The Mechanical Insulator's Campaign to Encourage GHG Reductions and Energy Savings in New Brunswick's Commercial and Institutional Buildings

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August, 2022

Abstract

Buildings and the construction process are major contributors to energy use and greenhouse gas (GHG) emissions. Canada's emissions per capita are among the highest globally. Approximately 18% can be directly and indirectly attributed to buildings. Improving the energy efficiency of buildings is essential for Canada to reduce its carbon footprint. Mechanical insulation (MI) is a component of construction commonly overlooked by building managers and the construction industry. MI refers to the insulation of piping, ducts, boilers, furnaces and other parts of mechanical systems such as Heating, Ventilation and Air Conditioning (HVAC) systems. Done correctly, MI minimizes thermal losses from these systems, thereby reducing energy use and GHG emissions. MI can improve the energy efficiency of buildings significantly at a relatively low cost. Since 2017, Local Union 131, which represents mechanical insulators in New Brunswick (NB) and Prince Edward Island (PEI), has initiated MI energy auditing in numerous educational facilities to evaluate MI and recommend upgrades to building owners. It encourages MI contractors to bid on upgrades recommended by its audits and conducts follow up audits to ensure that specifications are met. Local 131 has completed audits in five of NB's seven public school districts and most of Mount Allison University's campus and is discussing auditing other facilities in NB. Clients report major financial savings with returns on investment (ROI) often within a year or two. They also note the positive energy, climate and environmental impacts enabling them to meet their climate policies. Local 131 demonstrates how a small union can contribute to achieving Canada's climate goals while expanding members' employment opportunities and strengthening their capacity to raise standards of installation in the industry.

Executive Summary

Buildings and building construction are major contributors to energy use and greenhouse gas (GHG) emissions, both globally and in Canada. Despite its small population, Canada's GHG emissions per capita are among some of the highest in the world. Approximately 18% can be directly and indirectly attributed to buildings. While there have been advances in energy efficiency in buildings in recent years, including the development of new technologies, materials and updated building codes, energy conservation within the building sector must undergo a rapid transformation if Canada is to reach Net Zero by 2050 and meet its Paris climate commitments.

There are many ways to improve building efficiency, such as upgrading lighting, sealing the building envelope, improving heating, ventilation and air conditioning (HVAC) systems, and adding roof and wall insulation. However, improving Mechanical insulation (MI) is commonly overlooked as a cost-effective method of lowering energy use and GHG emissions in buildings MI refers to the insulation of piping, ducts, furnaces, boilers and other parts of mechanical systems in HVAC systems. Installed correctly, MI reduces thermal losses, controls moisture, prevents mold, improves air quality and facilitates better temperature management in buildings.

Local Union 131 represents mechanical insulators in New Brunswick (NB) and Prince Edward Island (PEI). It has initiated an innovative MI energy auditing program in educational institutions across NB to evaluate the effectiveness of MI in their buildings and recommend appropriate upgrades. MI energy audits use thermographic cameras, coupled with industry standard 3E Plus software to take thermal images on-site of pipes, duct work, furnaces and other components of mechanical systems. The audits collect and analyze data to calculate surface temperatures, energy and heat losses, carbon dioxide emissions and fuel used. The software can also determine proper type and thickness of insulation needed as well as estimated return on investment (ROI), financial savings and GHG emissions reductions if MI is upgraded. The audit information enables building owners and facility managers to decide whether to commission MI upgrades.

Since 2017, Local 131 has audited a total of 43 schools in 5 of the province's 7 public school districts. Of these, 32 have carried out MI upgrades. It has also carried out a comprehensive review of the MI in most of Mount Allison University's 34 buildings and 3.5 km of tunnels. These audits have recommended cost effective MI upgrades, which have resulted in significant energy efficiency improvements, reduced GHG emissions, and major financial savings for the public. Interviews with building managers and school administrators have confirmed that projected savings from audits have been realized after their MI was upgraded.

Local 131's offers energy audits to building owners as a way of demonstrating the benefits of improved MI. Because most owners are not familiar with the insulation trade, the local shares its audits with MI contractors who may want to bid on this work. Building owners can then decide which bid to accept to have the work performed. The local inspects the completed work and, if necessary, requires contractors to fix any deficiencies to ensure it meets the specifications set out in the audit recommendations.

Aside from its financial benefits, the audit program also enables school and university administrators to meet some of their climate change objectives. Most public institutions and many private companies have adopted polices to reduce GHG emissions, lower energy use and improve their environmental footprint. Documenting the measures being taken to address climate change is an increasingly important factor in shaping the strategic plans of public institutions such as school districts and universities. Energy audits provide building managers with data that demonstrate an important way in which they can achieve their goals, providing evidence of the practical steps they are taking to addressing the climate change challenge.

Local 131 performs the audits free of charge for building owners. However, it requires the winning contractor to pay its audit costs once the bid is awarded. The building owner benefits because it does not have to organize and pay to have the audit performed. Contractors benefit because the audit tells them precisely what work is required for them to prepare a bid. They do not have to find prospective clients, nor do they risk of paying for an audit that may not result in work for their company if the client decides not to proceed, or that another contractor might win based on a client's competitive tendering rules. They only bid on work the client wants done and only pay for the audit if they win the bid.

The union benefits from the additional new work for members employed by the contractors who obtain the work. Without the union's auditing initiative none of this new work would be commissioned. But the auditing program has also enabled the union to promote higher standards of work performance among contractors and within its own membership because to meet audit specifications, all work must be done according to industry best practices. High quality work is essential for the program's credibility, the union's reputation and its ability to expand employment for its members. Recognition of the quality of the work required also enhances the member's own perception of the value of their work and the importance of their trade.

The work flowing from the audits has had other positive impacts, including: improvements to staff and student safety through reducing the risk of burns from mechanical systems; better temperature control and room comfort for building occupants; improved occupant health from cleaner air circulation; and identification and removal of hazardous material such as asbestos. School administrators and their building managers have expressed satisfaction with knowing that through the audits they are making a positive impact on the environment by reducing GHG emissions and energy use within their facilities.

The work performed by Local 131 demonstrates how a relatively small union can have a modest economic and climate change impact through developing an innovative program for promoting building energy audits. Upgrading MI saves energy and contributes to reducing Canada's carbon footprint. This program has also benefited the MI trade in NB by emphasizing the importance of using properly trained and qualified insulators committed to following industry best practices when installing MI in new and existing buildings. It has also facilitated a greater understanding within the building trades, school administrators, facility managers and unionized contractors of the contribution that a union can make to being a part of Canada's solution to climate change.

Introduction

Improving the energy efficiency of buildings presents a major opportunity to reduce greenhouse gas (GHG) emissions, conserve energy and generate financial savings for building owners. It is also an important component of society's efforts to address climate change. While there are many ways to improve building energy efficiency such as upgrading lighting, sealing the building envelope, triple glazing windows, improving heating, ventilation and air conditioning (HVAC) systems, and adding wall and ceiling insulation, upgrading mechanical insulation (MI) is one of the most cost-effective ways to reduce energy use. Poorly insulated boilers, pipes and ductwork are the source of considerable energy losses in many buildings. However, the positive role of MI in conserving energy is poorly understood and frequently overlooked. Building owners are often unaware of the extent of the energy losses or how improving MI can reduce them significantly.

Energy audits can be performed to assess the effectiveness of MI in buildings and to recommend appropriate upgrades. Audits can quantify the energy and monetary savings associated with improving MI as well as the potential to reduce GHG emissions. They can also be used as a education and marketing tool to highlight the importance of MI to building owners and managers by demonstrating the potential benefits of upgrading MI on their HVAC systems.

The purpose of this paper is to document the MI energy auditing initiative of Local 131, a union representing mechanical insulators in New Brunswick (NB) and Prince Edward Island (PEI). Through its innovative audit program, the local has contributed significantly to reducing energy use and GHG emissions by recommending improvements to MI in school districts across New Brunswick and a major provincial university. It is currently planning to expand its program to other public institutions and commercial building owners with a process for encouraging contractors to bid on the work proposed in audits and thus ensure that its recommendations lead to high quality insulation upgrades. The success of this model has significant implications for building owners, both provincially and across Canada who wish to lower their GHG emissions and energy costs. It also shows how a small, provincially based union local can contribute to meeting Canada's climate goals in the building sector while providing a positive example for other unions on how to promote an innovative approach to saving energy, reducing GHGs and cutting operational expenditures in buildings.

The content of this paper is the result of interviews with Mr. Joshua Sherrard, president of Insulator Local 131 based in Saint John, NB. It is based on the detailed energy audits he has provided to school districts and Mount Allison University as well as his discussion of the way in which the program has evolved since its inception in 2017. We have supplemented his interviews with additional interviews with public school finance directors, facility managers and a national insulation contractor that carries out MI installations in NB to confirm the accuracy of his account of the impact of the MI audit program. Appendix A provides a table illustrating the summary financial data provided in audits to building owners. It shows the initial investment required to upgrade MI, the projected annual financial savings, the cumulative savings over the life of the upgrade and the return on investment. Appendix B provides an example of an energy audit from one school in New Brunswick. Appendix C lists the school and university administrators that were interviewed in preparing this report.

The Key Role of Buildings in Addressing Climate Change Through Reducing Energy Use and GHG Emissions

Buildings are a major contributor to GHG emissions and energy use globally, making them a key target for climate change mitigation. The United Nations Environment Program (UNEP) notes that in 2020 buildings and the building construction sector were responsible for 36% of global energy consumption and 37% of global energy related CO_2 emissions over the lifecycle of buildings. [1]In its 2014 report on climate mitigation, the IPCC devoted an entire chapter - Chapter 9 - specifically on the role of buildings and construction as contributors to global warming.

"(B)buildings represent a critical piece of a low-carbon future and a global challenge for integration with sustainable development... Buildings embody the biggest unmet need for basic energy services…much existing energy use in buildings in developed countries is very wasteful and inefficient. Existing and future buildings will determine a large proportion of global energy demand [2]

The same point has been made in a more recent review of energy reduction options by some of the most well-known researchers in the field, including Rob Bernhardt, former head of Passive House Canada:

"Buildings, especially their heating and cooling, are among the few areas of energy use where a several-fold decrease in emissions and energy consumption is possible while maintaining or improving the level of energy services provided. As this end use comprises an important share of global energy demand, low-energy buildings are key to a climate-neutral future."[3]

A commitment to lowering energy use and GHG emissions in buildings was a key component of Canada's 2015 Paris Agreement and the subsequent federal-provincial Pan-Canadian Framework on Climate Change. Since then, there has been a veritable snowstorm of legislation at all levels of government to address mitigating or adapting to climate change. The recent *Canadian Net-Zero Emissions Accountability Act* of June 2021 gives the Federal Government the legal framework for significant additional climate commitments beyond Paris.[4] The Government expects the building and construction sector to make a major contribution to its objective of lowering GHG emissions by 40 to 45% by 2030 and net zero by 2050.[5]

[1] United Nations Environment Program and Global Alliance for Building and Construction (2021). Global Status Report for Buildings and Construction: Towards a Zero Emission, Efficient and Resilient Buildings and Construction Sector. Nairobi. Table p. 15. www.globalabc.org

[2] Intergovernmental Panel on Climate Change (IPCC). (2014). Mitigation of Climate Chnge: Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Chapter 9: Buildings. pp. 671 – 738. https://www.ipcc.ch/report/ar5/wg3/buildings/ p. 691.

[3] Urge-Vorsatz, Diana, Radhika Khosla, Rob Bernhardt et. al. (2020) Advances to a Net-Zero Global Building Sector. Annual Review of Environment and Resources. https://www.annualreviews.org/doi/pdf/10.1146/annurev-environ-012420-045843

[4] Canada. (2021) An Act respecting transparency and accountability in Canada's efforts to achieve net-zero greenhouse gas emissions by the year 2050 https://www.parl.ca/LegisInfo/en/bill/43-2/C-12 (referred to as the Canadian Net-Zero Emissions Accountability Act).

[5] Office of the Prime Minister (2021) Mandate Letter to Minister Guilbeault, Minister of the Environment. Dec. 16.

