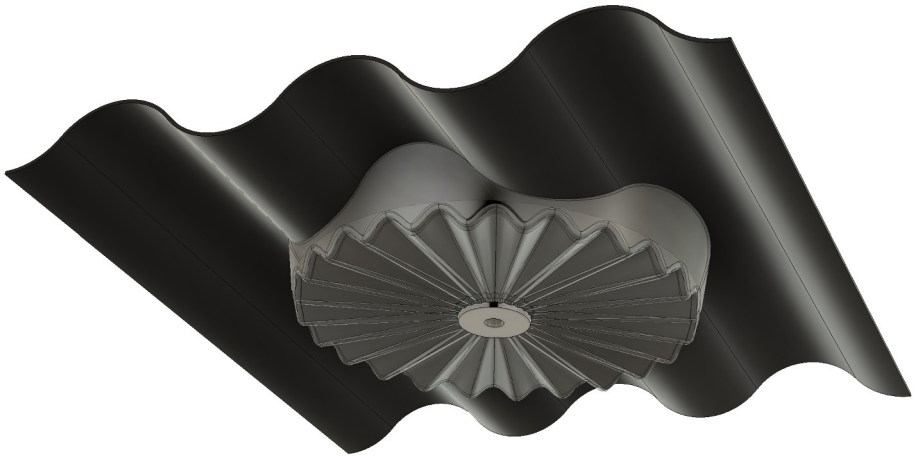
NightSkyLight

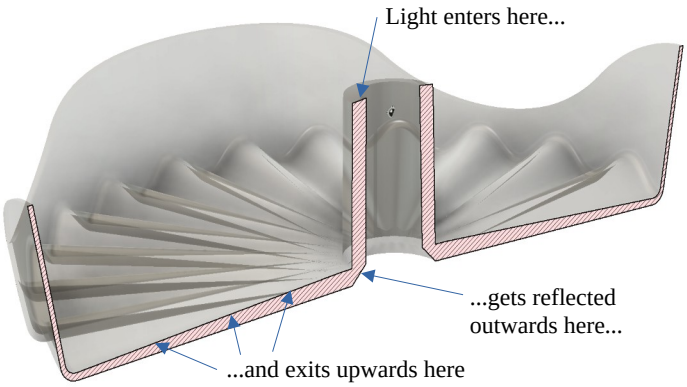


The NightSkyLight is a low cost, passive solar-powered toilet lighting solution for refugee camps. It utilises a strontium aluminate emitter, and an innovative compact light guide design for a minimally invasive installation in cubicles.

The innovative light guide based design enables the NightSkyLight to be permanently mounted and charged in-situ without allowing direct sunlight into the toilet cubicle. Installation is quick and simple, requiring only a small hole to be cut using commonly available tools.

Whilst considering design options for the NightSkyLight, the choice was made to make the luminaire non-removeable. This direction was taken (as opposed to an approach whereby all or part of the luminaire would be removed for charging) to reduce the chance of the luminaire being rendered inoperable due to loss of the emitter. Roof mounting was chosen over wall mounting as there could be situations where the wall that would be exposed to the sun might be obstructed by an adjacent structure, whereas the roof would have more chance of being unobstructed.

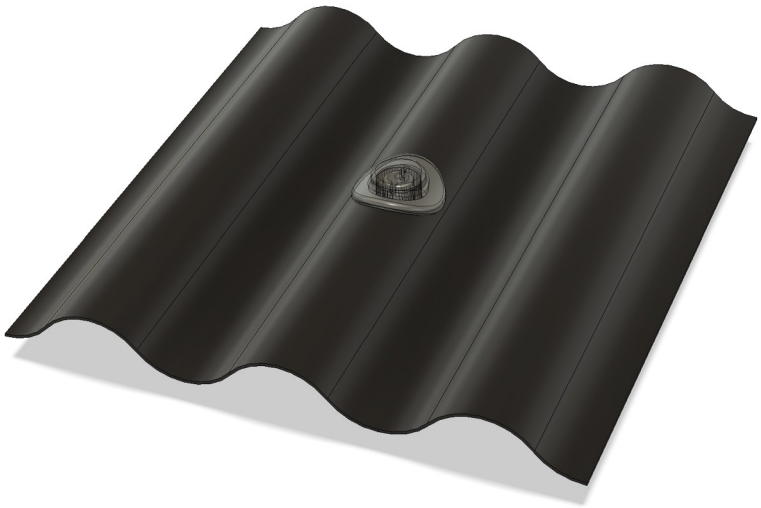
The intensity of the emitted light is essentially a product of the surface area of the emitter, and composition of the phosphorescent material. An emitter having a large surface area is therefore desireable, but to have this emitter directly charged by the sun requires a large cutout in the roof, which goes against the requirement for minimal compromise of the structure. In order then to get the sunlight in to charge the emitter, a light guide was chosen. The design of the light guide also eliminates direct sunlight entering the structure. A reverse thermochromic filter can also be included in the design to further eliminate light. This is a filter which is clear during the night when the ambient temperature is low, and black during the day when the temperature is higher.



