Design Project Proposal

Gavin Barter
Devin Sceles
Chris Brennan
Majd Al Zhouri
Katie Robinson

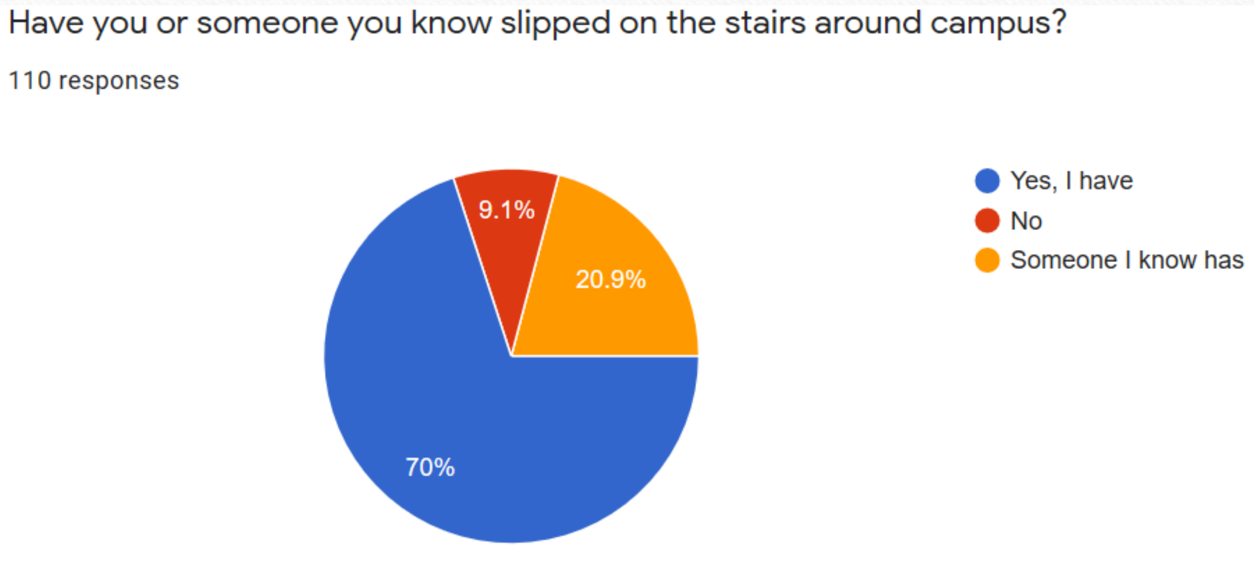
Introduction

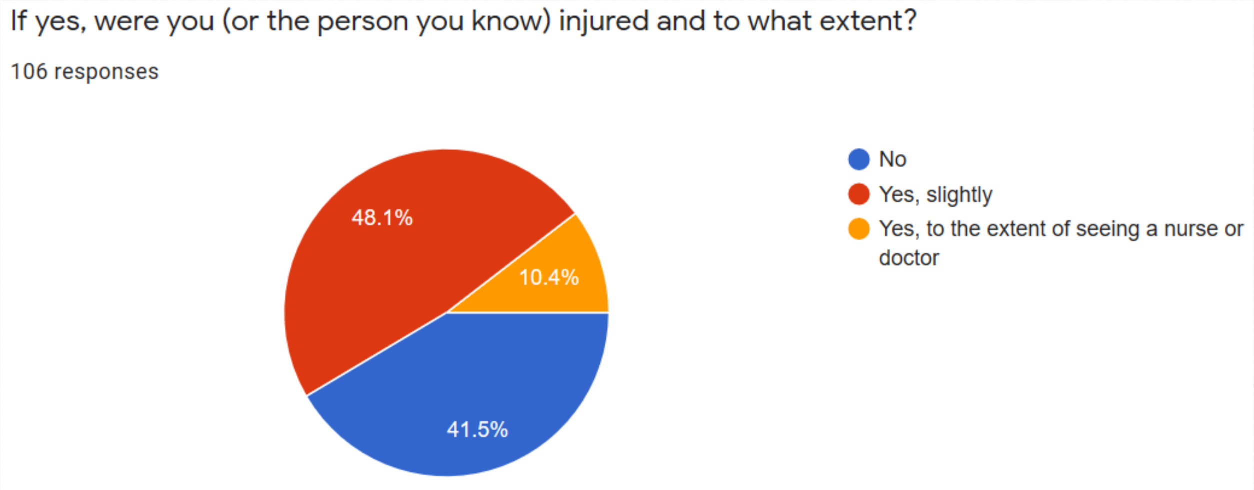
- Safety is of the upmost importance for any university.
- Accidents on campus are an increasing concern after the recent amounts of snow and ice accumulation.
- Snow removal around campus is a time, cost and labor-intensive process.

