Smarter Science
Better Buildings

SMARTER SCIENCE BETTER BUILDINGS

Educator Manual



A program for Grade 7 developed by the
Western Development Museum
and the
Saskatchewan Environmental Society

EDUCATION PROGRAMS

Saskatchewan Environmental Society

EDUCATION PROGRAMS

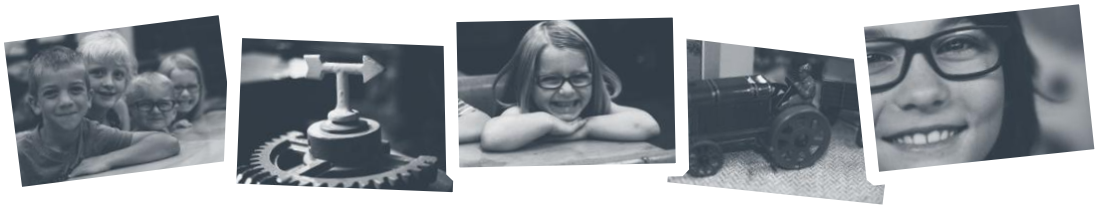
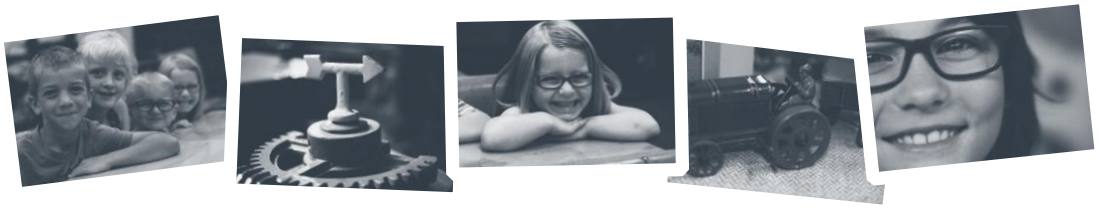


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Brief Description

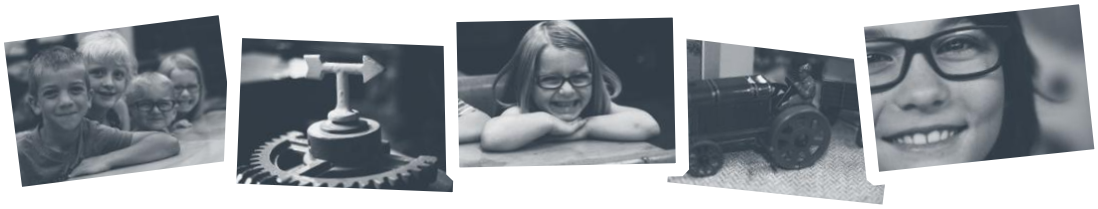
In 2010, the WDM Saskatoon hosted the temporary exhibit of a net zero home constructed by Vereco Homes. A net zero home produces as much energy and electricity as it uses each year. While the home was on display, the WDM, the Saskatchewan Environmental Society (SES), Vereco Homes and educators from Saskatoon Public Schools worked together to design a school program about energy efficient buildings.

When the net zero home left the Museum in 2011, the WDM and SES redesigned the program with the goal of educating students about energy efficient buildings. The WDM launch the Smarter Science Better Buildings program in 2014. That year the Regional Centre for Expertise on Education for Sustainable Development - Saskatchewan recognized the program for its success in promoting sustainable education.

The program is made up of two components. In the first component, students explore six workstations designed around various themes related to sustainability and energy efficiency. These hands-on workstations encourage students to think and talk about energy efficiency and sustainable living.

The second component consists of a museum gallery tour. Students and their chaperones are provided materials to help guiding them to various exhibits in the Museum galleries where they can take a close look at historical examples of energy efficiency.

The program is updated every five years to keep it up-to-date and to include new technologies.



Curriculum Connections and Program Goals

Grade 7

Science

Curriculum Connection HT7.1: Assess the impact of past and current heating and cooling technologies related to food, clothing, and shelter on self, society and the environment.
Program Goal: By exploring the hands-on workstations and touring museum exhibits, students see and experience examples. Through answering questions and reflection, they learn how heating and cooling choices impact the present and future.

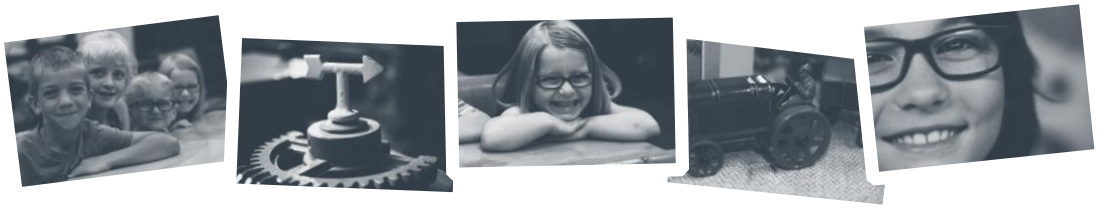
Curriculum Connection HT7.3: Investigate principles and applications of heat transfer via the processes of conduction, convection and radiation.
Program Goal: Through examples on the hands-on workstations and the pre-visit video, students learn about these processes. Guiding questions and exploration of workstations assist students in this learning.

Curriculum Connection IE7.4: Analyze how ecosystems change in response to natural and human influences and propose actions to reduce the impact of human behaviour on a specific ecosystem.
Program Goal: Through the guiding questions and information provided on the workstations, students learn about human influence on the environment and ways to reduce human impact.

Social Studies

Curriculum Connection IN7.2: Examine the effects of globalization on the lives of people in Canada and in circumpolar and Pacific Rim countries.
Program Goal: Through the pre-visit video and hands-on workstations, students consider where building materials come from and how this impacts the environment.

