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A comparison of U.S. and European approaches to regulating fan efficiency

Michael Ivanovich,[1*] Neil Jones[2]
[1] *AMCA International, USA. Member ASHRAE*
[2] *European AMCA, Belgium*
**Correspondence author. E-mail: mivanovich@amca.org*

The United States and European Union began regulating commercial and industrial fan efficiency around the same time in 2007; however, they took very different approaches. The European Union began with product regulations stemming from Ecodesign directives. The U.S. began with adopting fan efficiency requirements into model codes and standards for energy efficiency and green construction published by ASHRAE and the International Code Council (ICC). A U.S. federal regulation began through the U.S. Department of Energy after the ASHRAE and ICC provisions had been initiated. This paper describes and compares the U.S. and European approaches regarding fan efficiency regulation. For the U.S. section, emphasis is placed on the use of model codes and standards such as ASHRAE Standard 90.1 because the U.S. Department of Energy regulation is not expected to become effective until 2020. For the European section, an outline of Commission Regulation (EU) No. 327/2011 is provided.

KEYWORDS

Commercial fans. Regulation. Codes & standards. Equipment standards.

1. INTRODUCTION

Although fans applied in commercial Heating, Ventilation and Air Conditioning (HVAC) systems can account for a significant fraction of an energy budget, and about 1.25 Quads per year for all commercial buildings in the U.S. (Westphalen and Kozalinski 1999), only recently have agencies developed and incorporated rating standards for fan efficiency into codes, standards and regulatory policies in Europe and the U.S. (Cermak and Ivanovich 2013; Hauer and Brooks 2012).

In Europe, Commission Regulation (EU) No. 327/2011 (2011), the Regulation, sets minimum efficiency targets that building-ventilation fans must meet. The Regulation targets fans that are driven by electric motors with input powers from 125 W to 500 kW. Compliance with Regulation Tier 1 targets became mandatory on 1 January 2013, and more stringent Tier 2 targets will take effect on 1 January 2015. The Commission Regulation is a product requirement, not a building code. Product requirements differ from building codes in that they place minimum efficiency restrictions directly on manufactured devices or equipment. Building codes place requirements on products that are applied in systems installed in facilities; these products may have applications, such as industrial processes, which are unaffected by building codes. Building code provisions may also have application requirements, such as size limits, that are not usually a component of product regulations.

In the U.S., fan efficiency regulation has been addressed in model codes and standards for energy efficiency and green construction. Model energy codes and standards place baseline (minimum) energy performance requirements on building components and systems. ASHRAE Standard 90.1 is a model energy standard; the International Energy Conservation Code is a model energy code. Green model construction codes and standards address buildings holistically by including provisions for the building site, envelope, lighting, plumbing, and HVAC systems that are more stringent than baseline codes and standards. ASHRAE Standard 189.1 is a model green construction standard; the International Green Construction Code is a model green construction code. Energy efficiency and green construction codes and standards are driven by their publishing authorities to become progressively more stringent. For example, ASHRAE set a goal that the 2010 version of Standard 90.1 would be 30 per cent more stringent than the 2004 version of the Standard (Gowri 2009). Increasing stringency can be accomplished several ways, for example, by increasing the scope of coverage to include previously uncovered features, or by increasing the stringency of covered equipment or systems. Hence, fans, which were not previously covered by a model energy code or standard, drew interest as a means for achieving increasing stringency (AMCA 2009).

Fans also have not been covered by U.S. federal product efficiency standards; however, in 2011, the U.S. Department of Energy (DOE) initiated a federal rating standard and minimum efficiency regulations for commercial and industrial fans (U.S. Department of Energy 2013a). The rulemaking process, which will establish a product requirement (not a building code), is expected to conclude in 2015 or 2016, with enforcement beginning in 2020. The DOE rulemaking will include the establishment of a federal test standard for fans, which will be used for compliance verification and enforcement, and minimum energy performance standards for fans covered by the regulation (U.S. Department of Energy 2013a).

Although they were started at approximately the same time, European and U.S. regulatory approaches are quite different, from the regulated equipment's technical boundaries to the structure and rigour of market surveillance and enforcement. The significance of the difference is that many fan manufacturers have international scope. Having to comply with different fan efficiency standards in Europe and the U.S. imposes additional regulatory burden on affected companies. This creates market inefficiencies as it constitutes a diversion of staff time, marketing effort, communications programs, and engineering literature. Perhaps most significantly it results in a fan that is acceptable in one geographic region not being acceptable in another, and therefore fan sizing and selection software must be upgraded to take into account were a fan is to be sold. This upgrading requires a research and development effort that deflects effort away from actually making the fan itself more efficient. U.S. and European stakeholders, including manufacturers, regulatory bodies, and non-governmental organisations, are discussing fan regulation harmonisation from an international perspective, but there is no formal movement as yet to initiate a harmonisation effort. Although not covered in this paper, stakeholders from Asia also are involved in these discussions because fan efficiency regulation is also taking place in this region, and international business interests are similarly affected.

This paper summarises European and U.S. approaches to fan-efficiency regulation, with emphasis on commercial HVAC systems. It examines equipment rating standards, as well as model codes and standards and government regulations that reference them.

2. U.S. FAN CODES, STANDARDS, & REGULATIONS

The basis of U.S. fan efficiency provisions in model codes and standards is the Air Movement and Control Association (AMCA) Standard 205 *Energy Efficiency Classification for Fans.* AMCA International is a not-for-profit manufacturers association with more than 320 member companies worldwide. First published in 2010, AMCA 205 was revised in 2012 and approved by the American National Standards Institute (ANSI/AMCA 2012). AMCA 205 has two significant attributes. First, it rates fan efficiency using a non-dimensional index called a Fan Efficiency Grade (FEG), which one calculates from data obtained during performance rating tests. FEGs are presented as a family of curves (Figure 1a, Figure 1b). Each FEG band represents a range of efficiencies that vary depending on fan impeller diameter. For example, FEG 67 includes fan efficiencies of 64, 65, 66 and 67 at the plateau for fans > 20-in. in diameter, and efficiencies as low as 35 in the 5-in. diameter sizes.

