Faculdade de Engenharia da Universidade do Porto

SOLAR TRADE

Final Report

HCI Project 2024/2025

Team 05

Class 07 + 08

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Phase I - User and Task Analysis

1. Project’s idea description

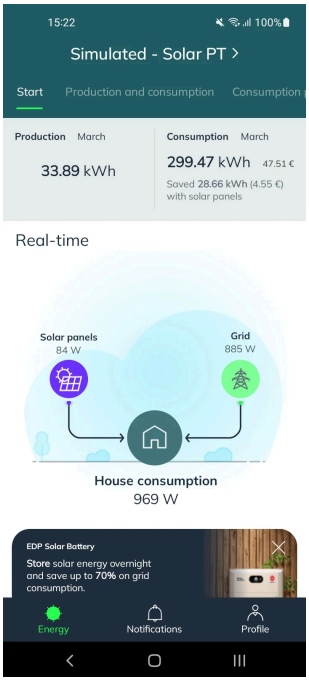
SolarTrade is a mobile app designed to help users manage and optimize their solar panel systems. It allows users to monitor energy production and consumption in real-time, perform auto-repairs through embedded robots, and sell excess energy to the grid, including internationally. The app provides detailed energy reports to help users improve efficiency and live sustainably. Leveraging smartphone technologies and wireless connectivity, it offers a user-friendly solution for managing solar energy and promoting sustainable living.

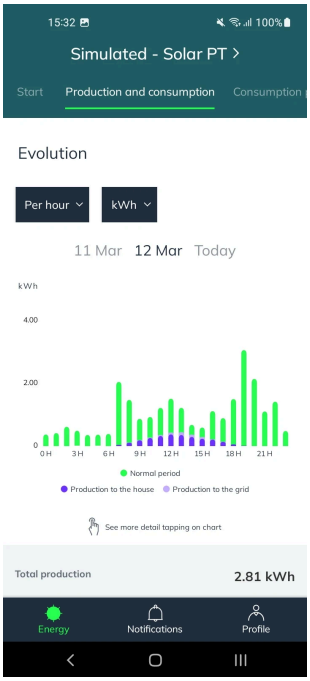
2. Related apps

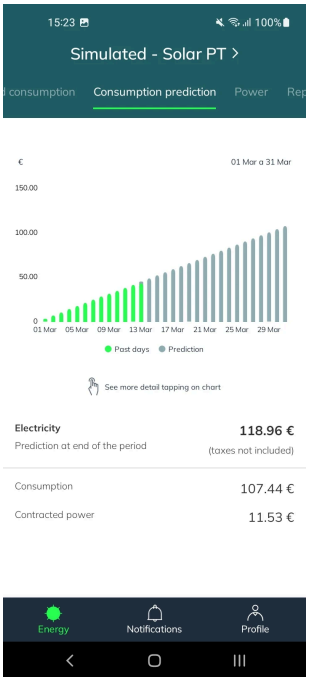
- **EDP Solar**

  A comprehensive app for real-time monitoring and control of home energy usage, solar production, and smart devices.

With the EDP Solar app, users can control and monitor their energy consumption and the production of their solar panels, just like in our app. It also alerts users when there are issues with the panels. However, unlike EDP Solar, Solar Trade can automatically resolve these minor issues.



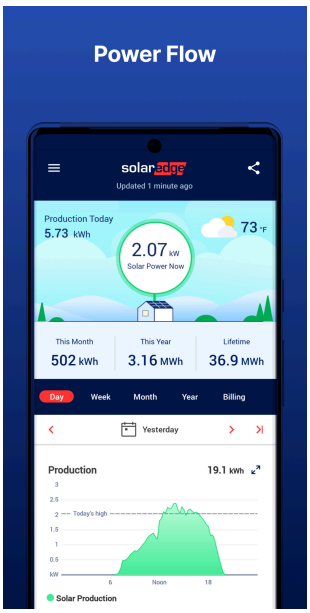


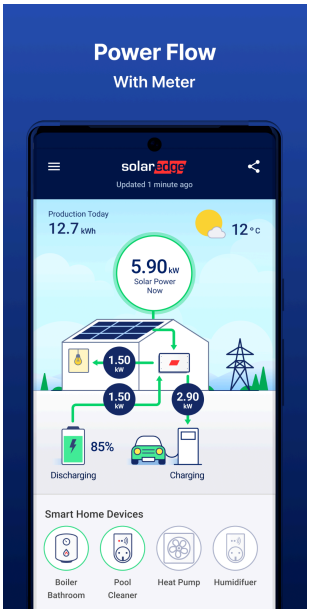


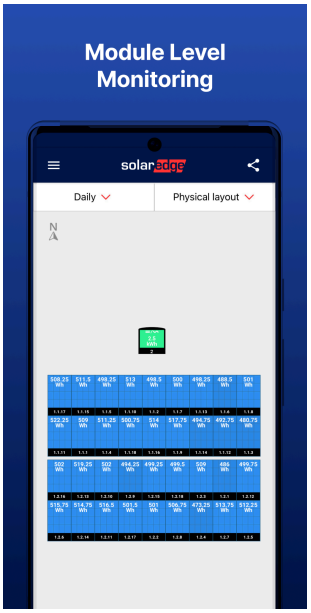
- **mySolarEdge**

  A monitoring tool developed for owners of photovoltaic systems but also offers functions that allow customers to quickly and independently troubleshoot routine issues without needing to involve the installer.

Like Solar Trade, with mySolarEdge, users can track their energy production and consumption in real time. The app offers ways to become more energy efficient. It would be interesting to add features present in our app, such as quick scheduling with a technician when there is a serious issue, or automatic panel rotation for better energy production efficiency.







3. Questionnaire Highlights

The survey was distributed during the week of October 4th, 2024, and received a total of 40 responses from individuals across all age groups, ranging from 14 to 78 years old. The majority of respondents were 20 years old (37.5%).

Most respondents do not regularly monitor their energy consumption or only check it when they receive their bill; however, 65% feel that their access to energy usage data is convenient. From the sample collected, it was found that a large portion (around 92%) of those with installed solar panels are satisfied with the savings these devices provide and would be interested in earning money from any excess energy produced.

None of the respondents preferred a fully manual control of their energy consumption. The preferences were either fully automated (39.5%) or a combination of manual and automated control (60.5%). About 87.2% see the ability to remotely repair minor issues with solar panels through a mobile app (90%) without requiring extensive technical knowledge as a significant advantage. For more complex issues requiring the presence of a technician, 84.2% expressed interest in scheduling maintenance appointments for their solar panels directly through the app.

The survey aimed to understand people's current energy usage habits, helping to analyze their needs and interests.

4. PACT Analysis

4.1. People

Our target audience includes people of all ages, who either already own or are interested in getting solar panels. This group ranges from beginners learning to manage their systems to experienced users. We're focused on those who care about their energy usage and aspire to lead sustainable lifestyles.

4.2. Activities

The majority of people do not actively monitor their energy consumption or electricity prices, typically only checking it when the bill arrives. Among those who own solar panels, there is a general sense of satisfaction with their performance so far. However, there is room for improvement in making energy monitoring more engaging and accessible, as well as providing more information on cost savings and efficiency over time.

4.3. Context

While traditionally, energy management activities occur at home, with our app, users will be able to interact with their solar panels from anywhere. Whether they are at home, at work, or on the go, they can monitor energy production, manage consumption, and potentially sell excess energy. Despite the fact that over half of the users find accessing their energy meter at home convenient, there is a clear demand for a more automated and mobile-friendly solution. This shift allows users to engage with their energy systems in a way that fits their busy schedules, enabling flexible, remote management that caters to daily, weekly, or more occasional interaction, depending on individual preferences.

4.4. Technologies

The app uses features already available in smartphones, like touchscreens and notifications. It connects wirelessly to solar panels, ensuring stable communication for real-time monitoring and control. The app also works with high-tech robots inside the solar panels that can perform auto-repairs whenever users request them, allowing for efficient and easy maintenance. Additionally, the app uses advanced technology to enable users to sell excess energy internationally, making energy trading more flexible and accessible.

5. Personas

ANNE GREEN

Basic information

- **Age:** 29
- **Occupation:** Marketing Manager
- **Location:** Urban area, lives in a solar-powered condo
- **Technology Proficiency:** Comfortable with technology and apps
- **Energy Goals:**
    - ➔ Reduce energy costs
    - ➔ Minimize her carbon footprint
    - ➔ Stay informed about energy consumption

Background

Anne recently installed solar panels on her condo roof and is enthusiastic about renewable energy. She aims to lead a sustainable lifestyle but is still learning how to manage her energy consumption effectively.

Pain Points

- She finds it challenging to monitor her energy usage and often forgets to check her consumption until she receives her bill.
- Anne wishes there was a more engaging way to track her energy savings and the performance of her solar panels.

PETER BLUE

Basic information

- **Age:** 45
- **Occupation:** Small Business Owner (grocery store)
- **Location:** Suburban area, owns a home with solar panels
- **Technology Proficiency:** Moderate; uses technology for business but is not overly tech-savvy

- **Energy Goals:**
    - ➔ Maximize energy savings
    - ➔ Learn more about optimizing solar energy production
    - ➔ Sell excess energy to the grid

Background

Peter installed solar panels a few years ago and is satisfied with the savings they provide. However, he often overlooks monitoring his energy consumption, typically only checking his bills. He is interested in improving his understanding of solar energy management to benefit both his household and business.

Pain Points

- Peter struggles to stay informed about his energy production and usage due to his busy work schedule.
- He wants an easier way to manage energy consumption and reliable maintenance support without needing extensive technical knowledge.

6. Activity Scenarios

Scenario 1: Anne's Energy Monitoring and Management

After finishing her workday, Anne picks up her smartphone and opens the **SolarTrade app** to check how much energy she used that day. As she navigates through the app, she finds the **detailed reports** that offer a **visual representation** of her **monthly consumption**. Spotting some **energy spikes** during the evenings, she decides to set a **personal goal** to reduce her usage by switching to more **energy-efficient appliances**.

Feeling proactive, Anne then uses the **virtual repair tool** to check for any minor issues with her solar panels. After ensuring everything looks good, she schedules an **annual maintenance checkup** with a technician and takes a moment to explore some suggestions for optimizing her energy use even further.

Scenario 2: Peter's Energy Optimization and Selling

While taking a break at his grocery store, Peter pulls out his tablet and opens the **SolarTrade app** to see how much energy his solar panels are currently producing. He dives into the **detailed reports** to get a clear picture of the **excess energy** he has available for sale. Excited about the possibilities, Peter checks out the option to **sell energy to the grid**, carefully selecting the best country option to maximize his returns.

As he reviews his energy production, a reminder pops up for an upcoming **maintenance review**. Realizing the importance of keeping everything running smoothly, he quickly schedules a **maintenance appointment** through the app to ensure **peak efficiency** across all his properties. Before he wraps up his break, Peter takes a moment to check for any **minor issues** with his solar panels, using the **repair tool** to address them promptly, ensuring his investment is well taken care of.

Keywords: SolarTrade app, check energy usage, detailed reports, visual representation, consumption, energy spikes, personal goal, virtual repair tool, excess energy, sell energy to the grid

7. Functionalities

- **Interactive Virtual Repair Tool with Real-Time Control & Review Scheduling**:

  The app highlights areas needing repair on solar panels using color codes (e.g., red for critical issues). Users can remotely control real-time repairs through their mobile devices, addressing minor issues efficiently.

  Additionally, the app allows users to schedule maintenance checkups with technicians via a calendar interface, sending reminders to ensure timely reviews. This integration ensures optimal panel performance through both user-controlled repairs and professional maintenance.

- **Energy Selling to the Grid with Country Selection**:

  Energy Selling to the Grid with Country Selection: Users can sell excess energy generated by their solar panels to the electrical grid, with the ability to select which country they want to sell to, enhancing international energy trading flexibility.

  The primary goal is not just to earn money from excess energy, but also to contribute to global energy accessibility. According to The Energy Progress Report 2023, over 675 million people lived without electricity. By enabling energy trading, users can help support sustainable energy solutions and contribute to efforts to provide electricity to underserved regions, helping to make a meaningful global impact.

- **Detailed Energy Usage Reports**:

  The app provides users with comprehensive reports on energy consumption metrics, helping them analyze their energy patterns, identify trends, and optimize their energy efficiency based on historical data. By tracking usage and suggesting ways to reduce consumption, the app empowers users to make informed decisions that contribute to a more sustainable lifestyle.

Phase II - Lo-fi prototype and heuristic

1. Project abridged description

SolarTrade is a mobile app designed to help users manage and optimize their solar panel systems. It allows users to monitor energy production and consumption in real-time, perform auto-repairs through embedded robots, and sell excess energy to the grid, including international markets. The app provides detailed energy reports to help users improve efficiency and live sustainably. Leveraging smartphone technologies and wireless connectivity, it offers a user-friendly solution for managing solar energy and promoting sustainable living.

For this prototype, we chose the 3 main tasks and their respective functionalities to work with:

- **Real-Time Monitoring & Energy Reports:** The user can access detailed, real-time reports on their energy consumption directly from the home screen. This feature allows users to monitor and track their energy usage at any moment, helping them make more informed decisions about energy efficiency.

