Ecodesign Fan Review

Review study of Commission Regulation (EU) No 327/2011

Final report

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Acronyms

a	year (annum)
AC/DC	Alternating/Direct Current
ADCO	Administrative Co-operation
AHRI	American Air Conditioning, Heating and Refrigeration Institute
AMCA	Air Movement and Control Association
ATEX	ATmosphères EXplosibles
BC	Backward Curved
CECED	European Committee of Domestic Equipment Manufacturers
CEN	European Committee for Standardization
CFD	Computer Fluid Dynamics
CIRCA	Communication and Information Resource Centre
CLP	Classification, Labelling and Packaging (Regulation)
DigitalEurope	Association representing the digital technology industry in Europe
DoC	Document of Conformity
DoE	US Department of Energt
EC	Electronically Commutating
EN	European Norm
EPEE	European Partnership for Energy and the Environment
Eurovent	Association of European refrigeration, air conditioning, air handling, heating and ventilation industry
EVIA	European Ventilation Industry Association
FC	Forward Curved
GWh	Giga Watt hour 10^9 Wh
HNL	Howden Netherlands
ICSMS	Information and Communication System on Market Surveillance
ISO	International Standardisation Organisation
JBCE	Japan Business Council in Europe
JRAIA	Japan Refrigeration and Air Conditioning Industry Association
kW	kilo Watt, 103 W
N	Efficiency grade
Pa	Pascal (unit of pressure)
RAPEX	EU Rapid Alert System
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals (Regulation)
RoHS	Restriction of Hazardous Substances (directive)
rpm	rounds per minute (unit for fan rotation speed)
TC	Technical Committee (in ISO, CEN, etc.)
TWh	Tera Watt hour 10^{12} Wh
WEEE	Waste of electrical and electronic equipment (directive)
WG	Working Group (of a TC)
yr	year

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Executive summary

Industrial fans are currently using 300 TWh per year in electricity, making this group the third largest electricity consumer in the current Ecodesign scope after industrial motors and light sources. This industrial fan industry is well underway to save approximately 28 TWh/yr in 2020 with respect to a situation without Commission Regulation (EU) 327/2011, making a significant contribution to policy goals in global warming, energy security of supply, innovation and keeping EU jobs.

Taking into account the 'overlap' with other actual and planned Ecodesign measures, on e.g. motors, ventilation units and air conditioners, the net saving is still some 14 TWh/year in 2020. And with the measures proposed in this report the net saving could be approximately 10 TWh/year extra in 2030.

But there is 'no gain without pain'. Industries where fans are an auxiliary component, especially in the air conditioning sector, are reluctant to pay the extra costs for the more efficient fans. Producers of specialty industrial fans, produced in small series or tailor-made, are struggling to meet the minimum requirements and stay within the verification tolerances. And even in sectors where the fan is the core component like the ventilation unit industry, that is generally supportive of stringent measures, there are producers of so-called box- and rooftop fans that don't want to pay for the extra testing costs.

The fact that there is practically no market surveillance and that the volume-segments of the fan market continue to be invaded by low-cost imports does not really help.

Over the past four years, while the industry was busy transforming large parts of its catalogue to meet the requirements of the regulation, there have been no major developments in the metric underlying that regulation. The 'extended product approach' for part load testing, which is part of several other Ecodesign-regulated products, has hardly been explored by the sector. The change from the geometry-based categories to a functional pressure/volume flow approach is still in its infancy. A universal way to work noise requirements into the efficiency metric has not been touched.

In short, the definition of fan categories in test standards is almost the same making it very difficult to 'reduce the number of categories' or 'reduce the scope of the exemptions' as suggested in the review article (Art. 7) of the regulation. Instead, there have been numerous requests by stakeholders to vastly extend the number and nature of exemptions and make important changes with respect to spare parts, non-final assembly and the general scope.

Over the past 10 months the study team has made a comprehensive inventory of all grievances and has explored the boundaries of the current metric, trying to plant the seeds for a much needed update of that metric. A highly valuable result is a collection of close to 80 position papers from stakeholders, totaling over 500 pages, that has been made accessible and transparent through the project website. As a follow-up, this report makes tentative recommendations for the review, with various alternative routes on particular subjects, trying to find the right the balance between ambition and practical boundaries for a reviewed regulation.

1. Introduction

The purpose of this study is to provide background information to the Commission in relation to the revision of Commission Regulation 327/2011 with regard to ecodesign requirements for fans driven by motors with an electric input power between 125 W and 500 kW [1], as required according article 7 of said regulation:

"The Commission shall review this Regulation no later than 4 years after its entry into force and present the result of this review to the Ecodesign Consultation Forum. The review shall in particular assess the feasibility of reducing the number of fan types in order to reinforce competition on grounds of energy efficiency for fans which can fulfil a comparable function. The review shall also assess whether the scope of exemptions can be reduced, including allowances for dual use fans".

The assignment asks to address a number of specific tasks:

1. Reduce (differentiated minimum requirements for) fan types;
2. Reduce exemptions;
3. Adequacy of dual use allowance;
4. Requirements for jet fans;
5. Adequacy of market surveillance;
6. Deal with definition problems addressed in the Fan FAQ document.

At the same time, the study addressed, in consultation with the Commission policy officer, the myriad of problems signalled by the stakeholders regarding the current legislation, regarding scope, definitions, spare parts, new exemptions, non-final assembly, update of efficiency limits and benchmarks, etc..

The study started in April 2014.

[1] COMMISSION REGULATION (EU) No 327/2011 of 30 March 2011 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for fans driven by motors with an electric input power between 125 W and 500 kW, OJ.L 90, 8. 6.4.2011.

2. Consultation and data-retrieval

2.1 Methodology

The study was launched in April 2014, with a (draft) final report due in March 2015. In the first few months the study team made stakeholders aware of the project, by launching the project website www.fanreview.eu and informing the stakeholders, amongst others through presentation of objectives and content stakeholder associations. The website gave background documents, i.e. the 2008 Preparatory Study (Lot 11) and the 2011 Impact Assessment, and provided all necessary project information.

In parallel, through desk-research the stakeholder consultation was prepared. On 26 June VHK posted a survey with over 50 questions on the study website www.fanreview.eu and sent by email to 138 registered stakeholders on 26 June 2011. 28 Completed surveys were returned. The answers have been summarised in this report, together with some supplementary information from the study team based on desk research.

A first interim report, dated 31 July 2014 was published on the project website one month later (4.9.2014) and discussed in the first stakeholder meeting on the 1st of October. Presentation slides and the minutes of this first stakeholder meeting, attended by almost 60 stakeholders, can be found on the website.

Based on that meeting, several position papers and own research, VHK published a second interim document and discussion document on the 25th of November. This document treated the Regulation 327/2011 article-by-article, showing the original text, a proposal for a new text and considerations for that proposal. It also contained an analysis of the few scarce data available to propose new limits. This document evoked, as intended, a host of new position papers and a record interest (80 participants) in the second stakeholder meeting on the 22nd of January 2015.

The presentation slides of the second stakeholder meeting and the minutes can be found on the website.

All through the consultation process the study team was in contact with the European Commission policy officer, who was also present at plenary and several multi-lateral meetings with the stakeholder associations.

2.2 Position papers and other feedback

2.2.1 Before first stakeholder meeting

On 6 June 2014 HVAC-R manufacturer's association Eurovent published a first position paper, recommending to

- Provide clear definitions and clarify what exactly is in the scope of the measure.
- Ensure alignment with relevant EU legislation, EN and ISO standards in order to avoid differing and contradicting classifications.

- Make the revised Regulation coherent with other Ecodesign measures.
- Ensure that the Ecodesign methodology is respected.
- Evaluate the inclusion of spare-parts in the measure and
- Close unjustified loopholes.

Manufacturer's association EVIA presented a paper on fan efficiency slopes (by Helios) on the 4th of July. The paper proposes new slopes --not absolute values-- for the minimum efficiency limits, dividing the power range in 3 sections: 125W-1 kW (example axial fan slope 4.81LN(P)-8+N), 1-10 kW (slope 3.47LN(P)-8+N) and >10 (1.47LN(P)-3.38+N). The rationale is in following the slopes of the motor regulation, which are significantly lower for the small motors <1 kW.

This was followed by a second EVIA paper on fan efficiency slopes by Witt&Sohn on the 9th of July. It recommends to reduce the target efficiency for fans below 0.75 kW by making a new slope that is 5 % below the combined Fan Motor slope from directive 327-2011 EU and Motor slope from IEC 60034-30-1. The argument is motor regulation and fan laws show that this would be appropriate.

On the same date Eurovent issued a first position paper on Fan definitions, recommending basically to exclude the 'not final assemblies' section from the regulation because for fan testing only complete assemblies (impeller, motor and housing) give meaningful test results and comparable results. The Annex gives examples of a 'bare-shaft fan' and a 'motorised impeller' to prove its point. At the same time, Eurovent also shows that a minority of its members disagrees with this position and thinks that using default values for the 'missing' parts should continue.

On 14 July, Eurovent issued a position paper on replacement parts. It protests against the current regulation (Article 1, 3)d)) that stipulates that also replacement fans should comply with the ErP 2015 (Tier II) level. Reportedly this is in contrast with commercial practice where manufacturers have to be able to supply identical fans for a period of 10 years. It is thus recommended to exclude replacement fans, clearly marked as such, from the scope.

2.2.2 First interim report 31 July 2014

On 29 September, following the first interim report, Replacement Parts are again subject of an Eurovent paper, which brings extra arguments to the table, i.e. that also in the RoHS directive the spare parts are exempted, that not having proper spare parts will cause a premature end of the product life with a negative environmental impact or that if the spare parts cannot be produced anymore manufacturers will be forced to hold a large stock –if that would be allowed under the regulation—to respect commercial contracts. This option forces manufacturers into additional investment, storage capacity, and finally a lot of waste when the spare parts are not being used after all, according to Eurovent.

A second Eurovent paper of the same date calls for good Market Surveillance to protect the EU single market from extra-EU non-compliant products and guarantee a level playing field. It signals that market surveillance is hardly visible in the market today and that surveillance authorities, apart from funding, also lack sufficient testing facilities and know-how. Eurovent still favours self-declaration and thinks that third-party certification is no solution; an independent and knowledgeable surveillance is needed, especially regarding imported products. Eurovent is prepared to assist in identifying adequate test facilities.

And in that same period Eurovent sent its position paper on Box and Roof fans. Eurovent is aware that some manufacturers want to extend the Regulation scope to also include ‘box and roof fans’. To them, the benefit would be that fans inside a product need not be removed for the purpose of compliance testing. However, Eurovent holds that the current number and definition of fan categories as defined in the ‘EU Fan Regulation’ 327/2011 is correct and shall remain. It believes that an exemption of box and roof fans from the Regulation on Ventilation Units and adding these to the scope of the revised ‘EU Fan Regulation’ would prove counter-productive.

The EVIA position on the first interim report was received 30 September

EVIA’s key points are:

1. **Fans incorporated into products -** fans incorporated into products must be retained.
2. **Market Surveillance –** It should be enforced across all Member States.
3. **The Impeller -** an impeller is not a fan. It is a component of a fan and therefore should not be in the Regulation.
4. **Replacement fans -** EVIA sees it as a bigger problem that has to be solved before the 1 January 2015 and that of course will influence the decision in the review.
5. **Box and Roof Fans –** Roof and box fans should be within the future Regulation.
6. **The measurement and calculation method -** our proposal is to simplify by only having direct measurement and therefore removing not-final assembly. EVIA disagrees in reducing the number of categories.

EVIA agrees to remove the exemptions on ATEX and emergency use fans if sensible practical limits are set that considers the necessary design safety aspect that impact efficiency and is consistent with the EC Motor Regulation. EVIA does not see this as a potential loophole as products designed for high or low temperature are typically more expensive.

In answer to the question about third party verification, EVIA does not see that third party verification solves any problems within EC Regulation 327/2011.

The exclusion on fans for toxic, highly corrosive, abrasive environments the exclusion should be maintained. EVIA notes that a lack of a clear definition for such fans provides a loophole. EVIA therefore strongly recommends the consultant provides a clear definition.

On dual use fans EVIA agrees with the consultant’s clarification as an addition to the existing text in EC Regulation 327/2011.
Regarding efficiency levels EVIA agrees that there is a particular problem with small fans (125 W – 1kW) and agrees that there is a problem with dual use fans as of 2015.

2.2.3 First stakeholder meeting 1 October 2014

On the 2nd October the air conditioning manufacturer Daikin released its general position paper and case study on cascading. As regards spare parts, the Daikin position is similar to that of Eurovent (29 Sept.). It also thinks that incomplete assemblies should be excluded from fan regulation for reasons as stated by EVIA and Eurovent. Furthermore, at the end of its paper, Daikin agrees with using the best efficiency point –and not the nominal operating point—to determine the fan efficiency.

Most of Daikin's paper, and the example also given by Daikin, is about their position that 'cascading' (in later papers also referred to as 'double regulation') must be avoided, as it does not make sense from an economical and environmental point of view. This means that when an end-product with a fan is already subject to an Ecodesign regulation, such as room air conditioners, heating boilers, ventilation units, etc., its components should not be subject to another Ecodesign regulation and the designers/manufacturers should have the freedom to optimise costs and end-product efficiency without being forced to buy expensive fans. The example from Daikin wants to demonstrate that there are more cost-effective ways to reach efficient end-products and that thus the consumer is paying more than he/she should.

CECED brought forward its position paper on the fan review study. It agrees with the position of Daikin on cascading (here 'double regulation'), incomplete assemblies and spare parts (should not be part of the regulation). CECED thinks that all existing exemptions should be maintained. Fans not in the scope of the regulation should not have documentation requirements. CECED supplies technical information for the specific operating conditions of fans in laundry driers (but the 3 kW relates to the total drier power and should be changed), vacuum cleaners (>8000 rpm) and range hoods <280 W. These will be addressed later in this report. Furthermore CECED believes that the slopes for fans <750W should be revisited in the light of the motor regulation.

The months of October and November saw the publication of

- Eurovent position paper on Cooling towers
- EBM Papst position paper and data on Efficient motors and Small fans 30-125W
- Multi-Wing position paper on Fan Regulation
- Joint industry position papers on the Fan Regulation and Spare parts
- Howden position papers on Not Final Assembly and Replacement Fans

Howden Netherlands makes the point that if the non-final assembly option were to be simply removed from the regulation this would mean that the main product sold by Howden NL (bare shaft impellers) would no longer be considered a fan and as such would no longer fall under the regulation directly. This would then put customers in a very difficult position of then becoming the party that places a fan on the market, making them responsible for having to prove conformity to the efficiency criteria.

Under the current regulation this would then mean that they would not be able to use a calculation method to determine the fan efficiency but would be obligated to experimentally determine the efficiency of the fan in their installation. (note that this could be a 12 meter diameter fan in an air-cooled condenser positioned 20 to 50 meters above ground level). From experience HNL believes it to be unrealistic to require our customers to perform such on-site tests. The amount of time and cost required to perform this type of testing is quite severe and the overall accuracies that can typically be achieved on-site are limited, even when the test is conducted by highly skilled and experienced personnel.

As regards replacement fans Howden addresses air cooled condenser (ACC) fans, typically equipped with a large number of identical fans with a diameter of 28-38ft (8 - 12 meters). ACC's with 20-60 fans are not uncommon and ACC's with over 100 fans (especially at larger power plants) also occur. In these configurations customers want to keep on using identical fans for replacement, according to Howden. Howden also supplies to nuclear plants and here, over the up to 40 years life of the plant, the customers require identical fans for safety reasons.

The Multi-Wing position is similar to that of Howden, i.e. that the 'non-final assembly' section –even though not ideal—at least gives this Danish impeller manufacturer the possibility of compliance testing. Multi-Wing makes the point that required air distribution to maximize cooling power in a unit is different from the requirement to maximize ventilation fan efficiency. Examples given are oil coolers, where there supposedly is no space for bell-mouths and other aerodynamic optimisation, and (as Howden) cooling towers.

In its position paper of 18 November, Eurovent now asks for an exemption for cooling towers, because of

- dimensional problems (too big to test),
- the fan system cannot feasibly be separated to make fan efficiency measurements,
- Cooling towers are not off-the-shelve, standardised products
- An exemption is not going to lead to lower energy efficiencies of cooling towers
- Cooling tower manufacturers as integrators of fans/impellers place a different product on market than a fan.
- Speed and noise requirements (low noise, low speed)

Based on the low volume of energy savings, the applicability of other more relevant metrics, the potential for unintended increases in fan energy use, and the design challenges detailed above, Eurovent and its members recommend that fans used in cooling towers to be exempted from the 'EU Fan Regulation'. Eurovent mentions that in the US, a similar request was made by AHRI, the American Air Conditioning, Heating and Refrigeration Institute. American manufacturers face similar issues with regard to the Rulemaking on Commercial and Industrial Fans and Blowers (US Department of Energy, DOE).

The joint industry paper summarises CECED, DIGITALEUROPE, EPEE, JBCE and JRAIA's comments related to the first interim report in the framework of the Fan Regulation review that was published in July 2014 and to the stakeholder meeting that took place on October 1st. It addresses the following key areas of concern:

- Scope
- Double regulation
- Replacement fans
- Additional product categories
- Ecodesign information requirements
- Exclusions for impellers and fans in tumble dryers and kitchen hoods
- Market surveillance

The paper is a compilation of the earlier position papers of these industry organisations and their members (e.g. Daikin) on these issues.

In the separate paper on spare parts the above joint industries call for an exemption for spare parts, for reasons mentioned earlier.

2.2.4 Discussion document

In December, after the publication of the Discussion document on the 25th of November, the study team received the Eurovent position paper.

Eurovent was positive on:

- The clear definition of a 'fan' (...' a major improvement')
- Exclusion of 'not final assembly' from the legislation ('.. a significant simplification .. also avoids currently persisting contradictions and complications resulting from having the impeller in the scope').
- No extension of the scope towards 'box and roof fans'('..current number and definition of fan categories as defined in the current Regulation is correct and shall remain')
- Allowing for a 'grace period' of 5 years regarding a replacement of no longer compliant fans ('..support this compromise solution... would still appreciate a concrete line of action concerning the current Regulation in place).
- Internal design control as a conformity assessment procedure ('..effective market surveillance is essential to protect the EU market from non-compliant products. While encouraging a flexible use of conformity assessment procedures as outlined within Decision 768/2008, we hold that third-party certification is not the right approach.')

Eurovent voiced concerns/amendments on the following issues:

- The exemptions of kitchen hoods, laundry and washer dryers.(creates artificial division in the technical standard; largely commercial-based arguments as valid enough to justify these exemptions. Please reconsider)

- The 10% allowance is too little for ATEX fans. 'Given the very small size of the market..regulating them is probably not justified. If a requirement must apply, it must be different according to the category of the product — a Category 1 fan is subject to heavier impacting design requirements than a Category 3 fan. The improvement in the technology of fans for standard applications may also not be possible for ATEX fans...'

Merging the three current categories for <u>centrifugal fans</u> (forward-curved, backward-curved without scroll, backward-curved with scroll) into one, because. The three existing main types of centrifugal fans may be optimised for the same applications, but result in radically different optimal shapes and dimensions. A restriction of designers' options regarding fan types in combination with physical constraints leads to a choice of a non-optimum size of fan when operating in off-design duty, which results in an unsatisfactory operating efficiency ..and operating noise levels. Since drafting the existing Regulation 327/2011 no change in technology was introduced that would justify different conclusions. This is particularly true regarding the difference between forward and backward-curved fans. Eurovent proposes to unify just backward-curved fans with and without scrolls into a single category and retain a separate category for FC and radial fans.

<u>Centrifugal fans:</u> Regarding the proposed efficiency levels for 2018 and 2020 Eurovent finds that in many cases, the suggested values for centrifugal fans significantly exceed the best available technology as recorded during the development of the current Regulation 327/2011, ANNEX IV. There is a limit to the improvement of technology and efficiency, and the suggested further steps imply a progressively increasing technological challenge without evidence that it may be available in the timeframe given within the 'discussion document'. Each regulatory step requires a significant investment from the European industry to adjust its product ranges. The typical payback time for industrial investments in the current economic climate in the European Union is three years or more. A legislation requiring repeated redesigns every two or, at the most, three years is financially not sustainable. Eurovent recommends not to increase the number of power sub ranges, and to rather keep the existing two.

Eurovent members are evaluating options for a single further level of efficiency requirements involving either a change in the slope or just the height of the curves. Any such further requirement should not come into force before 2020, i.e. after the European industry had a chance to recover the investment done in order to fulfil Tier II requirements of Regulation 327/2011.

<u>Axial fans:</u> keep the existing power sub ranges and equations, and increase the N-value for installation types A and C, from N=40 in 2015 to N=42 in 2020, while keeping the current value for N for installation types B and D, as this value is considered to already be at the technology limit.

<u>Jet fans:</u> Due to the very special and specific definition of energy efficiency adopted for jet fans, Eurovent suggests to completely separate axial jet fans and centrifugal jet fans from other fan types.

<u>Mixed-flow fans:</u> Eurovent suggests to keep the existing power sub ranges and equations, and to increase the N-value for installation types A and C, from N=50 in 2015 to N=52 in 2020, and to increase the N-value for installation types B and D, from N=62 in 2015 to N=64 in 2020.

Forward-curved fans: Keep the existing power sub ranges and equations, and increase the N-value for installation types A and C, from N=44 in 2015 to N=46 in 2020, and increase the N-value for installation types B and D, from N=49 in 2015 to N=51 in 2020.

Other issues: Regarding emergency fans, Eurovent holds that the words 'of 1 hour or more' should be deleted, because they conflict with at least one of the classes defined in EN12101-3. Regarding 'fans handling toxic, highly corrosive or flammable gases or vapours' Eurovent states that the addition of the reference to Regulation (EC) No 1272/2008 does not help to distinguish real special purpose fans from more standard designs, but offers no alternative. Regarding the fan definition Eurovent suggests to replace the term 'stator' by 'stationary aerodynamic parts'. This is due to the fact that the word 'stator' might generate confusion with the part of an electric motor.

Eurovent also handed in a separate position paper on the Working definition 'placing on the market' and Extended position on cooling towers. In the first paper Eurovent proposes (similar to the intention of the Working document) as a working definition:

A complete fan, suitable to be evaluated for compliance with Ecodesign requirements, is sold by the manufacturer to an independent integrator for incorporation into a different product. The fan is considered already placed on the market at the time of the first documented transfer of ownership. As such, it must comply with the legal requirements at that time, and it can then freely circulate or be installed within the EU Common Market, even in case of revisions to the applicable legislation or the relevant harmonised standard.

In the second paper Eurovent re-iterates the case for excluding cooling tower fans from the legislation, arguing that –according to their understanding— using the cooling tower as a 'stator' is impossible, given the complex design constraints. For example, the components involved (*in an evaporative cooling tower*) that have an impact on the fan are, inter alia:

- The water flow,
- The type and quantity of packing,
- The type of water distribution,
- The presence and definition of the sound attenuators at the inlets, at the outlets. the types of drift eliminators,
- The use of plume abatement coils.

Eurovent also points to the small market size (unit sales < 10 000/year), testing problems (especially of the large fans up to 12 m diameter) and the fact that cooling tower fans are not optimised for air displacement (which is also the current focus of testing) but for cooling.

In January 2015, Eurovent follows-up with a structured overview of the above proposed amendments to the discussion document. A new suggestion is that the Fan Regulation must be clearer about the operating point for bep, i.e. along the maximum performance boundary or at any duty point within the achievable performance. 'Regulation 327/2011 EC does not require that the nominal best efficiency of the fan is measured along the maximum performance boundary. The proposed EN/ISO 12759 standard requires that such maximum is measured along the boundary. Restricting the measurement of the best efficiency to the boundary curve may lead the manufacturer to underestimate the absolute best efficiency of the fan. Leaving the choice of the best efficiency duty point unrestricted may allow for the option to design the drive system to deliberately move the best efficiency duty point below the 125W limit.'

