Efficient Motor Technology for the Home Appliance Industry

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Legal requirements on energy efficiency of home appliances

The conservation of energy in the white goods industry is driven by continuously enhancing legal requirements on minimum efficiency grades. The specific requirements on an international level vary depending on the laws, rules and directives in place.

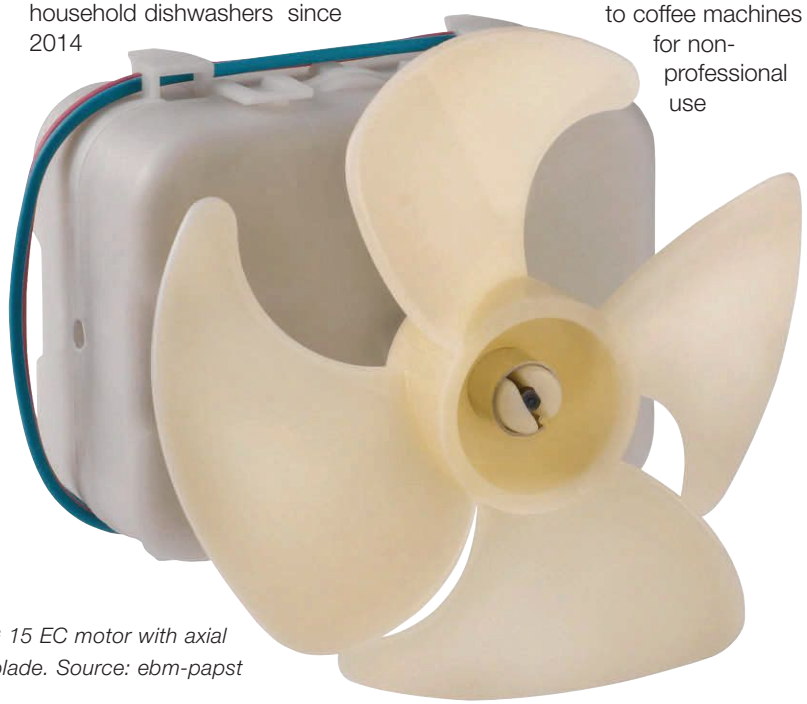
Situation in Europe

By implementing the directive 2005/32/EC the European Parliament established in July 2005 a framework for the setting of ecodesign requirements for energy-using products (EuP). In October 2009 it was extended to energy-related products (ErP) in general by directive 2009/125/EC. Within this so-called ErP process different product groups became the subject of an assessment regarding their environmental footprint. Already, two working plans (2009-2011 and 2012-2014) have been concluded while the study to establish a third one (2015-2017) has been initiated in January 2014. The final reports of this Ecodesign Working Plan study are in the process of being approved for publication.

Several product groups related to the home appliance industry have been within the scope of the first two working plans. Several regulations of the European Commission have been the result of it setting minimum efficiency grades for the concerned appliances and which are listed here after:

- Lot 13 / 22nd July 2009: Commission Regulation (EC) No 643/2009 ecodesign requirements for household refrigerating appliances
- Lot 14 / 10th November 2010: Commission Regulation (EU) No 1015/2010 ecodesign requirements for household washing machines Commission Regulation (EU) No 1016/2010 ecodesign requirements for household dishwashers since 2014
- Lot 16 / 3rd October 2012: Commission Regulation (EU) No 932/2012 ecodesign requirements for household tumble driers
- Lot 25 / 22nd August 2013: Commission Regulation (EU) No 801/2013 ecodesign requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment – refers e. g. to coffee machines for non-professional use

under revision / completion expected within 2016



BG 15 EC motor with axial fan blade. Source: ebm-papst

NiQ 32 - explosion view. Source: ebm-papst

- Lot 22/Lot 23 / 14th January 2014: Commission Regulation (EU) No 66/2014 ecodesign requirements for domestic ovens, hobs (cooktops) and range hoods

All these regulations are submitted for revision on a regular basis.