The scope of AMCA 205 is limited to fans having an impeller diameter of 125 mm (5 in.) or greater, operating with a shaft power 750 W (1 hp) and above, and having a total efficiency calculated in accordance with procedures specified in test standards for rating fan performance:

- ANSI/AMCA 210 (ANSI/ASHRAE 51) *Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating;*
- ANSI/AMCA 230 *Laboratory Methods of Testing Air Circulating Fans for Rating and Certification;*
- AMCA 260 *Laboratory Methods of Testing Induced Flow Fans for Rating*; and
- ISO 5801 *Industrial Fans - Performance testing using standardised airways*.

Fans that cannot be tested to one of these standards are excluded from AMCA 205, which means they are subsequently excluded from codes, standards and regulations with fan efficiency provisions based on AMCA 205. Examples of excluded fan types include air curtains and jet fans. Compliance checking is further complicated by the fact that, even if a fan type falls under the scope of a particular standard, the fan's size may exclude it. For example, the scope of AMCA 230 is limited to fans up to 1.8 m (52-in.), which exempts the larger high-volume, low-speed (HVLS) ceiling fans.

The second important attribute of AMCA 205 is that it goes beyond fan efficiency to recognise that fan energy consumption is highly dependent on sizing and selection practice. Thus, AMCA 205 prescribes that the '…fan operating efficiency at all intended operating point(s) shall not be less than 15 percentage points below the fan peak total efficiency' (Figure 2).

The intent of the sizing/selection window is to encourage what AMCA refers to as 'right-sizing.' It is often the case that electronic sizing and selection software will provide multiple fan selections for a given airflow and pressure duty point. In most cases, the software's output will be a spectrum of fan types and diameters. The smaller diameter fans will typically be less efficient that the larger diameter fans, and therefore will satisfy the duty point requirements using higher horsepower motors and running at a higher speed. Thus the smaller diameter fans will typically consume more energy than their larger-diameter counterparts.

Although they consume much energy, smaller diameter fans have a lower first cost. Therefore there is a tendency for ventilation system designers to specify and purchase lowest-first-cost solutions from the options available (Danfoss 2010). A prescribed sizing and selection window will change a fan selection to a larger diameter such that its operating points fall within the 15 percentage points of the fan's rated peak total efficiency.

In summary, AMCA 205 impacts manufacturers by defining an efficiency rating system for fans, and it impacts practitioners by prescribing a sizing and selection window that can lead to larger, more efficient fans operating closer to their peak efficiency.

2.1 First-Generation Model Codes and Standards

When ASHRAE first considered fan efficiency provisions for ASHRAE Standard 90.1, they considered a 'straight line' 65 per cent efficiency requirement as a starting point (Cermak and Ivanovich 2013). However, because smaller-diameter fans are inherently less efficient than larger diameter fans of the same type, setting a 65 per cent minimum fan efficiency would eliminate many fan types under 20-in. in diameter (Figure 3).

2.2 About Fan Total Pressure

Fan efficiency grades are based on fan total pressure for all fan ratings, and the sizing and selection window also is based on fan total pressure. The use of total pressure when sizing and selecting fans is counter to standard practice in the U.S., where the majority of design practice, manufacturers' data, and sizing and selection software programs are based on fan static pressure (Cermak and Murphy 2011). This is especially true for fans that are installed in systems where the fan is not connected to an outlet duct, as this arrangement provides little or no opportunity to recover the velocity component of total pressure.

Transitioning from static pressure to total pressure for a fan will require replacing a substantial amount of the manufacturers' hardcopy and electronic literature; training of distributors; and the design community's education and training. Since the publication of AMCA 205 and its adoption into codes and standards, manufacturers have started including fan total pressure data and FEG ratings in their software. Manufacturers are also participating in the AMCA Certified Ratings Program for FEG ratings and peak fan total pressure. The AMCA Certified Ratings Program is a voluntary program that assures buyers and specifiers that manufacturer's ratings are based on standard test methods and procedures, and are subject to review by AMCA International as an impartial authority. As of December 2013, 52 companies have certified more than 430 fan models (AMCA 2013).

2.3 Codes and Standards based on AMCA 205

After AMCA 205 was published in 2010, work began in earnest to have U.S. model codes and standards adopt fan-efficiency provisions written around it. Table 1 lists the model codes and standards that have or are considering fan-efficiency provisions based on AMCA 205.

The fan efficiency provisions referenced in Table 1 are written around AMCA 205, following its two-part fan-efficiency provisions. Part 1 sets a minimum fan efficiency rating using the FEG metric. Part 2 sets a sizing/selection window relative to the fan's rated peak total efficiency. Scope of coverage and exemptions are also part of these provisions, and these tailor the fan FEG and selection provisions to what today's state-of-the-art designs and manufacturing can practically attain. Efficiency provisions in the four model codes and standards are summarized in Table 2. The Notes section lists the exemptions in ASHRAE 90.1, which are also explicitly listed in IECC. The exemptions are adopted by reference in the proposals for ASHRAE 189.1-2014 and IgCC-2015.

Because these are first-generation requirements for fan efficiency, the provisions are not as stringent as some would expect and energy savings most likely will be negligible. The ASHRAE 90.1 Mechanical Subcommittee deemed this conservative approach essential, and their conservative nature carried through to the fan efficiency provisions in subsequent codes and standards. The rationale is that manufacturers and engineers need to become familiar with the FEG metric and accommodate wider use of fan total pressure before minimum fan efficiency requirements are increased significantly.

