Greening the HVACR Trades

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Contributor's Self Location

Conestoga is a leader in polytechnic education and one of Ontario's fastest growing colleges, delivering a full range of career-focused education, training, and applied research programs to prepare students for success in the new knowledge economy and promote economic prosperity for all peoples throughout our region and across Ontario.

Located on the Haldimand Tract, Conestoga College acknowledges the Haudenosaunee, Anishinaabek and Neutral peoples and recognizes the land itself with gratitude and appreciation. Conestoga College is committed to supporting Indigenous learners with approximately 400 Indigenous students currently studying at our school and more initiatives actively being established to welcome more. Indigenous (First Nations, Metis, and Inuit) students are supported through Bedahbin Gamik, the Indigenous Student Centre, which provides cultural and academic supports. All our faculty are encouraged to complete professional development courses offered through our teaching and learning department with indigenous knowledge holders to better support the success of these students and enlighten the broader student community et al.

Indigenous led education is an ongoing commitment that Conestoga endeavours to prioritize when developing programming, curriculum, and course content. We acknowledge that this work is ongoing and must be led by Indigenous methodologies, like Two-Eyed Seeing." https://www.conestogac.on.ca/indigenous

Albert Marshall is a respected Mi'kmaq Elder whose concept of two-eyed seeing recognizes the strength of Indigenous ways of knowing and the strength of western ways of knowing and uses both competencies together. (Bartlett, Marshall, & Marshall, 2012, p. 335).

This avoids a clash of knowledges (Canadian Council on Learning [CCL], 2007). Thus, Two-Eyed Seeing intentionally and respectfully brings together our different ways of knowing, to motivate people to use all our gifts so we leave the world a better place and do not compromise the opportunities for our youth (Bartlett, Marshall, & Marshall, 2007). The concentration on the common ground between Indigenous and Western ways of knowing means that one does not have to relinquish either position but can come to understand elements of both (Brandt, 2007). The place-based learning experience- Ik ka nutsi follows a two-eyed approach.

Course Learning Outcomes

1. Interpret scientific data understanding the process of discovery and verification among peers.
2. Identify various forms of environmental damage caused by the HVACR trade.
3. Discover opportunities in the curriculum to build upon colleagues and students' knowledge of greening the trades.
4. Develop teaching strategies that incorporate greening opportunities and their application that allow students to differentiate between those that damage and those that prevent damage and or repair the environment.
5. Apply solutions to prevent environmental damage in the course of teaching labs and working in the trade.
6. Demonstrate the value of greening in the protection of the environment and the potential alignment with decolonization to students and the public at large.
7. Evaluate critically, new technologies and methodologies for the greatest practical impact on greening and the protection of the environment using credible sources and vetted data.
8. Apply options to balance the needs of the environment, Indigenous peoples, the trade generally and customers.

Environmental Stress & Climate Change Perspectives

Link: TED Explores: A New Climate Vision - TED Countdown

Video Segment Markers

0-5:30 Introduction to a New Climate Vision

5:31-13:04 Tipping Point to Exponential Growth

13:06-22:51 Electric Vehicles, Past to Present

22:53-33:51 Renewable Energy, 1954 to Present

33:52-36:20 Equitable Energy Distribution

36:23-43:30 Sustainable Communities

43:35-52:20 Agriculture

52:22-56:51 Wrap Up

Chapter 1 - Understanding Science

The discussion pieces below are excerpts from an article that was presented by Edweek.org and is worth taking a look at to understand what may be behind some of the issues we have experienced in students and society at large lately relating to the belief that the science may be in doubt due to disagreement among their peer group.

“Attitudes and dispositions toward science are shaped by personal beliefs and networks, by cognitive misperceptions, and by a fundamental lack of understanding of how scientific knowledge develops.”

“There are a number of psychological factors that lead to doubt, resistance, and even denial of that scientific information: emotions, motivations, identity. So, the kinds of things that really influence whether or not people accept the scientific point of view depend on a host of factors, not just how much they understand that basic science itself.”

“Science is usually conveyed as what’s in your textbook: a collection of facts. It’s not conveyed as what it really is. What it really is a process, a process for understanding the natural world. And in that process, a strength of science is its ability to change based on new evidence and new ways of thinking. So, when we present science to students as a collection of facts in your textbook, they don’t expect planets to change from planets to something else.”

(Book: Science Denial) (Co-Authors, Gale M. Sinatra, a professor of psychology at the University of Southern California, and Barbara K. Hofer, a professor emerita of psychology at Middlebury College in Vermont.)

This means learning what makes a source credible, how scientists develop reliable knowledge about the world, how scientists are willing to change conclusions as they

receive more evidence, and how to be aware of their own biases regarding scientific information.

For example, when we talk about lateral reading, where you can't just trust what a website says about itself, we need to look at what other websites and independent resources at our disposal say about that organization or concept before we weigh its assertions highly.

