Appliance Standards Awareness Project
American Council for an Energy-Efficient Economy
Natural Resources Defense Council
New York State Energy Research and Development Authority

February 28, 2022

Mr. Jeremy Dommu
U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Building Technologies Office, EE-5B
1000 Independence Avenue SW
Washington, DC 20585

RE: Docket Number EERE-2020-BT-TP-0011: Proposed Rule for Test Procedures for Electric Motors

Dear Mr. Dommu:

This letter constitutes the comments of the Appliance Standards Awareness Project (ASAP), American Council for an Energy-Efficient Economy (ACEEE), Natural Resources Defense Council (NRDC), and the New York State Energy Research and Development Authority (NYSERDA) on the notice of proposed rulemaking (NOPR) for test procedures for electric motors. 86 Fed. Reg. 71710 (December 17, 2021). We appreciate the opportunity to provide input to the Department.

We generally support DOE's approach to revising the electric motor test procedures as proposed in the NOPR. It is estimated that electric motors are responsible for nearly half of all global electricity consumption.[1] However, the current electric motors test procedure covers only a small subset of electric motor types. DOE's recent preliminary analysis for electric motor standards estimates nearly 20 quads of energy savings are available and generally cost effective for small non-small-electric-motor electric motors (SNEMs), air-over motors, and relevant synchronous motor substitutions.[2] Thus, we strongly support DOE's proposal to expand the scope of the test procedure to cover these additional electric motor types. In this proposed rule, DOE is expanding the test procedure scope to include both efficient and inefficient motor types.

The current lack of coverage for many efficient motor types (e.g., synchronous motors) obscures potential energy savings opportunities available from market shifts to these motors, while lack of coverage for inefficient motor types (e.g., shaded pole motors) may lead to substitutions that undermine overall efficiency efforts. Further, modern motor topologies and conventional AC induction motors often have the same end use applications; more complete regulatory coverage would ensure that purchasers have access to consistent testing data to inform purchase decisions.

However, we urge DOE to address several issues. First, while we strongly support expanding the scope of coverage to include air-over motors, we encourage DOE to further investigate the most

[1]P. Waide & C.U. Brunner, IEA Working Paper: Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems, p. 18. www.iea.org/reports/energy-efficiency-policy-opportunities-for-electric-motor-driven-systems
[2]EERE-2020-BT-STD-0007-0010, pp. 10-22, 23. www.regulations.gov/document/EERE-2020-BT-STD-0007-0010

representative method to test these motors. Second, while we support expanding the scope to AC induction motors above 500 horsepower (hp), we encourage DOE to consider raising the motor power threshold above 750 hp. Third, in expanding coverage to SNEMs, we encourage DOE to include multi-speed motors. Fourth, we urge DOE to clarify the definition of synchronous motors to ensure that a large portion of the market is not excluded. Finally, we urge DOE to evaluate electric motor efficiency at multiple load points and to consider test procedure amendments that would reward motors utilizing speed control technologies. Our support for various expansions of scope, our concerns, and other comments are described in more detail below.

We support DOE's scope expansion to cover air-over and submersible motors. DOE is proposing to define air-over and submersible motors and develop test procedures for them based on industry procedures introduced since the previous rulemaking. Air-over motors and submersible motors are significant as they are used in two of the largest energy consumers in commercial and industrial applications: fans/blowers (#2) and pumps (#3) according to a 2021 DOE motors market assessment.[3] Further, DOE's recent preliminary analysis for electric motor standards estimates a potential for 4.6 quads of energy savings for air-over motors that are generally cost-effective for the purchaser.[4] Thus, extending coverage to these motor types could help achieve large, cost-effective energy savings. Furthermore, both air-over and submersible motors generally have the same basic motor construction as currently regulated AC induction motors except that they are cooled differently. For example, there is little distinction between a totally enclosed air-over (TEAO) motor and a totally enclosed fan-cooled motor (TEFC); the only difference is the TEFC motor uses its fan for cooling while the TEAO motor relies on external airflow. DOE notes in the NOPR that a user could easily remove the fan from a currently covered motor (e.g., a TEFC motor) and then place it in an air-over motor application where the cooling is provided by an external airflow.[5] Therefore, a test procedure for air-over motors is needed to reliably compare motor performance and reduce opportunity for inefficient substitutions.

Similarly, we support DOE's proposal to include testing for submersible motors. DOE is proposing to expand coverage to submersible motors, which are defined as motors submerged in a liquid that provides cooling, while defining test procedures based on the air-over methods. We understand that the market size for submersible pumps is significant and growing for diverse applications in wastewater processing, irrigation, and the fossil fuels industry.[6] Some concerns were raised about submersible motor testing at the DOE public meeting, but industry expressed a willingness to submit ideas for an alternative (e.g., water-based) test method.[7] We encourage DOE to continue to investigate options for submersible motor testing to support development of test procedures that are representative of their real-world energy usage.

We encourage DOE to further investigate the most representative method to test air-over motors. While we support the scope expansion to include air-over motors, we encourage DOE to ensure that the proposed test procedure is representative. DOE is proposing to specify a single target test temperature

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[3]P. Rao et al. U.S. Industrial and Commercial Motor System Market Assessment Report, 2021, pp. 36-48. escholarship.org/uc/item/42f631k3
[4]EERE-2020-BT-STD-0007-0010, pp. 8-66, 10-23. www.regulations.gov/document/EERE-2020-BT-STD-0007-0010
[5]86 Fed. Reg. 71730.
[6]Submersible Pumps Market Overview, www.mordorintelligence.com/industry-reports/global-submersible-pump-market-industry
[7]EERE-2020-BT-TP-0011-0016, p. 70. www.regulations.gov/document/EERE-2020-BT-TP-0011-0016

of 75 °C for all air-over electric motors regardless of insulation class. We are concerned that testing all air-over motors at a single target temperature may not be representative and could result in inaccurate relative rankings of air-over motors. As DOE notes in the NOPR,[8] electric motors are typically more efficient at lower operating temperatures. Thus, we are concerned that motors that run hotter in the field (i.e., require more external cooling to reach 75 °C) will have an artificial advantage relative to motors that run cooler in the field and require little external cooling to reach 75 °C. Artificially cooling a hotter running motor beyond realistic real-world operating temperatures may result in efficiency ratings that are not representative. Thus, we encourage DOE to further investigate air-over electric motors testing.

We support DOE's scope expansion to include AC induction motors greater than 500 hp but encourage the Department to consider raising the horsepower threshold above 750 hp. Currently, the scope of electric motor standards and test procedures applies only to electric motors up to 500 hp. However, the NOPR proposes to expand the scope to motors up to 750 hp, which was deemed the upper limit of relevant motors on the market. While we understand that most large electric motors (e.g., greater than 500 hp) are medium voltage motors (i.e., greater than 600 V) and are not covered within scope, we did identify several 750 hp motors that would be included. However, we also identified models up to 1000 hp that appear relevant to this scope expansion.[9] We understand that large motor efficiency is usually determined using an alternative efficiency determination method (AEDM), so we do not anticipate significant issues for testing large motors greater than or equal to 750 hp. Thus, we support scope expansion for AC induction motors greater than 500 hp but encourage DOE to investigate the upper hp limit such that it is set at or beyond currently available models.

We support DOE's scope expansion to cover SNEMs but encourage the Department to also cover multi-speed SNEMs. In the NOPR, DOE is proposing to cover additional motors considered small, referred to as SNEMs, by specifying combinations of frame sizes, rated motor horsepower, and enclosure construction that are not currently covered as either electric motors or small electric motors. These included SNEMs are all single-speed AC induction motors and cover six additional motor topologies.[10] DOE's recent preliminary analysis for electric motor standards estimates a potential for 8.3 quads of energy savings for SNEMs that are generally cost-effective for the purchaser.[11] In general, various motor topologies can have significant differences in energy efficiency but may be used in similar applications. For example, we understand that permanent split capacitor (PSC) motors, which are inefficient relative to synchronous motors, can have efficiencies up to twice those of shaded pole motors.[12] Thus, comprehensive inclusion of various motor topologies, including for SNEMs, within the DOE test procedures is crucial so that manufacturers can differentiate new technologies in the marketplace while also enabling buyers to make informed purchasing decisions.

While we support the scope expansion to include SNEMs, DOE should also cover multi-speed SNEMs. In the NOPR, DOE is only proposing to include single-speed induction motors as part of the scope expansion for SNEMs. This is inconsistent with other motor types within the proposed scope expansion

[8] 86 Fed. Reg. 71735.
[9] 2022 Industrial Catalog, www.toshiba.com/tic/datafiles/catalogs/TIC_Catalog.pdf
[10] PSC, capacitor-start induction-run (CSIR), capacitor-start capacitor-run (CSCR), shaded-pole, split-phase, and polyphase induction squirrel cage.
[11] EERE-2020-BT-STD-0007-0010, pp. 8-54, 10-23. www.regulations.gov/document/EERE-2020-BT-STD-0007-0010
[12] Comparing Shaded Pole, PSC and EC Motors, news.ewmfg.com/blog/comparing-shaded-pole-psc-and-ec-motors

(e.g., inverter-only), which may include variable-speed capability. We are also concerned that excluding multi-speed SNEMs poses some risk for a loophole, wherein inefficient multi-speed SNEMs could be used in place of covered single-speed SNEMs. Thus, we encourage DOE to cover multi-speed SNEMs.

