INTRODUCTION

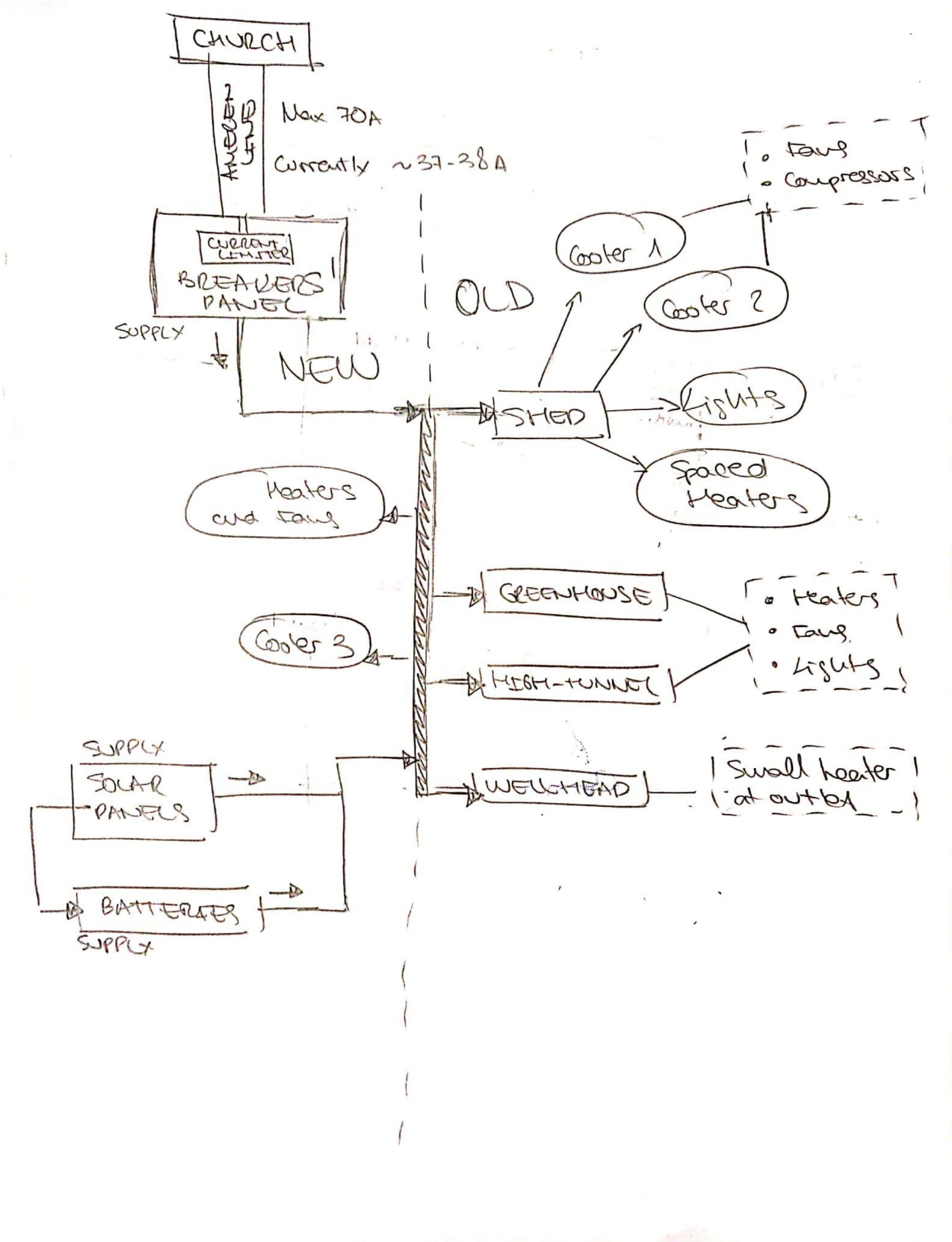
Problem and Solution Overview:

Sola Gratia Farm is a charity organization that donates at least 10% of its production to hunger programs. The farm does not invest a lot of money on improving their items, they depend on major cases from external donations. In the case of the electricity the get it from the Ameren Line which comes from the church. This line has a capacity of 75A, however, an electrician that talk with the farmers told them to not overload the line above 70A to avoid tearing up the breakers. Currently, they have on their facilities two coolers, one greenhouse and one high-tunnel, a wellhead and a shed. Inside these places, there are located heaters, lights, fans and compressors which take power from the line. During a full test of use, it was found that the line was running at 37-38 A, those numbers could increase during the items' start-up, the moment in which they demand the greater amount of energy.