Despite its small population, Canada ranked as the tenth highest GHG emitting country in 2019.[6] That year, its 15.4 Mt per capita of carbon emissions was only slightly lower than in major oil producing countries like Saudi Arabia and Oman.[7] The building and construction sector is one of Canada's three largest sources of energy use and GHG emissions, placing third after fossil fuel production and transportation. In 2019, the sector accounted for 90.7 Mt of Canada's 730 Mt total of carbon emissions.[8] Buildings directly account for about 13% of Canada's GHG emissions due to the combustion of fossil fuels for space and water heating, and this increases to 18% if electricity use for cooling, lighting, and appliances is included (Government of Canada).[9] To summarize, buildings are a major source of energy use and GHG emissions. Reducing their climate footprint is essential to meet Canada's ambitious climate goals.

There have been some notable advances to energy efficiency in buildings in recent years, including tougher building and energy codes, stricter minimum energy performance standards for appliances and shifts to more efficient heating technologies like heat pumps.[10] While it is encouraging to see countries implement regulations for higher energy efficiency, Canada remains far from where it needs to be to reach net zero emissions by 2050. Building sector energy intensity would need to drop at a rate nearly five times greater over the next ten years than it has over the last five to achieve Paris climate targets.[11] An additional challenge is the increasing demand in buildings for technologies and services that use more electricity. With global temperatures very unlikely to be contained below the 1.5-degree Celsius target Canada has endorsed, there will be growing pressure to reduce energy use in buildings in the coming decades. This highlights the importance of improving energy efficiency, reducing GHG emissions and simultaneously addressing increasing energy demands in buildings.

The Role of Mechanical Insulation in Conserving Energy and Reducing GHG Emissions

MI refers to the thermal insulation of pipes, boilers, ductwork, and other components of HVAC systems. MI provides the insulation used to control both high and low temperature applications on HVAC systems. It serves numerous functions, including improving energy efficiency, reducing GHG emissions, regulating temperatures within buildings, protecting occupants from exposure to hot surfaces, minimizing noise and facilitating the transfer of temperature-managed liquids in HVAC systems. MI also controls humidity and improves air quality by limiting particulate concentrations, bacteria and mold in pipes and air circulation systems with corresponding health benefits. Proper application of MI requires detailed knowledge of the wide variety of industrial, commercial and institutional HVAC systems, their specific insulation

[6] World Resources Institute web site. https://www.wri.org/initiatives/buildings-initiative
[7] World Bank, 2020.
[8] Environment and Climate Change Canada (2021) National Inventory Report 1990 – 2019 Greenhouse Gases Sources and Sinks in Canada. https://www.canada.ca/content/dam/eccc/documents/pdf/cesindicators/ghg-emissions/2021/greenhouse-gas-emissions-en.pdf; p. 18.
[9] The reason the share of energy use in buildings in Canada is considerably lower than in other developed countries is that Canada is a major producer and exporter of fossil fuels. Absent this factor, the share of energy use in buildings would, arguably, be similar to that of other developed countries.
[10] International Energy Agency. (2021). Net Zero by 2050: A Roadmap for the Global Energy Sector. Ch. 3 pp. 141 – 150. https://www.iea.org/reports/net-zero-by-2050
[11] Ibid.

requirements and the appropriate type, quality, thickness and other aspects of the insulation itself.[12] It also requires installers to keep up with the latest developments in insulation products.

Insulators working in the industrial sector put MI on equipment such as steam turbines, boilers, storage tanks, and heat exchangers in manufacturing and processing facilities including power plants, pulp mills, chemical manufacturing operations, and oil refineries. Insulators in the commercial sector primarily provide insulation to HVAC systems for heating, air conditioning and hot water uses in apartments, offices, shopping malls and many other buildings. In the institutional sector, insulators work on a wide variety of heating and cooling equipment used in hospitals, schools, universities, municipal facilities and other public buildings.

Most HVAC systems are direct contributors to GHG emissions because they are powered by fossil fuels such as natural gas, propane, oil or coal. Those not using fossil fuels are still significant consumers of electricity for space heating, air conditioners, refrigeration units and chillers for hospitals, supermarkets, shopping malls and a wide range of industrial, commercial, and residential applications. Even where fossil fuels are the major source of energy, HVAC systems also use electricity to power motors, fans and other system components that circulate air, steam, water and other fluids in buildings. Depending on the source of electricity (coal, gas, propane, nuclear, hydro, or renewable) the energy used may contribute, indirectly, to increasing GHG emissions.

To meet climate change goals, governments have taken steps to raise the energy performance standards in buildings, including requiring more efficient HVAC systems. Much of this effort has focused on changes to building codes requiring new buildings to meet tougher energy efficiency standards, including specifying higher performance targets in new HVAC installations. Various well-known public and private initiatives have also focused on implementing higher standards, for example the ASHRAE system in the US, the International Code Council used globally, and the LEED certification program widely used in Canada. However, the specifications for MI within these standards tend to be lacking in precise detail, resulting in a regulatory gap.

Although it may seem simple to put insulation on the pipes, ductwork, and other components of HVAC systems, this is not the case. Systems differ widely depending on the economic sector in which they are located. They vary dramatically in size and function. They are produced by many different manufacturers and use varying materials and technologies. [13] Pipes can be made of copper, stainless steel, or a variety of plastics and composites. The type and thickness of insulation required varies accordingly. Similarly, the appropriate insulation for ductwork depends on the type installed, its location in a building system, whether it handles hot or chilled

[12] A more detailed discussion of the various functions of MI can be found on the web page of the Thermal Insulation Institute. https://insulationinstitute.org/

[13] Daşdemir, Ali, Tolga Ural, Mustafa Ertürk, Ali Keçebaş. (2017). Optimal Economic Thickness of Pipe Insulation Considering Different Pipe Materials for HVAC pope Applications. Applied Thermal Engineering. Vol. 12, July, pp. 242 – 254.

air, controls moisture content and a range of other factors.[14] Thus installers must become knowledgeable about a wide variety of different applications of MI.

Unfortunately, there is a widespread assumption in much of the building and construction industry that installing MI does not require much skill and that most of it can be done by almost any construction worker. Hence the way MI is (or is not) installed does not receive much attention, even in buildings that are promoted as low, or zero, energy.[15] Decisions about the qualifications of installers are largely within the responsibility of the contractors who perform this work. In a low-bid, competitive construction industry such as Canada's, it is often much cheaper for contractors to hire, or sub-contract, the work to building workers who have not undergone an apprenticeship in the insulating trade and whose level of training may be wholly inadequate for the job they are assigned to perform.[16]

Recent literature on the effectiveness of energy conservation initiatives in buildings has highlighted the 'performance gap'.[17] This is the difference between the designed energy use of high-performance buildings and the actual energy use once buildings are finished or renovated. Numerous factors influence the performance gap, such as the basic design of the building, materials used, windows, roof and cavity insulation, air tightness and many others. However, the energy efficiency of the HVAC system is also a critical factor. Furthermore, building performance is contingent on all elements of the system being properly insulated so that energy consumption meets design standards such as ASHRAE 90.1.[18]

Too often construction engineers and prime contractors pay scant attention to the details of the type, quality, thickness, and other properties of MI in the plans they provide to contractors and installers. Normally, they give a general description of what they want along with a few basic details and then rely on those installing the MI to make the right choices. Even where HVAC manufacturers and building engineers specify more detailed standards, often they are not able to ensure those installing MI are qualified and their specifications followed properly. This problem

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[14] Thermal Insulation Association of Canada (TIAC). (2019). TIAC Mechanical Insulation Best Practices Guide. (nd). http://tiac.ca/en/resources/best-practices-guide/

[15] Unfortunately, there is no standard terminology to describe low energy, low GHG building standards. Common terms include net zero, nearly zero, high performance, zero carbon, Passive House and a range of others which often reflect subtle nuances in the expectations of each approach for reducing energy and GHG emissions.

[16] H. C. Lanarc. (2010). Pipes Need Jackets, Too: Improving the Performance of BC Buildings Through Mechanical Insulation Practice and Standards – A White Paper. BC Insulators. Vancouver: http://www.mechanicalinsulators.com/research.htm
See also the presentation on "Pipes Need Jackets, Too" from the 2012 BC Green Jobs Conference. https://vimeo.com/39297946

[17] King, Ronald L. (2009). Insulation Investment = Energy Savings and Exceptional Financial Returns. Strategic Planning for Energy and the Environment. Vol. 28, No. 3. pp. 37-52; Zero Carbon Hub (2014) Closing the Gap Between Design and As Built Performance: Evidence Review Report. London: March. www.zerocarbonhub.org/; Hart, Reid and Michael Rosenberg. (2015). "Increasing Flexibility in Energy Code Compliance: Performance Packages." ASHRE Transactions/ASHRE Annual Conference Papers. AT-15-CO13; Gleeson, Colin. (2016). Labour and Low Energy Buildings: the Energy Performance Gap as Social Practice. London: University of Westminster - Westminster Research *34th International Labour Process Conference*. Berlin 04 - 06 Apr 2016. Labour and Low Energy Buildings: the energy performance gap as Social Practice

[18] Gleeson, C.P. and Lowe, R. 2013. Meta-analysis of European heat pump field trial efficiencies. *Energy and Buildings*. 66, pp. 637-647.

is compounded by other trades, or contractors, not appreciating the importance of MI and, for example, failing to leave sufficient clearance for MI to be installed according to industry best practices. Contractors often fail to give insulators adequate time to install MI properly in their rush to complete jobs. As many HVAC components are largely hidden in basements and furnace rooms, improper installation practices often go unnoticed. This results in a significant disparity between what is specified and what gets done.

There are other reasons why MI installations may not meet their design specifications. Contractors may simply not install it in the first place to cut labor and material costs and save time, often with the knowledge that the absence of MI will not be noticed because uncovered pipes and ductwork will be hidden behind new partitions. They may use the wrong type of MI, the wrong thickness or install it carelessly, leaving gaps or ignoring difficult areas such as joints or simply not installing it in hard-to-reach areas. Improperly installed MI can be also hidden by the reflective PVC coating normally wrapped around the insulation, covering up faulty workmanship.

In addition, MI can deteriorate over time and needs to be replaced to restore its protective functions. Effectiveness can also be compromised by building owners or contractors removing it when they perform HVAC maintenance, or repairs, and failing to put it back properly.

Despite its importance for improving energy efficiency in buildings, MI is undervalued by building and facility owners and managers, even though investing in state-of-the-art MI is normally a financially smart decision. In new builds, it normally represents less than 1% of total construction cost, while it can account for saving up to 14% of overall building energy consumption. [19] The return on investment (ROI) for MI work in existing buildings is also normally quite rapid, with costs typically being recovered within a year or two, yet producing ongoing savings for years, or decades, into the future.

Local 131's Efforts to Promote the Benefits of MI Energy Audits

The key element of Local 131's innovative approach to improving MI in buildings is its use of energy audits. The purpose of energy audits is to identify thermal losses from missing, damaged, or improperly installed mechanical insulation. After collecting data from inspecting the piping, ductwork and other areas of mechanical systems, appraisers can determine what upgrades are required, how much this will cost, future energy savings and reductions in GHG emissions. Local 131's energy audit program has been designed to inform building owners and managers of the benefits of carrying out a thorough evaluation of the MI in their HVAC systems.

Once a building owner has agreed to participate in a MI audit, the local has to identify the buildings where audits are needed. Once these are chosen, the local's MI auditor works with building managers to schedule and carry out the audits. On completion, the auditor prepares a report with thermal readings, energy calculations, instances of missing or inadequate insulation, estimated costs and projected savings. It includes thermographic and regular photos of the key areas where energy is being lost. (see Appendix B for a sample audit.) Local 131 also offers to identify qualified contractors willing to bid on the recommended work. The building manager

[19] H.B. Lanarc, op. cit.

then reviews the report and decides whether to tender out contracts for the work. After the work is completed, Local 131 returns to do a final quality control inspection to ensure the upgrades meet the specifications in the audit report. The costs of performing the audit and subsequent inspection are charged to the successful bidder.

