Working document for an ecodesign measure on fans

Chapter 1
Subject matter and scope

1. The measure establishes ecodesign requirements for the placing on the market of fans within a 125 W – 500 kW power range, including those integrated in other products.

2. The measure shall not apply to:

   (a) fans within a 125 W – 500 kW power range designed to operate in potentially explosive atmospheres as defined in Directive 94/9/EC [1];

   (b) fans within a 125 W – 500 kW power range designed for emergency use only, at short-time duty, with regards to fire safety requirements set out in Directive 89/106/EC [2];

   (c) fans within a 125 W – 500 kW power range specifically designed to operate:

      (i) where operating ambient temperatures exceed 100ºC;

      (ii) where operating ambient temperatures are lower than -40ºC;

      (iii) with a supply voltage >1,000 V AC or >1,500 V DC;

      (iv) in toxic, highly corrosive or flammable environments or in environments with abrasive substances.

Chapter 2
Definitions

In addition to the definitions set out in Directive 2009/125/EC, the following definitions shall apply:

(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;

   – is an axial fan, centrifugal radial bladed fan, centrifugal forward curved fan, centrifugal backward curved fan, centrifugal backward curved fan with housing, cross flow fan, box fan, mixed flow fan or roof fan;

   – may or may not be equipped with a motor when placed on the market;

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1 OJ L 100, 19.4.1994, p. 1.
2 OJ L 40 , 11.2.89, p. 12.

(2) ‘Impeller’ means the part of the fan that is imparting energy into the airflow and is also known as the fan wheel

(3) ‘Axial fan’ means a fan that propels air in the direction axial to the rotational axis of one or more impeller(s) with a swirling tangential motion created by the rotating impeller(s). The axial fan may or may not be equipped with a cylindrical housing, inlet or outlet guide vanes or an orifice panel or orifice ring;

(4) 'Inlet and/or outlet guide vanes' are vanes positioned before and/or after the impeller to guide the air stream towards and/or from the impeller and which may or may not be adjustable;

(5) 'Orifice panel' means a panel with an opening in which the fan sits and which allows fixation of the fan to other structures;

(6) 'Orifice ring' means a ring with an opening in which the fan sits and which allows fixation of the fan to other structures;

(7) ‘Centrifugal fan’ means a fan in which the air enters the impeller(s) in an essentially axial direction and leaves it in a direction perpendicular to that axis. The impeller may have one or two inlets and may have or may not have housing.

(8) ‘Centrifugal radial bladed fan’ means a centrifugal fan where the outward direction of the blades of the impeller(s) at the periphery is radial relative to the axis of rotation;

(9) ‘Centrifugal forward curved fan’ means a centrifugal fan where the outward direction of the blades of the impeller(s) at the periphery is forward relative to the direction of rotation;

(10) ‘Centrifugal backward curved without housing’ means a centrifugal fan where the outward direction of the blades of the impeller(s) at the periphery is backward relative to the direction of rotation and which does not have a housing;

(11) ‘Housing’ means a casing around the impeller which guides the air stream towards, through and from the impeller.

(12) ‘Centrifugal backward curved fan with housing’ means a centrifugal fan with an impeller where the outward direction of the blades at the periphery is backward relative to the direction of rotation and which has a housing;

(13) ‘Cross flow fan’ means a fan in which the air path through the impeller is in a direction essentially at right angles to its axis both entering and leaving the impeller at its periphery;

(14) ‘Box fan’ means a centrifugal fan or mixed flow fan that has an additional box or enclosure around the fan to provide the required air flow direction and a means of fitment to ducts where the box is not a housing as defined in the measure;

(15) ‘Mixed flow fan’ means a fan in which the air path through the impeller is intermediate between the air path in fans of centrifugal and axial types;

(16) ‘Roof fan’ means a fan designed for mounting on a roof or wall having exterior weather protection and that is fitted with either an axial, centrifugal, mixed flow fan inside the device;

(17) ‘Short-time duty’ means a motor working at a constant load, but not long enough to reach temperature equilibrium;

Chapter 3
Ecodesign requirements

The ecodesign requirements for fans within a 125 W – 500 kW power range are set out in Annex I.

