The SEAD Global Efficiency Medal Competition: Accelerating Market Transformation for Efficient Motors

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Abstract

The SEAD Global Efficiency Medal competition is a global and regional awards recognition program that encourages the production and sale of super-efficient products and is a cornerstone activity of the Clean

Energy Ministerial's Super-efficient Equipment and Appliance Deployment (SEAD) Initiative. This winner-takes-all competition guides buyers towards the most efficient product choices and spurs efficiency innovation among manufacturers.

Electric motors and systems (EDMS) account for 44%-46% of electricity end-use globally. The operating cost of a medium or large size motor can be several-fold (sometimes an order of magnitude) the purchase price. Hence, even small increases in efficiency can result in significant reduction of ownership (capital plus operational) costs of the motor. In the U.S. alone, it is estimated that cost-effective efficiency technologies and practices can reduce the electricity demand from motors by 11%-18% (62 TWh to 104 TWh) and save US$3 billion to $5 billion a year (Waide and Brunner 2011) [Ref 2]

The SEAD Global Efficiency Medal competition for electric motors seeks to advance efficiency improvements by:

- Recognizing products with the best energy efficiency;
- Guiding buyers who want to purchase the most energy efficient products; and
- Demonstrating the levels of efficiency that are achievable with commercially available and emerging technologies.

By recognizing both induction and new technology motors, the competition aims to accelerate efficiency gains in existing technologies and promote emerging technologies in the market. In addition, this competition is an opportunity to harmonize performance testing globally by allowing governments to recognize comparable and transparent test procedures for energy efficient products. Harmonizing these test procedures will make it easier for manufacturers to operate in the global market and consequently provide more cost-effective products for consumers.

The competition for electric motors launched in June 2013, runs through November 2013 and winners will be announced in September 2014. There are 18 award categories across 4 geographic regions. The award categories include both National Electrical Manufacturers Association (NEMA) and International Electrotechnical Commission (IEC) standard induction motors, and new technology motors. This paper discusses the framework and requirements of this competition, as well as the program design challenges faced in developing a global awards competition for electric motors.

Introduction

Figure 1. SEAD Global Efficiency Medal award logo.

The SEAD Initiative

The Super-efficient Equipment and Appliance Deployment (SEAD) Initiative of the Clean Energy Ministerial (CEM) is a voluntary international government collaboration whose primary objective is to advance global

market transformation for energy efficient products. SEAD seeks to achieve this objective by engaging both the public and the private sector. To this end, SEAD is engaged in the following five activities: awards (the SEAD Global Efficiency Medal competition), procurement, incentives, standards and labelling, and technical analysis. The first three activities focus on mechanisms to increase demand for energy efficient products, the fourth facilitates exchange of technical information, and the last creates a strong analytical foundation for SEAD activities.

The SEAD awards program is led by government representatives from Australia, Canada, India, Japan, Sweden, the United Kingdom, and the United States. The Collaborative Labeling and Appliance Standards Program (CLASP) serves as the Administrator of the SEAD Global Efficiency Medal competition [Ref 1]. Each activity is managed by a working group comprised of government representatives from CEM participating countries. The policy makers of the SEAD working groups have been advised by a variety of international technical experts to collaboratively accelerate the pace of efficiency standards and labelling programs of specific product categories, including electric motors.[1]

Motors

Electric motors and systems (EMDS) account for 44%-46% of electricity end-use globally and result in 6040 Mt of CO_2 emissions [Ref 2]. Motors are segmented in three broad categories; (1) small motors that are rated less than 0.75 kilowatts (kW); (2) medium motors from 0.75 kW to 375 kW; and (3) large motors that are rated higher than 375 kW. While the number of units in the market of the first category far exceeds the other categories, the profile of the cumulative electricity consumption of the categories is quite different. Small motors account for 9% of all electric motor power consumption, medium motors account for 68%, and large motors account for 23%[Ref 2]. Due to its considerable share of electric motor power consumption, medium motors are the focus of the SEAD Global Efficiency Medal competition, as they provide the greatest opportunity to drive significant energy savings.

SEAD Global Efficiency Medal Competition

The SEAD Global Efficiency Medal competition is a global and regional awards recognition program that encourages the production and sale of super-efficient products; a cornerstone activity of the SEAD Initiative. This winner-takes-all (single winner per category) competition seeks to advance efficiency improvements by:

- Recognizing products with the best energy efficiency;
- Guiding buyers who want to purchase the most energy efficient products; and
- Demonstrating the levels of efficiency that are achievable with commercially available and emerging technologies.

By recognizing both induction and new technology motors, this competition aims to accelerate efficiency gains in existing technologies and promotes the introduction of new technologies into the market. This competition complements existing standards and labeling programs in promoting energy efficient products.

