Project Deliverable D: **Conceptual Design**
GNG 1103 – Engineering Design

Faculty of Engineering – University of Ottawa

Introduction:

The purpose of this deliverable is to propose possible solutions to the identified problems related to the solar panels through thoroughly breaking down the problems and detailed analysis. At least three solutions will be suggested for each problem and both will be compared in order to find the most efficient solution based on the predetermined benchmarking design criteria. It is worth noting that all proposed conceptual solutions will be developed to a certain extent, so that if, for whichever reason the chosen concept no longer proves efficient or faces difficulties in the future, there will always be a plan B in the background to be even further developed. The main priority is to present ideas which all have respective pros and cons, in order to present to the client the options which they can choose to utilize moving forward with the construction.

Subsystems

1. Mounting/ Installation
    - Solar panel should be able to be mounted continually when it is extended
    - Maneuverable; Can be installed anywhere on the shed
    - Solar panels easily removable and reconstructed, and transported (resistant to damage)

2. Usage & Maintenance
    - Must be able to function through various weather conditions
    - Removal of snow or minimizing snow buildup
    - Functional in times with low light
    - Solar panels must provide benefits regardless of the location
    - Inexpensive

3. Efficiency
    - Store solar energy created during the daytime
    - Able to share energy between neighbouring sheds (collective energy bank)
    - Central heating control system (Not easily accessible by children)

4. Capacity/ Maintenance
    - Solar panels should generate enough energy to power the lights, heating, water heating, small refrigerator, miscellaneous power outlets
    - Heat insulation

5. Safety
   - The solar panels as well as all of its wiring should be child-safe (preventing children from injuring themselves or causing damage).
   - Satisfy building code requirements (regulations involving solar panels)

Problem: Mounting / Installation

The solar panels must be able to mounted continually when extended and it can be installed anywhere on the shed.

Solutions:

1. Material selection (Arun)

Solar panels must be removable and reconstructed, and transported easily therefore a certain types of bolts are needed. We need to make sure that if there's ever a situation where the solar panels need to be moved it can be moved easily. What we were thinking is using a brace strap tensioners, these are easily removable with the right tool and when it is attached to the panels it will hold it place. We also need to communicate with the construction team and tell them what our plan is and how they can help us.

2. Non-penetrating system (Jenn)

Non-penetrating systems allow us to install traditional solar panels (rigid, glassed, crystalline solar panels on rails) on a sloped roof without drilling holes. This allows for quick installation and mounting time, as well as making the removal process quicker and easier. Because it is preassembled, it also reduces the costs of labour. The system uses standardized rails bracketed together and “draped” over the peak of the roof. By distributing the panel load,

the system manipulates the wind to keep the panels on the roof.[1] In especially windy areas, one or two penetrations may be needed, although that is still much less than in traditional systems. Furthermore, because it is non-penetrating, it does not cause damage to the roof, therefore does not compromise the integrity of the roof's strength.

Brands: SolarPod Crown (pictured)

3. Railless system (Jenn)

This solar panel mounting system is mostly preassembled and can be easily snapped in place. This system has separate components for module connections and roof attachments. All mounting components, including roof attachments, are self-bonded and grounded with one grounding lug[2]. By removing rails, suppliers are cutting manufacturing and shipping costs, and installers are limiting time on the roof with fewer components to handle and install.

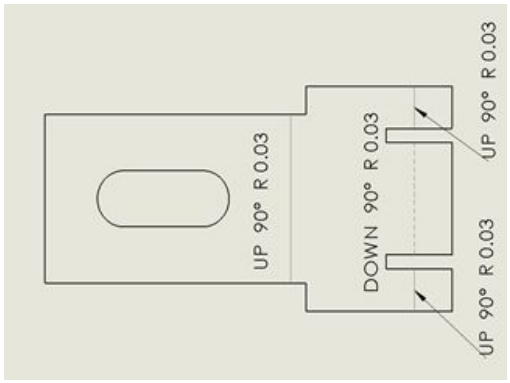
[1] Pickerel, K. (2017). Is it possible to install solar on a sloped roof without drilling holes?. Solar Power World. Retrieved 15 February 2019, from https://www.solarpowerworldonline.com/2017/01/possible-install-solar-sloped-roof-without-drilling-holes/

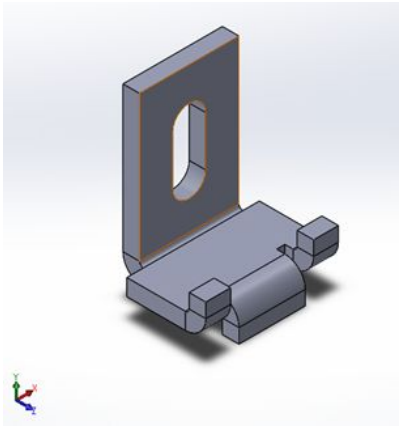
[2] Crowell, C. (2017). We look at the pros and cons of rail and rail-less PV mounting systems | Solar Builder. Solar Builder Magazine. Retrieved 18 February 2019, from https://solarbuildermag.com/mounting-solutions-guide/pros-cons-rail-rail-less-pv-mounting-systems/