2.4 Energy Codes/Standards Adoption and Compliance

The amount of energy that the implementation of model codes and standards will save will depend upon the speed with which jurisdictions adopt the most recent versions. Jurisdictions exist at national, state, and municipal levels and adoption rates vary widely. At the time of writing, early 2014, only a few states have adopted ASHRAE 90-2010 or its equivalent, IECC-2012. ASHRAE 90.1-2013 has just been released and IECC-2015 has been finalised, each with their first fan efficiency provision. Energy savings from the fan efficiency provisions may not begin accruing until the 2020 timeframe under the current energy-code adoption paradigm.

Two other factors in energy savings for model codes and standards are compliance and enforcement. A meta-analysis of energy code compliance studies at the state level found that the local jurisdictional level generally enforces U.S. energy codes, even for state projects (Misuriello *et al*. 2010). The study also found that compliance often suffers from a number of confounding and compounding issues, such as:

1. As-built conditions are sometimes different from plans. For example, contractors often have to change duct runs to go around obstacles not known during the design phase.
2. There is little on-site review of construction to compare with plans. For example, construction features that may be hidden from inspectors, such as installations within wall cavities.
3. Substitution of non-complaint products is common. For example, replacing one model of a fan for another.
4. Education and training needs exist for many states.

With these types of challenges in mind, AMCA has developed measures and resources simultaneously with fan efficiency codes/standards provisions, including:

1. Requirements for independently certified FEG ratings and an energy label in model codes (IECC and IgCC).
2. Online fan model database that has been AMCA-certified for FEG and peak total efficiency (www.amca.org/feg/feg-finder.aspx).
3. ANSI/AMCA 205-12 available online at no cost (www.amca.org/feg/codes-and-standards.aspx).
4. Extensive online library of technical articles, white papers and PowerPoint presentations about FEGs and relevant codes/standards developments (www.amca.org/feg/best-practices.aspx).

2.5 U.S. Department of Energy Action

In 2011 the U.S. Department of Energy (DOE) signaled its intent to regulate commercial and industrial fans. DOE published a ‘Request for Information’ that stated they had preliminarily ruled that the DOE has the authority to regulate fan efficiency. The Request for Information also indicated a need for stakeholders such as manufacturers to provide the Department with information about fans and the fan market (U.S. Department of Energy 2011). As part of the next stage of DOE's regulatory process, a Framework Document was released for public review on February 1, 2012. The Framework Document described how the DOE is considering regulating fan efficiency, and identified fan efficiency rating standards, fan market data, the EU fan regulation, and other information DOE would consider. Following the completion of additional milestones, the DOE will issue a final rule in 2015 or 2016, and enforcement is expected to begin around 2020 (U.S. Department of Energy 2013b).

Based on the Framework Document, the DOE vision for regulating fan efficiency is very different from the approach that the model codes and standards have taken. The DOE scope is much broader, including industrial process fans and a size range from 125 W to 500 kW. The DOE will define multiple fan categories, each having an independently considered metric, test standard, minimum efficiency performance requirement, and range of covered products. The DOE also is considering regulating 'extended products', defined as fans sold with motors and fans sold with motors and drives, in addition to fans sold without motors or drives.

Because the DOE appliance and equipment standards are restricted to products, the federal regulation cannot include the provisions in model codes and standards having a sizing and selection window. The significance of this is that operating efficiency is dependent on fan size. A fan efficiency requirement without a sizing and selection window might not yield energy savings. In fact, such a requirement could lead to *increasing* fan energy consumption if smaller fan sizes are selected/purchased to recoup higher purchasing costs of higher efficiency fans.

The Framework Document generated considerable commentary from industry stakeholders, including proposed redefinitions of the fan categories by AMCA International to align with current industry practice (AMCA 2013).

Whilst the DOE is developing the federal fan efficiency standard and regulation, ASHRAE and ICC will have implemented or finalised second and third generations of fan efficiency provisions in model codes and standards, as scheduled in Table 3. As discussed earlier, first-generation provisions are already in place or proposed. Development of second-generation provisions will soon begin, possibly appearing first in ASHRAE 90.1-2016. Some of the early thinking on second-generation provisions is to incorporate knowledge gained by participating in the DOE rulemaking process, such as defining fan categories and setting separate requirements for each. Third-generation provisions would harmonize model codes and standards with applicable DOE requirements; hence, their development would begin after the DOE final rule is published in 2015 or 2016.

Of particular significance to the U.S. federal regulation will be strict market surveillance. The DOE regulations for equipment include the establishment of a testing standard for each type of covered product. The test standard is used for compliance testing, which manufacturers use to certify that their products meet federal minimum energy performance requirements. The DOE also will use the same test standard for enforcement testing, whereby independent third party contractors conduct periodic check tests on product samples and compare results against manufacturers' data. Products that fail the check tests can result in fines and face removal from the market.

3. EUROPEAN FAN REGULATIONS

The European Union (EU) has been intensively regulating energy efficiency and emissions relating to climate change under the European Ecodesign Directive. The European Ecodesign Directive provides a framework for establishing requirements for energy-related products and the Directive's Implementing Regulations that will impact all member states. The EU has published more than a dozen 'Implementing Measures,' covering products ranging from TV sets to light bulbs and fans. These regulations are for products only. They are not building code provisions.

To identify targets for Implementing Measures, the European Commission relies on a network of consultants to launch a series of studies with input from stakeholders. Impact assessments establish priorities based on estimated potentials for energy saving. The Commission then prepares working documents based on the outcomes of the studies and impact assessments.

The department, known as a Directorate General, that is responsible for a particular Implementing Measure will convene one or more Consultation Forum meetings to discuss the working document with industry stakeholders and member states' government representatives. Based on feedback, the Directorate General prepares a draft Implementing Measure to discuss with a Council of member-state experts and the Commission in a Regulatory Committee. Once the Regulatory Committee has endorsed the draft

Implementing Measure, the Council and European Parliament have typically from two to four months to consider the proposed legislation prior to its adoption as a legally binding European Regulation.