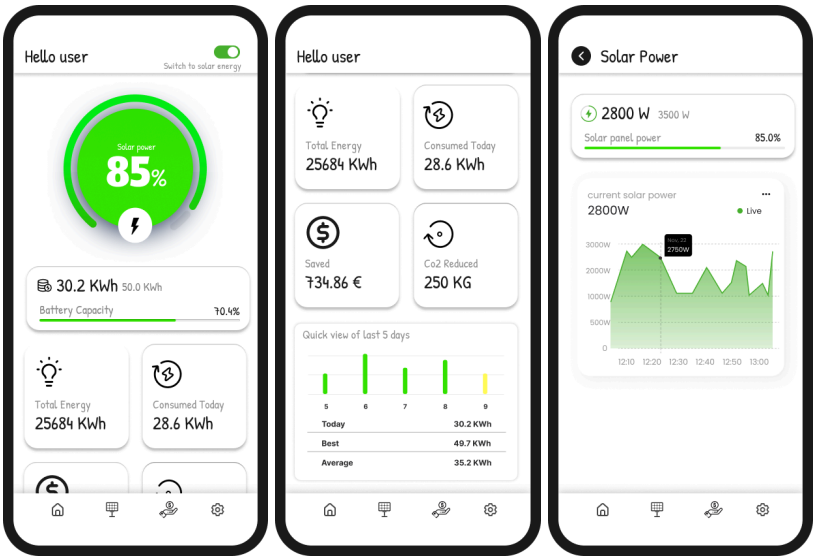
- **Auto-Repair Functionality:** This feature leverages embedded robots within the system to automatically perform minor repairs on solar panels. When a user notices an issue, such as a malfunctioning solar panel, they can click on the error or fault section within the app's interface. The system will then activate the embedded robotic units to initiate the repair process. These robots are designed to detect and fix common, non-invasive issues, such as cleaning panel surfaces, adjusting misaligned components, or resetting sensors. However, if the issue is too complex for the robots to address, the system will notify the user and recommend scheduling a fix with a professional technician.

- **Energy Sales:** This feature allows users to buy, sell, or donate excess energy generated by their solar panels. Through the app, users can sell surplus energy to the grid, trade it with other individuals in a peer-to-peer marketplace, or choose to donate it to others in need, such as community programs or low-income households.

2. Prototype’s Wireflow

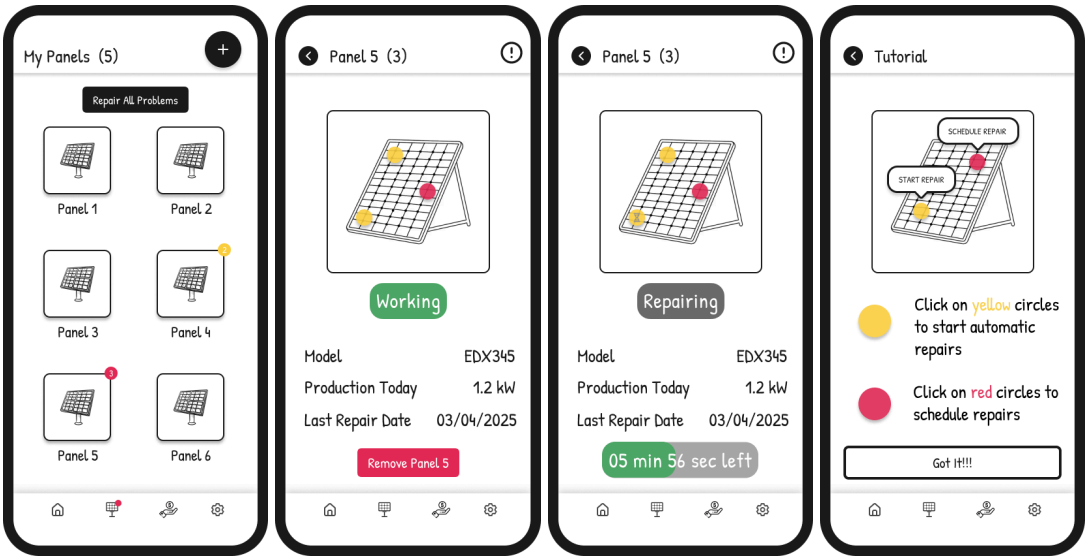
Home Screen

Provides an overview of your solar system, showing real-time power usage, battery capacity, total energy produced, today's consumption, savings, and CO2 reduction.



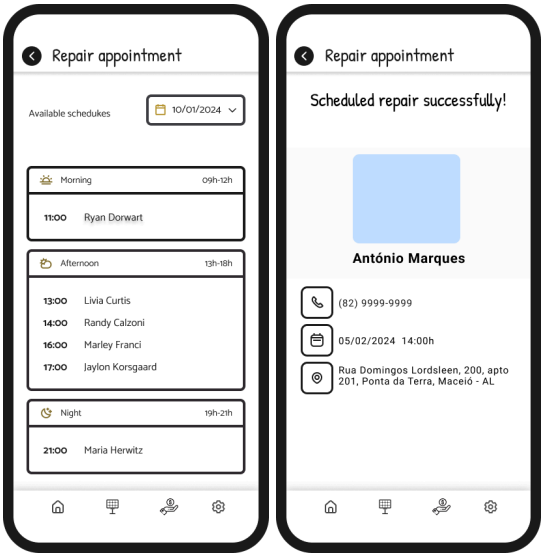
My Panels

Manage solar panels and auto-fix small problems in solar panels. Users can fix the problems with simple clicks, and if they don’t know how to do it, the app provides a small tutorial for it.



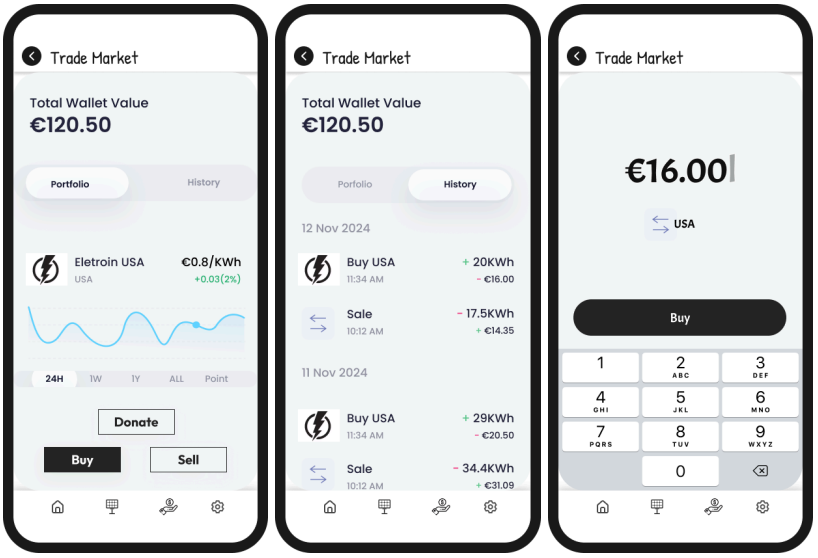
Schedule a repair

This section lets users book a professional technician for critical repairs or maintenance tasks beyond the scope of auto-repair.



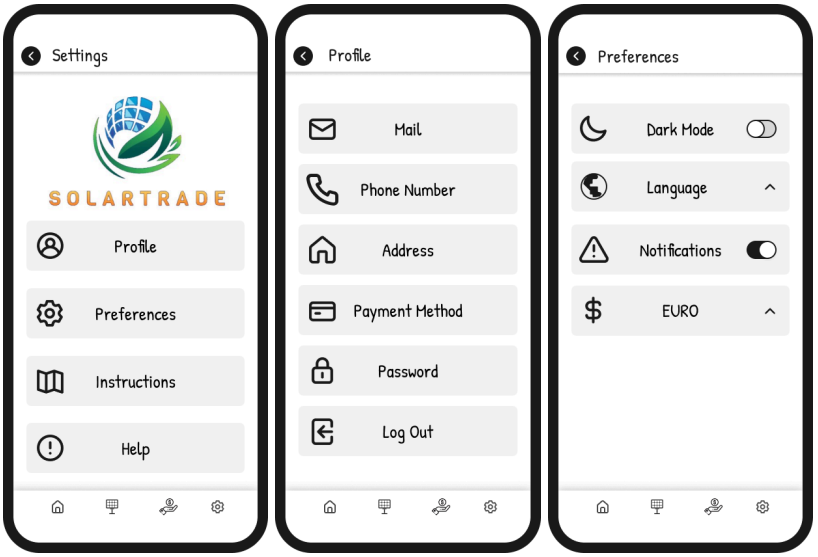
Trade Market

A marketplace where users can sell, buy, or donate excess energy from their solar panels.



Settings

Customize and manage your app preferences.



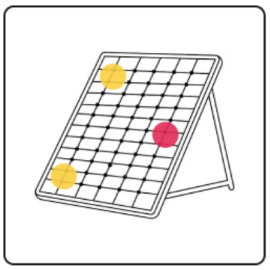
3. Digested Heuristic Evaluation Results

I. The second button (wrench) and the fourth one (cogwheel) can both mean “preferences” or “configuration”, but here they have different functions.

Heuristics: Match between system and the real world, Consistency and standards.
Severity: 2

II. The circles in the solar panels were not intuitive that they were clickable.

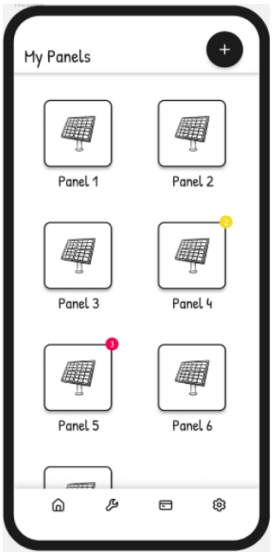
Heuristics: Recognition rather than recall.
Severity: 2



III. There is no option to remove a solar panel added by accident.

Heuristic: User control and freedom.

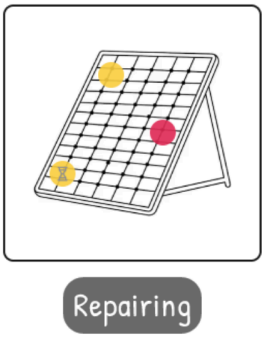
Severity: 3



IV. A panel repair should warn the user about the impacts it will have on the panel as well as ask for confirmation, since panels stop working when being repaired.

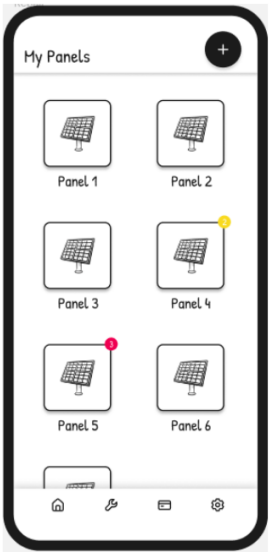
Heuristic: Error prevention.

Severity: 2



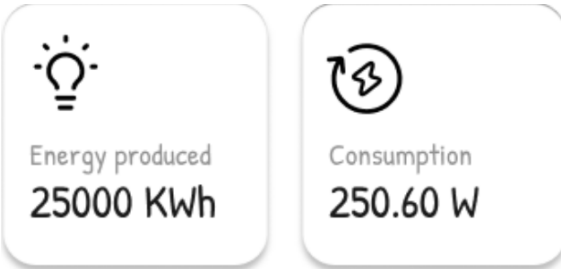
V. The user might have several panels in need of repair, for an advanced user to start repairment in all panels, they must do it individually. A “repair all” accelerator might allow experienced users to perform this task quickly.

Heuristic: Flexibility and efficiency of use.
Severity: 1



VI. The units for "energy produced" and "energy consumption" are inconsistent, as one uses watts (W) and the other uses kilowatt-hours (kWh).

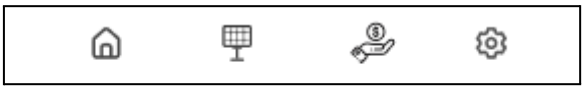
Heuristic: Consistency and standards
Severity: 3



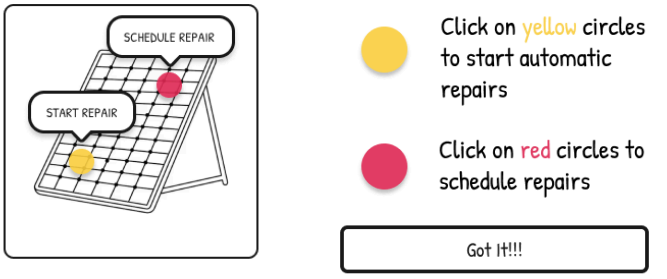
4. Corrections to perform in Phase III

Although this section is meant to outline the corrections to be made in Phase 3, we have already addressed the issues based on the results of the Heuristic Evaluations.

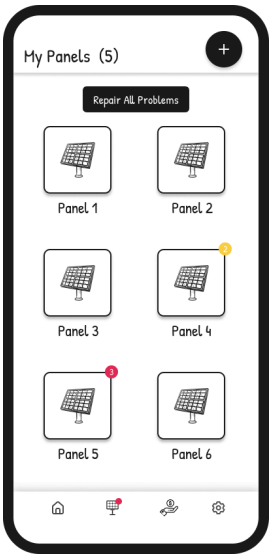
I. Changed some icons for more intuitiveness.



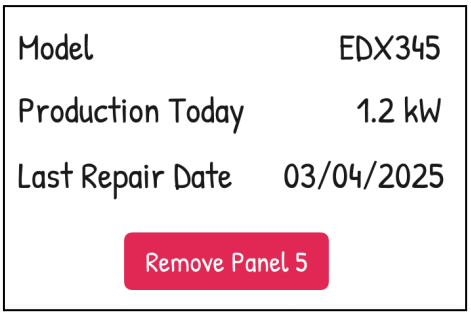
II. Added some shadows to the circles for better intuition and also a mini tutorial.