Regarding the new definition of 'test fan', Eurovent holds that the proposed text is entering too deeply into the practical details of testing. To be truly technology independent, we strongly hold that it has to be more general. It is widely known that scaling procedures are not universally accepted within the industry, because the amount of efficiency improvement with the fan size and Reynolds number is not completely agreed. Scaling should be kept only as a last resort. Enough testing equipment is available at European independent laboratories to allow for testing at full size fans having an impeller diameter as large as 1 or even 2 meters. The effect of changing the fan speed while testing is generally less controversial than the effect of testing a geometrically scaled down model.

Also in January, EVIA presents its position paper on the discussion document and supporting document on indicative benchmarking.

EVIA welcomes the proposal to remove 'not-final-assembly' from the regulation as this resolves problems with impellers, motor default values and compensation factors. EVIA sees the proposal to provide a 5 year grace period for spare parts as a benefit for manufacturers, users and the environment.

But EVIA has serious concerns regarding the proposed slopes, limits and allowances for specific fans, which they consider flawed, too high, not in line with market and not backed-up by an impact study. Specifically EVIA does not agree with the notion that the new motor regulation with more stringent motor efficiency limits would necessarily lead to higher fan efficiency limits, because in the original fan study these higher efficiency values were already taken into account.

EVIA believes the indicative benchmark levels in the current regulation are wrong and do not clearly represent what is possible. A fundamental problem of the indicative benchmarks is that they do not consider the fan speed, size, the duty point, or specific volume characteristic – (static to total pressure ratio). For one input power there is a range of indicative benchmarks efficiency points depending on these variables. EVIA provides a supporting document that elaborates on a) the differences in efficiency depending on the number of poles of the motor and b) the specific volume/pressure ratio.

Forward curved fans: The proposed level for centrifugal fans will result in the removal of forward curved fans from the market. EVIA does not agree with the statement that forward curved fans offer no unique qualities that cannot be reached with a backward curved fan. The forward curved fan has a higher power density and improved subjective acoustic characteristics and therefore demonstrates an environmental advantage over the backward curved centrifugal. EVIA suggests keeping a separate limit with a change of slope; e.g. use the backward curved slope and a level of N52 (static) for 2020. This has a small increase for the small fans and a large increase for 10kW and above. As Eurovent, EVIA thinks an interim slope for 2018 will be too great an impact on the industry. 'If these revisions come into force in 2016 then the industry will need at least three to four years to develop the technology.'

For axial fans EVIA recognizes that there is room for improvement and proposes the same slope as centrifugal fans (simplifies the regulation) with an N value of N48 (static) for 2020. The difference between static and total limits of the current regulation is too great. The difference between the 2013 static and total limits was 14, which increased to 18 for 2015. For axial fans this should be a maximum of 12. Hence EVIA proposes N=62 (total pressure) for axial fans, which is still a considerable increase.

For backward-curved centrifugal fans EVIA can see no technical measures in the foreseeable future to increase the efficiency of these fans to justify an increase from the current level of N62 (static), unless the category is subdivided in various categories and subcategories, which would not be in line with the wish for simplification.

For mixed flow fans, EVIA agrees with the discussion document to take intermediate values between axial and BC-centrifugal.

As regards small fans, EVIA thinks that the current levels are more challenging for small fans than large fans. They have addressed this problem with the slopes discussed above that provide a small increase for small fans and a larger increase for large fans. EVIA would like to stress that any increase in the small fans would be very challenging and should be taken into consideration.

Regarding dual use fans, EVIA states that, as the limits of standard fans are increased, the allowance for dual use fans and ATEX fans needs to be increased.

EVIA proposes that the limit for a reversible axial fan is at 10% below the regulated limit.[2]

EVIA agrees with the inclusion of ATEX fans when ATEX motors are regulated in the motor regulation. EVIA does not agree with the proposed allowance until an appropriate study is undertaken and the ATEX motors are regulated.
Jet fans: EVIA strongly requests that the regulation follows the technical draft standard ISO 13350 and cannot agree with the limits proposed until the correct methodology is included.

Other issues:

- Regarding Annex 1, new definition (19) test fans: The limit of 1m is too low we propose 1,6m.
- Regarding roof fans and box fans EVIA restates its position that it supports the inclusion of roof fans and box fans in this regulation.
- EVIA restates its position in respect to exemptions and refers to the discussion document figure 6.
- 9. Annexe 1 requirements 2 (6) year of manufacture: This requirement is for the product and cannot be for the free access website.

From individual manufacturers position papers on the discussion document were received:

[2] VHK clarification: From the 2nd stakeholder meeting it became clear that for a fan that is both dual use and reversible EVIA intends it to be accumulative, i.e. a factor 0.9 x 0.9= 0.81 of the default regulated limit

- German fan manufacturer Witt & Sohn,
- French fan manufacturer Aldes,
- Danish cooling fan manufacturer Multi-Wing,
- The Swedish division of Fläkt Woods (as far as industrial fans are concerned part of US agglomerate Howden),
- The Netherlands-based professional printer manufacturer Océ Technologies (subsidiary of Japanese Canon),
- The Belgium-based European headquarters of Japanese (room) air conditioning manufacturer Daikin.

The Witt & Sohn position paper addresses the proposed slopes in the Discussion document and advocates to continue to use the ISO 12759 slopes, because they are global (except possibly in the US) and thus good for the EU competitive position.

In Aldes comments on the Discussion document, the French fan manufacturer greatly appreciates the 5 year tolerance period for spare parts and the removal of the non-final assembly procedure. Aldes is also glad to see that you did not add a separate category for Box and roof fans, what would have endangered the level playing field between ventilation units manufacturers sourcing their fans by oem and those producing their own fans.

However, Aldes is not happy with the two tiers; he proposes one tier in 2020. Also he thinks the limits for centrifugal fans in the discussion document are too high. The level proposed in the discussion document may be acceptable for fans in large Air Handling Units working in the range 700– 1200 Pa. But for other specific application like decentralized ventilation or low pressure ventilation (commonly used in retrofitting of shaft natural ventilation in collective housing), this requirement would be unreachable, although fan operating at lower pressure consume less energy for the same amount of air moved. It would have been an option to take into account pressure, airflow, speed, part load (...) in setting requirements, but it would have been complex. For the sake of simplicity the approach of the regulation is acceptable but low pressure applications with the best available technologies must be kept on the market. Aldes thus proposes a 2 points increase in 2020 compared to 2015 (instead of the 8 points in the discussion documents).

If the above Aldes-propositions are respected, i.e only a slight increase compared to 2015 levels and only one Tier in 2020, a single requirement for centrifugal fans may be acceptable. That would ban forward curved fans from the market in 2020 and ensure high energy savings in most of the case, according to Aldes.

The Danish cooling fan manufacturer Multi-Wing presents its Multi-Wing's policy guidelines and recommended policy guidelines for integrated and built-in fans. Basically Multi-Wing echoes the arguments brought forward by the latest Eurovent paper on cooling towers and mentions similar problems with (motor) cooling fans. Multi-Wing then elaborates proposals to solve the problem of compliance testing by defining a strict orifice test rig for these fans.

Fläkt Woods Ltd. fully supports the EVIA position paper on the Discussion document, especially regarding axial fans. He makes the case for an additional allowance for reversible fans. ‘Reversible fans are used in dual use normal / emergency applications where there is already a proposed 5% allowance. This allowance goes some way to address the inherent loss in performance due to the increased clearances required for the high temperature condition. However, reversible fans cannot employ the efficiency improvement technologies that are available to unidirectional fans, such as aerofoil blade sections and guide vanes, since to do so would render them non-reversible. Therefore, without an additional allowance for reversible fans, such products will progressively become non-compliant. This will then lead to an increase in energy consumption. Such a counter intuitive scenario arises from the main requirement behind the demand for reversible fans. The applications are typically underground or retrofit, where there is insufficient space to accommodate two complete installations for separate extract and supply. It has long been apparent that, when two unidirectional fan installations are fitted into the space of a single reversible one, the adverse installation effects far outweigh the potential gains in the catalogued fan efficiency.'

The position paper by Netherlands-based Océ Technologies (subsidiary of Japanese Canon), who uses fans in their printer equipment, outlines the following key areas of concern,

- Inefficiency caused by replacement of electric input power with aerodynamic output power, e.g. promoting the use of inefficient fans in order to stay below the 50W limit (proposed in the discussion document as an alternative).
- One combined minimum efficiency for centrifugal fans (backward and forward curved) is unfavourable for applications that require small and quiet (forward curved) fans.
- Introducing correction factors to include power supply energy losses leads to needless complexity, e.g. if you correct for AC-DC conversion you should also correct for power factor.

In its position paper air conditioner manufacturer Daikin wants to underline that the current discussion document lacks necessary evidence to change the current requirements. The discussion document is from this perspective not robust enough to take any other conclusion. Also for the discussion points raised, there has been no additional investigation to substantiate the positions taken.

Daikin has evaluated the discussion document and supports positions for exclusion of non-complete-assembly from the scope of fan regulation, and the proposal not to extend the scope of regulation to fans below 125W. Daikin re-iterates its position on 'double regulation', where it finds no merit for environment or consumer and it stresses that the regulatory context for HVAC equipment has changed considerably since the introduction of the current regulation. In addition, Daikin signals the problem of different tiers (and their timing) from different Ecodesign regulations (on motors, fans, room air conditioners, boilers, etc.). The difficulty of market surveillance in HVAC products without specific fan testing know-how and tools tailored to HVAC products. Meaningful regulation of fans integrated in products that are already covered by other Ecodesign measures will not lead to reduced energy consumption and limits innovation.

As regards axial fans, Daikin mentions they use propeller fans because of the compact design and can --for space reasons-- not use the more efficient tube-axial or vane-axial fans. Thus, the requirements are too high. Also with centrifugal fans there is no space to use the more efficient centrifugal backward curved ('turbo') fans, because for the given operating point, they are bigger than the forward curved ('Sirocco') fans that Daikin uses. Therefore the forward curved fans should remain.

Daikin elaborates on that by giving an example with two design options for their product. Regarding the definition of best efficiency point Daikin supports the discussion document “on clarification of best efficiency point as a relative value to be set at any operating point on the qv - Δp curve because the current fan regulation has been based on this method. Any change without a sufficient analysis on possible consequences would potentially create huge burden on Industry. As such, the current interpretation shall be maintained.”

Daikin re-iterates its position that spare parts should be fully excluded from the scope and that 5 years is not enough to ensure the functioning of our products during their life time. It forces manufacturers to prematurely predict amounts and de-facto will create a shortage or abundance of these spare parts with necessary consequences towards waste (if too much is predicted) or customer satisfaction (if too little is predicted). In the Annex, Daikin elaborates on practical testing problems where fans are incorporated in HVAC-products: Either one extracts the fan for testing, which has the problem the housing/nozzle of the fans being an integral part of the end product, or one tests the fan inside the product. “This requires the extraction of the other components from the equipment as some might affect the external static pressure. With DC fans, the fans are controlled by a PCB; nevertheless, in an HVAC product, the PCB also controls the other components of the unit, such as the compressor. By taking out these other components, the PCB might give an error, and to solve this error, specifically dedicated fan testing know-how and tools are necessary.”

2.2.5 Second stakeholder meeting

After the 2nd stakeholder meeting in February, the Witt & Sohn paper gives a detailed overview and examples of the possible technical challenges with dual use, ATEX, reversible and other special fans, which necessitate wider tip clearances, symmetrical blades, etc.. As regards axial fans, Witt & Sohn proposes, different from EVIA, to keep the current (ISO 12759) slope for axial fans but with the new efficiency grade N=62 (total pressure).

Soler & Palau addressed the verification tolerance which is proposed to be changed from 0,9 to 0,93 in the discussion document. S&P argues that the comparison with the one used in the ventilation units regulation is not fair. Any change should be based on a deep and technical analysis, also taking into account production tolerances. Soler & Palau considers it needs a 0.9 tolerance to consider all uncertainties. “As an example, the aerodynamic efficiency deviation in a typical axial fan when is manufactured with a tolerance pitch angle ±1º, results in an aerodynamic efficiency deviation of 0,95. Together with the motor tolerance (also 0.95) this gives a tolerance of 0.9 (=0.95 x 0.95).”

The discussion and proposal paper by leading manufacturer Ebmpapst, one of the fan manufacturers providing the best ErP-data both on their website and in contributing to the review-study, is in fact a compilation of papers:

1. The discussion document on backward curved fans shows, by supplying a scatter diagram of Ebmpapst models, that the slope proposed in the discussion document is too lenient for small fans and too strict for high-power fans. Instead, the current slope should be maintained.

2. A second document ‘no to reducing the limit for small fans’ builds on that and concludes that “It is seen that the market has responded to the requirements of the fan regulation 327/2011 and that technology is available to increase the efficiency of small fans. A reduction of the current limits would be a backward step and could result in an increase in energy consumption.

3. As regards fans integrated in other energy related products, Ebmpapst states that “ If the scope of the ecodesign fan regulation 327/2011 is changed to exclude those integrated in other energy-related products then a loophole is created. Energy related product produced outside of the EU and imported into the EU would not need to use fans that meet the fan regulation limit. They could revert back to using the less efficient fans used before January 2013 when the regulation came into force. It can be foreseen that energy-related equipment manufacturers would move their production outside of the EU to compete with those already outside using the cheaper less efficient fans. They are unlikely to continue to use the higher efficient fans manufactured in the EU and would replace them with less efficient ones. The 1.75 TWh saving to date would be lost plus the additional saving from tier 2. 99% of the 2 million units placed in the EU market by Ebmpapst are subsequently integrated in other energy using products. Ebmpapst is typical of many large European fan manufacturers.” Ebmpapst concludes that “The ecodesign fan regulation 327/2011 is effective. Even without any market surveillance and enforcement … €4.2 revenue and tens of thousands of jobs would be lost if the European Commission succumbs to the pressure to adversely change the scope of the regulation.”

4. Regarding extension of the scope of fan regulation 327/2011 to smaller fans (30-125 W), Ebmpapst claims that "There is an opportunity for a further 525 GWh/year saving in the short term by the simple extension of the scope of regulation 327/2011 (EU, 2011) to cover smaller fans. The 2011 Study on Amended Working Plan (VHK, 2011) identified a savings potential of small fans (<125 W) of 21.4 PJ/year by 2030. An extension of the scope of the current ecodesign requirements for fans below 125 W would be a simple implementation of the proposal of the study. It would set the path for future up lifts of limits to achieve the projected 21.4 PJ/year savings by 2030. The proposal is to extend the scope to include fans with input power between 30 W and 125 W. Specifically to set efficiency grade N27 for axial fans and forward curved centrifugal fans and N37 for centrifugal backward curved fans, using the static efficiency category. The negative impact is low as the proposal would use long established technology that can be applied with minimum change using the frame work of the current regulation. A new separate study would not be needed to consider a separate regulation. This would save cost to the Commission and industry and deliver energy savings in a few years."

5. The Ebmpapst proposal to fix a loophole in the fan regulation with respect to Mixed Flow Fans is as follows: “The definition of mixed flow fans has created a loophole where subtle physical design geometry provides a potential to lose 0.9TWh/year savings. We propose to split the mixed fan group in two sub-groups so that limits can be set that reflect the true aerodynamic potential of the fan. We propose an efficiency grade N50 for mixed flow fans with a ɑ angle of ≥20° to ≤45° and N58 for ɑ angle ≥45° to ≤70°. What needs to be considered is that a mixed flow can be right in the middle with an ɑ angle of 45°, but it could be more like an axial fan if the ɑ angle is closer to 20°, in which case the target level is tough compared to the axial target of 32.9%. Or it could be more like a backward fan in characteristic if the ɑ angle is closer to 70°, in which case the target is much too easy compared to the backward curved of 50.2%. It can be seen that clever geometry of a mixed flow fans will realise an alternative to backward curved with a very low efficiency target.

A mixed flow could be designed with an α angle of 69°, 1° less than a backward curved fan, and then need meet a much lower energy target." This is illustrated by a scatter-diagram. Ebmpapst concludes "Taking a typical input power of 0.75 kW, the output air power of a backward curved fan would be 0.4 kW. A mixed flow fan meeting the same output air power and meeting the lower mixed flow limit would consume 0.9 kW, a 0.15 kW increase."

6. Regarding the increase of the limit of Axial Fans, Ebmpapst's proposal is to increase the static efficiency category limit from N40 (using the current slope 2.74xln(P)-6.33+40) to N50 (using the slope 4.56xln(P)-10.5+50). "We see that most of our fans are used as components in other energy-related products and an energy efficiency assessment using static pressure is the correct way. The MEL based on total pressure could also be increased but we do not have any figures to discuss the pros and cons of such a change. However if the total pressure is not increased then a loophole can be created whereby fans could be assessed using the total pressure equations even though they are not intended to be used in an application where the total pressure is utilised."

7. Regarding the increase of the limit of Backward Curved Centrifugal fans, Ebmpapst proposes that the minimum energy efficiency limit (MEL) of backward curved centrifugal fans can be raised from the current N62 to N64. This will increase energy saving by 78 GWh/year according to Ebmpapst. However, the slope in the current regulation should be maintained.

8. Regarding the increase of the limit of Forward Curved Centrifugal Fans, Ebmpapst states that the limit can be raised from N44, using current slope, to N54 using the backward curved slope (static efficiency category).

Ebmpapst also gives its own calculation of the possible energy savings from their proposals. This is summarised by the study team in the table below.

Table 1. Summary of savings from Ebmpapst measures proposed above (fans <10 kW)

Ebmpapst										VHK***		
Item	**Fans concerned**	**EP sales**	**EU production**	**EU (imports-exports)**	**power**	**Proposal**	**Saving/ fan**	**EU sales affected**		**saving on annual sales**	**saving at stock change (15 yr)**	**saving lost (15 yr)**
		m units	*m units*	*m units*	*kW*		*kW*	*m units*	*%*	*GWh/yr*	*TWh/yr*	*TWh/yr*
4	**small fans 30-125W**	0.46	2.3	2.3	0.075	N27 (Ax), N37 (Centr.)	0.038	4.6	100%	524	7.9	
		fans with shaded pole motor sales*										
5	**Mixed flow, loophole**	40% BC	1.15	1.15	0.750	split 20-45°-->N=50; >45-70°-->N=58 **	0.150	2.3	100%	1035		15.5
6	**Axial fan limits**	0.70	3.50	3.50	0.750	N40-->N50 (static)	0.090	0.7	20%	378	5.7	
7	**BC centrifugal limits***	0.58	2.90	2.90	1.000	N62-->N64 (static)	0.034	0.46	16%	95	1.4	
8	**FC centrifugal limits**	0.62	3.10	3.10	0.750	N44-->N54 (static)	0.050	0.46	15%	140	2.1	
	TOTAL									**2172**	**17.0**	**15.5**

*Ecodesign WP2 estimates total small fans at 11 m production + 11 m imports - 2.2 m exports= 20-21 m apparent consumption. Of this Ebmpapst produces 5.24 m small fans, of which 0.46 m shaded pole (9%). The measure would phase out shaded pole motors, i.e. replace them by capacitor AC motors and thus double efficiency.

**VHK comment: not symmetrical to the median between their newly proposed limits for axial (N=50) and BC centrifugal (N=64), so probably needs updating (e.g. split 20-45°-->N=54; >45-70°-->N=60)

***=VHK calculated on the basis of Ebmpapst data, with 3000h/yr for small fans (half 20%, half 50% of 8760h/yr) and 5000h/yr for others. EBM gives only saving on annual sales, with small deviations (~10%) from VHK. The usual savings are calculated at complete stock change, i.e. after 15 years.

The discussion document of Ziehl-Abegg gives a detailed overview showing that the actual given efficiencies from the discussion document are not possible to be achieved for fans with the highest possible motor efficiency (IE 3) when the power input is higher than 2 kW (axial) or 5 kW (centrifugal).. Proposed slopes are based on the EVIA proposal and on one TIER coming into force in 2020. Calculation is done on a theoretical base and by using the efficiencies of the component impeller and motor in their best efficiency points.

Ziehl-Abegg concludes that for the so called axial propeller fans, due to the lower achievable maximum efficiency, the efficiency grade must be reduced. They propose a reduction of the efficiency grade of the axial category by 4% points if it is a fan with a maximum static pressure of 300 Pa at its best efficiency point.

For mixed flow fans it is preferred to have the same slope as used for backward curved fans. Definition of only one efficiency grade makes sense to avoid developments for low efficient mixed flow fans with a more axial oriented angle between 20° and 45°.

The cap for forward curved fans over 5 kW input power is acceptable. The efficiency grades for the centrifugal fans are already very high, but an increase of 2 % (N64) in the efficiency grade could be accepted.

Nuaire explains that dual purpose smoke ventilation fans are third party certified (at considerable expense) under EN 12101-3 as a requirement of the Construction Products Regulation, fulfilling both ventilation and emergency smoke extraction, and as such, the tip clearance for this fan type is greater than that of ambient temperature fans. The maximum rise in motor efficiency between IE2 and IE3 is 2.5%. The combination of reduced tip clearance and IE3 motor will not improve the efficiency of the product by 13% as is required by the current regulation. This will mean that fans which are required for dual purpose operation will not be available throughout Europe after 1/01/2015 should these regulations remain unchanged.

Howden show in its paper that the proposed minimum requirements for fan efficiency for 2018 and 2020 as documented in the discussion document are too high (especially above 10kW the requirements are too high) and would require impeller efficiencies which are unrealistic for a rotor-only axial cooling fan.

Furthermore, Howden strongly believes that a revision of the current regulation must not lead to a situation where low noise fan designs are banned from the EU market. The benefits these fan designs offer with regard to their noise characteristics outweighs their lower efficiency figures.

Howden proposes a compensation for low noise fans of 10 percentage points with regard to the minimum required efficiency. Where low noise fans are defined as a fan having a characteristic noise emission value C = 32 dB(A).

Where[3],

$$C = PWL_{impeller} - 30\log u_{tip} - 10\log\frac{Q\,FSP}{1000} + 5\log D_{impeller}$$

[3] EU commission BREF: Integrated Pollution Prevention and Control (IPPC) Reference document on the application of best available techniques to industrial cooling systems, December 2001.
Spek H. van der, 1993, CTI TP93-03 "Reduction of Noise Generation by Cooling Fans"

C	Characteristic noise emission value	[dB (A)]
$PWL_{impeller}$	Impeller sound power level	[dB (A)]
u_{tip}	Impeller tip speed	[m/s]
Q	Air volume flow rate	[m^3/s]
FSP	Fan static pressure	[Pa]
$D_{impeller}$	Impeller diameter	[m]

In the position paper of Torin-Sifan three key issues were raised:
The role of forward curved centrifugal fans in the market vs. backward curved variants, the slope of forward curved centrifugal fans and the timing of change.

Torin-Sifan agrees with EVIAs suggestion that forward curved fans are more crucial at lower input powers <5kW. At powers >5kW there is no role for forward curved fans.

Concerning the slopes Torin-Sifan fully supports the EVIA proposed slope and N52 Level. This allows the use of forward curved fans where needed at BAT level. In order to be able to deal with new proposed requirements the first TIER after 2015 would have to be set in 2020. This gives the industry time to redesign there products.

European AMCA proposes in addition to Nuaire's statements on dual use fan to use the definitions in EN 12101-3 as this test standard has received a positive vote and is ready to be published in the OJ.

Powered Smoke and Heat Control Ventilators" (PSHC ventilators).
See Definition 3.2 on Page 8. "Powered smoke and heat control ventilator PSHC ventilator: smoke-ventilating fan that is suitable for handling smoke and hot gases for a specified time/temperature profile"
The so-called Dual Use Fan is correctly referred to as a "Dual Purpose PSHC ventilator". The definition is in clause 3.3."Dual purpose PSHC ventilator: smoke-ventilating fan that has provision to allow its use for comfort (i.e. day to day) ventilation".

