SolarEase

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Graduation Project Presentation
Academic Year 2023-2024
Final Presentation

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Project Idea

Ideas That Shaped Our App Innovation

Project Idea

Mitigate climate change by automating the process of reducing carbon emissions resulting from using conventional electricity. We achieve this by raising awareness about solar energy and assisting users in determining the right solar system for them.

Problem Significance

Problems, Why and How? , Pervious Solutions

Problems

Awareness:

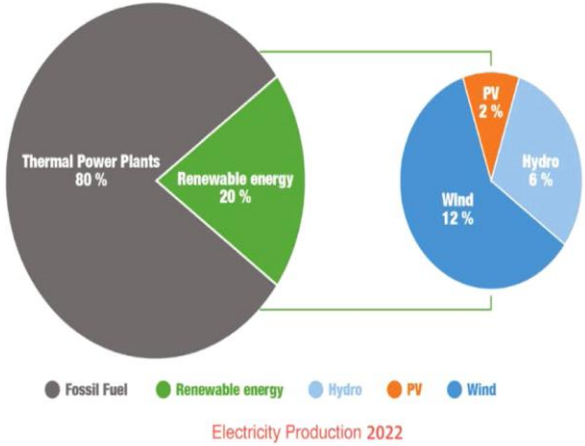
- People underestimate how solar systems can help the environment and positively affect climate change.
- People struggle to find clear details about solar installation process.
- It is hard to determine whether solar energy is suitable for users and financially beneficial in the long run or not.
- People may not be aware of government permits or financial support.

Facilitating:

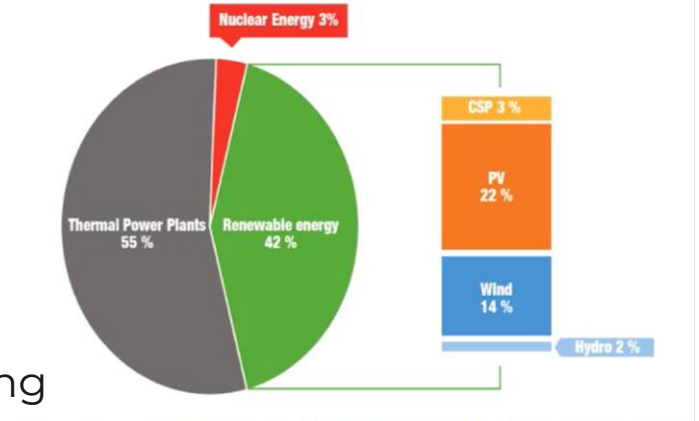
- Complicated calculations needed to figure out solar savings and payback time and solar system output.
- Finding trustworthy solar installers and suppliers is hard.

Why?

- Our planet is experiencing rising temperatures and extreme weather events.
- Egypt possesses abundant solar energy potential to mitigate climate change.
- People are not aware enough of this not-exploited energy.
- The Egyptian government's efforts and the Vision 2030 initiative.
- Given the continuous rise in electricity prices, finding a lasting solution is essential.



Electricity Production 2022



Electricity Production 2035

How To Solve ?

01.

Assisting users in choosing the right solar system efficiently.

02.

Calculate solar system payback period, financial and environmental impact.

03.

Facilitate the buying and selling of solar components.

04.

Predict solar system productivity.

05.

Integrate a chatbot for information and terms.

Previous Solutions

Features \ Solutions		PV Output WebSite	Energy Sage WebSite (2009)	PVWatts WebSite (2012)	Solar Reviews WebSite (2012)	Solar Market Egypt WebSite (2018)	Know Solar App (2021)	Solar .com Website (2023)	SolarEase (Our App)
Decision Making	**SolarCalculator** Solar System Size & Cost Calculator		✓		✓			✓	✓
	SolarSaving Cost Savings & Payback period		✓		✓			✓	✓
	SolarEnergyPredictor Predict Solar Panels Production (Hourly – Daily)			✓			✓		✓
Installation	**SolarInstallerFinder** Solar Companies & nearby companies		✓		✓	✓		✓	✓
	SolarMarketPrices Products Price & Favorite Products		✓		✓	✓		✓	✓
	OnlineTradeMarketPlace Favorite Posts								✓
Awareness	**SolarGreenImpact** Environmental Savings	✓							✓
	SolarChatBot								✓

Project Specifications

System Architecture

Stakeholders

Functional Requirements

Non-Functional Requirements

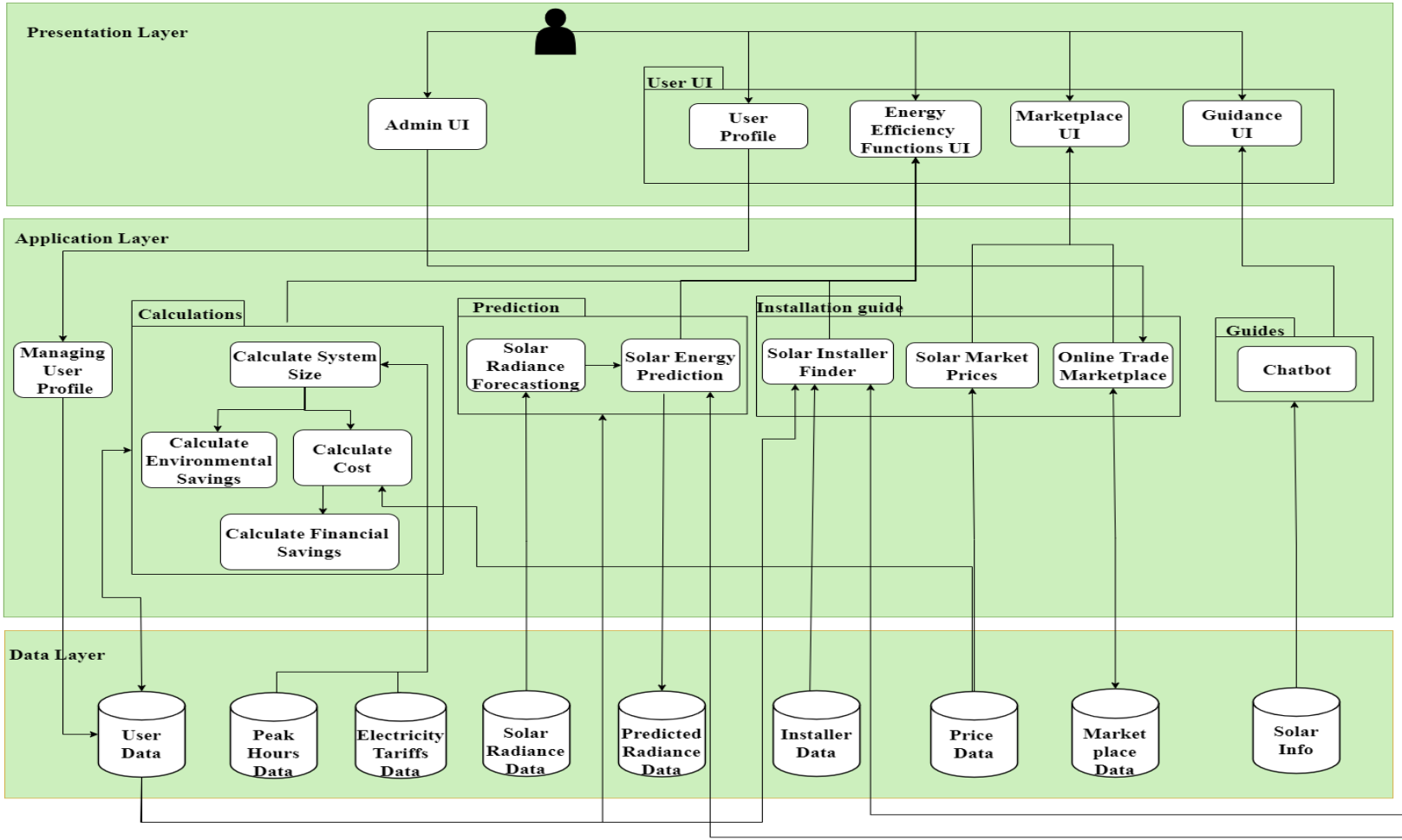
Use-Case Diagram

Class Diagram

Sequence Diagram

Entity Relationship Diagram

System Architecture



Stakeholders

01. Customers

02. Companies

03. Administrators

Functional Requirements

01 — Calculate System Size

02 — Calculate Cost

03 — Calculate Financial Savings

04 — Calculate Environmental Savings

05 — Predict Solar Energy

06 — Find Solar Installers

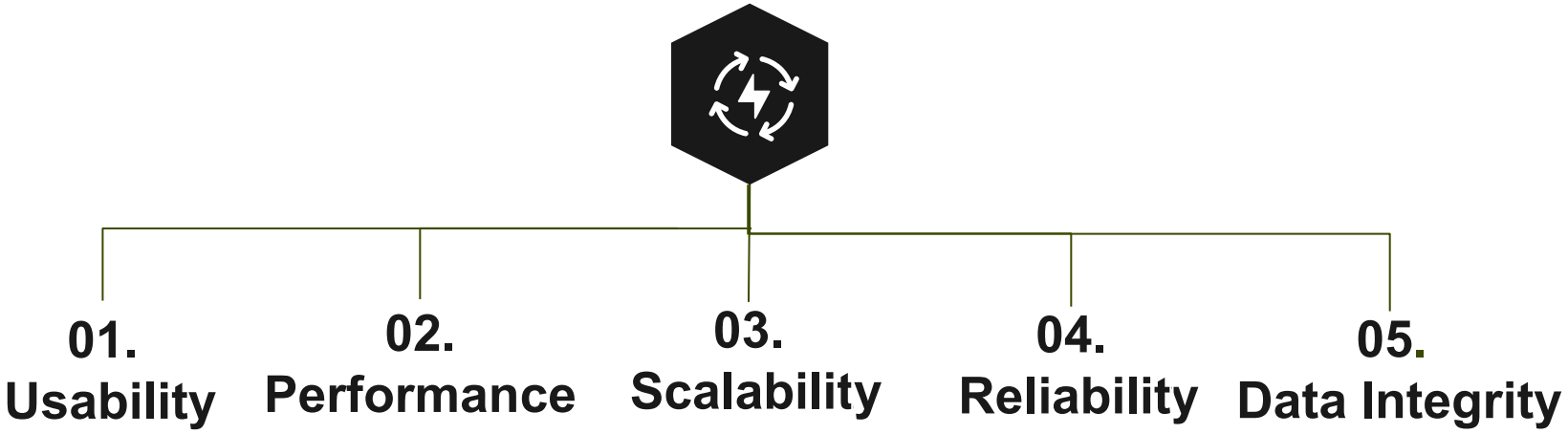
07 — Solar Market Prices

08 — Online Trade Marketplace

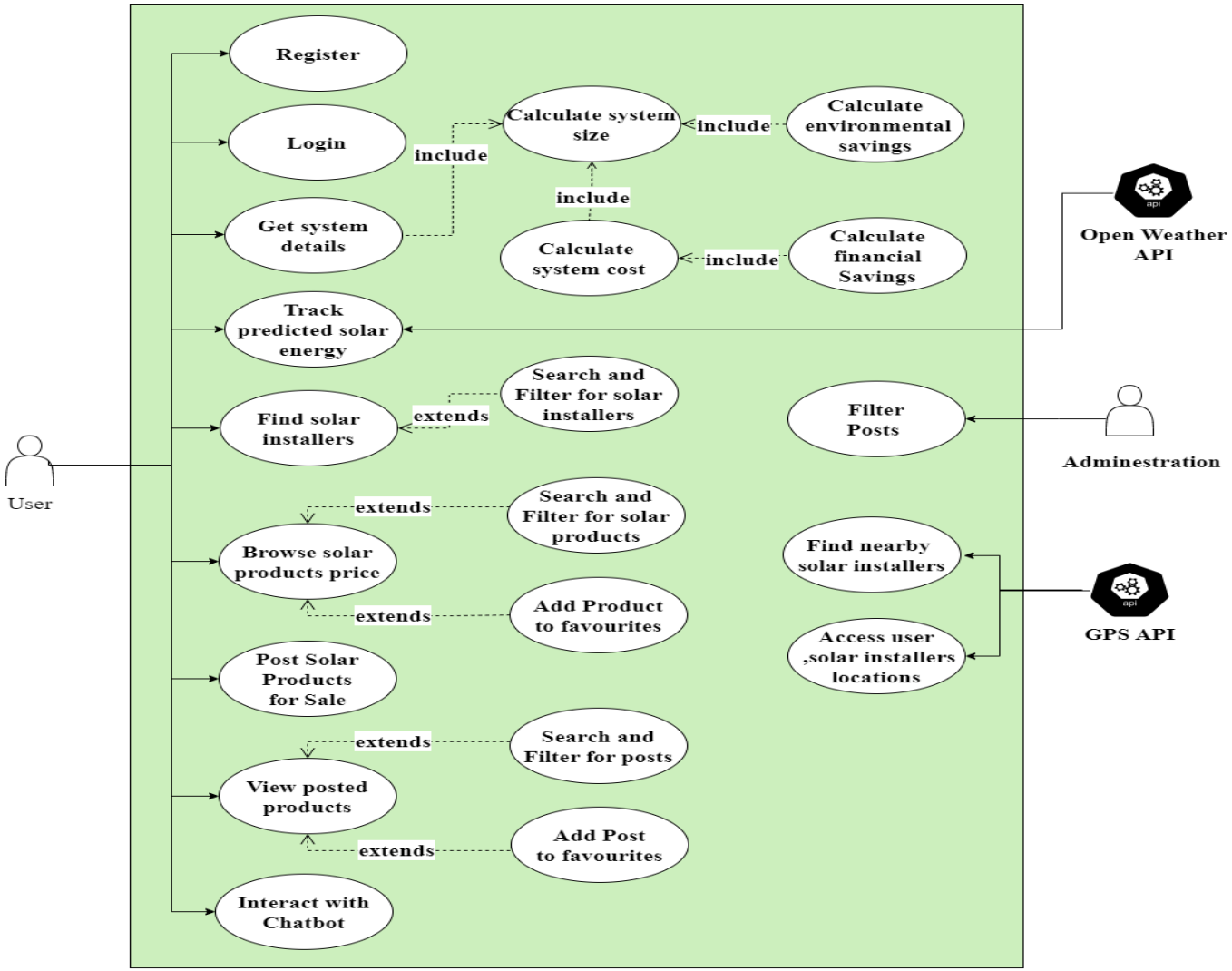
09 — Chatbot

10 — Filter Posts

Non-Functional Requirements



Use-Case Diagram



Time Plan

Previous 8 Months

Time Plan

Task	Start Date	End Date	Days
Brainstorming	1-Oct	21-Oct	21
Search for Resources	22-Oct	28-Oct	7
Collecting Datasets	29-Oct	7-Nov	10
Searching for Related work	8-Nov	14-Nov	7
Determine Features	8-Nov	30-Nov	23
Requirement Specification	1-Dec	7-Dec	7
Design and Database Analysis	8-Dec	31-Dec	24
Study the Needed Technologies	1-Jan	10-Mar	70
Mid-Year Documentation	1-Feb	10-Feb	10
Data Cleaning	1-Mar	2-Mar	2
Build Ml Models	3-Mar	17-Mar	15
Implementation	12-Mar	5-May	55
Deployment	6-May	10-May	5
Integration	11-May	20-May	10
Testing	15-Jun	26-Jun	12
Final Documentation	27-Jun	1-Jul	5

