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DIGITAL ROADMAP OF SMART HOMES IN MALAYSIA

INTRODUCTION

Malaysia is one of the few Southeast Asian countries with the infrastructure required for IoT adoption. The Malaysian Government released a strategic roadmap for adopting IoT nationally in 2015. And yet, there are quite a few stumbling blocks in the way for IoT to take off in a big way in Malaysia.

The Malaysian smart home market is expected to exceed US\$ 235 million by 2025. Smart homes are residences equipped with information and computing technology devices that anticipate and respond to the owner's requirements effectively and efficiently. There is a growing demand in the Malaysian market for a safe and secure living environment, especially concerning safety functionalities and discrete monitoring for the elderly. According to the World Meters, in 2018, 77.3% of the Malaysian population lived in an urban area. By 2030, roughly 83.4% of the population is expected to live in urban areas. This creates an enormous opportunity for the smart home market players. The overall revenue of Malaysia's smart home automation market is forecasted to reach 51.26 million U.S. dollars in 2020.

Smart homes provide comfortable, fully controlled and secure lifestyles to their occupants. Moreover, smart homes can save energy and money, possibly profiting from selling clean, renewable energy to the grid. On the other hand, the probable decrease in total domestic energy loads encourages many governments to support promising smart-home technologies.

Some countries have already put out many rules, laws and subsidy programmes to encourage the integration of smart homes, such as encouraging the optimisation of the heating system, supporting building energy storage and/or deploying smart meters. For instance, the European Standard EN 15232 and the Energy Performance of Building Directive 2010/31/E.U., which are in line with Directive 2009/72/E.C. and the Energy Road Map 2050, encourage the integration of smart-home technologies to decrease power demand in residential areas.

Malaysia Smart Home Market classified by application areas; Smart Appliances captured maximum share of the Malaysia smart home market, security is the second biggest application segment of the Malaysia smart home market, being followed by Home Entertainment, Energy Management application segment captured least share

of the Smart Home market, The average revenue per Smart Home in the Comfort and Lighting segment presently amounts to US\$ 44. Control and Connectivity segment captured highest share of the Malaysia Smart Home active households in 2018, being followed by Home Entertainment and Comfort and Lighting segment. In Malaysia, the household penetration for Security applications is expected to hit around 7.2% by 2025, Energy Management application captured least share of the Smart Home active households in 2018, This report titled Malaysia Smart Home Market, Number, Household Penetration & Key Company Analysis - Forecast to 2025 provides a comprehensive assessment of the fast-evolving, high-growth Malaysia Smart Home Industry. Other than that, application of smart home divide into six categories such as Control and Connectivity (Home Automation), Comfort and Lighting (Home Automation), Home Entertainment, Smart Appliances, Energy Management, Security Application. Internet provider in Malaysia such as Telekom Malaysia (TM), biggest internet provider in Malaysia endorsed their service on smart home solutions consists of security and safety, user configurable, monitor and control from anywhere, affordability (flexible plan), easy to use, and open platform.

SMART-HOME DEFINITION

The term 'smart home' has been used for about two decades to describe houses with controlled energy schemes. This automation scheme confirms more leisurely lifestyles for homeowners than ordinary unautomated homes, especially for elderly or disabled persons. Recently, the concept of 'smart home' has a broader description to include many technologies applications in one place. There are several definitions of smart homes as follows:

- 1) 'Houses that provide their occupants a comfortable, secure, and energy-efficient environment with minimum possible costs regardless of their occupants.'
- 2) 'Integrating technology and services through home networking for better living.'
- 3) 'Incorporated residential houses with smart technology to improve users' comfort level (residents) by enhancing safety and healthcare and optimising power consumption. Users can control and monitor smart-home appliances remotely through the home energy-management system (HEMS), which provides a remote monitoring system that uses telecommunication technology.'
- 4) 'Any residential building uses different communication schemes and optimisation algorithms to predict, analyse, optimise and control its energy-consumption patterns according to pre-set users' preferences to maximise home-economic benefits while preserving predefined conditions of a comfortable lifestyle.'

Distributed clean energy generated by smart homes provides many benefits for prospective smart grids. Soon, smart homes will play a significant role as a power supplier in modern grids, not only as power consumers.

Traditional Home product VS Smart Home products

Disadvantages of Traditional Home Product	Advantages of Smart Home Products
<ul style="list-style-type: none"> – Crossing wires – Security issues – Disassemble issues 	<ul style="list-style-type: none"> – Easy in control – Flexibility – Maximising home security

Table 1: Comparison between Traditional Home Product and Smart Home Product.

ADVANTAGES OF SMART HOME PRODUCTS

1. Easy in control

The advantage of the smart home product is it is easy to control. Unlike the traditional remote controller, one can control all the smart devices through the smartphone or voice control. One may also control the devices even when one is not in the house but with a smartphone. For example, one can switch on the light before he reaches home.

2. Flexibility

Furthermore, one can easily add new smart devices with the smart home system. The installation step of smart home products is easy, and no professional renovation work is needed. So, one is flexible in adding or removing the smart home product. Moreover, if one is moving to a new house, the smart home product can reuse again.

3. Maximising home security

Smart home security systems are better than traditional security systems because of their all-around security and convenience. They have more innovative features, cover a larger area of your home, and connect to apps on your devices. They also combine with your smart home features. In addition, a smart home product like a smart I.P. camera can help one maximise home security since all the recorded security video will

be uploaded to the cloud storage or the S.D. card. Thus, one can check the security video all the time and anywhere in the world as long as there is an internet service. If there is an emergency issue, one might detect it earlier.

‘Google Home’ and ‘Amazon’s Alexa’ are becoming more commonplace in Malaysian homes.

Smart devices include, but are not limited to, the following components:

- Smart appliances (dryers, washers, refrigerators, etc.)
- Smart home safety and security systems (sensors, monitors, cameras, and alarm systems)
- Smart home energy equipment (smart thermostats and smart lighting)

MALAYSIAN’S SMART HOME LANDSCAPE

Smart home technology has been a critical means by which households can optimise their use of energy-consuming appliances. Application areas classify Malaysia Smart Home Market; Smart Appliances captured the maximum share of the Malaysia smart home market. Security is the second most prominent application segment of the Malaysia smart home market, followed by Home Entertainment and Energy Management application segment captured the most negligible share of the Smart Home market. The average revenue per Smart Home in the Comfort and Lighting segment presently amounts to US\$ 44. Control and Connectivity segment captured the highest share of the Malaysia Smart Home active households in 2018, followed by Home Entertainment and Comfort and Lighting segment. In Malaysia, the household penetration for Security applications is expected to hit around 7.2% by 2025, and Energy Management applications captured the most negligible share of the Smart Home active households in 2018.

The Malaysian smart home market is driven by factors such as the significantly growing IoT market, cost reduction measures enabled by home automation systems, manufacturers expanding their product portfolios, and the increasing importance of home monitoring from remote locations.

Examples of smart home projects in Malaysia include:

- Mitral and Group's 31-storey Andaman Residences serviced apartment
- I-Berhad's RM9 billion urban development, i-City.
- TA First Credit's Damansara Idaman smart homes.
- Tropicana Corp's collaboration with PanaHome, the Malaysian arm of PanaHome Corp, to build 272 semi-detached innovative eco homes at Cheria Residences.

Despite the emerging market opportunities of smart homes, the adoption rate among individual users is generally low, especially in developing countries in Asia. While the revenue growth projection for Asia is expected to be stable in the coming years, smart home technologies are not as widely accepted as compared with the European and American markets.

Nonetheless, just as smartphones took over traditional mobile devices, the adoption of smart homes will naturally increase, particularly as technology evolves and demands living standards and quality of life increases.

