Final Presentation

SMART HOME ENERGY MANAGEMENT SYSTEM (SHEMS)

With AI Optimization

Smart Home Energy Management System (SHEMS)

2025 Spring CS595

05/10/2025

Team Members

Zhiyu (Zoey) Zhang

AI/ML & Deployment Developer

Nang Thiri Wutyi

Electrical & IoT Engineer

Yin Yin Phyo

Full-Stack Developer

Timeline

Week 1-3
Planning and researching

Week 4-7
Hardware development and AI Algorithm development

Week 8-9
Integration phase

Week 10
App deployment

Week 11-13
System testing and Optimization

Week 14-15
Documentation and Presentation

Why SHEMS?

- SHEMS addresses energy waste with smart, sensor-driven automation
- Automates control of lights, heaters, and fans based on real-time data
- Uses AI to optimize usage patterns and schedules
- Remote control through a mobile app + real-time monitoring via Firestore
- Reduces energy bills and supports sustainability

Hardware and Cloud Integration

- Connected PIR and DHT11 sensors to Raspberry Pi
- Integrated Kasa smart plugs for controlling light and heater
- Implemented automation logic based on real-time sensor data
- Enabled real-time data upload to Firebase Firestore

Automation & Remote Control

- Light ON when motion detected; OFF after 1 hour of inactivity
- Heater ON if temperature < 25°C; OFF if ≥ 25°C
- Mobile app sends ON/OFF commands via Firestore
- Raspberry Pi listens and triggers smart plug control instantly

Manual Hour Override & Dynamic Billing

- Manual commands pause automation for 1 hour
- Automation resumes based on sensor data after timeout
- Cost rate fetched from Firestore (user-editable)
- Real-time energy usage and cost logged every minute

Final Testing & System Validation

- Verified automation and override logic across devices
- Ensured auto-restart with systemd and Wi-Fi reconnect
- Minimized Firestore writes to once per minute
- Fully tested with mobile app for real-time sync

