Solar Panel with Mechanical Tracking

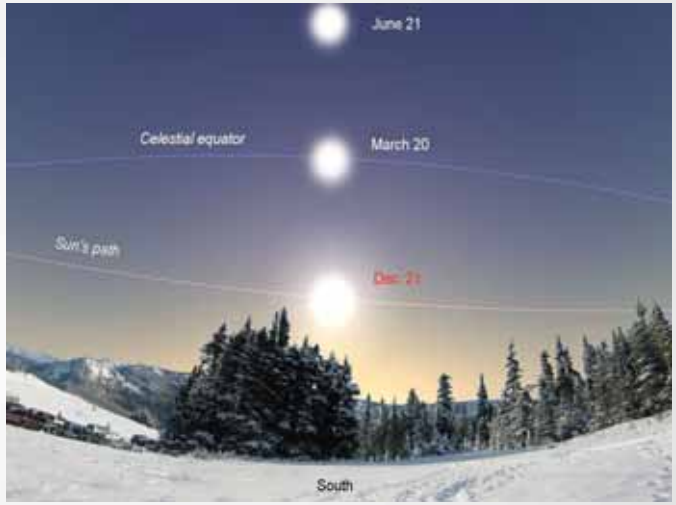
Who’s my kind of customer?

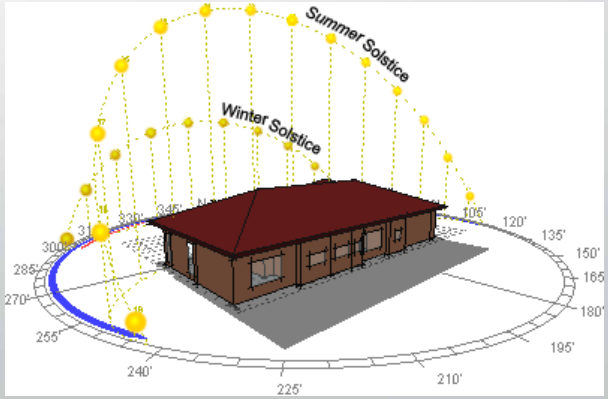
We want to attract a customer who requires a large quantity of solar panels.

Therefore, these customers could be developing countries which not only have large and unexploited areas, but which also have an increasing demand for energy.

How many freedom degrees should the support have?

- To understand which movements the support has to be able to perform it is important to know the sun path during the day in different seasons.

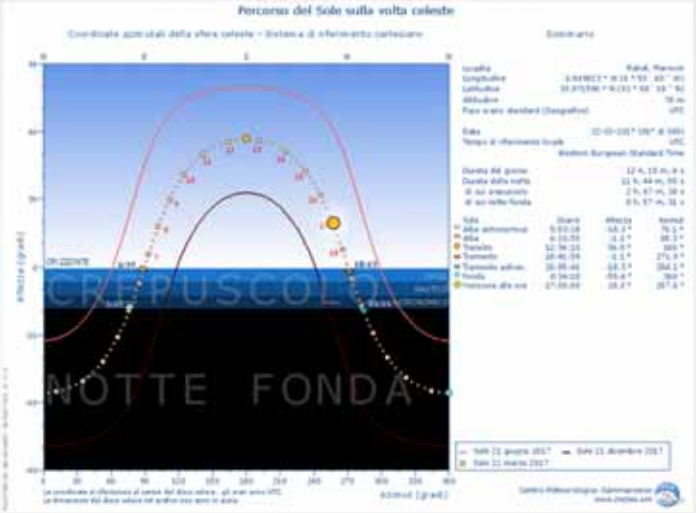


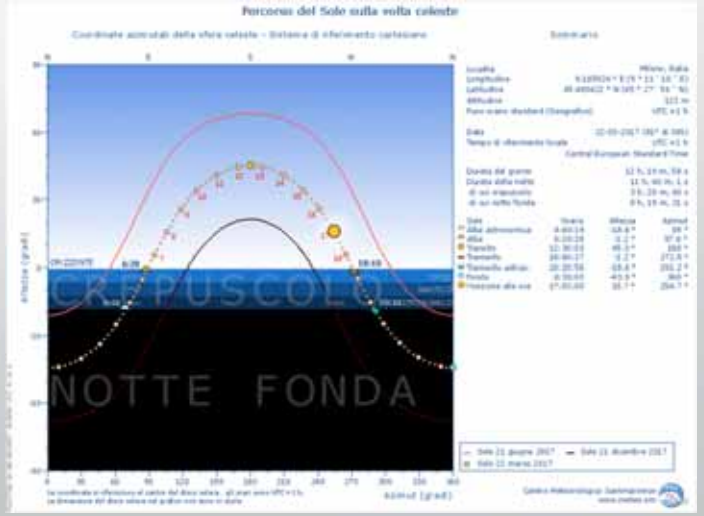


The sun’s movement in the sky changes according to the position on the earth.

Two angular coordinates identify the sun’s position: azimuth and height.