In line with the rapid technological advances, the Malaysian Government seeks to move the industry forward and provides various initiatives. The National Policy on Industry 4.0 or Industry4WRD was launched on 31 October 2018 to drive the digital transformation to accelerate the services sectors in Malaysia further. The Government has initiated mandatory compliance to use Industrialised Building Systems (IBS) by 2020 as the first step to encouraging the adoption of smart home technologies. Investors are encouraged to leverage the incentives related to smart homes technology, such as:

<ul style="list-style-type: none"> • Pioneer Status or Investment Tax Allowance under Section 112 or 113 Income Tax Act 1967 to produce IBS components. • The IBS project must be certified by CIDB to enjoy this incentive. <p>[for manufacturers]</p>	<ul style="list-style-type: none"> • Full exemption of the 0.125 per cent levy imposed by CIDB for housing projects with an IBS score of more than 50. <p>[for contractors]</p>	<ul style="list-style-type: none"> • Automation Capital Allowance (Automation CA) announced in 2015 to further encourage manufacturing companies to engage in innovative and productive activities as well as the quick adoption of automation, especially for industries that are heavily reliant on foreign labour. • Smart Homes can be considered under Category 2 whereby an Automation CA of 200% will be provided on the first RM2 million expenditure incurred within 5 years of assessment from 2015 to 2020. <p>[for manufacturers]</p>	<ul style="list-style-type: none"> • Incentives for electrical and electronic products and components manufacturers related to smart homes technology: <ul style="list-style-type: none"> - Information and communication technology (ICT) products, systems or devices - Digital entertainment or infotainment products - Electronic tracking or security systems or devices - Alternative energy equipment, products, systems, devices or components - Energy saving lighting
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Table 2: Incentives related to smart homes technology

The Core of Smart Home

The most important device is the wireless router modem that provides wireless signal of internet either 2.4 GHz or 5 GHz. On top of that a smart home owner also need to subscribe to the internet service either optical fibre, conventional copper wire of wireless phone line. There are many ISP's available in Malaysia which provides internet services.



Figure 1: Wireless internet router/modem.



FIGURE 2: Smart Home Solutions provided by TM

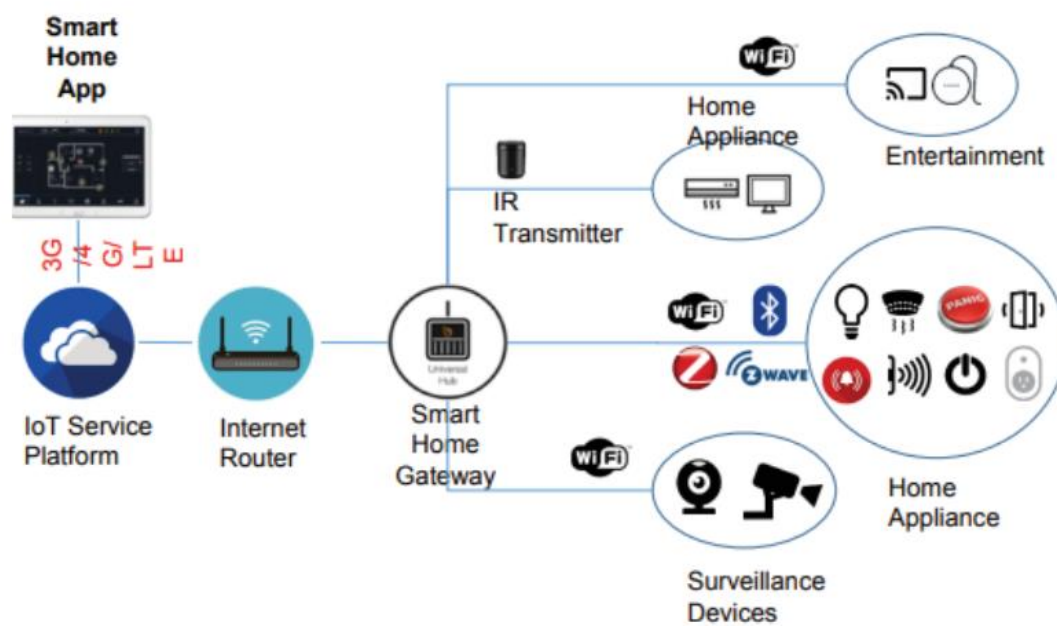


FIGURE 3: Smart Home Apps: How it works?

CONFUSION OVER WHAT A SMART HOME REALLY IS

Owning a digital assistant - like Google Home or Amazon Alexa - does not mean that one's house is truly smart. Not even a smart thermostat or any smart device alone can be part of a home automation design. Instead, one can talk about "connected home" or "partial home automation" solutions.

A truly smart home is a multi-component system requiring minimum management on the user's part. It is an ecosystem of a series of smart devices communicating through a smart home controller. A real smart home can make decisions based on historical and real-time data. It can identify significant user actions, assess the probability of events those actions might trigger, and issue relevant commands to other smart devices within the same network.

Smart Home Technology

Smart houses technology usually connects sensors, devices and appliances over a network of communications to monitor, access and control the living environment remotely. In addition, this smart home system also provides services that meet the needs of users. Using web services is the most open and interoperable way to provide remote service access or allow applications to communicate with each other. Internet Of Thing (IOT) is classified as a system that can be used as connectors such as internet television, sensors and movers to the internet to any device intelligently linked to forming a new communication among users. Smart Home Technology application can be either wired or wireless.

There are few components in wireless systems, which are, Bluetooth system, Infrared, Radio Frequency, Wireless Figuration System (WiFi), and Global System for Mobile communication (GSM).

Bluetooth system is usually available on portable computers, tablets and mobile phones. Bluetooth system are usually help in connecting various nearby devices to work and collecting data. However, Bluetooth system can only be used in the existing of their own networks. By the emerging of Wireless Figuration system (WiFi), bluetooth is no longer reliable as WiFi can be used in a personal computer-based web browser (PC) which connected to home-based devices [9]. Wifi are more reliable because it has central networks that can integrate multiple devices in one time even though the devices are apart away from one and another. Wifi system are most globally and famously used as it is the most connected systems.

In terms of security, Global system technology network systems for mobile communications (GSM), Short Message Service (SMS), and web cameras are used to detect home infiltration via the internet and at the same time warn sounds. The normally used parameters in home security are 24 hours monitoring of any intruders, easy in use, high reliability, high efficiency, and precise notification in the systems. The system is using web camera, install in the house premises and operated by software installed in a personal device that connected to the wifi. This system has its own interface and it will usually respond to alarm incidents by monitoring everything in moving cameras. In short, any intrusion will be detected by the camera and short message will be sent quickly to notify the home owner so that they can take an action instantly.

In terms of energy management, the components in smart homes are able to communicate with each other wirelessly by sending data to users which facilitate long distance communication in order to reduce energy consumption. The strategy is to calculate all actions by the home owner including switching commands and any other parameters that are executed by the home automation system. There are few sample of system regarding energy management through smart home system. One of them is thermostat control which programmed to combine all board tables where the user sets various time points with different temperature setting up by reducing heating and cooling load at unnecessary time. Moisture data, occupants, light levels and outdoor weather are available in this thermostat application. The energy management can also be applied in smart devices which involve the use of energy through a portal application in a smart phone. So, if there is a correction the appliances or home owner wanted to know the condition of the equipment, they can change and view through smart phone as a remote control.

TYPES OF SMART HOMES IN MALAYSIA

There are two (2) types of smart home systems in Malaysia. The first is the Wired Smart Home system, the earliest version of the smart home. In Malaysia, many houses still use wired smart homes. Still, after 5g technology have been released, most Malaysian tend to change to wireless smart home. This is because a wireless smart home is much more affordable and easier to install. These are some pros and cons of a wired and wireless smart home.

Smart Home	Pros	Cons	Prices
Wired Smart Home	- Security Protected	- Expensive	High

	<ul style="list-style-type: none"> - Reliability - Onetime installation cost 	<ul style="list-style-type: none"> - Professional renovation worker needed - Disassemble issues 	
Wireless Smart Home	<ul style="list-style-type: none"> - Convenient - Smart device control - Simple installation - Time-saving - Home wall remains intact 	<ul style="list-style-type: none"> - Cybersecurity issues - Coverage issues - Extra cost 	Low

Table 3: Pros and cons of wired and wireless smart home

PROS OF MALAYSIA WIRED SMART HOME

1. Security Protected

In Malaysia, most Malaysian choose a wired security system. The wired security system, like CCTV, is connected by cabling; all the videos are recorded and processed through NVR (Network Video Recorder). So, the advantage of using wired CCTV is it will not affect by Wi-Fi connection when the Wi-Fi system is breaking down, but the CCTV is still functioning. The home's security will also improve because there is no risk of being hacked using a wired smart home system.

2. Reliability

The wired smart home is much more reliable than the wireless smart home. This is because the wired smart home system is connected with cable, so it can make sure all the devices are connected and functional. Whatever the wire goes, you will get the connection.