With increasing global production of motors, the SEAD Global Efficiency Medal competition is also an opportunity to harmonize performance testing globally. Global harmonization allows more standardized comparison of products available in different markets, which in turn can drive the demand for more efficient products within each market. In addition, global harmonization reduces the burden on manufacturers by allowing them to test once and sell globally and can therefore result in lower prices for those more efficient

[1] The SEAD collaboration for motors has recently initiated a project to devise internationally comparable compliance, certification, and enforcement (CC&E) data definitions, reporting requirements, and scope definitions that reflect commonalities (and differences) among different national and international standards and definitions for electric motors. This project is expected to be completed in January 2014.

products. Through this competition, governments may more readily recognize comparable and transparent test procedures for energy efficient products and through broad adoption of these test procedures make it easier and more cost effective to operate in the global market.

The SEAD Global Efficiency Medal competition for motors launched in June 2013 and will run through November 2013, with winners being announced in September 2014. There are 18 different award categories across 4 international regions, covering both National Electrical Manufacturers Association (NEMA) and International Electrotechnical Commission (IEC) standard induction motors, and new technology motors. The SEAD awards program is led by government representatives from Australia, Canada, India, Japan, Sweden, the United Kingdom, and the United States. The Collaborative Labeling and Appliance Standards Program (CLASP) serves as the Administrator of the SEAD Global Efficiency Medal competition.

Competition Considerations

The primary objective of the SEAD Global Efficiency Medal competition is to drive energy savings by increasing the market share of energy efficient products. Since general purpose AC induction motors between 0.75 kW (1 horsepower [HP]) to 375 kW (500 HP) account for the largest share of power consumption among motors and will continue to dominate the market for price reasons, SEAD seeks to encourage the production of super-efficient motors and realize the efficiency gains in this particular size category.

The last few years have seen the commercial introduction of new technology motors with efficiencies beyond those possible with AC induction motor technology. However, these new technologies still have a significant price premium and/or require an electronic controller for their operation. SEAD seeks to promote new technologies that show promise of being commercially available in the near future through a separate New Technology category in the competition.

Increasing the market share of products is also influenced by shipment thresholds. Given the prevalence of AC induction motors, nominated products in this category are required to have plans to ship a certain number of units within a more immediate time period. The New Technology category nominations are required to become commercially available within two years of winning the SEAD Global Efficiency Medal. The shipment thresholds also ensure that nominated products are not custom-made products or prohibitively expensive.

While innovation is encouraged, it is recognized that the use of standard frame sizes for induction motors is a major benefit when new technologies are being introduced. Accordingly, this competition stipulates adherence to the following accepted norms:

- Continuous rated duty
- Standard frame sizes
- Rated voltage in the range 230 – 600 VAC
- 4 pole speed for induction motors, (tested at 1800 revolutions per minute (RPM) for new technology motors)
- Totally enclosed fan cooled
- Standard torque: speed characteristics

Regional Awards and Differences

The motors competition covers four regions – Australia, India, Europe and North America. . Motors products are not homogenous across the markets within these regions and may differ in both frame sizes and frequency. Generally, the NEMA frame standard dominates the North American markets with motors designed for 60 Hertz (Hz) operations. The IEC frame standard is designed for 50 Hz operations and is the norm in Australia, Europe, and India.

Induction motor efficiency is critically dependent on the mains frequency, as a 50 Hz motor will be larger than an identically rated 60 Hz motor. Therefore the cost effectiveness of achieving a given efficiency will be different. Further, the IEC and NEMA frame sizes do not match exactly; so it may not be possible to replace an IEC motor with a NEMA motor and vice-versa. However, guided by the main purpose of this competition to maximize efficiency gains and energy savings within the respective markets, the SEAD Global Efficiency medal competition targets the most common product categories in each market, i.e. 60 Hz NEMA motors in North America and 50 Hz IEC motors in the other regions. In reality the markets are more complex than this, with different frequencies used in some parts of these regions. (For example, NEMA motors may be made with 50 Hz designs for use in equipment built for export). In addition, the competition includes an IEC category for the North American market in order to allow for comparison of motors globally.

The above choice will inevitably result in nominations that are not entirely comparable, including between the North American NEMA products and the IEC products from the various regions. This situation is a classic example of the significant challenge in designing a global competition: balancing the need for (1) standardization (whether it be product definitions, common test procedures, or eligibility requirements) and the accurate comparison of motor efficiency across markets, and (2) flexibility to address market-specific requirements, such as variations in motor design and sizes, to ensure that winning products represent a significant share of their respective markets.

Part-load Weighted Efficiency

The design of this competition also tried to ensure that the efficiency evaluation criteria accurately represented real-world performance. Although motor efficiency regulations are based on full load efficiency, in practice electric motors spend the majority of time at a lower load.