Curriculum Connection IN7.3: Analyze the relationship of technology to globalization.
Program Goal: In the pre-visit video students learn about sustainable development. This includes recognizing how sustainable living is influenced by the economic and/or political conditions in which people live and that some communities may not have access to the latest technology.



English Language Arts

Curriculum Connection CC7.1: Create various visual, oral, written and multimedia texts that explore identity, social responsibility and efficacy.
Program Goal: The guiding questions for the hands-on workstations and museum exhibits provides students and opportunity to discuss and record their observations about sustainability and energy efficiency.

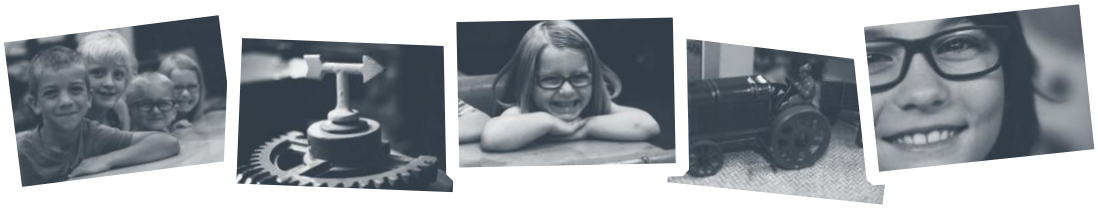
Arts Education

Curriculum Connection CP7.12: Use image-making skills, tools, techniques, and problem-solving abilities in a variety of visual art media.
Program Goal: Students interact with hands-on components of the workstations and record and illustrate their findings in their student package.

Math

Curriculum Connection P7.1: Demonstrate an understanding of the relationships between oral and written patterns, graphs and linear relations.
Program Goal: The hands-on workstations contain examples of patterns and linear relations. Students review these examples though guiding questions in their student packages.

Curriculum Connection SP7.2: Demonstrate an understanding of circle graphs.
Program Goal: The hands-on workstations contain a number of circle graphs, which provides students an opportunity to review and discuss the information provided.



Pre-Visit Resources and Preparation

Smarter Science Better Buildings offers your students an educational and entertaining way to learn about energy efficient buildings. To make your visit more enjoyable and productive, we have included a list of instructions and suggestions. Before attending the program, please familiarize yourself and your chaperones with the program instructions.

Resources

The Smarter Science Better Buildings program is made up of six workstations and a tour of Museum exhibit buildings and related artifacts.

This 11-minute Smarter Science Better Buildings video introduces the program and gives an overview of the concepts of heat and temperature. Please watch the video with your students before your visit to prepare them for the concepts discussed in the program. Video link: https://www.youtube.com/watch?v=xVsDdP2Zg3E

Review the vocabulary list of key terms used in the program under Appendix A.

Appendix B provides a copy of the program introduction.

Appendix C lists additional resources and information.

Preparing for your visit

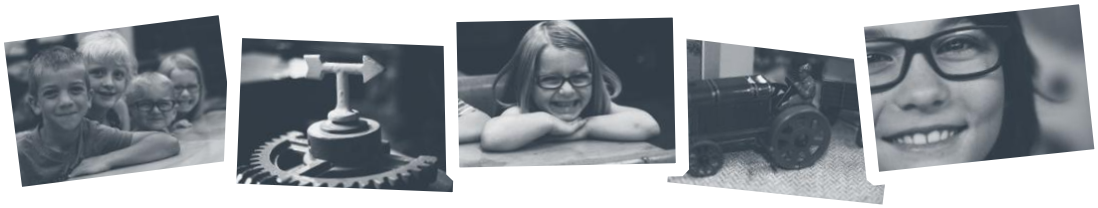
Before your visit, divide your class into six groups. Please make these groups as equal in size as possible. Each group should, ideally, have no more than six or seven students. If you have a larger class (more than 40 students), please consult with Education staff to determine how to best divide your students into groups.

It is highly recommended that you bring adult chaperones to assist with student supervision. Chaperones are admitted free of charge at a ratio of 1 adult per 5 students. Chaperones for children with significant needs are allowed at a 1:1 ratio at no charge.

Print copies of the student package which includes the program guiding questions. You will need six packages or one per group. Copies can be found at: https://wdm.ca/program/smarter-science-better-buildings/

Be sure to get the package for the WDM location where you are attending the program, as they contain location-specific information.

Bring a clipboard and pencil for each group.



Program Visit

WDM staff will greet your group when you arrive.

The program involves two components of approximately 50 minutes each. Component one involves students investigating themed workstations. The second component consists of a visit to the Museum galleries looking at exhibits relating to energy efficiency and sustainable living. Please note that with larger groups, half of your students will start on the workstations while the other half starts in the Museum galleries. After 50 minutes, these groups will switch places.

Hands-On Workstations with Guiding Questions

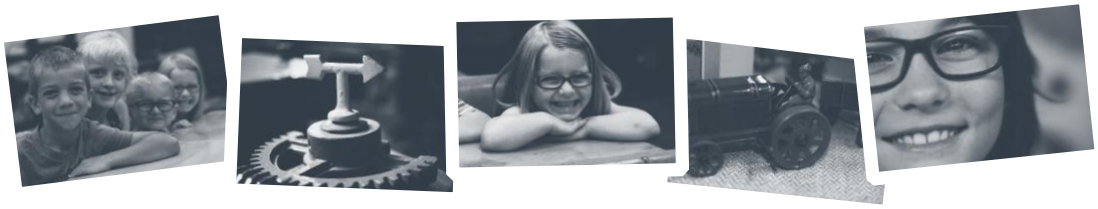
The workstations are designed to discuss six themes. Students will explore each workstation by answering questions about the themes.