3. Onetime installation cost

Lastly, the wired smart home is difficult to deconstruct and relocate. Due to a cabling issue, one cannot transport one's used wires to the new location. Therefore, when one moves to a new house, one needs another expensive payment. On the other hand, smart wireless devices can travel anywhere freely.

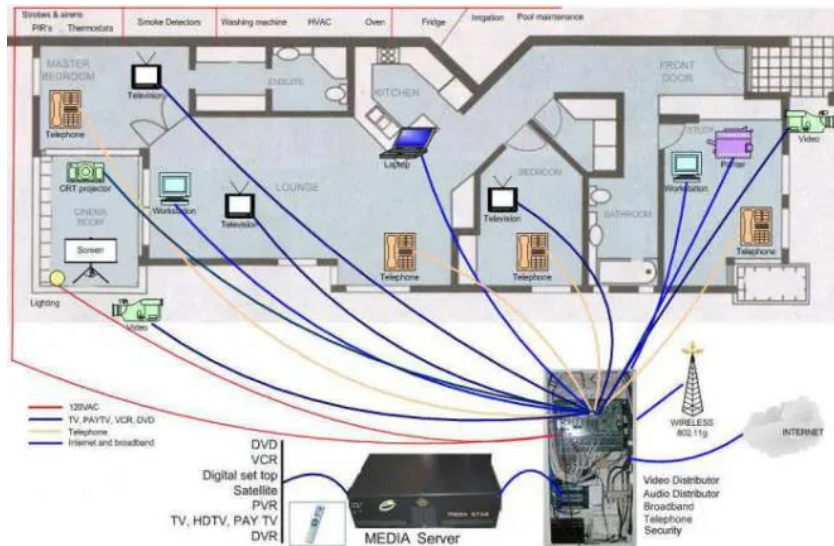


Figure 4: Wired Smart Home

CONS OF MALAYSIA WIRED SMART HOME

1. Expensive

First, you may choose a wireless smart home since it provides you with a comfortable and convenient life. Besides, you can still control your home equipment with any number of home control devices without using a wired system. For example, you can use the smartphone application to control the lighting or curtain in your home. With a wireless smart home system, you can also control your home devices by voice control. Different control ways can fulfil every different need.

2. Professional renovation workers needed

Moreover, unlike the complicated wired smart home system, the wireless smart home system does not require renovation. You do not need to pay for the renovation workers to install cables. Therefore, it can reduce your cost. The process of installing a wireless smart home is simple. You need to add smart devices to the smart home application, and then you can control your smart devices on your own.

3. Disassemble issues

The installation of a wireless smart home system is simple, and the installation process can finish within one day. Therefore, you can save a lot of time.



Figure 5: Examples of Wireless Smart Home Devices

PROS OF MALAYSIA WIRELESS SMART HOME

1. Smart device control

First, you may choose a wireless smart home since it provides comfort and convenience. Besides, you can still control your home equipment with any number of home control devices without using a wired system. For example, you can use the smartphone application to control the lighting or curtain in your home. With a wireless smart home system, you can also control your home devices by voice control. Different control ways can fulfil every different need.

2. Simple installation

Moreover, unlike the complicated wired smart home system, the wireless smart home system does not require renovation. You don't need to pay for the renovation workers to install cables. Hence, it can reduce your cost. The process of installing a wireless smart home is simple. You need to add smart devices to the smart home application, and then you can control your smart devices on your own.

3. Time-saving

The installation of a wireless smart home system is simple, and the installation process can complete within one day.

4. Home will remain intact

Wireless smart home does not connect by wiring; hence, drilling holes in the wall is unnecessary. Thus, the home wall will remain intact. Meanwhile, you can move the wireless smart home freely. Hence, you can continue to use the same smart devices in a new home when you move home.



Figure 6: Wireless Smart Home Control

CONS OF MALAYSIA WIRELESS SMART HOME

1. Cybersecurity issues

Even though there are a lot of pros of wireless, the cybersecurity issue is the biggest problem of Malaysia's wireless smart home. Since the wireless smart home system is connected to Wi-Fi, it could be hacked by someone. If your wireless smart home system is hacked, the person can control your home devices or steal your data.

2. Coverage issues

Sometimes, the wireless system may create a dark spot in the house. In this case, you would not be able to control devices from these dark spots. For example, some of your lights may be unreachable. In this situation, you may spend extra costs to solve this problem.

REASON WHY SMART HOME PRICE IS AFFORDABLE?

1. Hardware

Overall, the price of the wireless smart home is much more affordable than the wired smart home. From the hardware aspect, the wireless smart home requires some smart devices, where it is unnecessary to drill holes in the wall and install traditional switches. Hence, wireless smart home price is much more affordable.

2. Installation and settings

Wireless devices can also be easily installed and connected to the smart home system. As a result, installing a wireless smart home is not time-consuming. The entire installation process could be completed in a single day. You neither have to pay extra for installation nor professional workers' fees. Therefore, this makes smart home prices affordable to everyone.

SMART HOME CONTROL TYPE

1. Voice control

In Malaysia, the common smart home brand is Google Home, Apple HomeKit, Amazon and Mi Home. After installation, the user can set and control all the smart devices through Google Assistant, Siri, Amazon Alexa, or 小爱同学. Everything can be controlled when you say "Hey, Sir...", "Hi, Google...", "Alexa..." or "小爱同学...." For example, if your phone is not with you, voice control can also control all the smart devices in the house.

2. App

You can use the app on your phone to control your smart home product. You may choose to control the smart home product in voice control or click on the app. In Malaysia, many smart home apps are available such as Google Home, HomeKit app, Alexa, Mi Home and others. In those apps, user can change their set of smart home products easily through their apps. Installing apps and connecting smart home products is simple and easy. Just follow the instructions, and everyone can enjoy your smart home life.

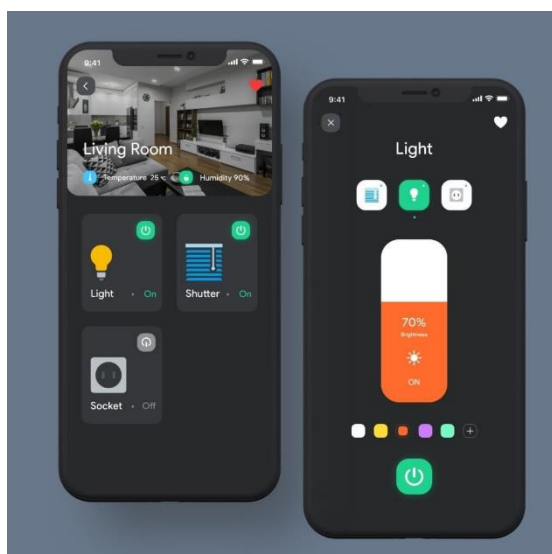


Figure 7: Smart Phone Interface

3. Timer

Additionally, the user can use the timer to control the smart devices. After setting, the smart devices will work automatically, and the user can always change the timer setting. For instance, you can use the timer to control the opening of the room's curtain every morning at 7.30 a.m.

4. Automation

Automation is another type of smart home control. Automation is very convenient for the user because it works when it detects your movement. For example, by installing the motion detector in the bathroom, the light in the bathroom will be switched on automatically when it detects your movement. After that, the light will automatically switch off when the motion detector does not detect any motion in the bathroom.

5. Wireless switch

In addition, smart home users can choose a wireless switch to control the smart devices. Normally wireless switch is small in size, and you can easily bring it everywhere. For example, the user can put it beside their bed and click to switch off all the lights in the room before sleep.



Figure 8: Wireless Smart switch

STEPS TO MAKE SMART HOME

Step 1: Choose A Smart Home System (Platform)

If you opt for a smart speaker without a built-in hub, the first and most important step to making your home a smart home is to choose a smart home platform. Smart home platforms allow you to set up, organise, and control your smart home devices and automation with greater ease. Examples of smart home platforms are Amazon Alexa and Google Home with Apple HomeKit and Samsung SmartThings.

These smart home platforms come in the form of smart assistants, usually smart speakers such as the Amazon Echo, Google Nest Audio, and Apple HomePod assistant. Alexa or Google Home Assistant are currently more developed and have better overall features.