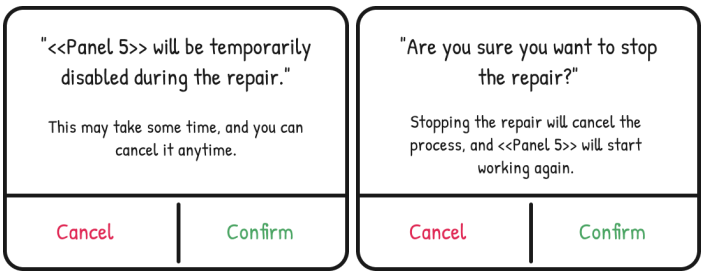
III. Added a “Repair All Problems” button in the “My Panels” section of the application.



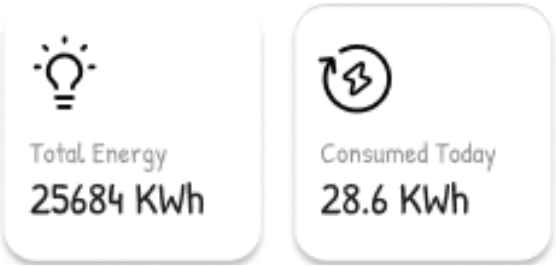
IV. Added an option to remove a panel when clicking on the specific panel in the “My Panels” section to view its details.



V. Added confirmation pop ups when clicking to repair or clicking to cancel repair.



VI. To ensure consistency, all energy production and consumption metrics are displayed in KWh.



After the presentation, we incorporated the teacher’s feedback to improve the app's quality. In the next phase, we plan to:

- Add filters to the production history for better data navigation and analysis.
- Introduce a calendar view before listing available technicians, making the repair scheduling process more intuitive and user-friendly.

Phase III - Hi-fi prototype and user evaluation

1. Changes to Parts I and II

There were no significant changes to Part I, as we maintained all the main features planned from the beginning.

From the feedback received in Part II, we worked on building the app's UI, understanding that the interface is crucial for making a strong first impression. To enhance the user experience, we added features like a loading screen to simulate tasks that might take some time. While the prototype doesn't have actual delays, this simulation helps replicate a more realistic experience.

We also included feed screens and ensured that all buttons in the prototype are functional. For buttons without implemented features, we added guiding screens and pop-ups to direct users to the appropriate sections.

We successfully implemented all the corrections suggested in Part II, introducing new features such as detailed history of energy consumption for each house section or device, filters to view power usage on a daily or weekly basis, and interactive hint buttons that display tips when hovered over.

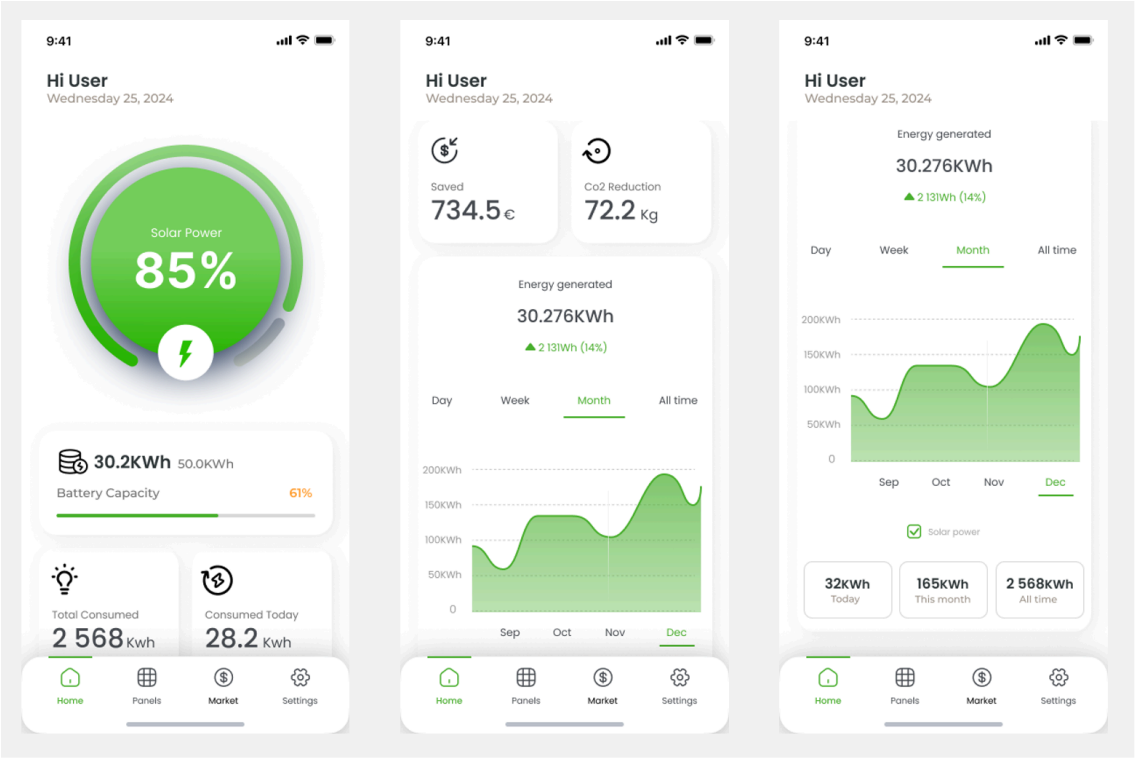
2. Prototype's Wireflow

The prototype was fully designed in **Figma**, with the link provided in the Annexes. Users can navigate between various sections using the button navigation bar for a seamless experience.

1. Overview of the Solar Panel Ecosystem

The home screen (scrollable) provides a clear overview of the solar panel system's current state, including:

- **Current Solar Power Usage:** A percentage showing how much of the panels' power capacity is being utilized relative to their maximum capacity.
- **Battery Capacity:** The amount of stored energy available.
- **Total and Today's Consumption:** Energy used so far and energy used today.
- **Savings:** Money saved since the solar panels were installed.
- **CO2 Reduction:** The environmental impact in terms of reduced carbon emissions.
- **Total Energy Generated:** The overall energy produced by the panels.



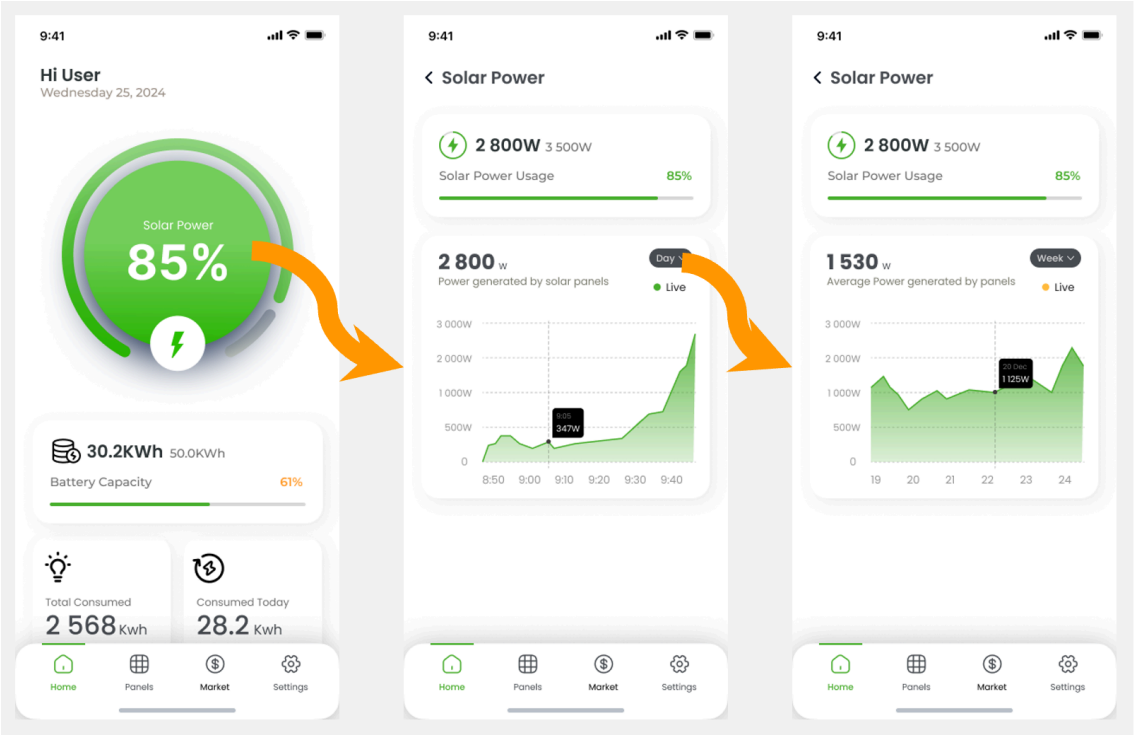
Note: *Watts (W) measure the rate of electricity use, while kilowatt-hours (kWh) represent the total amount of electricity consumed over time.*

2. Detailed Solar Power Usage

By clicking on the green circle on the home screen, users can access detailed insights into solar power usage. This screen displays:

- The current solar power percentage (relative to the panels' maximum capacity).
- A breakdown of power usage at different times of the day.

Additionally, users can filter data by **day** or **week** and view a graph showing usage trends over specific dates and times.



3. Detailed Energy Consumption

By clicking on the consumption section on the home screen, users can view detailed insights into their energy usage. This screen provides:

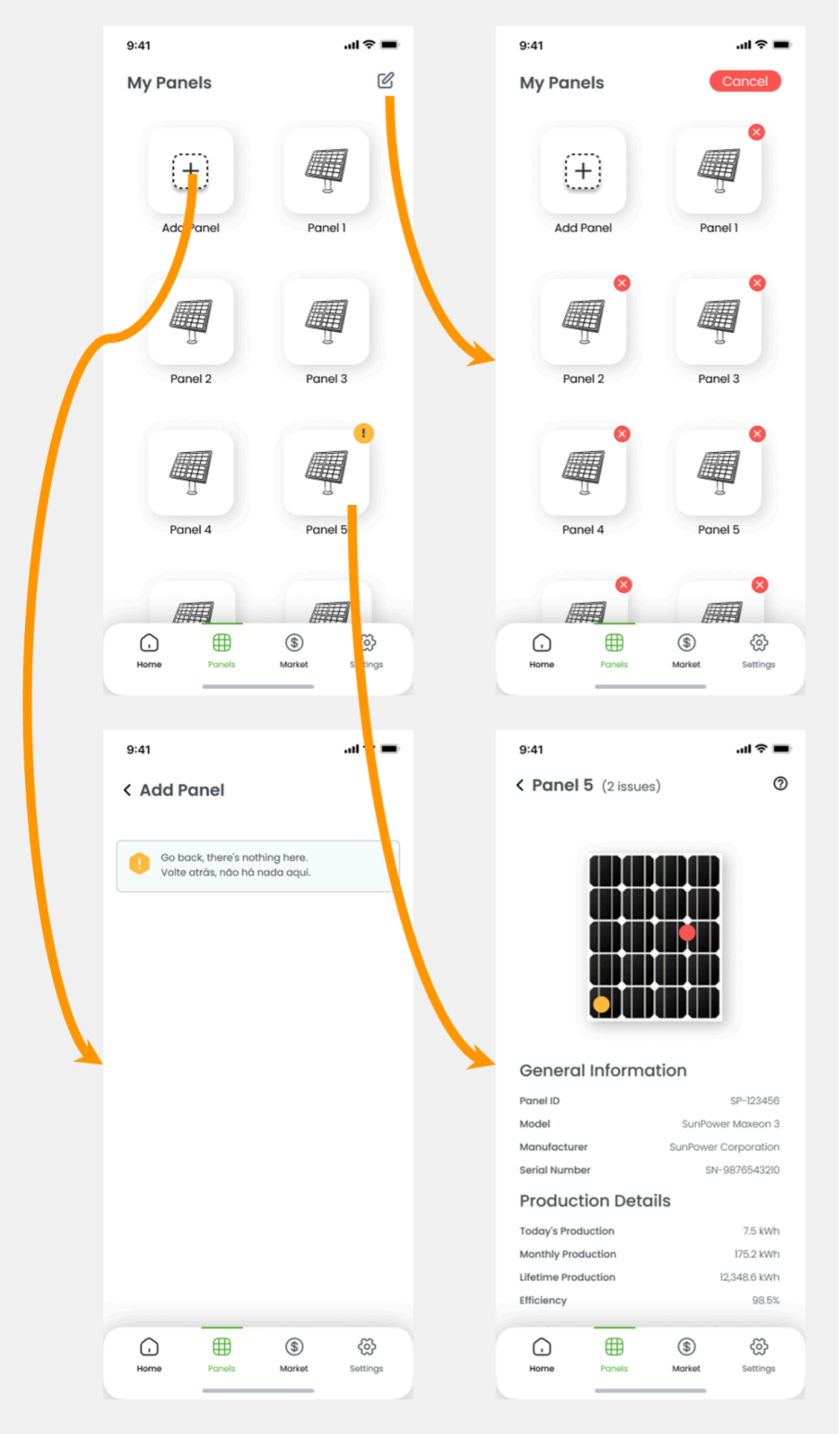
- **Daily** and **weekly** energy consumption breakdowns.
- Percentages of energy consumed by different areas or appliances in the home.

Clicking on "Consumed Today" will directly filter the data to show daily consumption. Users can view a graph illustrating usage trends over selected dates and times.

4. Manage My Panels

In the "Panels" section, users can view and manage their solar panels with the following options:

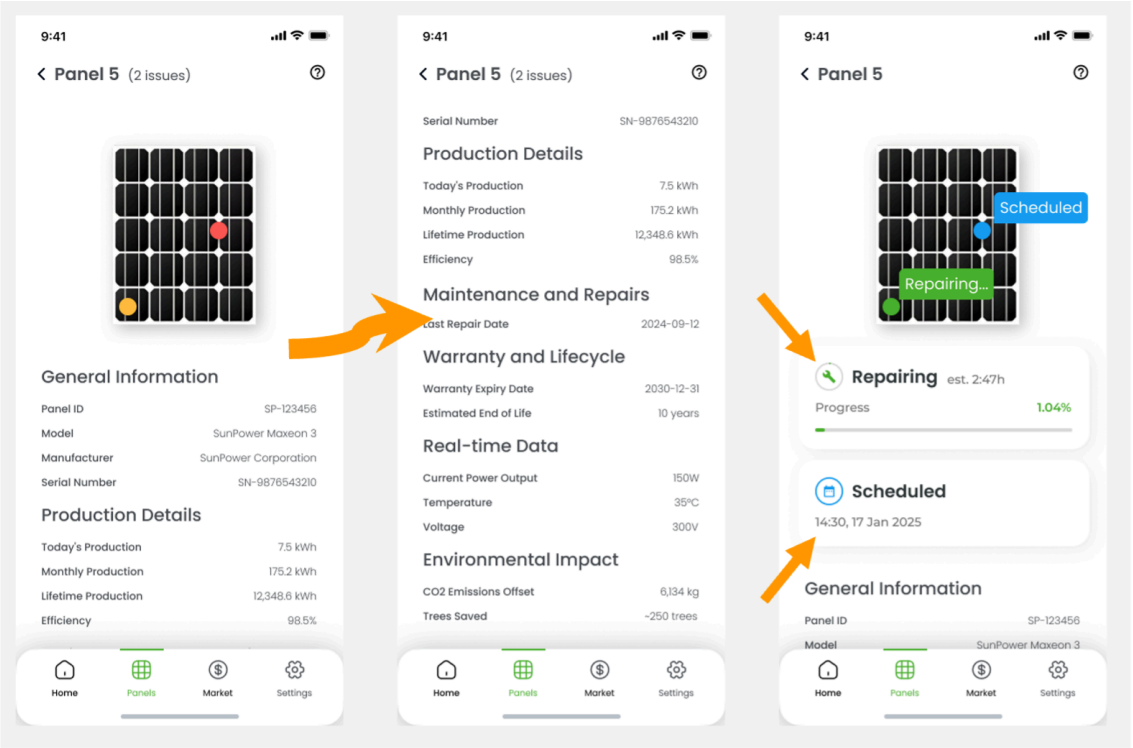
- **Panel Management:** View the list of panels and access details for each.
- **Add Panels:** Since adding panels is not a primary function, clicking this will display a guide screen to redirect users through the correct task.
- **Problem Alerts:** Panels with issues will show a (!) icon in the top-right corner, signaling that attention is needed.


9:41
My Panels
Add Panel
Panel 1
Panel 2
Panel 3
Panel 4
Panel 5
Home
Panels
Market
Settings
9:41
My Panels
Cancel
Add Panel
Panel 1
Panel 2
Panel 3
Panel 4
Panel 5
Home
Panels
Market
Settings
9:41
Add Panel
Go back, there's nothing here.
Volte atrás, não há nada aqui.
Home
Panels
Market
Settings
9:41
Panel 5 (2 issues)
General Information
Panel ID SP-123456
Model SunPower Maxeon 3
Manufacturer SunPower Corporation
Serial Number SN-9876543210
Production Details
Today's Production 7.5 kWh
Monthly Production 175.2 kWh
Lifetime Production 12,348.6 kWh
Efficiency 98.5%
Home
Panels
Market
Settings

5. Solar Panel Details

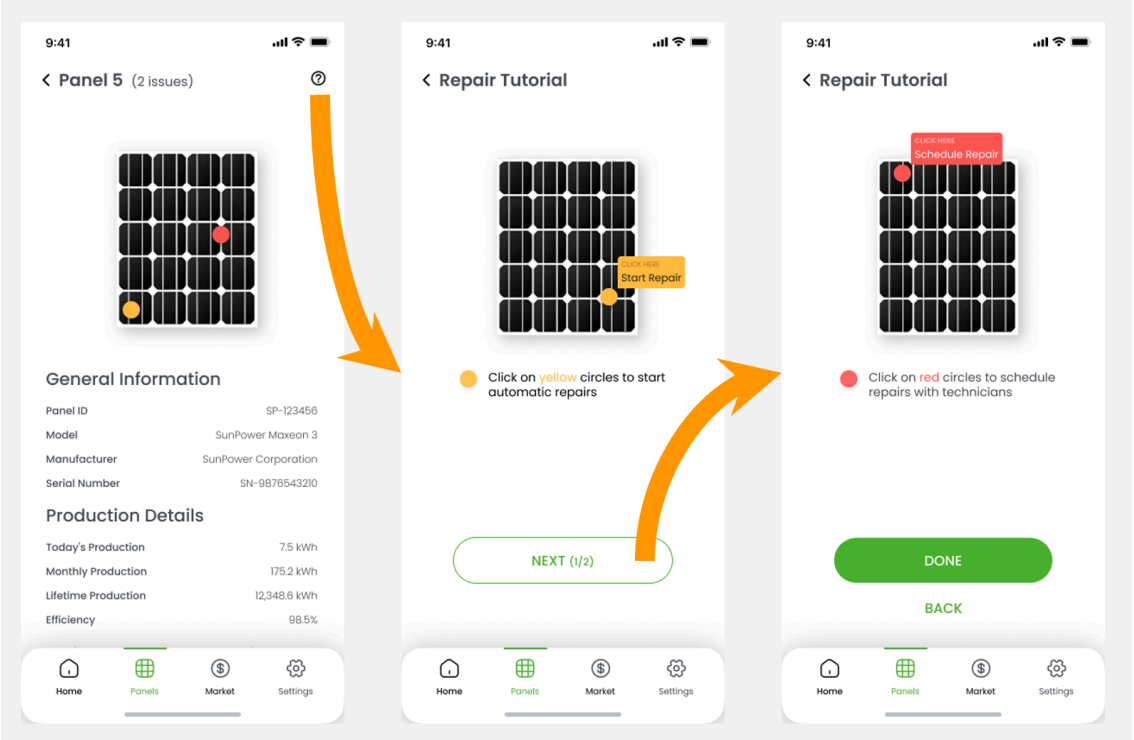
By selecting a specific panel, users can view detailed information about its performance and status, including:

- **Panel Details:** General information such as model, manufacturer, serial number, production details, performance, last repairs and maintenance dates, warranty, lifecycle, real-time data, environmental impact, etc.
- **Current State:** Information about any existing issues, including alerts for repairs, as well as the current repair status or scheduled technician details.



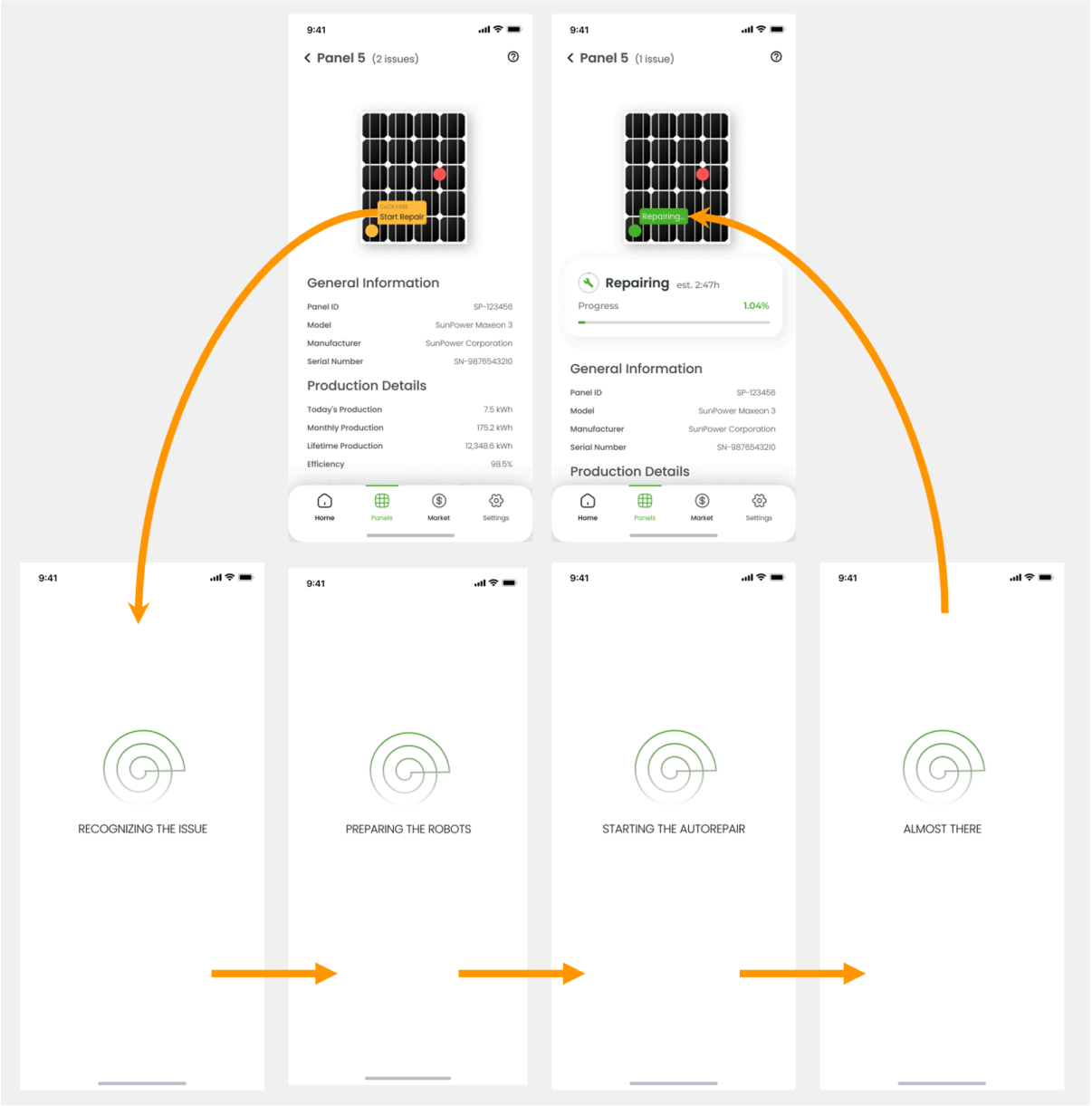
6. Repair Tutorial

On the solar panel details page, users can access a tutorial by clicking the (**?**) icon in the top-right corner. The tutorial provides guidance on using the auto-repair feature and scheduling repairs with a technician.



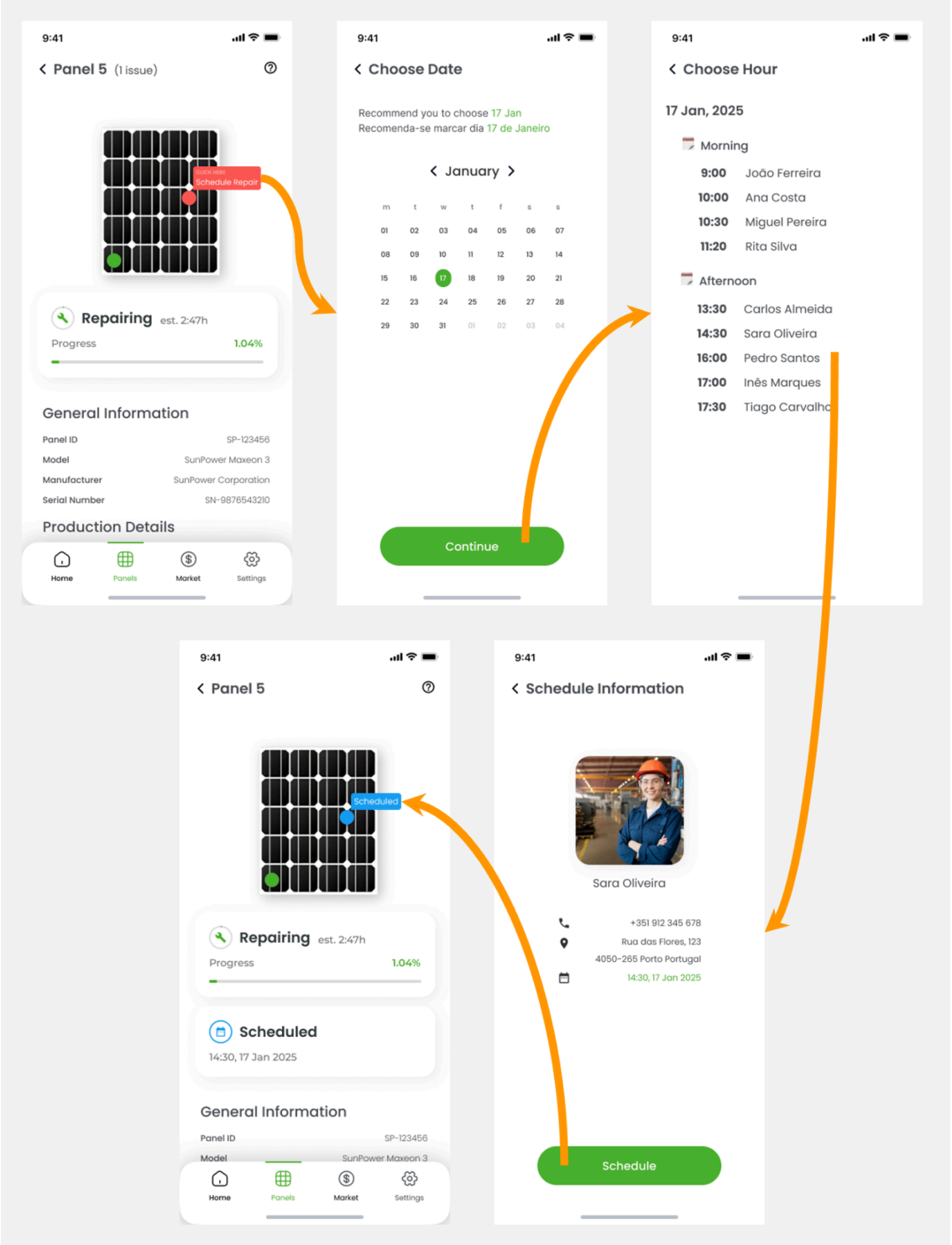
7. Start Auto-Repair

For non-critical issues, indicated by a yellow warning icon on the panel's picture, users can start an auto-repair for the specific panel with some simple clicks.