A high temperature fan test will typically cost between €4000 and €6000 per fan in sizes up to 75/80 kW. At higher powers, the costs can escalate to €25k/30k per fan. A minimum of 3 tests is typically required to certify a range of fans from 400mm to 1250mm Dia. Each fan tested cannot be re-used and has to be scrapped after the test at a cost of between €3000 and €30000. The additional cost of documentation preparation, verification and certification of a new range is typically €20k.The certification of physically larger and higher power fans will cost significantly more. The costs for a single fan of between 300kW and 500kW are not a lot different from those incurred in the certification of a complete range of smaller sizes.

On ATEX fans European AMCA states that it is not easy to set minimum energy efficiency requirements as safety is their main concern.
For truly reversible fans (the reversible fan design must ensure that the volume flow rate, at the maximum operating speed, at the B.E.P., when running in reverse-flow mode, is between 100% and 80% of the volume flow rate of the same fan, measured at the maximum normal speed and at the B.E.P., but in normal forward flow) European AMCA would like to see a 10% reduction added in the future regulation. These fans are similar to the dual use fans.
The last point is that there is a need for more realistic target efficiencies for Forward Curved Centrifugal Fans.

ELTA group states that the reduction of fan categories will result in the misapplication of an efficient fan operating far from its best efficiency point in order to comply with a pared down fan regulation. Furthermore, the 5% allowance for dual use fans should be increased for the same reasons as mentioned by Nuaire and European AMCA. Proposals on requirements for ATEX fans should only be made after it is clear if they will be included in the revised motor Regulation.

Helios' position paper states that Box and Roof fans should be included in the revised fan regulation as a separate category. As minimum efficiency requirements they propose to use exactly the same fan efficiency values: ηVU as required in regulation EU 1253/2014 for tier 2 (2018).

In the paper by Mr. William Cory it can be found that even a small improvement in efficiency of one or two percent can only be achieved by a great effort and the proposed efficiencies in the discussion document would lead to big problems for SME's.

JRAIA raises some concerns in there paper that can be summarised as:

- Double regulation should be avoided; "Fans incorporated into products" should be excluded from the scope.
- Exclusion of "not-final-assembly" from the regulation is welcomed.
- The existing category of a centrifugal fan should be maintained.

TLT Turbo asks to keep the verification tolerances at 0.9 instead of 0.93 and the benchmark values in Annex IV should stay the same as in the current Regulation.

Woodcock & Wilson discuss various issues in the position paper. Among others within ATEX fans safety should come before efficiency and in the calculation method of energy efficiency the volume/pressure ratio should be taken into account. Furthermore, fans dealing with dust should have separate energy efficiency values than BC fans and VSD's should still be allowed a bonus.

In the position paper of Multi-Wing the static efficiency limit for axial impeller fans is addressed in different configuration. The relationship between compliance and different configurations linked to rpm and/or stator is explained and the difficulties in the calculation of pressure losses and noise generation in aerodynamic systems have been outlined.
Moreover, Multi-Wing proposes a bell-mouth set up and one target if a simplified (test) approach is needed. The truly reversible fans should have an air flow of at least 85% of the normal flow.
A challenge for most non-ventilation manufacturers if not allowed to estimate the overall efficiency and input power is the testing cost. Another challenge are the potential design challenges in general with tight space constraints and for oil coolers / radiators.

Siemens Wind Power share most opinions put forward by Multi-Wing. Space, noise emissions and machine and site depended cooling are the most important issues for wind power manufacturers.

Nicotra Gebhardt submitted a document intended to provide a technical assessment of the state of technological development of centrifugal fans, with particular attention to the fans intended for application in the HVAC&R business, and including some additional remarks extending to the use of common types of motors in other fan types. It is intended to identify the currently available technological margins and constraints for improvement of the fan efficiency.

In the position paper of ECOS the general timing is mentioned as a big concern and fans integrated into other products need to be maintained. Furthermore, savings related to the setting of an energy label should at least be assessed. The lower input lever should be set at 30W instead of the current 125W. ECOS supports the decrease in fan categories and the proposal of having higher efficiencies for smaller fans and flat efficiencies for the bigger ones. ECOS proposes to remove the 2018 TIER and start in 2020 as the industry has more time to adjust to the Regulation. Finally, ECOS invites the study team to make proposals on how to improve recovery of Rare Earth elements and the durability of fans. [see also Chapter 10 in this report]

In the position paper on jet fans, Witt & Sohn recommend not to set limits for jet fans and to exclude them from the scope of the regulations. Jet fans have to be able to operate from -50°C continuously to 600°C for 2 hours and be up to 100% reversible at least a 0,85 x 0,85 compensation factor would be required effectively making the limits meaningless. [see also Chapter 6 in this report]

Halifax states in the position paper that an exemption period of 5 years for spare parts is too short as the lifetime of industrial products is often >20 years. One Regulation for products in such a wide range (125 W- 500kW) is not practical and a subdivision into more precise market segments would be advisable. The correction for compressibility factor should be removed. Furthermore, the proposed levels are too high and in Halifax's opinion unachievable using current or foreseeable technology.

EVIA presents an extensive position paper where it reacts to other stakeholders and re-iterates some issues regarding the discussion document. Amongst others EVIA states to disagree with the proposal to exempt cooling towers and also does not support an exemption for fans handling high-humidity air. EVIA agrees with Eurovent to keept FC-fans but with a cap of 5 kW. It states that verification tolerances of 10% are needed (not 7%). EVIA believes that its proposal is challenging and a whole series of allowances are proposed for special purpose fans. [see Chapter 5 in this report for more details] Furthermore, EVIA gives an improved version of its considerations regarding benchmarks, stating an appropriate bandwith to be taken into account.

The above comments and position papers were all placed on the public project website www.fanreview.eu, with permission of the authors.

2.3 Other consultation activities

The study team also received dozens of e-mails with --in part-- confidential data or data otherwise not intended for publication. These messages included

- proprietary technical data as a background to public papers (Witt & Sohn),
- client data (SODECA, as background to the position that ATEX data are 100-150% more expensive than non-ATEX fans, illustrated by its public list-prices),
- commercial data of specific manufacturers that were not the author (Zitron as part of standardisation work; very useful but needs to be made anonymous),
- messages accompanied by non-disclosure agreements (from Italian manufacturers such as Elco E-trade, Vortice, Nicotra-Gebhardt, Sabiani, etc.) amongst others making the points that small forward curved fans and propeller fans should be maintained,

- showing small AC motor fans <1 kW with efficiency grades of 40-44% and small EC motor fans <1 kW with efficiency grades in the range 53-63% for FC centrifugal fans and 42-44% for axial fans),
- various cooling fan manufacturers and –users, based in Scandinavia or Belgium, bearing testimony to the problems that are mentioned regarding cooling towers and cooling fans in the public papers above.

Furthermore, the study team engaged in two bilateral meetings with industry associations, one with Eurovent regarding evaporative cooling towers (with company visit in Belgium and expert-meeting) and one debriefing meeting with all manufacturing associations after the 2nd stakeholder meeting.

The study team performed desk research on

- Legal documents for consistency and definitions. This includes the most recent Ecodesign regulations, (draft) working documents, preparatory studies on fans and related products (motors, ventilation units, pumps, circulators, compressors) and the legislation that is used as reference in the Working Document, e.g. on corrosive, toxic, etc. gases. Furthermore international developments in the US (DoE), China were studied.
- Catalogue data and publications on efficiency to find first limit and benchmark values. This includes Ebmpapst, Ziehl-Abegg, Nicotra-Gebhardt, Soler & Palau, Helios, Rosenberg, Systemair, Howden, Fläkt Woods Ltd., Zitron, Witt &Sohn, Vortice, Elco E-Trade, SODECA, Aldes.
- Scientific data regarding aerodynamic efficiency improvements (best diffusor angles for forward curved centrifugal fans, optimal bell-mouth radius, diffusor-efficiency contributions in general, secondary flow optimisation of especially axial fans (skew angle, camber/attack angles, 3D dimensioning of aerofoils, trailing edge geometrical adjustments to improve airflow, hub optimisation, etc.), variable control (variable pitch, VAV-boxes, VSD, etc.) and for scaling-methods (not just Ackeret based on Reynolds numbers, but also more recent by University of Darmstadt taking into account also tip clearances, pitch, surface smoothness, etc.)
- Test standards for consistency and definitions, most importantly ISO 5801, ISO 12759 and the CENELEC Work Items under the current mandate for the current regulation, but also various reference standards.
- Market surveillance, including relevant documents from the market surveillance authority (MSA) in Denmark and Sweden, as well as reports from the ATLETE, ATLETE II, Come On Labels and Ecopliant project. Databases from ADCO[4], CIRCABC[5] , RAPEX[6] and ICSMS[7] were searched for surveillance activities for fans.

[4] ADCO Member States are obliged to participate in Administrative Cooperation (ADCO) Working Groups. The ecodesign ADCO is chaired by the Netherlands and meets twice a yearas a forum for MSAs to exchange information and best practices. Ecodesign ADCO:
http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=2601&Lang=NL
Energy labelling ADCO:
http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=2647

[5] CIRCABC: The Communication and Information Resource Centre (Circa) is an electronic workspace developed by the Commission to allow with the secure sharing of documents for the various ADCO and other working or interest groups.

[6] RAPEX: the EU Rapid Alert System (RAPEX) is a system used to facilitate the rapid exchange of information and actions by MSAs to prevent or restrict products which present a serious risk to the health and safety of consumers.

Some technical experts from associations –in particular European AMCA[8]—were able to supply anecdotal data on fan market surveillance.

- Literature on use and recycling options of Rare Earth Elements (REE).

[7] ICSMS: (Information and Communication System on Market Surveillance - https://webgate.ec.europa.eu/icsms) is an IT system owned by the European Commission which provides a comprehensive communication platform for the market surveillance authorities of the Member States. However, ICSMS is not only a mechanism for the reliable exchange of information among authorities but also the platform for the implementation of European market surveillance policy.

[8] European AMCA, pers. comm. Neil Jones

3. Fan categories

3.1 Introduction

According to Art. 7 of Regulation 327/2011 'The review shall in particular assess the feasibility of reducing the number of fan types in order to reinforce competition on grounds of energy efficiency for fans which can fulfil a comparable function'. This assumes implicitly, as was discussed at the time of the conception of Article 7, that a new metric would have been developed that does not focus on strict types (axial, centrifugal, etc.) but that would, amongst others, use the pressure/volume flow ratio as a basis for setting minimum requirements. In the review study it became apparent that the sector is still far from reaching consensus on such a new metric that would make the current typology redundant. The contours of such a new metric, that would not only look at pressure/volume flow ratios, but also incorporate the 'extended product approach' for part-load situations and take into account the increasingly important role of noise power restrictions, are visible. And there is a willingness from industry and standardisation bodies to develop new metrics, but –given the complexity and diversity of the sector—it will take several years before it is robust enough to incorporated in legislation.

3.2 Definitions

Regulation (EU) 327/2011 (hereafter 'the fan regulation') distinguishes fan categories by the main flow-path of the gas through the impeller. For axial, centrifugal and mixed-flow fans the definition is most easily determined by the blade geometry and –position with respect to the rotation axis, which is more or less also the center and the direction of the incoming flow.

The center of the outgoing flow is then more or less (±20°) parallel for *axial fans*, perpendicular for *centrifugal fans* and somewhere in between for *mixed-flow* --a.k.a. 'diagonal'-- *fans*. Instead of actually measuring the center line of the outgoing flow, it is easier to determine the exit angle of a fan blade, as is indicated in the text with figure 1.

Centrifugal fans are subdivided into *forward-curved* ('FC'), *radial*, *backward-curved* ('BC') based on the inclination of the blade respectively towards, perpendicular or away from the direction of rotation of the impeller. This is indicated in figure 2. The BC-fan is the further subdivided in a version *with or without housing* ('stator').

Cross flow fans are different: In a section perpendicular to the rotation axis, the gas flows towards the center of the rotor at one part of its periphery and at another part of the rotor's periphery, typically at least 90° later, the gas leaves the rotor.

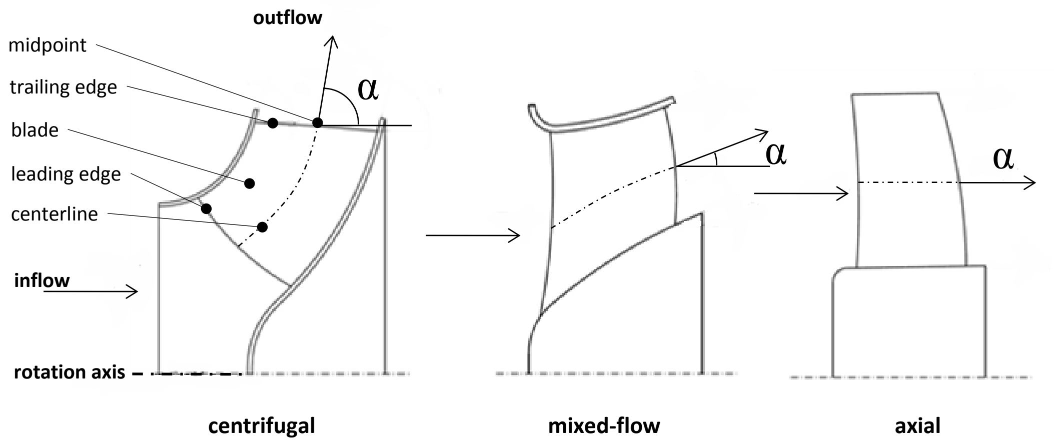


Figure 1. Definition fan flow angle α with axial (α<20°), mixed-flow (20°≤α<70°) and axial (α ≥70°) fan impeller. In text: 'Fan flow angle α' means the angle of the center-line of the air-conducting surface of a fan blade, measured at the midpoint of its trailing edge with the centerline of the rotation axis, in a plane through the rotation axis and the midpoint of the trailing edge. A fan is defined as 'axial' if α<20°, 'mixed-flow' if 20°≤α<70° and 'centrifugal' if α ≥70°.

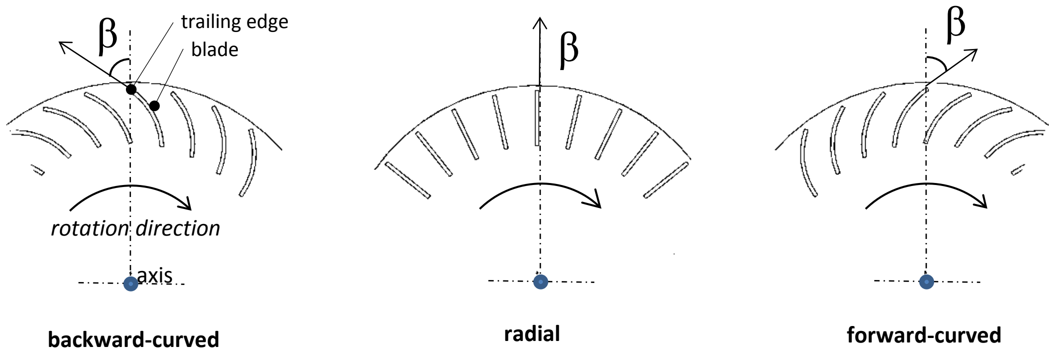
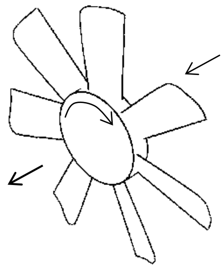


Figure 2. Definition of centrifugal blade angle β with backward-curved (β<-1°), radial (-1°≥β≤1°) and forward-curved (β>1°). *[illustrative, actual geometry of BC and FC may be different]*. In text: 'Centrifugal blade angle β' means the angle between the tangent of the air-conducting surface of the blade and the radial through the fan rotation axis, at the midpoint of the blade's trailing edge and in a plane perpendicular to the fan rotation axis. The angle is defined positive when it is inclined in the direction of the rotation of the impeller. A centrifugal fan is defined as 'backward-curved' if β <−1°, 'radial' if −1°≤ β ≤1° and 'forward-curved' if β >1°.

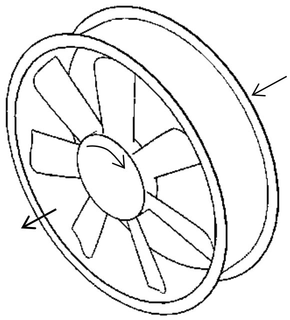
Figure 3 shows the most common fan rotor types.

- The top row shows types of axial fans, such as the propeller-type (a.k.a. 'sirocco') which is without stator, the tube-axial fan which is with housing and the vane-axial fan with housing and also stationary inlet and/or outlet vanes that 'straighten' the swirling flow. There are variations of axial fans, not shown, with variable pitch blades and/or vanes and there are more exotic types with contra-rotating axial fans, similarly to propellers in some planes or helicopters. The axial fan blades come in all forms and sizes: From rectangular to complex scythe contours, from single-thickness to airfoil sections, from radial to skewed attachments to the hub, from diameters of 10 millimeters up to 12 meters.
- The second row shows the forward curved and radial centrifugal fans. The forward-curved fan is typically a 'squirrel-cage' type with many (up to 60) short blades that in fact 'kick' the gas out of the rotor. The air in an FC-fan has to make twice a 90° turn, coming in through the center of the rotor and then towards the periphery and second when being 'kicked' out by the blade into the housing's diffuser. This is aerodynamically quite hard and costs a lot of power, but with a relatively small rotor and relatively low tip speed (lower noise) it can generate a relatively large flow rate. The housing (or 'scroll' and especially the diffuser (or 'volute') of an FC-fan is critical for a proper functionality. There are some variations on the 'squirrel cage' rotor such as rotors that have longer full blades with shorter 'semi-blades' in between, but these are rare.

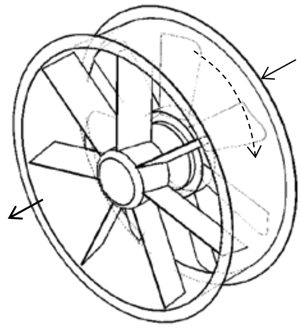
  Radial fans also have a low efficiency. They are typically used either as conveyer fan (to avoid the high dust load to clog up the fan) or when the fan has to be reversible (able to rotate in both direct directions, e.g. for a dual use fan).
- The third row shows various BC-fans: a standard backward-curved with single thickness blades, a backward-inclined fan with straight blades to avoid clogging in case of high dust loads that is also easier to make in a one-off production and a more sophisticated BC airfoil bladed fan. The gas in a BC-fan are not kicked out, like with an FC-fan, but rather are guided smoothly along the blade before they are 'thrown' or 'swung' out by the centrifugal force. It means that the fan is aerodynamically more efficient, but –for the same pressure/flow operating point—it is bigger than the FC fan. And (thus) the tip speed is higher, resulting in higher sound power. The housing is less critical and mainly an envelope that ensures that the air goes out in the right direction. But if the direction is irrelevant –e.g. in a plenum fan-- a properly designed BC-fan also works –and even more efficiently—without a housing. For larger flow-rates also double entry fans are used, both BC and FC, which means that the air enters the rotor from both sides.



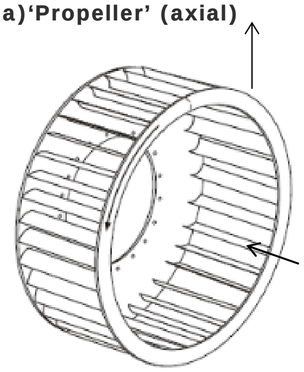
(a)'Propeller' (axial)



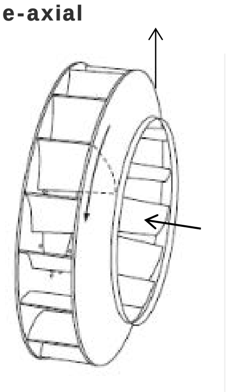
(b) Tube-axial



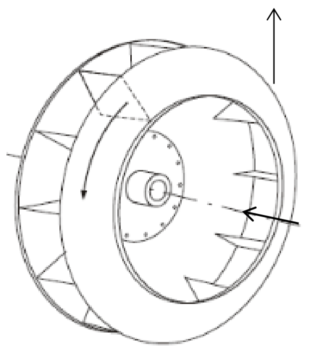
(c) Vane-axial



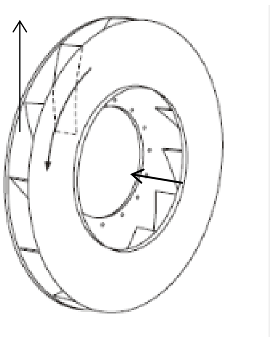
(d) Forward-curved



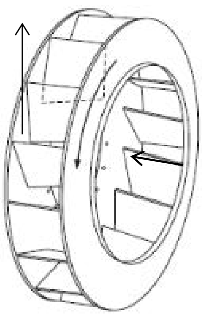
(e) Radial-shrouded



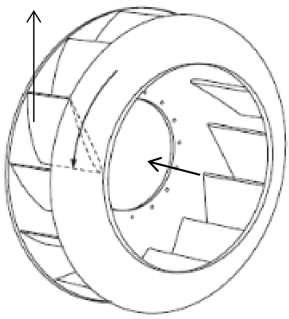
(f) Radial-tipped



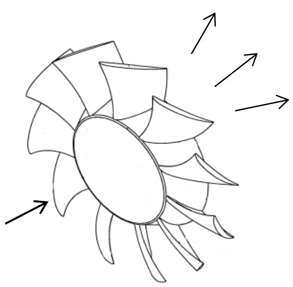
(g) Backward-curved



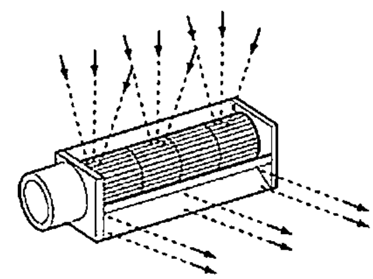
(h) Backward-inclined



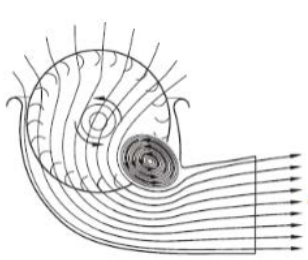
(i) Backward aerofoil



(j) Mixed-flow



(k) Cross-flow



Cross-flow (section view)

Figure 3. Basic impeller-types: Top row: Axial; 2nd row: Centrifugal forward-curved & radial; 3rd row: Centrifugal backward-curved; Bottom row: Mixed-flow and cross-flow. Picture sources: CEN/TC 156/WG 17 Fans Working Draft for Harmonised Standard under elaboration; VHK (computer drawings)

Another characteristic of BC-fans is that, unlike other fan types, they hardly have a critical *stall* area. Stall is a phenomenon where the flow-rate is too small for the attack angle of the blade or, vice versa, the attack angle is too large for the flow-rate causing the flow to lift from the blade towards its trailing edge. The result is a considerable amount of recirculation and turbulence inside the impeller, which is detrimental for the efficiency and longevity of the fan. In the pressure/ flow rate curve of a fan it is clearly visible as a sudden drop in flow-rate and pressure. For FC-fans this happens at around 40% of the nominal flow rate. In principle this makes speed-control for FC-fans more critical. However, as is described in the paper of Brivio (Feb. 2015), there are low-cost ways around that, e.g. if the FC-fan uses a (cheap) high-slip AC motor that 'automatically' reduces its speed and thus avoids stall.

- The fourth row of figure 3 shows mixed-flow and cross flow fans. The mixed flow fan is a middle-way between an axial fan, ideal for lower pressure and higher volume flow, and a centrifugal fan, ideal for higher pressure and low/medium flow. If the mixed-flow fan also has a minimum efficiency limit between axial and BC-centrifugal fan, there might be a loophole –as pointed out by Ebmpapst—of mixed flow fans that almost have the same flow angle as a centrifugal fan (e.g. 69° instead of 70.1°) and thus would have to meet only the lower 'mixed-flow' minimum efficiency limit.