Requirements on minimum efficiency grades have also been set for applications dedicated to professional use or are actually in preparation like:

- ENTR Lot 1 / 5th May 2015: Commission Regulation (EU) 1095/2015ecodesign requirements for professional refrigerated storage cabinets, blast cabinets, condensing units and process chillers
- Lot 24 draft document of Possible requirements for non-household washing machines, non-household textile dryers and non-household dishwashers

Together with the ecodesign requirements the European Union established an energy efficiency labeling system for the respective appliances. These labels with their colored A, B, C classifications and in domestic refrigeration with their A+, A++ and A+++ categories are well-known by the European consumers.

Situation in the U.S.

One key element of the policy for improving energy efficiency in the U.S. is the appliance and equipment efficiency standards. The first standard was set on a state level in California in 1974. One year later it was followed by the Energy Policy and Conservation Act (EPCA). A special focus on energy conservation standards was implemented with the amendment in 1979 and minimum efficiency standards for household appliances were established in 1987 (National Appliance Conservation Act). The Department of Energy (DOE) is in charge of reviewing and updating these standards. Furthermore it develops test procedures and executes verification testing. Like this it supports the Environmental Protection Agency ENERGY STAR Program and the Federal Trade Commission ENERGY GUIDE labeling. Actually 60 products representing 90 precent of home energy use are part of it. The standards program led to gains in energy efficiency of household appliances as follows:

- refrigerators – 75 percent less energy at 20 percent more storage capacity since 1973
- clothes washers –70 percent less energy since 1990
- dishwashers – 40 percent less energy since 1990.

Radial blower for evaporator use with BG15 EC motor. Source: ebm-papst

Since 2005 the DOE started to focus on different rulemakings / up-dates to enhance necessary test procedures. In 2013 the President's Climate Action Plan was announced. It foresees a reduction of carbon pollution by a minimum of 3 billion metric tons cumulatively by 2030. This leads to an acceleration of the rulemaking process. A goal was set to reach a total of 26 standards rulemakings between 2014 and 2016 covering 30 products and 10 more between 2017 and 2020 covering an additional 12 products.

The following examples are among these rulemakings for energy conservation standards:

2011
residential refrigerators
76 FR 57516 – final standard
compliance mandatory as of 15th September 2014

2012
residential dishwashers
77 FR 65942 – final standard residential
clothes washers
77 FR 59719 – final standard
compliance mandatory as of 2015 respectively 2018

2013
microwave ovens
78 FR 36316 – final standard / 2016: 81 FR 7965 – correction notice
consumer clothes dryers
78 FR 49608 – final standard
compliance mandatory as of 1st July 2015

2014
commercial clothes washers
79 FR 74492 – final standard
compliance mandatory as of 1st January 2018

conventional cooking products first standard set 1990 / rulemaking started and in progress

2015
residential refrigerators - ice making final standard
compliance mandatory as of 1st January 2018
2016
miscellaneous residential refrigeration rulemaking in progress **including wine chillers** *final determination, pre-publication status*

In conclusion it could be recognized that the energy conservation standards will continue to tighten in the coming years.