The latitude influences the variation of these coordinates during the seasons .





In countries where the azimuth variations aren’t relevant, it’s convenient to only require the height regulation.

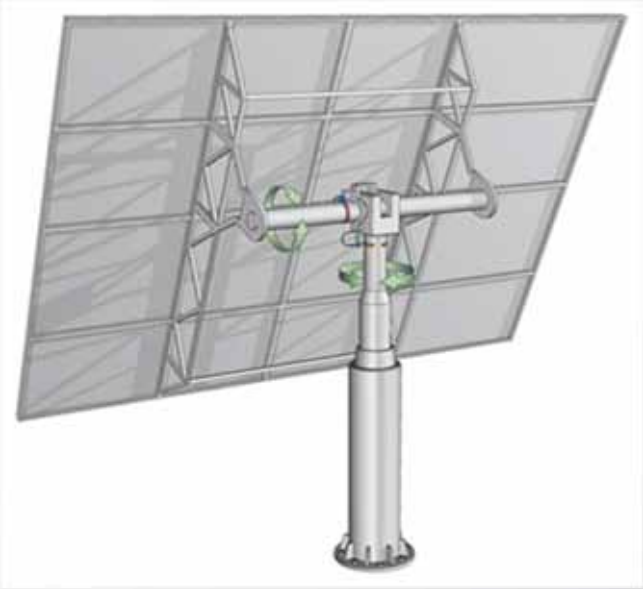
Instead, in countries where the height variations aren’t relevant, it’s convenient to fix a medium height and rotate around the azimuth axis.

We are thinking to install our panels in places at different latitudes; thus, we will develop a support which is adaptable to any situation with two regulation systems.

Despite the fact that a bi-axal support is more costly, we have decided to opt for it due to efficiency reasons (+40% of energy).

Indeed, we will make sure that the support is able to hold enough panels to justify the support cost and we will develop a tracking support which is as easy and cheap as possible.

The Azimut-rise system is our choice because it allows us to build a support which is slightly easier.

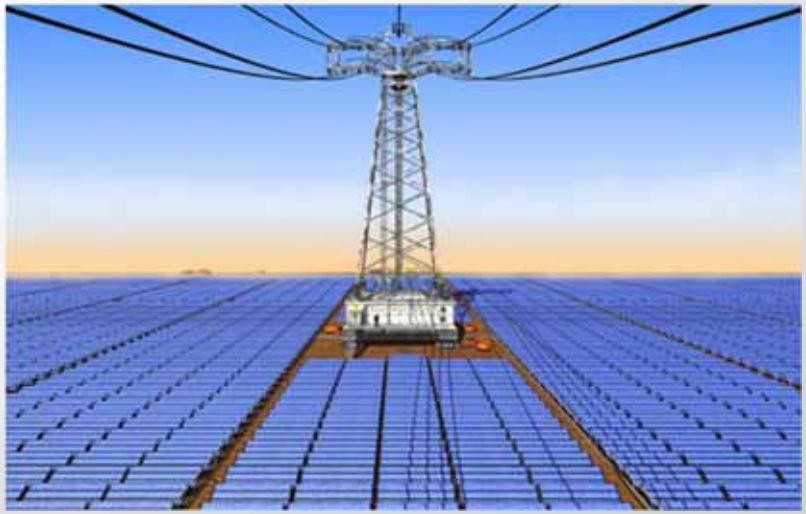


Source of power and command system

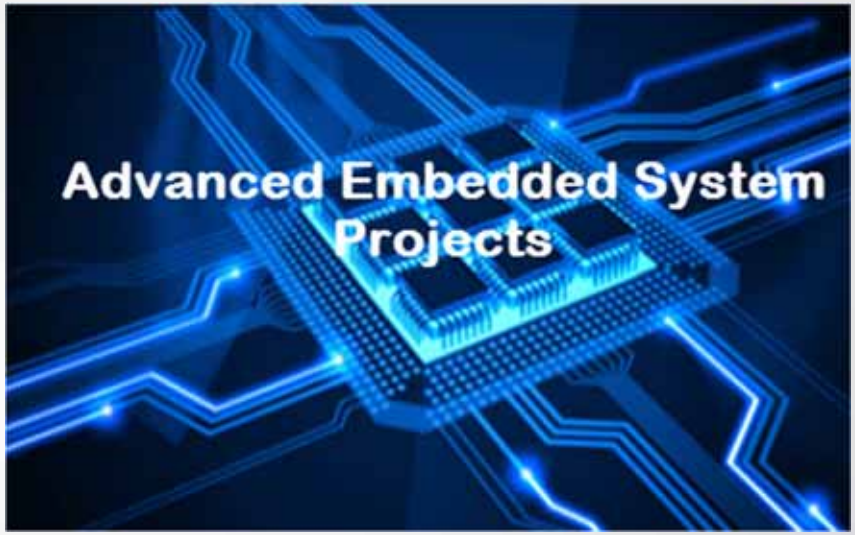
The type of power source depends on the location and characteristics of the solar panel farm.