In developing its energy audit program, Local 131 is building on well-established pathways to improving the energy performance of buildings. There is a wealth of evidence supporting how MI energy audits have led to major energy and cost savings. For example, for over a decade, the US Department of Energy's "Save Energy Now" program has helped numerous major industrial and commercial facilities to benefit from upgrading MI. Through this program, Goodyear Tire found that one of its plants was losing about 1500 lb/hr of steam due to improper insulation. Insulating their process equipment to reduce steam demand has lowered energy consumption significantly and produced annual cost savings of around $400,000. The Department of Energy has a long list of similar case studies on the benefits for firms from refurbishing MI including: Boise, Chrysler, Dow Chemicals, Kaiser Aluminum Shaw Industries, US Steel, West Lin Paper and many more. Auditing the energy performance of MI is a well-established method of conserving energy in HVAC systems.[20]

The engineering community has had a longstanding interest in the question of how to calculate the energy losses (or gains) associated with various kinds and thicknesses of insulation because this can have major financial implications for its clients. With the advance of technology, methods for measuring the energy losses from pipes and ductwork have become more sophisticated. Among the most widely used is a system built around using a thermographic camera to obtain infrared images of the energy released by HVAC components. Local 131 utilizes thermographic cameras to collect data for its MI energy audits and analyses the data using a software called 3E plus, which calculates energy cost savings and allows the appraiser to determine the proper insulation type and thickness.

MI audits utilize thermographic cameras to collect images from key areas of heating and cooling systems within a facility including pipes, duct work, boilers, and related equipment. The type of information collected by thermography cameras for MI audits includes system operating temperature, room temperature, surface temperatures of pipes and ductwork and fuel conversion efficiency. The surface temperature feature identifies dangerously high temperatures in the equipment as a safety warning for personal protection of workers and building occupants. It can also indicate condensation levels and provide information on the correct insulation material and its thickness to minimize this problem.

The camera images are analyzed using a software package called 3E Plus which is now freely available on the internet for the engineering community.[21] 3E Plus software can use its reference tables to make various calculations. According to the US Insulation Institute, 3E Plus software can do the following as part of its analysis of energy use and insulation requirements in HVAC

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[20] See the Department's "Save Energy Now" Website. https://www.energy.gov/search/site?keywords=save+energy+now+program. There are numerous examples in the publications of the Insulation Institute. https://insulationinstitute.org/about-naima/institute-experts/

[21] It can be downloaded from the Insulation Institute at: https://insulationinstitute.org/tools-resources/free-3e-plus/

systems: determine economic thickness of insulation based on fuel cost, installed cost, tax rates, maintenance, and other economic factors; calculate insulation needed for personnel protection in various design conditions; calculate thickness of insulation for condensation control; calculate greenhouse gas emissions and reductions; determine surface temperature and heat loss or gain efficiency; perform calculations for flat surfaces and various pipe sizes.[22] It can also estimate the return on investment (ROI) once the costs of fuel, insulation materials and labor are entered into the system.

This information is then used to compile a final report for building managers and owners. The software has the capacity to calculate the insulation impact of a wide variety of standard insulation materials at different thicknesses. It covers HVAC systems using the following energy sources: natural gas, oil, liquified petroleum gas (LPG), coal and electricity using appropriate measurement units such as BTUs. It also covers the insulation capacity of 15 jacket materials, such as aluminum, steel, copper, canvas and PVC cladding. New materials coming on to the market can readily be added to its calculation tables.

History of MI auditing in Canada – The BC Insulators and Salamander Inspections

The MI auditing work of Local 131 in NB has drawn upon earlier work by BC Insulators Local 118 between 2010 and 2017 which was designed to inform building owners of the value of MI in conserving energy, lowering GHG emissions and saving money. The BC Insulators explicitly linked its promotional campaign to Canada's efforts to lower the climate footprint of the construction sector, using as its moto the phrase: 'saving energy and saving the planet'.

Its campaign was triggered in 2010 by witnessing the extent to which the newly constructed Olympic Village in Vancouver failed to meet its heavily promoted environmental and climate benefits. The union's detailed on-site examination of the project's HVAC installations found that much of the specified insulation was either missing, of the wrong type and thickness, or improperly installed. Failure to conform to industry standard MI practices undermined achieving the sustainability goals the Olympic Village builders advertised to the public.[23] In fact, some of the problems, such as rapidly growing mold, were already emerging before the final units were completed. The local also noted that faulty MI compromised the health of building residents due to excessive condensation, dampness, mold and contaminated air circulating in HVAC systems.

Facing resistance from the engineering firm overseeing the Olympic Village construction and the City of Vancouver, who denied the significance of the issue, the BC Insulators used its media contacts to demand that the work be rectified. It also commissioned a 74-page report on the state of the MI industry in BC by a well-respected consulting engineering firm, H.C. Lanarc entitled: "Pipes Need Jackets, Too".[24] The report highlighted the widespread failure of the industry to install MI properly. It documented the high cost to building owners of this failure through excessive energy consumption, premature deterioration of building components from

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[22] Ibid. (Insulation Institute web page)
[23] Calvert, John and Corinne Tallon. (2016) "The Union as Climate Change Advocate: The BC Insulator's Campaign to 'Green' the Culture of the Building Industry in British Columbia" International Labour Process Conference. Berlin, April. https://yorkspace.library.yorku.ca/xmlui/handle/10315/39424
[24] H. C. Lanarc, op. cit.

condensation and mold, adverse health impacts and shortened life span of HVAC systems. It identified numerous gaps in BC's regulatory framework and made the case for much stronger MI standards in the provincial and municipal building codes. It also pointed to the need for governments to increase their capacity to regulate the industry to require it to comply with industry best practices.

Noting the extensive confusion about the appropriate methods and standards required to install MI, the local also commissioned an 86-page manual on best practices entitled: "Mechanical Insulation Guide and Specifications for British Columbia" which it provided at no charge to the industry through a web site it established to promote higher insulation standards.[25]

Local 118's work has also influenced the training program for apprentices that the International Association of Heat and Frost Insulators (the International) provides for its member locals. Copies of "Pipes Need Jackets, Too" and the MI training manual are made available to students taking its program. Drawing on the research of the BC Insulators and working with the industry, the International has encouraged members of its affiliated locals to learn energy auditing and the use of 3E thermography software to enable them to become certified to perform MI energy audits.

Another impact of its campaign has been the adoption of much more detailed MI specifications in Canada's building and energy codes. As provinces base their codes and those of their municipalities on the national codes, these, too, have been modified to require higher standards of insulation. Additionally, the revised Red Seal requirements for apprenticeship training now include more detailed requirements about best practices in applying MI.

Increasingly, insulator locals are now highlighting the positive role of their trade in contributing to lowering the climate footprint of the building industry. Over the past decade, the role of MI in reducing society's climate emissions has become more widely understood in the industry, as has the value of carrying out energy audits to provide the evidence to building owners of the benefits of higher standards of MI.

The BC Insulators followed their campaign to raise awareness of the value of MI by establishing a new, not-for-profit company, Salamander Inspections, to provide free energy audits to building owners and managers as a way of demonstrating MI's potential energy savings and climate benefits. The company conducted comprehensive audits of MI on a number of HVAC systems in hospitals, schools, and shopping malls in BC, government buildings in Alberta and the legislature in Saskatchewan. It shared the audit reports with building owners at no charge to encourage them to refurbish the MI in their pipes, ductwork and boilers.[26]

[25] BC Insulators. (2012). Mechanical Insulation Guide and Specifications for British Columbia. August 7. https://www.energyconservationspecialists.org/wp-content/uploads/2019/03/Mechanical-Insulation-Guide-for-BC-Aug-7-2012.pdf

[26] Calvert, John and Corinne Tallon. (2019). The BC Insulator Union's Campaign to Promote Climate Literacy in Construction (Salamander Report): Documenting Its Efforts to "Green" The Industry's Culture. This paper summarizes the details of these inspections. https://yorkspace.library.yorku.ca/xmlui/handle/10315/39313

While the audits indicated areas where significant savings could be made, the BC insulators had difficulty in getting the managers of public buildings to implement the recommended insulation improvements. Senior policy makers did not understand – or did not believe – that there were significant potential energy savings. The BC Insulators also found that owners were reluctant to tender out the proposed work as they were not familiar with the insulation industry and had other priorities. Non-union contractors were not receptive to supporting a union initiative and did not follow up on the work proposed in the audits. Unfortunately, without buy-in from contractors, the BC Insulators did not have the resources to continue this free auditing work. But by initiating the Salamander program, Local 118 provided a model for the more recent MI auditing work now being carried out by Local #131 on the other side of the country.

Local 131 and the Development of Its MI Energy Auditing Program

Local 131 currently represents approximately 300 mechanical insulators and 100 apprentices in New Brunswick (NB) and Prince Edward Island (PEI). Members work in industrial, commercial and institutional settings. Historically, the local has focused primarily on the industrial sector, including pulp and paper mills, oil refineries and electrical power plants, including nuclear facilities. In the industrial sector, noted above, the market share of unionized MI contractors has historically been about 95% because this work requires a high degree of skill and careful installation practice. Industrial facility managers are acutely aware of their energy expenditures and correspondingly, the costs of faulty or inadequate insulation. Accordingly, they have demanded high standards of energy performance. However, parts of the industrial sector have contracted in recent years in NB as pulp and paper mills and manufacturing plants have downsized or closed. Industrial facilities have also become more automated and less energy intensive, impacting jobs and employment security of members of the insulating trade.

However, in the commercial and institutional sector, the historical pattern of work for unionized MI contractors has been quite different. According to Mr. Joshua Sherrard, President of Local 131, the market share of unionized contractors in this sector was only about 5% until recently. Most building owners and managers in this sector are not aware of the impact of MI on their energy consumption and do not recognize the significant benefits from refurbishing their MI. The local realized that there was a large, untapped need for improving MI in many commercial and institutional buildings. This would also provide additional employment opportunities for its members.

Since 2017, the local has become increasingly involved in retrofitting MI installations in this sector, including numerous public schools and Mount Allison University. Overall, Local 131 has completed MI energy audits in 43 public schools throughout NB, of which 32 have resulted in follow up work to implement the recommended upgrades. In the last year, an impressive 14 of 16 audits in public schools resulted in follow up work. The local has also been involved in a larger scale audit of the entire Mount Allison campus which comprises over thirty buildings and approximately 3.5 km of tunnels for their heating system. Its audits have identified where upgrading MI is needed to improve energy efficiency, reduce GHG emissions, and generate financial savings for the facilities.

A key factor incenting building owners to refurbish their MI has been the very short time frame for the ROI which is well documented in the literature. Typically, the ROI for MI upgrades is under two years. and sometimes it is less than one year. This is far less than many other energy conservation initiatives. Since initiating the audit program in 2017, Mr. Sherrard estimates the market share of unionized contractors in this sector has increased to about 85%.

MI audits have been very successful in creating new work for mechanical insulators. Local 131's membership has roughly doubled in size since 2017, largely through its auditing program. The number of apprentices has also increased from averaging 20 to 30 before the audit program, to its present size of about 100, a remarkable increase in so short a time

Local 131's Auditing Work Using Thermographic Cameras and 3E Auditing Software

Mr. Sherrard began performing MI energy audits in public schools in NB after taking a thermography course sponsored by the International Association of Heat and Frost Insulators in cooperation with the US National Insulation Association (NIA) in Edmonton in 2017.[27] This week-long course taught attendees from locals across Canada how to use the 3E Plus software for the purpose of MI energy audits. As noted, this software is an industry standard used across North America. Following this training, Mr. Sherrard also took a Level 1 certification course at the Infrared Training Center in Toronto in 2017 to further develop his skills in using this technology. This training course focused on adjusting the thermography camera settings to increase the accuracy of photographs and temperature readings used in the audits. It is recognized throughout North America and is targeted to a variety of professionals who utilize thermography cameras, from mechanical insulators to firefighters. As a result of this training, Mr. Sherrard felt that promoting energy audits could significantly expand the MI trade in NB. He then persuaded the local to invest roughly $10,000 on the purchase of a thermography camera.

