ecoENERGY Innovation Initiative

Research and Development Component

Public Report

Project: ETRE-003 Developing Electrical Safety Standards to Introduce Electric Vehicles into Canada

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Contents

1 Project Summary

The ecoEnergy Initiative Research and Development Component was focused on "Developing Electrical Safety Standards to Introduce Electric Vehicles (EVs) into Canada". This project was introduced in 2011 and work commenced in 2012 bringing the deliverables to completion March 2016. Financial contributing partners included NRCan, SaskPower, Standards Council of Canada, and CSA Group. The success of this project must also recognize the dedicated time and effort from all of the in-kind contributors providing support to our committees not only in Canada and the USA but internationally as well.

The Project successfully achieved its objectives through focusing its resources on the following tasks:

Task 1 – Updating the Canadian Electrical Code (CE Code), Part I

The result of this task is the inclusion of electric vehicle supply equipment (EVSE) definitions in the 2015 Canadian Electrical (CE) Code, which will result in the safer use of EVSEs. Optimized alignment with the US National Electrical Code was achieved through this task, and recommendations have been made towards the 2018 CE Code.

Task 2 - North American Standards Harmonization

The publication of tri-national standards between Canada, the USA and Mexico was accomplished under this task, and should facilitate cross-border travel. With similar requirements in place in the three countries, equipment operation, performance and safety will be similar. In addition, a working group encouraged by manufacturers continues to make progress on the development of wireless power transfer for electric vehicles, putting safety at the forefront.

Task 3 - International Standards Development

CSA Group participated in two technical committees at the International Electrotechnical Commission (IEC), with the objectives to remove trade barriers by ensuring that Canadian requirements are considered when developing and revising international standards requirements. This, in turn, ensures alignment of standards, which facilitates adoption into respective member countries. As a result of the activities performed in this task, CSA Group established itself, and Canada, as an active contributor on the international scene towards the EV industry.

Task 4 - Research on Technical Requirements for EV Battery Safety

This task resulted in two international battery standards being adopted as national standards in Canada. This will benefit Canadian manufacturers and consumers as it will result in international requirements alignment, potentially leading to decreased battery costs due to streamlining of products. The task also resulted in discussions between certification organizations, automobile and battery manufacturers pertaining to the lack

of enforcement of current safety testing procedures and the development of standards for battery second-life use and recycling requirements to ensure public safety.

Task 5 – Research and Outreach on Emerging EV Standards
CSA Group researched and identified a number of EV technology gaps where codes and standards could be applied. This was done through participation at various technical workshops and conferences as well as through literature search. CSA Group prepared a number of detailed reports for NRCan and presented at networking events. The task also contributed to direct input into international standards.

Task 6 - Administration of the Contribution Agreement (CA)
Management and reporting was completed under this task.

Task 7 - EV infrastructure recommendation report highlighting key differences and gaps between the Canadian National Building Code and the CE Code
In order to assist industry and regulators develop and revise codes and standards that are affected by electric vehicle supply equipment, CSA Group engaged with key stakeholders such as the NRC, who publishes the Canadian National Building Code (CNBC), and other key stakeholders. CSA Group publishes the Canadian Electrical (CE) Code. A report identifying key differences and gaps between the two aforementioned codes was written as the output for this task.

Task 8 - EV Direct Current (DC) Charger Standard
Discussions with the Council for Harmonization of Electrotechnical Standards of the Nations in the Americas (CANENA) took place to introduce an electric vehicle direct current (DC) charging standard harmonized between Canada and the United States. A harmonized standard is in development, which should benefit charging equipment manufacturers as well as consumers in terms of product streamlining and savings.

The Project has enhanced and promoted Canada's participation in the development of EV codes and standards through three approaches. The first is the establishment and updating of Canadian standards for Electric Vehicle Supply Equipment (EVSE). The second is the development and harmonization of EVSE product requirements for North America. The third is the establishment, harmonization and adoption of standards at an international level, in order to minimize international trade barriers to EV adoption. These activities allow Canada to leverage the technical expertise of the international community and establish Canada as a leader in the global EV community.

2 Background

Vehicle electrification is quickly proving to be one of the most effective strategy to decarbonize the transportation sector. Codes and standards to support the integration of Electric Vehicles (EVs) are needed to achieve and secure these clean energy and economic benefits. This Project was well aligned under the ecoENERGY Innovation Initiative strategic priority of the Electrification of Transportation for research and development needed to support codes and standards work.

