Ref. Ares(2021)3911106 - 15/06/2021

European Commission

Review of Regulation 206/2012 and 626/2011

Air conditioners and comfort fans

Addendum regarding fixed double duct air conditioners

Draft

Date: 15 February 2021

ARMINES

viegand maagøe energy people

Viegand Maagøe A/S
Nr. Farimagsgade 37
1364 Copenhagen K
Denmark
viegandmaagoe.dk

Prepared by:
ARMINES and Viegand Maagøe
Study team: Flemming Andersen, Rikke Naeraa, Philippe Riviere
Quality manager: Jan Viegand
Contract manager: René Kemna, VHK

Prepared for:
European Commission
DG ENER C.4
Office: DM24 04/048
B-1049 Brussels, Belgium

Contact person: Cosmin Codrea
E-mail: cosmin.codrea@ec.europa.eu

Specific contract no.: No. ENER/C4/FV 2019-467/08/FWC2016-542/11

Implements Framework Contract: № ENER/C3/2016-542

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

Table of contents

List of tables

List of figures

Abbreviations

BAT	Best Available Technology
BAU	Business-as-usual (describing a scenario without any further intervention)
BNAT	Best Not yet Available Technology
COP	Coefficient of Performance for air conditioners in heating mode
EER	Energy Efficiency Ratio for air conditioners in cooling mode
GHG	Greenhouse gas
GWP	Global warming potential
HTO	The number of hours the unit is considered to work in thermostat off mode for air conditioners
HSB	The number of hours the unit is considered to work in standby mode for air conditioners
HOFF	The number of hours the unit is considered to work in off mode for air conditioners

IA	Impact Assessment
IEC	International Electrotechnical Commission; global standardisation organisation
IoT	Internet of Things
LCC	Life cycle cost over the whole lifetime of a product, including purchase cost and energy costs
LLCC	Least life cycle cost; used to determine the energy efficiency requirements that minimize costs of a product for its whole lifetime.
MEErP	Methodology for Ecodesign of Energy-related Products
MS	Member State
MSA	Market Surveillance Authority (in charge of enforcing ecodesign regulation in a Member State)
msp	Manufacturer Selling Price
MtCO2eq	Mega tonne CO_2 equivalent
NGO	Non-Governmental Organisation
OEM	Original Equipment Manufacturer
POFF	The electricity consumption during off mode.
R&D	Research and Development
SHR	Sensible Heat Ratio for air conditioners
SEER	Seasonal Energy Efficiency Ratio for air conditioners, cooling mode
SCOP	Seasonal Coefficient of Performance for air conditioners, heating mode
VRF	Variable Refrigerant Flow
Y or a	Abbreviation used as denominator for units expressed per year (e.g. TWh/y or TWh/a)

Introduction to this additional report

This report completes the main review report with information on fixed double duct air conditioners required to derive the least life cycle cost analysis and to design possible policy scenarios.

The report follows the MEErP[1] structure (Task 1: Scope, Task 2: Markets, Task 3: Users, Task 4: Technologies, Task 5: Environment and Economics, Task 6: Design options, Task 7: Scenarios).

1. Scope

1.1 Product definition

As explained in the Review report (Task 1 report, Table 1), two main types of double duct products can be distinguished: "*the first type is exactly similar to a single duct but a second hole at the condenser enables to take the condenser air from outside thus reducing outside air infiltration inside the room to be cooled. The second type is similar, but of a more permanent installation through the wall and in that case, the two ducts*

[1] R. Kemna, Methodology for Ecodesign of Energy-related Products, 2011, Prepared for the European Commission DG Enterprise and Industry Unit B1 Sustainable Industrial Policy under specific contract SI2.581529.

may be concentric." Fixed double duct illustration is given in Figure 1 below (extraction of the Review report (Task 1 report, Table 1).

This report focuses on fixed double duct products.

Double duct air conditioner (through the wall installation)

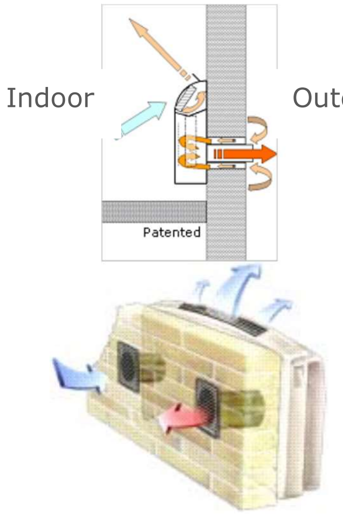


Figure 1. Fixed double duct product illustration, source Review report (Task 1 report, Table 1)

1.2 Testing standards

Performance testing standard is EN14511[2]. Fixed double duct air conditioners energy efficiency metrics are presently:

- In cooling mode, the Energy Efficiency Ratio (EER) in standard rating conditions.
- In heating mode, the Coefficient of Performance (COP) in standard rating conditions.

1.3 EU Legislation

Regulation n° 206/2012[3] (Ecodesign) and Regulation n° 626/2011[4] (Energy labelling)

In present Regulation (EU) 206/2012 and Regulation (EU) 626/2011, there is no distinction between portable and fixed double duct air conditioners.

A double duct air conditioner is defined as an air conditioner in which, during cooling or heating, the condenser (or evaporator) intake air is introduced from the outdoor environment to the unit by a duct and rejected to the outdoor environment by a second duct, and which is placed wholly inside the space to be conditioned, near a wall.

[2] EN14511:2013 - Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling

[3] Commission Regulation (EU) No 206/2012 of 6 March 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for air conditioners and comfort fans

[4] Commission Delegated Regulation (EU) No 626/2011 of 4 May 2011 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of air conditioners

As a consequence, all clauses for double duct air conditioners in these EU regulations apply to fixed double duct air conditioners presently.

F-gas Regulation - (EU) No 517/2014[5]

There is no specific requirement as regards the use of low global warming potential (GWP) refrigerant fluid for fixed double duct air conditioners. As regards air conditioners, bans of product for which the GWP of the refrigerant is higher than specific thresholds only exist for portable air conditioners (where a portable air conditioner is defined as "hermetically sealed equipment which is movable between rooms by the end user"), and split air conditioners.

2. Markets

2.1 Market and stock

There is no PRODCOM data available for fixed double air conditioners.

The following sales data were supplied by manufacturers, national sales for Italy and exports outside Italy (Figure 2). For years available (data is missing for years 2013 and 2014), data have been relatively stable until 2017 with a significant increase to about 30 000 units sold in 2018 and 2019. This increase is supported by both export and national sales increase.

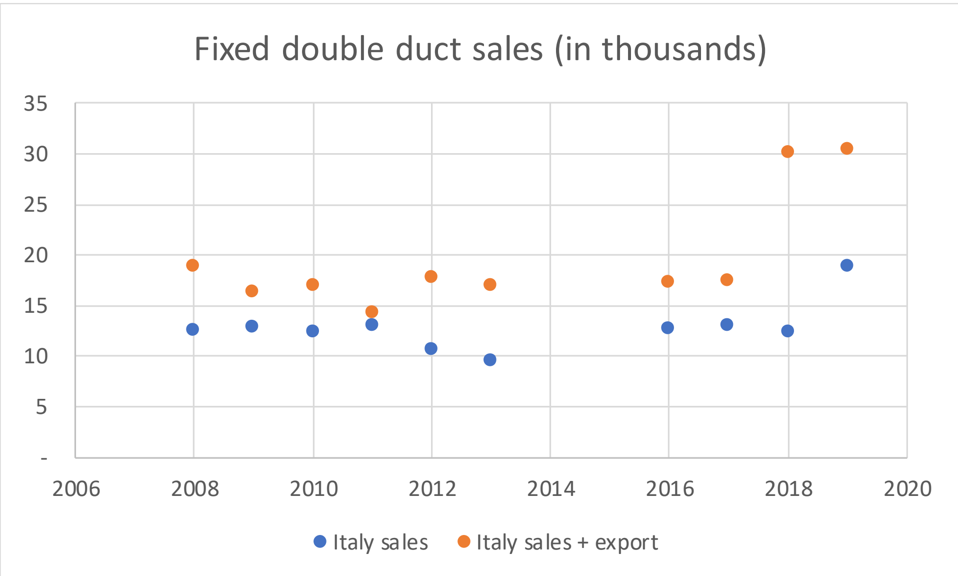


Figure 2. Fix double duct sales in Italy, and internal sales plus exports from Italy (in thousand products per year)

In 2018, the sum of Italian sales and export of fixed double ducts represent an estimated 0.8 % of the sales of all air conditioning products sold in Europe (in quantity). These figures are supposed representative for Europe but probably underestimates the sales at EU level because there are direct imports from China in other EU countries which are not accounted for in these figures (see part 2.2).

[5] REGULATION (EU) No 517/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006

According to manufacturers, sales (in number) are split between residential sector (70 %) and tertiary sector (30 %). About 70 % of the products sold are reversible; this share appears to decrease very slowly (0.4 % per year over the period 2015 to 2020). Some of these reversible products also include an electric backup heater.

Products have cooling capacities ranging from 1.7 to 3.4 kW. For reversible products, standard heating capacities are similar to standard cooling capacities (slightly lower or higher depending on product design).

Product lifetime for these products is estimated to be of 12 years. On this basis, and supposing the present share of 0.8 % of the total EU sales remains constant in the future, the stock evolution can be calculated (Figure 3).

One manufacturer estimates the sales and stock are likely to curb after 2030 (15 % lower stock value by 2050 than presented in Figure 3) because of the impact of the EU circular economy strategy.

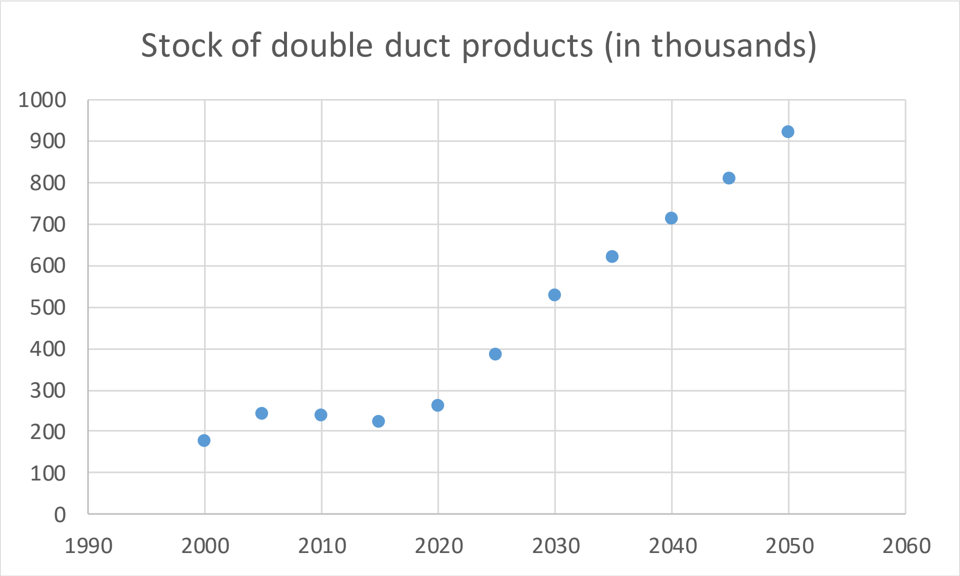


Figure 3. Estimated fixed double duct stock of air conditioners in EU27 (in thousands of units)

2.2 Market trends

Product main features

Regarding performances in standard rating conditions for fixed double duct products:

- Cooling mode EER varies between 2.6 (MEPS according the Regulation (EU) 206/2012) and 3.2. For retail and professional sales routes in Italy, 97 % of the sales are in A class (EER between 2.6 and 3.1) and 3 % in A+ (EER between 3.1 and 3.6) according to manufacturers. In A+ class with EER superior to 3.1, only small units (capacity in the range 2 to 2.5 kW) using inverter compressors with BLDC motors can be found.
- Heating mode COP varies between 2.6 (MEPS) and 3.3. Most models are in class A (COP of 3.1 or above) and a few in class B (COP strictly lower than 3.1).

Inverter penetration in the sales has been fairly constant over the years 2015 to 2020, with a share lying between 36 % and 39 %. Fixed double duct air conditioners do not use seasonal performance ratings which could show the inverter energy consumption reduction. However, EER values are generally higher for units with inverter. In addition, the inverter price premium has been declining to about 20 % and is advertised as an energy efficiency option. This may explain the development of inverter compressor for these products despite the absence of seasonal performance metrics.

In Italy, fiscal incentives exist air conditioners but are estimated by manufacturers to only give a small incentive to fixed double duct sales as energy efficiency requirements are difficult to reach for these products:

- For new installation, financial scheme known as "bonus mobili", there is a 50 % tax credit for A+ class product (EER ≥ 3.1)
- For replacement, financial scheme known as "bonus casa", there is also a 50 % tax credit with the following conditions: EER of the new system must have a better EER than the one of the replaced units. This option is suitable for units below 12 kW capacity in cooling mode (units can be reversible).
- For building retrofit, financial scheme known as "conto termico": in case of replacement of the existing heating system and/or if the system replaced was the only heating system; however, in that case, minimum COP are out of reach (inverter: COP ≥ 3.7 and EER ≥ 3.2; on off cycling: COP ≥ 3.9 and EER ≥ 3.4).

The main type of refrigerant is R410A, with only one model over all products identified already using R32. R32 is planned to be the short-term replacement fluid for R410A, with significant conversion shares planned for 2021.

Sound power values indoor (in dBA) vary between 53 and 60 depending on product size and model. Maximum threshold according to Regulation (EU) 206/2012 is of 60 dBA. Although outdoor sound power (which transits through the air duct connexion(s)) is limited to 65 dBA, this information is almost never available.

As for split[6], network capability is typically not included by default but rather offered as an option.

Market drivers and competition

Fixed double duct air conditioners are part of the solutions allowing air conditioning installation when an outdoor unit installation is not feasible (for instance for new installations in historical buildings in city centres or in multi-family buildings) or when people do not want to install an outdoor unit (e.g. for aesthetics and architectural quality, neighbouring or noise reasons). According to a survey conducted by manufacturers in Italy towards residential end-users of fixed double duct reversible air conditioner, these two main reasons respectively explain about 75 % and 20 % of the purchase decisions in the residential sector. Fixed double duct manufacturers focus on supplying very compact products, which can easily be integrated in the living space. They also have a strong focus on aesthetic design for the same reason. In the new developments, a double duct unit is also coupled to a hot water storage to offer a heat pump water heater without outdoor unit (able to provide space cooling, space heating and a limited quantity of domestic hot water).

[6] Review report, Task 2, Figure 27.