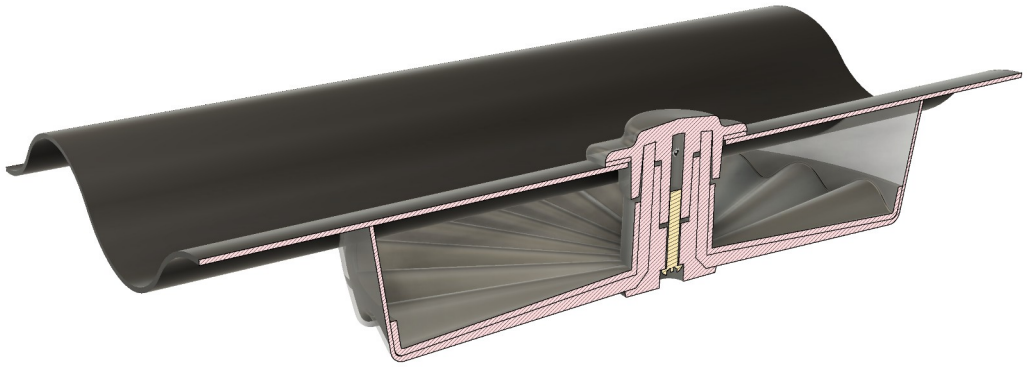
In the NightSkyLight, light passes through the top cover and enters the top of the light guide, which protrudes through the cubicle roof. From here it travels down the centre of the light guide and is reflected outwards, exiting through the upper surface of the light guide. The light guide tapers in thickness from the centre outwards, and the upper surface of the light guide is textured so as to enable light

to leak out and charge the emitter. During the night, light is emitted back down through the light guide and into the cubicle. The top cover obviously needs to be transparent to supply the light guide, but as it also has to be used to clamp the light together it then lets light through the centre section and into the cubicle. In order to prevent this, the bottom cover is opaque and extends past the reflector portion of the light guide to catch stray light.

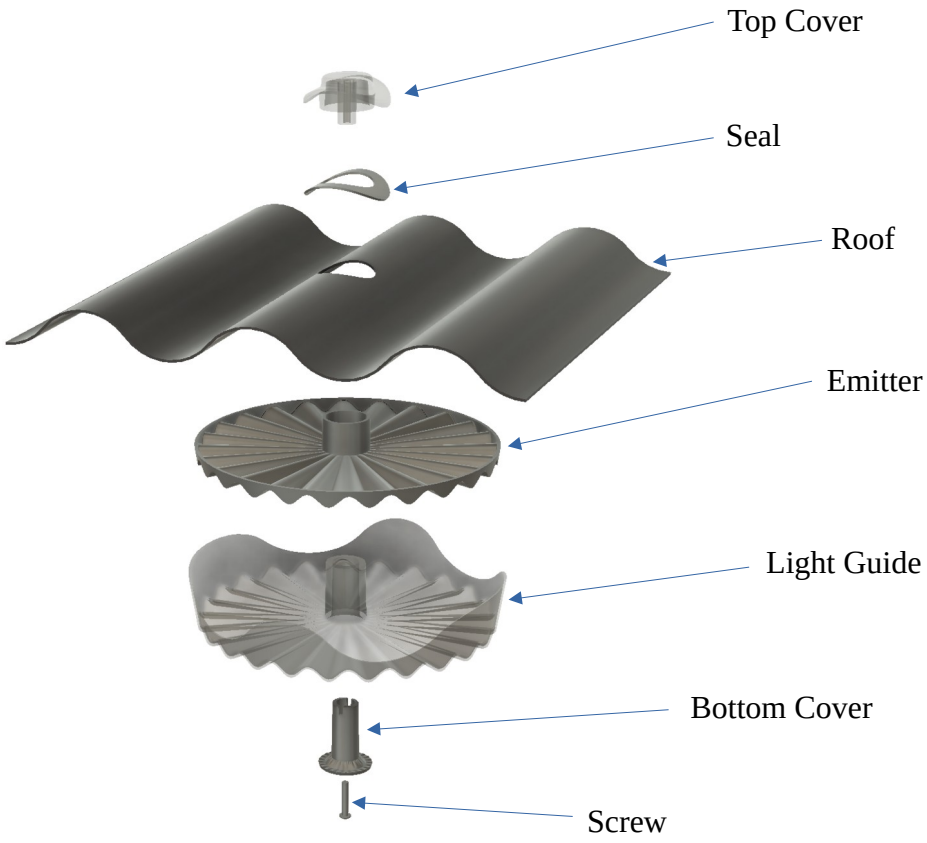
As the majority of roof structures appear to be constructed using corrugated iron, the NightSkyLight has made use of the inherent shape of the iron to its advantage (although the design can still be readily adapted for other types of roofing). Installation requires only a small hole to be cut using a 1” hole saw (which is often used for pipework etc, so should be commonly available). This hole is positioned at the peak of the corrugation, helping to keep the roof weatherproof with minimal effort. The shape of the NightSkyLight locks into the corrugations ensuring it is not able to rotate and work loose, and is retained by a single recessed screw. The top and bottom covers are also keyed together. During installation, offering up the light guide and bottom cover together serves to locate a pilot hole in the correct position to then use the hole saw. Having the periphery of the light guide extended up to match the profile of the corrugated iron makes it harder to get behind the light to attempt to pry it off. Having the screw recessed into the bottom cover removes the possibilty of using pliers or similar to remove it. Using a one-way screw can then mean that the NightSkyLight cannot be removed once installed without damage.