Workstation Themes

- Heating and cooling
- Model of a net zero home
- Lighting and appliances
- Water conservation
- Solar
- Home retrofits



Heating and Cooling workstation



Each workstation is designed to highlight these three areas:

- General information (centre panel)
- Innovative technology and design (left panel)
- Making changes in our homes (right panel)

Guiding questions (like the example on the right) are found at each display and in student packages to help focus student investigations. A list of display topics appears below. The guiding questions do not cover all topics and you may want to ask students to focus on specific areas to help them generate inquiry questions for further research. Students will have about eight minutes at each station.



Workstation Details
Below are some of the topics and questions featured in the workstations:

Heating and Cooling
General information

- How heat moves – definitions of conduction, convection, radiation
- How radiant floor heating works

Innovative technology and design

- Lifecycle of cellulose insulation
- Heat pumps – how they move heat energy
- Furnace efficiency – comparing modern heating to the past
- okáwímá askiy míkwahp - Mother Earth Dwelling project

Making changes in our homes

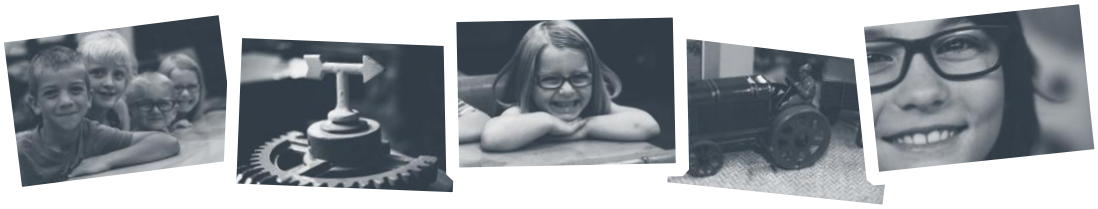
- Reducing energy use by lowering the thermostat

Net Zero Model Home
General information

- What is net zero? Definitions of reduce, reuse, replace
- What has history taught us about good design?

Innovative technology and design

- Building Envelope
- Canada's National Energy Code
- Double wall construction. Model of a wall with separate pieces of insulation to install



Making changes in our homes

- The connection between energy efficient homes and climate change
- Moving closer to net zero
- Q = A x ΔT/R: Adjusting home size, temperature and insulation values to change energy use
- Renewed use of cisterns

Lighting and Appliances

General information

- Electricity use of an average Saskatchewan home compared to a net zero home
- Where Saskatchewan's electricity comes from
- How electricity is used in Saskatchewan homes
- Net zero use of electricity - reduce, reuse, replace
- How lighting works - display of different lamps and their energy use

Innovative technology and design

- Daylighting - mirror ducts, light shelves and light pipes
- Gym lighting retrofit shows reduced power use
- Smart Power Bars - reduce phantom load

Making changes in our homes

- Reading an EnerGuide label
- What is Energy Star®?
- Audits Turn out the lights
- Drying clothes outside

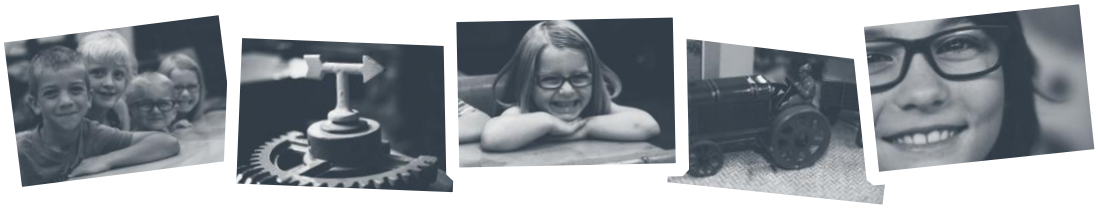
Water

General information

- Daily water use per person comparison between Saskatchewan and the United Kingdom
- How water is used in Saskatchewan homes
- Logan Green Water Management System in Yorkton
- Water saving showerheads and aerators
- Water use in toilets - old tank compared to new 2 button flush tank

Innovative technology and design

- Water treatment process
- Rainwater system
- Drain water heat recovery with example pipe



Making changes in our homes
- Rain barrels, reducing lawn watering and shower water use

Solar
General information
- Solar Energy - light and heat
- Solar photovoltaic panels
- Solar panels on typical Saskatchewan home compared to a net zero home
- Average annual hours of sunshine

Innovative technology and design
- Passive solar design
- Solar panels
- Buildings that generate power

Making changes in our homes
- Solar evacuated tubes
- Pesâkâstêw Solar Project
- How we use solar panels

Retrofits
General information
- Timeline of homes and energy ratings/energy use
- Innovative window design

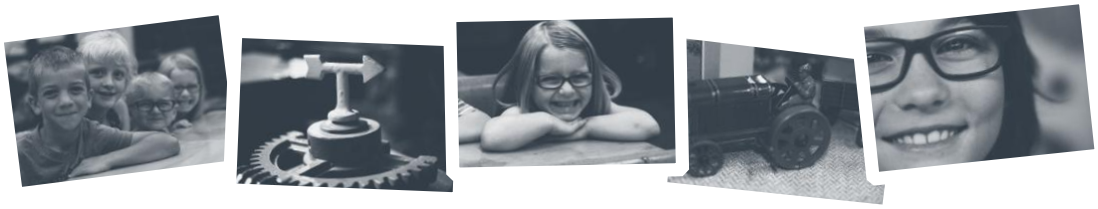
Innovative technology and design
- A real retrofit – energy retrofit of insulation, heating system and windows
- A deep retrofit – add solar panels, seal air leaks, upgrade to heat pump
- EnerGuide Rating System

Making changes in our homes
- Window shades to keep heat and cold out
- Saskatchewan heritage schools energy upgrades

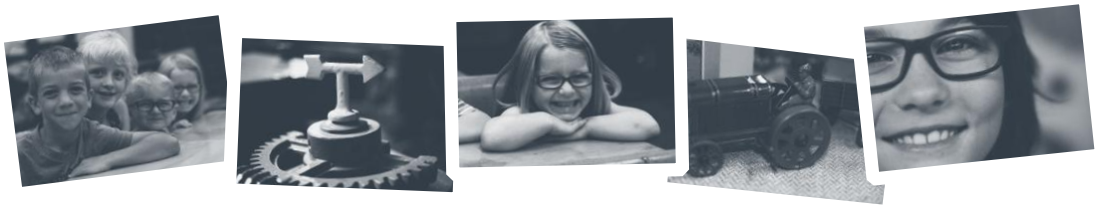
Post-visit, in-classroom discussion

Once back in your classroom, discuss with your students their guiding question sheets. Ask students to consider the following questions:

- Name some things that were new to you. What technologies were interesting?