Reflect upon your own biases toward information that you may have experienced and challenge what your foundation of knowledge is.
Is that foundational knowledge reliable and authentic? How can you be sure? Are you willing to consider other possibilities? With more information and clarity are you prepared to change your position even if you are an outlier among your piers?

Chapter 2 – What is the HVACR Trade

The Heating, Ventilation, Air Conditioning and Refrigeration (HVACR) group of trades can be described as tradespeople who install and service systems that create controlled environments in the presence of other external conditions that are working against the desired outcome of the controlled space. These trades are primarily heating (gas fitters/ technicians), ventilation (sheet metal mechanics), air conditioning, and refrigeration (refrigeration mechanics) but also include are electricians and plumbers. As with any system that requires services and structures all the construction trades work together to complete and maintain the finished project. Construction truly is a team effort of tradespeople each with specialized skills.

The education of tradespeople working in HVACR is accomplished across Canada through apprenticeship where the curriculum is very tightly prescribed. In some areas of the country enhanced education before apprenticeship provides an opportunity for students to obtain a diploma or certificate. The latter has more flexibility to include environmental and Indigenous content which provides for more understanding of the related issues. This module is designed considering the combination of post-secondary education and apprenticeship training that allows for broader discussions and opportunities for awareness beyond the traditional scope of a tradesperson working in the HVACR industry.

Chapter 3 - Evolution of environmental damage awareness

The media of the day unknowingly supported environmental damage through suggested handling of wastes. For example, Popular Mechanics magazine in the 1960s promoted this method to manage waste motor oil. Reddit Link: Popular

Mechanics Magazine Article These learned habits become incredibly challenging to create change that includes environmentally friendly decisions and options.

A student once commented after environmental awareness training that his company brought retired air-conditioning condensing units to their shop as a normal part of system replacement projects. Once there the refrigerant was released to the environment and oil from the compressor was drained and dumped into a storm drain that terminated in a local river. He asked, is that ok, and if not, what should I do? The response must be to offer the proper solution to handle these materials in an environmentally green manner, which would include refrigerant recovery and reclamation and oil capture and return for processing at a waste oils recovery centre. Respectfully, the student could address the owner/supervisor and pass on the learned knowledge and if that failed to create change seek a new employer that does respect the environment and greening options. Additionally, the previous employer could be reported anonymously to an environmental agency.

Now let's take a look at ripple effect, extrapolating the impact small actions that are seemingly unimportant and benign but cause damage in the environment. A tradesperson cleans their hands of oil residue at a sink connected to the sanitary waste system where when intercepted at the treatment plant oil is diverted and doesn't enter the natural environment. Now consider on many new construction and outdoor projects that that same residual oil being washed off hands or tools, may never reach a treatment plant because facilities don't exist or the sewage system isn't hooked up, and the waste oil may enter the natural environment. Over time, because oil floats on water, it makes its way further into the environment ending up in creeks, streams and rivers eventually reaching the ocean. Imagine the amount of oil that accumulates over time on the surface of the oceans from this and all other sources of non-diverted oils. Among the many disruptions that oil contamination causes to the ocean, one of the most significant impacts is to phytoplankton. Phytoplankton is a keystone species in the ocean food web, and a major contributor to making our atmosphere inhabitable, given these tiny plants produce half the world's oxygen. In addition, the film of oil on ocean surfaces can affect the natural evaporation of moisture and thereby affect ocean temperatures making the environment less hospitable and further reducing phytoplankton populations, as well as other species.

If you cannot imagine this effect, take a look at the swimming pool treatment that reduces evaporation and heat loss. The commercial additive, shown in this video, works by creating a film that floats on the surface of the water to control the loss of water and heat. This is how oil from dumping, spills, or as a by-product of washing oil off tools, machinery, and hands behaves when it reaches the waterways – like a film floating on the water's surface.

NRCan has produced an article that calculates the losses through evaporation and heat from a pool and that can be used as a lens to consider the same aspects associated with our oceans and lakes, both of which deposit huge amounts of energy into our atmosphere that is responsible for our storms. It would be logical to think that slowing evaporation and retaining heat could be a good thing, but nature is all about balance and when we upset that balance these actions can create catastrophic consequences that are immediate or develop over time to establish themselves and as an example could kill off the phytoplankton, we discussed earlier altering the ecosystem dramatically. Like the climate change we are dealing with once we reach that climacteric (tipping) point it's too late. The damage that occurs as we scramble to find solutions is irreversible.

These examples help to explain many theoretical foundations of the HVACR trades and the relationship between HVACR and our natural environment, including the climate.
Using examples of the natural environment to teach these theories, students are able to personally relate to the material, drawing from their own life experiences and prior learning providing a deeper understanding.

When addressing climate change and the ensuing impacts, we all have a role to play, and our individual actions contribute to a collective change. What is our role? How can we prevent these life-changing sequences of events currently being experienced throughout the world that start as seemingly inconsequential actions?

