Compétition canadienne d'ingénierie
Canadian Engineering Competition

Senior Team Design
Competitor Information Package

March 6-9 2008
University of Waterloo

Context

It is certain that energy will be one of the dominant global issues of the 21st Century. This competition thus draws influence from the cost of energy: the economic, social, and environmental cost. The future is bringing higher demand for energy and a greater strain on the environment that supports us. This is pertinent to Canada, where we consume more energy per person than almost any other nation on earth - in 2003, an annual total of 96.5 MWh per person (International Energy Agency - IEA - Statistics Division). In a country with varied and plentiful renewable energy resources, attention is turning from conventional fossil fuel power to alternatives and conservation. Can we continue to improve our quality of life with less power? Is it feasible that we will ever be able to shut off our choking coal power plants in Ontario, Saskatchewan, and Alberta? Can the world develop a long-term energy solution as nonrenewable sources become more precious?

Energy brings a different set of challenges to developing countries, where the abundance or lack of energy leads to wealth, debt, and governance issues. Consider being an engineer in a country such as Bangladesh where the per capita annual energy use is 1.9 MWh, 50 times less than our own. How can such a country afford the power required to raise the standard of living closer to our own? What needs to be done to ensure that this can be done in a socially and environmentally sustainable nature? This competition challenges future engineers to be innovative and insightful in conserving energy and harnessing energy from renewable resources.

The competition is based on the challenge of dealing with the extremes in Canadian weather; we spend enormous amounts of energy to simply heat and cool our homes for our own comfort. Have we built our homes to take advantage of the natural resources we have available? Consider the conservation possible if every building improved efficiency by a few percent. This competition challenges competitors to rethink the heating and cooling issue and solve it from scratch using old and new materials, resources, and strategies.

Objective

Teams must design a structure, machine, housing, or apparatus, henceforth called the prototype, that manipulates heat. Specifically, the prototype must maintain both a hot temperature and a cold temperature. Though there are no quantitative temperature requirements, the effectiveness of the prototype will be evaluated during the Ice Cube Test in the Testing Phase. Teams will be given two ice cubes, called the Hot Cube and the Cold Cube, which will be placed in their prototypes no more than 1cm apart. Prototypes will attempt to heat and melt the volume of the Hot Cube and to cool and maintain the volume of the Cold Cube. The electricity consumed by the prototype to accomplish this task will be considered in scoring.

Additionally, teams will use engineering analysis to monitor and predict how effective their prototype performs. Prototypes must included a visual indicator of the progress of

the Hot Cube melting. Teams must also submit before testing a quantitative prediction of the final weights of their ice cubes.

Materials

Each team will be given:

- 60cm x 60cm plywood design board
- Power bar
- Laptop
- Paper and pen
- Digital storage device
- Red and blue permanent markers
- Utility knife
- Scissors
- Measuring tape
- Breadboard
- Thermometer
- Duct tape

Each teams will have four natural resources available:

- Wind - 25cm oscillating fan
- Solar - 100W heat lamp
- Hot geothermal (96ºC) - Hot plate with 2L of water (low setting, steady state)
- Cold geothermal (5ºC) - Ice cubes and 2L of water

Teams can use any or all of the natural resources but they will count toward the team's electricity consumption. Teams are entitled to one "free" natural resource - that one resource will not be counted towards the team's electricity consumption total. Note that during the Design Phase, CEC volunteers will provide water and ice cubes to maintain the geothermal resources.

Teams will be given $1200 to purchase materials from the store (TC0217). In addition to dollar amounts, all materials have a green cost and an orange cost. Green cost represents the additional cost to manufacture the item in an environmentally sustainable nature. Orange cost represents the additional cost required to manufacture the item in a socially responsible, ethical nature. Points for minimizing these costs will be considered in scoring. These materials, prices, and store rules can be found in the Store Information Package.

Please note that the following powered resources are available at the store.

- Pump
- Motor

All electricity consumed by powered resources will be counted toward the consumption total. Teams may only purchase one of each powered resource, if available.