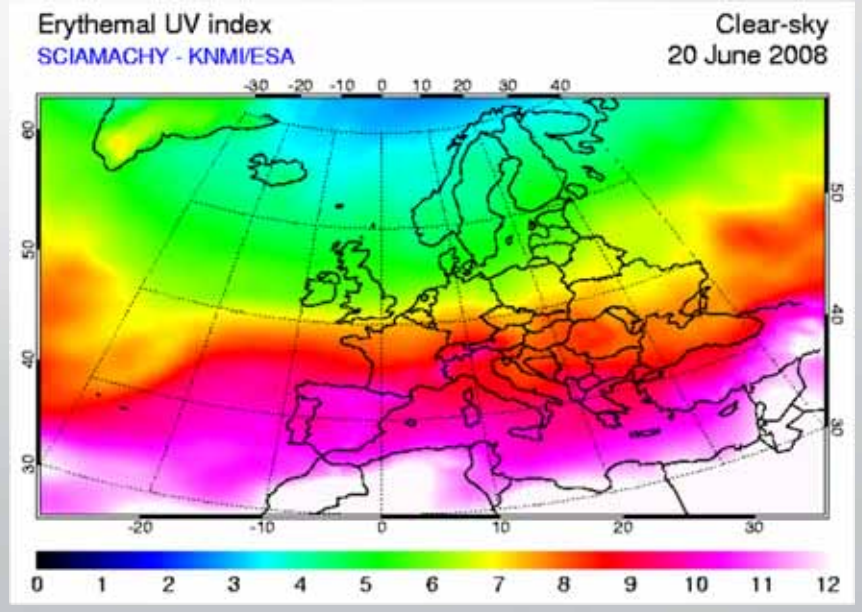
However, in order to stick with our principles (building something which is adaptable to as many situation as possible) we will consider the most general situation which is when we are able to access an energy grid.

In the event of a lack of an energy grid, there would be the possibility to install a battery capable of supplying the tracking support with enough energy to allow the orientation which will allow energy directly from the solar panels.

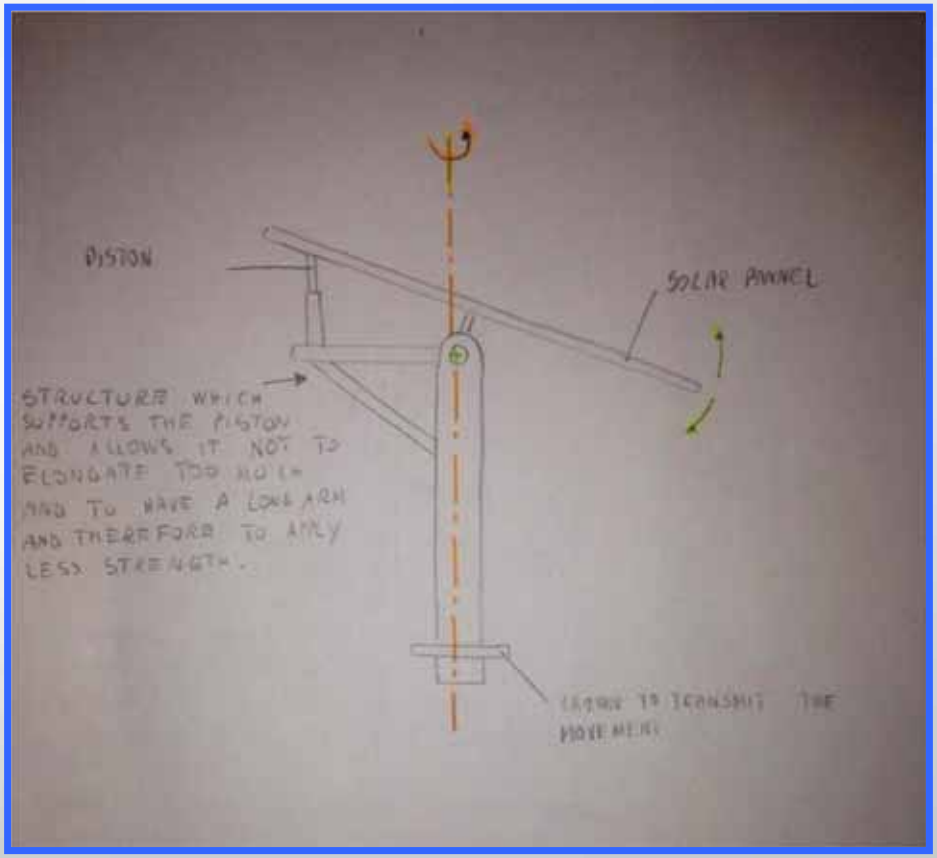


Shifting the attention to the command system, we think that the best solution is to adopt an embedded system which gathers data about the sun's position throughout the day. Furthermore, this system will be able to understand whether or not it is convenient to activate on a cloudy day, analyzing the UV index provided by a weather forecast channel.