8. Schedule a Repair

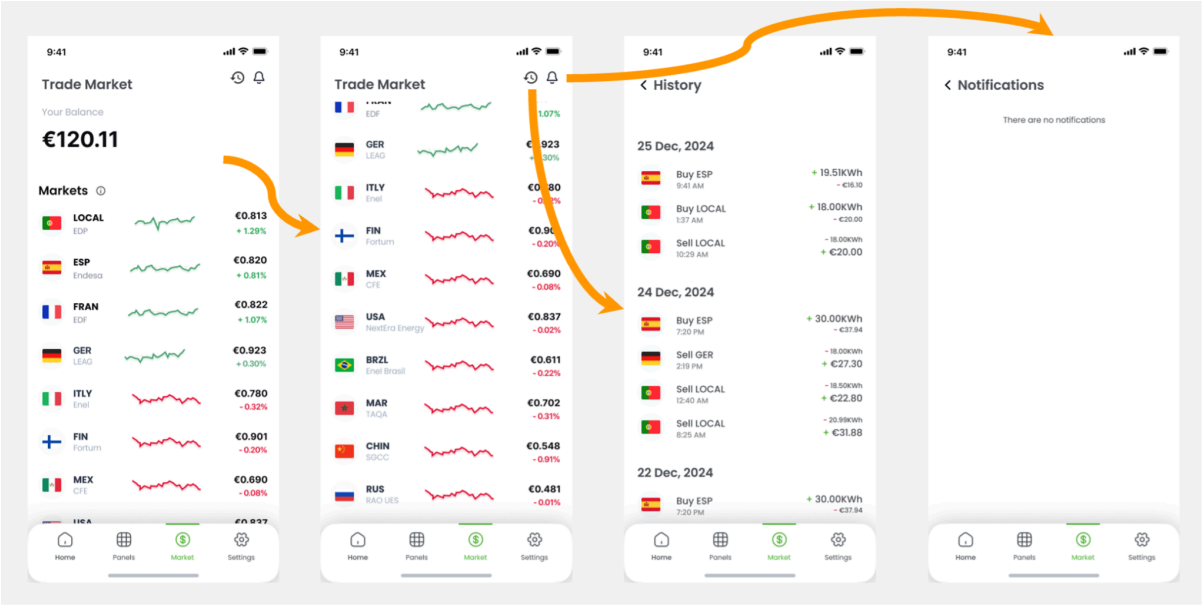
For critical issues, indicated by a red warning icon on the panel's picture, users can schedule a repair appointment with a professional technician directly from the panel details page. Users can choose a specific day and time that works best for them.



9. Navigate the Trade Market

Users can explore a global marketplace to **buy**, **sell**, or **donate** energy within a large community. On this screen, users can:

- View their balance.
- Access transaction history and notifications about the trades.
- Explore various markets by country, including information about each country's affiliated energy company and the current price per kWh.

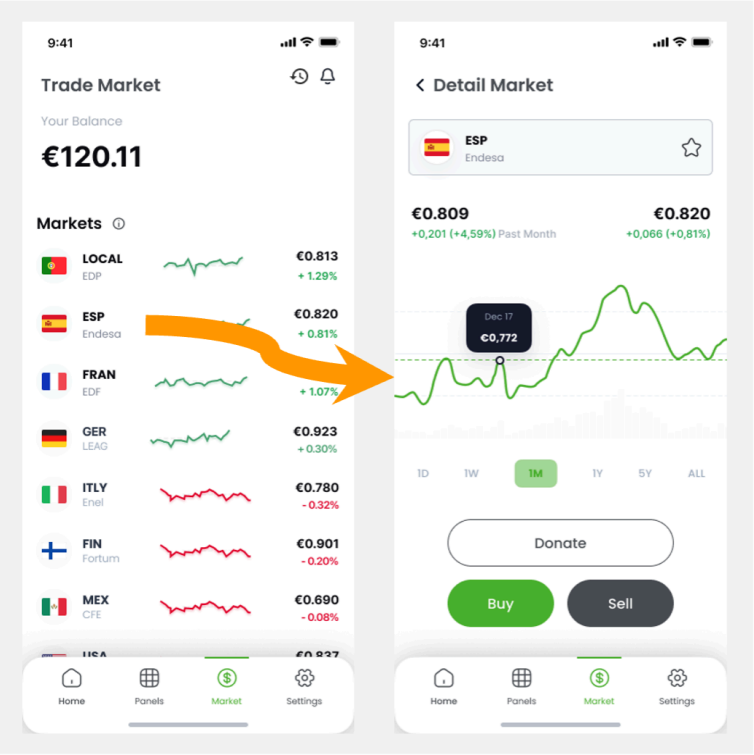


10. Market Details

By selecting a country, users can view detailed information, such as:

- Current price per kWh.
- Historical pricing, with monthly averages compared to the current price.
- A graph showing price variation over time.

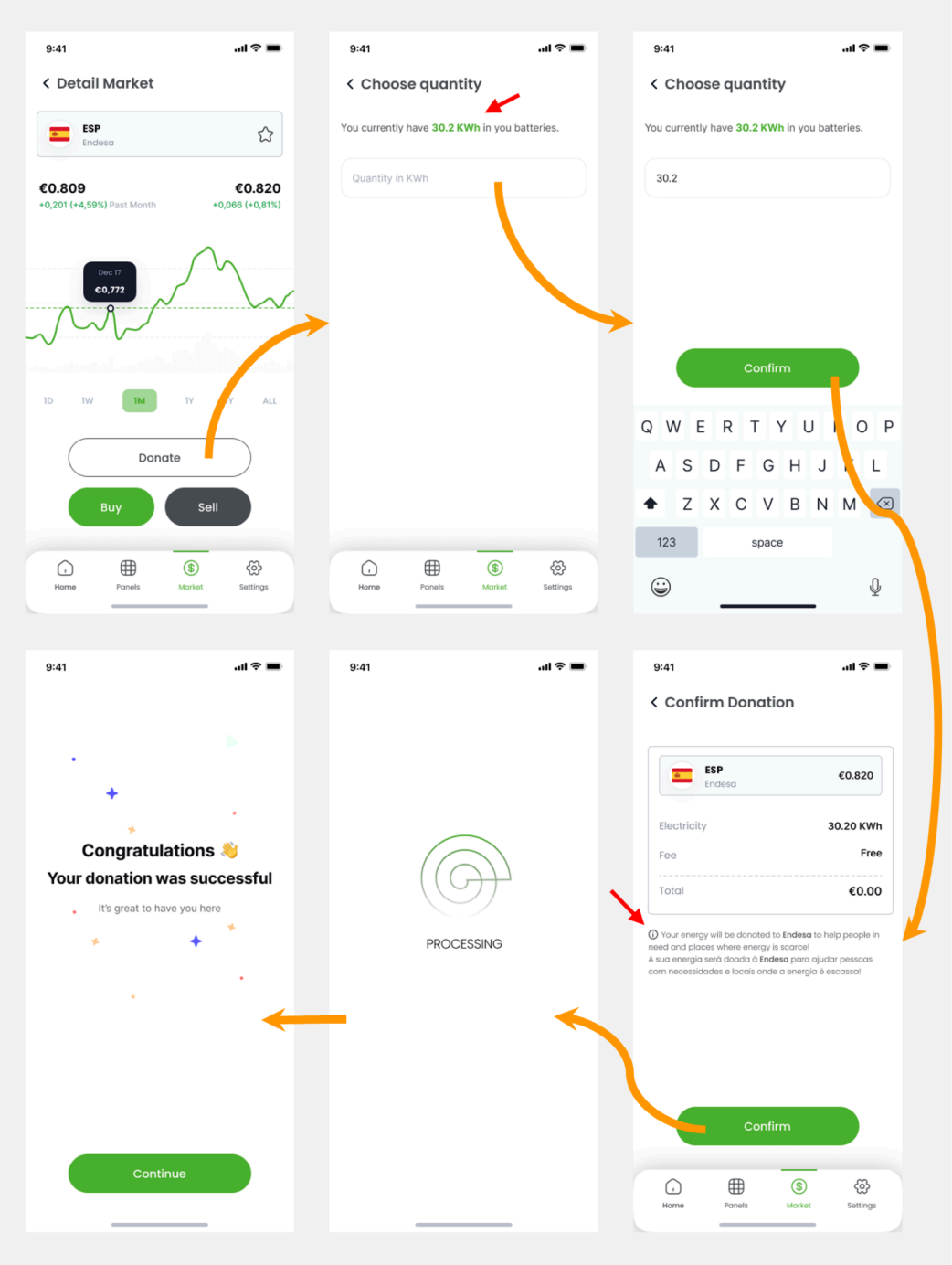
Users can also choose to donate, sell, or buy energy from that country. Additionally, they can save markets by clicking the **star** icon to receive future notifications.



11. Donate Energy

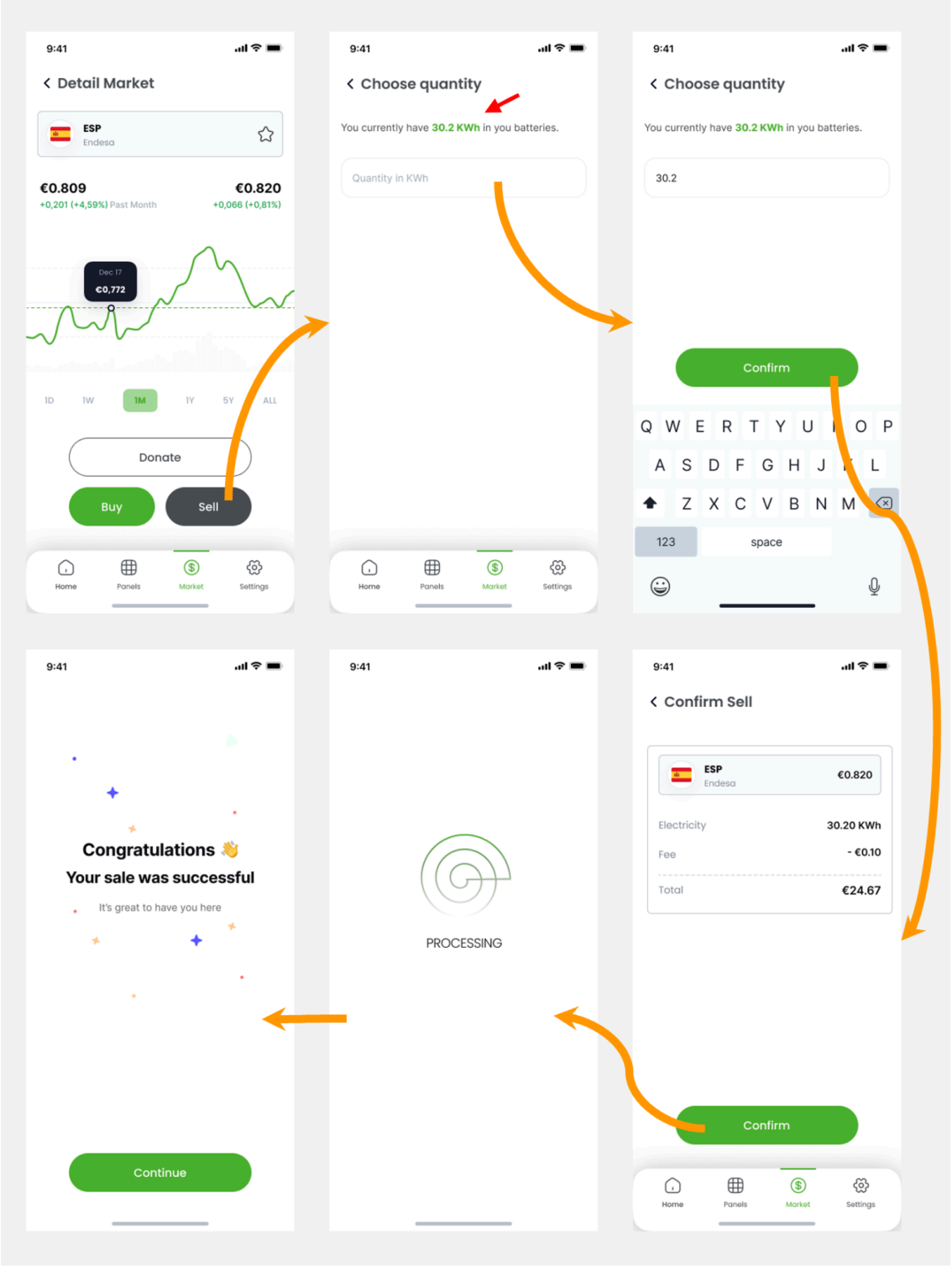
By clicking the donate button, users can:

- Select the amount of energy they want to donate.
- View their current battery energy levels.
- Confirm the donation on a screen that displays donation details along with helpful tips and explanations.