Chapter 4 - Pre-environmental awareness HVACR Trade Industry

1) In the 1970s to the 1980s there were dramatic cost increases of energy creating the first wave of energy conservation measures focused on cost savings not environmental impact. There were several newly engineered leading-edge technologies such as heat recovery systems that were employed to collect the energy contained in wastes from processes used in manufacturing or heat containing waste waters and biogas generation from waste digestion. It was the first time we saw widespread use of the first consumer level heat pump systems that collected heat from outside air and delivered it to indoor environments. Chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants are widely used and performing extremely efficiently during this time. Humans had not yet detected/ understood the resulting holes in the ozone layer from these chemicals.

Keep in mind that the focus of these technologies was energy recovery to offset the cost of operation. Heat recovery in industrial environments had far more attention due to its impact on reducing energy costs and those savings could then be applied to the bottom line. It was a very attractive and lucrative opportunity to showcase and

deploy the latest technologies and through experience develop them further. The CFC and HCFC refrigerants of that time were often used in refrigeration systems to absorb and reject the energy that was recovered, and solar heat collectors were also used to pre-heat or in some cases fully heat water and other fluids. The rejected and collected energy was directed to processes that in many cases pre-warmed air or water thus saving on the amount of energy to bring the medium to the desired temperature.

Many of these energy recovery systems we installed in government buildings ostensively highlighting the opportunities for industry and institutions demonstrating that savings after the initial capital investment would be realized. Some of the leading industrial manufacturers of the time incorporated these systems into existing and new buildings.

Over time, as with any mechanical system, regular upkeep was required to maintain efficiency levels. In many cases, optimizing these systems even proved to require extensive work beyond simple maintenance. Despite the initial promise of cost savings, maintenance/ optimization was expensive, leading to many abandoned systems by the late 1980s.

2) Over time the condenser of a water-cooled refrigeration system develops a scale resulting from waterborne minerals. That insulating layer reduces the heat transfer efficiency and restricts waterflow amplifying the effect. When its performance has diminished enough maintenance is required that involves the use of a highly corrosive acid solution. The solution is circulated through the coil usually from a bucket until the scale has been removed or the solution is weakened. Often, people go against the manufacturer's suggested use, believing that if a small amount of a product works, then using more will work better and faster. Most often, this work is done on systems indoors and the solution is poured down the closest drain, from where it can enter the hydrological cycle. Some chemicals cannot be removed by treatment facilities resulting in environmental damage and potentially causing harm to wildlife and human health. Not always, but in some cases, chemicals that get poured down drains and are directed through the wastewater system ending up at a treatment facility. If the facility has appropriate filtration processes in place, the chemicals released into the wastewater drain will be neutralized and made safe before the water is reintroduced into the hydrological cycle. Wastewater that is not treated but instead is directed from stormwater drains or wastewater pipes directly into local water bodies end up in the hydrological cycle. If this water contains any chemicals, such as oils, descalers, or other HVACR chemicals that were dumped or rinsed into the water, they can negatively affect the ecosystem, potentially killing wildlife.

Training of apprentices to handle these chemicals is rarely provided and even with guidance from a journeyperson the waste material may not be properly handled because neither have had appropriate disposal training. This exercise provided an example of the potential hazards that can result from tradespeople handling chemicals without the proper precautions. With proper training, tradespeople should know how to dispose of chemicals and waste properly and choose products that cause less or no harm to the environment. Where should this training be provided?

3) The condenser and evaporator coils found in HVACR equipment that are transferring heat to and from air eventually need to be cleaned. This is done usually with a pressure washer and some type of cleaner. These cleaners are often harsh, and the containers carry exposure warnings which often are ignored. They are either diluted or full strength and sprayed on the coils. If the equipment is mounted on a rooftop, the waste pours onto the roof and into storm drains, eventually flowing directly into a creek or river. However, if it's indoors, the drain connects to the sanitary system, directing the waste usually, but not always, to a treatment facility.

Again, even with the direction of a journeyperson an apprentice may not be given proper guidance to avoid inappropriate drainage of the waste chemicals because neither person has been trained to properly handling and dispose of these wastes. The employer must provide necessary equipment to collect the waste and direction to a centre that can safely dispose of it.

4) We have discussed refrigerant, oil and chemical contamination of the environment but part of HVACR is also heating and in the heating systems we most often burn some type of fuel is burned resulting in carbon emissions, even with properly installed and adjusted burners. When the burners aren't installed properly, the carbon emissions rise dramatically producing carbon dioxide, carbon monoxide, carbon particles (soot) and other chemical contaminants like aldehydes. Each of these chemical byproducts causes environmental damage that contribute to climate change. Due to their size, Industrial, institutional, and large commercial burners have a much more obvious impact than small commercial and residential systems. Given their collective volume, residential heating contributions cannot be underestimated just because individually they produce less GHG emissions than individual industrial systems do.

Picture a large roof-mounted, indirect, fired make-up air unit burning very inefficiently, causing a high level of aldehydes at ground level. Despite it being approximately, 30 feet below, workers exiting service vehicles in the parking lot below were experiencing immediate irritation to their nose and eyes.