CSA Group manages the evolution of the Canadian Electrical Code and standards to accommodate the technical requirements of electric vehicles. Since 2009, CSA Group has engaged industry and federal/provincial bodies, to ensure that Canada is active, and represented internationally in the development of an EV infrastructure. Following the publication of the Government of Canada's Electric Vehicle Technology Roadmap in 2010, CSA launched the development of harmonized North American standards and practices for the integration of EV components, including the charger interface. As CSA Group is the publisher of the Canadian Electrical Code and many of the standards referenced, it has direct experience, technical knowledge and access to the multiple researcher communities and documents needed to guide the integration of electric vehicles into society, whether by direct connection to the supply grid or through the electrical components used in the vehicles.

The decision to include codes and standards in this initiative clearly demonstrated the innovative thinking needed to accelerate and assist in progressing the EV evolution into Canada while recognizing that public safety must remain as the number one priority in the decarbonizing efforts primarily achievable with proven, tested, and qualified codes and standards.

3 Objectives

The objectives of the Project are to deliver a series of safety standards and protocols related to the supply, charging and storage of electricity for electric vehicles.

The Project was to enhance Canada's participation in the development of EV codes and standards through three approaches. The first is the establishment and updating of Canadian standards for Electric Vehicle Supply Equipment (EVSE). The second is the development and harmonization of EVSE product requirements for North America. The third is the establishment, harmonization and adoption of standards at an international level, in order to minimize international trade barriers to EV adoption.

These activities will allow Canada to leverage the technical expertise of the international community and establish Canada as a leader in the global EV community.

3.1 Objective 1 – Updating the Canadian Electrical Code (CE Code), Part I

EV-specific requirements are needed for the installation of Electric Vehicle Supply Equipment (EVSE) in Canada. EVSE are electrical devices that provide electricity to the vehicle's on-board battery charger. These installations include residential EVSE and public/commercial EVSE, both requirements are quite different. The CE Code Part 1 operates on a 3 year development cycle. Objective 1 activities oversaw the anticipated revisions to the installation requirements of EV equipment incorporated into the 2015 edition, and initial work to prepare updates to the 2018 edition of the CE Code.

3.2 Objective 2 – North American Standards Harmonization

Objective 2 focused on safety requirements for the EV supply equipment for Canada which were established by CSA Group in June of 2011 through the development and publication of five Technical Information Letters (TILs). CSA Group was then to embark on a North American harmonization project with Underwriters Laboratories in the U.S. and the Association of Standardization and Certification (ANCE) in Mexico on four standards.

3.3 Objective 3 - International Standards Development

International standards development activities for the electrical safety of EV supply and charging equipment are primarily covered by two technical committees at the International Electrotechnical Commission (IEC). These are the TC69 (Electric road vehicles and electric industrial trucks) and SC23H (Plugs, Socket-outlets and Couplers for industrial and similar applications, and for Electric Vehicles).

This objective of participating and adopting international standards has an enormous impact on opening doors for international trade and removing trade barriers as requirements included in international standards become aligned with all countries participating in manufacturing, exporting, distribution, and installation.

3.4 Objective 4 – Research on Technical Requirements for EV Battery Safety

Batteries are a critical component of electric vehicles. Battery technology is moving at an accelerating pace as manufacturers are trying to reduce costs and weight from products while increasing the energy storage capacity. In this emerging state, battery safety becomes paramount. Objective 4 activities support leveraging the international community to conduct research in battery safety, and researching existing standards. Stakeholder identification and engagement, and the participation in international committees may be a requirement of this research.

3.5 Objective 5 – Research and Outreach on Emerging EV Standards

Leveraging global EV experience and expertise, objective 5 tasks CSA Group to actively participate in regional and international technical workshops/conferences to demonstrate Canada's leadership in Electric Vehicle technologies and to research emerging EV standards information. The annual conferences of Electric Mobility Canada (EMC) and Electric Drive Transportation Association in the US allow for a regional participation and speaking opportunities, while organizations such as SAE International, formerly the Society of Automotive Engineers, and the Electric Vehicle Symposium and Exhibition series of EV conferences are opportunities to share knowledge and further engage the international EV community.

Objective 5 activities included travel and participation of experts to these venues for project related research and meetings. These experts included CSA Group staff on the Project and other professional technology experts. Detailed summary reports on the progress made to address specific EV technology gaps, as well as the identification of new linkages established between research experts, was delivered as part of this task activities.

3.6 Objective 6 – Administration of the Contribution Agreement

This objective consisted of the management and accurate reporting of this Project including budgets, schedules, and completion of tasks.