Problem Definition

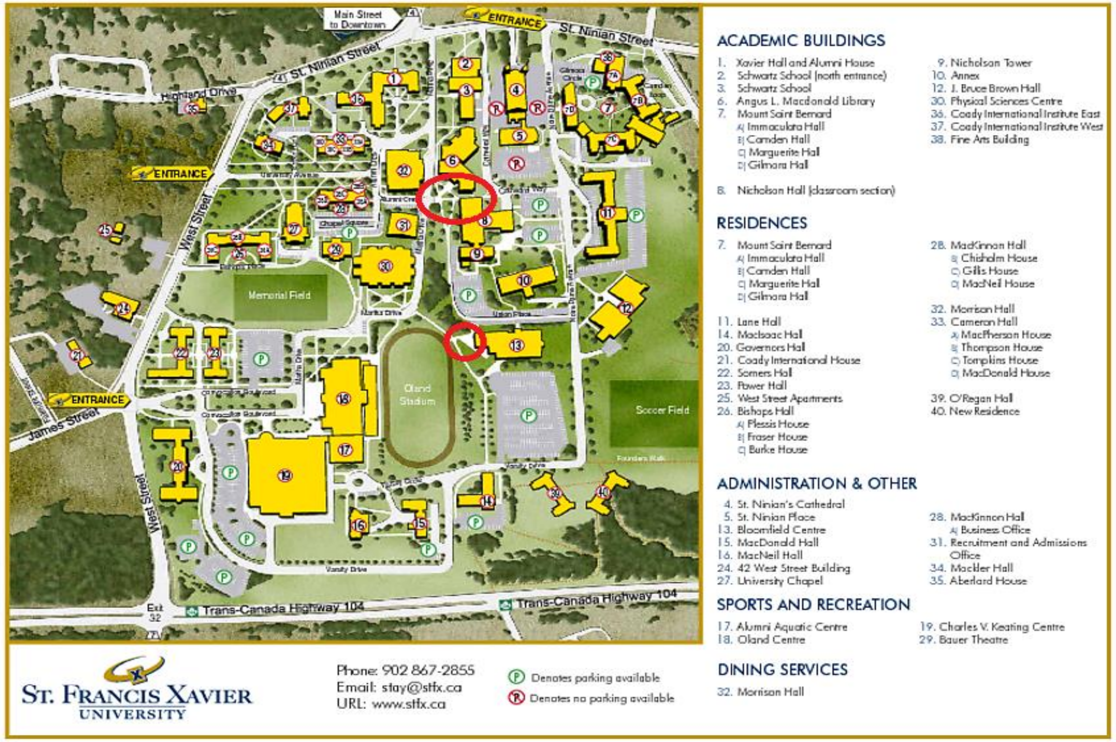
- Unlike pathways, stairs cannot be cleared with a snowplow.
- Stairs must be cleared manually, either by shovel or salting of the concrete.
- Following a quick introductory survey of students from St.FX, we concluded that icy stairs on campus were a concern to the student population.

Student Survey





Problem Areas



Potential Solution

- Design and installation of heated stairway paneling around campus to be used during the winter season to reduce the risk of accidents.
- This product will be designed such that it can easily be installed and used, but also can be relocated if needed at any point.
- Product should be relatively cost efficient for its features.

Features

- Product will include heated wires/elements that will be designed into the panels.
- Reduction of electric costs by designing panels to absorb solar energy.
- Must be made of durable material as problem points around campus are high traffic areas.
- Activation device (timer, measure of sunlight, temperature, manually...)