The problem arises at the moment they want to add a new third cooler and new heaters and fans. The heaters and fans won't be a problem as the amount of energy they demand are much smaller in comparison with the energy demanded by the cooler. The electrician that talked with the farmers estimated that adding these new items to the farm will cause an overload on the line being above the 70A of maximum capacity. Again, our field of study is the start-up period.

The solution we suggest is trying to reorganize the electrical installation of the farm making it more efficient and less dependent on the Ameren Line. To achieve that we have thought of adding solar panels and batteries to supply extra energy to the farm's items. Moreover, we plan to include a current limiter to avoid exceeding the maximum capacity of the line. The batteries and solar panels will be monitor by a microcontroller which, with the help of a Hall Effect current sensor, can measure the current over the line, the one supply by the solar panels and by the batteries. With this, the microcontroller will be able to activate/deactivate MOSFETs to reduce the current through the line and take the needed current from the batteries and the solar panels.

Visual Aid:

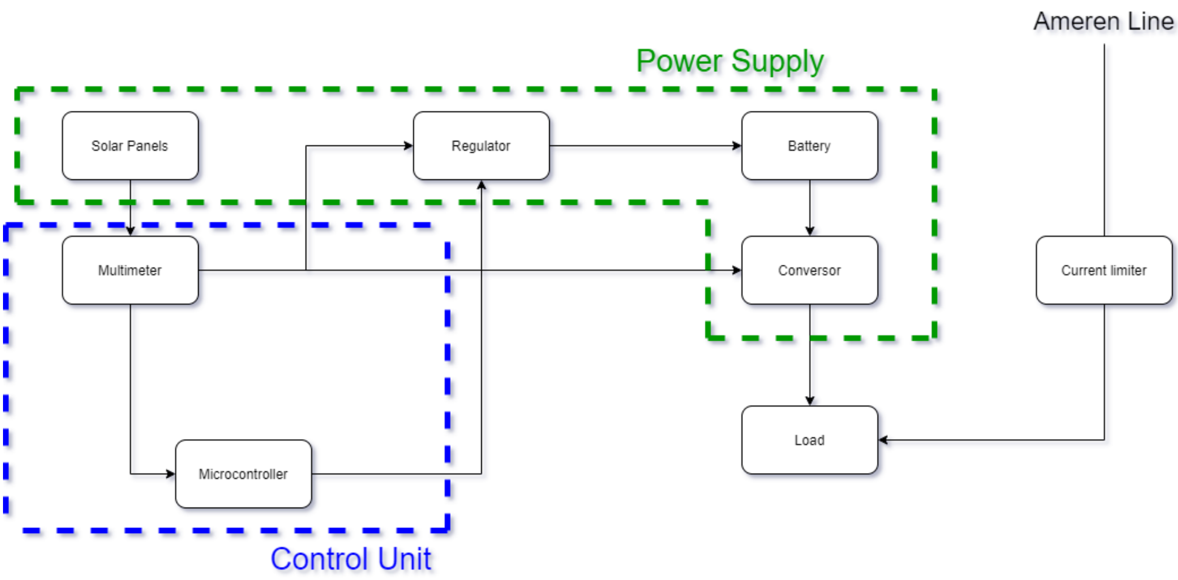

CHURCH
AMERICAN LINE
Max 70A
Currently ~37-38A
CURRENT LIMITER
BREAKERS PANEL
SUPPLY
NEW
OLD
Cooler 1
Cooler 2
• Fans
• Compressors
SHED
Lights
Spaced Heaters
Heaters and Fans
GREENHOUSE
• Heaters
• Fans
• Lights
Cooler 3
HIGH-TUNNEL
SUPPLY
SOLAR PANELS
WELLHEAD
Small heater at outlet
BATTERIES
SUPPLY

