



Efficient Electric Motors and Motor Systems: Challenges and Solutions for Effective Regulation

SEAD Policy Exchange Forum Summary
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Background

United for Efficiency (U4E) estimates that transitioning to more efficient motors can reduce their global electricity demand by up to 30 percent in 2030 – equivalent to 300 TWh of electricity savings and 200 MT of CO₂ emissions reduction. Minimum energy performance standards (MEPS) for motors are essential to the success of market transformation, and the supporting policies have already been implemented by many major economies globally. Mandatory energy efficiency policies cover over 25 percent of global electric motor energy use, but a third of motor energy is consumed by unregulated motors either in countries without MEPS or motors fall outside the technologies covered by energy efficiency policies. In 2014, the International Electrotechnical Commission (IEC) released new testing and efficiency classification standards requirements for motors, which cover a wider range of motor sizes. However, countries yet to have enact MEPS that cover this expanded range. In addition to adopting and enforcing the MEPS for motors, harmonization with international standards is essential to eliminate barriers to competition, including trade. Harmonized standards and sharing or accepting test reports from accredited third party or other countries' laboratories can help reduce costs both to manufacturers and for participating countries – allowing them to allocate their limited resources to cost-effective compliance efforts rather than investing in new national motor testing laboratories.

The eighth SEAD Policy Exchange Forum (SPEX) presented various requirements and challenges to building an effective program to promote energy efficient electric motors. This SPEX was attended by nearly 50 representatives from governments, international organizations, industry, academia, and civil society.

Summary of Presentations

IEA 4E Electric Motor Systems Annex (EMSA)

Mr. Maarten van Werkhoven from IEA 4E EMSA provided an overview of motors technology, international standards and current national regulations, and benefits and challenges of regulating motors:

- Motors consume about 53% of electricity produced globally. The biggest energy savings come from high efficiency electric motors integrated into motor systems for pumps, fans, compressors, and machines. The energy used by motors has nearly doubled between 2000 and 2017, and the majority of electric motors in use are at the lower (IE0 or IE1) efficiency levels.
- Harmonized IEC standards can be directly used as basis for Minimum Energy Performance Standards (MEPS). Currently, most the countries with MEPS for motors have set their policy requirements at IE2 and IE3 levels.
- Motor electricity use is expected to nearly double by 2040 as compared to today, but, as forecasted by IEA New Policies Scenario, in 2040 more than 60% of motors will meet IE3 class or better.

European Commission

Mr. Ronald Piers de Raveschoot from the European Commission shared lessons learned and challenges in developing energy efficiency policies and setting MEPS levels for electric motors:

- Among the 25 Ecodesign regulations, four cover motors:
 - 640/2009: Electric motors
 - 641/2009: Circulators
 - 327/2011: Industrial fans
 - 547/2012: Water pumps
- A total of 17 measures, covering 11 products, are currently under review – which includes electric motors and variable speed drives (VSD). The scope of the current regulation 640/2009 will be expanded to cover motors up to 1,000 kW. The efficiency class will be increased to IE3 for most regulated motors, while IE4 requirement will apply for 75-200kW sizes, 3 phase, and 2/4/6 pole motors. Three phase variable speed drives will be regulated as well.
- It is estimated that this change in the policy regulating the efficiency of motors will reduce energy consumption by motors by more than 9% in 2030 as compared to business as usual.

The Laboratory for Electrical Machines and Drive Systems at Bern University of Applied Sciences

Prof. Dr. Andrea Vezzini, Laboratory for Electrical Machines and Drive Systems, Bern University of Applied Sciences, provided an overview of the infrastructure requirements and methodology of efficiency measurements of electrical machines:

- IEC 60034-2-1:2014(B) is intended to establish methods of determining efficiencies from tests and to specify methods of obtaining specific losses.
- To guarantee a high degree of precision and repeatability, a fully automated test system for efficiency measurements with high performance equipment is required.
- Under ISO/IEC 17025, a laboratory's competence is assured via an on-site assessment process and participation in applicable Proficiency Testing programs. The on-site assessment assures that the laboratory is capable of producing accurate, traceable, and reproducible data.
- The effort to setup, manage, and maintain such accredited testing labs is not to be underestimated and often a coordinated effort should be considered.