Environmental Impact

- It is our goal and duty to protect the environment. We are aiming to reduce any environmental impacts that occur with our product.
- Introducing renewable energy sources saves money.
- For this reason, our design involves converting solar energy into useable electric energy, stored in batteries

Research Phase

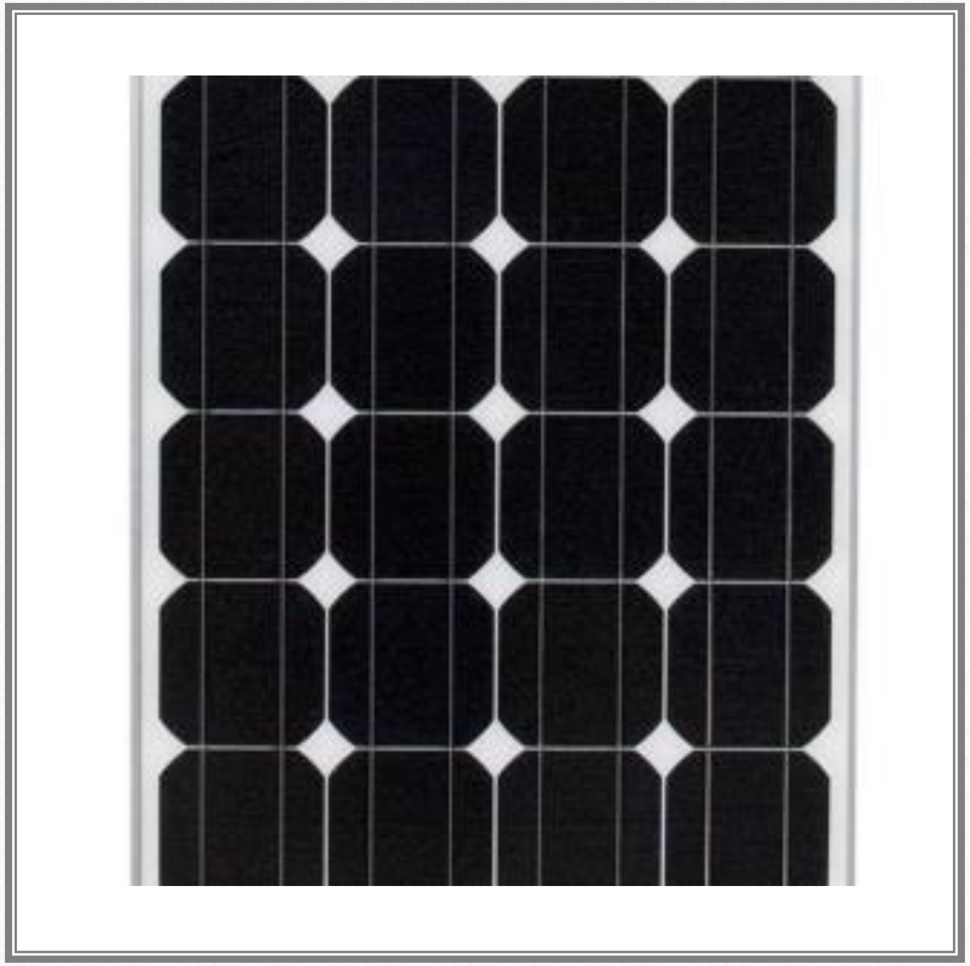
- The following slides will be points of research needed to successfully design the product proposed.
- Each category is broken down into the different options that are currently available given present technology.

Powering with Solar Energy

- Panel efficiency is in the range of 10-22%
- The cost of solar cells has decreased by 70% since 2010
- Currently contributing 11-16% of global electrical consumption