  Cross flow fans have, by nature, a very low efficiency and are only applied in indoor units of (room) air conditioners or in some low-cost fan-coil units, where the flow-direction of the cross-flow is ideal for creating a low-velocity (0,5 m/s comfort limit) convection loop a room to be heated/cooled. Almost all cross flow fans have an input power lower than 125W and would thus be out of scope, but obviously for the few models >125W it was found necessary to set a prohibitively high efficiency limit of 21%.

3.3 Measurement categories

For the purpose of compliance testing, the fan regulation makes a further subdivision of the above fan types by measurement category (A, B, C, D), which depends on whether the fan-inlet and outlet are free or connected to a duct.

For categories A and C the inlet is free, the outlet is either free (cat. A) or ducted (cat. C), and the efficiency is determined through static pressure. For categories B and D the inlet is ducted, the outlet is either free (cat. B) or ducted (cat. D) and the efficiency is determined through total pressure. This categorization comes from the test standard ISO 5801. Note that for BC-fans without housing only categories A and C apply, while for cross flow fans only categories B and D apply.

In a more recent version of the EN draft working item under mandate M500, it is specified that the inlet and outlet side are separated. Furthermore, a category E is added –probably to accommodate jet fans—where there is no separation between the free inlet and the free outlet side. [source: EN ISO 13349:20xx, definition 3.4.5 [9]]. The efficiency is determined through 'effective dynamic pressure' (source: ISO/DIS 13350:2014).

Taking into account both the fan typology and the measurement categories there are now 10 categories with different minimum efficiency requirements in the fan regulation.

[9] ISO 13349:2010, Fans -- Vocabulary and definitions of categories

3.4 Stakeholder feedback

3.4.1 Combining BC-fans with and without housing

Most stakeholders agreed to combine the centrifugal BC-fan with and without housing (see position papers of EVIA and Eurovent on the subject). At the moment the minimum requirement for BC-fans without housing is 2 percentage points (N=2%) higher than that of BC-fans with scroll-housing, but by only a slight adjustment of the level no energy savings will be lost.

3.4.2 Combining FC-fans with BC-fans above 5 kW

As regards combining FC-fans with BC-fans into one single ‘centrifugal’ category, which was a proposal in the discussion document, most stakeholders disagreed although there were a few (Witt & Sohn, Aldes) that would agree. Most stakeholders, agreed to its lower efficiency but insisted that the power density (the smaller rotor compared to the BC-fan) and its lower noise were indispensable. As a compromise the manufacturer associations EVIA, Eurovent and European AMCA, accepted that the FC- and radial fan category would be limited to 5 kW input. Beyond that level the FC- and radial fans would have to be meet the generic centrifugal fan requirements.

3.4.3 New category of jet fans

On a possible new category of ‘jet fans’ there was initially little debate, but more recently individual manufacturers like Witt & Sohn pleaded for an exemption of this whole category. Whether or not that is acceptable, even an exemption needs a verifiable, measurable definition if it is not to be turned into a loophole.

The definition in the discussion document[10], which anyway was contended, is not good enough, because it basically depends on the declaration of the fan manufacturer himself whether a fan is a ‘jet fan’ or not.

The problem is, that the basic geometry of the ‘jet fan’ is not different from the other fans, it is just optimised not to displace gas but to generate thrust.

Usually a product is defined by its performance. In the case of a jet fan this is the ability to transform electric input power into thrust T. Hence the efficiency (or efficacy) in making that transformation could be the measure that determines whether something is or isn’t a ‘jet fan’. The definition than becomes
‘Jet fan’ means a fan that is declared as being a jet fan and that transforms at least the equivalent of 50% of its electric energy input into thrust energy output as defined in Annex III (Measurement and calculation methods), point 1.

In Annex III, point 1, there would then be the definition of Fan overall efficiency for jet fans from ISO/DIS 13350 (to be extended):

[10] 'Jet fan' means a fan used for producing a jet of air in a space and unconnected to any ducting, for which an alternative test and calculation method applies based on the measured thrust.

The fan impeller efficiency η_r(T) is calculated using the following equation:

$$\eta_r(\mathrm{T}) = q_v(\mathrm{T}) \cdot \frac{\Delta p(\mathrm{T})}{P_r} = 0{,}5 \sqrt{\frac{T_m}{\rho \cdot A_2}} \cdot \frac{T_m}{P_r}$$

The 50% value is up for discussion and could also be an equation (see section on minimum requirements).

This definition would be, in terms of testing costs, very efficient because it serves a dual purpose: It determines if the declared jet fan is really a 'jet fan' and –if it is— what is its efficiency value. In fact, if the minimum value/equation is well chosen, we can exempt 'jet fans' from meeting the minimum requirements and still have an effective regulation for this category (eliminate the worst).

If a fan does not meet the 'jet fan' criterion, then it has to comply with the criteria for its specific 'normal' type.

3.4.4 Rooftop and box 'fans'

some manufacturers of rooftop and box-type ventilation units, in particular Rosenberg and Helios, made their case that these ventilation units, currently in the scope of the Ventilation Unit regulation 1253/2014, should actually be included in the fan regulation. EVIA supports this vision *'to avoid the loophole caused by the ventilation Regulation. Roof fans and box fans are not just ventilation products they are used in other applications. They should be included in the above fans categories with suitable compensation factors.'*

The topic was discussed during the first Consultation Forum for the fan regulation in 2010-2011 and as well during the Consultation Forum for the ventilation unit regulation during 2012-2013 and on both occasions it was decided that rooftop and box 'fans' are in fact ventilation units. They incorporate a fan, but also other elements like an external casing, safeguard grills, anti-rain provisions, directional louvers, etc. that influence the internal pressure drop of the product.

In the fan test standard that is currently developed it is clearly marked what is the difference between the testing of the bare fan and the testing of a rooftop or box ventilation unit. Should there be a significant number of box- and rooftop 'fans' in other than ventilation applications, then indeed the damage is limited because anyway the fan inside the box- and rooftop product is covered by the fan regulation.

3.4.4 Axial fans <300 Pa

In the most recent EVIA position paper there is also a request to give an allowance of a factor 0.9 on the minimum efficiency requirements for axial fans with a pressure difference smaller than 300 Pa. Effectively this means that EVIA wants to split the axial fans into two categories, one above and one below 300 Pa.

EVIA gives no argumentation for its proposal.

Of course it may well be that at lower pressures some axial fan designs may find it harder to meet the requirement, but on the other hand the catalogues of manufacturers (e.g. see the Figures in Chapter X) demonstrate that there are plenty of axial fans that would meet the limit.

Furthermore, applying a factor 0.9 would mean for the smaller fans <300 Pa that in the EVIA proposal the requirement becomes more lenient than the 1.1.2015 tier of the current fan regulation.

3.5 Recommendations

From the above, the study team recommends the following actions for the new regulation regarding the fan categorisation in the new regulation:

Combine centrifugal BC-fans with and without housing into one category;

Up to 5 kW allow a separate category for radial and centrifugal FC-fans. Beyond 5 kW the same minimum efficiency requirements as for centrifugal BC-fans apply.

Define a new fan category ‘jet fans’ and a new measurement category E, using a minimum efficiency requirement based on thrust as defining element, and subsequently exclude jet fans from the scope of the minimum requirements (not of product information requirements).

Do not define a new category of ‘box- and rooftop fans’ or a split of the ‘axial fans’ above and below <300 Pa.

4. Exemptions

4.1 Introduction

There are legal and practical reasons why exemptions exist.

Exemptions are intended, especially for such a generic product group as 'fans', to ensure that several conditions of Art. 15, sub 5 are met, i.e. that there shall be no significant negative impact on functionality, health, safety, environment, affordability and life cycle costs, industry's competitiveness, etc..

In principle, it is thinkable that the possible conflict with the provisions of Art. 15, sub 5, does not result in an exemption but instead in a (set of) specific allowance(s) that should ensure that –with these allowances—it is still possible to regulate energy efficiency without jeopardising e.g. the functionality, safety, etc.. If the exemption means a large loss of energy saving then this may be the way forward, i.e. the legislator investigating the matter in-depth so as to be able to make the appropriate adjustment for specific individual products. However, if the impact (lost savings) is small and the efforts and risks of the exercise are large, it is better to make an exemption.

The potential problem, however, is to avoid that an exemption that was made for all the right reasons, turns into a loophole for products for which it is not intended. In that sense, the exemptions should ideally be technically verifiable, through very precise references, test methods and certification. On top of that, there should be no economic inventive to use the exemption; i.e. the technical requirements should be such that they would imply a significant price increase of the product.

Another problem is one of consistency. E.g. if motors in handheld equipment are exempted from the motor regulation, it is consistent that also fans (including such a motor) would be exempted.

The number and nature of the exemptions was extensively studied and discussed with stakeholders. Existing exemptions were made legally more robust, verifiable against technical values or reference documents, and they were made consistent with other regulations:

4.2 Description

The current fan regulation has two types of full exemptions from the scope, i.e. for fans integrated in certain products (Article 1.2) and for fans designed for specific purposes (Article 1.3). And then there are exemptions just for meeting the minimum requirements but not for the product information (Article 3.4).

In the first category the exemptions apply to fans integrated in

i. Products with a sole electric motor ≤3 kW where the fan is mounted on the same shaft used for driving the main functionality,
ii. laundry and washer dryers ≤3 kW maximum electrical input,
iii. kitchen hoods <280 W maximum electrical input attributable to the fan(s).

In the second category (Article 1.3) exemptions are made for

a) ATEX fans[11];
b) emergency fans[12];
c) fans designed specifically to operate
   i. (a) with gases >100°C [13];
      (b) in environments >65°C [14];
   ii. in environments <−40°C [15];
   iii. with voltages > 1000 V AC or >1500 V DC;
   iv. in environments that are toxic, highly corrosive, flammable or with abrasive substances;
d) replacement fans, placed on the market before 1.1.2015 to replace identical fans in integrated products which were placed on the market before 1.1.2013.

For exemptions under a), b), c) the packaging, product information and the technical documentation must clearly indicate that the fan shall only be used for the purpose for which it is designed and regarding d) the product(s) for which it is intended.

Furthermore, in article 3.4 there are exemptions on the minimum requirements (but not on the information requirements) for fans designed to operate

a) With an optimum energy efficiency at 8000 rpm or more;[16]
b) In applications in which the specific ratio is over 1.11;
c) As conveying fans used for the transport of non-gaseous substances in industrial process applications.

4.3 Optimisation of existing exemptions

Some of the above exemptions have core elements that are undefined (what is ‘highly corrosive, flammable, etc.’ ?; what is a ‘conveying fan’?) or impractical to assess (how to determine ‘an annual average temperature of the gas being moved’). The following revisits each of the articles 1.2, 1.3 and 3.4 critically.

[11] Designed specifically to operate in potentially explosive atmospheres as defined in Directive 94/9/EC
[12] Designed specifically for emergency use only at short time duty with regard to fire safety set out in Council Directive 89/106/EC, now replaced by Regulation (EU) No. 305/2011 (emergency fans)
[13] Where operating temperatures of the gas being moved exceeds 100°.
[14] Where operating ambient temperature for the motor, if located outside the gas stream, driving the fan, exceeds 65 °C;
[15] Where the annual average temperature of the gas being moved and/or the operating ambient temperature for the motor, if located outside the gas stream, are lower than -40°C.
[16] This first exemption (>8000 rpm) typically relates to vacuum cleaner fans. With a small adjustment to 7000 rpm it can also apply to combustion fans.

4.3.1 For fans integrated in products

Products with a sole electric motor ≤3 kW where the fan is mounted on the same shaft used for driving the main functionality (Art. 1.2, i)

This definition relates to fan-rotors[17] that are mounted on the shaft of electric motors with the sole purpose of cooling the motor itself. Was it the intention to exclude fans integrated in products that have two motors with that feature, like washing machines (drum-motor and water-pump motor with both such an impeller)? Probably not; yet the definition mentions a 'sole' electric motor. And how are we to know that these impellers serve only to cool the motor? There is only an implicit understanding based on the fact that the shaft is used to drive some (other?) 'main functionality', but it is ambiguous. All stakeholders agree that this exemption should be kept, but it needs to be reformulated.

Laundry and washer dryers ≤3 kW maximum electrical input (Art. 1.2, ii)

The second definition relates to household laundry driers and washer dryers. To indicate that they are 'household' a practical limit of the electric power input of a household fuse box, i.e. 3 kW, is used. Alternatively, one could refer to the definition according to the Ecodesign Regulations for these products, but in principle there is nothing wrong with '3 kW'. The manufacturer's association for these household appliances CECED wants to keep this exemption, based on the special technical qualities (as described in its presentation) and preferably but not necessarily would like to expand it to all fans in Ecodesign-regulated domestic appliances. The fan industry (EVIA, Eurovent) is not against having the exemption for circulation fans in these appliances, probably because they are outside the scope anyway (<125 W). But it wants to eliminate the exemption for all other fans. These 'other fans' are probably evacuation fans in a vented dryer and the fans of a heat-pump dryer/washer-dryer. The fan industry feels that <u>any</u> exemption is detrimental for market surveillance and would allow incompliant fans to show up in European catalogues. The study team proposes, in the discussion document, to keep the exemption on the grounds that the number of operating hours for household dryers/washer driers (300-400h/year) is considerably lower than the average number of hours (3000 h/year and above) for which the LLCC[18] of the fan efficiency limits were calculated.

Kitchen hoods <280 W maximum electrical input attributable to fan(s).(Art. 1.2, iii)

The third definition relates to kitchen hoods with <280W max. fan power. Also here a reference could be made to the definition of hoods in the Ecodesign regulation, but in general the term 'kitchen hood' is clear enough as is the reference to the nameplate power of the fans. Basically, the situation with opposing views of manufacturers of hoods (CECED) and fan industry (EVIA, Eurovent) is the same. On the same grounds the study team proposed to keep the exemption in its discussion document.

4.3.2 Fans designed for specific purposes (Article 1.3)

ATEX fans (Art. 1.3, a)

[17] Is it really a 'fan' according to the latest definition, which excludes 'non-final assembly'. Does it always have a stator? To avoid the ambiguity it is better to speak of a fan-rotor.
[18] Least Life Cycle Costs, according to the Ecodesign directive 125/2009/EC the measure to determine a target that is economical to the end-user.

The definition refers to Directive 94/9/EC and thus the harmonised standards that need to be respected for compliance. There is a discussion on whether or not to keep the exemption on ATEX fans due to the latest drafts on the review of the motor regulation that is going on almost in parallel (but a few months in advance), where it is proposed –as opposed to the current motor regulation-- not to exempt ATEX motors. Hence the question is whether, with the proper allowance, ATEX fans (motor+rotor+stator) should not be included in the scope. The discussion document hence proposed a 10% allowance (factor 0.9 on the minimum efficiency values) that takes into account the larger tip clearances (the clearance between rotor and stator where a spark may occur if both components touch). However, when really taking a closer look after the second stakeholder meeting, it turned out not to be so easy to establish a single allowance that in all cases would permit a truly safe ATEX fan, unless it would be a really large value to cover even the worst case. Especially the research by European AMCA and the paper by SODECA was meaningful in that respect. These contributions from stakeholders also confirmed that the risks of allowing a full exemption are small. The ATEX fans need to be certified and thus surveillance is easy. The price of an ATEX-fan is about 2 to 3 times higher than that of a comparable non-ATEX fan, as revealed by the SODECA (public) pricelist. so there is no financial or commercial incentive for manufacturers to use this exemption as a loophole.

Emergency fans (Art. 1.3, b)

This definition refers to fans designed specifically for emergency use only at short time duty with regard to fire safety set out in Council Directive 89/106/EC[19]. This definition needs to be updated because the Council Directive 89/106/EC is now replaced by Regulation (EU) No. 305/2011[20]. The legislation is backed by test standards for compliance assessment. The fans need to be certified by a notified body, following EN 1201-3:2005. The fire safety classes relate to temperature and the time that the fans need to resist and are known as F200 (200 °C/120 minutes), F300 (300 °C /60 minutes), F400-90 (400 °C /90 minutes), F400-120 (400 °C /120 minutes), F600 (600 °C /60 minutes) and F842 (842 °C / 30 minutes).

Given the certification and the significantly higher price there is no risk of misusing this exemption, whereas the possible safety repercussions of eliminating this exemption and replacing it by an allowance would be considerable. The discussion document proposed to keep the exemption and all stakeholders agreed.

<u>Fans designed specifically to operate in extreme temperature conditions or with high voltages</u>

These exemptions relate to fans specifically designed to handle gases >100°C or <−40°C and/or operate in environments >65°C or <−40°C. Normally one would expect that such definition, appropriately split up for reference, would be enough in the legislation. These definitions would then be backed up by some sort of endurance test in a harmonised standard. However, the current definitions do not always help to design a simple compliance test. For instance, what does it mean '*Where the annual average temperature of the gas being moved and/or the operating ambient temperature for the motor, if located outside the gas stream, are lower than -40°C*.'

[19] OJ L 40, 11.2.1989, p. 12
[20] OJ L 88, 4.4.2011, p.5

How can an '*annual average temperature*' be tested? Is that a test of a year according to a specific temperature fluctuation pattern? Why is it not a test of e.g. a week (say 200h)? There has been no consultation on the subject, e.g. in the discussion document but it is recommended that these temperature definitions be revisited and possibly simplified. A good example is the exemption on voltages (>1000 V AC and >1500 V DC), which is simple and clear.

Fans designed specifically to operate in environments that are toxic, highly corrosive, flammable or with abrasive substances

This definition is unclear, imprecise and incomplete. First of all, it is unclear why specifically the 'environment' is targeted and not –as would seem more logical—the gases that are being handled. It can be assumed that this exemption allows certain fans to apply all sorts of precautions like seals, special materials, etc. that have a negative effect on efficiency but are necessary to protect the workers, consumers and the environments.
Secondly, unlike the ATEX and emergency fans, there is no clear reference that would allow a surveillance authority or, if it comes to that, a court of justice to determine what is 'toxic', 'highly corrosive', 'flammable' or 'abrasive'.
Thirdly, if the definition is intended --by allowing certain precautions-- to protect the workers, it is incomplete and should at least also cover biohazardous and carcinogen or mutagen substances.

Following the above, the discussion document proposes to relate the exemption to the gases (or abrasive substances) being handled;

- to the CLP regulation 1272/2008[21] and its adaptations[22] as a comprehensive (1353 pages) reference to what gases are considered toxic, highly corrosive, flammable and in what concentrations;
- to the bio-hazardous substances of risk groups 2, 3 and 4 as set out in Regulation (EC) 2000/54/EC[23] and its adaptations;
- to carcinogen and mutagen substances as set out in Regulation 2004/37/EC and its adaptations;
- to the technical limit values for abrasive substances (hardness≥5 Mohs, concentration ≥100 mg/m³) as defined in the Commission Fan FAQ document.

As regards the second point (the CLP Regulation) the fan industry suggested that they might come up with a better alternative, but in the most recent discussion of CEN TC156 WG 17 of 23 February 2015 the CLP Regulation was adopted as a reference. But otherwise the above adaptations did not lead to discussion with the stakeholders.

Replacement fans, placed on the market before 1.1.2015 to replace identical fans in integrated products which were placed on the market before 1.1.2013.

The limited extend of this exemption in the current regulation, i.e. that there was no spare part provision for fans that are phased out by the second (1.1.2015), led to

[21] OJ L 353, 31.12.2008, p.1.
[22] Implying all amendments and recasts, which means that the fan regulation does not have to be updated every time this reference is updated.
[23] OJ L 262, 17.10.2000, p.21.

furious reactions from all industrial stakeholders, both fan suppliers and fan buyers. It was pointed out, inter alia, that

- Commercial contracts require the delivery of spare parts for a long time;
- The dimensions, electrical connections, controls of new fans typically prohibits their use as a replacement for phased-out fans;
- For nuclear power plants it is a requirement that identical parts shall be delivered during the full life of the power plant (40-50 years);
- Also the RoHS Directive allows an unlimited production of spare parts;
- The lack of spare parts would lead to early end-of-life for many products or prohibitive costs for stocking the fans by the suppliers/manufacturers;
- While for large industrial components it may be practice to repair/replace just one piece of the product (e.g. the motor or the rotor), for small and medium-sized fans (say <10 kW) this was not customary and/or very expensive;
- Spare parts are currently only 1-2% of the total fans placed on the market (confirmed by the study team for one manufacturer).

In the first stakeholder meeting it was mentioned by the study team that a spare part provision was more the exception than the rule. Such a spare part provision, where it is enough for the manufacturer to write 'spare part for product XX[24]' on the nameplate to be able to sell an incompliant fan, creates a potentially large loophole and thus a provision, if truly unavoidable to avoid a significant negative impact of a measure, should be restricted in time as much as possible.

Taking maximum found in existing Ecodesign regulation, the discussion document a period of 5 years, starting from the data that the tier is applicable, was proposed and –although they would have preferred a longer period—was acceptable to the fan manufacturing industry (Eurovent, EVIA, European AMCA). The Japanese and Korean (room) air conditioner manufacturers (Daikin, Mitsubishi, LG) and their representations (EPEE, JRAIA, JBCE, DigitalEurope) insisted that un unlimited period should be granted.

4.3.3 Fans exempt from meeting the minimum requirements (Article 3.4)

Fans with an optimum energy efficiency at 8000 rpm or more

This exemption is for vacuum cleaner fans with typically only 50 operating hours per year. Based on the same arguments as for dryers and hoods (Art. 1.2) it was proposed in the discussion document to keep the exemption. Article 8 of the Vacuum Cleaner Ecodesign Regulation (EU) No 666/2013 has already amended Regulation (EU) No. 327/2011 in the sense that it was deleted from Art. 3.4 and moved to Art. 1.3 e).[25]

[24] Insert name of the incompliant fan to be replaced
[25] Commission Regulation (EU) No 666/2013 of 8 July 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for vacuum cleaners Text with EEA relevance

Fans in applications in which the specific ratio is over 1.11

This is not so much an exemption as an addition to the fan definition in Article 2 and sets 'fans' apart from high pressure blowers and compressors. It should be transferred to Article 2 and deleted from Article 3.4.

Conveying fans used for the transport of non-gaseous substances in industrial process applications

This exemption contains many elements with a meaning that is not self-evident. What is a conveying fan, i.e. are there conveying fans that are not used for the transport of non-gaseous substances? And what is a non-gaseous substance, e.g. is air with a certain dust-load 'non-gaseous'? Are conveying fans in non-industrial processes not excluded?

In the discussion document it is proposed to take the definition of the EVIA Guidance Document, which stipulates that fans specifically designed for gases with a solid particle concentration of more than 200 mg/m^3 and/or particles with an average diameter of 1 mm fall under the definition of this exemption.

It is recognised by the study team, although not widely by all relevant stakeholders, that this proposal exempts many (bespoke) process fans for the cement, steel, paper, etc. industry from the scope. The cement industry would also be exempt because of abrasive substances. The steel industry fans (dust loads from 0.5 g/m^3 upwards) would also be exempt on the basis of the temperature of the gases. Extraction fans for unfiltered flue gases from heavy oil or coal combustion would also be exempted.

4.4 New exemptions

Although the aim of the review according to Article 7 was to eliminate existing exemptions, several stakeholders put forward new exemptions:

4.4.1 Fans in products already regulated under Ecodesign

Air conditioner manufacturers and their representations (EPEE, JRAIA, JBCE, DigitalEurope), as well as initially CECED (domestic appliances) and EHI (heating appliances) proposed to make an exemption for all fans that are used in products that are already regulated by other Ecodesign Regulations.

Basically they don't want to be forced to pay for a more expensive fan, while they have more low-cost options to meet the Ecodesign requirements for their end-products. They claim it is more expensive for the consumer, a suboptimal limitation of the design freedom and inefficient for the legislator and market surveillance authorities, coining the expression 'double regulation'.

Minimum requirements might make products, at least until their production volume comes to par with the current solutions, more expensive to purchase but cheaper to run and overall more economical.

Should a large part of the fan-market be exempted, the production volumes will stay lower, efficient solutions will not become cheaper to produce and there would be little incentive for innovation to produce even more efficient and better products. Low-cost uncertified fans will (continue to) be available on the EU-market.

The concept of 'double regulation', suggesting that the same thing is done twice, is misleading. Most energy-using products are regulated double, triple or even quadruple. But it is not a problem: No-one complains that they have to use electrical cables and plugs, pressure vessels, etc. that are safe, i.e. CE-marked to indicate that they comply with the safety legislation. And no producer of e.g. water heaters would state that they don't have to use safe electric cables or pressure vessels because they are already testing the maximum-temperature safety requirements of the end-product. The safety of the components is an integral part of the safety of the end-product and he is using cables and a pressure vessel when he does the maxim-temperature safety test, but he is not testing the same thing twice; he is testing a different parameter.
Does this mean that the end-product manufacturer has to do the compliance tests for the electric cables himself? No, he can rely on the system of CE-marking and the Document of Compliance (DoC) from the supplier to avoid testing the electric cables. The only thing he has to do is to ask for the document and keep it on file, i.e. accessible for inspection.

The same goes for efficiency requirements: The motor has to comply, the fan (including the motor) has to comply, the ventilation unit (including the fan or fans) or other heating/cooling device has to comply and finally the building (including the ventilation unit or other heating/cooling device) has to comply. None of the compliance tests is the same and in all steps the compliance with the preceding steps can be demonstrated through the CE-mark/DoC.

4.4.2 Cooling tower fans

Following the proposed exclusion from the scope of 'non-final assembly' products, a proposal supported by the majority of industry, the manufacturers of cooling tower fans, and manufacturers of evaporative cooling towers, asked at several stages of the consultation for an exemption in some form. Several papers by Eurovent and individual manufacturers (e.g. Multi-Wing) bare testimony to the special position of cooling tower fans that would warrant such an exemption. In reality, much of the concerns stemmed from premature assumptions on how the problem would/could be handled in practice under a reviewed regulation.
Most importantly, there was the assumption –also given that new fan definition that specifically mentioned the 'stator' as a defining element of the fan—that the compliance testing of their 'motorised impellers' should now take place by their customers, using the whole cooling tower as a 'stator'. For various reasons (know-how and test facilities of customers, size of the impeller, etc.) this would be impossible. The study team ascertained, also in bilateral meetings, that this was never the intention; the aim was always to find a practical solution through test standards that

1. would prescribe compliance testing of a complete fan, i.e. with a relevant part of the stator (to be determined by the manufacturer and following procedures as should be described in a future test standard) .
2. would deliver a document of conformity (DoC)/ CE-mark for the tested configuration,
3. but would not necessitate the actual physical delivery of the stator part; i.e. it would be sufficient for the cooling tower manufacturer that is buying the fan to

copy the geometry of the stator (within tolerances) into the relevant part of the cooling tower.

To this end, and also to address a series of practical concerns of stakeholders, the Annex in the discussion document contained very explicit references to 'test fan' . This solves practical concerns but with respect to a situation where the 'non-final assembly' is still part of the regulation this still signifies some important improvements:

1. Already the current regulation was unclear on several practical aspects of compliance testing (scaling, etc.), which will now be handled.
2. Suppliers of complete fans and of 'motorised impellers' can now compete on an equal basis: test results of complete fans, whereby –if the cooling tower manufacturer does not want to do his/her own testing—the buyer of the fan is obliged to copy any physically missing elements of the product that he/she buys.
3. For market surveillance authorities this is equally helpful: they don't have to test the cooling tower with the fan, they can just test the fan and b) ensure that the buyer does not deviate –for the missing parts—from the configuration and geometry as tested.
4. Last but not least, it gives the manufacturers of the 'motorised impeller' some extra design options, especially on in- and outlet (inlet vanes, bell-mouths, diffusors, etc.) to significantly increase the efficiency of his product.

Furthermore, although it still needs to be debated in how much this constitutes a possible loophole in the current formulation, a proposal was made to make an exemption for fans handling gases/vapours with high relative humidity. This is specifically intended to accommodate (extraction) fans in cooling towers [see also the paper by Brivio which briefly touches upon aerodynamics and fan laws of an airstream with humidity load].

4.4.3 Fans in nuclear power stations, wind turbines, military and civil defence equipment.

Following the discussion on spare parts and the requirements on nuclear safety, the discussion document already proposed an exemption for nuclear power safety. Equipment for nuclear safety is firmly regulated under Euratom regulations and there is no danger of such an exemption leading to loopholes. The draft motor regulation uses the full text
'*This Regulation shall not apply to(...) the motors placed into service in nuclear installations, as defined in Article 3 of Directive 2009/71/EURATOM, after having undergone equipment qualification, in order to demonstrate compliance with national nuclear safety requirements as required by Directive 2009/71/EURATOM amended by the directive 2014/87/EURATOM*'.

The impact of the exemption will be limited. The EU has around 132 nuclear power plants in 14 of 28 EU Member States and approximately 1000 fossil fuel fired power plants[26], of which 600 >200 MW (total 472 GW→ avg 472 MW). A rough estimate by the study team is that one fossil fuel fired plant has on average scrubber, fuel and

[26] 1996 SEI

cooling tower fans with a combined electric power input for the fans of 4000 kW fan /plant. At 6000h/a this gives an electricity consumption of 24 GWh/a. Assuming that the fan power of a nuclear plant is comparable, the EU electricity consumption of fans in EU nuclear plants is around 3 TWh (132 x 0.024). The nuclear park is hardly growing and thus the chance that an Ecodesign regulation would have any influence on this energy use is small. Furthermore, energy efficiency is already an important priority for these plants. Hence the impact of missed energy savings from the exemption is estimated is estimated at less than 0.1 TWh per year.

The exemption for wind turbines is new and follows on one hand from the persistence of cooling fan manufacturers for this sector (Multi-Wing, Witt & Sohn) and on the other hand the turbine builders that space requirements are critical. For the housing of a wind-turbine this focus on space requirements does not come from habit (‘*we are used to taking a fan this much space, so we don’t want it to be bigger*’) but a technically and functionally understandable consideration that is linked to the fact that this housing is 50-60 metres up in the air and its size and geometry may influence the functionality of the wings (recirculation and turbulence). Furthermore, the chances that this exemption becomes a loophole are limited, because there are only a few, and very well-known builders of wind-turbines in the EU. Finally, the impact of cooling fan in what is still a limited number of wind turbines built per year, will be very small.

The latter, i.e. the fact that there will be very few fans that will be sold under defence contracts (for bunkers) or public civil defence contracts (for bomb shelters) makes it easy to make an exemption, whereas to make an allowance –as suggested by the manufacturer—would require truly in-depth knowledge of the very specialised area of making bomb-proof fans. For that reason it is proposed that these fans should be exempted.

4.5 Other new exemptions

4.5.1 Gases with compressibility 1.00

This provision means that the regulation deals with gases and vapours that have roughly the same characteristics as air. The formulation is specific to ensure that a ‘simplified’ efficiency calculation applies, i.e. without the compressibility factor that would otherwise need to be taken into account according to ISO 5801.
Formulation: handling gases with a compressibility factor, rounded to the nearest 2 decimal places, in the designated pressure and temperature range of the scope that is not equal to 1,00;

4.5.2 Battery-operated and handheld

The exemptions relate to fans

- in cordless or battery operated equipment;
- in hand-held equipment whose weight is supported by hand during operation;

Both exemptions were added for consistency with the draft Motor Regulation.

4.5.3 Low-noise fans

Finally, there is a proposal by Howden that is too recent for stakeholders and others to have had an opportunity to react to, which proposes a 10% allowance (a factor 0.9 on the minimum energy efficiency values) for a 'low noise' fan, especially in the range 10-200 kW. The definition relates to a 'characteristic noise emission value C' with value ≤32 dB(A).

The parameter is the impeller sound power, corrected for diameter, tip speed, flow rate and static pressure, referenced by an IPPC-BREF 2001[27] and van der Spek[28]. Though the suitability of this parameter and the limit value still have to be debated and the robustness of test standards still to be checked, it at least addresses a true performance issue where there is undoubtedly a grounds in physics. Furthermore, it addresses a true sub-optimisation problem [see paper Howden].

4.5.4 BC-fans with narrow impellers

In the latest joint position paper (21 Jan. 2015) the joint fan industry (Eurovent, EVIA, European AMCA) agreed on the following text for the exemption of centrifugal backward curved fans with narrow impellers:

'...those fans are used in systems requiring moderate volume flows and high pressures such as burners. Due to friction losses within the impeller they have always a lower efficiency than fans with broader impellers. Ratios L/d and d/D (where L is the width, d the internal diameter and D the external diameter of the impeller) are the relevant parameters to quantify the efficiency drop. Based on actual test data we propose to exclude from the regulation the BC centrifugal fans for which the dimensions of the impeller satisfy both conditions L/d ≤ 0.22 and d/D ≤ 0.28.'

There has been no time to discuss this issue within the review study, but these dimension-ratio's L/d and d/D do not seem too uncommon. It is suggested that these fans are combustion fans for (pre-mix) burners but they are not fans commonly used in residential boilers. A typical combustion fan in a 30 kW heating boiler has an electric power input of around 60-70 W. Combustion fans >125W are thus probably used for non-residential jet burners above 60-70 kW. Given enough time it must be possible to find an efficient solution, also because there are little space limitations in a non-residential boilers.

An elegant alternative solution might be to lower the exemption for fans with best efficiency point from 8000 rpm to e.g. 7000 rpm [29].

[27] EU commission BREF: Integrated Pollution Prevention and Control (IPPC) Reference document on the application of best available techniques to industrial cooling systems, December 2001.

[28] Spek H. van der, 1993, CTI TP93-03 "Reduction of Noise Generation by Cooling Fans".

[29] Most combustion fans are nominally at high speeds. Typical specification of a fan for a 30 kW boiler (ebmpapst RG128/1300-3612): 7400 rpm, 67 W, 134 m³/h, 2000 Pa.

5. Allowances

5.1 Introduction

The current fan regulation knows one allowance, in Article 3.5, for dual use fans. The formulation is:

'For dual use fans designed for both ventilation under normal conditions and emergency use, at short-time duty, with regard to fire safety requirements as set out in Directive 89/106/EC, the values of the applicable efficiency grades set out in Annex I Section 2 will be reduced by 10% for Table 1 and by 5% for Table 2.'

Knowing that Annex I, Section 2, Table 2 applies to the second tier, this means that per 1.1.2015 the allowance is 5%.

To investigate whether this is appropriate, the study team consulted the stakeholders and performed desk research.

The outcome is that an allowance of 5% is not enough and should be changed to 10%, i.e. a factor 0.9 of the minimum efficiency values should apply.

A dual use fan, depending on its classification (see paragraph 4.1), has to resist a heat up to 400 to 600 °C. The materials for the vanes and the stator are thus often aluminium or steel, which tend to expand considerably at these high temperatures, and still have to be able to run free. When the vanes return to normal temperatures of 20 °C there will thus be a considerable gap between the rotor-blades and the stator, i.e. much more than with a normal fan. This gap, referred as 'tip clearance', is important for the efficiency. It is the point with the highest air-velocity just before the air 'leaves' the blade. Any interruption in the flow at that point causes therefore the maximum turbulence and possibly recirculation and efficiency may drop by 6-7% only because of this effect.

The second cause of the efficiency loss is related to the fact that many dual use fans are reversible. For reasons of fire safety dual use fans will be expected to extract the smoke from the building and avoid inducing fresh oxygen. This implies that, even if they don't meet the 'reversible' requirement of 80% reverse flow versus normal flow, the blade geometry will be less asymmetrical (=aerodynamically optimal) than with a normal fan.

5.2 New: Reversible fans

In the discussion on dual use fans, stakeholders proposed to make an extra allowance for truly reversible fans. This means fans where the reverse flow rate is at least 80% of the original flow rate.

As explained above, reversibility is often a requirement for dual use fans and in those cases where the fan has to be both 'dual use' and truly reversible the 10% allowance would not be enough. This would leave the choice for a much more lenient dual use allowance or make the distinction between dual use and reversible with differentiated allowances. The latter was deemed more attractive.

Secondly, there are a number of applications where, also without being 'dual use', reversible fans are required. An example is timber drying, where the flow in the drying room has to periodically reversed.

In those cases of true reversibility, the vanes and stator have to be symmetrical. The vanes have to be symmetrical, which limits optimal curvature (if any), and also the possibilities to optimise aerodynamics at the inlet and outlet side (outlet diffusers, inlet vanes, etc.).

EVIA proposed an extra allowance for true reversibility, on top of the possible dual use allowance, of 10%. This would mean an accumulative allowance of 19% (0.9 x 0.9 = 0.81 times the minimum efficiency value).

In literature and from a comparison of unidirectional versus reversible fans an allowance of 15% would seem more appropriate for dual use & true reversibility. For reversible fans that are not dual use, an allowance of 15% should certainly be enough.

5.3 Allowances for special purpose fans

In its latest position paper EVIA mentioned that its proposals are challenging and need compensation factors to consider the variations:

- For axial fans with less than 300 Pa at best efficiency point we propose a compensation factor of 0.9
- For axial fans, to allow for aerodynamic losses due to externally cooled motors, V-belt drives and external shaft drives a compensation factor of 0.93
- For heavy duty axial fans, for example military, nuclear, mining, where an increased air tip clearance is technically necessary these should get a compensation of 0.93 total fan efficiency
- For fans where a shaft seal is necessary a compensation factor of 0.98 is required.
- Free form hollow fabricated axial blades (Non cast and moulded blades) have a compensation factor of 0.95.
- A compensation factor of 0.97 where anti-stall rings are integrated.

EVIA points to a benchmark paper by Witt & Sohn. Witt & Sohn gives several examples of the allowances they would like to see (See Table)

For centrifugal fans the compensation factors discussed in axial fans apply here, in addition EVIA proposes the following:

- For double inlet fans there needs to be a compensation for the loss due to the mounting arm.
- For fans with overhanging shafts (VHK: meaning that the shaft-length protruding from the casing is relatively long and supported by 2 sets of bearings, instead of 1)
- Back blades (VHK: probably short for 'backward-inclined blades')
- For fans with two separate drive units

Table 2. Combined allowances requested per application of axial fans (Witt & Sohn, Feb. 2015)

Application	Efficiency redo	Compo Factor	Application	Efficiency redo	Compo Factor
Wind mill generator cooling	**11%**	**0,85**	**Military fan (bomb shelter)**	**15%**	**0,80**
heavy duty design	4%		shock/ earth quake resistant	8%	
increased air gap	7%		increased air gap	7%	
Mining fan/ steel mill	**14%**	**0,81**	**Smoke extract fans**	**12%**	**0,84**
heavy duty design	4%		increased air gap	5%	
shaft seal	2%		reverse flow	4%	
V belt drive	8%		high temperature motor	3%	
Pulp & paper/ cement (small)	**10%**	**0,87**	**Pulp & paper/ cement (large)**	**13%**	**0,83**
externally cooled motor	5%		V belt	8%	
shaft seal	2%		shaft seal	2%	
heavy duty construction	2%		heavy duty construction	2%	
star/ delta motor (cables)	1%		star/ delta motor (cables)	1%	
Wind tunnel	**12%**	**0,84**	**Atex blower (zone 1, infrequent gas)**	**13%**	**0,83**
reverse flow	4%		increased air gap	7%	
externally cooled motor	5%		heavy duty design	2%	
free form fan blades	3%		large terminal box	4%	
Nuclear	**11%**	**0,85**	**Fan with stand by motor (gas turbine)**	**10%**	**0,87**
shock/ earth quake resistant	8%		heavy duty design	2%	
decontaminable	3%		external shaft	8%	
Very cold climate ventilation fan	**13%**	**0,83**	**Food industry**	**14%**	**0,81**
free form fan blades (50°C)	3%		externally cooled motor	5%	
reverse flow	5%		shaft seal	2%	
heavy duty design	2%		increased air gap	3%	
anti-stall	3%		high pressure (filters)	4%	

All these allowances were proposed 'last minute'. They show that the producers of specialty fans are very worried about how close the proposals, even of their own association, come to the limits of their practice.

However, a closer look reveals that a considerable part of these concerns were already taken into account in the discussion document and most is now taken into account not through allowances but through exemptions:

- Fans in nuclear power plants, windmills, military and civil defence are explicitly exempted in article 1.2;
- ATEX blowers are proposed to be explicitly exempted in article 1.3 a);

- Smoke extract fans a.k.a. ‘emergency fans’ are explicitly exempted in article 1.3 b);
- Fans in
  - cement industry (dust load >0.2 g/m3, abrasive substances),
  - mining/ steel mills (dust load >0.2 g/m3, high temperatures),
  - paper mills (high dust load > 0.2 g/m3, sometimes higher temperatures) and
  - very cold climate ventilation (low temperature, probably also high dust load as it is a mining fan)
- are exempted on the basis of being designed for special purpose/conditions in article 1.3 c).

Furthermore, wind tunnel fans are reversible fans for which an allowance of 0.85 is proposed.

The matter of the very specific fan-solution for the food industry needs further investigation and discussion. Desk research shows no food-industry standards that would necessitate the specific solution of an extended shaft. It is unclear why the specific question (no contact with the lubricants) was chosen with food-grade lubricants. The presence of an externally cooled motor is not a ‘special’ solution but applies to most belt-driven fans, for which –by the way—EVIA has not asked an allowance.

As regards the allowances that EVIA asks for centrifugal fans they are specific technical solutions (not technology-neutral) and lack any argumentation as regards functionality or otherwise. In this form they will not convince any policy maker that special allowances should be made.

6. Jet fans

6.1 Introduction

The European Commission has asked the study team to assess the possibility of setting minimum requirements for jet fans.

Jet fans are used in tunnels and parking garages to deliver a maximum amount of thrust, i.e. the ability to drive forward an air mass in a two-way open envelope. The jet fans are not defined by their blade geometry, i.e. they can be axial (most) or centrifugal (rare), but it is proposed to define them by their performance (see Chapter 3).

Annex A estimates the EU electricity consumption for road tunnel ventilation at 5.8 TWh/yr, for rail- and subway tunnels at 0.5 TWh/yr and for parking garage jet fans also at 0.5 TWh/yr. In total this amounts to an electricity consumption 6.8 TWh/year.

6.2 Test standard and data retrieval

Technical Committee ISO/TC 117, *Fans*, Working Group 13, *Jet Fans*, prepared a draft standard ISO/DIS 13350 for performance/efficiency testing of jet fans, which is currently in the stage of voting. The preparation involved the contribution of experts from major producers for the EU (Zitron, Howden, Fläkt Woods, Witt & Sohn).

Through this working group, the study team received a first overview, for 179 models, of the efficiency according to ISO/DIS 13350 and through the data published on the websites of the 4 major EU manufacturers. This overview was received in May 2014 from Zitron, for both unidirectional and reversible large jet fans. This was the basis for the scatter-diagram presented in the discussion document.

An update was received from the same source in January 2015. The update relates only to reversible fans which reportedly make up 90% of all jet fans sold.

The graph shows a population of 169 models with a power range from 0.55 to 90 kW (average 26.7). The fan impeller efficiency[30] ranges from 35 to 66% (average 52.7%). The logarithmic trend-line runs from 47% efficiency at 0.55 kW to 54% at 90 kW. At 10 kW, the anchor point used in the current regulation the value is 52%.

If, for instance, a minimum efficiency would be set at 50%, 49 of 169 models (23%) would be eliminated and the average efficiency of the remaining population of 120 models would become 54.9% compared to 52.8% for the original population.

If a minimum efficiency is set at the trend-line (1.4232*LN(P)+47.914) 79 models (47% of the population) would be eliminated and the average efficiency of remaining models would become 55.9%. In both cases the 3 smallest models (below 1.1 kW) would be eliminated, but some members of the working group believe the measurements for these very small models (for a jet fan) might be flawed.[31]

[30] Meaning the efficiency without the motor (motor efficiency=1)

[31] Note that usually not every fan is tested but scaling (Ackeret, based on Reynolds numbers) is used to inter-/extrapolate from some known test points, which especially may have a large effect for the small fans.

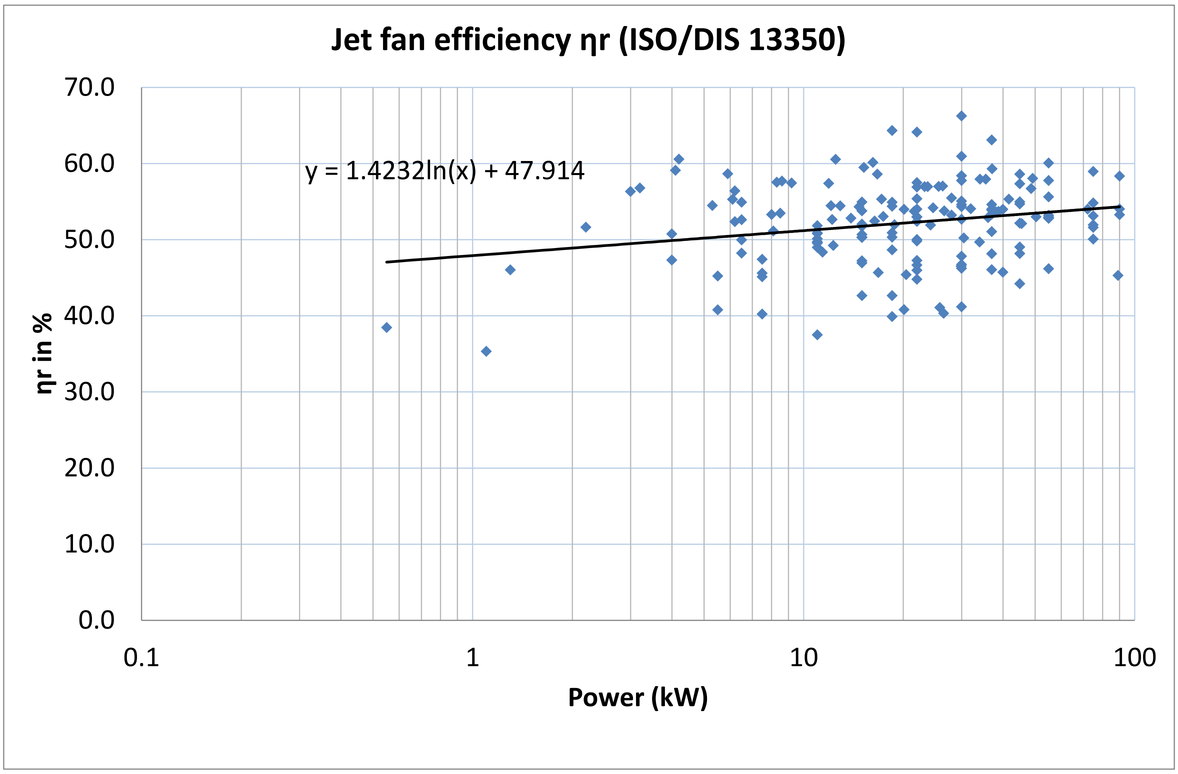


Figure 4. Reversible jet fans, input power versus fan impeller efficiency according to ISO/DIS 133560 (Zitron, Jan. 2015). The Y-axis uses a logarithmic scale.

6.3 Considerations

Inside the working group there seems to be a minority proposal to use not the efficiency η_r as indicated in the standard but the ratio of thrust and input power (Tm/P). To avoid ambiguity this means it is prudent to make the efficiency measure explicit in the regulation.

The dispute is also reflected in the recent paper by Witt & Sohn, who makes a case not to set minimum efficiency standards for jet fans on the grounds that 'Contrary to most uses of fans jet fans are mainly bought by with public funds and their specification based on national and international rules and guide lines[32]. It is a very transparent market where it is customary for almost all projects that a performance test which includes the comparison of performance versus energy consumption is measured in each case. If there is a need to improve the energy consumption of jet fans introducing life cycle cost comparison into the public tenders seem to be a better way than setting efficiency targets, especially since the actual system performance of the jet fans do not correlate very much with the proposed Total Fan Efficiency measure used in the report.' [33]

[32] For an overview of guidelines on fire safety of road tunnels see http://www.wtcb.be/?dtype=services&doc=FIT_Annex3_Technical_report_part_2_Fire_safe_design_Road_tunnels.pdf&lang=en.

