Falls Brook Centre
Energy Experience
Design Challenge 2008

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Energy Experience Design Challenge 2008

1 Introduction

The *Energy Experience Design Competition* is an engineering design competition for New Brunswick High School Students with a focus on energy efficiency, energy conservation, and renewable energy. More details on the competition itself including a handbook to help you organize a team can be found at www.fallsbrookcentre.ca/experience.

This document outlines the Design Challenge for 2008. It is important that your team understand everything presented here and that anything that you do not understand is cleared up before you get started on your design. Please feel free to contact the FBC Crew at 506-375-4310 or technology@fallsbrookcentre.ca.

2 Important dates

All teams participating in the competition should add the following dates to their calendar:

Posting of Design Challenge 2008	March 3rd, 2008
Registration Deadline	April 11th, 2008
Design Document Submitted	May 9th, 2008
Design Challenge Rally	May 17th, 2008

Figure 1: Table of important dates

3 Challenge Definition

The 2008 design challenge is to **build a solar thermal water heating system**.

Your system will be built using a combination of **materials** provided by the Falls Brook Centre and materials that must me independently sourced by each team. See **section 4** of this document for a breakdown of the materials and related rules and regulations.

Your entire design should not exceed the following dimensions: 1.2 m (width) x 0.8 m (depth) x 3.5 m (height)

Your design must consist of **four main components**: **solar thermal, solar electric, storage, and control**. The requirements relating to each component are given in the following sections.

3.1 Solar thermal

Your design will need to include some sort of solar thermal energy collection. The collector you design and build may not be larger than one square meter in area and 15 cm in depth.

3.2 Solar electric

If your design requires electrical power it may only be produced by a solar module built using the solar cells provided to your team by the Falls Brook Centre. Twenty full cells are provided and but only 32 – 36 half cells should be needed. Each registered team should sign up for a workshop with the Falls Brook Centre staff to teach them about solar photovoltaic power and help them build their solar electric module.

A 10W pump capable of direct solar powered operation is also provided.

3.3 Storage

Each team will be provided with a 16 L bucket which will serve as their solar heated water storage tank. Your team will need to design an interface from this bucket to the rest of your system. The storage tank itself should not be used to collect solar energy from solar radiation. If it is determined that your design could be getting added performance from solar radiation shining on your storage tank the judges will shade your tank during your evaluation. A structure may be built around your storage tank but access to the screw cap on the lid of the bucket must be available for the performance evaluation of the system by our judges.

3.4 Control

A control system involving circuits, sensors, actuators, valves, motors, pumps can be designed and built to optimize the performance of your system. During evaluation of your design no manual (or wireless) intervention will be permitted so all operation of your system should be automated. Section 4 has more specific details on what types of materials specific to control systems are allowed.

4 Materials

4.1 Provided by Falls Brook Centre

- 20 x 1.8 W Evergreen PV cells (example array shown in Figure 2) with two attachment points (i.e. cells can be cut into two halves)

Figure 2: Evergreen Solar Array

- 1 x SID10PV 10W pump (see Figure 3) intended for direct solar PV applications from IVAN LABS

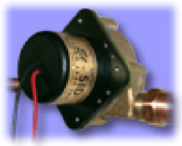

Figure 3: SID10PV Pump

- Sufficient Sylgard 184 silicone encapsulant for construction of one solar PV module.

Figure 4: Silgard 184

- 1 x 16L plastic pail

Figure 5: 16 L plastic pail

4.2 Provided by each team (required)

- 1 x glass pane 48cm x 52cm (minimum for 6x6 arrangement of 36 half-cells, other arrangements are possible, contact FBC for any questions or concerns).


Figure 6: Glass pane

- Aluminium U-channel (sliding door track works well) to build a frame around the glass. If your U-Channel is deep then make sure that your glass is sized larger to account for the lost area at the edges which will be under the U-Channel.

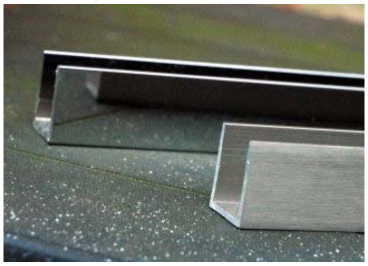
Figure 7: Aluminium U-Channel

4.3 Provided by each team (other)

Any other materials required to complete the design challenge must be provided by each team themselves. We encourage the use of used or recycled materials whenever possible. If you approach businesses in your area and tell them about your project they may be willing to donate some supplies.