- Would you like living or working in any of the buildings or spaces you saw in the Museum?
- Which buildings would be more energy efficient and why?
- What are inexpensive things you can do to make buildings more energy efficient?



Appendix A – Vocabulary

Building Envelope – The walls, roof, windows, doors and the foundation of a building. It separates the inside environment from the outside environment.

Climate Change – The long-term shifts in temperatures and weather patterns that can be caused by human activities such as burning fossil fuels and by natural occurrences such as volcanic eruptions or the changes in the sun's activity.

Cistern – A large concrete, stone or plastic container that stores collected rainwater from the eavestroughs of a house for later use.

Conduction – Heat that moves through materials that are touching. For example, metal such as copper is good at conducting heat.

Convection – The transfer of heat energy that happens when heated gas or liquid particles move from one location to another. Convection is driven by temperature changes.

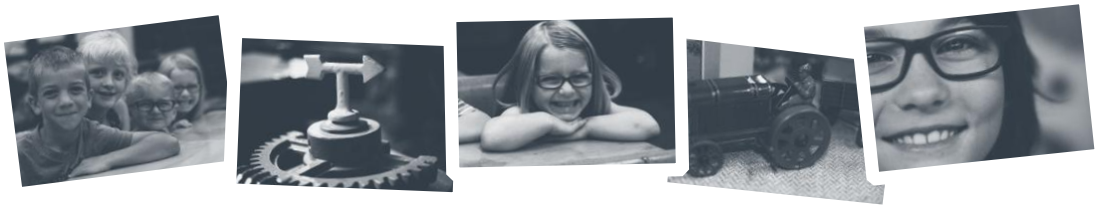
Drain Water Heat Recovery – Warm wastewater from, for example, a shower flows down the drain and clean cool water flows through copper pipes that wrap around the drain. The drain water's heat is conducted through the copper pipes which pre-heats the clean water on its way to the shower. Drain Water Heat Recovery (DWHR) can capture 40-75% of drain water heat.

Eaton's Catalogue House – A mail-order house that was purchased through the T. Eaton Company catalogue. In the early 20th century, house plans and materials were ordered and shipped to the purchaser so they could build a house themselves. This was advantageous for early settlers who did not live near stores or lumber yards.

EnerGuide Rating System (ERS) – Rates the energy efficiency and performance of a home. This system has been developed by and is regulated by the Government of Canada.

ENERGY STAR® - An international symbol of energy efficiency. Products with this label meet or exceed high standards of energy efficiency.

Greenhouse Gas Emissions – Certain gases like carbon dioxide or methane that are released into the atmosphere when burning fossil fuels. These gases trap heat and act like a blanket wrapped around the earth causing temperatures to rise.



Heat Pump – A heating/cooling system that uses the process of thermal energy transfer to warm or cool a building by using the refrigeration cycle. A heat pump can move heat from a cooler space to a warmer space.

Insulators – A substance or device that resists heat transfer.

National Energy Code for Buildings (NECB 2020) – A set of rules that regulate how we build for safety and energy efficiency.

Net Zero Home – A home that produces as much energy and electricity as it uses over the course of a year.

Passive Solar Design – The use of the sun's energy to heat and cool living spaces by exposure to the sun.

R Value – The measurement for how well something insulates against heat loss or gain or resists the movement of heat.

Radiant Floor Heating – A heating or cooling system that can be installed in the floor, wall or ceiling. It is dependent on radiant heat transfer or the delivery of heat directly between a heated surface and the people and objects in the room via radiation. It is more efficient than baseboard or forced air heating.

Radiation – Heat energy that moves through space in waves.

Rainwater System – A method of collecting and storing rainwater for use in your home.

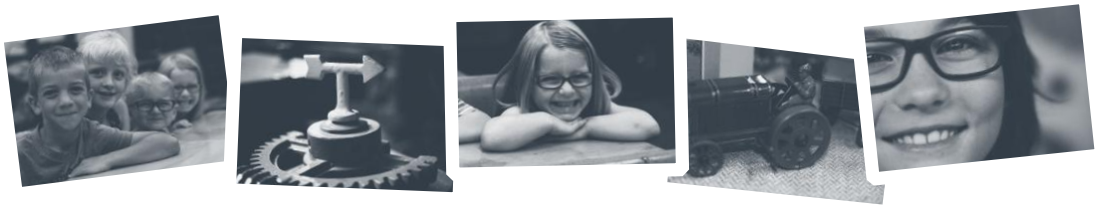
Solar Evacuated Tubes - Converts the energy of sunlight into heat that can be used for water or home heating.

Solar Panels – A panel designed to absorb and convert the sun’s rays into a source of energy.

Sustainably Made – The energy needed to produce or create an item is lower than typical methods; and the item can be made from renewable or recycled sources; and it can be recyclable or recoverable at the end of its life.

Thermal Bridging – An area where there is more heat transfer than the areas near it. This is normally caused by a gap in insulation, or by a lower R-value material with higher R-value materials around it.

Thermal Mass or Heat Capacity – The ability of a material to store heat. High thermal mass material takes a long time to heat up and to cool down, regulating the temperature in a building.