At their core, these devices are similar in functionality. They control the other smart devices in your home, play music, answer your questions, shop, set reminders, and much more. However, it would be best if you considered some major differences for each device, which resulted in the compatibility issue. There are also different tiers of smart speakers ranging from the smaller new Echo Dot 4 gen and Google Nest Mini 2 gen, medium-sized Amazon Echo 4 Gen, along with the larger Google Nest Audio mentioned above and Amazon Echo Studio high-fidelity smart speaker. You can also utilise smart speakers with screens, such as the Echo Show 10, Nest Hub 2 gen, and Nest Hub Max.

The main differences between these smart assistants are the speaker quality, price, physical size, and the fact the Amazon Echo and Echo Studio contain a built-in smart hub. However, their built-in smart hub only supports ZigBee smart devices and does not support Z-Wave smart devices. ZigBee and Z-wave are two different protocols that certain smart home devices use. Currently, the lack of a standardised protocol creates the problem of lock-in when you choose one smart home platform over another, which means that certain smart devices you buy for one smart home platform may not be compatible with another platform.

Step 2: Choose a Smart Hub

If you opt for a smart speaker without a built-in hub or want access to Zigbee and Z-wave smart devices, a smart home hub is the next smart device you should consider getting. This device allows you to control and automate all the smart devices within your home. It is essentially the brains of your smart home operation. It connects to almost any type of smart home device, be it Zigbee or Zwave, allowing for the ultimate home automation.

More importantly, smart hubs allow you to control the majority of the smart devices and appliances in your home with only one app. This makes managing your smart

home much easier and less complicated without dealing with multiple apps. For example, the Aeotec Smart Home Hub with Aeotec is a smart home hub that wirelessly connects and controls a wide range of compatible smart devices and smart home platforms, including Amazon Alexa, Google Assistant, and of course, Samsung SmartThings.

Step 3: Gradually Add Smart Devices to Your Home

After selecting your smart home platform and a smart home hub, the next step is to incorporate the smart devices you wish to add to your home.

Wireless Smart Devices in Smart Home

Smart home devices are connected and can be accessed through one central point—a smartphone, tablet, laptop, or game console. Door locks, televisions, thermostats, home monitors, cameras, lights, and even appliances such as the refrigerator can be controlled through one home automation system. Home Security/ Home Intrusion

Smart home security systems are electronic systems that run off Wi-Fi and include various smart devices, all working together to provide comprehensive home protection.

Wireless CCTV Outdoor/Indoor

CCTV uses the wireless network of the home. The real-time video can be viewed worldwide, providing a data connection to the mobile phone and the CCTV. The video can be accessed via the manufacturer or third-party apps.



Figure 9: Wireless indoor/outdoor CCTV.

Wireless Smoke Detector/Alarm

According to Fire Safety Department Malaysia, every single home must have at least a fire extinguisher. The Universal Building By-Law 1985 provides that fire protection is one of the main concerns in developing architectural house design. Fire extinguisher will work more efficient with the installation of smoke detector. For smart home systems to warn residents, smoke detectors are installed in order to trigger alarms when an emergency occurs. The alarm will ring to indicate the fire is happening. This smoke detector is not recommended to be placed close to the stove to prevent an alarm issuing an inaccurate warning. The ideal distance of smoke detector is 2/3 distance from kitchen door and front doors as kitchen are having higher risks of fire emergency.

When an alarm is triggered, the smart smoke detectors use Wi-Fi or similar communication technology to connect to your smart home hub (if you have one) and an app on your smartphone. If you accidentally burn a batch of peanut butter cookies and trigger a false alarm, you can use the phone app to silence the alarm.



Figure 10: Wireless smart smoke detector/ fire alarm sensor

Wireless Door Lock

This digital device can be viewed on a smartphone worldwide, providing a data connection to the mobile phone. The lock can be set to engage or disengage. It can also be set according to the time preferred, for example, locked from midnight to 6 a.m. And locked again when nobody is at home. The lock can also be set to 'be able to open from inside only' or locked from both sides.



Figure 11: Wireless smart door lock

Window Break in Sensor

A door and window alarm sensor works by using a sensor and a magnet. The sensor is placed on or inside the door or window frame. The magnet is placed on or inside the door or window itself. When the door or window is opened, the magnet will separate from the sensor, causing it to activate.



Figure 12: Smart wireless door/window break in sensor

Window Glass Break Sensor

Glass break detectors work by sensing specific high-pitched sound frequencies like shattering glass and splintering wood. While it's uncommon, glass break sensors can sometimes be triggered by noises that may sound like breaking glass, for example, — dropping keys on the floor.



Figure 13: Smart wireless glass break sensor

Motion Sensor

A motion detector is an electrical device that utilises a sensor to detect nearby motion. Such a device is often integrated as a system component that automatically performs a task or alerts a user of motion in an area. They form a vital component of security, automated lighting control, home control, energy efficiency, and other useful systems. Normally the motion sensor is installed outside the house. This smart device can be connected to a mobile phone to notify the owner if a motion has been detected.



Figure 14: Wireless motion detector/sensor

Motion Sensor activated light/ spotlight

A motion sensor light triggers a response when motion is detected. They can be installed indoors, on walls, ceilings, and doorways, or on the exterior of buildings and homes. Some motion sensor lights, called occupancy sensors, operate by turning off lights in unoccupied rooms and spaces. When motion is detected, the sensor triggers the light; when the motion stops and ends, the sensor shuts off the light. Occupancy sensors are one low-maintenance method for cutting down on electricity bill charges from lights left on when no one is home or in a room.



Figure 15: Motion Sensor activated spotlight

Motion Sensor Activated Audio Warning/Motion Security Alarm

A security alarm is a system designed to detect intrusion into a building or other areas, such as unauthorised entry. Security alarms used in residential, commercial, industrial, and military properties protect against burglary (theft) or property damage and personal protection against intruders. Security alerts in neighbourhoods show a connection with a diminished robbery.

Motion sensor wireless alarm



Figure 16: Wireless Alarm Motion Sensor

Some alarm systems serve a single purpose of burglary protection; combination systems provide fire and intrusion protection. Intrusion-alarm systems are combined with closed-circuit television surveillance (CCTV) systems to record intruders' activities and access control systems for electrically locked doors. When a motion is detected, the sensor will automatically produce many kinds of audio, sounds, noises, and microwave sounds, depending on the purpose of the motion detector.

Other Wireless Smart Home Application

Wireless Home Automation

Home Automation, often referred to as “Smart Home Technology”, is the use of technology to automate your home. Home automation allows you to control almost every aspect of your home through the Internet of Things (IoT).



Figure 17: Smart wireless home automation

Home Automation started with the invention of the thermostat and has developed into one of the biggest and fastest-growing markets in technology. Home Automation's potential continues to grow. You can use it for home security, controlling appliances, monitoring energy use, as a personal assistant, looking after the elderly or disabled and more.

Wireless Energy Management

Smart switches, smart energy air-conditioning devices, E.V. Battery Charger. Home energy management (HEM) enables domestic consumers to participate in demand-side activities. However, it confronts some problems resulting from the uncertainties of renewable energy resources and consumers' behaviour. In contrast, domestic consumers aim at the highest level of comfort that should be considered by minimising the "response fatigue" phenomenon.



Figure 18: Smart home energy management system

The term Energy Management System can also refer to a computer system designed specifically for the automated control and monitoring of those electromechanical facilities in a building which yield significant energy consumption, such as heating, ventilation and lighting installations.

The scope may span from a single building to a group of buildings such as university campuses, office buildings, retail stores networks or factories. Most of these energy management systems also provide facilities for reading electricity, gas and water meters. The data obtained from these can then be used to frequently perform self-diagnostic and optimisation routines and produce trend analysis and annual consumption forecasts.

Energy management systems are also often commonly used by individual commercial entities to monitor, measure, and control their electrical building loads. Energy management systems can centrally control devices like Home Ventilation, Air Conditioning, HVAC, units, lighting systems, and charge an electric vehicle.

Wireless Home Entertainment

Smart home entertainment systems are very popular these days. They are great because systems are versatile and can be expanded with almost no limits and without needing extra wires, ports, outlets, or other things that can get in the way.

Personalise any screen or audio speaker in the home that appeals to every member of the family. Connect everything wirelessly, and it's ready to go. With today's technology, almost everything can be smart.

There are smart light bulbs now. However, there are a few standard options when considering what can be added to the system. Smart T.V.s are usually the center of a smart entertainment system.