An impact assessment will evaluate all the environmental aspects from design through manufacture to disposal of a product. However, the regulation of the efficiency of a typical energy-using product or an energy-related product is primarily focused on the amount of electricity consumed as a result of using or deploying the product. Hence, the Commission has chosen to regulate fan efficiency on the assumption that an electric motor drives the fan, whether it is fitted to the product at the point of sale or not. Consequently, Fan Motor Efficiency Grades (FMEG), as defined by the European (EN) and International Standards Organization (ISO) EN ISO 12579 *Fans –Efficiency classification for fans*, were adopted as an efficiency metric rather than Fan Efficiency Grades. The FMEG designation addresses the overall efficiency of an entire fan assembly, accounting for losses in, for example, a belt-drive system, electric motor, and variable speed drive, and for losses from suboptimal combinations of those components (Figure 4) (Hauer and Brooks 2012).

The European Commission has used relevant information from EN ISO 12759, together with market benchmarking studies, to determine the target FMEG for fans based on type (e.g. axial, forward or backward curved centrifugal, mixed flow, etc.) in both ducted and non-ducted operating conditions for ventilating applications in buildings (Radgen *et al.* 2008). Ducted applications use fan total pressure as the basis for efficiency calculation; non-ducted fans use fan static pressure. Manufacturers declare the FMEG based on full fan speed and they list the chosen efficiency category as static or total. For most types of fans, manufacturers provide efficiencies for static and total pressure installations.

However, the way one installs and uses many energy-using products determines the efficiencies and energy consumption. This is often beyond the control of the product manufacturer or supplier. The European Commission, therefore, decided that they would set Minimum Efficiency Performance Requirements (MEPRs) at optimum or peak efficiency operating points for products such as electric motors and fans and then adopt an 'Extended Product Approach' to regulate such equipment.

In the case of fans as an 'Extended Product,' this could mean that the motor that drives the fan must comply with a MEPR before a manufacturer can legally place it on the market. The fan manufacturer may not always be using the compliant motor at its optimum efficiency point but the fan must comply with the MEPR that is required in the fan regulation. In continuation of this Extended Product Approach, the EU is introducing and drafting more Implementing Measures, which will set MEPRs for a range of equipment and products that incorporate both the fans and the motors. Note that the Extended Product Approach also means that whereas fans used in 'fan units' such as air handling units, box fans, and roof fans, are within the scope of Regulation 327/2011, the 'fan units' themselves are not. These will be dealt with in a separate regulation. For fans and fan-using equipment installed in HVAC applications in buildings, implementing the Energy Performance of Buildings Directive should further control the minimum efficiency of the systems that utilise them. Some member states have already introduced totaled specific fan power targets, based on the electricity used to provide the required air volume flow, for the fans installed in building HVAC systems.

3.1 Fans Regulation

Commission Regulation (EU) No. 327/2011 sets minimum efficiency targets that fans driven by electric motors with input powers from 125 W to 500 kW must meet. Compliance with Tier 1 targets became mandatory from 1 January, 2013, and more stringent Tier 2 targets will apply, beginning on 1 January, 2015. Determination of FMEG is based on applying two standards: EN ISO 12759 to determine target efficiency and FMEG, and EN ISO 5801 *Industrial Fans - Performance testing using standardised airways* for setting up and measuring air performance and air power. Subsequently, the Commission has issued a mandate (M500) for drafting a specific Harmonised EN Standard that will pull together all the relevant information and specify the required methodologies and calculations to demonstrate compliance with Regulation 327/2011. This work is now progressing in the European Committee for Standardization CEN TC/156 WG/17, but meanwhile, this regulation is still, and will be, in force. Tabulated minimum efficiencies according to EU 327/2011 are available as a PDF and an Excel spreadsheet at www.amca.org/feg/fmeg.aspx.

To guide the application and enforcement of Regulation 327/2011, the European Commission has published two, non-legally binding, FAQ Guidance Documents:

1. Frequently Asked Questions on the Ecodesign Directive 2009/125/EEC (contains general information and pages dealing with specific issues from Implementing Measures, including Regulation 327/2011).

2. Guidelines (an FAQ document specific to Regulation 327/2011).

Both documents are downloadable from the European Commission website at http://ec.europa.eu/enterprise/policies/sustainable-business/documents/eco-design/guidance/index_en.htm. These, unlike Regulation 327/2011, are 'living documents' in so far as the Commission can update or add to them at any time as it sees fit.

Once an Implementing Measure is published, it is difficult to persuade the European Commission to consider any amendments. Even then, an amendment agreed by the Commission would have to go through the Council and Parliamentary procedures and take some considerable time. However, although the Tier 2 fan efficiency targets are already set and compliance will become mandatory from January 2015, the European Commission is committed to complete a review of Regulation 327/2011 in 2015. To meet this schedule, the review process will commence early in 2014 and will involve scrutiny such as impact assessments to date and stakeholder consultations. The review process will provide opportunity for introducing amendments if review participants find sufficient justification.

The energy and emissions savings projected to result from Regulation 327/2011 are significant. A European Commission Impact Assessment study identified a stock of 143 million fans in 2005, possibly rising to 227 million units in 2020. When assessed at the EU level, fan energy consumption was 390 TWh annually representing approximately 179 million tons of CO_2 in emissions for fossil fuel burning power stations in 2005, with an estimated rise to 630 TWh annually in 2020 (a 60 per cent increase).

The Impact Assessment predicted that Regulation 327/2011 could achieve a reduction of 54 TWh annually by 2020. This equates to savings of 25 million tons of CO_2 and an associated 7 billion Euro reduction in the cost of electricity needed to drive the installed fan base. To give this an EU perspective, this is approximately equal to the amount of electricity consumed in Greece in 2006. The Impact Assessment also identified that member states monitor the situation through market surveillance which is intended to ensure that manufactures comply with the requirements of the Regulation. However, the level of enactment of Market Surveillance is limited by the availability of resources and fragmented across the EU.