Appendix B – Program Introduction Script

Do you know what a net zero home is? A net zero home is one that produces as much energy and electricity as it uses each year. It does this by being highly energy efficient and by producing energy with solar panels placed on the south side of the home. Is your home like this? Do you think there are things you can do in your home to make it more energy efficient?

Today, you will be exploring six workstations that focus on how a net zero home uses energy efficiently and generates the energy it needs. The displays also show innovative technologies to help us build better, smarter buildings. While you are at each workstation, use the guiding questions to help you focus your investigations. Take some time to read the information and examine the technologies. You can touch these displays, but treat them respectfully. You will have eight minutes at each workstation. We will use a timer and when it beeps, your group will move to the next station.

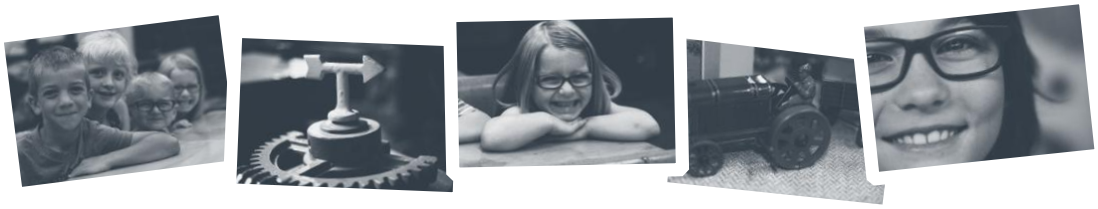
You will also be touring some of the exhibit buildings at the Museum, as well as some of the other exhibits that center around generating electricity or using energy efficiently. While you are touring the Museum's exhibit buildings, use the guiding questions to guide your groups' discussion. Buildings in the Museum are full of artifacts that should not be touched. Stay with your group on the tour and return to the room when you are done (about 50 minutes).

There is a connection between the workstations and the exhibit buildings in the Museum. Throughout history, people in Saskatchewan have been using local, natural materials to build their homes, and to try to keep themselves comfortable through long, cold winters and hot summers. These people learned a lot about how to be energy efficient with what they had. Now we know many things about how both natural and synthetic materials can be used to save energy in our buildings. A tool we use to measure a building's energy efficiency is the Energy Rating System. (Show photo on the right of the Energy Rating System.) One way to determine this is to have a blower door test done.



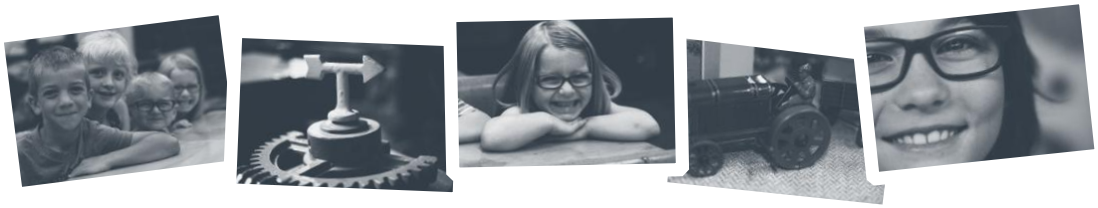
Have any of you had a blower door tests done in your own home?

A blower door test helps to show where heat is escaping your home and where cold air is getting in. It shows you where you can make changes to improve the energy efficiency of your home.



The WDM had Sun Ridge Residential rate the energy efficiency of many of its historical buildings. When you tour these buildings, you can compare their efficiency to the modern buildings that are included in the workstations. Try to figure out why they are efficient or inefficient. There are other exhibits at the Museum that connect to energy efficiency – your guiding questions will lead you to them.

Remember, the workstations are made to be explored and touched respectfully. The Museum exhibits are not to be touched.



Appendix C – Additional Resources

Saskatchewan Environmental Society – Teacher Resources
https://environmentalsociety.ca/resources/teachers/

SaskEnergy - https://www.saskenergy.com/ways-save

SaskPower - saskpower.com/Power-Savings-and-Programs

Government of Canada - natural-resources.canada.ca/energy-efficiency/homes/what-energy-efficient-home/20548

Government of Canada - natural-resources.canada.ca/energy-efficiency/homes/make-your-home-more-energy-efficient/20550

National Energy Code of Canada for Buildings 2020 - publications.gc.ca/site/archivee-archived.html?url=https://publications.gc.ca/collections/collection_2022/cnrc-nrc/NR24-24-2020-eng.pdf

The Vereco Homes – Vereco.ca

Saskatoon Water Treatment Plant - saskatoon.ca/services-residents/power-water-sewer/wastewater/wastewater-treatment-plant

Yorkton - Logan Green Water Management System - https://www.yorkton.ca/living-in-yorkton/water-and-sewer-services/source-water-management/logan-green-water-management-system/

Annual Hours of Sunshine - currentresults.com/Weather/Canada/Saskatchewan/average-saskatchewan-weather.php

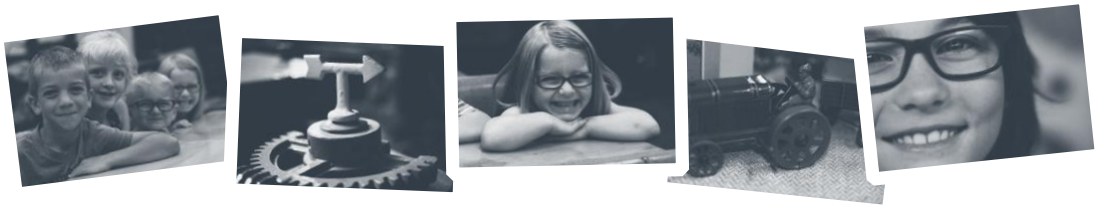
Pesâkâstêw Solar Project - naturalforces.ca/projects/pesakastew-solar-project/

