Unit 5: Experiencing Alternative Energy Modularly

Unit 5 Overview

The purpose of this unit is to provide students with an introduction to alternative energy experientially. The use of modules in this instance is to ensure that all students have an equal opportunity to access the equipment in question. The hands-on activities are designed to give students access to a full range of the available technologies in the area of alternative energy production. As stated before, these technologies will involve a significant amount of electrician methodology and will, in the future, be a major determinant in the field. Students will learn how to operate tools and machinery specific to the power and energy world. They will learn to use them properly and safely within the fabrication lab environment. The teacher takes on more of a facilitation role in these instances, working with individual student groups in an advisory role. It is suggested that the teacher introduce the modules to all students and review them periodically so that students are prepared for what they will be doing.

Organization

The purpose of this unit is to give students an introduction to and practical working knowledge of alternative energy production. This is a pure example of theory into practice. The previous unit introduced the theoretical while this unit emphasizes the practical. This entire unit will be encompassed by a design process, with an implementation design as its final project.

The following unit topics will provide these experiences:

- Topic 1: Design for Construction (2 hours)
- Topic 2: Windmill Technology (8 hours)
- Topic 3: Solar Cell Technology (8 hours)
- Topic 4: Service Panel Wiring (8 hours)
- Topic 5: Hydrogen Fuel Cells (8 hours)
- Topic 6: Heat Pump Technology (8 hours)
- Topic 7: Sustainable Housing (8 hours)

Assessment

This section constitutes approximately 40% of the course time and the value attributed to it should reflect that status. It is expected that most of the assessment opportunities in this section will involve hands-on activities and assessment tools dealing with observation and experiential learning will be the most effective.

Topic 1 – Design for Construction

Specific Curriculum Outcomes

Students will be expected to

5.1.1 identify the steps in the design process [1.401]

Delineation

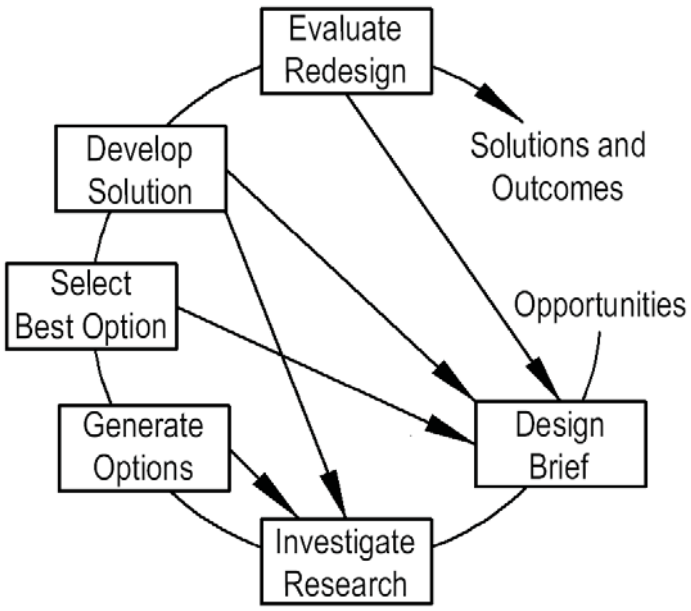
The discussion should focus on:

- Needs identification
- Defining the Problem
- Generating Options
- Selecting the Best Option
- Developing the Solution
- Prototyping and Testing
- Evaluation and Redesign

Suggested Learning and Teaching Strategies

It is essential in any design that the student be familiar with the steps in the design process and their relation to construction or renovation. This differs from fabrication because of the limitations it introduces. Normally in fabrication the only limitation is tooling and space. In this instance the limitations are resultant from the size of the structure and how the solutions can be introduced within it.
Using a case study example, the teacher should discuss the concepts of renovation and construction and how each introduces different constrictors in the process of design.
The teacher must also introduce the concept of problem solving in both individual and group environments and the related advantages/disadvantages in each case.

The Design Process can be encapsulated in the following diagram.



Topic 1 – Design for Construction

Suggestions for Assessment

Paper and pencil

- Students develop a poster outlining the steps of the design process. This poster could be complete with examples of the various stages of a product in design.

Presentation

- Students present to the class their interpretation of the design process in their own words.

Paper and pencil

- Students outline and explain the steps of the design process. This outline should include language such that a student in grade 4 or 5 would understand what was being explained.

Discussion

- Students debate and discuss the order of the steps of the design process. Links to the scientific method and other problem-solving approaches should be introduced here.

Resources

TEXT

- *Design and Fabrication 1202 Curriculum Guide*
- *Design and Fabrication 2202 Curriculum Guide*

WEB

- The Technology Student - http://www.technologystudent.com/designpro/despro1.htm
- Nuclear Engineering Site - http://www.nuceng.ca/ep716/chap7.pdf
- Robotics Design Process - http://www.galileo.org/robotics/design.html

Topic 1 – Design for Construction

Specific Curriculum Outcomes

Students will be expected to

5.1.2 apply the design process in the design of a simple alternative energy implementation [1.402, 1.403]

Suggested Learning and Teaching Strategies

The design in this instance is very specific and can be very practical. Designing for construction is centered around making something work in an existing design or an existing structure. Many houses are being designed with alternative energy solutions in mind, but few are designed around them. These specific designs can be discussed in class and examples of such shared, but the more practical design for renovation and/or construction should form the basis of the design challenge.

This objective has the capability of becoming very practical not only in class but in the student's own experience. Most of these alternate energy solutions are readily available through local hardware stores and being able to calculate the benefits of such while designing an implementation into an existing or new structure will have value.

The remainder of the outcomes in this section will give the student some practical experience with the alternative energy products that will be part of the designed solution. Students should identify what sort of solution they are designing for, an existing structure or a new build. Floor plans and general layouts of the structures should be either procured or drawn. The next stages of the design should include the discussion of what is easily possible in the situation the students have identified.

Cost of implementation, cost of operation and savings possible (if any) should all enter into the process. Alternative energy solutions tend to have large capital outlays with savings being realized in operating costs over a number of years.

Topic 1 – Design for Construction

Suggestions for Assessment

Practical activity

- Students begin the design of their alternative energy solution. At this juncture, the type of structure for implementation, a suggestion of what types of alternative energy could be used and an estimate of cost should be included.

Design Portfolio

- Students create a design portfolio at this point. This portfolio will contain all of the designs, design elements, meeting notes and drawings that students will have undertaken in this section of the course. The portfolio could be paper-based, digital or some other media that students will feel comfortable reporting in.

Research/Presentation

- Students research the installed costs of various alternative energy solutions, as well as their proposed savings over a period of years. A cost-benefit analysis is undertaken, taking into account long-term maintenance costs as well. This could be presented to the class or as a poster for display in the fabrication lab.

Resources

TEXT

- *Design and Fabrication 1202 Curriculum Guide*
- *Design and Fabrication 2202 Curriculum Guide*

WEB

- The Technology Student - http://www.technologystudent.com/designpro/despro1.htm
- Nuclear Engineering Site - http://www.nuceng.ca/ep716/chap7.pdf
- Robotics Design Process - http://www.galileo.org/robotics/design.html

Topic 1 – Design for Construction

Specific Curriculum Outcomes

Students will be expected to

5.1.3 review the legislation dealing with the use of windmill and solar power generation methods in Newfoundland and Labrador [1.405]

Suggested Learning and Teaching Strategies

The purpose of this outcome is to introduce the legislative requirements for dealing with aspects of alternative energy production. The two types of energy production specifically are wind and solar which have the capability of producing electricity directly.

There is no specific legislation dealing with wind and solar power generation, but power generation in general is covered under the Newfoundland and Labrador Hydro Act. That act gives an absolute monopoly for power generation to Newfoundland and Labrador Hydro. No other company or individual can add power to the grid unless they first sell it to Hydro. Some inferences can also be made from the Provincial Energy Plan and the "2009 Lower Churchill deadline". There are references to this in the notes section found in appendix A From an small energy production perspective

- Utilities are governed by the PUB. Only registered utilities can sell power to customers and rates are set by the PUB for classes of electrical users.
- Individuals or companies do not have to be a utility to produce electricity but can only sell it to a utility.
- On-the-grid facilities are not permitted to include personally owned alternative solutions at the same time unless inspected and approved by the utility.
- Off-the-grid facilities have no barrier to use, beyond the restriction of who excess power can be "sold" to.

Student Activity:

Students discuss what these legislative powers could mean to personal use of windmill power generation.

Topic 1 – Design for Construction

Suggestions for Assessment

Research/Presentation

- Students define the difference between an economic limit and a technical limit. In the process they could discuss what is needed in the province to make these higher.

- Students research the role of the Public Utilities Board in power generation and regulation. In the process they also research who is on the board and who they represent.

Resources

WEB

- Newfoundland and Labrador Government Energy Plan - http://www.nr.gov.nl.ca/energyplan/
- Energy Corporation Act - http://assembly.nl.ca/Legislation/sr/statutes/e11-01.htm
- Newfoundland and Labrador Government Energy Plan - http://www.nr.gov.nl.ca/energyplan/
- Electrical Power Control Act - http://assembly.nl.ca/Legislation/sr/statutes/e05-1.htm
- Public Utilities Act - http://assembly.nl.ca/Legislation/sr/statutes/p47.htm

NOTES

- Appendix A - Notes section pg. 14

Topic 2 – Windmill Technology

Specific Curriculum Outcomes

Students will be expected to

5.2.1 review and demonstrate proper safety procedures when working with a wind turbine power generation system [1.405]

Suggested Learning and Teaching Strategies

Windfarms are extremely safe and are designed for life of at least 20 years in all weather extremes. All major manufacturers use international safety standards in turbine design, which allows for complete shut down during times of excessive wind speeds. Turbines should have a "survival speed" brake system. (turbine spins above set speed and it automatically shuts down)
Wind turbines produce no harmful emissions in their generation of electricity, as they have a direct mechanical energy transfer system in most cases. Most modern turbines use lightning-protection systems engineered to direct lighting safely to the ground.
Safety issues during construction include working at heights in windy conditions, working with cranes, heavy machinery, rotating machinery, and high voltage. Mounting turbines to a roof top is not recommended unless it is a small unit (1 kW of rated output or less). Turbines tend to vibrate and transmit this vibration to the structure resulting in damage to the structure.

For the specific purpose of safety in this course, students will be working with electricity and the wind turbine.
Points to emphasize

- A wind turbine must be treated with respect at all times, and no movement should be undertaken unless the brake is engaged.
- Any time the turbine is in operation it must be properly guarded or isolated in such a way as to be clear of obstructions and/or accidental contact
- Electricity safety is covered in Skilled Trades 1201 and the Technology Education Safety Guide. These documents should be heavily referenced before students are engaged in an electrical activity.