Regal Beloit, representing National Electrical Manufacturer's Association

Mr. Dan Delaney from Regal Beloit presented an overview of the GMEE programme and discussed its opportunities and benefits:

- The IEC Energy Efficiency (IECEE) Global Motor Energy Efficiency Programme (GMEE) aims to promote harmonization of national standards with the IEC International Standards.
- Harmonization has multiple benefits: reducing the costs to regulators for testing and enforcement efforts; reducing barriers to trade; and decreases the burden on manufacturers to meet market entry requirements.
- The GMEE program can also help address further challenges to industry such as the costs of compliance and product availability.

For more information, please see the presentations and webinar recording on the webpage for this SPEx: superefficient.org/events/sead-policy-exchange-forum-efficient-electric-motors-and-motor-systems

Group Discussion and Q&A:

The following questions were raised during the discussion:

Questions on the European motors requirements:

1. *Will the new EU requirements become mandatory, or be set in law, from 2021?*
 - The updated regulation is expected to be adopted (set in law) in July this year. It would then enter into application (become mandatory) on the 1st of July 2021.
2. *What is meant by variable speed drives? Does this refer to both motor and drive efficiency IE2 combined?*
 - Energy efficiency is not required for both, motor and drives. Drive efficiency is referred to efficiency of the drive itself and not combination of motor and drive. There is an opportunity to fix the standard for a motor and drive together, but this is not done at the moment.
 - There is a separate standard for VSD - IEC 61800-9-2 that combines the testing and certification of the VSD.
 - The possibility of setting requirements for combinations of motors and VSDs placed on the market together (IES levels) is indicated explicitly among the aspects to be considered for the next review in article 9 of the regulation.
3. *Is 2023 requirement for IE4 the first time that is coming into a regulation?*
 - Yes, that is correct.
4. *Why are EU manufacturers exporting IE1 motors to Pakistan while there are minimum IE2 with VFD or IE3 motor sales allowed in the EU?*
 - The EU regulation only covers motors that are placed on the EU market (whether manufactured in the EU or imported). The manufacturers in EU are not required to meet the EU regulatory requirements when they export products to other countries, which do not have energy performance standards.

Questions on testing motors:

5. *What sensors do you recommend for measurements per standard?*
 - The sensors that are required are current sensors. Preference is for shunt sensors as they are a bit better and more precise. There is no need to have 3 sensors - actually 2 sensors can be used which can also co-collect data for the 3rd current. In such cases, adapting the sensor range to the power range of a motor in test is necessary. For example, if you have 10 A motor and run it with 500 A sensor, the reading scale range error will be too large. The voltage sensor can be part of power analyzer providing quite good reading. Different brands such as Hioki, Zimmer, Yokogawa have about the same voltage precision.
 - May also need a torque sensor – most standard torque sensors today also provide a speed reading, which is not difficult to do with quite high precision. The torque sensors used at Bern University laboratory are from Kistler and HBM, which have resolution of 0.05 to 0.1% of Full Scale Output (FSO) (the best ones) and have to be calibrated on a regular basis. The problem is the quality of the coupling, which can introduce large errors in the torque sensor readings.
6. *What sensors do you recommend to measure the temperature?*
 - The standard defines measuring the temperature on the surface of the motor throughout the testing to IEC 60034. The laboratory at Bern University uses PT100 temperature

sensors. A good voltage meter is needed to readout the voltage of the bridge using the PT (can sometimes use PT1000, but PT100 also works). The temperature is used in both calculations for efficiency and resistance, but it does not have such a big impact in temperature sensor resolution (between 0.25-0.5% of FSO is sufficient). The Bern University laboratory does not do vibration testing for efficiency class testing.

