SUSTAINABLE DEVELOPMENT

Link between United Nations Sustainable Development Goals and *CSA C390 Test Methods, Marking Requirements, and Energy Efficiency Levels for Three-Phase Induction Motors*

Enabling Sustainable Development through Standards





United Nations Sustainable Development Goals Addressed:

SDG 3 – Good Health and Well-being
SDG 7 – Affordable and Clean Energy
SDG 9 – Industry, Innovation and Infastructure
SDG 10 – Reduced Inequalities
SDG 11 – Sustainable Cities and Communities
SDG 12 – Responsible Consumption and Production
SDG 13 – Climate Action

August 2025

About CSA Group

CSA Group is a global organization dedicated to safety, social good and sustainability. We are a leader in North American Standards and in Testing, Inspection and Certification around the world. Our mandate is to hold the future to a higher standard. The mission of CSA Group's not-for-profit Standards organization is to enhance the lives of Canadians through the advancement of standards in the public and private sectors. We are a leader in standards research, development, education, and advocacy. The technical and management standards developed with our more than 11,000 members improve safety, health, the environment, and economic efficiency in Canada and beyond.



Prepared for CSA Group by Delphi

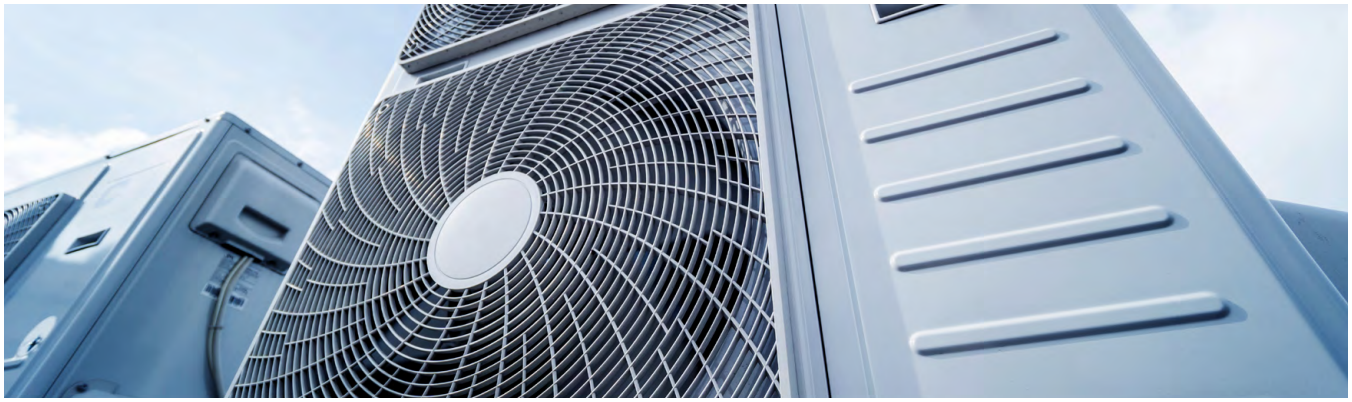
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Summary

The Sustainable Development Goals (SDGs) are a set of aspirational targets that aim to define global sustainable development priorities and mobilize efforts to address them in a comprehensive and integrated manner. Adopted by all United Nations (UN) member states in 2015, the 17 goals call for worldwide action among governments, businesses and civil society on issues including poverty, gender equality, water pollution and clean energy. Canadian Standards Association (CSA Group), a North American leader in standards development, has conducted research to demonstrate how standards can help organizations achieve their SDG-related objectives.

This case study explores the potential of CSA C390:10 (R2019) *Test Methods, Marking Requirements, and Energy Efficiency Levels for Three-Phase Induction Motors* ("C390") to contribute to the SDGs. Interviews with users of the standard and technical experts revealed that implementation of the standard could result in progress toward SDGs 3, 7, 9, 10, 11, 12, and 13. The contributions to the SDGs stemmed from improvements in energy efficiency and related Greenhouse Gas (GHG) emissions and air pollution reductions.