The following items will be available for public use in the shop (TC0225). The shop opens after 1 hour of the Design Phase has elapsed. Only one team member is allowed in the shop at one time, and competitors must honour first-come, first-served priority and all safety procedures. These items may not leave the shop.

- Thermodynamics and Heat Transfer textbook
- Calculator
- Multimeter
- Hammer
- Hand saw
- Handheld drill
- Pliers
- Wrench
- Screwdriver set
- Wire cutters

Constraints

General:

- The design space comprises the design base as the bottom of the prototype and up to 60cm above the design base. The prototype, natural and powered resources, and any other materials must fit within this space. The power cord from the power bar will cross the space boundary.
- Natural resources may not be closer than 15cm in 3D space from the base of any ice cube at any time. It must be easy for CEC volunteers to measure this with a ruler.
- Water from the geothermal sources or purchased from the store must be controlled. This water may never come into direct contact with an ice cube from the Ice Cube Test. This water must drain to a container, not the design board.
- You may not electrocute yourselves. Please ensure that water does not come into contact with any electrical components.
- You may not create a fire hazard or burn yourself. Please do not place anything in contact with the burner other than the warming container. Do not place anything in contact with the bulb or heating lamp.
- You may not alter the power bars in any way.

Ice Cube Test:

- Teams will designate the two ice cube loading regions by drawing two 4cm x 4cm squares on or within their prototype. The surfaces of the squares must be such that the ice cube will not move due to gravity once it had been placed at rest by the CEC volunteer.
- The square for the Hot Cube is to be coloured red and the square for the Cold Cube is to be coloured blue using the supplied permanent markers. All surfaces within these squares must be coloured the appropriate colour.
- The prototype may be enclosed provided that CEC volunteers can load ice cubes into the prototype with tongs. A 6cm by 6cm opening is required to load ice cubes.

- One team member is permitted to close these openings after the ice cubes are loaded but the closing action must be accomplished with just the index finger.
- When the ice cubes are placed in/on the prototype by the CEC volunteer the prototype may be in direct contact with no more than 4 faces between the two cubes.
- The hot and cold squares must be separated by a maximum distance of 1cm. It must be possible for CEC volunteers to measure this distance.
- The hot and cold squares must be on the same vertical plane.

- The visual indicator must provide a quantitative measure of how much weight has melted off the ice cube. It should indicate at least 3 different discrete levels of progress.
- The visual indicator should be on the outside of the prototype to allow easy reading.
- The visual indicator must indicate a change in order to be considered for points during the testing.

- Ice cubes used for the Ice Cube Test will be 3.3cm x 3.6cm x 2.2cm large.
- Final weight predictions will be considered accurate if they are within 5% of the actual values. Please see the Ice Cube Test Prediction Sheet for further information.

Fabrication Test:

- The prototype must be fabricated soundly so that the entire design board can be flipped upside-down in the Fabrication Test. The prototype will fail this test if any piece falls off the prototype.
- Natural resources, pumps, and the power bar may be removed before the Fabrication Test.
- The Fabrication Test is conducted after the Ice Cube Test so the prototype may be weakened by water from the melted ice cubes

Procedure

As per the CEC Official Senior Design Competition Rules, there will be a 15 minute question period following the briefing. Only time used to ask the questions by competitors will be counted, not time used to ask questions by the judges or to answer questions. Teams are free to ask questions outside of the question period, but in all cases only the Competition Director (TC0228) can answer questions regarding rules, competition interpretation, or procedures. Any answers during the Design Phase will be provided to all teams in writing, though not immediately after the question was asked.

Teams will be given 8 hours for the Design Phase, starting when all teams have reached their work areas. No Internet access or external communication is permitted. At the 2.5, 4, and 6 hour marks teams may send one member to the store to receive 2 free ice cubes. These will not be official-sized ice cubes that are used for the Ice Cube Test. Ice cubes will not be available at any other times. Teams may not purchase or create their own ice cubes nor remove ice cubes from the cold geothermal source.

