Smart Home Energy Management System (SHEMS)

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When Should Windows be Opened?

Overall Heat Loss

- Ventilation should bring enough cool air to remove heating caused by solar radiation and internal loads
- Should lead to achieving desired setpoint temperature

Factors to be considered

- Air velocity
- Direction of airflow
- Air temperature
- Outdoor humidity
- Solar radiation on window
- Internal heat
- Desired temperature and humidity setpoint

When should we switch to AC?

If the total heat gains **cannot be removed by natural ventilation -> Desired room temperature cannot be attained**

Other issues Related to Natural Ventilation (NV)

Air pollution	Noise	Excessive daylight/glare
Insects	Wind draft	Privacy

	Commercial	Residential
Technology	Professionally installed, High End Technology	DIY, Consumer grade technology
Affordability		
Operator		

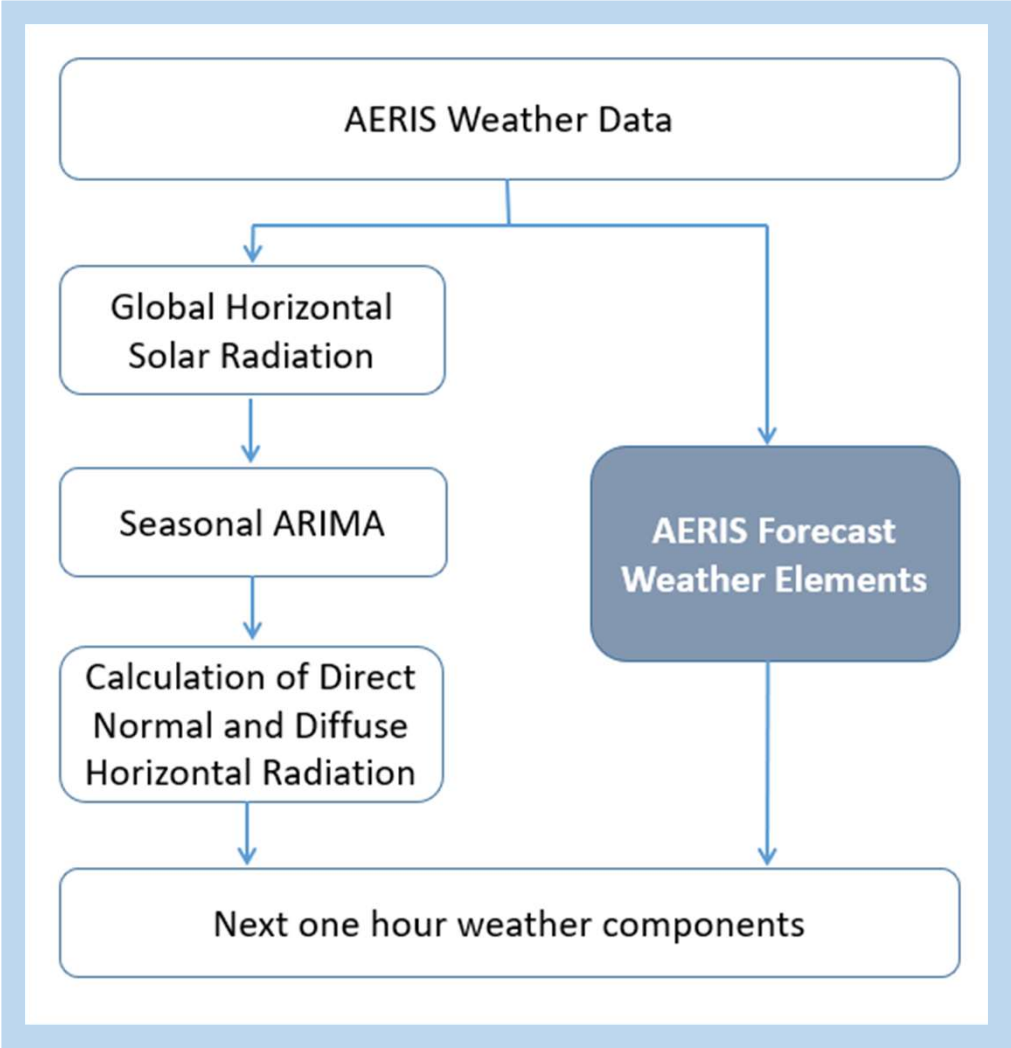
Real-time Control of MM Building

Methodology

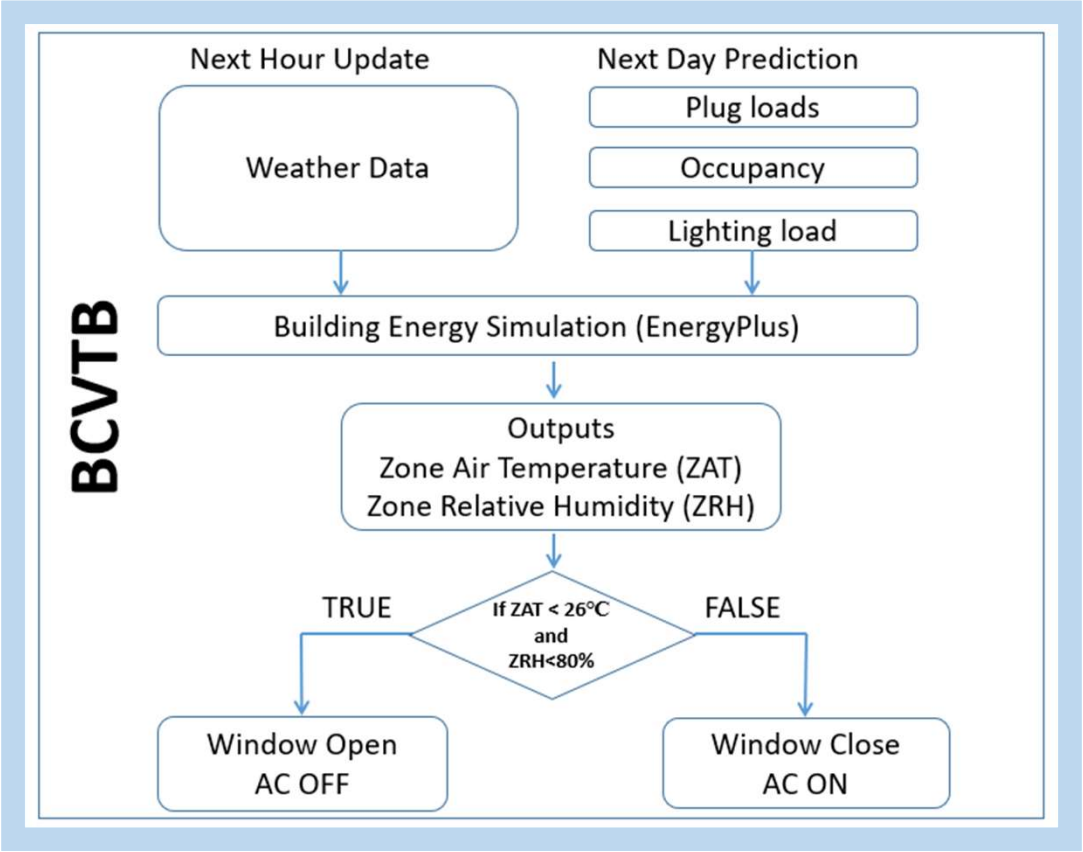
- The target building is modeled in EnergyPlus.
- Local weather forecast data is fetched every hour through AERIS Weather Data[1].
- A day ahead prediction is modeled for lighting load, electric load, and the occupancy profiles using Seasonal Autoregressive Integrated Moving Average (SARIMA) Models.
- Co-simulation of EnergyPlus is done with the software – Building Controls Virtual Test Bed (BCVTB) to enable real-time simulation.
- According to indoor and outdoor weather conditions, EnergyPlus outputs the signal for opening/closing of windows.

[1]Source: https://www.aerisweather.com

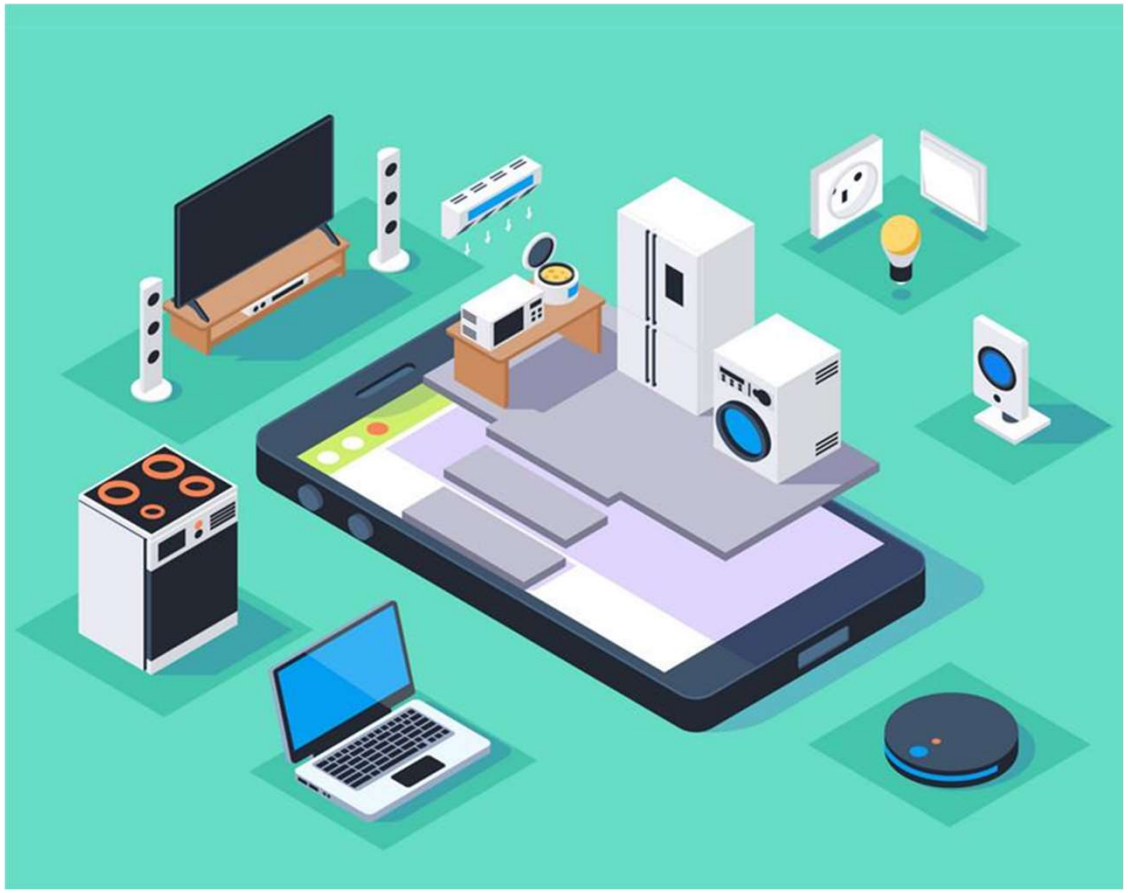
Real-Time Weather File Generation



Methodology Flowchart

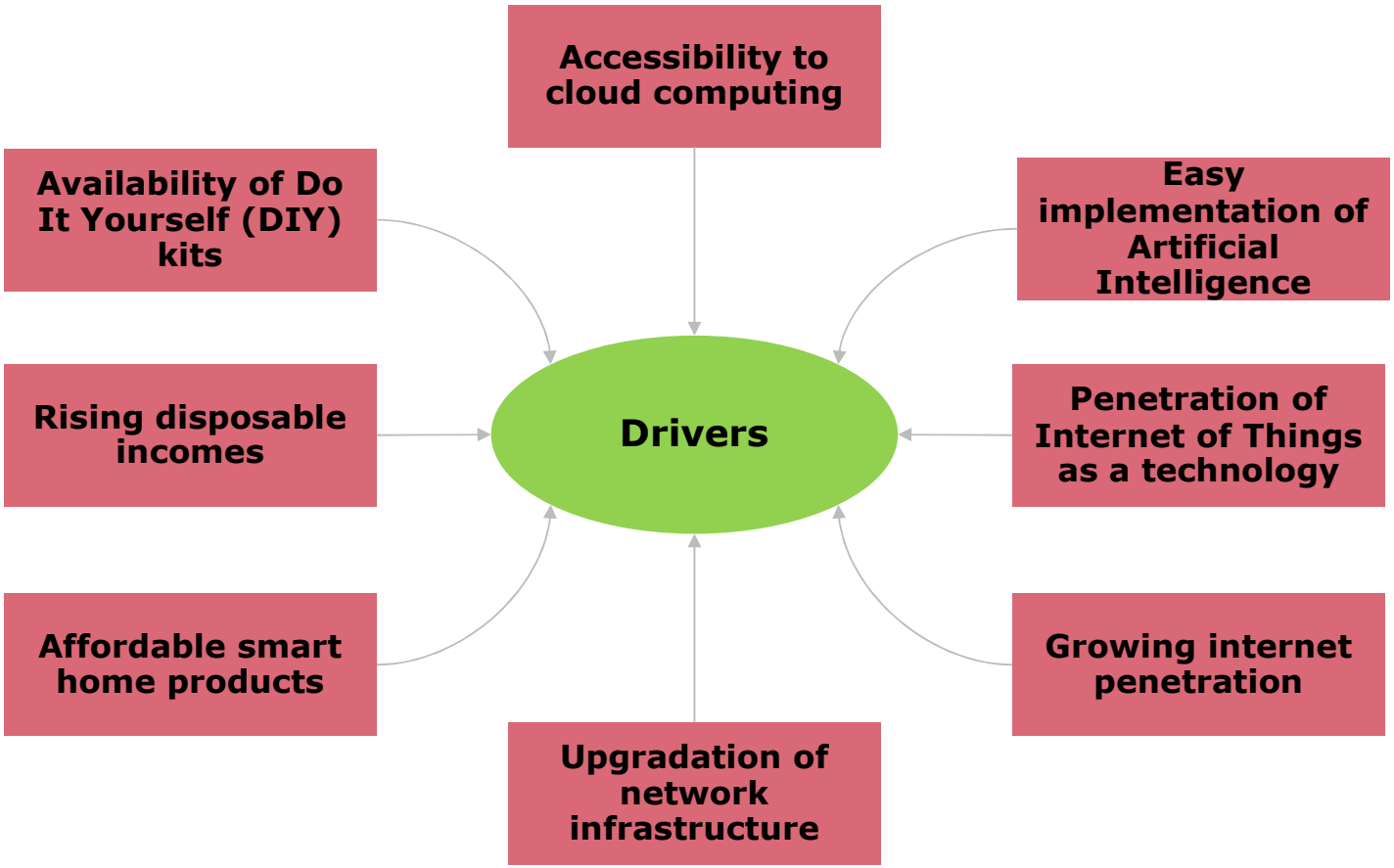


Smart Home Energy Management Systems (SHEMS)



https://www.dreamstime.com/d-isometric-smart-appliances-home-mobile-phone-concept-remote-control-laptop-television-light-refrigerator-microwave-washing-image160529887

Driving Factors

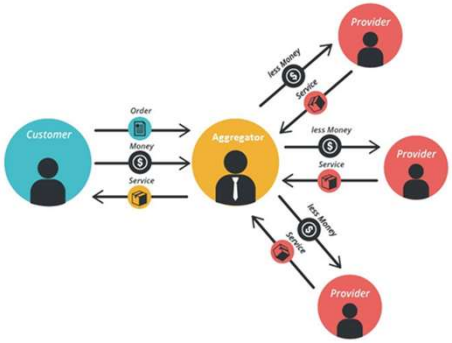


Technology Trends

Entry point devices - Voice controlled speakers, routers, Set-top boxes

Smart homes as a service

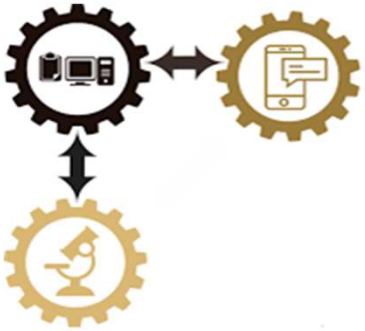
Smart devices



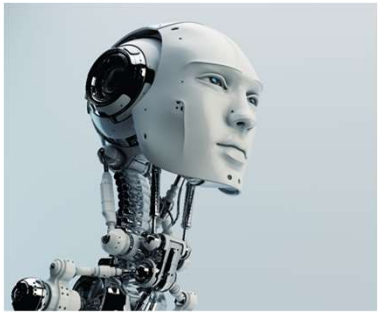
Smart home aggregators

https://plopdo.com/2018/12/24/aggregator-model/
https://plopdo.com/2018/12/24/aggregator-model/

Technology Trends



Standardization & interoperability



Artificial Intelligence

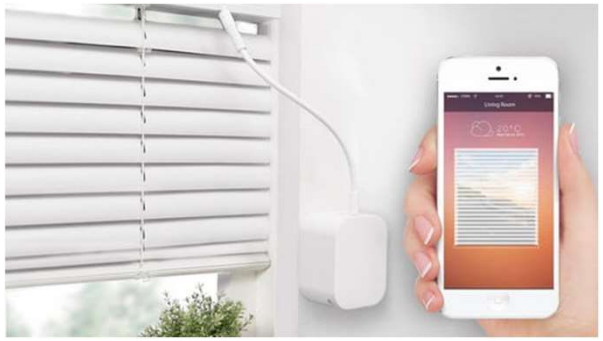
Chatbots

Energy harvesting

https://in.pinterest.com/pin/50876670777658258/
https://vectorified.com/interoperability-icon

https://www.podfeet.com/blog/2020/02/ces-2020-wi-charge-wireless-power/
https://fulcrumdigital.com/why-does-your-business-need-a-next-gen-chatbot/

Technology – Smart Appliances



Smart Blinds

Smart Air Conditioner

Smart IAQ Device

Smart Thermostat

digitaltrends.com/home/best-smart-blinds/
123rf.com/photo_70900755_iot-concept-remotely-controlling-smart-air-conditioner-with-app-on-smartphone.html

https://www.airthings.com/en/wave-plus
greentechmedia.com/articles/read/Honeywell-Launches-Glossy-Thermostat-Lyric

Technology – Smart Appliances

Smart Washing Machine

Smart Refrigerator

Smart Geyser

Smart Lights

https://www.alliedmarketresearch.com/smart-connected-washing-machine-market
https://www.racold.com/electric-storage-geyser/omnis-wifi

https://www.samsung.com/in/refrigerators/french-door/810l-black-stainless-rf28n9780sg-tl/
https://time.com/4318290/samsungs-smart-refrigerator-family-hub/

Barriers


Lack of standardization
Technology cost
Data security & cyber risk
Limited awareness & complexity of installation

RESIDE* - Design & trial SHEMS

- SHEMS will be deployed in 200 homes in Hyderabad over 12 months
- The system will provide a detailed understanding of the usage pattern to generate an online repository of residential energy and thermal comfort
- Load profiles will be mapped by regular monitoring of household appliances like geysers, air conditioner, fridge and washing machine
- Control and automation options will be provided along with energy saving tips to enable save energy and participate in demand response

*RESIDE is DST supported India-UK research project

RESIDE- SHEMS

1. Energy Meter
Monitors voltage, current, power, power factor, frequency, at a frequency of 1 second

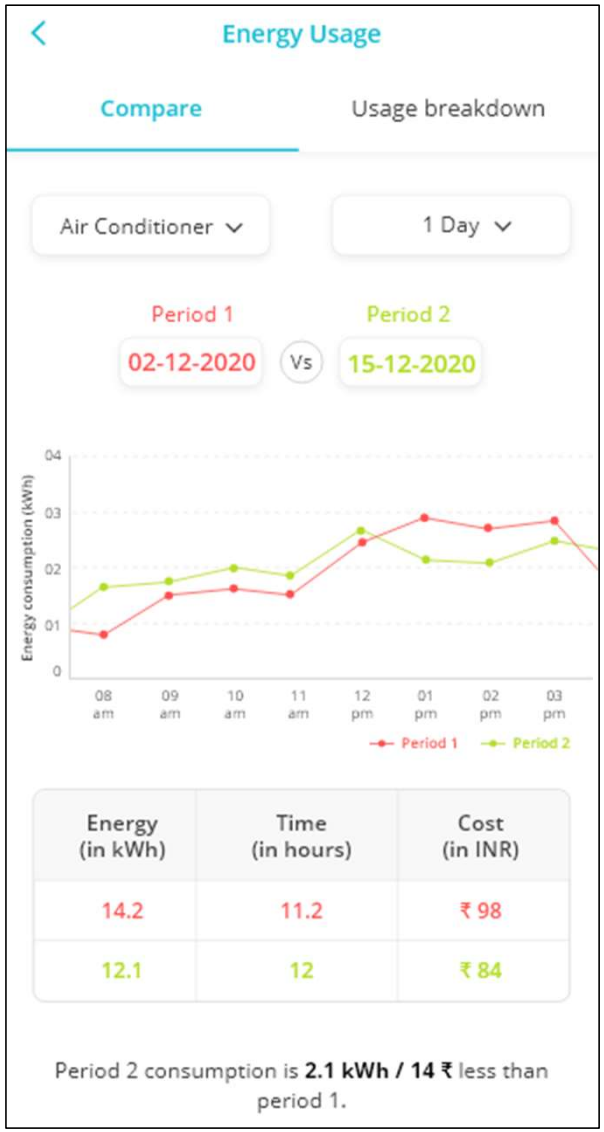
4. Smart Socket
Monitors energy consumption of appliance, enables ON & OFF device using app.

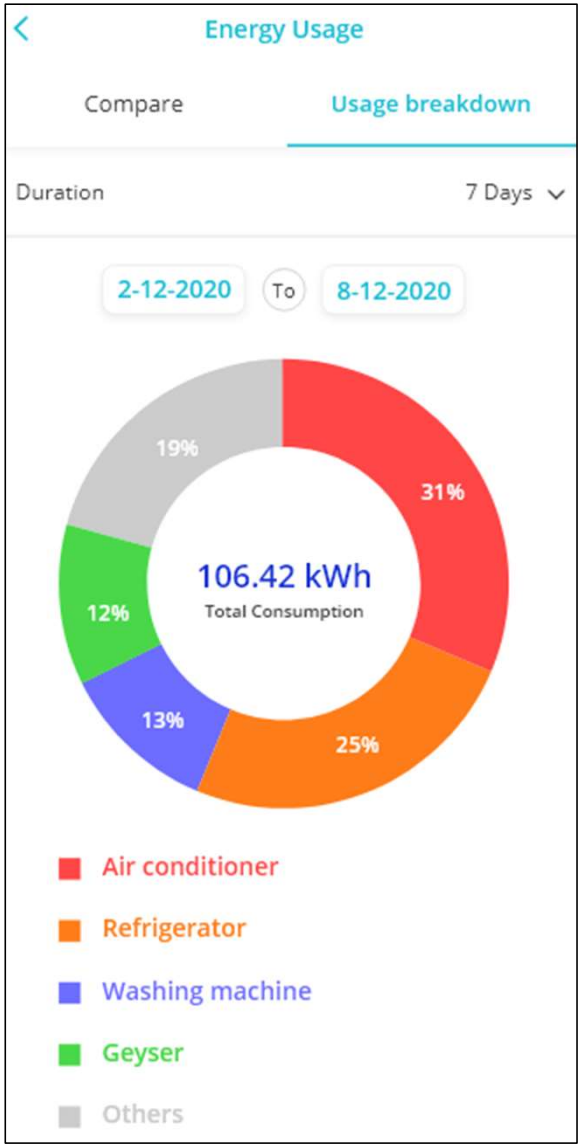
3. Window open/close sensor
Detects door open & close events.

5. IR Emitter
Can be programmed as a remote & implemented using the app on a smart phone.
In built **temperature sensor** is to monitor indoor conditions of the Air-conditioned room

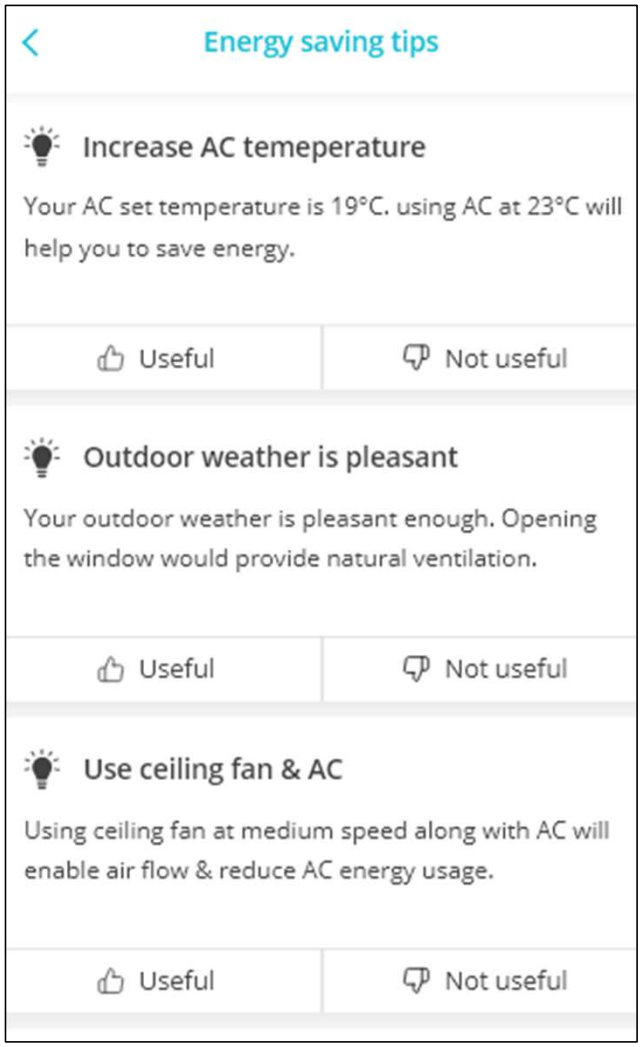
3. Temperature Humidity Sensor

Trial 1: Information on weekly/monthly power consumption with trend analysis over time

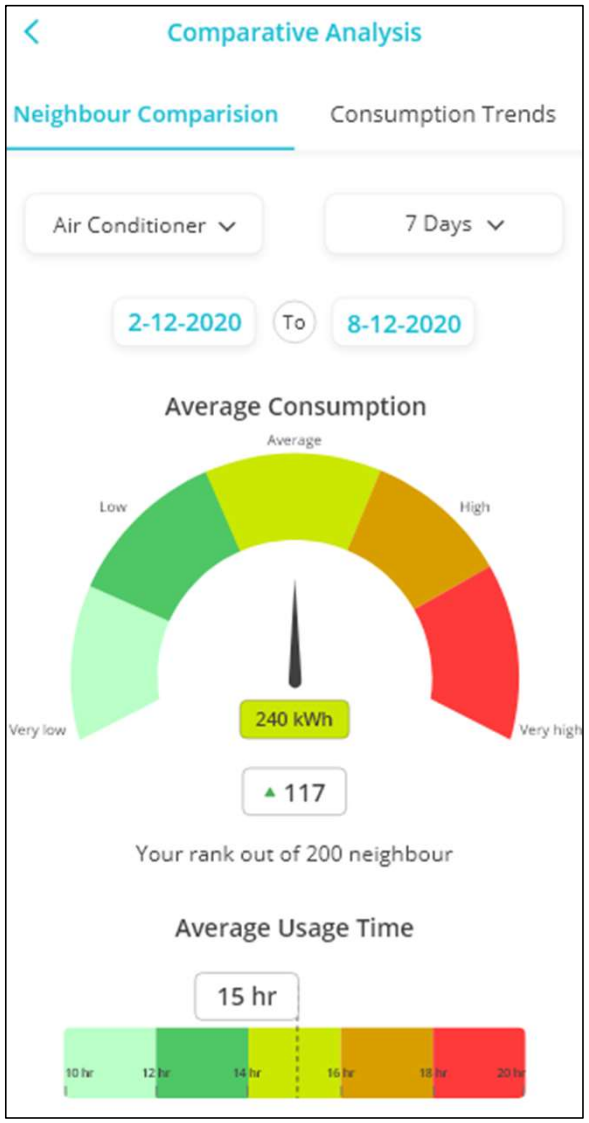


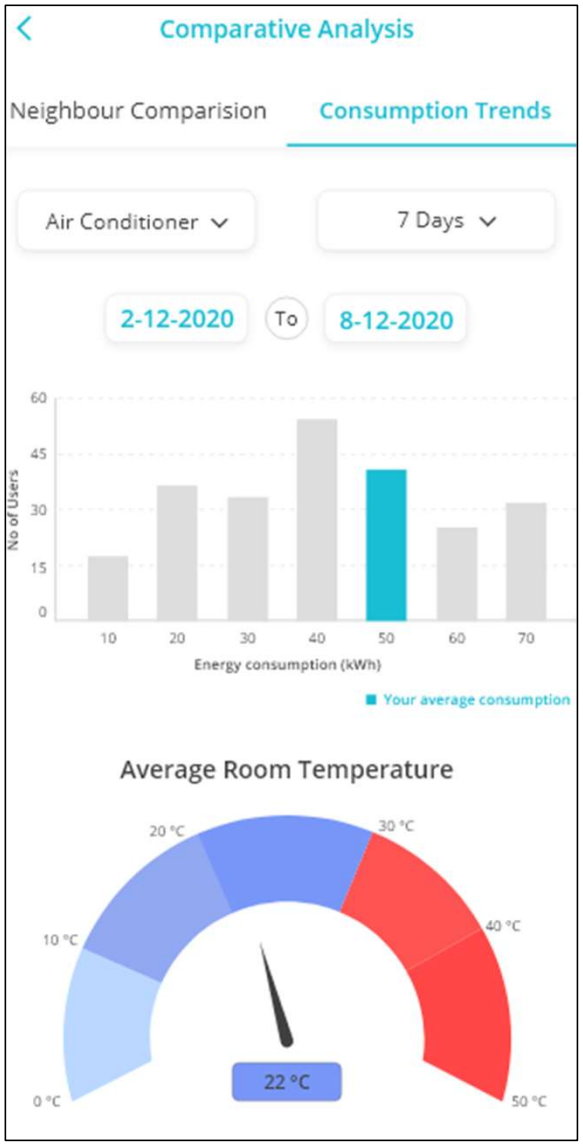


Trial 2: Energy Saving Tip

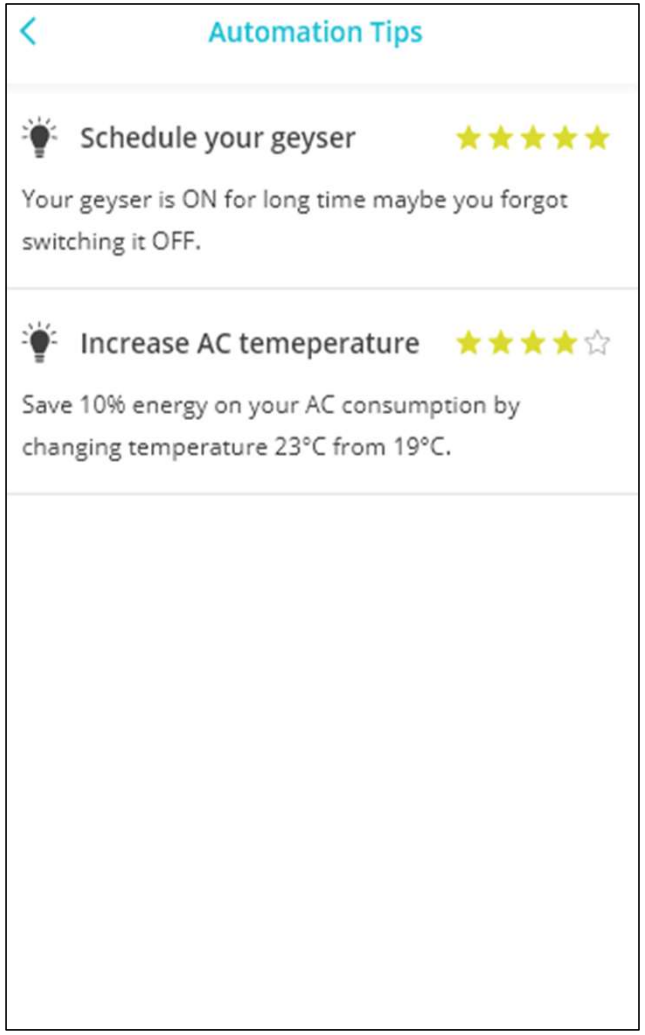


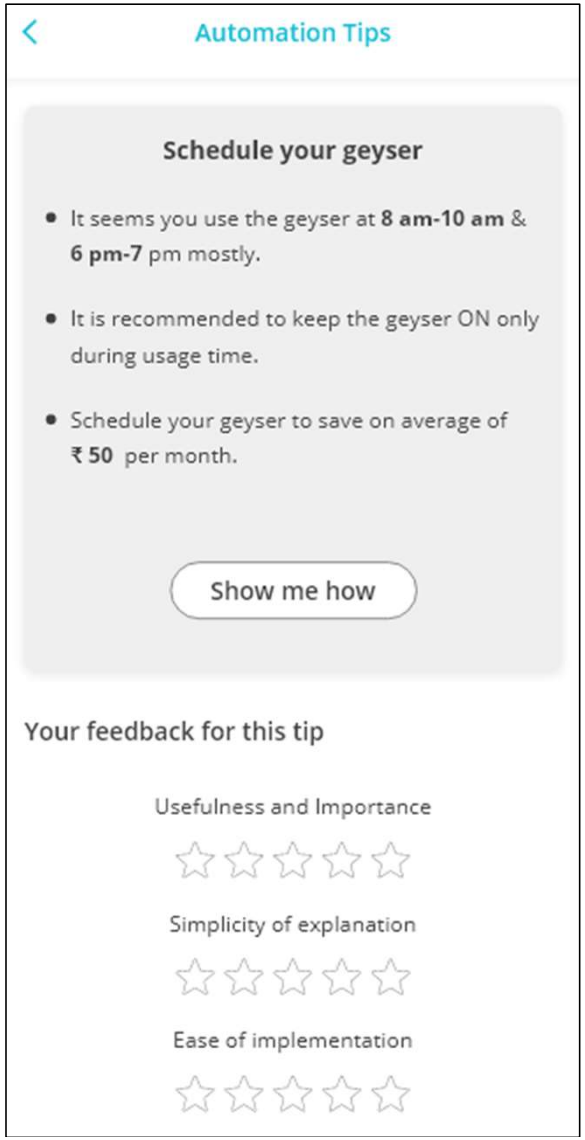
Trial 3:Comparison of energy use with other households of similar nature and location.