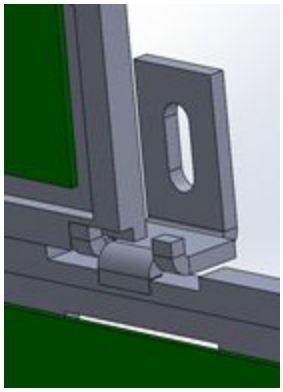
Brands: Snap N Rack (pictured left) and MageMount (pictured right)

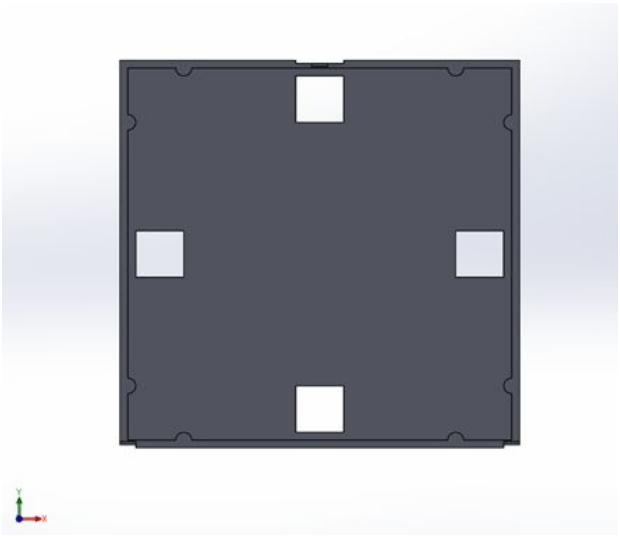
4. Custom Mounting bracket system (Giulian)

Simplicity, practicality, and functionality are key factors to consider when considering a mounting design for the solar panels. A custom mounting mechanism was designed to reduce the number of installation screws, allowing the brackets to be installed in a running-bound pattern. For the custom mounting mechanisms to be utilized effectively, a housing unit (back panel) is recommended for various reasons: 1. Minimize thermal expansion; 2. Provide a sturdier backbone for the mounting system in order to create a more solid foundation for the panels. An example of this proposed housing unit, as well as the SolidWorks design of the mounting units are shown in the Figures below.



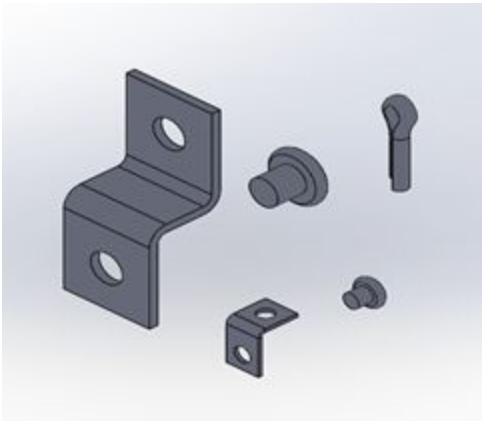


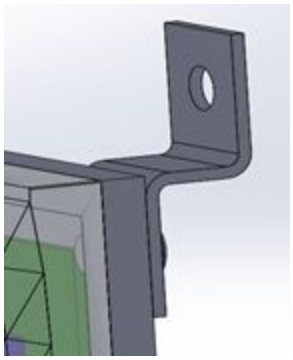


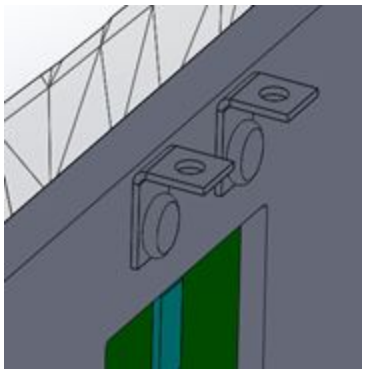


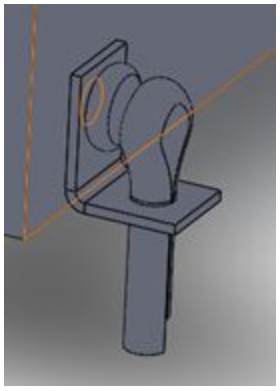
5. ‘Off the shelf components’ mounting system (Giulian)