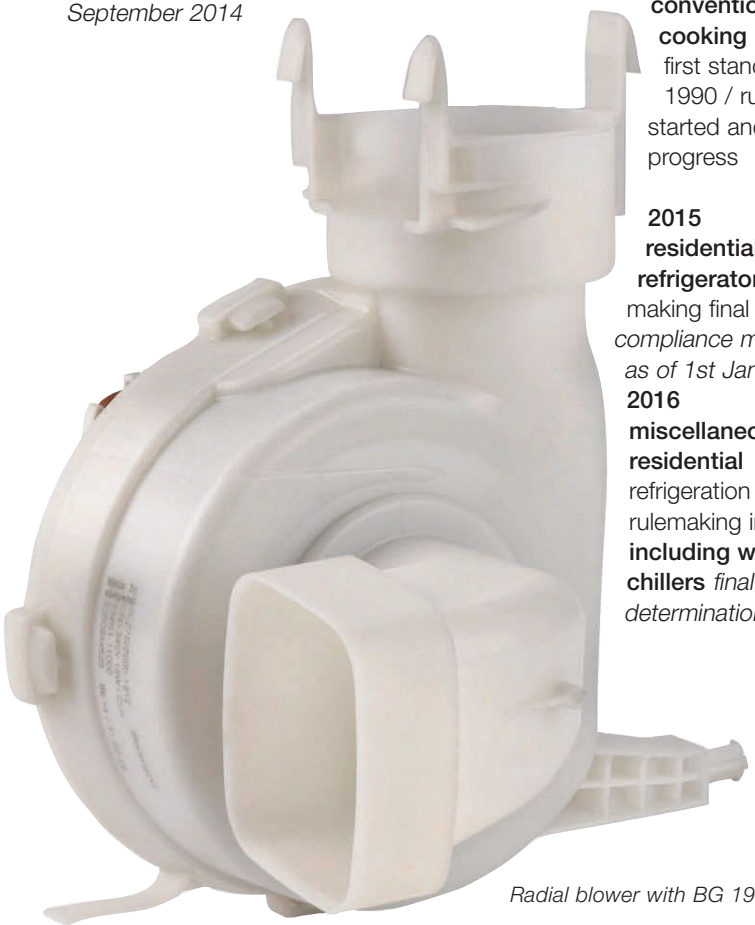
Like in the European Union a label was also introduced in the US to provide consumers information about energy consumption, efficiency and operating cost. This label is called ENERGYGUIDE. Its development was mandated by the Energy Policy and Conservation Act of 1975 and it was introduced for all products since 1980. Besides that another voluntary one exists with ENERGY STAR label. It sets more stringent requirements on energy saving than the ENERGYGUIDE.

Usage of Efficient Electronically Commutated Motors

Driven by a continuously tightened energy conservation policy EC motors are in the meantime widely used in large white goods equipment. With its high electrical efficiency (typically between 45 percent to 80 percent compared to low efficiency shaded-pole motors (typically between 15 percent to 20 percent which transform the main part of its power consumption in dissipated heat and with a significantly reduced usage of resources (copper, electric sheets etc.) for their production they not only have a positive effect on the CO^2 foot print but also on the sustainable usage of resources also shown as ecodesign in general.

Refrigerators and Freezers

The prime example of the successful



Radial blower with BG 19 EC motor. Source: ebm-papst

implementation of EC technology and product placement of small EC motors in white goods applications are the refrigerators and freezers. As these appliances are permanently operated to store perishable goods for a reasonable time they are the most energy consuming domestic major appliances. Thus it has been clear that they have been in primary focus of energy conservation policies.

As a consequence gaskets, compressors, controllers and other components have been improved to maximize efficiency. Vacuum panels started to be used as an alternative insulation, LED lighting was introduced in high-end and premium products and especially EC motors became very popular increasing significantly the efficiency of evaporator and condenser fan units whereupon mains supply driven ones permitted an easy drop-in replacement of the commonly used C-frame shaded-pole motors with their axial impellers.

Another step forward to reduce energy consumption and additional noise emissions has been the development of smart radial blowers in EC technology to be fit into optimized air ducts.

Ovens

But not only its energy saving capabilities makes EC technology so smart. It offers a broader functionality and options for either the appliance design or its mode of operation. While standard AC shaded-pole motors could only be operated in a single direction EC motors could be operated in clockwise or counterclockwise direction. Furthermore EC motors with variable speed capability allow the motor speed to be adjusted via sensors or following specific programs for its operation. Therefore, design engineers are in the position to control its operational behavior in detail and to adjust it according to the process requirements.

BG43 sensorless BLDC motor. Source: ebm-papst

Kitchen Hoods

Variable speed capabilities make EC technology a perfect choice for such kind of appliances which require a correct setting to different working conditions at any time to provide the highest comfort for the consumer. Besides a nice appearance in the kitchen due to some exceptional design features a range hood has to provide sufficient suction capability to fulfill its operational duties and at an acceptable noise level. By using the signal-in of the motor interface the speed could be adjusted in different steps or even continuously. Combined with an optimized aerodynamics and assembly concept of such an exhaust fan the sound level could be kept at comfortable levels.

Dishwashers

The main process of a dishwasher is carried out by the spray arm operation; it moistens dried food residues and cleans the dishes. This is an energy consuming process. The usage of EC technology reduces the power consumption. Furthermore, an adjustable speed leads to further process optimization.