Mr. Sherrard performed his first two energy audits in the elementary and high schools he had attended in the Anglophone North School District. The school district currently has about 7,000 students and 29 schools according to its 2021 annual report. It spends about $4 million on energy annually. Mr. Sherrard chose the schools he attended because he was familiar with their layouts and because he realized that there would be a learning curve to become proficient in the use of the 3E Plus technology. Public schools were also less challenging than facilities such as hospitals with their complex heating systems. Mr. Sherrard knew the finance director and the facility manager of his local school and persuaded them to allow him to try out what he had learned in the 3E Plus thermography course. The school district gave him the time and support to do these first audits thoroughly, which was important for Mr. Sherrard given this was his initial attempt at using the technology.

The audits found major energy losses in the school HVAC systems due to inadequate MI. The software provided extensive data on the estimated energy losses, GHG emissions and fuel use.

[27] The National Insulation Association is a not-for-profit trade organization that includes unions and insulation employers installing industrial and commercial insulation. It carries out research, education and training programs for the industry and offers a thermal insulation inspector certification for engineers and trades' installers. Information about its activities and its publications can be found at its web site: https://insulation.org/about-nia/

Inadequate MI was costing the school district significantly, given the high price of the fuel being used to power its heating and hot water systems. The audits indicated that energy use could be significantly reduced by re-doing the MI. Specifically, the estimated 5-year savings for the two schools were $1957.40 and $10,799.45, with projected return on investment (ROI) periods of 4.2 years and 1.6 years, respectively. Annual CO_2 reductions were estimated at 1.95 Mt and 9.95 Mt. These findings indicated that getting the work completed would be a strategic investment for the school district. After viewing the data in the audit reports, the school district's finance director agreed to tender contracts to complete the work in one school.

The school district agreed for Mr. Sherrard to share the audits with insulation contractors he knew and ask them to bid on the work. Three contractors with whom the union had collective agreements submitted bids. The school district selected its preferred contractors for each school and proceeded to have the work done. Once completed, Mr. Sherrard performed a second audit of the HVAC systems to check if it had achieved the anticipated reduction in energy use and corresponding cost savings. The findings confirmed that the MI upgrades had achieved the expected results. This confirmed the value of the audit initiative.

The Anglophone North School District was also the host of a new school being built as a model for other schools in New Brunswick due to its incorporation of the latest LEED specifications. During Mr. Sherrard's presentation to the school district on his initial two audits, the provincial engineer involved with the project and the school district agreed that he could do an audit of the new school to assess its efficiency compared with the older schools. The audit found that the HVAC system in the new school was no more energy efficient than the older schools. This alerted the school district that it had to take a more 'hands on' role in ensuring that both the specifications and the delivery of future low energy technology in schools met current industry standards of insulation. This experience also encouraged the school district to have Local 131 perform additional audits on many of its other school buildings. Approximately 75% of its schools have now been audited.

Based on his success in the first school district, Mr. Sherrard was keen to expand the auditing work to other educational facilities in the province. However, at first, he faced considerable skepticism from provincial school building managers elsewhere in New Brunswick about the savings that could be achieved. They questioned whether a union could have the capacity to use the sophisticated technology capable of identifying potential energy savings from refurbishing MI. Mr. Sherrard was not a professional engineer and questions were raised about the accuracy of his audits. However, since he was using the same 3E Plus technology that engineers use across North America, the results of the audits conformed to the industry standards and could be readily duplicated by any engineer. His credibility was further supported by the evidence from the audits he had successfully performed.

After persistent lobbying, Mr. Sherrard met with the provincial Department of Transportation and Infrastructure committee to explain the audit process and present the findings from his own school district. These findings sparked interest within the Department and with other school boards and their school facility managers. His presentation opened the door to other school districts requesting Mr. Sherrard to carry out audits on their buildings to see if they could also benefit from MI upgrading. Since then, it has expanded its auditing program significantly. Local 131 has now performed audits on school buildings in five of NB's seven school districts.

While his initial audits were performed in NB's public schools, Mr. Sherrard wanted to expand the scope of his work to larger facilities. Mount Allison University had considered making upgrades to the MI on its campus for years prior to the audit the local conducted. However, organizing this work was not easy. For a university to justify funding a major retrofitting project, it requires information on the capital cost and return on investment to ensure the money will be well spent. Without the expertise to carry out the audits, Mount Allison was not equipped to make these estimates. Identifying contractors to complete the work without contacts in the insulation trade posed further challenges. For these reasons, Mount Allison had delayed taking steps to upgrade MI in their buildings. However, one of the contractors working with the university, Icon Insulators, suggested to the University's energy manager that it might benefit from Local 131's auditing program.

After being introduced to the energy manager at Mount Allison University, Mr. Sherrard was given authorization to perform two pilot audits, one involving the central heating plant and another a newly retrofitted building. After seeing the high level of detail in the reports and the savings that would be generated by the upgrades, the energy manager decided to commission an audit of the entire Mount Allison campus, comprising over thirty buildings and the school's 3.5 km tunnel system. About three quarters of this work is now completed.

Mr. Sherrard is currently working with McCain Food's to conduct thermography imaging in some of their processing plants. They have recently completed work in one plant in Alberta, and there has been discussion of performing similar work in plants in Graham Falls and Florence Ville, NB, and possibly two plants in Manitoba. The audits in provinces outside of NB might involve insulators from locals in those provinces, providing a way of expanding the program nationally and perhaps providing opportunities for other insulation locals to gain experience in auditing. He has also been in contact with several hospitals in PEI to explore performing initial audits on several of their facilities. While completing energy audits in hospitals is challenging due to infection control issues and the heightened complexity of hospital heating and cooling systems, the potential for energy and financial savings within healthcare systems is also very significant. Finally, local 131 is exploring a federal government pilot project involving auditing six public buildings in NB. If it moves forward, this project may provide opportunities for the expansion of the program nationally which would bring other insulator locals across Canada into energy auditing work.

Local 131's Audit Model – An Innovative Approach to Engaging Contactors

As noted, the British Columbia Insulators Union initiated an MI energy auditing program called the Salamander Inspectors (named after an icon symbolically used by insulators),[28] similar to what Local 131 has recently carried out. Through this program, it audited 6 hospitals on

[28] For an account of the history of the use of the term Salamander, see: https://www.insulators.org/salamander-story#:~:text=It%20is%20believed%20to%20have%20been%20the%20symbol,their%20reasoning%20have%20been%20lost%20over%20the%20decades.

Vancouver Island, a large shopping mall in Coquitlam, a number of government buildings in Alberta and part of the Saskatchewan legislative building. Its inspectors provided detailed calculations about the potential energy savings and GHG emissions in their audits to the officials operating these facilities.

However, a major problem the BC Salamander audit program faced was that the union did not have the ability to ensure that the free audits it provided to public and private building owners were followed by contracts to do the work.[29] Consequently, although the Salamander program had carried out a significant number of audits, and indicated where building owners could make significant savings, most never resulted in actual work orders.

Local 131 took a different approach to ensure that building owners followed up on its audit reports by tendering the work required to upgrade their MI systems. The local already had collective agreements with various insulation contractors in the province. Based on the experience learned from the first schools it audited, where it had shared audits with prospective contractors, it decided to assist school administrators and facility managers in its subsequent projects by linking them to MI contractors interested in performing the work. This meant sharing the audits with potential contractors as a standard practice. To guarantee competition, the local has normally arranged to have at least three contractor bids per project so that school districts have a choice of who does the work. The local also made clear that school districts were free to use the audits to find other contractors if they did not feel the unionized contractors working with Local 131 were sufficiently competitive.

Local 131 developed several quality control measures to ensure the work meets industry standards. It provides contractors with detailed information about the work, including a description of the standards of material and workmanship required to meet the terms of the contract, and a 'walk through' of the facilities being upgraded to explain the technical details of the project. The union also promoted another key quality control measure: a requirement that the work be performed by qualified Red Seal insulators (or apprentices working under them). This is because the MI upgrades had to be done properly or the projected energy savings would not materialize. While any contractor employing Red Seal insulators – both union or non union - could meet this requirement, in reality meeting it was not a problem for unionized contractors as they employed fully qualified Red Seal insulators.

Additionally, Local 131 committed to providing follow up audits after the contractors complete their work to ensure standards have been met. If the work does not meet the specifications in the audit report, the local requires the contractor to redo the work in accordance with industry

[29] The reasons for the failure of owners to pursue the potential savings identified by the Salamander audits are not clear. One possible reason is that the owners did not have the capacity to identify appropriate contractors to perform the work because they were not familiar with the insulation business. Another is that more senior managers had little interest in seemingly minor issues associated with the operation of their HVAC systems and were skeptical of the potential savings. So the audits failed to gain the attention of those with the decision making capacity and budget authority to authorize tendering the work. A third reason is that the union did not have collective agreements with contractors who, potentially, could have performed the work. Non-union contractors had little interest in working on a project initiated by the union. Finally, the union's own resources were limited. It did not have the capacity to carry out the follow up work needed to keep the audit issue alive and on the agenda of decision makers in large institutions such as health authorities where facility managers had little influence in the overall budgeting process.

standard specifications. It has done this on several occasions, resulting in a greater attention to detail by the contractors. The union has made clear to its own members that high quality work is essential if the initiative is to continue to obtain further work for them. This helps to provide additional security for the clients because they can be confident that the quality of the work and the savings generated align with the estimates in the audit report.

One of the challenges facing insulation contractors was generating work for their companies. Typically, contractors would be doing outreach to clients and advertising the benefits of MI. However, persuading potential clients to do an energy audit was a burden for them because they had to show clients the benefits of an audit and then persuade clients to pay to have it done. This was not always easy to do as clients were not necessarily keen to pay for something whose benefits were not obvious from a company that would benefit from doing the audit.

Alternatively, contractors could do it free of charge. But they had no guarantee that clients would budget for the upgrades proposed in their audits, leaving them with nothing to show for the time and money spent. Even if the prospective client decided to pay for the work, they had no guarantee that their firm would get the contract if the work were tendered out because other contractors might be the successful bidders. The model created by local 131 eliminated these risks by offering contractors the opportunity to bid on jobs after the audits have been completed with the specifications of the work clearly spelled out and a commitment from the client to do the work. Consequently, while the local charges the winning contractor for its costs for performing the work, firms have found this acceptable because they only pay if they get the contract. And it is the union that has provided them with the work.

In the initial years of the project, Mr. Sherrard took primary responsibility for communicating with prospective school districts during the auditing, bid development, contractor outreach and subsequent auditing of the completed work. However, more recently contractors who have participated in the initiative are playing a greater role in advertising the local's auditing work to other prospective clients. As this generates more work for them, they have an interest in promoting the initiative. As noted earlier, Icon Insulators, connected the energy manager at Mount Allison University with Mr. Sherrard resulting in audits of buildings across its entire campus. The mutually beneficial relationship between the local and the contractors employing its members is at the center of what makes this model so effective.

Addressing Other Barriers

As discussed above, the local's audit process has helped to address barriers for those involved in facility management who may lack the knowledge or tools to conduct their own MI audits by providing detailed and reliable information. In addition, Mr. Sherrard has made a point of establishing relationships with facility managers and other administrators involved. This involved discussing his findings with them and going over the cost projections and savings to ensure they understood the basis of his calculations. Meeting with finance directors has been particularly valuable as they are often the final arbiters of whether to proceed with the contracts and, consequently, they need to feel comfortable that the ROI projections are accurate.

Building managers have commented that he often makes suggestions about how to improve other aspects of their HVAC systems in his ‘walk throughs’, even if this will not result in any work for insulators. He has shared his knowledge of how MI systems work so that facility managers will have a deeper understanding of how these systems work and be able to identify and address potential problems in the future.

Another factor facilitating the expansion of the program has been the very short time period of the ROIs compared with other options. As part of their commitment to climate change, school district administrators had been promoting other energy saving programs such as replacing conventional lighting with LEDs, installing low flow toilets, double glazing windows, upgrading to more efficient boilers and so forth. They were encouraging facility managers to think about ways to meet climate and energy targets. However, the experience with some of these upgrades was not always positive. Initial investments were often quite expensive, the ROI for them took up to a decade before they broke even and it was not easy to measure precisely how much benefit flowed from some of the investments in the first place. In contrast, as the data from the school district audits demonstrated, the ROI for upgrading MI was normally not much more than a year and the audits provided good estimates of energy savings and GHG reductions.