Topic 2 – Windmill Technology

Suggestions for Assessment

Research/Presentation

- Students research working safe websites, dealing with rotational machinery, as well as their own fabrication lab safe tool use for machinery that has common features with a windmill, and create a list of safe work rules dealing with windmill technology. This could be presented to the class or passed in as an assignment.

- Students review the safety precautions in place when working with electricity and extrapolate them for use in this area. A poster for safe windmill technology use could be created or this could be entered into their work log.

Discussion

- Students search the Nalcor Energy website for examples of safety procedures used in their generating facilities. A search of other windmill generating stations and their websites may contain further information. A small group or class discussion around this topic could ensue.

Resources

TEXT

- *Progressive Education Alternative Education Teacher's Guide*
- *Progressive Education Alternative Education Student Manual*

WEB

- Wind Turbine FAQ - http://www.hybridynepower.ca/Page_80.02.htm
- Renewable Energy UK - http://www.bwea.com/ref/faq.html
- How safe is Wind Energy? - http://wiki.answers.com/Q/How_safe_is_wind_energy

VIDEO

- Wind Turbine Setup - Skilled Trades and Technology Professional Learning Video Series

Topic 2 – Windmill Technology

Specific Curriculum Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
5.2.2 outline the historical use and development of windmill technology [1.405]	The current interest in wind energy was started by the need to develop clean, sustainable energy systems that can be relied on for the long-term future. But wind energy has been used in a variety of ways for centuries. This section should encompass the breadth of that use, including the specific high points of: • circa 500 BC - Persians used wind energy to pump water • circa 1000 - wind-driven ships start to explore the world • circa 1500 - Dutch use wind energy to drain marshes and lakes • 1920's - over a million wind turbines pumped water and provided electricity to farms in North America Wind turbines now provide reliable, cost-effective, pollution-free energy for individual, community, and national applications. Student Activity: • Students develop a timeline of windmill technology, emphasizing the high points of its use in history. Comments could be made at each of these points as to how these developments have lead to the modern wind turbine.
5.2.3 describe the planned wind-farm technology to be used in Newfoundland and Labrador [1.404, 1.405, 2.404]	This outcome is intended to make students aware of the great potential this province has to be a leader in alternative power generation. Many are aware of the potential and already developed projects on the Churchill River, but wind is another untapped resource. An examination of the wind atlas of Canada, indicates that Newfoundland and Labrador is one of the best areas in the country for windfarming. Almost all of our coastal areas have sufficient and consistent wind speeds to sustain a windfarm. Several projects have been initiated to test the viability of producing electricity in this way. Along with these projects, test and pilot sites around the province are being used to examine methods to provide

Topic 2 – Windmill Technology

Suggestions for Assessment

Research/Presentation

- Students research some of the reasons why windmills were used and how they have developed into a major alternative energy solution.

Discussion

- Students discuss, in small groups or as a class, how some of the historical uses for windmills may still have applicability today. These could include but are not limited to, pumping water, driving machinery, etc.

Research/Assignment

- Students research the planned wind farms to be used in the province and create maps that show their location. These could be compared to maps of the prevailing winds in Newfoundland and Labrador as a method to discover why they were placed at their location.

Resources

TEXT

- *Progressive Education Alternative Education Teacher's Guide*
- *Progressive Education Alternative Education Student Manual*

WEB

- Wind Energy History - http://www.thesolarguide.com/wind-power/history.aspx
- History of Wind Energy - http://www1.eere.energy.gov/windandhydro/wind_history.html
- History of Wind Power - http://www.windturbinesnow.com/history-wind-power.htm

NOTES

- Appendix A - Notes section pg. 14

WEB

- Newfoundland and Labrador Government Energy Plan - http://www.nr.gov.nl.ca/energyplan/

NOTES

- Appendix A - Notes section pg. 14

Topic 2 – Windmill Technology

Specific Curriculum Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
5.2.3 describe the planned wind-farm technology to be used in Newfoundland and Labrador [1.404, 1.405, 2.404] (cont'd)	consistent power from wind, which even in this province is not always of sufficient speed to generate electricity. Within the notes section in the appendix is an overview of the specifications of these new projects. The amount of CO_2 produced versus the amount of energy produced would be an area to highlight. Student Activity: • Students compare this amount of greenhouse gas reduction to the amount a typical family would produce in a year (2 tons). This comparison can include aspects of the "1 ton challenge" (an initiative of Environment Canada) and how such an energy solution could enable a global reduction in the production of greenhouse gases.
5.2.4 determine the proper placement for a wind turbine, taking into account wind gusts, placement, safety and other considerations [1.402, 2.401, 2.404]	Two important factors when setting up a wind turbine are the amount of energy needed and the amount of wind available. Students could refer to Environment Canada's Wind Atlas for the latter. Their maps graphically show available winds for all regions in Canada and at different elevations, http://www.windatlas.ca/en/index.php Points to emphasize • wind consistency • noise • proper safety such as fencing and signage • environmental impact • zoning, and • aesthetics Basic system will include a turbine, a controller, a battery bank, an inverter to provide AC output. Students should consider all of the above when placing their wind turbine. Student Activity: • Students place a wind turbine, taking into account the major factors for maximum generation potential. • Students compare output from the wind turbine with output from the weather station in their schools.

Topic 2 – Windmill Technology

Suggestions for Assessment

Practical Activity

- Students, over a number of classes, determine the prevailing wind direction around their school. This can be accomplished through taking measurements, collecting data from the school weather station, from internet weather sites or from Environment Canada. A chart of the wind directions around the school could be completed.
- Students examine the footprint of their school and determine the safest place that a wind turbine could be set up.

Resources

TEXT

- *Progressive Education Alternative Education Teacher's Guide*
- *Progressive Education Alternative Education Student Manual*

WEB

- Best Places to put a Wind Turbine to Produce Electricity - http://www.ehow.com/way_5159049_places-wind-turbines-produce-electricity.html
- Canadian Wind Atlas - http://www.windatlas.ca/en/maps.php
- Picking the best location for a wind turbine - http://www.omafra.gov.on.ca/english/engineer/facts/03-047.htm#location

Topic 2 – Windmill Technology

Specific Curriculum Outcomes

Students will be expected to

5.2.5 monitor wind turbine efficiency by comparing output to general daily wind speeds or to artificial variations to account for same [2.401, 2.404]

Suggested Learning and Teaching Strategies

German physicist Albert Betz proved in 1919 that the highest efficiency possible from a wind turbine is around 59%, and this is really unattainable given other constraints. This became known as Betz Law.
Efficiency is a mathematical relationship that is sometimes expressed as

input/output x 100%

A given turbine has a "design point" that defines its peak efficiency at the wind speed for which it is designed. For speeds above and below the design point the efficiency will be the same or less.
Data loggers can be used to measure the power output & efficiency of the turbines using various sensors. Typical sensors include, but are not limited to:

- anemometers,
- wind vanes,
- temperature sensors,
- solar radiation,
- electrical current,
- resistance,
- power, and
- voltage.

Student Activity:

- Students construct a performance curve of power output versus wind speed that can then be used to measure efficiency.
- Students also compare this efficiency to the "design point" efficiency of the wind turbine in use. Part of this task includes finding the "design point" efficiency.

Topic 2 – Windmill Technology

Suggestions for Assessment

Practical Activity

- Students, using the in-class wind turbine assembly, monitor wind turbine efficiency at different wind speeds. As well, they can check the efficacy using the load device. An assignment or series of log entries on this material would be suggested.

Research/presentation

- Students research material on measuring wind speeds, and in so doing, create a system where the speed of wind can be measured and compared to the output of a wind turbine. The weather station, in use in many schools, has specific utility here.

Research/Practical Activity

- Students, using the load device, test the effects of using compact fluorescent bulbs instead of incandescent bulbs. This could be compared to claims made by the manufacturers as to which uses less energy long term.

Resources

TEXT

- *Progressive Education Alternative Education Teacher's Guide*
- *Progressive Education Alternative Education Student Manual*

WEB

- Wind Turbines and the Energy in Wind - http://www.ftexploring.com/energy/wind-enrgy.htmlCanadian Wind Atlas - http://www.windatlas.ca/en/maps.php
- Wind Energy Planning - http://www.windenergyplanning.com/wind-turbine-efficiency/
- Wind Turbine Efficiency 101 - http://windturbinesforsale.net/wind-turbine-efficiency-101/

Topic 3 – Solar Cell Technology

Specific Curriculum Outcomes

Students will be expected to

5.3.1 review and demonstrate proper safety procedures when working with a solar cell power generation system [1.405]

Suggested Learning and Teaching Strategies

Unlike many technologies used for the generation of electricity, the solar cell (photovoltaic cell) does not contain any visibly moving parts. Photovoltaic is the direct conversion of sunlight into electricity at the atomic level. Based on the photoelectric effect first observed in 1839 and later made famous by Albert Einstein in 1905, it results from the fact that certain materials absorb photons and release electrons, thus forming an electric current.

Due to the fact that there are no moving parts, and that from each separate cell only a little current is produced, it is generally the safest alternative energy generation method. The solar cell is actually a number of photovoltaic cells working in tandem. The amount of electricity generated from it gets larger for each cell added.

Safety concerns for the solar cells exist around breakage hazards, falling hazards and electrical hazards. For the specific purpose of safety in this course, students will be working with electricity and solar cells.

Points to emphasize

- A solar cell must be treated with respect at all times, risk of shattering can occur if the cell is mishandled.
- Any time the cell is in operation it must be placed in such a way as to be clear of obstructions and/or accidental contact.
- Electricity safety is covered in Skilled Trades 1201 and the Technology Education Safety Guide. These documents should be heavily referenced before students are engaged in an electrical activity.

Topic 3 – Solar Cell Technology

Suggestions for Assessment

Research/Presentation

- Students research working safe websites, dealing with electrical production machinery, as well as their own fabrication lab safe tool use for machinery that has common features with a windmill, and create a list of safe work rules dealing with windmill technology. This could be presented to the class or passed in as an assignment.

- Students review the safety precautions in place when working with electricity and extrapolate them for use in this area. A poster for safe windmill technology use could be created or this could be entered into their work log.

Discussion

- Students search the Nalcor Energy website for examples of safety procedures used in their generating facilities. A search of other windmill generating stations and their websites may contain further information. A small group or class discussion around this topic could ensue.