All teams must bring their finished prototypes and the Ice Cube Test Prediction Sheet to CEC volunteers at the main floor Tatham Centre lobby (top of the stairs) before the end of the Design Phase - 5pm Friday. This deadline will be strictly enforced. Teams are required to clean up their room and vacate within 10 minutes of the end of the Design Phase. All non-waste material must be brought to the main floor Tatham Centre lobby (laptop, easel, etc).

Presentation

Teams are required to create a presentation on their design. All teams must submit their finished presentation on a digital storage device to CEC volunteers at the main floor Tatham Centre lobby before the end of the Design Phase. This deadline will be strictly enforced. It is recommended that presentations be submitted early so that they may be verified by CEC volunteers. CEC volunteers will not verify any presentations delivered less than 10 minutes before the end of the Design Phase. The presentation must be in .ppt or .pptx format. Teams may include supplementary files for the presentation on the digital storage device, provided that they will be viewable on the presentation computer. The presentation computer will be equipped with MS Office 2007, Windows Media Player, and photo and video viewing software. Teams may verify other file types up to 1 hour before the end of the Design Phase in TC0228.

Presentations will take place on Saturday in the Competition Room (DC1350) in front of an audience and a panel of odd-numbered judges as per the CEC Official Senior Design Competition Rules. The presentation order will be determined randomly and announced 30 minutes before the first presentation commences (8:30am). Teams are not permitted to switch order. All team members must be present and participate in the presentation. Teams will be permitted to bring their prototype to their presentation but they may not power the resources. Teams are permitted to bring additional props into the presentation provided that they are submitted with the presentation at the end of the Design Phase.

Each team will be given a 30 minute time slot. Competitors have a maximum of 15 minutes to present their designs. The remaining time will be indicated to competitors 5 minutes and 1 minute before the end of the alloted time, and a visual countdown will be given during the last 30 seconds. Judges will have a maximum of 15 minutes following the presentation to ask questions.

The judges at the presentation will represent a company responsible for heating and cooling two areas within a 60m x 60m x 60m box; thus, prototypes represent 1:100 scale models. Teams will formally present their prototype and design with the intention of convincing the judges to invest in their product.

Judges will be looking for a prototype that is soundly built and uses innovation and technical expertise. They will want to know about the design process: a design strategy, preliminary designs, evaluation of alternatives, and the prototype build process. As investors, the judges are equally committed to the prototype with the lowest cost. This includes economic, social, and environmental costs and extends beyond whether the device is within the budget.

The presentation should also suggest a location within Canada for the company to build the units, based on the natural resources used in the design and and other materials used in fabrication. Judges are expecting real world considerations for scaling up this prototype, including construction and maintenance issues.

Please bear in mind that the judges have to sit through 9 presentations. Please do not spend more than 1 slide repeating the problem statement as no marks will be given for reciting information from this package. It is recommended that teams make their presentations unique and memorable. Visual aids and diagrams are encouraged.

Testing

Following the Presentation Phase, all teams will gather in the Competition Room. There will be two tests that take place: the Ice Cube Test and the Fabrication Test.

Ice Cube Test:
The Ice Cube Test will test the heat manipulation qualities of all prototypes at the same time. Prior to beginning, teams will be given 5 minutes to confirm setup and/or prime their prototype. Note that the burners for the hot geothermal sources will be coordinated by CEC volunteers during the Presentation Phase to preheat water for the Testing Phase. During the 5 minute setup period, the burners will be unplugged for all teams and the burners will be returned to the prototypes. All team power bars will be plugged into an outlet but the switch will be left in the OFF position.

CEC volunteers will load prototypes one at a time and in the same order as that used for the presentations. Two cubes will be removed from the freezer, weighed, and loaded. When this is complete for all teams, there will be one 10-second period during which time one team member from each group is permitted to close any covers on their prototype. They are only allowed to use their index finger to do this. Shortly thereafter, the official clock will begin simultaneous to one member from each team powering ON their power bar.

The Ice Cube Test will take place for 20 minutes. During this time, each team is invited to the podium one at a time for 2 minutes. Since the testing will be fairly inanimate, teams are encouraged to use this time to provide humourous, insightful, serious and/or ridiculous commentary of the testing. There will be a live video feed of the prototypes that teams may direct as necessary. No points are directly awarded for this commentary but the audience will know which teams leave 2 minutes of dead air.