When asked if he received pushback from facility managers who might resent him intruding into their area of responsibility and, by inference, indicating that they were not on top of the issue of how competent they were in managing their power plants, Mr. Sherrard indicated that occasionally this was an issue. Some were initially wary about him auditing their facilities. The word ‘audit’ was sometimes misinterpreted to mean that he was going to audit them, personally, on their work performance. Understandably, they were not enthusiastic about audits if this meant having their performance evaluated by an outsider. However, once he explained that the audit was not about assessing their performance, but rather about using his technical expertise to assess the quality of the insulation on the system, they were normally receptive to him performing the audits. Moreover, the prospect of having a better work environment in the boiler rooms and connected facility offices due to better temperature and moisture control from upgraded MI was a benefit they recognized. Improvements to MI could also show they were helping school administrators meet climate objectives.

Perhaps the biggest initial barrier Mr. Sherrard faced was from the provincial Department of Transportation and Infrastructure. It was reluctant to support his initiative as it did not appreciate the value of MI audits and was not convinced that he was presenting information which was normally within the scope of professional engineers who designed HVAC installations. How was he as a trades’ person able to second guess the work of these professionals who were not raising concerns about the issue of MI.

Given its responsibility for school infrastructure and its role in establishing specifications for buildings, the Department was also concerned that he was working directly with the school districts to perform the audits rather than through its provincial building management system. Hence it was not in control of the process. It took Mr. Sherrard considerable time to finally be permitted to do a presentation to the provincial committee, an opportunity which came about largely due to the advocacy of some of the school building managers for whom he had done audits. Its reluctance was overcome once it became clear that the audit program was generating significant savings for school districts. Additionally, school districts that had used the audits were strong advocates for expanding the program.

Another potential barrier was that the new work generated by audits might not be shared among contractors in a way they felt was equal or fair. The union has understood the need for it to be seen as completely impartial. It has felt it important to demonstrate that it does not try to favour any bidder and that contractors see its position as neutral. This is also important internally for the union because it has members with all the unionized contractors and cannot be seen to advantage one over the others. Thus far allocations of contracts among school districts appears to be balanced. In 2021 educational institutions awarded contracts for 16 MI projects of varying sizes. Each of the three contractors has received about the same value in dollar amounts, with some getting more, but smaller, contracts and others getting fewer, but larger ones.

Projects have been spread out across different regions in NB. Contractors tend to have manpower concentrated in certain regions. Those who have more manpower in a region where there is a potential project are typically able to offer lower bids compared to contractors who need to account for the cost of travel for their workers. So on balance things have worked out in a manner that gives each a fair opportunity to gain work. Thus far, contractors have not had reasons to believe the union is favoring any of them over the others and this ensures that they are all willing to continue to bid on projects. Being able to show that there is fair competition is a major selling point for the union in persuading school districts to tender contracts for MI upgrades.

Cost Savings from the Initial Five Audits

The scale of the financial savings generated by completing MI upgrades is illustrated in the audit reports. Audits from the five of the first schools audited found that significant savings could be realized because the insulation on many HVAC components did not meet industry standard best practices, resulting in excess thermal loss as revealed in the thermography images. Savings could be realized by upgrading under-insulated areas to 1-inch-thick fiberglass or to replacing 1-inch by 1.5-inch where appropriate. Taking account of the initial capital investments, the estimated annual cost savings associated with the recommended upgrades for these five schools ranged between $2,159.00 and $65,474.00 depending on the size of the respective schools' HVAC systems and the extent of the recommended upgrades. Additionally, carbon dioxide emissions reductions were estimated at between 9.39 Mt and 137 Mt annually. Remarkably, the estimated ROIs for all five projects was around one year, with the longest being 1.8 years.

The following table presents the estimated savings, carbon dioxide emissions, and ROIs from the five energy audits.

Table 1. Summary of Energy Audits Conducted in the Initial Five New Brunswick Public Schools

Schools	Contract Cost ($)	Energy Savings (kBtu)	Cost Savings ($)	CO2 Reduction (Mt/Yr)	ROI (years)
School 1	2,961.00	140,448	2,159.00	9.95	1.6
School 2	41,966.00	2,348,299	65,474.00	137	0.7
School 3	43,532.17	862,146	38,512.00	58	1.3
School 4	10,545.22	255,168	7,527.00	14.79	1.6
School 5	7,239.13	154,629	4,547.69	9.39	1.8

Source: Energy Audits by Local 131 as presented to the initial 5 schools

In addition, the audits included a detailed breakdown of the savings in each section of the HVAC system where MI upgrades were recommended. For each section, the audits provided specific information on annual fuel cost, one-year savings, five-year savings, and carbon dioxide emission reductions as well as the type and thickness of insulation recommended for each component of an HVAC system. (See Appendix B for illustrations.) This level of detail allowed facility managers the option to choose their priority areas to commission MI upgrades if a full upgrade was not within their budget. Thus, they could choose to focus initial work on the area with the greatest potential savings and leave other work to be carried out later as their budget permitted. As the savings in most areas were still quite substantial, in practice school districts tended to do the entire project rather than space it out over several budget cycles.

Expanding the Scope of the Program

Having established that audits could be a viable way for schools to reduce their energy consumption, Mr. Sherrard expanded the scope of his work to many more schools across the province. As of August, 2022, he has now completed audits in 43 schools. He has also carried out a comprehensive audit of buildings in the campus of Mount Allison University which we will discuss further in this paper.

School districts have now completed MI upgrades in 32 of the 43 public schools which the local has audited. The following table presents the projected annual energy savings, cost savings, and CO2 reductions from these investments in upgrading their MI. The table also includes the projected savings from the upgrades at Mount Allison University. The audits have generated projected annual savings of over 22 million kBtu (one-thousand British thermal units) of energy. They will result in estimated financial savings of over five hundred thousand dollars per year while lowering GHG emissions by over 33,000 Mt per year.

These numbers do not take into account the hundreds of thousands of dollars that school districts will continue to save each year for the life of the upgrades. The average ROI period for these schools is only 1.43 years, with the lowest at 0.5 years and the highest at 3.6 years. The average contract cost is $24,254.81, with the lowest at $2,961.00 and the highest at $366,490.00. Schools 1-32 in the table below are public schools, and school 33 is Mount Allison University.

Table 2. Summary of Projected Energy and Cost Savings Generated by MI Upgrading

Schools	Contract Cost ($)	Energy Savings (kBtu)	Cost Savings ($)	CO2 Reduction (Mt/Yr)	ROI (years)
School 1	2,961.00	140,448	2,159.00	9.95	1.6
School 2	41,966.00	2,348,299	65,474.00	137	0.7
School 3	43,532.17	862,146	38,512.00	58	1.3
School 4	10,545.22	255,168	7,527.00	14.79	1.6
School 5	7,239.13	154,629	4,547.69	9.39	1.8
School 6	9,312.17	174,689	5,728.00	20	1.9
School 7	21,488.00	2,143,494	26,886.01	123.3	0.7
School 8	5,335.00	50,793	5,913.67	28.38	1
School 9	4,243.00	35,387	3,990.69	18.68	1.2
School 10	3,985.00	76,449	3,045.69	14.73	1.2
School 11	10,656.00	138,271	8,531.00	27.93	1.4
School 12	22,485.00	2,139,657	56,626.90	180.76	0.5
School 13	4,752.00	8446	1,319.88	3.87	3.6
School 14	7,806.00	11,894	5,802.44	18.06	1.3
School 15	29,174.00	1,686,992	45,546.99	148.82	0.6
School 16	12,859.00	25,779	5,942.01	14.18	0.9
School 17	8,020.00	23,548	6,055.40	14.52	1.1
School 18	12,052.00	33,194	8,758.54	21.43	0.9
School 19	5,340.00	25,322	5,185.92	12.24	1.2
School 20	19,981.00	411,957	10,774.00	26.74	1.9
School 21	7,827.00	36,226	5,823.00	13.86	1.3
School 22	10,017.00	20,079	6,006.00	1576	1.7
School 23	8,805.00	19,665	4,972.00	12.32	1.8
School 24	21,264.00	932,606	22,866.50	57.74	0.9
School 25	4,660.00	20,612	3,838.00	8.99	1.2
School 26	16,210.00	488,861	9,131.00	30.63	1.8
School 27	32,153.00	1,438,253	28,958.00	112.37	1.1
School 28	5,554.00	137,958	5,173.00	22.5	1.1
School 29	12,806.00	225,790	8,519.00	37.54	1.5
School 30	7,857.00	94,459	3,501.00	15.75	2.2
School 31	15,595.00	662,394	13,168.00	43.91	1.2
School 32	7,439.00	240,933	4,859.45	19.48	1.5
Mt Allison	366,490.00	7,584,579.27	95,168.40	483.00	3.6
Total	797,447.69	22,648,977.27	528,151.18	3326.91	--

Source: MI Audits conducted by Joshua Sherrard 2018 – 2022 (note: this table excludes the other 10 audits which have been completed but which have not yet resulted in MI upgrades.)

The Contribution of MI to Addressing Climate Change

As can be seen in the above table, the MI upgrades in the buildings Local 131 has audited have generated major energy savings as well as significant CO_2 reductions. The program will result in an estimated 22 million kBtu in energy savings annually, as well as reductions in CO_2 emissions of over 3,327 megatons per year.

Despite MI upgrades being a cost-effective way for institutions to save energy, its environmental role has been frequently overlooked to 'green' the building sector and meet climate objectives. One reason is that MI is often ignored as an important contributor to a building's energy efficiency, compared to other components of construction such as building design and orientation, sealing and insulating the building envelope, energy efficient windows, heat pumps and a wide variety of other materials and technologies. School districts have normally focused on these other options because they were not aware that MI could unleash major savings in energy use. It was through the MI audit program that refurbishing MI became a priority for them.

Many public institutions including schools, universities, colleges, and hospitals, as well as provincial and federal governments, are actively looking to increase the energy efficiency of their buildings. For some the motivation may be to meet public policy commitments on climate change which have been incorporated into their policy mandates or their business plans. For others, energy savings may be viewed primarily through the lens of reducing costs. And for others, the motivations are mixed as reducing energy use has both climate and financial benefits.

Mount Allison University has made a major commitment to lowering its climate footprint. The University is committed to being a leader in promoting progressive climate solutions in all aspects of its operations. This involves creating a campus culture in which faculty, students and staff are committed to lowering the carbon footprint of their various activities. The University regularly issues reports on its progress in meeting climate objectives. Demonstrating progress on the issue is also an important signal to students who, increasingly, are involved in sustainability projects on campus and who want to see the university taking a leadership role in tackling climate change. Mount Allison now incorporates its MI audit program as a component of its overall climate strategy. In its report to the campus community, the Finance Vice President has referenced the program on several occasions as an example of how the University is taking practical measures to support its commitment to meeting its climate targets by reducing its energy footprint.

The use of 3E Plus software as part of the auditing process encourages building owners to think about their climate impact. Because 3E Plus software provides data on the volume of carbon emissions being released from HVAC systems, it provides clients, such as Mount Allison University, with concrete evidence of the impact of their efforts to lower the carbon footprint of their buildings. Having access to this data also encourages clients to think about the impact of MI on the climate when considering whether to proceed with commissioning work because the audit reports highlight the anticipated GHG reductions.

The auditing process has another climate benefit. Producing data on GHG emissions as part of the auditing process encourages apprentices and qualified insulators to view their trade through a climate lens and to understand its value in meeting society's climate change commitments. It raises awareness of the importance of addressing the climate challenge. Teaching apprentices to use the software provides an excellent opportunity to expand classroom discussions about the value of their work and how the MI trade and the construction industry, more broadly, can be part of the climate solution.

Client feedback On the Impact of Local 131's MI Energy Audits

In our interviews with building facility managers, they noted that MI upgrades improve the health safety and overall comfort of building users. Better insulated pipes and ductwork reduce the risk of burns or scalds from hot pipes and boilers. State of the art MI makes buildings more comfortable because temperatures are better controlled, something staff appreciate. It also makes working in furnace rooms less challenging because they reduce the extent to which many of these rooms are over-heated due to the energy coming off poorly insulated fixtures. Insulation also reduces condensation and resulting growth of hazardous mold which can circulate through air flowing in the ductwork and cause major health problems for building occupants.