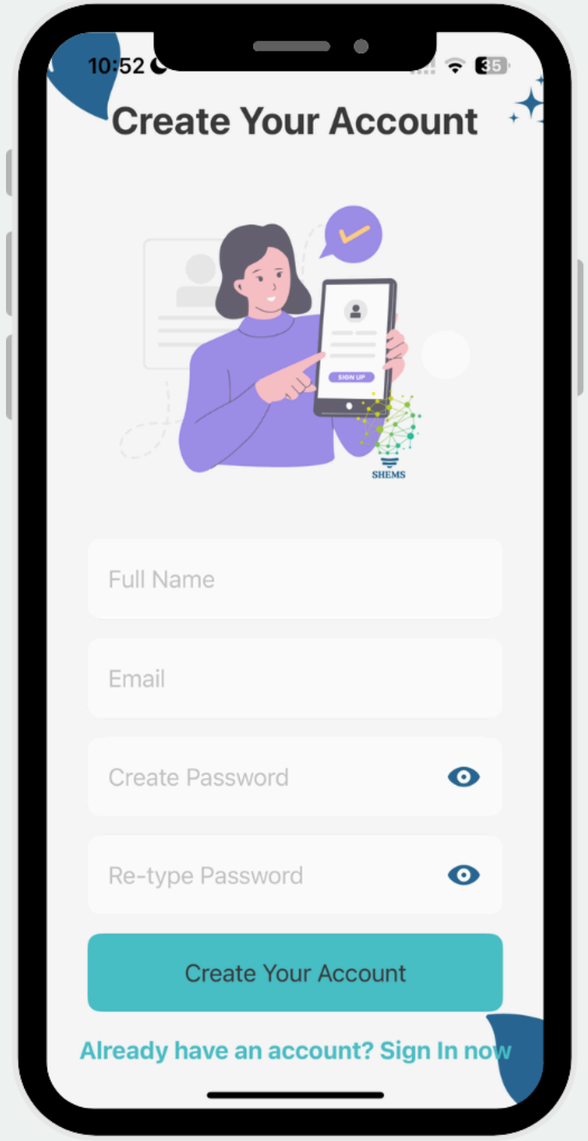
Demo Video

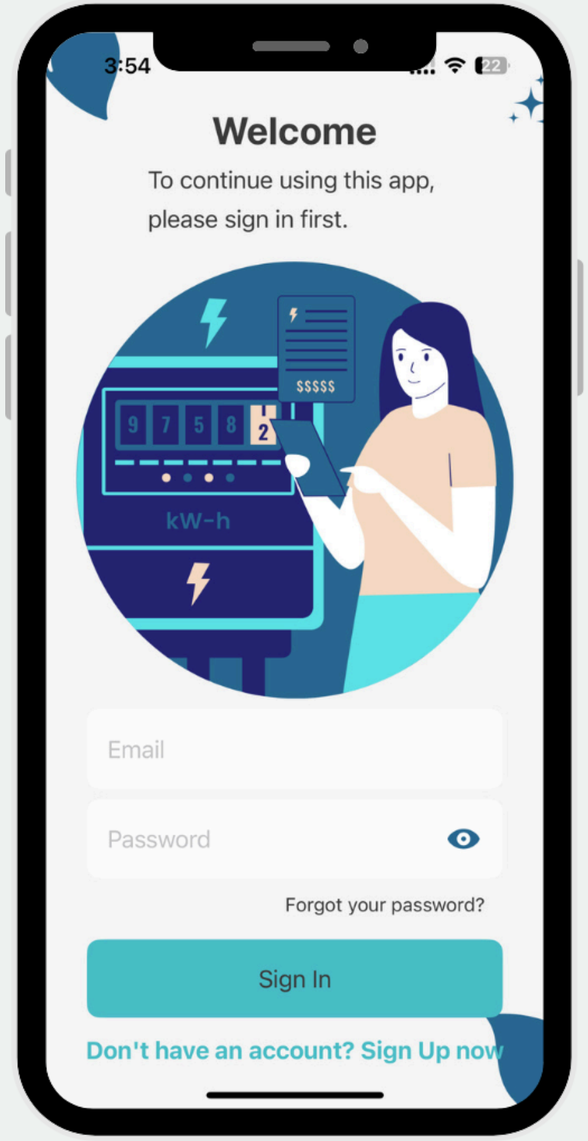

Welcome home,
Yin Yin Phyo!
Filter By:
All
Light
Heater
Appliances
My Light
ON
13 H 37 M
Today
My Heater
ON
13 H 47 M
Today

SHEMS Mobile App “Features”

Login & Authentication

- Register and login with Firebase email authentication
- Secure email/password login
- Password reset option

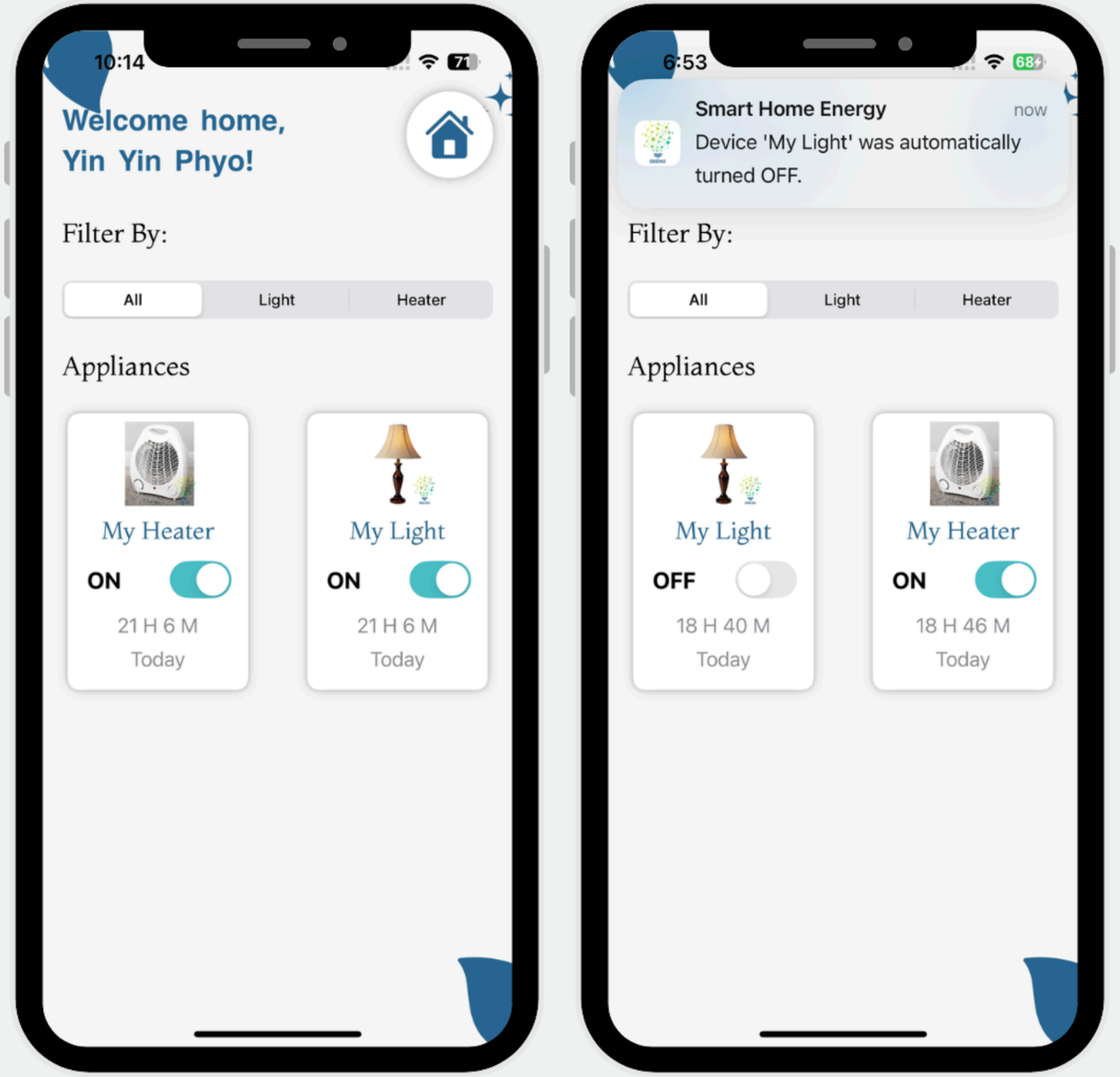




SHEMS Mobile App “Features”

Device Control

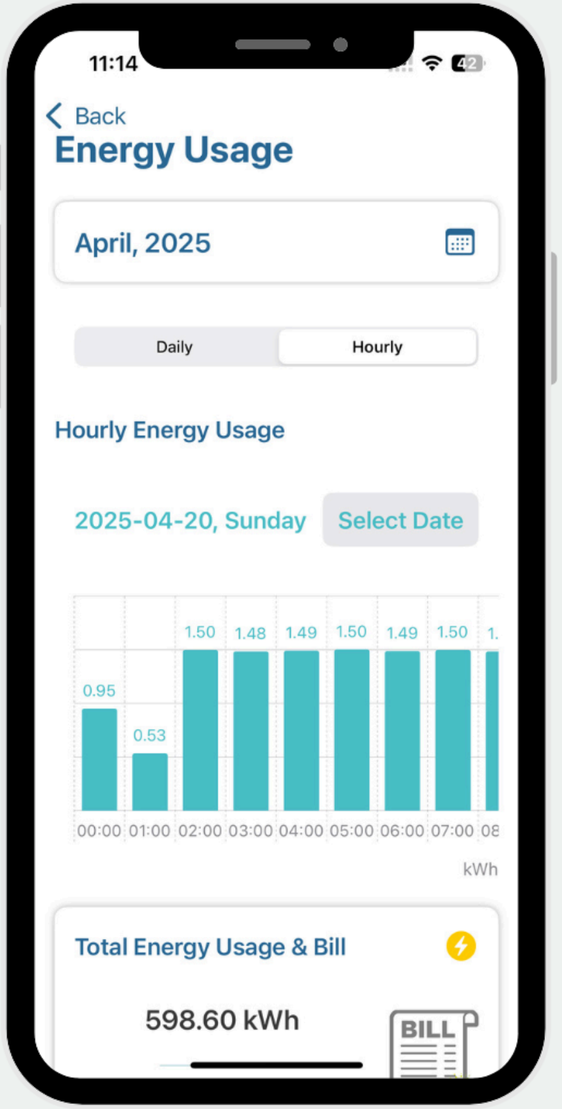
- Manual ON/OFF control
- Motion sensor–based automation for energy saving

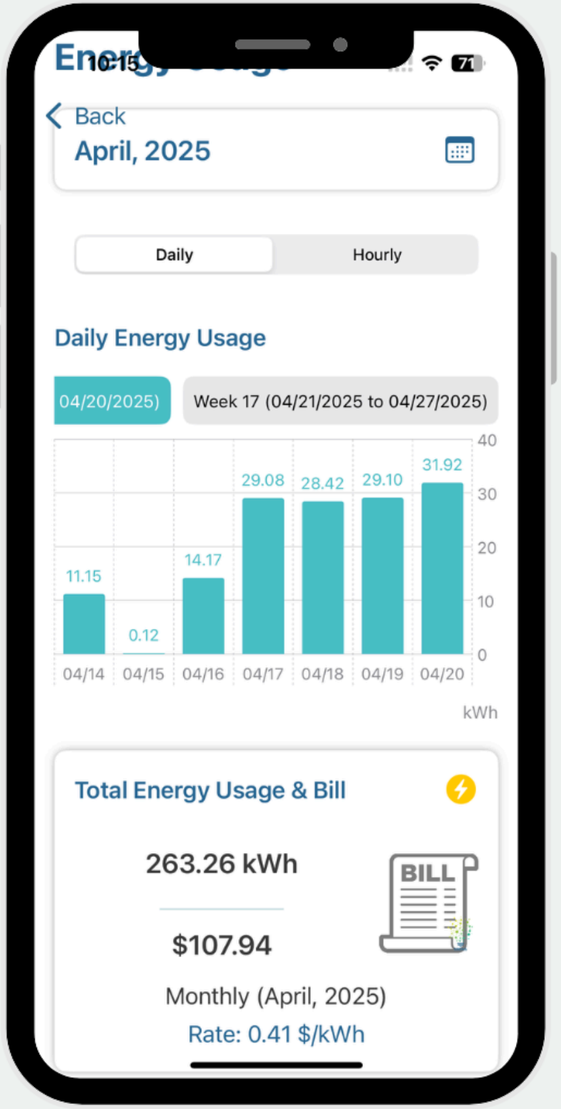


SHEMS Mobile App “Features”

Energy Monitoring

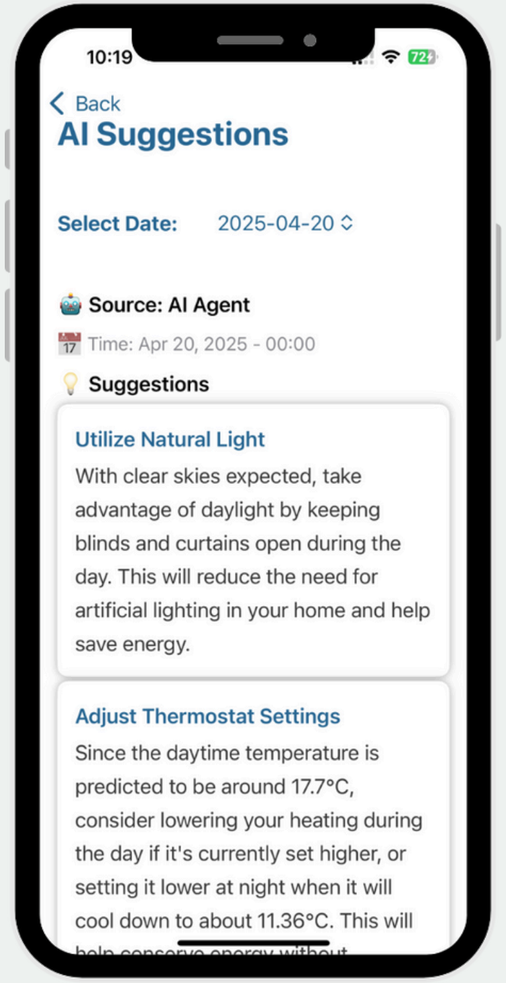
- Interactive graphs for real-time, daily, hourly & monthly energy usage
- Estimated monthly usage and bill cost



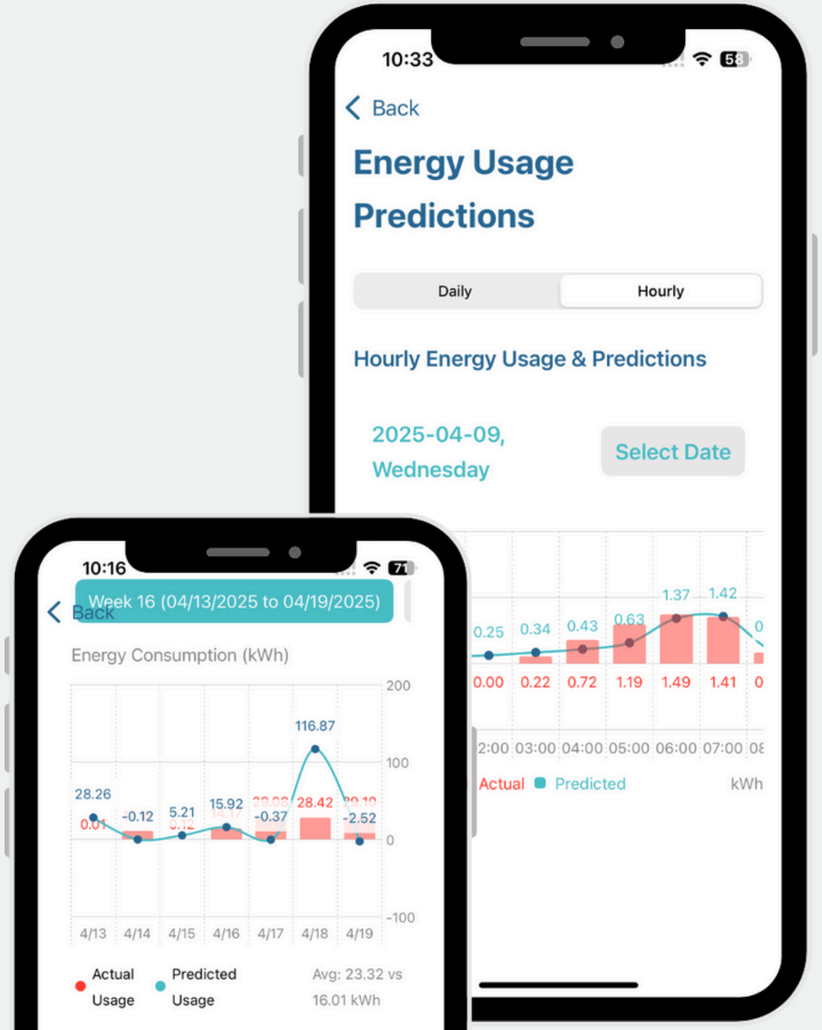


SHEMS Mobile App “Features”

Energy Usage Prediction & AI Suggestions

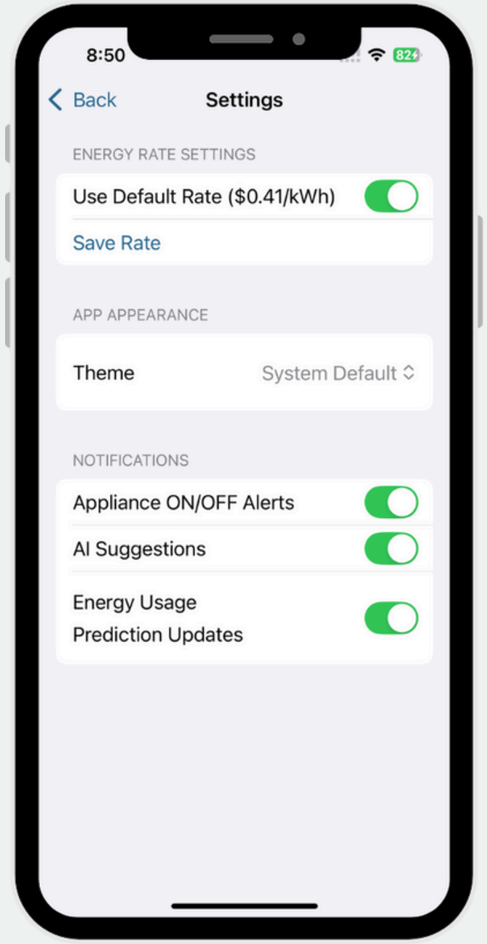


- Comparison with visualized charts for real-time and prediction of energy usage
- Estimated bill prediction
- Daily generated AI suggestions

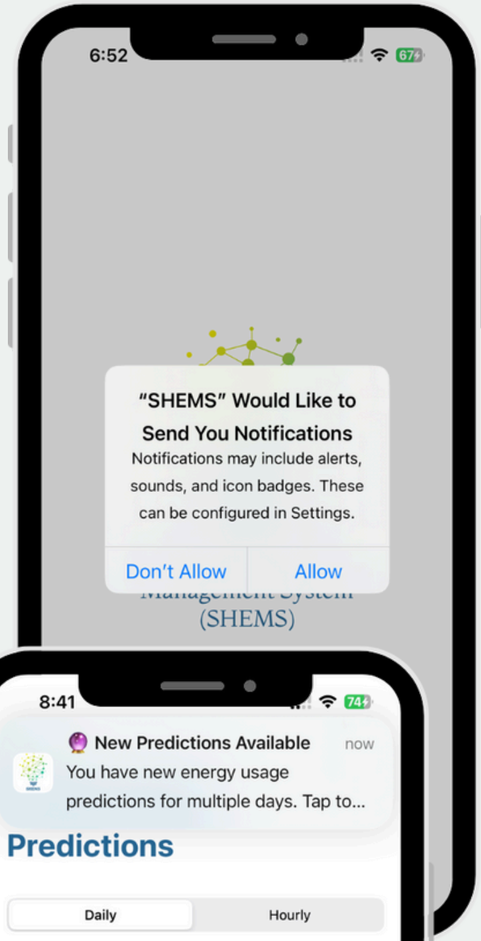


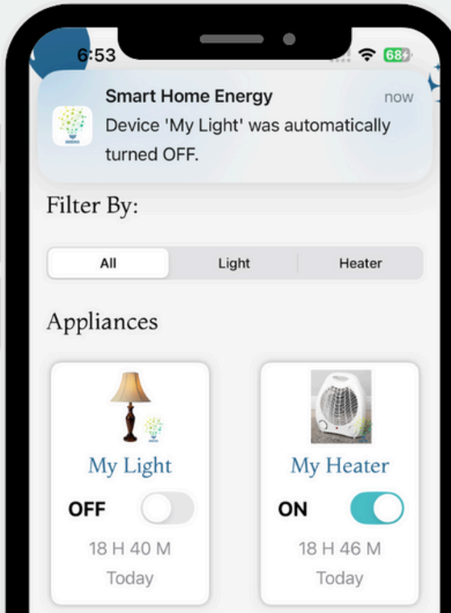
SHEMS Mobile App “Features”

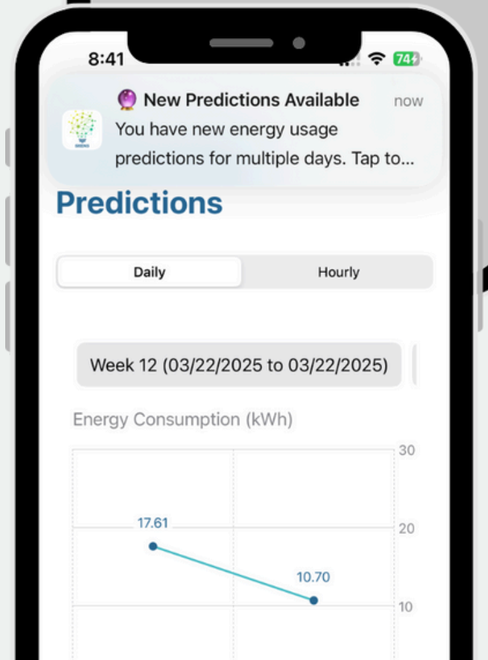
Settings

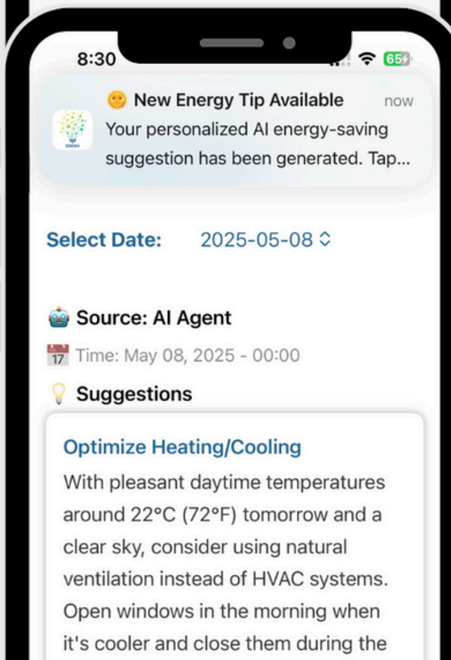


- Energy rate configuration (default/custom)
- App theme selection (System/Light/Dark)
- Manage notifications
  - Appliance ON/OFF, AI tips, and Energy Usage Prediction updates









Backend & ML/AI

Overview

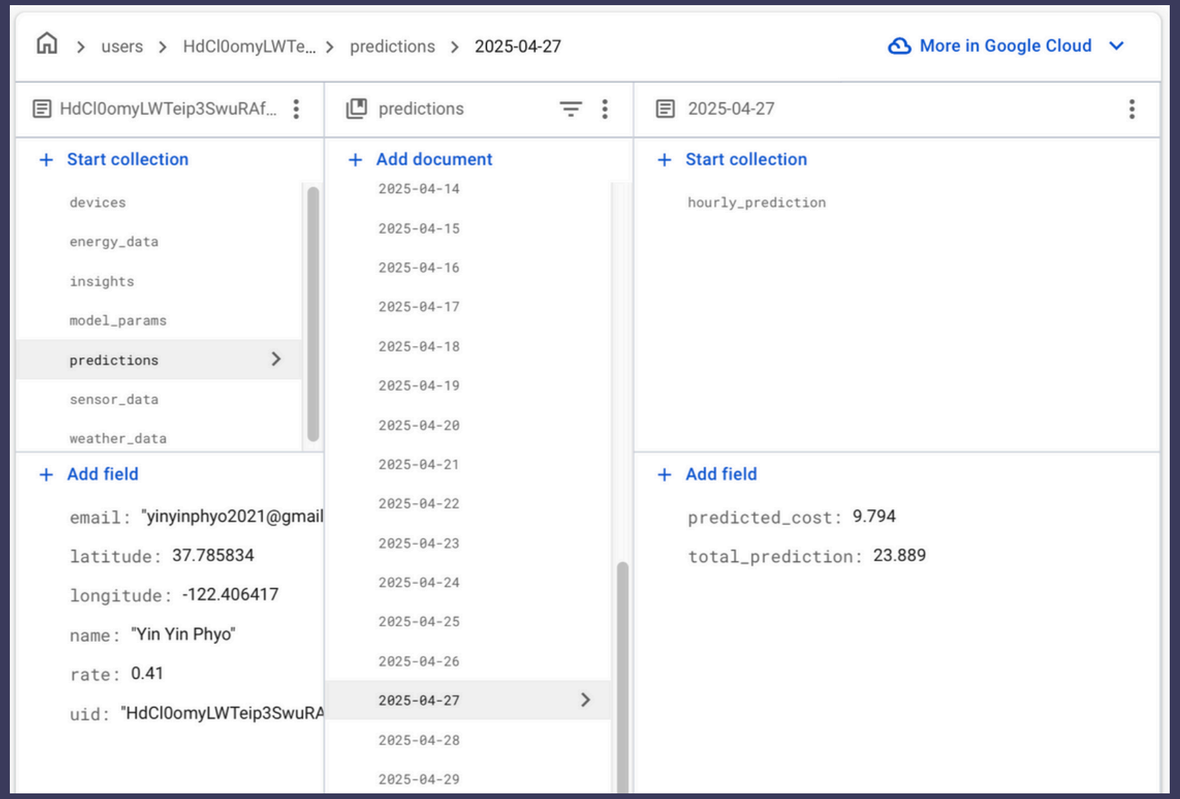
- Developed energy usage **forecasting and optimization pipelines**
- Built and deployed **AI agent** for daily smart suggestions
- Designed **Firestore schema** for scalable, real-time data management
- Automated backend workflows using **GCP**
- Ensured production-grade **deployment** and system reliability

Backend & ML/AI

Forecasting Model - Prophet

- Fine-tuned Prophet model for hourly and daily energy predictions
- Custom seasonalities: weekly & monthly
- Trained on **real household data**, dynamically adjusts to behavior
- Read energy data from Firestore and write predictions into Firestore

	Model	MAE	MSE	RMSE
0	Hourly (Fine-Tuned)	0.107321	0.032279	0.179663
1	Daily (Aggregated Hourly)	1.171207	2.455835	1.567110



Backend & ML/AI

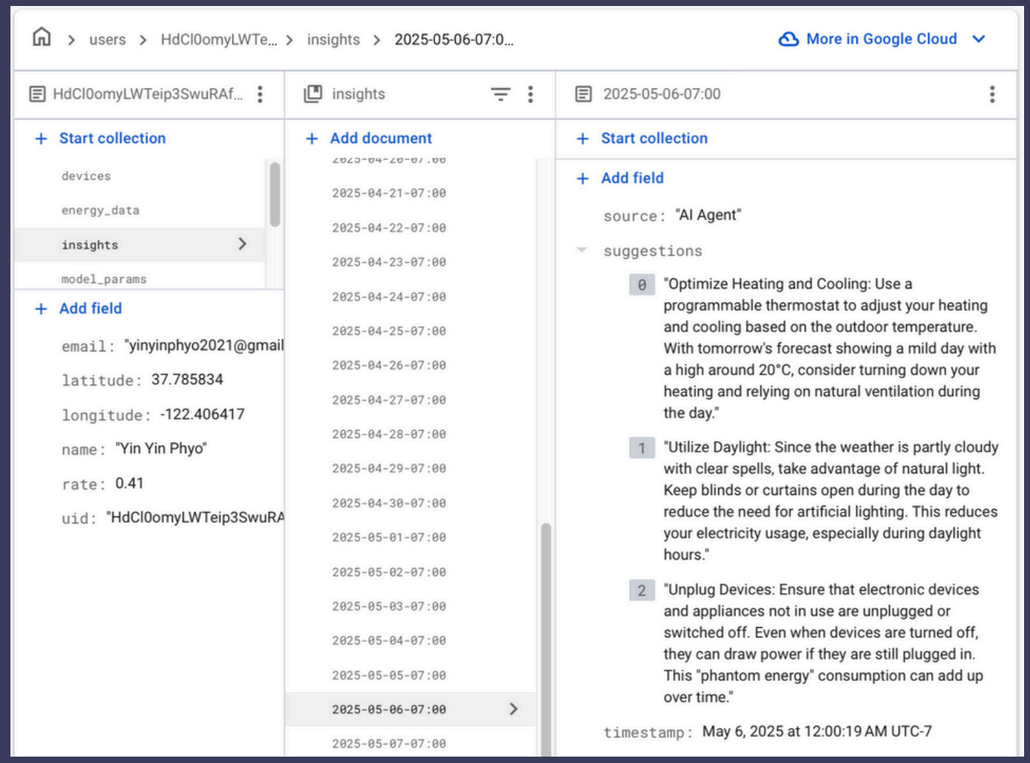
Model Optimization

- Missing data handling (forward/backward fill)
- Clipping and filtering to prevent invalid predictions
- Support for user-customized electricity rates for cost estimates
- Automated monthly grid search to re-tune hyperparameters
- Minimized Firestore reads/writes to reduce latency and cost

Backend & ML/AI

AI Suggestions for Smarter Energy Usage

- Combines: forecast data + historical usage + weather data
- Uses **OpenAI API** (gpt-4o-mini) to generate human-readable tips
- **Examples:** reduce heater use because of warm weather; avoid heavy loads at peak hours
- Outputs written to Firestore, shown in mobile app



Backend & ML/AI

Backend Deployment & Maintenance

- **3 RESTful API endpoints**
- **2 Dockerized microservices** on Cloud Run
- **3 Cron Jobs** on Cloud Scheduler
- Production server via **Gunicorn**
- API Keys managed with **GCP Secret Manager**
- Failure monitoring + email alert system

Services

Filter Filter services

Name	Deployment type	Req/sec	Region	Authentication	Ingress
ai-agent	Container	0	us-west1	Allow unauthenticated	All
predict-model	Container	0	us-west1	Allow unauthenticated	All

Cloud Scheduler / Jobs

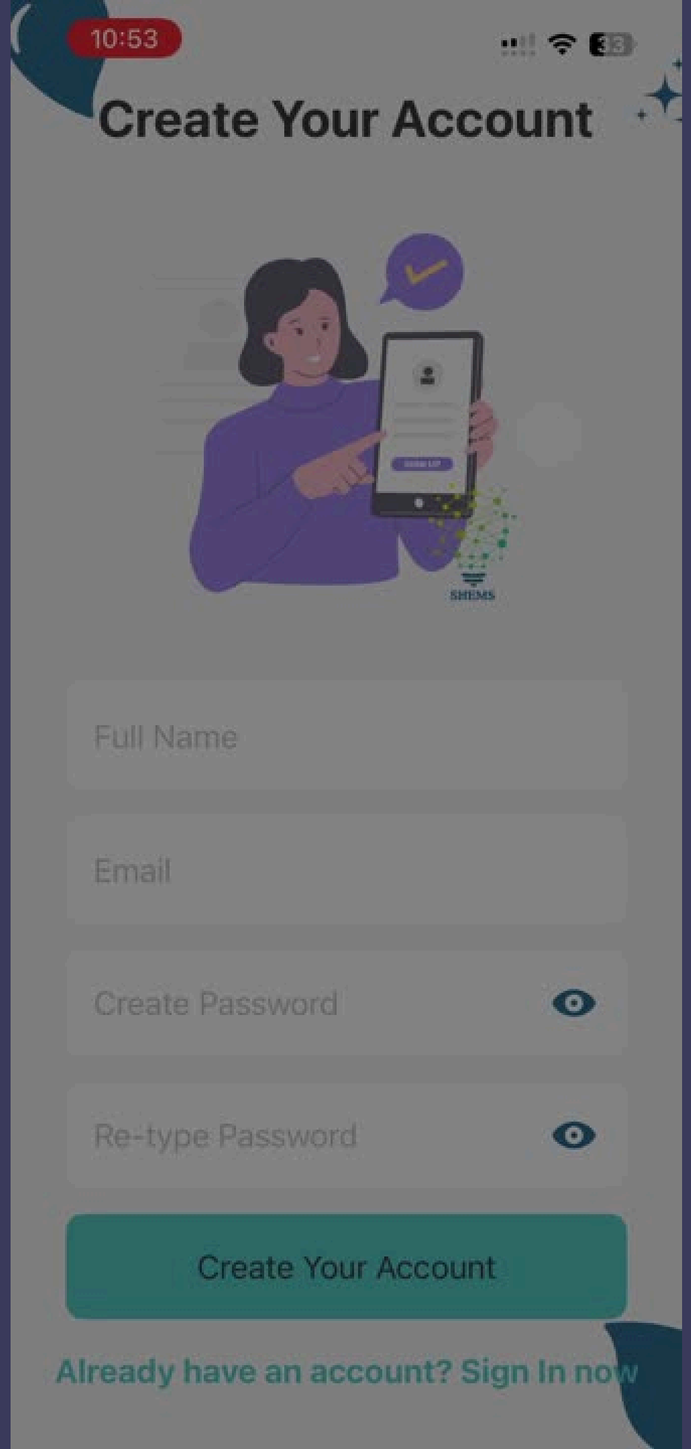
Jobs CREATE JOB REFRESH FORCE RUN EDIT COPY PAUSE RESUME DELETE

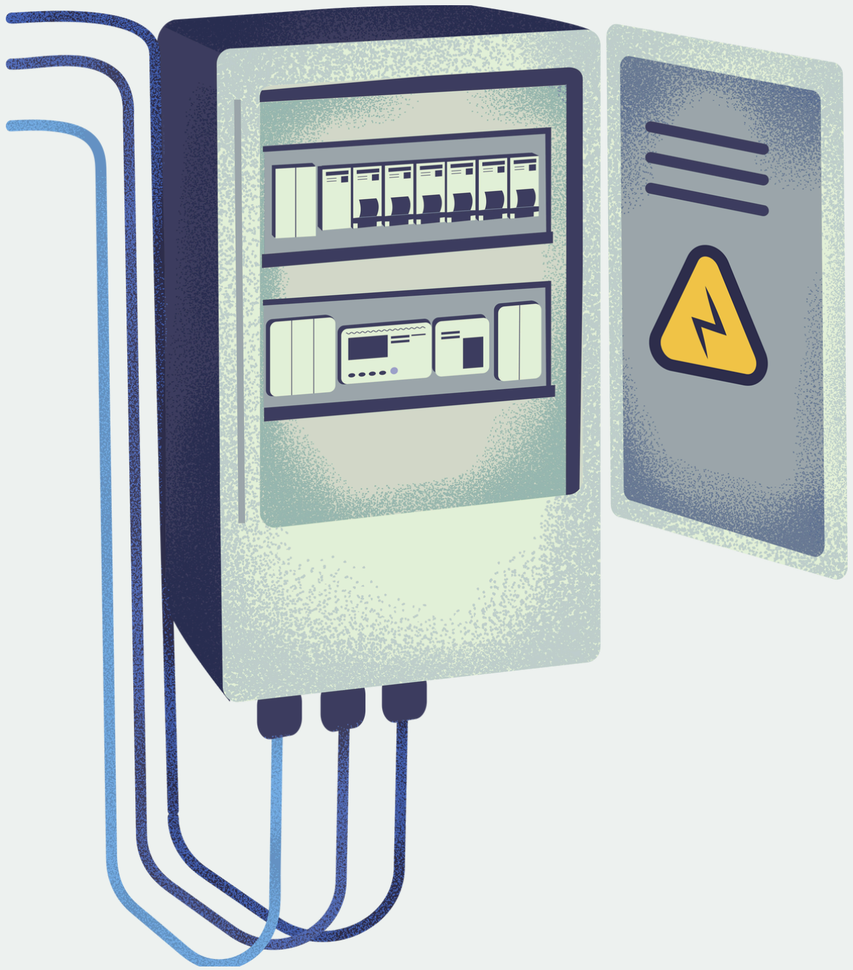
SCHEDULER JOBS APP ENGINE CRON JOBS

Filter Filter jobs

Name	Status of last execution	Region	State	Description	Frequency	Target
daily-ai-suggestion	Success	us-west1	Enabled		0 0 * * * (America/Los_Angeles)	URL : https://ai-agent-399301927568.us-west1.run.app/trigger_all
daily-prediction-job	Success	us-west1	Enabled		0 0 * * * (America/Los_Angeles)	URL : https://predict-model-399301927568.us-west1.run.app/run_daily_pred
monthly-grid-search-job	Success	us-west1	Enabled		0 0 1 * * (America/Los_Angeles)	URL : https://predict-model-399301927568.us-west1.run.app/run_grid_searc

Demo


10:53
Create Your Account
SHEMS
Full Name
Email
Create Password
Re-type Password
Create Your Account
Already have an account? Sign In now



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Kaur, H., Awasthi, A., & Lam, J. S. L. (2020). Smart home energy management systems: Recent advances and future trends. Renewable and Sustainable Energy Reviews, 121, 109637. https://doi.org/10.1016/j.rser.2020.109637

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Thanks!