As we know carbon monoxide and carbon dioxide are colourless, tasteless, and odourless chemicals but generally speaking, if aldehydes are present carbon monoxide is also. Carbon monoxide exists over a range of concentrations measured in the parts per million (ppm) level that, combined with length of exposure, may result in negative health effects, including death of humans and other air breathing organisms. These are the immediate effects of the toxicity, as opposed to longer term environmental damage from the aldehydes that also contributes to climate change.

The principal effect of low concentrations of aldehydes on humans and animals is primary irritation of the mucous membranes of the eyes, upper respiratory tract, and skin. Aldehyde emissions result from incomplete combustion of hydrocarbons and other organic materials. The major emission source appears to be vehicle exhaust, but significant amounts may be produced from incineration of wastes and burning of fuels (natural gas, fuel oil, and coal).

Link: EPA: Air Pollution Aspect of Aldehydes

With the advancement in computer and electronic technologies and active sensors these systems could be made much greener by adjusting and controlling the burners based upon monitoring the fuel/air mixture pre and emissions post combustion. In doing that, the volume of and type of emissions could be reduced or eliminated. Not all HVACR tradespeople would have the occasion for a conversation at this level but being aware of the possibilities is valuable if an opportunity arises.

These burners can be compared to other combustion systems, for example, comparing a burner on a range and a candle to help students understand the differences between relatively clean combustion and poor combustion. The burners on a range in the kitchen burn the fuel with a blue flame as a result of premixed primary air and fuel while the candle with its yellow flame only burns using secondary air that surrounds the flame. There are other contributing factors to the quality of a candle flame that are caused by the combustion of the wax. As we change the ratio of fuel to oxygen the flame quality (colour) and efficiency (heat) changes. If we use a carbon monoxide (CO) detector to monitor the flame in close proximity during the adjustment of the ratio, the presence of CO and carbon particles can be noted. That same demonstration can be made with the commonly used oxygen/acetylene torch. This an effective visual demonstration clearly identifying the concepts we are discussing here.

Students should be encouraged to reflect on their own experiences with combustion and open flames, for example, a campfire, and discuss in the classroom.

What could we do to reduce or eliminate the pollutants associated with combustion of fuels thereby creating a greener process? Can a technology be created that would

pre-treat combustible materials to enhance their combustion efficiency and reduce emissions?

Chapter 5 - Post Environmental Awareness

Reflect on the relevance of it in the context of this course.

Environmental awareness became a major focus in the HVACR trades following the discovery of how chemicals used in HVACR were causing damage and depleting the earth's ozone layer. The National Aeronautics and Space Administration (NASA) first discovered damage to the ozone layer in 1985., Scientists discovered that when halogens, such as chlorine and bromine reach the stratosphere, they destroy ozone (O3), putting holes in the ozone layer. In fact, one chlorine atom alone can damage more than 100,000 ozone molecules. These chemicals can also enter the atmosphere as part of a chemical group - either chlorofluorocarbons (CFC's) or hydrochlorofluorocarbons (HCFC's), which interact with ultraviolet light, breaking down, releasing the ozone depleting chemicals chlorine and bromine into the stratosphere. CFCs and HCFCs, which are powerful greenhouse gases, have high Global Warming Potential (GWP), meaning a CFC molecule can trap heat at a rate of 4,750 – 14,400 times that of a CO2 molecule.) With even more scrutiny the HVACR industry found itself with new regulations, mandatory ozone depletion prevention (ODP) training, and enhanced best practices to reduce and eliminate the release of chlorine- containing refrigerants, which also included HCFC's.

In Canada, the Heating Refrigeration and Air Conditioning Institute of Canada (HRAI) became the authority providing and overseeing training, certification, and refrigerant management. The training involved terms like recover, reuse, recycle, reclaim. This new knowledge became the impetus for conscientious tradespeople to be more aware of the dangers from other chemicals that are used, such as, mercury in controls, oils for lubrication, degreasers for general cleanup, cleaners for coil cleaning, acids for cleaning of other components and surplus materials to landfill that also affect the environment. Each of these poses a threat to not only the users, but also occupants and the environment if not disposed of appropriately.

Ozone can be an interesting discussion topic with students when we make them aware of the importance of ozone beyond their familiarity. For example, after a thunderstorm that freshness we often smell outdoors is ozone at ground level that was created when lightning separated oxygen molecules and created ozone. That same process exists in our electronic air cleaners with arcs of electricity caused if the airflow is too low and in photocopiers as static energy is discharged during the

printing process. Notably, the building code requires ventilation of photocopy rooms to control the ozone levels. As you can see ozone that exists at ground level is considered a component of smog and is harmful while ozone in the stratosphere is protective. In addition, students usually do not realize that ozone is toxic, and it does not make sense, given that ozone is made up of 3 oxygen atoms and the oxygen we breathe to sustain ourselves is made of 2 oxygen atoms. Most believe that if oxygen is involved it, must be safe.