It should be noticed that the need for an outdoor unit in split systems is also a limiting factor for air-to-water heat pump space heater development, where several solutions are being proposed by manufacturers of these products: integration of the outdoor unit in a cavity of the outdoor wall, installation of the outdoor unit on the roof (even in tilted position) and installation of the outdoor unit inside (in the basement for instance) with ducts going through the wall for air inlet and outlet. And these products may also ensure the cooling function. Installing an air conditioner or a heat pump without an outdoor unit is thus not a market reserved to fixed double duct products. Alternative air conditioning solutions on the segment of air conditioning without permanent outdoor units are:

1. Portable package air conditioners (single or double duct).
2. Portable split air conditioners, which require a window and at least a small balcony / windowsill to locate the outdoor unit (for this solution, there is no permanent outdoor unit installation and it can sometimes be used although a fix outdoor unit installation would not be possible). This type of product is estimated to have negligible and declining sales in Europe[7].
3. Window air conditioners in some cases (there is no outdoor unit, still part of the window air conditioner is located outdoor, which is a limiting aesthetic factor and may also not be authorized by specific local building regulations). This type of product is estimated to have negligible and declining sales in Europe[8].
4. Fix double duct air conditioner (there is also an option for a double duct air conditioner with a supplementary indoor unit, as for a bi-split unit to cool/heat two distinct rooms).
5. Air-to-air split unit with "outdoor" unit located inside the building and connected to the outdoor via ducts passing through the wall with the exterior (as for fixed double duct products); connection between the "outdoor" unit and the terminal units in the rooms is via refrigerant piping; this solution requires more space than the fix double duct solution as in that case, it is necessary to find a place to install the internalised outdoor unit (attics and basements are places which avoid noise in living places but this internalised unit can also be insulated for noise as there is no air flow indoors at the level of this unit). This solution is proposed for small split, multi-split and even for VRF. Because of larger air flows, air passages may be wider than for fixed double ducts. Performances may also be higher for these in general larger size units. Seasonal performances are not always published for these products, but an example could be found[9] with SEER indicated in A++ class (SEER > 6.1) and SCOP in A+ class (SCOP > 4) (based on the Regulation (EU) 626/2011 scale) for a 2.6 kW unit.
6. Air-to-water unit with "outdoor" unit located inside the building and connected to the outdoor via ducts passing through the wall. Same solution as 6 with distribution of chilled water indoors in place of refrigerant.
7. Water-to-air split unit: one unit containing compressor and water cooled condenser is located indoors; it is generally cooled directly by the water network, which is very costly (as it implies an important additional consumption of water) and so is generally considered to be the last resort despite being more efficient.

[7] Review report, Task 2
[8] Review report, Task 2
[9] Klimaanlagen mit VERSTECKTEN (unsichtbare) Außeneinheit (inklima.at)

8. Water-to-water air conditioner plus fan coil: this solution is similar to the above one in principle, but cooling distribution indoors is done via chilled water instead of refrigerant fluid.

Residential customers have an easy access to solutions 1 to 4, as they are readily available through most white good standard sale channels. Solutions 5 to 8 are mainly accessible for now via specialized sites or installers, but still are available for the general public. Installation costs may be higher. The comparison of the performances of these units is quite difficult for now, indeed:

- Solutions 1 and 4 use EER and COP metrics.
- Solutions 2, 3, 5, 6 use SEER and SCOP metrics (Regulation (EU) 206/2012).
- Solutions 7 and 8 use primary energy seasonal performance metrics η_{SC} and η_{SH}, respectively in cooling and heating mode (Regulation (EU) 2281/2016[10])).

Competition may even be larger in case of decisions at building level: in that case indeed, the outdoor unit of a split or of a VRF system might not be possible to install for a single dwelling but might become accessible through a collective decision at building level.

In order to allow the comparison of the different solutions (including centralized versus decentralized), it would be easier for the end-user (or installer depending on situations) if all these different systems had comparable performance metrics.

Production structure

Innovaenergie and Olimpia Splendid manufacture fixed double duct units in Europe. Argoclima manufactures partly its products in Europe, the remainder being imported from China. Other brands correspond either to rebranded products from these manufacturers (as in the case of Riello or Technibel) or to products manufactured in China and imported and possibly rebranded (e.g. Aeroconfort, Aerfor, Finteksrl, Optimeo, Tekno Point or Zymbo).

Firms manufacturing their products in Italy are SMEs. For these firms, major components (e.g. compressors) may be imported, but the assembling is done in Europe. Some of the importing firms are also EU SMEs, some of these firms also sell other products without outdoor units.

Because of the low volume of sales of fixed double duct units, SMEs indicate that their procurement is under-optimal: they cannot always access to most efficient technologies at competitive prices. In addition, they do not have the power to force the development of components adapted to their products, which drives them to use available components for more common products as split.

[10] Commission Regulation (EU) 2016/2281 of 30 November 2016 implementing Directive 2009/125/EC of the European Parliament and of the Council establishing a framework for the setting of ecodesign requirements for energy-related products, with regard to ecodesign requirements for air heating products, cooling products, high temperature process chillers and fan coil units

2.3 Consumer expenditure

EU consumer prices vary greatly depending on the sales channel and country. These variations are more important than the ones due to additional functions, components, features or bigger size. Average price is estimated to 860 euros for on-off cycling cooling only products and 950 euros for reversible products (including VAT), with variations from 70 % to twice these values for the same product.

Installation cost has been estimated by manufacturers based on installer estimates of the material, tasks performed and time required. The value of 400 euros is used hereafter.

This leads to a total initial cost (product price plus installation) of 1260 up to 1350 euros.

For repair and maintenance, a 4 % yearly fixed share of the total initial cost for the end-user is used as for split systems.

3. Users

3.1 Use phase: heating mode

Manufacturers provided the results of an enquiry led in 2019 on a representative panel of Italian residential end-users or reversible fixed double duct air conditioners; it shows that 24 % of the end-users declare the fixed double duct unit to be their primary heating system.

Manufacturers also enquired about the use of the product by season, which shows that reversible fixed double duct are used in average by about 7 % of end-users (residential sector) in the winter period (October – March) and about 12 % in the spring period (this could be for cooling or heating, but most likely cooling). The reason for the difference between 24 % primary heating system and only 7 % use is not known.

3.2 End-of-life

A typical technical lifetime of 12 years is used, as for small split systems. A yearly leakage rate of 1 %[11] for factory-sealed products (as for single duct air conditioner) is assumed.

4. Technologies

4.1 Existing products

Main characteristics of reversible existing products are summarized in Table 1. Information originates from publicly available information.

Table 1. Technical product characteristics

		Minimum	Median	Mean	Maximum	Number of products

[11] Review study, Task 3, page 59.

						having this information
Cooling capacity	**kW**	1.7	2.3	2.4	3.4	28
Heating capacity	**kW**	1.7	2.4	2.3	3.5	28
EER	**-**	2.6	2.7	2.8	3.2	26
COP	**-**	2.7	3.1	3.1	3.3	27
Volume	**L**	79	99	100	136	28
Sound power indoor	**dBA**	53	55	55	60	16
Sound power outdoor	**dBA**	69 (*)	69	69	69	1
Thermostat-off power	**W**	12	14	17	45	16
Standby power	**W**	0.5	0.5	0.6	2.0 (*)	16
Indoor air flow	**m3/h**	215	380	366	490	18
Outdoor air flow	**m3/h**	380	460	460	600	16
Refrigerant charge	**Kg**	0.4	0.5	0.5	0.7	16
Weight	**Kg**	29.0	39.0	40.2	52.0	25

(*) this value is above the maximum threshold of in Ecodesign Regulation (EU) 206/2012

All products have similar components:

- R410A is the main refrigerant type (only one product offers R32 already)
- Rotary compressor; 16 products out of 28 have a DC inverter compressor, which is always advertised as an efficiency improvement.
- There is no oil heater for these compressors according to manufacturers and consequently no crankcase power to be considered.
- The expansion valve is either a calibrated orifice or an electronic expansion valve (the latter is reserved for units having an inverter compressor).
- Tube and fin indoor heat exchanger.
- Tube and fin outdoor heat exchanger.
- Some products advertise a system to evaporate the condensates on the outdoor heat exchanger; it is however thought to be standard.
- Centrifugal outdoor side fan, with 2 or 3 speeds, and AC or BLDC motor.
- Tangential indoor side fan, with 3 speeds, and AC or BLDC motor.
- Some product variants include an additional electric resistance with power between 500 W and 2 kW.
- Defrost in heating mode is ensured by cycle inversion thanks to the four-way valve (it is the valve which allows the unit to change from cooling to heating mode).

As cooling only products are identical to reversible products except for the absence of the heating function (reversibility is generally proposed as an option of the cooling only unit), their cooling performances and constructive characteristics are supposed equal to the ones of reversible products in what follows.

4.2 Standard products, improved products, BAT and BNAT levels

Summary of main performance characteristics

The main performance parameters of estimated standard product, best available product (noted BAT) and best non available technology level (BNAT) are summarized in Table 2 below.

Table 2. Performance parameters of standard, BAT and BNAT levels

Product performance	Standard	BAT	BNAT

Cooling capacity	**kW**	2.3	2.3	2.3
Heating capacity	**kW**	2.3	2.3	2.3
Thermostat-off power	**W**	24	18	3
Standby power	**W**	0.5	0.5	0.5
EER	**-**	2.71	3.1	3.45
SEERon	**-**	2.95	3.76	5.19
SEER	**-**	2.88	3.67	5.14
$\eta_{s,c}$[12]	**-**	134%	172%	242%
COP	**-**	3.1	3.24	3.64
Pdesignh	**kW**	1.7	1.7	1.7
Backup	**kW**	0.8	0	0
SCOPon	**-**	1.88	2.57	2.89
SCOP	**-**	1.87	2.56	2.89
$\eta_{s,h}$[13]	**-**	86%	119%	135%

Notations in Table 2: SEERon: cooling seasonal energy efficiency ratio in active mode, SEER: cooling seasonal energy efficiency ratio, $\eta_{s,c}$: space cooling energy efficiency (in primary energy and in %), Pdesignh: declared maximum heating load at -10 °C for SCOP calculation, Backup: declared share of Pdesignh covered by electric backup heater in kW, SCOPon: heating seasonal coefficient of performance in active mode , SCOP: heating seasonal coefficient of performance, $\eta_{s,h}$: space heating energy efficiency (in primary energy and in %)

Regarding standard product, EER and COP match the average characteristics of on-off cycling and inverter units.

Regarding BAT level, best EER and COP of models with inverter compressors have been used as a basis to estimate the performance parameters.

Regarding BNAT, one manufacturer offers a product of larger size with better nominal performances, which does not seem however to be available in Europe yet: cooling capacity 3.0 kW, EER 3.3, heating capacity 2.9 kW, COP 3.6. Such performances can only be reached with high efficiency compressors, which, according to manufacturers are not available to EU SMEs for average product sizes of 2.3 kW.

<u>Estimation of seasonal performance indicators</u>

Seasonal performances are not yet required and had to be estimated.

In cooling mode, the same model used in the review study to estimate design options[14] in terms of SEER has been adapted for fixed double duct products. For the case of on/off fixed air conditioners, a supplementary iteration has been added to compute the capacity at the different test points. The evaporation of the condensates on the outdoor coil is included in the model.

In heating mode, the average climate is used. Information on capacity evolution at low ambient temperatures is limited:

- Inverter units: the tests performed by one manufacturer are used. The unit (without backup heater) is able to supply about 75 % of its capacity in standard

[12] $\eta_{s,c}$ = SEER / 2.1 – 0.03 (see Review study, Task 7)
[13] $\eta_{s,h}$ = SCOP / 2.1 – 0.03 (see Review study, Task 7)
[14] Review study, Task 6, § 6.2.1 page 16

rating conditions when operating in the design conditions of the average climate (-10 °C ambient temperature). 75 % of the rated heating capacity is used for all products as the standard Pdesignh value in standard conditions. SCOPon / COP ratio is close to 80 %.

- On-off cycling units: the tests performed by one manufacturer are used. The unit (without backup heater) is able to supply 38 % of its capacity in standard rating conditions when operating in the design conditions of the average climate (-10 °C ambient temperature). Capacity variation is close to other data published by one manufacturer[15]. A backup electric heater is included to deliver 75 % of the rated heating capacity as for the inverter model. SCOPon / COP ratio is close to 0.6.

Improvement options from standard model to BNAT

Refrigerant fluid

R32 should progressively replace R410A in the coming years. It gives an efficiency advantage (nominal conditions) of up to 4 %[16] if using the same unit with optimized charge and control[17]. A higher gain is possible if heat exchanger design is adapted.

Heat exchangers

Heat exchange area increase is not an option pursued by manufacturers. Designs aim at having the most compact unit as possible. With the change of fluid from R410A to R32, a small gain in heat exchanger area is anticipated by manufacturers resulting in an estimated EER and COP increase of 2 %. In addition, manufacturers foresee possible paths to minimize the pressure losses of the outdoor heat exchanger with potential EER and COP gains of up to 2 %.

As for single duct products, micro-channel heat exchangers refrigerant distribution fluid issues are a problem for frost and condensate evaporation, and thus are not included in BNAT evolution.

Compressor

In these small compressor sizes, for EU SMEs, DC rotary inverter compressor with nominal EER up to 3.1 – 3.2 (AHRI test conditions) only are available. These SMEs estimate that more efficient DC inverter compressors with compact designs could become available in the next 5 years, with possible EER efficiency increase up to 6 %.

DC inverter compressor gives better performances in part load. However, for now, frequency is only reduced to 35 or 40 Hz for noise and vibration reasons which limits the minimum capacity that can be reached. This also limits the increase of SEER due to inverter option. The development of small size efficient DC inverter twin rotary compressors, if indeed the technology allows to reduce vibrations and noise at low speed[18], could allow an important increase in terms of SEER.

Fans

---

[15] Information on capacity at low ambient, page 8 of Icool product technical documentation (www.zymbo.eu)
[16] Manufacturers indicate a 1.5 to 2.5 % gain based on tests in nominal conditions.
[17] Review study, Task 6, p10.
[18] Okoma, K.; Tahata, M.; and Tsuchiyama, H., "Study of Twin Rotary Compressor for Air-Conditioner with Inverter System" (1990). International Compressor Engineering Conference. Paper 745.

Improved products use latest DC fan motors and double inlet centrifugal fan with forward curved blades (which also allows noise reduction) on the outdoor side.

Thermostat-off

Thermostat-off is calculated as the sum of the estimated indoor fan power and controls. Estimated values are higher that values that can be found in product documentation. In the BNAT evolution, it is considered the thermostat-off power can be reduced to 3 W by using an additional temperature sensor in the room.

Summary of options per model

The design improvement options and characteristics of standard, BAT and BNAT products are given in Table 3.

Table 3. Performance parameters of standard, BAT and BNAT levels

Product options	Standard	BAT	BNAT
Fluid	R410A	R410A	R32
Compressor EER			6 % gain
Compressor control	On-off	Inverter	Inverter
Compressor minimum frequency	50	35	15
Fans and motors/drives	Standard	Improved	Improved
Outdoor heat exchanger design			- Reduced pressure losses - Small tube diameter and area increase (R32)
Indoor heat exchanger design			Small tube diameter and area increase (R32)
Thermostat-off			External thermostat

4.4 Bill-of-Materials (BOM)

The same bill-of-materials used for single ducts in the Review study is adapted for fixed double duct products by adjusting the product mass.

5. Environment and economic

5.1 Product specific inputs

Base case definition for Task 5

Depending on product configuration, reversible or not, on off or inverter controlled, energy consumption, environmental impact and costs will vary. The base case for Task 5 is defined as a fictitious product, which allows to obtain total energy consumption, economic and environmental impacts when multiplied by product sales and stock.

Test standard

EN14511 test standard is presently used, but it only gives access to energy efficiency and capacity for one test condition in cooling mode and another one in heating mode, which does not enable to assess the energy consumption of these products.

Performance and consumption evaluation are thus based upon the **EN14825** standard, using the hours in the different modes (equivalent full load hours, thermostat off and standby hours) of Regulation (EU) 206/2012.

Economic data

The sales and stock information from Task 2 is reported below in Table 4.

With average unit size of 2.3 kW, total capacity installed in 2015 is estimated to 510 MW.