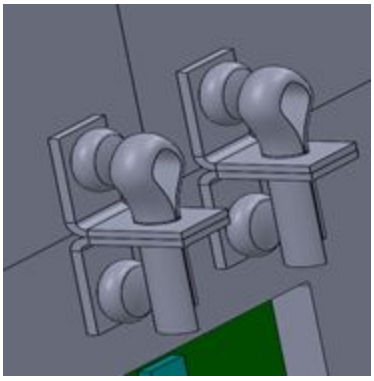
Should the custom mounting design described above prove to be too expensive for the client's constraints, commercial off the shelf components can be used to perform a similar function. For what this design sacrifices in long term durability, it makes up for in relatively low cost of construction. Since finances are limited in the conception of this solar panel unit, this mounting system proves to be one of the most logical ideas to use, averaging around $3/solar panel. The figures below display the assembly of the bracket, alongside the individual costs of the commercial components to create the bracket in its entirety.











Company	Part no.	Description	Cost per unit ($)	units	Total cost ($)
Panduit	PAO	Z bracket	0.49	2	0.98
Keystone	615	L Bracket	0.26	4	1.30
BoltDepot	9631	6-32 x 1/8	0.04	4	0.16
BoltDepot	9673	1/4-20 x 1/4	0.10	2	0.2
BoltDepot	14548	1/8 cotter pin	0.08	2	0.16
					2.8

Problem: Usage & Maintenance

Due to the location of the shelter in Ottawa, snow buildup is inevitable. We need to make sure the solar panels can withstand through snow in order to continue generating enough energy to be fully functional throughout the winter. In other words we need to minimize the snow build up that could block the sunlight from reaching the panels that would eventually decrease the panel's efficiency.

Solutions:

1. Tilt the panel (Arun)

Since there is going to be a lot of snow we need to make sure not a lot of snow is on the panel. One thing we can do is tilt the panels at a certain angle where if the snow were to fall on it, it will go straight to the ground. One thing we need to do is communicate with the construction team since they are the one building the roof. We need to make architecture of the roof in such way that it is suitable in winter time. The roof needs to be as steep as possible so the panels can easily just wipe the snow to ground. Another way we could solve this problem is by installing heat cables on to the roof, however budget restrictions apply.

2. Windshield wipers (Jenn)

Wipers (functioning in the same way as windshield wipers for cars) could be used to efficiently remove snow buildup on the roof. Just like for cars, they operate after the user presses a button. This method allows the snow removal process to be easy and efficient, requiring no manual work and therefore lowering the risk of accidents.

The wipers would be installed on the roof, above the solar panels.

3. Leaf blower and hoses (Doga)

We can create a system where we connect a leaf blower to long plastic air hoses or PVC pipes. This system either blows the snow off the panels or produce warm air that will help melt the snow that has previously built up on the roof. An important consideration for this solution would be the strength of the leaf blower since we will need one that is powerful enough to blow all the snow. However, it will take up some of the electricity produced for other appliances.

4. Facilitate manual snow removal (Jenn)

For a cost-efficient solution, it is possible to facilitate manual snow removal by allowing easy access to the roof with a mountable and secure ladder. This solution could integrate the panel tilting solution as well to facilitate snow removal. This method can also be used with other methods of snow removal, therefore serving as a backup.

5. Heat control (Miguel)

This is a very expensive solution as it requires the solar panel to sense if there is snow on the surface of the cells. What ends up happening is the solar panel will generate more heat than usual and begin to melt the snow on top of it.

Problem: Efficiency

Since the sun goes down at night there will be no power to give energy to the panels, so at night time we need to make sure there is enough stored energy so the people in there can still feel like home. Also, because Canadian winter days are much shorter than they are in the winter, there is less sunlight in the winter, therefore less energy can be generated during that time of the year. Energy storage is necessary to store the excess energy generated in the summer for usage in the winter where energy is lacking.

Solutions:

1. Battery banks (Arun)

During the day the solar panels produce energy where some of the energy will be used in the house any other excess energy will begin to charge the battery. These rechargeable batteries will store enough electricity and this can be drawn upon in the evening which will satisfy the people living there.

2. Hot Water Tanks (Doga)

Water and air heating are the two highest energy expenses in a household. Therefore, using the excess energy to do one of those things in advance would increase the efficiency and not let the excess energy go in waste. The idea is very similar to using batteries, but this way the energy is used to power a water heater, then the heated water is stored in an insulated tank. The most efficient way to realize this concept is via a air-source heat pump which requires only about 0.4 kWh of electricity to deliver 1 kWh of heat.

3. Amorphous panels (Miguel)

Solar panels need sunlight in order to function properly, this means that when night time comes around, they won't be working at all. A solution to this is using an amorphous panel. An amorphous panel is one that doesn't require much sunlight in order to generate solar energy. This means that they can be set in shady locations where not much light is coming through. They have low life spans but are very cost efficient for what they do. The light they provide will be dim however, since they don't provide enough energy. Therefore, when the sun comes around, monocrystalline solar panels and polycrystalline panels will generate as much solar energy as possible, but the installation of amorphous panels will work in situations the other panels cannot.

Problem: Capacity / Maintenance

Most of the time it will be cold in canada so we need to make sure that there is enough heating to warm up the people living in the area.

Solutions:

1. Ventilation Preheating (Arun)

Using a Ventilation Preheating system is very beneficial for us, you can take advantage of the sun's free abundant energy to heat your home for free. Heating your home with a solar heating system can significantly reduce your winter fuel bills. A Ventilation Preheating system will also reduce the amount of air pollution and greenhouse gases that result from your use of fossil fuels such as oil, propane, and other petroleum products. How it works is the Solar air heating systems use air as the working fluid for absorbing and transferring solar energy. Solar air collectors can directly heat individual rooms or can potentially pre-heat the air passing into a heat recovery ventilator or through the air coil of an air-source heat pump. Also air systems don't freeze in winter times which will be very beneficial to us

2. Insulation (Doga)

One way to make sure the energy produced by the solar panels is used to its full potential to satisfy all the needs is by protecting the energy that has already been produced. This means a well insulated house. In order to achieve this, fiberglass insulation or foil backed compressed insulation can be installed between the studs. Then the insulation can be covered with plywood, sheetrock or some other similar material. Fiberglass insulation can also work as a vapor barrier that keeps humidity low. This is important to keeping a wooden shed in shape as well as protecting more delicate stored items. Another important consideration is using double pained windows. Finally, a good underlay and laminate will allow adequate insulation for the floors.

Selection Table

Problem	Solutions	Pros	Cons	Best
Mounting/ installation	Brace Strap	-Easy to attach and easy to remove.	-During extreme weather it might hard to remove.	X
	Non-penetrating system	- very quick and inexpensive installation and removal (modular) - no drilling required - preassembled - very efficient for sloped roof - reduces labour costs - does not compromise integrity of roof's strength	- affordable in the long run but not the cheapest option initially	$?
	Railless system	- quick installation (mosty preassembled) - reduces labour costs	- requires many holes to be drilled - take a bit more planning upfront to properly lay out and level the mounts - harder to install	X
	Custom Mounting System	-Delivers as the most efficient, practical, and strongest mounting system	-complexity in design, as well as material requirements can prove to be expensive when constructing the mounting bracket	$?
	'Off the shelf components' system	-completely accessible components -cheap solution -fulfills function effectively	-construction of the brackets can prove to be tedious, as there are many small components to consider	✓
Snow buildup	Tilt the panel	- inexpensive - low maintenance - works "automatically"	- slow and not always reliable - may not work during big snow storm	✓

			- not the most efficient method	
	Windshield wiper	- very quick and efficient - reliable	- expensive - requires energy to function - may cause snow buildup around the shelter (after snow is blown out of the roof) - may require periodical maintenance - must be activated by pressing a button, so cannot function without the user being present - with too much buildup, it may lose efficiency	X
	Heat control system	- Automatic (doesn't rely on a person to take off the snow) - Very reliable - When the solar panel doesn't sense any more snow, it goes back to regular mode	-Expensive	X
	Leaf blower and hoses	- very quick and efficient - would work during big snow storms	- expensive - requires energy to function - may cause snow buildup around the shelter (after snow is blown out of the roof) - may require periodical maintenance - snow blowing may be a safety hazard	✓
	Heated panels	- efficient most of the	- requires a lot of	X

		time	energy - expensive - loses efficiency during big snow storms	
	Facilitate manual snow removal	- inexpensive - efficiency dependent on human cooperation	- efficiency dependent on human cooperation (strength and personal will), therefore not always reliable - because it requires manual work, it has higher safety risks - time-consuming	✓
Storing energy	Battery banks	-Stores energy that can be used for later. -Saves electricity and cost.	-Takes up alot of space -Expensive -High maintenance	X
	Amorphous panels	- Cost efficient - works in shady areas - used for areas where much light isn't needed, ex. streetlights	- low lifespan - doesn't generate as much electricity as a mono or poly solar panel	✓
Heating	Ventilation Preheating	-reduce your winter fuel bills -reduce the amount of air pollution and greenhouse gases that result from your use of fossil fuels such as oil, propane, and other petroleum products.	-Expensive -Takes up alot energy	X
	Insulation	- long term method - energy saving - tried-and-true,	- can be initially costly - can add weight to project, causing more	✓

		therefore reliable	trouble for transportation	

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