Following a great effort that united the world producers of these ozone-destroying substances, the engineering community developed alternatives and consumers and tradespeople adapted. Addressing this environmental issue by changing the way we approach standards of practice and chemicals we use, actually worked, and with a reduction of ozone-depleting chemicals, the ozone layer has proven to be repairing itself. This unique cooperation around the world through the 1985 Vienna Convention, and later Montreal Protocol (1987) is empowering and provides encouragement to come together to resolve other environmentally threatening issues.

CFCs have been banned globally since 2010, however, HCFC production and use is still being phased out. Generally, these were replaced by the less ozone-depleting hydrofluorocarbons (HFCs) starting in the late 1980s when the Montreal Protocol was first implemented, but by 2009 at the latest, the United Nations was calling for HFC phaseout as well, given the chemicals high Global Warming Potential (GWP).

Further to the issue of ozone damage from chlorine and bromine chemicals used in refrigerants and fire suppression, we have now recognized that global warming associated climate change is enhanced by chemicals that replaced them in refrigerants known as methane and other carbon-based substances. In manufacturing these replacements that are similarly effective refrigerants, we have discovered that these too persist in the environment for a long period of time causing substantial accumulated damage. One of the solutions is to engineer refrigerants with a view to their rapid breakdown once released into the atmosphere reducing the cumulative damage. Other refrigerants that are organic or naturally occurring substances such as carbon dioxide, ammonia and propane are being used.

An interesting discussion with the students revolves around the use of carbon dioxide (C02) as a refrigerant. Given that CO2 is the major greenhouse gas and also leads to the acidification of our oceans, would it make for a sustainable replacement for other refrigeration gases that have much high global warming potential than CO2 and can also damage our environment and waters?

How is this an environmentally friendly choice?

Chapter 6 – Governance

The United Nations (UN) 2030 agenda of Sustainable Development Goals (SDGs) (Link: What are the Sustainable Development Goals?) envisions a future of inclusive equity, justice and prosperity within environmental limits, and places an important emphasis on education as stated in Goal 4. Education is acknowledged as a means for achieving the remaining Goals, with sustainability as a goal for education in target 4.7.

Link: Education for Sustainable Development: A Systemic Framework for Connecting the SDGs to Educational Outcomes

Several of the SDG's are reflected in this training module. Goal 3 is reflected in the discussion around the use of air-conditioning, heating, and air quality control equipment to maintain healthy environments that support well-being. Goal 4 is being represented through the education of our tradespeople in the areas covered in it. Goal 5 is reflected in the representations we have used of women and gender diverse people in the trades and the use of none gendered titles. Goal 6 is being reflected in our concern for the damage caused by inappropriate choice, use and disposal of chemicals. Goal 9 is reflected in our discussions about innovative technologies. Goal 11 is reflected in our discussions of energy conservation methods and selection of materials. Goal 13 is reflected throughout the module with discussions about climate action. Goal 17 is reflected in our discussions about the various contributions from all parties involved in construction and the inclusion of Indigenous ways to arrive at environmentally friendly solutions.

As you teach and live your life, look for intersections with the Sustainable Development Goals and reflect on them with the aim of building enduring connections.

The trades have long been regulated through acts, regulations, codes and permits. These were developed to protect the public from unsafe work and now must evolve to include the protection of the environment from the use of environmentally damaging products and practices requiring them to be greener where technologies exist and encouraging further development and adoption.

Most of us will have been trained in ozone depletion prevention which as we have stated is one of the standout successes of worldwide collaborative change. This is still a work in progress as we turn our attention to greenhouse gases whose removal from use has a much broader economic impact and are present in many more facets of our lives as we try to reduce them with government incentives to levels that are needed to slow and hopefully stop climate change. The stress of this change is felt by both individuals and corporations alike.

Government controls industry practice through regulation and limiting national sales of low- efficiency equipment or prohibiting or phasing out the production of chemicals and processes identified as having a negative impact on the environment.

In the HVACR industry, a significant number of residential furnaces are gas-fueled, these low-efficiency furnaces belong to Category 1. While they are no longer permitted to be sold in Ontario, Ontario manufacturers can still produce them for sale in other markets. Since January 1, 2022, Vancouver has required all equipment for space and hot water heating in new low-rise residential buildings to be zero emissions; and by 2025, all new replacement heating and hot water systems must be zero emissions. Since December 31, 2021, Quebec has banned oil-powered heating in new construction projects and making it illegal to replace existing furnaces with any fossil fuel-powered heating system starting on December 31, 2023. Another example of designated and regulated chemicals in this industry is the manufacturing and sale of refrigerants that are in the CFC and HCFC categories and more to follow as new products are developed with the anticipated discontinuance of HFC's.

Government action is required because the newer greener technologies and equipment initially tend to be more expensive, which can prevent market uptake, especially in the beginning. Even though there may be longer-term energy and cost savings there is a general reluctance to adopt these newer technologies because of the initial capital investment costs.