Interviewees also noted that improving MI can lead to better functioning of other systems in buildings. For example, one school district wanted to switch to a less costly refrigeration system in a school but was unable to proceed because the temperature of the utility room to be used by the unit was too high for the system to work efficiently. Once the HVAC system was insulated properly, the temperature become low enough to facilitate switching to the new, more cost-effective refrigeration system. This generated savings for the school in addition to those associated with the direct energy savings from MI upgrades. One of the interviewees noted that improved insulation had benefitted many other components of his mechanical systems. Lowering the air temperature in furnace rooms meant electrical equipment operated at more optimum temperatures, meaning it lasted longer with fewer break downs.

Facility managers and school administrators who have worked with Mr. Sherrard have gone out of their way to recommend his work to other institutions, effectively becoming 'cheerleaders' for the program. Based on their experience with the MI upgrades, Anglophone North School District managers promoted Mr. Sherrard's work to the seven other school districts in NB and the union has now completed audits in schools in five of the districts. The manager at Mount Allison University has recommended Local 131's work to facility mangers of the Atlantic Universities and Colleges network, suggesting that they bring Mr. Sherrard in to do energy audits on their campuses.

After working with Mr. Sherrard and learning about the numerous ways in which MI affected the performance of his HVAC system, another manager indicted that he had learned a great deal about the system which he did not know before the audit. Now when he walks around his buildings, he is constantly looking at the equipment and thinking about how it could become more efficient. He wonders what is underneath the nice white PVC covering on his pipes and remembers that previously this sometimes covered up insulation that was not properly installed. He also thinks much more about the quality of equipment. How efficient is it? How long will it last? Does it make sense to use cheaper, but lower quality, parts when this will likely result in extra costs for the labor required to repair systems more frequently?

An example he gave was that although more expensive, installing high quality filters is more economical, not only because they last longer but also because they save labor and do a better job of what they are designed to do than cheaper substitutes. He is more sensitive to the reality that getting the cheapest equipment or the lowest bid on maintenance is often far more expensive in the long run, an observation reinforced by experience with some low bid contractors whose work proved to be sub-standard. Thus, the experience with upgrading MI has had other positive impacts on the overall approach to building maintenance of some building managers.

Protecting the Health and Safety of Building Occupants

Many older HVAC systems were insulated with asbestos. This creates a significant health risk for those working or studying in schools, universities, and other buildings. Asbestos removal is a specialized job which requires specific training and the use of extensive precautions both to protect the workers removing it and to ensure that the asbestos is not released into buildings where exposure to it can damage the health of occupants. Refurbishing older MI thus has to be done in a way that takes account of the possibility (or in many cases likelihood) that asbestos is present in the pipes, ductwork and boilers. The cancers caused by asbestos, and particularly mesothelioma, are now the largest expenditure for workers' compensation boards across Canada. Asbestos caused cancers are responsible for thousands of deaths each year in Canada. For this reason, it is essential that those performing work on HVAC systems are properly trained and qualified to do this work.

The members of Local 131 receive extensive training in asbestos removal and disposal as part of the trade's apprenticeship program. They are fully aware of how hazardous the mineral is and consequently how careful they have to be in handling it. They also are taught to recognize the various forms of asbestos which, historically, have been used to insulate HVAC systems. One component of the union's audit program involves checking to see if asbestos is present. If it is, safe removal is part of the recommendations included in the audit. This is another benefit to building owners as the use of qualified MI contractors ensures that work will be carried out safely. In his interview, Mr. Sherrard stated: "I am not sending somebody into the school to create a health hazard."

A related issue is fire stopping in buildings. At the interface between building walls or ceilings where pipes and ductwork flow from one room to another, appropriate insulation is necessary to ensure that the cavities do not permit fires from moving from one part of a building to another. Regardless of how good the fire-retardant capacity of the materials used in building walls and ceilings, if there are gaps in the piping and ductwork, fires can readily spread. Insulation is thus essential to minimize fire hazards in buildings. Again, this is part of the training of qualified Red Seal insulation workers.

Temperature variations between the different surfaces of HVAC systems and adjacent building components generate moisture. As noted, this provides a breeding ground for mold and various other bacteria and contaminants. It can then circulate in the air that building occupants breathe, a particular concern for those suffering from asthma or other breathing disorders. However, high humidity and resulting dampness has other damaging impacts on buildings. It promotes rust on machinery and can damage electrical components leading to premature failures. It rots drywall, particle board, wood and other materials that deteriorate from exposure to moisture.

Shifting the industry – Emphasizing Quality, Not Low Bid

One of the MI contractors who has worked on several projects stemming from the energy audits has seen how the auditing program has raised client understanding of the importance of requiring high standards in the insulation work they commission. The auditing experience encourages clients to recognize the value of quality installation work. This understanding sensitizes them to the problems associated with the low bid construction culture which has tended to push down quality and encourage building owners to focus narrowly on price at the expense of other factors when commissioning work. Audits have encouraged building managers to focus on quality. They enable managers to recognize the value of using contractors employing properly trained staff capable of doing the work properly and to a high standard. Consequently, building managers are now more diligent in developing clearer MI specifications in their tenders for new work. They are also more concerned to monitor the work and to check to ensure that the standards they establish in their contracts are met in the final product.

For contractors employing fully trained Red Seal insulators, this change in approach is very positive as it means that school officials want work performed by people with the appropriate training and technical knowledge. They are no longer looking for the cheapest option but rather the option that meets high industry standards.

For example, one audit identified significant quality issues in the work of a contractor on a new building. Covers on insulation were stapled instead of sewn, insulation was not secured tightly, water lines were taped in place rather than fastened with adhesives, insulation thickness and jacketing was inconsistent. These problems resulted in noticeable heat and energy losses which the audit revealed. The audit also identified significant differences between the quality of work of two different contractors who had earlier worked on projects. Such feedback is not what those who invest in new buildings want to hear, or for those whose problematic quality of work has been exposed. Increasing awareness of these issues enables facility mangers to take a more active role in overseeing their energy systems. It also encourages contractors to improve their performance standards.

The MI energy audits have also provided a tool to illustrate the importance of quality when MI apprentices are undergoing their classroom training. The thermography camera and 3E Plus software show the differences between shoddy and quality work. One of the benefits of using the 3E Plus thermography program is that it provides an opportunity to give apprentices concrete data on the energy savings, GHG reductions and monetary benefits of properly installed MI. Instructors can explain what the actual gains are, both in terms of dollars and cents, and in terms of environmental benefits. It also provides apprentices with a way of assessing how they are performing as they can see if their work is not up to standard. In showing apprentices the importance of doing their work properly, and the consequences of not doing it properly, Local 131 believes it is fostering a more climate aware workforce for the future, especially among its younger apprentices. Knowing the benefits to the climate increases their understanding of the value of the work and provides a strong argument that their work and their trade is important.

According to Mr. Sherrard, the ability to provide data on the benefits of MI increases respect for the trade, both among other trades and in the industry more widely. More people are aware of the role of the trade and the skills required to perform it well, including having a Red Seal trades' qualification. Because Mr. Sherrard is regularly making presentations to decision makers such as building managers, school finance directors, university facility managers, provincial officials and because he is demonstrating the value of the work of his members, he believes that this is generating a more positive attitude to their trade among both apprentices and working insulators. He also thinks it has increased the members' pride in their work.

The audit program has also had a positive impact on the union itself. When Mr. Sherrard began the audit program in 2017 there was some skepticism within the membership of the local. Some wondered how the time and the money required to complete free audits could be justified. This was not something that the local or most other insulation locals in Canada were doing. It was new and perhaps risky from a financial perspective for the local as there was no guarantee it would be successful. There was also some reluctance about how the use of thermography would act as a method of evaluating the quality of work being performed. Some members were uncomfortable with the quality control implications of using this new technology as it might force them to change some of their practices to meet the standards that the software's calculations required. However, the dramatic increases in work, employment security, total membership and number of apprentices has confirmed the importance of the initiative within the union.

The audit program has also facilitated union organizing. Although the industrial MI sector was well organized, some of the same contractors operated in the commercial and institutional sectors on a non-union basis. The union found it challenging to organize in this sector. However, the fact that the union's auditing initiative was generating new contracts meant that some of these non-unionized contractors were prepared to recognize the union to access more work opportunities.

Conclusion

Local 131's energy audit program has benefits for the clients, the contractors, and the local's membership. For clients, the energy, GHG and ROI estimates in the audits enables them to get a clear idea about how much the project will cost them if they tender the work, backed up by extensive financial data on the savings they will enjoy. This also reduces the workload for facility managers as they do not have to find someone qualified to do the audits (or learn how to carry out their own audits themselves) and then locate suitable MI contractors to bid on the work, which, as noted, can be especially challenging for facility managers with limited knowledge of MI or the insulation industry. The local's willingness after completing the initial audit to walk prospective contractors through the facility to be upgraded also provides additional assurance that the contractor would be fully aware of the specifications and hence that the work it performs will reflect a detailed knowledge of the actual job requirements. And the post-completion inspection provides a further guarantee that the work will meet the specifications set out in the audit report. Educational institutions also benefit from the contribution the upgrades make to meeting their climate change objectives.

Contractors benefit because the local finds work opportunities for them. They do not have to persuade building owners of the potential benefits of MI or take the risk of doing audits themselves with no guarantee of work orders. Rather, they only have to bid on work on which the clients have already expressed interest in having done and whose specifications are already set out in the audit reports. Because most insulation contractors do not have contacts with educational institutions, they are often reluctant to spend the resources needed to cultivate new clients and persuade them that they would benefit from refurbishing their MI. The local's program has opened up new areas of work for contractors in the educational sector where they had not earlier had a significant presence.

The benefits for the union are numerous. It has dramatically expanded the work available for its members, doubling the union's membership. It has also enabled the union to expand its apprenticeship program, providing opportunities for young workers to enter the trade. It has led to new organizing as contractors wishing to benefit from the work generated by the audits have been willing to sign agreements with the union. It has enhanced the union's reputation, both in terms of its commitment to promoting progressive environmental and climate issues and its competence in producing audit reports that are leading to major new investments in energy conservation by building owners. And it has provided a model for other insulating locals across North America on how to promote MI to building owners and contractors.

Local 131 has taken on more responsibility in finding work for its members than is typically expected of a union. However, its auditing work has produced jobs and generated new opportunities for an expanding number of apprentices in a skilled trade. It has also enhanced the reputation of the trade as MI is becoming increasingly recognized as an essential component of energy efficiency in buildings and a way to meet some of the climate change objectives that are now part of the strategic plans of educational institutions.