Solar Wall by Conserval Engineering - solarwall.com

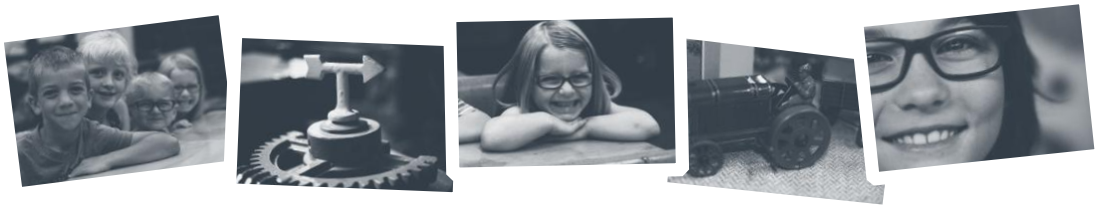
EnerGuide® Home Evaluation - https://natural-resources.canada.ca/energy-efficiency/product-energy-ratings/energuide/energuide-energy-efficiency-home-evaluations

Forest Stewardship Council Canada (FSC lumber) – fsc.org/

Recycle Saskatchewan website - recyclesaskatchewan.ca



Saskatchewan Waste Reduction Council website - saskwastereduction.ca



Appendix D – Teacher Resources

What is the Building Envelope?

The **Building Envelope** is the outer layer of the home - Walls, roof, windows and doors. It separates the inside from the outside environment.

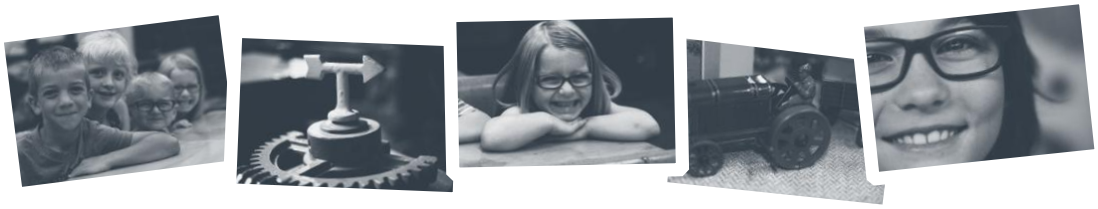
The better it is, the more comfortable the home will be:

- Warmer in winter
- Cooler in summer

Two Important Factors:

Airtight construction:
Air that leaks in and out of your home wastes energy. Air and vapour barriers, insulation and air sealing help to achieve a house that is airtight.

Good ventilation:
The more airtight a house is, the more important good ventilation is in providing fresh air. Heat Recovery Ventilators provide fresh air, while recovering the heat from stale air. Fresh and stale air pass by on opposite sides of a membrane, so that the heat is transferred, but the air does not mix.

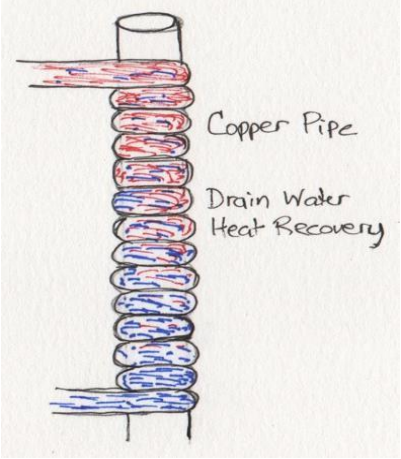


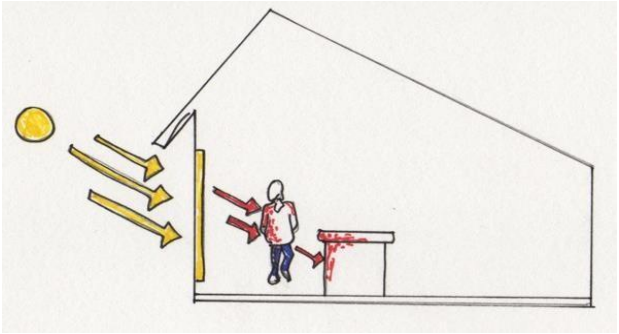
What are Conduction, Radiation and Convection?

This is what your *Pearson Saskatchewan Science 7* textbook says about them:

Conduction is: “The transfer of heat energy between substances that are in contact.”
Radiation is: “The transfer of heat energy in the form of radiant waves.”
Convection is: “The transfer of heat energy that happens when heated gas or liquid particles move from one location to another.”

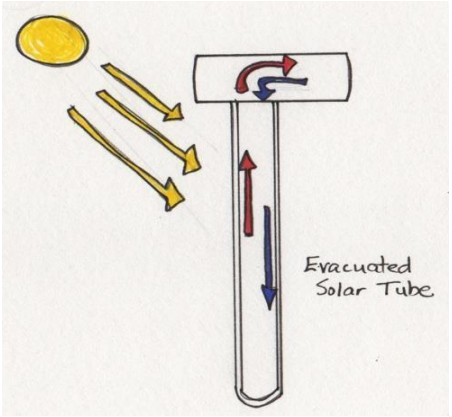
Conduction

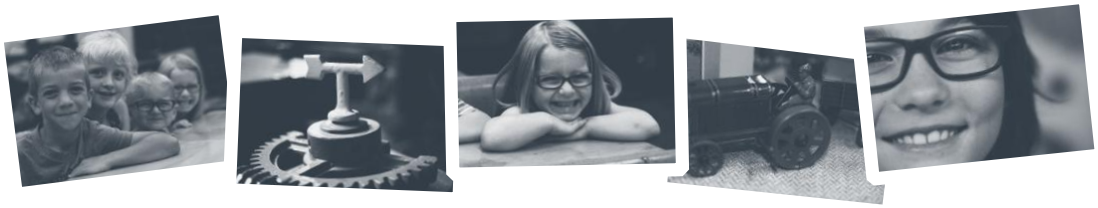




Radiation

Convection





Innovative Saskatchewan Design

Saskatchewan Conservation House



Designed by: Saskatchewan Research Council (SRC)

