,60 ≤ SEER < 5,10	3,10 ≤ SCOP < 3,40
C	4,10 ≤ SEER < 4,60	2,80 ≤ SCOP < 3,10
D	3,60 ≤ SEER < 4,10	2,50 ≤ SCOP < 2,80
E	3,10 ≤ SEER < 3,60	2,20 ≤ SCOP < 2,50
F	2,60 ≤ SEER < 3,10	1,90 ≤ SCOP < 2,20
G	SEER < 2,60	SCOP < 1,90

Figure 2 Current energy efficiency classes for air conditioners other than single and double ducts set by Regulation 626/2011

As a comparison with current energy efficiency class (Figure 2), the current class A+++ for air conditioners other than portables would be the proposed class C for SEER and SCOP. The requirements are different for double duct air conditioners, depending on whether it is portable or fixed. For portable air conditioners, the current class A+++(Figure 3) for EER of 4.1 and above would be in the proposed class B.

Energy efficiency classes for double ducts and single ducts

Energy Efficiency Class	Double ducts		Single ducts	
	EER_{rated}	COP_{rated}	EER_{rated}	COP_{rated}
A+++	≥ 4,10	≥ 4,60	≥ 4,10	≥ 3,60
A++	3,60 ≤ EER < 4,10	4,10 ≤ COP < 4,60	3,60 ≤ EER < 4,10	3,10 ≤ COP < 3,60
A+	3,10 ≤ EER < 3,60	3,60 ≤ COP < 4,10	3,10 ≤ EER < 3,60	2,60 ≤ COP < 3,10
A	2,60 ≤ EER < 3,10	3,10 ≤ COP < 3,60	2,60 ≤ EER < 3,10	2,30 ≤ COP < 2,60
B	2,40 ≤ EER < 2,60	2,60 ≤ COP < 3,10	2,40 ≤ EER < 2,60	2,00 ≤ COP < 2,30
C	2,10 ≤ EER < 2,40	2,40 ≤ COP < 2,60	2,10 ≤ EER < 2,40	1,80 ≤ COP < 2,00
D	1,80 ≤ EER < 2,10	2,00 ≤ COP < 2,40	1,80 ≤ EER < 2,10	1,60 ≤ COP < 1,80
E	1,60 ≤ EER < 1,80	1,80 ≤ COP < 2,00	1,60 ≤ EER < 1,80	1,40 ≤ COP < 1,60
F	1,40 ≤ EER < 1,60	1,60 ≤ COP < 1,80	1,40 ≤ EER < 1,60	1,20 ≤ COP < 1,40
G	< 1,40	< 1,60	< 1,40	< 1,20

Figure 3: Current energy efficiency classes for single and double ducts set by Regulation 626/2011

The proposed energy efficiency class is summarised in Table 2 and Table 3. Since the current energy labelling does not distinguish the scale for 0 – 6 kW range and 6 – 12 kW range, it is proposed to keep this approach and set the same scale for fixed air conditioners and there is no technical reason for why larger air conditioners cannot achieve the same BNAT levels for 0 – 6 kW range.

The class length is regular with 15 % increase for each class. This is a minimum value so that class width is superior to maximum uncertainties implied by present version of EN14825 standard (2016). In parallel, the study team aims at gathering stakeholders view on the feasibility to lower these tolerances. See more about proposed tolerances and uncertainties in section 7.1.6.

Given the extension of SCOP performances for split air conditioners, this leads to not using F and G classes.

Table 2: Proposed new label schemes for SEER

Label scheme	Other than portable air conditioners	Portable air conditioners
A	SEER ≥ 11.5	SEER ≥ 4
B	9.7 ≤ SEER < 11.5	3.5 ≤ SEER < 4
C	8.1 ≤ SEER < 9.7	3.0 ≤ SEER < 3.5
D	6.8 ≤ SEER < 8.1	2.6 ≤ SEER < 3.0
E	5.7 ≤ SEER < 6.8	2.3 ≤ SEER < 2.6
F	4.8 ≤ SEER < 5.7	SEER < 2.3
G	SEER < 4.8	

Table 3: Proposed new label scheme for SCOP

Label scheme	Other than portable air conditioners
A	SCOP ≥ 6.2
B	5.5 ≤ SCOP < 6.2
C	4.9 ≤ SCOP < 5.5
D	4.3 ≤ SCOP < 4.9
E	4.9 ≤ SCOP < 4.3
F	SCOP < 3.8
G	NA

Currently, consumers are not aware of the difference in energy efficiency when comparing fixed and portable air conditioners as the current energy labels for both types are largely the same. To enable better comparison, it is proposed that requirements should be set using seasonal performance metrics for both, proposed metrics with default infiltration values described in section 7.1.5 can be used as transitional method. However, it is the opinion of the study team that an energy class should only be proposed for portable air conditioners (single and double ducts) in cooling mode using proposed SEER metrics. SCOP is to be declared on the energy label but no energy class is proposed; see an example of visual presentation for proposed energy label in Figure 4 below. When seasonal performance (that accounts for infiltration) of these products is widely known, an energy class scale for SCOP can be then proposed.

Lastly, infiltration measurement should be proposed in the future mandate for standards.

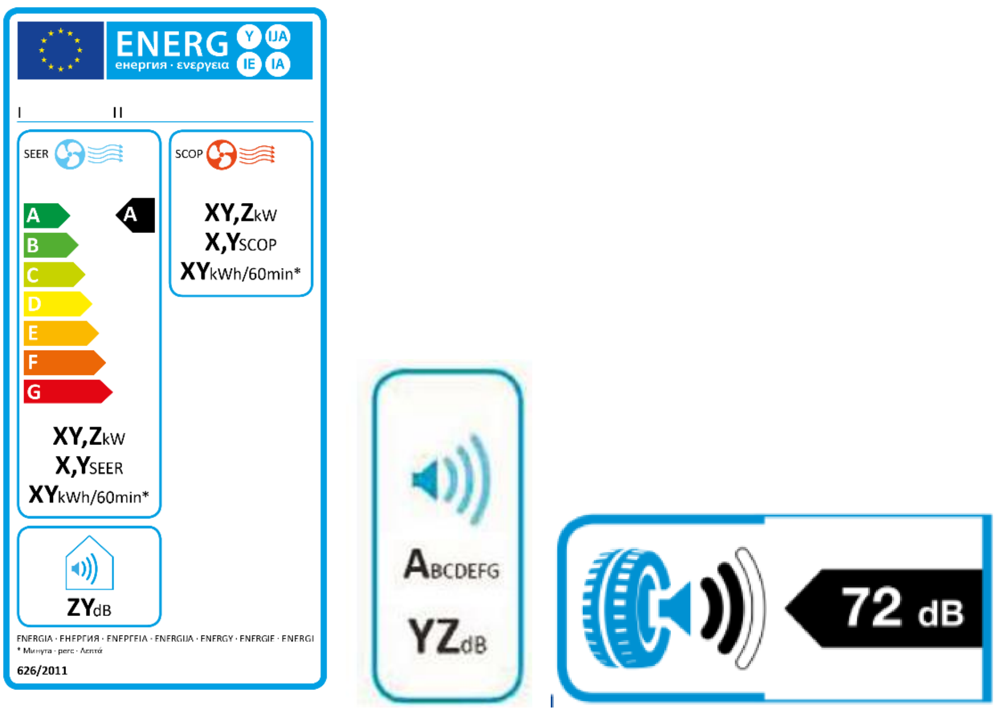

Figure 4: Example of proposed energy label for portable single and double duct units (not final revised label), example of expressing sound power level in a scale of A-G (middle), and example of sound power level expressed by pictograms of sound waves used by tyre labels (left).

Furthermore, some stakeholders[9] have suggested to establish a sound power level scale for all heat pumps and add it on the energy label. Since the noise is an increasing concern of the consumers, the energy label should indicate the sound power levels in a scale of A–G or the loudness should be indicated by pictograms the sound waves already used in the icon, tyre label can be of inspiration, see Figure 4.

Combined label scheme

For better comparison between fixed and portable air conditioners, a combined label scheme is suggested based on primary seasonal space heating and cooling efficiency ($\eta_{s,h}$ and $\eta_{s,c}$). A combined label scheme may influence positively the effect of the label, as the class length proposed above is elongated due to the efficiency development and it is too difficult and costly to improve the product to a better class. Another challenge is the difference in the SCOP and SEER calculations which means that the products not are 100 % comparable. The benefit of a combined label based on primary seasonal space heating and cooling efficiency ($\eta_{s,h}$ and $\eta_{s,c}$) is the better comparison of products, so the consumers can see the differences in efficiency of the different technologies.

Primary seasonal space heating and cooling efficiency is also used in e.g. Regulation (EU) No 811/2013 for space heaters, combination heaters and Regulation (EU) No 2015/1187 for solid fuel boilers etc. Ideally, the use of $\eta_{s,h}$ should be aligned with all relevant regulations so all heating products can be compared.

Table 4 represents a suggestion on how the classes could be defined in a combined label scheme. Note that SEER and SCOP are replaced with $\eta_{s,c}$ and $\eta_{s,h}$. $\eta_{s,c}$ is calculated as the SEER value divided by the primary energy factor[10] and $\eta_{s,h}$ is calculated as the SCOP value divided with the primary energy factor.

Table 4: Proposed new label schemes for a combined label

Label scheme	$\eta_{s,c}$	$\eta_{s,h}$
A	$\eta_{s,c} \geq 4.6$	$\eta_{s,h} \geq 2.5$
B	$3.3 \leq \eta_{s,c} < 4.6$	$2 \leq \eta_{s,h} < 2.5$
C	$2.4 \leq \eta_{s,c} < 3.3$	$1.6 \leq \eta_{s,h} < 2$
D	$1.8 \leq \eta_{s,c} < 2.4$	$1.3 \leq \eta_{s,h} < 1.6$
E	$1.3 \leq \eta_{s,c} < 1.8$	$1 \leq \eta_{s,h} < 1.3$
F	$0.9 \leq \eta_{s,c} < 1.3$	$0.8 \leq \eta_{s,h} < 1$
G	$\eta_{s,c} < 0.9$	$\eta_{s,h} < 0.8$

7.1.4.3 Comfort fans

Regarding comfort fans the same challenges still exist (since the preparatory study) and it is further elaborated in Annex 1. Based on the findings of this assessment there are options which are:

- Setting minimum energy efficiency requirements on comfort fans with the proposed requirements (from the preparatory study) with the risk of banning many comfort fans in the European market (expected savings in the preparatory study was slightly below 1 TWh).

[9] NGOs such as ANEC and BEUC, Member states such as Germany and EEA country Norway
[10] Primary energy factor is assumed 2.5 until the European Commission published a new value.

- Enforcing better market surveillance on the current information requirement and gathering accurate information on comfort fan efficiency and test methods through a complementary study/efficiency tests with corresponding costs.

7.1.4.4 Material efficiency requirement

Material efficiency requirements are very difficult to model, as the material efficiency is dependent on the waste handling system. This system can change due to commodity prices which potentially can change the business model of shredders. If the commodity prices are subject to a significant increase the recycling may be improved due to improved economic incentive and vice versa. As long as the preferred recycling option is shredding all suggestions regarding improved disassembly are not reasonable regarding improvement in recycling rates. The affordability of repair could be improved due to design for disassembly, but manufactures have indicated that they already are targeting to improve the reparability so they do not believe that there is a need to include these requirements. This was supported by exploded views of appliances where it was visible that the assembly was proportionate simple and parts like the PCBs was easily reachable, see Table 5 for more detail. Furthermore, air conditioners already have to comply with the requirements in the WEEE directive, but the transposition of the directive is different in Member state.

Another challenge is the End-of-Life shredding if air conditioners are mixed with other types of appliances (E.g. refrigerators). Then the impact of material requirements (e.g. requirements of the type of plastic used for the casing) will be reduced as air conditioners are mixed with other products containing different materials and the risk of contamination will increase. To improve the recycling rate of air conditioners the best solution is to make horizontal requirements of product families so products that are recycled together consist of compatible materials. Another solution is to improve the recycling facilities by investing in improved sorting technologies or new technologies such as carbon capture technologies[11]. Carbon capture technologies can in the future use CO_2 (e.g. from combustion of plastic) as a feedstock for polymers.

Opportunities for setting material efficiency requirements in ecodesign exist, however without the appropriate assessment tool the impacts of any requirements cannot be properly assessed. EcoReport tool can assess the impacts of the amount of raw materials used, the percentage of mass fraction at end of life is reused, recycled or utilised for heat recovery. Nevertheless, the EcoReport tool focuses mainly on energy and CO2-related indicators, with the significant use phase energy consumption, any impacts of potential material efficiency requirement are in comparison very small, in Task 5 it was also concluded that the use phase related to the highest impacts due to the high energy consumption. In addition, the environmental impacts of improving material efficiency cannot be properly assessed as it is expected to have greater influence on other environmental indicators not included in EcoReport Tool such as abiotic depletion.

Industry stakeholder implied that material efficiency requirements would have very little impact as air conditioners are assembled and designed with repair and maintenance in mind, and unlikely to affect the recycling process for air conditioners, as most of the household appliances are shredded. In the sensitivity analyses in section 7.4, the potential impacts of increasing the recycling rate to maximum are calculated and the results shows little significance.

[11] https://setis.ec.europa.eu/setis-reports/setis-magazine/carbon-capture-utilisation-and-storage/co2-feedstock-polymers

Table 5: Discussion on material efficiency improvements options presented in Task 4.

Difficulties	Ecodesign opportunities	Current situation[12]
Many consumer products are facing reduction in their useful life. This means an increased resource consumption for production of new materials.	Requirements of availability of spare parts (selected parts)	Consulted European manufactures are providing spare parts as a service in the range of 7-12 year which seems reasonable as inefficient/old air conditioners should be replaced at some point. Though, this may not be always true for the lower end of the market.
To avoid premature disposal of efficient air conditioners the cost of repair should be reduced so more air conditioners are repaired. This will minimise the resource consumption of raw materials.	Requirements of exploded views[13] and instructions for disassembly	Exploded views are already available from the largest manufacturers for repair (not for disassembly as the products are shredded[14] anyways). Stakeholders have suggested that manufactures have a genuine interest in informing the professional installers about the detailed design of each product to make the repair as easy as possible. It seems reasonable not to provide these information for regular customers due to safety risks (inappropriate disassemble and repair). End-of-Life the products are most likely shredded and instructions for disassembly would be redundant for recyclers but may prove useful for reparation and refurbishment of appliances[15].
Regarding repair and recycling efficiency it is beneficial if certain components are easy to repair or remove End-of-Life. Especially PCBs are of interest regarding repair (among the most sold spare parts) and End-of-Life treatment (critical raw materials).	Requirements regarding the number of operation to remove targeted components (e.g. printed circuit boards greater than 10 square centimetres)	Consulted European manufacturers have stated that most air conditioners already are designed for fast and easy access and exchange of parts for repair, therefore they assumed that recyclers easily can remove the PCBs before shredding if desired.
Most refrigerants today have an GWP above 2000 and pose a serious threat to the environment.	Requirements of pump-down systems to minimise leakage of refrigerants End-of-Life	According to stakeholders the pump-down function is only useful if the End-of-Life at the site is planned. If the End-of-Life is caused by malfunctions the installer would anyways recover the refrigerant. Furthermore, the amount of leakage during decommissioning is difficult to quantify and the F-gas regulation will limit the impact. In addition, it is assumed that most air conditioners are equipped with a pump down function.

However, if material efficiency requirements are aligned across several regulations as mentioned above, the impact may be much greater and it ensures regulatory consistency within ecodesign framework. In Table 6, different material efficiency requirements in other regulations are presented.

[12] Based on inputs from EPEE
[13] A technical drawing of the appliance showing position of each components inside
[14] Currently, due to economic constraints most household appliances are shredded at recyclers and then e.g. the printed circuit boards are removed by eddy-current separation of sink/float separation.
[15] Confirmed by former operator on AVERHOFF, Tom Ellegaard

Table 6: Alignment with other regulations

	1. Information requirements for refrigeration gases	2. Requirements for dismantling for the purpose of avoiding pollution, and for material recovery and recycling	3. Spare part availability	4. Spare part maximum delivery time	5. Access to repair and maintenance information
Dishwashers (Not yet adopted)	x	x	x	x	x
Washing machines (Not yet adopted)	x	x	x	x	x
Domestic refrigerators and freezers (Not yet adopted)		x	x		
Water Heaters					x
Domestic and commercial ovens, hobs and grills					x
Residential Ventilation					x
Circulators and pumps					x
Ventilation Fans					x
Electric motors					x
Vacuum cleaners					x
Local room heating products					x
Domestic and commercial ovens, hobs and grills					x
TVs					x
Personal computers and portable computers		x			

Dishwashers and washing machines may have the most ambitious requirements regarding resource efficiency and requirements that support the circular economy. These regulations are not yet adopted but they received general support[16]. Previously there have been different requirements regarding information relevant for the disassembly, but one of the greatest barriers towards increased repair and refurbishment is the lack of available spare parts[17]. Though these requirements are difficult to quantify with the current methodology, a study from Deloitte[18] suggest that the following options might have a positive effect on the environment:

- Measures to ensure provision of information to consumers on possibilities to repair the product (corresponds to requirement 5 in Table 6)
- Measures to ensure provision of technical information to facilitate repair to professionals (corresponds to requirement 1, 2 and 5 in Table 6)
- Measures to enable an easier dismantling of products (corresponds to requirement 2 in Table 6)

[16] Industry stakeholders did not strongly oppose resource efficiency requirements, however proposed change of wording in the current formulation of a few requirements, stakeholder comments 2017.

[17] Deloitte (2016) Study on Socioeconomic impacts of increased reparability – Final Report. Prepared for the European Commission, DG ENV.

[18] Deloitte (2016) Study on Socioeconomic impacts of increased reparability – Final Report. Prepared for the European Commission, DG ENV.

- Measures to ensure availability of spare parts for at least a certain amount of years from the time that production ceases of the specific models (corresponds to requirement 3 and 4 in Table 6)
- Different combination of the above-mentioned options

It is therefore recommended to consider aligning with material efficiency requirements regulations for dishwashers, washing machines or domestic refrigerators and freezers.

7.1.5 Metrics changes

Impact of infiltration for single duct and double duct air conditioners

A mandate to CEN should be delivered to develop a test procedure to measure infiltration air flow (i.e. condenser air flow when the unit is operated in cooling mode) for single duct air conditioner. Different methods may be possible; for each of them, uncertainties for these different methods need to be characterized.

7.1.5.1 Portable air conditioners: change in standard rated conditions in cooling mode

To account for infiltration impact on performances, it is necessary to measure single duct unit capacity and efficiency at test condition 27 °C indoor (wet bulb 19°C) / 27 °C outdoor (wet bulb 19°C). This point should be used to define the rated capacity instead of 35 (24) / 35 (24).

For portable double duct units, a supplementary test point, that defines the product rated capacity, is to be done at 27 °C (and 19 °C wet bulb temperature) outdoor inlet air temperature / 27 °C (and 19 °C wet bulb temperature) indoor air inlet conditions.

7.1.5.2 Portable air conditioners: cooling mode metrics

To account for infiltration impact on cooling capacity and performance, the following air flow (AF) should be considered for single duct in absence of test to measure the infiltration air flow: 200 m3/h/kW rated cooling capacity

To compute **seasonal efficiency** in cooling mode:

$$SEER = \frac{Qce}{\frac{Qce}{SEER_{on}} + H_{TO} \times P_{TO} + H_{SB} \times P_{SB}}$$

with

$$Qce = 10/24 \times \sum_{1}^{n} hj \ \times \ Pc\_corr(Tj)$$

and

$$SEER_{on} = \frac{\sum_{j=1}^{n} hj \ \times \ Pc\_corr(Tj)}{\sum_{j=1}^{n} hj \ \times \left(\frac{Pc\_corr(Tj)}{EER_{bin}(Tj)}\right)}$$

Where,

- *Tj = the bin temperature*
- *j = the bin number*

- *n = the amount of bins*
- Qce: cooling energy supplied by the unit over a season
- SEER: the seasonal energy efficiency ratio in cooling mode
- SEERon: the seasonal energy efficiency ratio in cooling mode without accounting standby and thermostat-off electricity consumption
- *Pc_corr(Tj) = below equilibrium point: the cooling demand of the building for the corresponding temperature Tj; above the equilibrium point: the capacity of the unit for the corresponding temperature Tj*
- *hj = the number of bin hours occurring at the corresponding temperature Tj*
- *$EER_{bin}(Tj)$ = the EER values of the unit for the corresponding temperature Tj.*
- *H_{TO}, H_{SB}: the number of hours the unit is considered to work in thermostat-off mode*
- *P_{TO}, P_{SB}: the electricity consumption during thermostat-off mode*

Calculation of *Pc_corr(Tj)* and *$EER_{bin}(Tj)$* for single duct air conditioners
The rated capacity Qc(Tj) for temperature of bin j should be computed as follows.

$$Qc(Tj) = Qc(27)\ (Eq\ 1)$$

Where:

- *Qc(27): rated capacity at 27(19) indoor and outdoor*

Capacity should then be corrected for infiltration as follows:

$$Qc\_corr(Tj) = Qc(Tj) + Q_{INF}(Tj)\ (Eq\ 2)$$

Where:

- Qc_corr(Tj): maximum capacity of the unit corrected with infiltration
- Qc(Tj): maximum capacity in bin Tj without accounting for infiltration

The infiltration impact is calculated with the following formulas:

$$If\ Tj < 27, Q_{INF}(T_j) = \frac{27 - T_j}{27 - 20} \times \left[AF \times \left(rho_{air_{27}} \times h_{27} - rho_{air_{20}} \times h_{20}\right)\right]$$

$$If\ Tj > 27, Q_{INF}(T_j) = \frac{27 - T_j}{35 - 27} \times \left[AF \times \left(rho_{air_{35}} \times h_{35} - rho_{air_{27}} \times h_{27}\right)\right] = \frac{27 - T_j}{35 - 27} \times INF$$

Where:

- $Q_{INF}(T_j)$ *: Heat loss by infiltration (W)*
- *Tj: outdoor temperature of bin j*
- *AF: infiltration air flow (m^3/s)*
- $rho_{air_{20}}$*= 1.20 kg / m3, density of dry air at 20 °C (1 atm)*
- $rho_{air_{27}}$*= 1.17 kg / m3, density of dry air at 27 °C (1 atm)*
- $rho_{air_{35}}$*= 1.15 kg / m3, density of dry air at 35 °C (1 atm)*
- h_{20} *= 42.2 kJ/kg_{da} specific enthalpy of infiltration air at 20 °C dry bulb and 15 °C wet bulb temperature per kg of dry air*
- h_{27} *= 54.2 kJ/kg_{da} specific enthalpy of infiltration air at 27 °C dry bulb and 19 °C wet bulb temperature per kg of dry air*

- h_{35} *= 72.5 kJ/kg$_{da}$ specific enthalpy of infiltration air at 35 °C dry bulb and 24 °C wet bulb temperature per kg of dry air*
- *INF = infiltration in kW (cooling capacity loss - negative capacity value due to infiltration)*

Equilibrium temperature, which is the intersection between building load curve (Eq 3) and capacity corrected with infiltration (Eq 2) is determined and noted Teq.

$$Qc\_corr(Tj) \;=\; Qc(27) \;+\; \frac{27 - T_j}{35 - 27} \times INF \;(Eq\;2)$$

$$BL(Tj) = \;Qc(27)\; \times (T_j - 23)\;/\;(35 - 23)\;(Eq\;3)$$

$$T_{eq} = \;\frac{Qc(27) + \frac{27}{35 - 27} \times INF + \frac{23}{(35 - 23)} \times Qc(27)}{\frac{Qc(27)}{35 - 23} + \frac{INF}{(35 - 27)}}\;(Eq\;4)$$

Pc_corr(Tj) is then computed as follows:

$$If\;Tj\; \leq \;Teq: Pc\_corr(Tj) = BL(Tj)$$
$$If\;Tj\; > \;Teq: Pc\_corr(Tj) = Qc\_corr(Tj)$$

To compute EERbin(Tj), two cases may occur. In both cases, the capacity ratio should be computed as follows:

$$CR(Tj) \;=\; min\;(1\;;\;Pc\_corr(Tj)\;/\;BL(Tj))$$

Case 1: on-off unit

$$If\;CR(Tj) \;<\; 1;\;EERbin(Tj) \;=\; EERrated\;x\;(1 \;-\; Cdc\;x\;(1 \;-\; CR(Tj)))$$

With Cdc cycling coefficient with a value 0.25 by default.