Appendix A: Sample Table Showing Investment, Annual Savings, Cashflow and Cumulative Savings

Sample Table Showing Investment, Annual Savings, Cash flow and Cumulative Savings for a Typical School

Results	
Simple Payback Period, yrs	0.9
Internal Rate of Return (IRR or ROI)	108.8%
Net Present Value,	$513,009

Calculations				
Year	Investment	Annual Savings	Annual Cash Flow	Cumulative Cash Flow
0	$-24,711	$0	$-24,711	$-24,711
1	$0	$26,886	$26,886	$2,175
2	$0	$26,886	$26,886	$29,061
3	$0	$26,886	$26,886	$55,947
4	$0	$26,886	$26,886	$82,833
5	$0	$26,886	$26,886	$109,719
6	$0	$26,886	$26,886	$136,605
7	$0	$26,886	$26,886	$163,491
8	$0	$26,886	$26,886	$190,377
9	$0	$26,886	$26,886	$217,263
10	$0	$26,886	$26,886	$244,149
11	$0	$26,886	$26,886	$271,035
12	$0	$26,886	$26,886	$297,921
13	$0	$26,886	$26,886	$324,807
14	$0	$26,886	$26,886	$351,693
15	$0	$26,886	$26,886	$378,579
16	$0	$26,886	$26,886	$405,465
17	$0	$26,886	$26,886	$432,351
18	$0	$26,886	$26,886	$459,237
19	$0	$26,886	$26,886	$486,123
20	$0	$26,886	$26,886	$513,009

Appendix B: Sample Full Audit Report

ENERGY AUDIT

[redacted]

Total 5 year savings of

$10 799.95

CO_2 Reduction of

9.95 MT/Year

[redacted]

Benefits:

- Simple payback period
- CO_2 Reduction
- Personnel safety

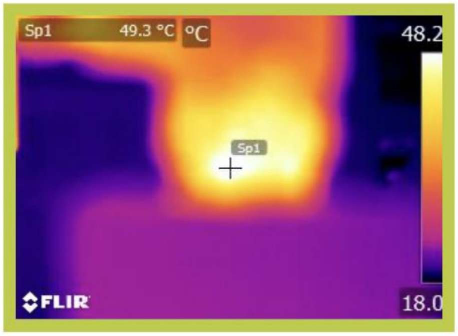
Audit Done By:

Joshua Sherrard

Certified Thermographer

Certified 3E Plus Auditor

Mechanical Room Ground Floor

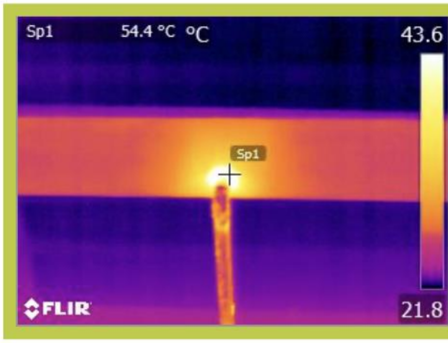


Operating Temperature, *F	122	Emittance of Surface	0.95
Ambient Temperature, *F	75	Expected Useful Life of Insulation System	20 yrs.
Insulation selected	Fiberglass	Operating hours per year	8750
		Selected fuel	Electric
		Cost of Fuel,$/KWH	13.51 ¢

Thickness **(inches)**	Surface Temp **(°F)**	Heat Loss **(Btu/h)**	Cost of Fuel **($/yr)**	**1st year Savings**	**5 Year Savings**	**20 Year Savings**	CO2 Emissions (MT/yr)
0	**122**	**154**	**$59.27**	**59.27**	**296.25**	**1185**	**0.34**
1	**77**	**18**	**$6.95**	**52.32**	**261.6**	**1046.4**	**0.03**
1.5	**76**	**15**	**$5.63**	**53.64**	**268.2**	**1072.8**	**0.03**

*Estimated Calculations supplied by National Institute of Building Sciences Mechanical Insulation Energy Calculator *

Mechanical Room Ground Floor

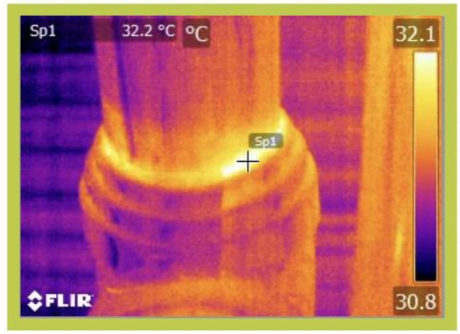




Operating Temperature, *F	122	Emittance of Surface	0.95
Ambient Temperature, *F	75	Expected Useful Life of Insulation System	20 yrs.
Insulation selected	Fiberglass	Operating hours per year	8750
		Selected fuel	Electric
		Cost of Fuel,$/KWH	13.51 ¢

Thickness **(inches)**	Surface Temp **(°F)**	Heat Loss **(Btu/h)**	Cost of Fuel **($/yr)**	**1st year Savings**	**5 Year Savings**	**20 Year Savings**	CO2 Emissions (MT/yr)
0	**133**	**1714**	**$660.71**	**660.71**	**3,303.55**	**13,214.2**	**2.57**
1	**78**	**217**	**$83.63**	**577.08**	**2,885.4**	**11,541.6**	**0.41**
1.5	**77**	**174**	**$67.11**	**593.6**	**2,968**	**11,872**	**0.33**

***Estimated Calculations supplied by National Institute of Building Sciences Mechanical Insulation Energy Calculator ***

Mechanical Room Second Floor

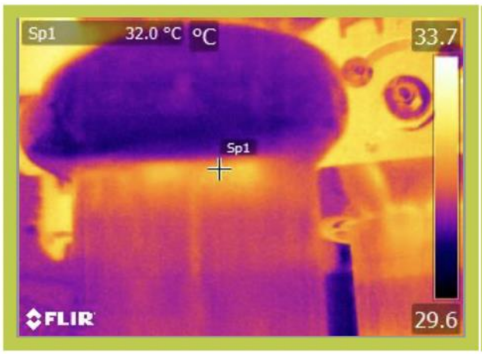


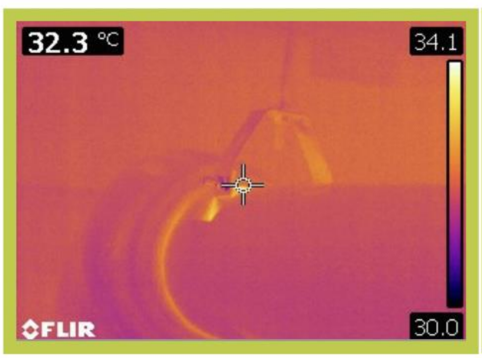
Operating Temperature, *F	122	Emittance of Surface	0.95
Ambient Temperature, *F	75	Expected Useful Life of Insulation System	20 yrs.
Insulation selected	Fiberglass	Operating hours per year	8750
		Selected fuel	Electric
		Cost of Fuel,$/KWH	13.51 ¢

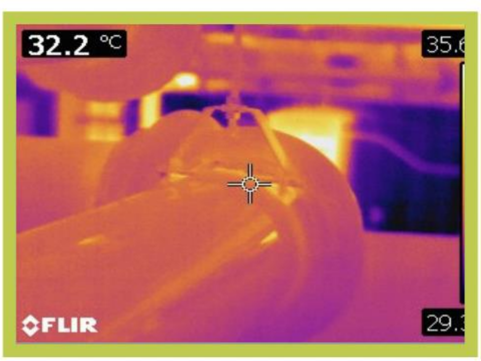
Thickness **(inches)**	Surface Temp **(°F)**	Heat Loss **(Btu/h)**	Cost of Fuel **($/yr)**	**1st year Savings**	**5 Year Savings**	**20 Year Savings**	CO2 Emissions (MT/yr)
0	**90**	**3792**	**$1,751.66**	**1751.66**	**8758.3**	**35033.2**	**8.56**
1	**78**	**479**	**$221.07**	**1530.59**	**7652.95**	**30611.8**	**1.08**
1.5	**77**	**384**	**$177.41**	**1574.25**	**7871.25**	**31485**	**0.87**

*Estimated Calculations supplied by National Institute of Building Sciences Mechanical Insulation Energy Calculator *

Mechanical Room Second Floor

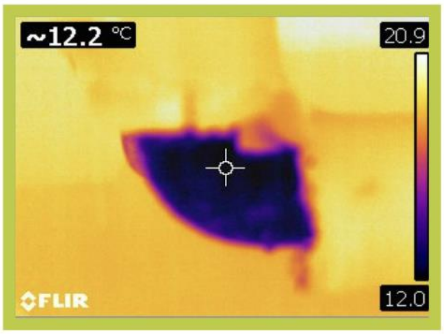


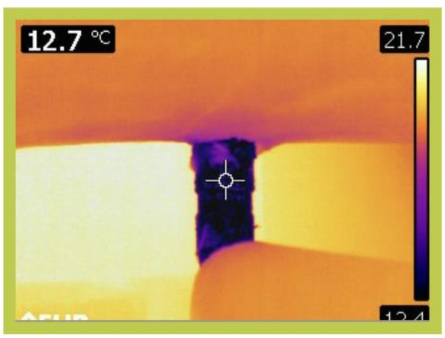




*Estimated Calculations supplied by National Institute of Building Sciences Mechanical Insulation Energy Calculator *

Mechanical Room Ground Floor





Thickness **(inches)**	Surface Temp **(°F)**	Heat Flow **(Btu/h/FT)**
0	**54**	**32**
1	**73**	**4**

*Estimated Calculations supplied by National Institute of Building Sciences Mechanical Insulation Energy Calculator *

Results	
Simple Payback Period, yrs	1.6
Internal Rate of Return (IRR or ROI)	63.4%
Net Present Value,	$39,775

Calculations

Year	Investment	Annual Savings	Annual Cash Flow	Cumulative Cash Flow
0	$-3,405	$0	$-3,405	$-3,405
1	$0	$2,159	$2,159	$-1,246
2	$0	$2,159	$2,159	$913
3	$0	$2,159	$2,159	$3,072
4	$0	$2,159	$2,159	$5,231
5	$0	$2,159	$2,159	$7,390
6	$0	$2,159	$2,159	$9,549
7	$0	$2,159	$2,159	$11,708
8	$0	$2,159	$2,159	$13,867
9	$0	$2,159	$2,159	$16,026
10	$0	$2,159	$2,159	$18,185
11	$0	$2,159	$2,159	$20,344
12	$0	$2,159	$2,159	$22,503
13	$0	$2,159	$2,159	$24,662
14	$0	$2,159	$2,159	$26,821
15	$0	$2,159	$2,159	$28,980
16	$0	$2,159	$2,159	$31,139
17	$0	$2,159	$2,159	$33,298
18	$0	$2,159	$2,159	$35,457
19	$0	$2,159	$2,159	$37,616
20	$0	$2,159	$2,159	$39,775

*Calculation are based off Energy Cost Escalation Rate of 0%/yr

*Estimated Calculations supplied by National Institute of Building Sciences Mechanical Insulation Energy Calculator *

Appendix C: Interviews with Educational Officials and an MI Contractor (by Zoom)

Perry Eldridge peldridg@mta.ca
Energy Manager
Mount Allison University June 13, 2022
Dunn, Tim (ASD-N) Tim.Dunn@nbed.nb.ca
Director of Finance and Administration
Anglophone North School District June 14, 2022
Lavigne, Ronald (ASD-N) Ronald.Lavigne@nbed.nb.ca
Facility Manager
Anglophone North School District June 14, 2022
Marc d'Entremont marc.dentremont@iconinsulation.ca
Project Manager/Estimator Icon Insulation
Contractor June 14, 2022

Bibliography

Altamirano-Medina. H., M. Davies , I. Ridley , D. Mumovic and T. Oreszczyn (2009). "Guidelines to Avoid Mould Growth in Buildings." Advances in Building Energy Research, 3:1, 221-235.

American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) (2009). Indoor Air Quality Guide: Best Practices for Design, Construction and Commissioning. Atlanta. http://iaq.ashrae.org/Download.aspx?type=registrants&pubid=395&source=a3f0d566-66de-4ed8-a316-d955c86e830f

ASHRAE. (2013) ASHRAE Handbook - Fundamentals. https://www.ashrae.org/technical-resources/ashrae-handbook

ASHRAE. (2014). Advanced Energy Design Guide for Small to Medium Office Buildings: Achieving 50% Energy Savings Towards a Net Zero Energy Building. Atlanta. (orig. pub 2011) http://aedg.ashrae.org/Download.aspx?type=registrants&aedg=71&source=a3f0d566-66de-4ed8-a316-d955c86e830f

ASHRAE. (2018). ASHRAE 90.1. https://www.ashrae.org/technical-resources/bookstore/standard-90-1.

ASHRAE Multidisciplinary Task Force (2020) Damp Buildings, Human Health and HVAC Design. https://www.ashrae.org/file%20library/technical%20resources/bookstore/dampbldgs-humanhealth-hvacdesign.pdf

Aste, N., R.S. Adhikart, et. Al. (2020). nZEB: Bridging the Gap Between Design Forecast and Actual Performance Data. Energy and Built Environment. Vol. 3, No. 1

Aydin, C., and Ozerdem, B. (2006). Air Leakage Measurement and Analysis in Duct Systems, Energy and Buildings, 38: pp.207-213.