View from above of installed NightSkyLight



Cross-section of installed NightSkyLight



Instead of being a single luminaire product, the NightSkyLight is a product family which can be configured to suit. The size can easily be adjusted to in order to control price and luminosity.

Mass production requirements dictate an injection molding approach in order to reduce the number of secondary manufacturing steps. Strontium Aluminate is available as a masterbatch from several manufacturers (one example being Zhejiang Minhui Luminous Technology Co Ltd., who offers a SrAl2O4:Eu+2,Dy+3 based masterbatch) which is added as part of the molding process. This removes the need to apply as a secondary process such as a coating which must be mixed and applied to the molded part. Also available as a molding additive is the thermochromic pigment (if this is used).

Regarding material selection, either a polycarbonate (PC) or acrylic (PMMA) are suitable candidates. PMMA has better optical properties than PC and also costs less, but PC is much tougher than PMMA. As PC still has good optical properties, this would be the preferred choice due to the robustness. The seal is molded from a thermoplastic elastomer (TPE).

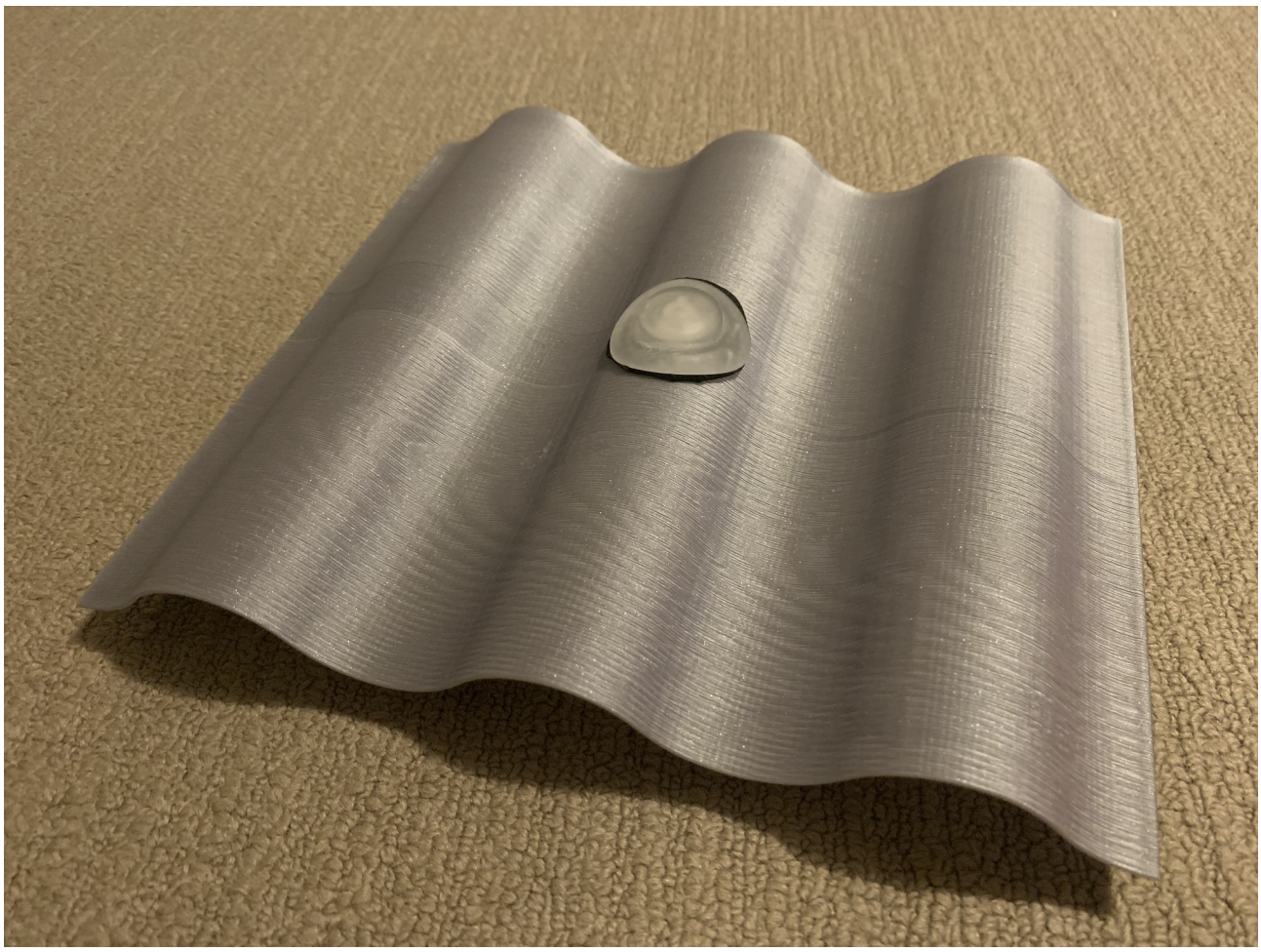
CHIMEI PC-122 is one example of a suitable PC material, and RTP 2740-S30 is one example of a suitable TPE.

The screw used would be made to spec by a screw manufacturer, with one such manufacturer being Dongguan Ganggu Hardware Product Co Ltd.

Bill of Materials:

Part Name	**Volume (mm3)**	**Material**	**Weight (g)**	**Cost (USD)**
Top Cover	5147	PC	40	0.23
Seal	681	TPE	6	0.13
Emitter	16390	PC	128	1.89
LightGuide	35186	PC	276	1.56
Bottom Cover	3292	PC	26	0.15
Plastite Screw				0.02
Total				**3.98**

The prototype shown has a nominal diameter of 138mm. This was dictated by the size of 3d printer available to hand. The active area of this is 15,456mm2. The height of the light itself is 35mm, and once installed protrudes down 10mm from the bottom of the corrugated iron. The weight of the prototype is 209g.