Built: 1977

- Airtight building envelope
- R 40 walls, R 60 ceiling

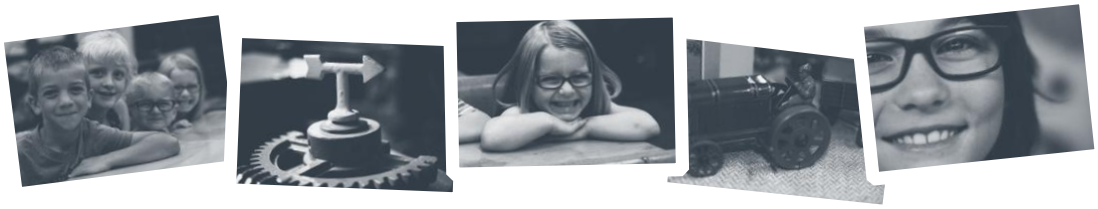
Dr. Rob Dumont and other Saskatchewan Research Council researchers developed the science. It went on to become a model for the internationally recognized passivhaus (Passive House) design.

Factor 9 House
Built: 2007



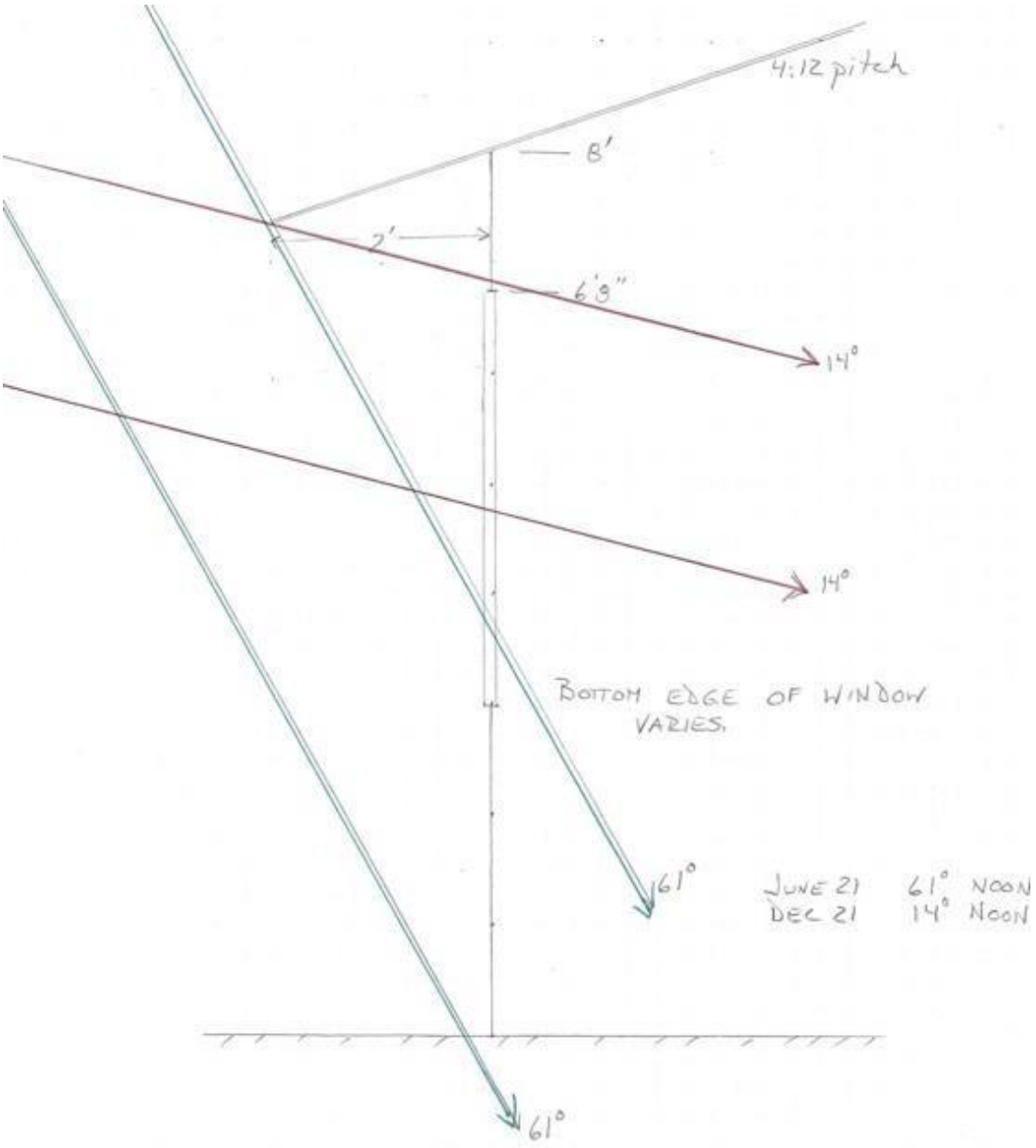
- Uses 90% less energy than typical homes of same size
- Passive, PV and solar thermal energy
- Rainwater collected for toilets/outdoor use

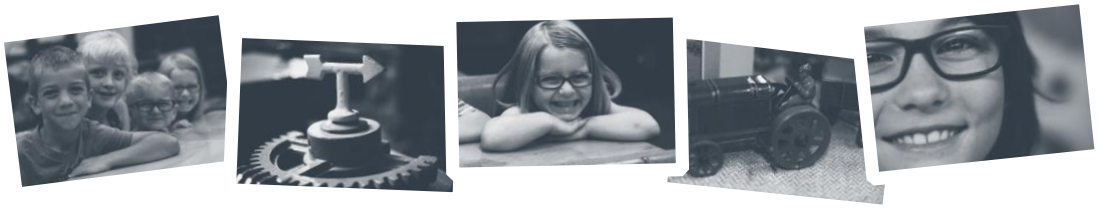




Passive Solar Design

This diagram shows the size of the roof overhang in relation to the angle of the sun at the summer and winter solstice. The overhang allows winter sun to reach far into the room but shades the house from the hot summer sun.





