INSTILLING A NEW CULTURE FOR RESEARCH AND INNOVATION

Incubator Project
Energy Conservation in the Heavy Construction Sector
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FINAL REPORT

EXECUTIVE SUMMARY

The construction sector is a major engine of Canada's economy as well as creator of over 1.25 million domestic jobs. Despite economic headwinds in some of Canada's natural resource sectors, the construction sector continues to experience growth and opportunity given demand for new infrastructure, need for restoration of existing infrastructure and demand for Canadian goods globally. The sector is a heavy consumer of Canada's resources and energy. Furthermore, in recent years, the energy intensity of the sector, and related greenhouse gas emissions, has been rising at 2.5% per year. On average, other industrial end users have been reducing their intensity by roughly 1.3% per year.

As the federal government's priorities drive significant new infrastructure investment, there is also a strong priority to ensure that this be done in a way that considers climate change impacts and greenhouse gas emissions. As the construction sector gears up to deliver on the government's infrastructure priorities, the development of an industry-led energy conservation program will support progress in these important areas.

With support from Natural Resources Canada, Canadian Construction Innovations (CCI) brought together leaders of Canada's heavy civil construction sector in an Energy Conservation Incubator to explore the opportunity to improve the sector's energy performance and to determine key considerations in the design of a longer term, industry-led, energy conservation program.

Through the incubator process, many recommendations were identified for the design of the program such as defining the sector, improving sector and sub-sector level data, understanding existing and emerging technological solutions, better information and dissemination practices, tools for supporting employee training and a robust set of best management practices and other tools to help the sector improve its overall performances. In addition, a CCI advisory committee will be established with members drawn from the broad membership of CCI and others who represent important elements of the construction industry. This committee will guide the energy conservation program on a longer term basis.

Detailed recommendations are provided at the end of this report.

1.0 Introduction

The construction industry represents players involved in the construction of residential and non-residential buildings, civil infrastructure and other constructed facilities. The industry is one of Canada's largest industries and captures a wide array of activities and businesses including planners, architects, engineers, contractors, vendors and operators.

The construction sector – representing a sub group of this industry made up of contractors and operators – employs over 1.25 million workers in Canada, accounting for roughly 7 percent of the country's total workforce. It generates close to $100 billion in economic activity, or 7 percent of Canada's total GDP. There are more than a quarter of a million firms in the construction sector, many of which are small enterprises.

The construction sector has been experiencing economic growth in recent years and employment has grown steadily over the last two decades. The sector's ongoing success will be driven primarily by growing demand for new infrastructure and the need to modernize and restore Canada's aging infrastructure. Furthermore, the sector's ability to adapt to changing market forces through innovation will support the potential to export Canadian construction know-how around the world and to defend against the arrival of foreign competition in Canada.

Launched in 2014, Canadian Construction Innovations (CCI) is an organization of leaders of the construction industry with a mission to instill a new culture of research and innovation in the Canadian construction sector. CCI brings together key construction stakeholders from owners, contractors, architects, engineers and more to enable the innovation opportunity pipeline.

The establishment of CCInnovations was propelled by a need for industry-driven research and innovation. In order to solve industry problems, an institute was required that could identify industry solutions. This model has been seen in other industries in Canada, including mining, aerospace and forestry, and countries around the world. While innovation occurs in small, incremental ways across the country and in the Canadian construction industry, it is only through a national, collaborative and industry-driven approach that systemic change can be realized. The development of an industry-led energy conservation program is extremely well aligned with the CCI mandate. For more information on CCInnovations, visit the institute's website (www.ccinnovations.ca).

The Canadian Industry Program for Energy Conservation (CIPEC) is an industry-government partnership that promotes voluntary actions to reduce industrial energy intensity. Through its work in awareness raising, tool development, training and promotion, CIPEC supports industry in reducing its costs, improving its productivity and reducing greenhouse gases.

