Cascading does not make sense not make sense from an economical and environmental point of view and should be avoided: case study

Ecodesign aims at minimizing the environmental impacts of a product, keeping in mind their affordability.

When components of already ecodesign regulated products are regulated, the affordability of the product is jeopardised without any clear gains for the environment.

The fan study does not take into account whether the improved fan increases the energy efficiency of the product in which it is integrated in and against what cost, this is type of evaluation is performed in the study on the product level.

When the fan is the most cost-efficient part to improve, this action will have been taken by the manufacturer to improve the energy efficiency of the products. In this case the fan measure is redundant and only burdens the product manufacturer.

When the fan is not the most cost-efficient part to improve, the fan measure forces the product manufacturer to replace the fan by a more efficient fan. Nevertheless, to keep the cost increase minimal, while meeting the minimum requirements, the product manufacturer will save on other parts. In this case, the price of the product will go up, but not the energy efficiency.

This will be explained by means 2 case studies:

- Preparatory study ENER lot 10: Air conditioners < 12 kW
- Preparatory study ENTR lot 6: Air conditioners > 12 kW

This is only an example, with other products the same effects can easily be demonstrated.

Preparatory study ENER lot 10: fan measure does not lead to higher energy efficiency values

The products in scope of Ecodesign ENER lot 10 are air conditioners < 12 kW. These products are ecodesign regulated since March 2012 with a first tier in January 2013 and a second tier in January 2014. Next to this, when the fan has a power input > 125W, they also have to comply with the fan measure from January 2015 onwards.

In this paragraph, an example of the improvement options for the base case of the 3.5 kW reversible split air conditioner will be given. The conclusions are similar for all base cases investigated in the ENER lot 10 study.

For this base case, several improvement options were considered:

- Compressors: CP1 = 3 EER compressor, CP2 = 3.2 EER compressor, CP3= 3.4 EER compressor, INV AC = AC compressor variable speed, INV DC = DC compressor variable speed, ALL DC = DC compressor and fan

- Expansion valve: TXV = superheat gain: 1.5% and Cd: 0.12, EXV = superheat gain: 3% and Cd: 0.06
- Frost and defrost: DEF = improved control
- Heat exchanger and fan: HE1 = 20%, HE2 = 40%, HE3 = 60%, HE4 = 80%, HE5 = 100% improvement of service value of fan and heat exchange surface
- Compressor oil for reversible units: CK1 = electrified static coil, CK2 = improved crankcase heater control
- Standby: Sb = 0.7 W standby with separation of reactivation and crankcase heater functions

First of all it is clear from the study that the improvements of the fans are not considered separately. When the fan is improved, also the compressor (options INV AC, INV DC and ALL DC) or the heat exchangers (options HE1 to HE 5) is improved. A redesign of the fan will lead to a redesign of other components as well.

When looking at each option individually, the study shows that the more expensive options relate to options HE1 to HE5.

When looking at the cumulative result, see the table below, the least life cycle cost is reached by improving the expansion valve (EXV), the compressor (All DC and CP2), improving oil return (CK2) and increasing the heat exchange surface and fan efficiency by 20% (HE1).

Unit description	Improvement to	Purchasing Price Euros	SEER	SCOP
Base case	-	683	2.6	2.3
TXV	Expansion valve	693	2.7	2.4
INV AC	Compressor	751	3.5	2.8
CP1	Compressor (EER 3)	769	3.7	3
DEF	Defrost control	777	3.7	3.1
CK2	Crankcase heater control	788	3.7	3.1
EXV	Expansion valve	806	3.8	3.2
CP2	Compressor (EER 3.2)	850	4	3.4
INV DC	Compressor	905	4.3	3.6
ALL DC	**Compressor and fan**	**982**	**4.6**	**3.8**
HE1	**Heat exchanger and fan**	**1035**	**4.7**	**4**
HE2	Heat exchanger and fan	1090	4.9	4.2
CK1	Oil heater reversible units	1104	4.9	4.2
SB	Standby	1126	5.8	4.2
HE3	Heat exchanger and fan	1180	6	4.4
HE4	Heat exchanger and fan	1234	6.1	4.5
HE5	Heat exchanger and fan	1288	6.2	4.6
CP3	Compressor (EER 3.4)	1398	6.4	4.8

The minimum energy efficiency requirements are set one step below the least life cycle cost option, leading to a minimum of 4.6 in SEER and 3.8 in SCOP.

Note: When looking at the step just below the least life cycle cost, an improvement on SEER by 1 will be made with an average investment cost of 149.5 euro, when looking at the LLCC, this cost

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increases to 166.2 euro. The conclusion to set minimum requirements just below the least life cycle cost were based on a thorough analysis, which cannot be performed on a component level.