Add smart speakers, controllers, and various Bluetooth devices, such as video game consoles, Blu-ray players, Roku devices, stereos, tablets, smartphones, and more. It's really a matter of personal preference. Besides visual and audio entertainment, other smart home devices can be added to your media room.



Figure 19: Smart wireless home entertainment system.

Wireless Home Appliance

This can include grills, refrigerators, cleaning devices, and more. Smart devices can access the home automation system. A smart device or smartphone control the home automation anywhere, as long as there is access to a network.



Figure 20: Smart wireless home appliances.

Central Control System

Central Control System acts as brain to the whole system of smart home concept. It centralised the systems of all smart home devices and appliances in order to ensure the integration of all devices works efficiently. This central control system is put in a control box where it is connected to home owner smart phones or computers through wireless figuration (Wi-Fi). This control hub simplifies the workflows and giving effortless methods of control for home owner. This intelligent system will send notification regarding any extreme measurement produce by any smart home devices. Installation of central control system does not need major hacking to the house. However, it might need a complex rewiring in order to connect physical smart home devices. Central control system is usually set up near to home main electrical power switch so that easier to locate in case of emergency. It is also recommended to put the control box near to any architectural opening of the house. This is because complex wiring has bigger risk towards short circuits and fire.

CHALLENGES OF SMART HOME

There are several speculations and factors that contributed to the slow growth of Smart City, which directly impacts the Smart Living development.

Firstly, the whole development plan is claimed to be a rerun of traditional capitalism that incur market monopoly in term of technology by introducing unnecessary changes that prioritise Information Communication Technology (ICT) over the supply of basic needs. In other words, the whole development concern is mainly technology-driven rather than problem-driven.

Besides, failures to share mutual ground between private and public sectors for comprehensive project development adds up to the issue of market monopoly. This implies the false adoption of a procurement system that does not match the position for a 'level playing field' therefore incurred a scenario of overpricing Smart Living projects.

Thirdly, many private construction sectors gave feedback about the implications of comparatively high capital cost. This is due to the need to comply with the Smart requirements before being awarded the 'Smart' title. Thus, it requires them to narrow down their profit margin while maintaining the selling price range for their target markets. As a matter of fact, the third factor is the most concerning and are reflected by the scenario of mass housing market overhang that is reported to be due to the mismatch of housing price with their target markets.

Home automation technology connectivity shortcomings

However, there are more issues and challenges in adopting IoT for home building in Malaysia as follows:

Network connectivity

Network connectivity is one of the most common challenges that smart device owners will encounter. It can be annoying and even seriously disruptive when one's smart devices stop communicating together because of a network issue.

A connected home solution should be available even if the Internet goes down. This challenge is relevant for home automation products relying heavily on the Cloud and the latest IoT technologies. When the Internet connection is not available or not stable, you can use your phone and other devices to control your smart home equipment. IoT creates a more extensive network of devices: there are more than 3 billion mobile users globally and almost 8 billion IoT devices. The enormity of the network is both an advantage and a security risk.

For instance, a user connecting his smart light with his app also provides information about his habits and current location. If not appropriately designed, home automation solutions can expose users to unintended compromises and risks. For this reason, it is essential to rely on smart home solutions providers with evidence of previous home automation experience and reliable technology.

Smart Home Market Segmentation

When your devices are not communicating as they should, it also means that they are not fully integrated. This can mean that the smart thermostat is not responding or that the security camera is not connecting. This problem can affect all systems, from a smart assistant to a centrally controlled heating system. It often occurs when homeowners or non-specialist home automation providers install smart devices themselves. You then end up having a smart home where several smart devices are incompatible with each other.

Security, Privacy and Protection of Consumer Data

The main challenges of IoT implementation are issues related to security and privacy. It was also found that there is a lack of information related to the ways to overcome the challenges, although the challenges were discussed in length.

Security and invade privacy are potential of smart home technology complications. Personal privacy is exposed by access through a smartphone or personal computer at home. Although it is reported that the industry has established many security technologies and practices to keep individual privacy, it will unavoidably come down to lawmakers to decide whether security agencies are permitted to enter citizen's homes. It is also expected that security services, will lead to the accumulation of a large number of sensitive personal data for day-to-day activities.

Likewise, the hackers attack in the smart home may cause a huge loss of security and safety of the homeowner. Among threats that may be caused by the hackers are data loss and data hacking, counterfeiting, denial of services, eavesdropping, buffer overloading, malicious amendments, password-based attacks and etc.

At present, the ability of smart home to foresee human behavior correctly is restricted. Precisely, a smart home whose technical mechanisms are functioning without flaw may still deliver an unreliable service, as the system is not intelligent enough to correctly understand or correctly anticipate the needs of its consumer. Although smart homes have many benefits that make human lives useful, these smart properties are costly. The cost of the smart home is high due to the technology that is comparatively new.

Furthermore, quoted the improvement of common standards and protocols, the data storage migration to the cloud and last but not least, an armada of security issues comprising the opportunity of data breaches, backdoors into home systems and vehicles being hacked by hostile intruders, need to be dealt with. The 'disclosure and consent' model which governs digital products could now cover into other products, as lines are blurred between digital and physical items. These usually uniform terms and conditions give consumers no flexibility for cooperation and give providers full opportunity to command how products and services can be used.

Consumers International has identified other areas where multiple connected devices and services could give cause for serious concern: the development of hybrid products; the erosion of ownership norms; remote contract enforcement; lack of transparency; complex liability; lock-in to products and systems; locked out of alternatives; and data, privacy and security. Stated that consumer protection as presently perceived and implemented will be sufficient to uphold consumer privileges in an environment where appliances and devices in our homes, our vehicles and about our persons, become smarter and more connected – to each other, to the Internet and to third parties.

While data privacy and protection has attracted a lot of attention, wider issues about what it means to be a consumer of highly networked products and services also need urgent consideration. A momentous issue is the risk that intellectual property arguments and digital rights management will extend to products and services containing software, and risk superseding consumer protection law.

Even babies are getting connected through Mimo, a baby monitor that's actually a onesie with sensors. Monitoring respiration, temperature, and sleep status, it sends a stream of data to parents' phones. Then there are also important research and IoT products in the works to help end the tragedies of children's deaths in hot cars. Studies show also IoT has become widespread, and it opens the opportunity for cyber-attack and fraud. The extreme quantity of data that will flow between the connected vehicles, connected home and insurance company is unprotected to interception. The new IoT products are also likely to lead to new application and claim frauds. Insurers will need to invest more for data security and fraud protection.

Lack of IoT Awareness among Malaysians

One of the major challenges before Malaysia today is a deficiency of IoT awareness. People might have heard about IoT but mainly in the consumer space – wearables and smart homes applications. However, since the cost is still expensive, not many are willing to use them except for the few, i.e., the early adopters. Now, we all know that wearables and smart home appliances become outdated just as quickly as they become trendy or fashionable.

Absence of Enterprise IoT Applications in the Country

Another challenge is the absence of enterprise IoT applications in the country. These devices are not as trendy and fashionable as their consumer counterparts. Sensors that are being used in enterprises will last longer — maybe 3-5 years or even more. They are more robust and sometimes well-hidden somewhere. Thus, there is no need for some fancy design to house the sensors. However, these sensors can be more

expensive, and when we talk about hundreds or thousands of sensors, the cost of deployment can become very prohibitive.

Resistance from Within the Company

The industry necessities to come up with a win-win business model for both the IoT vendor and the user to solve this dilemma. However, before that, businesses need to tackle the resistance from within the company also. Transparency is the key to IoT implementation because it will translate to productivity. It is easy to see how too much transparency can send jitters to some group of people or how pushing productivity eliminates jobs, that in turn may cause social issues. To put it simply, most people just do not know where to start their IoT journey.

Users Perceptions on IoT as Part of their Daily Life

Persuasive technologies, such as feedback systems providing real-time energy monitoring and recommendations, have been shown to raise the awareness of users about their energy consumption and induce a long-term change in their behavior and lifestyle. Studies related to IoT challenges stated that human aspect should be considered since IoT technology involves humans as the main platform for interaction and the main challenge in the adoption of new technology such as IoT is the acceptance of the users.

As suggested by Technology Acceptance Modelling (TAM), the predictive factors of accepting the technology are ease of use and usefulness. Issues related to privacy and confidentiality are largely emphasised in the business perspective. The stakeholders are unlikely to adopt IoT solutions if there is no surety in terms of data confidentiality, authenticity and privacy.