Case 2: inverter unit

A supplementary test should be made at 27 (19) / 27 (19) temperature conditions and at 33 % capacity ratio. The part load coefficient of EER variation noted PLc should be computed as follows:

$$PLc = \frac{\frac{EER(27;33\%) - EER(27;100\%)}{EER(27;100\%)}}{\frac{Qc(27;100\%) - Qc(27;33\%)}{Qc(27;100\%)}}\;\text{(Eq 5)}$$

And EERbin(Tj) should be computed as follows:

$$If\;CR(Tj) \geq \;0.33;\;EERbin(Tj) \;=\; EERrated\;x\;(1 \;+\; PLc\;x\;(1 - CR(Tj)))$$

$$If\;CR(Tj) \;<\; 0.33;\;EERbin(Tj) \;=\; EERrated\;x\;\big(1 \;+\; PLc\;x\;(1 - 0.33)\big)x\big(1 - 0.25\;x\;(1 - CR(Tj)/0.33)\big)$$

Calculation of *Pc_corr(Tj)* and *EER$_{bin}$(Tj)* for double duct air conditioners

$$Qc(Tj) = Qc(27)\ +\ (Qc(35) - Qc(27))/8\ x\ (Tj - 27)\ (Eq\ 1bis)$$

Where:

- *Qc(27): rated capacity at 27(19) indoor and outdoor*
- *Qc(35): rated capacity at 27(19) indoor and 35(24) outdoor*

Capacity should then be corrected for infiltration as follows:

$$Qc\_corr(Tj)\ =\ Qc(Tj)\ (Eq\ 2bis)$$

Equilibrium temperature, which is the intersection between building load curve (Eq 3) and capacity corrected with infiltration (Eq 2) is determined and noted Teq.

$$Qc\_corr(Tj)\ =\ Qc(27)\ +\ (Qc(35) - Qc(27))/8\ x\ (Tj\ -\ 27)\ (Eq\ 2bis)$$

$$BL(Tj) =\ Qc(27)\ \times (T_j - 23)\ /\ (35 - 23)\ (Eq\ 3)$$

$$T_{eq} =\ \frac{Qc(27) - 27 \times \frac{Qc(35) - Qc(27)}{8} + 23 \times \frac{Qc(27)}{(35 - 23)}}{\frac{Qc(27)}{35 - 23} - \frac{Qc(35) - Qc(27)}{(35 - 27)}}\ (Eq\ 4)$$

Pc_corr(Tj) is then computed as follows:

$$If\ Tj\ \leq\ Teq: Pc\_corr(Tj) = BL(Tj)$$

$$If\ Tj\ >\ Teq: Pc\_corr(Tj) = Qc\_corr(Tj)$$

To compute EERbin(Tj), two cases may occur. In both cases, the capacity ratio (CR(Tj)) should be computed as follows:

$$CR(Tj)\ =\ min\ (1\ ;\ Pc\_corr(Tj)\ /\ BL(Tj))$$

For double duct units, the efficiency at maximum capacity should be computed as follows:

$$EER(Tj) = EER(27)\ +\ (EER(35) - EER(27))/8\ x\ (Tj\ -\ 27)$$

Where:

- *EER(27): rated EER at 27(19) indoor and outdoor*
- *EER(35): rated EER at 27(19) indoor and 35(24) outdoor*

Case 1: on-off unit

$$If\ CR(Tj)\ <\ 1;\ EERbin(Tj)\ =\ EER(Tj)\ x\ (1\ -\ Cdc\ x\ (1\ -\ CR(Tj)))$$

With Cdc cycling coefficient with a value 0.25 by default.

Case 2: inverter unit

A supplementary test should be made at 27 (19) / 27 (19) temperature conditions and at 33 % capacity ratio. The part load coefficient of EER variation noted PLc should be computed as follows:

$$PLc = \frac{\frac{EER(27;33\%) - EER(27;100\%)}{EER(27;100\%)}}{\frac{Qc(27;100\%) - Qc(27;33\%)}{Qc((27;100\%)}} (Eq\ 5)$$

And EERbin(Tj) should be computed as follows:

$$If\ CR(Tj) \geq\ 0.33;\ EERbin(Tj)\ =\ EERrated\ x\ (1\ +\ PLc\ x\ (1 - CR(Tj)))$$

$$If\ CR(Tj)\ <\ 0.33;\ EERbin(Tj)\ =\ EERrated\ x\ \left(1\ +\ PLc\ x\ (1 - 0.33)\right)x\left(1 - 0.25\ x\ (1 - CR(Tj)/0.33)\right)$$

7.1.5.3 Metrics change for double duct products (fix and portable) in heating mode

The intent is to use the same methodology for double duct as for split air conditioners in heating mode following EN14825 standard. There is in fact no difference to be made as infiltrations are already included in the tests done for double duct units.

Because of the effect of infiltration, bivalent temperature points should be set higher than for products without infiltration. Bivalent temperatures used in Regulation EU no 206/2012 can be used for double duct heat pumps.

Changes in metrics for fixed air conditioners and heat pumps
Crankcase hours should be adjusted.

7.1.6 Proposed tolerances and uncertainties

Present tolerance levels in Regulation (EU) No 206/2012

Tolerances are defined as follows:

- EER of single duct and double duct appliances: 10 %
- SEER and SCOP of split air conditioners: 8 %

Tolerance and uncertainty: background

Fixing tolerance is a political decision. CEN/CENELEC Eco-design Coordination Group[19] defines the general policy for Ecodesign measures on how to choose appropriate tolerance levels. This should be based upon the expanded measurement uncertainty which includes the repeatability and reproducibility components. Repeatability refers to measurement uncertainty of the same unit tested several times in the same laboratory. Reproducibility refers to variations between laboratories. This leaves to manufacturers the charge of the variations due to manufacturing.

Expanded measurement uncertainties should be based upon the results of Round Robin tests (RRT), if available. According to CEN/CENELEC Eco-design Coordination Group, "the expanded uncertainty is taken as the product of (a) a coverage factor (usually equal to 2) that yields an interval of values within which the true value lies with a level of

[19] http://ecostandard.org/wp-content/uploads/ECO-CGN0195-Recommendations-for-establishing-verification-tolerance-considering-measurement-uncertainty.pdf

confidence of approximately 95 %, and (b) the standard deviation of the results divided by the square root of the number of results".

It is thus strongly advised to lead Round Robin tests for both SEER of portable air conditioners and SEER and SCOP of fixed air conditioners. However, at the time this report is written, such results are not available. For portable air conditioners, a preliminary report on a still on-going Round Robin test reported by UBA[20] could allow to compute EER expanded uncertainties: reproducibility standard deviation was determined to be of 1 % (test in 2 different laboratories) and the repeatability standard deviation was not greater than 0.6 % in each test laboratory (with 4 tests by laboratory). Further results from additional laboratories are expected by mid-2018 to deliver statistically valid reproducibility value. Applying Eco-design coordination group methodology to present results (an approximation is used here as individual test results have not been supplied) would lead to expanded uncertainties below 3 % ($2 \times \sqrt{0.01^2+0.006^2} = 2.3$ %). This seems very low as compared to present tolerances of 10 % on EER for single duct air conditioners in Regulation (EU) n° 206/2012 so it seems better to wait for the complete RRT to be completed and final report to become available.

In absence of Round Robin test indications, existing standard EN14825:2016 includes maximum measurement expanded uncertainties (including both repeatability and reproducibility) for capacity and electricity values so that it is possible to calculate maximum expanded measurement uncertainty for seasonal performance indicators. These expanded measurement uncertainties are also used for portable air conditioners here because the same measurement method as for split air conditioners (calorimetric room) is also used for these products. A supplementary measurement is required for single duct air conditioners, this is the condenser air flow, which measurement expanded uncertainty is 5 % according to EN14511-3:2013.

To calculate the expanded uncertainty, as measurement uncertainties indicated in EN14825:2016 are expanded measurement uncertainties, it is enough to propagate the uncertainties to compute seasonal performance metrics expanded uncertainties of measurement from these values.

We then use this method to determine the maximum expanded uncertainties from available standard information for a number of representative units. Calculation of SEER and SCOP uncertainties are done using the software EES[21], which allows to prevent uncertainty propagation uprate due to derivative calculation simplifications or errors. Discussion with test laboratories on this subject show there might be a need for a CEN TC 113 guidance on how to calculate measurement uncertainties for SEER / SCOP as the calculation by hand is quite complex and time consuming (and then may lead to significant errors).

Individual measurement uncertainties

Expanded individual measurement uncertainties are defined as:

- (EN14825:2016) Regarding thermal capacities: 15 % below 1 kW, 10% between 1 and 2 kW, 5 % above 2 kW and 10 % (or 15 % if capacity is less than 1 kW) in non-stationary conditions - i.e. for test points including frost/defrost cycles.

[20] UBA and BAM, Comments received February 6 2018.
[21] Klein, S.A., EES – Engineering Equation Solver, Version 10.039, 2016, F-Chart Software, http://fchart.com

- (EN14825:2016) Regarding electric power: 1 % with a minimum value of 0.1 W below 10 W (useful for auxiliary power mode measurement[22])
- (EN14511:3, 2016) For infiltration measurement of single duct air conditioners, 5% on the air flow rate.

Best possible values achievable by the time of the measures have been discussed with test laboratories:

- Regarding thermal capacities: 10 % below 2 kW, 5 % above 2 kW and 5 % (or 10 % if capacity is less than 1 kW) in non-stationary conditions - i.e. for test points including frost/defrost cycles.
- Regarding electric power: 1 % with a minimum value of 0.1 W below 10 W
- For infiltration air flow measurement of single duct air conditioners, 5%.

Note that for infiltration air flow of single duct air conditioners, manufacturers indicated that the air flow test is to be done in realistic operating conditions because the air flow decreases when the quantity of condensates increases in the condenser air flow (most single duct units indeed recirculate the condensates from the evaporator to the condenser so that they may be evaporated). The impact of a higher uncertainty level of 10 % is thus tested hereafter.

EU test laboratories have indicated that to further decrease expanded measurement uncertainties for thermal capacities, which are the major components in the final repeatability uncertainty of SEER and SCOP value, it would be necessary that EU test laboratories build new calorimetric room chambers of smaller size, which, even if they had the money to invest in, could not be realistically ready at the time revised air conditioner regulations enter into force. Basing upon the example of measurement uncertainty in other economies, manufacturers believe it is still possible to go lower by forcing all test laboratories to standardize some of the measurement methods between the laboratories.

Expanded uncertainty calculation for split air conditioners

Six different unit types are considered. For these units, all parameters required to compute SEER / SCOP are available. For all these units, as explained before in Task 4, the building load required at D point condition cannot be reached. This tends to reduce the measurement uncertainty for lower capacity units as measurement uncertainties presently increases with decreasing capacity. Consequently, it is supposed in what follows that the same efficiency at D point can be obtained without cycling but by adjusting the capacity to the required building load. This gives an idea of the uncertainty increase for machines that can reach such low capacity levels. This tend to increase SEER/SCOP expanded uncertainty between 0.5 % (smaller units) to 0.3 % (larger units).

Calculation results are shown in Table 7 for both present uncertainty levels and the improved scenario described above.

[22] Note this value is to be increased to 0.3 W in the next revision of EN14825:2016, but this has a negligible impact on SEER and SCOP uncertainty values.

Table 7: Measurement uncertainty calculation results for 6 split units of different sizes.

Expanded uncertainty				
Products Cooling capacity (kW)	**SEER**	**SCOP**	**Unc_SEER %**	**Unc_SCOP %**
1.5	5.7	4.0	7.1%	8.4%
2.5	7.8	4.6	5.3%	6.5%
3.5	8.5	4.7	4.8%	5.8%
5	6.1	4.2	3.2%	5.9%
7	7.1	4.0	3.1%	5.8%
10.5	6.1	4.0	2.8%	5.8%
Expanded uncertainty				
Products Cooling capacity (kW)	**SEER**	**SCOP**	**Unc_SEER %**	**Unc_SCOP %**
1.5	5.7	4.0	5.1%	5.6%
2.5	7.8	4.6	4.9%	5.7%
3.5	8.5	4.7	4.3%	5.6%
5	6.1	4.2	3.2%	3.6%
7	7.1	4.0	3.1%	3.6%
10.5	6.1	4.0	2.8%	3.0%

Tolerance in Regulations (EU) n°206/2012 and 626/2011 should be set close to the expanded uncertainty levels. The 8 % tolerance in these regulations is compatible for all units except in heating mode for less than 2 kW unit for which expanded measurement uncertainty is 8.4 %. However, the D point capacity in real life cannot be reached and so the expanded uncertainty is close to 8 %.

With present expanded measurement uncertainties in EN14825:2016, tolerance could already be reduced for the higher capacity range. In the present situation, the following maximum expanded uncertainties could be used to set tolerances as follows:

- SEER tolerance: 8 % below 2 kW cooling capacity, 6 % between 2 and 6 kW and 4 % between 6 and 12 kW.
- SCOP tolerance: 8 % below 2 kW cooling capacity, 7 % between 2 and 6 kW and 6 % between 6 and 12 kW.

With the improved accuracy in the second scenario, (expanded uncertainties and so) tolerances could be reduced to 6 % below 6 kW cooling capacity and 4 % between 6 and 12 kW for both SEER and SCOP.

Expanded uncertainty calculation for portable air conditioners

For portable air conditioners, the base case single duct appliance is used, part load control is either on/off cycling or with compressor inverter; in that later case, it is supposed the test point capacity at 33 % can be reached by reducing the frequency (this maximize capacity measurement uncertainty at low load). Two values regarding air flow measurement uncertainties are considered given that the measurement methodology is not yet fixed, 5 % and 10 %.

Calculation results are shown in Table 8 below.

Table 8: Measurement uncertainty calculation results for 2 single duct units of different sizes

Existing individual uncertainty							
Products Cooling capacity (kW)	**Unc_Air flow rate %**	**SEER**	**T_eq**	**P[T_eq]**	**Unc_SEER %**	**Unc_Teq %**	**Unc_P[T_eq] %**
2.44 kW (27) ON/OFF	5%	2.1	30.0	1.42	5.8%	0.4%	6.5%
2.44 kW (27) ON/OFF	10%	2.1	30.0	1.42	5.9%	0.7%	6.9%
2.44 kW (27) Inverter	5%	2.9	30.0	1.42	7.5%	0.4%	6.5%
2.44 kW (27) Inverter	10%	2.9	30.0	1.42	7.6%	0.7%	6.9%
1.90 kW (27) ON/OFF	5%	2.1	30.0	1.10	11.3%	0.7%	12.7%
1.90 kW (27) ON/OFF	10%	2.1	30.0	1.10	11.4%	0.9%	13.0%
1.90 kW (27) Inverter	5%	2.9	30.0	1.10	10.0%	0.7%	12.7%
1.90 kW (27) Inverter	10%	2.9	30.0	1.10	10.1%	0.9%	13.0%
With reduced individual uncertainties - Repeatability only							
Products Cooling capacity (kW)	**Unc_Air flow rate %**	**SEER**	**T_eq**	**P[T_eq]**	**Unc_SEER %**	**Unc_Teq %**	**Unc_P[T_eq] %**
2.44 kW (27) ON/OFF	5%	2.1	30.0	1.42	5.8%	0.4%	6.5%
2.44 kW (27) ON/OFF	10%	2.1	30.0	1.42	5.9%	0.7%	6.9%
2.44 kW (27) Inverter	5%	2.9	30.0	1.42	5.8%	0.4%	6.5%
2.44 kW (27) Inverter	10%	2.9	30.0	1.42	6.0%	0.7%	6.9%
1.90 kW (27) ON/OFF	5%	2.1	30.0	1.10	11.3%	0.7%	12.7%
1.90 kW (27) ON/OFF	10%	2.1	30.0	1.10	11.4%	0.9%	13.0%
1.90 kW (27) Inverter	5%	2.9	30.0	1.10	8.8%	0.7%	12.7%
1.90 kW (27) Inverter	10%	2.9	30.0	1.10	8.9%	0.9%	13.0%

Air flow measurement uncertainty has a very limited influence on the performance parameters. Although no smaller than 2 kW (capacity @ 27/27) unit could be identified in today EU market, if such a unit was available, tolerances should be much higher than for higher than 2 kW units. If inverter units become available on the EU market, the uncertainties and tolerances need to be higher.

In the present situation, the following maximum expanded uncertainties could be used to set tolerances as follows:

- SEER: 6 % for on/off and 8 % for inverter (12 % for lower than 2 kW @ 27/27 units)
- Pc(Teq): 7 % (13 % for lower than 2 kW @ 27/27 units)
- Teq: 0.3 K (0.4 K for lower than 2 kW @ 27/27 units)

The improved accuracy scenario would allow to lower the SEER uncertainty as follows:

- SEER: 6 % (12 % for lower than 2 kW @ 27/27 units)

Conclusion: proposal regarding tolerances of performance parameters

According to previous definitions, tolerances should be higher than the repeatability measurement uncertainty alone and lower or equal to the expanded uncertainty. In absence of RRT, tolerance values should be fixed to the maximum possible value, i.e. to the level of the maximum expanded uncertainties.

With present measurement uncertainties, tolerance levels can be set as follows:

- split air conditioners:
    - SEER tolerance: 8 % below 2 kW cooling capacity, 6 % between 2 and 6 kW and 4 % between 6 and 12 kW.
    - SCOP tolerance: 8 % below 2 kW cooling capacity, 7 % between 2 and 6 kW and 6 % between 6 and 12 kW.
- portable air conditioners:
    - SEER: 6 % for on/off and 8 % for inverter (12 % for lower than 2 kW @ 27/27 units)
    - Pc(Teq): 7 % (13 % for lower than 2 kW @ 27/27 units)
    - Teq: 0.3 K (0.4 K for lower than 2 kW @ 27/27 units)

SEER and SCOP tolerance levels in Regulations (EU) No 206/2012 and 626/2011 need to be revised.

With improved measurement accuracy, tolerances could be reduced to the following levels:

- split air conditioners:
    - SEER: 6 % below 6 kW cooling capacity and 4 % between 6 and 12 kW
    - SCOP: 6 % below 6 kW cooling capacity and 4 % between 6 and 12 kW
- portable air conditioners:
    - SEER: 6 % (12 % for lower than 2 kW @ 27/27 units)

Further discussions with test laboratories and manufacturers are required about the conditions of feasibility and timing of this improved scenario.

These proposed air conditioner performance indicators should be the subject of regular Round Robin Tests amongst EU laboratories. These RRT should be used to calculate the expanded measurement uncertainties from test results and to lower tolerances depending on the RRT results. Individual measurement uncertainties on capacity should also be adjusted depending on the results of such campaigns.

A RRT campaign is on-going for portable air conditioners and could be used to reduce the expanded uncertainty on EER measurements and thus also on the performance parameters indicated here.

7.2 Scenario analysis

The scenario analysis investigates the impact of the current regulation and revised regulation regarding reduction in energy consumption and emission of CO_2-eq. The impact of changes to material composition are not included as the impacts are very limited due to changes in the material composition. Nor are suggestions towards improved material efficiency included due to the limited impact (industry have already improved due to a focus on reparability) and to the difficulties with quantifying the improvement potential.

The options investigated are all related to improved energy efficiency and sound power level. The investigated options are:

- Option 0 and 1: BAU scenario (before and after current regulation)
- Option 2: Revised Ecodesign requirement
- Option 3: Revised Energy labelling
- Option 4: Combination of revised Ecodesign and Energy labelling

These options are all modelled according to the assumed effect on the proposed requirements and are used to model different scenarios. These scenarios are dependent on the different potential improvement options presented in Task 6. The modelled scenarios and the correlation with the improvement options presented in Task 6 are shortly described in the table below.

Table 9: Summary of policy scenarios and brief descriptions

Policy scenario	Description
Scenario 0 (0 BAU)	BAU before EU regulation – In general low yearly improvements. The only improvement included is the use of inverter technology
Scenario 1 (1 BAU)	BAU scenario (current regulation) – The impact of the current regulation with only limited incentive to improve products beyond the A+++ label
Scenario 2 (1 tier eco)	Ecodesign minimum efficiency requirement with one tier based on LLCC (BC 1 for BC 1, -10%Ua_cond for BC 2 and HE1with R290for BC 3)
Scenario 3 (lbl)	Energy class A as BNAT (combining the different improvement for each of the base cases)
Scenario 4 (eco+lbl)	Ecodesign and Energy labelling scenario 2 + scenario 3

The impacts of the different scenarios are calculated based on the stock and the annual sales. Furthermore, all scenarios are built on different assumptions from Task 5 and Task 6 and are presented in Annex 1.

The development of SEER and SCOP in the different scenarios are presented below in the different scenarios.

7.2.1 Before EU regulation – 0 scenario

The before EU regulation scenario is used as a baseline to show how effective the EU intervention has been so far. Though, this is difficult since the regulation in countries outside of the EU also have an effect on the European market. The assumptions made to model the improvements on SEER and SCOP are mainly focusing on the shift to inverter technology which supposedly also would have happened without any intervention from EU. The assumed average SEER and SCOP development for air conditioners sold are presented in Table 10.

Table 10: Development of SEER and SCOP of air conditioners sold - with no EU regulation

	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
SEER										
BC1	2.18	2.30	2.76	3.22	3.68	4.14	4.59	5.05	5.51	5.65
BC2	1.88	1.99	2.41	2.84	3.26	3.68	4.11	4.53	4.95	5.08
BC3	1.22	1.28	1.34	1.39	1.44	1.50	1.55	1.60	1.66	1.68
SCOP										
BC1	1.85	1.93	2.21	2.48	2.76	3.03	3.31	3.58	3.86	3.96
BC2	1.60	1.67	1.93	2.18	2.44	2.70	2.95	3.21	3.47	3.56
BC3	-	-	-	-	-	-	-	-	-	-

Without the EU regulation the SEER and SCOP levels in 2040 are not even on par with the current situation in 2017. So, the regulation has accelerated the development significantly. The energy and emission of CO_2 are calculated based on these values in Table 11. Note that the hours in heating mode and cooling mode are the same in all scenarios to make the impacts in the different scenarios comparable.

Table 11: The annual energy consumption and emission of CO_2-eq in scenario 0 (no intervention from EU)

	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
Electricity consumption (TWh)										
BC1	4.5	13.2	26.7	37.9	38.7	36.4	42.6	52.2	62.7	75.3
BC2	2.4	6.7	12.8	19.6	22.7	22.4	25.3	29.3	33.7	38.7
BC3	0.4	0.9	1.1	1.2	1.1	1.0	1.0	1.0	1.0	1.0
Total	**7.3**	**20.8**	**40.6**	**58.6**	**62.6**	**59.8**	**69.0**	**82.6**	**97.4**	**115.0**
mt CO_2-eq										
BC1	2.6	6.6	12.9	17.4	17.6	16.5	18.7	22.2	26.3	31.5
BC2	1.3	3.3	6.2	9.0	10.4	10.2	11.2	12.5	14.2	16.2
BC3	0.2	0.4	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5
Total	**4.1**	**10.3**	**19.7**	**27.1**	**28.6**	**27.2**	**30.4**	**35.2**	**40.9**	**48.2**

Sound power level

Before the regulation the sound power level varied a lot for the different air conditioners from quieter to more noisy air conditioners than today. It should be noted that it is difficult to link air flow and sound power level. Though, air flow is clearly one of the main factors in determining the sound power levels, and it is challenging to increase efficiency while reducing sound power level further. The sound power level of air conditioners is presented in Figure 5 and Figure 6.

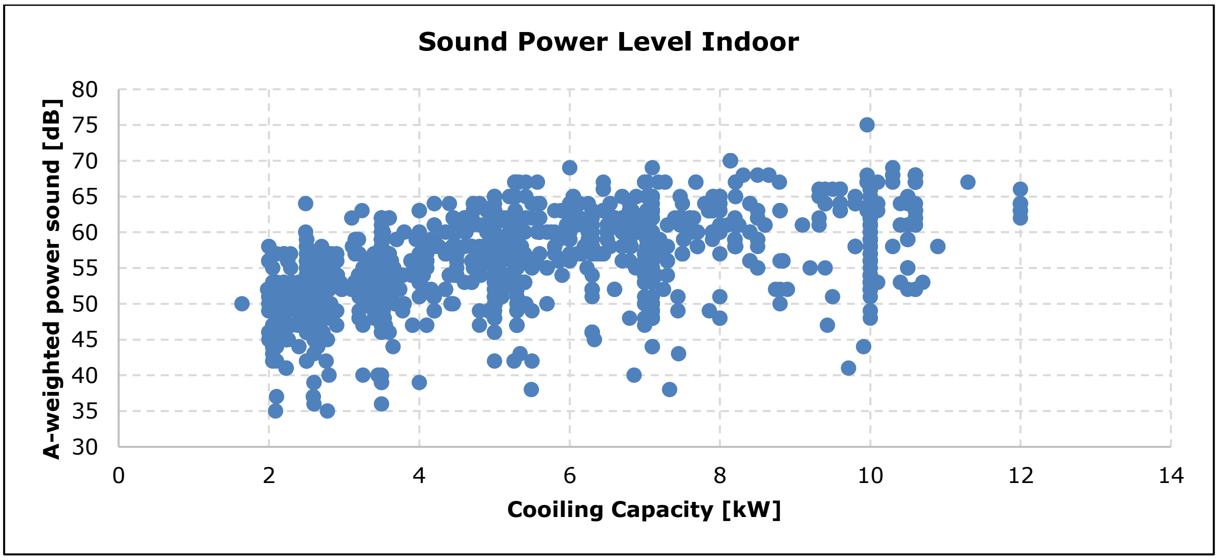

Figure 5: ECC directory 2006, air conditioners below 12 kW, sound power level of indoor unit in cooling mode

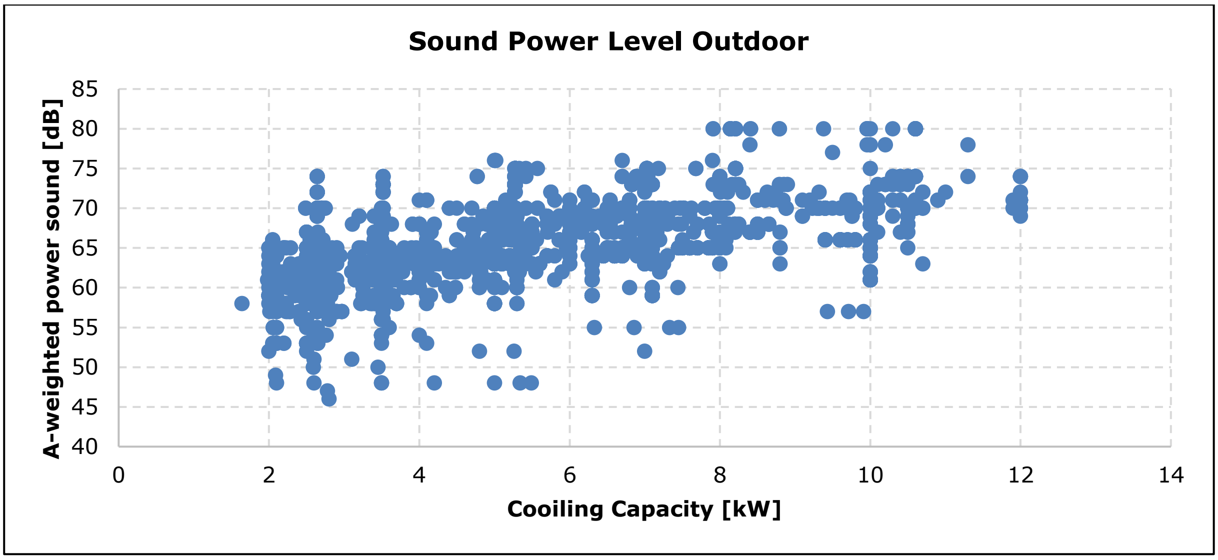

Figure 6: ECC directory 2006, air conditioners below 12 kW, sound power level of outdoor unit in cooling mode

These figures show the sound power level of air conditioners before the current EU regulation.

7.2.2 Business-as-Usual (BAU) - scenario 1

The business-as-usual scenario quantifies the effect of the current regulation (Ecodesign Regulation 206/2012 and Energy Labelling 626/2011) so far and estimate the development until 2040. By comparing scenario 0 and scenario 1 it is possible to calculate the saved energy and emission of CO_2-eq due to the current regulation.

The SEER and SCOP values are based on the current development until today and with no other enforcement for improvement it is estimated that BAT levels (from the preparatory study) first will be reached in 2050. The assumed SEER, SCOP are presented in Table 12.

Table 12: Development of SEER and SCOP with the current regulation

	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
SEER										
BC1	2.18	2.44	3.63	4.81	6.00	6.36	6.71	7.07	7.43	7.79
BC2	1.88	2.15	3.37	4.58	5.80	6.01	6.23	6.44	6.66	6.87
BC3	1.22	1.31	1.48	1.65	1.83	1.87	1.91	1.96	2.00	2.05
SCOP										
BC1	1.85	2.01	2.67	3.34	4.00	4.09	4.17	4.26	4.34	4.43
BC2	1.60	1.77	2.51	3.26	4.00	4.04	4.09	4.13	4.17	4.21
BC3	-	-	-	-	-	-	-	-	-	-

Just by comparing the improvement in SEER and SCOP it is visible that the current regulation has had a significant impact for fixed air conditioners. The improvements are approximately 50 % for SEER and SCOP in 2020. This development in SCOP are properly also one of the main reasons for the increased use of fixed air conditioners in heating mode. Air conditioners are replacing inefficient electric radiators as the savings are increasing due to the improved performance of air conditioners. The replacement of inefficient heaters will lead to even larger savings which not are accounted in the presented values below. The smallest increase in efficiency is for portable air conditioners. The SEER has improved from 1.50 in scenario 0 to 1.87 in scenario 1 (2020).

The annual energy consumption and emission of CO_2-eq of scenario 1 are calculated compared to scenario 0 in the presented figures below.

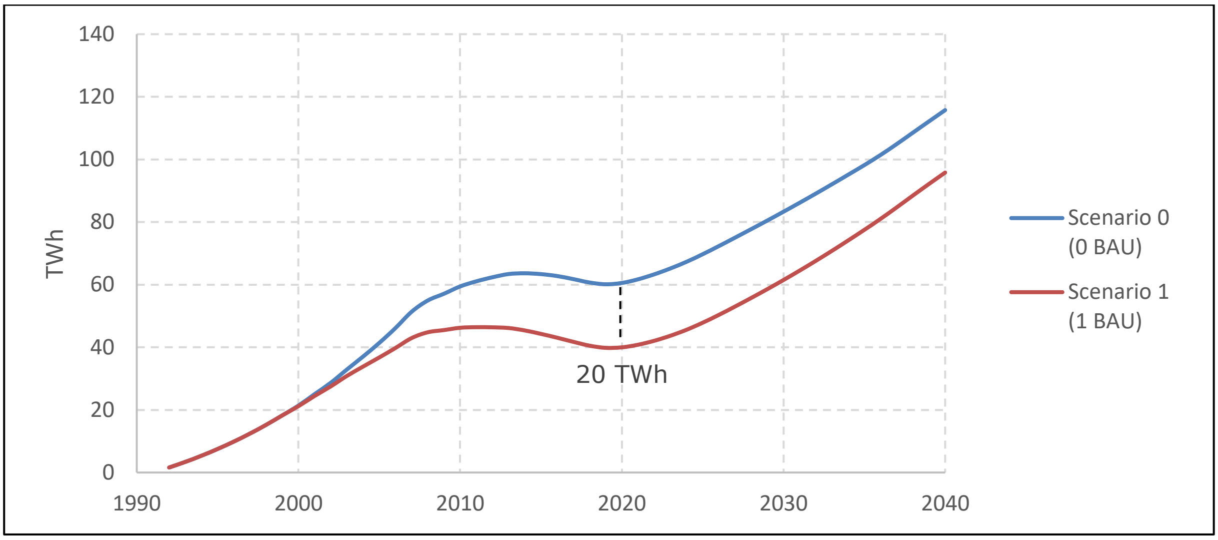

Figure 7: Comparison of the annual energy consumption of scenario 0 and scenario 1.

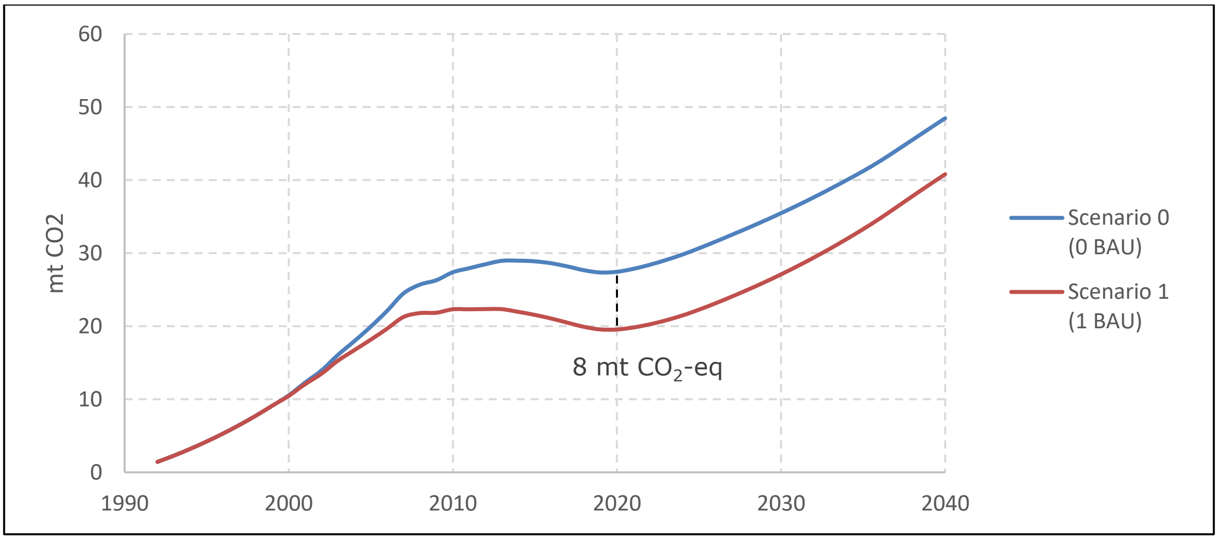

Figure 8: Comparison of the annual emission of CO_2-eq in scenario 0 and scenario 1.

It is visible that both the energy consumption and emission of CO_2-eq have been reduced significantly due to the current regulation. The annual savings of energy and CO_2-emission is approximately 20 TWh and 8 mt CO_2-eq. In Table 13, the annual electricity consumption and emission of CO_2-eq for each of the base cases are presented and the annual saving compared to scenario 0 (before regulation).

Table 13: The annual energy consumption and emission of CO_2-eq in scenario 1 (current regulation)

	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
Electricity consumption (TWh)										
BC1	4.5	13.1	24.0	30.4	28.4	25.3	30.7	40.2	51.2	64.1
BC2	2.4	6.6	11.3	14.7	15.1	14.0	16.6	20.8	25.7	31.1
BC3	0.4	0.9	1.0	1.0	0.9	0.8	0.8	0.8	0.8	0.8
Total	**7.3**	**20.6**	**36.3**	**46.2**	**44.5**	**40.2**	**48.1**	**61.8**	**77.7**	**96.0**
mt CO_2-eq										
BC1	2.6	6.5	11.9	14.6	13.6	12.2	14.2	17.6	21.9	27.2
BC2	1.3	3.3	5.6	7.1	7.5	7.0	7.8	9.2	11.1	13.3
BC3	0.2	0.4	0.5	0.6	0.5	0.4	0.4	0.4	0.4	0.4
Total	**4.1**	**10.2**	**18.0**	**22.3**	**21.6**	**19.6**	**22.4**	**27.2**	**33.4**	**40.9**
Annual energy and mt CO_2-eq savings compared with 0 BAU										
Electricity consumption (TWh)										
BC1	0	0.10	2.71	7.42	10.32	11.04	11.89	12.04	11.48	11.24
BC2	0	0.06	1.58	4.88	7.60	8.35	8.78	8.56	8.04	7.64
BC3	0	0.00	0.04	0.12	0.18	0.20	0.21	0.19	0.18	0.18
Total	**0**	**0.17**	**4.33**	**12.43**	**18.10**	**19.59**	**20.87**	**20.79**	**19.70**	**19.06**
mt CO_2-eq										
BC1	0	0.04	1.04	2.85	3.96	4.24	4.57	4.62	4.41	4.32
BC2	0	0.02	0.61	1.88	2.92	3.21	3.37	3.29	3.09	2.94
BC3	0	0.00	0.02	0.05	0.07	0.08	0.08	0.07	0.07	0.07
Total	**0**	**0.06**	**1.66**	**4.77**	**6.95**	**7.53**	**8.02**	**7.99**	**7.57**	**7.32**

The majority of the saving are originating from small fixed air conditioners due to their high improvements in SEER and SCOP and the large stock.

In the table below is the combined accumulated savings in energy and emission of CO_2-eq presented.

Table 14: The accumulated savings in energy and emission of CO_2-eq in scenario 1 (effect of current regulation) compared to scenario 0

	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
TWh	0	0	11	58	138	234	336	441	542	638
Mt CO_2-eq	0	0	4	22	53	90	129	169	208	245

The current regulation has by 2015 saved more than 138 TWh electricity and avoided more than 53 mt CO_2-eq. These accumulated saving are only increasing in the future.

Scenario 1 are used as the current baseline in the policy scenarios.

Sound power level

The sound power level in 2016 shows the sound power levels of air conditioners after the enforcement of the regulation, see figures below.

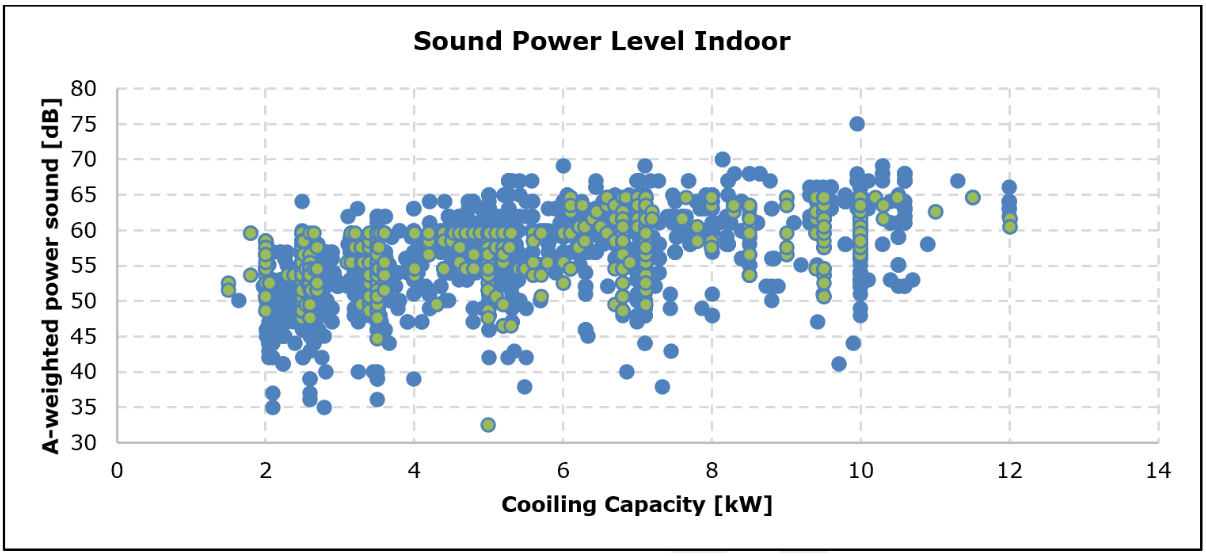

Figure 9: Comparison of the indoor sound power level in 2006 (blue dots and) and 2016 (Green dots)

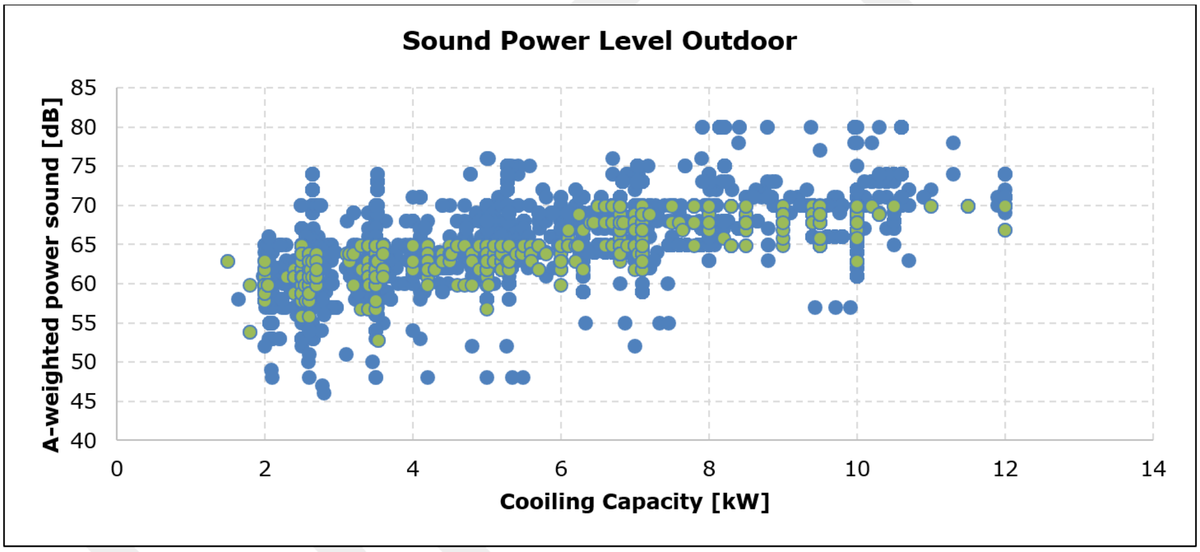

Figure 10: Comparison of the outdoor sound power level in 2006 (blue dots and) and 2016 (Green dots)

It is visible that the current regulation has been effective since the noisiest air conditioners are removed from the market. It is also visible that many air conditioners are close to the current requirements and without sound power level requirements the air conditioners would have had higher values. Today the average indoor sound power level of fixed split air conditioners (≤6 kW) is 56.3 dB(A) while the average outdoor sound power level is 62.3 dB(A). For larger air conditioners (>6 kW) the average indoor sound power level is 61 dB(A) while the average outdoor sound power level is 67.6 dB(A).

As discussed in Task 6, there is little to none margin for sound power level improvement while increasing energy efficiency of 0 – 6 kW capacity air conditioners as well as portable air conditioners. Although there is slightly more room for improvement for 6 – 12 kW range, it may require a more precise requirement of sound power level proportional to the capacities.

7.2.3 Policy scenarios

The policy scenarios show the potential for future requirements. Other countries around the world are also progressively strengthening their requirements and EU should not lag behind in this positive development. Both USA and Japan have currently more ambitious requirements that will benefit the environment.

Based on the LLCC and BAT technologies in Task 6 it is possible to determine a new set of requirements and a new label scheme. These are presented in Table 2 and Table 3 above. Based on the new requirements it is possible to model the future evolution on SEER and SCOP. The predicted evolution is presented in the table below:

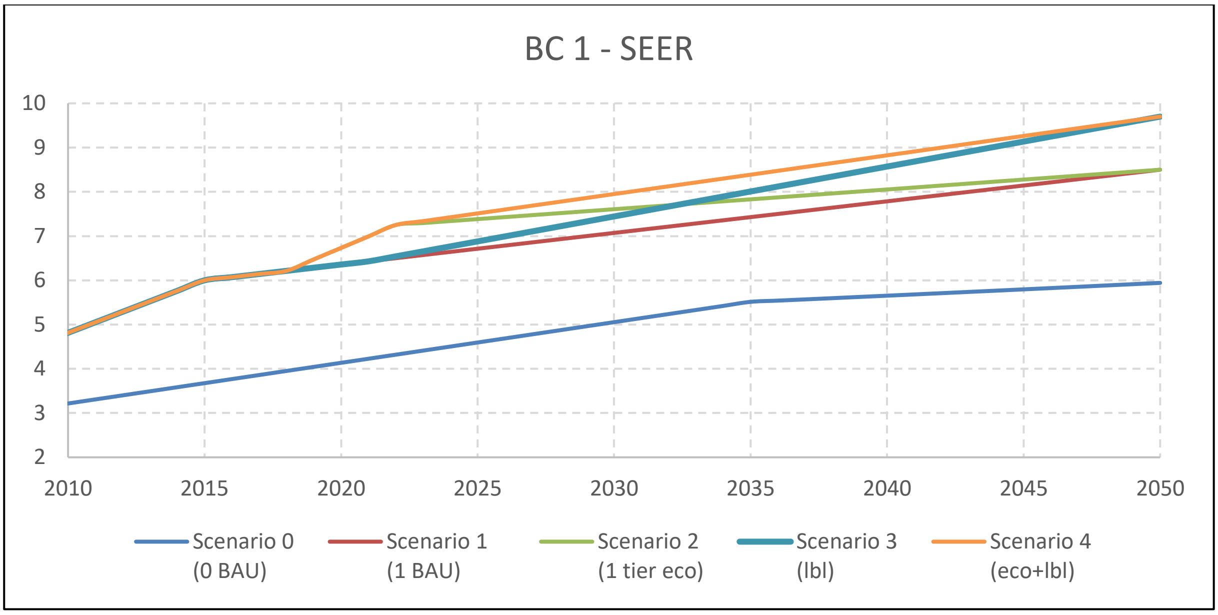

Figure 11: Comparison of the SEER development for BC1 in all scenarios

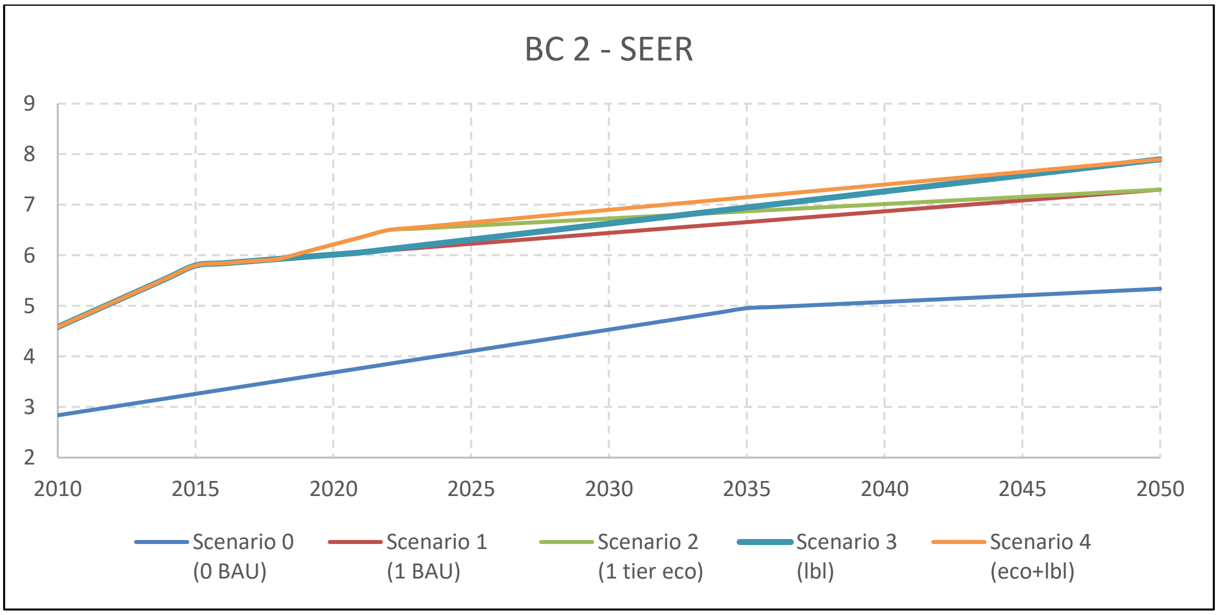

Figure 12: Comparison of the SEER development for B2 in all scenarios

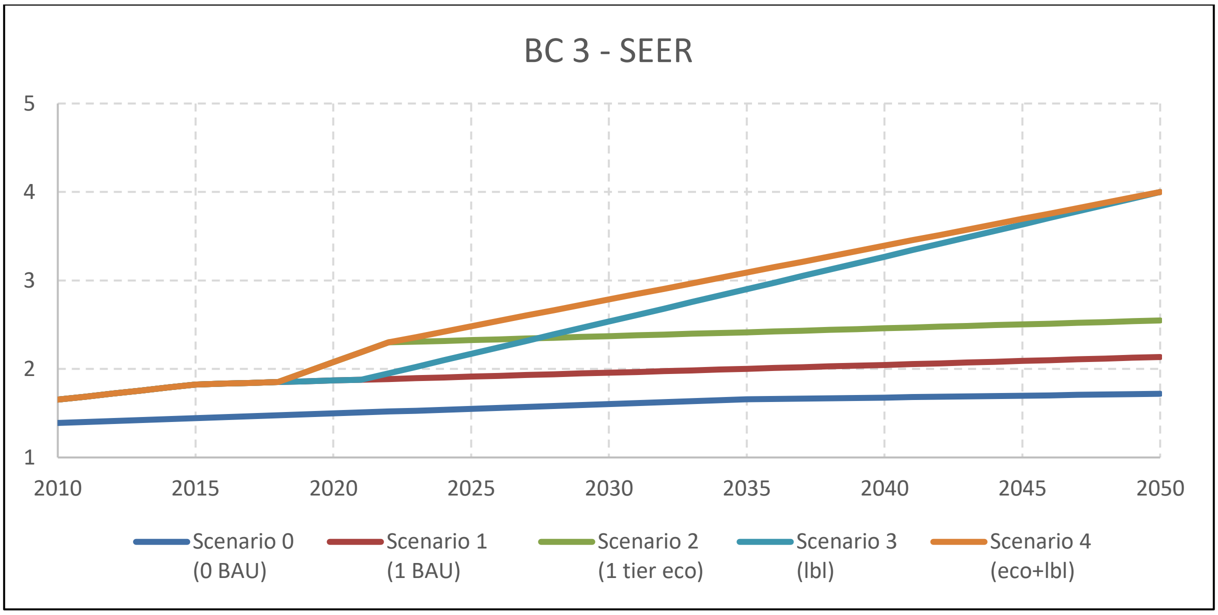

Figure 13: Comparison of the SEER development for BC3 in all scenarios

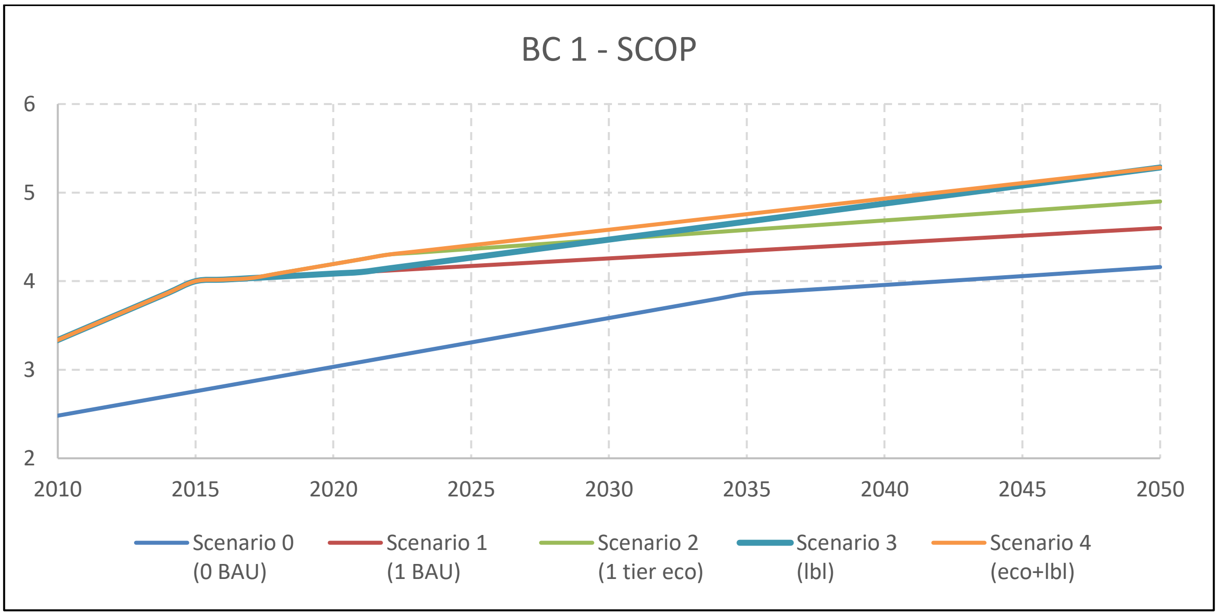

Figure 14: Comparison of the SCOP development for BC1 in all scenarios

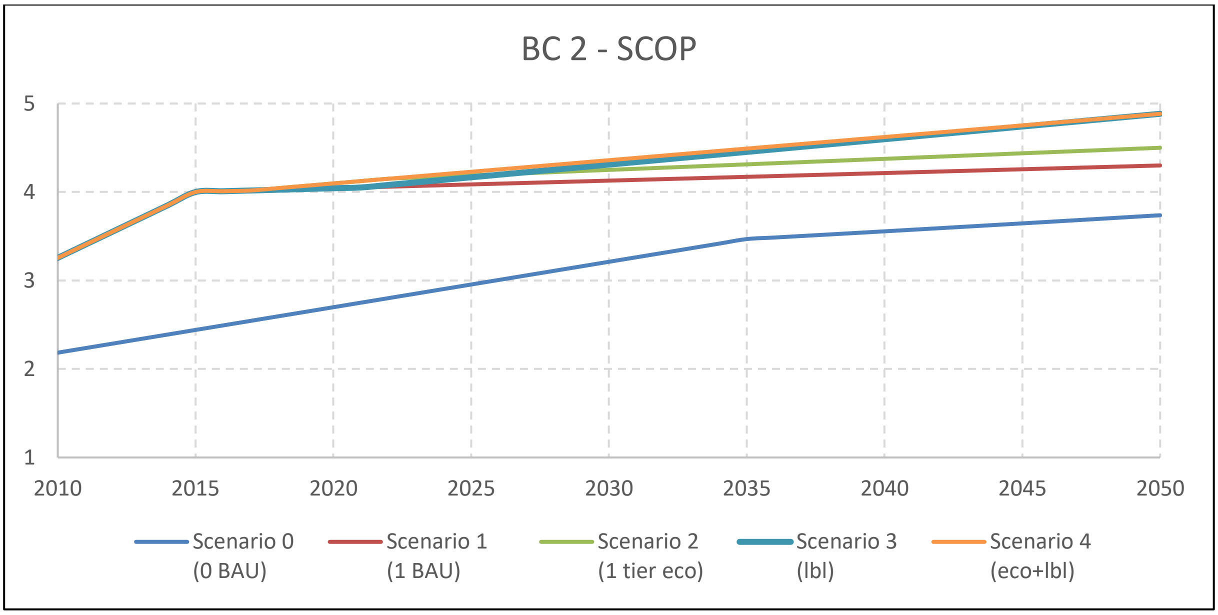

Figure 15: Comparison of the SCOP development for BC2 in all scenarios

From the figures it is visible that air conditioners still have the technological potential for further improvement in efficiency for both heating and cooling. These assumptions are based on the different improvement options in Task 6. With a new and stricter Ecodesign requirements the development can be boosted in the coming years as less efficient products are banned from the market. After this boost in efficiency the improvements are assumed to flatten. If only the labelling scheme are adopted a steady improvement are assumed until BNAT levels are reached in 2050.

Comparing the different base cases, it is visible that fixed air conditioners have the highest improvement potential compared to scenario 1. Currently portable air conditioners have not improved at the same pace as fixed air conditioners.

The annual energy consumption and emission of CO_2-eq are calculated for all the scenarios and presented figures below. All values are also presented in Table 33 to Table 37 in Annex 3 where the values per base cases are presented. Primary energy consumption is also presented in these tables in Annex 3.

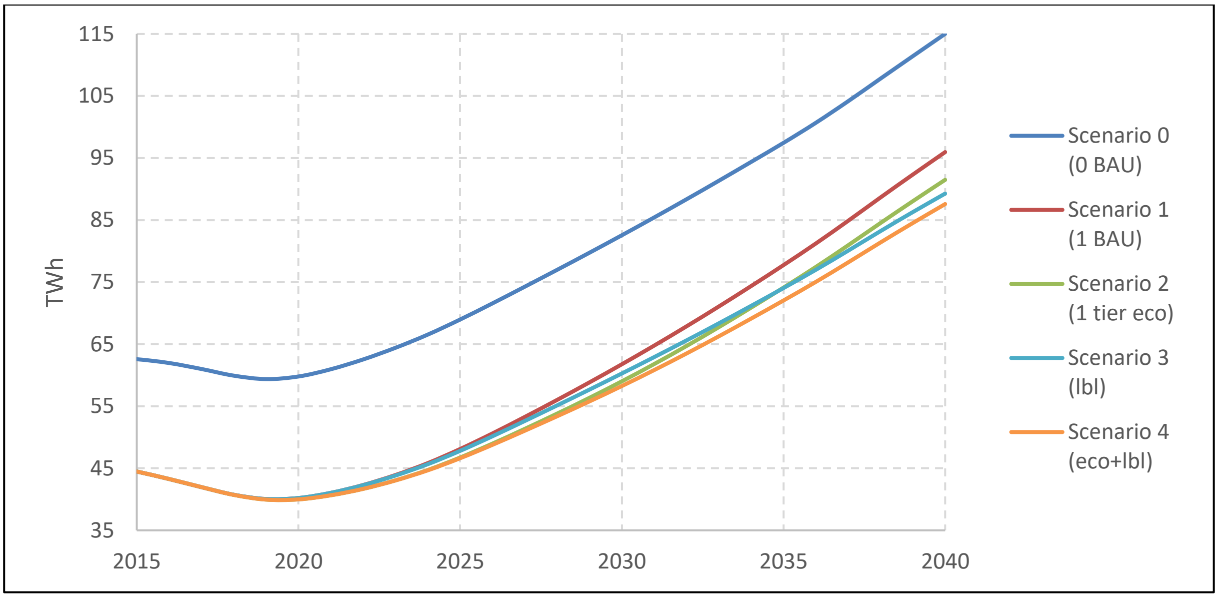

Figure 16: Comparison of the annual energy consumption of three base cases in all scenarios

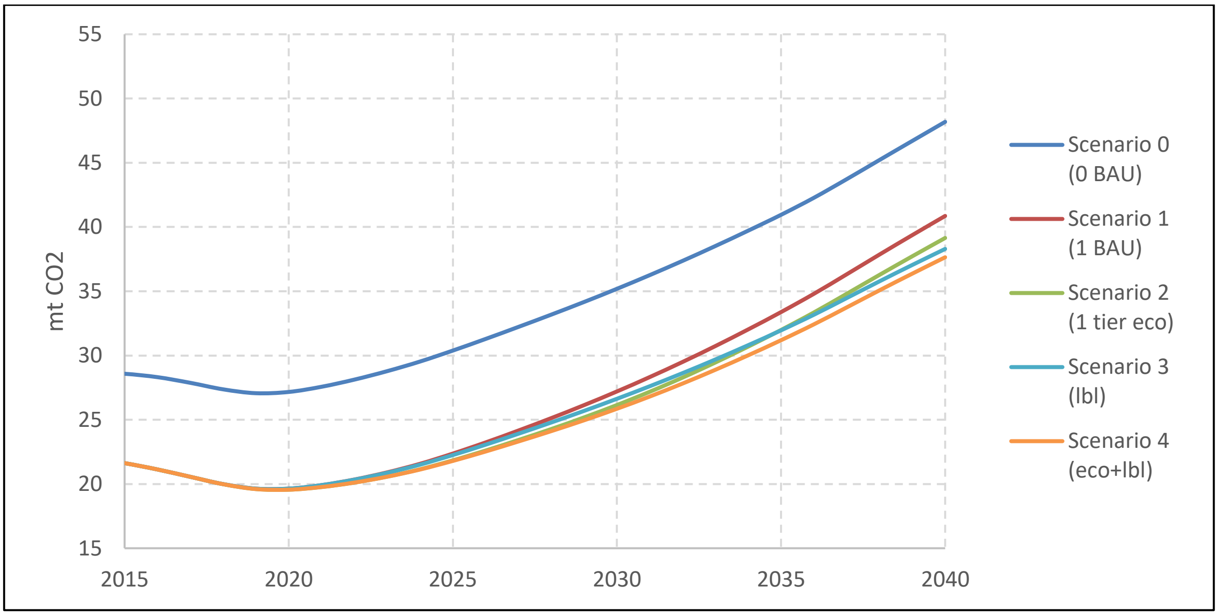

Figure 17: Comparison of the annual emission of CO_2-eq of three base cases in all scenarios

From the figure it is visible that the annual saving is the highest for scenario 4a with annual saving of 3.5 TWh and 1.4 mt CO_2-eq in 2030 (compared to scenario 1). From the figures it is not possible to see how the scenarios effect each of the base case. The annual savings compared to scenario 1 (current regulation) for electricity, primary energy and emission of CO_2-eq for each of the base cases are presented in the tables below. In Annex 3 the annual energy consumption for different policy scenarios are presented.

Table 15: Impacts of scenario 2 (1 tier eco) – Annual savings compared to scenario 1 (current regulation) in TWh, Primary energy and CO_2-eq

		2010	2015	2020	2025	2030	2035	2040
Scenario 2 (1 tier eco)								
TWh (Electricity)	BC1	0	0	0.16	0.99	2.00	2.67	3.31
	BC2	0	0	0.05	0.29	0.60	0.81	1.01
	BC3	0	0	0.01	0.09	0.14	0.15	0.14
	Total	**0**	**0**	**0.21**	**1.37**	**2.75**	**3.63**	**4.46**
PJ (Primary energy)	BC1	0	0	1.40	8.88	18.04	24.02	29.77
	BC2	0	0	0.41	2.65	5.41	7.29	9.11
	BC3	0	0	0.12	0.79	1.30	1.31	1.30
	Total	**0**	**0**	**1.92**	**12.32**	**24.75**	**32.63**	**40.18**
Mt CO_2-eq	BC1	0	0	0.06	0.38	0.77	1.03	1.27
	BC2	0	0	0.02	0.11	0.23	0.31	0.39
	BC3	0	0	0.01	0.03	0.06	0.06	0.06
	Total	**0**	**0**	**0.08**	**0.53**	**1.06**	**1.39**	**1.72**

Table 16: Impacts of scenario 3 (lbl) - Annual savings compared to scenario 1 (current regulation) in TWh, Primary energy and CO_2-eq

		2010	2015	2020	2025	2030	2035	2040
Scenario 3 (lbl)								
TWh (Electricity)	BC1	0	0	0	0.19	0.98	2.48	4.57
	BC2	0	0	0	0.08	0.40	1.02	1.85
	BC3	0	0	0	0.03	0.11	0.20	0.27
	Total	**0**	**0**	**0**	**0.30**	**1.49**	**3.70**	**6.69**
PJ (Primary energy)	BC1	0	0	0	1.71	8.79	22.33	41.09
	BC2	0	0	0	0.70	3.61	9.18	16.67
	BC3	0	0	0	0.24	0.98	1.79	2.42
	Total	**0**	**0**	**0**	**2.66**	**13.39**	**33.30**	**60.18**
Mt CO_2-eq	BC1	0	0	0	0.07	0.38	0.95	1.75
	BC2	0	0	0	0.03	0.15	0.39	0.71
	BC3	0	0	0	0.01	0.04	0.08	0.10
	Total	**0**	**0**	**0**	**0.11**	**0.57**	**1.42**	**2.57**

Table 17: Impacts of scenario 4 (eco+lbl) - Annual savings compared to scenario 1 (current regulation) in TWh, Primary energy and CO_2-eq

		2010	2015	2020	2025	2030	2035	2040
Scenario 4a (eco+lbl)								
TWh (Electricity)	BC1	0	0	0.16	1.06	2.48	4.01	5.87
	BC2	0	0	0.05	0.33	0.83	1.44	2.20
	BC3	0	0	0.01	0.10	0.20	0.26	0.30
	Total	**0**	**0**	**0.21**	**1.48**	**3.51**	**5.70**	**8.38**
PJ (Primary energy)	BC1	0	0	1.40	9.52	22.36	36.06	52.83
	BC2	0	0	0.41	2.95	7.45	12.96	19.83
	BC3	0	0	0.12	0.88	1.76	2.30	2.72
	Total	**0**	**0**	**1.92**	**13.34**	**31.57**	**51.32**	**75.38**
Mt CO_2-eq	BC1	0	0	0.06	0.41	0.95	1.54	2.26
	BC2	0	0	0.02	0.13	0.32	0.55	0.85
	BC3	0	0	0.01	0.04	0.08	0.10	0.12
	Total	**0**	**0**	**0.08**	**0.57**	**1.35**	**2.19**	**3.22**

The highest savings are all connected with small air conditioners as they have higher annual sales and because of their high improvement potential. For portable air conditioners the savings are smaller.

The accumulated savings of the different policy options are compared to current regulation (scenario 1) and presented in the figures below.

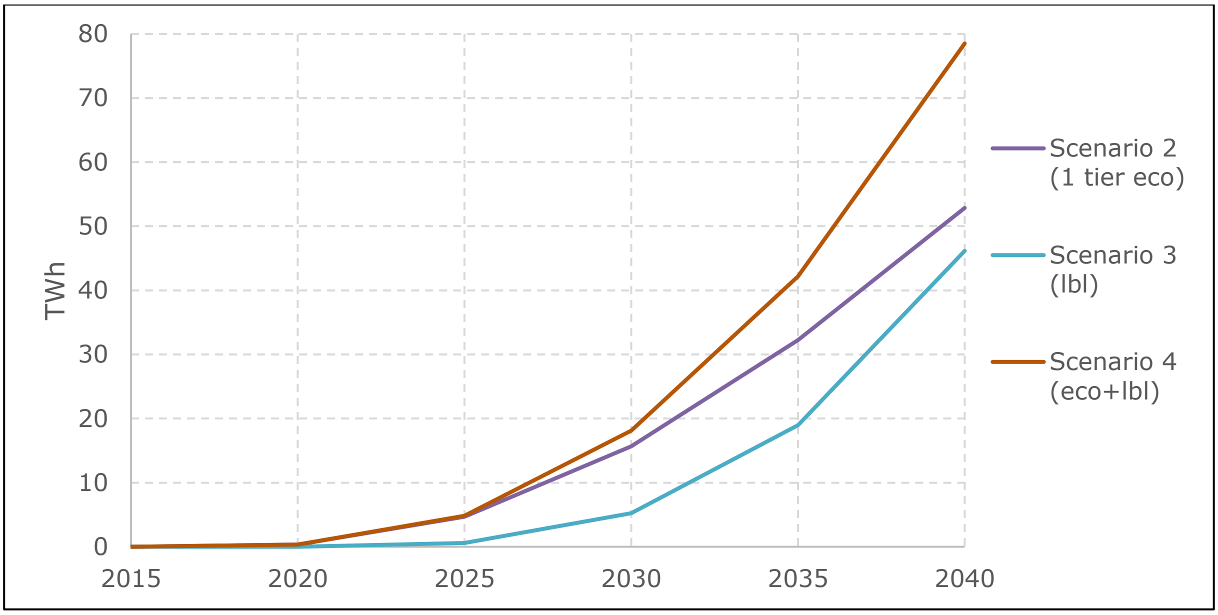

Figure 18: The accumulated savings in electricity (TWh) and emission of CO_2-eq of the policy options compared to the current regulation (scenario 1)

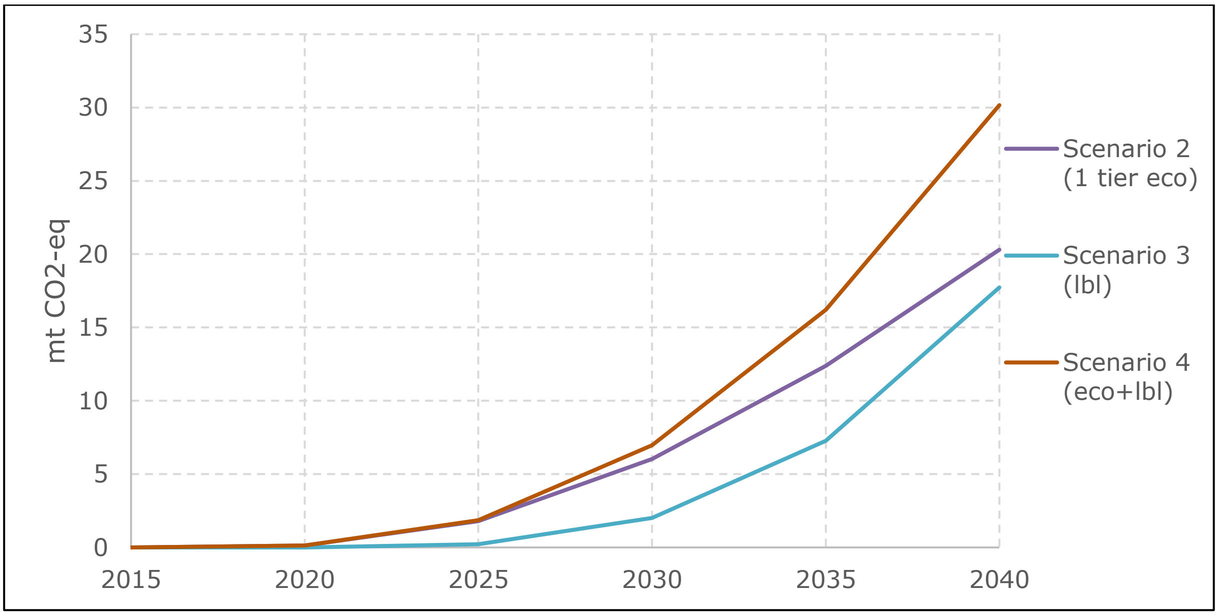

Figure 19: The accumulated savings in emissions of CO_2-eq of the policy options compared to the current regulation (scenario 1)

By applying both Ecodesign requirements and a new energy label scheme the accumulated savings in 2040 are almost 80TWh and above 30 mt CO_2-eq compared to scenario 1 (current regulation). Improving the current regulation will definitely have a positive and significant impact on the environment.

7.3 Impact analysis for consumers and industry

7.3.1 Consumer impacts

The consumer impacts are related to the electricity consumption and the purchase price of the equipment. The maintenance price and installation costs are assumed to be almost unchanged from the different scenarios, so they are only calculated based on a fixed rate and the annual sales.

The purchase price of the unit is dependent on the technological development in SEER, and an annual product price decrease by 2 % which is according to MEErP[23]. The correlation between SEER for the different base cases are calculated based on the different improvement options presented in Task 6. In all options there seems to be a correlation between SEER and then the product price. The correlation for the different base cases are:

- BC1 – 138 EUR/SEER point increase
- BC2 – 355 EUR/SEER point increase
- BC3 – 168 EUR/SEER point increase

This correlation and an annual price decrease are used to calculate the development in purchase price. The assumed development in purchase price are calculated and presented in Table 39 in Annex 3.

In most scenarios the price of air conditioners is expected to increase and especially the most ambitious scenarios. The price increase is present in the scenarios including Ecodesign requirements as the improvements are accelerated. In scenario 3 (only labelling scheme) the annual cost reduction of 2 % exceeds the increase in price due to voluntary efficiency improvements resulting in lower prices. The expected purchase price is used to calculate the annual consumer expenditures in Figure 20. The annual consumer expenditures are calculated based on the expected purchase price and expected annual sales, see exact values for the base cases in Table 40 in Annex 3.

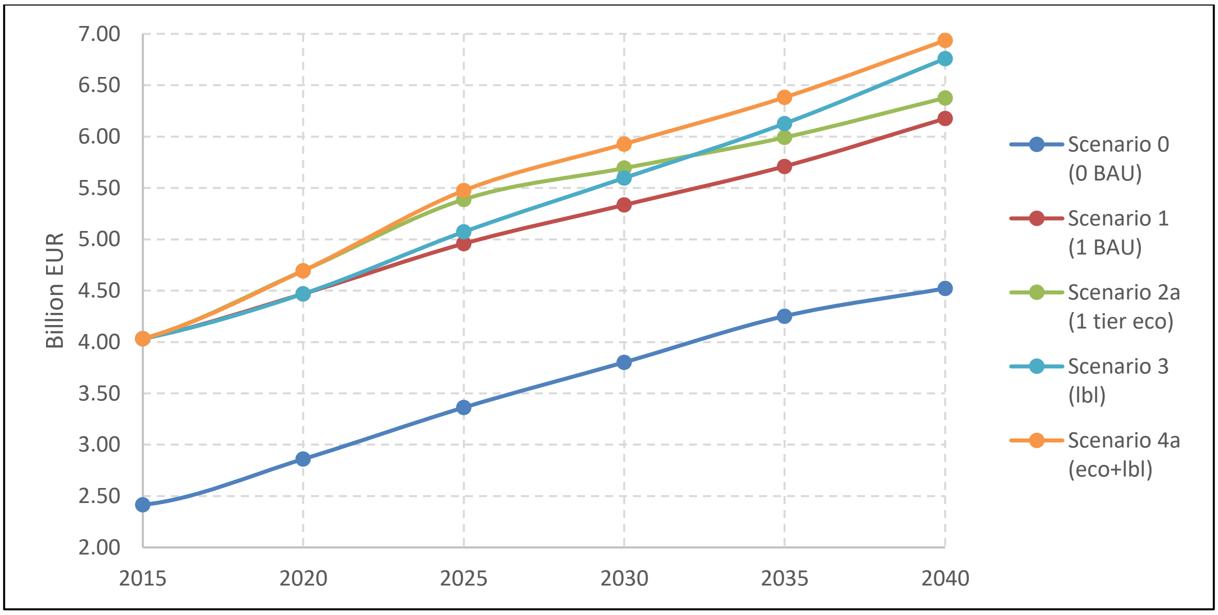

Figure 20: Annual consumer purchase costs of air conditioners in absolute values

The electricity price is expected to increase by 1 % per year. The assumed expected annual energy consumption and the stock model is used for modelling the consumer expenditures for the electricity presented in the Figure 21, see exact values of electricity costs for the base cases in Table 41 in Annex 3.

[23] VHK(2011), MEErP 2011 METHODOLOGY PART 1.

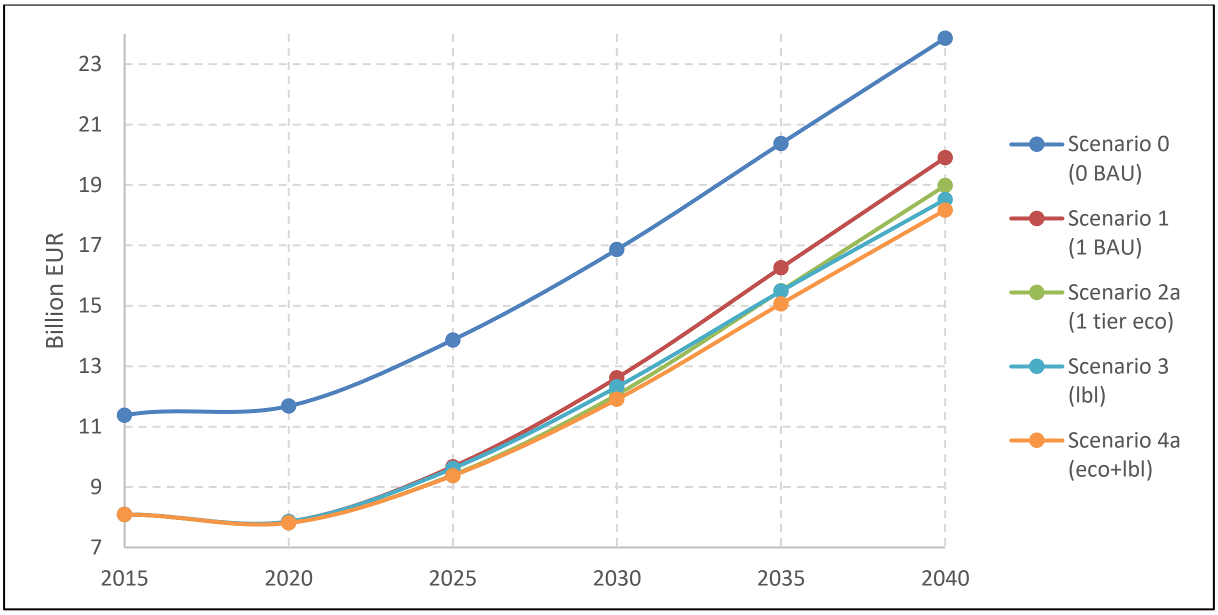

Figure 21: Annual consumer electricity costs in absolute values

The annual consumer expenditures for installation and maintenance are assumed negligible and therefore are equal in all scenarios. For comparison with the other costs, the exact installation and maintenance costs for each scenario are presented in Table 42 in Annex.

Total annual consumer expenditure is calculated as the sum of purchase cost, electricity costs and annual installation and maintenance costs. The total annual consumer expenditures are presented Figure 22 , and the annual consumer savings compared with 1 BAU current regulation in different policy options are presented in Table 18.

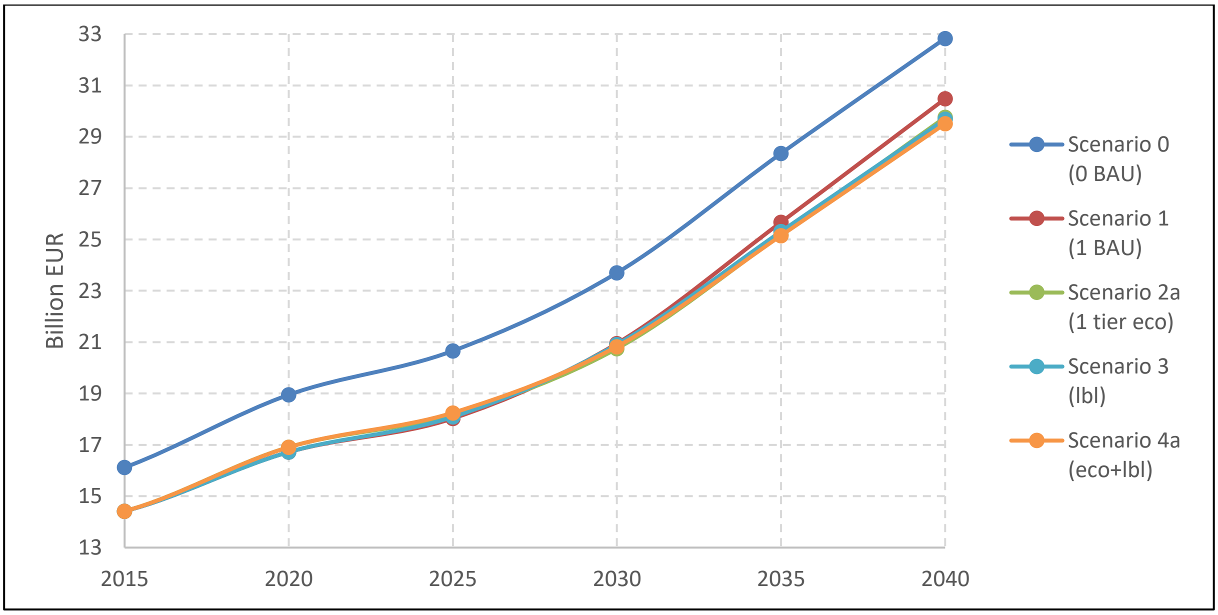

Figure 22: Total annual consumer expenditures in absolute values

Table 18: Total annual consumer expenditures in absolute values and annual savings compared with 1 BAU current regulation

	2010	2015	2020	2025	2030	2035	2040
Total annual consumer expenditures (billion EUR)							
Scenario 0 (before regulation)	14.23	16.12	18.95	20.66	23.7	28.35	32.83
Scenario 1 (current regulation)	13.51	14.42	16.72	18.03	20.95	25.67	30.48
Scenario 2 (1 tier eco)	13.51	14.42	16.91	18.19	20.75	25.19	29.76
Scenario 3 (lbl)	13.51	14.42	16.72	18.09	20.91	25.31	29.68
Scenario 4a (eco+lbl)	13.51	14.42	16.91	18.25	20.83	25.15	29.51
Annual consumer expenditure saving compared with 1BAU							
Scenario 2 (1 tier eco)	0	0	-0.18	-0.15	0.20	0.48	0.72
Scenario 3 (lbl)	0	0	0	-0.06	0.04	0.36	0.80
Scenario 4a (eco+lbl)	0	0	-0.18	-0.22	0.12	0.52	0.98

As the figures show that the annual consumer expenditures are similar in all policy options but in the long term the scenarios with both Ecodesign requirements and labelling scheme are the most advantageous for the consumers.

7.3.2 Industry impacts

The impacts for the industry are based on a number of assumptions from task 2 and from MEErP. The assumptions are presented in the table below:

Table 19: Assumptions to model to industry impacts.

Impact	Value	Source
Fixed Manufacturer Selling Price as fraction of Product Price [%]	45%	From task 2 markup 2.2
Portable Manufacturer Selling Price as fraction of Product Price [%]	59%	From task 2 markup 1.7
Margin Wholesaler [% on msp]	30%	MEErP
Margin Retailer on product [% on wholesale price]	20%	MEErP
Manufacturer turnover per employee [mln €/ a]	0.00035	Sector turnover 2109 mln euro / 6099 employed persons[24]
OEM personnel as fraction of manufacturer personnel [-]	1.2	MEErP
Wholesaler turnover per employee [mln €/ a]	0.00051	the entire wholesale sector turnover 5.3 trillion Euro10.4 million employees[25]
Fraction of OEM personnel outside EU [% of OEM jobs]	80 %	

[24] Stakeholder input, January 2018
[25] http://www.eurocommerce.eu/commerce-in-europe/facts-and-figures.aspx

The markups presented are average numbers covering both retail and wholesale. Portable air conditioners (not installation), are mainly sold directly by retailers. Only about 5 % are surely sold via installers according to BSRIA leading to a mark of 1.7[26].

For split air conditioners, the proportions of the different routes are more balanced, and comparing with GfK total B2C sales, it can be assessed this share is larger than just the retailer share in BSRIA statistics on first point of sales, higher than 40 %. According to BSRIA it should also be lower than about 60 % (as installers and contractors represent about 60 % of the total). Assuming a 50/50 sharing between final B2C retail and sales via installers, this leads to a total markup of 2.2[27].

Based on these assumptions the industry impacts are calculated for the different scenarios in the figures below.

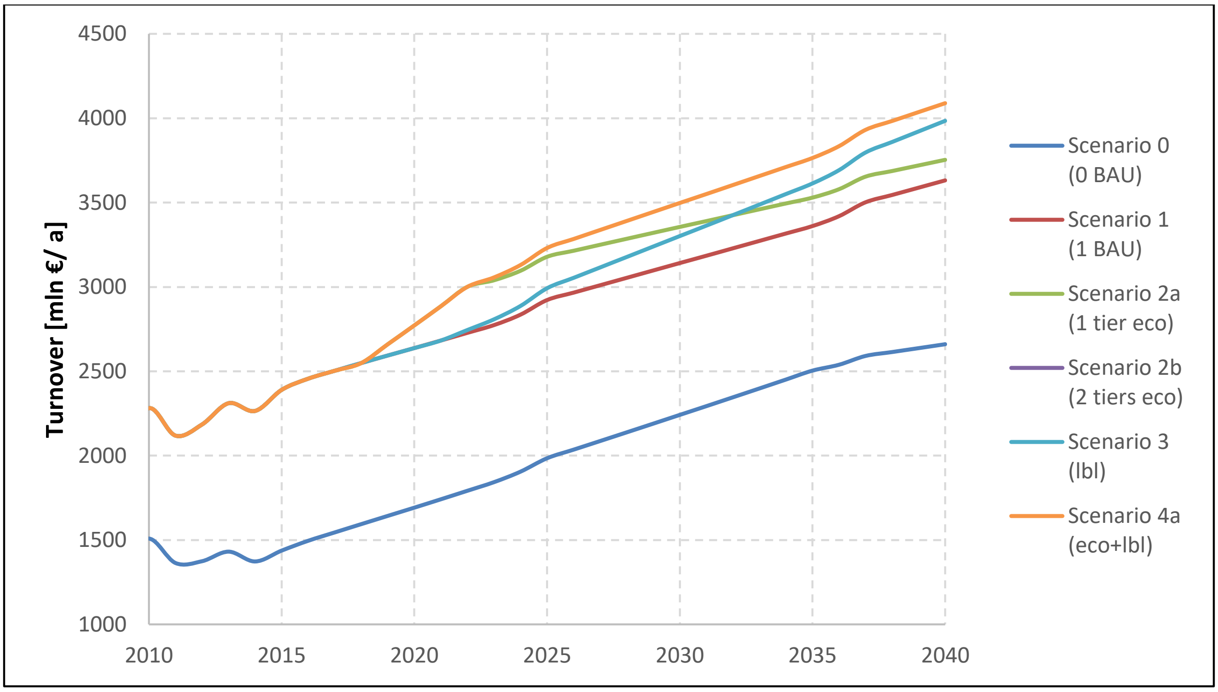

Figure 23: Industry turnover per year for different policy scenarios

[26] The markup value for portable air conditioners are explained and calculated in Task 2
[27] The markup value for fixed air conditioners are explained and calculated in Task 2

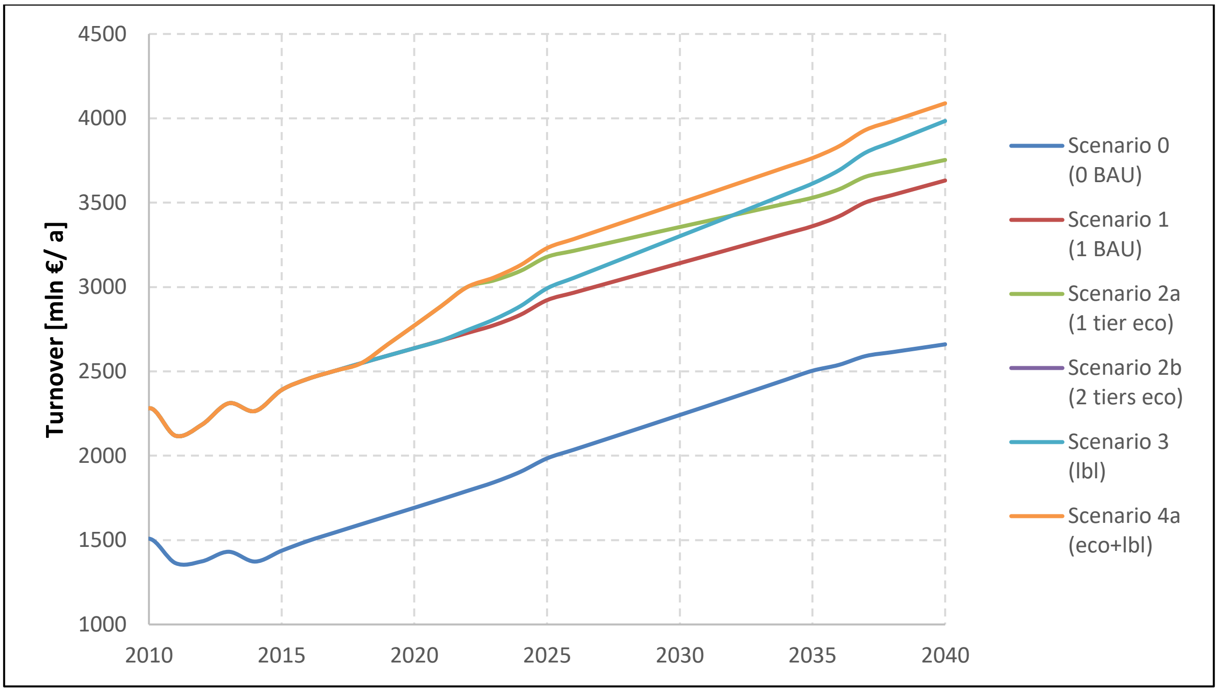

Figure 24: Number of personnel in air conditioner industry for different policy scenarios

From the above figures it is also visible that the most ambitious options also are the most beneficial for the manufactures as their turnover will increase and more workers will be employed in the sector. The values presented in the above figures are also presented in tables and divided into categories (manufacturer turnover, manufacture total personnel, OEM total personnel, OEM total personnel (EU), wholesaler turnover and wholesaler total personnel) in Annex 3 – Tables.

7.4 Sensitivity analysis

The sensitivity analysis is focusing on the leakage of refrigerant and the material composition of the air conditioner. These analyses are made for scenario 5 as these factors have a higher impact in this scenario due to the reduced energy consumption. Regarding the sensitivity analysis the following adjustments are made:

- Sensitivity of the material composition
    - 95 % recycling
- Sensitivity of the leakage of refrigerant
    - Double the leakage rate

The impact of these changes is calculated as the difference in CO_2-eq as this measure can be used in both analyses.

Table 20: The calculated impacts of higher levels of recycling and the effect of higher leakage.

		2010	2015	2020	2025	2030	2035	2040
Sensitivity (95% recycling) – Reduction in emission								
Mt CO_2-eq	BC1	0.10	0.09	0.11	0.16	0.33	0.69	1.19
	BC2	0.06	0.06	0.07	0.09	0.18	0.34	0.57
	BC3	0.02	0.01	0.01	0.02	0.03	0.05	0.07
	Total	**0.18**	**0.16**	**0.19**	**0.26**	**0.54**	**1.08**	**1.83**
Sensitivity (Double leakage) – Increase in emission								
Mt CO_2-eq	BC1	2.92	2.84	2.34	1.92	1.44	1.29	1.47
	BC2	1.47	1.64	1.44	1.17	0.83	0.71	0.78
	BC3	0.05	0.05	0.04	0.02	0.00	0.00	0.00
	Total	**4.43**	**4.53**	**3.82**	**3.10**	**2.26**	**1.99**	**2.25**

Note that in Table 20, for 95% recycling rate, the figures are the reduction in emission, for double leakage rate, the figures are the increase in emission

The sensitivity analysis show that increased recycling can reduce the annual emission of CO_2-eq with approximately 0.2 mt, but the recycling rates in this scenario are very optimistic and may not be obtainable in the near future. If the leakage is higher (e.g. twice as high) than assumed, then the emission of CO_2-eq be 3.8 mt higher in 2020. Due to the f-gas regulation this impact is reduced to 2.3 mt CO_2-eq in 2040 and the impact of leakage is reduced. These tables are also presented in absolute values in Table 49 in Annex 3.

It is also proposed that sensitivity analysis to be carried out for product prices and overcosts in the impact assessment.

7.5 Comparison of air-to-air heat pumps and other heating products

Air-to-air heat pump, despite being a specific product group and having presently its own Ecodesign and Labelling regulations (No. 206/2012 and 626/2011), are competing with other heating means. This includes, direct electric heating, larger than 12 kW air-to-air heat pumps, but also water-based heating solutions.

From an end-user point of view, it would be easier if all these products competing on the heating function could be compared directly, for instance using the same energy label or energy class scale.

Above national differences, it should also be avoided that minimum performance requirements and or different labelling scale lead to distort the heating market in a wrong direction (i.e. leading to more energy consumption or CO2 emissions). For instance, to excessively increase minimum efficiency requirement for air-to-air heat pumps could significantly increase their price making those units less affordable. It could thus affect their sales and make direct electric heating more economical for buildings with average to low heat loads. The same might be true for consumers who consider replacing fossil fuel boiler with air-to-air heat pumps at the time when heating system and generator need to be replaced.

Ecodesign and Energy Labelling Directive only require impact assessment including environmental impacts, costs and competitiveness within the same product group. As competition exists between this various product groups that all have the same "space heating" function, it is advised to include a supplementary dimension in the impact assessment of future or revised Ecodesign and labelling regulations or to conduct a dedicated study on the comparison of the proposed and existing regulations across the different product groups that offer space heating.

7.6 Conclusions and recommendations

Policy options

Based on the assessment, the following policy options are chosen for further analysis:

- No action option – Business as usual (BAU), the current regulations are to be retained as they are. This BAU scenario will be used as reference for comparison with other policy scenarios.

- Ecodesign requirements (under the Ecodesign Directive (2009/125/EC)): Including revised mandatory minimum requirements acting as a “push” instrument for products to achieve better performance.
- Energy labelling (under the Energy Labelling Regulation (2017/1369/EU)[28]): This implies a revised scale for mandatory labelling of the products’ efficiency.

Based in these policy options, six scenarios are modelled and are presented in Table 21.

Table 21: Summary of policy scenarios and brief descriptions

Policy scenario	Description
Scenario 0 (0 BAU)	BAU before EU regulation – In general low yearly improvements. The only improvement included is the use of inverter technology
Scenario 1 (1 BAU)	BAU scenario (current regulation) – The impact of the current regulation with only limited incentive to improve products beyond the A+++ label
Scenario 2 (1 tier eco)	Ecodesign minimum efficiency requirement with one tier based on LLCC (BC 1 for BC 1, -10%Ua_cond for BC 2 and HE1with R290for BC 3)
Scenario 3 (lbl)	Energy class A as BNAT (combining the different improvement for each of the base cases)
Scenario 4 (eco+lbl)	Ecodesign and Energy labelling scenario 2 + scenario 3

Ecodesign requirements

The LLCC identified in the Task 6 is used for setting the immediate minimum requirement for fixed air conditioners in ecodesign scenario 2. The BNAT level specify the energy class A for energy labelling, only revised energy labelling regulation without revising ecodesign, this is simulated in scenario 3. Scenario 4 represents the combination of the Ecodesign requirements (scenario 2) and the Energy labelling (scenario 3).

The proposed ecodesign requirements and timing are presented in Table 22.

Table 22: Proposed minimum efficiency requirements for air conditioners in a potential revised ecodesign regulation

	Tier 1, January 2023	
	SEER	SCOP
Other than portable, < 6 kW	6	4
Other than portable, 6 – 12 kW	5.5	3.9
Portable	2.3	-

No SCOP minimum requirement is proposed for portable air conditioners. However, it is proposed that ecodesign should include information requirement of SCOP using the proposed metrics for portable on top of the existing minimum requirement on COP from current regulation. It is also proposed to start the development of a new standard in line with EN14825 plus infiltrations. With this potential new standard in place, portable products will have to be adjusted to stay on the market. It is proposed that the portable would not be allowed to operate in thermodynamic heating mode. Once performances of new double duct products for new standard are known, then it can be evaluated how far their performances should be increased.

[28] Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU

For portable air conditioners in general, it is recommended to have seasonal performance metrics (SEER and SCOP) for setting requirements in the future.

Ecodesign requirement for comfort fans

Regarding comfort fans the same challenges still exist (since the preparatory study) and it is further elaborated in Annex 1. Based on the findings of this assessment there are two options which are:

- Setting minimum energy efficiency requirements on comfort fans with the proposed requirements (from the preparatory study) with the risk of banning many comfort fans in the European market (expected savings in the preparatory study was slightly below 1 TWh).
- Enforcing better market surveillance on the current information requirement and gathering accurate information on comfort fan efficiency and test methods through a complementary study/efficiency tests with corresponding costs.

Energy Labelling requirements

The proposed new label schemes are presented in Table 23 and Table 24. The label scheme is based on the BNAT levels identified in Task 6 as the top level at energy class A. This means that the best product currently available on the market only are able to achieve the B class. This however does not apply to portable air conditioners, as products with alternative refrigerants (as R410A will be banned after 2020) are not widely available and it is difficult predict the refrigerant that will be used.

Table 23: Proposed new label schemes for SEER

Label scheme	Other than portable air conditioners	Portable air conditioners
A	SEER ≥ 11.5	SEER ≥ 4
B	9.7 ≤ SEER < 11.5	3.5 ≤ SEER < 4
C	8.1 ≤ SEER < 9.7	3.0 ≤ SEER < 3.5
D	6.8 ≤ SEER < 8.1	2.6 ≤ SEER < 3.0
E	5.7 ≤ SEER < 6.8	2.3 ≤ SEER < 2.6
F	4.8 ≤ SEER < 5.7	SEER < 2.3
G	SEER < 4.8	

Table 24: Proposed new label scheme for SCOP

Label scheme	Other than portable air conditioners
A	SCOP ≥ 6.2
B	5.5 ≤ SCOP < 6.2
C	4.9 ≤ SCOP < 5.5
D	4.3 ≤ SCOP < 4.9
E	4.9 ≤ SCOP < 4.3
F	SCOP < 3.8
G	NA

It is the opinion of the study team that an energy class should only be proposed for portable air conditioners in cooling mode using proposed SEER metrics in section 7.1.5. SCOP is to be declared on the energy label but no energy class scale is proposed. When seasonal performance (that accounts for infiltration) of these products is widely known, an energy class scale for SCOP can be then proposed. A combined label is also being considered so consumers can compare fixed and portable air conditioners.

A combined label can be based $\eta_{s,c}$ and $\eta_{s,h}$ and have the following classes presented in Table 25. Ideally the label for heating should be aligned with other regulations so all products/heaters can be compared.

Table 25: Proposed new label schemes for a combined label

Label scheme	$\eta_{s,c}$	$\eta_{s,h}$
A	$\eta_{s,c} \geq 4.6$	$\eta_{s,h} \geq 2.5$
B	$3.3 \leq \eta_{s,c} < 4.6$	$2 \leq \eta_{s,h} < 2.5$
C	$2.4 \leq \eta_{s,c} < 3.3$	$1.6 \leq \eta_{s,h} < 2$
D	$1.8 \leq \eta_{s,c} < 2.4$	$1.3 \leq \eta_{s,h} < 1.6$
E	$1.3 \leq \eta_{s,c} < 1.8$	$1 \leq \eta_{s,h} < 1.3$
F	$0.9 \leq \eta_{s,c} < 1.3$	$0.8 \leq \eta_{s,h} < 1$
G	$\eta_{s,c} < 0.9$	$\eta_{s,h} < 0.8$

Finally, infiltration measurement should be proposed in the future mandate for standards.

Tolerances and uncertainties have been assessed in earlier Tasks and two approaches have been proposed to adjust tolerances. According to the previous definitions, the tolerances should be higher than the repeatability measurement uncertainty alone and lower or equal to the expanded uncertainty. In absence of Round Robin Tests, tolerance values should be fixed to the maximum possible value, i.e. to the level of the maximum expanded uncertainties.

With present measurement uncertainties, tolerance levels can be set as follows:

- split air conditioners:
    - SEER tolerance: 8 % below 2 kW cooling capacity, 6 % between 2 and 6 kW and 4 % between 6 and 12 kW.
    - SCOP tolerance: 8 % below 2 kW cooling capacity, 7 % between 2 and 6 kW and 6 % between 6 and 12 kW.
- portable air conditioners:
    - SEER: 6 % for on/off and 8 % for inverter (12 % for lower than 2 kW @ 27/27 units)
    - Pc(Teq): 7 % (13 % for lower than 2 kW @ 27/27 units)
    - Teq: 0.3 K (0.4 K for lower than 2 kW @ 27/27 units)

SEER and SCOP tolerance levels in Regulations (EU) No 206/2012 and 626/2011 need to be revised accordingly.

With improved measurement accuracy, tolerances could be reduced to the following levels:

- split air conditioners:
    - SEER: 6 % below 6 kW cooling capacity and 4 % between 6 and 12 kW
    - SCOP: 6 % below 6 kW cooling capacity and 4 % between 6 and 12 kW

- portable air conditioners:
  - SEER: 6 % (12 % for lower than 2 kW @ 27/27 units)

Before EU regulations and BAU

Scenario 0 (before EU regulation) and scenario 1 (current BAU with EU regulations) show that the current regulations have been effective and efficient, it is estimated that current regulations (Ecodesign Regulation 206/2012 and Energy Labelling 626/2011) have accumulatively by 2015 saved more than 138 TWh electricity and avoided more than 53 mt CO2-eq. It is expected that annual savings in period 2015 - 2020 is around 20 TWh compared with consumptions before EU ecodesign and energy labelling regulations.

Sound power levels have also shown that the regulations have been effective, as the sound power levels reported are kept below the maximum allowed levels when comparing data from 2006 with the data from 2016. However, it is identified very limited further improvement potential for sound power level if energy efficiency is to be continuously increased.

Scenario analyses

Based on the newly proposed ecodesign requirements and labelling scheme, the impacts of the different scenarios are modelled. The assessed impacts are electricity consumption, primary energy and emission of CO_2-eq. The annual impacts of the different scenarios in 2030 are presented in Table 26.

Table 26: The annual electricity consumption, emission of CO_2-eq and associated savings in 2030

Scenario	Electricity (TWh)	Savings from 1 BAU (TWh)	Emission of CO_2-eq (mt)	Savings from 1 BAU (mt CO_2-eq)
Scenario 0 (0 BAU)	83.3	-	35.2	-
Scenario 1 (1 BAU)	61.8	-	27.2	-
Scenario 2 (1 tier eco)	59.0	2.8	26.1	1.1
Scenario 3 (lbl)	60.3	1.5	26.6	0.6
Scenario 4a (eco+lbl)	58.3	3.5	25.9	1.3

From the scenarios is it is visible that the largest savings are the combination of both ecodesign requirements and the energy label with annual electricity saving of 3.5 TWh in 2030. The energy label alone has smaller impacts than the Ecodesign requirements in the presented values, but for future reduction in the impacts the labelling scheme are important to push for further improvements beyond 2030.

Table 27 shows the savings in 2040, as the revised regulations will have long-lasting effects due to the continuous change of stock air conditioners to efficient new air conditioners, the savings in 2040 are greater than those in 2030. Scenario 4 which combines ecodesign and energy labelling is expected to yield 8 TWh electricity savings per year.

Table 27: The annual electricity consumption, emission of CO2-eq and associated savings in 2040

Scenario	Electricity (TWh)	Savings from 1 BAU (TWh)	Emission of CO_2-eq (mt)	Savings from 1 BAU (mt CO_2-eq)
Scenario 0 (0 BAU)	115	-	48.2	-
Scenario 1 (1 BAU)	96	-	40.9	-
Scenario 2 (1 tier eco)	91.5	4.5	39.1	1.7
Scenario 3 (lbl)	89.3	6.7	38.3	2.6
Scenario 4a (eco+lbl)	87.6	8.4	37.6	3.2

The presented savings are supposedly even larger than the presented values as the replacement of inefficient heaters due to more and more end-users operate reversible air conditioners in heating mode are not accounted.

The sensitivity analysis showed that an improved recycling of the materials only will have a limited impact regarding emission of CO_2-eq, but this impact may not be a proper measure for the material efficiency impacts. The leakage of refrigerant is important and could pose a threat, but the f-gas regulation is already limiting the potential negative impacts.

Due to the progressive development in efficiency to comply with ecodesign requirement and energy labelling, the product price is expected to increase in the coming years, but the extra costs will slowly reduce again over time. Overall, the consumer net expenditures decrease in the scenarios with the highest efficiency, as energy costs savings offset the increase in product price. In the future, the energy costs are even more important for the consumers as the electricity prices are expected to increase.

The improved energy efficiency is not only beneficial for the consumers and the environment but also for the industry. The industry is expected to grow and improve their annual turnover and more persons are expected to work in air conditioner industry.

Material efficiency

Based on the assessment on possible material efficiency requirements for air conditioners, as well as other studies for different product groups where possible material efficiency requirements have been assessed, the following general conclusions are drawn:

- Ecodesign opportunity for material efficiency requirement for air conditioners exists but the impact of such requirements is anticipated to be minimal without addressing the issue at system level.
- EcoReport tool although has been revised in 2014, but it is not adequate for properly assessing environmental impacts of material efficiency.
- Possible material efficiency requirements – even if they contribute to as high as 95% of recycling rate, the results from EcoReport Tool show that material efficiency has only small impact in terms of the product's entire LCA, this is due to that the focus and the environmental indicators of the EcoReport Tool are mainly on energy, for proper assessment, other environmental indicators should be included.

- There could be synergies with DG Environment's development of Product Environmental Footprint (PEF). The methodology can be simplified and applied in Ecodesign to assess other environmental impacts.
- Material efficiency of electrical and electronic products requires a system approach within which the recycling processes, methods and facilities are addressed together with product design. However, system approach of recycling processes, methods and facilities is rather in the scope of WEEE directive than ecodesign.
- Furthermore, material efficiency is an issue that should be addressed at a horizontal level, as per product group, the associated saving potential is low, but horizontally across all electrical and electronic products, large savings potential can be achieved. Therefore it may prove effective to align material efficiency requirements with other regulations (such as for dishwasher, washing machines and domestic refrigerators and freezers).
- Looking prospectively, to address the issue at a horizontal level, voluntary labelling of recycled materials and minimum percentage used in product could be considered as a policy model. FSC labelling approach from the European Union Timber Regulation(EUTR) could be of inspiration.
- Unpredictable consequences and barriers exist for ecodesign requirements on material efficiency that encourages reuse, as it is currently unclear who should take on the ownership of a refurbished product and responsibility of the product's safety.

Summary of suggestions

This section summarises the suggestions from Task 1 to Task 6.

- **Ventilation exhaust air-to-air heat pumps and air conditioners ≤ 12 kW**
  It is advised to include these products in the scope of Regulation (EU) No 206/2012 and 626/2011 when their thermal power is below or equal to 12 kW and to specify SEER and SCOP rating conditions and also to better specify which air is used indoor and outdoor for air conditioners and heat pumps in Regulation (EU) No 206/2012.
  Test conditions proposed for SEER and SCOP determination of exhaust air-to-outdoor air heat pumps and air conditioners are described in Task 1, Annex 1. However, the latest update in April 2018 of this issue is that according to CEN TC 113 WG 7, it is not possible to develop a SEER/SCOP for these units. Without SEER/SCOP, it is difficult to include these products in scope. The reason is that these units are ventilation units where heat recovery is made by the heat pump instead of being done by a heat recovery heat exchanger. The fact that these units have two functions would make SCOP / SEER results not directly comparable to the ones of other heat pumps. In other words they indeed supply capacity but part of it might be supplied at an indoor temperature below 20 °C so capacity related to heating (and so to Pdesignh declaration) is only a part of measured capacity.

- **Definition of a heat pump and air-to-air heat pump**
  The definition of a heat pump and air-to-air heat pump will also be added to the regulation. The definitions will be adapted from Regulation (EU) No 2016/2281 and are described above in section 1.1.1.2.

- **Residential fan heaters**
  It is recommended to include information requirement on the "air movement" function of residential fan heaters in Regulation (EU) No 2015/1188 (similar to the information requirement for comfort fans in Regulation 206/2012).

- **Noise standards - EN 12102:2013**
  A draft version of this standard (prEN12102-2016) has been submitted for approval with no major change identified. According to convenor of CEN TC 113 / WG8, this standard could include rating conditions in the future. In order to link SCOP value and sound power measurement in heating mode, it is planned to use the point C in heating mode (outdoor air 7 °C / indoor air 20 °C / capacity 50 %) in order to rate the sound power level of air conditioners in heating mode. This is to be taken into account in any future regulation.

- **EU Regulation 206/2012/EU - Ecodesign Requirements for air conditioners and comfort fans**
  Regarding the calculation method, following input from test laboratories reported in the description of standard EN14825 in Task 1 section 1.2.2, it is advised not to allow performance tests to measure cycling performance degradation coefficients Cdc and Cdh, but to use the default value 0.25 instead as there is no proof the value can be measured satisfactorily for inverter units. However, in a possible mandate to CEN for the revised regulation could emphasize the need to define properly cycling tests for inverter units.
  In the future, SEER and SCOP values should be replaced by primary energy efficiency ratio in cooling and in heating mode following the example of more recent regulations (e.g. Regulation (EU) No 2281/2016).
  For heating only air-to-air heat pumps, it is also suggested that the test conditions to measure sound power level in heating mode are specified. The planned test conditions are heating mode point C in EN14825:2016 (outdoor air temperature + 7°C / declared capacity 50 %).
  Finally, the crankcase hours should be changed from 2672 to 2363.

- **Backup heater capacity**
  It is suggested to indicate the necessary additional backup heater capacity required to reach Pdesignh even if it is not included in the unit. So it is proposed to require the following additional information requirement under the naming "backup heater":
    - Required additional backup heater capacity: 3 values in kW to be supplied for warm / average/cold climates; this corresponds to the difference between Pdesignh for a specific climate and unit capacity of the unit at Tdesignh;
    - Backup heater included in the unit: Yes or No (3 values for the 3 different climates).

- **EU Regulation 1275/2008/EU - Ecodesign Requirements for standby and off mode, and networked standby, electric power consumption of electrical and electronic household and office equipment**
  It should be noted that air conditioners are not included in the standby regulation but the requirements for standby in Regulation 206/2012 (with and without a display) and off mode are in line with the standby regulation. Stakeholders have

raised the question whether air conditioners also should comply with the requirements of networked standby and HiNA equipment. The standby consumption is already included in the SEER calculation and leaves more room for development for manufacturers. It is suggested that if the air conditioners are networked by default, the networked standby consumption should be included in the efficiency calculation instead of standby consumption, present standby hours can be used.

- **Low power mode hours**
  Low power mode hours have been reviewed. In the EN 14825:2016, the crankcase heater consumption is measured in test condition D in both heating and cooling mode, it means that for the average climate, there are two values for P_{CK}, and thus potentially also for P_{TO}, P_{SB} and P_{OFF}.
  It is proposed to require two distinct **crankcase power values** for reversible units, respectively for cooling mode - measured at 20 °C - and for heating mode - measured at 12 °C. Cooling (or heating) only unit crankcase power measurement should be done at 20 °C (12 °C), as already written in standard EN14825:2016.
  Minor adjustments of **crankcase hours** are proposed, see above.

- **Measurement of blown air temperature**
  It is proposed, for units in the scope of this study, to complete the data supplied in test report of EN14511-3 with a measurement of the blown air temperature in heating mode and blown air temperature and humidity in cooling mode. These temperatures are normally measured during tests but not published. They should be available in the technical documentation of the products for data collection purpose. These values are to be reviewed at the time of the next revision of Regulation 206/2012 and 626/2011 and evaluate the possible impacts and the required changes in the standard and the regulation to ensure that SEER and SCOP remain representative of real life. More details in Task 3, section 3.1.7.

- **In situ continuous performance measurement**
  On-board measurement and others similar methods for in-situ continuous performance measurement could be generalized and used by all manufacturers, some of the manufacturers are already developing these methods themselves. However, it is important to carry out standardization work to ensure their reliability. This should include methods to correct performance evaluation for dynamic conditions and the way faults are filtered, as well as possible checks of on-board measurement capabilities by third parties. This is an important topic to improve further the efficiency and to reduce real life consumption of air conditioners, as well as to ensure that test standards are aligned with real life operating conditions as regards sizing, equivalent full load hours and other operating hours.

- **Additional information to end-user to reduce real life consumption**
  Another suggestion to cut real life energy consumption is to ensure continuous monitoring. It is proposed to include the electricity consumption measurement in the standardisation work to be done regarding in-situ continuous performance measurement mentioned above. It is necessary to fix a certain number of requirements (e.g. maximum uncertainty, minimum acquisition and averaging times, test of the functionality in the unit based on standard tests).

- **Testing information for set-up in technical documentation**

It is thus proposed that testing information required to set up the machine to reach claimed values be indicated in the technical documentation of the product, instead of being provided upon request or to include it in the EU energy labelling database (where it can only be accessed by market surveillance authorities). To make it mandatory in the product information would also help the development of competitive surveillance systems where manufacturers can check the claims of their competitors.

Annex 1 – Comfort fans assessment

Sales

The sales of comfort fans in the preparatory study was based on data from PRODCOM. The PRODCOM statistics are the official source for product data on the EU market. It is based on product definitions that are standardised across the EU thus guaranteeing comparability between Member States. Data are reported by Member States to Eurostat.

The PRODCOM statistics have some limitations given the complexities in the market and so are they not always as detailed as necessary to support decision making within ecodesign preparatory studies (e.g. data for air conditioners).

Within this study, the PRODCOM statistics are used to compare against product data sourced from other data sources and expert assumptions in order to provide a higher degree of confidence in the final product dataset. The product data sourced was used to establish annual sales for product categories in scope, and subsequently for establishing the installed base in the EU (i.e. stock).

PRODCOM EU sales and trade (i.e. the EU consumption) is derived by using the following formula based on data from PRODCOM:

$$EU\ sales\ and\ trading = production + import - export$$

For and comfort fans, the following PRODCOM categories have been used in the preparatory study and the current study.

Table 28: Prodcom categories covering products relevant for this study.

PRODCOM code	PRODCOM Nomenclature
27.51.15.30	Table, floor, wall, window, ceiling or roof fans, with a self-contained electric motor of an output <= 125 W

Figure 25 illustrate the EU-28 production, import and export quantity according to the current PRODCOM data for comfort fans below 125 W and Figure 26 shows the calculated EU sales and trading for comfort fans below 125 W.

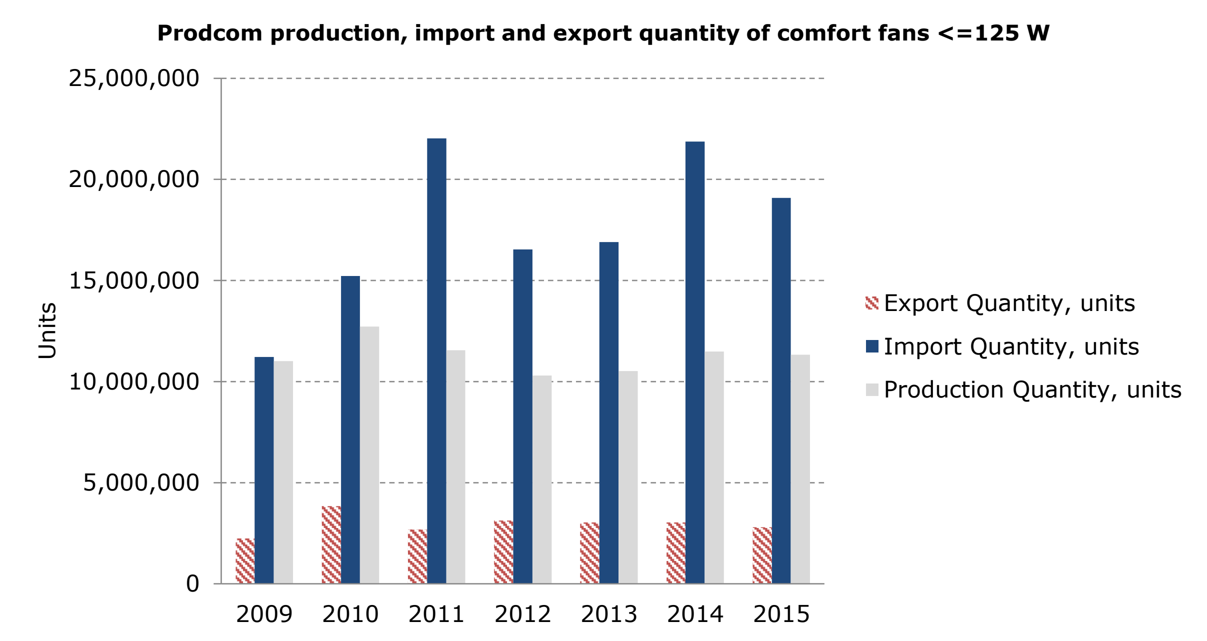

Figure 25: Total production, import and export quantity of comfort fans below 125 W 2009-2015. PRODCOM assessed April 2017.

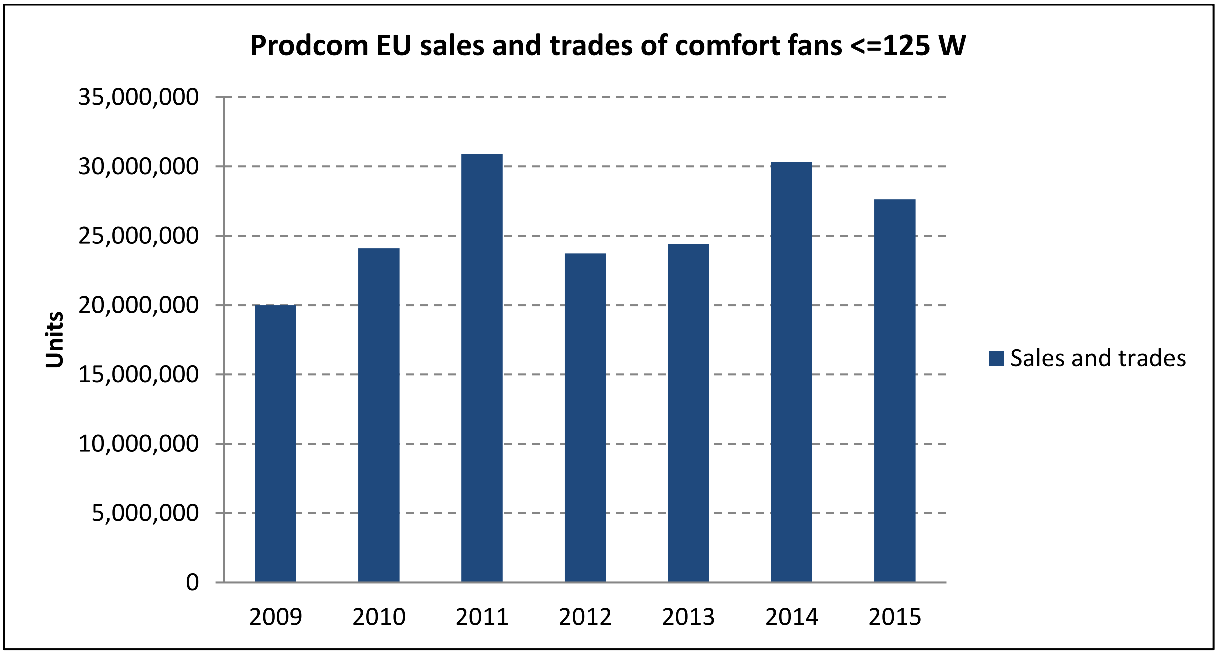

Figure 26: Total EU sales and trading of comfort fans below 125 W 2009-2015. PRODCOM assessed April 2017.

From the current PRODCOM data the general tendency is a slight increase in the period from 2009 to 2015. The sales and trading are expected to be highly connected with the weather in the year concerned, so over a period of time one must expect some fluctuation in the sales and trading. Since 2012 the EU sales and trading of comfort fans has increased with an average increase of 5 % per year. This increase is highly connected with the increase in import. The production and export of comfort fans only have minor fluctuation over the years with an almost flat trend.

Since no other data has been available for comfort fans, PRODCOM data is used still used in the current assessment. The assumptions made in the preparatory study assumed a decrease in the annual sales. Current PRODCOM data presented in Figure 26 shows an increasing trend, but by expanding the timeframe it is possible to see a falling trend in the current data as well. In Figure 27 the assumptions on EU sales and trading of comfort fans in the preparatory study are compared with current PRODCOM data.

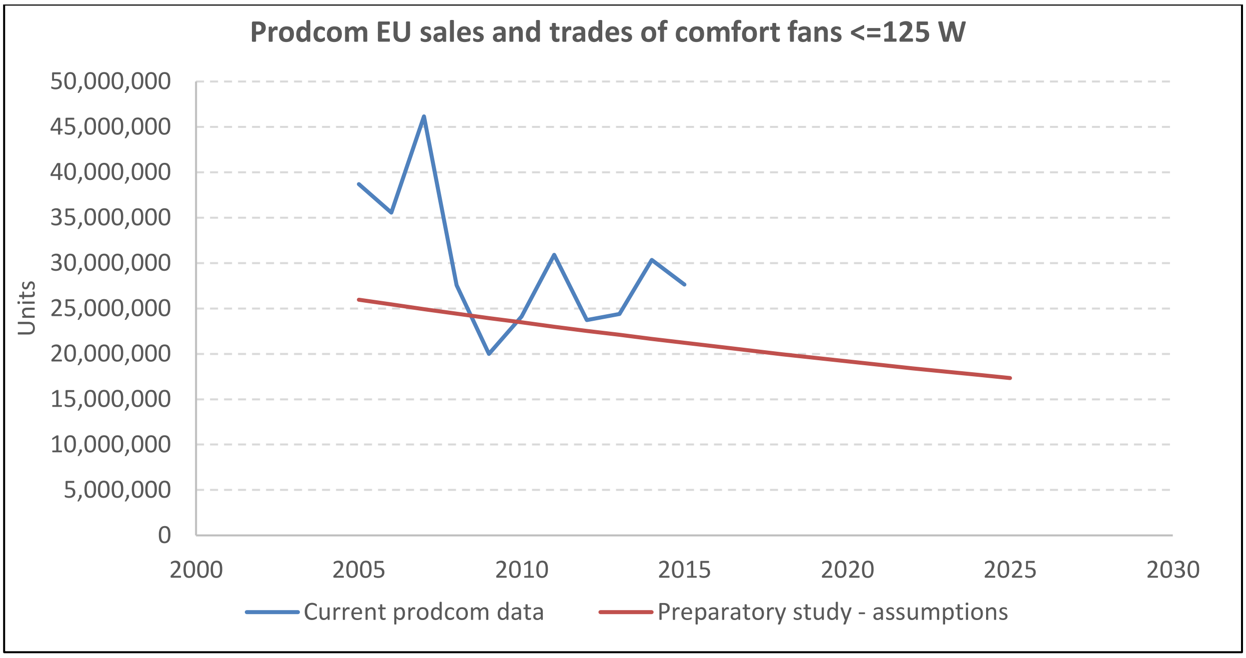

Figure 27: Comparison of EU sales and trading of comfort fans below 125 W 2009-2015 of current PRODCOM data (assessed April 2017) and expected sales and trades from the preparatory study

From the figure it is visible that the sales of comfort fans were expected to progressively fall in the preparatory study (2 % per year due to the competition with air conditioners). In reality the sales are very much dependent on the weather but overall the sales are expected to fall. Based on the sales figures it is assumed that the data in the preparatory study still are representative to the current situation despite the expected large fluctuations. This means that the assumptions made on stock also is representative. The stock in the preparatory study is presented in Figure 28.

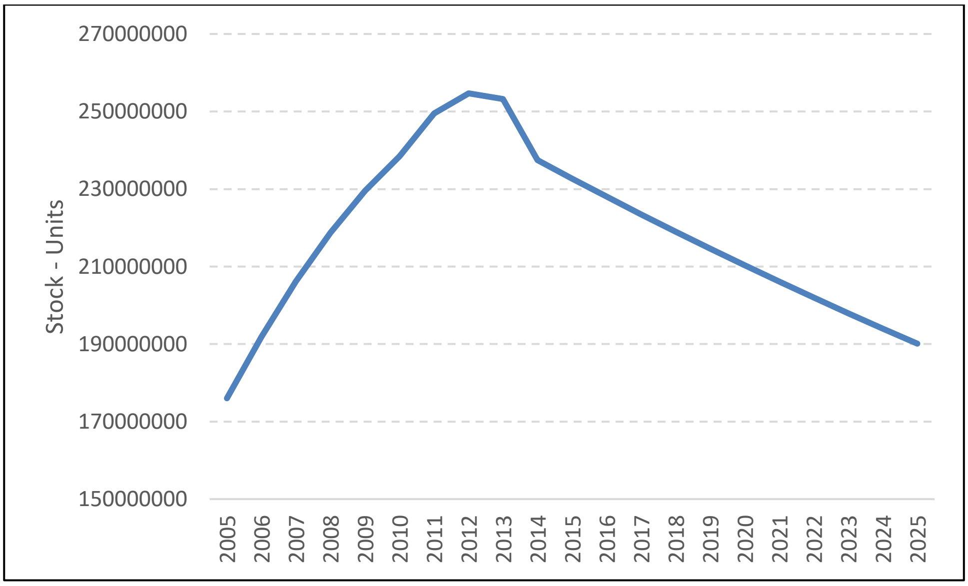

Figure 28: Assumed stock development - preparatory study

The PRODCOM data does not distinguish between the different types of comfort fans but this was also assessed in the preparatory study by internet and store surveys. The distribution of comfort fan types is presented in Figure 29.

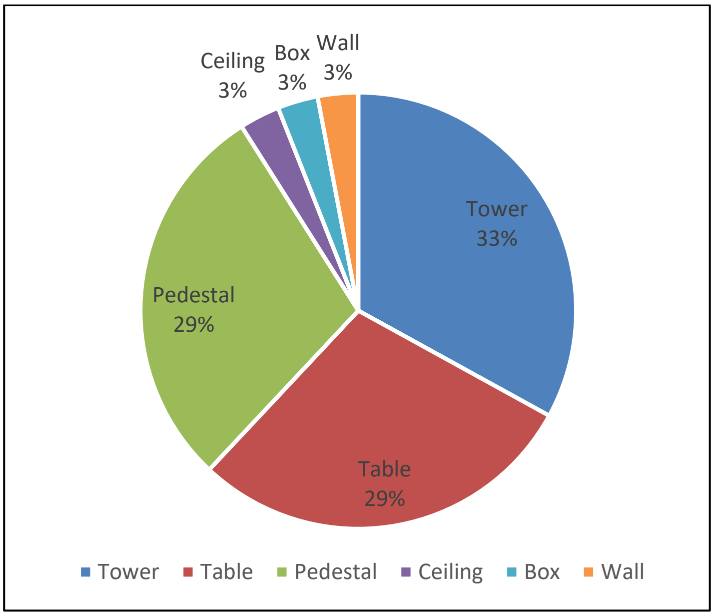

Figure 29: Types of comfort fans - assumption from the preparatory study

Tower fans, pedestal fans and table fans are the dominant type of fans based on the internet and store survey in the preparatory study. This distribution of fan types is still believed to be representative to the current situation.

Market overview

Based on data retrieved from topten[29] it is possible to assess the current efficiency of comfort fans on the European market. This data contained information on 158 models of comfort fans that are presently available on the market. topten[30] informed that the product declaration was very poor despite the current information requirements. Of the whole sample only 67 models declared sufficient information to assess the Service Value of the products. For 8 models, the information was available on the retailer's website. For the remaining 137 models, the information on the service value and maximum fans flow rate was not declared. This means that the consumers are buying comfort fans without the knowledge of potential energy consumption. This also means that the consumers cannot compare the different comfort fans regarding energy consumption.

The available data (75 comfort fans) are used to make the following figures. In Figure 30 is the distribution of wattage and service values presented and Figure 31 visualises the spread in service values of the different types of comfort fans.

[29] http://www.topten.eu/
[30] http://www.topten.eu/

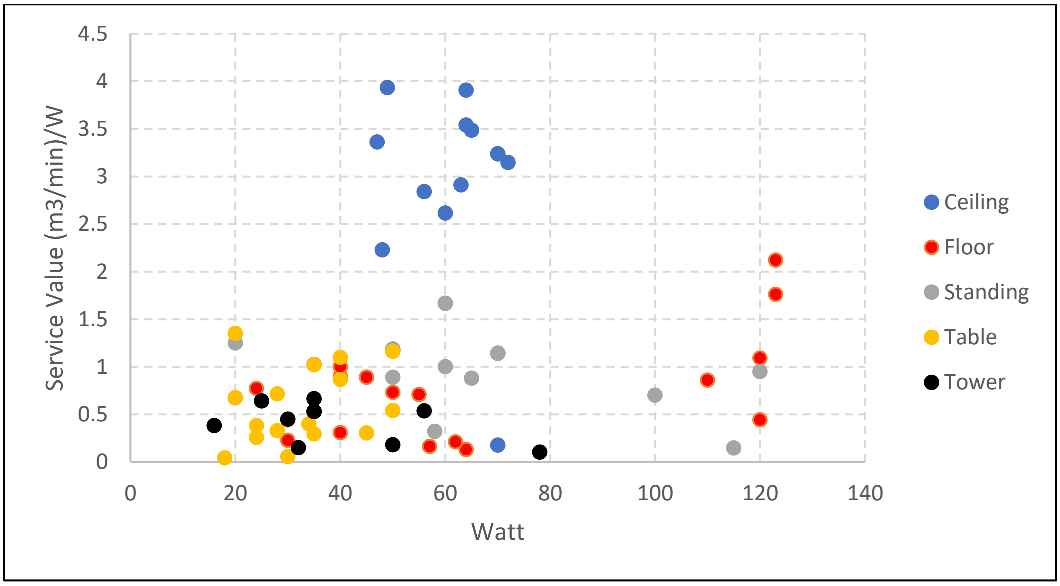

Figure 30: Spread in wattage and service values of comfort fans

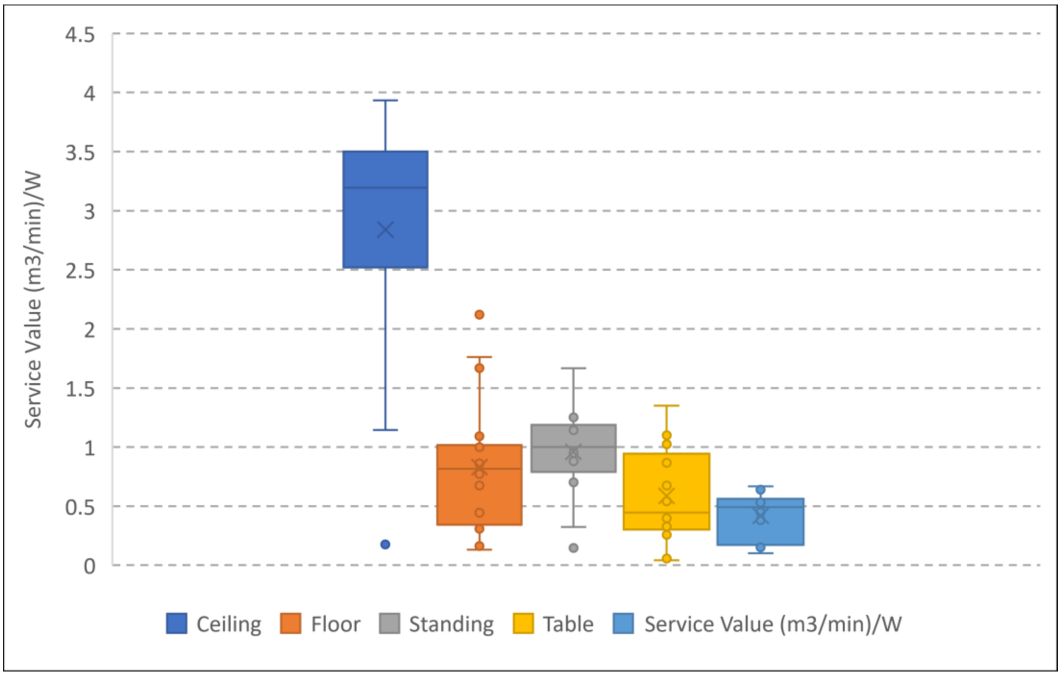

Figure 31: Spread in service values of the different types of comfort fans

From the figures it is visible that the service value of comfort fans is very widespread, and it is of special concern that very inefficient models are available on the European market. For all types of fans, the difference of the most and least efficient fans are more than (0.5 m^3/min)/W.

Despite the information requirements there is still a lack of data, which also was the case during the preparatory study. In the impact assessment the following is stated:

"As to comfort fans, the heart of the issue is the lack of robust data on the performance of fans sold in the EU. The preparatory study recognised this problem and proposed as possible solution the setting of minimum efficiency (and noise) requirements as applied in China and Taiwan. These values were thought to be attainable (since applied in the manufacturing country of origin for comfort fans) leading close to 1 TWh/a savings by 2020.

However, during the impact assessment study it became apparent that the results of fan efficiency established using IEC 60879 are not compatible with the Chinese requirements. Additional input from stakeholders and experts revealed that there is no certainty to what actual measurement standards are applied when the performance of fans is declared and whether the fans actually meet the Chinese requirements. This removed the basis for the proposal to introduce minimum efficiency requirements in line with the Chinese legislation. In the second Consultation Forum meeting three options were considered:

1) *Setting efficiency requirements at similar level as in China/Taiwan with risk of removing virtually all comfort fans from the EU market;*
2) *Setting requirements at lower levels than proposed in the preparatory study with loss of savings potential. However, the insufficiency of data and test results would result in 'blindly-set' requirements with corresponding risk of lost savings or banning of appliances;*
3) *Setting information requirements only for the indication of the measured efficiency of the appliance and the measurement method used. Savings would be postponed until the setting of minimum efficiency and/or labelling requirements, but the information requirements would help supporting national authorities in their market surveillance activities and provide sound basis for energy efficiency data for any future measures. Information requirements will not lead to any considerable administrative burden, as the efficiency tests will provide this information for each model anyway. While today appliances include information based on EER and COP, they will include information based on SEER and SCOP after the coming into force of requirements.*

The third option was chosen, as options 1 and 2 were considered unacceptably risky. As the setting of product information requirements is not estimated to differ significantly from the baseline scenario in terms of costs against the obvious benefits, this option is not further analysed."

The available standard is still IEC 60879 so there is a still a risk that service values not are comparable across borders. This makes it very difficult to suggest any reasonable requirements as the efficiency on the market is unknown. Furthermore, the standard does not include tower fans which are assumed to cover 33 % of the market.

By implementing the MEPS suggested in the preparatory study the concern was that comfort fans were banned from the market. The suggested minimum requirements in the preparatory study are presented in Table 29.

Table 29: Suggested minimum requirements in the preparatory study

Fan type	Fan diameter (cm)	Service value minimum acceptable ((m^3/min)/W)	Maximum acceptable noise (dB(A))
Tower fans	0-20	0.54	59
All comfort fans except tower and ceiling	20-23	0.54	59
	23-25	0.64	60
	25-30	0.74	61
	30-35	0.81	63
	35-40	0.9	65
	40-45	1	67
	45-50	1.1	68
	50-60	1.13	70
	60+	1.3	73
Ceiling fans	0-60	0.54	62
	60-90	0.87	62
	90-120	1.15	65
	120-130	1.46	67
	130-140	1.45	70
	140-150	1.45	72
	150+	1.47	75

Whether these requirements still are assumed to ban comfort fans from the market is unknown. The available data is not divided in fan diameter and since there is a clear link between fan diameter and obtainable service value it is difficult to suggest new requirements based on data currently available.

Instead of assessing fans based on their fan diameter the requirements could be dependent on the type. This may mean that small comfort fans (small diameter) are banned from the market. These requirements could be based on the LLCC found in the preparatory study. The LLCC and BAT found in the preparatory study are presented in

Table 30: LLCC and BAT for different types of comfort fans - based on the preparatory study

	LLCC	BAT
Service Values for Table fans ((m^3/min)/Watt)	1	1.77
Service Values for Pedestal fans ((m^3/min)/Watt)	1	1.77
Service Values for Tower fans ((m^3/min)/Watt)	1.5	2.2

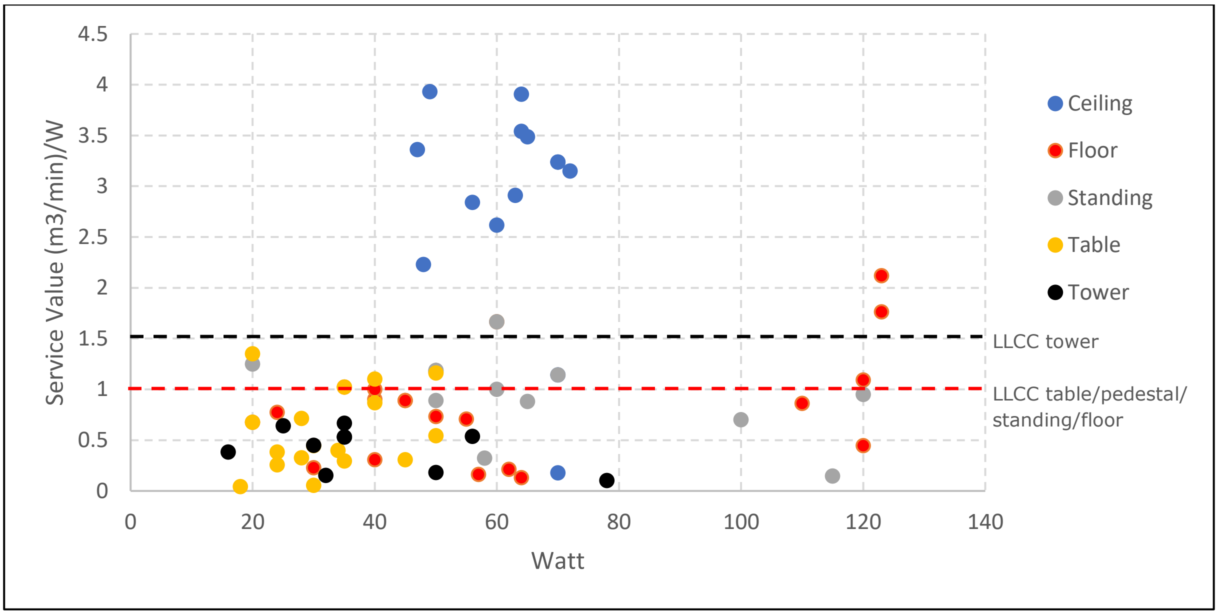

Figure 32: LLCC from the preparatory study and current service value.

From the figure it seems like the majority of the table fans currently not even are able to reach the LLCC level from the preparatory study. This means that there has been very little technological development on comfort fans in Europe. Most comfort fans are also low priced, so this may affect the possibilities for further improvement. The lack of improvement in Europe may also be due to the lack of requirements so all the inefficient comfort fans are shipped to Europe. Topten have informed that it seems like comfort fans in e.g. china are more efficient than in Europe.

Impact of requirements

If any minimum requirements are suggested it is unknown how this will affect the market due to the inconsistencies with standards (Europe/Asia) and also the lack of data. If the service value in Europe and Asia is comparable there is room for improvement. The most efficient comfort fans are present in China and India. This is based on the topten list requirements in Asia. The service value requirements to reach the topten list in China are presented in table

Construction type	Energy efficiency value (m^3/min/W)
Standing	≥ 1.31
Ceiling	≥ 3.08
Other	≥ 1.40

The presented threshold values in China are considered weak, but if these threshold values are adopted to Europe it seems difficult for topten to populate the list. Though, there is still the uncertainty regarding standards. So, it is unknown whether comfort fans in China are rated better due to differences in the standard or lack in control.

So overall the same challenges still exist regarding requirements for comfort fans and the following two options from the impact assessment is still valid to consider:

- Setting minimum energy efficiency requirements on comfort fans with the proposed requirements (from the preparatory study) with the risk of banning many comfort fans in the European market (expected savings in the preparatory study was slightly below 1 TWh).

- Enforcing better market surveillance on the current information requirement and gathering accurate information on comfort fan efficiency and test methods through a complementary study/efficiency tests with corresponding costs.

Annex 2 – Policy scenarios assumptions

All scenarios consist of a set of assumptions that are fixed which are presented in the table below.

Table 31: Assumptions in all scenarios

	Cooling capacity kW	Cooling hours	Pdesignh (kW)	Leakage rate
BC 1	3.5	350	3	3%
BC 2	7.1	350	6.5	3%
BC 3	2.6			1%

All scenarios also consist of some values that are changing due to annual development. Though are these assumptions alike in all scenarios. These assumptions are:

- Assumptions for hours in heating:
  - 0 hours in 1992 to 700 hours in 2015 (linear regression until full load hours are reached in 2038 for new products)
- Assumptions for refrigerant:
  - R410 until ban, then R-32 for fixed and propane for portable. For fixed air conditioners there is a linear regression in the conversion from R410 until the ban. This means that the GWP will gradually decrease until the ban.

Annex 3 – Tables and figures

This annex presents additional tables and figures to support the analysis in this report.

Development of SEER and SCOP average sales values in the different policy options

The assumed SEER and SCOP development for the different policy options are presented in the table below.

Table 32: Development of SEER and SCOP average sales values in the different scenarios.

		2010	2015	2020	2025	2030	2035	2040
Scenario 2 (1 tier eco)								
SEER	BC1	4.81	6.00	6.73	7.38	7.61	7.83	8.05
	BC2	4.58	5.80	6.21	6.59	6.73	6.87	7.01
	BC3	1.65	1.83	2.08	2.33	2.37	2.42	2.46
SCOP	BC1	3.34	4.00	4.19	4.36	4.47	4.58	4.69
	BC2	3.26	4.00	4.10	4.19	4.25	4.31	4.38
	BC3	-	-	-	-	-	-	-
Scenario 3 (lbl)								
SEER	BC1	4.81	6.00	6.36	6.88	7.44	8.01	8.57
	BC2	4.58	5.80	6.01	6.31	6.63	6.95	7.26
	BC3	1.65	1.83	1.87	2.17	2.54	2.90	3.27
SCOP	BC1	3.34	4.00	4.09	4.27	4.47	4.67	4.88
	BC2	3.26	4.00	4.04	4.17	4.31	4.45	4.60
	BC3	-	-	-	-	-	-	-
Scenario 4 (eco+lbl)								
SEER	BC1	4.81	6.00	6.73	7.51	7.95	8.39	8.83
	BC2	4.58	5.80	6.21	6.65	6.90	7.15	7.40
	BC3	1.65	1.83	2.08	2.48	2.79	3.09	3.39
SCOP	BC1	3.34	4.00	4.19	4.41	4.58	4.76	4.93
	BC2	3.26	4.00	4.10	4.23	4.36	4.49	4.62
	BC3	-	-	-	-	-	-	-

Environmental impacts of the different scenarios for each of the base cases

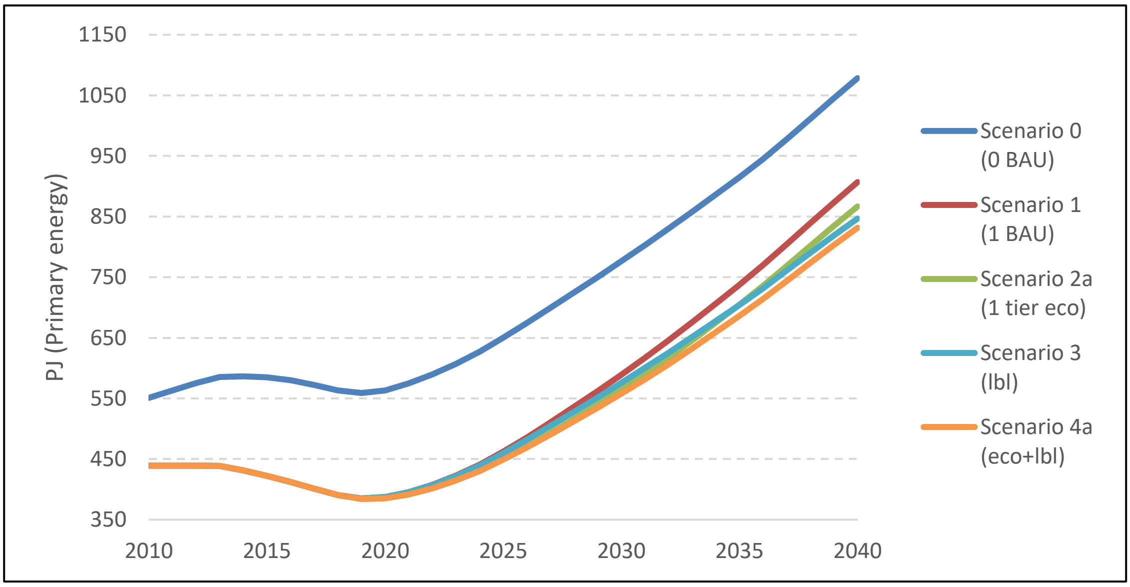

Figure 33: Comparison of impacts of the different scenarios – Primary energy (PJ) in absolute values

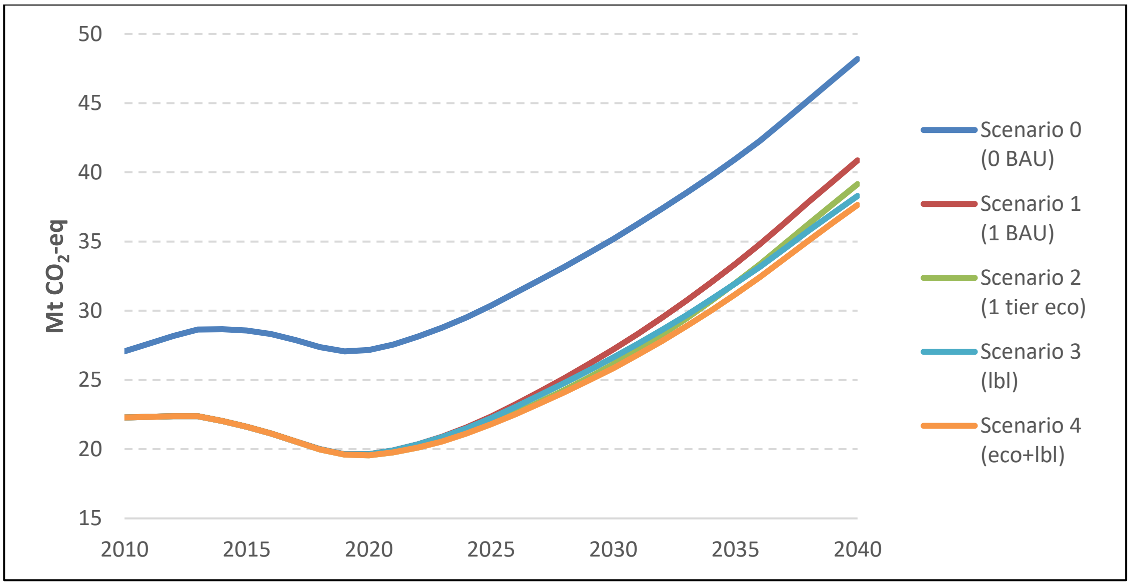

Figure 34: Comparison of impacts of the different scenarios – Emission of CO_2 (Mt) in absolute values

Table 33: Impacts of scenario 0 (before regulation) - TWh, Primary energy and CO_2-eq in absolute values

		2010	2015	2020	2025	2030	2035	2040
Scenario 0 (current regulation)								
TWh (Electricity)	BC1	37.9	38.7	36.4	42.6	52.2	62.7	75.3
	BC2	19.6	22.7	22.4	25.3	29.3	33.7	38.7
	BC3	1.2	1.1	1.0	1.0	1.0	1.0	1.0
	Total	**58.6**	**62.6**	**59.8**	**69.0**	**82.6**	**97.4**	**115.0**
PJ (Primary energy)	BC1	354.4	360.2	341.8	400.9	490.0	587.5	704.8
	BC2	184.0	213.0	210.7	238.4	275.5	316.4	362.7
	BC3	12.5	11.9	10.9	11.0	10.9	11.0	11.0
	Total	**551.0**	**585.1**	**563.4**	**650.2**	**776.4**	**914.9**	**1078.5**
Mt CO_2-eq	BC1	17.4	17.6	16.5	18.7	22.2	26.3	31.5
	BC2	9.0	10.4	10.2	11.2	12.5	14.2	16.2
	BC3	0.6	0.6	0.5	0.5	0.5	0.5	0.5
	Total	**27.1**	**28.6**	**27.2**	**30.4**	**35.2**	**40.9**	**48.2**

Table 34: Impacts of scenario 1 (current regulation) - TWh, Primary energy and CO_2-eq in absolute values

		2010	2015	2020	2025	2030	2035	2040
Scenario 1 (current regulation)								
TWh (Electricity)	BC1	30.4	28.4	25.3	30.7	40.2	51.2	64.1
	BC2	14.7	15.1	14.0	16.6	20.8	25.7	31.1
	BC3	1.0	0.9	0.8	0.8	0.8	0.8	0.8
	Total	**46.2**	**44.5**	**40.2**	**48.1**	**61.8**	**77.7**	**96.0**
PJ (Primary energy)	BC1	287.6	267.4	242.5	293.9	381.7	484.2	603.6
	BC2	140.0	144.5	135.5	159.4	198.4	244.1	293.9
	BC3	11.4	10.3	9.1	9.1	9.2	9.3	9.4
	Total	**439.1**	**422.2**	**387.1**	**462.4**	**589.3**	**737.5**	**906.9**
Mt CO_2-eq	BC1	14.6	13.6	12.2	14.2	17.6	21.9	27.2
	BC2	7.1	7.5	7.0	7.8	9.2	11.1	13.3
	BC3	0.6	0.5	0.4	0.4	0.4	0.4	0.4
	Total	**22.3**	**21.6**	**19.6**	**22.4**	**27.2**	**33.4**	**40.9**

Table 35: Impacts of scenario 2 (1 tier eco) - TWh, Primary energy and CO_2-eq in absolute values

		2010	2015	2020	2025	2030	2035	2040
Scenario 2 (1 tier eco)								
TWh (Electricity)	BC1	30.4	28.4	25.2	29.7	38.2	48.6	60.7
	BC2	14.7	15.1	14.0	16.3	20.2	24.9	30.0
	BC3	1.0	0.9	0.8	0.7	0.7	0.7	0.7
	Total	**46.2**	**44.5**	**40.0**	**46.7**	**59.0**	**74.1**	**91.5**
PJ (Primary energy)	BC1	287.6	267.4	241.1	285.0	363.6	460.1	573.9
	BC2	140.0	144.5	135.1	156.7	193.0	236.8	284.8
	BC3	11.4	10.3	9.0	8.3	7.9	8.0	8.1
	Total	**439.1**	**422.2**	**385.2**	**450.1**	**564.5**	**704.9**	**866.8**
Mt CO_2-eq	BC1	14.6	13.6	12.2	13.8	16.8	20.9	25.9
	BC2	7.1	7.5	6.9	7.7	9.0	10.8	12.9
	BC3	0.6	0.5	0.4	0.4	0.4	0.4	0.4
	Total	**22.3**	**21.6**	**19.6**	**21.8**	**26.1**	**32.0**	**39.1**

Table 36: Impacts of scenario 3 (lbl) - TWh, Primary energy and CO_2-eq in absolute values

		2010	2015	2020	2025	2030	2035	2040
Scenario 3 (lbl)								
TWh (Electricity)	BC1	30.4	28.4	25.3	30.5	39.2	48.7	59.5
	BC2	14.7	15.1	14.0	16.5	20.3	24.7	29.2
	BC3	1.0	0.9	0.8	0.8	0.7	0.6	0.6
	Total	**46.2**	**44.5**	**40.2**	**47.8**	**60.3**	**74.0**	**89.3**
PJ (Primary energy)	BC1	287.6	267.4	242.5	292.2	372.9	461.8	562.5
	BC2	140.0	144.5	135.5	158.7	194.8	234.9	277.2
	BC3	11.4	10.3	9.1	8.9	8.2	7.5	7.0
	Total	**439.1**	**422.2**	**387.1**	**459.7**	**575.9**	**704.2**	**846.8**
Mt CO_2-eq	BC1	14.6	13.6	12.2	14.1	17.2	20.9	25.4
	BC2	7.1	7.5	7.0	7.8	9.1	10.7	12.6
	BC3	0.6	0.5	0.4	0.4	0.4	0.3	0.3
	Total	**22.3**	**21.6**	**19.6**	**22.3**	**26.6**	**32.0**	**38.3**

Table 37: Impacts of scenario 4 (eco+lbl) - TWh, Primary energy and CO_2-eq in absolute values

		2010	2015	2020	2025	2030	2035	2040
Scenario 4a (eco+lbl)								
TWh (Electricity)	BC1	30.4	28.4	25.2	29.7	37.7	47.2	58.2
	BC2	14.7	15.1	14.0	16.2	19.9	24.2	28.9
	BC3	1.0	0.9	0.8	0.7	0.6	0.6	0.5
	Total	**46.2**	**44.5**	**40.0**	**46.6**	**58.3**	**72.0**	**87.6**
PJ (Primary energy)	BC1	287.6	267.4	241.1	284.4	359.3	448.1	550.8
	BC2	140.0	144.5	135.1	156.4	191.0	231.1	274.1
	BC3	11.4	10.3	9.0	8.2	7.4	7.0	6.7
	Total	**439.1**	**422.2**	**385.2**	**449.0**	**557.7**	**686.2**	**831.6**
Mt CO_2-eq	BC1	14.6	13.6	12.2	13.8	16.6	20.3	24.9
	BC2	7.1	7.5	6.9	7.7	8.9	10.5	12.4
	BC3	0.6	0.5	0.4	0.4	0.3	0.3	0.3
	Total	**22.3**	**21.6**	**19.6**	**21.8**	**25.9**	**31.2**	**37.6**

The accumulated savings

The accumulated energy savings compared to scenario 1 (the current regulation) are presented in the table below.

Table 38: The accumulated savings in energy and emission of CO_2-eq of the policy options compared to the current regulation (scenario 1)

	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
Electricity consumption (TWh)										
Scenario 2 (1 tier eco)	0	0	0	0	0	0	5	16	32	53
Scenario 3 (lbl)	0	0	0	0	0	0	1	5	19	46
Scenario 4a (eco+lbl)	0	0	0	0	0	0	5	18	42	79
Primary energy consumption (PJ)										
Scenario 2 (1 tier eco)	0	0	0	0	0	0	5	47	171	415
Scenario 3 (lbl)	0	0	0	0	0	3	44	163	380	707
Scenario 4 (eco+lbl)	0	0	0	0	0	0	5	47	171	415
mt CO_2-eq										
Scenario 2 (1 tier eco)	0	0	0	0	0	0	2	6	12	20
Scenario 3 (lbl)	0	0	0	0	0	0	0	2	7	18
Scenario 4 (eco+lbl)	0	0	0	0	0	0	2	7	16	30

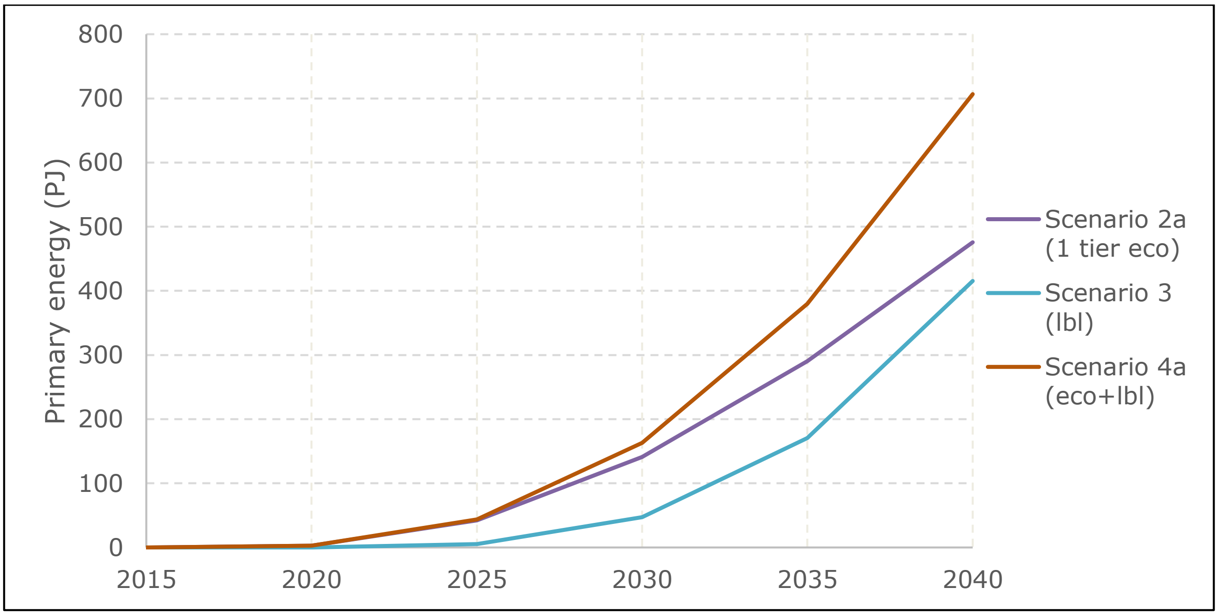

Figure 35: The accumulated savings in primary energy (PJ)of the policy options compared to the current regulation (scenario 1)

Development of purchase price per unit in different policy options

Table 39: Development in purchase price per unit in absolute values

		2010	2015	2020	2025	2030	2035	2040
Scenario 0 (before regulation)								
EUR	BC1	492	509	517	520	517	509	472
	BC2	1114	1157	1182	1191	1188	1174	1088
	BC3	259	243	228	213	199	186	170
Scenario 1 (current regulation)								
EUR	BC1	737	830	795	759	723	686	650
	BC2	1799	2059	1929	1806	1689	1577	1472
	BC3	308	307	284	263	243	225	208
Scenario 2 (1 tier eco)								
EUR	BC1	737	830	842	835	777	723	673
	BC2	1799	2059	1994	1910	1764	1628	1502
	BC3	308	307	316	320	295	271	250
Scenario 3 (lbl)								
EUR	BC1	737	830	795	778	761	740	716
	BC2	1799	2059	1929	1830	1738	1646	1556
	BC3	308	307	284	298	315	326	332
Scenario 4a (eco+lbl)								
EUR	BC1	737	830	842	849	813	775	737
	BC2	1799	2059	1994	1928	1809	1694	1585
	BC3	308	307	316	341	346	347	344

Consumer impacts for each of the base cases in absolute values

Table 40: Annual consumer purchase costs of air conditioners in absolute values

		2010	2015	2020	2025	2030	2035	2040
Scenario 0 (before regulation)								
Billion EUR	BC1	1.53	1.32	1.69	2.04	2.34	2.66	2.89
	BC2	0.85	0.96	1.06	1.22	1.37	1.50	1.55
	BC3	0.15	0.14	0.10	0.10	0.09	0.09	0.09
	Total	**2.53**	**2.42**	**2.85**	**3.36**	**3.8**	**4.25**	**4.53**
Scenario 1 (current regulation)								
Billion EUR	BC1	2.29	2.16	2.60	2.99	3.27	3.58	3.98
	BC2	1.38	1.70	1.74	1.85	1.94	2.02	2.10
	BC3	0.18	0.17	0.13	0.12	0.12	0.11	0.10
	Total	**3.85**	**4.03**	**4.47**	**4.96**	**5.33**	**5.71**	**6.18**
Scenario 2 (1 tier eco)								
Billion EUR	BC1	2.29	2.16	2.76	3.28	3.52	3.77	4.11
	BC2	1.38	1.70	1.80	1.96	2.03	2.09	2.14
	BC3	0.18	0.17	0.14	0.15	0.14	0.13	0.13
	Total	**3.85**	**4.03**	**4.7**	**5.39**	**5.69**	**5.99**	**6.38**
Scenario 3 (lbl)								
Billion EUR	BC1	2.29	2.16	2.60	3.06	3.45	3.86	4.38
	BC2	1.38	1.70	1.74	1.88	2.00	2.11	2.22
	BC3	0.18	0.17	0.13	0.14	0.15	0.16	0.17
	Totals	**3.85**	**4.03**	**4.47**	**5.08**	**5.6**	**6.13**	**6.77**
Scenario 4a (eco+lbl)								
Billion EUR	BC1	2.29	2.16	2.76	3.34	3.68	4.04	4.51
	BC2	1.38	1.70	1.80	1.98	2.08	2.17	2.26
	BC3	0.18	0.17	0.14	0.16	0.16	0.17	0.17
	Totals	**3.85**	**4.03**	**4.7**	**5.48**	**5.92**	**6.38**	**6.94**

Table 41: Annual consumer electricity costs in absolute values

		2010	2015	2020	2025	2030	2035	2040
Scenario 0 (before regulation)								
Billion EUR	BC1	6.3	7.1	7.1	8.6	10.7	13.2	15.7
	BC2	3.2	4.1	4.3	5.1	5.9	7.0	8.0
	BC3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Total	**9.7**	**11.4**	**11.7**	**13.9**	**16.9**	**20.4**	**23.9**
Scenario 1 (current regulation)								
Billion EUR	BC1	5.1	5.2	5.0	6.2	8.3	10.8	13.4
	BC2	2.4	2.7	2.7	3.3	4.2	5.3	6.4
	BC3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Total	**7.7**	**8.1**	**7.9**	**9.7**	**12.6**	**16.3**	**19.9**
Scenario 2 (1 tier eco)								
Billion EUR	BC1	5.1	5.2	4.9	6.0	7.8	10.2	12.7
	BC2	2.4	2.7	2.7	3.2	4.1	5.2	6.2
	BC3	0.2	0.2	0.2	0.1	0.1	0.1	0.1
	Total	**7.7**	**8.1**	**7.8**	**9.4**	**12.1**	**15.5**	**19.0**
Scenario 3 (lbl)								
Billion EUR	BC1	5.1	5.2	5.1	6.1	8.2	10.2	12.5
	BC2	2.4	2.7	2.7	3.3	4.1	5.2	6.1
	BC3	0.2	0.2	0.2	0.2	0.1	0.1	0.1
	Totals	**7.7**	**8.1**	**7.9**	**9.6**	**12.4**	**15.5**	**18.7**
Scenario 4a (eco+lbl)								
Billion EUR	BC1	5.1	5.2	5.0	5.9	7.9	9.9	12.2
	BC2	2.4	2.7	2.7	3.2	4.0	5.1	6.1
	BC3	0.17	0.16	0.16	0.14	0.12	0.12	0.11
	Totals	**7.7**	**8.1**	**7.9**	**9.3**	**12.0**	**15.1**	**18.4**

Table 42: Annual installation and maintenance costs in absolute values

		2010	2015	2020	2025	2030	2035	2040
All scenarios – installation								
Billion EUR	BC1	1.5	1.8	3.3	2.5	2.1	2.6	3.1
	BC2	0.3	0.4	0.7	0.6	0.7	0.7	0.8
	BC3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**1.8**	**2.1**	**4.0**	**3.1**	**2.7**	**3.3**	**4.0**
All scenarios – maintenance								
Billion EUR	BC1	0.2	0.2	0.3	0.3	0.2	0.3	0.3
	BC2	0.0	0.0	0.1	0.1	0.1	0.1	0.1
	BC3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Totals	**0.2**	**0.2**	**0.4**	**0.3**	**0.3**	**0.4**	**0.4**

Industry impacts

The Industry impacts are presented in the table below.

Table 43: Industry impacts - Manufacturer turnover (Mln EUR)

	2010	2015	2020	2025	2030	2035	2040
	Manufacturer turnover (Mln EUR)						
Scenario 0 (0 BAU)	1160	1106	1301	1527	1724	1926	2046
Scenario 1 (1 BAU)	1755	1838	2029	2248	2417	2585	2794
Scenario 2 (1 tier eco)	1755	1838	2132	2445	2581	2715	2887
Scenario 3 (lbl)	1755	1838	2029	2302	2540	2779	3065
Scenario 4 (eco+lbl)	1755	1838	2132	2485	2690	2896	3145

Table 44: Industry impacts - Manufacture total personnel (Persons)

	2010	2015	2020	2025	2030	2035	2040
	Manufacture total personnel (Persons)						
Scenario 0 (0 BAU)	3356	3197	3764	4415	4986	5570	5918
Scenario 1 (1 BAU)	5075	5316	5867	6501	6988	7476	8079
Scenario 2 (1 tier eco)	5075	5316	6166	7071	7465	7851	8349
Scenario 3 (lbl)	5075	5316	5867	6656	7344	8038	8863
Scenario 4 (eco+lbl)	5075	5316	6166	7187	7780	8374	9096

Table 45: Industry impacts - OEM total personnel (Persons)

	2010	2015	2020	2025	2030	2035	2040
	OEM total personnel (Persons)						
Scenario 0 (0 BAU)	4027	3837	4516	5298	5984	6684	7102
Scenario 1 (1 BAU)	6090	6380	7041	7801	8386	8971	9694
Scenario 2 (1 tier eco)	6090	6380	7400	8485	8958	9421	10019
Scenario 3 (lbl)	6090	6380	7041	7988	8813	9646	10636
Scenario 4 (eco+lbl)	6090	6380	7400	8624	9337	10049	10916

Table 46: Industry impacts - OEM total personnel – EU (Persons)

	2010	2015	2020	2025	2030	2035	2040
	OEM total personnel – EU (Persons)						
Scenario 0 (0 BAU)	805	767	903	1060	1197	1337	1420
Scenario 1 (1 BAU)	1218	1276	1408	1560	1677	1794	1939
Scenario 2 (1 tier eco)	1218	1276	1480	1697	1792	1884	2004
Scenario 3 (lbl)	1218	1276	1408	1598	1763	1929	2127
Scenario 4 (eco+lbl)	1218	1276	1480	1725	1867	2010	2183

Table 47: Industry impacts - Wholesaler turnover (Mln EUR)

	2010	2015	2020	2025	2030	2035	2040
	Wholesaler turnover (Mln EUR)						
Scenario 0 (0 BAU)	348	332	390	458	517	578	614
Scenario 1 (1 BAU)	526	552	609	674	725	776	838
Scenario 2 (1 tier eco)	526	552	640	734	774	814	866
Scenario 3 (lbl)	526	552	609	691	762	834	919
Scenario 4a (eco+lbl)	526	552	640	746	807	869	944

Table 48: Industry impacts - Wholesaler total personnel (Persons)

	2010	2015	2020	2025	2030	2035	2040
	Wholesaler total personnel (Persons)						
Scenario 0 (0 BAU)	683	651	766	899	1015	1134	1205
Scenario 1 (1 BAU)	1033	1082	1194	1323	1423	1522	1644
Scenario 2 (1 tier eco)	1033	1082	1255	1439	1520	1598	1700
Scenario 3 (lbl)	1033	1082	1194	1355	1495	1636	1804
Scenario 4a (eco+lbl)	1033	1082	1255	1463	1584	1705	1852

Sensitivity analysis in absolute values

Table 49: The calculated impacts of higher levels of recycling and the effect of higher leakage in absolute values.

		2010	2015	2020	2025	2030	2035	2040
Scenario 4 (eco+lbl)								
Mt CO_2-eq	BC1	14.6	13.6	12.2	13.8	16.6	20.3	24.9
	BC2	7.1	7.5	6.9	7.7	8.9	10.5	12.4
	BC3	0.6	0.5	0.4	0.4	0.3	0.3	0.3
	Total	**22.3**	**21.6**	**19.6**	**21.8**	**25.9**	**31.2**	**37.6**
Sensitivity (95% recycling)								
Mt CO_2-eq	BC1	14.5	13.6	12.1	13.6	16.5	20.2	24.7
	BC2	7.1	7.4	6.9	7.6	8.8	10.4	12.3
	BC3	0.5	0.5	0.4	0.4	0.3	0.3	0.3
	Total	**22.1**	**21.5**	**19.4**	**21.6**	**25.6**	**30.9**	**37.3**
Sensitivity (Double leakage)								
Mt CO_2-eq	BC1	17.5	16.5	14.5	15.7	18.1	21.6	26.4
	BC2	8.6	9.1	8.4	8.8	9.7	11.2	13.2
	BC3	0.6	0.5	0.5	0.4	0.3	0.3	0.3
	Total	**26.7**	**26.2**	**23.4**	**24.9**	**28.1**	**33.2**	**39.9**