Resources

TEXT

- *Progressive Education Alternative Education Teacher's Guide*
- *Progressive Education Alternative Education Student Manual*

WEB

- Solar Panel FAQ - http://www.solarhome.org/solarpanelsfaqs.html
- Solar Power Kits - http://poweredbysolarpanels.com/industry/solar-power-kits/

VIDEO

- Solar Cell Setup - Skilled Trades and Technology Professional Learning Video Series

Topic 3 – Solar Cell Technology

Specific Curriculum Outcomes

Students will be expected to

5.3.2 outline the historical use and development of solar cell technology [1.405]

Suggested Learning and Teaching Strategies

The underlying theory behind the solar cell is the photoelectric effect. This section is most effectively covered by using independent research or a time-line approach. In either case there are certain high points that should be covered:

- 1839 - discovered in by Edmund Bequerel
- 1905 - further refined and described by Albert Einstein
- 1958 - first actual module built by Bell Laboratory
- 1960's - space race - satellites and capsules used them for a power source, technology refined
- 1970's and 80's - energy crisis - further refined, became more mainstream.
- 1980's and 90's - technology advances for home use

The technology continues to advance and decrease in price. As costs for other methods of lighting and heating a home continue to increase, the attractiveness of this alternative will also increase.

Student Activity:

Students be engaged in practical activities at this point, relating examples of how solar cells have become more mainstream from their own lives. Solar cells used for toys, RVs or home that are available at the local hardware store are one example.

Topic 3 – Solar Cell Technology

Suggestions for Assessment

Research/Presentation

- Students research some of the reasons why solar cells were used and how they have developed into a major alternative energy solution.

Discussion

- Students discuss, in small groups or as a class, how some of the historical uses for solar cells and in particular gathering energy from the sun, may still have applicability today. Such things as heating and cooling the air in a structure would be a good place to start.

Assignment

- Students research how solar cells work then write them in an explanation such that a ten year old could understand it. This assignment could be passed in or entered into a portfolio or work log.

Resources

TEXT

- *Progressive Education Alternative Education Teacher's Guide*
- *Progressive Education Alternative Education Student Manual*

WEB

- Photovoltaics History Timeline - http://inventors.about.com/od/timelines/a/Photovoltaics.htm
- The History of Solar - http://www1.eere.energy.gov/solar/pdfs/solar_timeline.pdf
- Solar History 101 - http://www.gosolarcalifornia.org/solar101/history.html
- Wikipedia - http://en.wikipedia.org/wiki/Solar_cell

NOTES

- Appendix A - Notes Section

Topic 3 – Solar Cell Technology

Specific Curriculum Outcomes

Students will be expected to

5.3.3 describe common usages for solar cell technology in Newfoundland and Labrador [1.402,1.405, 2.401, 2.404]

Suggested Learning and Teaching Strategies

Solar cells are in use all around Newfoundland and Labrador. The technology provides power that can be used to run devices as well as stored in batteries. The most seen use for the technology is the interpretation centers on the highway going through Terra Nova National Park. These centers have lighting and some small devices in use that require power. Rather than running electrical lines and wires through the pristine environment, Parks Canada used solar cell technology to power these devices. Transport Canada used solar cells to power isolated lights and buoys that are in place for navigation. Solar technology is being tested as a power source for isolated communities. The examples listed are a good cross-section of the many areas it is in use, and may suggest to students other areas the solar cell may have applicability.

Points to emphasize

- Places where solar cells have the greatest use are those which running electrical wire is impractical
- Most of the solar cell technology in use in Newfoundland and Labrador has been for government use.
- As cell technology decreases in price it is expected that the number of uses in the private sector will also increase.

Student Activity:

- Students outline the areas which they feel solar cell technology could be used in Newfoundland and Labrador.
- Students research the areas solar cell technology is currently in use in Newfoundland and Labrador.

Topic 3 – Solar Cell Technology

Suggestions for Assessment

Research/Assignment

- Students research solar cells as currently used in the province and create maps that show the locations. Discussions of why they were used in this instance could occur, as well as a written assignment.

- Students take the list they have created of areas they feel solar cell technology could be used for, and compare it to a list of those places that are currently using it. A discussion could ensue as to why the two lists are different or the same.

- Students research the use of other types of solar technology in the province, those that do not include solar cell technology. This could be completed as an assignment, or presented to the class as a whole.

Resources

WEB

- A Solar Cell Home In Newfoundland and Labrador - http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V4S-4967CX7-1&_user=10&_coverDate=02%2F29%2F2004&_rdoc=1&_fmt=high&_orig=search&_sort=d&_docanchor=&view=c&_searchStrId=1313184066&_rerunOrigin=google&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=eb585a6f6a4c51d68c5e2229dcb2b76d
- Cross Canada in a Solar car - http://www.engineering.com/Library/ArticlesPage/tabid/85/articleType/ArticleView/articleId/84/Cross-Canada-in-a-Solar-Car.aspx
- Newfoundland Power - http://www.newfoundlandpower.com/KidZone/eew/learn/make.html

Topic 3 – Solar Cell Technology

Specific Curriculum Outcomes

Students will be expected to

5.3.4 set-up a solar cell, taking into account sunlight exposure, angle, placement, safety and other considerations [1.402, 2.401, 2.404]

Suggested Learning and Teaching Strategies

Solar cell arrangements have to be set up to capture the most sun to be of the most benefit. To do this effectively there are several items to consider:

- The direction of the cell
- The hemisphere you are in
- The season
- The angle of the sun

To be most effective, solar cells cannot be fixed year round. The have to be able to be adapted depending up the season. Generally all solar panels in the northern hemisphere will point south. In the southern hemisphere they would point north. This direction does not change, but the tilt of the panel itself, how far it is from horizontal will.

There are two methods of dealing with this effect, one is the simple one of changing the tilt of the solar cell as the seasons change. There are many charts showing the angle of the sun, and simple calculations that can be done to determine the best orientation. The general rule of thumb for this orientation is that you take your latitude plus 15^{o} for winter and minus 15^{o} for summer.

The second way of dealing with this effect is to use a sun-tracking system. This automated system will track the sun and using motors adapt the angle and position of the solar cell as needed. For the purposes of this course we will be dealing with the manual method.

Finally the last consideration for placement of the solar cell is a simple one, shade. Cells should be placed such that they are exposed to sun at all times, not shaded at any time.

Student Activity:

- Students research the tilt angles of solar cells to determine

Topic 63– Solar Cell Technology

Suggestions for Assessment

Practical Activity

- Students, over a number of classes, determine the best direction around their school for taking in sunlight. This can be accomplished through taking measurements, collecting data from the school weather station, from internet weather sites or from Environment Canada. A chart of the solar path around the school could be completed.

- Students examine the footprint of their school and determine the best and safest place that a solar cell could be set up.

- Students place a solar cell outside their school. They should take into account:
  - the direction the cell should point;
  - the season; and
  - the angle of the sun.

Resources

TEXT

- *Progressive Education Alternative Education Teacher's Guide*
- *Progressive Education Alternative Education Student Manual*

WEB

- Solar Panel FAQ - http://www.solarhome.org/solarpanelsfaqs.html
- Solar Power Kits - http://poweredbysolarpanels.com/industry/solar-power-kits/
- Solar Research - http://www.nrel.gov/solar/

LEARNING MATERIALS

- Progressive Education System Solar Cell Apparattus

VIDEO

- Solar Cell Setup - Skilled Trades and Technology Professional Learning Video Series

Topic 3 – Solar Cell Technology

Specific Curriculum Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
5.3.4 set-up a solar cell, taking into account sunlight exposure, angle, placement, safety and other considerations [1.402, 2.401, 2.404] (cont'd)	whether the rule of thumb actually is the optimum method for determining the angle. • Students calculate the angle the cell should be placed at for different latitudes in Newfoundland and Labrador. These angles can be plotted on a graph or map to show the differences. • Students use information from the weather station on their schools to determine the sunniest times of the year. This data could be used to determine the best times to deploy a solar cell.
5.3.5 wire a solar cell into a solar charge controller and green meter panel [1.402, 2.401, 2.404]	The two devices to be wired are integral to the process of wiring off the grid. The charge controller keeps a steady charge in place, while the green meter indicates cost savings. The final piece would be a charge inverter to permit DC-AC conversion. The three devices together create a functional system that will allow for normal power use while ensuring proper charging and indicating savings. Off-the-grid as discussed previously is the easiest application for this technology. If no other power sources are available then legislative questions do not arise. Other scenarios in this area should also be explored, namely the partial off-the-grid solution and the on-the-grid solution. The partial solution would mean that one distinct part of the power use in a home would be isolated from the main. That part would then be supplied through an alternative solution. The on-the-grid solution would require a sign-off from an electrician. In this case you are using the alternative solution to off-set the amount of electricity you are using on a grid. Inspections of such a solution are necessary, but the legislation governing their use has not as of yet been developed.

Topic 3 – Solar Cell Technology

Suggestions for Assessment

Practical Activity

- Students attach a solar cell to the charge controller and battery assembly. This could be done on a group per group basis or done once as a whole class demonstration.
- In small groups, students use the bench-top trainer for solar cells and examine how they are wired into a charge controller and how they are wired internal to the solar cell assembly as well.

Resources

TEXT

- *Progressive Education Alternative Education Teacher's Guide*
- *Progressive Education Alternative Education Student Manual*

WEB

- Solar Panel FAQ - http://www.solarhome.org/solarpanelsfaqs.html
- Solar Research - http://www.nrel.gov/solar/

LEARNING MATERIALS

- Progressive Education System Solar Cell Apparattus

VIDEO

- Solar Cell Setup - Skilled Trades and Technology Professional Learning Video Series

Topic 3 – Solar Cell Technology

Specific Curriculum Outcomes

Students will be expected to

5.3.6 monitor solar cell efficiency by comparing output to sunshine availability [1.402, 2.401, 2.404]

Suggested Learning and Teaching Strategies

This outcome also links the weather station installed in all high schools with the solar cell. Using data from the weather station on sunshine availability, also visual data of the sky, a measurement of the output of the solar cell can be taken and compared to this other data.

Points to emphasize

- Solar cells will produce electricity even when it is cloudy.
- The amount of sunlight that is available should be compared to the output from the panel
- Output from the panel should be measured on the green meter
- Tilt and placement will also have to be taken into effect when working on this section

Student Activity:

- Students graph the output of the solar cell to the sunshine availability and plot a light vs electricity graph. Simple experiments can also be carried out on this using a high intensity flash light.

- Students discuss and comment on the variability of sunlight availability in Newfoundland and Labrador and what this may mean for solar cell use in this province.

Topic 3 – Solar Cell Technology

Suggestions for Assessment

Practical Activity

- Students, using the solar cell assembly, monitor solar cell efficiency at different sunlight levels. As well, they can check the efficacy using the load device. An assignment or series of log entries on this material would be suggested.

Research/Assignment

- Students research material on measuring sunlight levels, and in so doing, create a system where the amount of sunlight can be measured and compared to the output of a solar cell. The weather station, in use in many schools, has specific utility here.

Research/Practical Activity

- Students, using the load device, test the effects of using compact fluorescent bulbs instead of incandescent bulbs. This could be compared to claims made by the manufacturers as to which uses less energy long term.