High-level requirement list:

- Remaining the line at a maximum of 70A without overloading it. Being able the third cooler they need.
- Make the installation efficient reducing the amount of current through the line if the solar panels and batteries are able to supply part of the demanded energy. The microcontroller should take care of this.
- Every device or item have to work at any moment, we need to have the demanded energy from the devices at every moment.
- Efficient choice of the solar panels making the installation cheaper and useful.
- Todos los devices deben ser food friendly.

DESIGN

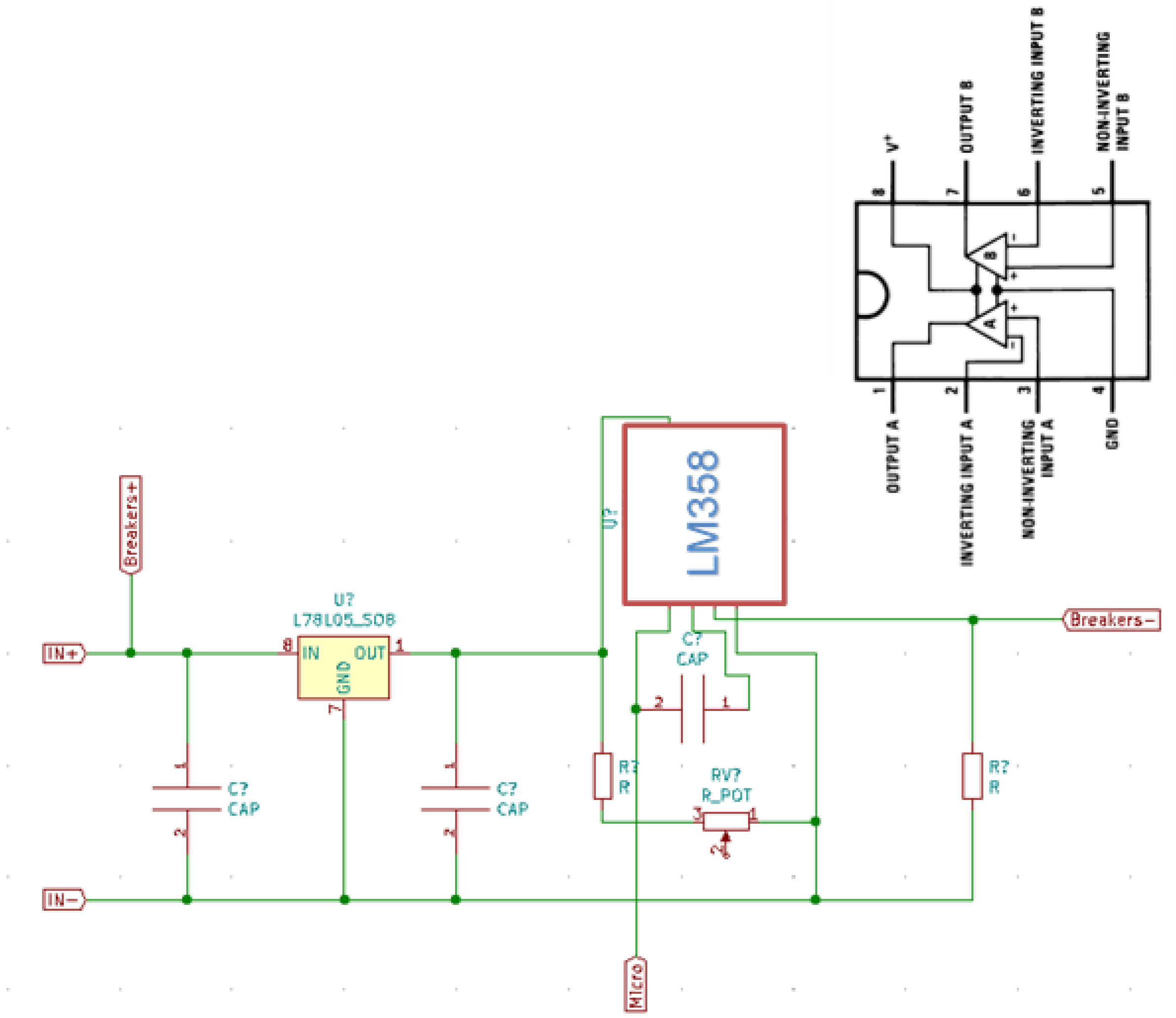
Block Diagram



Subsystems

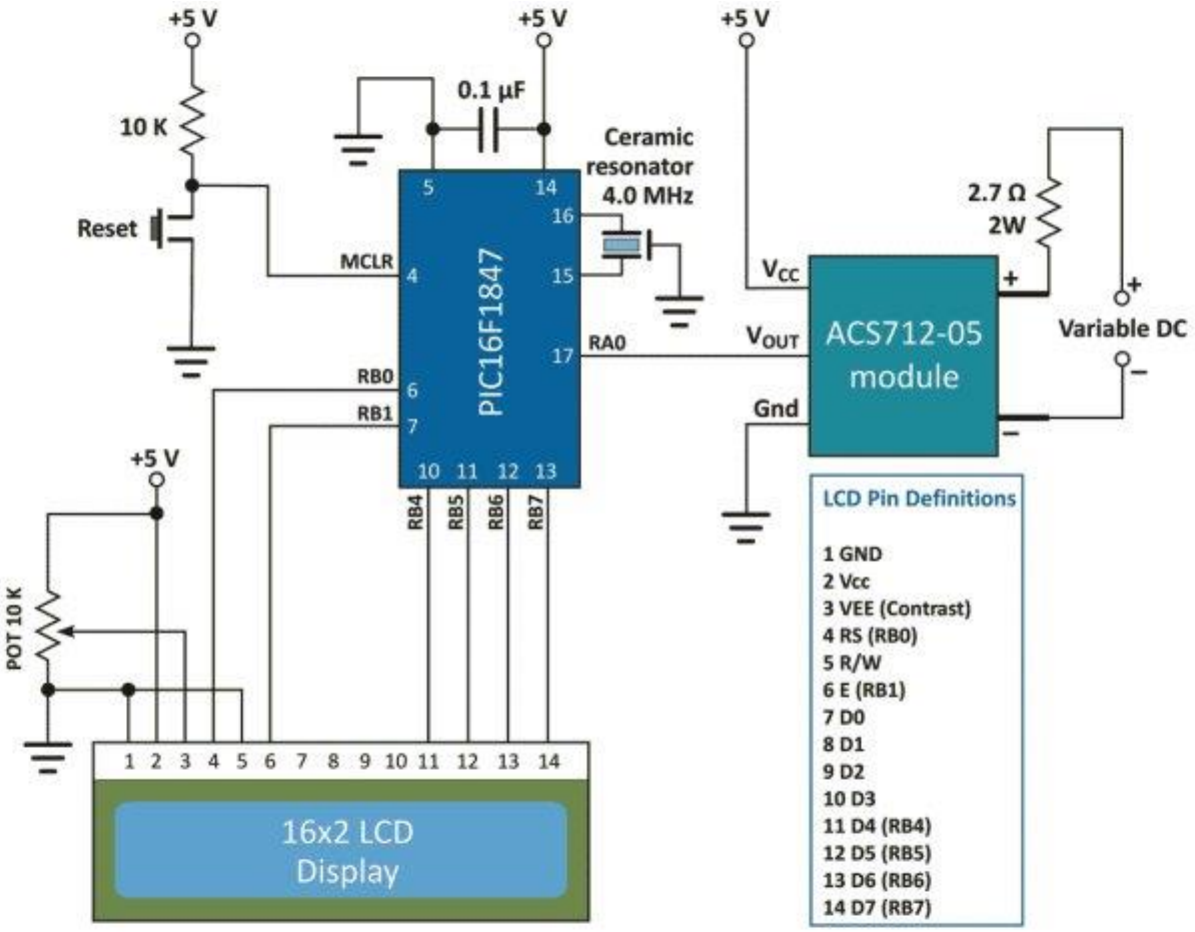
- <u>Current Limiter</u>: the current limiter will be placed just before the breakers' panel to avoid exceeding the maximum capacity of the line, 70A. The input will be connected to the current supply, in this case the Ameren Line, and the output to the breakers' panel. For this we are using some capacitors and resistors from where we can adjust the current limit. One of the resistors it is going to be a digital potentiometer that will be monitor by the microcontroller to reduce the amount of current demanded from the Ameren Line. We will use a voltage regulator in the input of the limiter, L7805, and a IC LM358. The IC also will tell the microcontroller when are we reaching the maximum current we have adjust.