Post secondary education for apprentices is highly specified and time limited. By adding more environmental awareness into the curriculum from the beginning, students will be job-ready, especially as new regulations are introduced to building codes and standards across the country. How can you incorporate more meaningful awareness into your classroom?

Incentives through rebates

One of the common methods for various levels of the government to create change and the speed up adoption of environmentally friendly products, technologies, and services is to provide funding through grants and or financial sponsorship. In the HVACR industry we have had a number of rebate programs that created change. Some of those supported the adoption of geothermal, heat pump, and renewable energies. They have been used with various degrees of long-term success, and those industries once supported with rebates often see the failure of continuous adoption because it remains a more expensive option.

This is a link to: Main Directory of Energy Efficiency and Alternative Energy Programs in Canada | Natural Resources Canada

Some addition websites containing supporting data are found below.

HVAC & Energy Systems

Air Conditioning Your Home

Heating and Cooling with a Heat Pump

Energy Efficiency Trends Analysis Tables

Enforcement and Penalties

It is common for us to not want more government intervention and oversight but if persuasion and encouragement with education and incentives does not work then the alternative is enhanced inspection and supervision of trades practices combined with harsher fines and imprisonment supported by more stringent environmental standards.

Chapter 7 - Engineering/Design

As we contemplate new construction or renovations, we must hire a design team whose emphasis is on the total carbon impact of materials and building operations, thus setting the appropriate tone for the project. Like many environmentally friendly considerations, there will be cost implications, but there have been some advancements in materials and techniques that can save money.

There are many architectural treatments that can reduce energy consumption and therefore the carbon footprint associated with a building. Careful consideration of exterior landscaping particularly related to solar heat gain by strategically using and orienting trees of several types can be very impactful. During the summer months leafy deciduous trees can provide shade and reduce the energy required for cooling while in the fall and winter months when the leaves have fallen the solar energy can add heat to the building saving more energy. Incorporating coniferous trees at an appropriate distance can be used to reduce the prevailing wind effect on the structure. These concepts are covered more thoroughly within the landscape module.

Using solar reactive glazing and reflective exterior materials can reduce the carbon footprint further when combined with the proper use of internal and external barriers and sealants that control air infiltration and exfiltration. Some more typical measures like insulating the building can be enhanced with modern technologies and materials that reduce the manufacturing carbon footprint and insulate more

efficiently. Again, these concepts are covered more thoroughly within the carpentry and electrical modules.

Passive systems are favoured for their low energy use. Examples include evaporative technologies, which absorb heat and cool through evaporation, although their effectiveness depends on outdoor climate conditions. More suitable for our climate are economizer systems, which use outdoor air for cooling without refrigeration, and heat recovery ventilator (HRV) and energy recovery ventilator (ERV) systems, which recover energy from exhaust air to pre-condition incoming fresh air. Digital control systems and CO2 sensors further optimize ventilation and reduce energy consumption based on occupancy and demand.

Link: Venmar HRV's

When it comes to buildings, we are not only concerned about their environmental impacts but also about indoor environments and impacts on occupants' health. Air conditioning and heating systems maintain temperature levels, while additions like HRVs, high-efficiency particulate air (HEPA) filtration systems and activated carbon components control air quality. However, given their expense, many people may find these systems unaffordable to purchase or maintain, and without these systems, people may be at increased risk of various health concerns, such as lung and heart conditions, or even an increased mortality rate. As climate change intensifies, indoor air quality will worsen, for example wildfire smoke can significantly erode indoor air quality without air filters in place. This is just one of the many reasons why it's important to address the affordability of systems, and how this can impact people's health, especially where social inequity is concerned, for example in First Nation housing. Indigenous, black, and racialized people are statistically more likely to suffer from environmental pollution than non-racialized and non-Indigenous people – this is also known as environmental racism. Addressing the inequities in Indigenous and racialized people's homes and communities is one step toward addressing environmental racism.

Link: Indoor air quality and health - Science Direct Article
Link: A renewed attention on environmental equity and justice - NCCEH-CCSNE

Grey and Ivy is an organization that combines Indigenous people's values and needs with building design, providing a valuable resource for understanding the relationship between them. Link: Grey and Ivy

Chapter 8 - Institutional Greening Options

Geothermal Use

With energy cost a substantial percentage of the budget for institutional buildings green technologies that save costs and reduce the carbon footprint are more economically feasible. Geothermal systems, which bring heating or cooling to buildings from under the earth, make use of temperature-stable earth and underground water/ reservoirs. Accessing heat sinks with geothermal heat- pump technology, or the use of other types of geothermal energy can provide enough heat for direct heating and power generation.