Table 4: EU 27 sales and estimated stock of fixed double duct air conditioners

	2010	2015	2020	2025	2030	2035	2040	2045	2050
EU28 annual sales, (000) units									
FDD	17	17	38	44	50	57	66	74	85
EU28 estimated stock, (000) units									
FDD	235	222	260	383	527	619	709	808	917

Product prices for the fixed double duct products have been derived in Task 2. With 70 % of reversible products and 30 % of cooling only products, this leads to a rounded product price of 950 euros. With 35 % of inverter-based products, and a price premium for inverter units estimated to 20 %, the product price increases due to inverter penetration and is estimated to 985 euros in 2019.

As seen in Task 2, repair and maintenance costs is derived as 4%/year of the initial investments and in a lifetime of 12 years.

The PRIMES reference scenario is used for the development in the electricity prices, the prices is stated in 2019 price level. The residential electricity rate is 0.214 euro/kWh for households and 0.180 euro/kWh for service sector in 2020. With the distribution of 70 % of the sales in the residential sector and 30 % in the service sector, this leads to an average electricity price of: 0.205 euro/kWh in 2020. The electricity price increases 0.5 % per year from 2020 to 2035 and decreases by 0.25% per year from 2035 to 2050.

The following values regarding SEER and SCOP values are used:

- In cooling mode, average EER is of 2.7. The SEER/EER ratio is estimated to be of 1.07 for on-off units and of 1.18 for inverter units. With inverter sales representing 35 % of the total sales, average fixed double duct SEER is estimated to: 3.0.
- In heating mode, average COP is of 3.1. SCOP/COP ratios are 0.61 and 0.79 respectively for on-off and inverter units. With inverter sales representing 35 % of the total sales, average fixed double duct SCOP is estimated to: 2.08.

In the EcoReport Tool, there is an input for the ratio between average efficiency of the stock and average efficiency of the new sales, this is to account for the difference of average efficiency of the stock and the higher efficiency of the new sales, so the energy consumption calculated would not be underestimated.

- As regards EER in standard rated performance, manufacturer indicate a 0.9 % yearly growth of EER. Over a half time of 6 years, this results in a stock to sales ratio of 0.95.
- The same EER evolution is supposed to apply to the COP and to the same stock to sales ratio of 0.95.

As regards actualization of future expenditures, the Present Worth Factor accounts for a 0.5 % escalation rate for electricity consumption, repair and maintenance, and an actualization rate of 4 %. This leads to a PWF value of 9.67 (for the product lifetime of 12 year).

Table 5: Input economic data for EcoReport tool

Description	Unit	FDD
Product Life	Years	12
Annual sales	mln. Units/year	0.017
EU Stock	mln. Units	0.222
Product price	Euro/unit	985
Installation/acquisition costs (if any)	Euro/ unit	400
Electricity rate	Euro/kWh	0.205
Yearly repair & maintenance costs (before escalation and actualization)	Euro/unit/year	55
Discount rate (interest minus inflation)	%	4%
Escalation rate (project annual growth of running costs)	%	0.5%
Present Worth Factor (PWF)	(years)	9.67
Ratio efficiency STOCK: efficiency NEW, in Use Phase	-	0.95

Annual resources consumption (energy)

In the Review study, it was assumed that at EU level, the rate of reversibility use was of 30 % for the stock of reversible air conditioners and of 50 % for the sales after 2015.

The following explanations are given for this hypothesis: *"In Commission decision 2013/114/EU*[19]*, it is supposed that 10 % of the reversible air to air conditioners are used for heating in warm climates, 40 % in average climates and 100 % in Northern climates. This amounts to about 25 % (weighting by 2015 stock numbers and 28 % weighting by capacity) reversible units used for heating. This is close to the value declared for Italy for 2015 in the Energy Efficiency Directive*[20]*. Furthermore, in the Impact assessment for Regulations (EU) 626/2011 and 206/2012*[21]*, a value of 33 % was assumed. However, stakeholders of the current review study suggest that the present rates of reversible units used for heating are higher, with residential rates between 20 % (only heating*[22]*) and 60 % (used in addition, partial replacement or replacement of an existing central systems)*

[19] COMMISSION DECISION of 1 March 2013 establishing the guidelines for Member States on calculating renewable energy from heat pumps from different heat pump technologies pursuant to Article 5 of Directive 2009/28/EC of the European Parliament and of the Council.
[20] http://ec.europa.eu/eurostat/web/energy/data/shares
[21] Impact Assessment of Commission Regulation (EU) No 206/2012 of 6 March 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for air conditioners and comfort fans (OJ L 72, 10.3.2012, p. 7)
[22] Note: unique or principal heating system means

and commercial rates around 85 %. Using 20 % for residential and 85 % for services, this leads to about 50 % reversibility use with 2015 sales. Hence, it is assumed that only 30 % of the fixed air conditioners currently are used for heating purposes, but this number is expected to increase to 50 % from now and over the next 12 years."

As regards fixed double duct, the enquiry led in Italy and reported in Task 3 for fixed double duct air conditioners shows that 24 % of reversible fixed double are the primary heating means in the residential sector in Italy. Based on this information, and on the fact that 70 % of the product only supply heating, a minimal share of all fixed double duct used as main heating means can thus be estimated to be 24 % x 70 % (share of reversible products) = 17 %.

However, there is no information on the use of reversibility at EU level, while the number of Italian exports is growing and that all direct imports to other EU countries from abroad may not be included in the sales data. And for central and northern climates, a reversible product appears more likely to be used for heating. In addition, there is no information at EU level on the use of reversibility for products installed as a secondary heating means; and the use of reversibility in the tertiary sector (30 % of the sales of fixed double duct) appears to be higher than in the residential sector.

For all these reasons, it seems that the most reasonable hypothesis to establish an average at EU level is to keep the value used for other reversible air conditioners. 50 % of new reversible products are thus supposed to be used for heating.

Nevertheless, as the value is uncertain, a lower value of 25 % is kept for sensitivity analysis of LCC results in Task 6.

Table 6: Information to calculate the energy consumption

Type	Reversible fixed double duct [0-6kW]
Pdesignc kW	2.3 kW
SEER	3.0
Hours (cooling full load)	350
Pdesignh kW	1.7 kW
SCOP	2.08
Hours (heating)	1400
Share of reversible products	70 %

With information supplied in Table 6, the base case energy consumption can then be derived as follows:

$$Energy\ consumption_{annual} = \frac{2.3\ kW \times 350h}{3.0} + 0.7 \times \frac{1.7\ kW \times 1400h\ \times 50\ \%}{2.08} = 669\ kWh$$

Resources and End-of-Life

The average weight of a 2.3 kW unit is of 40 kg (information from Task 4). It is a ratio of 17.4 kg / kW, higher than the ones of split and portable air conditioners. The same material composition used for other products in the Review study is applied[23]. This gives the material composition in Table 7.

Table 7: The calculated material composition of fixed double duct

Description	Share	Fixed double duct (kg)	Material group	Material
Plastics	16%	6.2	1-BlkPlastics	4 -PP
Plastics	2%	0.6	2-TecPlastics	12 -PA 6
Ferrous metals	48%	18	3-Ferro	24 -Cast iron
Non-ferrous metals	17%	6.8	4-Non-ferro	31 -Cu tube/sheet
Non-ferrous metals	7%	2.8	4-Non-ferro	27 -Al sheet/extrusion
Coatings	0%	0	5-Coating	
Electronics	1%	1.2	6-Electronics	98 -controller board
Various other materials	11%	4.4	7-Misc.	
Total	100%	**40**		

The weight of the refrigerant in the base case is included in the category "various other materials", however EcoReport Tool cannot properly calculate the impacts of refrigerants (or the impacts of leakage), therefore the impact of refrigerant and leakage are calculated separately and incorporated back into the EcoReport result as in the Review study.

Table 8: Calculated leakage of refrigerants per year

	Reversible fixed double duct [0-6kW]
Refrigerant charge	0.5 kg
Annual leakage rate	1 %
GWP	R410A (GWP 2088)
Average Leakage kg/year	0.005 kg/year

Hypothesis regarding primary scrap production and recycling rates are the same as in the review study. For the distribution phase, a volume of 0.25 m^3 is used.

The consumption of critical raw materials is mainly focusing on copper in the heat exchanger and gold in the printed circuit boards (PCBs). It is supposed fixed double duct are equipped with only one PCB, which weight is of 200 g. The PCB composition of the review study is used, as well as the environmental and cost impacts of copper and gold, the most critical raw materials.

5.2 Base case environmental Impact Assessment

The impacts of the fixed double duct base case are presented and discussed in this section. The conclusions obtained are similar to the conclusions for other base cases:

[23] A single PCB of 200 g is considered, and additional weight in the original composition is added to ferrous metals.

- The highest energy consumptions and CO_2-eq emissions are related to the use phase (Figure 4 and Figure 5)
- 94 % of the energy consumption and 93 % of the CO_2-eq emissions appear in the use phase (Table 9).
- In general, the use phase is responsible for the highest impacts for most categories calculated in the EcoReport tool (Table 10).
- The leakage of refrigerant, which is not assumed to have any impacts on the energy consumption but only on the emission of CO_2-eq, is responsible for about 4 % of the CO_2-eq emissions in the use phase.

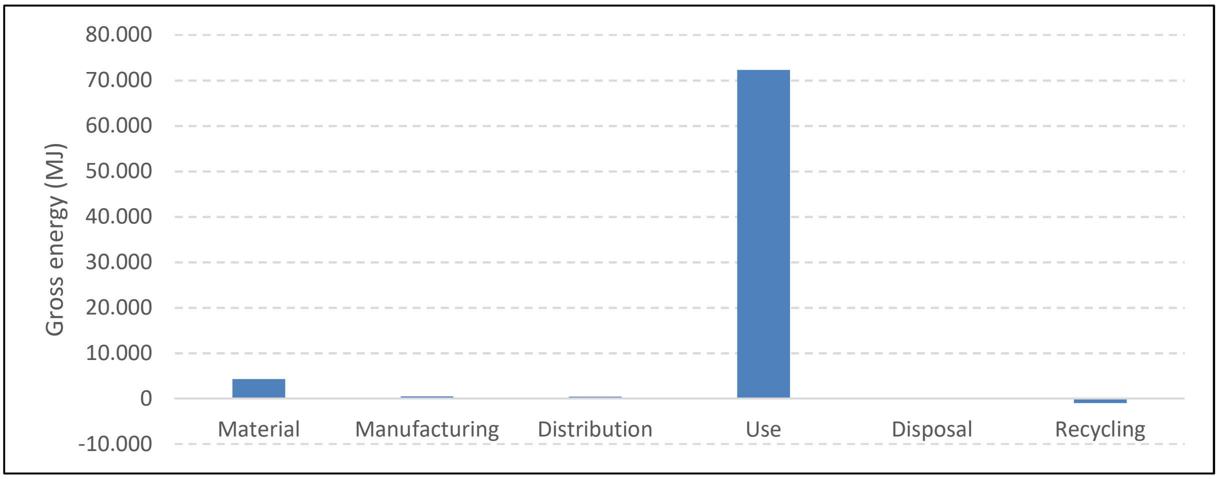


Figure 4: Gross energy consumption fixed double duct

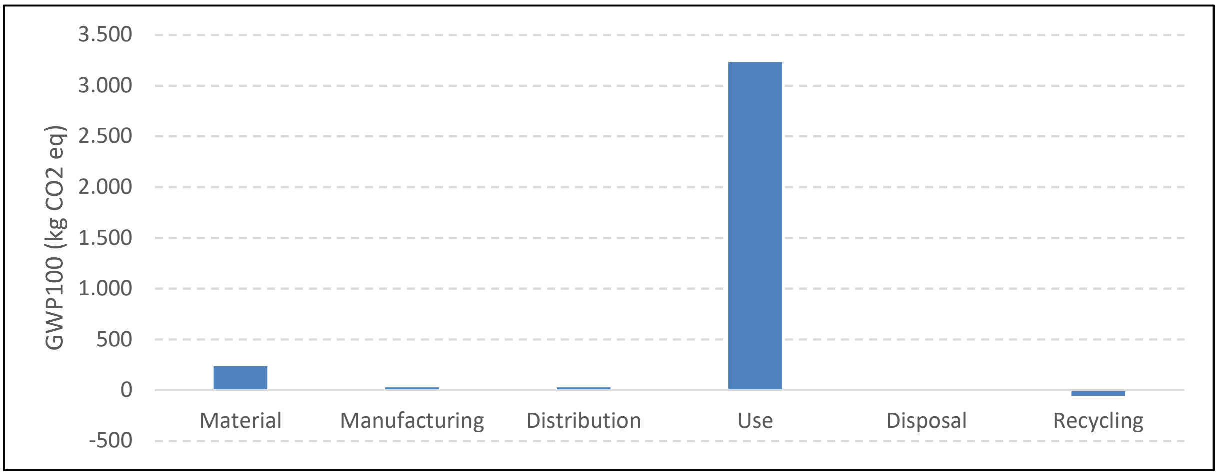


Figure 5: Global warming potential fixed double duct

Table 9: Impacts fixed double duct

	Material	Manufacturing	Distribution	Use	Disposal	Recycling	Total
Total Energy share	6%	1%	1%	94%	0%	-1%	100%
GWP100 share	7%	1%	1%	93%	0%	-2%	100%

Table 10: All impact categories for fixed double duct. The life cycle phase with the highest impact for each of the categories is highlighted with red text.

	Material	Manufacturing	Distribution	Use	Disposal	Recycling	Total
Other Resources & Waste							
Total Energy (MJ)	4 272	491	**410**	**72 295**	103	-984	**76 588**

of which, electricity (MJ)	2 233	290	1	72 274	0	-455	74 344
Water – process (litre)	569	4	0	6	0	-116	462
Water – cooling (litre)	486	131	0	3 216	0	-67	3 767
Waste, non-haz./landfill (g)	9 560	1 882	256	37 329	203	-3 145	46 085
Waste, hazardous/ incinerated (g)	156	0	5	1 142	0	-27	1 275
Emissions (Air)							
GWP100 (kg CO_2-eq)	234	28	28	3 229	0	-58	3 461
Acidification (g SO_2-eq.)	1 923	119	83	13 667	6	-511	15 288
VOC (g)	8	0	5	1 614	0	-2	1 625
Persistent Organic Pollutants (ng i-Teq)	205	26	1	171	0	-76	327
Heavy Metals (mg Ni eq.)	784	60	13	738	5	-210	1 390
PAHs (mg Ni eq.)	371	0	14	172	0	-131	427
Particulate Matter (g)	1 303	18	855	302	43	-324	2 198
Emissions (Water)							
Heavy Metals (mg Hg/20)	528	2	0	316	1	-176	671
Eutrophication (g PO_4)	5	0	0	14	1	-1	19

The consumption of critical raw materials is also determined. The amount of gold and copper calculated and the derived impacts regarding energy, emission of CO_2-eq and market value in euros.

- For fixed double duct:
  - 0.06 grams of gold, 15 MJ, 1.4 kg CO_2-eq. and 2 euros
  - 6832 grams of copper, 348 MJ, 18 kg CO_2-eq. and 40 euros

5.3 Base case Life Cycle Costs for consumer

Based on the input in Task 2, and the energy consumption for the base case computed in part 5.1, the life cycle cost calculation for the base case situation is show in Table 11.

Table 11: Life cycle cost of the fixed double duct product

	FDD 2.3 kW
Product price (€)	985
Installation/ acquisition costs (€)	400
Electricity (€) (*)	1327
Repair & maintenance costs (€) (*)	536
Total (€)	3248

(*) The discount rate is assumed to be 4 % and the escalation rate (annual growth rate) of running costs is assumed to be 0.5%, with a resulting PWF of 9.67 (lifetime of 12 years). Both electricity costs and repair and maintenance costs are discounted in proportion to the ratio PWF to lifetime.