After 20 minutes have elapsed on the official clock, one member from each team will turn OFF their power bar and open any covers on their prototype. CEC volunteers will remove and weigh both ice cubes. This will take place in the same order as at the start of the competition.

Fabrication Test:
Following the Ice Cube Test, natural resources, pumps, and the power bars may be removed from the prototypes. One member from each team will hold their prototype by the design base and slowly rotate it upside-down and then right side up. Teams have 90

seconds to complete the test. The test will be performed by one team at a time in the same order as that used for the presentations.

Judging Matrix

Presentation		**40%**
	Design Process	
	Goal/Strategy	3%
	Preliminary Design	3%
	Evaluation of Alternatives	3%
	Build process	3%
	Presentation Quality	
	Teamwork	5%
	Presentation Delivery	4%
	Originality	2%
	Costs	
	Economic	4%
	Social	4%
	Environmental	4%
	Practical Considerations	
	Resource and location choice	1%
	Construction considerations	2%
	Maintenance considerations	2%
Design Quality		**20%**
	Critique of Design	4%
	Compliance	3%
	Met Budget	2%
	Technical Innovation	5%
	Critique Impacts	
	Economic	2%
	Social	2%
	Environmental	2%
Testing		**40%**
	Ice Cube Test	
	Cold Cube Formula	10%
	Hot Cube Formula	10%
	Electricity Consumption Formula	10%
	Indicator	
	Accuracy	3%
	Readability	1%
	Robustness	1%
	Fabrication Test (pass/fail)	5%
	TOTAL	**100 %**

Senior Team Design Schedule

	Friday		Saturday
8:00	Competitors Briefing - TC2218		
8:30			Presentation order announced - DC1350
9:00	Design Time		Team 1 Presentation - DC1350
9:30			Team 2 Presentation - DC1350
10:00	Shop opens - TC0225	Store open for single quantity purchases - TC0217	Team 3 Presentation - DC1350
10:30			Team 4 Presentation - DC1350
11:00		Store open for all purchases - TC0217	Team 5 Presentation - DC1350
11:30		Free ice cubes - TC0217	Team 6 Presentation - DC1350
12:00	Lunch delivered to design rooms		Lunch
12:30			Team 7 Presentation - DC1350
1:00		Free ice cubes - TC0217	Team 8 Presentation - DC1350
1:30			Team 9 Presentation - DC1350
2:00			Testing Period (all teams) - DC1350
2:30			
3:00		Free ice cubes - TC0217	
3:30			
4:00	End of presentation file type verification - TC0228	Store closed	
4:30			**Legend**
4:50	End of presentation verification - TC main lobby		All teams
5:00	Presentations, prediction sheet, and prototypes due - TC main lobby		Design Time
5:10	Design rooms cleaned and vacated		Store Information
5:15	Travel back to hotel		Presentations

Ice Cube Test Prediction Sheet

Team: _____

		To be completed by CEC volunteers		
	Predicted Final Weight as percent of initial weight(%)	Initial Weight (g)	Predicted Final Weight (g)	Actual Final Weight (g)
Hot Cube				
Cold Cube				

	Resources Used
Wind	
Solar	
Hot geothermal	
Cold geothermal	
Pump	
Motor	

For score calculation, a +/- 5% tolerance will be applied to the predicted weight: teams will be awarded the highest score obtained within this tolerance.

Cold Cube Formula:

$$\text{Score} = 10\left(\frac{Weight_{final}}{Weight_{initial}}\right)\left(1 - \frac{\left|Weight_{predicted} - Weight_{actual}\right|}{Weight_{actual}}\right)$$

Hot Cube Formula:

$$\text{Score} = 10\left(1 - \frac{Weight_{final}}{Weight_{initial}}\right)\left(1 - \frac{\left|Weight_{predicted} - Weight_{actual}\right|}{Weight_{actual}}\right)$$

Electricity Consumption Formula:

Score = 10-2(*number of non-free resources*)