Data confidentiality indicating the confirmation that only particular entities have the right to gain and manipulate data, whereby data may represent an asset to be protected to secure the competitiveness. However, the recent solutions for ensuring data privacy are not straightforwardly applied in IoT framework due to the demand of observing the access to information in an on-line and controllable way.

Thus, in order to confirm confidentiality and privacy in knowledge management system, numerous access control techniques have been suggested, which comprises Role-Based Access Control (RBAC) that seriously used as a successful alternative to conventional discretionary and obligatory access control. The above revealed presents some of the issues related to the acceptance of IoT technology. Hence, it is critical to give attention to customer's good insight towards technology so that they will not hesitate to accept and use the technology in their daily routine.

Other Technical Challenges of Smart Homes

Many technical challenges arise for modern grids due to the increasing mutual exchange between smart homes and utility grids, especially power-quality control. Electric power-quality studies usually confirm the acceptable behaviour of electrical sources such as voltage limits and harmonics analysis. Recently, smart power grids have diverse generation sources from different technologies that depend mainly on power electronics devices that increase the difficulty in power-quality control. Power-quality constraints should be taken into consideration for any energy management systems to provide harmony between modern sources and loads.

On the other hand, power-quality issues should not form an additional obstacle against the integration of new technologies in modern grids. Therefore, both advanced communication schemes and AI-based techniques make modern grids 'smart' enough to cope with selective power quality management. Smart homes exchange power with utility grids. With the prospective increase in such smart homes, the effect of their behaviour should be studied and controlled. Smart homes affect the grid-power quality in three different areas, as will be discussed in the following paragraphs.

Generating equipment

Integrated micro-generation schemes in smart homes are mainly single-phase sources based on inverters with high switching frequencies that reach to many kHz. Low-order harmonics of such a generation type can usually be disregarded. However, with the expected continuous increase in such micro-generators, the harmonics of low-voltage networks may shift into a range of higher frequencies, perhaps from 2 to 9 kHz. Therefore, more research is needed to re-evaluate the appropriate limits for generation equipment in smart homes. Moreover, single-phase generation increases the risk of an unbalanced voltage in low-voltage grids. Therefore, negative-sequence voltage limits should be re-evaluated, particularly for weak distribution networks. Also, a need for zero-sequence voltage limits may arise.

Home appliances

Modern home appliances depend mainly on electronic devices, such as newer LED lighting systems, E.V. battery chargers, etc., with relatively low fundamental current and high harmonic contents compared to traditional ones. According to many power-system analysers, many harmonics will increase significantly to risky levels, particularly fifth-harmonic voltage, with an increase in such new electronic appliances.

Distribution network

In future grids, significant unusual operating scenarios may be possible with high penetration of domestic generation, especially with the possibility of an islanded (self-balanced) operation of smart homes. Short-circuit power will differ significantly during different operating conditions compared to classical grids. Moreover, low-voltage networks may suffer from damping-stability problems due to the continuous decrease in resistive loads, in conjunction with the increase in capacitive loads of electronic equipment. In addition, resonance problems may occur with low frequencies according to the continuous change in the nature of the load.

Although smart homes have bad impacts on utility grids, there are no charges applied from the grid authority to homeowners based on their buildings' effects on grid power quality. Therefore, home planners and SHEMS designers are usually concerned only with the economic benefits of their proposed schemes.

CASE STUDY FROM SELECTED COUNTRIES

Findings – Smart Living in Developed Countries and Southeast Asian Countries

Table 4: Ranking of Smart City in 2020.

Developed Countries			South-East Asia Countries		
Cities	Countries	Rank	Cities	Countries	Rank
Singapore	Singapore	1/109	Singapore	Singapore	1/109
Helsinki	Finland	2/109	Kuala Lumpur	Malaysia	54/109
Zurich	Switzerland	3/109	Bangkok	Thailand	71/109
Auckland	New Zealand	4/109	Ho Chi Min	Vietnam	83/109
Oslo	Norway	5/109	Hanoi	Vietnam	84/109

Source: IMD World Competitiveness Center, IMD Business School, Singapore University of Technology and Design & SCO Smart City Observatory (2020)

Table 4 shows Singapore as the leading country in the application of smart home. According to Singapore Government Agency, their Smart Living concerns are towards achieving greater convenience, utility savings, as well as ensure peace of mind for families with elderly family members. The adoption of Smart Living priorities towards units produced by Singapore Housing and Development Board (HDB) houses or in Malaysia is known as affordable subsidised houses because there are up to 80% of Singaporeans stay in HDB units.

Through the HDB Smart Enabled Home Initiative, the smart components offered are firstly elderly monitoring system, secondly home energy management system and

thirdly home water or waste management system. Features for the elderly monitoring system are interactive sensors like a panic button, door contact sensor and motion sensor.

While for home energy management system will be smart lighting with anticipatory software for optimising provision of lights and solar panels under the name of SolarNova program for deployment of solar photovoltaic (P.V.) systems in Singapore, to promote and aggregate demand for solar P.V. across government agencies to achieve economies of scale, as well as drive the growth of Singapore's solar industry.

Lastly, for the home water and waste management system, the Government proposed Pneumatic Waste Conveyance System. It is an automated waste collection system that uses a vacuum-type underground pipe network to collect household waste, which is then transported through underground pipes to a sealed container. Trucks then periodically collect the waste for disposal.

Table 5: Smart Living Practice in Singapore

Singapore	
Priority	Making Smart Living affordable and elderly care
Adoption Practice	Apply smart features on residential units occupied by the majority
Initiative	HDB Smart Enabled Home Initiative
Features	Interactive sensors; Home energy management; Water and waste management

Source: Singapore Government Agency (n.d.)

The second leading country in the application of smart home—Helsinki, Finland is continuously at the top of comparisons and evaluations of the European and global smart cities. Helsinki is launching three new projects as part of its Re-thinking Urban Housing program, which will result in 274 housing units.

The program aims to improve the quality and appeal of flats as housing through customised solutions and collaboration. The construction of the rapidly growing city rests on an increasingly dense urban structure and 86 per cent of housing units in Helsinki are located in blocks of flats.

For developers, the Rethinking program aims to provide an opportunity to try new things and receive valuable guidance from municipal experts. For residents, the program creates new housing alternatives and examples of how to improve the quality of flat housing.

The Excess Plus-Energy House project in the Kalasatama neighbourhood's – Työpajanpiha, is set to be realised through the Hitas system for owner-occupied flats. The four-year project involves 21 parties from eight countries and is funded by the E.U. Horizon 2020 program for research and innovation.

It aims to prove the feasibility of transitioning from low-energy houses to Plus-Energy Houses, a building that on an annual basis generates more energy than it uses. The other two Re-thinking Urban Housing projects make use of a loan with a 20-year

guarantee provided by the Housing Finance and Development Centre of Finland (ARA). These houses are going to be outfitted with smart home solutions, smart meters and renewable energy sources, such as e-mobility charging networks.

Table 6: Smart Living Practice in Helsinki, Finland.

Helsinki, Finland	
Priority	Making Smart Living affordable
Adoption Practice	Apply smart features on residential units occupied by the majority
Initiative	Re-thinking Urban Housing program, Excess Plus-Energy House project
Features	Smart home solutions - smart meters; Renewable energy sources - e-mobility charging networks

Source: Hämäläinen (2020); Weekes (2019)

In the South East Asian nation, the smart home trend for example in Bangkok, Thailand put extra effort into easing the burden of the elderly since they found out growing numbers of the elderly population have a higher dependency rate. The ageing society has been a concern for the Government of Thailand to prepare for policies regarding healthcare projects where one of the efforts is investing in an elderly assisted system – Smart Home.

The concept of assistive technology has been developed to facilitate self-care and enhance the independence of the elderly living in their homes. Some examples of assistive technology include devices that compensate services for cognitive, sensory, and physical disabilities; adoptions to the design, lighting, and furnishing of living environments; sensors and network systems that monitor daily activities to help the elderly maintain their health and safety while living independently; and various methods of social communication.

These features are: video monitoring as an activity monitoring system is used to monitor activities in daily life; fall detection for the exchange of signals between Bluetooth beacons attached in several places in the house and wearable devices can be used to detect falls; then the use of robotics like an intelligence cooking hob, oven and robot vacuum cleaners; shade and climate control for the fine-tuning control of shading related to home temperature, humidity, lighting, and ventilation; lighting control with the automatic lighting system allows any lights to be activated on and off when the elderly is in the room; Smartwatch as a wearable device for medical monitoring and fall detection; lastly video door entry systems.