Barrett, D., (2000)."The renewal of trust in residential construction part II: commission of inquiry into the quality of condominium construction in British Columbia." Submitted to The Lieutenant-Governor in Council Government of British Columbia. Victoria, BC. http://www.qp.gov.bc.ca/condo/c1_ii.htm

BC Insulators. (2011). Saving Money, Energy and the Planet: Mechanical Insulation to Increase Building Efficiency. Vancouver: BC Insulators, Local 118. https://www.workingdesign.net/wordpress/wpcontent/uploads/2011/06/HeatFrost_saving-money-energy-and-the-planet.pdf

BC Insulators. (2017). BC Insulators Talking Sustainability with Mechanical Insulation to City Councils. BC Insulator's Newsletter. June 20. http://www.energyconservationspecialists.org/?s=salamander

BC Insulation Contractors. (2019). BCICA Quality Assurance Manual. http://www.bcica.org/

Babich, F.; Demanega, I. et. al. (2020). A. Low Polluting Building Materials and Ventilation for Good Air Quality in Residential Buildings: A Cost–Benefit Study. Atmosphere. Vol. 11. https://www.mdpi.com/2073-4433/11/1/102

Besant, Jeff, Fraser, Bud and Micah Lang. (2012). MI Guide and Specifications for British Columbia. Vancouver: HB Lanarc – Golder. August 7. http://mispec.org/wp-content/uploads/2013/03/Mechanical-Insulation-Guide-for-BC-Aug-7-2012.pdf

Bridge, T. and Gilbert, R. (2017). Jobs for Tomorrow - Canada's Building Trades and Net Zero Emissions. https://columbiainstitute.eco/wp-content/uploads/2017/09/Columbia-Jobs-for-Tomorrow-web-revised-Oct-26-2017-dft-1.pdf

Cali, Davide, Tanja Osterhage, et. al. (2016). Energy Performance Gap in Refurbished German Dwellings: Lessons Learned from a Field Test. Energy and Buildings. Vol 127, 1146 – 1158.

Calvert, John and Corinne Tallon. The Union as Climate Advocate: The BC Insulators' Campaign to Green the Building Industry in BC. (2016). Toronto: York University. ACW Working Paper 105. https://adaptingcanadianwork.ca/wp-content/uploads/2018/03/105_Calvert-John_Union-as-climate-change-advocate.pdf

Calvert, John and Corinne Tallon (2017) Promoting Climate Literacy in British Columbia's Apprenticeship System: Evaluating One Union's Efforts to Overcome Attitudinal Barriers to Low Carbon Construction. Toronto: York University ACW Working Paper 201. https://adaptingcanadianwork.ca/wp-content/uploads/2018/03/201_Calvert-John_Climate-Literacy.pdf

Calvert, John. (2019). The BC Insulator Union's Campaign to Promote Climate Literacy in Construction: (Salamander Report) Documenting its Efforts to 'Green' the Industry's Culture. Adapting Work and Workplaces to Climate Change. York University. https://yorkspace.library.yorku.ca/xmlui/handle/10315/39313

Canada. (2016). Pan-Canadian Framework on Clean Growth and Climate Change. https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework/climate-change-plan.html

Canada. (2021). Bill C-12: An Act respecting transparency and accountability in Canada's efforts to achieve net-zero greenhouse gas emissions by the year 2050. Chapter 22. June 29, 2021. https://parl.ca/DocumentViewer/en/43-2/bill/C-12/royal-assent

Canadian Apprenticeship Forum. (2018). Making Apprenticeship a National Skills Priority. Ottawa. August. www.caf-fca.org.

Canadian Apprenticeship Forum. (2019). National Strategy for Supporting Women in the Trades. Ottawa: https://caf-fca.org/wp-content/uploads/2020/09/SWiT-National-Strategy_en-web.pdf

Canadian Commission on Building and Fire Codes. (2015). National Building Code of Canada. National Research Council. https://nrc.canada.ca/en/certifications-evaluations-standards/codes-canada/codes-canada-publications/national-building-code-canada-2015

Canadian Commission on Building and Fire Codes. (2017) National Energy Code of Canada National Research Council. https://nrc.canada.ca/en/certifications-evaluations-standards/codes-canada/codes-canada-publications/national-energy-code-canada-buildings-2017

Crall, P. Christopher and Ronald King. 2011. Montana MI Energy Appraisal Report. http://www.insulation.org/articles/article.cfm?id=IO110501

Environment and Climate Change Canada. (2021). Government of Canada Confirms Ambitious New Greenhouse Gas Emissions Reduction Target. (Press Release). Ottawa: July 12. https://www.canada.ca/en/environment-climate-change/news/2021/07/government-of-canada-confirms-ambitious-new-greenhouse-gas-emissions-reduction-target.html

FLIR. (2011). Thermal Imaging Guidebook for Building and Renewable Energy Applications. www.flirmedia.com/MMC/THG/Brochures/T820325_EN.pdf

Fox, M., D. Coley et. al. (2014). Thermography methodologies for detecting energy related building defects. Renewable and Sustainable Energy. Vol. 40.

Fox, M., S. Goodhew et. al. (2016). Building Defect Detection: External versus internal Thermography. Building and Environment. Vol. 105. http://dx.doi.org/10.1016/j.buildenv.2016.06.011

Gleeson, C.P. and Lowe, R. 2013. Meta-analysis of European heat pump field trial efficiencies. *Energy and Buildings.* 66, pp. 637-647. https://doi.org/10.1016/j.enbuild.2013.07.064 Meta-analysis of European heat pump field trial efficiencies

Global Status Report for Buildings and Construction: Towards a Zero-Emissions, Efficient and Resilient Buildings and Construction Sector. 2021. Nairobi . https://globalabc.org/sites/default/files/2021-10/GABC_Buildings-GSR-2021_BOOK.pdf

HB Lanarc. (2010). Pipes Need Jackets, Too: Improving the Performance of BC Buildings Through Mechanical Insulation Practice and Standards – A White Paper. Vancouver: http://www.mechanicalinsulators.com/research.htm

HB Lanarc. (2011). The BC Insulators: Communications Strategy. Vancouver: June 3. (Authors: Micah Lang and Alex Boston).

HB Lanarc. (2012). "Mechanical Insulation Guide and Specifications for British Columbia" HB Lanarc and Besant and Associates. Vancouver, Aug. 7. 86 pp.

International Energy Agency and Efficiency Canada. (2018). Energy Efficient Potential in Canada to 2050. https://iea.blob.core.windows.net/assets/e9800ef6-2517-43ad-8a56-1d899026774d/Insights_Series_2018_Energy_Efficiency_Potential_in_Canada.pdf

IPCC. (2014a). Mitigation of Climate Chnge: Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Chapter 9: Buildings. pp. 671 – 738. https://www.ipcc.ch/report/ar5/wg3/buildings/

IPCC. (2021). Climate Change 2021: The Physical Science Basis. Summary for Policymakers: Contribution of Working Group I to the Sixth Assessment Report of the IPCC. https://www.ipcc.ch/report/ar6/wg1/#FullReport

IPCC. (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Summary for Policy Makers. Contribution of Working Group II to the Sixth Assessment Report of the IPCC1. https://report.ipcc.ch/ar6wg2/pdf/IPCC_AR6_WGII_SummaryForPolicymakers.pdf

International Association of Heat and Frost Insulators and Allied Workers. (IAHFIAW). (2019). Written Submission for the Pre-Budget Consultations in Advance of the 2019 Budget. https://www.ourcommons.ca/Content/Committee/421/FINA/Brief/BR10007287/br-external/InternationalAssociationOfHeatAndFrostInsulatorsAndAlliedWorkers-e.pdf

International Code Council. (2018). International Green Construction Code. Paris. https://www.ashrae.org/File%20Library/Technical%20Resources/Bookstore/2018-IgCC_preview_1102.pdf

Insulation Institute. (2019). Insulation Codes and Standards. https://insulationinstitute.org/tools-resources/resource-library/codes-standards/

Kylili, Angeliki. (2014) Infrared Thermography (IRT) Applications for Building Diagnostics: A Review. Applied Energy. Vol. 134, Dec. pp. 531 – 549.

Lang, Mich, Bud Fraser, and Jeff Besant. (2012). Mechanical Insulation Case Study – Timely Opportunity for Retrofits and New Construction. Journal of Green Building. Spring 2012, Vol. 7, No. 2, pp. 3-14.

Lillie, Thomas. (2012). What We Have Learned From 20 Years of HVAC System Commissioning. ASHRAE Transactions. Vol. 118, Issue 2 pp. 122-132.

McGill, Grainne, O. Lukumon, Oyedeli, Greg Keeffe and Peter Keig. (2015). "Indoor air quality and the suitability of mechanical ventilation with heat recovery (MVHR) systems in energy efficient social housing projects: perceptions of UK building professionals." International Journal of Sustainable Building Technology and Urban Development. Vol. 5, No. 4, pp. 240–249.

National Insulation Association. (2009). “Mechanical Insulation: A Powerful Solution for Improving US Building Efficiency and GHG Reductions on an Industrial Scale.” May 18. http://www.mechanicalinsulators.com/research.htm

National Insulation Association. (2010). “Mechanical Insulation Industry Measurement Survey” http://www.mechanicalinsulators.com/research.htm

National Institute of Building Sciences (NIBC) (2017). Mechanical Installation Design Guide. http://www.wbdg.org/guides-specifications/mechanical-insulation-design-guide/installation

National Institute of Building Sciences (National MI Committee (NMIC) 2012. Design Objectives (2012) Updated: 02-23-2012 . http://www.wbdg.org/guides-specifications/mechanical-insulation-design-guide/design-objectives

National Institute of Building Sciences (2016) Mechanical Insulation Design Guide. http://www.wbdg.org/guides-specifications/mechanical-insulation-design-guide/introduction

North American Insulation Manufacturers Association (NAIMA). (2010). Mineral Fibre Insulation Products for Commercial and industrial Applications: Codes and Standards for Insulation Used on Pipes – Temperatures from 40 F to 1400 F per ASTM C547. Pub. No CI225 7/10

North American Insulation Manufacturers Association (NAAIMA) Facts 82: 2010 Codes and Standards for Insulation Used on Pipes https://insulationinstitute.org/wp-content/uploads/2015/11/CI225.pdf

North American Insulation Manufacturers Association (NAIMA). Insulation Institute. (2012). 3EPlus Insulation Thickness Computer Program: User Guide Version 4.1. August 2012. www.PipeInsulation.org

Potvin, Catherine et. al. (2017). “Re-Energizing Canada: Pathways to a Low Carbon Future” McGill University and Sustainable Canada Dialog. May 24. (labour and training contribution) http://sustainablecanadadialogues.ca/en/scd/energy
Commissioned by Natural Resources Canada

Racusin, Jacob Deva. (2017). Essential Building Science: Understanding Energy and Moisture in High Performance House Design. New Society Publishers.

Salamander Inspections (2016). Energy Audit for Alberta Infrastructure, Building 6950 – 133 Street Edmonton Alberta. Edmonton (April 7). Note: similar audits were performed for the Brownlee Building, 10365 – 97 Street, Edmonton, 6309 – 45 Street (April 5); Food Processing Development Centre 6309 – 45 Steet, Leduc, Alberta (April 1); Provincial Government Building 4920 – 45 Street Red Deer (April 13); Reynolds Museum 6246 – 40 Avenue Wetaskiwin (April

12); OS Longman Laboratory Building 6909 -116 Steet, Edmonton (April 6); Royal Tyrell Museum 1500 Dinosaur Trail, Drumheller (April 14).

Salamander Inspections, Vancouver Island Audits, 2017. Note: the audits were sent as a package in a letter to the Vancouver Island Health Authority on January 5, 2017. The facilities were: Eagle Park Health Care Facility, 777 Jones Street, Qualicum Beach; Oceanside Health Centre, 400 Alberni Highway, Parksville; Tofino General Hospital, 261 Neill Street, Tofino; Trillium Lodge, 401 Molliet Street, Parksville; West Coast General Hospital, 3949 Port Alberni Hwy, Port Alberni.

Srivastava, Rohini, Mohammed Awo Jobi et. al. (2020) Training the Workforce for High-Performance Buildings: Enhancing Skills for Operations and Maintenance: Research Report. American Council for an Energy-Efficienty Economy.. September. https://www.aceee.org/sites/default/files/pdfs/b2003%20%281%29.pdf

Thermal Insulation Association of Canada (TIAC). (2019). TIAC Mechanical Insulation Best Practices Guide. (nd). http://tiac.ca/en/resources/best-practices-guide/

United Nations. (2015). Paris Agreement. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement