ElectroCap Pitch Deck

Automated Solar Panel Tracker for Energy Efficiency

Team 15:

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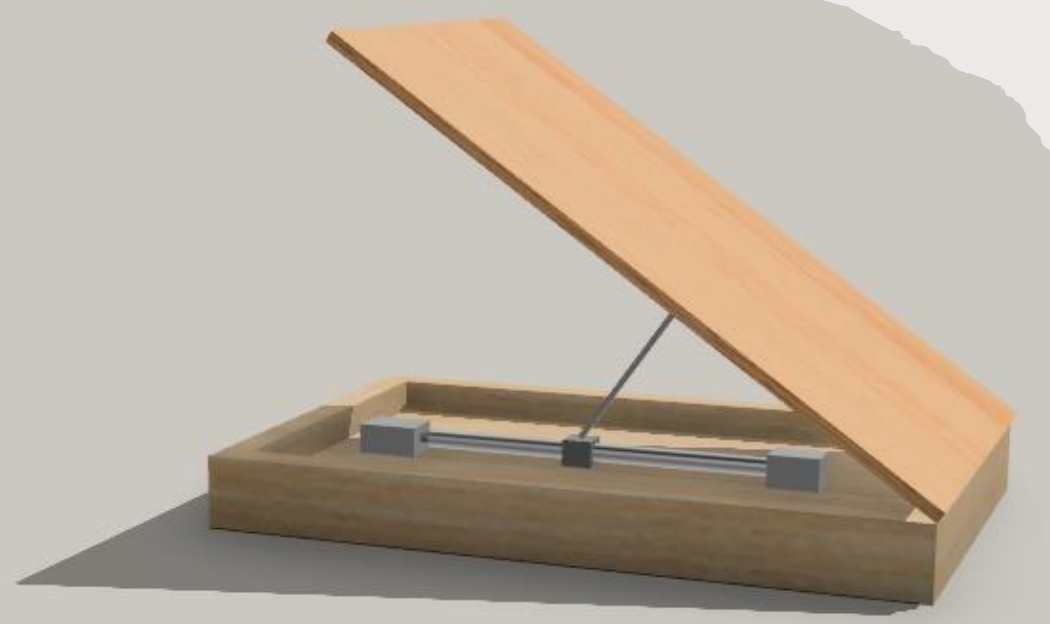
1. Problem definition



The challenge addressed is **maximizing** solar energy production in areas where space is limited. Traditional fixed solar panels are often inefficient, as they cannot continuously align with the sun's movement throughout the day, leading to suboptimal energy generation. While advanced solar tracking systems exist, they typically require significant space for installation and operation, making them unsuitable in limited space areas, particularly in densely populated urban settings or small properties and specific low size applications. A solar tracking system, however, can increase energy efficiency by up to **40%** compared to fixed solar panels, making it a transformative solution for **maximizing energy output** in limited spaces.

2. Solution beneficiaries

- The Automated Solar Panel Tracker for Energy Efficiency primarily benefits individuals and communities with **limited space** for solar energy systems, such as those living in urban or rural areas, small homes, or apartments with constrained rooftops. By enabling maximum energy production from compact spaces, the solution empowers these users to adopt renewable energy sources efficiently.

- Additionally, this system is particularly beneficial for people with **campervans** and **boats**, where space is extremely limited, and energy demands are high due to the variety of electronic devices used within the vehicles. Most current campervans and some yachts rely on fixed solar panels, which are less efficient. Our project addresses this gap by providing a solution that allows campervan and yacht owners to achieve **greater energy efficiency**, making better use of their limited roof and deck space and ensuring a more reliable energy supply for their travels.

- Furthermore, the system benefits environmentally conscious users seeking cost-effective ways to increase their energy efficiency, as well as small businesses and institutions looking to optimize solar energy use in tight spaces. The project contributes to broader societal goals by promoting renewable energy adoption, reducing dependence on traditional energy sources, and fostering sustainability in resource-limited environments.

3. Technological solution

- The *Automated Solar Panel Tracker for Energy Efficiency* uses a combination of **hardware** and **software** to optimize solar energy production in limited spaces. The hardware includes a solar panel mounted on a platform controlled by a **linear actuator**, which adjusts the inclination of the panel. This entire structure is mounted on a **rotating base**, which is controlled by a stepper motor connected to two gear disks, ensuring precise orientation towards the sun. The system integrates **sunlight sensors** to detect the sun's position and a **control unit** programmed with algorithms to process sensor data and calculate the necessary adjustments. The software ensures real-time motor coordination, enabling the panel to maintain an optimal angle throughout the day.
- This technological solution addresses the constraints of space by being compact and highly adaptable, making it suitable for rooftops, decks or small installations. It maximizes energy efficiency while remaining cost-effective, providing a practical and accessible renewable energy solution for individuals and communities with space limitations.

4. Competitors and previous work

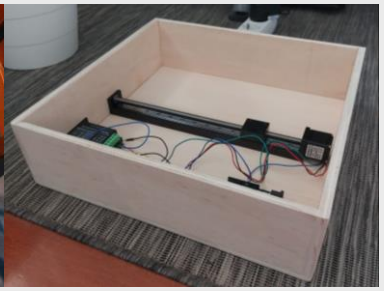
- In the solar energy market, several companies and projects have developed solar tracking systems to enhance energy efficiency. Competitors include established manufacturers of solar trackers, which typically offer **large-scale**, **single-axis** or **dual-axis** systems for commercial and industrial applications. These systems are highly effective but often require **significant installation space** and are prohibitively **expensive** for small-scale users, making them unsuitable for the specific constraints addressed by this project.
- Previous work in solar tracking includes mechanical systems that adjust panels based on preprogrammed algorithms or real-time sensor data. While effective, many of these designs are bulky, costly, or overly complex for individuals or communities with limited space and resources.
- Our product distinguishes itself by targeting **a unique niche**: compact, cost-effective, and adaptable systems specifically designed for small spaces. By addressing the limitations of existing products, this solution meets the needs of users who have been underserved by conventional solar tracking systems.

5. Team

- Afonso Gama – Licenciatura em Engenharia Eletrotécnica e de Computadores
- Francisco Teixeira - Licenciatura em Engenharia Eletrotécnica e de Computadores
- Manuel Barreiras - Licenciatura em Engenharia Eletrotécnica e de Computadores
- Henrique Mancellos - Licenciatura em Engenharia Eletrotécnica e de Computadores
- Tomás Bastos - Licenciatura Bolonha em Ciências Militares Aeronáuticas - Engenharia
- Rodrigo Martins - Licenciatura Bolonha em Ciências Militares Aeronáuticas - Engenharia

6. Prototype Evolution

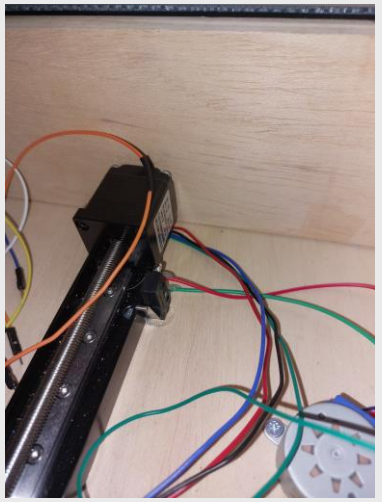
- Wooden base structure
  - 34 cm x 35 cm x 9 cm base structure that holds the components
- Tilting mechanism
  - Linear actuator to tilt the solar panel vertically
- Rotating mechanism
  - Lazy Susan bearing to implement a rotating base that is controlled with custom 3D-printed gears and powered with 12V stepper motor
- Photo-resistors for sun detection
  - Array of 4 photo-resistors in a structure to detect sun’s direction



7. Technical Challenges & Solutions

- Linear actuator couldn’t lift the panel when fully lowered
  - × *Problem:* The actuator alone lacked enough torque to overcome the panel's weight at low angles.
  - ✓ *Solution:* Added a gas spring to support the load, reducing strain on the actuator.