3.7 Objective 7 - EV infrastructure recommendation report highlighting key differences and gaps between the Canadian National Building Code and the CE Code

As EVs continue rapid deployment in Canada it is imperative that regulations, Codes and Standards are also evolving in order to support the emerging technology, and more importantly, ensure consumer safety. EVSEs are electrical devices that provide electricity to the vehicle's on-board battery charger. These installations include residential EVSE and public/commercial EVSE with requirements that are quite different. This objective is to help Canadian industry and regulators develop and revise the codes and standards required to support the Canadian safety system, which is the foundation of consumer confidence as new technologies emerge. Working with members from the Canadian National Building Code published by the National Research Council (NRC), the CE Code published by CSA Group, and affiliated organizations we will promote transparency across Canada with EVSE. By bringing thought leaders together to engage in dialogue on the current status of EVSE technology and pending R&D activities, CSA Group was to facilitate agreement on recommendations to support current technology and evolving technological needs of the

industry. The key outputs in this objective is a recommendation report highlighting key differences and gaps between the codes as they relate to EVSE as a result of two events conducted by CSA Group.

3.8 Objective 8 – EV Direct Current (DC) Charger Standard

EVSE is an element in an infrastructure that supplies electric energy for the recharging of plug-in electric vehicles, including all-electric cars and plug-in hybrids.

As battery EV ownership is expanding, there is a growing need for widely distributed publicly accessible charging stations, some of which support faster charging at higher voltages and currents than are available from residential EVSE. Many charging stations are on-street facilities provided by electric utility companies or located at retail shopping centers and operated by many private companies. These charging stations provide one or a range of heavy duty or special connectors that conform to the variety of electric charging connector standards.

Battery capacity and the capability of handling faster charging are both increasing, and methods of charging have needed to change and improve. New options have also been introduced (on a small scale, including mobile charging stations and charging via inductive charging methods). The differing needs and solutions of manufacturers have slowed the emergence of standard charging methods, and in 2015 there is a strong recognition of the need for standardization. Fast Charging is the fastest type of charging currently available for EVs. As a convenience to the Canadian public, one can recharge up to 80% of a full charge while getting lunch. Quicker charging times make it far more practical to drive beyond an EV's single-charge range in one day which is a key priority of EV buyers.

In Canada there are two standards that address certain aspects of DC charging system equipment for recharging the batteries in EVs such as the requirements for d.c. electric vehicle (EV) charging stations for conductive connection to the vehicle, with an a.c. or d.c. input voltage up to 1 000 V a.c. and up to 1 500 V d.c. and it provides the general requirements for the control communication between a d.c. EV charging station and an EV. The United States also has a unique standard. The intent of this objective is to introduce either one harmonized bi-national standard between the United States and Canada managed through the Council for Harmonization of Electrotechnical Standards of the Nations in the Americas (CANENA) process or a single Canada only standard.

4 Achievements of Project and Research Methods

4.1 Achievement 1 – The 2015 Canadian Electrical Code (CE Code), Part 1 included updated relevant safety requirements for electric vehicle supply equipment (EVSE)

The significance of including EVSE in the CE Code, Part 1 is that it is legislated meaning it becomes mandatory by law. This legislated code will ensure compliance so that EV equipment is safe to operate. As the CE Code is published every three years significant changes have been made as the technology is evolving and there is a drive to ensure national consistencies. Revisions to the 2015 CE Code included an alignment of definitions and updates to some of the Rules. As all changes were proposed, discussed, and balloted by neutral and equally represented committees the process of implementing the changes was fair and agreed upon.

The CE Code, Part 1 published in January 2015 with the following EV related updates:

- The definition of Electric Vehicle Charging Equipment was replaced by Electric Vehicle Supply Equipment and the definition updated to coincide with other national and / or international definitions.
- All other definitions were reviewed and updated to coincide with other national and / or international definitions
- Rule 20-114 Electric Vehicle Charging was removed.
- Rules 20-200 to 20-206 Residential Storage Garages were deleted.

The objective was met as the 2015 CE Code published with coherent updates made for EV related rules. Furthermore, requirements for the 2018 CE Code publication have already been provided for consideration and inclusion. Every effort was made to ensure that there was consistency between the CE Code and the National Electrical Code in the USA.

4.2 Achievement 2 - Harmonization of EV Supply Equipment Standards

Under the ecoEII program four tri-national standards have been published involving Canada, USA, and Mexico:

- NMX-J-677-ANCE-2013/C22.2 No. 280–13/UL 2594: Electric vehicle supply equipment;
- NMX-J-668/1-ANCE/C22.2 No. 281.1–12/UL 2231-1: Standard for safety for personnel protection systems for electric vehicle (EV) supply circuits: General requirements;
- NMX-J-668/2-ANCE/C22.2 No. 281.2-12/UL 2231-2: Standard for safety for personnel protection systems for electric vehicle (EV) supply circuits: Particular requirements for protection devices for use in charging systems; and

- NMX-J-678-ANCE/C22.2 No. 282– 13/UL 2251: Plugs, receptacles, and couplers for electric vehicles

All four standards are currently under revision and scheduled to publish towards the end of this fiscal year. Tremendous effort was made in organizing all three countries to work on these four standards and come to agreement on the content. Ensuring harmonization between Canada, USA, and Mexico is vital to the EV industry. The thought of crossing our borders and worrying about plugging in EV's to their respective chargers only to find out that they are not compatible would have been a grave mistake for the EV initiatives

The significance of publishing tri-national standards is that manufacturers of EV supply equipment (EVSE) all work to the same requirements and products do not differ as they are shipped to different countries. In addition, the consumer can have confidence in knowing that the equipment will work the same way regardless of whether they cross the border. Since the first publication of these standards, content development was completed on all four standards and the second editions are in-work.

Under the harmonization deliverables, a working group consisting of members across Canada continues to make excellent progress on standards C22.2 No. 317 – Wireless Power Transfer (WPT) for EV's and the adoption of IEC 61980-1 – EV Wireless Power Transfer (WPT) Systems – Part 1" General Requirements. The importance of these standards is that manufacturers have been approaching us to work with us in progressing this new technology so that as their products evolve safety is at the forefront.

4.3 Achievement 3 – Enhanced Leadership of International Standards Development

Canada's participation over the last few years has been critical in the development of standards relating to EV related international committees:

- IEC/TC69 Electric road vehicles and electric industrial trucks
- IEC/TC23/SC23H Plugs, Socket-outlets and Couplers for industrial and similar applications, and for Electric Vehicles

The importance of participating in these committees is to ensure Canadian requirements are heard and considered when developing and revising standards. Doing so ensures that when Canada is ready to adopt these international standards, there are little or even no deviations required thus lending to an easier adoption of international standards into Canada. Easier adoption implies two fundamental advantages:

1. Faster publication of standards urgently required by manufacturers, and
2. Common international requirements as opposed to country specific.

Adopting international standards has an enormous impact on opening doors for international trade and removing trade barriers as requirements included in international standards become aligned with all countries participating in manufacturing, exporting, distribution, and installation.

CSA Group has recently established a mirror committee to the TC69, which grants Canada a full participating status for the first time. This mirror committee, referred to as "Standards Mirror Committee to IEC/TC69" (SMC), allows Canada to provide technical direction and form positions on these international documents, in addition to leverage global expertise on a standard that may eventually be adopted for use in Canada. These activities involve the development and management of the Canadian Mirror Committee (SMC), including meetings and international travel where warranted

In February 16-19, 2016 Canada hosted the SC23H committee meetings in Toronto at the CSA Group head office where members from all over the world attended. The significance of hosting IEC meetings is that it provides exposure of our Canadian expertise, facilities, creates networking for potential business opportunities, provides tourism opportunities, and helps to highlight that Canada is not sitting back to see what happens in the EV industry but actively participating and helping to lead the initiatives.

Furthermore, by participating at IEC as Canadian delegates, representatives' return to Canada sharing their input and advising the Canadian Mirror Committees to gain consensus on putting forth Canadian comments, proposals, and votes pertaining to various topics. International standards development work does not end at the completion of this project as new standards are being developed and revisions are being made to existing ones. Canada has truly gained world recognition for our work internationally.

4.4 Achievement 4 – Research on Technical Requirements for Battery Safety

Canada continued to participate at the international level on IEC SC 21A: Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes and IEC TC120: Electric Energy Storage (EES) and has recently adopted two EV battery standards in Canada:

- CAN/CSA-E62660-1 (Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 1: Performance testing)
- CAN/CSA-E62660-2 (Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 2: Reliability and abuse testing

In order to actively participate and provide input into international standards development CSA Group has been closely following EV battery research and attended seminars and conferences to conduct technical research in the area of EV battery and energy storage.