[33] Meaning in the ISO/DIS 13350 standard, which the report follows.

Furthermore Witt & Sohn argues that ‘Because jet fans have to be able to operate from 50°C continuously to 600°C for 2 hours and be up to 100% reversible at least a 0,85 x 0,85 compensation factor would be required effectively making the limits meaningless. Even if a limit was to be set it should be very different from the curves shown in the report.’

More can be found in the Witt & Sohn paper on the subject. Note that no other papers were received on the subject and the position of Witt & Sohn is not supported by any of the associations.

6.4 Recommendation

At this point it is up to the Consultation Forum to decide, but –even if it is decided to exempt jet fans—there is still the matter of a robust definition that allows no loopholes. In that sense, the proposal from Chapter 3, i.e. to require a minimum efficiency to both define and exempt these jet fans. This minimum could be 50%, which seems reasonable given the above analysis.

7. Surveillance issues

7.1 Market surveillance authorities

The study team consulted stakeholders and performed desk research on the topic of market surveillance. The former resulted in a statement that there virtually is no market surveillance by Member States. The desk research by the study team comprised

- ADCO (ADCO) Working Groups on Ecodesign and Energy labelling
- CIRCABC: The Communication and Information Resource Centre (Circa)
- RAPEX: the EU Rapid Alert System (RAPEX).
- ICSMS: (Information and Communication System on Market Surveillance)
- Danish Energy Agency, misc. papers on market surveillance fans, 2014
- Swedish Energy Agency, pers. comm., Feb. 2015.
- The Ecopliant project
- The ATLETE and ATLETE II projects and the
- Come On Labels project.

The result was that probably, with some uncertainty on the situation in Denmark, that there has been no compliance testing on industrial fans by market surveillance authorities in the Member States.
Some countries like Denmark and Sweden are in preparation, but mainly the activity is limited to document inspection.

The Swedish Energy Agency, who is the surveillance authority in Sweden, reports that 'the issue of responsibility of the fans is of outmost importance for market surveillance. Monitoring and verification of products under any ecodesign regulation, e.g. by testing products, is of very little use if the regulation is not enforceable. For the regulation to be enforceable, it must be perfectly clear in who to address in case on suspected non-compliance, i.e. which economic operator is legally responsible for the non-compliant fan.

Document inspection is a form of market surveillance. This is a procedure we often use as a first step. Based on document inspections alone, MSAs can take legal action against a product, including sales ban. The document inspection will also often serve as an input for the MSA on which brands or models to target for testing. When performing document inspection, it is not unusual to find products that are out of scope of a regulation. Also uncertainties with the regulation will surface in this first step. As for industrial fans, it was discovered that there is no certainty as to which manufacturer that is responsible for the fan. The Commission FAQ gives guidance, but it is not legally binding. So to "waste" a lot of money on testing fans, when it is not known whom to address if it is discovered that the fan does not comply is not ideal.'

The Swedish Energy Agency is planning to engage in actual fan testing later this year.

The fan industry signals and regrets the lack of market surveillance, but offers no real solution to the lack of funding at MS-level that most certainly is one of the causes. The associations are, however, resolute in their statement that third party certification (TPC) is not the answer. It would not, according to them, solve the problem of free-riders but instead would just create a lot of administrative burden.

Manufacturers think that for effective market surveillance also the availability of test facilities is problematic and suggested a collaboration, possibly perhaps the use of their certified laboratories.

7.2 Verification tolerances

For Ventilation Units, a product that incorporates fans and more, the regulation (EU) No. 1253/2014[34] prescribes verification tolerance of 7%. Following this example and verification of applicable standards, the discussion document proposed to reduce the verification tolerances for industrial fans from the current 10% also to 7% (factor 0.93).

Not everyone of the stakeholders had a problem with that, but several manufacturers of especially bespoke industrial fans (produced one-off or in small series) gave fairly convincing evidence on deviations in tip clearances and rotor-angles that would necessitate to keep the 10% tolerance.

Pragmatically speaking, given that it is unpractical to make a differentiation, it is recommended to keep the 10% tolerance (factor 0.9 of the minimum efficiency value).

7.3 Testing practice and costs

Several manufacturers have given an indication of testing costs per fan according to EN ISO 5801, sometimes even differentiated by fan size. On average these costs are around € 3000,- per fan.[35]

The problem is, that there are so many fans to test. In general, a manufacturer uses a base geometry and then many variations of that geometry with a different diameter. The diameter-series follows a logarithmic scale.

Large fan manufacturers and medium-sized specialty fan manufacturers may thus be able to supply up to 30 000 models in their product range. Even without Ecodesign regulation, the specifications of these fans have anyway to be established for their customers and their catalogue. To avoid huge testing costs the manufacturers do typically test only a few models with different diameters and then inter-/extrapolate for the other models.

The ‘scaling’ algorithm used for the inter-/extrapolation is typically based only on Reynolds numbers (Ackeret method 1951; Reynolds numbers are based on the amount of turbulence that can be expected). This method is conservative, e.g. predicting only a 3-4% efficiency rise between 10 and 200 kW, and ensures that –

[34] OJ L 337, 25.11.2014, p. 8.

[35] For special purpose military fans (bunkers, bomb shelters), which are anyway recommended to be exempted, Witt & Sohn indicates testing costs of € 50 000,- and more for actual bomb-proof testing.

despite e.g. production tolerances—the efficiency and performance is certainly not overstated.

However, this also creates a possibility of over-dimensioning for a given specification and operation at a suboptimal efficiency point. This comes then on top of the over-specification by the customer, due to all sorts of safety factors.

For the legislator striving for best efficiency this practice is also confusing. It may well be that the industry needs to extrapolate the same base geometry over a large power range, but –as some manufacturers also confirm—there is no 'one-geometry-fits-all' solution. In principle, for every operating point there is a technically superior geometry. Usually this does not show too clearly when looking only at one geometry range, but it typically shows when the same medium operating point is covered by a low-to-medium size product range and a medium-to-high product range.

To improve the situation, i.e. to make the efficiency and performance values closer to reality, an improved scaling-method could be used that not only takes into account Reynolds numbers but also surface smoothness, attack angle, etc.. Such a method is proposed by the University of Darmstadt. For more information see the 'References' section of this report.

8. Scope and definitions

8.1 Introduction

During the stakeholder consultation it became evident that there is a great deal of confusion and malcontent amongst stakeholders concerning the scope of the regulation and the fan definition(s). For that reason the study team made alternative proposals in the discussion document which overall contributed to a consensus amongst the majority of the stakeholders on more appropriate texts. Whether such texts would fully pass legal scrutiny is another matter, yet to be established in the follow-up.

8.2 'Scope' in article 1.1

The scope of the regulation is in principle indicated in Article 1.1, but in the background there are legal documents such as the EC Blue Guide and the Ecodesign Directive with its definitions of 'products', 'components', 'sub-assemblies' and 'parts' that make it very difficult to find an exact text that would cover the intention.

The intention, as welcomed by (most) stakeholders, is that the fan manufacturer is responsible for the compliance testing and CE-marking (including the Document of Conformity DoC) and that the buyer/user of the fan is responsible for asking the DoC and CE-mark and keep it on file for possible inspection.

In other words, in as much as the fan user does not alter (within limits) the geometry of the fan design/configuration being tested for compliance by the manufacturer it is not necessary to test again.

If the manufacturer of the fan and the manufacturer of the end-product are one and the same, then this manufacturer has to test the bare fan and –should the end-product also be regulated under Ecodesign—also the end-product. The same applies if the fan user makes significant changes to e.g. the stator, rotor or drive package of the fan, the fan user becomes de facto a fan manufacturer and has to test the bare fan configuration.

To be clear: The test of the fan is <u>never the same test</u> as for the end-product. For instance, for ventilation units, which may appear very close to a 'fan', the test comprises the internal pressure drop from the product casing, internal and in- and outlet ducting, heat exchangers, etc. and even on the fluid dynamic efficiency gives a different outcome from a fan efficiency test according to EN ISO 5801 that does not include all these items.

8.3 Fan definition in Article 2

Article 2 introduces the definition of a 'fan' and all the elements of such a definition. It thus limits the scope of the regulation but also prepares, through definition of categories and key parameters, how the minimum requirements should be established.

In the discussion document a proposal was made to improve the clarity of the scope and to introduce key elements that, later on in the Annexes, will provide a simplification.

The proposal for article 2.1 is

Regulation 327/2011 (current) **Article 2.1**	**Discussion document Nov. 2014 (new)** **Article 2.1**
1. 'Fan' means a rotary bladed machine that is used to maintain a continuous flow of gas, typically air, passing through it and whose work per unit mass does not exceed 25 kJ/kg, and which: — is designed for use with or equipped with an electrical motor with an electric input power between 125 W and 500 kW (≥ 125 W and ≤ 500 kW) to drive the impeller at its optimum energy efficiency point, — is an axial fan, centrifugal fan, cross flow fan or mixed flow fan, — may or may not be equipped with a motor when placed on the market or put into service;	1. 'Fan' means a configuration of impeller, stator, electric motor, transmission or direct drive and possibly a variable speed drive, intended for the continuous displacement of gas with at its bep an electric input power between 125 W and 500 kW (≥ 125 W and ≤ 500 kW), a pressure-increase ratio lower than 1.1 and an output air velocity lower than 51,5 m/s, and which is an axial fan, centrifugal fan, cross flow fan, mixed flow fan or jet fan.

In the new definition the separate components constituting a fan are added, following proposals in draft standards and 1st stakeholder meeting that try to define a 'fan', also when it is not a self-standing product but a set of components in another product.

The fan industry (EVIA, Eurovent, European AMCA) welcomes the new definition, but would like to use *'drive system'* here and define later that this means *'electric motor, transmission or direct drive and possibly a variable speed drive'*.

Other elements are:

- *'continuous'* sets the 'fan' apart from e.g. devices that create a single burst of gas displacement;
- *'displacement'* of gas is also the functionality of ventilation units (see below), but here the goal is not further specified and thus can include also convection fans, combustion fans, etc.;
- *'bep'* (best efficiency point), defined hereafter, is used throughout the regulation.
- The *'pressure-increase ratio'* and *'electric input power'* range define the scope in terms of performance, and sets fans apart from compressors (pressure-increase > 1.1), motors <125W (typical for residential ventilation units and other household appliance fans) and excludes bespoke large heavy duty fans >500 kW for the process- and power industry, where market forces probably don't need EU regulation to achieve highest energy efficiency;
- The addition of the *air velocity* of 51,5 m/s means that --according to ISO 5801-- the Mach factor is lower than 0,15 and can thus be neglected. Fans above 51,5 m/s are extremely rare (e.g. high-pressure combustion/pre-mix centrifugal fans with a very small outlet) and are mostly already excluded on the basis of their pressure ratio above 1,1 (>10 kPa)

Note that, following the most recent update of ISO 5801 the industry proposed to use 65 m/s.

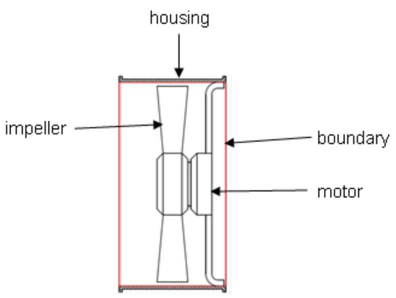
- The inclusion of several types (*axial, centrifugal, etc*.) already in Art. 1 (or 2) is common in several Ecodesign regulations;
- *'Rotary bladed'* is not strictly needed and unnecessarily restrictive (why exclude future reciprocating solutions, acoustics?);
- The specification of *'not exceed 25 kJ/kg'* is deleted, because it is redundant and unnecessary restrictive when already using a specific pressure ratio of 1.1 and electric power input 0.125-500 kW. It would be more consistent with other regulations to replace the electric power input with e.g. aerodynamic power, e.g. between 50W and 450 kW power output, but the change could be difficult (see also later);
- The addition of *'electric'* excludes e.g. fossil fuel driven engines (e.g. motor cooling fan for vehicles), steam (engine) driven and compressed air driven (pneumatic) fans. We do not propose the expression 'mains-electric' as in other regulations because many fans do not use 230 V 'mains' but 12, 24, etc.V DC as a power source or medium-voltage (1000 V).
- *‘may or may not be equipped with a motor when placed on the market or put into service’* is deleted from the definition because, following stakeholder consultation, it was recommended to eliminate the ‘*not final assembly’* option from the regulation, which eliminates a considerable loophole and barrier for market surveillance.

Note that the new definition combines a number of elements of the old definition into one. This simplifies the structure and makes it easier to understand. The rest of the Article 2 can be limited to definition of the components (stator, rotor, vsd, etc.) fan types (axial, centrifugal, etc., see Chapter 3) and concepts like ‘*bep*’[36], ‘*pressure ratio’*[37] and –for the benefit of defining emergency fans ‘*short time duty’*.[38]

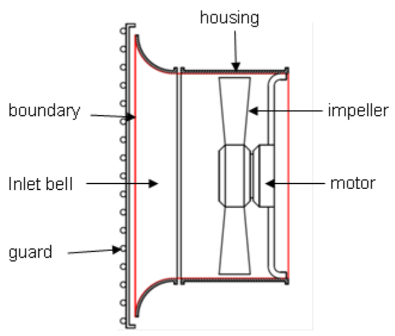
Possibly ‘dual use’ and ‘reversible’ also will need to be defined in Article 2, before allowances can be given in Article 3.

The figures on the next pages give examples of practical boundaries around rotor, stator and drive system for testing. Figure 5 is taken from the draft standard currently being prepared by CEN TC156 WG17 under mandate M500. Figure 6 gives two examples elaborated by VHK.

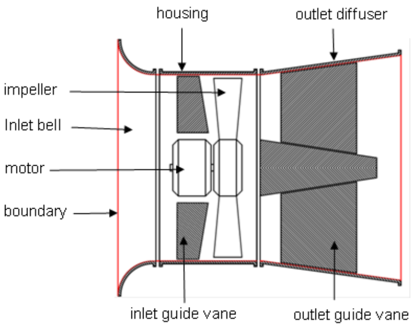
[36] 'bep' is the best energy efficiency point for fan operation, as declared by the manufacturer and specified by the applicable fan speed, expressed in rounds per minute (rpm);
[37] The ‘specific pressure ratio’ means the stagnation pressure measured at the fan outlet divided by the stagnation pressure at the fan inlet at nominal flow rate. This is the current definition; could be improved.
[38] ‘Short-time duty’ means working of a motor at a constant load, which is not long enough to reach temperature equilibrium. This is the current definition; could be improved.



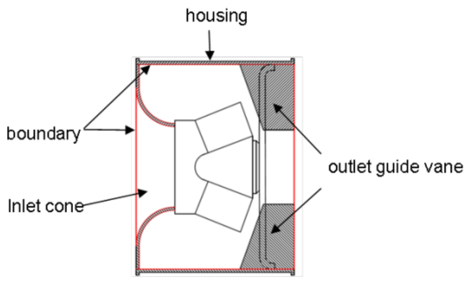
(a) Tube-axial



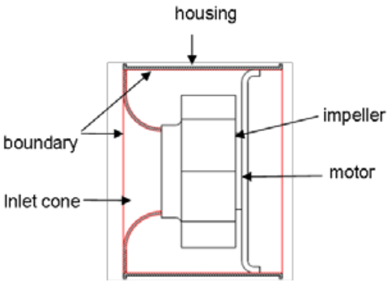
(b) Tube-axial with bell (guard not in boundary



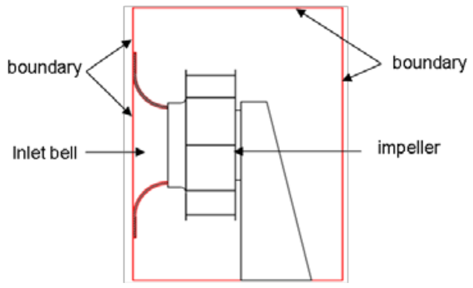
(c) Vane-axial with inlet bell, inlet guide vane, outlet diffuser & vane.



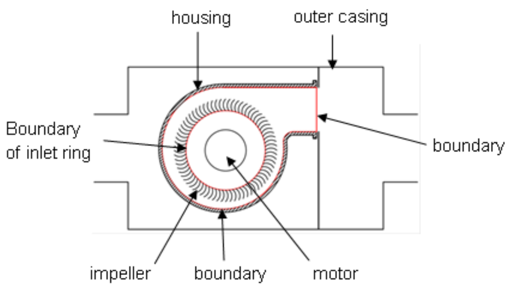
(d) Mixed-flow with inlet cone and outlet guide vanes



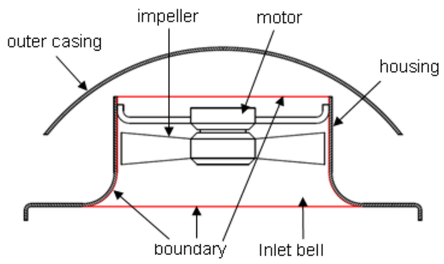
(e) Centrifugal fan with housing



(f) Centrifugal fan without housing (plenum fan)

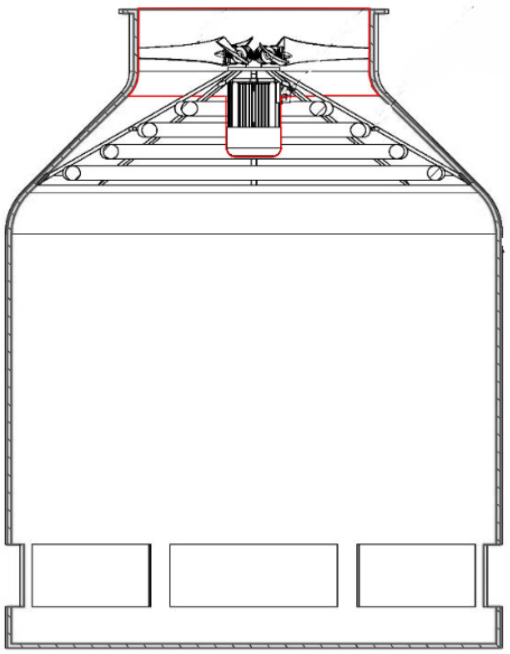


(g) Boundaries of centrifugal fan inside a box-fan

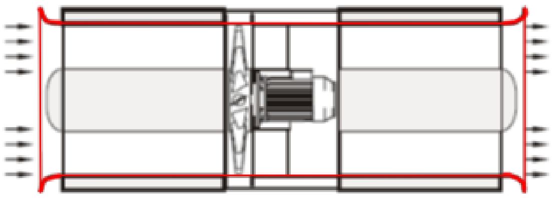


(h) Boundaries of an axial fan with bell, inside a rooftop-fan

Figure 5. Examples of 'fan' boundaries for compliance testing. (source: CEN/TC 156/WG 17 Fans Working Draft for Harmonised Standard under elaboration)



(d) Illustrative boundaries of axial fan inside a cooling tower, with bell and possibly inlet vanes, diffuser area.



(d) Jet-fan with in- and outlet bell, vanes, attenuators

Figure 6. More possible examples of 'fan' boundaries for compliance testing. Cooling tower modalities are currently being discussed in the standardisation WG. The idea is that for compliance testing the 'fan' manufacturer has to use a real stator delineated by the indicated boundaries, but he does not necessarily have to deliver that part to the customer, as long as the customer, i.e. the cooling tower manufacturer, follows (within tolerances) the test-stator geometry. In that case the customer would not be required to perform a new fan compliance test. *(Boundaries drawn by VHK as illustration. Back-picture source: Multi-wing and CEN/TC 156/WG 17 Fans Working Draft for Harmonised Standard under elaboration)*

8.4 Technical definitions in Annex I

In the discussion document the technical definitions were made more exact and verifiable.

In general, the stakeholders welcomed the improvements. Only Océ contested the introduction of the power conversion factor for DC-motors and ECOS contested the compensation factor for variable speed drives.

8.4.1 Power conversion factor for DC-motors

By definition, given that battery powered fans are excluded, DC power comes from a transformer (or in rare cases that will be neglected: a fossil fuel fired generator, solar PV or thermos-acoustics with DC output) and it would be fair, like e.g. for low voltage halogen light sources, to include a correction for the transformer energy losses (e.g. following Ecodesign regulation 278/2009 for external power supplies with active efficiency 0.87 for >51W; Proposal 0.9 for power conversion, see Annex I, Cp).

Printer manufacturer Océ (subsidiary of Japanese CANON) does not agree with the power conversion for DC-transformers and thinks that it unnecessarily complicates matters because then there should also be a correction for the power factor (cos phi) with AC-motors. The study team does not agree with this assessment. The influence of the power factor is an order of magnitude lower than the transformer losses, the proposal for this correction means that the legislator is consistent across legislation and wants to provide a level playing field for all.

8.4.2 Compensation factor for variable speed drive (VSD)

ECOS states that no bonus (factor 1.04) should be given to variable speed drives. The advantages should be self-evident and no bonus is needed.

The study team would like to point out, as did several stakeholders in the stakeholder meeting, that this is not a 'bonus' but a compensation for the fact that –without an extended product approach that would test at part loads— a fan with VSD uses at nominal load more energy than the same (single speed) fan without the VSD.

In other words, a situation might occur without the compensation factor the single speed fan may pass the minimum energy efficiency limit and the VSD-solution with the same fan is banned. This is not acceptable and thus the compensation was introduced.

However, it is clear that for a product like a fan, as is already the case for circulators and probably soon for water pumps, the extended product approach should be introduced and then the compensation factor for VSD is no longer needed.

Unfortunately, for various reasons (preparation of the standard, round robin tests, consensus within industry) this will be a while.

9. Limits & benchmarks

9.1 Introduction

In every Ecodesign review study it is customary to update the requirements to technological progress. In this particular case, there is even more reason because the sector did not succeed in having a new metric in place that would e.g. fully explore the possibilities of variable speed control, optimum choice of products on the basis of performance parameters (pressure, flow rate, noise), etc.. This prompts an exploration of the limits under the current metric and possibly an opportunity to prepare for the direction that a new metric could take.

After a hesitant start and a provocative proposal in the discussion document, many manufacturers supplied necessary data and in the end –either individually (ebmpapst) or through the fan industry associations—came up with ambitious proposals. Also the many concerned reactions, not only to the values in the discussion document but also the proposals of EVIA, the proposals are probably at the limit of what can be done within the constraints of Ecodesign legislation.

In the opinion of the study team The proposal takes full account of the latest technical developments in

- motors, moving ever more towards EC motors for the ever larger sizes, improving efficiency by up to 20-30% with respect to standard designs,
- diffuser and bell-mouth designs adding some 30% or more to the bare fan efficiency
- CFD-simulation[39] and 3D-print prototyping to optimise impeller design with up to 10%
- increased use of direct drives instead of belt drives, saving each time 5 to 7%.

But it is still, also with the exemptions and allowances discussed in this report, respectful of the possible limitations in space, noise limits, possible contaminations of the gas (air) as well as fans that are operating within but close to the exemption limits in Article 1.

As regards benchmarks, EVIA has put into evidence that, even within a fan category there may be a range of achievable efficiencies that spans an efficiency grade of 10%-points (N=10). Likewise, the discussion document may have based its comparison on 4-pole motors but in reality AC motors with 6-, 8- have lower efficiencies and are still sometimes necessary for noise reasons.

In other words, EVIA is saying that it is possible to find catalogue values that are 15 or even 20% better than what they are proposing, but taking into account the p[ossible constraints their proposal of a minimum efficiency is ambitious.

Having studied not only the data made public by market leader ebmpapst, but also having received confidential databases from other producers, several of them SME, the study team agrees.