Each ecodesign requirement shall apply in accordance with the following timetable:

(1) from 1 January 2012, all fans within a 125 W – 500 kW power range shall not have a lower efficiency grade than as defined in Annex I, point 1, Table 1;

(2) from 1 January 2015, all fans within a 125 W – 500 kW power range shall not have a lower efficiency grade than as defined in Annex I, point 1, Table 2.

The product information requirements on fans are as set out in Annex I, point 2, and shall apply from 1 January 2012.

Compliance with ecodesign requirements shall be measured and calculated in accordance with requirements set out in Annex II.

Chapter 4
Conformity assessment

The conformity assessment procedure referred to in Article 8 of Directive 2009/125/EC shall be the internal design control system set out in Annex IV to that Directive or the management system for assessing conformity set out in Annex V to that Directive.

Chapter 5
Verification procedure for market surveillance purposes

When performing the market surveillance checks referred to in Article 3(2) of Directive 2009/125/EC, the authorities of the Member States shall apply the verification procedure set out in Annex III to the measure.

Chapter 6
Indicative Benchmarks

The indicative benchmarks for the best-performing fans within a 125 W – 500 kW power range available on the market at the time of entry into force of the measure are identified in Annex IV.

Chapter 7
Revision

The Commission shall review the measure in the light of technological progress of fans within a 125 W – 500 kW power range no later than five years after its entry into force and present the result of this review to the Ecodesign Consultation Forum.

ANNEX I
Ecodesign requirements for fans within a 125 W – 500 kW power range

1. DEFINITIONS FOR THE PURPOSES OF ANNEX I

(1) ‘Measurement category’ means test, measurement or usage arrangement that defines the inlet and outlet conditions of the fan under test.

(2) ‘Measurement category A’ means an arrangement where the fan is measured with free inlet and outlet conditions;

(3) ‘Measurement category B’ means an arrangement where the fan is measured with free inlet and with a duct fitted to its outlet;

(4) ‘Measurement category C’ means an arrangement where the fan is measured with a duct fitted to its inlet and with free outlet conditions;

(5) ‘Measurement category D’ means an arrangement where the fan is measured with a duct fitted to its inlet and outlet;

(6) ‘Efficiency category’ means the fan air output energy form used to determine the fan efficiency, either static efficiency or total efficiency;

(7) ‘Static efficiency’ means the efficiency of a fan, based upon measurement of the difference between the stagnation pressure at the fan outlet and the stagnation pressure at the fan inlet minus the fan dynamic pressure corrected by the Mach factor;

(8) 'Static pressure' (p_{sf}) means the fan total pressure (p_f) minus the fan dynamic pressure corrected by the Mach factor;

(9) 'Stagnation pressure' means the pressure measured with respect to absolute zero pressure, which is exerted at a point at rest relative to the air around it;

(10) 'Dynamic pressure' means the pressure calculated from the velocity and density of the air;

(11) 'Mach factor' means a correction factor applied to dynamic pressure at a point, defined as the stagnation pressure minus the pressure with respect to absolute zero pressure which is exerted at a point at rest relative to the air around it and divided by the dynamic pressure;

(12) ‘Total efficiency’ means the efficiency of a fan, based upon measurement of the difference between the stagnation pressure at the fan outlet and the stagnation pressure at the fan inlet;

(13) "Total pressure' (p_f) means the difference between the stagnation pressure at the fan outlet and the stagnation pressure at the fan inlet;

(14) ‘Efficiency grade’ is a parameter in the calculation of the target energy efficiency of a fan of specific electric input power at its optimum efficiency point (expressed as parameter 'N' in the calculation of the fan efficiency);

(15) 'Variable speed drive' (abbreviation: 'VSD') means an electronic power converter, integral with the motor, that continuously adapts the electrical power supplied to the electric motor in order to control the mechanical power output of the motor according to the torque-speed characteristic of the load being driven by the motor, excluding variable voltage controllers where only the supply voltage for the motor is varied.

2. FAN EFFICIENCY REQUIREMENTS

The minimum efficiency requirements for fans are set out in Tables 1 and 2.

Table 1. First tier minimum energy efficiency requirements for fans

Fan types	**Measurement category** (A-D)	**Efficiency category** (static or total)	**Efficiency grade**
Axial fan	A, C	static	36
	B, D	total	56
Centrifugal forward curved fan and centrifugal radial bladed fan	A, C	static	37
	B, D	total	42
Centrifugal backward curved without housing	A, C	static	58
Centrifugal backward curved fan with housing and mixed flow fan	A, C	static	58
	B, D	total	61
Cross flow fan	B, D	total	18
Box fan	B, D	total	35
Roof fan (axial fan within)	A, C	static	27
Roof fan (centrifugal or mixed flow fan within)	A, C	static	48

Table 2. Second tier minimum energy efficiency requirements for fans

Fan types	**Measurement category** (A-D)	**Efficiency category** (static or total)	**Efficiency grade**
Axial fan	A, C	static	40
	B, D	total	60
Centrifugal forward curved fan and centrifugal radial bladed fan	A, C	static	42
	B, D	total	47
Centrifugal backward curved without housing	A, C	static	62
Centrifugal backward curved fan with housing and mixed flow fan	A, C	static	61
	B, D	total	64
Cross flow fan	B, D	total	21
Box fan	B, D	total	39
Roof fan (axial fan within)	A, C	static	31
Roof fan (centrifugal or mixed flow fan within)	A, C	static	52

3. PRODUCT INFORMATION REQUIREMENTS ON FANS WITHIN A 125 W – 500 KW POWER RANGE

The information on fans set out in points (1) to (10) shall be visibly displayed on:

(a) the technical documentation of fans;

(b) the technical documentation of products in which fans are incorporated;

(c) free access websites of manufacturers of fans;

(d) free access websites of fans and manufacturers of products in which fans are incorporated.

The information in the technical documentation must be provided in the order as presented in points (1) to (10). The exact wording used in the list does not need to be repeated. It may be displayed using graphs, figures or symbols rather than text.

(1) nominal efficiency (η) at the full rated load and voltage (U_N), rounded to one decimal place;

(2) measurement category used to determine efficiency (A-D);

(3) efficiency category (static or total);

(4) efficiency grade (FMEG) at optimum efficiency point;

(5) whether the calculation of fan efficiency assumed use of a VSD and if so, whether the VSD is integrated within the fan or the VSD must be installed with the fan;

(6) year of manufacture;

(7) manufacturer's name or trade mark, commercial registration number and place of manufacturer;

(8) product's model number;

(9) the rated power input(s) at optimum efficiency (kW);

(10) information relevant for disassembly, recycling or disposal at end-of-life;

(11) description of additional items used when determining the fan efficiency, such as ducts, that are not described in the measurement category and not supplied with the fan.

The information referred to in points (1), (2), (3), (4) and (5) shall be durably marked on or near the rating plate of the fan, where for point (5) one of the following three options shall be used to indicate what is applicable:

– "A Variable Speed Drive must be installed with this fan";

– "A Variable Speed Drive is integrated within the fan";

– "A Variable Speed Drive is not required".

Manufacturers shall provide information in the technical documentation on any specific precautions that must be taken when fans are assembled, installed or maintained.

ANNEX II
Measurements and calculations

1. Definitions

(1) The 'target energy efficiency' η_{target} is the minimum efficiency a fan must achieve in order to meet the requirements and is based on its electrical input power at its point of optimum efficiency, where η_{target} is the output value from the appropriate equation in section 3 of Annex II, using the applicable integer N of the efficiency grade (Annex I, section 1, Tables 1 and 2) and the electrical power input $P_{e(d)}$ of the fan at its point of optimum efficiency in the applicable energy efficiency formula.

(2) 'inlet stagnation volume flow rate' (q) is the volume of air that passes through the fan per unit of time (in m^3/s) and is calculated on the basis of the mass of air moved by the fan (in kg/s) divided by the density of this air at the fan inlet (in kg/m^3)

(3) p_{sf} means fan static pressure;

(4) p_f means fan total pressure;

(5) 'compressibility factor' is a dimensionless number that describes the amount of compressibility that the air stream experiences during the test and is calculated as the ratio of mechanical work exerted by the fan on the air and the same work exerted to a incompressible gas at the same flow rate, taking into account the fan pressure as 'total pressure' (k_p) or 'static pressure' (k_{ps});

(6) k_{ps} means compressibility coefficient for the calculation of fan static air power;

(7) k_p means compressibility coefficient for the calculation of fan total air power;

(8) 'final assembly', means a finished or assembled on site assembly of a fan that contains all the elements to convert electric input power into fan air power without the need to add more parts or components;

(9) 'not final assembly', means an assembly of fan parts, consisting of at least the impeller, which needs one or more externally supplied components in order to be able to convert electric energy into fan air power;

(10) ' Direct drive' means a driving arrangement for a fan where the impeller is fixed to the motor shaft, either directly or with a co-axial coupling, and where the impeller speed is identical to the motor's rotational speed;

(11) 'Transmission' means a driving arrangement for a fan which is not 'direct drive' as defined above. Such driving arrangements may include transmissions using a belt-drive, gearbox or slipping coupling;

(12) 'low-efficiency drive' means a transmission using a belt whose width is less then three times the height of the belt or using some other form of transmission apart from a 'high efficiency drive';

(13) 'high efficiency drive' means a transmission using a belt whose width is at least three times the height of the belt or using toothed gears.

2. Measurement method

For the purposes of compliance and verification of compliance with the requirements of the measure, measurements and calculations shall be made using a reliable, accurate and reproducible method, which takes into account the generally recognised state-of-the-art measurement methods, and whose results are deemed to be of low uncertainty, including methods set out in documents the reference numbers of which have been published for that purpose in the Official Journal of the European Union.

3. Calculation method

The methodology for calculating the efficiency of a specific fan is based on the ratio of air power to electrical input power to the motor, where fan air power is the product of air volume flow rate and pressure difference across the fan. The pressure is either the static pressure or the total pressure, which is the sum of static and dynamic pressure depending upon the measurement and efficiency category.

3.1 Where the fan is supplied as a 'final assembly', measure the fan efficiency at its optimum efficiency point

(a) Where the fan does not include a variable speed drive, calculate the efficiency using the following equation;

$\eta_e = P_{u(s)} / P_e$ where;
η_e is the overall efficiency
$P_{u(s)}$ is fan air power determined according to point 3.3, of the fan when it is operating at its optimal efficiency point;
P_e is the power measured at the mains input terminals to the motor of the fan when it is operating at its optimal efficiency point.

(b) Where the fan includes a variable speed drive, calculate the efficiency using the following equation:

$\eta_e = (P_{u(s)} / P_{ed}) \cdot C_c$, where;
η_e is the overall efficiency
$P_{u(s)}$ is fan air power determined according to point 3.3 of the fan when it is operating in its optimal efficiency point;
P_{ed} is the power measured at the mains input terminals to the variable speed drive of the fan when it is operating at its optimal efficiency point;

C_c is a part load compensation factor as follows:

- $P_e \geq 5kW$ then $C_c = 1.04$
- $P_e \geq 1kW$ then $C_c = 1.11$
- $P_e \leq 1kW$ then $C_c = 1.15$