  The pins from the IC follow the image on the right, not the numeric pins printed on the circuit diagram (Kicad does not have this type of IC)

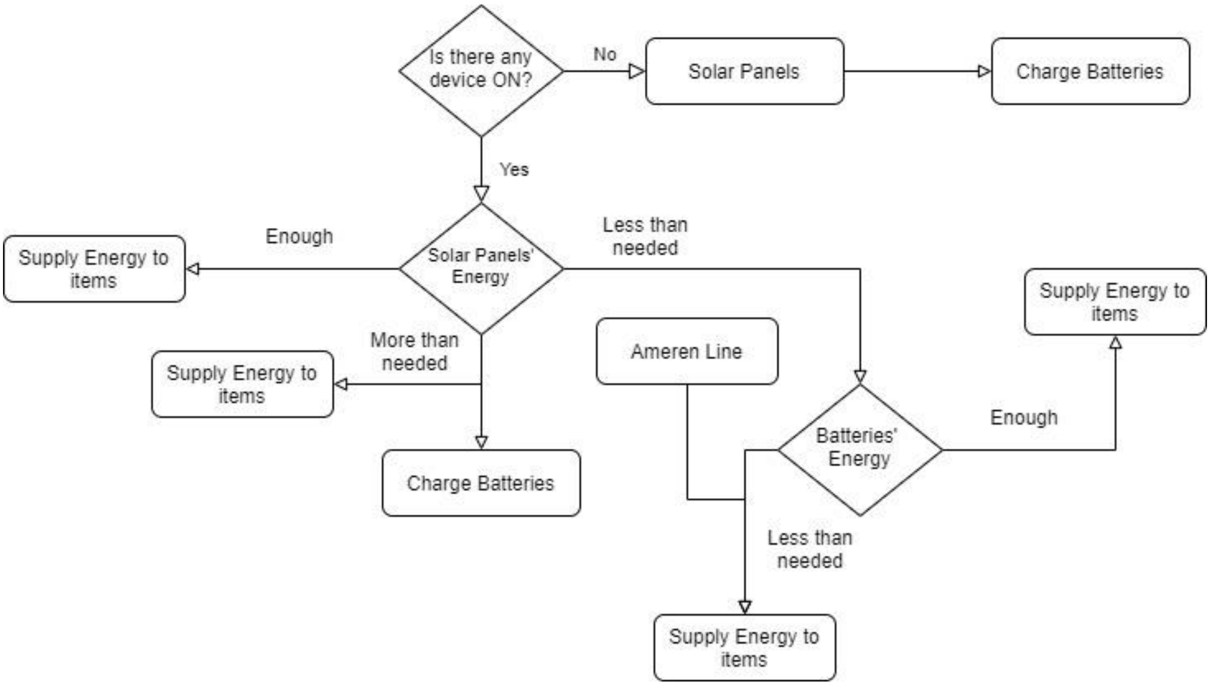


- Photovoltaic Solar Panels. Depending on the electric power consumption we will choose the panels that fits better. The ones we are going to use are made of silicon and they will be Polycrystalline because, although they are less efficient, they are cheaper than the monocrystalline ones. We will use the Kyocera KD 300-80 F Series KD325GX-LFB.
- Batteries. Depending on the electric power consumption we will choose a bigger set of batteries or if the consumption is relatively low we will choose smaller ones.
- Regulator. Depending on the batteries and the panels we will choose a PWM(if the batteries and the panels work at the same voltage) or MPPT(if the panels work at a higher voltage than the batteries).
- Multimeter: we will use an ACS712 module working with the PIC microcontroller. This sensor will be placed right after the solar panel to measure the amount of current is generating. We have to distinguish in a day when we have the maximum supply (usually at midday) and when we are not producing energy form the solar panels. Moreover, to monitor how much energy are we producing on those cloudy days. The sensor will provide information to the microcontroller that will use to decide whether take the energy from the batteries or the solar panels and how much. We can include an LCD to display the current flowing at the moment, to make it easier for future new

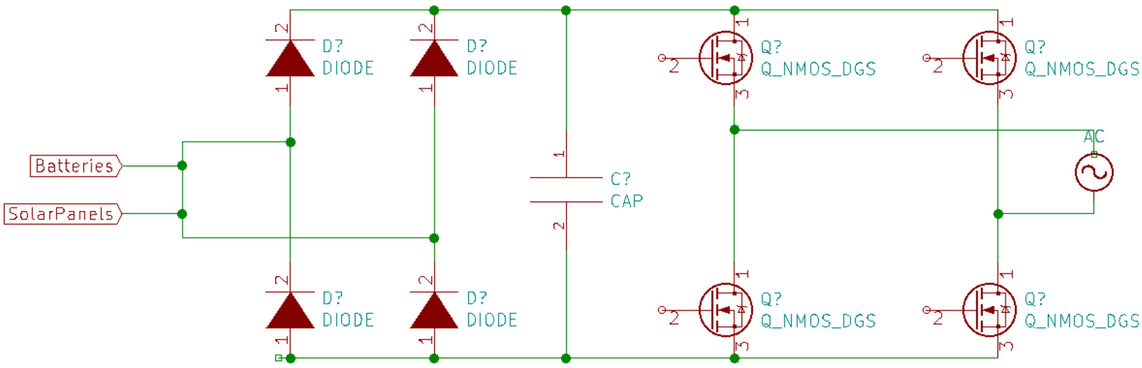
changes on installation or just for checking how much we are producing from the solar panels.