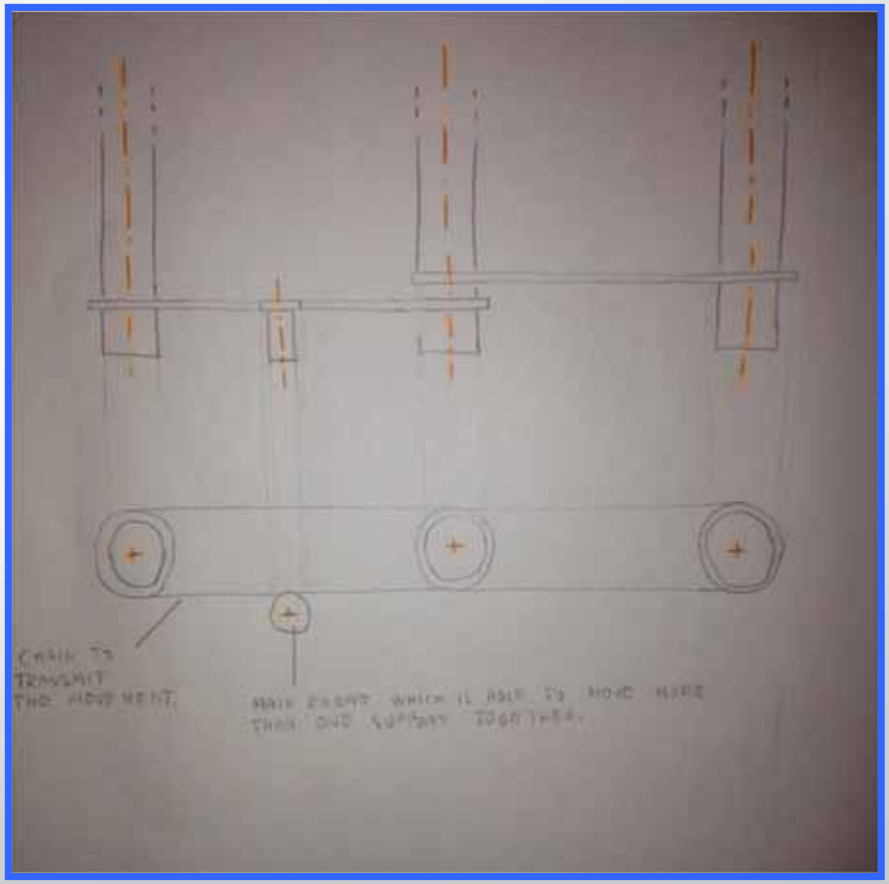




First draft of the support



An innovative way to rotate



The reason why we chose this design

1)Rotation around vertical axis: In order to minimize costs, we thought about a special method to avoid using one engine for each support. In this way, a single engine can move a whole row of supports through a system of chains.

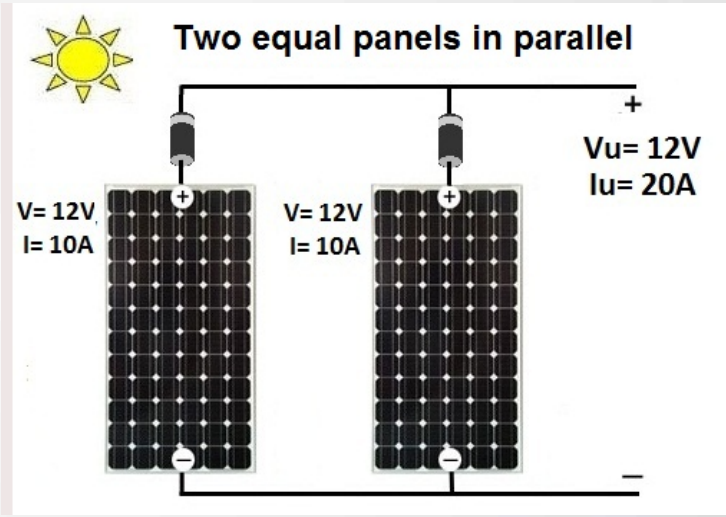
2)Pistons: In order to implement the rising movement we chose to use pistons which need less service than a mechanic system. Furthermore, with a hydraulic system, we can develop a unique pipe system for the whole row of solar panels which is powered by one pump.

3)Support for the piston: In order to avoid using too long pistons we have thought about an additional support which also allows the pistons to apply less strength due to the bigger arm.

4)Inner bore: we will develop our support with an inner bore in order to hide and protect all the cables (energy and hydraulic cables) from the external weather conditions.

Connection of the solar panels and batteries

Each panel is connected to the following one in parallel so we can reach certain values of output current without changing the voltage, connecting them in series we would increase the voltage keeping the same current.