7. *How much did setting up testing capacity cost in total for Bern University?*
 - The laboratory at Bern University of Applied Sciences has an 11kW small test-bench, which Prof. Dr. Vezzini purchased refurbished for 110,000 Euro. The bigger 40kW test-bench with an AC power source, two power analyzers, and the load motor amounted to a total cost of 230,000 Euro. Additionally, there is a lot of work that needs to be done to fully set up a motors testing laboratory. At Bern University, this was done by the laboratory staff. The laboratory also received some rebate on equipment from the university.
 - The SEAD Global Testing Costs project also includes information on the cost of testing and building motors testing capacity. The report will be available on the SEAD website.
8. *How many certified non-motor manufacturer related laboratories exist in Europe and how large are the motors that they can measure?*
 - Prof. Dr. Vezzini's laboratory works closely with Danish Technological Institute, which has an IEC 17025 accredited motor testing laboratory for motors up to 55kW. One can also use accredited labs in Germany or other EU countries.

Questions on the Global Motors Efficiency Program:

9. *What additional information is available for the 27 GMEE certificates issued so far?*
 - The 27 GMEE certificates are part of certification of category E3 for energy efficiency and cover a range of manufacture product families and not individual models. More information is available on IECEE website here: www.iecee.org/about/gmee
 - Test certificates are issued for each IE level. One cannot have a single certificate for IE1, IE2, and IE3 levels, but rather three separate certificates for each level.

General Questions:

10. *How can a country ensure compliance with MEPS when there is no national testing capacity?*
 - The countries can take advantage of the GMEE program, which provides access and benefits from its more than 54 member countries and many ILAC-approved test laboratories worldwide. There is no need for any national body to have a national laboratory to enforce compliance with MEPS. It is necessary, however, to understand the requirements written into national regulations, and ensure they permit collaboration and leveraging of programs such as the IEC GMEE program.
 - On the enforcement side, laboratories in the region can be used to support such programs.
 - It is not easy to build expertise internally, but it is important to build partnerships.
 - An example of making use of available test labs in the region: in the EU, where Member States are responsible for national enforcement of the EU MEPS, not all Member States have their own accredited test lab. Test results of tests initiated by one Member State are shared between the national Market Surveillance Authorities.
11. *What short term strategies can countries adopt to improve motor energy efficiency when their markets are not yet ready to adopt MEPS?*
 - There are other policy instruments such as subsidies and information campaigns.



- Capacity building towards all stakeholders involved, i.e. manufacturers, industry, end users, OEM, government.
- Market information on the possible benefits of efficient motors and motors systems: energy savings and lowering electricity demand.
- Raising awareness of available global standards for electric motors and of experiences and lessons learned in regulating the minimum efficiencies of electric motors.

12. *Is the “proto-plan” a sensible approach? (i.e. procurement of large motors, to regulation of larger motors, to approaching smaller motors)*

- When larger motors (i.e. >3 kW) are 100% imported, there are no risks for domestic manufacturers. Most MEPS regulations started at 0.75 kW upwards, the supply of IE2 motors in the segment >3 kW is quite good (lots of competitors), the upper limit has been 200 kW, and for last years in most countries 375 kW. The path to introduce procurement and regulation for ‘larger’ motors makes sense then. The MV&E/compliance scheme should also be developed, but beginning with imported motors may be an easier pathway to implementation.
- Approaching smaller motors: this is more complex, as it demands development of domestic manufacturers and concerns a lot more motors (numbers). Only the United States has adopted MEPS for small motors of 0.12-0.75 kW; but the EC plans to do so this year. It makes sense to take more time to begin regulating smaller motors.

13. *How can policies be pitched at the national level, where there are no governing bodies monitoring motors, and where there is no vision for motor efficiency policy, and where the majority of products only meet IE1?*

- Raising awareness at different levels (including political level) through campaigning and lobbying.
- See also question #11.

If you have any further questions for the presenters or other country representatives, or if you would like additional information, please contact the SPEX Coordinator, Lina Kelpsaite at lkelpsaite@clasp.ngo.