The knowledge gained by networking with other research bodies provided valuable input ensuring performance, reliability, and safety are all incorporated into standards. As a result the two battery standards were adopted as national standards in Canada with no deviations. The impact of having two international EV battery standards adopted and available in Canada truly benefits the Canadian battery manufacturers first. Working to ensure they meet the Canadian requirements puts them at a higher advantage as their designs will also conform to international requirements worldwide. The consumer also benefits because manufacturers who produce a battery with little variability will produce larger volumes of the same battery thus making the battery more cost effective not only to their manufacturing processes but also the consumer.

The research and outreach on emerging EV standards and development has been a critical contributor to Canada's persistence in being a recognized EV leader in various areas such as EV supply equipment (EVSE) including connectors, pins, cord-sets, chargers, and building code infrastructure requirements. CSA Group has been speaking and hosting events at regional and international technical workshops/conferences annual meetings to share our experiences and stimulate discussions. Research and development is ongoing with battery technology to improve performance while ensuring that batteries are lightweight, compact, and affordable.

Battery technology is advancing significantly and battery applications are becoming common in almost everything we use in our daily lives. Batteries are convenient and simple energy storage devices where-as the hazard that could arise from batteries could prove to be deadly. In some instances, battery hazards are stumbled upon as seen recently in the aircraft industry. The electric vehicle market is growing and is expected to continue to grow in the next decade. A major concern for EVs is that despite the exiting adopted standards, there is a lack of enforcement within countries like USA and Canada. Batteries are tested, in many cases, by OEMs and expected to meet the OEM internal procedure or requirements. Third Party Certification organizations, like CSA Group, need to work to develop standardized test methods for batteries for various applications including, but not limited to, medical, electric vehicles, grid application, and appliances. These organizations also need to work with government agencies to enforce the requirements for batteries. With the increased number of EV sales, consideration must be taken and standards developed to address second-life use of EV batteries as well as the recycling requirements to ensure public safety. With the increased number of EV sales, consideration must now be taken to develop standards addressing second-life use of EV batteries as well as the recycling requirements to ensure public safety. Although, not in scope of this project, discussions are starting to take place and further discussions with auto manufacturers, battery manufacturers, and third party certification bodies are warranted.

4.5 Achievement 5 – Research and Outreach on Emerging EV Standards

As a result of the objectives within the scope of this project, CSA Group has been invited to speak at regional and international technical workshops/conferences and annual meetings to share our experiences and stimulate discussions as recognized Canadian experts. One clear example of this is the nomination of one Canada's experts, also a Technical Advisor at CSA Group, on connectors, pins, cord-sets who was asked to chair a task force to find solutions as to why some connectors randomly heat up to dangerous limits causing potential fires. The task force did return with solutions which were written into the IEC standards. The research and outreach on emerging EV standards and development has been a critical contributor to Canada's persistence in being a recognized EV leader in various areas such as EV supply equipment (EVSE) including connectors, pins, cord-sets, chargers, and building code infrastructure requirements.

Furthermore, research and recognition on being considered strategic thinkers in the EV subject matter has led to invitations to national strategic meetings on helping to prioritize next steps for future roadmaps.

4.6 Achievement 6 – EV Infrastructure Recommendation Report Highlighting Key Differences and Gaps between the Canadian National Building Code and the Canadian Electrical Code (CE Code).

The EV Workshop was held on January 28, 2016 in partnership with Natural Resources Canada (NRCan) at CSA Group in Toronto. The workshop investigated current requirements for electric vehicle (EV) infrastructure in the National Building Code of Canada and the Canadian Electrical Code identifying differences and gaps in order to make recommendations to address these gaps. Attendees at this workshop consisted of industry experts, policy makers and regulators the research community, and various other interested stakeholders. The National Research Council of Canada (NRC) was instrumental in providing support and counseling at this event.

In order to set the stage for a workshop under this objective, CSA Group has hosted an event at the EMC Electric Vehicle EV2015 Conference in May 2015, where key industry leaders from organizations such as EMC, NRC, Leviton and CSA Group, were invited to present their views on the CE Code and the National Building Code as they relate to EVSE. A series of action items and further discussions have resulted from this event.

The key output of this objective is a recommendation report highlighting key differences and gaps between the codes as they relate to EVSE as a result of two events conducted by CSA Group. A recommendation report has been published and the impact of these recommendations will be significant in providing accessible infrastructure for EV charging. Only through the harmonization of the codes will buildings have the necessary provisions

mandated for providing the correct service to the EV chargers adhering to the requirements of the CE Code. In the end the consumer will have another reason to support the purchase of EVs as any new buildings will have the infrastructure already available without having to bring in contractors and electricians to provide power to the charger at substantial costs. In the development phase of a new construction, carpenters would work with electricians to plan and install the services so that no rework would be required.