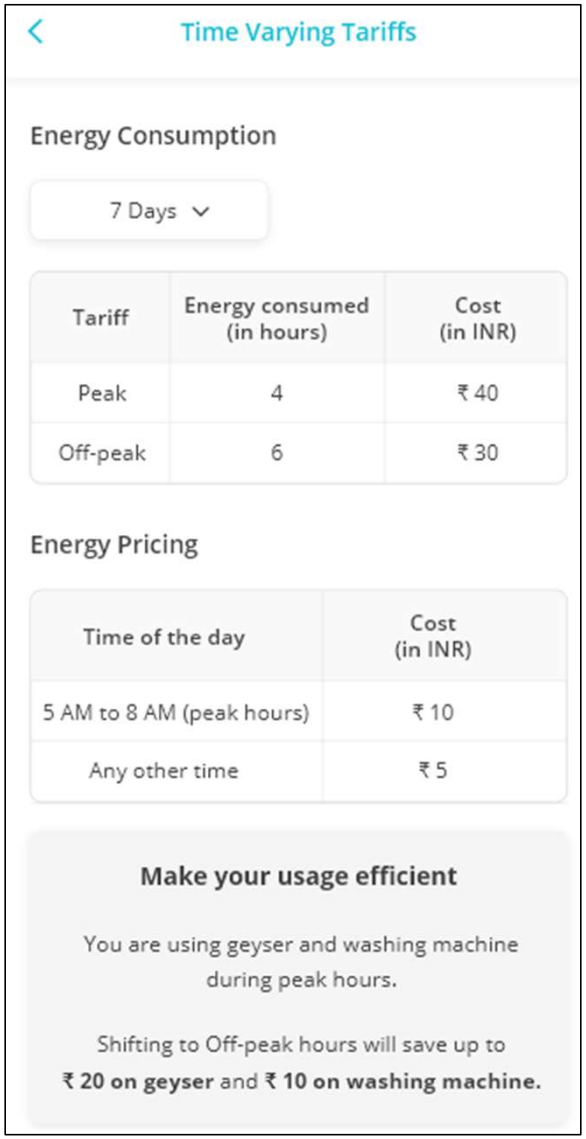


Trial 4: Possibility of remote/schedule-based/occupancy-based switching of devices





Trial 5: Time-varying tariffs



Annexure on Smart Homes in Eco Niwas Samhita 2021

Annex E-Smart Home

E

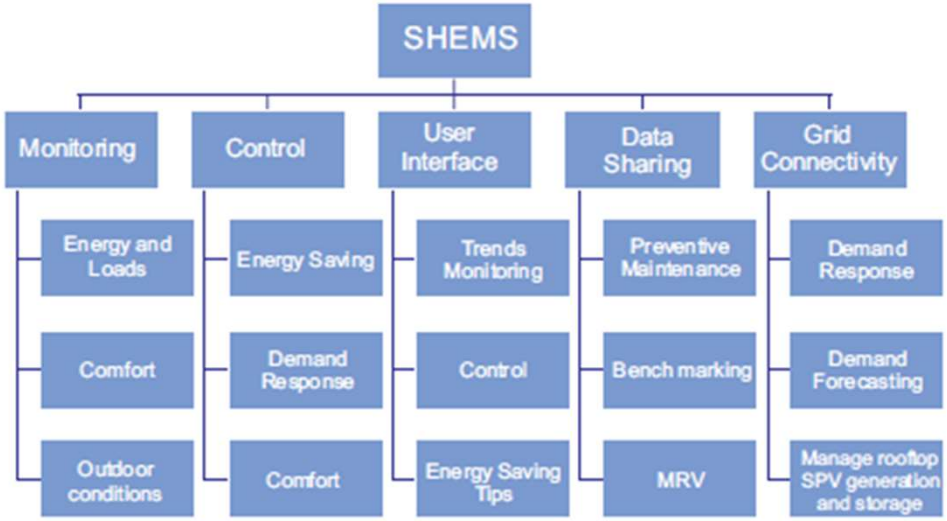
Smart Home

The concept of smart home is in existence for many decades; however, it has gained further importance in present scenario due to increase in demand for comfort and convenience (with growth of disposal income), increased dependence on appliances, increase in per capita electricity consumption and availability of rooftop solar PV and EV for potential onsite generation and storage respectively.

Alongside these drivers at consumer end; technology advancement in the form of availability of high speed computing devices (smart phones) and affordable internet data, reduction in size of IoT devices / sensors and by shifting sophisticated computing functions to cloud and development of complex algorithms to control systems as per user requirement and preference (using Artificial Intelligence) has provided fresh push to demand of smart home product and services.

The need of utility-based demand response program to match the variable consumer demand (due to use of diverse appliances) with dynamic electricity supply (due to penetration of renewable energy in grid) is gradually making the smart home solutions a must have product/service in every home, to make it demand response ready.

To manage the energy use in a home in order to make optimum use of these opportunities and for minimizing the demand supply gap, there is need of Smart Home Energy Management System (SHEMS). SHEMS can be defined[20] as the combination of a service and devices that are designed to work together to deliver occupancy-based optimization of energy use. SHEMS[21] consist of hardware and software, which are linked and integrated to, monitor energy usage, provide feedback on energy consumption, enhance control and provide remote access and automation provisions over appliances and devices that use energy in the home. SHEMS can deliver a range of services and benefits to households, which includes:



Minimum functionality requirement for smart home

Functionality	SHEMS device/service
Monitoring	Home level phase wise energy and load monitoring Two 15 A outlets for energy use monitoring of two appliances One temperature and humidity sensor One occupancy sensor
Control*	One AC Controller to control set point, mode of operations, ON/OFF with provision receiving control signals One Geyser Controller for ON/OFF, with provision of receiving control signals One Controllable light with provision of receiving control signal
User interface	Common user interface (app, voice or gesture based), to connect SHEMS devices over single software package for energy use monitoring and control
Grid connectivity	Able to participate in utility demand response program
Data sharing	Typical daily indoor conditions, and device-wise energy consumption, and hours of usage to be reported once a month in anonymous way

*All controllable devices to be able take control signals from hub/cloud

Thanks!

Acknowledgement

Project RESIDE

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