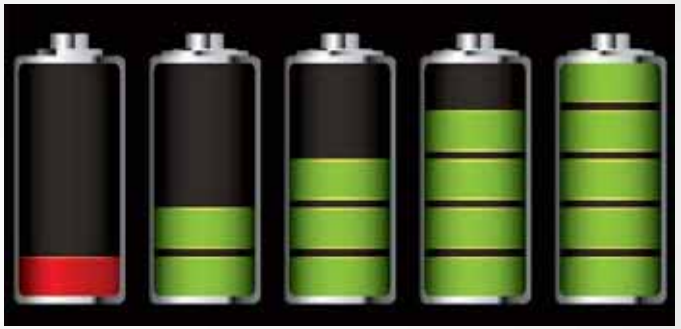
Using parallel connection is very efficient if:

- The panels are oriented in the sun at the same angle, to get the same irradiation
- They are far enough so they don't shade other solar panels (in order to get the same power)

The choice of the inverter is important so we can obtain the maximum energy from our solar panels and so the maximum efficiency, depending on the irradiation in a single moment.
The inverter has the task of finding the maximum power point of the string.

There are three types of batteries on the market:

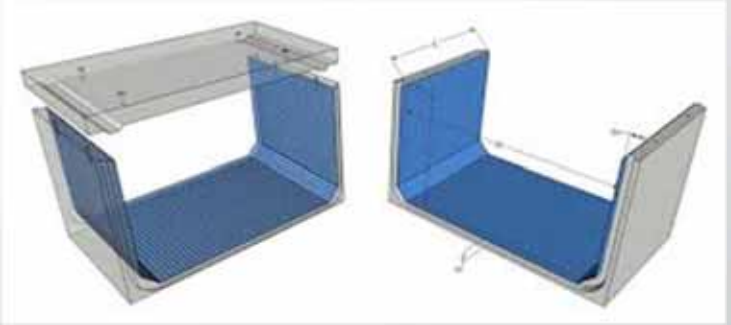
- Lead batteries
- Lead-gel batteries
- Lithium batteries



In case we couldn’t connect the solar panels to the electrical network we opt for a lithium battery because it’s the most efficient. It gives up to 80 % of the energy (if we need 4.5 kwh, we will have to accumulate 5.7 kwh). These batteries cost more than the lead and lead-gel batteries but they also last more, up to 10-12 years.

Everything will be underground

In order to avoid the wear and tear of the cables and chain system, we want to implement an underground tunnel built of concrete modules.



Not only will it be able to protect everything from exterior weather conditions, but it will also make it easy to service the solar farm whenever necessary.

This would not cause additional cost since an excavator would already be on scene.

Tracking system

How to power the tracking system?

There are three main methods to orientate the solar panels: hydraulic, electromechanical and manual.

We opted for a hydraulic system because they are not easily damaged by oxidation and rust.

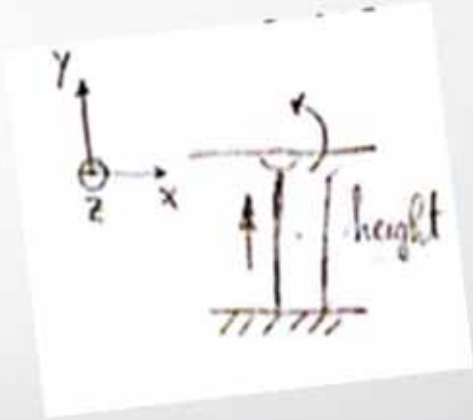
Secondly, the hydraulic cylinders may be cheaper than a mechanical system; however, they require additional components such as a pump, an oil tank and a grid of tubes. Therefore, in order to justify the purchase of them there have to be enough cylinders.

Kinematic Model

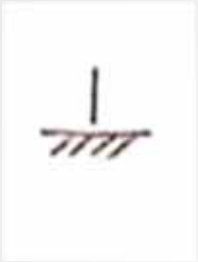
The solar panel was modelled in 3D like a beam 2m long

Typical solution where you can choose the height of your solar panel.

We also thought of a system capable of controling the height like a telescopic mechanism.



The joints will be the structure base



The hinges will be the rotating system

The beams will be the ones present in market or committed to a industry.

Function analysis and design specifications

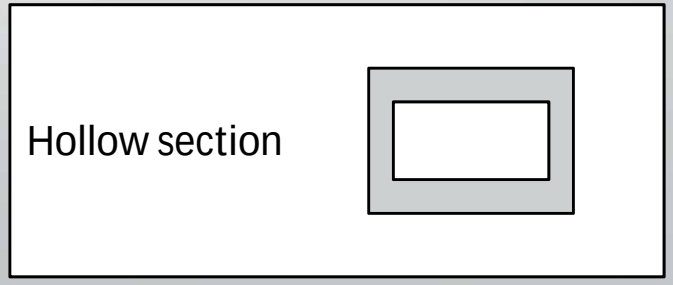
	Weight	Tree Configuration	Totals	Array Config.	Totals	Solo (Axis at Center)	Totals	Solo (Axis at Base)	Totals
Cost	5	2	10	3	15	4	20	5	25
Energy Output	4	5	20	4	16	4	16	3	12
Ease of Customer Use	4	4	16	4	16	5	20	4	16
Ease of Maintenance	4	2	8	4	16	4	16	5	20
Location (Availability)	3	4	12	4	12	5	15	4	12
Footprint	3	3	9	3	9	5	15	4	12
Safety	3	5	15	4	12	5	15	3	9
Ease of Installation	2	2	4	3	6	4	8	5	10
		Sum =	94	Sum =	102	Sum =	125	Sum =	116