5.4 EU totals

The contribution of fixed double duct to total EU impacts is in proportion of their low sales numbers (estimated to represent 0.8 % of all air conditioners in scope in Task 2 in 2018) and corresponding low stock numbers as compared to other types of air conditioners.

Estimated $CO_{2\text{-eq}}$ emissions during the lifetime of fixed double duct products sold in 2015 amounts to 0.06 Mt $CO_{2\text{-eq}}$ or 0.3 % of the emissions of the sales of all air conditioners in

2015. Estimated CO_{2-eq} emissions of the stock of fixed double duct products in 2015 amounts to **0.07 Mt CO_{2-eq}** or **0.2 % of the emissions of the stock of all air conditioners in 2015**.

Energy consumption during the lifetime of fixed double duct products sold in 2015 amounts to 1.3 PJ or 0.3 % of the energy consumption of the sales of all air conditioners in 2015. Estimated energy consumption of the stock of fixed double duct products in 2015 amounts to **1.45 PJ** or **0.2 % of the energy consumption of the stock of all air conditioners in 2015**.

6. Design options

6.1 Design options for fixed double duct

The improvement potential starts from the standard on-off model identified in Task 4, while in Task 5, a fictitious average model was built to represent the average energy consumption, costs and other environmental impacts.

Starting from the standard on-off product, the possible design options are reviewed by component type below.

Refrigerant fluid: the base case uses R410A as refrigerant fluid; according to fixed double duct manufacturers, the use of R32 could allow up to 2 % EER and COP gain in a near drop-in situation (only adjusting charge and control) and 4 % with additional heat exchanger adaptation. However, the adaptation cost is not known and EER or COP gain might not translate simply into direct SEER and SCOP gains. Consequently, R32 is not considered as an option[24]. Nevertheless, R32 will be deployed in the coming years and will help decreasing the emissions due to direct refrigerant emissions along the product life cycle.

Compressor: the base case is supposed equipped with a fixed speed compressor of EER 3.1. The first option here is to use a DC rotary compressor with a similar efficiency level and with minimum frequency of 35 Hz (because of vibration and noise at lower frequency). The second compressor option is a twin rotary compressor with an EER of 3.4 that could allow operation down to 15 Hz with acceptable vibration and noise level. This second option is not readily available, but it is estimated it could become available in the short term (5 years).

Heat exchanger: no significant improvement is deemed feasible here because of the size constraint. Even if reducing the tube diameter and changing fluid could allow to increase the total heat exchange coefficient of the heat exchangers, manufacturers would certainly seize the opportunity to decrease the size of the unit.

Fans: the base case is equipped with DC fans. An improvement option is to use more efficient DC motors, and better condenser fan (centrifugal with forward-curve blades).

Low power modes: the consumption in thermostat-off mode is relatively high. As for other air conditioners, an outside thermostat could be located in the room to reduce the

[24] The same approach was adopted for split air conditioners in the Task 6 of the Review study.

thermostat-off mode power consumption to 3 W, or alternatively a movement sensor could be used.

Table 12 below summarizes the options considered for improving the energy efficiency of fixed double duct products

Table 12: Design options of fixed double duct air conditioners

Component	Design option
Compressor	CP1: inverter compressor with EER 3.15 and minimum operating frequency of 35 Hz
	CP2: inverter compressor with EER 3.4 and minimum operating frequency of 15 Hz
Fans	FAN: improved motor (DC versus AC) and fan efficiency
Controls	THOFF: addition of an external thermostat to reduce thermostat-off power

6.2 Impacts of options

Energy efficiency

Electricity consumption calculation base upon EN14825. Modelling hypothesis are described in part 4.2. Electricity consumption calculations for the different options are given in Table 13.

Table 13: Design options of fixed double duct air conditioners

	Unit	BC	CP1	CP2	FAN	THOFF
P_C	**kW**	2.3	2.3	2.3	2.3	2.3
P_H	**kW**	2.3	2.3	2.3	2.3	2.3
P_{TH-OFF}	**W**	24	24	24	18	3
P_{SB}	**W**	0.5	0.5	0.5	0.5	0.5
EER	**-**	2.71	2.67	2.88	2.88	2.71
SEERon	**-**	2.95	3.44	4.2	3.16	2.95
SEER	**-**	2.88	3.35	4.06	3.10	2.93
η_{SC}	**-**	134%	156%	191%	145%	137%
COP	**-**	3.1	3.15	3.35	3.18	3.1
Pdesignh	**kW**	1.7	1.7	1.7	1.7	1.7
Backup	**kW**	0.8	0	0	0.8	0.8
SCOPon	**-**	1.88	2.50	2.66	1.93	1.88
SCOP	**-**	1.87	2.49	2.65	1.92	1.88
η_{SH}	**-**	86%	116%	123%	89%	86%
		Electricity consumption				
Cooling	**kWh/y**	279	240	198	260	275
Reversible (50 % reversible use)	**kWh/y**	635	478	450	619	634
Total for reversible products	**kWh/y**	915	718	648	879	908

Note 1: the base case single speed compressor EER (AHRI conditions) is of 3.1. As compared to the base case, the CP1 option has a compressor EER of 3.15 at 60 Hz. The specific operating conditions lead to a slight change in EER (slight decrease) and COP metrics (slight increase) due to taking into account the change in performance curves for the compressor and the drive efficiency based on manufacturer information.

Note 2: the SCOP calculation is based on the same Pdesignh value for all models in order to get comparable heating load values for all products. For on-off units, the SCOP value obtained in case of a bivalent point fixed at -7 °C is 0.03 point lower than values presented in Table 13.

Environmental impacts

As in the Task 6 of the Review study, the environmental assessment focuses on energy consumption and emission of CO2-eq, which are the most significant environmental impacts imposed by air conditioners. The improvement options are predominantly differentiated in their energy consumption.

Besides the energy consumption, also the material composition is slightly changed. The following modifications are considered to compute the environmental impacts of the options:

- Option CP1: 10% more electronics
- Option CP2: 10 % more copper and 10% more electronics
- Option FAN: 10 % more electronics (1 additional PCB)
- Option THOFF: 10 % more electronics (1 additional PCB and a movement sensor)

The refrigerant charge is unchanged as there is no design option regarding heat exchangers.

Case of reversible products

The impacts of the different improvement options for the reversible case (50 % heating use) are presented in Figure 6 and Figure 7.

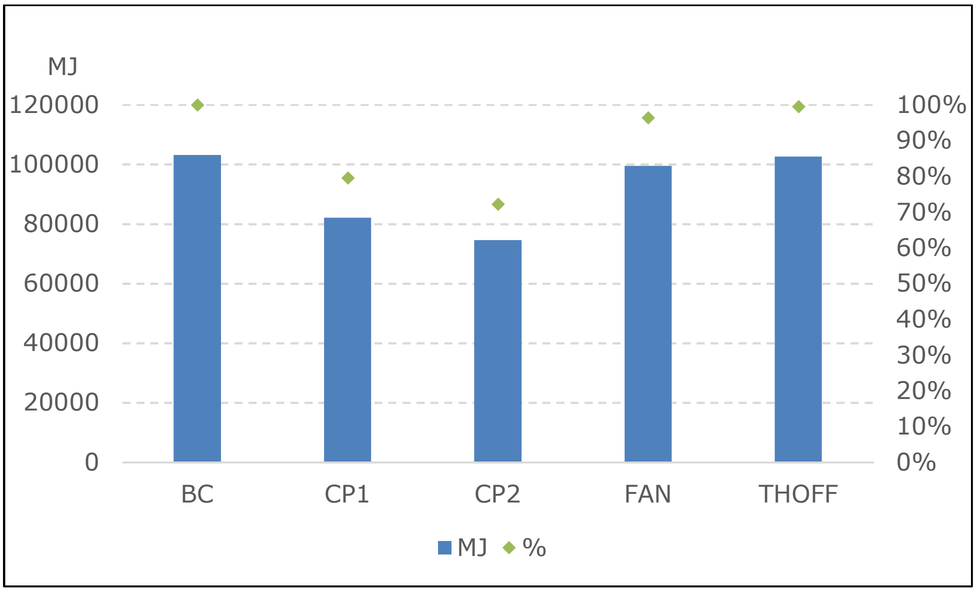


Figure 6: Primary energy consumption of the reversible base case and design options

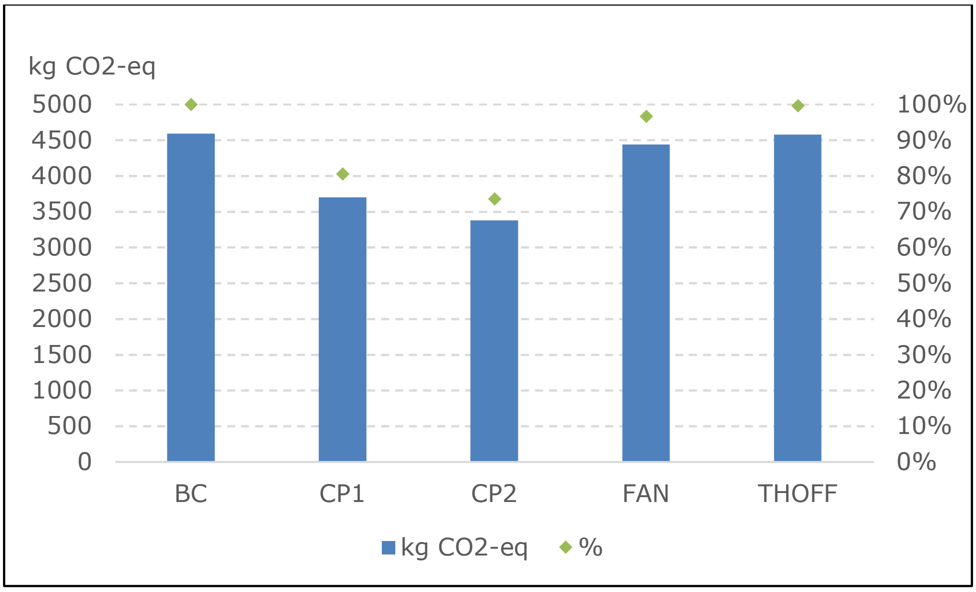


Figure 7: Emission of CO_2 (kg CO_2-eq) of the reversible base case and design options

The best improvement option is CP2 regarding all environmental indicators. The reduction in the different categories is:

- Primary energy consumption: reduction of 28550 MJ (28 %)
- Emission of CO_2-eq: reduction of 1216 kg (26 %)

The changed material composition only has limited influence on all impacts.

Case of cooling only products

The impacts of the different improvement options for the cooling only case are presented in Figure 8 and Figure 9.

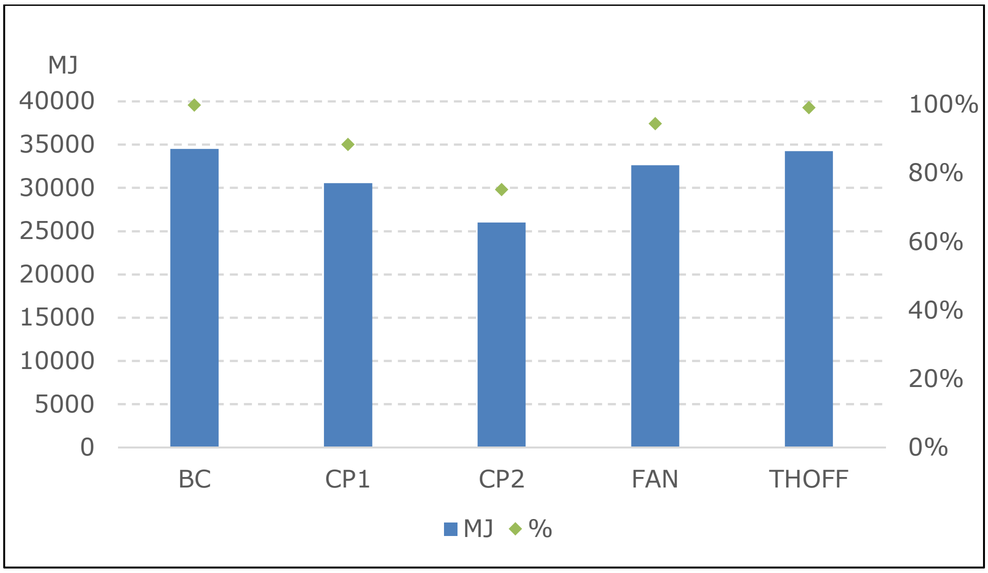


Figure 8: Primary energy consumption of the cooling only base case and design options

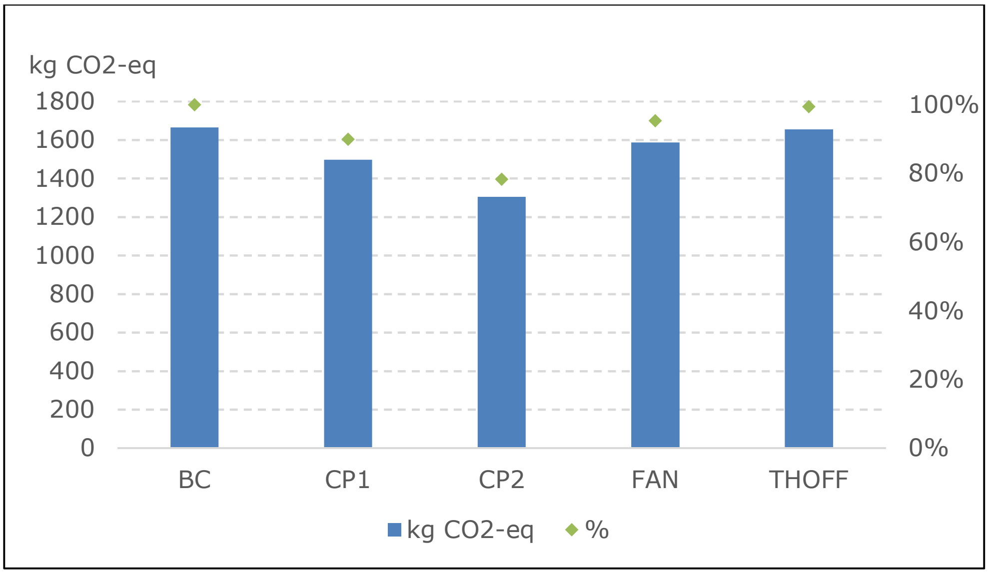


Figure 9: Emission of CO_2 (kg CO_2-eq) of the cooling only base case and design options

The best improvement option is CP2 regarding all environmental indicators. The reduction in the different categories is:

- Total energy consumption: reduction of 8512 MJ (25 %)
- Emission of CO_2-eq: reduction of 360 kg (22 %)

The changed material composition only has limited influence on all impacts.

6.3 Costs

The cost model of the fixed double duct base case builds upon the single duct base case of the Review study. The price is adjusted and the mark-up is conserved. It means that the relative price increase for the same option is similar for both products. As the price of fixed double duct products is much higher, the same option is thus more expensive in euros for double duct products. The cost breakdown by component is indicated in Table 14.

Table 14: percentage of cost per component for the fixed double duct

	Fixed double duct base case, 2.3 kW
Compressor	23%
Condenser	15%
Evaporator	8%
Outdoor fan	9%
Indoor fan	6%
Working fluid	4%
Refrigerant line	1%
Controller + Elec	8%
Casing	1%
Others	8%
Total Original Parts	12%

The price increase per option and more details on the corresponding component relative cost increase are given below for the reversible fixed double duct base case; the price reference year is 2019. The same price increase in % are supposed to apply to the cooling only fixed double duct air conditioners, for which the price of the base case model is lower (860 versus 950 euros).