Electrical energy	• All electrical energy used in your design should be produced by the PV panel your team builds with the Falls Brook Centre staff. • Additional energy storage for powering electronics is permitted as long as the capacity does not exceed the equivalent of 9 rechargeable AA batteries.
Wires	• Wire gauge is a measurement of how large a wire is, either in diameter or cross sectional area. This determines the amount of electrical current a wire can safely carry. http://en.wikipedia.org/wiki/American_wire_gauge has a table showing the amount of current different wire gauges can carry. Use only wire of the appropriate gauge for your application. • Your system will be a DC system. A proper wire colour standard uses red wires for positive, white for negative, and green or bare copper for ground. The pump itself may use red for positive and black for negative. This convention is very common however many electricians do not feel that this is appropriate because black wires in AC systems are “hot”.
Plumbing	• You can use whatever plumbing system you wish that is intended and certified to carry domestic water (e.g. copper, iron, PVC, polyethylene). • If you use copper pipe that requires soldering make sure you have qualified supervision to ensure appropriate safety measures are taken.

Solar collector	• Use whatever materials you feel appropriate other than commercial products specifically intended to be part of a solar thermal water heating system. • If you are using recycled or salvaged materials make sure you are aware of what substances were contained in or came in contact with the items you are considering using in your design. • Consult with your supervising teacher before taking apart any appliances or equipment.
Water/ propylene glycol	• Your system will not necessarily be intended for use in the winter so water should be an adequate thermal transport fluid. • If you are designing a system that is capable of operation in sub-zero conditions an anti-freeze solution will be required. • Use only food grade propylene glycol. Ethylene glycol antifreezes are poisonous and should not be used in systems that interact with the domestic water supply.
Pumps	• The provided pump should be sufficient for your needs. • Make sure to read the spec. sheet for the pump before designing and building your system. • Contact the FBC Crew if you are thinking of incorporating another pump into your design.
Storage tank	• The 16L plastic pail provided will serve as your solar heated water storage tank. • This storage tank can be pierced to add plumbing connection points as long as every connection point has a manual valve that can be easily closed to isolate the tank from your solar water heating system. • The hole in the top of the lid of the tank should not be used in your design as this will be where water will be added to your system and temperature monitoring will occur during evaluation. • The storage tank itself should not be used to collect solar energy. If it is determined that your design could be getting added performance from solar radiation shining on your storage tank the judges will shade your tank during your evaluation. • Design measures to insulate your storage tank are perfectly acceptable. • A heat exchanger can be built into the storage tank as long as the volume occupied by the exchanger does not exceed 10% of the volume of the pail.
Structural	• Frames, mounts, conduit, and other structural components of your design can be constructed using any materials you wish.
Programmable logic controller	• If your design requires additional control/monitoring of pump, actuated valves, or sensors a programmable logic controller can be used as long as it is not specifically designed for use in solar thermal water heating applications.

Circuit components	• Items such as resistors, capacitors, inductors, diodes, operational amplifiers, microcontrollers, LEDs, and LCDs are perfectly acceptable.
Temperature sensors	• Thermistors, thermocouples or other temperature sensors are allowed.
Thermostats	• Basic analog or digital thermostats are permitted. • Commercial differential thermostats are not permitted • Home made differential thermostats are permitted (e.g. http://www.jc-solarhomes.com/MTD/differential_thermostat.htm).
Electric motor	• Electric motors are permitted provided they are powered only by the PV cells provided by the Falls Brook Centre.

5 Design Documentation Requirements

1. Each team should maintain a **lab book** where team members can draw pictures and graphs, record testing results, take notes during brainstorming meetings, and write down information that may be required later in the design process or for the final report. The lab book will be submitted at the final evaluation rally. This book should be maintained throughout the design process and not only thrown together at the last minute. It will be an invaluable tool if you embrace the idea from the start.
2. Each design should include a **final report** which documents the procedures your team followed throughout the design process. The report should include such things as:
   - The team description, high level plan, and schedule
   - A brief statement of your understanding of the design requirements
   - The results of your research, data collection, and brainstorming efforts
   - The development of alternative designs for consideration
   - The evaluation process of the alternatives and the selection of the optimal design
   - The implementation of the final design
   - Final testing and performance evaluation of your design

6 Evaluation

All designs will be evaluated by a team made up of FBC staff and engineers and technicians from the local community. The evaluation will use the following breakdown in its consideration of each design:

• Performance of your system	50 %
• Evidence of a Scientific Engineering design process	25 %
• Creativity and innovation	15 %
• Overall completeness of Design documentation	10 %

Appendix

Additional resources

http://www.teachengineering.com/design_proc.php
http://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng_Design_5-12.html
http://www.thermo-dynamics.com/
http://www.enerworks.com/
http://en.wikipedia.org/wiki/Solar_thermal_energy
http://en.wikipedia.org/wiki/Solar_hot_water