Resources

TEXT

- *Progressive Education Alternative Education Teacher's Guide*
- *Progressive Education Alternative Education Student Manual*

WEB

- Solar Cell Efficiency - http://www.pvsociety.com/hottopic/Solar_Cell_Efficiency/
- Efficiency - http://www.renewableenergyworld.com/rea/news/article/2007/07/from-40-7-to-42-8-solar-cell-efficiency-49483

MATERIALS

- Progressive Education System WSEM -400 Wind/Solar Apparattus
- Heathkit RES-100 Solar/Fuel Cell Experiment Materials

Topic 4 – Service Panel Wiring for Off-the-grid technologies

Specific Curriculum Outcomes

Students will be expected to

5.4.1 describe the components and function of a standard residential electrical service [1.405]

Suggested Learning and Teaching Strategies

The service is made up of a number of key components.

- Main hot bus
- Neutral bus bar
- Ground Wire
- Main Power switch
- Breakers
- GFI Breakers

Each of these components has a function and these should be covered in detail.

Considering the practical nature of this course, the teacher could use the materials supplied to do a practical demonstration of what each of the terms is and how it would look. Then each of the components can be broken down and described as part of their function in the residence. At this time introducing changes that have happened to the electrical service would be useful. Fuses should be discussed at some point as students may be familiar with their function as well.

At no time should students be in close proximity to an operating panel with the panel cover off, unless they are in the presence of a certified electrician.

Student Activity:

Students create a flowchart as a class or in small groups that shows how electricity flows from the main service mast into the residential service and then into individual circuits.

Topic 4 – Service Panel Wiring for Off-the-grid technologies

Suggestions for Assessment

Research/Assignment

- Students create a table with two columns, listing the following items in column 1, describing the purpose/function of each of the items in column 2.
  - Breakers and fuses
  - Wires, (types and sizes)
  - Octagon and outlet boxes
  - GFCI
  - Neutral Bus Bar
  - Main Hot Bus
  - Ground Wire
  - Main Power switch
- For each of the items, examine the device and determine how wire is connected.

Work log

- Students create an entry outlining the information they have learned, in their work log.

Guest speaker

- Students invite a guest speaker to class who is a certified electrician. Each student could develop a question to ask of the guest speaker before the come to class and be responsible for not only asking the question but recording the answer to report back to the class.

Resources

TEXT

- *Skilled Trades 1201 Curriculum Guide*
- *Smart Guide To Wiring*
- *Modern Carpentry* - Chapter 26
- *Carpentry & Building Construction* - Unit 8, Chapter 39

WEB

- Electrical Safe Work Practices - http://www.aps.anl.gov/About/Committees/Electrical_Safety_Committee/ElectricalSafeWorkPractices.htm

VIDEO

- Hometime Video Collection (Hometime Video Publishing Inc.) - How-To Guide to Plumbing and Electrical

NOTES

- Appendix A - Notes Section pg. 15

Topic 4 – Service Panel Wiring for Off-the-grid technologies

Specific Curriculum Outcomes

Students will be expected to

5.4.2 demonstrate safe practices for use of tools and test equipment common in the installation of an electrical service [2.401][2.402] [2.405] [3.401][5.402]

Suggested Learning and Teaching Strategies

Before permitting students to work independently there are a number of demonstrations that must be accomplished.

Points to emphasize:

- Building code requires that the mast be of a certain size, type of material, distance above the finished grade.
- The meter socket be located 6 feet above the finished grade of the lot and properly grounded.
- The service panel must be located 5-6 feet above the finish floor and specific code requirements regarding how and where it is to be located.
- In most houses today the majority of the service electrical components are made from non conducting materials like plastic, adequate grounding must be provided through suitable ground wiring and the main water supply for the house.

The main service conductors are large copper cables that may be cut to size using a hack saw. Plastic insulation is removed using a utility knife of pocket knife and are inserted into lugs designed to hold the cables snug to prevent arching.

Student Activity:

As a homework activity, students should examine and sketch their home mast and service panel to ascertain where on the house it is located, what sort of fault interuption is present, where in the house it is located and whether there might have been a better place to install the panel.

Topic 4 – Service Panel Wiring for Off-the-grid technologies

Suggestions for Assessment

Only 100% on the written and performance components of the test for each tool is acceptable.

Pencil and Paper

- Assess tool safety and use with Tool Safety Quizzes from Skilled Trades Safety Guide. This is assessment for learning, and students must repeat the quizzes until 100% is attained. No tool use is permitted before successful completion of the quizzes.

Practical Activity

- Students must demonstrate the safe and proper operation of the following tools and devices:
  - Wire cutters
  - Wire strippers
  - Multimeter
  - Circuit tester
  - Screwdrivers

Work log

- Students create an appropriate entry in the worklog itemizing the tools they have qualified for.

Resources

TEXT

- *Skilled Trades 1201 Curriculum Guide*
- *Smart Guide To Wiring*
- *Modern Carpentry* - Chapter 26
- *Carpentry & Building Construction* - Unit 8, Chapter 39
- *Skilled Trades and Technology Safety Guide* - Safety Test Appendix

WEB

- Electrical Safe Work Practices - http://www.aps.anl.gov/About/Committees/Electrical_Safety_Committee/ElectricalSafeWorkPractices.htm

VIDEO

- Hometime Video Collection (Hometime Video Publishing Inc.) - How-To Guide to Plumbing and Electrical

Topic 4 – Service Panel Wiring for Off-the-grid technologies

Specific Curriculum Outcomes

Students will be expected to

5.4.3 discuss safe practices when working with electricity and an electrical service [2.401][2.402][2.405] [3.401][5.402]

Suggested Learning and Teaching Strategies

The general rules of safety for electricity established in previous courses of the Skilled Trades Program still apply in this instance. Special reference to them should be made at all times.

In this instance specific reference to the electrical service component is the main goal. The service is made up of a number of key components. Each of these should have been discussed in some detail in SCO 5.4.1.

These include but are not limited to:

- Main hot bus
- Neutral bus bar
- Ground Wire
- Main Power switch
- Breakers
- GFI Breakers

Extensive notes can be found in Appendix A notes section under SCO 5.4.1.

Students working with electrical circuits must be made fully aware of the dangers of working with electrical energy.

- Students must never energize a circuit that has not be inspected and approved by the instructor.
- Students must use only materials that are designed for a designated purpose. (eg. 14/2 AWG solid wire would not be appropriate for wiring baseboard heaters).
- Electrical test equipment must never be used until proper training on it application and use have be completed
- Students must be encouraged to plan out circuits and have them approved by the instructor wired before attempting to construct the circuit.

Student Activity:

Students define all of the terms associated with the key components of a main breaker box service.

Topic 4 – Service Panel Wiring for Off-the-grid technologies

Suggestions for Assessment

Research/Presentation

- Students develop a list of proper electrical safety in the skilled trades area. This list can mirror the one found in the *Skilled Trades 1201 Curriculum Guide* and could be put into a poster or presented to the class. It should include but is not limited to:
  - make sure the circuit is not energized before working on it;
  - use tools only for the task intended, and in the manner intended;
  - follow proper protocols for handling conductors, stripping insulation, and attaching them to devices;
  - ensure all devices are attached to ground as specified; and
  - treat all electrical devices as "hot" or energized until verification that they are not attached to any power source.

Safety Test/Practical Activity

- Students should complete a safety test on the use of tools and equipment in this section of the course. This test should include rules dealing specifically with safe use of electrical circuits.

Resources

TEXT

- *Skilled Trades 1201 Curriculum Guide*
- *Smart Guide To Wiring* pg. 4
- *Modern Carpentry* - Chapter 26
- *Carpentry & Building Construction* - Unit 8, Chapter 39

WEB

- Electrical Safe Work Practices - http://www.aps.anl.gov/About/Committees/Electrical_Safety_Committee/ElectricalSafeWorkPractices.htm

VIDEO

- Hometime Video Collection (Hometime Video Publishing Inc.) - How-To Guide to Plumbing and Electrical

Topic 4 – Service Panel Wiring for Off-the-grid technologies

Specific Curriculum Outcomes

Students will be expected to

5.4.4 review the building code requirements for placement of an electrical service and panel [1.405]

Suggested Learning and Teaching Strategies

The installation of the service panel should be completed prior to the commencement of work at this station. Students will then plan and install the necessary hardware to run branch circuits to service. There are certain aspects of the electrical service panel location that should be discussed within the group.

- Electrical panels need to be mounted on an outside wall, so that the service mast can be accessed.
- The distance from the nearest pole usually determines the location of the mast and will ultimately determine the location of the service panel
- Electrical panels need to be mounted off of the outside wall, usually on a sheet of plywood.
- Electrical panels have to be a certain distance away from water-based devices, such as sinks or water heaters. This reasoning is obvious given the incompatibility between water and electricity
- There are a variety of other regulations that can be found in the National Electrical Code. These may change according to the jurisdiction the structure is constructed in.

One of the important rules to be followed when working on a service panel is to insure that it is locked out, that is no power is moving through the panel. This is also true of work within the fabrication lab. No electrical panel that students are working on should be connected directly into the schools power system. These circuits should only be tested by using an isolated power supply or a circuit tester.

Topic 4 – Service Panel Wiring for Off-the-grid technologies

Suggestions for Assessment

Research/Assignment

- Students identify each of the provincial and Canadian electrical regulating bodies and how they interact with the electrical code sections of the National Building Code.
- Students briefly describe the function of each regulating body.

Paper and pencil

- Students identify the basic codes that regulate branch circuits in a residence and wiring to and of electrical panels in a residence.

Resources

TEXT

- *Skilled Trades 1201 Curriculum Guide*
- *Smart Guide To Wiring*
- *Modern Carpentry* - Chapter 26
- *Carpentry & Building Construction* - Unit 8, Chapter 39

WEB

- Electrical online - http://www.electrical-online.com/electricalcode.htm
- Newfoundland Act - http://www.assembly.nl.ca/legislation/sr/annualregs/1996/Nr969120.htm
- About Building in Canada - http://www.about-building-in-canada.com/provincial.html

VIDEO

- Hometime Video Collection (Hometime Video Publishing Inc.) - How-To Guide to Plumbing and Electrical

NOTES

- Appendix A - Notes Section

Topic 4 – Service Panel Wiring for Off-the-grid technologies

Specific Curriculum Outcomes

Students will be expected to

5.4.5 install breakers within a standard service panel [1.405, 2.401, 2.404]

Suggested Learning and Teaching Strategies

In this instance, the installation of breakers is the most important step within the process of setting up a panel. Essentially, the installation of a circuit requires a breaker or series of breakers. The theory is that a full examination of what electrical load will be on the circuit will determine the size of the breaker in question.