Link: Advantages of Geothermal

Evaporative Cooling

Every one of us has experienced the power of evaporative cooling and in fact it's an integral system of the human body. It controls our temperature by evaporating moisture off our skin generated in our sweat glands. You may have realized that weather conditions particularly high humidity and low to no air movement makes you feel much warmer than normal. These factors affect the rate of evaporation and will also affect the efficiency of evaporative cooling systems designed for use in HVACR systems. There is more urgency now to find passive or low energy consumption systems because as the earth warms more and more people will make use of air conditioning and the draw on the power grid will have an exponential effect. India is a notable example of this.

The advantage of these systems is their incredibly low energy consumption as they use a small pump to circulate water while a fan provides forced evaporation of the moisture as hot air passes through the evaporative media.

One example of these systems can be found here: https://ambiator.com/

The disadvantage is that if the humidity of the ambient air passing over the media is already high it reduces the evaporation and cooling rate. It also adds humidity to the cooled air leaving the media which increases the humidity in the controlled space. Additionally, because these systems need a constant water supply, in areas where water usage is a concern it may not be appropriate.

Of course, it would be possible to make use of this system in a hybrid arrangement with conventional cooling so that on those days when conditions permitted, the evaporative system could be used, saving energy costs and lowering environmental impact.

It's not new in the HVACR industry to evaporate water through cooling towers to remove heat from mechanical cooling systems. You may have seen plumes of moisture that appear to be fumes leaving buildings when in fact it is evaporated moisture from those systems.

Link: Conestoga College's Sustainability

Conestoga is in the process of creating a formalized approach with all interested parties being given an opportunity to contribute. There have been many projects undertaken some completed and operational, while others are in progress and still others are in the planning stage. The work of sustainability is continuous.

Solar Grazing Initiative

An interesting greening option implemented for the summer of 2024, involves a small group of grazing sheep visiting the Cambridge - Fountain Street campus solar field. Called “solar grazing”, this is a relatively new landscaping approach using livestock to control vegetation growing under solar panels, where it is otherwise difficult to mow. This method will eliminate the need for herbicides and gas-powered landscaping equipment, integrate urban agriculture into college operations, and provide a variety of education and engagement opportunities for the college community. Individually, this has a minor impact on the environment but if we all do what we can when we can, our cumulative efforts will be impactful.

Conestoga and other Colleges across Canada are installing solar panels to generate electricity working towards offsetting the power they consume to a NetZero value and in many cases providing more energy to the grid than they use.

There are some innovative outside the box ideas being experimented with. One is the use of the constant ground conditions to pre-cool or pre-warm air by drawing it through a tunnel or piping network and then into the building; this concept is known as an Earth Tunnel. See the data through the link provided.

Link: Performance Analysis of Earth-Air Tunnel System

Chapter 9 - Technology Advances

The biggest change in the HVACR industry that provides the greatest opportunity for energy efficiency improvements is the advent of less expensive microelectronics and some examples are digital controls, inverter compressor systems, and electronically commutated motors (ECMs). The technology used to vary the speed of motors digitally has been used for a long time in commercial and industrial applications and were known as variable frequency drives (VFD's). These systems were quite expensive until more recently when they were miniaturized, and the costs of components were reduced to a point where they could be used at the consumer level know as ECM's. The adoption of these motors allowed for more efficient systems that operated at a fraction of the cost of standard technology motors, which have not changed with any significance since their original design.

The HVACR industry has incorporated micro-electronics into various applications. With the capability for communication between components, more devices have transitioned to digital operation. As is typical with adoption, this has led to cost reductions and increased utilization. The most up-to-date and efficient systems in HVACR are inverter-based, using variable refrigerant flow technology (VRF). These advantageous systems can modulate capacities to meet demand, while operating efficiently. Interestingly, these consumer technologies are influencing commercial and industrial systems. They incorporate digitally controlled communication devices which enables efficiency based on responsiveness in addition to the common energy-efficiency found in newer appliances and electronics. As a result of these modern technological advances, there have been significant energy savings, benefiting the environment and greening the industry as a whole.

https://www.motili.com/blog/hvac-innovations/

https://lghomecomfort.ca/blog/hvac-technology-advancements/

The use of carbon dioxide in refrigeration systems primarily used in supermarkets has been gaining traction in the industry. While CO2 has proven to be an effective alternative to HFC refrigerants for quite some time, there are still questions around energy efficiency with other, more innovative solutions being designed to address those concerns. More recently we have seen CO2 refrigerants enter the domestic water heater heat-pump market, suggesting enhanced energy savings. To learn more about the technology, please review the article in the link below.

Link: Review and analysis of carbon dioxide heat pump water heaters

In what application and environment would these types of appliances provide the most effective energy savings, while providing relief from extreme temperatures and mitigating impact on the environment?

Can you list any countries whose environment would allow for savings in energy while providing comfort cooling?