Table 7: Smart Living Practice in Bangkok, Thailand.

Bangkok, Thailand	
Priority	Elderly care
Adoption Practice	Apply assistive technology on residential units
Initiative	Health-care Program
Features	Video monitoring; Fall detection for the exchange of signals between Bluetooth beacons; Robotic - intelligence cooking hob, oven and robot vacuum cleaners; Shade and climate control; Lighting control; Smartwatch for medical monitoring; video door entry systems

Source: Pal, Papasratorn, Chutimaskul, & Funilkul (2019); Visutsak & Daoudi (2017); Leeraphong, Papasratorn, & Chongsuphajaisiddhi (2015)

In another smart living practice city in the South East Asia, i.e., Ho Chi Minh, Vietnam, the total number of smart homes in 2020 is about 0.6 million according to the General Statistic Office of Vietnam. This number is relatively small compared to the total number of households in the nation. Moreover, as stated by one of their developers, most smart homes are developed in the residential sector of newly built or still under construction projects located mainly in the two most urbanised cities of Vietnam – Hanoi and Ho Chi Minh City.

However, installing smart technologies would result in a higher price tag for the properties, which would likely limit the target market to the high-end segment. This consequently explains one of the reasons why it was slow in the first phase to penetrate the smart home market in Vietnam. Nonetheless, the potential for market growth is still high as many developers have become more proactive in integrating the concept of smart home in their projects and offering smart techs as extras in a promotion or free experience program.

Particularly, when looking at the six key segments of smart home application, even though not accounting for the highest in terms of revenue as stated above, "control and connectivity", "home entertainment" and "comfort & lightning" are the most application for smart homes in Vietnam. It can be deduced that the ability to "control and connect" as well as entertainment and comfortless factors are the focal points of the smart home concept, which is supposed to bring the most added value the daily life in Vietnam. In addition, integrated devices that can connect to another device will dominate the stand-alone devices because of their usability and functional diversity. Most of the households equipped with smart appliances will be high-end apartments with modern electrical systems.

Table 8: Smart Living Practice in Ho Chi Minh, Vietnam.

Ho Chi Minh, Vietnam	
Priority	Launching new high-end residential projects
Adoption Practice	Apply assistive technology on residential units, new high-end projects
Initiative	No special initiative
Features	Control and connectivity; Home entertainment; Comfort & lightning

Source: Hong Loan & Van Tin (2018)

Lessons from Foreign Regions

All these countries share almost the same goals in the work on producing Smart Home – elderly care. Elderly care is described as the priority concern which aligned with the definition of Smart Living in the first place, which is to help occupants reach their convenient independence throughout their daily routines. The concerns towards the ageing population should be taken seriously and perhaps formed a part of their healthcare initiatives as it is a part of human well-being as emphasising in Sustainability Development. Well-being has been recognised as a complicated and multifaceted process where it takes different forms across time, settings and societies demanding for an all-inclusive environment for human settlement. This is important for better productivity and value creation. All in all, for the local context, the wellbeing of Malaysian should come as the priority in developing Smart Living.

Besides, Smart Living shall be made available for the majority like the practice by Singapore and Helsinki where they focus on retrofitting the HBR units and flats that are both affordable houses for their medium to low incomes citizens. In Malaysia context, the medium to low incomes communities are categorised as the M40 and B40 groups. In fact, these are the people who require the most assistance in their lives especially in regards to health, well-being and convenience. Perhaps, layers of Smart Living implementation are needed to accommodate various community needs. Further clarification about the type of Smart Living features to be adopted should be precisely defined and standardised with in-depth research within the Malaysia market so that the supply meets the market need practically.

SMART-HOME INFRASTRUCTURES: THE WAY FORWARD FOR MALAYSIA

The general infrastructure of smart homes consists of control centres, resources of electricity, smart meters and communication tools. These general infrastructure as in the following discussion are not available nationwide in Malaysia yet.

The control centre

The control centre provides home users with proper units to monitor and control different home appliances. All real-time data are collected by SHEMS to optimise the demand/generation coordination and verify the predefined objectives. The main functions of the control centre can be:

- (i) collecting data from different meters, homeowners' commands and grid utility via a proper communication system;
- (ii) providing proper monitoring and analysing of home energy consumption for homeowners.
- (iii) coordinating between different appliances and resources to satisfy the optimal solution for predefined objectives.

Smart meter

The smart meter receives a demand-response signal from power utilities as an input to the SHEMS system. Recently, advanced smart-metering infrastructures can monitor many home features such as electrical consumption, gas, water and heating.

Appliances

Smart-home loads can be divided according to their operating nature into two categories: schedulable and non-schedulable loads. Non-schedulable loads are operated occasionally according to the homeowner's desires without any predictable operating patterns, such as printers, televisions, and hairdryers, whereas schedulable loads have a predictable operating pattern that can be shifted or controlled via SMS, such as washing machines and air conditioners. Controllable devices are also classified into interruptible and non-interruptible load according to the effect of supply interruption on their tasks.

Electric vehicles (E.V.s) can be considered as an exceptional load. E.V.s have two operating modes: charging and discharging. Therefore, E.V.s are interruptible schedulable loads during the charging mode. Moreover, E.V. battery energy can also be discharged to supply power to the grid during critical events, which is known as vehicle-to-grid by SHEMS, E.V.s can participate in supplying loads during high-priced power periods. In low-priced power periods, E.V.s restore their energy from the grid.

Resources of electricity

Solar and wind plants are the most mature renewable energy sources in modern grids. Nowadays, many buildings have installed photovoltaic (P.V.) modules, thermal solar heaters or micro wind turbines.

For smart homes, various functions can be supplied by solar energy besides generating electricity, such as a solar water heater (SWH), solar dryer and solar cooler.

Moreover, P.V. plants are cheap with low requirements of maintenance, whereas hot water produced by SWHs can be used in many home functions, such as washing and cooking, which increases the home-energy efficiency.

Energy storage may be considered as the cornerstone for any SMS. SMS are usually installed with energy storage systems (ESSs) to manage their stored energy according to predefined objectives.

Many energy-storage technologies are available in the power markets. Batteries and fuel cells are the most compatible energy-storage types of smart-home applications.

A fuel-cell structure is very similar to a battery. During the charging process, hydrogen fuel cells use electricity to produce hydrogen. Hydrogen feeds the fuel cell to create electricity during the discharging process.

Fuel cells have relatively low efficiency compared to batteries. Fuel cells provide extra clean storage environments with the capability of storing extra hydrogen tanks. That perfectly matches isolated homes in remote areas.

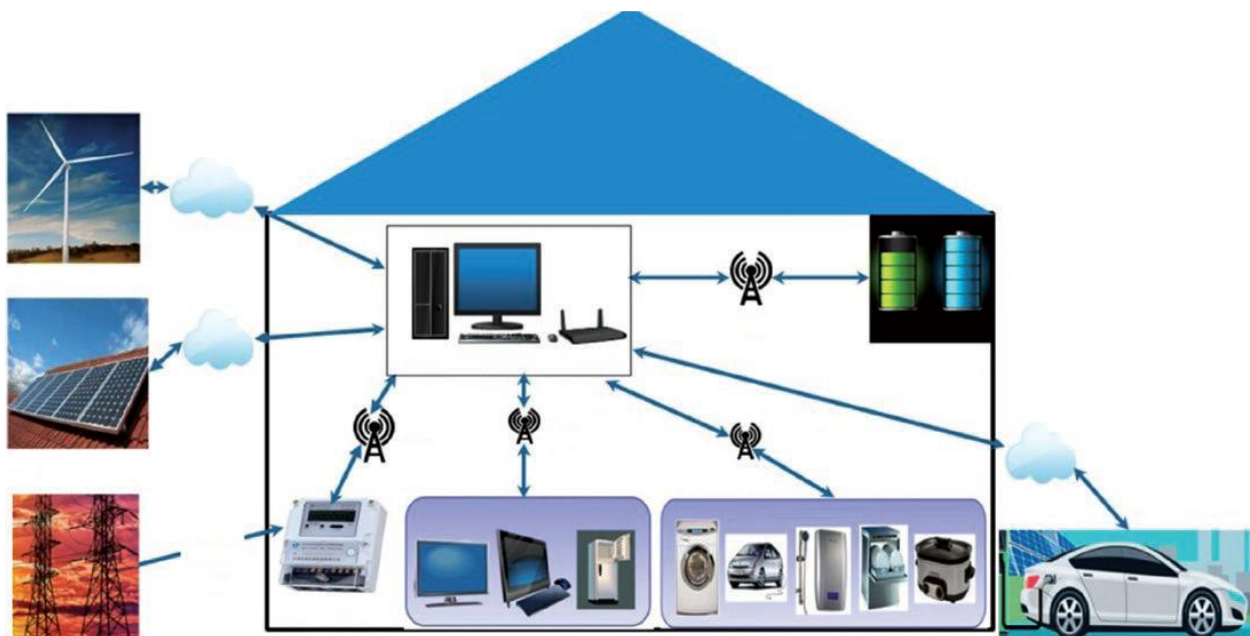


Figure 21: Connected Energy Control in Home Appliances.

