



TECHNOLOGY RESEARCH REPORT

TEAM 1

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Understanding Data Sources

in a Smart Home Environment

What are these Data Sources?

- Electrical Panels & Circuit Breakers
- Solar Panels
- Power
- Utility Providers
- Battery & Energy Storage
- Portable Generators & Inverters
- Edge Devices

To understand data sources currently existing in smart home environment, it is vital to look at some key players in this domain and data points they are delivering.



Span is developing products to enable rapid adoption of renewable energy and deliver an intuitive interface for the home.



Leviton offers Smart Circuit Breakers that can connect to their app and can easily access their load center's data and other related controls.



Solaredge offers solar panels connected to a SolarEdge Power Optimizer which transforms it into a smart module.



Sense offers solutions to understand home energy usage, appliance control & safety and several integration choices



Ecoflow offers a range of premium products including portable smart power stations and solar panel integrations to their product suite.



HomeDash offers a custom dashboard environment that is compatible with Apple HomeKit devices and a few third-party devices.

SPAN offers customizable whole home backup solutions centering around their smart electrical panels integrating well with their solar and backup power solutions. Additionally, they also offer real-time monitoring & control for home energy & backup.

100 homes in Vermont are being installed with their Gen2 panels as a part of their pilot program. Their mobile app offers the features mentioned below:

Power in Watts

From & to:

- Solar
- Grid
- Battery

In case of outage, appliances categorized as:

- Must have
- Nice to have
- Non-essential (user-customizable)

Solar insights
Daily/Weekly/Monthly/Yearly

Battery %

Categorized backup insights

Impact
Saved Energy

- Worth 20 Oil Barrels
- Worth 12 lb of Coal

Self-sufficiency %

Energy Insights

- Solar
- Battery
- Grid

Ability to control appliance

Watt Consumption by

- By Room
- By Appliance
- By Panel



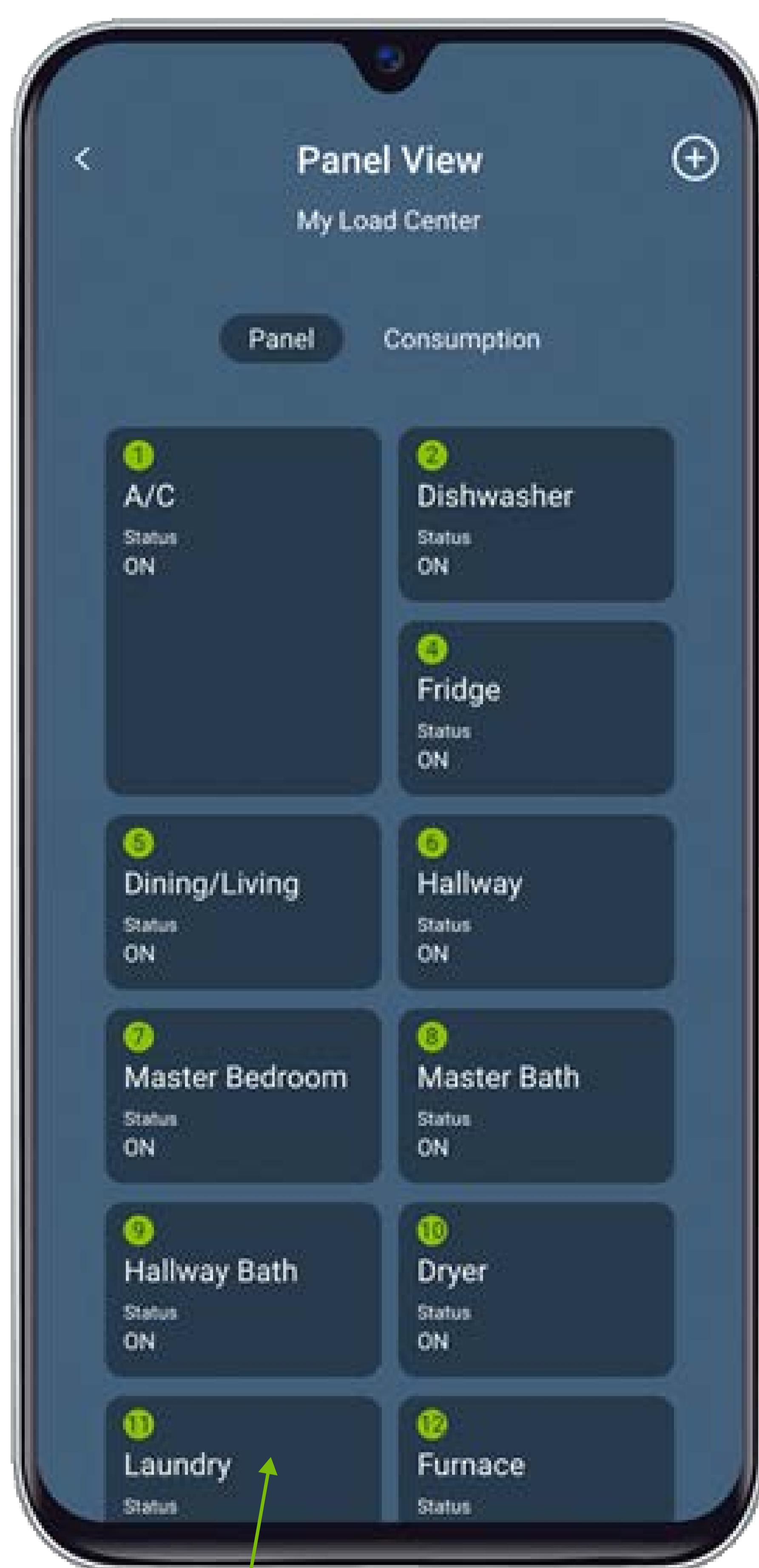
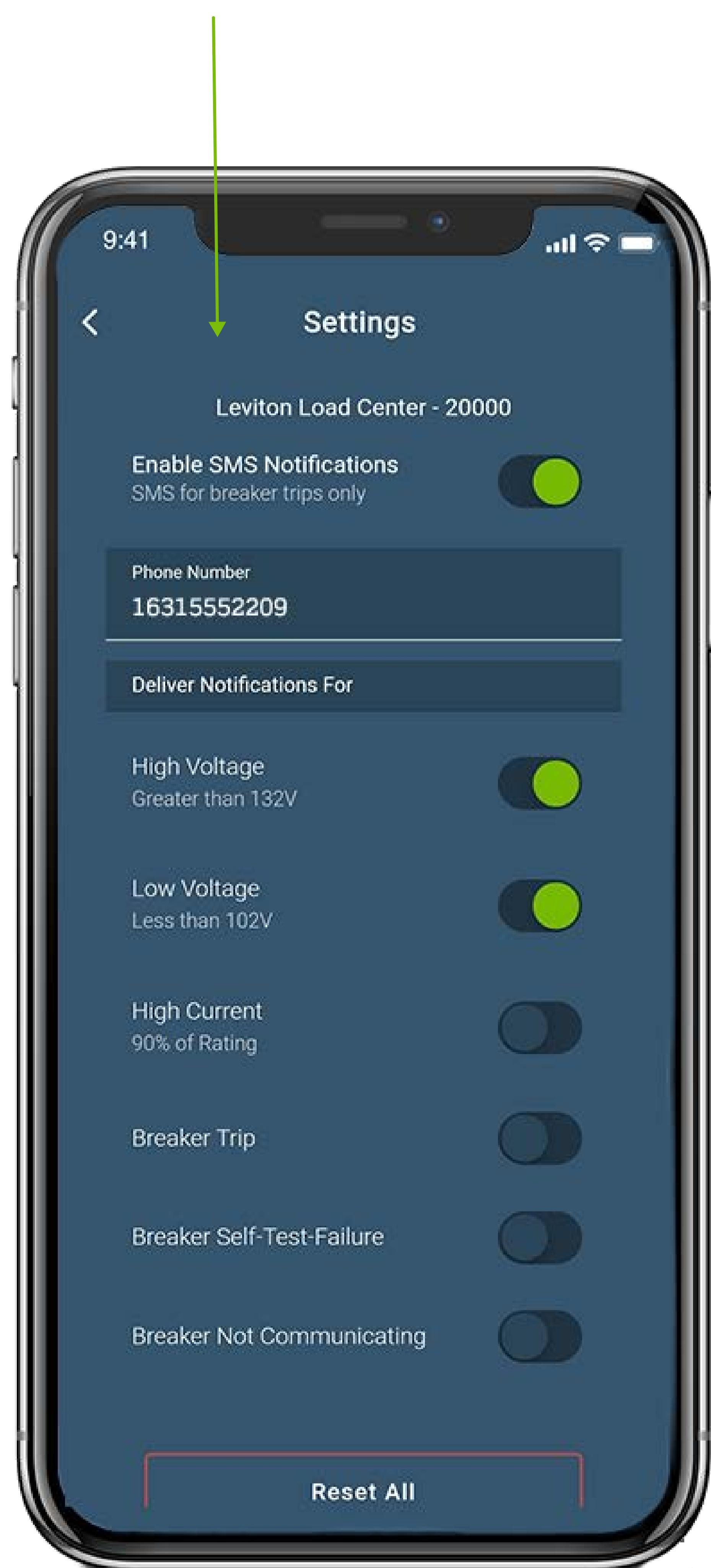
Leviton offers smart circuit breakers by integrating smart technology directly into the breaker box and individual circuit breakers, giving homeowners far more information on the power management in their homes.

They offer features in

- Energy Use
- Control
- Alerts & Updates

Customizable Notifications for:

- Breaker trip
- High Current
- Low Voltage
- High Voltage
- Breaker not communicating
- Breaker Selftest fail

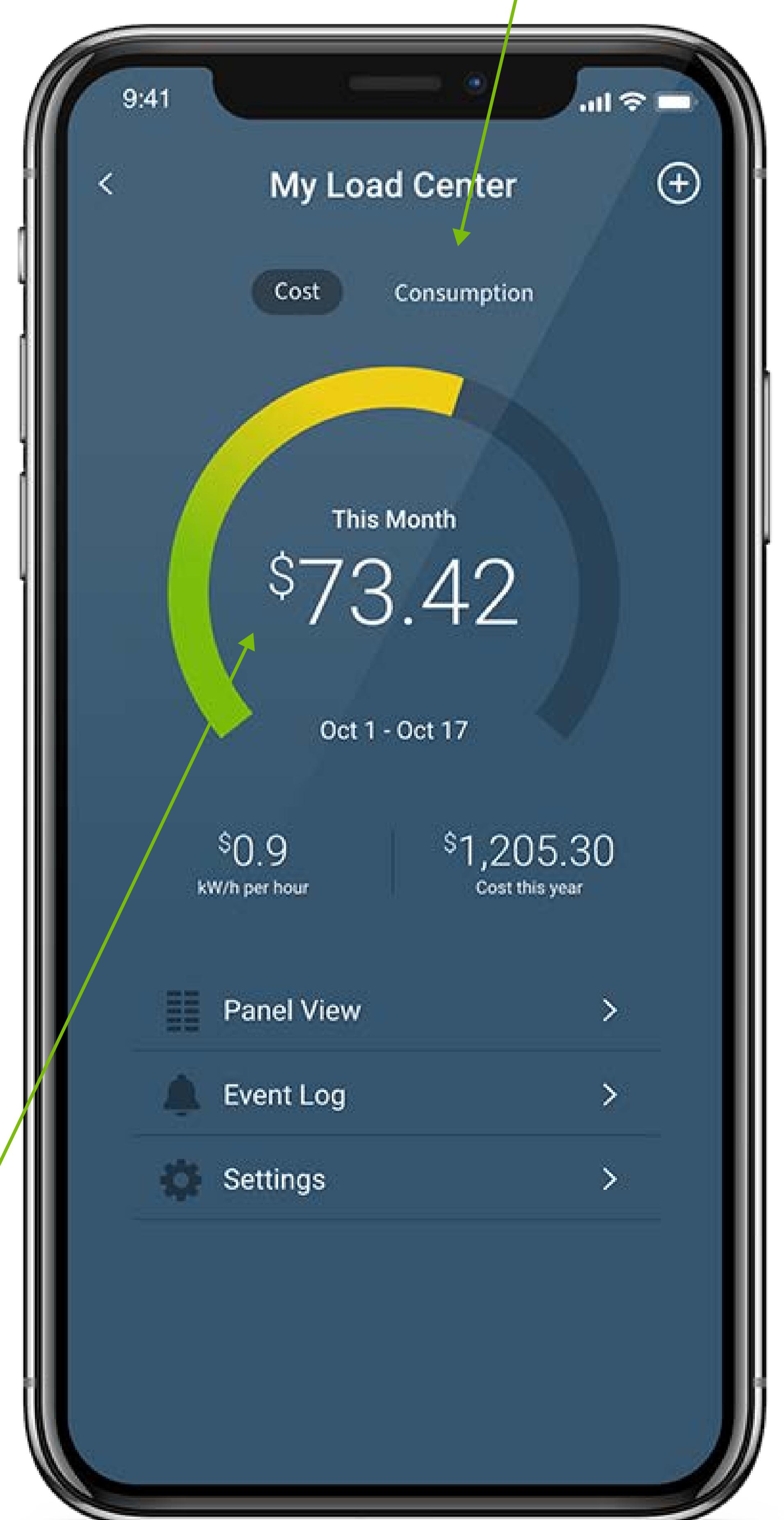


Status of Individual Breakers assigned to appliances or rooms

- Remotely turn OFF any breaker
- Real-time system status

Energy consumption graph

- Real-time energy consumption: total aggregate, individual circuit, or
- trends by day, week, month, and year



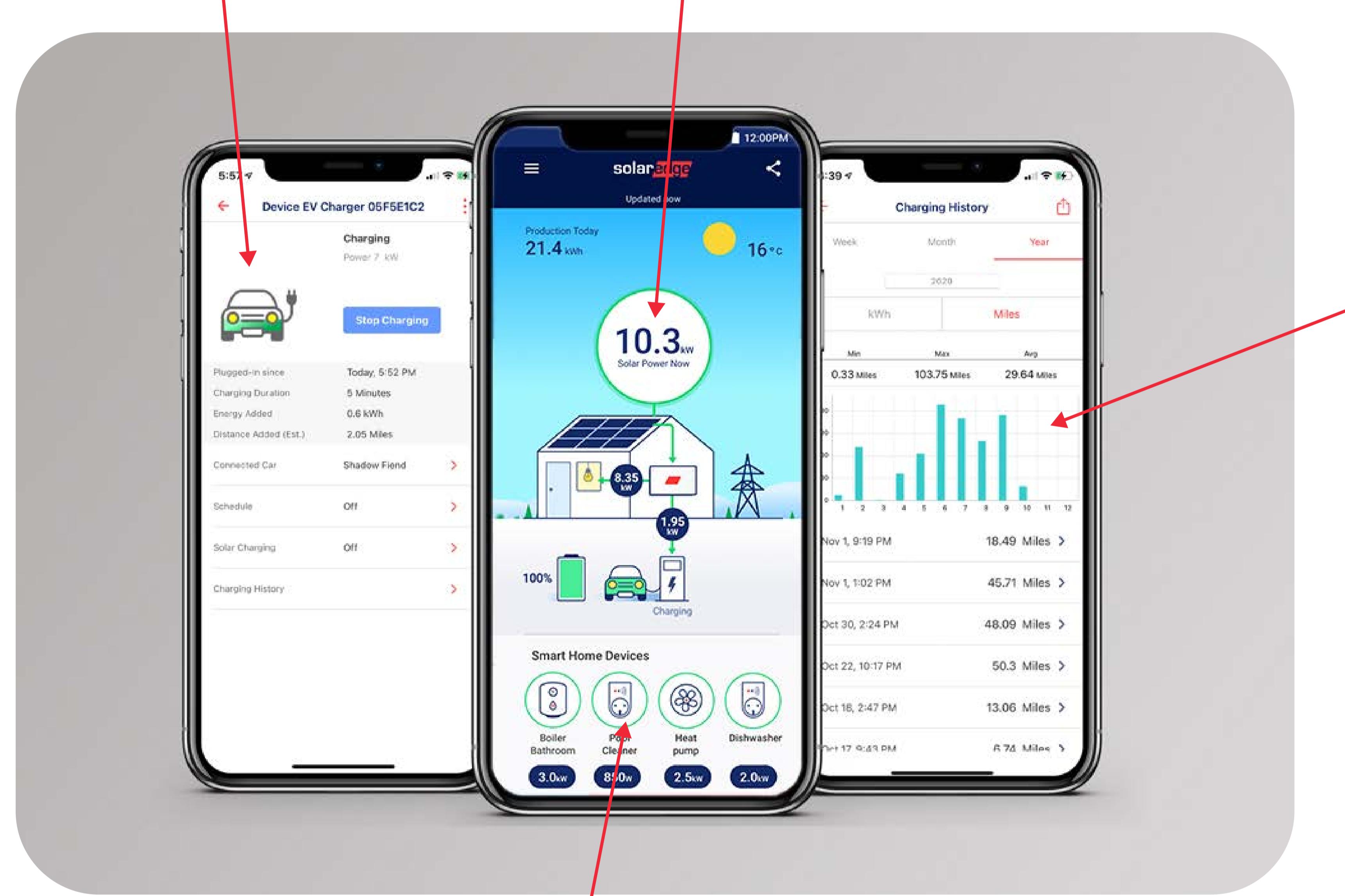
Savings in terms of money saved (\$)

A SolarEdge system focuses on lowering the user's electricity bills. It also keeps track of energy production and consumption of a home using their free mobile app. The installer gets their own application - the SolarEdge Monitoring Platform - which provides remote monitoring and maintenance down to the module level. They also offer Solar Inverters, EV Charging, and SolarEdge Energy Bank.

EV Charging Details

- Duration
- Energy Consumed
- Distance
- Scheduling

Live Solar Power



Charging History for EV

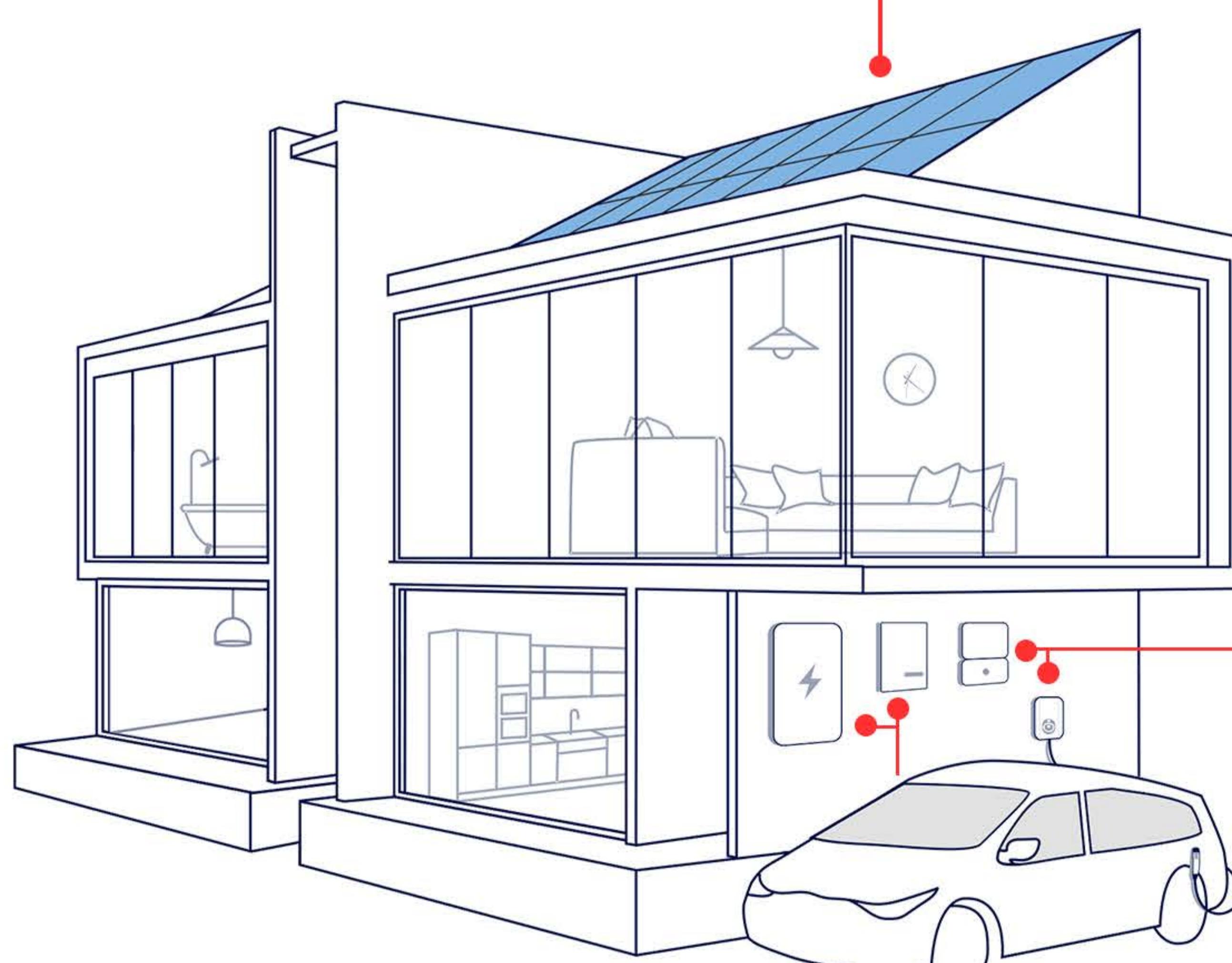
Smart Device Home Control

- ON/OFF Status
- Power Consumed



Power Optimizer

Attached to each solar module to maximize the module's energy output and communicate its performance



mySolarEdge App

Real-time dashboard of your energy production, consumption and CO₂ saved

EV Charging

Level 2 Smart EV Charger enables you to drive on sunshine



Solar Inverter

The brains of the system, converts the DC power from your solar modules to the AC power your home runs on



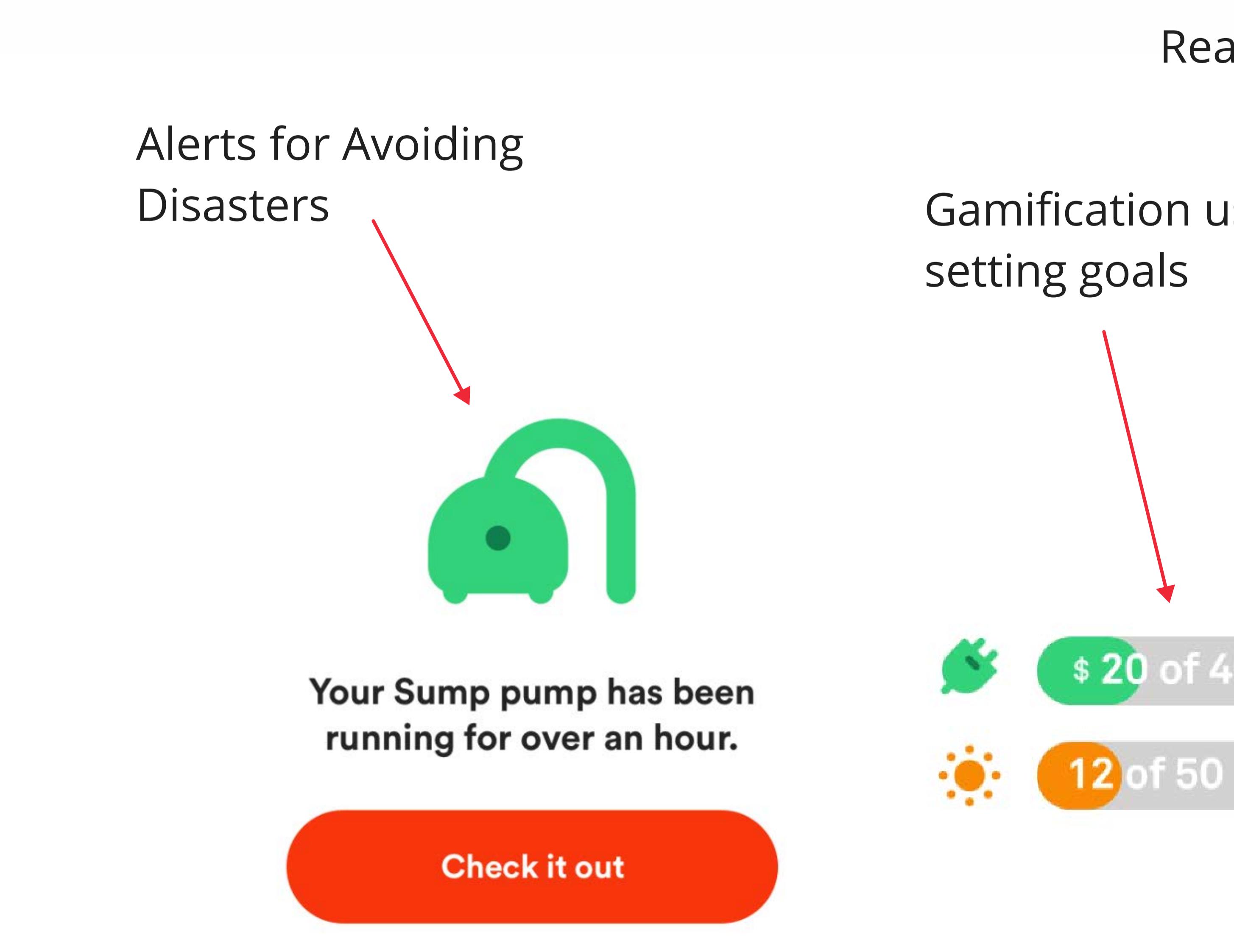
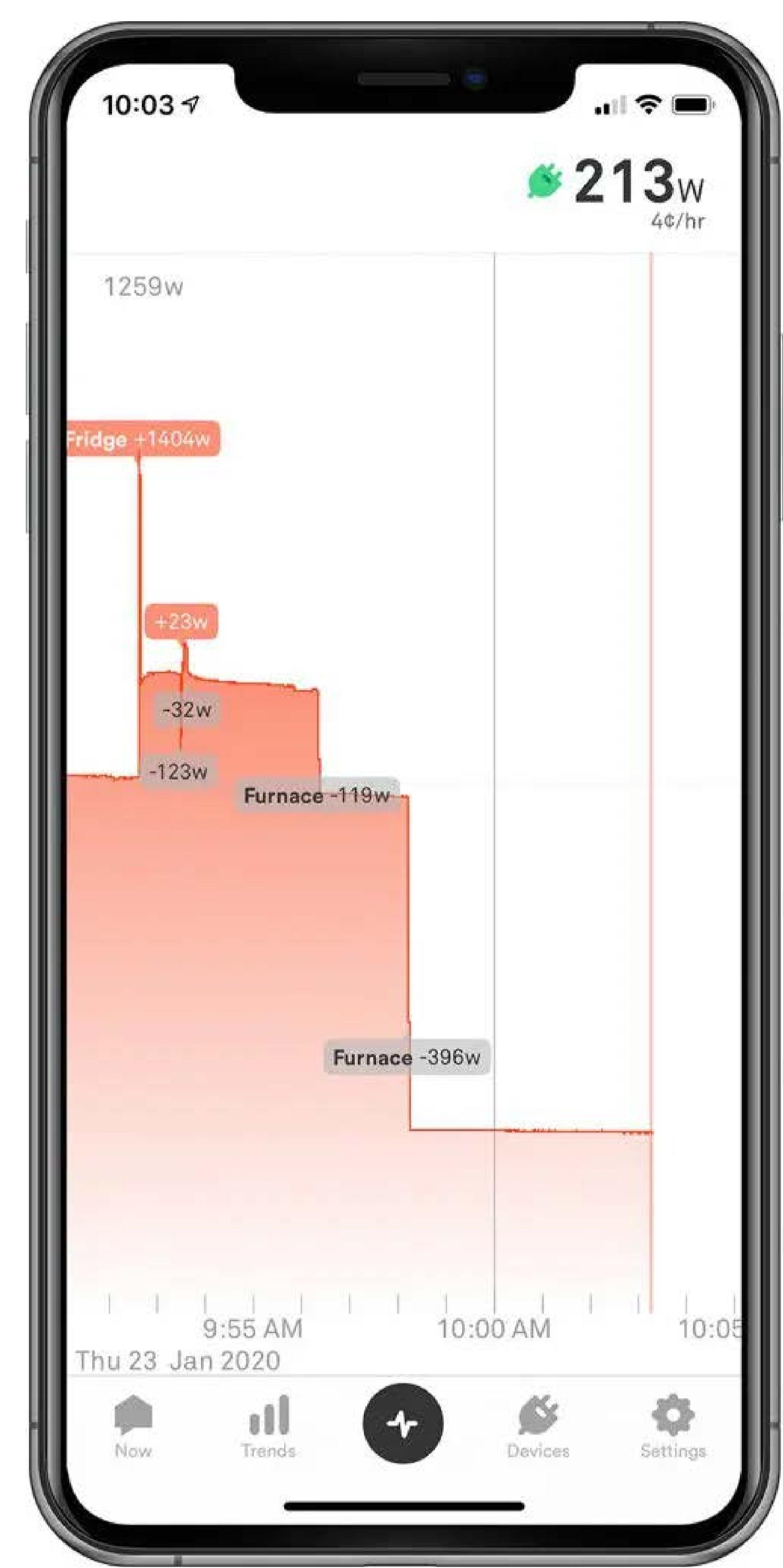
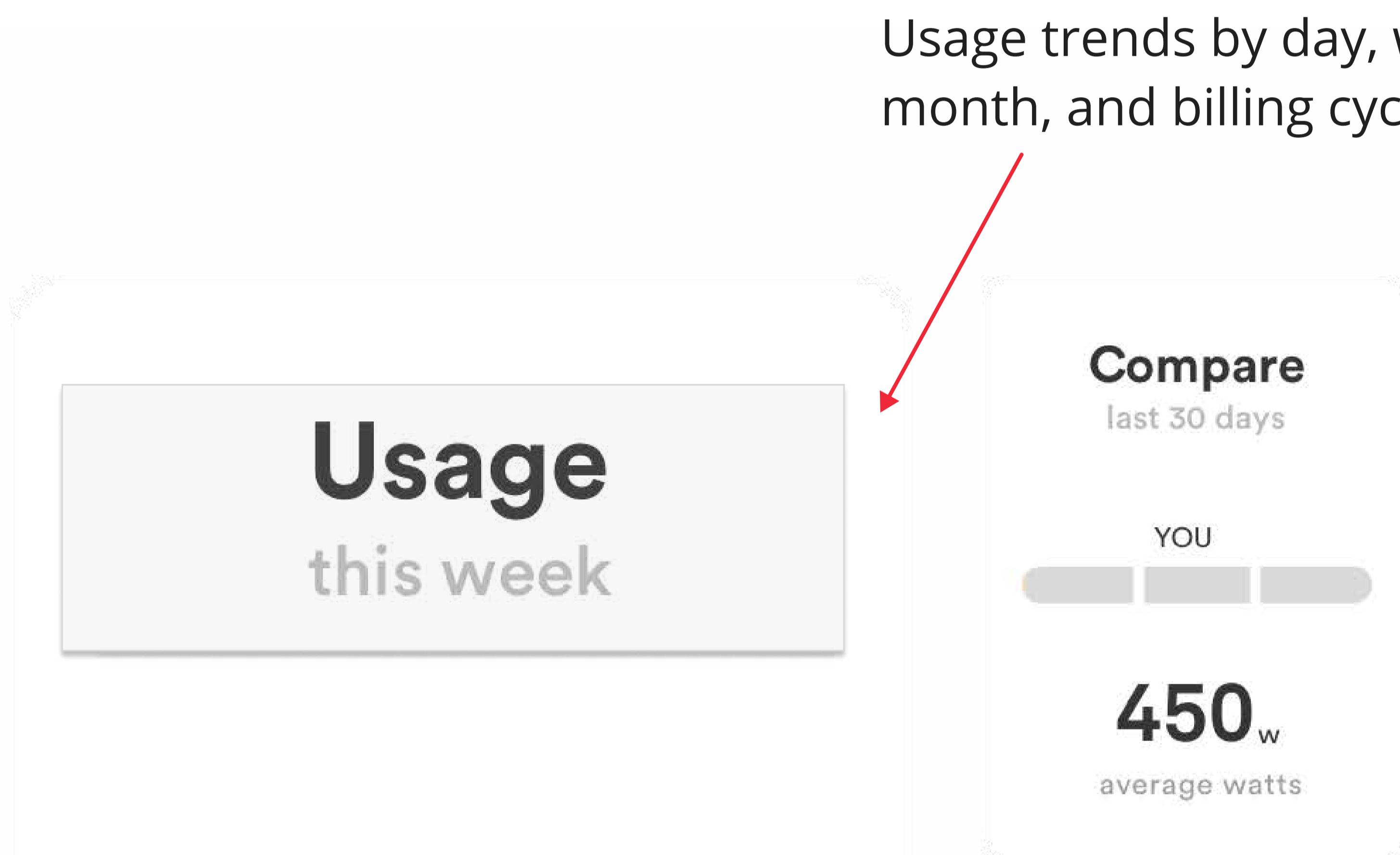
SolarEdge Energy Bank

Stores your excess solar energy to provide additional power when you need it, backup your home when the grid goes down and power high wattage appliances when utility rates are high

The Sense System offers total home monitoring solutions by focusing on 4 key domains which are focused on:

- Saving Energy
- Knowing Appliance Status
- Avoiding Disasters
- Reducing Carbon Emissions

The Sense System integrates well with select IoT devices like Philips HUE, TP-Link, WeMO, IFTTT, Amazon Alexa, Google Assistant and more.



Always On	148w
Cable Box	22w
Bedroom lights	6%
Dryer	5,217w
Microwave	1,668w
Other	67w
Soundbar	10w
Television Dining Room	
Garage Door	

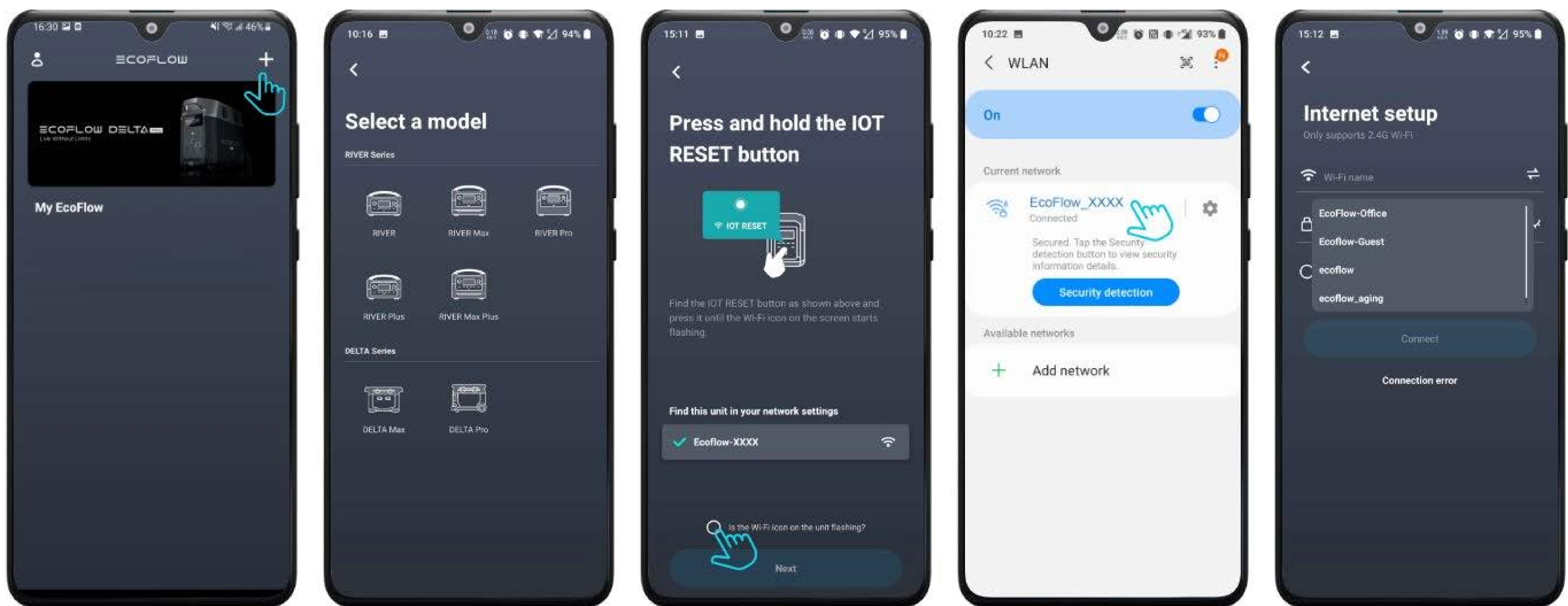
EcoFlow creates some of the best portable power stations.

Their product lines of DELTA and RIVER series equip the consumer with an clean, quiet and renewable power for life adventures, work and home backup power.

They have a wide range of products interfacing well with their solar panels and battery packs.



Mobile app setup screens



HomeDash allows you to setup, manage and control all kind of smart home devices that are compatible with the Apple HomeKit standard. The app has been developed with a clear focus on user experience, stability and performance.

Users can easily add new HomeKit devices, create rooms, zones and groups. Save preferred settings as scenes. Execute them from the app, Siri, Apple Watch or directly from the iOS home screen.



Categorizing & Merging Data

for a Smart Home Environment

Electrical Panels & Circuit Breakers

- Power Consumption (in Watts)
- Low Voltage & High Voltage Alerts
- Breaker Alerts (Trip, No Comm, Self test fail)
- High Current Alerts
- Power or Appliance ON/OFF (+Alerts)
- Money (\$) Saved
- Energy consumed per appliance
- All data filtered by
 - day/week/ month/year
 - Rooms
 - Appliances

Solar Panels, Power Inverters & Battery Backup

- Energy/Power Generated (in Watts)
- Solar Energy generated over a day/week/month/ year
- % Energy generated today as compared to Last day/week/month/year
- Self Sufficiency % for the home
- % Energy used by
 - An Appliance
 - A Room
- Battery %
- Battery Health
- Panel Life

Portable Generators & Inverters

- Fuel Quantity
- Battery in terms of % and Hours
- Output Power in Watts
- CO Alerts / Oil Alerts
- AC Power ON / OFF
- Devices Connected

Categorizing & Merging Data

for a Smart Home Environment

Smart Appliances

- Appliance Status & Health
- Energy Consumption
- Duration of Operation
- Real-time recordings of data
- Appliance context-based data

	DATA COLLECTED	WHO IS THIS DATA SHARED WITH?	USERS CONTROLS?	KEY PLAYERS/ COMPANIES
DOORBELLS	Real time recordings, other personal info	Third party partners	Some personal data sharing can be disabled	Ring, Zmodo, SimpliSafe
LOCKS	Location, IP address, photos, videos	Latch and its partners, landlords, perhaps police	No controls offered to tenants/ residents	Latch, Ultraloq, Kwikset
"SMART" CARS	Location, route data, contacts, emails, media, etc.	Car companies, data extraction firms, governments	Some, if smart phone if not connected	Tesla, Hyundai, Lexus, Toyota
SPEAKERS	Always listening, records when falsely triggered	Amazon, connected devices like Fitbit	"Delete what I just said" feature	Amazon Alexa, Google Voice Assistant
ROBO-VACUUMS	Cleaning scheduling, vacuum path maps	iRobot, maybe tech companies in the future	No known blocking features on device or account	Roomba, Shark, Bissell
TVS AND STREAMING	Device type, location, email, viewing history	Advertisers, social media/marketing companies	Different services offer different controls	Roku, Amazon Fire, Netflix, Hulu
SMART WORKOUT MIRRORS	Age, height, weight, video, audio, heart rate, location	The Mirror, marketing companies	Can put lens cap on video camera	The Mirror
REFRIGERATOR	Contact information, voice recordings	Business partners, third party partners	Some, depends on company	Samsung, LG, Kitchen Aid
SMART BEDS	Heart rate, respiration, other sleep pattern data	Mattress companies and their partners	No known blocking features on device or account	Sleep Number, Eight Sleep, Nectar Sleep

Making Data Actionable

Behavioral or automated

Behavioral changes

There are three different approaches in which data can be made actionable by bringing about a behavioral change in the users:

Information based programs

- Home energy reports
- Real time feedback
- Energy audit programs

Social Interaction programs

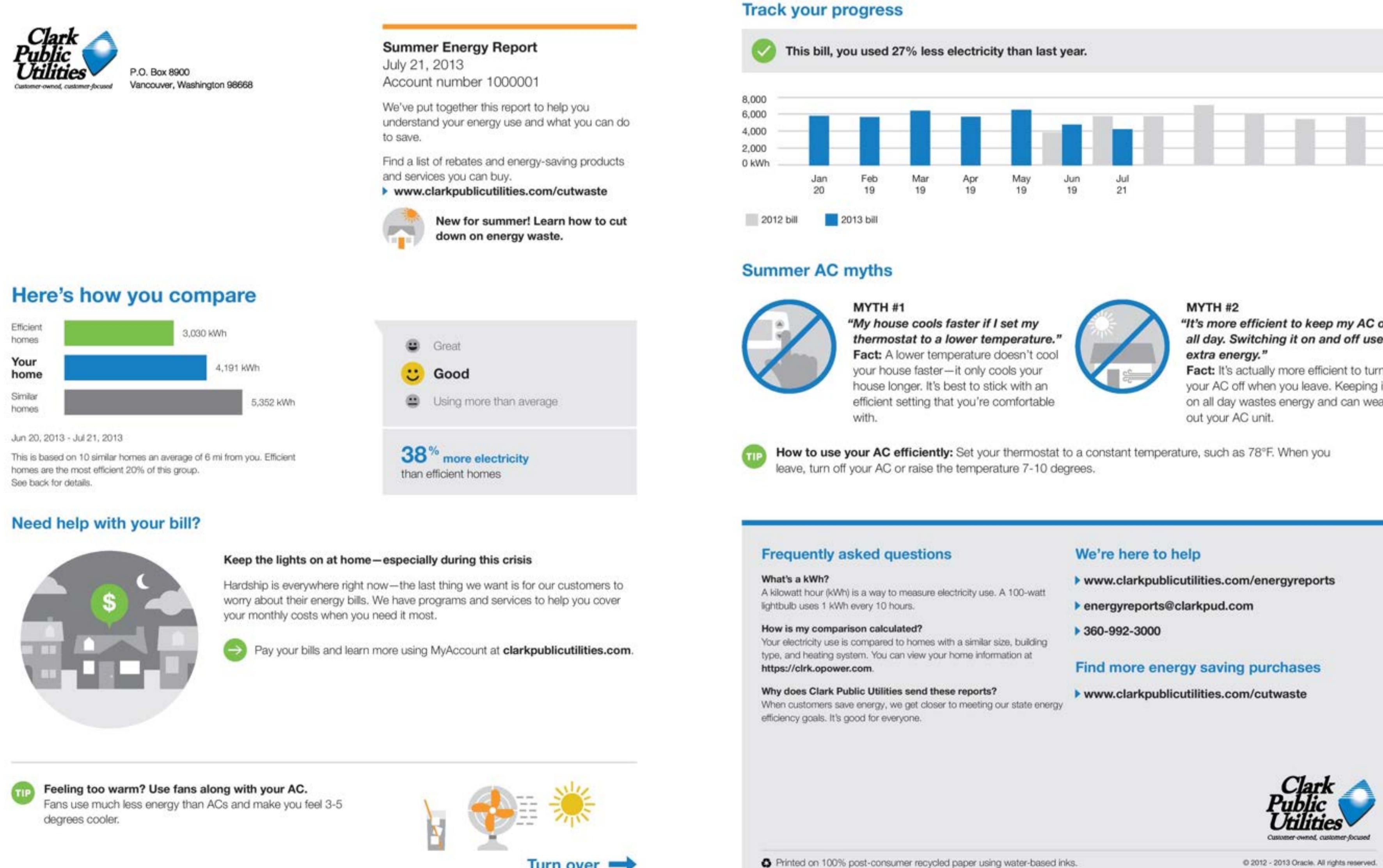
- Competitions and games
- Community based programs

Education and training programs

- Strategic energy management
- Training
- K-12 and campus education

Instruction based programs

Include alerting a user to perform a particular task. **Home energy reports** are sent either once a week, biweekly or monthly whereas **realtime data** give instantaneous alerts. It makes the user more aware of their energy consumption and help them be more cautious of it. **Audit programs** involve an auditor and resident interacting in person to determine issues with the way energy is currently being used. The auditor advises residents on how to better manage their energy.



Social Instruction based programs

These programs use a gamified experience method to encourage energy efficiency. This makes the process fun and the award system also helps in positive reinforcement.

Education & Training Programs

Education and training approaches may include a variety of elements from other programs but rely primarily on teaching as the vehicle for behavior change.

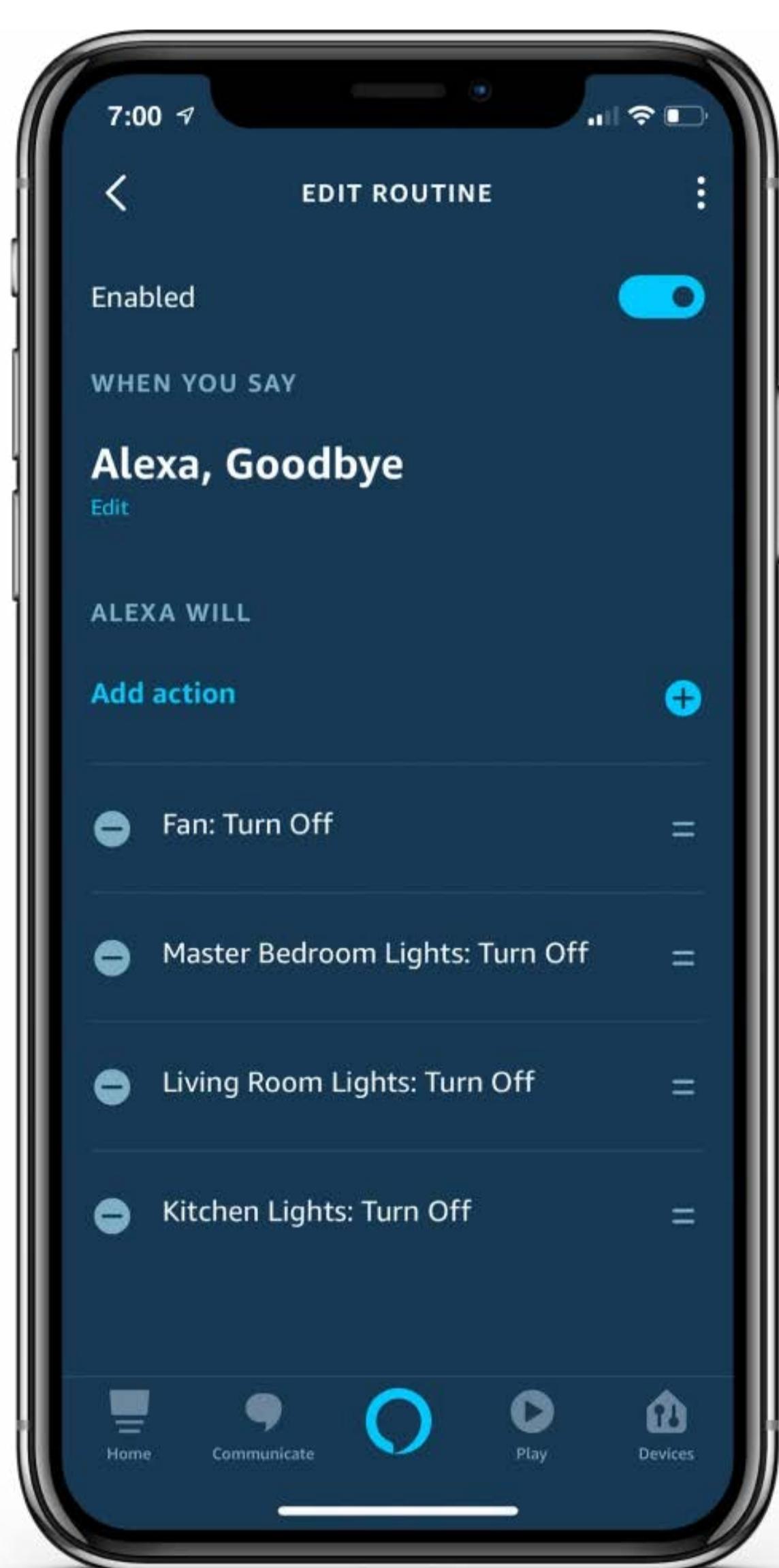
The three types of programs described and evaluated in this section are:

- Strategic energy management (SEM) programs
- Other community training programs
- K-12 and college campus programs

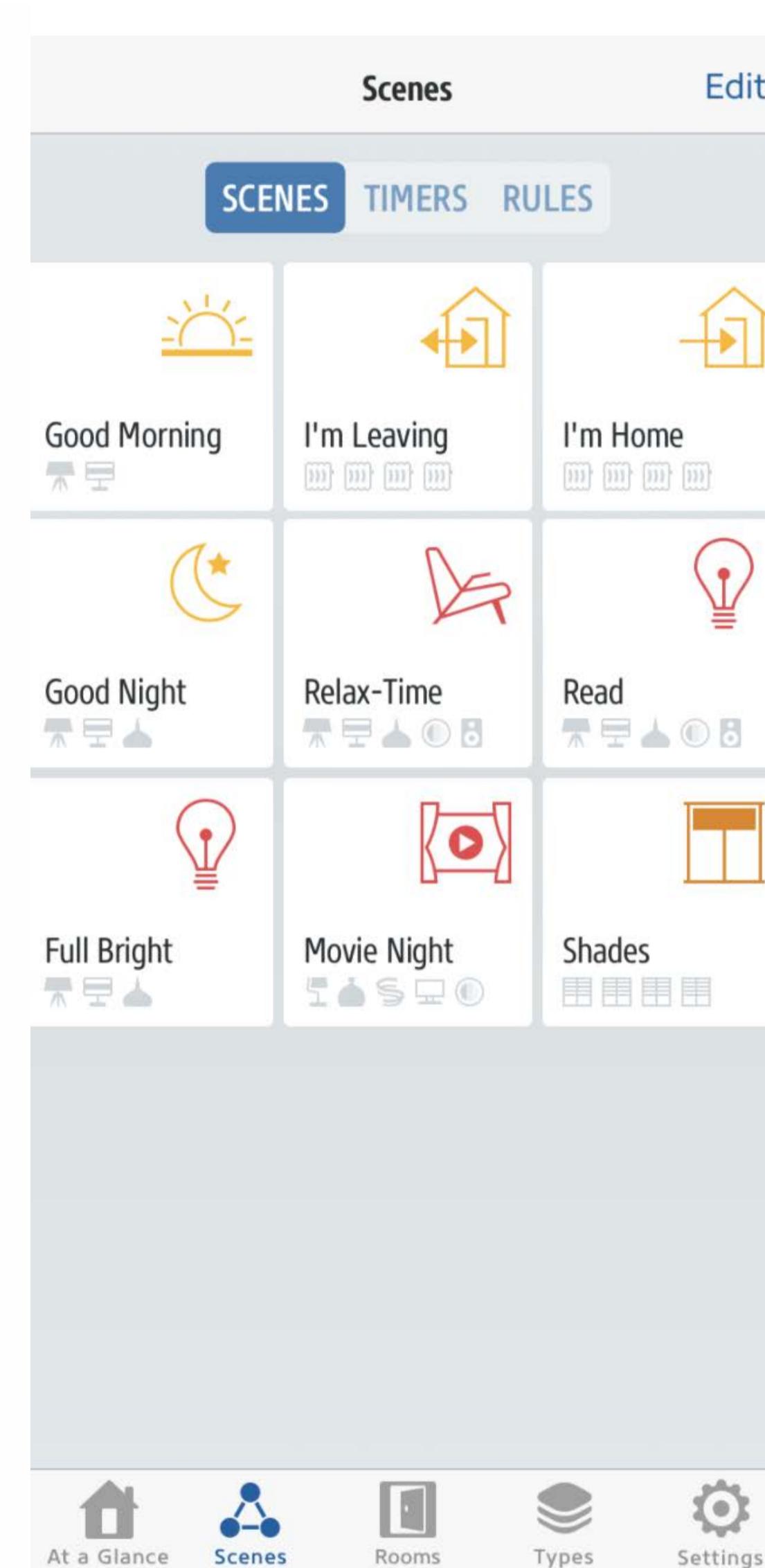
Automated Actions

Smart Hub Routines:

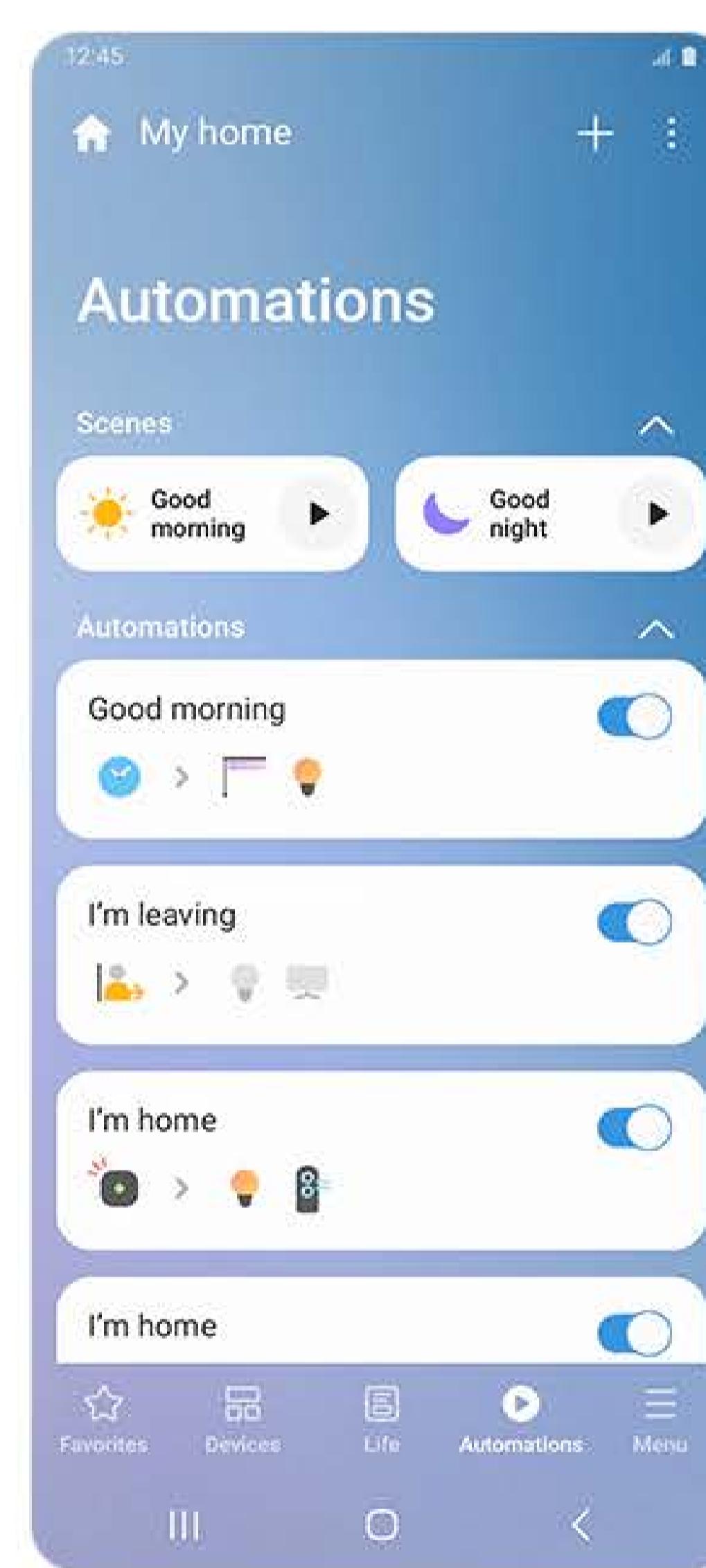
Smart home systems have the ability to trigger actions based on the routines set in the applications by the user. This could help the users perform multiple actions at once which can be used for energy saving. For example one command of "Alexa, turn off all lights" would ensure all lights are off when one leaves their house



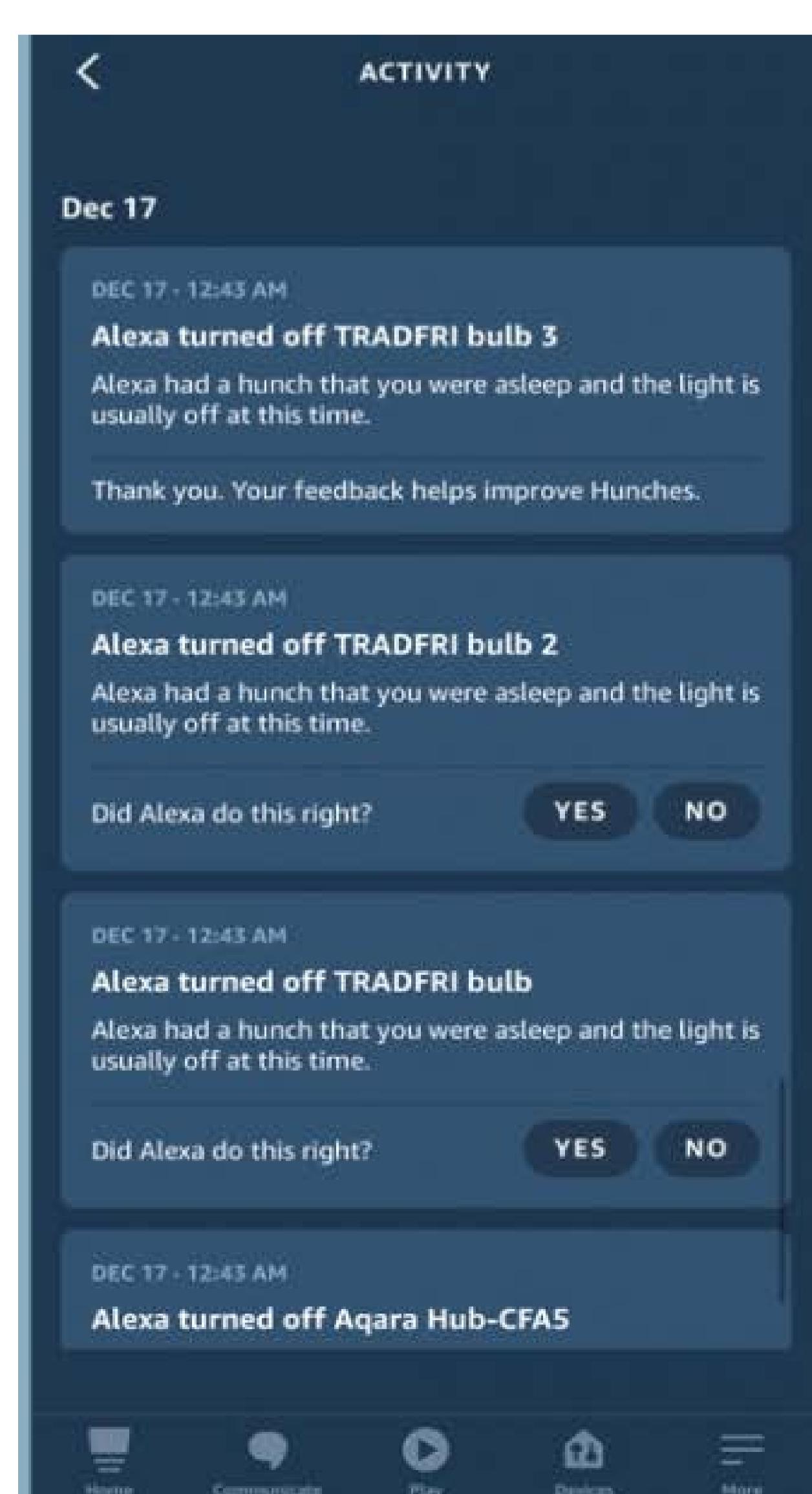
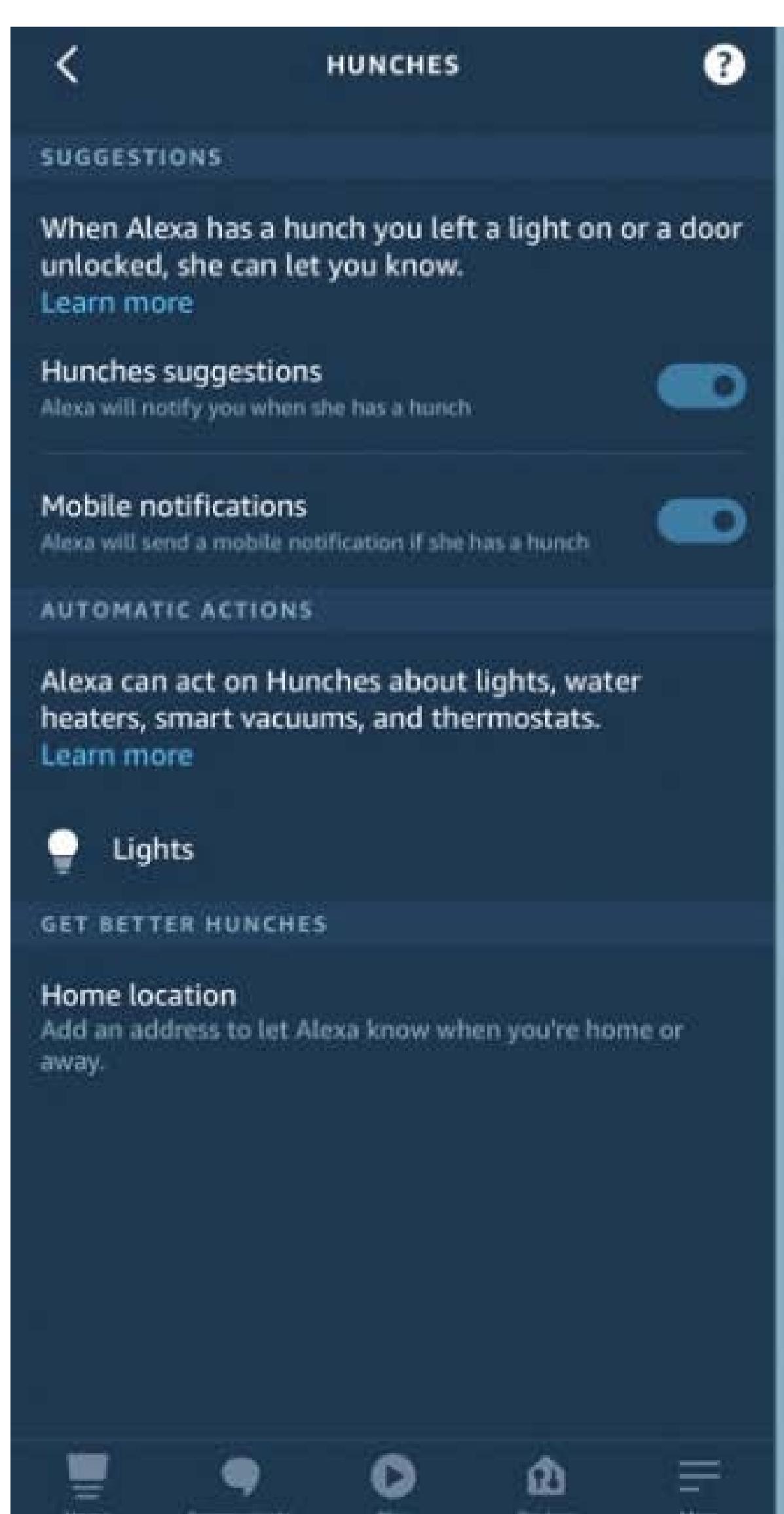
Amazon Alexa routines



Apple Eve Scenes



Samsung smartthings automations



Automated Hunches:

Hunches in a smart home system will automatically turn off devices based on a prediction model is another way to ensure energy efficiency.

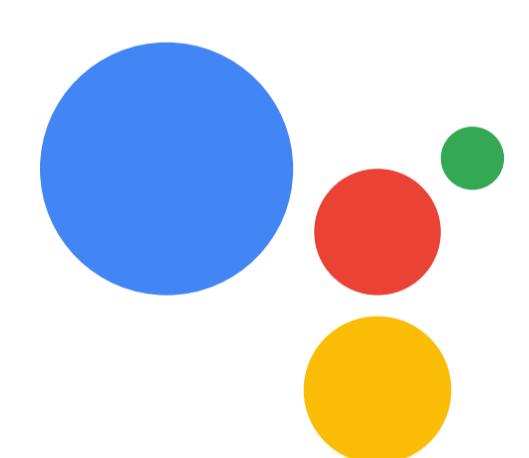
Understanding Smart Hubs

For a Smart Home Environment

How well connected is your home?

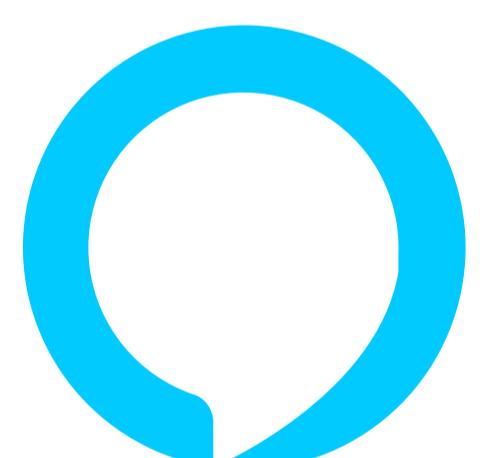
Left home without turning off the bedroom light? No problem! Smart home devices enable users to control their home efficiently by just a tap on their phone. Having these devices run your home add a layer of convenience and sophistication to live a hassle free life.

	Energy Savings	Predictive Maintenance	Voice Assistance	Energy Monitoring	Interoperability
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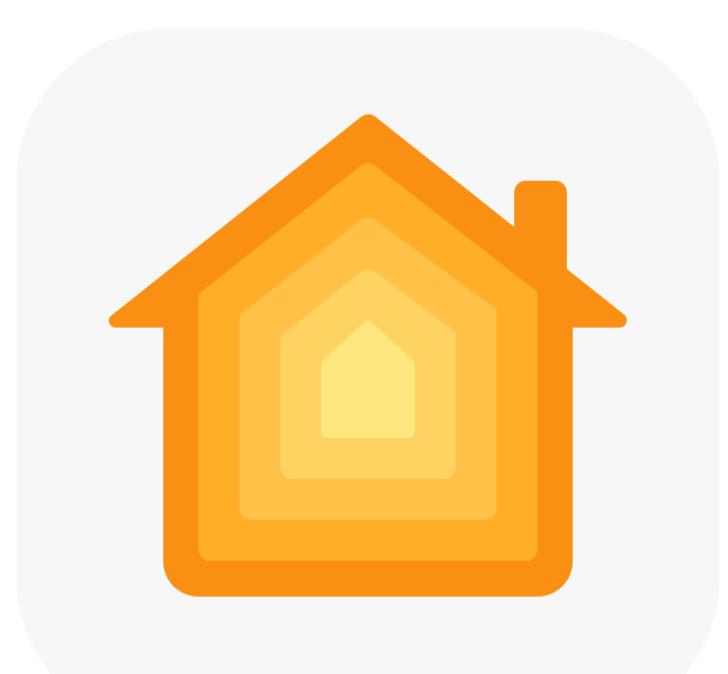
Google

✗	✓	✓	✗	✗
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Amazon

✓	✗	✓	✓	✓
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Apple

✓	✗	✓	✗	✗
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Samsung

✓	✓	✓	✓	✓
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Google Home Series

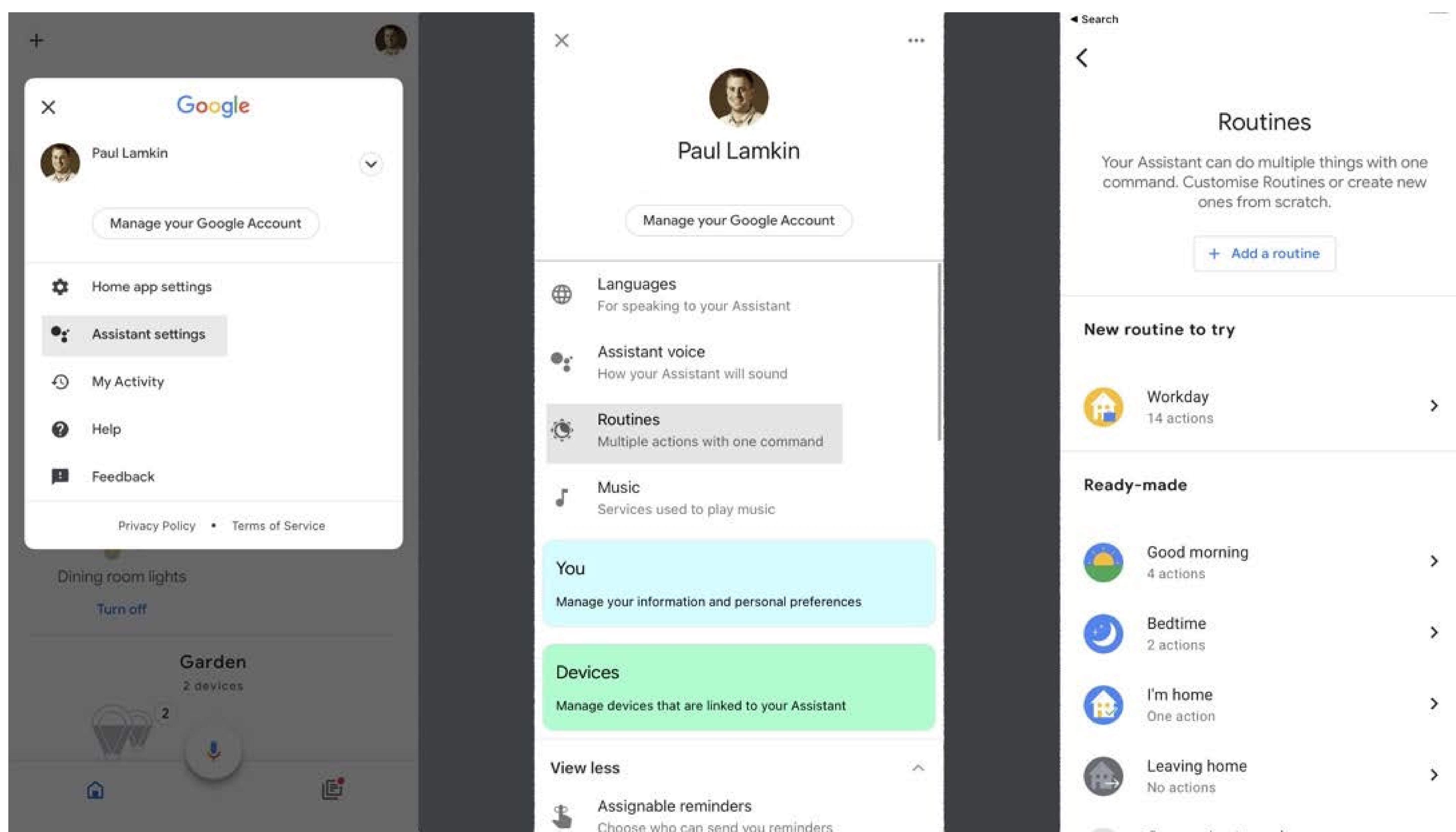
How does Google Assistant provide energy monitoring?

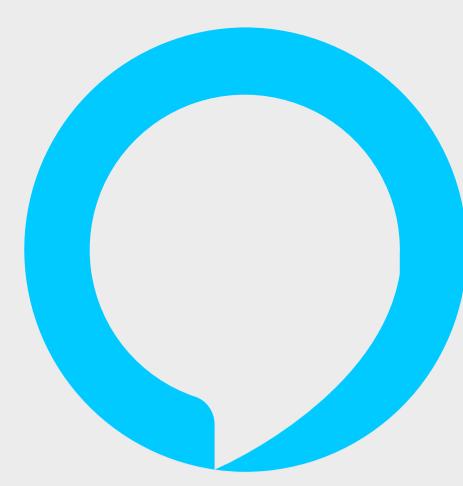
Google assistant as such does not have inbuilt energy monitoring enabled. Google assistant can provide energy monitoring services such as in collaboration with **Sense**. With the help of the Sense application, the user has a convenient way to know what's going on in their home. For instance, you can say, "Hey, Google, ask Sense if my oven is on," or "Ask Sense if the dryer has turned off," and get the answer.

Some of the other applications that can be connected with Google Assistant for energy tracking include applications like **Raycon Energy Meter** or **AGL Energy**, as well as being compatible with the **Wiser Energy System**.

How does Google Assistant help in Energy Saving?

Google assistant allows the users to set routines: short-hand commands to control smart appliances at home. Routines and commands that make sure your lights are off which in turn help in energy saving.



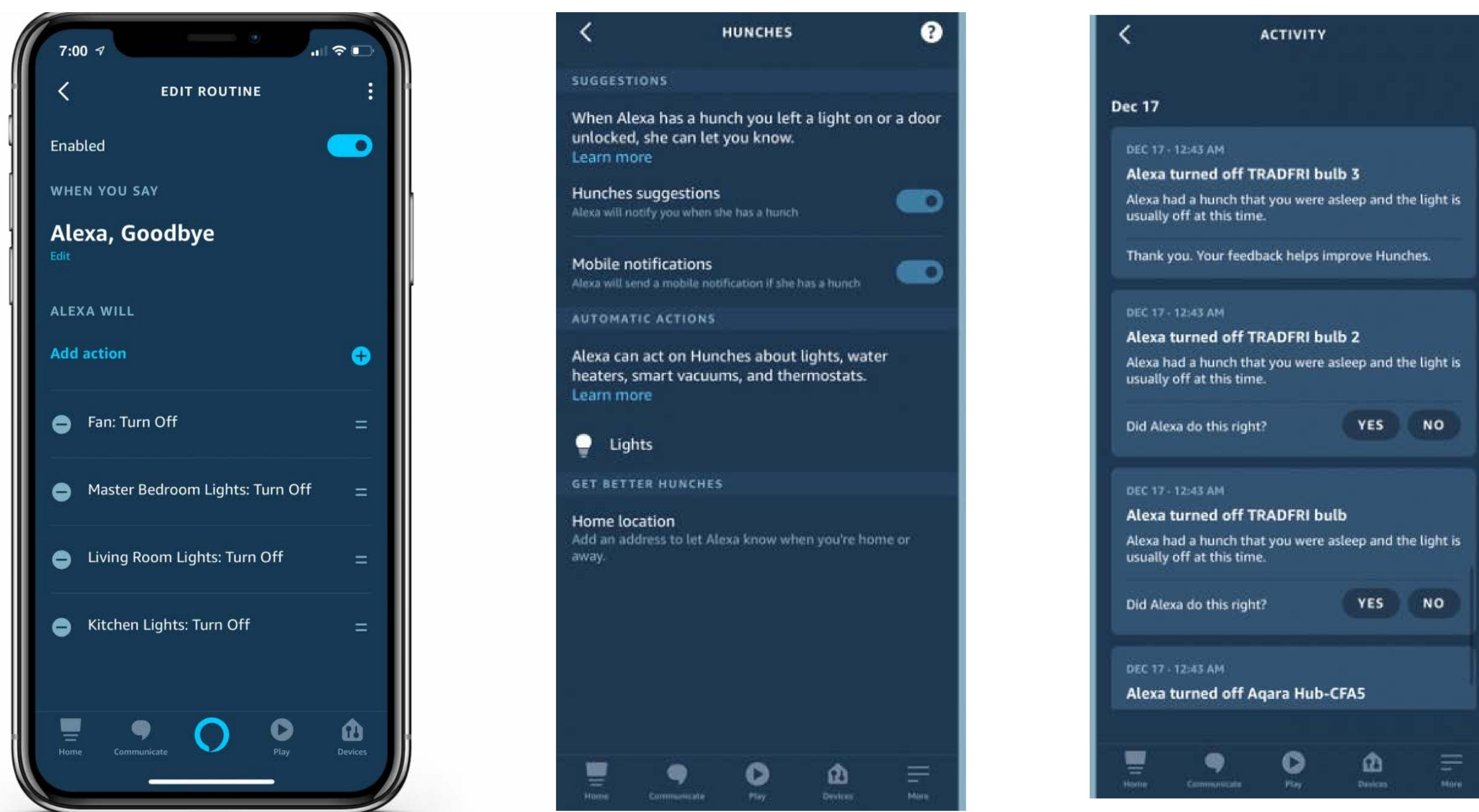


How can Alexa help you save energy?

Once Alexa connects to a compatible device, it enables users to get a better understanding of their energy consumption through the app.

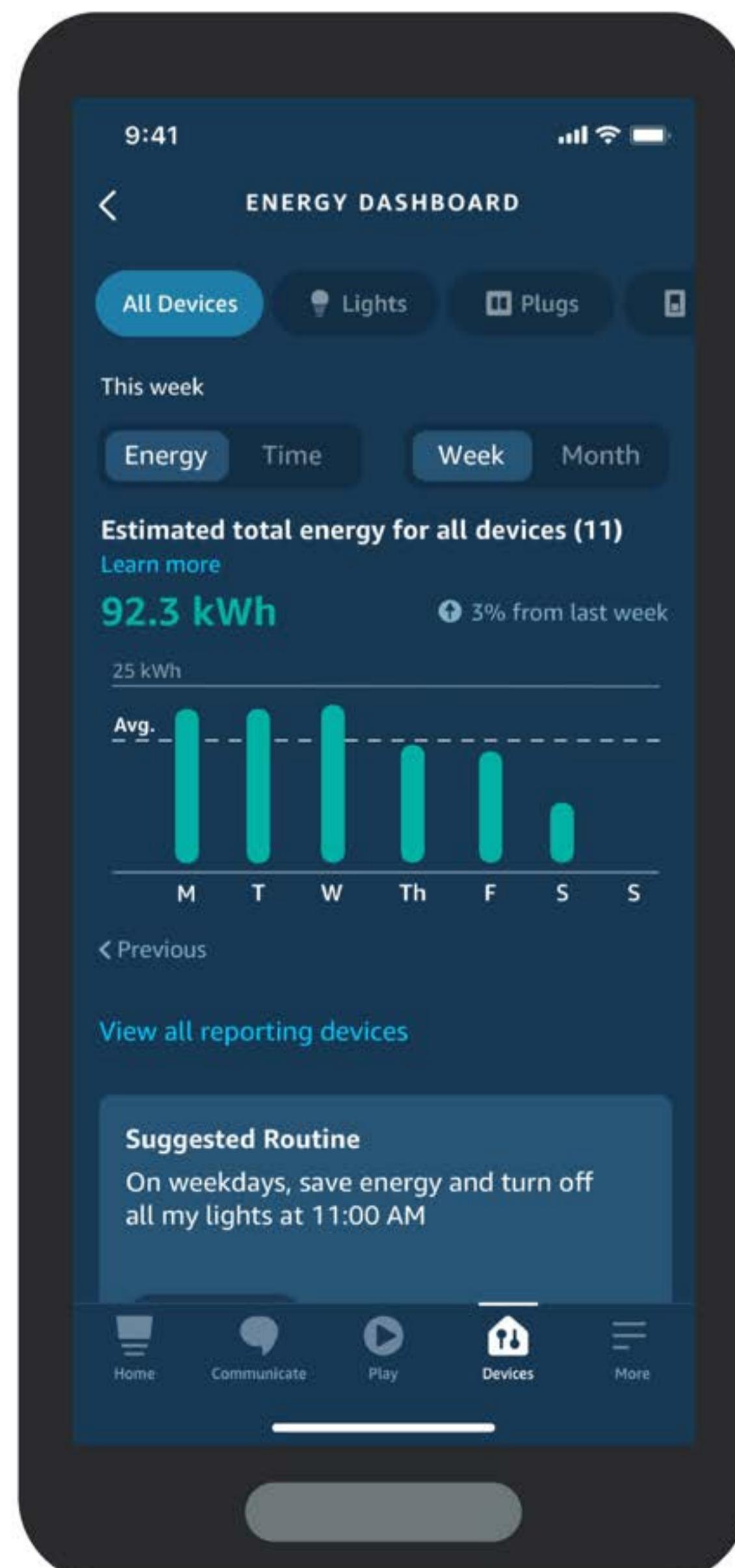
Two key features Amazon Alexa provides to manage energy are **Hunches** and **Routines**.

- Hunches lets users know when a connected appliance is behaving unusually. It can sense prolonged inactivity.
- Routines are short cuts. This lets users group a bunch of activities so they can use keywords to initiate it.



Example screens of routine, hunches, and activity

How is the Energy being monitored?



Various devices that consume energy like thermostats, light bulbs, plugs, and switches can easily be monitored and managed on the energy dashboard.

Alexa can also monitor energy usage for non-smart devices connected to your smart plugs, such as '90s-era televisions and microwaves.

The energy dashboard displays different devices, their energy consumption, estimated total energy for weeks and months, and more.

Alexa is also compatible with the Wiser Energy system.



Apple Homekit

How does Apple Homekit provide energy monitoring?

Apple Homekit does not intrinsically have a feature that can monitor energy consumption at home. A user needs to make use of **Eve Energy Smart Plug and Energy Meter**, an apple accessory in order to view energy consumption. The users can then view the data by launching the Eve app. ([source: appleinsider.com](http://appleinsider.com))

At a Glance

21,5 / 39% Eve Degree LIVING ROOM

ON Eve Energy LIVING ROOM

22,5°C Eve Thermo LIVING ROOM

ON Eve Energy LIVING ROOM

OFF Eve Light Switch LIVING ROOM

22,5°C / 42% Eve Room DINING ROOM

ON Floor Lamp DINING ROOM

OPEN Eve Window DINING ROOM

CLEAR Eve Motion DINING ROOM

19°C Eve Thermo DRIVING ROOM

180 CAM HD LIVING ROOM

22,5°C Eve Thermo LIVING ROOM

OFF Eve Energy LIVING ROOM

ON Media LIVING ROOM

23°C Eve Thermo DINING ROOM

OFF Reading Lamp DINING ROOM

19°C Eve Thermo BEDROOM

ON Eve Energy BEDROOM

OFF Floor Lamp DINING ROOM

At a Glance Scenes Rooms Types Settings

At a Glance Edit

Adjust thermostat levels

At a glance: View and manipulate different appliances

Rooms

Backyard EVE WEATHER

Dining Room EVE ROOM, FLOOR LAMP, EVE WINDOW, EVE MOTION

Living Room EVE DEGREE, EVE LIGHT SWITCH, EVE ENERGY, EVE...

Kitchen EVE ENERGY, CEILING LIGHT

Bedroom EVE THERMO, EVE WINDOW, EVE DEGREE

Kids Room EVE ROOM,

Bathroom EVE THERMO, EVE WINDOW

Basement EVE ENERGY

Front Porch EVE MOTION

Garage EVE MOTION

At a Glance Scenes Rooms Types Settings

Living Room

Indoor Climate 39% 1.012hPa 21.5°C

Fan 125W OFF ON

Thermostat 21.5°C ▲ ▼

Media 60W OFF ON

Ceiling Light 60W OFF ON

Air Quality EXCELLENT

Temperature 21.5°C

Humidity 39%

At a Glance Back Rooms Edit

At a Glance Scenes Rooms Types Settings



Apple Homekit

How does Apple Homekit help in energy saving?

Apple Homekit allows the users to set scenes, timers and rules that can be used to control multiple appliances with one command. Rules allow the user to set conditions of if this then that. For instance: turn on the lights when the sun goes down. These settings ensure that the users have an easy and efficient way of controlling appliances, thereby helping in energy saving.

The image shows two screenshots of the Apple Home app interface. The left screenshot displays the 'Scenes' screen with a grid of nine scenes: Good Morning, I'm Leaving, I'm Home, Good Night, Relax-Time, Read, Full Bright, Movie Night, and Shades. Each scene has a small icon above its name. The right screenshot shows the 'Rules' screen for a rule named 'Arrive Home'. It includes sections for Rule Name (Arrive Home), Enabled (switched on), Triggers (Arriving at Home), Conditions (Time: After sunset), and Scenes (I'm Home). A red arrow points from the 'I'm Home' scene in the Scenes grid to the 'I'm Home' scene in the Rules screen, indicating how a scene can be triggered by a rule.

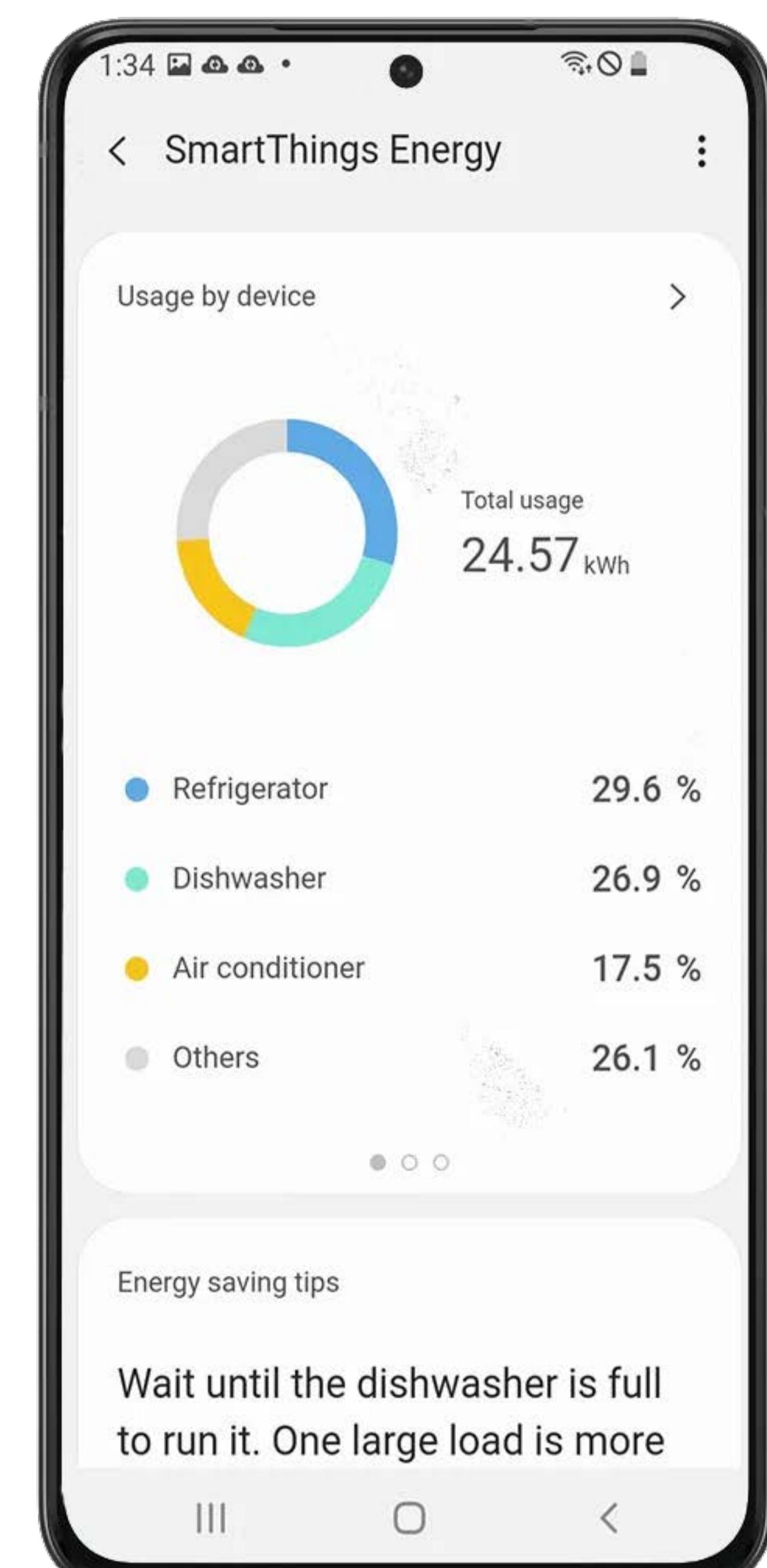
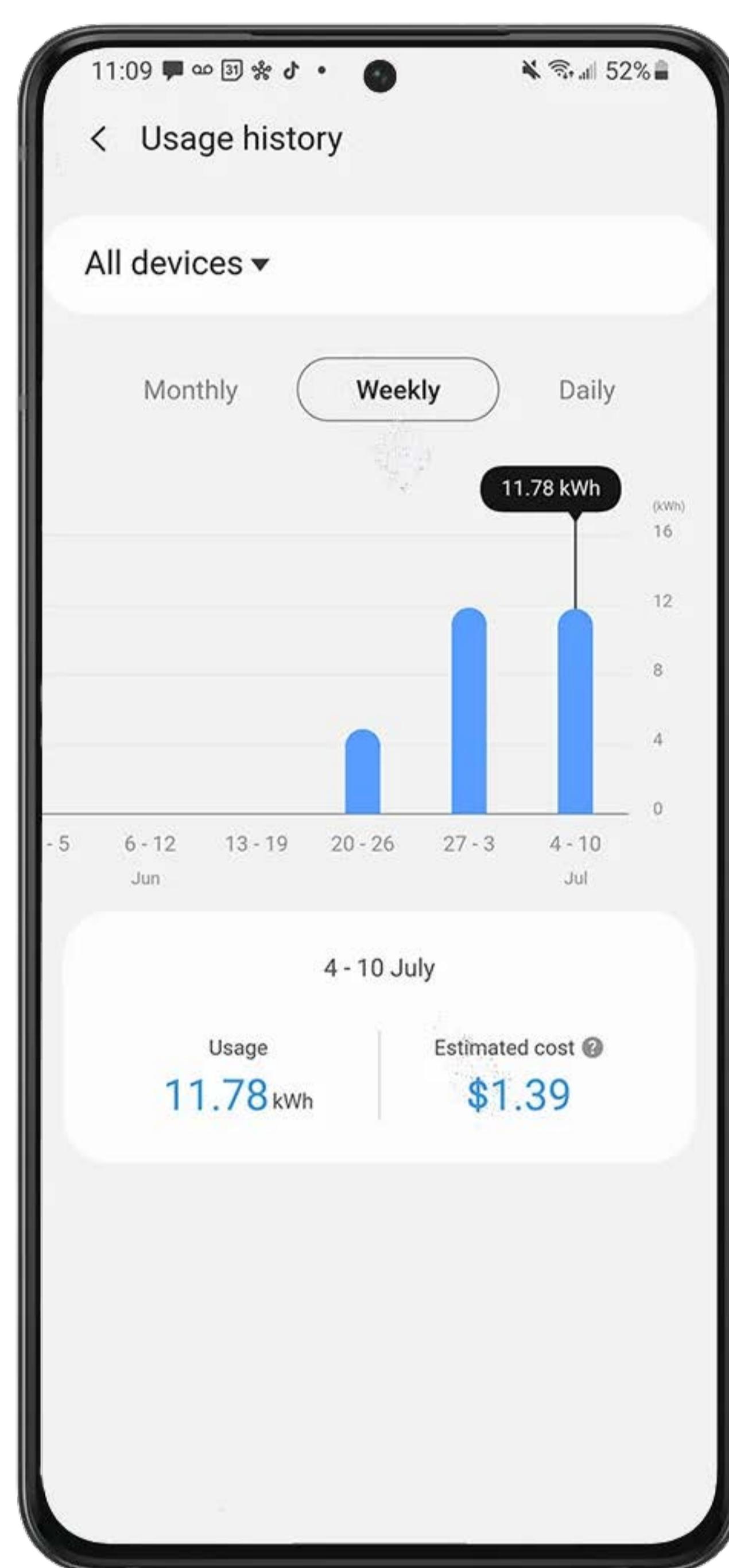
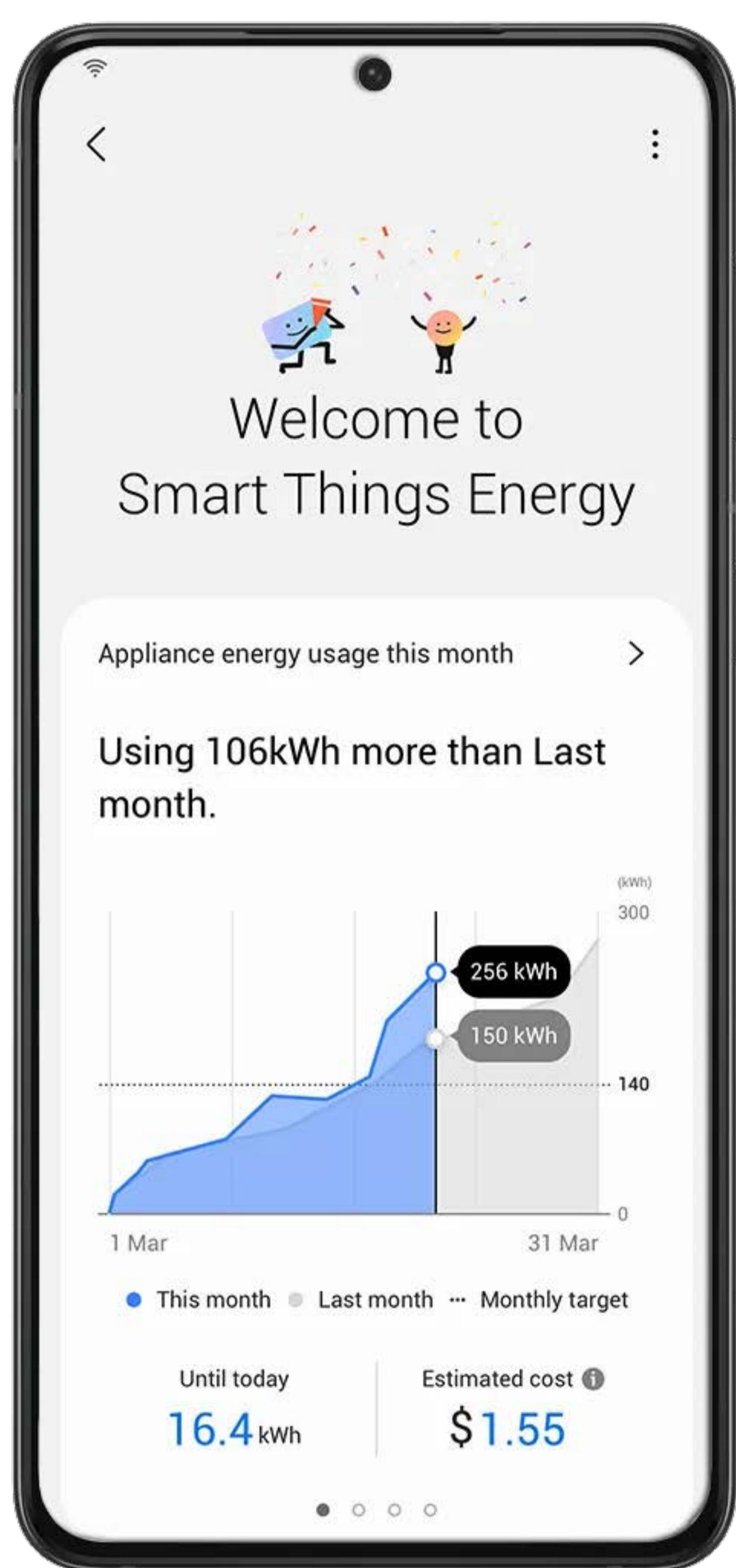
Scenes screens with conditions



Samsung Smart Things

How can Samsung Smart Things help Energy monitoring?

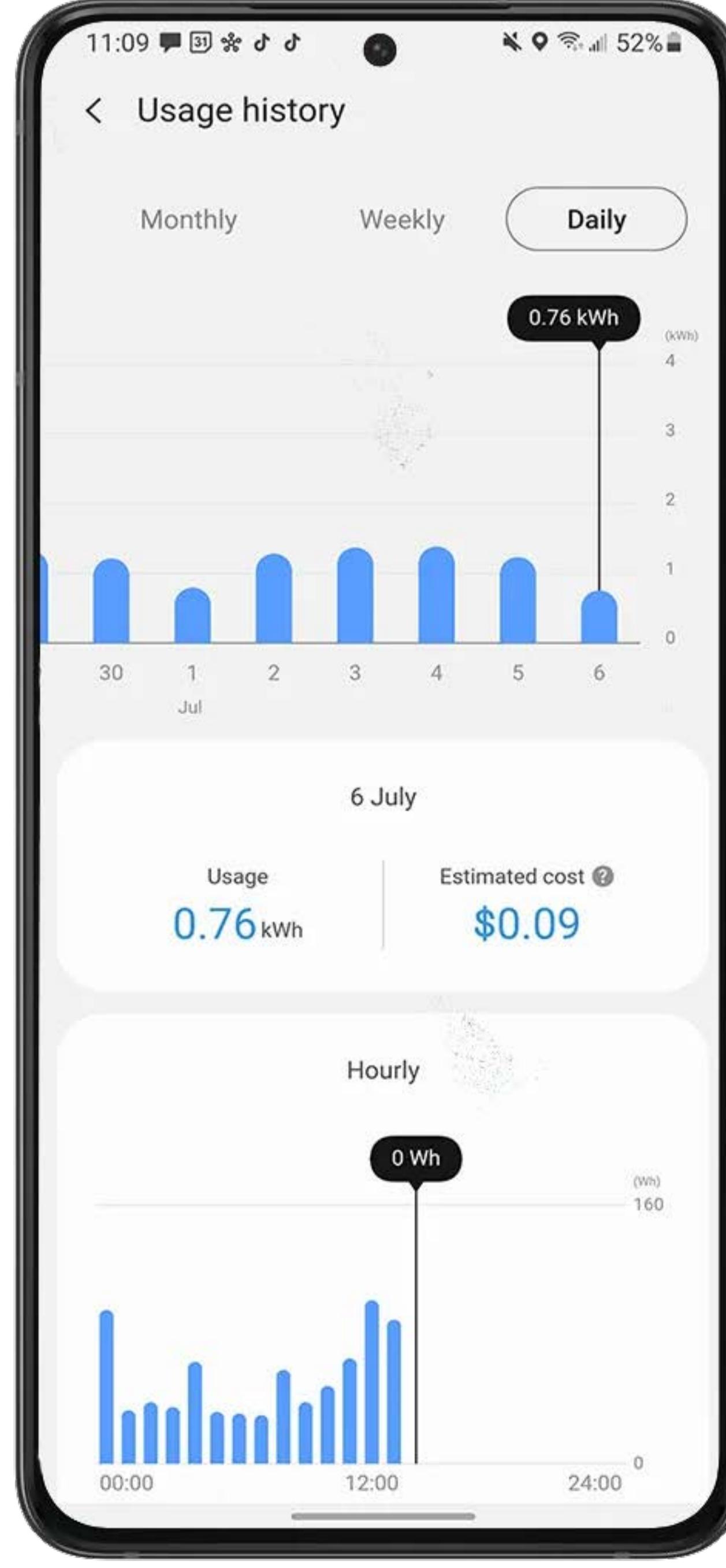
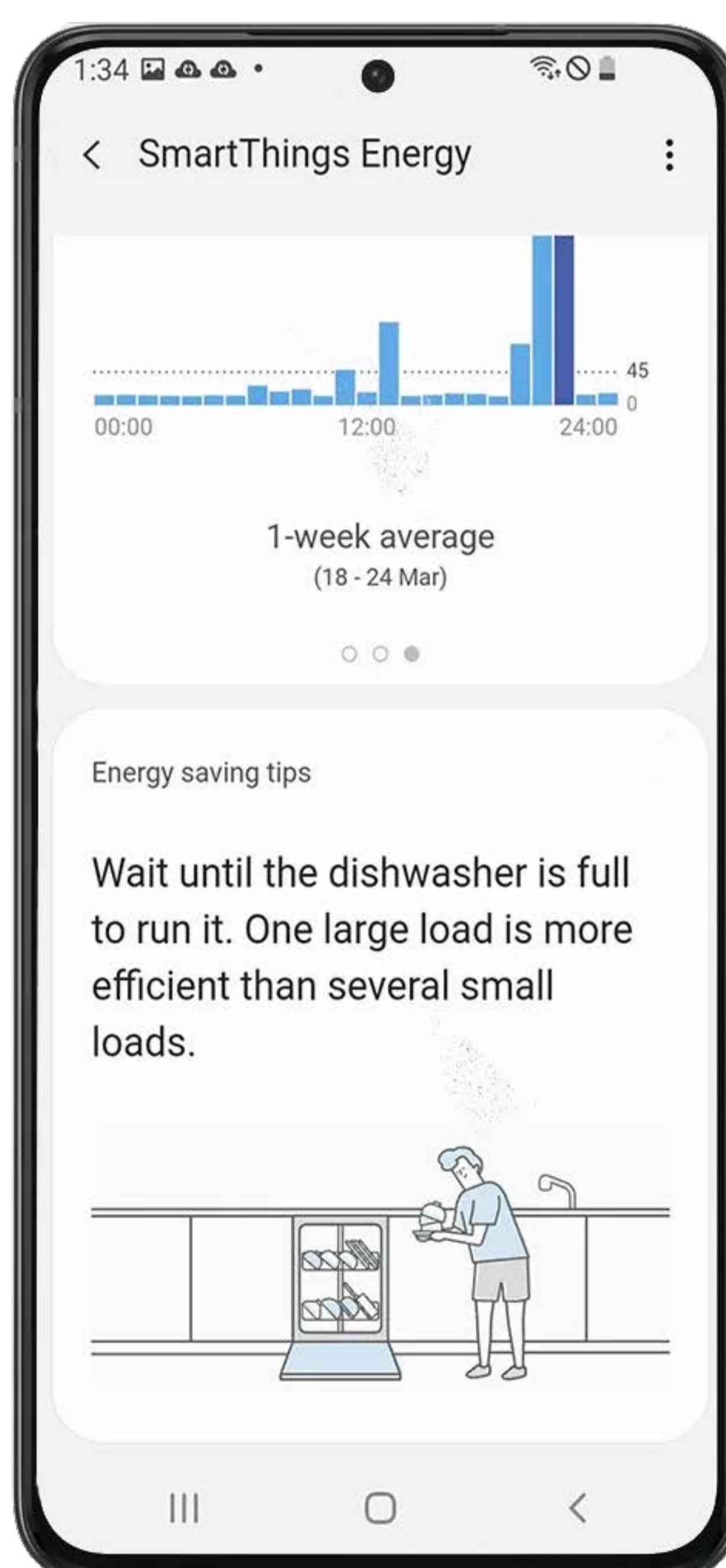
SmartThings Energy service allows you to monitor, track, and manage energy usage of Samsung home appliances and air conditioners. It provides the user with information about their energy consumption, predicts costs, as well as gives advices on how to effectively consume electricity. The energy consumption is shown by product which can be used for predictive maintenance by comparing the current utilization with the energy utilization history of a given product.



Welcome to smart things`

Energy usage history

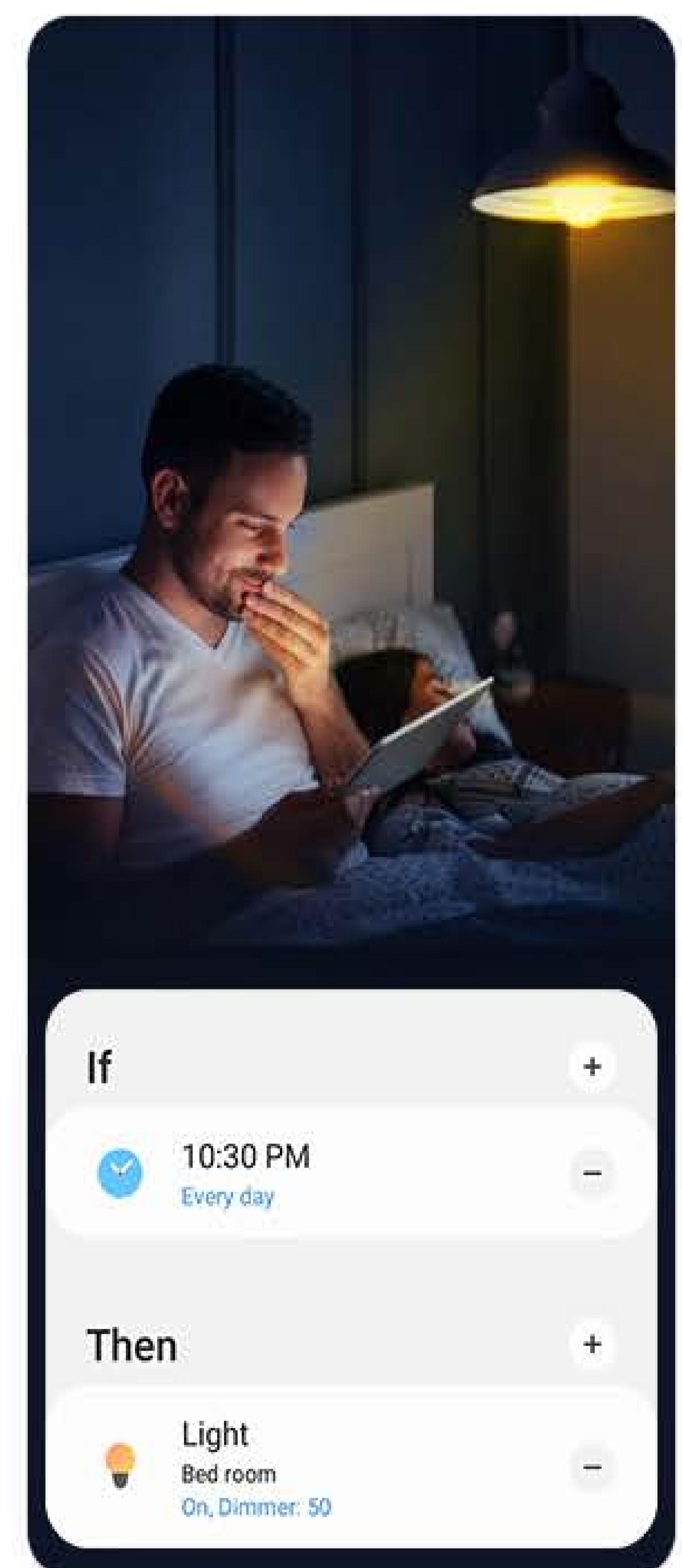
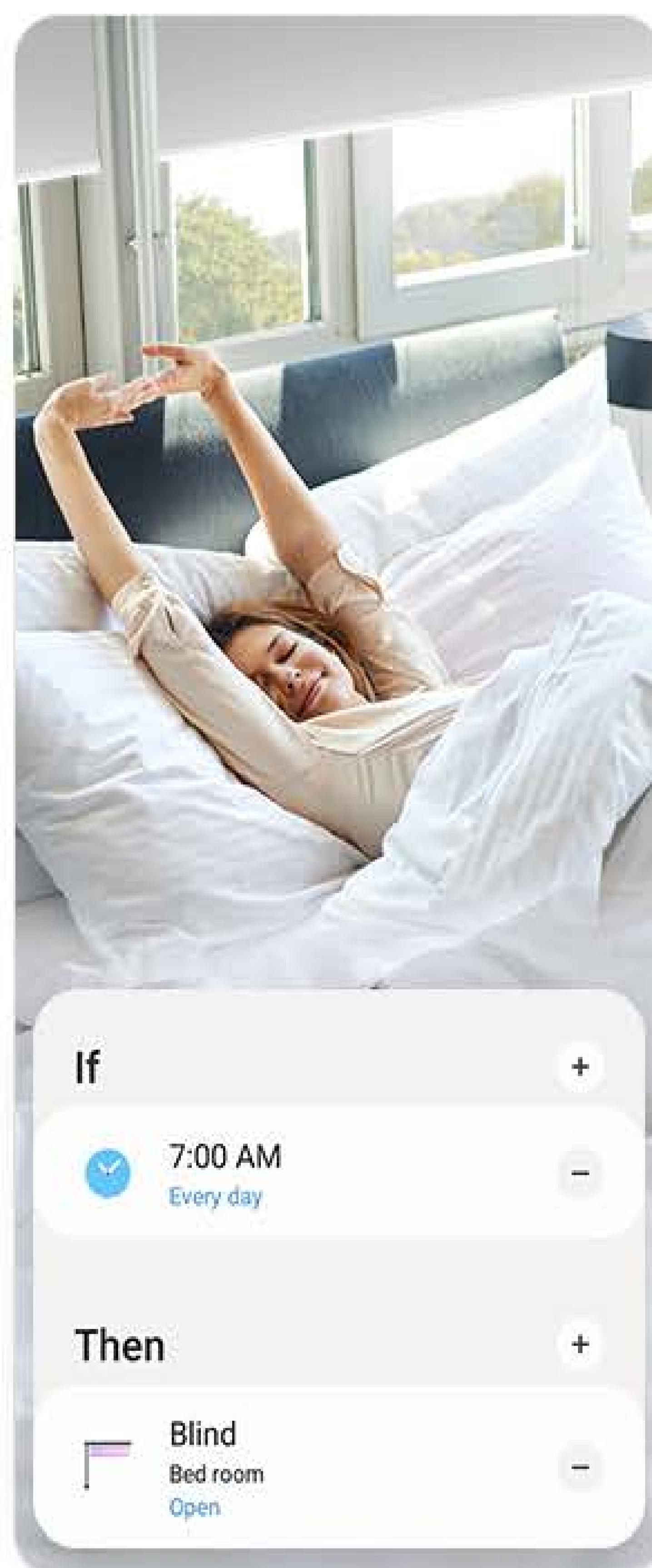
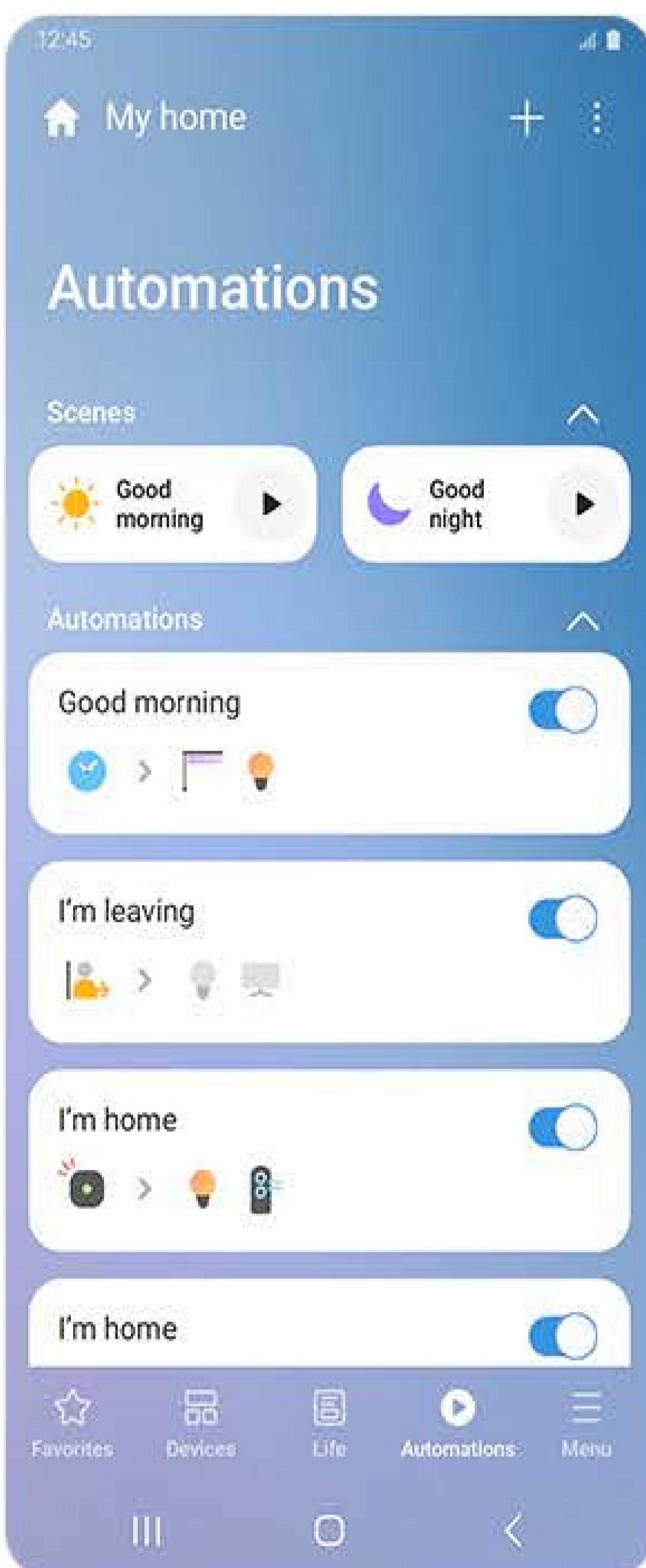
Energy usage by device





How can Samsung Smart Things help in Energy Saving?

Samsung Smart Things lets the user connect and check the status of all smart devices, manage rooms, create scenes, create automation, and add members. It helps save energy by sending the user notifications that alert users when they're using too much energy at a given time. It also lets the user set automations to control smart devices if a condition is satisfied.



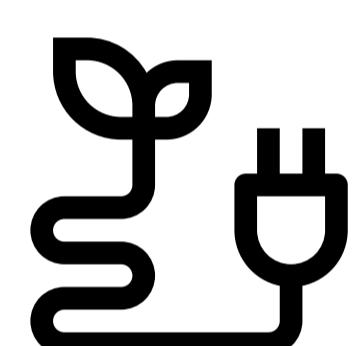
Automations that help control devices based on a condition without human intervention

Expanding on Smart Home Platforms

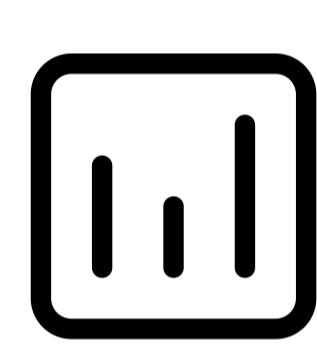
For Energy Monitoring Capabilities

What similarities do these smart home platforms have?

In addition to these key similarities, energy usage target and goals can be set with each platform in different ways, and Google Assistant & Amazon Alexa work with a variety of third party applications to provide energy tracking solutions. IoT and machine learning is used to predict user patterns with smart home appliances (such as with hunches from Alexa).



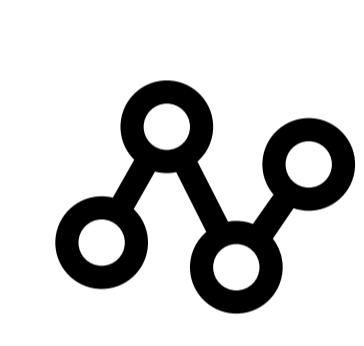
Energy consumption tracking



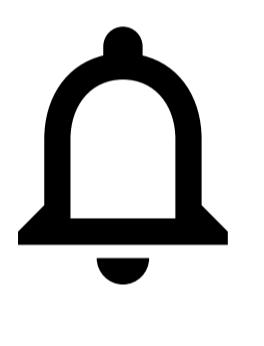
Usage statistics



Voice command control



Scenes & automation



Notifications when using too much energy

How can they expand energy monitoring capabilities?

- Use IoT and automation to monitor energy usage and consumption easily with less user input
- Possible faster integration/learning times for the system to learn usage and connect with devices
- Help reduce users' carbon footprint with axing unnecessary consumption
- Solar ready monitor options- homes with solar installed already or homeowners/builders considering solar, energy monitors allow to see how much energy solar panels are generating, when and how it is used.
- New Home builders have the advantage of having the opportunity to save the customer money down the road by integrating the energy monitoring system while building the house, providing the option of solar, and having electrician contractors that can install the energy monitor all at once.
- **Predictive maintenance** using the energy consumption data collected
- More insights can be drawn from the data like **optimal load distribution** on the phases or wiring issues. This would avoid situations like fire hazards benefiting the home owners, builder, electrical contractor, and insurance companies.



Capabilities of Smart Home Platforms

Strengths and Weaknesses

Energy savings: adjusting to users behaviour helps save upto 15% of electricity

Convenience: Remote capabilities to control most home appliances

Security: Reduced risk of intrusion. Immediate alerts for something uncharacteristic

Highly Inclusive: Reduced risk of intrusion. Immediate alerts for something uncharacteristic

Easy Maintenance: Seamless user integration for energy monitoring and other activities that help the user track their smart devices

Cybercrime: Hackers can gain easy access to personal information

Added Expenses: Getting all eqipment to complete the smart home can get pricy

Installations: Depending on the complexity of the system, installing a home automation device can be a significant burden on the homeowner.

Interoperability: Not all systems are compatible with each other

Predictive Maintenance: Minimal to no predictive maintanence in smart home devices

WEAKNESSES