The next phase is the implementation of the recommendations made which will have an impact on industry.

4.7 Achievement 7 – Introduction of EV Direct Current (DC) Charger Standard

The intent of this deliverable was to introduce either one harmonized bi-national standard between the United States and Canada managed through the Council for Harmonization of Electrotechnical Standards of the Nations in the Americas (CANENA) process or a single Canada only standard. The introduction of a DC Charger standard had two main goals; buy-in from CANENA for a harmonized standard and assembling a Canadian committee to commence planning for content development of a standard. Both goals were achieved.

In Canada there are two standards that address certain aspects of DC charging system equipment for recharging the batteries in EVs such as the requirements for d.c. electric vehicle (EV) charging stations for conductive connection to the vehicle, with an a.c. or d.c. input voltage up to 1 000 V a.c. and up to 1 500 V d.c. and it provides the general requirements for the control communication between a d.c. EV charging station and an EV. The United States also has a unique standard. Discussions with CANENA has recognized that a harmonized standard is long overdue and North American manufacturers need one set of requirements to work with. CANENA is in the process of requesting the major Standards Development Organizations in both countries (Canada and USA) to participate. This is significant as the harmonization of a DC charger standard ensures transparency of requirements and testing between the two countries which ultimately affords a manufacturer to produce one charger that complies with both Canadian and United Stated regulations that can be sold in both countries, which means larger volumes, which ultimately means cheaper prices for the consumer.

The second goal of this deliverable was to assemble a committee to initiate discussions and plan of the best approach for introducing a DC Charger standard. The committee did meet and discussions took place whether Canada & USA should adopt the IEC standard or whether they should combine the current Canadian & USA standards. It was agreed that the best short term approach is to work with the current Canadian and USA standards to harmonize them and then look at the IEC standard in a few years to see how it can be best

adopted into North America as work is currently being done on revising this standard internationally.

The harmonization of a DC charger standard is the preferred approach as manufacturers of charging equipment require transparency of requirements and testing between the two countries, however, if a Canada only standard is published, every effort will be made to align to the requirements in the United States. Once again, harmonization is preferred because a harmonized DC charger standard affords a manufacturer to produce one charger that complies with both Canadian and United Stated regulations that can be sold in both countries, which means larger volumes, which ultimately means cheaper prices for the consumer.

This objective has been successfully achieved as CANENA continues discussions with CSA Group in developing strategies for implementing a harmonized standard. After review of current requirements, an agreement has been made to harmonize a portion of CSA-C22.2 No. 107.1 (for Canada) and UL 2202 (for USA) combining the requirements and issuing one common harmonized standard. The second phase of harmonization will be to review requirements from an international perspective and develop appropriate deviations to adopt IEC 61851-23. Details are currently being worked out as careful planning from all parties is critical to the success of introducing a new DC Charging standard into Canada and ensuring consistency with the USA.

5 Benefits

5.1 Benefit 1 – Increased Stakeholder Engagement

In the area of standards development, CSA Group is supported by approximately 8000 expert technical members and 150 staff who contribute their time and knowledge to the development of more than 3000 CSA Group Standards and Codes. CSA Group's electrical codes and standards are integral to the National Electrical Safety System and form the basis of regulation for Electrical Safety in the Provinces. The value of CSA Group is the inclusive nature of the codes and standards development process, which engages stakeholders such as manufacturers, regulators, labours, consumers, testing agencies, academics and others.

Publishing standards and codes for electric vehicles led to the following benefits for these stakeholders:

- Reduced technical barriers to markets by articulating the minimum requirements to meet the needs of industry.
- Nurtured competition by allowing stakeholders to differentiate their technologies based on the performance outlined in the standards.

- Technology advancements by clearly defining minimum safety levels, thresholds and ensuring interoperability between different parts of the overall system.

The stakeholders, namely manufacturers and consumers, benefit in the harmonization of codes and standards with North America and Mexico by providing input into international standards development. Although stakeholder engagement has increased, it continues to be an ongoing effort as consideration needs to apply to all product standards and revisions to current standards be made to stay relevant and current with new technology.