I am entering this challenge as an individual solver.

As part of designing and manufacturing injection molded parts, I have been involved in all of the steps of the molding process including part design, tooling design and manufacture, and part production as well as sourcing other required parts such as fasteners. Therefore I can take the NightSkyLight from prototype to production and am very interested in a potential partnership .

The NightSkyLight has been designed to use simple two sided tooling to keep tooling costs down.

Tooling costs would be around $41,000USD. There may be the possibility to reduce this to around $29,000USD if the emitter and light guide cavities can be located in the same tool.

Once the tooling design is finalised, production tooling can be ready in two months for T1 part trials.

To get to final tooling design, the next steps are:

- Revise the NightSkyLight design after feedback from relevant parties.
- Consideration of logistical aspects of production
- Confirm material selection and initiate procurement process.
- Initiate tooling design and quoting process
- Produce a small run of lights for field trials using cast resin to provide a functional equivalent to production molded parts.
- Once relevant parties are happy with the NightSkyLight design, issue final design for tooling manufacture

This would take approximately 3 months plus the time for the field trials (allowing for 2-3 design iterations).

The biggest risk with this solution is the robustness of the product, and the different types of roofing materials used. To counter any robustness issues, there is room to be able to increase wall thicknesses (at a cost penalty due to more material useage). The NightSkyLight design has also used part geometry such as curved walls etc. to give extra strength. The design has also considered from the start the possible need for alternative parts for differing roofing materials (i.e. flat vs corrugated). These can also be included in the existing tooling as an option at the time of molding.