1 Introduction

Electric motors are very efficient devices for producing mechanical energy from electricity. When introduced, they quickly transformed the industrial productivity of many motor-driven systems (e.g. compressors, pumps, fans, HVAC systems, process equipment, etc.) and became an essential component for energy efficiency in manufacturing. There are two main categories of electric motors: single-phase, and three-phase motors. The phases represent the amount of electricity required to power them. Three-phase induction motors (referred to as "motors" within the report) are most commonly used in commercial and industrial sites as they are significantly more powerful than single-phase motors which are used in residential applications.

In 1988, CSA C390 was developed to establish a repeatable method for testing the energy efficiency of three-phase induction motors. The standard transformed industrial and commercial motor driven equipment by establishing an energy efficiency testing method for manufacturers, designers, and testing labs, and has been integrated into several sub-national and federal regulatory frameworks in Canada and the US.

CSA Group conducted a mapping exercise in which CSA C390 and other standards were mapped to the 17 SDGs. This exercise was a part of a larger initiative to identify opportunities to raise awareness about the SDGs among standards users and explore how standards might help them achieve their SDG-related objectives.

This case study of CSA C390 will complement existing case studies published by CSA Group and further explore the links identified as part of the mapping exercise.

This case study was written based on information gathered from publicly available sources (e.g. CSA Group and the United Nation's SDG websites) but primarily focused on interviews with users and other experts on the standard. The goal of the interviews was to better understand how the standard is being used in practice and what benefits are being incurred as a result, allowing an assessment of the potential contributions to the SDGs. The research showed that there is potential for the use of this standard to contribute to a wide range of SDGs, including SDG 7, 9, 11 and 13, with additional indirect links to SDG 3, 10 and 12. As these SDGs have been identified to be the ones most relevant to CSA C390, this study will explore these connections.



SDG 3 – Ensure healthy lives and promote well-being for all at all ages.



SDG 7 – Ensure access to affordable, reliable, sustainable and modern energy for all.



SDG 9 – Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.



SDG 10 – Reduce inequality within and among countries

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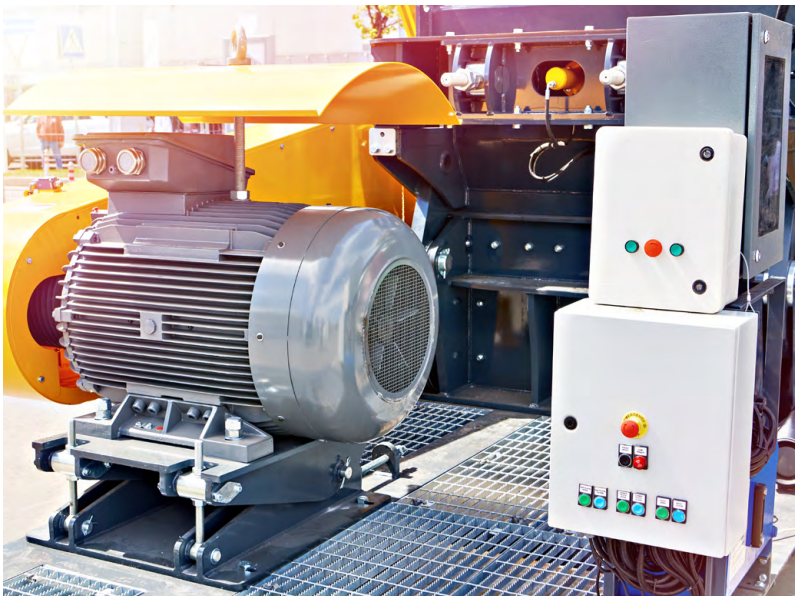
SDG 11 – Make cities and human settlements inclusive, safe, resilient and sustainable.