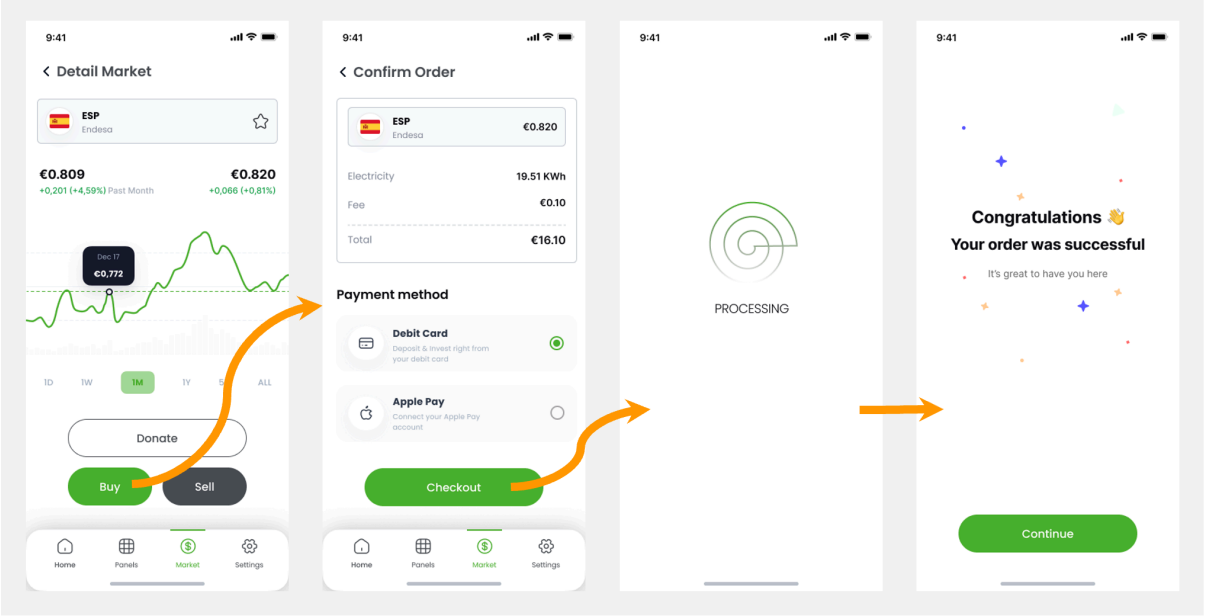
12. Sell Energy

By clicking the sell button, users can sell energy to a selected country. The process is similar to donating.



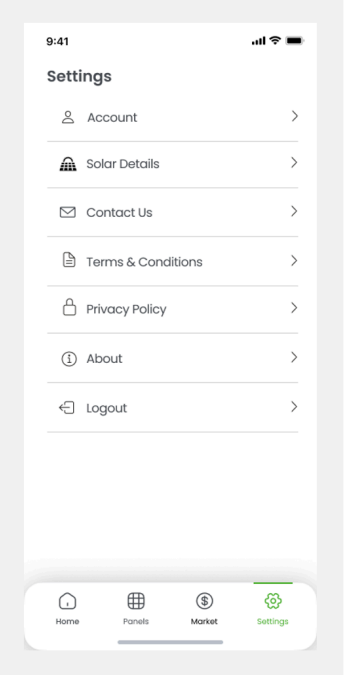
13. Buy Energy

By clicking the buy button, users can purchase energy from the selected market. The screen shows transaction details, including the current price and available payment methods.



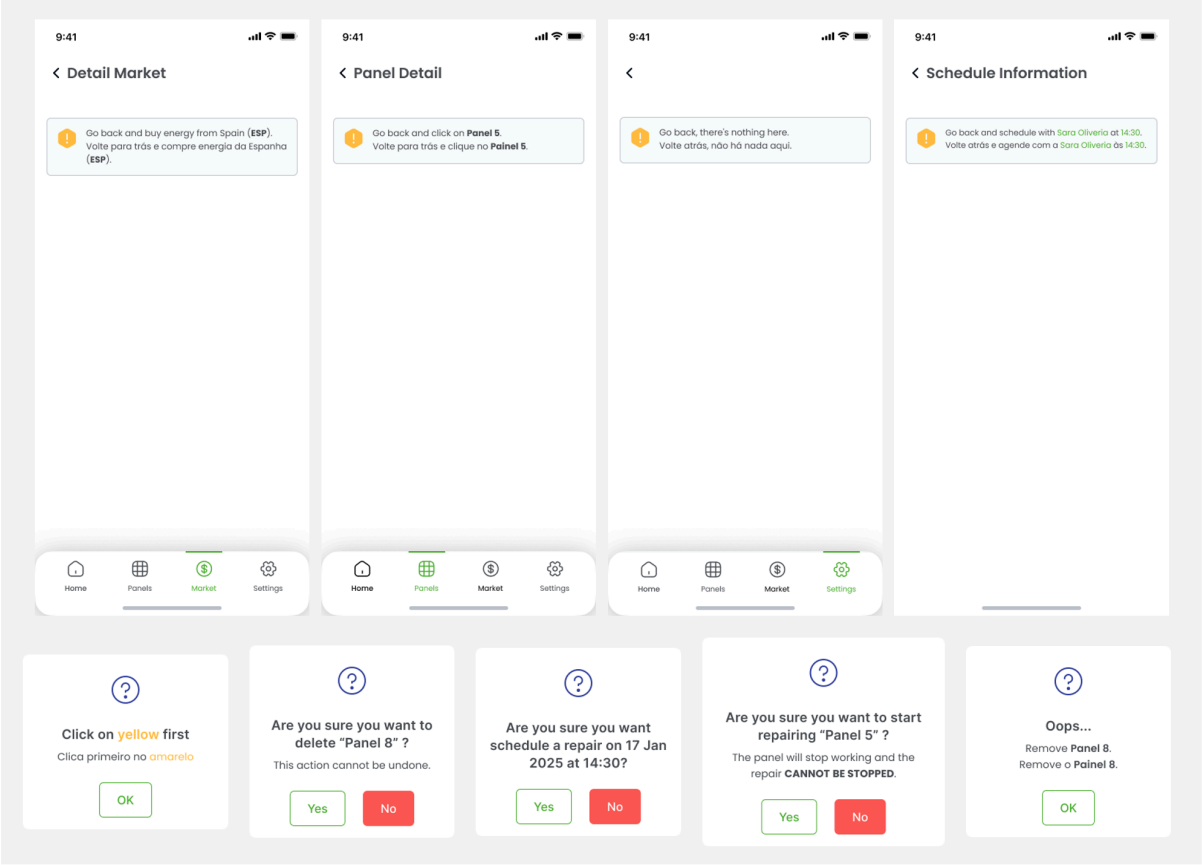
14. View Settings

Users can access and manage their app settings on the settings page. For the prototype, we only designed the interface and did not implement any additional functionality.



Guiding Screens and Pop-ups

To enhance the prototype's interactive experience, we made all buttons clickable. To ensure users can navigate seamlessly and avoid getting stuck, we added guiding screens and pop-ups that direct them to the correct tasks.



3. User evaluation protocol

Objective

This evaluation aims to assess the usability and user experience of the app designed to help users manage their solar panel systems. Participants will complete 7 tasks covering the app's 3 core features, including energy monitoring, panel management, and the trade market.

The session will take about 5 minutes and concludes with a short survey to gather feedback on user satisfaction. This evaluation helps validate the app's design and identify any usability challenges.

Users

The evaluation is open to everyone, as the app is designed to be inclusive and suitable for all age groups and backgrounds. Given its universal usability, we did not find it necessary to collect demographic data such as age or expertise. Participants were self-selected volunteers who accessed the evaluation via the provided URL.

Since all participants were Portuguese, the evaluation was conducted entirely in Portuguese, including all instructions, questions, and tasks, to ensure clarity and accessibility for the users.

Method

The usability evaluation was conducted using Maze (maze.co), a platform that seamlessly integrates with our Figma prototype. This compatibility made the evaluation process straightforward and efficient.

The Maze report provided valuable insights, including success rates and average task duration, along with heatmaps for each screen. Additionally, it offers a unique feature that distinguishes between direct and indirect task success. This means it tracks whether users followed the optimal path defined for each task or completed it through an alternative route. These metrics are crucial for evaluating task effectiveness and overall usability.

In addition, we used Google Forms (www.google.com/forms/about/) to distribute a quick satisfaction survey, which included the Maze evaluation link in its header.

Tasks

The usability evaluation included a sequence of tasks designed to guide users through exploring key features of the app. This sequence was carefully chosen to provide a smooth learning curve for first-time users while testing various functionalities. Each task included a title, a detailed description, the task's goal, and hints if necessary.

Task 1: Ver a potência média semanal produzida pelos painéis solares

Testar funcionalidade de ver estatístcas.

Dica: clicar no círculo "Solar Power"

Task 2: Ver o consumo diário dos dispositivos

Testar a funcionalidade de ver estatísticas de consumo.

Task 3: Comprar energia da ESPANHA

Testar a funcionalidade de compra de energia no "Trade Market".

Task 4: Vender energia para a ESPANHA

Testar a funcionalidade de venda de energia excessiva no "Trade Market".

Task 5: Ver tutorial sobre reparação de painéis

Visualizar tutorial, situado no "painel 5", sobre reparação de painéis até ao fim.

Task 6: Reparar painel 5 com "Auto-Repair"

Testar a funcionalidade de ativar o "auto-repair" de um painel em mau funcionamento.

Task 7: Agendar reparação do painel 5 com um técnico

Testar a funcionalidade de agendar uma reparação com a Técnica "Sara Oliveira" às 14:30 dia 17 de Janeiro.

The sequence of tasks was grouped by similarity and type, progressing from easier to more complex tasks. This approach ensured that users could learn and explore the app's features in a logical order, providing valuable usability insights throughout the evaluation.

Measures

For this evaluation, we collected both objective and subjective data to assess the app's usability.

1. **Maze Data**

Maze helped us collect important usability data during the evaluation:

- **Success Rate:** Percentage of tasks completed successfully.
- **Drop-offs:** Percentage of users who abandoned tasks or ended up on the wrong screen.
- **Direct and Indirect Success:** Whether users completed tasks using the optimal path (direct) or another method (indirect).
- **Average Duration:** Time taken to finish each task.
- **Heatmaps:** Visual representations of user interactions on each screen, highlighting areas of high activity and identifying steps where users encountered difficulties.

2. **Survey Data**

The satisfaction survey (via Google Forms) to gather users' feedback, mainly consisting of ratings on a 1 to 4 scale for satisfaction, usability, and perceived usefulness of the app and also a 1 to 10 scale for overall rating.

The 1 to 4 scale was chosen to encourage participants to express clear opinions, either positive or negative, avoiding neutral responses.

4. Results

Sample characterization

The collected sample includes a total of 24 responses from the Maze usability questionnaire and 21 satisfaction survey responses via Google Forms, completed after testing the app's usability. As mentioned earlier, the app was designed to be inclusive and suitable for everyone; therefore, no demographic information such as age, gender, or occupation was collected from participants.

Statistical analysis

Task 1: Ver a potência média semanal produzida pelos painéis solares

Quantitative Analysis

Duration (s)

Mean	Median	SD (σ)	95% CI	LCI	UCI	Expected
31,5	18,9	49,9	20,9	10,6	52,3	15

Success Rate

91.7% (22 successful completions out of 24 responses).

This task did not involve an optimal path, as the goal was simply to reach the target screen.

Drop-Off Rate

8.3% (2 participants did not complete the task).

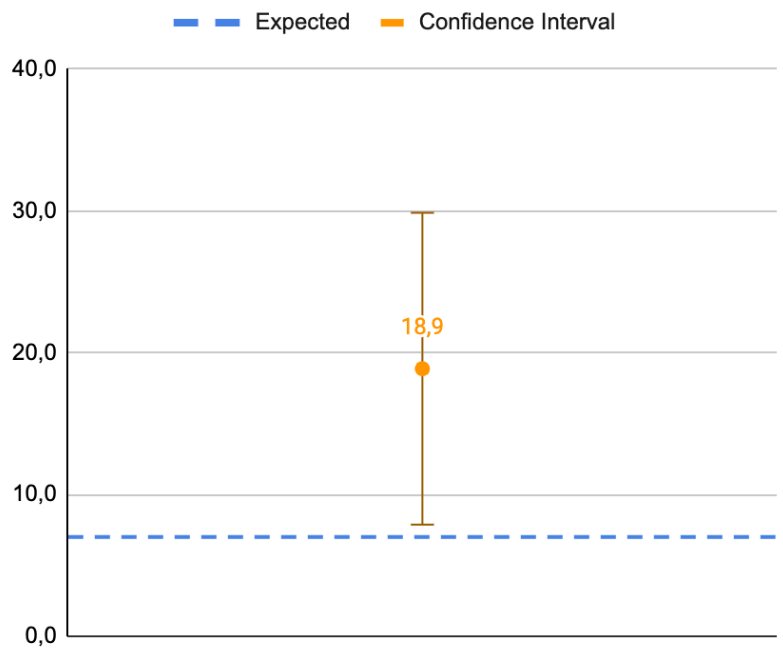
Qualitative Analysis

Overall, the results were positive and within expectations. The expected time for task completion falls within the confidence interval. Although the task was relatively simple, many users, upon their first contact with the app, chose to explore various features instead of completing the tasks. Additionally, analysis of the heatmaps captured by Maze revealed that some users struggled with the logic of the maze and testing process. They mistakenly believed they had completed the task and proceeded to explore other features and screens.