Accordingly, the SEAD Global Efficiency Medal competition was designed to evaluate efficiency performance of nominated induction motors at part loads using a weighted efficiency scheme (see *Figure 2*). The competition uses an assumed typical load profile, with losses at each load point weighted in proportion to the time spent at each load point. In using a weighted efficiency scheme for this competition, SEAD hopes to encourage the regulators, manufacturers and users alike to consider performance at various load points since evaluating efficiency at the rated (100% load) point is not necessarily representative of real-world usage.

$$\eta_{AVG} = (0.05 \times \eta_{25\%}) + (0.20 \times \eta_{50\%}) + (0.40 \times \eta_{75\%}) + (0.35 \times \eta_{100\%})$$

Where:

η_{AVG} *is the calculated weighted average efficiency;*
$\eta_{25\%}$ *is the efficiency measured at 25% load;*
$\eta_{50\%}$ *is the efficiency measured at 50% load;*
$\eta_{75\%}$ *is the efficiency measured at 75% load; and*
$\eta_{100\%}$ *is the efficiency measured at full load.*

Figure 2. Weighting scheme for part load conditions for induction motors

Award Categories

Induction Motor Size Classes

As previously discussed, the size categories for the competition focused on medium size motors between 0.75 kW (1 HP) and 375 kW (500 HP), as they represent the largest share of electric motor power consumption. Further analysis of North American market data suggested that 5 HP (NEMA 184T) and 15 HP (NEMA 254T) motors represent the greatest energy savings potential, as calculated by the number of units in sales and the expected per unit improvement (Figure 3).

In determining the appropriate IEC induction motor size equivalent to the 5 HP NEMA induction motor, this competition was again faced with the challenge of balancing comparability for a global award while accommodating market-specific trends. In India, 3.7 kW (IEC 112M) motors are more common and generally regarded as the equivalent to 5 HP motors, whereas 4 kW (IEC 112M) motors are more common in Australia and Europe. This could have resulted in a slight disadvantage for the 3.7 kW category compared to the 4 kW motor. Hence, 3.7 kW was established as the size category for India whereas the Australian and European region has a 4 kW (IEC 112M) size category. On the other hand, the IEC equivalent of the 15 HP motor is the 11 kW (IEC 160M) motor size category in all the regions. The best performing IEC induction motor in each size class among all of the award regions will be declared an "international winner" for the size class. A total of up to ten (10) awards will be granted in the IEC Induction Motor Category, with eight (8) regional awards and two (2) international awards,. A total of up to two (2) winners in North America will be granted in the NEMA Induction Motor Category (see *Figure 3*).

		Region				
Category	**Size Class**	Australia	European Region	India	North America	Inter-national
IEC Induction Motor	3.7 kW - 4 kW	•	•	•	•	•
	11 kW	•	•	•	•	•
NEMA Induction Motor	5 HP				•	
	15 HP				•	

Figure 3. Induction Motor Award Categories

New Technology Motor Category

The New Technology Motor Awards are designed to promote the efficiency improvements that are emerging in the market. This competition seeks to showcase IEC motors that achieve the high efficiency IE4 levels and NEMA motors that meet the Premium level+1 efficiency band. While new technologies have already begun to drastically improve efficiency in large motors, few have succeeded in reducing energy consumption of relatively smaller motors. Therefore, SEAD Global Efficiency Medals will be awarded to new technology motors that demonstrate the greatest potential to reduce energy consumption of motors with a maximum output rating of less than 75 kW and 100 HP (see *Figure 4*). Furthermore, the winners in the new technology motor category are required to be commercially available within two years of receiving the SEAD Global Efficiency Medal to ensure that these products will result in meaningful energy savings.

	Region				
Category	Australia	European Region	India	North America	Inter-national
New Technology Motor (< 75 kW)	•	•	•	•	•
New Technology Motor (< 100 HP)				•	

Figure 4. New Technology Award Categories

Shipment Requirements

The purpose of establishing shipment threshold requirements is to ensure that winning products represent a sufficient share of the market to result in significant energy savings. Applicants may nominate products for consideration in any of the four award regions, regardless of the location of the manufacturer of the product, provided that the region sales/availability requirements are satisfied for each product nominated (see *Figure 5*). For example, a product manufactured in Japan and sold globally may be entered in any and all regions.

Minimum Shipments (units)	IEC Induction Motor		NEMA Induction Motor	
	3.7 kW - 4 kW	11 kW	5 HP	15 HP
Australia	1400	500		
Europe	1400	500		
India	1400	500		
North America	420	150	980	350

Figure 5. Minimum projected annual shipment of motors (start date 3 June 2013 to 1 September 2014)

Test Methods

Three major goals of the SEAD Global Efficiency Medal competitions are to support test procedure harmonization, provide internationally-comparable and transparent test results, and support test laboratory capacity building in the participating regions. The competition uses a well-established and internationally accepted test method, when possible, to validate manufacturers' energy efficiency performance claims of nominated products. In the previous SEAD competitions for televisions and computer monitors, this was achieved by utilizing the internationally-accepted test method IEC 62087 Ed.3. However, utilizing a single efficiency test procedure for the electric motors competition is impossible under the design choices described above.

Separate Test Methods for IEC and NEMA Induction Motors

IEC motors are tested using the IEC 60034-2-1 Summation of Losses method whereas NEMA motors in North America are tested against the IEEE 112b test procedure. Therefore, the respective test procedure used in the different regions will be consistent with the test procedure that is appropriate for the market. The test methods are similar and competition officials are considering opportunities to contribute to test procedure harmonization.

IEC 60034-2-1 Revision

Although selecting the IEC test method to verify the efficiency performance of nominated IEC induction motors appeared to be relatively simple, there were a number of complications. The IEC is currently in the process of revising the IEC 60034-2-1 test method, which was previously published in 2007. Industry stakeholders and international policy makers alike strongly recommended that the SEAD Global Efficiency Medal competition use the revised test method in performing verification testing since the 2007 version does not thoroughly outline testing protocols and can cause problematic variances in test results. Unfortunately, the revision of IEC 60034-2-1 is not scheduled to be finalized and published until February 2014, well after the launch of this competition.

Many of the issues found in IEC 60034-2-1:2007 have been addressed by the International Energy Agency's Efficient Electrical End-use Equipment program Electric Motor Systems Annex (IEA-4E EMSA) *Guide for the Use of Electric Motor Testing Methods Based on IEC 60034-2-1, Version 1.1* (heretofore referred to as the "EMSA Guide") [Ref 3]. The IEC has incorporated much of the EMSA Guide in its revision of IEC 60034-2-1. Therefore, this competition adopted IEC 60034-2-1:2007, Summation of Losses Method and followed the methodology and sequencing detailed in the EMSA Guide to validate the energy efficiency performance of nominated IEC induction motors.

New Technology Motor Test Methods

There are no established test methods for measuring the efficiency performance of new technology motors. Hence, this competition utilizes direct output:input test methods and includes loss measurements within any electronic controller. Because there are slight differences between new technology motors that are built with output ratings measured in kilowatts and those measured by horsepower, this competition utilizes different, but very similar test methods for each award category, as shown in *Figure 6*. For new technology motors with a maximum output of 75 kW, efficiency is measured using the IEC 60034-2-1:2007 Direct Test Method: Out/Input. Nominated new technology motors with a maximum output of 100 HP are measured using the IEEE direct input-output test method, IEEE Standard 112, Efficiency Test Method A.

Award Category	**Test Method**
IEC Induction Motor	IEC 60034-2-1:2007, Summation of Losses Method
NEMA Induction Motor	U.S. Department of Energy test procedure for Electric Motors and Small Electric Motors, as specified in 10 CFR part 431
New Technology Motor (< 75 kW)	IEC 60034-2-1:2007, Direct Test Method: Out/Input
New Technology Motor (< 100 HP)	IEEE Standard 112, Test Procedure for Polyphase Induction Motors and Generators, Efficiency Test Method A, Input-Output

Figure 6. Test methods to be used for measuring motor efficiency

Test Laboratory

Nominated products are expected to be fairly similar in terms of energy efficiency. In order to eliminate any testing variations between the motors, SEAD will test all nominated motors in a single laboratory to verify manufacturers' energy performance claims.

Winners Selection and Desired Outcomes

Manufacturers are invited to nominate energy efficient induction and new technology motors through 29 November 2013. CLASP, as the competition Administrator, will identify the presumptive winning models based on each product's claimed efficiency performance. Randomly selected samples of these models will then undergo testing to verify energy performance claims. Upon completion of verification testing, nominated products whose efficiency performance is successfully validated will be awarded SEAD Global Efficiency Medals.

As challenging as it was to design a global competition for motors that accommodates both internationally-standardized and market-specific requirements, the program design process provided significant insight for the governments responsible for overseeing the SEAD Global Efficiency Medal competition. It is hoped that the lessons learned and data that result from this competition will accelerate international efforts to harmonize existing regulations for induction motors, and will result in an internationally-accepted efficiency test method for new technology motors. The ultimate objective, however, is that this competition will incentivize (1) buyers to purchase these award-winning motors, and (2) manufacturers to produce highly efficient medium electric motors, thereby achieving market transformation and significantly reducing motor energy consumption globally. SEAD also hopes this competition will result in additional spill-over benefits, such as more stringent energy efficiency standards and labels and test laboratory capacity building.

References

Ref 1. SEAD Global Efficiency Medal home page. (n.d.). *http://www.superefficient.org/en/Activities/Awards.aspx* .

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