VERDECITY

The Raman's

Rodrigo Marín
Marina Morgado
Adriana Renjifo
Luis Villarreal

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RESEARCH

The Challenge

Despite the significant progress over the past decades on improving access to electricity for everyone, increasing renewable energy usage in the electricity sector and improving energy efficiency, **the world is still not able to provide affordable, reliable, and sustainable energy for all.**

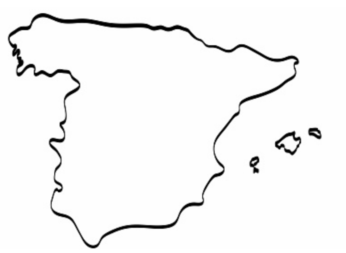
Goals 2050

We start from The Green Deal at European level, where the objectives are marked until the year 2050 of zero emissions of greenhouse gases. There is a "mini-stop" in this pact in 2030 where it is established that until then, greenhouse gas emissions must have been reduced by at least 55%. This pact also considers nuclear and natural gas as renewable energies. The final objective is established by the EU and is climate neutrality by 2050.

Targets and indicators:

- By **2030, ensure universal access** to affordable, reliable, and modern energy services.
- By **2030, increase substantially the share of renewable energy** in the global energy mix.
- By **2030, enhance international cooperation** to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.
- By **2030, expand infrastructure and upgrade technology** for supplying modern and sustainable energy services for all in developing countries, particularly in less developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support.

Spain



At the Spanish level, we find the **PNIEC (2021-2030)** which includes the strategy to be followed to **reduce greenhouse gas emissions by 23%** compared to 1990.

Decrees

- Decree-law 16/2019, on **urgent measures for the climate emergency** and the promotion of renewable energies. (For example, the size of the facilities).

- Decree-law 28/2021, **regulation of facilities to improve energy** or water efficiency and renewable energy systems in buildings subject to the horizontal property regime.
- Decree 244/2019, of April 5, which **regulates** the administrative, technical, and economic conditions of **self-consumption of electrical energy**. A law of self-consumption and shared self-consumption. There is also a new concept known as Prosumer, which is the one who produces and at the same time consumes.

Catalonia

In the energy prospective of Catalonia **PROENCAT 2050**, it comes from Law 16/2017 on climate change and from the bases of the National Pact for Energy Transition (PNTE):

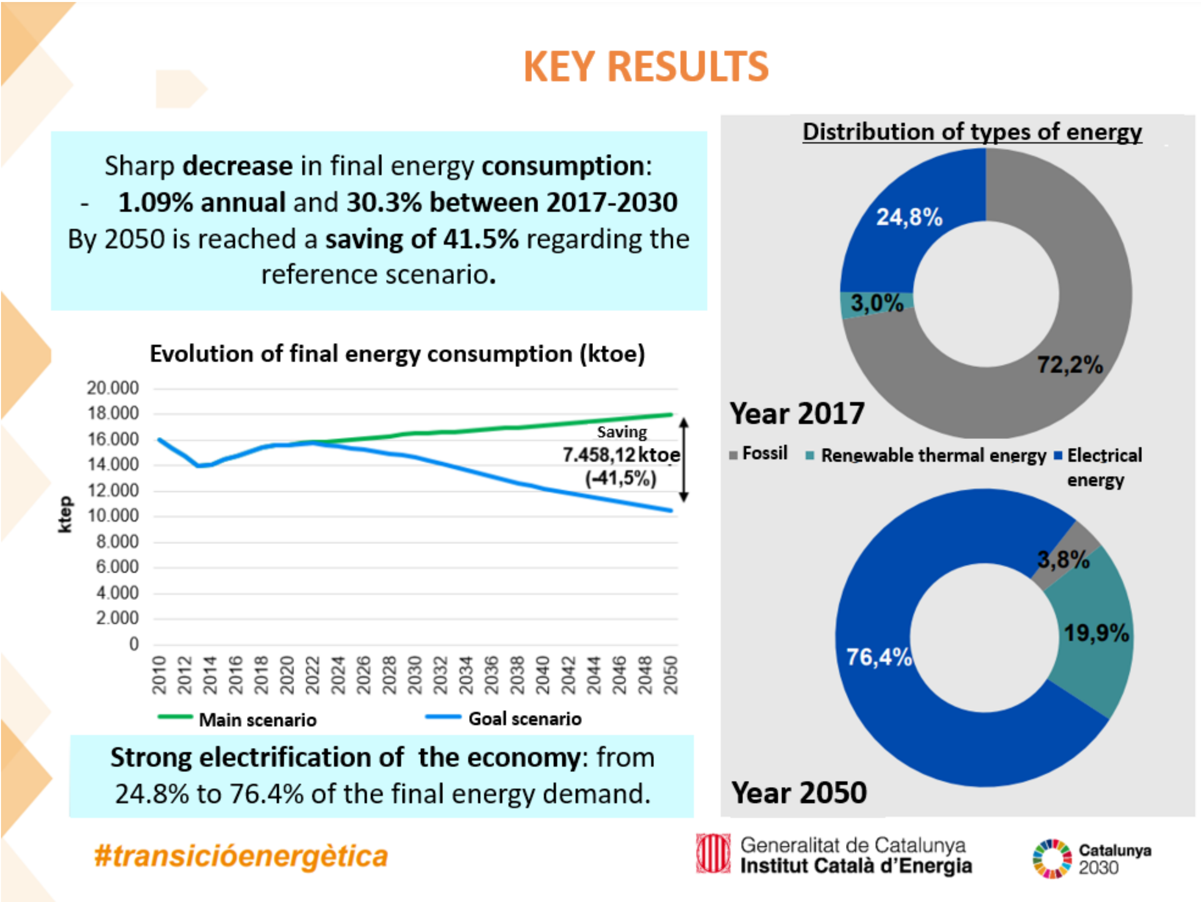
- Facilitate the transition towards a neutral economy in greenhouse gas emissions, competitive, innovative, and efficient in the use of resources.
- Economic, social, and environmental sustainability and guarantee security of supply.
- New net energy model, competitive, decentralized and distributed, participatory, democratic, and socially inclusive.
- Establish strategies to achieve the energy transition towards an energy model based 100% on renewable energies in 2050.

The PROENCAT has as backbone principles:

- Achieve climate neutrality by 2050
- Abandon nuclear fossil energy model
- Achieve energy sovereignty with EERR
- Minimize the occupation of the territory
- Empower citizens and businesses and drive social transformation
- Develop a prosperous, modern, competitive, and circular economy
- Put energy efficiency first
- Leave no one behind
- Apply the principle of efficient cost technology neutrality
- Ensuring an affordable and secure energy supply
- Design a new electrical system and its operation
- Make a firm commitment to research, development, and innovation

It has as strategies:

- Large-scale take-off of renewable energies
- Reduce energy consumption without reducing well-being and economic growth
- Establish adequate financing and taxation for the energy transition
- Boosting the circular economy and promoting the bioeconomy
- Decarbonization of the primary sector
- Empower citizens and companies as protagonists of the energy system
- Orientation of research, development, and innovation in the energy field towards the energy transition
- Implement clean, safe, and connected mobility
- Decarbonization of the industrial sector
- Bet on self-consumption and proximity generation
- New electrical system design. Prominence of the distribution network, mutual support with neighbouring electrical systems
- Electrification of the economy
- Fight against energy poverty and defend vulnerable consumers
- Just and inclusive transition
- Minimize the use of territory for energy uses and preserve the most valuable uses
- Preserve the use of biomass for thermal uses and as raw material
- Selective use of renewable hydrogen
- The energy transition as an opportunity for business development and the creation of qualified and quality work
- Decarbonization of buildings and services not associated with buildings. NZEB zero energy buildings and zero emission buildings. Widespread rehabilitation of the existing building stock
- Very relevant role of electricity storage (pumping and batteries)



Types of renewable energies and Big Data

Renewable energies

- Wind energy: the energy obtained from the wind
- Solar energy: the energy obtained from the sun. The main technologies are solar photovoltaic (uses sunlight) and solar thermal (uses heat from the sun)
- Hydraulic or hydroelectric power: the energy obtained from rivers and freshwater streams
- Biomass and biogas: the energy that is extracted from organic matter
- Green hydrogen: is produced from water and renewable energy. Obtaining by electrolysis from renewable sources consists of the decomposition of water molecules (H_2O) into oxygen (O_2) and hydrogen (H_2).
- Geothermal energy: the heat energy contained in the interior of the Earth
- Tidal energy: the energy obtained from the tides
- Wave energy: the energy obtained from waves
- Bioethanol: organic fuel suitable for the automotive industry that is achieved through fermentation processes of vegetable products.
- Biodiesel: organic fuel for the automotive industry, among other applications, obtained from vegetable oils.

As energy of the future....

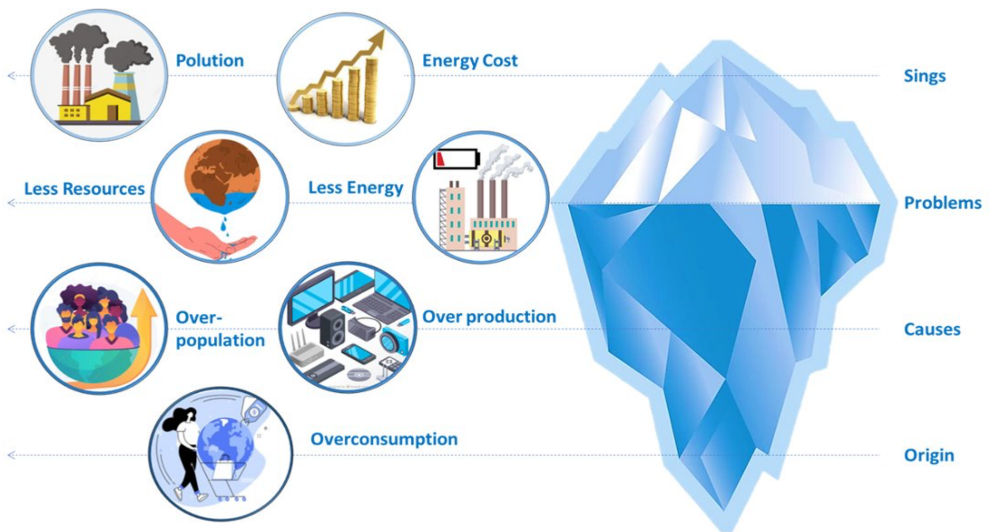
- Nuclear fusion: the technology that aspires to solve the world's energy needs. Its use would allow us to have "infinite" free energy and we could "get rid" of the use of renewable energies. The kit of the question of this energy is to fuse hydrogen atoms (the explanation is longer and more complex). This process would hardly generate any nuclear waste and would generate much more heat than the nuclear fission process. It would be necessary to reach 10 times the temperature of the Sun and point it with a laser (ITER PROJECT)

Big Data in the energy sector

Digitization is important to make it more predictable, how the installation behaves with big data, and even to see the technical conditions of the network so as not to cause disturbances in the network.
Applications:

- Constantly monitors of the power requirements.
- Smart meters: to more exhaustively monitor consumption minute by minute and have data in "real time" to see the behaviour pattern of users.
- Predictive maintenance: monitor certain components of the installations to be able to find a pattern and in the event of a mismatch, to be able to carry out maintenance ahead of time.
- Fraud detection: “lack of electricity”, that is, what goes out is not what goes in. For example: criminal behaviour such as marijuana plantations.

Iceberg model



The iceberg model allowed us to shift our perspective and see beyond the immediate events that everyone notices. It helped us to uncover root causes of why those events happen. That's possible by looking at deeper levels of abstraction within the system that are not immediately obvious.

Problems

We must increase the input of renewable energy that is injected into the main power grids because only the 20% -30% of the energy comes from renewable resources, so there is dependency on carbon fuelled generated energy, oil and coal industries have the economic power to keep the renewable energies on standby. The 90% of the world's population is being affected. So, we need affordability of energy sources at a micro level.

The problem with the widespread use of renewable energies is that they generate uncertainty, such as what we could do on a day when there is no sun, there is no wind and there is no stored energy to cover our demands. What is now known as Blackout could occur, that is, a general blackout.

In solar energy, one of the things that is currently more relevant is self-consumption or shared self-consumption. With large amortization and savings on the bill, and the energy that is not used by the panel in the houses can return to the network, but there are several problems that apply to large cities where it is difficult to implement it, which would be the following:

- Population density
- Necessary space vs. Available space
- Noises generated by certain infrastructures (shadows)
- Shared self-consumption establishes that you must be at the most 500 meters away from each other.
- Seasonal problem (winter)

Today we are also still working with crystalline silicon cells, but they are fragile and not very flexible, to address this, organic solar cells are currently being manufactured.

Mini wind turbines have distinct advantages, but they are noisy and still are technologically behind when considering their counterparts, therefore they have not succeeded in the market.

Other renewable energies that are notable would be geothermal and hydrogen. Geothermal takes advantage of the heat of the earth through heat exchangers but depending on the terrain this may or may not be useful.

On the other hand, we have hydrogen as a renewable source. Using it as a source of energy generates controversy, since many experts believe that it is the future while others are against all these thoughts. The goal in the future is to end up doing electrolysis process with renewable energies to end up saying that this process is totally made by renewable energies.

Energy storage

One of the GAPS that exists is the issue of energy storage. Currently the batteries are made of lithium, a material that is difficult to recycle (super problem), in addition to being a toxic material and an exhaustible resource.

The power electronics, they also must be improved to get the maximum production possible.

Materials

The fast deployment of clean energy technologies implies an increase in demand for certain minerals. This situation leads us to use critical and controversial minerals. Some of these minerals create controversy because of their scarcity and others are being imported from countries with socio-political disputes such as forced labour in the Uyghur Region in China.

Cost of Energy and prices of CO2 emissions

Levelized Cost of Energy (LCOE)

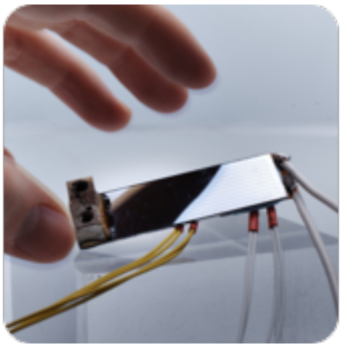
To evaluate the cost of a technology, an important term today is the Levelized Cost of Energy (LCOE €/kWh). It is the value of the total costs of building and operating an installation that generates energy throughout its useful life. It is calculated by dividing the total costs throughout its useful life with the total energy that it will be able to produce throughout its useful life. It depends on each technology.

CO2 emission prices

The issue of the cost of CO2 emissions, due to the fact of using gas and the emission quotas that the production plants themselves have to pay, is also a current issue. This makes the price of electricity more expensive. On the other hand, it is speculated that in the future even the companies themselves will have to pay a kind of penalty/tax for generating this type of emissions.

CERN/Other technologies research

2D Heat

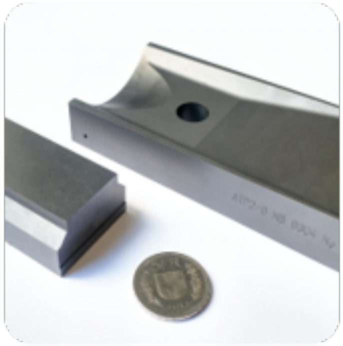


Efficient heat transfer systems that meet the requirements for CERN's Ultra High Vacuum Requirements. Significant synergy with energy storage systems as they help with heat/energy dissipation.

SIEMENS – Smart Grid

Smart Grid Operational systems that push for decentralization of renewable energy production allowing for the integration of multiple systems.

Graphite



Graphite based components that allow for efficient thermal management and high temperature operability.

CONCEPT DEVELOPMENT

What if …

Define the problem

Currently, the entire energy monopoly is held by large energy companies and all these companies have control over the entire system. They mostly follow a centralized fossil-fuelled based model that generates more than 72.2% nuclear-fossil energy.

In Catalonia there is a large foreign energy dependency of 94.2%.
Moreover, there's a lack of renewable energy communities, as they haven't been defined yet. A consumer has to be the figure that we want to look alike, but we're still having many barriers in that aspect.

First ideas

Small Wind Generators
Apply the new technology of small wind power generators, that were develop for an urban context and try to integrate them on different strategical sectors in Barcelona, where we could use them as nods for a connected system that could generate energy for the nearest blocks or buildings.

Power up thermoelectric generators
Apply the efficient CERN heat transfer to improve the thermoelectric generators and make them also efficient on a domestic use, were the extra heat that was created, could be add to the electrical grid.

Organic solar cells
Replace the conventional solar panels that use monocrystalline silicon solar cells with solar panels made of organic solar cells and try to fix the environmental issues that deteriorates the organic cells, so it could be feasible.

Windows that absorb solar energy
Implement this technology at the more than hundred glass buildings that are spread all over Barcelona, to turn them into solar generators that may give their energy excess to the surrounding buildings.

How can we solve all these problems?

The first thing it came to our minds was to pursuit a decentralized model. This decentralized model is based on following a producer and consumer model where they are the main characters as individuals. A renewable energy community could apply as a new way of following this path, where the energy production inside the community would be for individual and collective usage and its production and consumption would be managed by the community itself.

What if we could find a way to change the current system into another one that allows us to be completely independent in terms of energy production and consumption but in a sustainable manner?

Our proposal

Verdecity

We stablish that people must change the way of living in society, to have an affordable energy, that could apply the conventional and new technologies that are being developed, so families can work as a community for bigger good, that becomes self-sufficient when each member complements the rest.

Our proposal is a full develop small settlement built from scratch, that has been designed to generate as much energy as possible. In which energy is produced for individual and collective self-consumption for the community so this community, does not only will have enough energy for their activities, but also, it would power up the cities that are near, by injecting the energy that is not being consumed back to the grid.

In this way, proximity energy is generated for the rest of the people outside of the community. Following all these steps, a clean, decentralized, participatory and democratic energy model is offered in which all people within the community have transparency of the energy they produce and consume.

Design of Verdecity

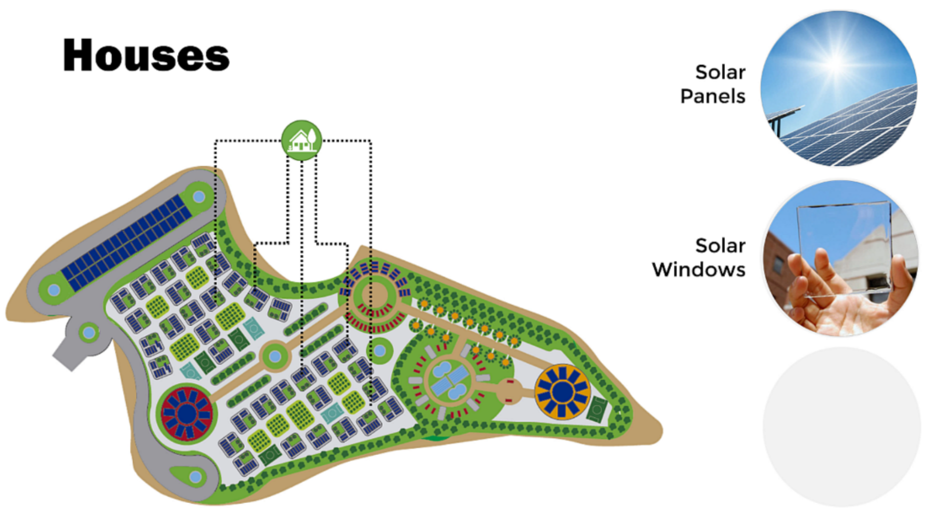
Verdecity will be built nearby Mataró in Catalonia, because of the proximity of its facilities such as hospitals, train station and many more.

It will have renewable energy generators in housing and communal areas. A green policy mobility will be enforced within the community members.

Houses

There are going to be 34 housing units with solar panels in their rooftops and solar windows installed.

The average of people living in these houses is 3 people/house.



Parking

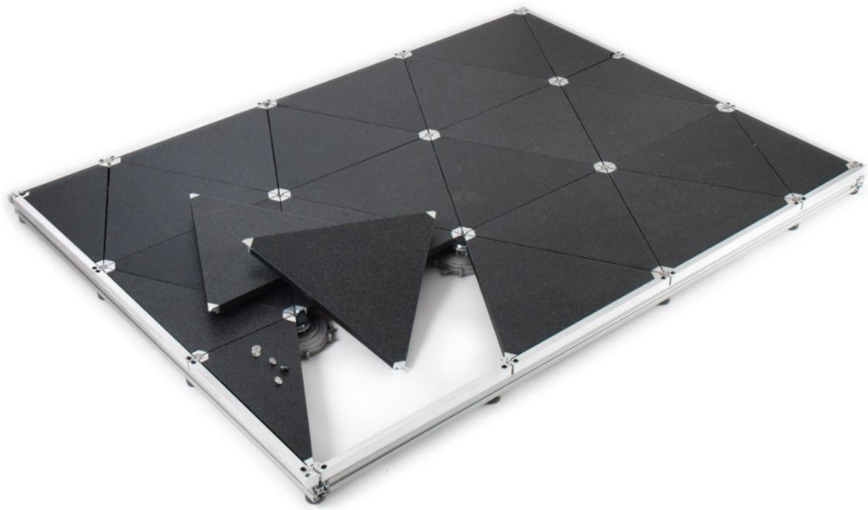
In Verdecity there's going to be a parking lot where all the community members will be able to park their electric cars. Solar panels are going to be installed on the roof of the car par to enable charging for them.

It's going to be built in the furthest part of the community because within the city people are going to follow a zero-car policy. The cars will only be used in case of need for going out of the community, if not they will remain in the parking lot.

Entrances

The entrances are the busiest parts of the community, therefore where more movement is being produced. That's why we are going to install kinetic floor in these areas to capture movement and turn it into clean energy.

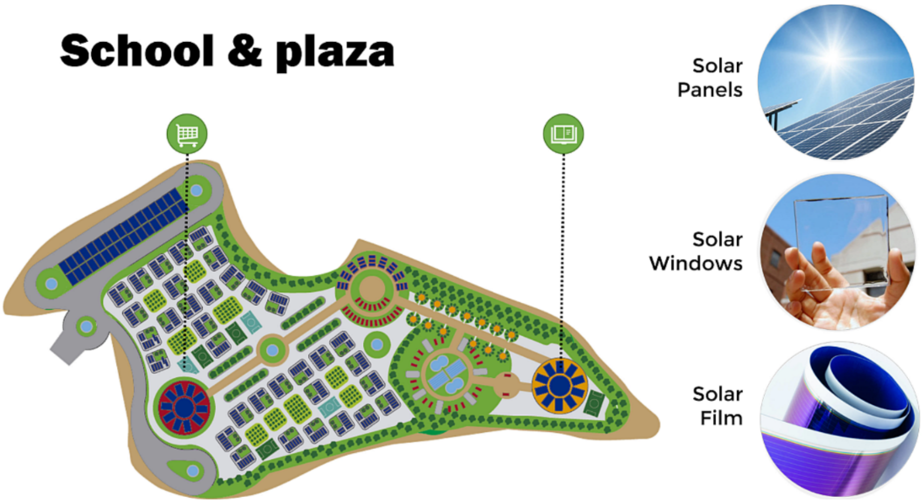
Part of our proposal, is to reduce the use of cars inside the community, so we can encourage people to walk, go on bike or move on a more sustainable way, that also can create energy.



Also, we design a strategy to take more advantage of this technology, by creating just a few roads, entrances and paths that the people must use or to enter into the different buildings and areas that the community has. Such as the school, the plaza, parking and the recreational areas that only have one way in.

School & Plaza

And finally, there's going to be a plaza and school. As they can be built fully with glass, we can take advantage of that fact and install solar windows through all the buildings. We will also cover the facades and walls with solar film and install solar panels in the rooftops. This will allow us to power up both building.



Technologies implemented in Verdecity

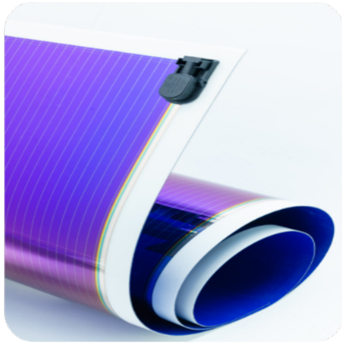
Ubiquitous Energy

Photovoltaic glass (PV), that transmit visible light, so works with the invisible ultraviolet and infrared light turning it into electricity. The materials are non-hazardous and non-toxic.

The concept of a transparent solar device that captures primarily non-visible light is invented by Vladimir Bulovic, Richard Lunt, and Miles Barr at MIT and Michigan State University, who are founders of Ubiquitous Energy.

In our project this product will be on all the windows like that of the houses, school, plaza.

Heliatek



Organic photovoltaics (OPV) uses materials from the field of organic chemistry to convert sunlight into electrical energy, so it's an organic solar film. Furthermore, it's non-toxic.

Their products are ultra-light, flexible, ultra-thin, and truly green. This makes them the perfect choice for all surfaces and applications where conventional PV modules do not fit. Surfaces like metal, concrete, membrane, glass and bitumen.

Their product comes with encapsulation to protect the organic stack against environmental influence, and it comes with an integrated backside adhesive with junction box with cables.

In our project this product will be used on some concrete walls like that of the school and plaza.

Conventional solar panels

Nowadays the photovoltaic glass and the photovoltaic organic film don't reach the efficiency of the conventional solar panels, that's why in our project we are going to use this product, and it will be on the housing rooftops, school, plaza, parking lot.

Instead of using the conventional ones made with monocrystalline silicon solar cells, we will try to move forward to use organic solar cells in solar panels as they provide more flexibility, and they could be attached in other places such as facades.

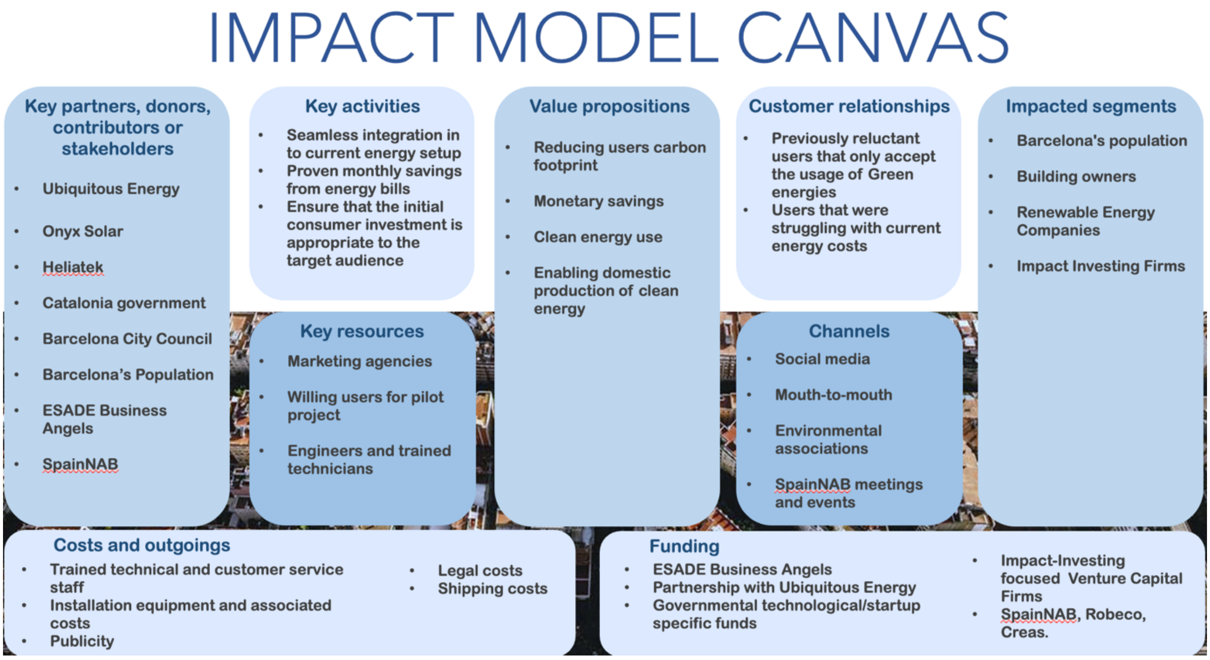
Energy Floors

Inside each tile there's an electromechanical system, which transforms the small vertical movement produced by people walking into a rotating movement that drives a generator.

In our project this product will be located in some places on the floors such as parks, plaza entrance, school entrance, parking entrance and common entrances.

BUSINESS MODEL

Business Model Canvas



As we can see in the impact model canvas, we have multiple stakeholders that range from the government to the developers of the different technologies that we are implementing. Even including the impact investing firms that are operating in Spain, allowing us for a better reach at our target investors.

For the implementation strategy of this venture, we have set 3 milestones:

Seed Round

This will seek 15M € in funding which will account for the acquisition of the plot to develop the entire project. Additionally, it will take into consideration the construction of 12 houses, respective parking space and small common areas. This figure evaluates the current cost per m^2 in Maresme while adding the construction costs and the purchase of the technologies involved. The main target for the investment sourcing is the SpainNAB which houses most of the impact investment firms in the country that focus on ventures at this maturity stage.

Series A

This round seeks a 12M € investment, allotting for 60% of the total housing construction completion and the totality of the common areas. This sourcing will be aimed at firms such as Robeco and Creas which look into ventures that are past the Seed Round and have validated ideas, looking for a fast-paced capital investment.

Series B

This round seeks a 8,125M € investment, this will target the remaining housing units and completing the project in its entirety, taking into account possible mishaps with the installed technology and additional maintenance costs. Our focus in this round is the investment of firms such as Ship2BFoundation which seek non active participation in the ventures in which they decide to invest.

Value Proposition

Our model allows for those individuals that fervently desire to distance themselves from the monopoly held by the energy production companies while having a positive impact in the environment. The added value is mainly attached to the megatrends of circular economy and green energy. By allowing our users to be their own producers and consumers, we relieve the dependence that is currently in place from fossil fuels.

Revenue Streams

The main source of income from this model will be the monetization of the energy that is sold back to the grid. Additional to this, the modern design and appeal to an upscale lifestyle while being environmentally friendly will tap into the market that will allow for larger profit margins. Other elements that will come into play will be the operation of the school and the leasing of the lots in the plaza. This will allow for external stakeholders to see the system that is in place and consequently increase the demand to be part of this ecosystem.

TECHNICAL DOSSIER

Technical Energetic Analysis

The amount of energy that a single solar panel produces is determined by various factors such as the amount of sunlight, size, and material of the panel.

Size
The size of the solar panel is the first and the most significant factor that will influence the amount of energy produced. It's logical to say that the larger the solar panel, the more sunlight it can absorb and therefore, the higher the amount of energy produced. Additionally, to these, our project incorporates Kinetic Tiles that transform kinetic energy, biofilms and transparent cells that absorb solar energy.

Conventional Solar Cells	Transparent Solar Cells	Flexible Organic Cells	Kinetic Tiles
2,2 m^2	5 m^2	1m^2	0,36 m^2

Area per unit

Amount of Sunlight
As the amount of sunlight increases, so does the solar energy absorbed by the panels and as a result, more electricity is generated. Solar panel technology has reached advancements that even in cloudy days significant amounts of sunlight can be absorbed.

We are considering an average daily of sunlight hours of 6,3 h/day.

Efficiency
Efficiency (%) = [Power Rating (watts)/Surface] * 100
Where;

Power Rating is the rating (in watts) indicated on the panel and,
Surface stands for the surface area of the panel

Calculate kWh

In order to calculate the energy output, we used two different formulas, one which is conservative in the manner that it considers the local radiation and another that uses the average daily sunlight hours which returns a higher result.
One formula for calculating the energy output is:

$$E = A * r * H * PR \qquad (1)$$

E = Energy (kWh)
A = Total solar panel Area (m2)
r = solar panel yield of efficiency (%)
H = Annual average solar radiation on tilted panels (shadings not included)
PR = Performance ratio, coefficient for loses (range between 0.5 and 0.9, default value=0.75)

Another formula, using the average daily sunlight hours is the following:

$$E = Power\ Rating(W) * Sunlight(h) * Nsolar\ panels * PR \qquad (2)$$

Consumption calculation

- Electric cars are based on a car with an average consumption of 60 kWh every 520 km, this means that we will have 0.12 kWh/km, if we consider an average of 50 km/day we have a consumption of 5.8 kWh /day.
- Consumption in Maresme is 353.8 kWh/year*person, therefore there will be a daily consumption for person in Maresme of 0.97 kWh/day for person
- Main areas, like the park and the parking

Consumption		
Electric Cars	5,8	kWh/day
Person	0,97	kWh/day
Main Areas	0,3	kWh/day
Total	**7,07**	**kWh/day**

Considering 1 person per house:

$$E\_{\substack{Consumption \\ by\ house}} = 5{,}8 + 0{,}97 + 0{,}3 = 7{,}07\ \frac{kWh}{day}$$

Considering 3 people per house:

$$E\_{\substack{Consumption \\ by\ house}} = 5{,}8 + 0{,}97 + 0{,}3 = 9\ \frac{kWh}{day}$$

For the first phase of the project, with 12 houses

$$E\_{\substack{Consumption \\ TOTAL}} = 12 * E\_{\substack{Consumption \\ by\ house}} = 12 * 7{,}07 = 84{,}84 \frac{kWh}{day}$$

Production calculation

Solar panels

The initial calculations were made based on the first phase of the project that includes:

- 12 houses, and each house will be 3 conventional solar panels and 5 windows with the transparent solar cells
- For one parking spaces 1,2 conventional solar panel (in the parking zone)

	Conventional PV Cells	Transparent Solar Cells
Power	0,54 kWh	0,3 kWh
Efficiency	0,212	0,1
Area	2,2 m2	5 m2
Amount in one 1 House	3	5
Amount for one parking	1,2	0

Considering:

- H = 4.6 kWh/m2*day — Average radiation in Maresme
- PR = 75% — Performance ratio
- Sunlight hours = 6,3 h/day — Average daily

Kinetic Tiles

This kinetic tiles would be in 2 public areas where the highest traffic is allocated. Each area will have 6 kinetic tiles, assuming a frequency of 10 uses per day per tile, we will be able to power these public areas. Thus, an amount of 120 kinetics tiles will be installed and generate approximately 3,6 kWh/day.

$$E_{\_Kinetic \atop tiles} = 0{,}03\ kW * 120 = 3{,}6 \frac{kWh}{day}$$

Final energy production

In total:

$$E\_{\underset{TOTAL}{Production}} = E\_{\underset{PV\ cells}{Conventional}} + E\_{\underset{solar\ cells}{Transparent}} + E\_{\underset{tiles}{Kinetic}}$$

By house:

$$E\_{\underset{by\ house}{Production}} = \frac{E\_{\underset{TOTAL}{Production}}}{12} = \frac{135}{12} = 11{,}3\ \frac{kWh}{day * house}$$

Energy returned to the grid

By house:

$$E\_{\underset{by\ house}{Returned}} = E\_{\underset{by\ house}{Production}} - E\_{\underset{by\ house}{Consumption}} = 2{,}3\ \frac{kWh}{day * house}$$

As we can see, using the conservative approach we return to the grid 2,3 kWh/day*house. If we consider the other energy output formula this can reach up to 6,3 kWh/day*house, almost producing the same amount of energy that a typical household would consume daily.

APPENDIX

Sources / Contacts

Rawlemon

André Broessel

UPC

Oriol Batiste
Sara Barja
Joaquim Puigdollers

Res

Eduardo Medina

Noima

Sonia Ruiz

SomEnergia

Guifré Bombilà

Institut Català d'Energia

Marta Morera

APPA Renovables

Lucía Dolera

9è Congrés d'Energia de Catalunya

Alicia Casart
Jaume Salom
Raúl Velazco

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