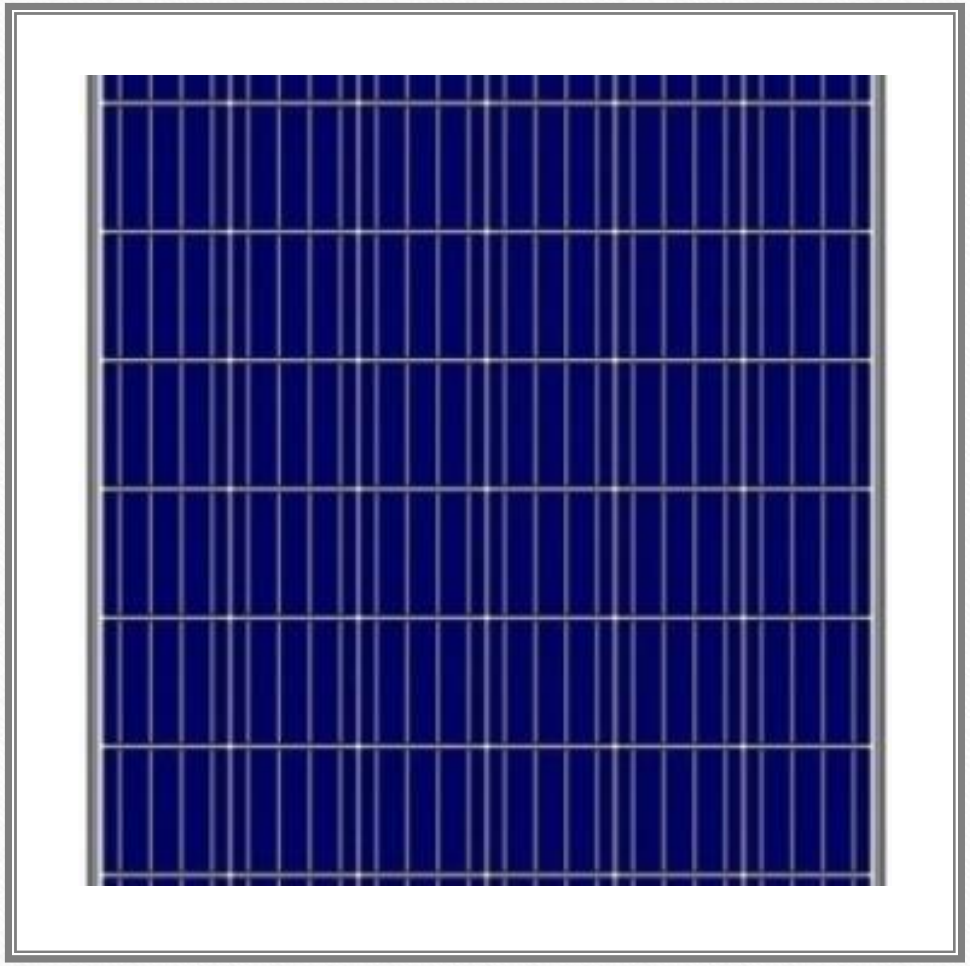
Types of Solar Panels

- Monocrystalline
- Polycrystalline
- Thin Film



Monocrystalline Panels

- Oldest solar panel on the market
- Most expensive
- Most efficient (15-22%)
- Longest lifespan
- Require less space



Polycrystalline Panels

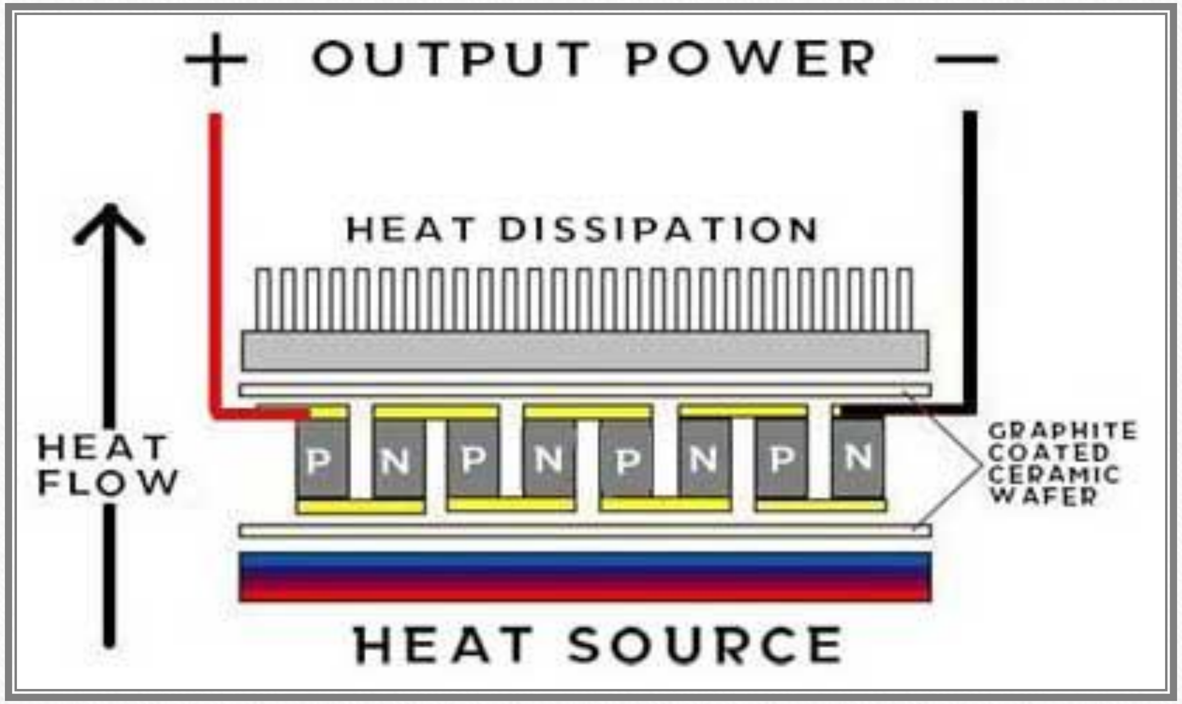
- A variation on the manufacturing process for monocrystalline panels
- Less expensive to manufacture
- Less efficient than monocrystalline (14-16%)
- Lower efficiency under high temperatures