In lot 10, the fan improvements are expressed in service value, while in lot 11, they are expressed in energy efficiency. Therefore, it is difficult to determine which option would fulfil the fan efficiency requirements of ENER lot 11. In the following, it is assumed that option HE1 is this option, nevertheless, the conclusion holds for options HE2 to HE5 as well.

In the next paragraphs we will demonstrate the effects of the fan measure in a simplified way by means of the improvement options tabled above.

Without a fan measure, the air conditioning manufacturer would follow the options in the table to reach the minimum requirements, stopping at option All DC.

With a fan measure, but without considering the economic aspects, a fan measure would lead to an increase in SEER with 0.1 and SCOP with 0.2, as follows:

Unit description	Improvement to	Purchasing Price Euros	SEER	SCOP
Base case	-	683	2.6	2.3
TXV	Expansion valve	693	2.7	2.4
INV AC	Compressor	751	3.5	2.8
CP1	Compressor (EER 3)	769	3.7	3
DEF	Defrost control	777	3.7	3.1
CK2	Crankcase heater control	788	3.7	3.1
EXV	Expansion valve	806	3.8	3.2
CP2	Compressor (EER 3.2)	850	4	3.4
INV DC	Compressor	905	4.3	3.6
ALL DC	**Compressor and fan**	**982**	**4.6**	**3.8**
HE1	**Heat exchanger and fan**	**1035**	**4.7**	**4**

Nevertheless, in reality, the manufacturer will opt to save on other components to make sure the minimum levels (SEER = 4.6 and SCOP = 3.8) are reached, with a minimum price increase. The following result would then be obtained:

Unit description	Improvement to	Purchasing Price Euros	SEER	SCOP
Base case	-	683	2.6	2.3
TXV	Expansion valve	693	2.7	2.4
INV AC	Compressor	751	3.5	2.8
CP1	Compressor (EER 3)	769	3.7	3
CK2	Crankcase heater control	780	3.6	3
CP2	Compressor (EER 3.2)	824	3.9	3.2
INV DC	Compressor	879	4.2	3.4
ALL DC	Compressor and fan	956	4.5	3.6

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HE1	Heat exchanger and fan	1009	4.6	3.8

Leading to a more expensive product with the same energy efficiency values.

In this case the fan measure will not lead to more efficient products, only more expensive products. This jeopardises the affordability of products and burdens product manufacturers without any clear gains.

Preparatory study ENTR lot 6:

The products in scope of Ecodesign ENTR lot 6 are air conditioners and chillers > 12 kW. These products will expectedly have a 1st tier in January 2017. Next to this, they also have to comply with the fan measure from January 2015 onwards.

In this paragraph, an example of the improvement options for the base case of a 55 kW VRF system will be given.

For this base case, several improvement options were considered:

- Outdoor heat exchanger and fan: OU1 = + 50%, OU2 = + 100% improvement service value of fan and outdoor heat exchange surface, MCHX = microchannel heat exchanger (same efficiencies as OU1)
- Indoor heat exchanger and fan: IU1 = + 20%, IU2 = +40%, IU3 = + 100% improvement service value of fan and indoor heat exchange surface
- Oil return: ORPH = oil return to high pressure mechanisms

Again it is clear from the study that the improvements of the fans are not considered separately. When the fan is improved, the heat exchangers (options HE1 to HE 5) is improved. A redesign of the fan will lead to a redesign of other components as well.

When looking at the cumulative result, the combination of OU1, IU2 and ORPH lead to the least life cycle cost.

Unit description	Improvement to	Investment cost k Euros	SEER	SCOP
Base case	-	36	3.53	3.1
OU1	Heat exchanger and fan	37.3	3.83	3.24
IU2	Heat exchanger and fan	38.7	4.43	3.5
ORPH	**Oil heater reversible units**	**39.5**	**4.6**	**3.64**

Again it very difficult to know with which option the minimum energy efficiency requirements for ENER lot 11 are reached. Nevertheless, as the improvement options that lead to the least life cycle cost already include a 50% increase in service value for the outdoor units and a 40% increase for the indoor unit, we will assume that the fans will meet the requirements.

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Without a fan measure, to go to the least life cycle cost, the manufacturer will follow the improvement options in the table above.

With a fan measure the manufacturer will do exactly the same thing, and in doing so he will meet the fan requirements.

In this case the fan measure will only put burden on the manufacturer, who will have to perform testing and will have to provide information, but in terms of energy efficiency the measure will not bring anything to the table.

Note: In the case no energy efficiency requirements are set on the indoor units, a fan measure would make sense as there is no other measure to ensure higher energy efficiencies for the indoor units.