SDG 12 – Ensure sustainable consumption and production patterns.



SDG 13 – Take urgent action to combat climate change and its impacts.



2 Results and Impact

2.1 Industry Use and Perception of the CSA C390 standard

CSA C390 is used by manufacturers, designers, and testing labs and provides a standardized method for testing the energy efficiency of motors. Standardized testing helps to assure end users that motors purchased with a CSA C390 certification meet a minimum efficiency performance level. This standard has been in place for over 30 years, and it continues to evolve to improve test reliability and accuracy.

In 1997, the Canadian federal government integrated CSA C390 into the *SOR/2016-311 Energy Efficiency Act*. The US Department of Energy also adopted CSA C390 into the *CFR; 64 FR 54141, Energy Efficiency Program for Certain Commercial and Industrial Equipment, under the Title 10, Chapter II, Subchapter D, Part 431 of the Code of Federal Regulations* in 1997 to improve harmonization between Canada and the US. As a result, this voluntary standard became mandatory for manufacturers of motors and required products to meet a prescribed level of efficiency. Utilities have been also incentivizing end users to encourage high and premium efficiency motors be replaced at an accelerated rate, thereby enabling raising the standard for minimum efficiency over time. Interviewees agreed that CSA C390 has been influential in helping to encourage the industry to reach a standardized efficiency level – even before regulations were introduced. Today, CSA C390 is referenced in federal regulation as well as several provincial regulations (e.g. New Brunswick, Nova Scotia, Quebec, Ontario, British Columbia) requiring that certain motors be tested and comply with CSA C390 (see section 2.2 – Target 13.2 for further details). Many interviewees also spoke highly of CSA Group's dedication to standards research and the forum it provides for experts to share new information to support the continuous development of the CSA C390 standard. Interviewees also indicated that they believe CSA C390 has remained relevant because of the involvement of various interested parties in its continued development and maintenance, a feature of CSA Group's standard development process.

2.2 Links to UN SDGs

Most interviewees were familiar with the SDGs and understood their relevance for business. One interviewee highlighted that their company's Environment, Social and Governance (ESG) strategies reference the SDGs.

However, the connection between CSA C390 and the SDGs was not initially obvious to all interviewees. Questions around the contribution of the CSA C390 to the SDGs were often met with replies of "It's regulated. We have to use it". They were more likely to consider an action that went above and beyond compliance requirements as a contribution to the SDGs. They attributed the benefits of adopting the standard to the regulation that set the energy efficiency requirements, rather than to the CSA C390 standard that outlined the

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testing method. However, any user of CSA C390 could reasonably demonstrate commitment to the SDGs that was linked to the energy efficiency of the motor (whether mandated or not). In other words, the fact that CSA C390 was mandated does not detract from the potential commitments to the SDGs.

Interviewees discussed the contributions of the CSA C390 standard to SDG 7, 9, 11, and 13. Additionally, indirect alignments were also uncovered for SDG 3, 10 and 12. They are discussed in more detail below.

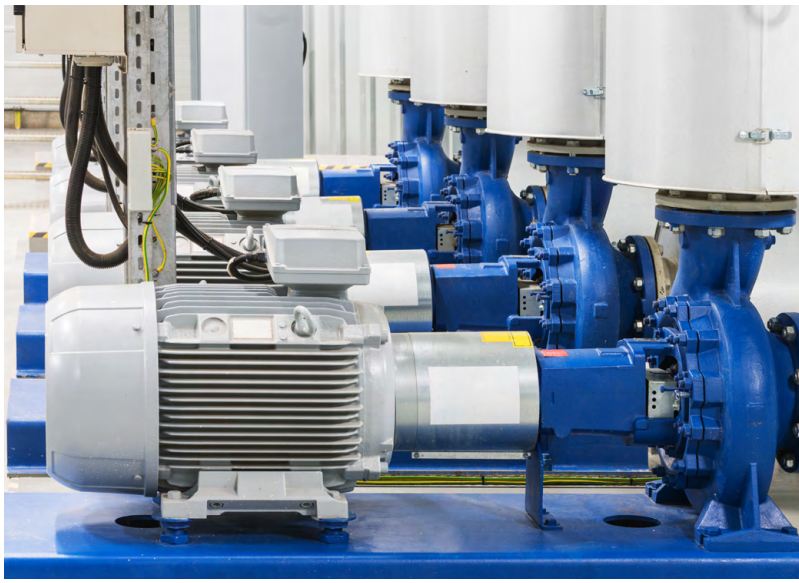
UN SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