Thin Film Panels

- Built from light weight and flexible materials
- Lower emissions to construct
- Least efficient (11-13%)
- Higher temperature resistance
- Shading effects are minimal with this panel.

Types of Heating

- Solar panels alone generate some heat as they reflect ~70% sunlight
  - Peltier heat pumps utilize the thermoelectric effect
    - Cost effective, but not cost efficient
- Electric heating coils/heating elements



Types of Energy Storage

- There are three different types of batteries used to store solar energy:
- Lead Acid
- Lithium Ion
- Saltwater
- Typically last between 5-15 years

Lead Acid Batteries

- Oldest battery type on the market
- Proven and well tested
- Least expensive
- Shortest lifespan
- Lowest depth of discharge

Lithium Ion

- Lighter and more compact than lead acid batteries
- Longest lifespan
- Most expensive option
- Average depth of discharge

Saltwater

- Optimal temperature range: -5 – 20 degree Celsius
- Easily recyclable
- Best depth of discharge
- Large batteries (12 on a pallet is 1.2m high, 1.3m wide and 1m deep weighing 1.5 tons)
- Less expensive than lithium ion batteries.

Battery Breakdown

Depth of Discharge: How much energy can be cycled into and out of the battery in one cycle.

Glass Types

- Solar panels and heating elements will need to be incased in glass for durability.
- Tampered glass
- Heat strengthened glass
- Annealed glass

Annealed Glass

- Most basic glass type
- Brittle and very strong in compression
- Low tensile strength
- Low toughness
- Low thermal shock resistance
- Breaks due to sudden changes in temperature

Tempered Glass

- 4 to 5 times stronger than the Annealed glass.
- Used for safety reasons.
- Grooves can be placed on the glass to offer further grip on stairs while still allowing sunlight to pass through
- Dirty glass only results in a small energy loss
- Designed to last 20 years minimum

Heat Strengthened Glass

- Approximately 2X the mechanical and thermal strength of annealed glass.
- Used for safety reasons.
- The compression strength is low
- Can resist temperature differential up to 130 ^{0}C.
- Due to its increased strength, it can resist more wind load, snow load, and thermal stresses.

Design Phase

- Generally about 4 hours of sunlight during the winter months in Antigonish (this varies since the solar panels are not angled)
- Determining where all elements of the product are placed (order)
- Grid style of coils to allow passage of sunlight
- Ideally, the coils/pump would only need to increase the temperature by 1 degree Celsius greater than surrounding temperature
- Mat-like so it is easily added and replaceable

Costs

- Upfront product purchasing
- Electric costs (solar energy dependent/backup grid energy)
- Maintenance and upkeep

Engineering Analysis

- Types of engineering analysis needed:
- Weight tolerance of the material.
- Heat transfer (how much heat is lost to the surroundings).
- Solar energy generation.
- Energy storage.

Potential Design Obstacles to Evaluate

- Is there enough sunlight during winter to successfully power this device by itself?
- Will the panels have to be cleaned frequently? If so, how will dirty panels effect efficiency?
- How will the solar energy be stored when not in use?
- Will the cold temperatures effect this device?
- Will the panels be able to recognize when snow or ice is on them or will they have to be manually turned on?
- How thick will the glass casing have to be to support weight but also effectively produce solar energy?
- How will the heating elements be arranged to successfully melt snow/ice but not inhibit the production of solar energy?
- Will panels on each stair be linked together powered as a group or will they be powered separately?

Questions