Furthermore, after having witnessed the impact of the current regulation on the catalogues of the manufacturers, i.e. the number of models replaced by more efficient

[39] CFD: Computer Fluid Dynamics.

level, the study team finds it reasonable to restrict the review to one single tier (Tier III) per 1.1.2020.

9.2 Current minimum requirements

The following table and graphs describe the minimum requirements in the current Commission Regulation (EU) 327/2011. Note that the table copies the legal text with decimal comma and percentages as integers.

Table 3. Current minimum requirements per 1.1.2013 and 1.1.2015

Fan types	Measure-ment category (A-D)	Efficiency category (static or total)	Power range P in kW	Target energy efficiency (*%)	Efficiency grade (N, *%)	
					1.1.2013	**1.1.2015**
Axial (AX)	A, C	static	0,125 ≤ P ≤ 10	ηtarget = **2,74** · ln(P) – 6,33 + N	36	**40**
			10 < P ≤ 500	ηtarget = 0,78 · ln(P) – 1,88 + N		
	B, D	total	0,125 ≤ P ≤ 10	ηtarget = **2,74** · ln(P) – 6,33 + N	50	**58**
			10 < P ≤ 500	ηtarget = 0,78 · ln(P) – 1,88 + N		
Centrifugal FC	A, C	static	0,125 ≤ P ≤ 10	ηtarget = **2,74** · ln(P) – 6,33 + N	37	**44**
			10 < P ≤ 500	ηtarget = 0,78 · ln(P) – 1,88 + N		
	B, D	total	0,125 ≤ P ≤ 10	ηtarget = **2,74** · ln(P) – 6,33 + N	42	**49**
			10 < P ≤ 500	ηtarget = 0,78 · ln(P) – 1,88 + N		
Centrifugal BC without h. (BC0)	A, C	static	0,125 ≤ P ≤ 10	ηtarget = **4,56** · ln(P) – 10,5 + N	58	**62**
			10 < P ≤ 500	ηtarget = 1,1 · ln(P) – 2,6 + N		
Centrifugal BC with housing (BC1)	A, C	static	0,125 ≤ P ≤ 10	ηtarget = **4,56** · ln(P) – 10,5 + N	58	**61**
			10 < P ≤ 500	ηtarget = 1,1 · ln(P) – 2,6 + N		
	B, D	total	0,125 ≤ P ≤ 10	ηtarget = **4,56** · ln(P) – 10,5 + N	61	**64**
			10 < P ≤ 500	ηtarget = 1,1 · ln(P) – 2,6 + N		
Mixed flow (MF)	A, C	static	0,125 ≤ P ≤ 10	ηtarget = **4,56** · ln(P) – 10,5 + N	47	**50**
			10 < P ≤ 500	ηtarget = 1,1 · ln(P) – 2,6 + N		
	B, D	total	0,125 ≤ P ≤ 10	ηtarget = **4,56** · ln(P) – 10,5 + N	58	**62**
			10 < P ≤ 500	ηtarget = 1,1 · ln(P) – 2,6 + N		
Cross flow (CF)	B, D	total	0,125 ≤ P ≤ 10	ηtarget = **1,14** · ln(P) – 2,6 + N	13	**21**
			10 < P ≤ 500	ηtarget = N		

The figures below give a graph, on a logarithmic scale, of the limits.

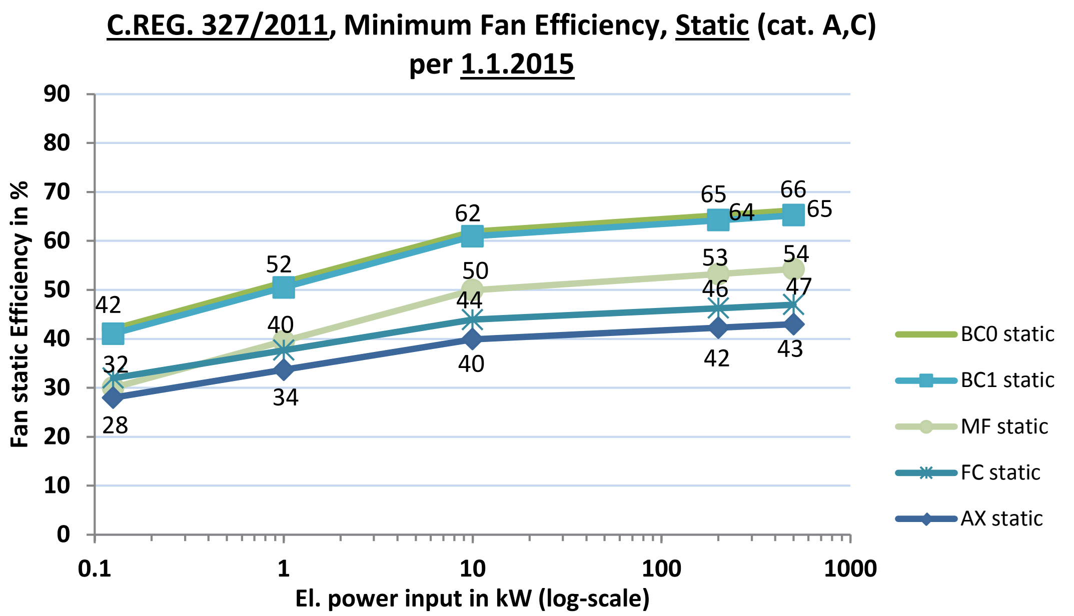


Figure 7. Current minimum efficiency limits per 1.1.2015 for measurement categories A & C, based on static pressure.

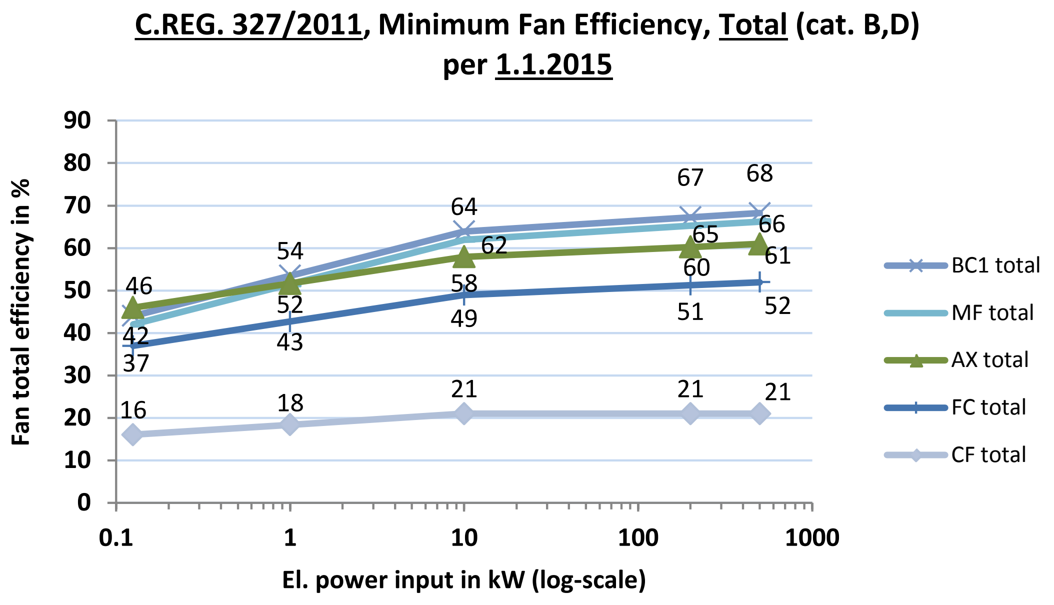


Figure 8. Current minimum efficiency limits per 1.1.2015 for measurement categories B & D, based on total pressure.

9.3 Industry proposal

The following gives the EVIA proposal ('N industry 2020') and compares it, in as much as is possible with the new slopes, to the current regulation (column 'N Reg 327/2011' 2015).

Table 4. Industry proposal for 2020.

Pe	ηmin for all types
0.125 ≤ Pe ≤ 10	ηmin= 4.56*LN(Pe)-10.5+N
Pe > 10	ηmin= 1.1*LN(Pe)-2.6+N

	N Reg 327/2011	N Industry	N increment	New curve
	2015	2020		
AX static (cat. A,C)	40	**50**	+10	BC curve
AX total	58	**64**	+4 (static+14)	BC curve
FC<5kW static	44	**52**	+8	BC curve
FC<5kW total	49	**57**	+8 (static+5)	BC curve
BC & FC>5kW static	62	**64**	+2	
BC & FC>5kW total	64	**67**	+3 (static+3)	
MF static	50	**57**	+5	
MF total	62	**67**	+3 (static+10)	
CF total	21	**21**	0	

BC no housing	combined with BC housing (consensus)	
FC	separate category up to 5 kW	
2020 tier	Only 1 tier per 1.1.2020 (design cycle minimum 4-5 years)	

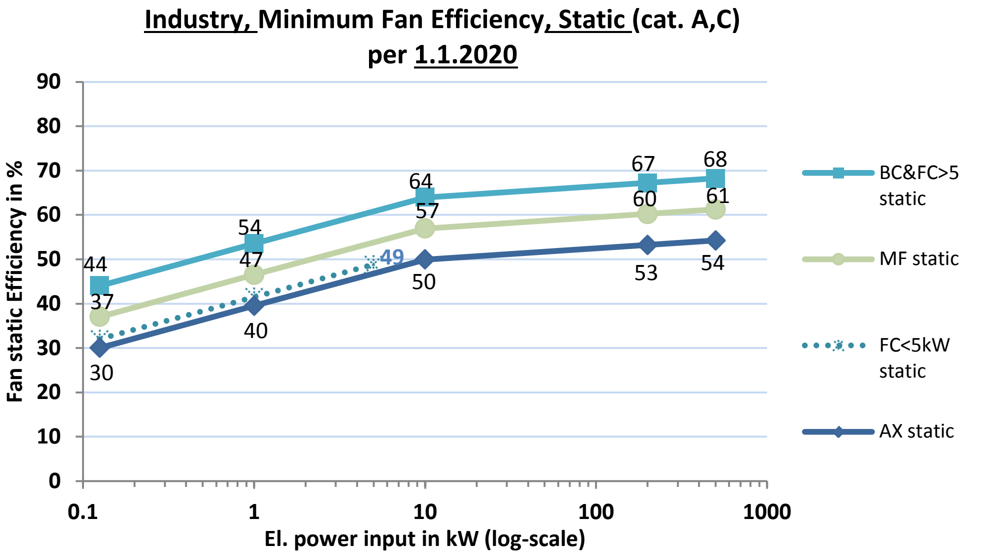


Figure 9. Industry proposal: Minimum efficiency limits for measurement categories A & C, based on static pressure.

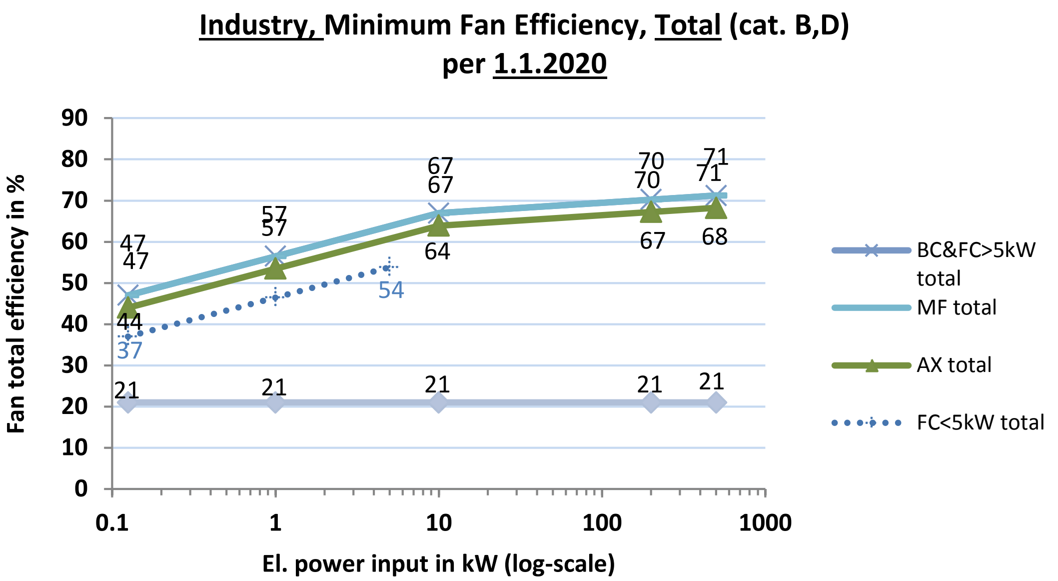


Figure 10. Industry proposal: Minimum efficiency limits for measurement categories B & D, based on total pressure.

9.4 Impact on product range

The following diagrams present the impact of the industry proposal in the scatter-diagrams of past and present ebmpapst models in the various categories.

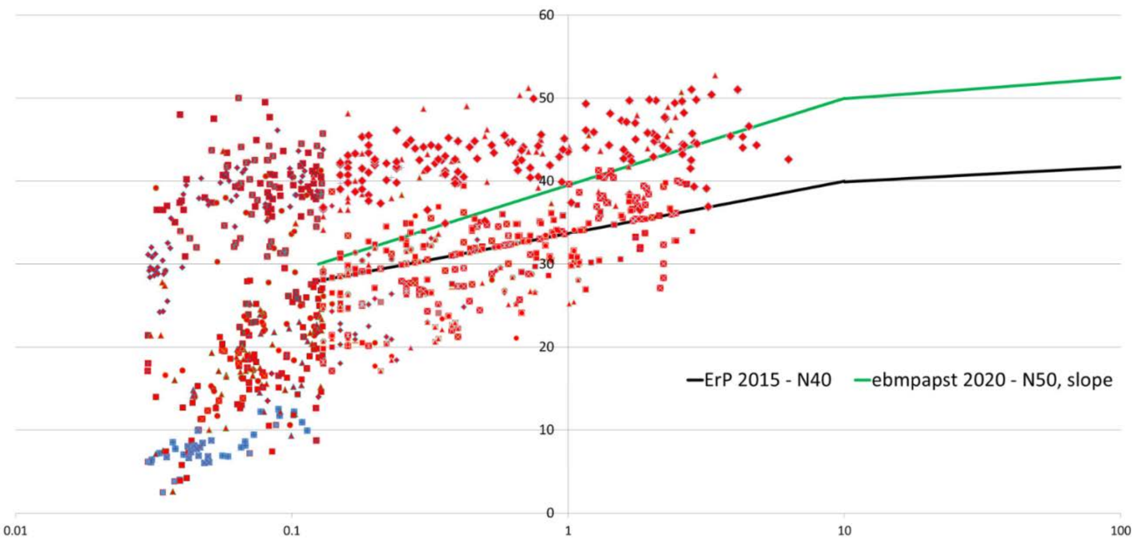


Figure 11. Limit lines in scatterdiagram of past and present ebmpapst production of axial fans

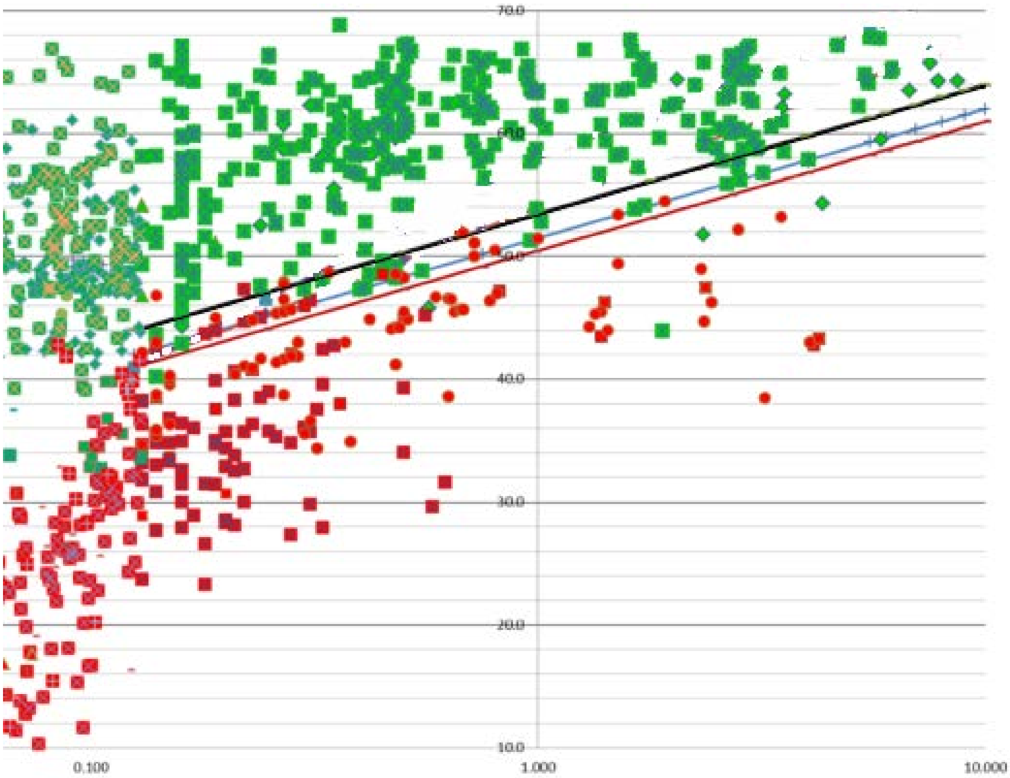


Figure 12. Limit lines in scatterdiagram of past and present ebmpapst production of Centrifugal Backward-Curved fans

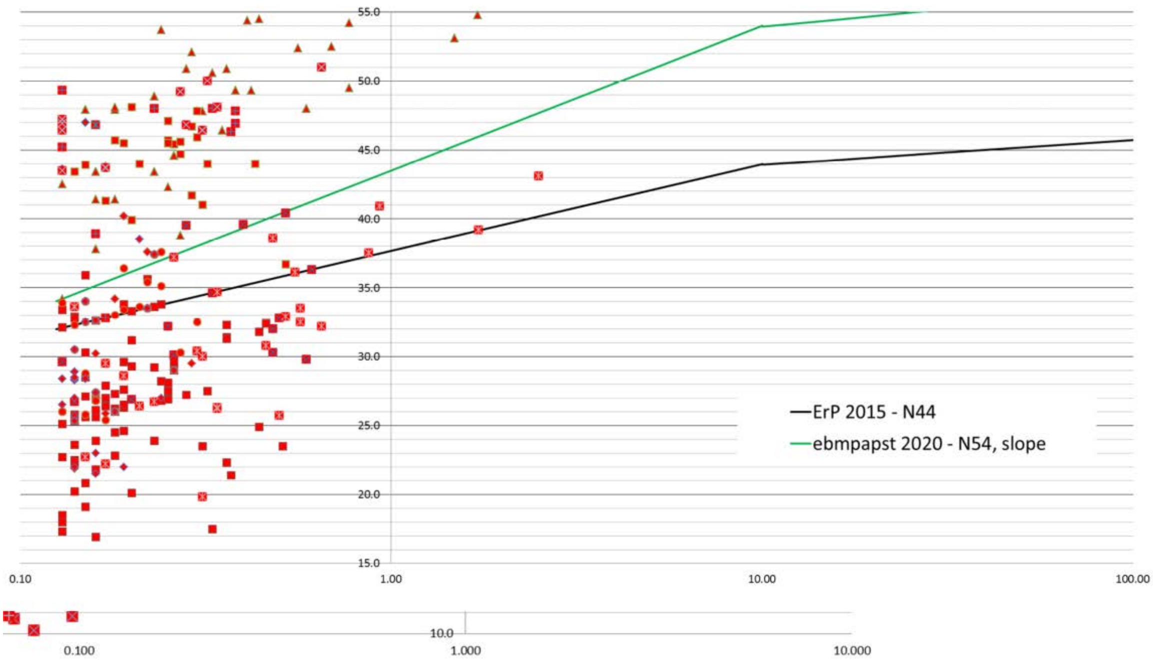


Figure 13. Limit lines in scatter-diagram of past and present ebmpapst production of Centrifugal Forward-Curved fans.

9.5 Mixed-flow fan, amendment

As mentioned in Chapter 2, manufacturer ebmpapst signals a possible loophole for mixed-flow fans that could be designed close to the limit with the centrifugal fans, i.e. with a fan flow angle of almost 70°. This could cost an energy saving of up to 15 TWh/year at complete stock change.

To avoid that loophole ebmpapst proposes to introduce, instead of one middle value of N=57 for static pressure (cat. A, C), two limit intermediate values for mixed-flow fans.

However, the study team believes that the ebmpapst solution will diminish but not fully solves the problem and thus proposes, only for the static pressure (for the total pressure the limits are anyway the same between mixed-flow) to set a variable limit based on the fan flow angle of the mixed flow fan.
Given the anchor value of N=0.57 of the EVIA proposal, the equation then becomes

$N=0.57 + 0.07\cdot(\alpha - 45)/25$

This makes that the N value varies linearly between N=50 for the axial fan and N=64 for the centrifugal backward curved fan.

9.6 Benchmarks

The figure below gives the best estimate of the study team for the benchmarks of industrial fans. The benchmarks are not a single line of fan efficiency depending on electric power input but an area between minimum and maximum values.

The maximum values relate to the achievable efficiency grade N in % (see minimum efficiency formulas) with clean air and no space and/or noise restrictions. The minimum values apply to contaminated air (some dust load) and space, noise and/or other operational restrictions at the limit of what is still in scope according to the exemptions in Article 1.

Table 5. Benchmark (N grades as proposed in Industry proposal)

	Minimum N in %	**Maximum N in %**
AX static (cat. A,C)	50	75
AX total	64	85
FC<5kW static	52	65
FC<5kW total	57	70
BC & FC>5kW static	64	80
BC & FC>5kW total	67	85
MF static	57	77
MF total	67	85
CF total	13	13

10. Other

10.1 Small fans

The assignment of the study team does not comprise an investigation of Ecodesign requirements for small fans in the range of 30 to 125W electric power input, as mentioned in the Ecodesign Working Plan 2 (VHK, 2011).

Nonetheless, ebmpapst –with the support of ECOS-- suggested that such a measure could be simply introduced in the fan regulation, using the minimum efficiency equations of the fan regulation that are recommended in this report at efficiency grade N values of 27 (axial) and 37%. The effect on ebmpapst production is shown in the figures below.

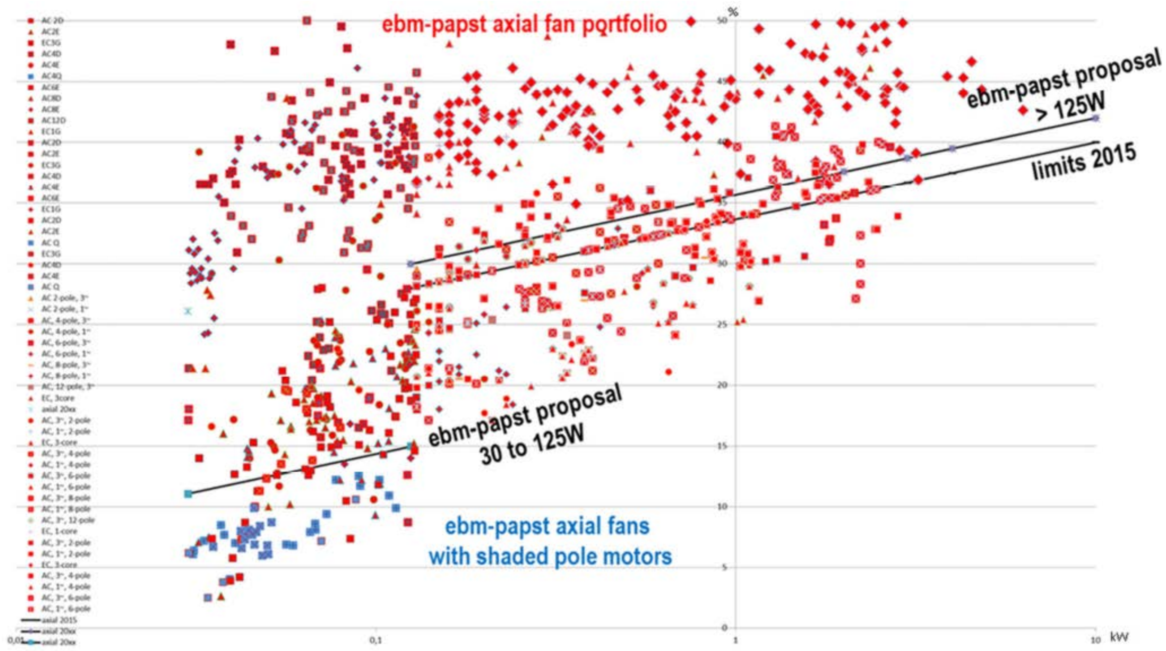


Figure 14. Ebmpapst maximum efficiency of axial fan in the range 30 W to 10 kW – in particular the proposed N27 limit for the 30 to 125 W range.