The use of Ohm's law

P = VI

will determine the wattage of each individual section of the circuit. Power usage is cumulative, with each section adding to the total. An example is:
A 15 amp breaker is to be installed. An analysis of the circuit shows that there are three lights, each with a 120 watt power use, and two receptacles. The receptacles include one used for a computer, with a 450 watt power supply and a 250 watt monitor. Normal household circuits carry 110 volts from their service.

Total wattage used on the circuit = 960 watts
Restriction from the breaker = 1650 watts
Total wattage leftover = 690 watts

This would be the restriction on what could be used in the other receptacle without tripping the breaker. Please note, that circuits are usually grouped by type and location within a residence. That is lights are usually grouped with lights within a certain section of a house, and put on a single or a brace or breakers. Receptacles are usually grouped as well, with some estimation of what will be used on each circuit. This can be done because as each area of the house uses different standard electrical appliances.

Topic 4 – Service Panel Wiring for Off-the-grid technologies

Suggestions for Assessment

Practical Activity

- Students use electrical plans or floor plans created in other activities as a reference, to complete the following task for the electrical systems installation of the major project:
  - install single breakers
  - install double breakers
  - test installation

Work log

- Students create an appropriate entry in the work log outlining the skills they have used.

Research/Practical Activity

- Students calculate the maximum number of household lights, receptacles, switches and appliances can be hooked into a 15 Amp residential circuit and a 20 Amp residential circuit.

- As an extension, students compare the watt production of the wind turbine and solar cell to a normal household circuit to determine how many devices the two of them, together, could power.

Resources

TEXT

- *Smart Guide To Wiring*
- *Modern Carpentry* - Chapter 26
- *Carpentry & Building Construction* - Unit 8, Chapter 39

WEB

- Electrical online - http://www.electrical-online.com/replacingabreakerinyourpanel.htm
- About.com - http://electrical.about.com/od/panelsdistribution/ss/wireelectpanel.htm
- Ask the builder - http://www.askthebuilder.com/B320_Installing_Circuit_Breakers.shtml

VIDEO

- Hometime Video Collection (Hometime Video Publishing Inc.) - How-To Guide to Plumbing and Electrical

Topic 4 – Service Panel Wiring for Off-the-grid technologies

Specific Curriculum Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
5.4.6 tie a branch circuit into an electrical panel [2.401, 2.404]	The branch circuit is the one which will be used to bring an alternative energy solution into a household service. There are many regulations dealing with this area within the National Building Code and provincial regulatory bodies. A study of these should be undertaken by the students in this section. From the point of view of this activity though the following is important to note: • Alternative energy production devices should be either the main supplier of energy for the service panel or should have a separate panel of their own within a household service. • No one can generate electricity and distribute it other than Newfoundland and Labrador Hydro. This means that an alternative energy solution will have to be distinctly separated from the main distribution network. • Alternative energy production devices are not continuous and require a source for charging so that energy is consistent. Battery banks are the storage solution of choice, and these devices must be converted to household AC current. • Battery banks must be continuously charge and periodically discharged and conditioned so that they have maximum power storage ability. The panel in this case will be tied into the battery bank rather than directly into the panel. It is expected that this section will include testing circuits using one of the available meters. This does not necessitate the hooking up of the panel into a regular service, but running some sort of low power levels than can be measured at different sections of the circuit. Voltage across the breaker, across the service and output, across the out wire and in wire will indicate the continuity of the wiring job. This process includes: • a visual inspection, • a review of the circuit diagram and • a series of tests across common testing points.

Topic 4 – Service Panel Wiring for Off-the-grid technologies

Suggestions for Assessment

Practical Activity

- Students use electrical plans or floor plans created in other activities as a reference, to complete the following task for the electrical systems installation of the major project:
  - mark out placement of the panel on the structure
    - include the alternate energy branch circuit
  - drill holes for wires to enter the panel box
  - install tie in of alternate energy production materials

Work log

- Students create an appropriate entry in the work log outlining the skills they have used.

Practical Activity

- As an extension to the calculations suggested in the pervious outcome, students compare the watt production of the wind turbine and solar cell to a normal household circuit to determine how many devices the two of them, together, could power.

Resources

TEXT

- *Smart Guide To Wiring*
- *Modern Carpentry* - Chapter 26
- *Carpentry & Building Construction* - Unit 8, Chapter 39

WEB

- Electrical online - http://www.electrical-online.com/
- About.com - http://electrical.about.com/od/panelsdistribution/ss/wireelectpanel.htm
- Ask the builder - http://www.askthebuilder.com/

VIDEO

- Hometime Video Collection (Hometime Video Publishing Inc.) - How-To Guide to Plumbing and Electrical

Topic 5 – Hydrogen Fuel Cells

Specific Curriculum Outcomes

Students will be expected to

5.5.1 trace the historical development of hydrogen as a fuel source [1.405]

Suggested Learning and Teaching Strategies

This section is an overview of the research that lead to the development of the hydrogen fuel cell. Hydrogen, since its discovery, has been seen as a possible fuel source and been used as one in some instances.

Beyond the history of hydrogen and the fuel cell, some of the focus should be on the use hydrogren has had outside this one area. Hydrogren and other combustible gases have been used in a variety of ways to initiatie energy. In the case of Newfoundland and Labrador, Hydrogen is used in concert with wind turbines as a methodology for providing power. A pilot project on Ramea uses wind energy to produce hydrogen which is then stored and burned cleanly in a hydrogen generator assembly.

Although the notes section concentrates on the fuel cell development, other types of hydrogen fuel use are documented, and some are still viable today. When examining fuel cells and other uses of hydrogen as a fuel source, students shoule be encouraged to seek out answers of why the fuel cell is so popular, and why some of the other methods developed are not.

Student Activity:

Students discuss, in the whole class or in small groups, some of the recent developments in fuel cells and what it could mean to the whole alternative energy debate.

Topic 5 – Hydrogen Fuel Cells

Suggestions for Assessment

Paper and pencil/Research

- Students develop a timeline from research they have done in this area. This section can be done as an individual research section, with students working independently.

Research/Assignment

- Students research the other uses that hydrogen has been put to since its discovery and how this may or may not have influenced its development as an energy source. This could be placed in their content portfolio or noted for their design portfolio.

Resources

TEXT

- *Heathkit Teacher Guide*
- *Heathkit Student Manual*
- *The Solar Hydrogen Civilization*

WEB

- Princeton Fuel Cell History - http://www.princeton.edu/~chm333/2002/spring/FuelCells/fuel_cells-history.shtml
- Smithsonian Institute - http://americanhistory.si.edu/fuelcells/
- Corrosion Doctors - http://corrosion-doctors.org/FuelCell/History.htm

VIDEO

- Heathkit Alternative Energy Video

NOTES

- Appendix A - Notes Section

Topic 5 – Hydrogen Fuel Cells

Specific Curriculum Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
5.5.2 review and demonstrate proper safety procedures when working with hydrogen fuel cell technology [1.405]	General shop safety rules are in place any time a student is working in the fabrication room. These should be reviewed with students at the beginning of the modular section. Specifically, hydrogen gas is a highly flammable substance that must be treated with respect. • Within the shop environment it is possible to electrolyze hydrogen gas for immediate experimental purposes. This is done using a small direct current (DC) power source (no more than 3 Volts). In no manner should this be done with an AC current. • Any experiment utilizing water and electricity must be carried out using the specific instructions provided. Such an experiment must be kept well clear of any alternating current (AC) electrical sources at all times. • When working in the lab students must wear safety glasses at all time Outside the fabrication room, the use of hydrogen gas for any sort of personal use is strictly forbidden. Hydrogen has a high degree of flammability, and the processes used to create it are quite simple. Teachers should insure that students leave any activity involving hydrogen with a healthy respect of the dangers.
5.5.3 explain how a fuel cell can produce electricity [1.405]	When introducing this concept teachers are reminded not to get too lost in theory of how it works. As simplistic and interesting an explanation as possible is suggested. A fuel cell is a storage device...it can be likened to a rechargeable battery. A battery, like a fuel cell, uses chemicals and chemical reactions to produce an electrochemical reaction. That is where the electricity comes from. The difference is that a fuel cell usually has a steady stream of chemicals to draw on, and that the two chemicals used are oxygen and hydrogen. Students should see that having two such friendly chemicals that produce a by-product of water as part of the process is part of the “charm” of the fuel cell.

Topic 5 – Hydrogen Fuel Cells

Suggestions for Assessment

Research/Presentation

- Students search a hydrogen manufacturers site for examples of safety procedures used in their production facilities. A search of manufacturers and their websites may lead to information about this.
- Students research common safe work sites, dealing with flammable gases, as well as their own fabrication lab safe tool use for machinery that has common features with gas production (such as a compressor), and try to come up with a list of safe work rules dealing with fuel cell technology. This could be presented to the class.
- Students review an MSDS sheet for hydrogen gas and outline the inherent dangers in a poster or presentation.

Research/Presentation

- Students create a presentation, a self-directed learning module or poster to explain how a hydrogen fuel cell works. They should put it in their own words and describe it in such a fashion that a grade 5 or 6 student could understand it.

Resources

TEXT

- *Heathkit Teacher Guide*
- *Heathkit Student Manual*
- *The Solar Hydrogen Civilization*

WEB

- Safe fuel cell use - http://www.standardslearn.org/documents/FuelCellStandards.pdf
- Fuel cells in cars - http://ezinearticles.com/?How-Safe-Are-HHO-Fuel-Cells-For-Cars?&id=1222904

VIDEO

- Heathkit Alternative Energy Video

WEB

- How Stuff Works - http://auto.howstuffworks.com/fuel-efficiency/alternative-fuels/fuel-cell.htm
- Energy Independence - http://www.energyindependencenow.org/pdf/fs/EIN-HowFuelCellWorks.pdf

NOTES

- Appendix A - Notes Section pg. 16

Topic 5 – Hydrogen Fuel Cells

Specific Curriculum Outcomes

Students will be expected to

5.5.4 differentiate between the types of fuel cell and their applications [1.405]

Suggested Learning and Teaching Strategies

The basics of this outcome are to introduce the fact that "fuel cell" is not a single entity but rather a series of cells that do the same thing for different purposes.

The types of fuel cells are classified by the types of electrolyte used and their operating temperature.

Types of Fuel Cells:

- Polymer Exchange Membrane Fuel Cells
- Solid Oxide Fuel Cells
- Alkaline Fuel Cells
- Molten-Carbonate Fuel Cell
- Phosphoric-Acid Fuel Cells
- Direct Methanol Fuel Cell

Introducing this topic after some student research into these areas may be enhanced by having a class discussion. In that instance each type could be discussed with students suggesting what uses may be appropriate.

Student Activity:

Students should be made aware of the different types and how they can be used for different purposes. Although this lends itself to direct instruction, a series of research projects in small groups could also be used here. In that instance, independent learning projects would be used as a method of garnering the information and then be followed up with presentations to pass that information on to the rest of the class.