Task 2: Ver o consumo diário dos dispositivos

Quantitative Analysis

Duration (s)



Mean	Median	SD σ	95% CI	LCI	UCI	Expected
18,9	9,7	25,1	11,0	7,9	29,9	7,0

Success Rate

95.2% (20 successful completions out of 21 responses).

This task did not involve an optimal path, as the goal was simply to reach the target screen.

Drop-Off Rate

4.8% (1 participant did not complete the task).

Qualitative Analysis

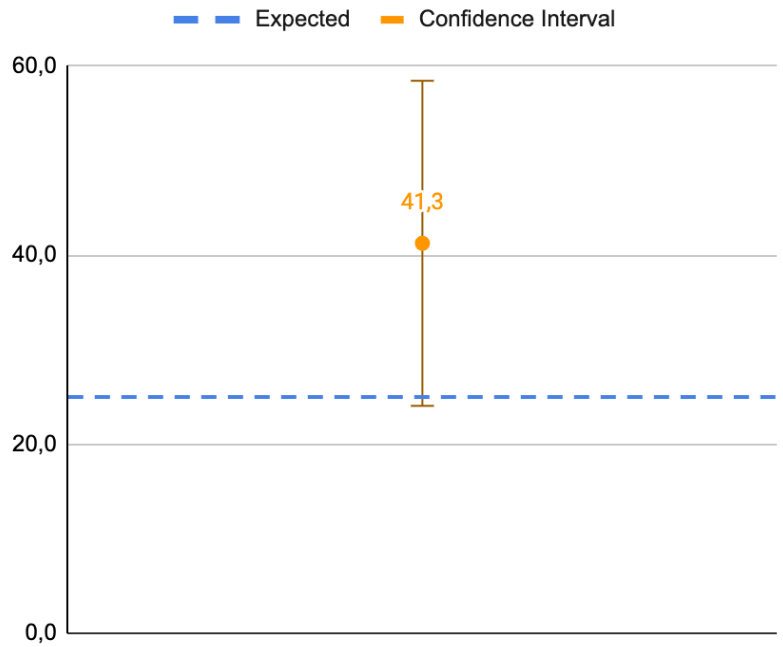
In this task, the time taken to complete the task was longer than expected, as shown by the confidence interval. The heatmap analysis revealed that many users explored other areas of the app instead of focusing on completing the task, as well as the previous task. Additionally, a number of users did not notice or understand how to use the filters on the consumption page, which likely contributed to the longer completion time and the unexpected results. This indicates that, while the task itself was simple, users' exploratory behavior and lack of understanding of certain features affected their performance.

Furthermore, compared to the previous task, we observed that some users gave up on completing the task, as reflected in the number of responses.

Task 3: Comprar energia da ESPANHA

Quantitative Analysis

Duration (s)



Mean	Median	SD (σ)	95% CI	LCI	UCI	Expected
41,3	27,5	37,2	17,2	24,1	58,5	25,0

Success Rate

90.0% (18 successful completions out of 20 responses).

This task included an optimal path to the target screen. Of the 18 successful completions, 3 were direct successes (16.7%), and 15 were indirect.

Drop-Off Rate

10% (2 participants did not complete the task).

Qualitative Analysis

In this task, the expected duration to complete was within the confidence interval, indicating that the performance aligned with expectations. This task was more complex than the previous ones, involving additional information and the introduction of a new functionality, so we anticipated more difficulties.

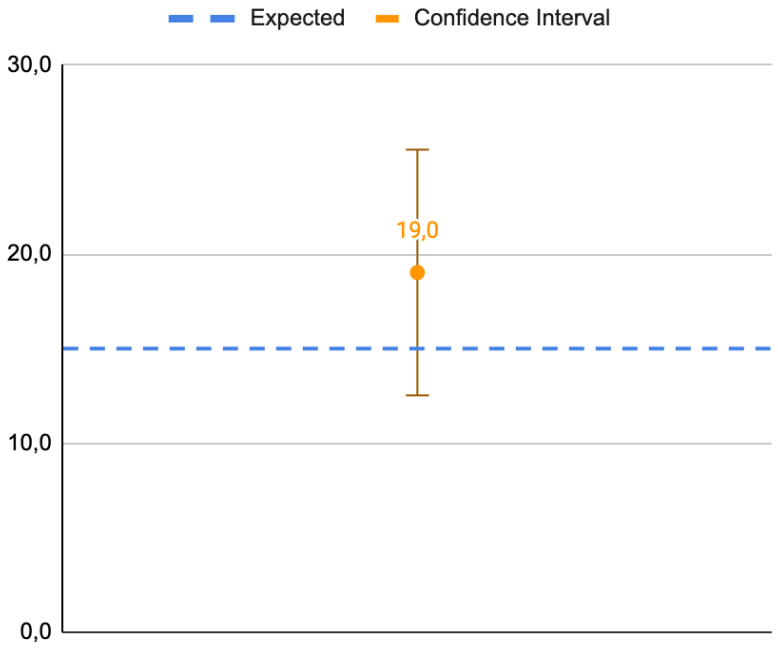
The heatmap analysis revealed that of the 15 indirect successes, approximately 7 were misclassified by the system. These participants followed the correct path, but the system registered their attempts as indirect successes rather than direct.

Furthermore, compared to the previous task, we observed that some users gave up on completing the task, as reflected in the number of responses.

Task 4: Vender energia para a ESPANHA

Quantitative Analysis

Duration (s)



Mean	Median	SD (σ)	95% CI	LCI	UCI	Expected
19,0	15,2	13,7	6,5	12,5	25,5	15,0

Success Rate

94.7% (18 successful completions out of 19 responses).

This task included an optimal path to the target screen. Of the 18 successful completions, 8 were direct successes (44.4%), and 10 were indirect.

Drop-Off Rate

5.3% (1 participant did not complete the task).

Qualitative Analysis

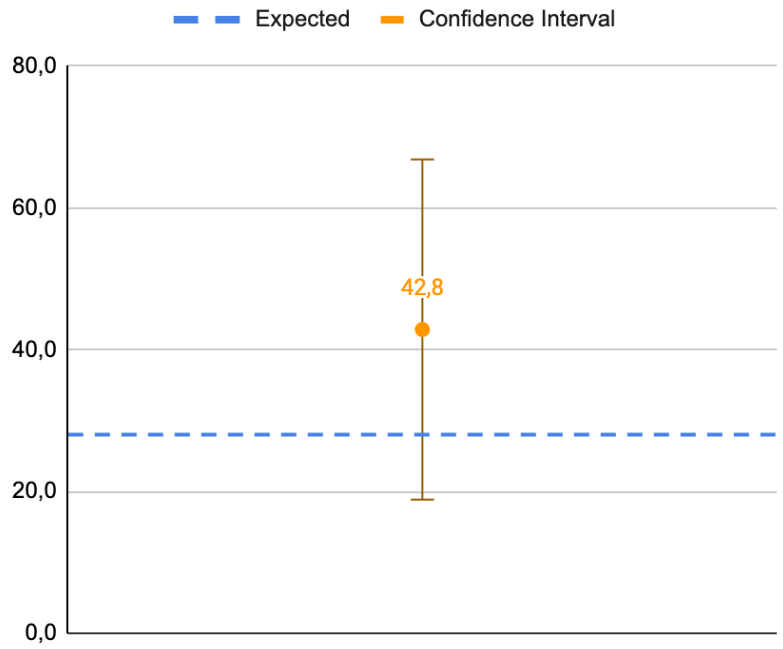
In this task, the expected duration fell within the confidence interval, which aligns with expectations, as this task is very similar to the previous one. Users likely felt more confident and experienced after completing the earlier task.

Analyzing the heatmap, we observed that 6 of the 10 indirect successes were misclassified by Maze. In reality, 14 out of 18 completions were direct, which is an excellent result. Additionally, we identified an outlier in the duration data (246.6 seconds) that was significantly above the mean (19 seconds). Upon closer inspection, we concluded that this outlier resulted from a user remaining on a single screen without making any clicks for 213.7 seconds. This value was excluded from the duration analysis to ensure it did not distort the results.

Task 5: Ver tutorial sobre reparação de painéis

Quantitative Analysis

Duration (s)



Mean	Median	SD (σ)	95% CI	LCI	UCI	Expected
42,8	27,3	50,5	24,0	18,9	66,8	28,0

Success Rate

100% (out of 17 responses).

This task did not involve an optimal path, as the goal was simply to reach the target screen.

Drop-Off Rate

0%.

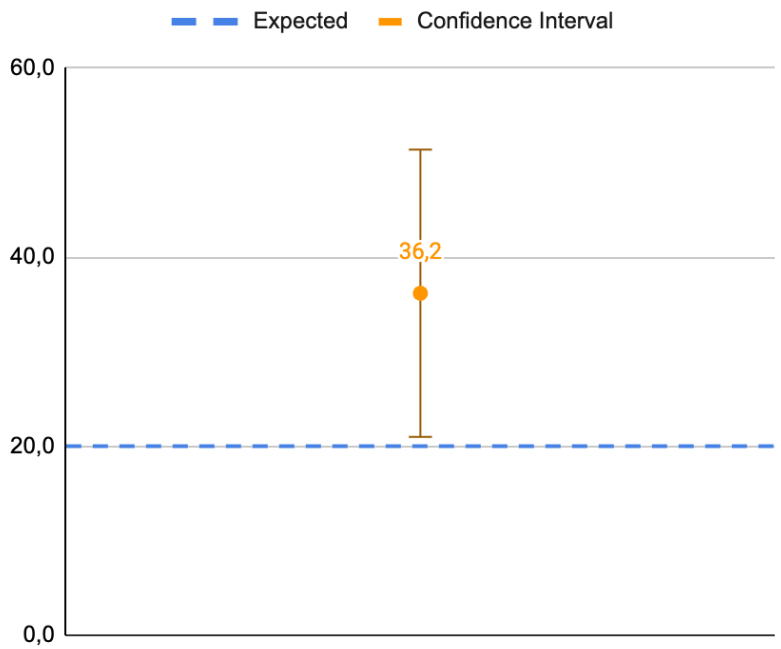
Qualitative Analysis

In this task, the expected duration was within the confidence interval, which aligns with expectations. It was a pleasant surprise that all participants successfully completed the task. This indicates a high level of success for the tutorial's functionality and overall intuitive design. However, upon closer analysis, we observed that some users underestimated their capabilities by proceeding to the “next tasks” without fully engaging with or completing the tutorial. This suggests they may have perceived the tutorial as less critical, which could lead to gaps in understanding key features, potentially affecting the proper use of the functionalities. Introducing a prompt or checkpoint to ensure users review essential steps in the real-world app could address this issue while maintaining a smooth user experience.

Task 6: Reparar painel 5 com "Auto-Repair"

Quantitative Analysis

Duration (s)



Mean	Median	SD (σ)	95% CI	LCI	UCI	Expected
36,2	22,6	32,0	15,2	21,0	51,4	20,0

Success Rate

100% (out of 17 responses).

This task included an optimal path to the target screen. All of the successful completions were indirect.

Drop-Off Rate

0%.

Qualitative Analysis

In this task, the expected duration was slightly below the confidence interval, indicating that participants took longer to complete the task than anticipated. Surprisingly, none of the completions were classified as direct successes. However, by analyzing the heatmap we found that 8 of these were misclassified by Maze, indicating that more users

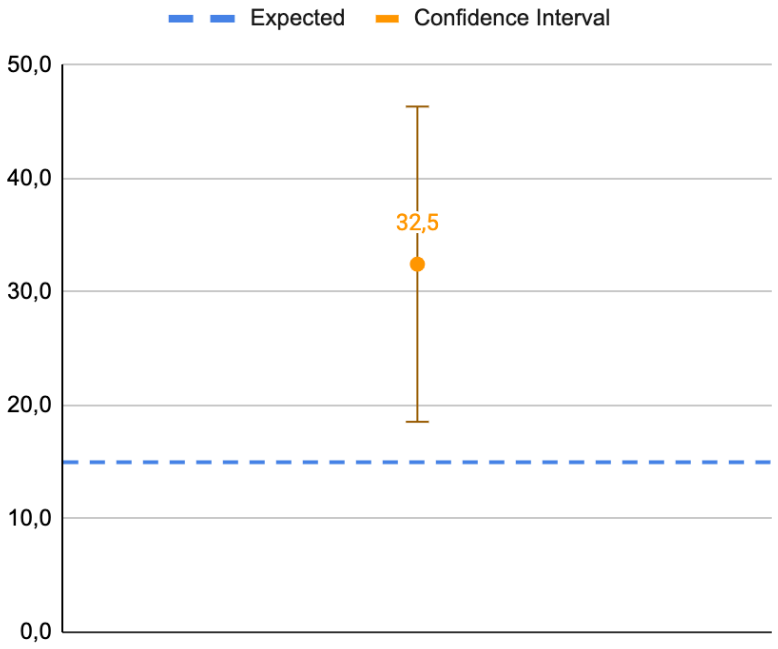
followed the optimal path than the reported.

We expected this task to be simpler, as the tutorial was clearly structured. However, the results reported that users might not have fully engaged with the instructions, possibly due to a lack of attention. This highlights the importance of ensuring tutorials are not only clear but also designed to capture and maintain user focus.

Task 7: Agendar reparação do painel 5 com um técnico

Quantitative Analysis

Duration (s)



Mean	Median	SD (σ)	95% CI	LCI	UCI	Expected
32,5	18,3	27,4	13,9	18,6	46,3	15,0

Success Rate

88.2% (15 successful completions out of 17 responses).

This task included an optimal path to the target screen. Of the 15 successful completions, 9 were direct successes (60%), and 6 were indirect.

Drop-Off Rate

11.8% (2 participants did not complete the task).