- Ensuring safe tilt limits
  - × *Problem:* Risk of over-driving the actuator past safe mechanical angles.
  - ✓ *Solution:* Installed end-of-course switches to safely cut power when limits are reached.



8. Results

To evaluate the effectiveness of our solution, we conducted tests during critical solar hours, comparing the energy production of the solar panel when placed horizontally versus when tilted towards the sun. The goal was to demonstrate that our system can significantly outperform a fixed panel setup, especially in situations where maximizing solar input is crucial.

At **18:30**, with the sun at a 25º angle, the horizontal panel generated **2.394 W**, while the tilted panel reached **9.339 W**, resulting in a power increase of **6.945 W**, which is a gain of 290%.

At **19:30**, as sunlight diminished and the sun dropped to 16º, the horizontal panel produced just **0.1575 W**, while the tilted panel still managed **2.9667 W**—an increase of **2.8092 W**, representing an impressive **1784% gain**.

Time	Orientation	Sun's angle	Voltage [V]	Current [A]	Power [W]	Gain [W]	Gain [%]
18:30	Horizontal	25º	6,84	0,35	2,394	--	--
18:30	Tilted	25º	14,15	0,66	9,339	6,945	290
19:30	Horizontal	16º	3,15	0,05	0,1575	--	--
19:30	Tilted	16º	8,99	0,33	2,9667	2,8092	1784

Note: The values shown in the table represent **instantaneous gains** measured at specific times of the day. They do **not** reflect the total energy gain over the entire day but rather illustrate the potential performance improvement during critical sunlight hours. The overall gain throughout the day is up to 40% more than a fixed solar panel.

Testing with panel at horizontal position

Testing with panel at tilted position

8. Results

These results clearly show that dynamic panel orientation drastically improves energy output, even under low-angle sunlight. This is especially relevant for **off-grid users**, such as those in campervans or remote areas, who rely entirely on solar energy for power. Our system provides a practical and impactful solution for these users, ensuring they can make the most out of every ray of sunlight.

9. Team members' contributions

Afonso Gama	Tomás Bastos	Francisco Teixeira
Sensor Design & Mechanical Assembly	**Programming and Electronics**	**Mechanical Design & Website Developer**
Design and build the sun sensor to detect sunlight direction	Develop and test the code for sun tracking and motor control	Design and assemble the tilting platform and ensure motor alignment with the structure
Creation of the poster	Collaborate with the Electronics Lead to integrate the microcontroller and sensors	Test mechanical stability and functionality during integration
Test the sun sensor for accuracy and optimize its placement on the platform	Help assemble and wire the system during integration	Development of the team’s website

9. Team members' contributions

Manuel Barreiras	Henrique Mancellos	Rodrigo Martins
Structure and Electronics	**Programming and Structure assembly**	**Structure assembly**
Design and structure assembly	Help developing the tracking software	Modulate and printing of the cogwheels
Assemble the circuit and connect the microcontroller, sensors, motors	Assist the structural team in the structure assembly	Assist the structural team in the structure assembly
Test all electronic components for proper functionality	Produced and edited the demonstration video	Assist in the circuit assembly

Note: Every team member contributed to the blog posts

10. Costs and benefits

- Base structure - 7€
- Solar Panel - 32€ (The solar panel depends on the costumer)
- Linear actuator - 47€
- Stepper motor - 5€
- Rotating base - 7€
- Lifting Spring - 7€
- Arduino R3 - 30€
- Others - 15€

Total: 150€

In addition to having an affordable production cost, the system also offers several important benefits. It significantly increases energy output by automatically adjusting the solar panel to follow the sun. This makes it especially valuable for people living off-grid or in areas where space is limited, such as on boats or motorhomes. The design is compact, uses fewer moving parts, and is easy to adapt and maintain, making it a reliable and practical solution for improving solar energy efficiency.

11. Useful links

Website

Website - Automated Solar Panel for Energy Efficiency

Youtube Channel

Automated Solar Panel Team - YouTube

Blog

Blog – Automated Solar Panel Tracker for Energy Efficiency

Note: The demonstration video is uploaded on our Youtube Channel