3.2. Where the fan is supplied as a 'not final assembly' the fan efficiency is calculated at the impellers optimum efficiency point, using the following equation:

$\eta_e = \eta_r \cdot \eta_m \cdot \eta_T \cdot C_m \cdot C_c$ where;

η_e is the overall efficiency

η_r is the fan impeller efficiency according to $P_{u(s)} / P_a$ where:

$P_{u(s)}$ is fan air power determined at the point of optimal efficiency for the impeller and according to point 3.3 below;

P_a is the fan shaft power at the point of optimal efficiency of the impeller;

η_m is the nominal rated motor efficiency of the supplied motor. If no motor is supplied a default η_m is calculated using the following values:

if the required electric input power "Pe(d)" is ≥ 0.75 kW,

$\eta_m = 0.000278(x^3) - 0.019247(x^2) + 0.104395*x + 0.809761$

where $x = \text{Log}(P_{e(d)})$

and $P_{e(d)}$ is as defined in 3.1.(a)/(b) ;

if the required motor input power "Pe(d)" is < 0.75 kW,

$\eta_m = 0.1462*\ln(P_{e(d)}) + 0.8381$

and $P_{e(d)}$ is as defined in 3.1.(a)/(b), where the electric input power Pe(d) recommended by the manufacturer of the fan should be enough for the fan to reach its optimum efficiency point, taking into account losses from transmission systems if applicable.

η_T is the efficiency of the driving arrangement for which the following default values shall be used:

for direct drive $\eta_T = 1.0$;

if the transmission is a low-efficiency drive as defined in (13) and

$P_a \geq 5$ kW, $\eta_T = 0.96$ and 1 kW < P_a < 5 kW, $\eta_T = 0.0175 * Pa + 0.875$

$P_a \leq 1$ kW, $\eta_T = 0.89$

if the transmission is a high efficiency drive as defined in (14) and

$P_a \geq 5$ kW, $\eta_T = 0.98$ and 1 kW < P_a < 5 kW, $\eta_T = 0.01 * Pa + 0.93$

$P_a \leq 1$ kW, $\eta_T = 0.94$

C_m is the compensation factor to account for matching of components = 0.9

C_c is the part load compensation factor:

For a motor without a variable speed drive $C_c = 1.0$

For a motor with a variable speed drive and $P_{e(d)} \geq 5$ kW then $C_c = 1.04$

For a motor with a variable speed drive and $P_{e(d)} \leq 5$ kW then
$C_c = -0.03 \ln(Pe) + 1{,}088$

3.3 The fan air power, $P_{u(s)}$, is calculated according to the measurement category test method chosen by the fan supplier:

(a) Where the fan has been measured according to measurement category A, fan static air power P_{us} is used from equation $P_{us} = q \cdot p_{sf} \cdot k_{ps;}$

(b) Where the fan has been measured according to measurement category B, fan air power P_u is used from equation $P_u = q \cdot p_f \cdot k_p$;

(c) Where the fan has been measured according to measurement category C, fan static air power P_{us} is used from equation $P_{us} = q \cdot p_{sf} \cdot k_{ps}$;

(d) Where the fan has been measured according to measurement category D, fan air power P_u is used from equation $P_u = q \cdot p_f \cdot k_p$;

4. Methodology for calculating the target energy efficiency

The target efficiency is the energy efficiency a fan from a given fan category must achieve in order to comply with the requirements set out in the measure. The target efficiency is calculated by efficiency formulas that include the electrical input power, $P_{e(d)}$ and the minimum efficiency grade as defined in Annex I. The complete power range is covered by two formulas: one for fans with an electric input power from 0.125 kW up to and including 10 kW and the other for fans above 10 kW up to and including 500 kW.