Space is extremely limited in dishwashers. Therefore, drying fans or process fans with AC motors are limited in their power density as these motors are restricted by the barrier of the synchronous speed limits from the mains supply. EC technology supports in breaking down these barriers. Small and powerful fans could be built with high speed motors. The reduced dimensions of an EC motor also enable its integration into the fan unit itself. The drive motor thus

becomes an integral part of it.

Motor Platforms

EC motor platforms are available in the market to satisfy the diverse and specific requirements of refrigerators, dishwashers, ovens or kitchen hoods. Depending on its purpose either one-phase or three-phase BLDC motors are available.

One-Phase BLDC Motors

BG 15 respectively BG 20 BLDC motor platform
These motors are widely used in domestic refrigeration. As single motors with up to 3 W power consumption and typical set speeds of e.g. 1,800, 2,100, or 2,500 rpm they provide retro-fit capabilities to easily up-grade existing appliance platforms from AC to EC. Depending on their design they are used either as an evaporator, compartment ventilation or condenser fan motor.

BG 15 motor platform furthermore works with constant speed. This means that the motor has an internal speed control adjusting the speed according to the load situation to its set point.
Integrated into a complete blower assembly they even serve to reduce complexity of parts, as to ease the assembly process as to optimize intralogistics (in-house logistic) processes on the customer side.

Apart from their usage as evaporator or condenser fans for refrigerators other versions of such EC motors are used to drive e. g. cross flow blowers or radial blowers for diverse applications. Depending on the working point required they perform with power consumption up to 20 W and cover a speed range up to 7,000 rpm.

BG 22 respectively BG 36 BLDC motor platform
These internal rotor BLDC motors are widely used to drive crossflow, axial and radial blowers. The smaller EC motor provides a power consumption of up to 20 W. Its speed range includes up to 15,000 rpm. The bigger EC motor is available in different stack sizes covering power consumption up to 350 W. Its speed range reaches up to 9,000 rpm.

In the area of professional food processing equipment such motors are operating (e.g. radial blowers) in dishwashers which require a powerful but quick drying cycle. Another application is food storage equipment where the EC motors serve to provide a constant flow of well-tempered air.

BG 32-1 BLDC motor platform respectively NiQ 32 motor
BG 32-1 platform is the core of the NiQ 32 motor. This is a new EC motor design to replace AC Q-motors (4 pole shaded pole motors) with a drop-in replacement. It operates in its standard design with either 1,550 rpm (catalog version in 110-120 V 50/60 Hz) or 1,300 rpm (catalog version in 220-240 V 50/60 Hz) at constant speed (similar to BG 15 motor platform mentioned above).

Due to its modular design it could be easily adjusted to other speed settings like 1,800 or 2,200 rpm.

Three-Phase BLDC Motors

BG 19 BLDC motor platform
This is a versatile motor platform especially designed to be integrated into diverse products like fans or pumps. With maximum possible power consumption P1 of 20 W, a speed range up to 12,000 rpm, and combined with its open mechanical design this platform provides to the appliance engineer high design flexibility. The functional aspect stays in the foreground. The motor becomes an integral part of a fan unit.

BG 32-3 BLDC motor platform
This is a three-phase motor platform which fits to the specific requirements of oven cooling fans or hot air convection fans providing a maximum possible power consumption P1 of 20 W and a speed range up to maximum 4,500 rpm. The motor provides a modular design with open mechanical interfaces similar to the before mentioned BG 19 motor platform. Its assembly concept permits the usage of the same core module for different applications. With its small dimensions it targets build-in situations with limited space.

BG 43 sensorless BLDC motor platform
This is a sensorless BLDC motor. It is available in different motors sizes with a power consumption of maximum 50 W, 80 W or 220 W. Its maximum speed range covers up to 4,000 rpm. It provides EC technology while having comparable mechanical interfaces as the ebm-papst PSC motor series. A separate electronic box which is part of the motor and contains the commutation electronics is attached either to the motor itself or placed outside of it and connected to the motors cable. The driver box provides a VSD interface to control the speed either by a 0-10 V analog or PWM signal. As a sensorless BLDC motor it provides a calculated speed signal. **IAM**

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Christian Oberpriller, Key Account Manager at ebm-papst

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