Radiant Floor Heating

How it works: Radiant floor heating uses *conduction*, *radiation* and *convection*.

- Some systems use an electric wire system. In Saskatchewan, electricity has high greenhouse gas emissions and is not recommended for heating when natural gas is available.

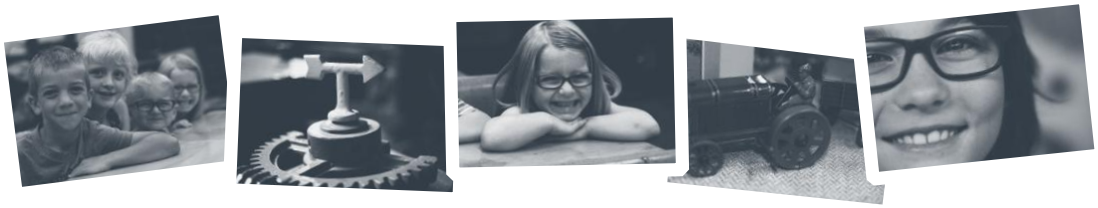
- The example here uses a mix of water and anti-freeze circulated through copper pipes.

- The solar thermal evacuated tubes or the solar flat panel heats the liquid.

- As the liquid circulates, its heat is conducted through the copper pipes to flooring that is usually a material with high thermal mass like concrete.

- The heat radiates from the floor, warming our feet, walls and furniture. Radiation never warms air. It can only warm another surface.

- Air picks up heat from the floor by convection. The heat then travels with the air to warm the room.



Solar Collectors

How They Work:

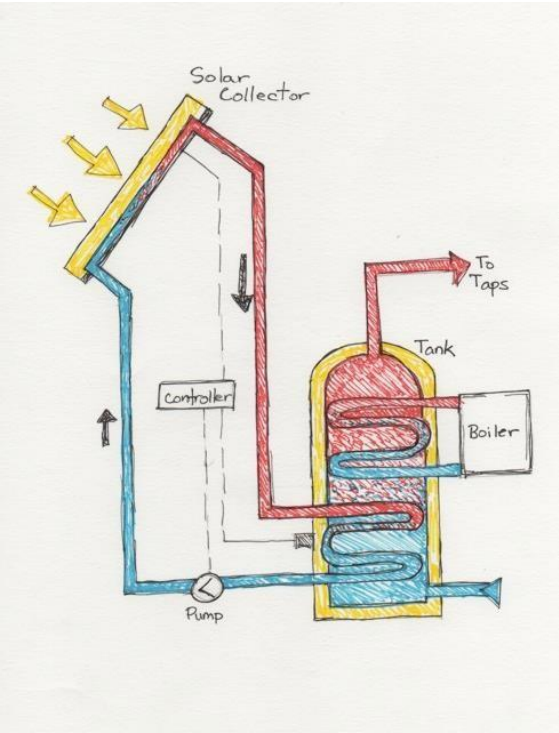
Solar Photovoltaic Panels: Convert the energy of sunlight directly into electricity.

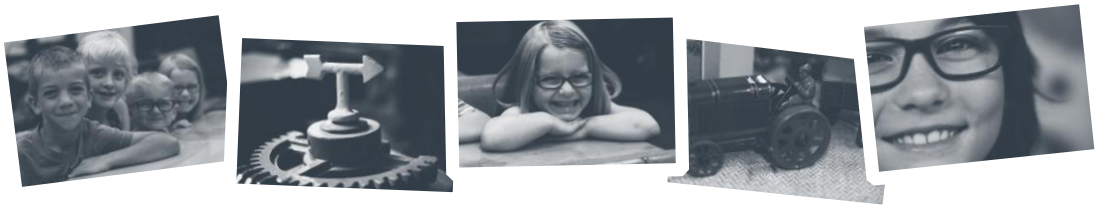
1. The silicon cells in the panel absorb the suns energy.
2. The energy causes electrons to become excited and move around more.
3. The cell is designed so the electrons move in one direction, and a current starts flowing, creating a usable amount of electricity.



Solar Evacuated Tubes: Convert the energy of sunlight into heat for water or home heating.

1. Evacuated tubes have no air between the two layers of glass.
2. The vacuum reduces convection and conduction heat loss to the outside.
3. The tubes are filled with a water/anti-freeze mix.
4. The suns heat is trapped and absorbed by the water/anti-freeze mix.
5. As the water heats it moves up the tube where the hot water is pumped through the system into a tank.
6. A heat exchanger in that tank captures the heat through conduction and convection, and takes it to a “domestic” water heater (water for washing and cooking), or to an in-floor radiant heating system.





Thermal Mass

Thermal mass is the ability of a material to store heat. Its value in building energy efficient homes is that while the material takes a long time to heat up, it also takes a long time to cool down, regulating the temperature in a building.

Have you ever felt the sidewalk or a rock after the sun has been on it?

That's thermal mass in action.

Thermal mass is often paired with *passive solar design*, to take advantage of, and hang onto, the sun's energy.

What kind of building materials can provide thermal mass?

Everything provides some thermal mass.

Dense materials that can hold a lot of heat are best.

- For example, concrete, absorbs heat when surroundings are warm, and will release heat later when surroundings are cool.
- Concrete floors or countertops.
- Stone tile floors or countertops.
- Rammed earth or adobe walls.
- A wall of water- how could you incorporate this into a house design, and how practical is it?