There are three series of fan categories for which energy efficiency formulas are developed to reflect the different characteristics of various fan types:

4.1. The target energy efficiency for axial, centrifugal forward curved, centrifugal radial bladed and roof fan (axial fan within) is calculated using the following equations:

Power range P from 0.125 kW to 10 kW	**Power range P from 10 kW to 500 kW**
$\eta_{target} = 2.74 \cdot \ln(P) - 6.33 + N$	$\eta_{target} = 0.78 \cdot \ln(P) - 1.88 + N$

where the input power P is either the electrical power input $P_{e(d)}$ if the fan has a Direct Drive' or fan shaft power P_a if the fan has a 'Transmission' and N is the integer of the energy efficiency grade required.

4.2. The target energy efficiency for centrifugal backward curved open wheel, centrifugal backward curved with housing, mixed flow, roof fan (centrifugal fan within) and box fan is calculated using the following equations:

Power range P from 0.125 kW to 10 kW	**Power range P from 10 kW to 500 kW**
$\eta_{target} = 4.56 \cdot \ln(P) - 10.5 + N$	$\eta_{target} = 1.1 \cdot \ln(P) - 2.6 + N$

where the input power P is either the electrical power input $P_{e(d)}$ if the fan has a 'Direct Drive' or fan shaft power P_a if the fan has a 'Transmission' and N is the integer of the energy efficiency grade required.

4.3. The target energy efficiency for cross flow fans is calculated using the following equations:

Power range P from 0.125 kW to 10 kW	**Power range P from 10 kW to 500 kW**

$\eta_{target} = 1.14 \cdot \ln(P) - 2.6 + N$	$\eta_{target} = N$

where the input power P is either the electrical power input $P_{e(d)}$ if the fan has a 'Direct Drive' or fan shaft power P_a if the fan has a 'Transmission' and N is the integer of the energy efficiency grade required.

5. Applying the target energy efficiency

The fan efficiency η_e calculated according to the appropriate method in section 3 of Annex II shall be equal to or greater than the target value η_{target} set by the efficiency grade to meet the minimum efficiency requirements.

ANNEX III
Verification procedure for market surveillance purposes

When performing the market surveillance checks referred to in Article 3 (2) of Directive 2009/125/EC, the authorities of the Member States shall apply the following verification procedure for the requirements set out in Annex I.

1. The authorities of the Member State shall test one single unit.
2. The model shall be considered to comply with the provisions set out in the measure if the overall efficiency of the fan (η_e) is at least target efficiency*0.9 calculated using the formulas in Annex II (section 3) and the applicable efficiency grades from Annex I.
3. If the result referred to in point 2 is not achieved, the market surveillance authority shall randomly test three additional units.
4. The unit shall be considered to comply with the provisions set out in the measure if the average of the overall efficiency (η_e) of the three units referred to in point 3 is at least target efficiency*0.9 using the formulas in Annex II (section 3) and the applicable efficiency grades from Annex I.
5. If the results referred to in point 4 are not achieved, the model shall be considered not to comply with the measure.

For the purposes of checking conformity with the requirements of the measure, Member States shall apply the procedure referred to in Annex II and reliable, accurate and reproducible measurement methods, which take into account the generally recognised state-of-the-art, including methods set in standards the reference numbers of which have been published for that purpose in the Official Journal of the European Union.

ANNEX IV
Indicative Benchmarks referred to in Chapter 6

At the time of adoption of the measure, the best available technology on the market for fans is as indicated in Table 1.

Table 1. Indicative benchmarks for fans

Fan types	**Measurement category** (A-D)	**Efficiency category** (static or total)	**Efficiency grade**
Axial fan	A, C	static	50
	B, D	total	75
Centrifugal forward curved fan and centrifugal radial bladed fan	A, C	static	50
	B, D	total	55
Centrifugal backward curved open wheel fan	A, C	static	70
Centrifugal backward curved fan with housing and mixed flow fan	A, C	static	72
	B, D	total	75
Cross flow fan	B, D	total	32
Box fan	B, D	total	65
Roof fan (axial fan within)	A, C	static	45
Roof fan (centrifugal or mixed flow fan within)	A, C	static	62