3.2 Market Surveillance and Regulation in the EU

One of the mainstays of the European Union single market is the free movement of goods. In this context, the proper functioning of the single market rests ultimately on consumer trust. Consumers and purchasers must have confidence that, irrespective of where a product is manufactured and in which member state they buy it, the product is both safe and compliant. This is the message from an explanatory statement in the draft report on the *Proposal for a Regulation on Market Surveillance of Products and Amendments to Existing Council Directives* that the 'European Parliamentary Committee on the Internal Market and Consumer Protection' published in June 2013.

Finnish MEP Ms Sirpa Pietikäinen, rapporteur on market surveillance, explained that efficient and high-quality market surveillance should act as the ultimate guarantor. This is a stance that the European AMCA has encouraged and supported. Market surveillance should not only ensure that products will not endanger the consumers' health and safety or present a hazard in the workplace, but also guarantee that products are compliant with applicable EU legislation such as rules for minimum efficiency, noise levels and emission limits.

However, it is clear that member states' market surveillance is already failing to adequately address the growing number of imports to the EU and the increased number of products circulating within the single market. Recent figures from the European Commission suggest that authorities check only 0.3 per cent of all goods placed on the market in the EU, including imported goods. Meanwhile, there is still an expectation that market surveillance authorities will be able rise to new challenges, such as the growth in e-commerce.

The enactment of adequate Market Surveillance is made more difficult by a complex legal structure. In 2011, a European parliament resolution on the revision of the General Product Safety Directive and market surveillance stated that the '*current legislative framework for market surveillance does not provide enough coherence and should therefore be reviewed and further coordinated'*. The resulting proposal would establish a common European framework for market surveillance that will impact all products circulating within the internal market, including those imported to the EU.

3.3 Surveillance Needed Beyond Health and Safety

Traditionally, the fragmented market surveillance activity within the EU has largely focused on health and safety. Member states of the EU now recognise that the Market Surveillance Regulation should not only safeguard health and safety, but also be a means to enforce EU legislation that seeks to uphold other public interests such as energy efficiency and the environment.

The Implementing Measures (regulations) that the EU is introducing for various products that fall within the scope of the Ecodesign Directive 2009/125/EC all contain rules for enacting market surveillance. Honest manufacturers put effort and resources into ensuring that they are compliant with EU safety, environment and other requirements. Market surveillance should ensure that players who do not abide by the rules do not gain advantage in the market over compliant operators. It is in the interests of trustworthy manufacturers, importers and distributors, as well as consumers that market surveillance authorities ensure that a Member State's legally empowered regulatory body can identify unsafe, harmful and otherwise non-compliant products and keep or take them off the market.

3.4 The Surveillance Resources Issue

The biggest challenge facing member states wishing to enact effective market surveillance is the lack of available resources and the growing volumes of trade. In its search for longer-term solutions, the European Commission has indicated an interest in exploring new, innovative market-based solutions that can complement market surveillance actions that the authorities currently solely undertake. Although there is an underlying suspicion of industry-sponsored certification and accreditation programmes, it is possible that the Commission may have to evaluate genuine contributions to effective market surveillance that responsible industry can provide, despite resistance to the idea on the part of the European Commission. Another suggested solution could involve third party auditing of operators' quality control systems, as well as of the end products.

4. COMPARING U.S. AND EUROPEAN FAN REGULATIONS

Although they were started at approximately the same time, European and U.S. regulatory approaches to fan efficiency regulation are quite different. Differences include the technical boundaries of the regulated equipment (fans alone vs. fans+motors+drives) to the present structure and rigor of market surveillance and enforcement.

The significance of the difference is that many fan manufacturers have international scope, and having to comply with different fan efficiency standards imposes extra regulatory burden on affected companies. Moreover, regulatory differences also create market inefficiencies and constitutes a diversion of staff time, marketing effort, communications programs, and engineering literature.

Ideally, harmonisation will occur by 2020, which is when the U.S. Dept. of Energy regulation for fan efficiency is expected to become effective. Some degree of harmonisation already exists in that EN ISO 12759 has a definition of fan efficiency grades that is consistent with AMCA 205. AMCA 205 currently is developing a metric consistent with FMEG (Ivanovich 2014), and the DOE is considering adopting or developing such a metric for regulating extended products (U.S. Department of Energy 2013b).

Table 4 compares U.S. and European approaches to fan efficiency regulation. Thus far, the majority of U.S. efforts have been with model codes and standards for buildings. These provisions are not included in the table because their development, adoption, and enforcement are not comparable to the European Union fan regulations, which like the future U.S. Department of Energy requirement, is strictly product focused.

5. CONCLUSION

The development of fan efficiency regulations for commercial and industrial fans is a relatively new phenomenon. Although started at approximately the same time in 2007, the U.S. and European Union have taken very different approaches.

The U.S. effort has primarily been through collaboration between AMCA International and organisations that publish model codes and standards for energy efficiency and green construction – namely ASHRAE and the International Code Council. Local code jurisdictions will eventually adopt and enforce these codes and standards. Adoption fan efficiency provisions began in 2012, but the provisions are not expected to have significant market impact until the 2019/2020 timeframe because of the slow uptake of revised model codes and standards by code jurisdictions.

The U.S. approach is characterized by having a single fan efficiency grade (FEG) requirement for all applicable fans, and a sizing and selection window that impacts design practice such that fans are sized upwards in diameter to operate closer to peak total efficiency more of the time. Table 2 identifies the provisions that are in each model code and standard. The primary difference between versions of the codes and standards is that the provisions in model codes (those under the auspices of ICC) include requirements for independently certified FEG ratings and an energy label. Provisions in the model standards (those under the auspices of ASHRAE) do not have certification and labeling requirements. All codes and standards provisions, both in place and proposed, have applicability to fans greater than 5 hp (3.7 kw), with a list of exemptions to help ease implementing first-generation provisions.

Development of a federal fan efficiency test standard and minimum energy performance standard began in 2011 and should be completed in 2015/2016. The U.S. federal regulations, administered by the U.S. Dept. of Energy, are expected to become effective in 2020. The DOE regulation will establish a number of fan categories, each with its own minimum energy efficiency standard and scope of coverage. The federal requirement will have uniform applicability and enforcement throughout the U.S. and its territories. Enforcement of U.S. federal product efficiency standards is rigorous.

U.S. model codes and standards will eventually be updated to be consistent with federal requirements. Because of the three-to-five year lag between publishing final federal requirements and enforcing them, model codes and standards could be updated to reflect federal requirements ahead of their enforcement. This convergence will harmonise fan efficiency standards throughout the U.S.

The European approach began with a market study and proposal that much of the industry considered to be unrealistic. This prompted the rapid drafting of a reference ISO standard for fan efficiency, and led to a European Commission regulation that went into effect 1 January, 2013 with an automatic escalation of stringency taking effect 1 January, 2015. The scope of the EC regulation ranges from fans with a low electrical consumption of 125 W to fans requiring up to 500 kW.

The EC approach uses the metric Fan Motor Efficiency Grade (FMEG) for fans, regardless of whether or not manufacturers actually sell them with the motor and specified ancillaries that will be required to enable them to function, and treats non-ducted and ducted fans differently.

If an extended product approach is included in the U.S. Dept. of Energy regulation and in second- and third-generation fan efficiency provisions in model codes and standards, these measures will bring U.S. and EU approaches closer together.

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Figure 1a. Fan Efficiency Grade Curves in I-P Units (ANSI/AMCA 2012)

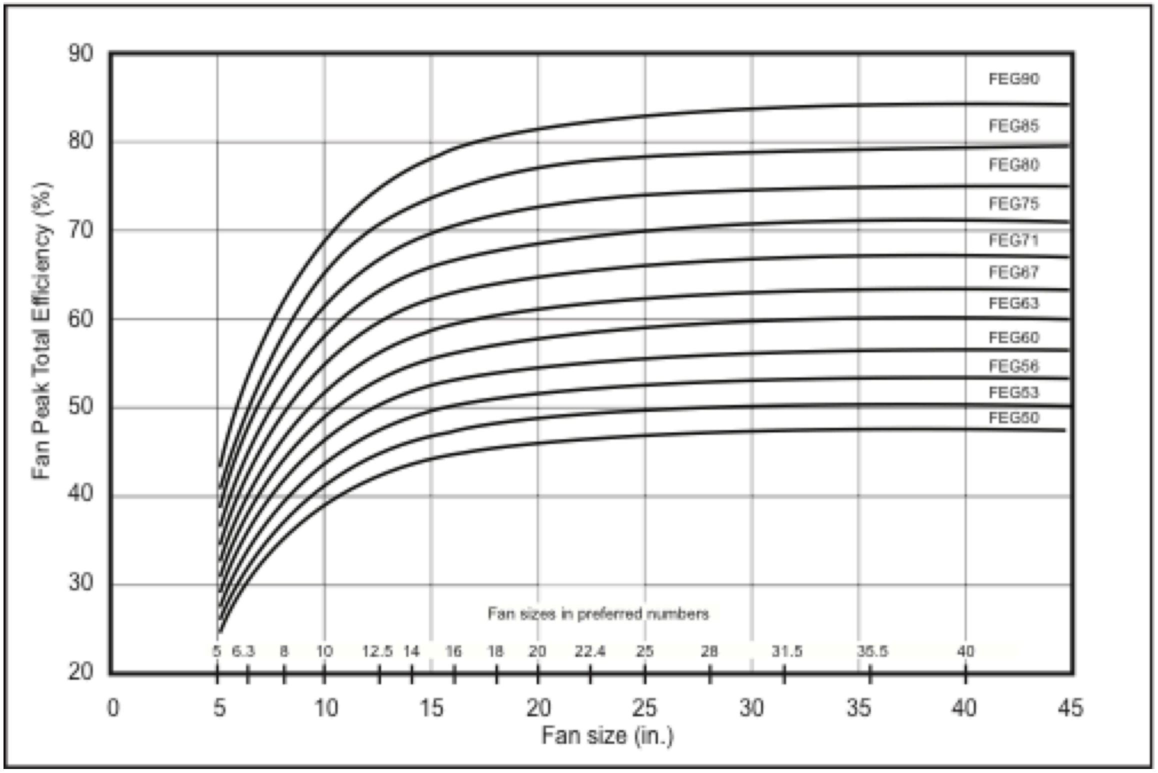


Figure 1b. Fan Efficiency Grade Curves in SI Units (ANSI/AMCA 2012)

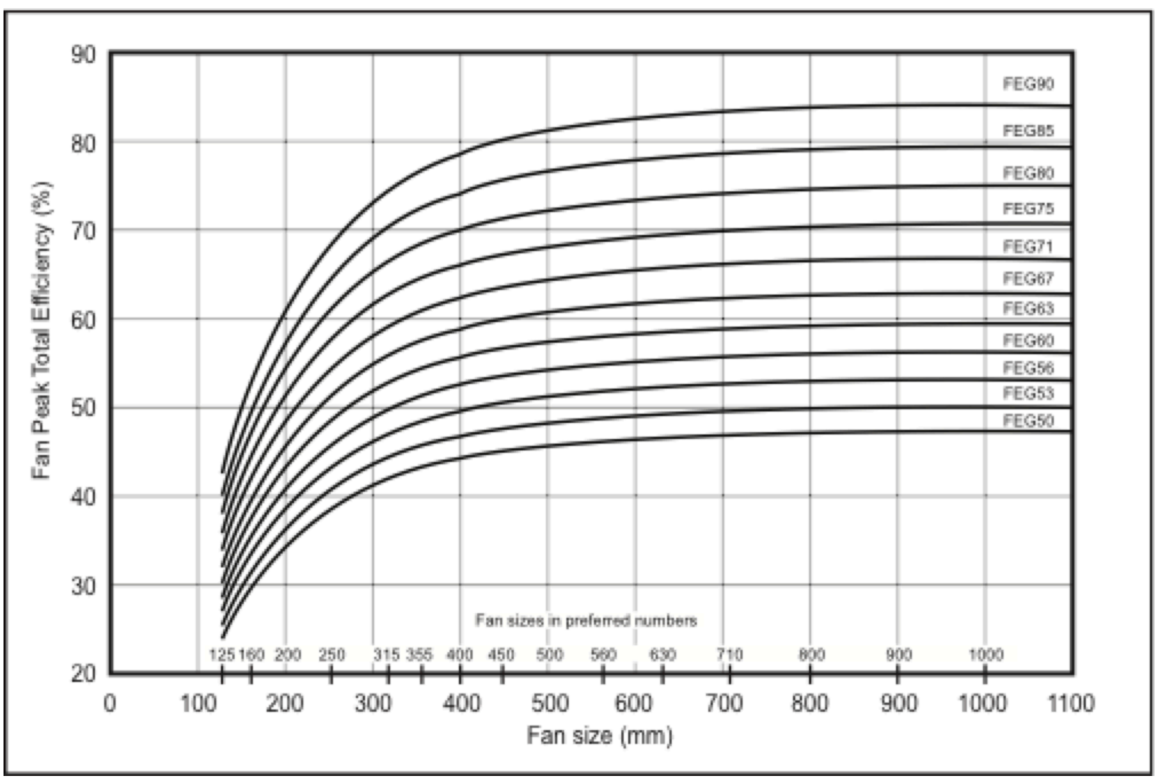
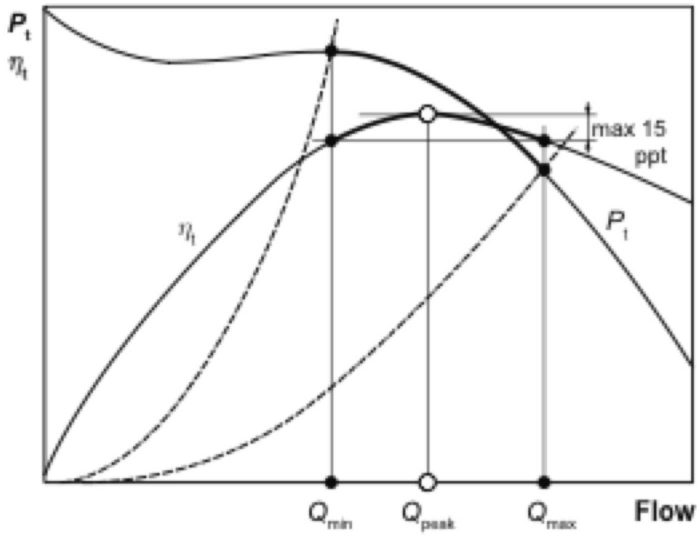


Figure 2. Sizing/Selection Window (ANSI/AMCA 2012)



Legend of symbols for Figure 2:

P_t = Fan total pressure line for the fan at varying flows and pressures
η_t = Fan total efficiency
Q_{min} = Airflow at the low end of the permissible window
Q_{peak}= Airflow at the fan's peak total efficiency point
Q_{max} = Airflow at permissible window's high end

Figure 3. FEG versus Straight-line Efficiency Requirement (Cermak and Ivanovich 2013)

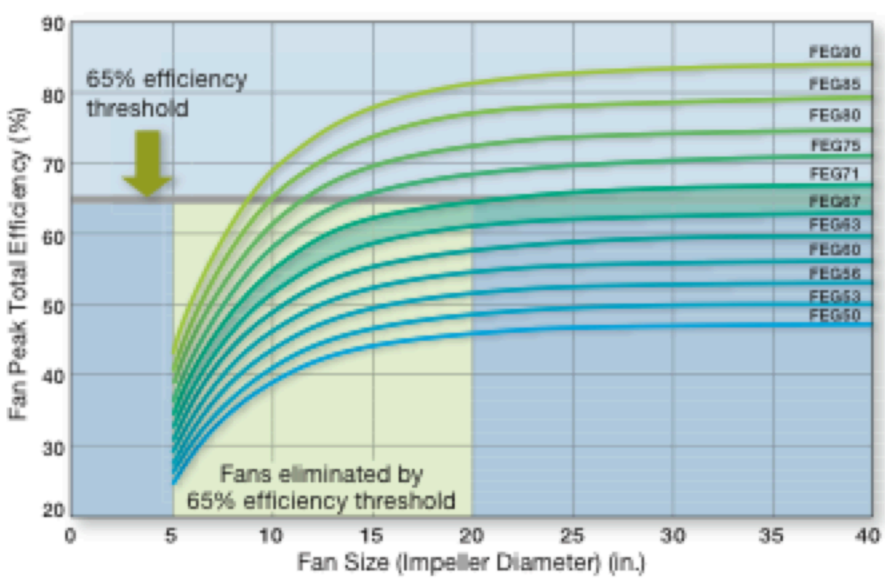


Table 1. Model Codes and Standards for Energy Efficiency and Green Construction		
Publication	**Type**	**Status**
ASHRAE, ANSI/ASHRAE/IES 90.1, *Energy*	Baseline energy	Exists in 2013 version.

Standard for Buildings Except Low-Rise Residential Buildings	standard.	
International Code Council, *International Energy Conservation Code (IECC)*	Baseline energy code.	Exists in 2015 version.
ANSI/ASHRAE/USGBC/IES 189.1 *Standard for Construction of High Performance Buildings Except Low-Rise Residential Building.*	Green construction standard.	Proposal undergoing public review for 2014 version.
International Code Council, *International Green Construction Code (IgCC)*	Green construction code.	Exists in 2012 version. Proposal for 2015 would harmonise with ASHRAE 189.1 and IECC.

Table 2. Fan Efficiency Provisions in U.S. Model Codes and Standards

Model Code/ Standard	Basis	Scope of Coverage	Fan Size[1] [hp]	Minimum Fan Efficiency Grade	Sizing/ Selection Window[2] [Percentage Points]	Certified FEG and Energy Label Required	Exemp-tions
2012 IgCC	AMCA 205-10	For buildings <25,000 sq ft, stand-alone supply, return and exhaust fans	> 1	FEG 71	10	No	None
2013 ASHRAE 90.1	ANSI/ AMCA 205-12	Buildings other than low-rise residential buildings	> 5	FEG 67	15	No	Yes[3]
2014 ASHRAE 189.1 (proposed)	ANSI/ AMCA 205-12	Buildings other than low-rise residential buildings	> 5	FEG 67	10	No	Yes[3]
2015 IECC	ANSI/ AMCA 205-12	Buildings other than low-rise residential buildings	> 5	FEG 67	15	Yes	Yes[3]
2015 IgCC (proposed)	ANSI/ AMCA 205-12	Buildings <25,000 sq ft	> 5	FEG 67	10	Yes	Yes[3]

Notes for Table 2:

1. Applies to fan arrays with aggregated motor nameplate ratings
2. Expressed as fan operating point selected to be within X percentage points of the fan's maximum total pressure (this is a rated value provided by the manufacturer).
3. List of exemptions below is in 90.1-2013 in IECC-2015. The list also is adopted by reference in change proposals for 189.1-2014 and IgCC-2015.
    1. Single fans with a motor nameplate horsepower of 5 hp (3.7 kw) or less
    2. Multiple fans in series or parallel (e.g., fan arrays) that have a combined motor nameplate horsepower of 5 hp (3.7 kw) or less and are operated as a single fan's functional equivalent
    3. Fans that are part of the equipment listed under Section 6.4.1.1 (note: in IECC, it is Section C403.2.3)
    4. Fans included in equipment bearing a third party-certified seal for the equipment package's air or energy performance
    5. Powered wall/roof ventilators (PRV)

6. Fans outside the scope of AMCA 205
7. Fans that are intended to operate only during emergency conditions

Table 3. Schedule of Model Codes and Standards Revisions

	1st Generation Year (Year Finalised)	2nd Generation Year (Year Finalised)	3rd Generation Year (Year Finalised)
ASHARAE 90.1	2013 (2013)	2016 (2016)	2019 (2019)
ASHRAE 189.1	2014 (2014)*	2017 (2017)	2020 (2020)
IECC	2015 (2013)	2018 (2016)	2021 (2019)
IgCC	2015 (2014)*	2018 (2017)	2021 (2020)

* Fan efficiency proposals are being evaluated during the current update cycle.

Figure 4. Power and Losses through an Entire Fan Assembly (Hauer and Brooks 2012)

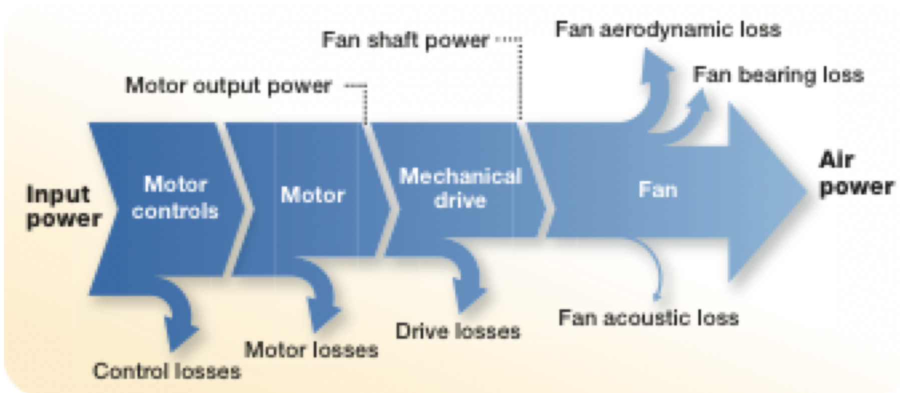


Table 4. Comparison of U.S. and E.U. Fan Efficiency Regulatory Approaches

Parameter	United States	European Union
Promulgating bodies	U.S. Department of Energy (DOE)	European Commission
Effectiveness dates	2020 (estimated)	January 1, 2013 for Tier 1 January 1, 2015, for Tier 2
Fan Efficiency Rating Standard	Draft DOE test standard is expected in 2014; finalisation in 2015/2016; taking effect in 2019/2020	Draft of Harmonised EN standard for Fans - Procedures and methods to determine the energy efficiency in preparation. 2015 target for introduction
Scope – Application	Fans for commercial and industrial applications, not restricted to building ventilation systems.	Fans, including those integrated into other energy-related products. Excludes fans for use in toxic, corrosive, flammable and abrasive environments, and at supply voltage >1000V ac or >1500V dc.
Scope – Size	125 W to 500 kW proposed in Framework Document.	Electrical Input Power from 125 W to 500 kW
Product Boundaries	Fan only, with possible extended product provisions, fans sold motors and fans sold with motors and drives.	Extended product: Fan+motor+drive (if specified).
Metric	Fan Efficiency Grade (FEG) for fan-only, as defined in ANSI/AMCA Standard 205. Metric for extended products is under development by AMCA.	Fan Motor Efficiency Grade (FMEG), as defined in EN ISO Standard 12759.
Pressure basis	To be determined.	Fan total pressure for ducted fans Fan static pressure for non-ducted fans.
Market surveillance	Manufacturer declaration of compliance using federal test standard, with federally administered periodic check tests.	Manufacturer documentation and declaration of compliance with FMEG target. Member state's targeted documentation check and possible independent test. EU wide sharing of results.
Projected annual energy savings	20 per cent of annual fan power for covered fans (U.S. Department of	54 TWh per year by 2020.

	Energy 2011).	