Chapter 10 - Tradespeople

Until the mid-1980s to 1990s, there were few distinguishing factors among systems, and tradespeople, who when once certified, had little need for additional training since many systems were manufactured with similar parts and technologies. We might say that the knowledge base was universal among manufacturers. With the advent of ever more efficient equipment and a changing array of innovative technologies it has become necessary to keep current with training and upskilling. The tradesperson of today is not like those of days gone by and is required to analyze, assess, and apply solutions that meet complex situations independently. They are also required to consider how their systems work as an integrated whole within a building. That has necessitated a more highly skilled and educated/trained person that is able to manage all the facets and work collaboratively with contractors from other trades. Those who perform work without direct supervision, must further be conscientious, dependable, compassionate, empathetic, respectful, and politically aware of the diversity that exists in our communities. These attributes support what is needed to always act with consideration for environmental and human health.

Does your current curriculum contain what is needed to develop these attributes and provide the tools to meet these demands? What can you add to your instruction in the classroom and labs that will provide this support?

Micro-credential education is a modern-day approach to support upskilling the workforce as we upgrade our infrastructure. How can you adapt these to support training that prepares a workforce for new regulations, climate change impacts, and Truth and Reconciliation?

Chapter 11 - Contractors

Contractors have a hand in the greening of the HVACR trades through education, adoption and hiring employees the exhibit the attributes that supports this aim. Establishing values, vision, and mission statements that act as reminders to everyone involved and indicate to customers their desire to perform to these standards. Contractors are facing a shortage of tradespeople to meet their needs and may have to settle for under-qualified and environmentally aware personal. At times like we have experienced in recent years there may an availability issue with preferred

efficiency and environmentally friendly equipment, leading to substitutions with lessor efficient types. The contractor can notify suppliers and manufacturers that they will only accept equipment and components that are produced in reduced or carbon neutral plants.

What else can a contractor do to create a comprehensive environment that supports a greener outcome?

Chapter 12 - Customers

In order for customers to contribute to a greener HVACR trade they must have improved knowledge of what a technically capable and environmentally conscious and compliant contractor looks like and how to identify them and contractually demand those outcomes. Some customers still do not verify the basics for example qualifications, certifications and licensing plus appropriate insurance, workers compensation clearance and safety policies/training etc. Additionally, understanding that the lowest price does not often include all these qualifications, compliances, and attitudes. Government could help in educating consumers in order to boost literacy and awareness regarding what makes for a credible and capable contractor and what are important components to consider.

Chapter 13 - Critical Awareness and the Environment

Taking action to ensure our even our smallest tasks are environmentally friendly can have significant benefits when collectively we take greening and climate action seriously.
A simple example is taking a box that had a single-use purpose and cutting off the flaps, giving it a second life.

Take into consideration, a new box is opened - is there an environmental advantage to reusing this box and not cutting a new one to fit?
Let's examine, that if we can leave the box as is, then we reduce the energy consumed in cutting a new one to size and reduce wear on the cutting tool – which lengthens its lifecycle, overall, allowing us to save energy and resources by reusing a box, in the condition it came in, where appropriate.

Take for example, the piping used to connect the evaporator and condenser known as a split system, which is often replaced with new material during a retrofit. Must it be replaced, or can it be reused? The conflict; will the time taken to reuse e.g. clean the original pipe have a negative cost impact on the contractor, will the industry develop a system to clean the pipe efficiently and economically, will the refrigerant industry design a replacement refrigerant to allow the reuse of piping (size), oil trace and components, will regulatory bodies require the reuse? If everyone gets on board, it will be a win for the contractor, the industry, the environment, and humanity. The contractor and homeowner will save money on new pipes, while reducing environmental damage and resource depletion caused by mineral mining and the energy needed to manufacture new products.

Chapter 14 – Indigenous Terms of Reference

Decolonization

Decolonization is the process of deconstructing colonial ideologies of the superiority and privilege of Western thought and approaches.

Indigenization

Indigenization is a collaborative process of naturalizing Indigenous intent, interactions, and processes and making them evident to transform spaces, places, and hearts.

Uncolonization

Uncolonization is the process of working towards an internal shift within ourselves – changing our own attitudes, perspectives, feelings about decolonizing and working toward Truth and Reconciliation.

Settlers can uncolonize, as that is voluntarily distancing, detaching from colonial moreys.

References

From Pulling Together: A Guide for Front-Line Staff, Student Services, and Advisors by Ian Cull, Robert L. A. Hancock, Stephanie McKeown, Michelle Pidgeon, and Adrienne Vedan

Decolonization, A Guidebook For Settlers Living On Stolen Land. | by Tres Rosa | Medium

https://pressbooks.pub/ftmcicanmodules/front-matter/introduction-from-grey-ivy/?

Chapter 15 – Reaching and engaging students with this message

The overarching purpose of this professional development course for our educators is to discover and reflect upon opportunities to raise awareness, empathy and compassion for the environment causing it to be considered before every decision and thereby greening the HVACR trade by creating engagement with examples of change and consequence. Building this into your lesson plan is the first step to creating that change and competence. Additionally, students who graduate with this additional knowledge will find more success and satisfaction in their careers, while meeting the needs of their future employers and helping to secure a thriving, balanced and peaceful society.