5.2 Benefit 2 - Canadian Leadership and Economic/Environmental Benefits

The codes and standards worked on and developed as deliverables under this project solidified a place for EVs in Canada and in the global marketplace. CSA Group published a comprehensive suite of standards for EV infrastructure and related electrical components which have input directly from electrical regulators from all jurisdictions in Canada. The results spurred economic growth from innovation of EV technologies by Canadian companies and facilitated the vision of Canada's Electric Vehicle Technology Roadmap and the number of projected EVs. As a result of the work performed by CSA Group, some of the barriers to the deployment of EVs have been addressed. This should lead to an increased uptake of EVs and a reduction of carbon emissions from on-road vehicles.

Establishing and harmonizing codes and standards in North America and globally minimized international trade barriers to EV adoption. These activities allowed Canada to leverage the technical expertise of the international community and establish Canada as a leader in the global EV community.

6 Lessons Learned

6.1 EV/EVSE Education

The lack of education or better described as the difference in levels of education regarding EVs and EVSEs had been a challenge and difficult barrier to address at the start of this project. The hand-off from the OEM automobile manufacturers to the consumers and regulators wasn't well defined. OEM's would work with the Society of Automotive Engineers (SAE) and their best practices as identified and described by SAE committees and task forces who operated under the confines of Transport Canada and the Department of Transportation. Others looked to Standards Development Organizations (SDO's) like CSA Group to provide answers regarding supply equipment related to the EVs but not physically attached to the EV. Although the responsibilities are fairly clear to everyone today that OEM's are responsible for everything on

or in the vehicle and equipment outside of the vehicle is regulated and managed by national safety standards and codes.

This project has helped to pull the various organizations together and increased the awareness of responsibilities. SDO committees have recruited OEM manufacturers to participate in EVSE standards development to communicate and share new technology or changes to old. The EV and EVSE knowledge has grown tremendously over the course of this project and every opportunity to continue this education progress will be taken advantage of.

6.2 North American Differences

Although Canada and USA have fundamental similarities they also differ especially when defining requirements for codes and standards. Independently both countries decide what the safety levels should be mandated by standards and certification programs developed to assure conformity. Prior to and during the course of this project, manufacturers voiced that both countries needed to decide on one set of rules to which the EVSE should comply with as harmonizing codes and standards in North America, and globally for that matter, would minimize international trade barriers to EV adoption.

One of the most important deliverables in this project was the harmonization of the four EVSE standards between Canada, USA, and Mexico. As with any harmonization effort, each country needed to give and take whilst not compromising safety. Complicating the process are the impacts that the changes made to other related codes and standards.

Having published and then commenced brainstorming updates to these harmonized standards clearly indicated that the barriers have been eliminated for open discussions between Canada, USA, and Mexico. This is not to say that each country stopped providing opinions and tries to push their beliefs on others, rather committees have learned to listen and weigh out each option before agreeing to one. Overcoming this barrier is important as it provides a smoother partnership for future standards development work which inevitably reduces the cycle time to publish.

6.3 Coordinating Communications

Whenever more than one party is involved with developing the testing requirements within standards there is a potential to omit someone from the discussions especially when it comes down to explicitly finding a solution to an issue and suggesting changes to the design of the product. This scenario became very apparent when a maintenance team was working with pins and connectors as an IEC initiative. The task force assigned to a deeper investigation had to ensure that some of the IEC experts of that committee participated, as well as national

committees from various countries, as well as the manufacturers of the connectors and pins and the OEM automotive manufacturers. The challenge of coordinating the communication was indeed daunting at times especially the scheduling of meetings with people all over the world. Careful consideration was made to ensure fair representation and agreement from all.

6.4 Canadian Expertise

Economics for Canadian manufacturers has forced the majority of manufacturers to move their businesses outside of Canada for many different reasons. As a result, Canadian expertise to participate on Canadian committees to help develop standards, and voice proposals and votes not only nationally but also internationally is getting harder and harder to find and a timely exercise. Not finding Canadian representation is not an option when it comes to standards development. In many cases supplementing committees with CSA Group technical expertise helps to fill voids. In other situations Canada works with USA expertise which not only solidifies our relationship but provides the rest of the world with a united North American front.