Qualitative Analysis

In this task, the expected duration was below the confidence interval, indicating that participants took longer than anticipated. We initially expected the task to be quicker than the previous one, given that users should have been more experienced. However, this task involved more complexity, requiring more clicks and interactions, which extended the completion time.

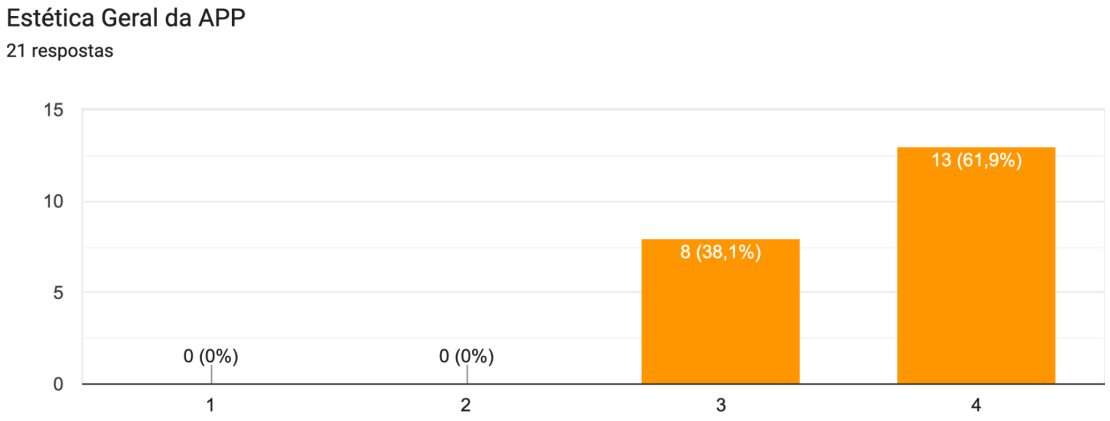
Despite these additional steps, the results confirmed our expectations that it would still be completed in less time than the previous task. By analyzing the heatmap we found that some users encountered difficulties and consulted the tutorial voluntarily, highlighting the importance of instructions for user guidance. Additionally, misclicks were observed in the confirmation pop-ups, where users canceled instead of confirming. While these misclicks did not impact on overall performance, they did slightly affect the results.

Satisfaction

After completing the usability test, users filled out a satisfaction survey, providing valuable feedback on various aspects of the app. We chose to structure the satisfaction survey with a rating scale from 1 to 4 for all questions, except the last one, to encourage participants to avoid neutral responses and make them choose a more definitive stance on various aspects of the app.

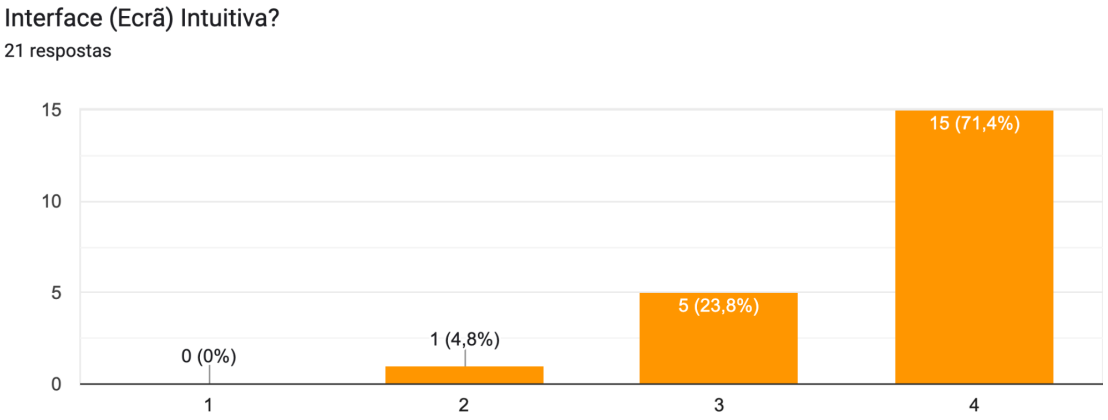
Overall Aesthetics (Estética Geral da APP)

All responses indicated a positive evaluation of the app's design, with ratings above the neutral midpoint (3 or 4). Notably, 61.9% of users found the app to be “really beautiful,” suggesting that the visual appeal of the app strongly resonated with the majority of participants.



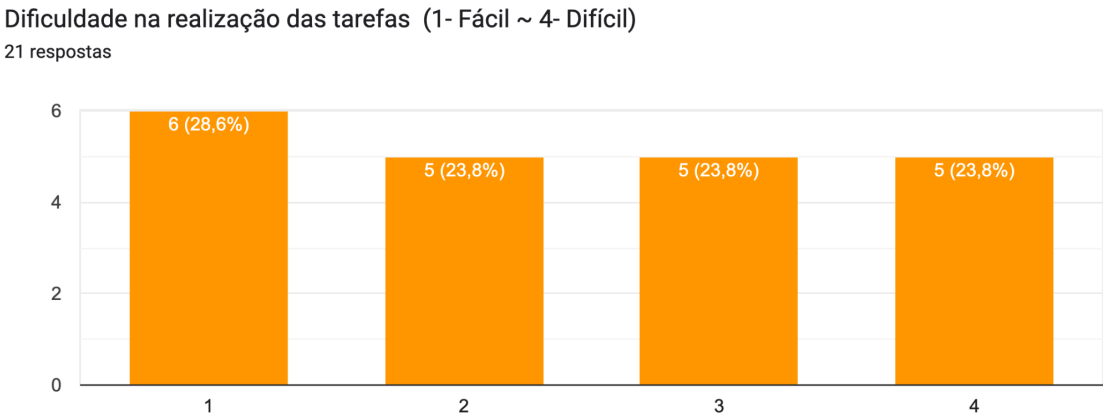
Interface Intuitiveness (Interface (Ecrã) Intuitiva?)

An impressive 95.2% of users considered the app’s interface intuitive. Furthermore, 71.4% of respondents rated it as “really intuitive” (score of 4). This result highlights that most users felt confident navigating the app without encountering significant usability challenges, indicating that the design effectively supported user interaction.



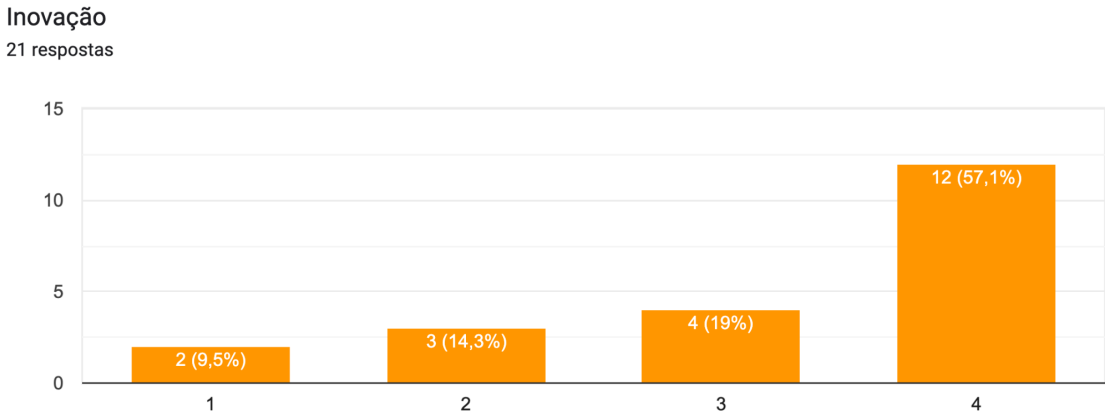
Tasks Difficulty (Dificuldade na realização das tarefas)

The difficulty of the tasks was perceived as well-balanced. 28.6% of users rated the tasks as “really easy” (1), while 23.8% found them “easy” (2). This suggests that a substantial portion of users found the tasks manageable, leading to a positive overall experience. However, the remaining participants likely felt that the tasks were appropriately challenging without being overwhelming.



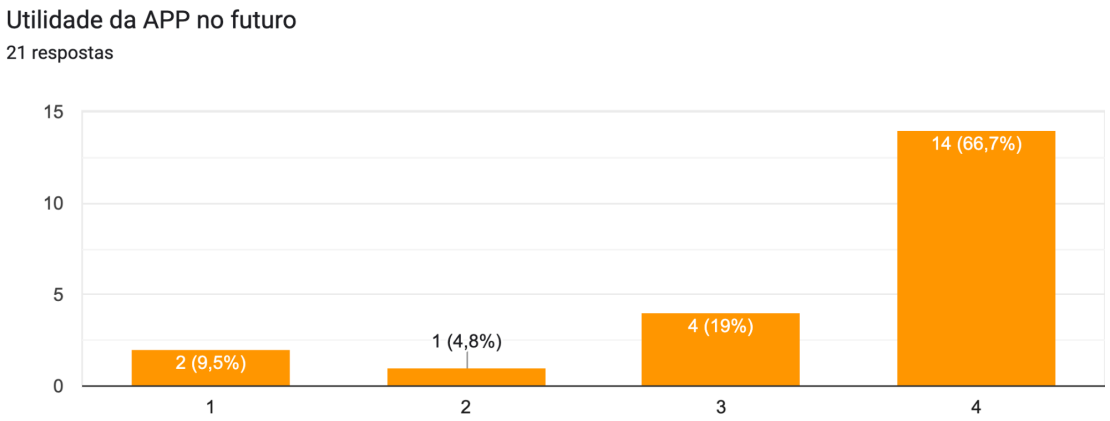
Innovation (Inovação)

Regarding the innovation of the app, 57.1% of users considered it highly innovative, while 23.8% rated it as average or not very innovative (1 or 2). This indicates that the app was largely perceived as fresh and inventive, though there was a small group of users who felt the app did not offer enough groundbreaking features to stand out.



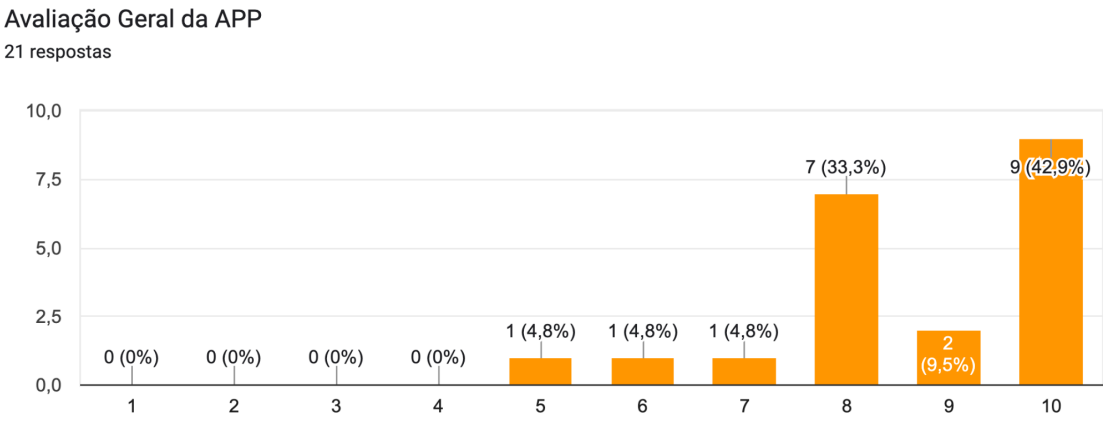
Future Utility (Utilidade da APP no futuro)

Despite the app's fictional functionalities, 66.7% of users found it very useful in the future. This is a strong indicator of the app's potential value in real-world applications, as users could recognize its practicality even with hypothetical features.



General Rating (Avaliação Geral da APP)

When asked for an overall rating on a scale from 1 to 10, the majority of users gave the app a high score. 42.9% rated it a 10, while 33.3% gave it an 8. These positive ratings reflect a strong overall satisfaction with the app, with users feeling confident in recommending it or using it again.



In conclusion, the satisfaction survey shows a positive reception, with high ratings for aesthetics, intuitiveness, and future utility. While the app is seen as innovative, there is room to enhance its perceived uniqueness. Overall, the feedback indicates a strong foundation for further development, which has motivated us and boosted our confidence in the app's potential.

Conclusion

Throughout the various stages of this project, we gained valuable insights into User-Centered Design (UCD). By focusing on creating user-friendly interfaces, we learned to develop the application with the user's perspective in mind, ensuring it meets their needs and expectations. This process taught us the importance of understanding and addressing user requirements when designing products. We believe that these skills and experiences will be highly beneficial for our future careers as engineers, helping us create more effective, user-focused solutions in any project we work on.

Annexes

Phase I

- EDP Solar: https://shorturl.at/EKyHS
- mySolarEdge: https://shorturl.at/FU3OL
- Questionnaire: https://forms.gle/a3tyLuNpXucd6TJy5
- Questionnaire results spreadsheet: https://shorturl.at/gkdCr
- ONU news: https://tinyurl.com/5rw4wdv5

Phase II

- Sent Evaluation Report to G01: https://tinyurl.com/u44pewp3
- Sent Evaluation Report to G02: https://tinyurl.com/34tv2de8
- Received Evaluation Report from G01: https://tinyurl.com/y46y6pe5
- Received Evaluation Report from G02: https://tinyurl.com/b4ce4rxj
- FIGMA Paper Wireframe: https://shorturl.at/BpURY

Phase III

- ✦ **FIGMA Final Prototype:** https://shorturl.at/Y8AVJ
- Questionnaire (Satisfaction + Usability): https://forms.gle/CLoL7fVCJh4RSnqK8
- Questionnaire results spreadsheet: https://tinyurl.com/yn7ryhjk
- MAZE Report: https://shorturl.at/lkpuk