Topic 5 – Hydrogen Fuel Cells

Suggestions for Assessment

Research/Assignment

- Students create a chart of the different types of fuel cells and their basic uses, whether industrial or commercial. This could be done as a poster.

- Students draw a diagram explaining one of the fuel cell types in detail and how it works. This should be done in such a way that a younger student could understand.

Resources

TEXT

- *Heathkit Teacher Guide*
- *Heathkit Student Manual*
- *The Solar Hydrogen Civilization*

WEB

- How Stuff Works - http://auto.howstuffworks.com/fuel-efficiency/alternative-fuels/fuel-cell.htm
- Energy Independence - http://www.energyindependencenow.org/pdf/fs/EIN-HowFuelCellWorks.pdf

VIDEO

- Heathkit Alternative Energy Video

NOTES

- Appendix A - Notes Section

Topic 5 – Hydrogen Fuel Cells

Specific Curriculum Outcomes

Students will be expected to

5.5.5 discuss barriers to mainstream use of fuel cell technology [1.401, 1.404, 1.405, 2.404]

Suggested Learning and Teaching Strategies

Before fuel cells can be adapted as a viable source of energy there are a number of problems that must be addressed.

The barriers are consistent with those for other non-fossil fuel based transportation systems. The main contender for fuel cell use in transportation is the polymer exchange membrane fuel cell (PEMFC) described in the last outcome. Below is an outline of the barriers involved:

- Cost - The components used to produce a PEMFC that can be used in transportation are made from expensive materials.
- Durability - Due to the start and stop cycles of a transportation vehicle the membrane becomes contaminated and looses it efficiency.
- Hydration - The membrane must be hydrated in order to produce electricity in subzero weather.
- Delivery - Compressor technology is not suitable for use in vehicle application.
- Infrastructure - Currently there is no infrastructure in place to produce large scale amounts of hydrogen and no system to deliver to the place of usage.

Student Activity:

For each of the barriers presented, in small groups or a full class discussion, students should develop some responses to the barriers. It is not enough for students to suggest that technology will fix the problem in each case, although that is a legitimate claim, but rather what could happen with existing technology.

Topic 5 – Hydrogen Fuel Cells

Suggestions for Assessment

Research/Assignment

- Students research the reasons why there has not been wide-spread use of fuel cell technology in transportation and what has to happen for it to be possible. This can be passed in as an assignment or added to a course portfolio.

Research/Presentation

- Students develop a short-term plan for what has to be done to make fuel cells a reality for at least mass transportation or public transit. This could be presented to the class as whole and used in a small group or class discussion.

Resources

TEXT

- *Heathkit Teacher Guide*
- *Heathkit Student Manual*
- *The Solar Hydrogen Civilization*

WEB

- Barriers to use of fuel cell technology - http://www.rise.org.au/info/Tech/fuelcells/index.html
- Advantages and disadvantages of fuel cell technology - http://www.fuelcelltoday.com/media/pdf/education-kit/Advantage-Disadvantages.pdf

VIDEO

- Heathkit Alternative Energy Video

Topic 5 – Hydrogen Fuel Cells

Specific Curriculum Outcomes

Students will be expected to

5.5.6 demonstrate the use of a hydrogen fuel cell device {1.405, 2.401, 2.404]

Suggested Learning and Teaching Strategies

There are two projects planned for this outcome. Working with a stand-alone fuel cell, and a model fuel cell car kit. The standalone fuel cell allows students to experiment with a fuel cell, working with electrolysis equipment and an experimental station. Students can produce hydrogen, transport to a fuel cell and measure the results. The model fuel cell car kit also produces hydrogen from electrolysis, but in this case demonstrates a direct motive application for the technology.

Points to emphasize

- Electrolysis is a process of separating bonded elements and compounds by passing electricity through them.
- The fuel cell actually works by reversing the electrolysis process
- Salt is added to the water to increase its salinity and in turn increase its conductivity
- Important to emphasize that the fuel cell works without a power source connected all the time. It is “charged” by power but will produce electricity independently.

Student Activity:

- Students research the amount of salt necessary to achieve a good return in the electrolysis process.
- Students experiment with the model fuel cell car kit, determining what its maximum ability is to store hydrogen.

Topic 5 – Hydrogen Fuel Cells

Suggestions for Assessment

Practical Activity

- Students, using the bench-top fuel cell trainer, test and experiment with a fuel cell. An assignment or series of log entries on this material would be suggested.

Research/presentation

- Students research material on fuel cells, and determine how large one would have to be to power a city bus. They can use the range of size for their own fuel cells and scale it up to move something much larger.

Research/Practical Activity

- Students could, using the fuel cell car, determine how much charging is required for how much motion of the car. As well they can research other methods of renewing a fuel cell rather than through the advent of producing hydrogen with an electric current.

Resources

TEXT

- *Heathkit Teacher Guide*
- *Heathkit Student Manual*
- *The Solar Hydrogen Civilization*

WEB

- How hydrogen cells work - http://auto.howstuffworks.com/fuel-efficiency/alternative-fuels/fuel-cell.htm
- Hydrogen fuel cell car video - http://www.alternative-energy-news.info/technology/fuel-cells/

VIDEO

- Heathkit Alternative Energy Video

MATERIALS

- HeathKit Fuel Cell car project pack
- HeathKit Fuel Cell project pack

Topic 5 – Hydrogen Fuel Cells

Specific Curriculum Outcomes

Students will be expected to

5.5.7 identify a series of machines that can be powered by fuel cell technology {1.401, 1.405]

Suggested Learning and Teaching Strategies

Much of the available literature promotes hydrogen as a source of energy which can be utilized in most internal/ external combustion engines with some minor modifications. The internet provides many examples of gasoline engines that have been converted to hydrogen fuel.

As well there are significant possibilities for use of fuel cells in power generation as well in the production of motive power.

In this section we have been looking at hydrogen fuel cells rather than hydrogen as a fuel used directly. There are a myriad of possibilities in this area for many power generation and motive power applications. One of the areas that students need to understand is that there are many more ways to get hydrogen, rather than simple electrolysis. A list is included below

1. Steam on heated carbon
2. Decomposition of certain hydrocarbons with heat
3. Reaction of sodium or potassium hydroxide on aluminum.
4. Electrolysis of water
5. Displacement of acids by certain medals

In the wind generation section, students will be looking at using hydrogen gas as a fuel source directly.

Topic 5 – Hydrogen Fuel Cells

Suggestions for Assessment

Research/Presentation

- Students research a number of transportation or mechanical devices that could run on fuel cells.

- Students research the variety of devices that can use hydrogen gas directly as a power source. This could then be compared to the list of those using fuel cells.

Research/Guest Speaker

- Students research the production of hydrogen gas at the pilot wind generating station on Ramea. This station uses wind energy to produce electricity that produces hydrogen which then is stored and burned in a hydrogen burning generator. A representative from Nalcor could be invited to the class as a guest speaker.

Resources

TEXT

- *Heathkit Teacher Guide*
- *Heathkit Student Manual*
- *The Solar Hydrogen Civilization*

WEB

- Vehicles that can be powered by hydrogen - http://en.wikipedia.org/wiki/Hydrogen_vehicle
- Hybrid Technology - http://auto.howstuffworks.com/fuel-efficiency/hybrid-technology/hydrogen-cars.htm/printable
- Ballard Fuel Cell research - www.ballard.com

VIDEO

- Heathkit Alternative Energy Video

Topic 6 – Heat Pump Technology

Specific Curriculum Outcomes

Students will be expected to

5.6.1 review and demonstrate proper safety procedures when working with a heat pump system [1.405]

Suggested Learning and Teaching Strategies

There are many considerations when using a heat pump. Some of them are specific to safety, but others are more specific to operational efficiency. Both are included here for completeness.

Points to emphasize

- Keep the temperature set point consistent. A standard heat pump thermostat has two controls, one for the heat pump and one for the supplemental heat. If the temperature difference between the room and thermostat set point is more than -17° C or -16° C (2° or 3° F), the supplemental heat will be activated.
- Manually adjusting the thermostat will result in greater reliance on the supplemental heaters and will reduce the efficiency of the heat pump system and increase operating costs.
- Replace filters regularly. Vacuum dirt and dust from the indoor coil once a year to prevent restricted airflow. Adequate air flow through a heat pump system is critical to ensure efficient and comfortable operation.
- Keep supply vents open and free from obstruction. Closing off supply vents will restrict air flow and reduce system efficiency as well as reduce the life of the compressor.
- Keep the coil in the outdoor unit clear of snow, leaves and other debris so that air flow is not restricted.
- In belt-driven indoor units, check this tension in belt once a year and adjust if loose
- Be extra careful around water
- Don't form a natural circuit. For example, don't touch a metal object (especially a faucet) as you unplug or plug in an appliance.
- Don't play electrician. What seems like a simple wiring project can easily turn deadly. Leave electrical wiring projects to the professionals.

Topic 6 – Heat Pump Technology

Suggestions for Assessment

Research/Presentation

- Students do and internet search for examples of safety procedures used in heat pump installation and use.
- Students research common safe work sites, dealing with heat pumps, as well as their own fabrication lab safe tool use for machinery that has common features with heat pumps, and try to come up with a list of safe work rules dealing with windmill technology. This could be presented to the class as a whole.
- Students review the safety precautions in place when working with water and electricity and extrapolate their use in this area. A poster for safe heat pump technology use could be created.

Resources

WEB

- How to install a heat pump - http://www.howtodothings.com/home-and-garden/a3778-how-to-choose-and-install-a-heat-pump.html
- Good practice guide to heat pump installation - http://www.energywise.govt.nz/node/7801
- Heat pump installation - http://www.buzzle.com/articles/heat-pump-installation.html
- http://thegreenblue.co.uk/practicalprojects/documents/CaseStudy12HeatPumpsBW.pdf

Topic 6 – Heat Pump Technology

Specific Curriculum Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
5.6.1 Review and demonstrate proper safety procedures when working with a heat pump system [1.405] (cont'd)	With heat pump technology, some aspects require the ducting to be buried. The following are considerations before moving into the digging phase: • Call before digging. Contact any service companies (electrical, natural gas, etc.) to ensure there are no obstructions ie: gas pipes. • Know where electrical equipment is at all times. Look around and look up to ensure a safe distance from wires. • Have a professional electrician check the main breaker panel to determine what your electrical supply is and to see if there are any alterations or additions required to be completed. Student Activity: • Students differentiate between those rules meant for safe operation and those meant for efficient operation. • Students also develop a series of rules for the specific use of the heat pump in the fabrication lab environment.
5.6.2 outline the historical use and development of heat pump technology [1.401, 1.405]	The heat pump history can be traced to two distinct scientific histories as a result of the two types of heat pumps, air source and ground source. The air source heat pump was theorized by Lord Kelvin, as outlined in the notes section. The ground source heat pumps derive some of their popularity from geothermal energy. The theory behind geothermal energy finds roots in ancient times through the use of hot springs and similar natural features. It is the capability and efficiency of the ground-source type of heat pump that has created the interest in this alternate source of heating. Even in Newfoundland and Labrador, new green buildings are deriving upwards of 90% of their heat energy from ground source heat pumps. New schools, swimming pools and hockey rinks will use the technology to recover

Topic 6 – Heat Pump Technology

Suggestions for Assessment

Research/Presentation

- Students research some of the reasons why heat pumps were used and how they have developed into a major alternative heating solution.