Table 15: Cost of individual options for fixed double duct air conditioner (reversible and cooling only)

	Purchasing Price €		Manufacturer overcost estimate	Price increase %
	Reversible	Cooling only		
Base	950 €	860 €	-	-
CP1	1128 €	1021 €	Compressor price increase by 83 %	19%
CP2	1306 €	1183 €	Compressor price increase by 166 %	38%
FAN	1093 €	989 €	Indoor and outdoor fan increase 100 %	15%
THOFF	979 €	886 €	Controller + elec increase by 40 %	3%

The most expensive option is CP2, while the cheapest improvement option is to achieve the reduction of the thermostat-off power consumption.

6.4 LLCC and BNAT

Ranking of the design options

For the calculation of the LCC, the following parameters, as reported in Task 2 and in Task 5 are used:

- Lifetime: 12 years
- PWF (present worth factor) of 9.67, calculated based on the product life time, a discount rate of 4 % and an escalation rate of energy, maintenance and repair prices of 0.5 %.
- Electricity price: 0.205 €/kWh.
- Heating hours: 700 hours for reversible products and 0 hours for cooling only products.
- Maintenance: 4% of the initial investment (purchase price plus installation; slightly increases with unit price; actualized).

Reversible

Results of LCC calculation for individual options are given in Table 16 and the energy consumption and life cycle cost calculations are graphically shown Figure 10.

Except for CP1, the individual options have simple payback time higher than the lifetime of the product and thus aren't of interest for the customer on a LCC basis. It should also be reminded that CP2 option is not readily available.

Table 16: Life cycle cost calculation for individual option, reversible product

	Unit	BC	CP1	CP2	FAN	THOFF
SEER	**-**	2.9	3.3	4.1	3.1	2.9
SCOP	**-**	1.9	2.5	2.6	1.9	1.9
Heat. Cons	**kWh/a**	1271	955	900	1238	1267
Cool. Cons	**kWh/a**	279	240	198	260	275
Total cons	**kWh/a**	915	718	648	879	908
Purchase Price	**Euros**	950	1128	1306	1093	979
Installation	**Euros**	400	400	400	400	400
Maintenance	**Euros**	522	591	660	577	533
Electricity	**Euros**	1813	1423	1284	1742	1801

LCC	**Euros**	3685	3543	3651	3812	3712
SPB	**years**		10	12	26	28

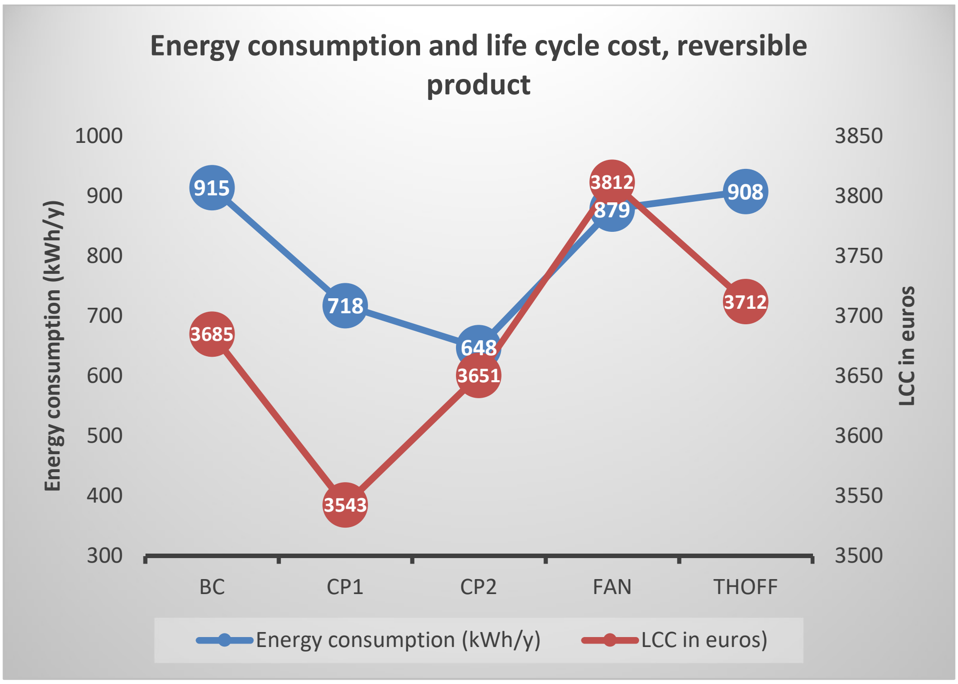


Figure 10: Life cycle cost and energy consumption of reversible base case and design options

Cooling only

Results of LCC calculation for individual options are given in Table 17 and the energy consumption and life cycle cost calculations are graphically shown Figure 11.

All individual options have simple payback time higher than the lifetime of the product and thus aren't of interest for the customer on a LCC basis. It should also be reminded that CP2 option is not readily available.

Table 17: Life cycle cost calculation for individual option, cooling only product

	Unit	BC	CP2	CP1	FAN	THOFF
SEER	**-**	2.9	4.1	3.3	2.9	3.1
Cool. Cons	**kWh/a**	279	198	240	275	260
Purchase Price	**Euros**	860	1183	1021	886	989
Installation	**Euros**	400	400	400	400	400
Maintenance	**Euros**	487	612	550	497	537
Electricity	**Euros**	554	393	477	544	515
LCC	**Euros**	2301	2587	2448	2328	2441
SPB	**years**		24	25	34	40

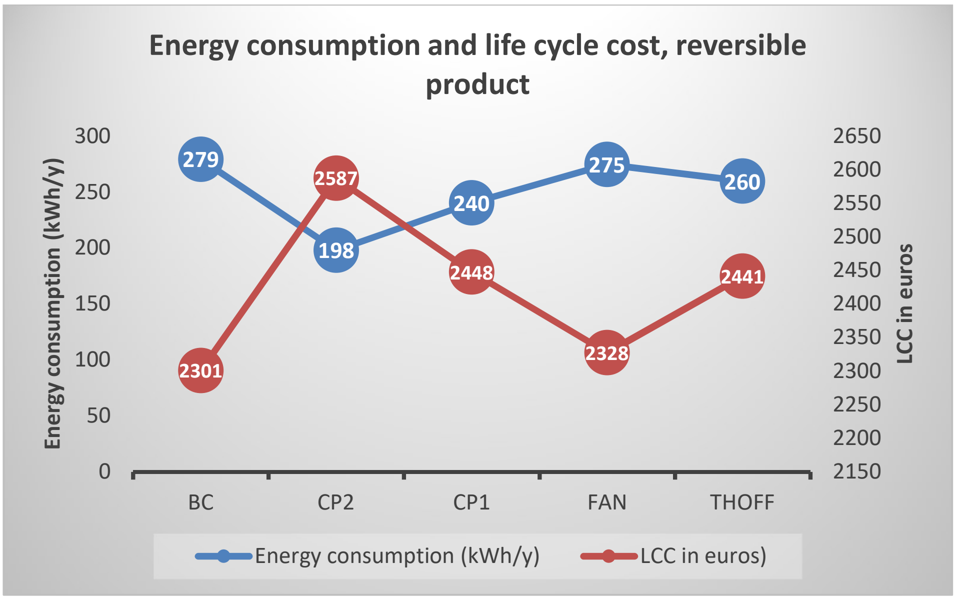


Figure 11: Life cycle cost and energy consumption of cooling only base case and design options

Cumulative improvement

Improvement potential has been computed by adding the option by increasing simple payback time order. As CP2 option is not readily available, it is added as the last option and so only considered in the BNAT configuration.

As regards the heating mode, the real use of reversibility has been found to be uncertain in Task 5. In addition to the default 50 % use kept as average EU value, a 25 % situation is also computed in order to establish the sensitivity of the LLCC level to this parameter.

The summary of energy gains, price increase, LCC variations as well as efficiency information and energy consumption are gathered in Table 18 for the reversible case (50 % reversibility use), in

Table 19 for the reversible case (25 % reversibility use) and in Table 20 for cooling only case. Graphs (Figure 12 for reversible products and 50 % reversible use, Figure 13 for reversible products and 25 % reversible use, Figure 14 for cooling only products) are also drawn to show LCC variation with energy consumption and to identify LLCC, BAT and BNAT values.

LLCC evaluation for reversible fixed double duct air conditioners

With 50 % reversible use, LLCC appears to be option CP1 with a LCC value 4 % lower than the base case. The break-even point (same LCC value as the base case) lies between options CP1+FAN and CP1+FAN+THOFF. The increase in LCC at BNAT level is limited to 1.5 %. The LCC curve appears relatively flat.

With 25 % reversible use, LLCC appears to be the base case. All other options increase the base case LCC value. CP1 option increases the base case of only 0.5 % (17 Euros). In that situation, the cost of options CP1+FAN and CP1+FAN+THOFF is significantly higher than the BC (respectively 5 % and 6). The increase in LCC at BNAT level reaches +9 %.

Given the uncertainty in reversible use in heating mode, it can be said that the LLCC for reversible fixed double duct products probably lies between the base case and CP1 efficiency levels. Nevertheless, as the LCC curve is relatively flat with 25 % reversibility use and considering that the cost of inverter option will probably decrease as it develops, the LLCC chosen is then the CP1 level:

- SEER 3.3
- SCOP 2.5
- LCC = 3545 €

The BNAT level corresponds to the following characteristics:

- SEER 5.1
- SCOP 2.9
- LCC = 3734 €

BAT is also indicated as the characteristics matching best available products on the market with following values:

- SEER 3.7
- SCOP 2.6
- LCC = 3673 €

Table 18: Life cycle cost calculation, combined options, reversible product (50 % reversibility use)

	Unit	BC	CP1	CP1+FAN	CP1+FAN+ THOFF	CP2+FAN+ THOFF
SEER	**-**	2.88	3.33	3.67	3.73	5.13
η_{SC}	-	134%	156%	172%	175%	241%
EER	**-**	2.71	2.67	3.1	3.1	3.45
SCOP	**-**	1.87	2.49	2.56	2.57	2.89
η_{SH}	-	86%	116%	119%	119%	135%
COP	-	3.10	3.15	3.24	3.24	3.64
Heat. Cons	**kWh/a**	1271	955	928	926	824
Cool. Cons	**kWh/a**	279	242	219	216	157
Total cons	**kWh/a**	915	719	683	679	569
Purchase Price	**Euros**	950	1128	1271	1299	1478
Installation	**Euros**	400	400	400	400	400
Maintenance	**Euro**	522	591	647	658	727
Electricity	**Euros**	1813	1426	1354	1345	1128
LCC	**Euros**	3685	3545	3673	3703	3734
SPB	**years**		6	8	9	9

Table 19: Life cycle cost calculation, combined options, reversible product (25 % reversibility use)

	Unit	BC	CP1	CP1+FAN	CP1+FAN+ THOFF	CP2+FAN+ THOFF
SEER	**-**	2.88	3.33	3.67	3.73	5.13
η_{SC}	-	134%	156%	172%	175%	241%
EER	**-**	2.71	2.67	3.1	3.1	3.45
SCOP	**-**	1.87	2.49	2.56	2.57	2.89
η_{SH}	-	86%	116%	119%	119%	135%
COP	-	3.10	3.15	3.24	3.24	3.64
Heat. Cons	**kWh/a**	1271	955	928	926	824
Cool. Cons	**kWh/a**	279	242	219	216	157
Total cons	**kWh/a**	597	481	451	447	363
Purchase Price	**Euros**	950	1128	1271	1299	1478
Installation	**Euros**	400	400	400	400	400
Maintenance	**Euro**	522	591	647	658	727
Electricity	**Euros**	1183	953	894	887	719
LCC	**Euros**	3055	3072	3213	3245	3326

SPB	years		9	13	14	14

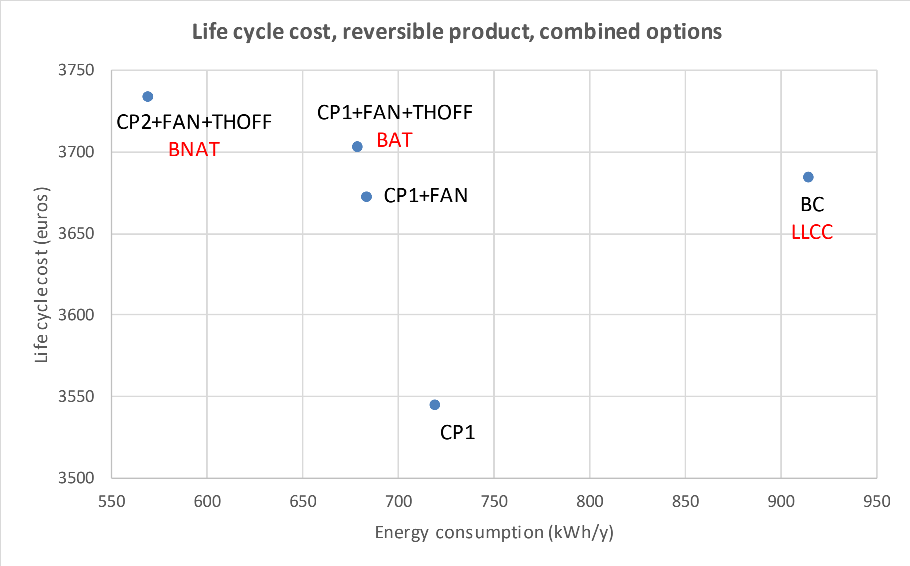


Figure 12: Life cycle cost and electricity consumption of reversible product (50 % reversibility use)

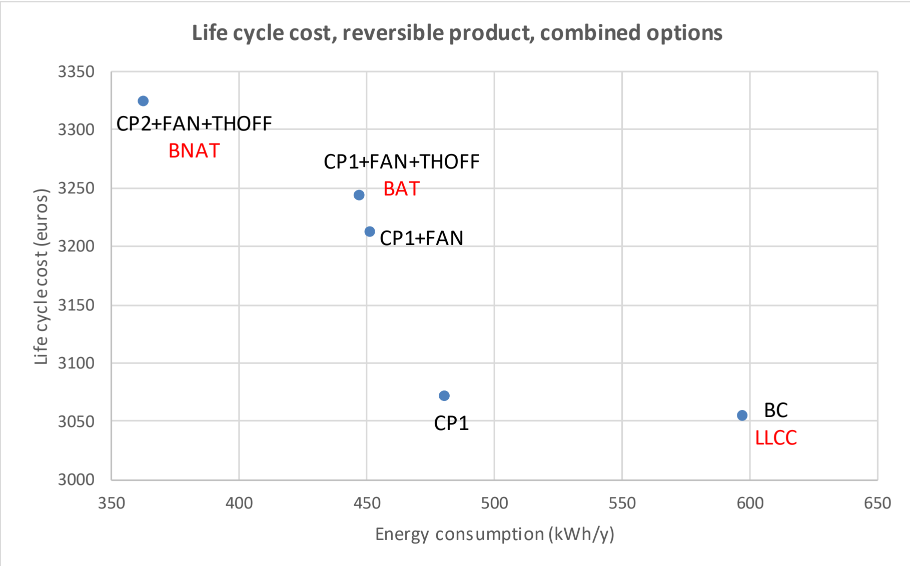


Figure 13: Life cycle cost and electricity consumption of reversible product (25 % reversibility use)

LLCC evaluation for cooling only fixed double duct air conditioners

LLCC appears to be the base case. All options increase the life cycle cost. Increase in LCC due to CP1 option is already significant (about 5 %) while the increase in LCC due to other combinations is larger (more than 10 %).