Implementation

Demo

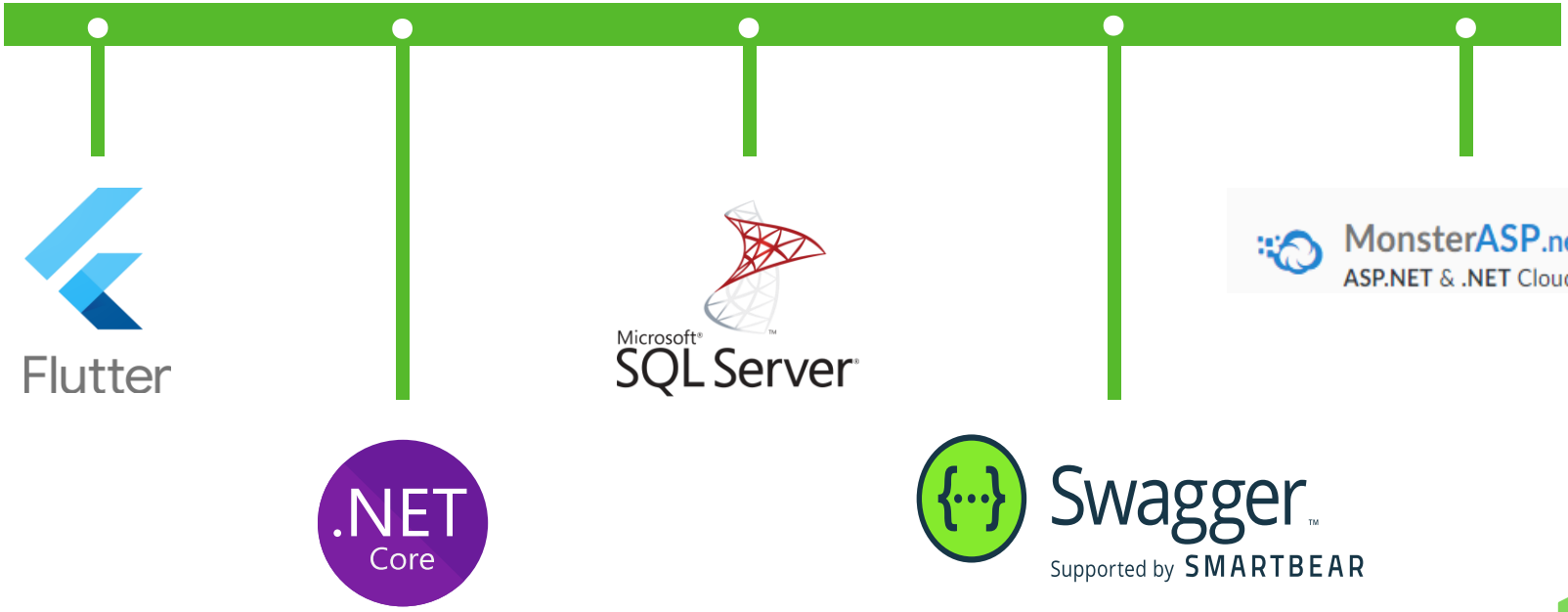
Front-End

Back-End

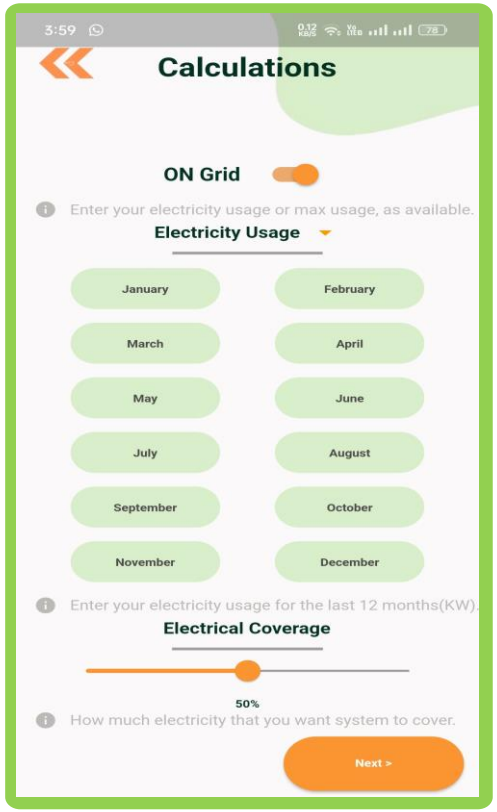
Features

Front-End & Back-End

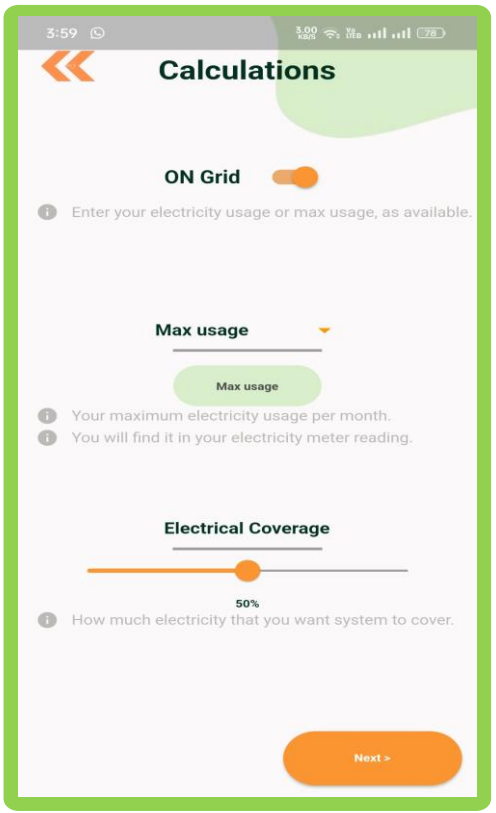
Technologies



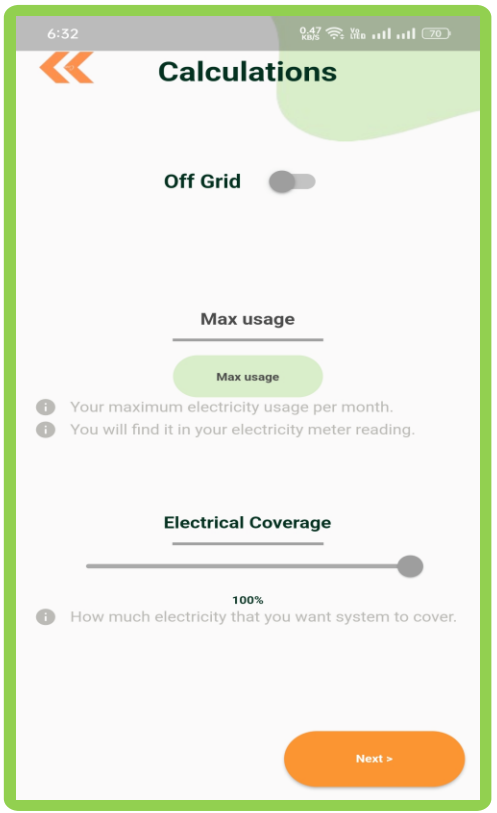
Calculations



User inputs electricity consumption for the last 12 months, if available, in an on-grid system



If data for the last 12 months is not available, the user enters the maximum electricity consumption (max load) in an on-grid system



The user inputs the maximum electricity consumption (max load) in an off-grid system

Calculations

Device	Watt	Numbers	Total
Air conditioning	1350.0	1	1350.0
Wall fan	65.0	4	260.0
Vertical fan	100.0	2	200.0
broom	1600.0	1	1600.0
laptop	100.0	2	200.0
Lamp	15.0	8	120.0
lcd TV	100.0	2	200.0
charger	7.0	5	35.0
Router	10.0	1	10.0
landline	5.0	1	5.0
Router	10.0	1	10.0
landline	5.0	1	5.0
Freezer	300.0	1	300.0
Fridge	500.0	1	500.0
washing machine	500.0	1	500.0
water cooler	600.0	1	600.0
Microwave	1700.0	1	1700.0
Cattail	1100.0	1	1100.0
Iron	1000.0	1	1000.0
New Device	1200	1	1200.0
New Device	800	2	1600.0

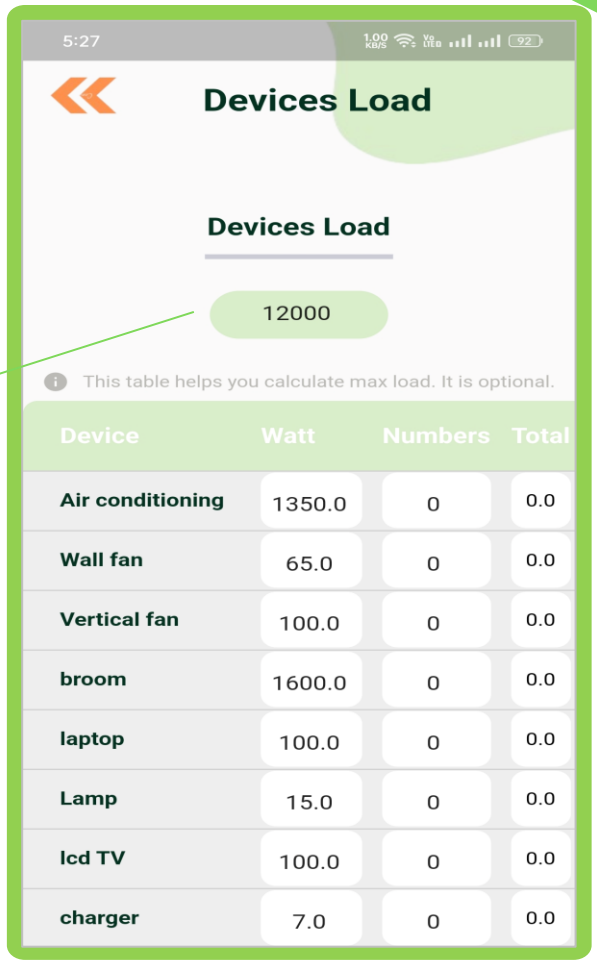
Total Load 12480.00

Next >

To determine inverter capacity, user can do one of the following:

1) Enters an estimate for the total device load.

2) Enters load for each device and its number in their home.



5:27

Devices Load

Devices Load

12000

This table helps you calculate max load. It is optional.

Device	Watt	Numbers	Total
Air conditioning	1350.0	0	0.0
Wall fan	65.0	0	0.0
Vertical fan	100.0	0	0.0
broom	1600.0	0	0.0
laptop	100.0	0	0.0
Lamp	15.0	0	0.0
lcd TV	100.0	0	0.0
charger	7.0	0	0.0

Calculations

This solar system calculator estimates the size and cost of a system based on user electricity usage and sunlight hours. It considers roof space, number of panels, inverter type and cost to provide a comprehensive cost estimate.

The financial savings calculation estimates monthly, yearly, and 25-year savings by comparing electricity costs before and after solar installation. The payback period calculation determines the time to recover the solar investment, using total system cost and yearly savings.

Estimates the reduction in CO2 emissions monthly, yearly, and over 25 years, based on 0.45-0.5 kg of CO2 saved per kWh of solar energy compared to fossil fuels.

Daily Model & Hourly Model

Dataset

- Solar and meteorological data sets from NASA POWER for all 27 governorates of Egypt.

Training Data

- 1/1/ 2014 -> 31/12/2023

Testing Models

- Daily model : 1/1/2024 -> 1/6 2024
- Hourly model : 1/1/2024 -> 1/3 / 2024

Algorithm

- Use SVR through extensive hyperparameter tuning using GridSearchCV

Our Experiments

Comparison of Our SVR and FNN Models Tested for Daily Solar Irradiance Prediction

Matrices \ Model	SVR (Cairo)	FNN (Cairo)
R2	0.844	0.768
MAE	0.405	0.505

Literature Review

Daily Model

Meenal and Immanuel Selvakumar (2018)

Matrices \ Model	Paper SVR	Our SVR (Cairo)
R2	0.911	0.844

The study concluded that SVR outperformed ANN SVR effectively captures complex relationships within meteorological datasets, making it the best choice for solar irradiance prediction.

Hourly Model

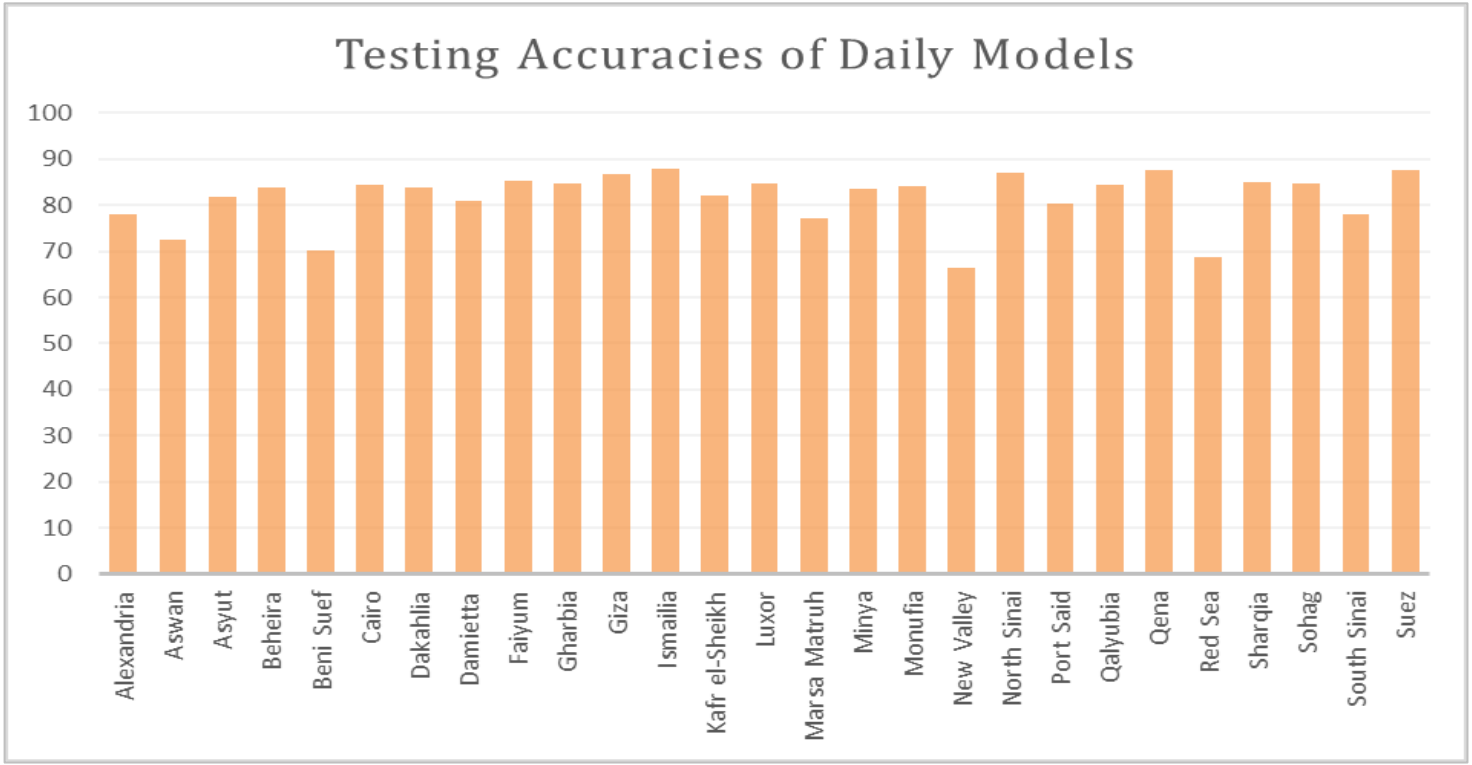
Muhammed A. Hassan et al. (2017)

Matrices \ Model	Paper SVR	Our SVR (Cairo)
R2	0.90	0.949

The study investigated tree-based ensemble methods for modeling hourly solar radiation across five solar-meteorological stations. They compared SVR, MLP, and DT for hourly solar radiation forecasting

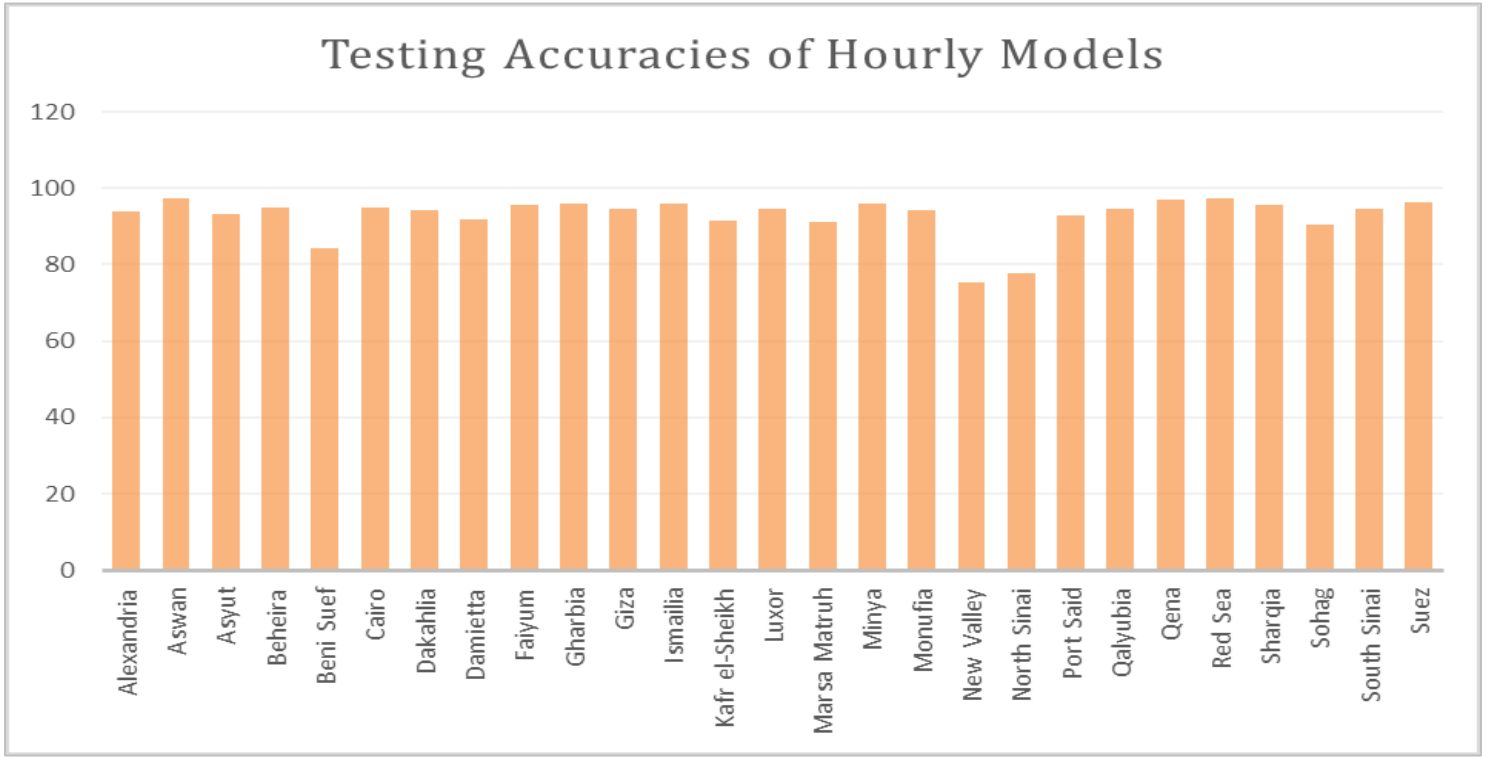
Daily Testing

- Daily testing accuracies for all 27 governorates SVR models



Hourly Testing

- Hourly testing accuracies for all 27 governorates SVR models



Daily Model Testing Examples

Location	Luxor	Port Said
Date	2024-03-12	
Meteorological Data	○ T2M: 22.35 ○ PS: 98.62 ○ RH2M: 15 ○ WS10M: 2.1 ○ PRECTOTCORR: 0.0	○ T2M: 18.38 ○ PS: 101.45 ○ RH2M: 63 ○ WS10M: 3.59 ○ PRECTOTCORR: 0.0
Predicted Solar Irradiance	6.83	5.6
Actual Solar Irradiance	6.44	5.5
	System 5 kW → 25.61 KW	System 5 kW → 21 KW

Surface shortwave downward irradiance (kW-hr/m^2/day), temperature (T2M), wind speed at 10 meters (WS10M), pressure (PS), corrected precipitation (PRECTOTCORR), and relative humidity at 2 meters (RH2M)

Hourly Model Testing Examples

Location	Asyut	Cairo
Date	2024-02-27 11:00	
Meteorological Data	○ T2M: 21.84 ○ PS: 99.77 ○ RH2M: 28.5 ○ WS10M: 6.46 ○ PRECTOTCORR: 0.0	○ T2M: 20.44 ○ PS: 100.05 ○ RH2M: 43.38 ○ WS10M: 5.26 ○ PRECTOTCORR: 0.0
Predicted Solar Irradiance	829.53	672.53
Actual Solar Irradiance	853.75	666.19
System 5 kW	3.11 KW	2.52 KW

Surface shortwave downward irradiance (Wh/m^2), temperature (T2M), wind speed at 10 meters (WS10M), pressure (PS), corrected precipitation (PRECTOTCORR), and relative humidity at 2 meters (RH2M)

Real-Time Solar Irradiance Prediction

Overview

We provide real-time solar irradiance predictions every 3 hours and daily, over five days across all governorates of Egypt.

Data Integration

Our models integrate with the OpenWeatherMap Api to retrieve real-time features such as temperature, wind speed, which are then utilized as input features SVR models.

OpenWeather

Scalability

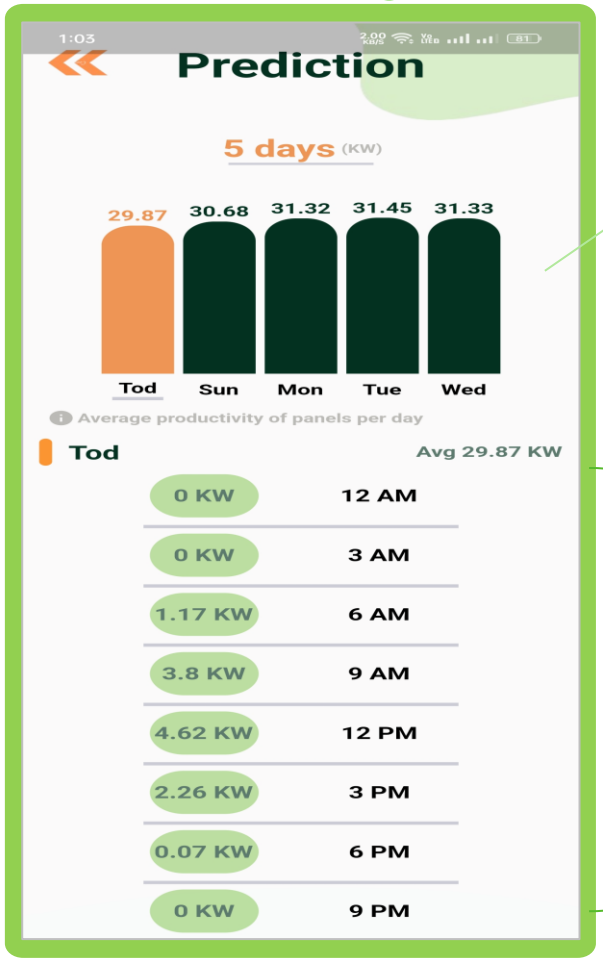
Our models are designed to handle different geographic locations across Egypt.

Models Deployment

Our prediction models Hosted and managed on the Hugging Face cloud platform.

Hugging Face

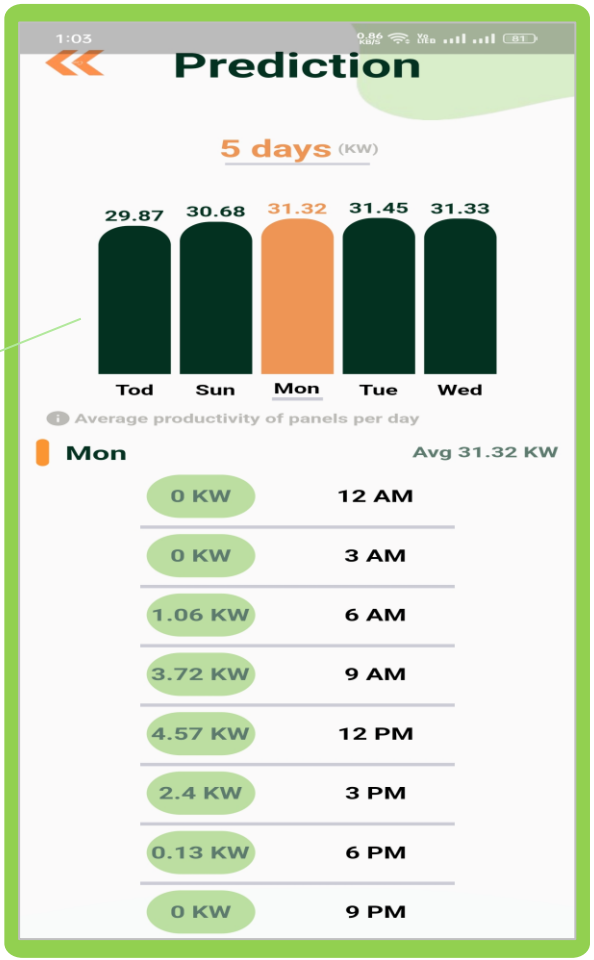
System Output Estimation



Daily electricity output in kW over 5 days.

Users can navigate through the days to view electricity output every 3 hours for each day.

Each day includes electricity output data every 3 hours.

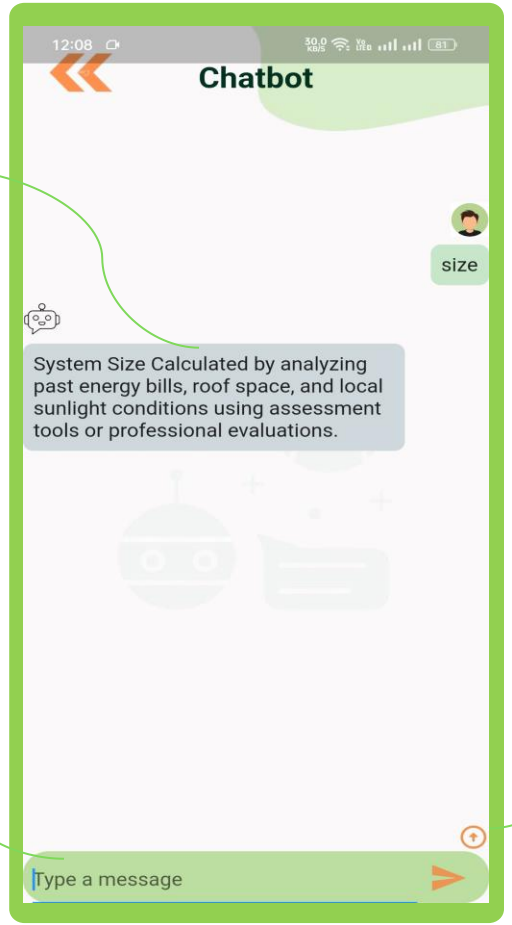


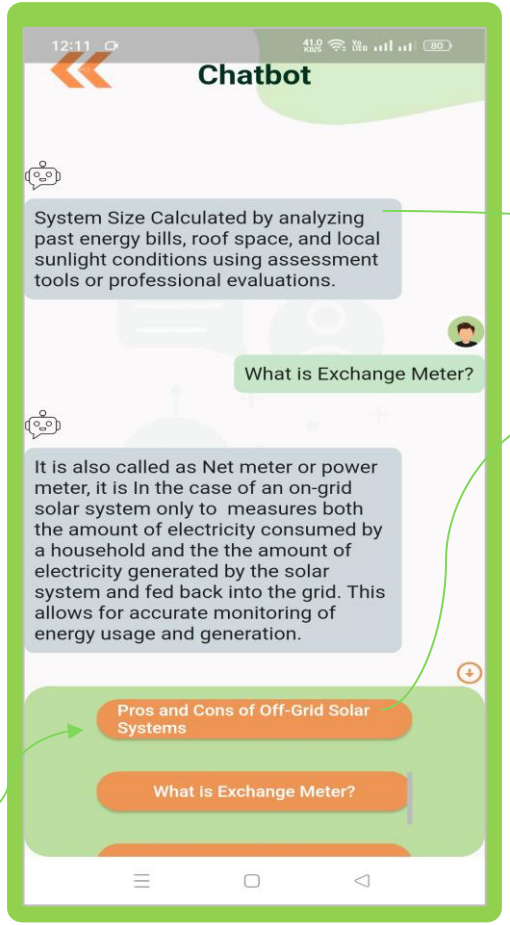
Chatbot

Interactive Chatbot:

For predefined responses triggered by specific keywords and phrases in the user's input, we utilize NLTK techniques such as tokenization, stemming, and Jaccard similarity. ensures accuracy.

Allows users to input questions.





Category-Based Question Chatbot:

Users receive answers generated from predefined responses.

Allows users to choose solar energy categories, browse related questions within each category, and select specific questions, enhancing access to solar energy information.

Chatbot Literature Review

A Thai-language chatbot using Jaccard similarity

- Chanakot and Sanrach (Feb 2024) developed a Thai-language rule-based chatbot that matches user symptoms with disease databases using Jaccard similarity, increasing disease identification accuracy.

Jaccard Coefficient for Keywords Similarity

- Niwattanakul et al. (2013) optimized information retrieval in search engines using Jaccard similarity , comparing its effectiveness with other similarity measurement techniques like cosine similarity, Vector Space model, and Engram. The study highlighted Jaccard's performance over alternative similarity measurement techniques in enhancing search result relevance despite challenges with typographical errors.

Find Solar Installers

Offers filtering by city.

Searching by company name for tailored selection of certified solar installers.

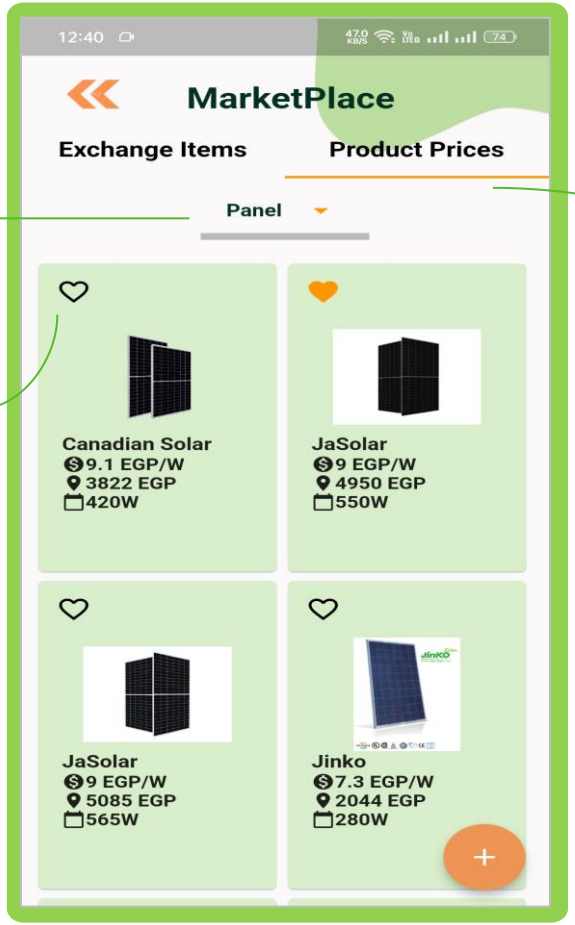
Users can view all certified solar installer companies in Egypt, sorted by nearest to user.

We used two Google Maps APIs, the Geocoding API and the Distance Matrix API to calculate the distances between the user's location and the solar installers , displaying from nearest to furthest.

Marketplace(Products)

Allowing users to filter products by category.

User can mark products as favorites.



The product prices section in the marketplace offers a variety of solar market products, featuring their latest prices, brands, and capacities.

Marketplace(Exchange Items)

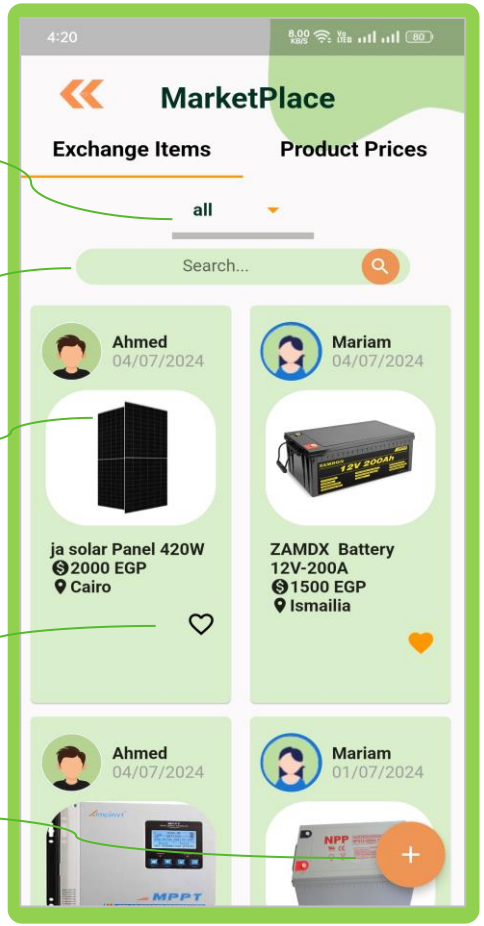
They can filter posts based on product categories

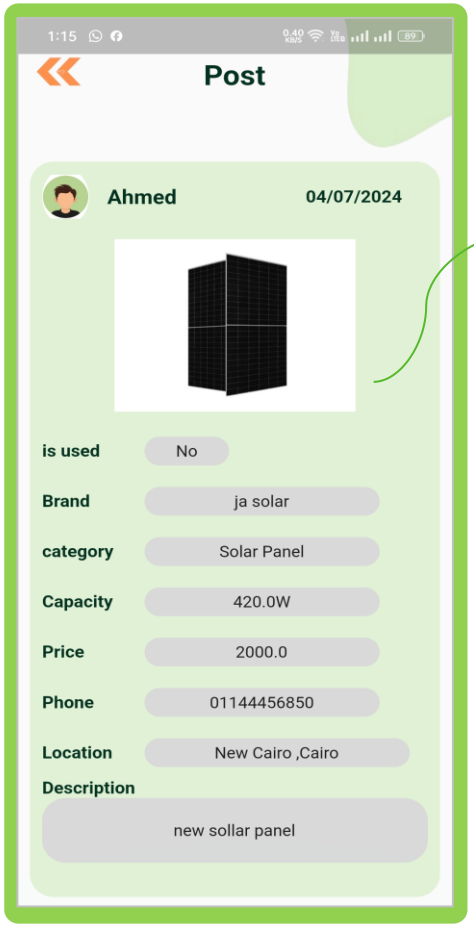
They can search by city to find relevant information

User can browse summarized posts of solar products for quick overviews.

User can mark posts as favorites.

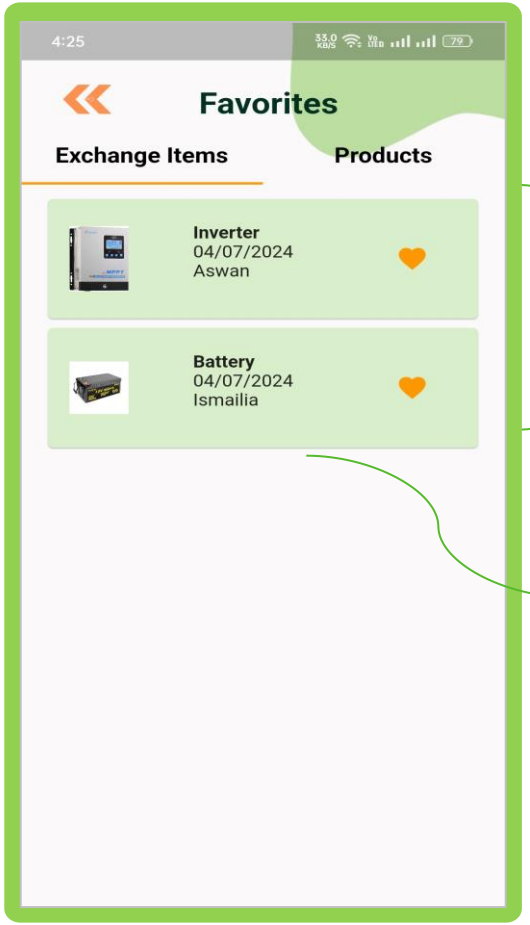
User can add new post for selling solar product.





User can access each post for more detailed information about specific products

Favorites



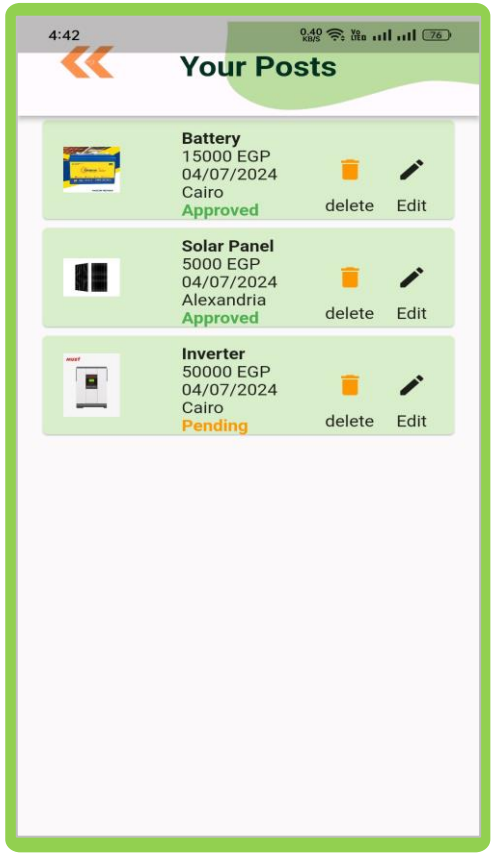
User can view their favorite posts for easy reference and comparison on their favorite posts page.

User can also access post for more detailed information

Offers filtering by category

User can view their favorite solar products for easy reference and comparison on their favorite products page

Posts



User can view and manage their posts, check the approval status, update or remove posts from marketplace.

When users submit a post, it waits for admin approval to make sure it meets quality and marketplace rules.

Users receive a message regarding the approval or rejection of their post, along with an email.

Future Work

1. Increase dataset diversity by integrating multiple meteorological sources for detailed local coverage. Start with Cairo and Giza, then expand to rest of governorates.

2. Explore advanced regression algorithms like Random Forests and Gradient Boosting for improved predictions.

3. Integrate paid OpenWeather API versions for enhanced hourly and daily data availability across Egypt.

4. Implement online payment integration in the marketplace for seamless consumer-to-consumer transactions.

Challenges & Solutions

For Both Hourly and Daily Models

Data Availability and Quality

Challenge: Meteorological data is often rare, unavailable, or inaccurate

Solution: Use NASA POWER datasets for reliable governorate-wide data.

Handling Temporal Features

Challenge: Capturing cyclical nature of time-related features.

Solution: Apply cyclical transformations (sine and cosine) to temporal data.

Challenges & Solutions

For Hourly Model

Handling Nighttime Data for Solar Irradiance Predictions

Challenge: Nighttime data, where solar irradiance is absent, introduces noise and biase.

Solution: Filter out nighttime hours (5 a.m. to 8 p.m.) to improve prediction accuracy.

For of OpenWeather API

Lack of Meteorological Data

Challenge: OpenWeather API provides meteorological data at 3-hour intervals, limiting direct daily and hourly weather predictions.

Solution: Implemented preprocessing to aggregate 3-hour data into daily averages for accurate daily weather predictions, while adjusting to provide predictions at 3-hour intervals for hourly forecasts.

Thank You

Do you have any questions?