We support DOE's scope expansion to include AC inverter-only motors. While full speed motor efficiency is an important factor in overall energy consumption, a motor's ability to operate at multiple speeds provides perhaps the greatest opportunity for energy savings. Variable-speed motors can significantly decrease energy consumption and provide other benefits such as reduced maintenance and improved process control.[13] The recent DOE market assessment for motors states that "nearly 100 percent of all commercial sector motor system electricity consumption utilizes technologies that can benefit from variable frequency drives."[14] This benefit derives in part due to the cubic relationship between speed and power for some motor-driven systems (e.g., fans and pumps), wherein a small decrease in speed can result in substantial energy savings. For example, reducing the speed of a pump to provide a 25% reduction in flow can reduce power consumption by more than 50%.[15]

Thus, inverter-only motors with variable-speed capabilities may serve as more energy efficient replacements for currently covered and newly included (e.g., SNEM) AC induction motors. Inclusion of these more energy efficient motor types may unlock significant potential energy savings. In the NOPR, inverter-only motors are defined as motors that can operate solely with the use of an inverter. For example, inverter-only AC induction motors are typically motors designed only for use with a variable frequency drive (VFD) that utilizes an inverter to modulate the input frequency and resulting speed of the motor. VFD technology is particularly advantageous for partial and/or variable load conditions as these motors can consume significantly less energy than single-speed AC induction motors under these conditions.

We support DOE's scope expansion to include synchronous motors but urge DOE to clarify their definition for synchronous motors to ensure it is inclusive of the motor topologies targeted for scope inclusion. Synchronous motors include the most efficient motor types[16] on the market such as permanent magnet and switched reluctance motors and typically exceed the efficiencies of both single- and variable-speed AC induction motors, particularly in partial and/or variable load applications. DOE's recent preliminary analysis for electric motor standards estimates a potential 6.3 quads of energy savings for cost-effective synchronous motor substitutions for currently covered NEMA Design A and B motors.[17] Expanding the motors test procedure scope to include synchronous motors is important to provide standardized efficiency information to the market, particularly given the potential for sales growth for synchronous motors as substitutes for less efficient AC induction motors.

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[13] E20-313, Power Drive Systems: Energy Savings and Non-Energy Benefits in Constant & Variable Load Applications, www.nema.org/docs/default-source/motor-and-generator-guides-and-resources-library/power-drive-systems-energy-savings-and-non-energy-benefits-in-constant-and-variable-load-applications.pdf

[14] P. Rao et al. U.S. Industrial and Commercial Motor System Market Assessment Report, 2021, p. 47. escholarship.org/uc/item/42f631k3

[15] Pumping System Tip Sheet #7, 2006, DOE and Hydraulic Institute. https://www.energy.gov/sites/prod/files/2014/05/f16/trim_replace_impellers7.pdf

[16] Line start permanent magnet ("LSPM"); permanent magnet AC ("PMAC," or brushless AC); switched reluctance ("SR"); synchronous reluctance motors ("SynRMs"); and electronically commutated motor ("ECMs")

[17] EERE-2020-BT-STD-0007-0010, p. 10-22. www.regulations.gov/document/EERE-2020-BT-STD-0007-0010

In the NOPR, DOE seeks comment on whether the criteria listed in Table III.8 accurately reflect DOE's intent to include synchronous motor topologies in the scope of the proposed test procedure. DOE proposes to define a synchronous motor as "a motor capable of operating on polyphase or single-phase alternating current 60-hertz (Hz); sinusoidal line power (with or without an inverter)". Concerns were raised at the DOE public meeting, where the NOPR definition was interpreted as requiring a synchronous motor to start and run on sinusoidal line power (i.e., not inverter-fed); DOE in response re-iterated that the definition of synchronous motors was intended to be inclusive of inverter-fed synchronous motors.[18] We understand that the concern with the definition pertains to common synchronous motor topologies. For example, in an ECM, DC power is generated by an inverter from a sinusoidal AC power supply, then converted to a pulsed AC signal (i.e., not pure 60 Hz, sinusoidal power per the definition) which the motor runs on. We understand that DOE's intention for the synchronous motor definition is to exclude only those synchronous motors that start and run directly from a DC power source. Thus, DOE should investigate this concern and clarify the definition of synchronous motors in the test procedure to reflect this distinction.

We support DOE's inclusion of electric motors that are contained within covered equipment. In the NOPR, DOE is not proposing to exclude electric motors used as a component of a covered product or covered equipment. As DOE notes in the NOPR, EPCA provides that standards for electric motors be applied to electric motors manufactured "alone or as a component of another piece of equipment." The current electric motors test procedure applies to motors contained within covered equipment, and DOE states in the NOPR that it is not aware of any technical issues with testing such motors using the current DOE test procedure.[19] In addition, many of the motors included in the scope expansion (e.g., SNEMs and synchronous motors) are also used in covered products, so excluding motors contained within covered equipment would undermine efficiency efforts and would likely create enforcement challenges.

We support DOE's proposed requirement that represented nominal efficiency be less than or equal to the average efficiency based on testing. In the NOPR, DOE is proposing to specify how manufacturers must apply the definition of nominal full-load efficiency. Specifically, DOE is proposing that the nominal full-load efficiency of a basic model must be less than or equal to the average full-load efficiency determined through testing or application of an AEDM. We support this specification to help ensure that reported nominal full-load efficiencies do not overstate actual efficiency.

We support DOE's efforts to improve transparency for determination and representation of rated test values. As part of the NOPR, DOE has proposed definitions for rated output power, rated load, rated frequency, and rated voltage as well as provisions regarding their representation. For example, while DOE is proposing to continue to allow manufacturers to choose the nameplate voltage for testing, manufacturers cannot make representations regarding voltages wherein the motor does not meet performance (e.g., efficiency) standards. We support the Department's efforts to clarify rated values, which will help ensure a level playing field for manufacturers and provide purchasers with clear performance-related information.

We urge DOE to amend the test procedure to incorporate efficiency at multiple load points. While the application of electric motors is broad, the recent 2021 DOE motors assessment indicates that the single

[18] EERE-2020-BT-TP-0011-0016, pp. 27-28. www.regulations.gov/document/EERE-2020-BT-TP-0011-0016
[19] 86 Fed. Reg. 71728.

greatest motor application grouping, by annual electricity consumption, was variable-load applications with average load factors between 40 and 75%.[20] Although some industry test procedures measure losses at multiple load points, DOE evaluates motor efficiency only at a single load point (90-100% speed, 100% rated torque). In the NOPR, DOE states that while motor efficiency varies depending on load, for AC induction motors, efficiency is relatively flat within the typical range of operation (50-75% load).[21] Thus, DOE suggests that an electric motor with a tested full-load efficiency will have fewer losses than another electric motor with a lower tested full-load efficiency within this typical range of operation. However, while this may be generally true for conventional single-speed AC induction motors, many advanced motor technologies (e.g., synchronous motors) included in the scope expansion have loss profiles (e.g., losses as a function of load) that deviate significantly from those of single-speed AC induction motors. In particular, advanced motor technologies typically better maintain high efficiency at low loads. Evaluating electric motor efficiency at a single load point is therefore not representative of real-world energy use and will not provide accurate relative rankings across different motor topologies. Thus, we urge DOE to evaluate multiple load points to ensure a level playing field for manufacturers and to better inform purchasers.

We encourage DOE to consider test procedure amendments that would capture the benefits of speed control technologies. As discussed above, motors with speed control can provide very large energy savings in commonly occurring variable load applications. In addition, speed control can provide significant energy savings even in constant load applications by "right-sizing" the motor-driven equipment to the actual system requirements. For example, most pumps are oversized, so the ability to reduce speed in place of using a throttling valve can reduce energy usage while maintaining desirable flexibility (e.g., the pump speed can be adjusted to match demand requirements over its lifespan). However, the current electric motors test procedure does not capture the energy saving benefits associated with speed control. In fact, these motors may be at a disadvantage relative to single-speed AC induction motors since the energy usage of the inverter (e.g., in a VFD-equipped inverter-only AC induction motor) is included in the overall efficiency calculation, while the benefits of the VFD (e.g., speed reduction at part load) are not. Thus, we urge DOE to consider test procedure modifications that would reward speed control capability.

Thank you for considering these comments.

Sincerely,

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[20]P. Rao et al. U.S. Industrial and Commercial Motor System Market Assessment Report, 2021, pp. 73-80. escholarship.org/uc/item/42f631k3
[21]86 Fed. Reg. 71744.

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