Target 7.3 *By 2030, double the global rate of improvement in energy efficiency*

All interviewees acknowledged a strong connection between improving the energy efficiency of motors and target 7.3. CSA C390 provides a credible and verifiable testing method for organizations to demonstrate that the motors meet a minimum energy efficiency level. It also provides a concise, controllable, measurable, and understandable method for demonstrating a company's commitment to target 7.3.

It is estimated that 40% of global electricity consumption is the result of using electric motors[i]. Currently, the most significant energy demand in Canada comes from the industrial sector (52%)[ii], which highlights the need to ensure that equipment in industrial settings (such as motors) is certified to meet a specific efficiency level. As one interviewee put it, "One motor won't do much. But thousands of motors, or hundreds of thousands of motors at the same time will use much less energy".

The testing method in CSA C390 helps to measure motor efficiency against the associated minimum nominal efficiencies listed by the International Electrotechnical Commission (IEC) and The National Electric Manufacturers Association (NEMA) based on a motor's rated power, enclosure and number of poles it contains. The IEC includes five ranking, with one being the lowest and five being the highest. NEMA has four categories which correspond with the majority of the IEC ranks:



NEMA	IEC
Standard Efficiency	IE1
High Efficiency	IE2
Premium Efficiency	IE3
Super Efficiency	IE4
No Standards	IE5

Based on *Natural Resource Canada's Regulatory Impact Assessment of the Energy Efficiency Regulations (Canada Gazette, Part I, Vol. 150, No. 18, April 30, 2016),* there is an annual reduction target of 0.7 megatonnes of GHGs by 2030[iii]. They estimate that regulating all motors to meet IE3 would lead to energy savings of 0.9 - 2.2%, depending on horsepower (HP). CSA C390 is referenced in the regulation and plays a role in facilitating a reduction in GHGs by providing a testing method to validate that new motors meet the required level of energy efficiency.

Interviewees also referenced the connection between CSA C390, energy efficiency, and how it can contribute to the sustainability of the electricity grid systems. Total electricity demand is anticipated to increase by 47% from 2021 to 2025[iv]. This demand is driven by increased electrification in industrial, residential, and commercial sectors, in addition to advancements in clean technology

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such as electric vehicles. Ensuring motors remain efficient and do not unnecessarily increase demand on local grids supports the sustainability of electrical infrastructure by freeing up capacity for other uses.

UN SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Target 9.4 *By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities*

Interviewees agreed that CSA C390 contributes to target 9.4. A standardized method to test efficiencies is instrumental in delivering business certainty. It also provides a mechanism for informed decision-making for upgrade and retrofit activities. Interviewees explained that in the past, motors under 75 HP would generally be replaced as it was considered more cost-effective than repair. Testing of motors during refurbishment could enable cost-effective repairs for premium efficiency motors – even for motors as low as 20 HP.

Furthermore, regulations (e.g. the Canadian Energy Efficiency Regulations) have strengthened energy efficiency requirements for electric motor manufacturing over time. Canadian and US regulations require that all new motors sold in Canada for construction, upgrade, and retrofit meet premium efficiency levels (IE 3). Interviewees pointed to airports as an example of an industry investing in operational retrofits and upgrades – particularly those airports that have made net zero commitments, such as Vancouver International Airport (YVR). Hundreds of motors power the conveyer belts within the baggage system and ventilation systems at airports, and upgrades to these motors could increase energy savings and reduce maintenance.

UN SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable

Target 11.6 *By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management*

Air pollution is the most significant risk to human health, with one out of nine deaths attributed to poor air quality[v]. Based on research conducted by the World Health Organization (WHO), it is estimated that 92% of the global population lives in regions where air pollution exceeds acceptable limits[vi]. Energy efficiency, particularly in industrial settings, has been identified as an effective solution to reduce concentrations of air pollutants. Given the amount of energy used by motors, there is an opportunity for a positive contribution towards target 11.6 if motor efficiency is improved (facilitated by compliance with CSA C390).

All interviewees agreed that ensuring motors are tested and meet a certain level of energy efficiency can reduce air quality risks and GHG emissions. Cities near industrial areas would benefit significantly from cleaner air.

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UN SDG 13: Take urgent action to combat climate change and its impacts

Target 13.2 *Integrate climate change measures into national policies, strategies and planning*

Interviewees agreed that there is a link between CSA C390 and international, federal, and provincial regulations that advance climate change measures. Standards play an important role to support regulations and policies, and CSA C390 has been widely referenced in climate-related policies (listed below) enabling clearer communication around how to test to help ensure requirements for energy efficiency are being met.

Electric motors were first referenced in a regulation in 1995 in the *B.C. Reg. 14/2015: Energy Efficiency Standards Regulation,* followed by other provincial frameworks such as:

- *O. Reg. 509/18: Energy and Water Efficiency – Appliances and Products (Electricity Act, 1998);*
- *Regulation N-1.01, r. 1: Regulation respecting energy efficiency in replacement tires (Quebec, Act to ensure safety in guided land transport, CQLR c N-1.01);*
- *Regulation 95-70: General Regulation – Energy Efficiency Act (New Brunswick, under the Energy Efficiency Act);*
- *N.S. Reg. 400/2008: Energy-efficient Appliances Regulations (Nova Scotia, O.I.C. 2008-501, under the Energy-efficient Appliances Act), as amended by O.I.C. 2012-295, N.S. Reg. 172/2012.*

Related to the discussion above on SDG 7 and the contributions around energy efficiency, compliance with CSA C390 can contribute to reduced GHG emissions, another indicator for this target.

This research uncovered other potential links not previously identified by CSA Group's mapping exercise. These additional links are less direct whereby the adoption of CSA C390 in regulation plays more of an enabling role. Building from the link between CSA C390 and air pollution (discussed above), one could make a connection to **SDG 3** (Ensure healthy lives and promote well-being for all at all ages) as air pollution can have a negative impact on health.



There is also a link between CSA C390 and **SDG 10** (Reduce inequality within and among countries). Higher efficiency motors generate lower pollution which may benefit lower-income communities living near industrial areas[vii].

In addition, the benefits of CSA C390 may filter through to other countries that do not yet have similar requirements in place.

Finally, CSA C390 could be linked to **SDG 12** (Ensure sustainable consumption and production patterns), when considered alongside other standards that allow for the refurbishment of motors (e.g. CSA C392 *Testing of three-phase squirrel cage induction motors during refurbishment* and CSA C391 *Testing of three-phase synchronous machines during refurbishment*). These standards may also provide assurance for business owners that efficiencies are maintained after repair.

3 Discussion

In discussion with interviewees about how CSA C390 could be modified to strengthen the connection to the SDGs, the possibility of requiring a higher level of efficiency for motors was raised. Given that efficiency targets are usually set by governments, interviewees reflected that advocating for regulatory change could be an effective path forward. Alternatively, standards could establish efficiency requirements for motors, and governments could incorporate the requirements in regulation.

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In relation to this, interviewees signalled that change is generally slow in Canada compared to other jurisdictions, such as the European Union (EU). The EU has recently implemented standards requiring any motor between 75-200 kW to meet IE4 (compared to most motors in Canada that require IE3), signalling that some markets are pushing for more efficiency within their supply chains. Canada and the US have harmonized regulations to make compliance easier, but have not signalled that they will follow suit to increase their requirements for three-phase motors. The US Department of Energy recently proposed more stringent requirements to their regulation to better align with NEMA levels but the amendments would be specific to small motors (e.g. single-phase)[viii].

Interviewees indicated that the lack of global harmonization in regulations makes it challenging to design and manufacture one motor that can be sold globally. One interviewee said, "In being a global company, one of the biggest challenges we face is that we operate in many jurisdictions and must comply with all these different test methods." The interviewee noted that there is an opportunity for CSA C390 to consider alignment with the EU standards in future updates.

Interviewees also pointed out that there might be better opportunities to contribute to overall energy efficiency through other standards that relate to other parts of the system in which the motor operates. Interviewees expressed that "the focus should be on systems, not only on motors" as systems consist of multiple components with varying efficiency and opportunities for energy losses. One interviewee stated, "We are at the point already where motor efficiency is pretty maxed out, and there is other lower-hanging fruit in other areas of the system." Further, while motors are regulated to meet an energy efficiency level of IE3, other components (such as inverters) may only need a minimum efficiency level of IE2. As a result, despite advancements in motor efficiency, if the other components of the industrial system are less efficient, this may not provide much overall benefit. Thinking about systems is also important in considering where the electricity to run the motor comes from, which can affect the lifecycle impact of using the motor.

A public label that demonstrates a standard's applicability to SDGs was another suggestion by interviewees. This could be a voluntary item under the marking section or within the annex to provide companies with guidance on how to better draw connections between conformance with CSA standards and contribution to specified SDGs.

4 Conclusions and Next Steps

CSA C390 has been in use for over 30 years and is recognized internationally. Standards, such as CSA C390 that are focused on measuring the energy efficiency of products have the potential to contribute to SDG 7, 9, 11, 13, mostly in relation to benefits around energy efficiency and reduced GHG emissions and air pollution (and related improvements to health outcomes). Additional indirect links were also found with SDG 3, 10, and 12. This standard offers clear guidance for testing three-phase motors, and provides the data needed to support manufacturer claims of energy efficiency. It is important to keep in mind that when looking for opportunities to contribute to the SDGs, users should consider the motor and the CSA C390 standard as part of a larger system. This could involve working with governments to modify regulations that establish energy efficiency requirements for motors and other related components.

In conclusion, future case studies could evaluate combinations of standards that apply to various phases of a product's lifecycle to further strengthen the connections between the role CSA Group plays in achieving the SDGs. As demonstrated in this case study, such evaluations could uncover additional indirect links that contribute to the well-being of populations, such as promoting healthy lives (SDG 3), reducing inequality (SDG 10), and promoting sustainable consumption and production patterns (SDG 12). Furthermore, providing voluntary guidance within the standards to help companies communicate how compliance contributes to sustainability goals may help raise awareness of these connections.

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Endnotes

i International Energy Agency (IEA) (2011), Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems

ii Canada Energy Regulator (2023), Provincial and Territorial Energy Profiles – Canada.

iii Government of Canada (2016), Energy Efficiency Regulations, 2016, Canada Gazette II.

iv Canada Energy Regulator (2022), Canada's Energy Transition – Key Findings

v IEA (2019), Multiple Benefits of Energy Efficiency, IEA, Paris 0

vi WHO, WHO releases country estimates on air pollution exposure and health impact

vii Gochfeld, M., & Burger, J. (2011). Disproportionate Exposures in Environmental Justice and Other Populations: The Importance of Outliers. American Journal of Public Health, 101(Suppl 1), S53.

viii US Federal Register (2023), Energy Conservation Program: Energy Conservation Standards for Small Electric Motors

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