Discussion

- Students discuss, in small groups or as a class, how some of the historical uses for heat pumps may still have applicability today.

Resources

WEB

- History - http://www.bookrags.com/research/heat-pump-woi/
- History of geothermal energy - http://www.top-alternative-energy-sources.com/history-of-geothermal-energy.html
- About heat pumps - http://www.igshpa.okstate.edu/about/about_us.htm
- An example of a heat pump - http://www.cedarwoodheating.com/webapp/GetPage?pid=253
- Wiki on Heat pump http://en.wikipedia.org/wiki/Heat_pump

Topic 6 – Heat Pump Technology

Specific Curriculum Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
5.6.2 outline the historical use and development of heat pump technology [1.401, 1.405] (cont'd)	waster heat as well. This is one area where new buildings in the province are using the technology in greater numbers. The possibility for linking with these new constructs and see the technology either while being installed or in action should not be passed over. Student Activity: Through an interactive discussion, the teacher should overview the historical evolution of the heat pump. Along with the historical discussion questions such as what is a heat pump, how a heat pump works, and some terminology should be answered.
5.6.3 differentiate between the different types of heat pump installations [1.401, 1.405, 2.401]	There are two different methods used in the technology of heat pumps. One involves gaining heat from the earth, or ground source heat pump technology; and one involves getting heat from the air, or air source heat pump technology. Some explanation of what the general physical characteristics are of each of the two types is necessary to understand the technology further. Ground source heat pumps The earth is a huge heat sink (an environment or object that absorbs and dissipates heat from another object.) Through a system of underground or under water liquid filled pipes and a heat exchanger that is located within the building, a ground-source heat pump extracts heat from the earth or ground water to use to heat your home, business, etc. It can work in reverse and be used for cooling when

Topic 6 – Heat Pump Technology

Suggestions for Assessment

Research/Assignment

- Students research heat pumps currently in use in industrial and residential areas within the province.

Research/Assignment

- Students create a chart of the different types of heat pumps and their basic uses, whether industrial or commercial. This could be done as a poster.
- Students draw a diagram explaining one of the heat pump types in detail and how it works. This should be done in such a way that a younger student could understand.

Resources

- United Association of Plumbers, Pipefitters and Steamfitters training centre - http://www.ualocal740.ca/3drendering.aspx
- City of Mount Pearl - http://www.mountpearl.ca/ckfinder/userfiles/files/recreation/Media%20Release%20-%20May%2019%20-%20Green%20Fund%20Cheque%20Presentation.pdf

NOTES

- Appendix A - Notes Section pg. 17

WEB

- Ground Source Heat Pump - http://www.greenspec.co.uk/documents/energy/GSHP1.pdf
- Space Heating - http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12650
- Heat Pumps - http://oee.nrcan.gc.ca/publications/infosource/pub/home/heating-heat-pump/booklet.pdf

Topic 6 – Heat Pump Technology

Specific Curriculum Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
5.6.3 differentiate between the different types of heat pump installations [1.401, 1.405, 2.401] (con'td)	it is too warm. Earth-energy systems (EES's) can be used with forced-air (water to air) and hydronic (water to water) heating systems. The system can be either and closed loop or open loop system. **Air source heat pumps** These systems draw heat from the outside air during cooler times and extract heat to the air during warm times. Through this we are able to heat and cool our homes. There are two types of air-source heat pumps, air to air and air to water. Student Activity:: Students create diagrams to illustrate the two forms of heat pumps and the variations of each of these. Diagrams are labeled and indicate how the systems actually work.
5.6.4 describe the common usages for heat pump technology in Newfoundland and Labrador [1.401, 1.405]	Through a class discussion/demonstration it should be shown that heat pumps are not new and are in use around us every day. They are mainly used for cooling but used in reverse they offer heat as well. There should be an explanation/demonstration of how heat is extracted from one place and released elsewhere. Common usages of heat pumps: Refrigerators Freezers Air Conditioning units Geothermal heat pumps Air source heat pumps

Topic 6 – Heat Pump Technology

Suggestions for Assessment

Research/Presentation

- Students research the common uses for heat pumps in industrial and residential areas and extrapolate from that how heat pumps could be used in Newfoundland and Labrador.

- As an extension, students research what types of heat pump technologies are actually in use in the province and how that differs from the list developed above. This result in a presentation to the class or as a group for whole class discussion.

Resources

NOTES

- Appendix A notes section

WEB

- Basics of heat pump use - http://www.house-energy.com/Heat-Pumps/Basics-Heat-Pumps.htm

Topic 7 – Sustainable Housing

Specific Curriculum Outcomes

Students will be expected to

5.7.1 describe what is entailed within the concept of sustainable housing [1.401, 1.405]

Delineation

Concepts to emphasize
- R-2000
- Air flow
- Insulative values

Suggested Learning and Teaching Strategies

There are a variety of things that people can do to reduce their impact on the environment and their energy use overall in their homes. The use of energy-efficient appliances, turning down thermostats, programmable thermostats, using compact fluorescent bulbs, the installation of a heat pump or other alternative energy device all can add to the savings realized within a household. Along with all of these measures comes the concept of sustainable housing.

Sustainable housing refers to that aspect of residential construction dealing with air flow and insulation. It is about reducing air-leakage and increasing the standards of insulation within a house. A test of a house from a sustainable housing perspective will not only involve determining location and amount of insulation in walls, ceilings, exposed areas but the use of air/vapour barriers in those areas. A blower-door device, allowing for a lessening of air pressure in the house, is used to map and quantify air-leakage within the residence. With this information, a model of how the house "breathes" and retains heat is able to be created, allowing for quantification of changes and the benefits that could be realized.

National Resources Canada has specified a series of requirements that will make a house perform at an excellent rate for energy efficiency, indoor air quality and the use of environmentally responsible products and materials. These requirements form the basis of the R-2000 standard. It does not in any way dictate how the house must be built or what it looks like, only how it should perform. Everything from protecting air quality by using water based paints and green carpets, to insuring that all floors, walls and ceilings are properly insulated is covered.

Topic 7 – Sustainable Housing

Suggestions for Assessment

Research/Presentation

- Students take one of the precepts of sustainable housing and do a presentation to the class as to what it entails. This could include but is not limited to:
  - R-2000
  - Air flow
  - Insulative values
  - Blower door

Research Assignment

- Students identify the trades involved in creating a sustainable house or an R-2000 designation. In determining the trade, students also research the level of work that has to be done to create a structure with that designation.

Resources

TEXT

- *Modern Carpentry* - Unit 14

WEB

- Study on sustainable housing - ftp://ftp.cmhc-schl.gc.ca/chic-ccdh/Research_Reports-Rapports_de_recherche/eng_unilingual/LifeCycle_WEB.pdf
- Home energy evaluation - http://www.sustainablehousing.ca/ and http://www.cmhc.ca/en/inpr/su/eqho/

Topic 7 – Sustainable Housing

Specific Curriculum Outcomes

Students will be expected to

5.7.2 define R-value in terms of energy loss over square footage of a material [1.405, 3.401, 3.402]

Delineation
- R-value
- U-value
- Methods of heat transfer
  - Conduction
  - Convection
  - Radiation

5.7.3 differentiate between different insulation types and their appropriate use in residential construction/renovation. [1.401, 1.405, 2.404]

Delineation

- R-value
- Batt or blanket insulation
- Loose-fill insulation
- Rigid board insulation
- Spray-foam insulation
- Radiant Barrier Insulation

Suggested Learning and Teaching Strategies

When engaged in a conversation about insulation and sustainable housing, the term R-value will be used extensively. Most people understand that the higher the R-value the better the insulative value of the material being used. For the designer or installer understanding what R-value pertains to will aid in insuring the right insulation for the right job.

R-value is defined as a commercial unit used to measure the effectiveness of thermal insulation. Further background and explanation material is found in the notes section.

Students should be familiar with where the the r-value comes from in a practical sense as well as a theoretical one. Understanding what the r-value might mean for energy savings is as important, if not more, than recognizing where the value came from.

There are a variety of insulation types available for the consumer. In many cases the type lends itself to the situation in which it will be used.

- Batt or blanket insulation- This is the most common type and most commonly used in exposed wall spaces and attics, and is usually installed early in the construction process once walls have been formed. Although easily cut and shaped as necessary, its large size necessitates large exposed areas for installation.
- Loose-fill insulation - Loose-fill can be installed in either enclosed cavities, such as walls, or unenclosed spaces, such as attics. Most often loose-fill insulation is blown in
- Rigid board insulation- This type of insulation is made to be used in confined spaces like basements, foundations, crawl spaces, and exterior walls. The rigid boards are permanently fastened to the surface and as

Topic 7 – Sustainable Housing

Suggestions for Assessment

Research/Assignment

- Students research the origin of R-value and how it has become synonymous with insulation in the residential world.
- Students research the various methods of heat transfer and how they are integral to the theory behind the use of insulation.

Practical Activity

- Students calculate what the actual heat loss is through a common value of insulation. This could be done as an assignment of a whole class activity.

Research/Assignment

- Students create a chart of the different types of insulation, their basic uses, whether industrial or commercial and the proper situation for its deployment.
- Students draw a diagram explaining one of the insulation types in detail and how it works. This should be done in such a way that a younger student could understand.

Resources

TEXT

- *Modern Carpentry* - Unit 14

WEB

- Definition of r-value - http://en.wikipedia.org/wiki/R-value_(insulation) and http://en.academic.ru/dic.nsf/enwiki/157906
- Insulating your house - http://www.cmhc-schl.gc.ca/en/co/maho/enefcosa/enefcosa_002.cfm
- About r-value - http://rvalue.net/

NOTES

- Appendix A notes section pg. 18

Topic 7 – Sustainable Housing

Specific Curriculum Outcomes

Students will be expected to

5.7.3 differentiate between different insulation types and their appropriate use in residential construction/renovation. [1.401, 1.405, 2.404]

(cont'd)

Delineation

- R-value
- Batt or blanket insulation
- Loose-fill insulation
- Rigid board insulation
- Spray-foam insulation
- Radiant Barrier Insulation

Suggested Learning and Teaching Strategies

such it is often easier and sometimes only possible to install this type during construction.
- Spray-foam insulation - Relatively new in the housing industry, but can be used in almost every situation where the others can. It is more expensive than the other types and has to be put in during construction of the structure.
- Radiant Barrier Insulation - usually an attic-based installation. Will create a barrier for heat and cold. Can replace batt installation in that regard.