The LLCC chosen is then the base case:

- SEER 2.9
- LCC = 2301 €

The BNAT level corresponds to the following characteristics:

- SEER 5.1
- LCC = 2721 €

BAT is also indicated as the characteristics matching best available products on the market with following values:

- SEER 3.7
- LCC = 2614 €

Table 20: Life cycle cost calculation for combined options, cooling only product

	Unit	BC	CP1	CP1+FAN	CP1+FAN+ THOFF	CP2+FAN+ THOFF
SEER	**-**	2.88	3.33	3.67	3.73	5.13
η_{sc}	-	134%	156%	172%	175%	241%
EER	**-**	2.71	2.67	3.10	3.10	3.45
Total cons	**kWh/a**	279	242	219	216	157
Purchase Price	**Euros**	860	1021	1150	1176	1338
Installation	**Euros**	400	400	400	400	400
Maintenance	**Euro**	487	550	600	610	672
Electricity	**Euros**	554	479	434	428	311
LCC	**Euros**	2301	2450	2585	2614	2721
SPB	**years**		26	29	30	24

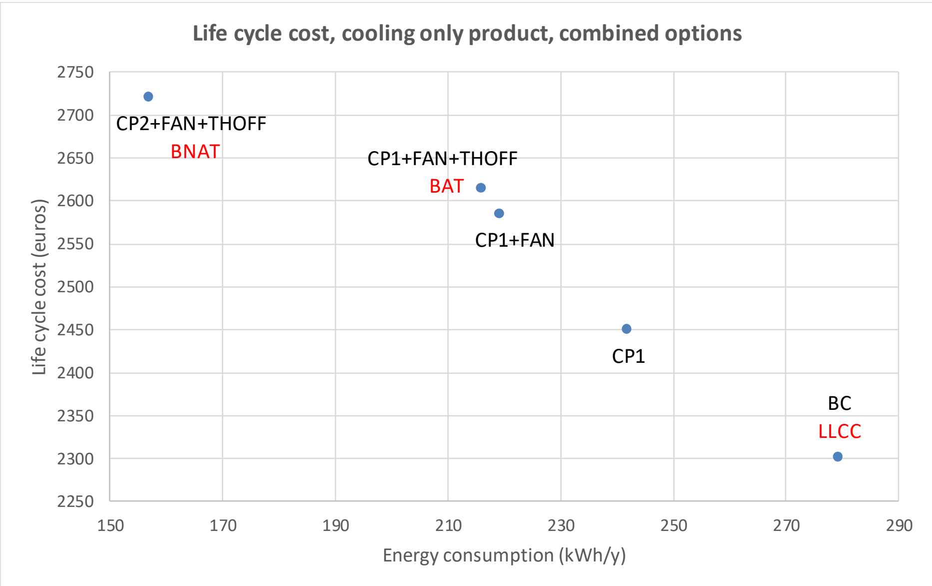


Figure 14: Life cycle cost and electricity consumption of cooling only product

Environmental impacts of LLCC and BNAT

The impacts of the base case (LLCC) and the BNAT are presented in Figure 15 and Figure 16 for reversible case and in Figure 17 and Figure 18 for cooling only case. The presented impact categories are the primary energy consumption and emission of CO_2-eq. The BNAT have environmental improvements in all categories compared with the base case (and LLCC for reversible products). The increased material composition has only limited impact.

Reversible

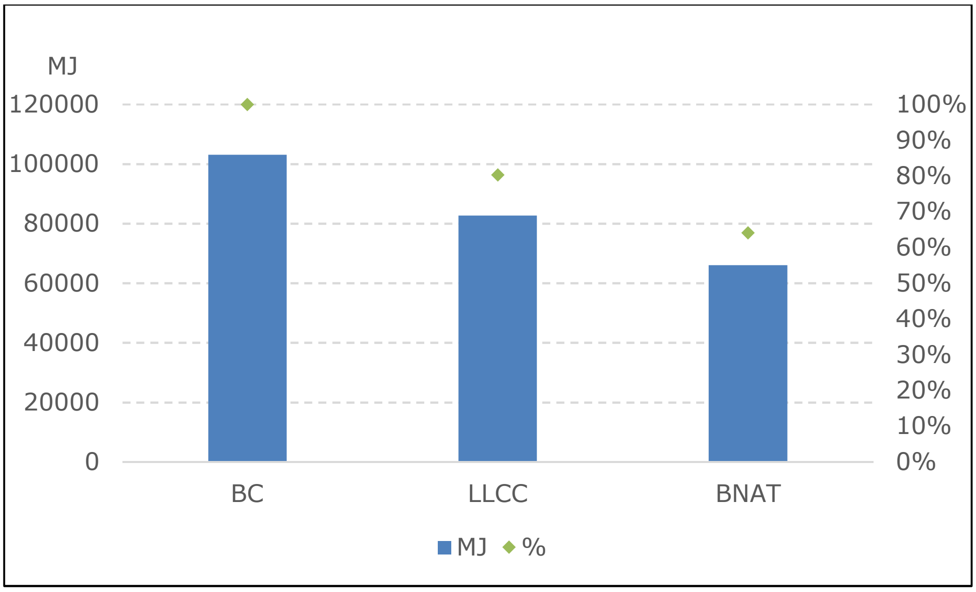


Figure 15: Total primary energy consumption of BC, LLCC and BNAT, reversible case (50 % reversibility use)

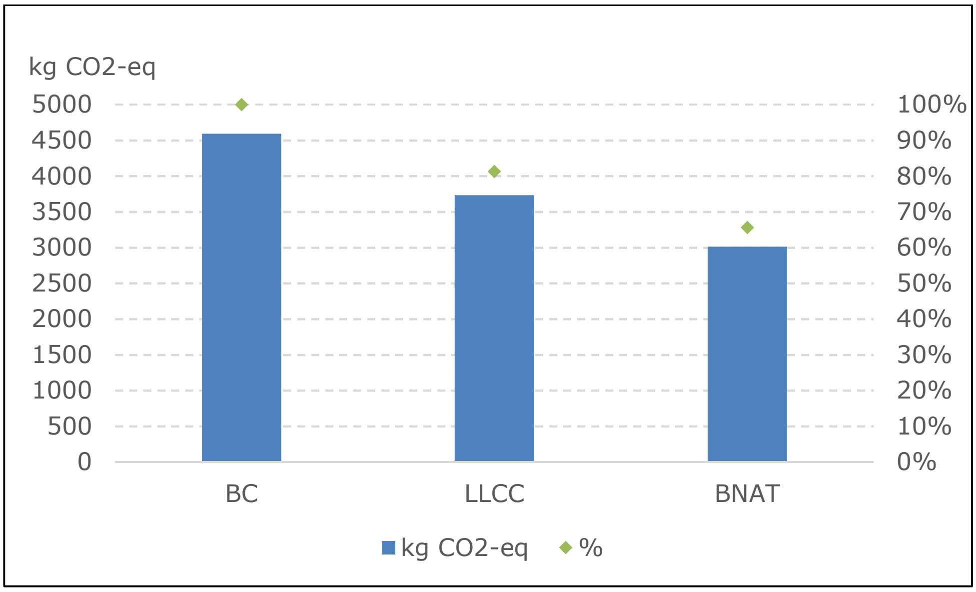


Figure 16: Emission of CO_2 (kg CO_2-eq) of LLCC and BNAT, reversible case (50 % reversibility use)

Cooling only

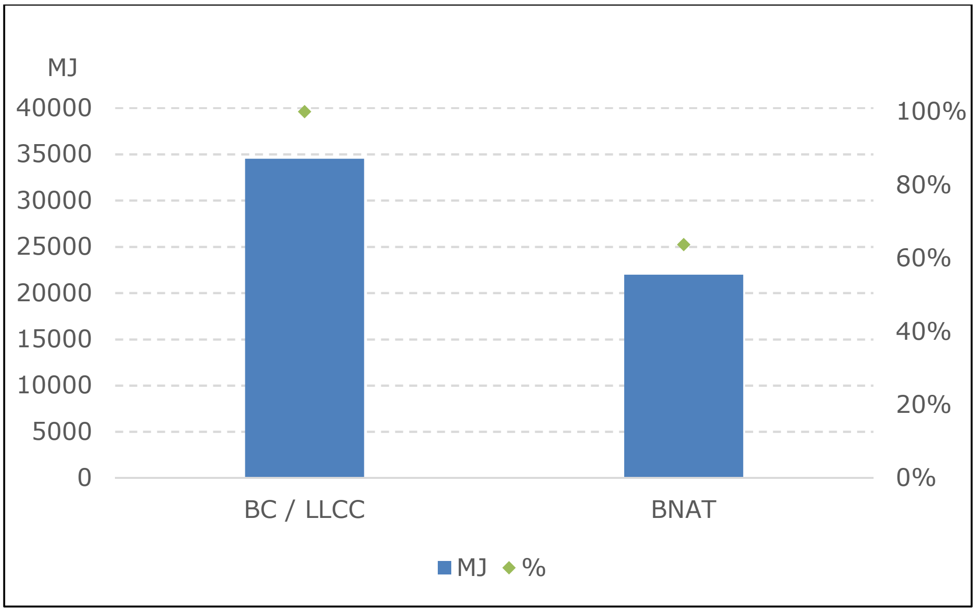


Figure 17: Total primary energy consumption of LLCC and BNAT, cooling only case

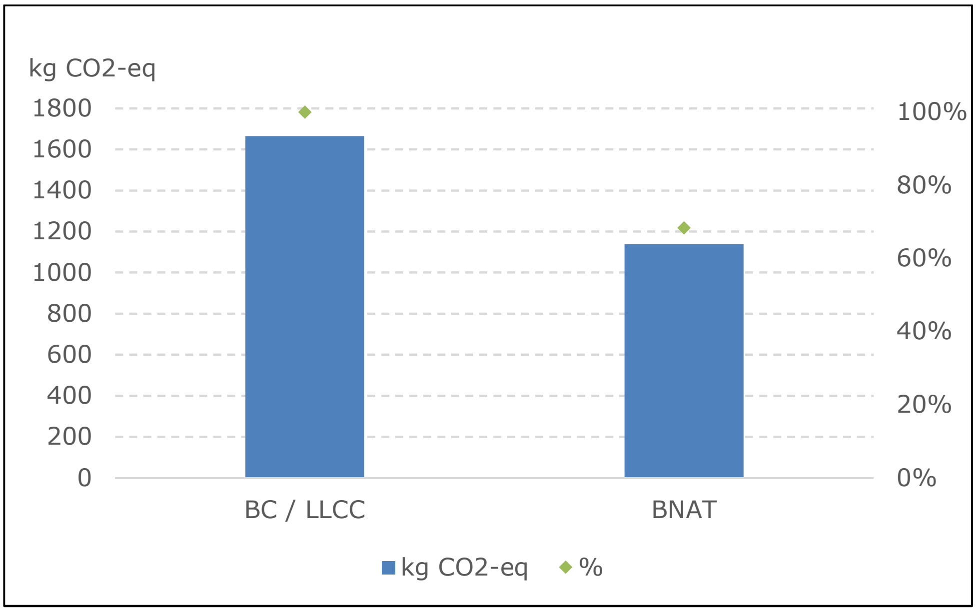


Figure 18: Emission of CO_2 (kg CO_2-eq) of LLCC and BNAT, cooling only case

6.5 Long-term targets

Based on the same product archetype, and given the competition on size reduction, the chances for energy efficiency improvement of fixed double duct air conditioners beyond BNAT efficiency level are estimated to be low.

However, as indicated in Task 2, there are already alternative options to fixed double duct air conditioners on the air conditioning market without outdoor unit. Amongst these solutions, some derive from both air-to-air and water-to-air split air conditioners. Depending on whether energy efficiency is considered important for this specific product segment, energy efficiency might increase for the entire segment, which could also change the design orientations for fixed double duct products and allow larger size and more efficient designs.

To reach such positive outcome however, it is necessary to allow the end-user to compare the energy efficiency of the different products, comparison which is difficult today as they use different metrics.

7. Scenarios

Scenario analysis of all air conditioners was already performed in the Review study. However, the results of the previous tasks of this report show the need to add specific requirements for fixed double duct air conditioners. This part only focuses on requirements specific to these products, excluding material efficiency and sound power which are already covered in the Review study.

7.1 Policy analysis

The review study considers two possible types of measures as regards energy efficiency measures, Ecodesign specific requirements and a revised energy label.

Ecodesign requirements

In Task 6, energy efficiency levels for LLCC were established. The LLCC levels are different for reversible and cooling only fixed double duct air conditioners, being lower for cooling only products. However, as the reversibility rate of the sales is already 70 % and growing (although very slowly, about +0.4 % per year), the dominant products are reversible and the LLCC of reversible products is fixed as objective for this product category.

These LLCC levels are thus proposed as MEPS levels in two tiers: the first tier corresponds to the base case and the second tier corresponds to the LLCC. This division in two tiers is necessary: according to the industry, about 65 % of the units sold are still on-off cycling and thus do not pass the tier 2 threshold. The timeline proposed for the first tier is the same as in the Review study.

Table 21: Proposed minimum efficiency requirements for fixed double duct air conditioners in a potential revised Ecodesign regulation

Product category	Tier 1, January 2023		Tier 2, January 2026	
	SEER	SCOP	SEER	SCOP
Fixed double duct	2.9	1.9 (*)	3.3	2.5

(*) A maximum bivalent temperature of -7 °C for the average climate has been proposed by some stakeholders for other fix installation than fixed double duct air conditioners; it is to be noticed that in case the bivalent point is fixed at – 7 °C or lower, a value of 1.85 should be used instead of the 1.9 value for the first tier[25].

Energy labelling requirements

In the review study, two different principles were proposed as regard energy labelling:

- Separate scales for portable and for other air conditioners
- A common scale for all air conditioners

In this report, only the option “separate scales” where only fixed double duct air conditioner and portable are put on the same scale is considered. Indeed, the scale for other air conditioners (in the case of separate scales) and the common scale are still not

[25] See note 2 below Table 13 regarding the impact on SCOP of the bivalent temperature choice.

established. These scales should be established following the discussions regarding thermal comfort and test method and depending also on the product coverage in heating mode (possible inclusion of local space heater indicated in the Review study).

In this policy option with a separate energy labelling scale for portable and fixed double duct air conditioners, as fixed double duct air conditioners may reach higher BNAT levels than portable air conditioners, it is necessary to rebuild the separate labelling scales proposed during the Review study.

In both heating and cooling mode, A labelling class threshold corresponds to fixed double duct air conditioners BNAT level, and G labelling class threshold corresponds to MEPS level for portable air conditioners are set. Class lengths are of about 15 % of the upper threshold of the class in cooling mode and 19 % in heating mode. In cooling mode, class B was extended downwards down to 4.3 instead of 4.4 in order to be aligned with BNAT level for single duct air conditioners identified in the Review study. Consequently, class C is a bit smaller (14 %) and class B a bit larger (16 %).

Table 22: Proposed new separate label scheme for portable and fixed double duct air conditioners

Label scheme	Cooling mode	Heating mode
A	SEER ≥ 5.1	SCOP ≥ 2.9
B	4.3 ≤ SEER < 5.1	2.4 ≤ SCOP < 2.9
C	3.7 ≤ SEER < 4.3	1.9 (*) ≤ SCOP < 2.4
D	3.2 ≤ SEER < 3.7	1.6 ≤ SCOP < 1.9 (*)
E	2.7 ≤ SEER < 3.2	1.3 ≤ SCOP < 1.6
F	2.3 ≤ SEER < 2.7	1 ≤ SCOP < 1.3
G	SEER < 2.3	SCOP < 1

(*) A maximum bivalent temperature of -7 °C for the average climate has been proposed by some stakeholders for other fix installation than fixed double duct air conditioners; it is to be noticed that in case the bivalent point is fixed at – 7 °C or lower, a value of 1.85 should be used instead of the 1.9 value in order to the labelling scale to match the MEPS requirements.

In heating mode, low efficiency fixed double duct air conditioners would be in class C and D. Inverter type fixed double duct air conditioners with present best available technology would be in class B, while class A would start to fill up only after 2025 according to manufacturers (BNAT level).

In cooling mode, low efficiency fixed double duct air conditioners would be in class D and E, best present units in class C and D, while class A and B would start to fill up only after 2025 according to manufacturers (BNAT level).

It is to be noted that this labelling scenario is probably not the policy option leading to maximum energy efficiency gains, that is assumed to be the scenario of a common labelling scale for all air conditioners, as explained in the Review study, as the common scale will help the consumer to compare all products with a single figure of merit. It could also allow the development of more efficient alternative solutions compared to the present fixed double duct archetype (see Task 6.5 above).

7.2 Scenario analysis

Scenario description

As in the Review study, the scenario analysis investigates the impact of different scenarios on energy consumption and emission of CO_2-eq. The impact of changes to material composition and improved material efficiency are not considered due to the limited impact and to the difficulties with quantifying the improvement potential.

The investigated options are:

- Policy option 0: BAU scenario (with current regulation)
- Policy option 1 (PO1): Revised Ecodesign requirement, only Tier 1 is applied
- Policy option 2 (PO2): Revised Ecodesign requirement (Tier 1 only) and revised Energy labelling with separate scale, where fixed double duct and portable are on the same scale.
- Policy option 3 (PO3): Revised Ecodesign requirement, Tier 1 and Tier 2
- Policy option 4 (PO4): Revised Ecodesign requirement (Tier 1 and Tier 2) and revised Energy labelling with separate scale, where fixed double duct and portable are on the same scale.

The description of the energy efficiency evolutions of each scenario is presented in Table 23.

Table 23: Description of policy scenarios

Policy scenario	Description
Scenario 0 (0 BAU)	BAU with present EU regulation – EER and COP increase by 0.4 % annually due to default technological progress. Inverter technology stagnates to 35 % of the sales (present value). Reversibility share continues to increase of about 0.4 % per year.
Scenario 1 (PO1)	In 2023, products with SCOP below 1.8 are removed from the market. This is supposed to represent 10 % of the sales of reversible units by 2023[26]. It is supposed this is done by increasing the share of inverter products[27]. Tightening the MEPS for the cooling mode is supposed to have a negligible effect (as the base case EER (2.7) is close to the current MEPS for EER (2.6)).
Scenario 2 (PO2)	In addition to the achievements in PO1, the energy labelling promotes the development of inverter units whose share increases by 2 % per year after 2023. Amongst these inverter units, CP2[28] inverter type compressor starts entering the market by 2026 to populate class A and B, with a total increase in share of 2 % per year.
Scenario 3 (PO3)	In addition to scenario 1 (PO1), in 2026 all products adopt compressor inverter technology to reach Tier 2 MEPS levels.
Scenario 4 (PO4)	In addition to scenario 2 (PO2), in 2026 all products adopt compressor inverter technology to reach Tier 2 MEPS levels.

[26] Estimated share of reversible fixed double duct air conditioners having a COP lower than 3.1 by 2023 and consequently having a SCOP lower than 2.2.
[27] According to Task 6, Table 18 and Table 20, this is the option having the lower life cycle cost after the LLCC.
[28] See Task 6; CP2 corresponds to high efficiency twin rotary compressors allowing to lower compressor frequency and increase SEER metrics beyond the ones of present best available products.

The resulting evolution of the stock, SEER and SCOP of fixed double duct air conditioners with time is shown in Table 24.

Table 24: Development of SEER and SCOP of air conditioners sold in the 5 scenarios

Scenario	Efficiency	2015	2020	2025	2030	2035	2040	2045	2050
BAU	SEER	2.9	2.9	3.0	3.0	3.1	3.1	3.2	3.3
BAU	SCOP	2.2	2.2	2.3	2.3	2.3	2.4	2.4	2.5
PO1	SEER	2.9	2.9	3.0	3.1	3.1	3.2	3.2	3.3
PO1	SCOP	2.2	2.2	2.3	2.4	2.4	2.5	2.5	2.6
PO2	SEER	2.9	2.9	3.0	3.2	3.4	3.6	3.7	3.9
PO2	SCOP	2.2	2.2	2.3	2.4	2.5	2.6	2.7	2.7
PO3	SEER	2.9	2.9	3.0	3.3	3.3	3.4	3.5	3.5
PO3	SCOP	2.2	2.2	2.3	2.7	2.7	2.8	2.8	2.9
PO4	SEER	2.9	2.9	3.0	3.3	3.5	3.6	3.8	4.0
PO4	SCOP	2.2	2.2	2.3	2.7	2.7	2.8	2.8	2.9

The total energy consumption and total CO2-eq emissions in the use phase for the 5 scenarios are shown in Table 25, Figure 19 and Figure 20 below.

Annual energy savings in absolute numbers are modest because of the limited size of the market. For scenario PO1, Ecodesign requirements (Tier 1) result in savings of about 3 % of the BAU annual energy consumption after 2023; this amounts to 0.013 TWh/y by 2030 and 0.023 TWh/y by 2050. For scenario PO2, Ecodesign requirements (Tier 1) and energy labelling results in a significant increase in these figures to 0.022 TWh/y in 2030 up to 0.088 TWh/y in 2050. For scenario PO3, the stronger Tier 2 Ecodesign requirement allows immediate energy savings: by 2030, yearly savings are nearly doubled, as compared to PO2 scenario. By 2050, PO3 electricity consumption is closed to the one in PO2. In scenario PO4, immediate Ecodesign requirements (Tier 2) are also realized and the label allow further gains up to 2050. Cumulative savings amount to roughly 0.5 TWh in 2050 in scenario PO1, 1.2 TWh in scenario PO2, 1.7 TWh in scenario PO3 and close to 2 TWh in scenario PO4.

CO_2-eq emissions follow similar evolutions as energy consumption. However, the CO_2-eq emissions per electricity consumption is decreasing because of the change in electricity mix of the reference scenario used[29]. By 2050, cumulated savings in terms of CO_2-eq emissions would reach 0.15 Mt CO_2-eq in scenario PO1, 0.37 Mt CO_2-eq in scenario PO2, 0.52 Mt CO_2-eq in scenario 3 and 0.59 Mt CO_2-eq in scenario 4.

Table 25: The annual energy consumption and emission of CO_2-eq in the 3 scenarios

Energy impacts (TWh/y)	Scenario	2025	2030	2035	2040	2045	2050
Electricity Consumption	BAU	0.30	0.42	0.49	0.56	0.64	0.72
Electricity Consumption	PO1	0.30	0.41	0.48	0.54	0.62	0.70
Electricity Consumption	PO2	0.29	0.39	0.45	0.51	0.57	0.63
Electricity Consumption	PO3	0.30	0.37	0.43	0.49	0.56	0.63
Electricity Consumption	PO4	0.29	0.36	0.42	0.48	0.54	0.61
Savings in Electricity Consumption	PO1	0.009	0.013	0.015	0.018	0.020	0.023

[29] PRIMES scenario: https://ec.europa.eu/clima/sites/clima/files/strategies/analysis/models/docs/primes_model_2013-2014_en.pdf

Savings in Electricity Consumption	PO2	0.011	0.023	0.037	0.051	0.069	0.089
Savings in Electricity Consumption	PO3	0.009	0.051	0.060	0.069	0.079	0.089
Savings in Electricity Consumption	PO4	0.011	0.054	0.067	0.080	0.095	0.111
Cumulative Electricity savings (TWh)	PO1	0.06	0.12	0.19	0.27	0.37	0.48
Cumulative Electricity savings (TWh)	PO2	0.06	0.15	0.31	0.53	0.84	1.25
Cumulative Electricity savings (TWh)	PO3	0.06	0.29	0.57	0.90	1.28	1.70
Cumulative Electricity savings (TWh)	PO4	0.06	0.30	0.61	0.99	1.43	1.95
Impact GHGs emissions (Mt CO_2-eq /y)	**Scenario**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Emissions of GHGs	BAU	0.11	0.14	0.16	0.17	0.18	0.19
Emissions of GHGs	PO1	0.11	0.14	0.15	0.16	0.17	0.18
Emissions of GHGs	PO2	0.11	0.13	0.15	0.15	0.16	0.16
Emissions of GHGs	PO3	0.11	0.12	0.14	0.15	0.16	0.16
Emissions of GHGs	PO4	0.11	0.12	0.14	0.14	0.15	0.16
Reduction in emissions of GHGs	PO1	0.003	0.004	0.005	0.005	0.006	0.006
Reduction in emissions of GHGs	PO2	0.004	0.008	0.012	0.015	0.019	0.023
Reduction in emissions of GHGs	PO3	0.003	0.017	0.019	0.021	0.022	0.023
Reduction in emissions of GHGs	PO4	0.004	0.018	0.021	0.024	0.027	0.029
Cumulative reduction in emissions of GHGs (Mt CO_2 eq.)	PO1	0.02	0.04	0.07	0.09	0.12	0.15
Cumulative reduction in emissions of GHGs (Mt CO_2 eq.)	PO2	0.02	0.06	0.11	0.18	0.26	0.37
Cumulative reduction in emissions of GHGs (Mt CO_2 eq.)	PO3	0.02	0.10	0.20	0.30	0.40	0.52
Cumulative reduction in emissions of GHGs (Mt CO_2 eq.)	PO4	0.02	0.11	0.21	0.32	0.45	0.59

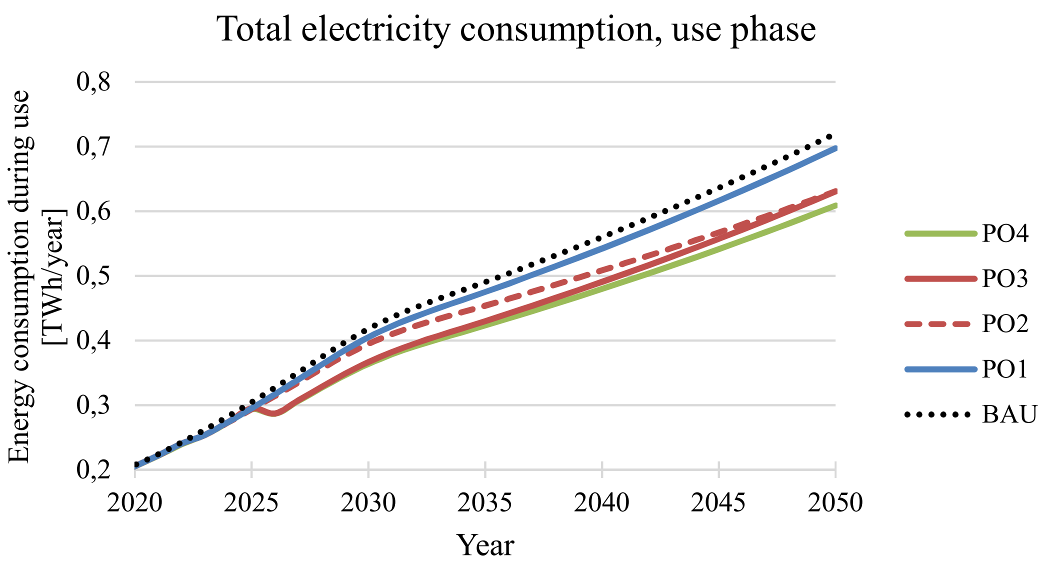


Figure 19: Comparison of the annual electricity consumption in the 5 scenarios

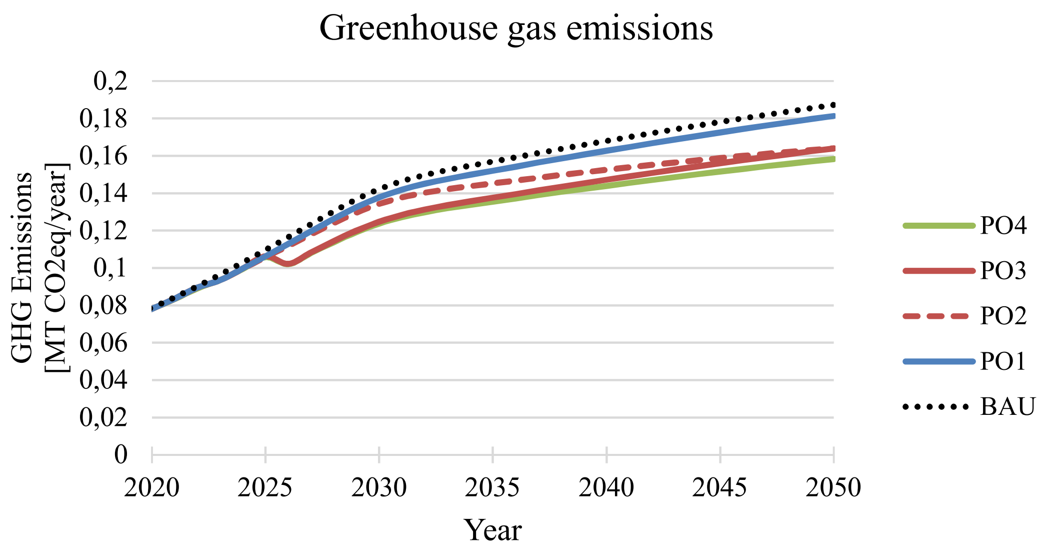


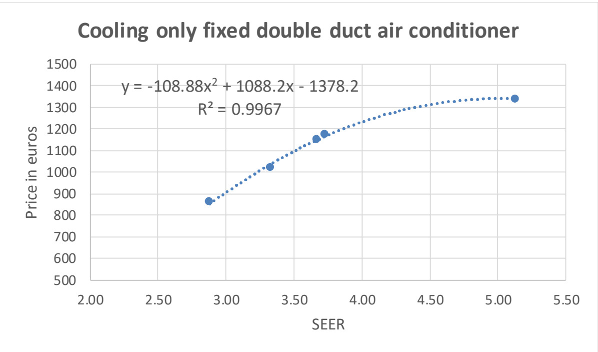
Figure 20: Comparison of the annual emission of GHGs in the 5 scenarios

7.3 Impact analysis for consumer and industry

Total consumer expenditure

The total consumer expenditure is related to the electricity consumption and the purchase price of the equipment. Installation price is assumed the same in all scenarios and maintenance cost is 4 % of installation and purchase cost. The electricity price increases 0.5 % per year from 2020 to 2035 and decreases by 0.25% per year from 2035 to 2050.

As regards the increase of the purchase price due to SEER and SCOP, for reversible fixed double duct air conditioners, a second order correlation based on Task 6 results is supposed to link price and SCOP increase; for cooling only product price and SEER, another second order correlation is used. The evolution of product price and correlations used are shown in Figure 21.