7 Technology/Knowledge Outcomes

CSA Group has been actively pursuing and involved with EV battery research by participating in seminars and conferences to conduct technical research in the area of EV battery and energy storage. The knowledge gained by networking with other research bodies provided valuable input ensuring performance, reliability, and safety are all incorporated into standards be adopted into Canada and hence development of conformity programs required for certification and testing. Battery technology is advancing significantly and battery applications are becoming common in almost everything we use in our daily lives. Batteries are convenient and simple energy storage devices where-as the hazard that could arise from batteries could prove to be deadly. In some instances, battery hazards are stumbled upon as seen recently in the aircraft industry. The electric vehicle market is growing and is expected to continue to grow in the next decade. A major concern is that there are no battery safety requirements enforced in North America. Batteries are tested, in many cases, by OEMs and expected to meet the OEM internal procedure or requirements. Third Party Certification organizations, like CSA Group, need to work to develop standardized test methods for batteries for various applications including, but not limited to, medical, electric vehicles, grid application, and appliances. These organizations also need to work with government agencies to enforce the requirements for batteries. With the increased number of EV sales, consideration must also be taken and standards developed to address second-life use of EV batteries as well as the recycling requirements to ensure public safety. The other area of significance, as research into this topic has identified, is the use of EVs as energy storage mediums that can send electricity back to the grid during peak electricity usage periods or the use of EVs for providing electricity to remote areas or emergency circumstances where power is not available or disrupted.

This project highlighted the significance of incorporating EVSE requirements into the CE Code, Part 1 as it would become legislated in Canada thus mandatory by law. This legislated code will ensure compliance so that EV equipment is safe to operate by everyone. Consumers would identify safe equipment by a certification stamp / label on the chargers applied by the manufacturer that they have complied with the CE Code.

Another significant area of technology/knowledge outcome on this project was the research of the Canadian EV infrastructure as it pertains to key differences and gaps between the Canadian National Building Code and the Canadian Electrical Code (CE Code). The recommendation report published highlighting key differences and gaps between the codes as they relate to EVSE must be actioned to assist in expediting and promoting the electrification of transportation.

A key outcome of this project is the publishing of four EVSE tri-national standards. It cannot be overemphasized the importance of having similar EV equipment requirements in Canada, the United States, and Mexico. From a manufacturers view, this implies a single product that can be shipped to all three countries without any product variances due to code requirements. For consumers, it means transparent travel commuting across borders knowing that they can plug their EV's to any compatible charger and when repair is required, get replacement parts more readily. Less product variance by the manufacturer leads to higher volumes of a single product which then drives production costs down, ultimately passing the savings down to the consumer for a lower cost of ownership.

The development of standards internationally must continue to be also at the forefront of new technology considerations. Adopting these international standards may not always be the appropriate and timely action take but certainly in North America, Canada and USA must make every effort to continue to harmonize their standards.

8 Conclusion and Next Steps

This project has been instrumental in the advancement of electric vehicles not only in raising public awareness but the advancement of safety codes and regulations. Every task deliverable was actioned and completed to progress the adoption of a clean and environmentally safe means of transportation. Like with any new construction the key to a successful roll-out is to ensure that the foundation is properly constructed. This project has ensured that everything is aligning itself and in place and that the foundation is solid for the rollout of EVs into Canada.

Achievements and outcomes of this project include a Canadian Electrical Code that has included important and legislated requirements with EVSE and that will constantly be updated to include the latest safety requirements. Having published four harmonized standards relating to EVSE with USA and Mexico and working on their next revisions has truly solidified relationships with

neighbouring countries and provided one North American voice. Canadian expertise participating on international committees has shined a spotlight on our forward thinking and extensive knowledge on EVSE. The research and input back into the EV battery community will help make batteries safer. Collaborating with industry experts from Canada and the USA to discuss gaps in the Canadian Electrical Code the National Building Code has provided a recommendation report that proposes changes incorporating legislature to prepare EV infrastructure in residential and commercial parking locations. Last but not least, addressing the public call to publish a DC Charging standard has been initiated and discussions are taking place to ensure once again that the requirements are harmonized with the USA.

The next steps and continuation of the excellent EV work that was started incudes the publication of the next revision of the harmonized standards with USA and Mexico. The 2018 Canadian Electrical Code will incorporate new changes in Section 86. Canada will continue to participate in international standards development bringing Canadian input into the EV related standards. The DC Charger standard for Canada will be worked on and published. CSA Group will work with the Federal Government to implement as many of the recommendations as possible pertaining to the EV infrastructure requirements within the National Building Code and Canadian Electrical Code. In addition to all of these next steps, CSA Group will continue to follow the EV progress being made at conferences and symposiums to ensure that Canada is not falling behind in the advancement of EV technology and more importantly that safety is at the forefront of this technology.

All of the successes and benefits of this Project could not have been made possible without the support and funding from the Canadian Federal Government. In order to pursue the next steps mentioned above and embrace emerging technologies such as EV wireless charging, two-way power flow, and battery re-use and recycling to mention a few, Canada must continue to invest and ensure codes and regulations are at the forefront ensuring public safety.