Students should be clear on the situations whereby each of the insulation types can be used. One of the reasons of the popularity of batt insulation is how easy it can be installed. While blow-in insulation is the easiest to use for existing wall structures due to the lack of destruction of the wall necessary to get the insulation in. When students see the examples of the insulation in action they will be able to better understand the situational as well as cost factors involved in each.

Student Activity:

Students should have some samples of the different types of insulation in class so that they can see for themselves the differences. The insulation could be loose or in an already prepared structure showing the various types.

Topic 7 – Sustainable Housing

Suggestions for Assessment

Research/Presentation

- Students create a presentation, a self-directed learning module or poster to explain how insulation works. They should put it in their own words and describe it in such a fashion that a 10 year old could understand it.

Discussion

- Students identify the most common insulation used in residential and industrial properties in this province, and then compare that to standards in other provinces. This comparison could be handed in as a written assignment or could be used for a small group or whole class discussion.

Research/Presentation

- Students research which of the listed insulation types has the least impact on the environment. This then be compared to the popularity for its use in this province and other parts of the country.

- Students do a comparison of the different R-value associated with the different types of insulation. This could be done as a relation of volume to R-value, or as one of cost to R-value. Extending this assignment to compare the popularity of the material as discussed previously is also an option.

Resources

TEXT

- *Modern Carpentry* - Unit 14

WEB

- Choosing insulation - http://oee.nrcan.gc.ca/residential/personal/new-home-improvement/choosing/insulation-sealing/materials/khi-insulation.cfm?attr=4
- Insulation types - http://www.insulation-guide.com/insulation-types.html
- Energy savers (US) - http://www.energysavers.gov/your_home/insulation_airsealing/index.cfm/mytopic=11510
- 10 Types of insulation - http://home.howstuffworks.com/home-improvement/construction/materials/10-types-of-insulation.htm
- Types of Home Insulation - http://www.heating-and-air-conditioning-guide.com/types-of-home-insulation.html
- Types of insulation - http://www.cmhc-schl.gc.ca/en/co/maho/enefcosa/enefcosa_002.cfm

NOTES

- Appendix A notes section pg. 19

Topic 7 – Sustainable Housing

Specific Curriculum Outcomes

Students will be expected to

5.7.4 describe the function of a vapour/ air barrier in insulation use [1.401, 1.405, 2.404]

Delineation:

- Differentiate Vapor Barrier / Air Barrier
- Role of House Wrap

Suggested Learning and Teaching Strategies

Generally speaking a vapour barrier and an air barrier are two separate entities. A vapour barrier is a construction material designed to stop or retard the passage of moisture as it diffuses through the assembly of materials in a wall.
The principle function of the air barrier is to stop air from entering the building through the walls, windows, or roof, and inside air from exfiltrating through the building envelope to the outside. For our purposes we will look at the function of a vapour barrier.

- To be effective a vapour barrier must be both resistant to the flow of water vapour and be durable.
- The effectiveness of a vapour barrier material is measured in terms of its "perm-rating". The higher the perm-rating the better the barrier.
- Many materials are effective vapour barriers and they include, polyethylene, aluminum foil, some types of paint, exterior grade plywood with polyethylene being the most common.
- Vapour barriers are generally not needed in climates where the temperature remains above freezing. Such is not the case in our climate.
- The function of the vapour barrier is to provide some protection against moisture damage to the structure and the insulation. It is placed on the warm side of a wall to keep moist laden air from collecting inside the wall structure. Once condensed inside a wall the result can be rot, mildew, and mold.

Because it is virtually impossible to stop all moisture from moving this poses a unique problem for attics. Warm moist air is constantly rising and trying to enter the attic and invariably some of it will penetrate the envelope. Therefore attics but be designed with adequate ventilation so that the circulation of fresh air will quickly remove the moist air.

Topic 7 – Sustainable Housing

Suggestions for Assessment

Research/Presentation/Discussion

- Students research the various types of material used in vapour barriers in residential construction and do a comparison of effectiveness versus cost. A class discussion or presentation could follow.

- Students research the role of house wrap in air barrier and vapour barrier support in residential construction. This could be done as a presentation or a whole class discussion.

Research/Assignment

- Students research the differences between the concept of air flow restriction and vapour restriction, with specific reference to differentiating between the need for a vapour barrier and an air barrier. This could be completed as an assignment.

Resources

TEXT

- *Modern Carpentry* - Unit 14

WEB

- Purpose of vapour barrier - http://www.energybooks.com/pdf/D1142.pdf
- Purpose of vapour barrier - http://www.cssbi.ca/Eng/_pdf/House-Chapter7Final.pdf
- Vapour barriers in home construction - http://www.nrc-cnrc.gc.ca/eng/ibp/irc/cbd/building-digest-9.html
- Installing a vapour barrier - http://www.rona.ca/content/installing-vapour-barrier_framing-excavation-foundation_renovation
- Insulating your house - http://www.cmhc-schl.gc.ca/en/co/maho/enefcosa/enefcosa_002.cfm
- Difference between a vapour barrier and an air barrier - http://www.nrc-cnrc.gc.ca/obj/irc/doc/pubs/bpn/54_e.pdf
- Roof vapour barrier - http://alcor.concordia.ca/~raojw/crd/essay/essay000223.html

Topic 7 – Sustainable Housing

Specific Curriculum Outcomes	Suggested Learning and Teaching Strategies
Students will be expected to	
5.7.5 follow safety rules and guidelines when working with various types of insulation installations [2.401] [2.402][2.405] [3.401][5.402]	The use of any insulation requires good skin, eye and breathing protection. Workers involved in the installation of insulative materials should wear good strong gloves, have their body covered by rough material to prevent irritation of the skin, and, as in all residential construction aspects, wear safety eye wear. In this instance, as the risk is based in small airborne particulates the most appropriate type of safety eye-wear is goggles type. The most serious risk to the installer in this instance is to their breathing. The same small airborne particulates that are a risk for the eye or skin are a much more pronounced risk for the lungs and air ways. A CSA approved breath mask should be used when handling any type of insulation at all times. Beyond the hazards to the individual when installing such materials, there are inherent hazards that need to be considered within the construction area. Some types of insulation are flammable and need to be covered by an approved fire-rated material and not left open to the air.
5.7.6 install a variety of insulations in different wall/roof/floor situations [1.402, 2.401, 2.404]	By far the most common and economic type of insulation is fiberglass batt insulation. It gives the homeowner the most value for their money. In wall fiberglass insulation in combination with exterior rigid board insulation and properly installed vapour barrier is R2000 compliant as such this is what we should have our students mimic. A discussion here on 2”x4” wall construction vs 2”x 6” wall construction is needed. By using 2”x6” exterior wall studs we increase the wall thickness thus allowing more insulation. What is often overlooked is that the switch from 4” to 6” studs also moves to 24” centers instead of 16” centers. Wooden studs provide what is called a “parallel heat conduction path” that is unaffected by the insulation’s R-value. In other words the studs will conduct heat from inside to the outside. By moving to 24” centers we will have a wall of the same length but you will use fewer studs and thus a better R-value.

Topic 7 – Sustainable Housing

Suggestions for Assessment

Research/Presentation

- Students search a variety of insulation manufacturers websites for examples of safety procedures used in the use of their materials. A search of other manufacturers and their websites may lead to further information and confirm that already garnered. A list of things to consider and watch out for should be formulated and completed as a poster or presented to the class as a whole.

- Students research common safe work sites, dealing with insulation, as well as their own fabrication lab safe tool use for activities that have common features with insulation installation, and try to come up with a list of safe work rules dealing with it. This could be presented to the class.

Paper and pencil

- Students could be assessed for this outcome using the one of the Rubrics found in the *Skilled Trades 1201 Curriculum Guide* Appendices.

Work log

- Students make an entry in their work log, outlining the skills and techniques they used to complete this task

Resources

TEXT

- *Modern Carpentry* - Unit 14

WEB

- Proper safety procedures when installing insulation - http://insulation.owenscorning.ca/homeowners/insulation-products/
- Safety when working with fiberglass insulation - http://www.naima.org/pages/benefits/hspp/appendix_1.html

TEXT

- *Modern Carpentry* - Unit 14

WEB

- Insulating walls, ceilings, crawl spaces, etc. - http://www.hometime.com/Howto/projects/health/hlth_3.htm
- Insulating attics. - http://www.ornl.gov/sci/roofs+walls/insulation/fact%20sheets/attic%20floors.pdf

Topic 7 – Sustainable Housing

Specific Curriculum Outcomes

Students will be expected to

5.7.6 install a variety of insulations in different wall/roof/floor situations [1.402, 2.401, 2.404]

(cont'd)

Suggested Learning and Teaching Strategies

The rigid foam insulation used on the exterior walls is generally attached with long roofing nails, screws and or washers of some sort. The seams are taped according to manufacturer's specifications and gaps larger than ¼" are filled with a closed cell expanding spray foam.
On the inside the stud bays are filled with the batt insulation. Begin at the top of the bay and work downwards towards the floor. Insulation is manufactured to the correct width to form a friction fit between the studs and will have to be cut to fit shorter or narrower openings such below windows or in corners.

Important notes

- Insulation must not be compressed or jammed into spaces as it will adversely affect R-value.
- Scraps off a batt can be used to fill the cracks around windows and doors but should not be jammed tight.
- Once complete the shoe plate should be caulked where it meets the floor and then the vapour barrier installed.

Topic 7 – Sustainable Housing

Suggestions for Assessment

Practical activity

- Students install insulation within a partition. It is suggested that the partition should be at least 1800 mm in height (6 ft), not be 1200 mm x 2400 mm (4 ft x 8 ft) and should contain an interior or exterior corner.
- It is also suggested that one side be sheathed with some material, and that smaller areas requiring cutting and fitting be used. This could be done with a vapour barrier included, and with a variety of insulative materials, showing the different methods used.
- A test of the insulated area, from at least an air barrier perspective should be made. A small fan and small string tendrils will permit for air flow to be observed. Students should be aware of the importance of proper insulation installation for the finishing portion of residential construction.

Resources

WEB (cont'd)

- Insulating your house - http://www.cmhc-schl.gc.ca/en/co/maho/enefcosa/enefcosa_002.cfm
- Install insulation - http://www.ornl.gov/sci/roofs+walls/insulation/fact%20sheets/attic%20floors.pdf
- Do it Yourself home insulation - http://www.diyhomeinsulation.com/
- How install insulation - http://www.homedepot.ca/webapp/wcs/stores/servlet/DisplayTemplate?display=eco_healthy14&langId=-15&storeId=10051