CCInnovations joined CIPEC in 2015. This program has given CCI access to valuable energy information and data. It also has given the organization exposure to champions from other industries who have played a significant role in their own sectors' efforts to minimize energy consumption. This exposure served as the catalyst for CCI to undertake its own program on energy conservation. While CCI represents a wide variety of players across the construction industry, the organization initiated the development of an energy conservation program aimed at the heavy construction segment of the construction industry; one that will be called upon to deliver on the billions of dollars soon to be spent on infrastructure renewal/expansion and that consumes a significant amount of energy.

Through CCI's involvement in CIPEC, the construction sector secured the opportunity to work with CIPEC and Natural Resources Canada's Office of Energy Efficiency to explore the development of a comprehensive, industry-led energy conservation program. A short-term energy conservation incubator for the sector was established to consider the opportunity.

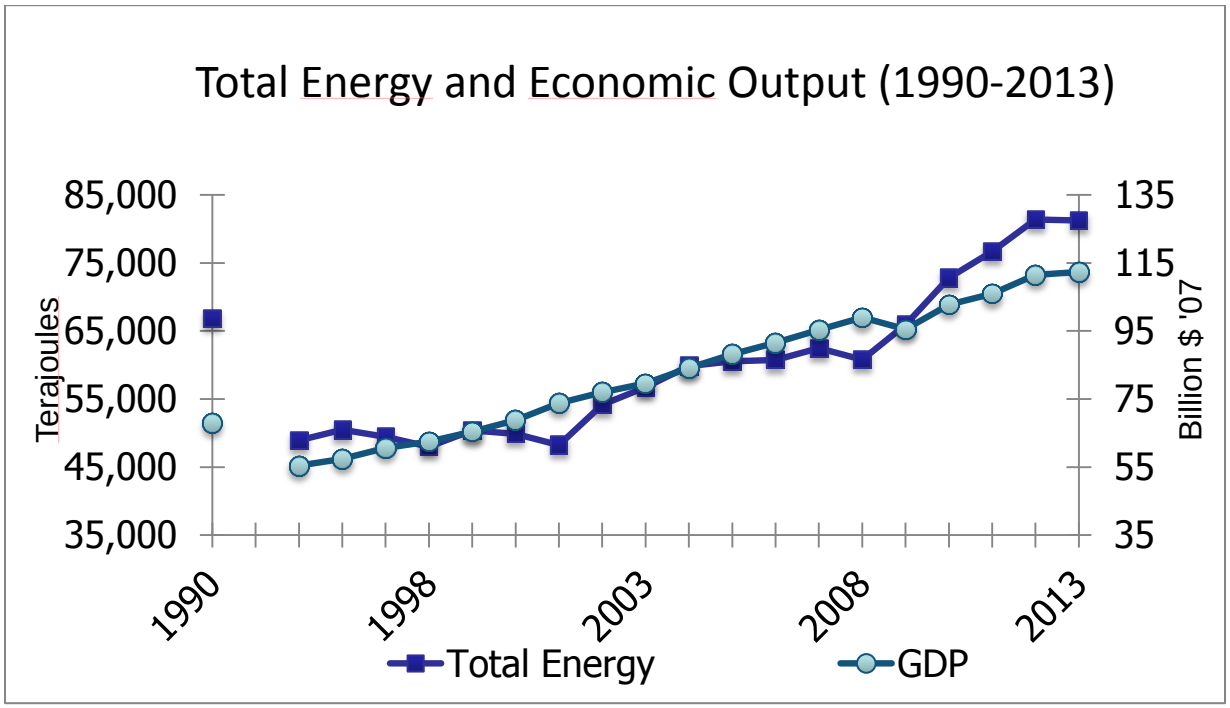
2.0 Project Rationale

The Canadian construction sector consumes 40 % of the country's energy and roughly 50% of its primary resources. The sector is a major energy user consuming 81,000 TJs (terajoules) per year (see Figure 1). By comparison, Canada's mining industry consumes 116,000 TJs per year.

Energy intensity for the sector has been increasing by approximately 2.5 percent every year between 2008 and 2012. By comparison, Natural Resources Canada's Office of Energy Efficiency reports that Canada's industrial end users improved energy intensity by an average of 1.3% per year. This comparison suggests that there is significant room for improvement in the construction sector and strongly justifies the development of a comprehensive energy conservation program for this sector. This performance suggests that there is a strong likelihood of early wins and high improvement potential when this program is implemented.

Moving forward, the design and implementation of an energy conservation program for the heavy civil construction sector is an important effort in meeting the federal government's current priorities. As witnessed in the Ministerial mandate letters, the Speech from the Throne and regular public communications, the federal government is driving forward key priorities in the areas of new innovation approaches, plans to green Canada's infrastructure and pathways for furthering clean technology adoption and export in support of improved productivity and climate performance. As such a significant sector of the Canadian economy, it is imperative that the construction sector improve its overall energy performance and contribute to these important objectives.

FIGURE 1: Construction Energy Performance
Source: Natural Resources Canada



3.0 Incubator Process and Meetings

In January, 2016, CCI and Natural Resources Canada's Office of Energy Efficiency agreed to undertake the Energy Conservation Incubator for the heavy civil construction sector. The incubator approach was intended to provide the opportunity for industry players to give input into future considerations and needs for the development of an industry-led energy conservation program.

It was determined that at least two consultation sessions would be needed to seek this input. These meetings took place on February 5th and 19th. In addition, some bilateral discussions took place for those players in the construction sector who were unable to participate in the meetings. The participation in these consultations was not limited to CCI membership. Effort was made to reach out to important players in the sector whether they were active in the CCI organization or not. Companies that were consulted represented a range of construction activities including road builders, sewer and water systems, tunnels, general contractors and suppliers.

Over the course of this two month discussion, the following construction companies were consulted and provided input:

1. Bockstael Construction, Winnipeg, MB
2. Cruickshank Construction, Kingston, ON
3. EllisDon, Mississauga ON
4. Lafarge Canada, Asphalt and Construction, Calgary, AB
5. Maple Leaf Construction, Winnipeg, MB
6. M. & C McNally Engineering Corp., Burlington, ON
7. Miller Group, Markham, ON
8. Modern Construction, Moncton, NB
9. Tomlinson Group, Gloucester, ON

The first meeting provided background information on the sector's energy performance, the rationale for proceeding with an industry-led energy conservation project and information on the priorities of the federal government. At this meeting the players in the heavy civil construction sector confirmed their interest and involvement in the project and the need for the program in the longer term.

The federal government participated in both meetings and provided invaluable insight into the federal government priorities, the government's assessment of the current performance of the sector, what tools might be considered and observations of the cost and environmental benefits of energy conservation projects experienced by others.

Detailed case studies from other sectors were also prepared and shared during the incubator and provided significant information and insight to the construction sector participants.

Detailed information (agenda, participants list) for each of these meetings is available through CCI.

4.0 Overall Issues & Recommendations

Throughout these consultations, opportunities and challenges were identified that would need careful consideration in an energy conservation program for this sector. The incubator made a variety of recommendations for future consideration in the development of the program. The remainder of this report captures the input from construction sector leaders on opportunities, challenges, and overall recommendations.

4.1 Advisory Structure

Given the nature, and scope of a future energy conservation program and the group's commitment to the issue, the decision was made to officially establish an Energy & Environment Advisory Committee of CCI to guide development on a go-forward basis. The founding members of this advisory committee include:

1. John Bockstael, CCI Board Chair, President and CEO, Bockstael Construction, Winnipeg, MB
2. Barry Brown, President, Maple Leaf Construction, Winnipeg, MB
3. Steve Cruickshank, CEO, Cruickshank Construction, Kingston, ON (By Phone)
4. Ryan Essex, Vice President, Miller Group, Markham, ON
5. Andrew Graham, Manager, Construction, Modern Construction, Moncton, NB
6. Bert Hendriks, Executive Vice President, Tomlinson Group, Gloucester, ON
7. Chris McNally, Director, M&C McNally Engineering Corp, Burlington, ON
8. Bob Spence, Vice President & GM, Asphalt and Construction, Lafarge Canada, Calgary, AB

Additional members will be sought from the sector over time and effort will be made to involve other members of CCI representing different segments of the construction industry, such as owners and designers, who also have a role in energy practices.

There was also discussion that the participation of key partners (such as the Readi-mix and other allied associations) would be important and outreach should be made to these groups to engage them.

4.2 Defining the Sector

The Canadian construction sector is highly complex in scope covering activities such as road and bridge building, residential and non-residential construction, to a wide array of contractors engaged in a significant variety of construction activities. Table 1 outlines the North American Industry Classification System (NAICS) codes for this sector that is used by Statistics Canada and others. As outlined in Table 1, the sector is divided into residential and non-residential categories, heavy and civil engineering and specialty trades. Non-residential is further broken down into: heavy industrial (manufacturing plants, factories); and institutional and commercial (such as schools, hospitals, stadiums, etc.). Heavy civil engineering includes highways, dams, water and sewage and bridges, etc. The sector is also highly fragmented with over a quarter of a million firms in the sector, many of whom are small enterprises.

Defining the sector for the purpose of the future energy conservation project will be critically important. The first step will be to identify all of the energy uses that exist within the sector and then determine the annual level of consumption associated with these uses. In this way,

the significant energy uses can be determined and prioritized not only in terms of consumption but also in terms of opportunities for energy performance improvement. Subsequently, resources can be focused on developing, planning, and implementing improvements for the uses that will provide the greatest benefit. While Table 1 provides information on the 4-digit NAICS codes for the sector, it is believed that energy use information is only available to the 2 digit NAICS code.

Furthermore, as discussed at the incubator session, overall the NAICS codes as outlined in Table 1 are too narrow in their definition of the sector. There are other players in the built environment that contribute to energy consumption and that have direct influence over the energy conservation opportunities for the sector. These players include planners, designers, engineers, material suppliers and are not included in the NAICS codes presently used to characterize the sector. As a result, work will need to be done to better define the players and their contribution to the industry's overall energy footprint.

Table 1: NAICS codes for sector, to 4 digit level
Source: Statistics Canada

23 **Construction**	
236 **Construction of Buildings**	
	2361 **Residential Building Construction** 2362 **Non-residential Building Construction**
237 **Heavy and Civil Engineering Construction**	
	2371 **Utility System Construction** 2372 **Land Subdivision** 2373 **Highway, Street and Bridge Construction** 2379 **Other Heavy and Civil Engineering Construction**
238 **Specialty Trade Contractors**	
	2381 **Foundation, Structure, and Building Exterior Contractors** 2382 **Building Equipment Contractors** 2383 **Building Finishing Contractors** 2389 **Other Specialty Trade Contractors**

4.3 Business Case for Collective Energy Management

Participants in the CCI energy conservation incubator identified the need to ensure broad buy in and support for action from the construction sector. An important step will be to develop a rigorous construction sector business case for pursuing energy management. It needs to be well understood that there are valuable benefits for collaboration within the industry aimed towards improving the sector's energy efficiency performance. There will be benefits from a variety of perspectives – cost savings, reputational improvement and greenhouse gas reduction.

The incubator participants reviewed key factors that influence the development of a sectoral level energy conservation and management program include:

- Existence of common areas of applicable energy efficiency opportunities that are cost prohibitive for a single company to pursue
- Cost and risk-share of related research
- Cost-share resources
- Shared burden of addressing energy related environmental issues and/or regulatory requirements
- Shared impact of reputational risk

As well, there are strong examples emerging of the direct benefits to the sector of implementing comprehensive energy management systems (such as, ISO50001). According to the U.S. Department of Energy, facilities are experiencing a 12% reduction in energy costs on average within first 15 months of implementation. In Europe, the results range from 5 to 30% reduction in energy costs.

The Canadian government has funding available for the adoption of ISO 50001 energy management systems. The incubator felt that the idea of developing energy management modules for the construction sector, leveraging available funding, should be explored. While certification may not be necessary, the elements of the ISO 50001 Energy Management System standard should be reviewed and considered in developing the construction sectors' energy conservation program.

The following table from the U.S. Department of Energy's Superior Energy Performance was reviewed as it illustrates explicit examples of energy performance improvements experienced across a wide array of companies through implementation of energy management systems.

Table 2: U.S. Department of Energy Superior Energy Performance

Superior Energy Performance Certified Partners Energy Performance Pathway	Energy Performance Improvement*	Year of Certification
• Volvo Trucks, NA: Dublin, VA	25.8%	2012
• Dow Chemical Company, manufacturing plant: Texas City, TX	17.1%	2011
• 3M Canada Company: Brockville, Ontario, Canada	15.2%	2012
• Cook Composites and Polymers Co.: Houston, TX	14.9%	2010
• General Dynamics: Scranton, PA	11.9%	2013
• Allsteel: Muscatine, IA	10.2%	2012
• Cooper Tire: Texarkana, AR	10.1%	2012
• Olam Spices: Gilroy, CA	9.8%	2013
• Owens Corning: Waxahachie, TX	9.6%	2010
• Dow Chemical Company, energy systems plant: Texas City, TX	8.1%	2011
• Nissan, NA: Smyrna, TN	7.2%	2012
• Freescale Semiconductor Inc.: Oak Hill, TX	6.5%	2010
• 3M: Cordova, IL	5.6%	2012

4.4 Data Quality

In March 2015, the Canadian Industrial Energy End-Use Data and Analysis Centre (CIEEDAC) at Simon Fraser University released a report "Energy Use and Related Data: Canadian Construction Industry, 1990 – 2013". The report studied the issues of data availability, trends in energy consumption and greenhouse gas emissions from the sector as well as identified areas for data quality improvement. The report found that overall there was incomplete data

available for the sector; a distinct lack of aggregated physical measures of output for the industry and insufficiently disaggregated energy use information.

The incubator sessions reviewed the data situation and supported these conclusions. The information available from the sector comes from the fuel and energy supply side and not the industry itself. The sector is aware of the need for improved data quality and incubator participants agreed that this needs to be an early area for action in the future energy conservation program. Several recommendations were made with respect to data quality for consideration:

- Begin data quality improvement by working with industry energy suppliers to verify the distribution of invoiced energy consumption data.
- Initiate collaboration with CIEEDAC and CIPEC in order to improve data quality.
- Collect data from major players in some key subsectors to develop an initial database of industry data from which to make approximations and set priorities.

4.5 Energy Conservation: Lack of Knowledge

Developing an awareness and understanding of how energy is used and how it can be managed will be an important step in the sector's efforts to become more energy efficient, reduce energy costs and reduce GHG emissions. This knowledge can be acquired through existing training programs, and by investigating technology applications and energy management techniques that are being used in other sectors.

Energy awareness training and energy manager training is readily available in Canada. A full series of workshops covering all aspects of energy conservation from basic energy principles to energy management systems is available through Natural Resources Canada's *Dollars to Sense* training programs. These workshops can be customized to meet a company's specific requirements. In addition, the Canadian Institute for Energy Training provides in depth training for individuals who wish to become Certified Energy Managers.

CIPEC can provide support as an excellent point of contact with a network of other sectors who are successfully managing energy. Through its CIPEC membership, CCI should support the sector in developing linkages with other sectors that are willing to share experiences in order to identify practices that are a best fit for the construction sector.

The incubator participants felt that there was an overall lack of knowledge of what energy management practices and energy efficient technologies are already being used in the

construction sector. It will be necessary to undertake a scan of existing practices and measures which are already being applied in various areas within the sector.

During the discussions at the incubator meeting, it became clear that some companies are already collecting energy data from their on-board equipment information systems. Others have instituted training programs for their employees related to equipment operations and energy practices – cold weather operations, vehicle idling etc. Capturing information regarding the sector's current energy awareness, training practices, and applied energy efficient technologies would provide a clearer picture of where the sector needs to head on its journey to become more energy efficient and reduce its carbon footprint.

4.6 Energy Conservation Priorities

As the design for an energy conservation program for the heavy civil sector proceeds, the advisory group identified a wide array of areas that have significant energy use in their business and/or areas that should be reviewed for energy savings opportunities. These areas included:

- Transportation
- Fleet Management
- Equipment mobilization
- Diesel consumption
- In-plant Energy Management
- Energy use reduction
- Energy Management Systems
- Mobile equipment
- Winter construction practices
- Materials (e.g. Portland-limestone cement, warm mix asphalt, etc.)
- Management processes (e.g. e-construction, intelligent compaction, etc.)

Contributions from these different priorities should be estimated and then development of management tools in the highest areas for improvement should be fully explored and considered.

4.7 Tools Development

The incubator reviewed several case studies of what other sectors have been doing to reduce energy. In reviewing these case studies, several key factors for improvement were found to be common -- technological solutions, better information, employee training and a robust set of tools to help individual players adopt better practices.

The development of best management practices is a tool that is often used by major Canadian sectors. While this has been limited for the construction sector, there was a Road Building Best Practices Guide developed in 2005 by CCA and CIPEC. The incubator group recommended that this guide be reviewed and updated as appropriate as an early deliverable. In addition, it would be important to consider how to disseminate and support the implementation of a renewed road building guide. Additional best management practices should also be considered in areas that are relevant to many companies, such as the development of a best management practice guide for winter construction activities or best practices in the area of warm asphalt. Done well, this type of guide would support both the construction activity in reducing energy use and the specifiers in understanding the impact of their terms on energy use.

The steel industry is an excellent case study for how sector benchmarking can improve energy performance. Global benchmarking of Best Available Technologies has been a key component of the Canadian steel industry's approach to managing energy use and improving energy efficiency. Worldwide technology specialists are conducting research to develop breakthrough technologies that will lead to major improvements in the future. These technologies are shared via continual benchmarking. ArcelorMittal (Dofasco) provides an excellent example of this practice. It holds international roundtables that provide "networking opportunities" that encourage contacts among plants to share information, best practices and expertise on energy efficiency and other issues.

The Canadian Steel Producers Association along with Natural Resources Canada have produced a benchmarking study – 'Benchmarking Energy Intensity in the Canadian Steel Industry' which presents energy performance criteria for the industry to compare itself to. This approach should be considered for the construction sector

The group discussed the possibility of developing energy management modules for the construction sector. A possible way to proceed would be to use ISO50001 standard as a guide and develop sector modules which could then be customized for individual companies.

It would also be important to understand how construction companies are currently incenting energy conservation with their employees. It is suggested that information should be collected in this area, potentially leading to a BMP for others to consider.

4.8 Role of Procurement

Procurement plays a significant role on the delivery of projects. It defines the contractual arrangements that need to be put in place as between the stakeholders: architects, engineers, contractors. It defines the level of risk assumed by the players involved in the construction chain. Through the tender documents it defines that ability of the players to introduce new

processes and materials depending on how prescriptive they are in very specific areas. The industry could perform better if the procurement process in Canada was geared toward innovation and if energy conservation goals were considered in a constructive way.

Incubator participants felt procurement specifiers play an important role in how energy is managed and considered in projects. It was suggested that outreach to specifiers that are part of CCI's existing membership, as well as others, would be important to find opportunities and ideas of how energy can be better addressed through the procurement process.

4.9 Role of Policy

Understanding how emerging government policies (such as climate change) and existing instruments (e.g. tax incentives) can support the goals of energy conservation in the construction sector will be important. For example, will a price on carbon provide the necessary economic drivers to modify energy use patterns? Or how do we further incentivize duel fuel conversions in equipment (from diesel to natural gas & diesel).

Over time it will be important for CCI and other representative groups of the sector to explicitly identify policy and program options that will assist this important objective.

4.10 Existing and Emerging Technology

The incubator reviewed a variety of solutions from other sectors aimed at reducing energy consumption in the key areas of transportation, equipment mobilization and in-plant emissions management. There were a number of explicit opportunities for technological solutions being used by others (such as FPInnovations efforts around intelligent transportation systems and fuel blending) that seem readily applicable to the construction sector. CCI will explore linking these technology opportunities to the sector through its clearinghouse initiative (available through its website).

In the construction sector there is a lack of coordinated information on technological solutions available to the sector. A starting point should be to undertake a scan of existing and readily available technological solutions. Furthermore, technological advancements are often being made within the equipment supplier community. Developing linkages with key equipment suppliers will be very helpful in understanding what exists.

The group also felt it would be highly relevant to understand how emerging technologies may play a role in the sector's future performance. Again, there is no existing scan of technologies that are at the 'emerging' end of the technology development pipeline.

4.11 Dissemination of Information and Communications

As CCI advances its efforts in this critical area, it will be important to profile the activities of the organization and its members broadly. There are existing broad-distribution newsletters through CIPEC (such as HeadsUP newsletter) and others that should be approached to feature the opportunities of the construction sector and to promote the availability of supportive information as it is generated.

A key area of effort should be on establishing a workable outreach program to the thousands of smaller enterprises in the sector for dissemination of information and tools that result from a comprehensive program. There is a strong regional infrastructure of Associations and networks in the construction sector that CCI can work with to accomplish this objective. Also a presence at future conferences where players in the sector gather may be appropriate. It is expected that the existing CCI clearinghouse initiative will be an ideal tool for the industry to access this information. Effort will need to be made to ensure it is well populated and shared within the sector.

An explicit effort to broaden reach with the members of CCI that represent specifiers will be necessary to ensure maximum savings are realized. The requirements specified in contracts have a significant impact on how the construction sector responds and manages infrastructure projects.

The opportunity to improve energy use through further energy awareness training of employees must be considered. Customized employee training modules for the sector would be very valuable in improving overall energy performance.

5.0 SUMMARY OF RECOMMENDATIONS & NEXT STEPS

1. In collaboration with Natural Resources Canada, CCI to develop an industry-led energy conservation program for the heavy civil construction sector.

2. CCI to establish an Energy & Environment Advisory Committee of construction sector leaders to guide the design and development of an industry-led energy conservation program on a go-forward basis. Support will be sought from allied partners (suppliers, manufacturers, providers of specialty services).

3. CCI to maintain an active role in CIPEC and seek opportunities to learn from others on best practices and their overall approaches to energy management.

4. An initial step will be to undertake a scan of existing practices in the construction sector to better understand what the sector is doing in the area of energy management.

5. A review of the existing best practice guide for road construction, will be undertaken to update as appropriate, disseminate within the sector and support its implementation. The development of new guides will be considered that will have strong applicability across the sector such as an energy best practice guide for winter construction.

6. The data quality for the sector needs to be improved. Work with the industry's energy suppliers to verify the distribution of invoiced energy consumption data. Initiate collaboration with CIEEDAC and CIPEC in order to improve data quality. Collect data from major players in some key areas to develop an initial database of industry data from which to make approximations and support the establishment of program priorities.

7. CCI will seek to engage specifiers in understanding their role related to energy use in the sector and explore opportunities for consideration of energy impacts in procurement practices. CCI is uniquely positioned to do this given that there are a number of specifiers that are members of this organization.

8. A scan of existing and emerging technology solutions should be undertaken to support the sector's energy use performance.

9. In order to improve the sector's understanding of the value of energy management, a rigorous business case for pursuing energy management should be developed for the sector. Consider developing energy management modules under ISO50001 to benefit from a systems-wide approach.

10. Overtime, an energy conservation program will be developed in a prioritized approach to action. Once data is improved, the program should be built off of the highest energy uses within the sector and target activities with the highest opportunity for improvement.

11. CCI to seek ways to reach the thousands of smaller enterprises in the sector for dissemination of information on how to conserve energy and to promote the use of tools that should be developed from this program