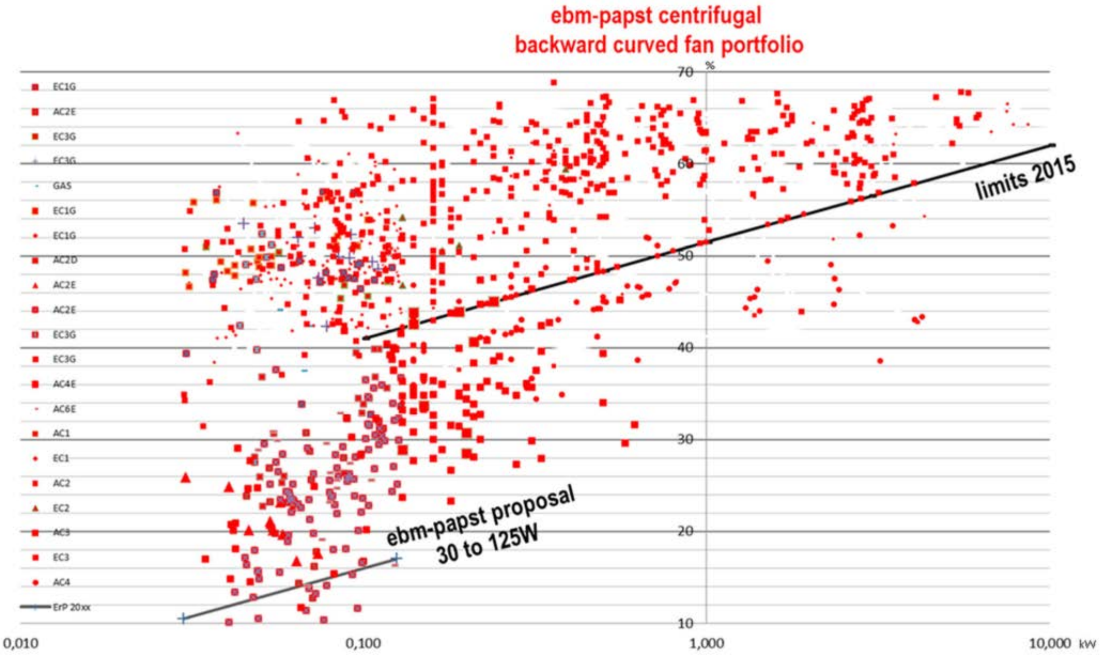


Figure 15. Ebmpapst: Maximum efficiency of backward curved centrifugal fans in the range 30 W to 10 kW – in particular the proposed N37 limit for the 30 to 125 W range.

The objective is to eliminate the few AC shaded pole motors (10% of the market) and replace them by AC capacitor motors. The aim of ebmpapst is not to allow only the very best (EC) motor technology, which would undoubtedly lead to much more savings but would not be economical[40] for all applications.

The energy saving impact of this 'small fans' measures is indicated in Chapter 2. It comes down to a saving of 524 GWh on annual sales or rather –at complete stock change—a saving of 7.9 TWh/yr in 2030.

The study team is critical of the ebmpapst proposal:

The ebmpapst calculations are based on applications with on average 3000 operating hours (half 20%, half 50% of 8760 annual hours) and an average power of 75W. This suggests application in fan coil units, fans in air terminal units of AC installations or larger ventilation units. In those cases the switch from AC shaded pole to AC capacitor motors would be economically plausible.

However, there are also many applications like comfort fans (only on hot days), timer-operated toilet fans (1-2h/day), incidentally used window/wall ventilation units in bathrooms or kitchens (2 h/day), hair-dryers (estimated 50h/year), drying or small heat pump fans in dishwashers (200h/year), (cross flow) fans in indoor units of cooling-only room air conditioners (400h/year), low-cost range hoods (400h/year), cooling fans in desktop computers (ca. 800-1000 h/year full load equivalent) and some outdoor signage displays, circulation fans in professional and commercial refrigeration (walk-in cold rooms, blast cabinets, etc.), residential boiler combustion

[40] From the viewpoint of Least Life Cycle Costs.

fans (1000 h full load equivalent), oxygen flow fans and similar in medical equipment (usually less than 1000 h/year), etc..

Secondly, the efficiency of fans with shaded pole motors is so low (5-10%) that even with the most lenient Ecodesign requirements, e.g. for range hoods, they will be phased out. In the much more stringent Ecodesign requirements for ventilation units it will be completed out of the question, even in an aggregated calculation with heat recovery, to use fans with AC shaded pole motors. So in this (extreme) case there is definitely a large ‘overlap’ with existing Ecodesign measures.

In short, the study team does not recommend to take on board the ebmpapst proposal for small fans. If Member States and Commission want to pursue the option and want to avoid significant negative impact of such a measure on stakeholders, it is recommended to engage in a full preparatory study that takes stock of all exemptions and allowances that are necessary to make a prepare an appropriate legislation.

10.2 Product information requirements

ECOS is one of the few stakeholders that has reacted to the current product information requirements:

1. ECOS states that the exemptions in Article 1 should relate only to the minimum efficiency requirements and that for all fans, including the exempted fans, the product information, including the efficiency, should be given;

2. ECOS proposes to add QR-codes to the name-plate and manufacturer’s website

- Annex I, 3: Product information requirements of fans,

1. The information on fans set out in points 2(1) to 2(14) shall be visibly displayed on:

(a) the technical documentation of fans;

(b) free access websites of manufacturers of fans.

(c) the rating plate of the fan; it shall include on the lower right bottom a QR-code that links directly to the respective technical documents on the manufacturer’s website.

(d) the rating plate of the motor; it shall include on the lower right bottom a QR-code that links directly to the respective technical documents on the manufacturer’s website.

3. As regards non-energy resource efficiency ECOS invites the study team to take a further look at the specific case of Rare Earth material used in Permanent Magnet motors and makes suggestions to ask to publish Bills of Material, exploded views as well as ask for technical provisions (no glue, no welding, etc.) to facilitate disassembly. Furthermore, ECOS would like the study team to investigate the durability of the fans.

The above items have not discussed with other stakeholders, but in a preliminary response the study team holds that

Given the fact that

a) there are good technical reasons why specific fans are exempted, some linked to excessive testing costs, and
b) the large amount of different models in this product group and the small production series per model would create a significant administrative burden and high testing costs,

it is felt that the proposal of ECOS to test all fans, including exempted fans, solely for the purpose of information leads to a disproportionate burden for this particular product group and is thus not recommended.

The addition of a QR-code to name plate and the presentation of the product on a website is supported. From experience the study team found it very hard to retrieve the relevant (and mandatory!) efficiency information from manufacturer's websites and for sure this communication aspect should be improved.

As regards the recovery of Rare Earth Elements (REE) the study team has performed desk research on the subject (see publications in the References section), from which it concluded that –although at the moment the quantities of Neodymium and other REE in permanent magnet motors are currently small—the recovery of REE may be an important issue, both from the point of view of resources efficiency, economy and the limited availability of these elements.
However, the administrative burden of the specific measures that ECOS is proposing seems disproportionate and –especially given the lack of surveillance—prone to failure in practice.

Instead, it is proposed that the manufacturer simply puts the weight (if any) of the permanent magnets, in kg with 2 digits (e.g. 'PM 2.12 kg'), on the nameplate and in the technical document. From literature it is known that the average Neodymium content of the magnets is around 18-20% (range 13-23%) and thus such a simple indication will be enough for a future recycler to judge whether it is economical to recover the REE from the product or not.

This means that there is no 'paper trail' from suppliers, no complicated test set-up (a scale or technical spec is enough) and just some attention is needed to put the right information on the nameplate of the right product.

As regards durability of the fans the new provisions for spare parts are already a large contribution to resource efficiency in this respect in general. Furthermore, as also indicated in the RRR-studies by Mathieux and Ardente (JRC-Ispra) longevity is not always beneficial to resource efficiency, especially if it blocks the introduction of more energy-efficient models in a sector where there is still considerable progress possible. Of course, if there is a matter of manufacturer-induced product failure or if the product quality can be exceptionally bad (e.g. vacuum cleaners), there would be a good reason to demand (costly) endurance tests, but for fans >125W this does not seem to be the case. The average life expectancy of an industrial fan is assumed to be around 15 years in the 2008 preparatory study and there are no indications that this figure is incorrect.

11. Impacts

11.1 Introduction

Impact assessment is not part of the assignment for this review study. Typically an impact assessment is performed after the Commission presents its draft Working Documents to the Consultation Forum.

Nevertheless, for a better understanding, this chapter makes a short introduction of the energy impacts that are given by past studies and by some stakeholders.

Indications of the energy impact of measures are given in the 2008 preparatory study and the 2011 impact assessment study for the current regulation (EU) 327/2011. The findings of these studies are used as inputs to the harmonized calculation in the Ecodesign impact accounting (VHK for the Commission, 2014).

The latter study has a special focus on the 'overlap' of the industrial fan measures with other measures. The energy-saving impact of the fan regulation on energy-saving cannot be answered without discussing the 'overlap' with other Ecodesign measures on the supply side on motors and the fan-demand side of fans that are incorporated in other Ecodesign-regulated end-products such as air-conditioners and ventilation units.

Determining the 'overlap' of energy savings from different Ecodesign measures is not an exact science and there are different approaches depending on your viewpoint.

As regards the extend of the overlap:

- There is the 'purist' assumption that assumes that industry will only just try to comply with minimum requirements and nothing more. Like Ecodesign legislation would be similar to e.g. criminal law.
- There is a 'holistic' assumption that assumes that the whole Ecodesign process of making energy efficiency relevant and measurable creates a competition on this aspect that will drive the efficiency of the products far beyond the minimum requirement and their prices down.

Trends in most regulated markets seem to prove the validity of the second assumption, but for sure there are examples –especially if promotional and surveillance aspects of the measures are flawed and there are many 'free-riders' — that will make that the 'purist' assumption on average prevails.

As regards which measure should get the credit:

- There is a 'supply push' approach that says that you need efficient components to make efficient end-products. For example, for an efficient ventilation unit you need an efficient fan and for an efficient fan you need an efficient motor. Hence, most of the credit goes to the components that enable the end-product to be efficient.
- There is a 'demand pull' approach that says that it is enough to regulate only the end-products, i.e. create a demand for efficient end-products and then the component-suppliers will follow anyway, with or without regulation. Hence, most of the credit goes to the end-products.

The truth, most likely, is in the middle. There are plenty of examples of 'supply push' turning around the market and there are plenty of examples of 'demand pull' doing the same.

The best question to ask in this context is what would happen without a measure. Will the manufacturers of end-products spontaneously ask for more efficient fans, even if they are more expensive in the beginning, or will they try to do everything they can to avoid this more expensive option and explore all other options that instantaneously save them money?

In this case it has to be considered that for air conditioners and any type of cooling application are an auxiliary component, accounting perhaps for only 20-30% of the total. So, when faced with minimum energy efficiency requirements the designers will first start to work on the compressor and heat exchangers before they even consider replacing the fan. So, when the Ecodesign requirements are lenient they don't have to tackle the fan efficient.

For end-products where the fan is the core-component, such as ventilation units, this is different. A stringent Ecodesign regulation will force them to look at the fan and then they want to have a fan that is both more efficient and affordable. One could say that in this case a separate fan regulation is largely redundant. Yet, a separate fan regulation is advantageous also for them and, in fact, the ventilation unit industry associations are in favor. There may be many reasons, but most importantly they have an interest in having the fan industry devoting all its effort in making more efficient fans and not having to split up its efforts in –on one side—producing low-cost, low-efficiency fans for other industries and at the same time producing high efficiency fans for less than 50% of their customers. Furthermore, the very presence of low-cost, low-efficiency fans on the EU-market is a big opportunity for free-riders, i.e. importers that use the low-cost fans also for ventilation units. They know that Member States are –to say the least—not spending much money on market surveillance and thus the possibilities of free-riders 'getting caught' are minimal.

11.2 Ecodesign Impact accounting

The Ecodesign Impact Accounting EIA (VHK 2014), based on the specific preparatory and impact assessment studies, indicates an electricity saving of 28 TWh/year in 2020 from the Industrial Fans regulation (EU) 327/2011. That the industry is well underway of achieving this target is confirmed by industry, claiming that at least some 1.75 TWh is being saved. Also the scatter-diagrams of the largest EU fan manufacturer (ebmpapst) in Chapter 9 show that, due to the measures some 30% of the models in their catalogues from before the measures have been replaced by more efficient ones. Confidential data from other fan manufacturers, to which the study team was granted conditional access, confirm that this applies also to these manufacturers with sometimes 'cut-out' percentages that are higher.

EIA also indicates an overlap of 50%, around 14 TWh/year, from savings claimed by other products with Ecodesign measures. This 14 TWh/year saving can be split on the demand side between 5 TWh for ventilation units, <1 TWh for combustion fans in boilers, <1 TWh for room air conditioners (see also above), 2 TWh for future measures on larger air heating/cooling units and perhaps 1 TWh for future measures on commercial and professional refrigeration. On the supply side the motor regulation may have an overlap of 5 TWh.

Given the total saving of the motor regulation (140 TWh/yr in 2020) this may seem small, but it has to be considered that the existing motor regulation (EC) 640/2009 does not impact the smallest fan motors, because it starts from 750 W output onwards (>1 kW input) and that for most industrial fans above 10 kW the IE3 or IE2+VSD motors are anyway the minimum standard in the market because of cost reasons. Furthermore, in the range up to 3-4 kW a part of the market –following developments in the smaller segment-- is already moving up to EC-motors, an efficiency level that goes far beyond the motor regulation level (beyond IE4 even).

As an illustration: The largest EU fan manufacturer (ebmpapst) claims that 50% of its models now has an EC motor. So effectively the motor regulation has its main impact in the 5 to 10 kW range.

11.3 Savings from new measures

Ebmpapst has made a projection of the savings that can be expected from its proposals. This is given in chapter 2, Table 1.

In summary, apart from the small fans, it is estimated that for the range from 125W to 10 kW a saving of 9.1 TWh/year extra can be expected at complete stock change (i.e. after 2030, at an average product life of 15 years), split up in savings from axial fans 5.7 TWh/year, BC centrifugal fans 1.4 TWh/year and FC centrifugal fans 2.1 TWh/year.

The calculation of ebmpapst is based on its own product range and the assumption that they represent 20% of the market in numbers. Note that the numbers in the Ecodesign Working Plan 2 are lower, but on the other hand the ebmpapst calculation does not include the savings on fans above 10 kW (up to 500 kW). In this high-power range there will be many exemptions for process fans under Article 1, but for ventilation and cooling/heating fans there will be a significant impact. For lack of better information, the study team assumes that with the inclusion of the fans above 10 kW there will be at least a 50% higher energy saving.

In rounded figures this means that at least some 15 TWh/yr extra savings can be expected after 2030 from the measures recommended for the new, reviewed fan regulation.

How much of these extra savings ‘overlaps’ with the effect of other measures is difficult to say. The ‘overlap’ with existing and planned measures for motors, ventilation units, air conditioners, etc. was already taken into account in the EIA study, and thus one could assume that there is no overlap-effect for the extra savings. But it is unknown what changes and updates will follow and therefore it would be prudent to indicate a range, i.e. from 10 to 15 TWh/year, for the extra savings to be expected.

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Standards

Existing standards

EN ISO 12759:2010 "Fans -- Efficiency classification for fans

EN ISO 5801:2008 "Industrial fans -- Performance testing using standardized airways"

EN ISO 5802:2008 Industrial fans – methods of performance testing in-situ

EN ISO 13349:2010 "Fans -- Vocabulary and definitions of categories"

CEN TC 156 WG 17 is currently working on multiple standardisation projects:

prEN14461 Fans (WI 00156221)— Safety requirements.

WI 00156222 Fans - Procedures and methods to determine the energy efficiency for the elec-

trical input power range of 125 W up to 500 kW.

prEN ISO 5801 rev (WI 00156180) Fans - Performance testing using standardized airways

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FprEN ISO 13350 (WI 00156176) Fans - Performance testing of jet fans (ISO/DIS

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Published Standards under remit of WG 17

EN ISO 5801:2008 (WI 00156130) Industrial fans - Performance testing using standardized airways (ISO 5801:2007 including Cor 1:2008)

EN ISO 5802:2008 (WI 00156132) Industrial fans - Performance testing in situ (ISO 5802:2001)

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https://circabc.europa.eu/

RAPEX: the EU Rapid Alert System (RAPEX).
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www.nicotra-gebhardt.com

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www.fanmanufacturers.com/ (Woodcock & Wilson Ltd)

www.nuaire.co.uk

www.elco-spa.com (small commercial refrigeration fans)

www.ruck.eu

www.twincityfan.com/tcf-international/tcf-europe (TCF Europe)

Fan buyers directly involved in consultation

www.daikin.eu , www.daikineurope.com (air conditioning)

http://www.fujitsu-general.de/ (air conditioning, heat pumps)

www.lge.com (air conditioners etc.)

http://www.mitsubishielectric.eu (air conditioners etc.)

www.utc.com, www.carrier.com (air conditioning, fan coil units, etc.)

www.vortice.com (air conditioning and ventilation, some fans)

http://www.sabiana.it/en/home.php (air conditioning, ventilation)

www.oce.com (professional printers, Canon)

www.zehndergroup.com (Zehnder, ventilation units)

www.aldes.com (ventilation products)

http://www.groupe-atlantic.com (ventilation units)

www.bshg.com (range hoods)

www.miele.de (laundry driers etc.)

http://www.fansct.com (PROFICOOL; power plants, steam generators, etc.)

www.luvata.com (heat exchangers, unit coolers and remote condensers)

Suppliers directly involved in the consultation

http://www.orientalmotor.de (motors)

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www.rpmitalia.it (motors>90%, some fans)

www.danfoss.com (VSD)

Associations involved in consultation

www.eurovent-association.eu

www.evia.eu/en/

www.europeamca.org

www.ecostandard.org (ECOS, NGO)

www.orgalime.eu

www.epeeglobal.org

www.ceced.eu (appliances industry)

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www.anima.it (Assoclima)

www.jraia.or.jp (Japanese air conditioning industry)

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ANNEX A: Calculation (indicative) of stock of dual use, parking garage and other specific fan applications

[Note: This information was collected for a different VHK study in 2010 and not updated since]

Tunnel ventilation

The EU-27 has 5860 km of tunnels[41] , including railroad (ca. 23%), subway (28%), and road tunnels (49% of km capacity). Road tunnel safety is regulated at Member State level[42] and under Directive 2004/54/EC on minimum safety requirements for tunnels[43]. The scope of the Directive is road tunnels longer than 300 m.

Road tunnels in the scope of the Directive 2004/54/EC are on average around 1.1 km and account for ¾ of the total road tunnel capacity. In the European Union they entail approximately 2000 tunnels that need to be equipped with adequate ventilation capacity to evacuate toxic fumes and guarantee the swift combustion of hazardous substances.[44]

Typical configurations for dual-carriage way tunnels include 2 jet fans with a capacity of 90 m^3/s per unit and 2 exhaust axial fans with capacity 70 m^3/s per unit (excluding stand-by capacity). Total peak airflow is 320 m^3/s or 1.15 million m^3/h per tunnel.[45] Part load operation levels differ widely, but a typical design value is an average of 50-60% part load, i.e. around 0,6 million m^3/h. For the EU as a total this amounts to 1200 million m^3/h or 0.33 million m^3/s. At an estimated average electric power of 2 kW per m^3/s during 8760 hours per year the EU-27 electricity consumption for road tunnel ventilation is 5.8 TWh/a. [46]

Vehicles in subway and railroad tunnels do not produce exhaust fumes and the ventilation is aided by the piston-ventilation caused by the trains moving through the narrow tunnels. Hence the ventilation requirement is significantly less: For this application an electricity consumption of 0.5 TWh is estimated.

Parking building ventilation

The EU-27 has about 100 mln. m^2 floor area of parking buildings. Ventilation is subject to strict fire safety regulations. ECN sets the average electricity consumption –for a modern system—at around 5 kWh/m^2 per year. For the EU-27 this comes down to 0,5 TWh/a.

[41] CIA World Factbook data 1.1. 2009

[42] ITA COSUF, Survey of existing regulations and recognised recommendations (road tunnels), Committee on Operational Safety of Underground Facilities, 30 April 2008.

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[44] Compare data for France (source: cetu): 765 road tunnels, of which 80 in range 300-500m, 40 in range 500-1000m, 32 >1000m. Total length of all road tunnels is 338 km, of which 76 km for tunnels <300m

[45] Note that capacity depends on the number of lanes, e.g. for a 4-6 lane tunnel capacity is two to three times as high. Example: 6-lane Australian Eastlink 1.6 km tunnel with fan electricity use 12.4 GWh/a.

[46] Calculation: 0.33 million m^3/s x 2 $kW/(m^3/s)$ x 8760 h= 5781 million kWh = 5.8 x 10^{12} Wh = 5.8 TWh

Fans for industrial exhaust fume purification

The E-PER database[47] lists 24.000 large industrial installations in the EU-27 and EEA-countries (2008). These installations are subject to several provisions of European emission regulation such as the LCP-directive (large combustion plants), the WI-directive (waste incineration), the IPPC directive (integrated pollution prevention and control), AAQD framework directive (ambient air quality as well as local or national regulations at Member State level.

For the purification of polluted process-air and flue-gases these installations operate special exhaust fans, designed to withstand high temperatures, abrasive substances and/or chemically aggressive fumes. The number of fans per installation is not known, but as a first dome estimate some 50.000 installed special fans are assumed at a capacity of 40-50 kW per fan. Assuming an operating time of 8000 h/a the total electricity consumption for these special fans is estimated at around 20-25 TWh/a.

Industrial oven fans

Industrial oven fans means fans that enhance the drying, curing, baking or heating process by forced air convection inside the oven and that are designed to withstand high temperatures. Combustion fans –normally not required to operate at high temperatures—are excluded.

Oven fans exist in all sizes and in almost all industrial sectors. At this stage it is very difficult to make an estimate, but even if we limit the application to fans above 3 kW there may well be >100.000 installations in the EU-27 that operate such fans. At 5000h operating hours per year, 4 kW per fan the total electricity consumption is estimated to be between 2 TWh, max. 4 TWh/a.

Mining fans

In the EU-27 there are probably some 100 operational deep mines that require special ventilation provisions for mining personal working underground. Most other mines are surface mines (quarrying, opencast pit) and most other deep mines extract ores fully mechanized (e.g. long-walling), requiring only a minimum workforce of machine operators.

Even if these mines would require a volume of 10 000 m^3 to be ventilated at 10 $m^3/m^3.h^{-1}$ the total equivalent volume for 100 mines would not amount to more than 10 million $m^3/m^3.h^{-1}$. This amounts to 2777 m^3/s and at 2 $kW/m^3.s^{-1}$ and 6000 operating hours per year it results in an electricity consumption of 33 GWh/a. Even allowing for some 500 mines the electricity consumption would not amount to more than 0.17 TWh/a.

[47] http://eper.ec.europa.eu/eper/