		Cylindrical (hollow)	Totals	Square (hollow)	Totals	Cylindrical	Totals	Square	Totals	Custom Shape	Totals
Strength	5	3	15	3,5	17,5	4	20	4	20	5	25
I/O Protection	4	5	20	5	20	2	8	2	8	4	16
Cost	3	4	12	4	12	5	15	5	15	2	6
		Sum	47	Sum	49,5	Sum	43	Sum	43	Sum	47

The sum of the product between the weight and the value allows us to find the best solution between all the proposed.

The final solution will be a Solo (axis at center) configuration with hollow square beams according the matrix above.

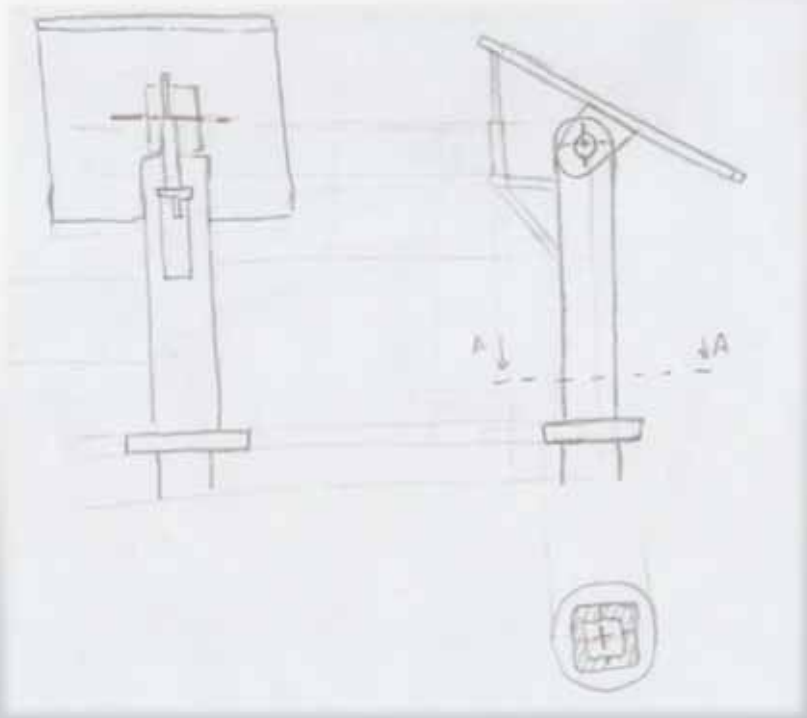
Hollow Section increases the space and cost, but you can use the internal space to protect the lines.



Conceptual design ideas

How to vary the panel inclination

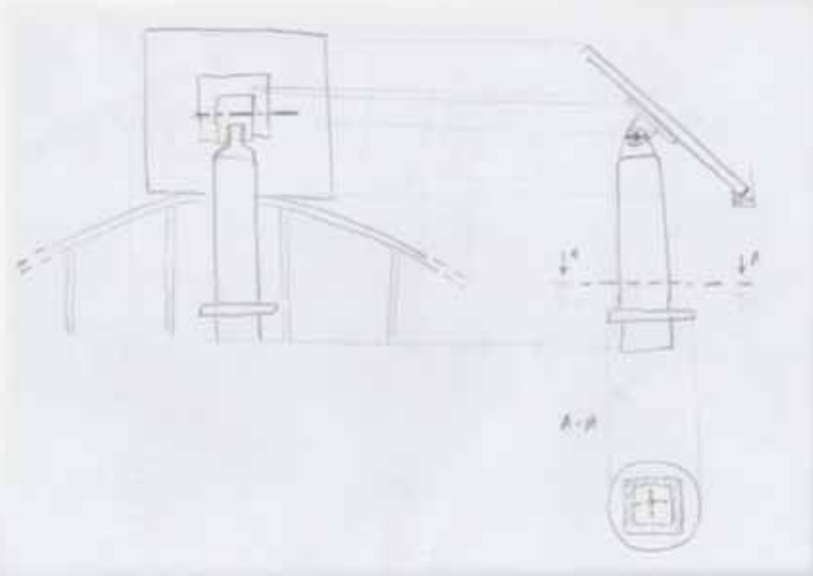
Solution number
1.
A hydraulic piston system regulates the panel inclination and a hollow square beam supports the system.



Solution number 2.