- Micrcontroller: the microcontroller it will be handling all the possible states of the line, the solar panels and the batteries. Deciding how much current to limit on the ameren line and being aware of whether this limit has been reached or not, measuring the current right after the solar panels and displaying it on a LCD, and monitoring the battery regulator controlling charge levels of battery and avoiding to overcharge it when full. We are planning on use as microcontroller a PIC32 or a PIC16, we will be more accurate when designing hardware.



● <u>DC to AC Converter</u>: Batteries and solar panels produce energy in DC, while coolers, heaters and compressors demand energy in AC. That's why we need to include an inverter to join both parts of the circuit. The DC-AC converter will be structured in three parts. Firstly, a rectifier circuit, then place a fixed voltage and thirdly an inverter circuit made of MOSFETs. The suggested diagram has been taken from Power Electronics' class.



Requirements and verification table

Tolerance Analysis

Cost Analysis

- Physical components
- Labour
- Schedule

Ethics and Safety

A potential unethical issue could be the misuse of the extra power supplied by either the batteries or the solar panels. The objective of these devices is to supply power to the third cooler and not to make a profit of it making at the same time an overload of the line. Since we have said before we can sell the extra power that solar panels produce but only in the case there is enough to feed the cooler.

Another threat could be selling the project to a third person/company and again make a profit of it. Or even take advantage of this project by realizing the profitable issue of the project, stopping using all of this to charity and profiting themselves.

The main risk of the project could have failures during the implementation and development of the design that could make the near areas to the cooler a dangerous place. We have to control every detail to avoid this to happen.

Apart from the implementation, there are other external risks that we can not handle but we can control as the batteries behavior, which can have unforeseen failures.