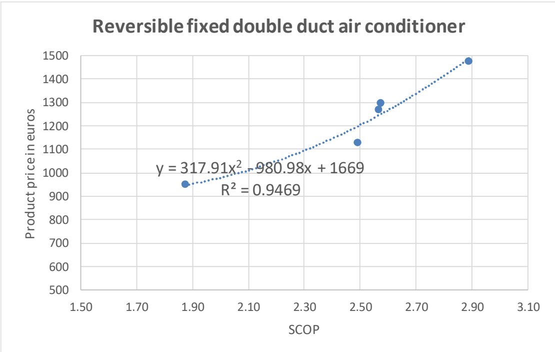


Figure 21: Price correlation versus SEER (left) for cooling only fixed double duct air conditioners and versus SCOP (right) for reversible products

Under these hypotheses, scenarios PO1 and PO2 allow to only slightly decrease the total consumer expenditure. Scenarios PO3 and PO4 allow a slight decrease in consumer expenditure until about 2035 and then a slight increase. The total consumer expenditure increases strongly in time due to growth in the stock (Figure 22).

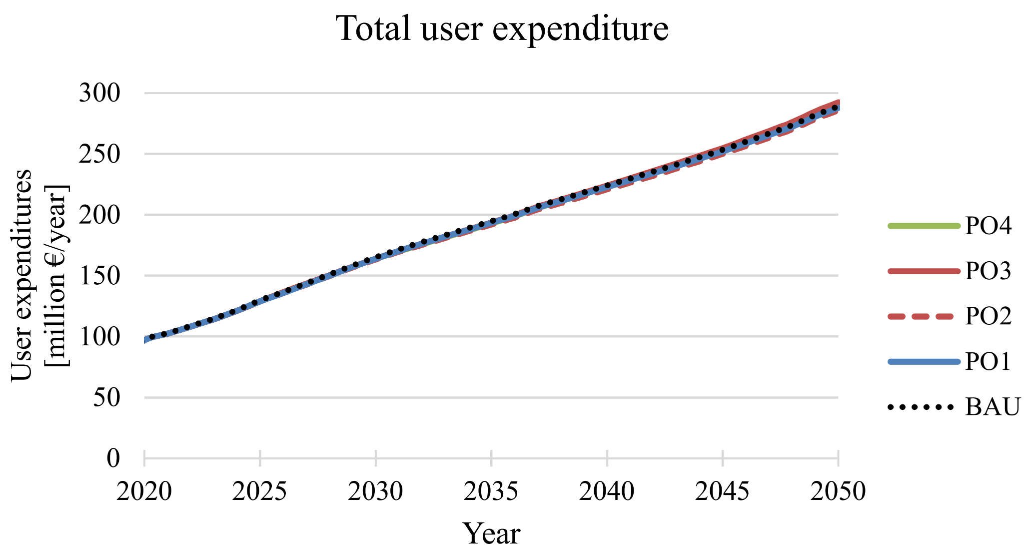


Figure 22: Evolution of total user expenditure in the 3 scenarios (2019 price level)

As shown in Table 26, the decrease in the yearly energy expenditure in scenarios PO1 and PO2 is of the same order of magnitude as the increase in purchase, installation and maintenance cost, resulting in a small decrease in the total consumer expenditure.

The cumulative savings in total expenditure for the consumers are:

- For scenario PO1: 27 mil. € from 2020 to 2040 and 40 mil. € from 2020 to 2050
- For scenario PO2: 42 mil. € from 2020 to 2040 and 75 mil. € from 2020 to 2050
- For scenario PO3: 20 mil. € from 2020 to 2040 and 4 mil. € from 2020 to 2050
- For scenario PO4: 28 mil. € from 2020 to 2040 and 33 mil. € from 2020 to 2050

Table 26: Consumer total expenditure, energy expenditure and total acquisition costs

Variable	Scenario	2025	2030	2035	2040	2045	2050
Total expenditure, mil. €/year	BAU	130	165	195	224	253	289
Total expenditure, mil. €/year	PO1	129	164	193	223	252	288
Total expenditure, mil. €/year	PO2	129	163	192	221	250	286
Total expenditure, mil. €/year	PO3	129	164	194	224	255	292
Total expenditure, mil. €/year	PO4	129	164	193	223	253	290
Savings, mil. €/year PO1	*BAU - PO1*	*1*	*1*	*1*	*1*	*1*	*1*
Savings, mil. €/year PO2	*BAU - PO2*	*1*	*2*	*3*	*3*	*3*	*3*
Savings, mil. €/year PO3	*BAU - PO3*	*1*	*1*	*1*	*0*	*-1*	*-3*
Savings, mil. €/year PO4	*BAU - PO4*	*1*	*1*	*2*	*1*	*1*	*-1*
Energy use expenditure, mil. €/year	BAU	64	89	107	121	135	151
Energy use expenditure, mil. €/year	PO1	62	86	104	117	130	146
Energy use expenditure, mil. €/year	PO2	62	84	99	110	120	132

Energy use expenditure, mil. €/year	PO3	62	78	94	106	118	132
Energy use expenditure, mil. €/year	PO4	62	78	92	104	115	128
Savings, mil. €/year PO1	*BAU - PO1*	*2*	*3*	*3*	*4*	*4*	*5*
Savings, mil. €/year PO2	*BAU - PO2*	*2*	*5*	*8*	*11*	*15*	*19*
Savings, mil. €/year PO3	*BAU - PO3*	*2*	*11*	*13*	*15*	*17*	*19*
Savings, mil. €/year PO4	*BAU - PO4*	*2*	*12*	*15*	*17*	*20*	*23*
Total acquisition costs, mil. €/year	BAU	66	76	88	103	119	138
Total acquisition costs, mil. €/year	PO1	67	78	90	106	122	142
Total acquisition costs, mil. €/year	PO2	67	79	93	111	130	154
Total acquisition costs, mil. €/year	PO3	67	86	100	118	137	160
Total acquisition costs, mil. €/year	PO4	67	86	101	119	138	162
Savings, mil. €/year PO1	*BAU - PO1*	*-1*	*-2*	*-2*	*-2*	*-3*	*-4*
Savings, mil. €/year PO2	*BAU - PO2*	*-2*	*-3*	*-5*	*-8*	*-11*	*-16*
Savings, mil. €/year PO3	*BAU - PO3*	*-1*	*-10*	*-12*	*-15*	*-18*	*-22*
Savings, mil. €/year PO4	*BAU - PO4*	*-2*	*-10*	*-13*	*-16*	*-20*	*-24*

Industry impacts

The estimate of the impacts on the industry is based on a number of assumptions based on the MEErP, the Review study and values adapted to the specific fixed double duct industry, including the higher share of production in the EU and the larger part of OEM estimated to originate from the EU (Table 27).

Table 27: Assumptions to model to industry impacts.

Impact	Value	Source
Manufacturer Selling Price as fraction of Product Price [%]	58%	Review study task 2, portable
Margin Wholesaler [% on msp]	20%	Review study task 2, figure for premium products
Margin Retailer on product [% on wholesale price]	15%	Review study task 2, figure for premium products
Share of production in EU	80%	Industry estimate
OEM personnel as fraction of manufacturer personnel [-]	1.2	MEErP
Fraction of OEM value outside EU [% of turnover]	46 %	Based on Task 6 (adding compressor, fans and electronics)
Manufacturer turnover per employee [mln. EUR/Employee]	0.241	EURO stat

The resulting estimated EU manufacture turnover is shown in Figure 23. It is estimated to increase from 10 to about 30 million euros from 2020 to 2050 in the BAU scenario due to increased sales mainly. More ambitious scenarios in terms of efficiency (PO1 to PO4) leads to higher turnover, which also increases the number of EU jobs for the sector (Figure 24).

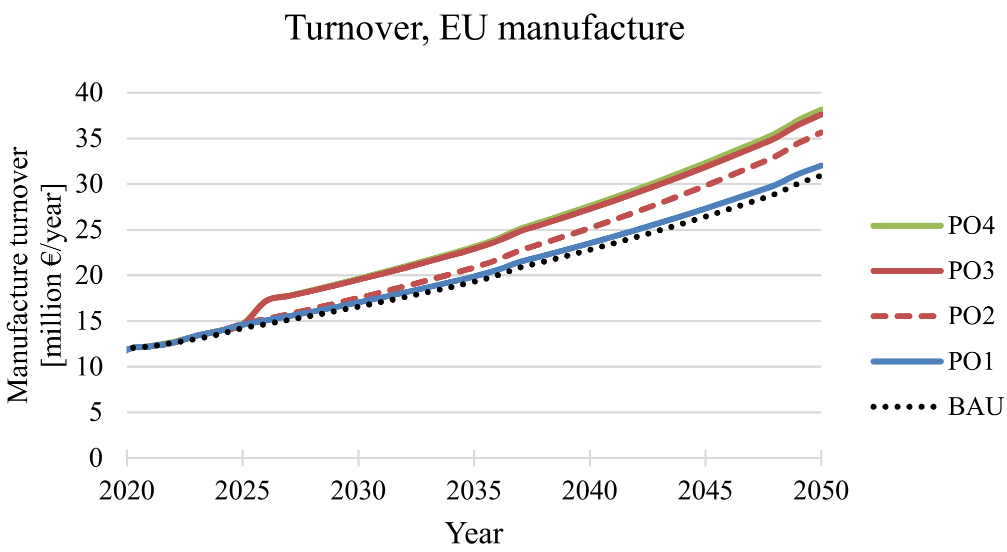


Figure 23: Industry turnover per year for different policy scenarios

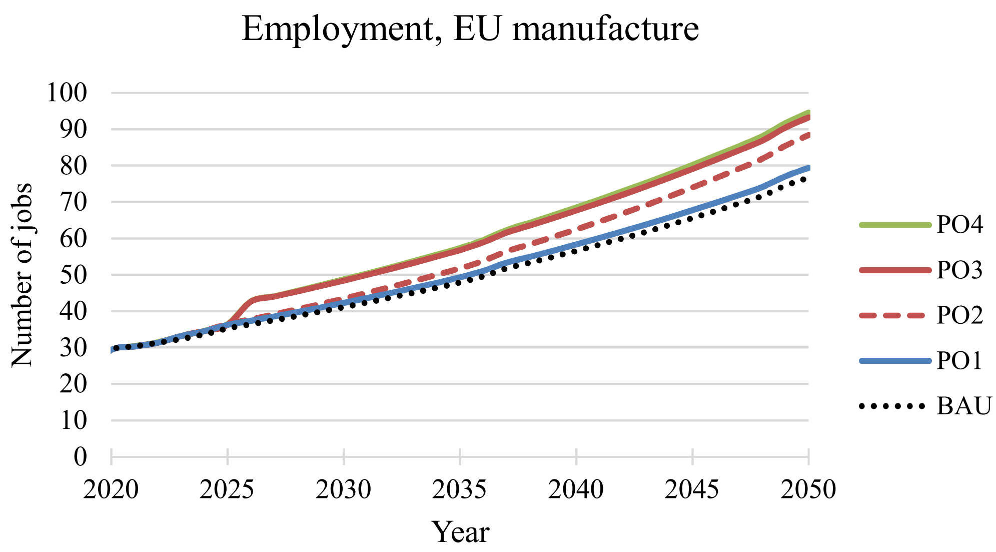


Figure 24: Number of personnel in air conditioner industry for different policy scenarios

7.4 Conclusions and recommendations

Policy options

The following Ecodesign requirements are proposed for fixed double duct air conditioners (Table 28).

Table 28: Proposed minimum efficiency requirements for fixed double duct air conditioners in a potential revised Ecodesign regulation

Product category	Tier 1, January 2023		Tier 2, January 2026	
	SEER	SCOP	SEER	SCOP
Fixed double duct	2.9	1.9 (*)	3.3	2.5

(*) A maximum bivalent temperature of -7 °C for the average climate has been proposed by some stakeholders for other fix installation than fixed double duct air conditioners; it is to be noticed that in case the bivalent point is fixed at – 7 °C or lower, a value of 1.85 should be used instead of the 1.9 value for the first tier[30].

In the Review study, a separate labelling scale was studied as one of the options for portable air conditioners. In this addendum study for fixed double duct air conditioner, a scenario was studied in which both portable air conditioner and fixed double duct air conditioner would be on the same scale (starting from 2023 onwards). In that case, it would be necessary to revise the separate portable labelling scale proposed in the Review study. The following scale (Table 29) can accommodate both portable air conditioners and fixed double duct air conditioners, the latter having higher BNAT levels and so requiring higher A class thresholds.

Table 29: Proposed new separate label scheme for portable and fixed double duct air conditioners

Label scheme	Cooling mode	Heating mode
A	SEER ≥ 5.1	SCOP ≥ 2.9
B	4.3 ≤ SEER < 5.1	2.4 ≤ SCOP < 2.9
C	3.7 ≤ SEER < 4.3	1.9 (*) ≤ SCOP < 2.4
D	3.2 ≤ SEER < 3.7	1.6 ≤ SCOP < 1.9 (*)
E	2.7 ≤ SEER < 3.2	1.3 ≤ SCOP < 1.6
F	2.3 ≤ SEER < 2.7	1 ≤ SCOP < 1.3
G	SEER < 2.3	SCOP < 1

(*) A maximum bivalent temperature of -7 °C for the average climate has been proposed by some stakeholders for other fix installation than fixed double duct air conditioners; it is to be noticed that in case the bivalent point is fixed at – 7 °C or lower, a value of 1.85 should be used instead of the 1.9 value in order to the labelling scale to match the MEPS requirements.

However, this separate labelling scale is not the preferred option. As mentioned in the Review study, a single labelling scale regrouping all air conditioners could theoretically lead to higher savings. However, it is not yet possible to establish this single scale, and it will be developed during the impact assessment study.

Scenario analysis

In the BAU scenario, the growth in sales and stock induces a strong increase in the energy consumption and $CO_{2\text{-eq}}$ emissions from 2020 till 2050. However, the overall impact of fixed double duct air conditioners is low overall as it only represents 0.8 % of the sales of air conditioners in the EU.

Four scenarios were analysed; the first scenario (PO1) only includes Ecodesign minimum performance requirements for tier 1 (enforced in 2023). In the second scenario (PO2), both Ecodesign tier 1 a new energy label enter into force in 2023. The third scenario consists in Ecodesign requirements for tier 1 (2023) and for tier 2 (2026). The fourth scenario includes both the two tiers of Ecodesign requirements and a new energy label in 2023.

The first scenario (PO1) leads to 3 % savings in the annual electricity consumption after 2023 as compared to the BAU and the second scenario (PO2) leads to up to 12 %

[30] See note 2 below Table 13 regarding the impact on SCOP of the bivalent temperature choice.

savings in the annual electricity consumption by 2050. The third scenario (PO3) also reaches 12 % annual savings by 2050 but the stricter Ecodesign requirements allows to reach 12 % annual savings already by 2030. In scenario 4 (PO4), the addition of the energy label as compared to scenario 3 (PO3) allows both rapid annual savings by 2030 (12 %) and increased savings by 2050 (15 %). Cumulative energy savings over the period 2020 to 2050 are limited to 0.5 TWh in the first scenario (PO1), 1.2 TWh in the second scenario (PO2), 1.7 TWh in scenario 3 (PO3) and 2 TWh in scenario 4 (PO4).

Impacts

The four scenarios proposed lead to cumulated savings (although minor) for consumers, and positive outcome for EU manufacturer turnover and job creation. All indicators improve in scenario 2 (PO2) as compared to scenario 1 (PO1) and in scenario 4 (PO4) as compared to scenario 3 (PO3). It means the best scenario encompasses both Ecodesign requirements and a new energy label.

In case a common labelling scale for all ACs is studied, specific care must be taken to properly assess the impacts on fixed double duct EU manufacturers which are SMEs.