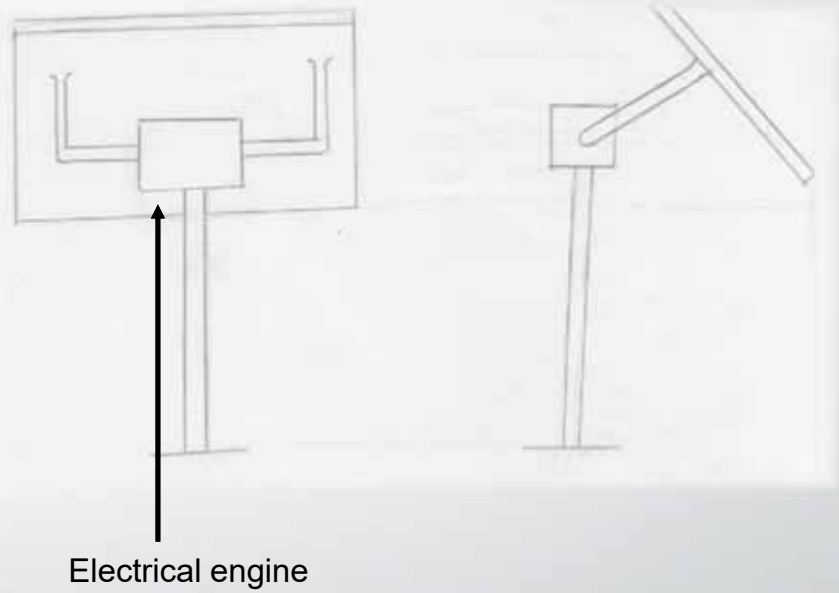
It is similar to the previous solution but the regulation of the inclination is realized by a railing system.

It is hard to realize because of the different hights during the days and the seasons.



Solution number 3.

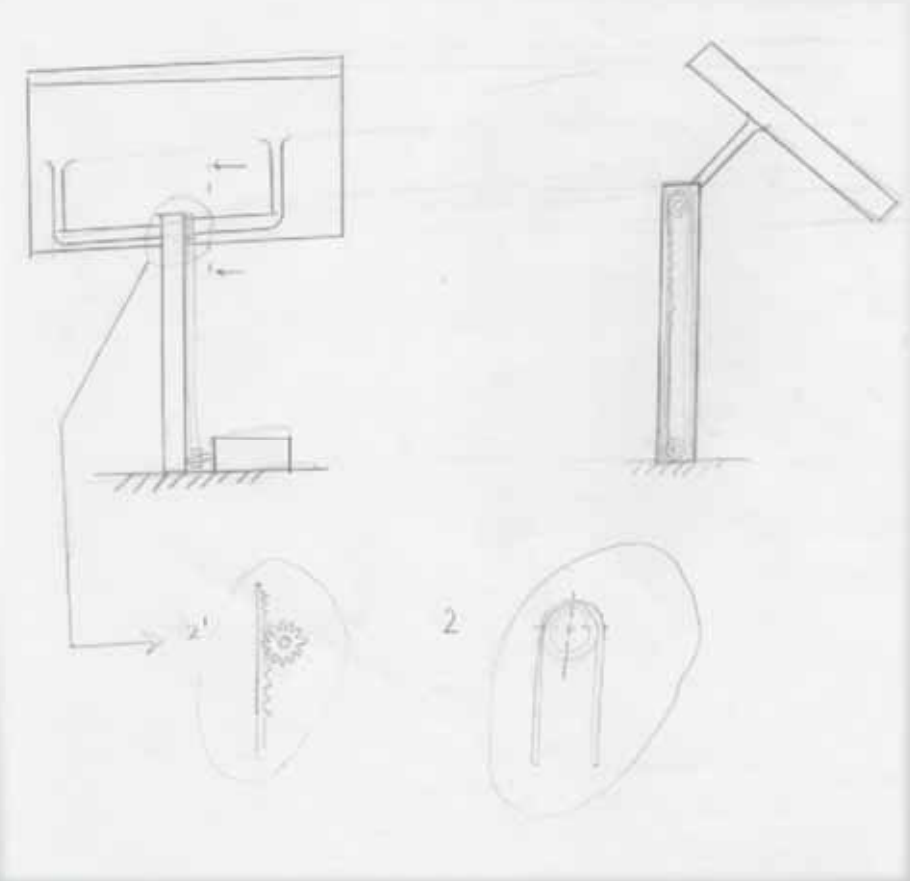
An electrical engine is directly joined with the axle which supports the solar panel.



Solution number 4.

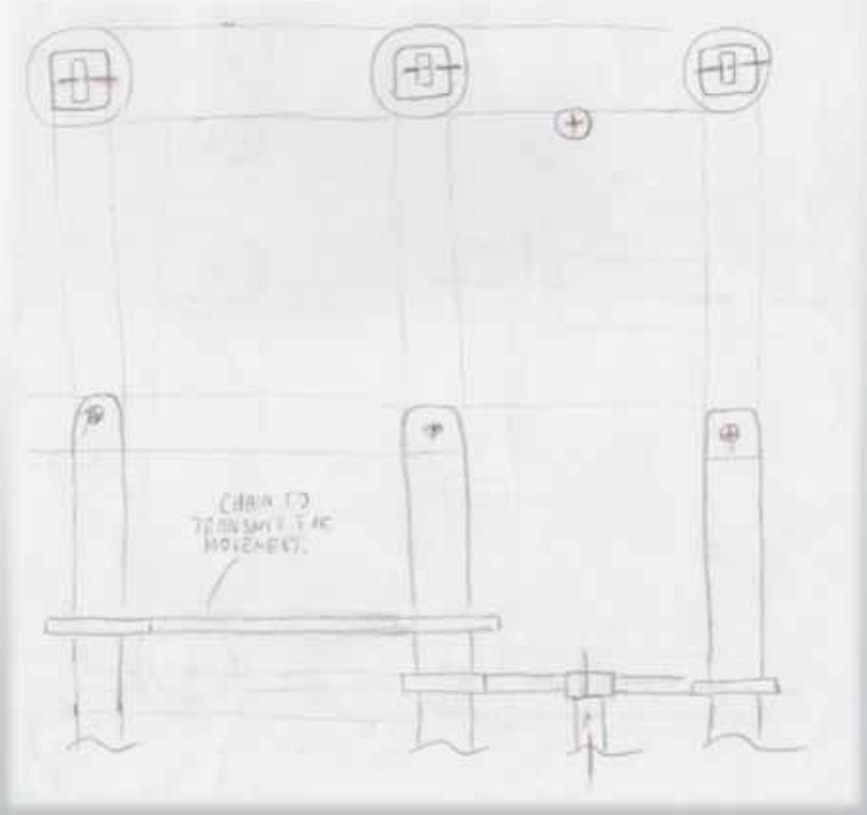
It’s similar to the previous solution but the engine is put on the floor to stress less the structure.

The movement transmission can be produced by a rack, belt or chain system.



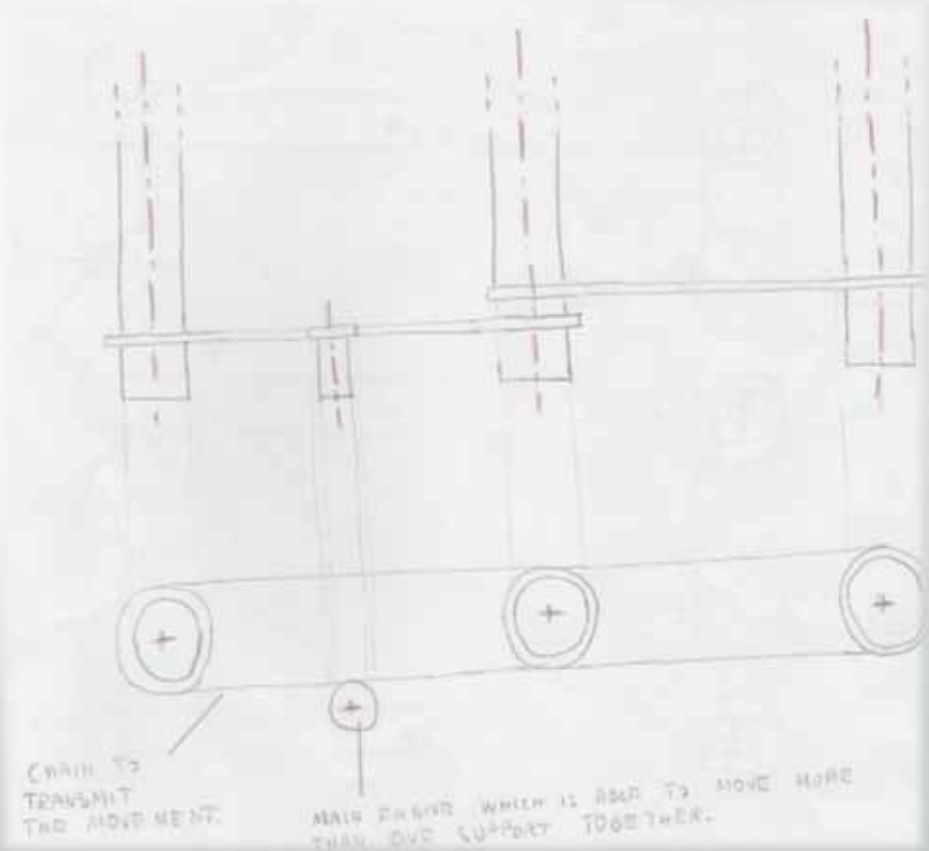
How to transmit the rotation of the vertical axis

A chain transmits the movement to the different supports.



The chain transmits the movement.

A main engine is able to move more than one support together.



Final result

The choice is the solution number one for the panel inclination and to move all the supports with a single engine for the vertical axis movement.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