Smart Home product in energy control

Although wind energy is more economical for large-scale plants, it has a very limited market for micro wind turbines in homes. Typically, micro wind turbines require at least a wind speed of 2.7 m/s to generate minimum power, 25 m/s for rated power and 40 m/s for continuous generated power.

A micro wind turbine is relatively expensive, intermittent and needs special maintenance requirements and constraints compared to a solar plant.

Recently, biomass energy has been a promising renewable resource alternative for smart homes. Many pieces of research have recommended biomass energy for different types of buildings.

Heating is the main function of biomass in smart homes. In addition, a biomass-fuelled generation system is examined for many buildings.

Communication schemes

Recently, communication systems are installed as built-in modules in smart homes. Both home users and grid operators will be able to monitor and control several home appliances in the near future to satisfy the optimum home-energy profile while preserving a comfortable lifestyle.

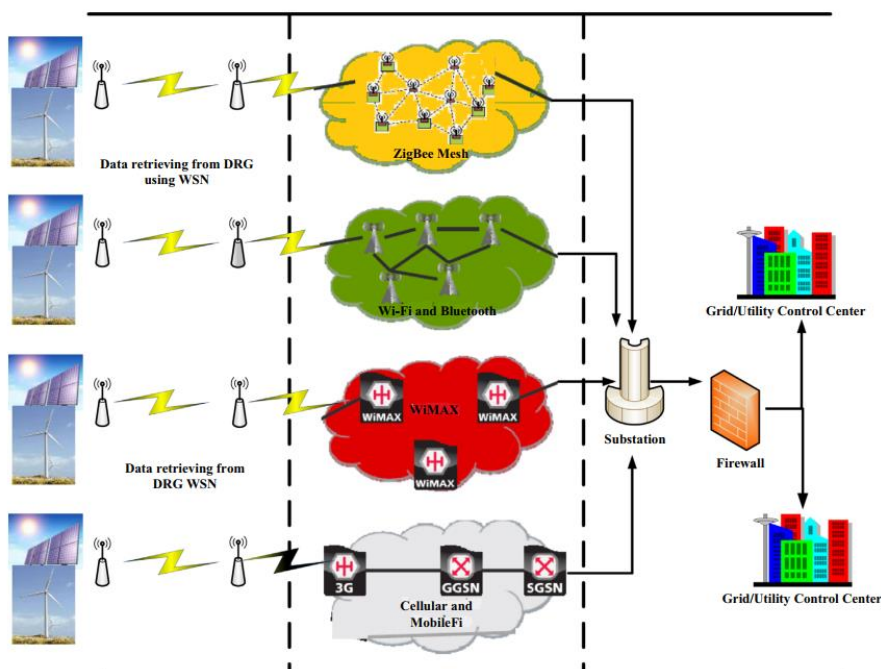


Figure 22: Communication Method for Grid/Utility Control Centre.

Therefore, both wired and wireless communication schemes are utilised, which is known as a home area network (HAN), to cover remote-control signals as home occupants' ones.

Energy-management systems for homes require three main components: the computational embedded controllers, the local-area network communication middleware and the transmission control protocol/internet protocol (TCP/IP) communication for wide-area integration with the utility company using wide-area network communication.

According to home characteristics, many wired communication schemes can be selected, such as power-line communication (PLC), inter-integrated circuit (I2C) and serial peripheral interface or wireless technologies such as Zigbee, Wi-Fi, radio-frequency identification (RFID) and the Internet of Things (IoT) to develop HANs. A few of the most common techniques will be discussed briefly in the following subsections.

PLC

PLC is a technique that uses power lines to transmit both power and data via the same cable to customers simultaneously. Such wired schemes provide fast communication with low interference of data. Moreover, PLC provides many communication terminals, as all power plugs can be used for data transferring. As all electrical home devices are connected by power cables, PLC can communicate with all these devices via the same cable. PLC set-up has a low cost, as it uses pre-installed power cables with minimum hardware requirements.

With a PLC communication scheme, home controllers can also be integrated easily with a high speed of data transfer. On the other hand, PLC has a high probability of data-signal attenuation. Furthermore, data signals suffer from electromagnetic interference of transmitted power signals.



Figure 23: Wireless PLC communication scheme.

Zigbee

Zigbee is a wireless communication technique. Zigbee follows the IEEE 802.15.4 standard as a radiofrequency wireless communication scheme. It does not require any licenses for limited zones such as homes. Also, Zigbee is a low-power-consuming technique. Therefore, it is suitable for basic home appliances, such as lighting, alarm systems and air conditioners.

Zigbee usually considers all home devices as slaves with a master coordinator/controller, which is known as a master-slave architecture. Zigbee provides highly secured transferred data, with high reliability and capacity. It also has self-organising capabilities.

Conversely, Zigbee is relatively expensive due to special hardware requirements with low data-transfer rates. Moreover, Zigbee is not compatible with many other protocols, such as internet-supported protocols and Wi-Fi.

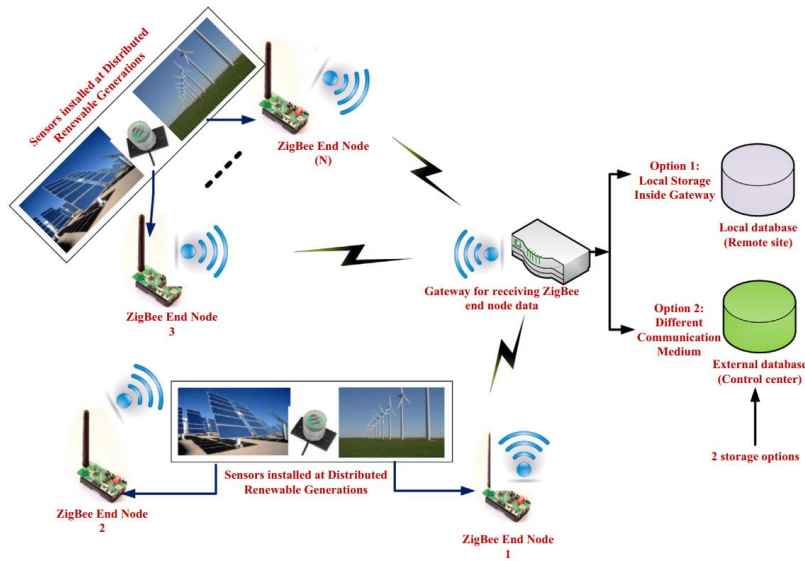


Figure 24: Zigbee Devices communication scheme

Wi-Fi technology

Wi-Fi is a wireless communication technique that follows the IEEE 802.11 standard. Wi-Fi provides high-rate data transfer that is compatible with many information-based devices such as computers, laptops, etc. Wi-Fi is a highly secured scheme with many of the familiar internet capabilities and low data-transfer delays (<3 ms). On the contrary, it is a relatively high-power consuming scheme compared to Zigbee schemes. Also, home devices can affect transmitted data signals by their emitted electromagnetic fields. Wi-Fi can also suffer from interference from other communication protocols such as Zigbee and Bluetooth.



Figure 25: Wi-Fi wireless communication scheme

RFID

RFID is a wireless communication technique that conforms to the electronic product code protocol. It can coincide with other communication schemes such as Wi-Fi and Zigbee. It can be utilised for a relatively wide range of frequencies, from 120 kHz to 10 GHz. It also covers a wide range of distances, from 10 cm to 200 m. Many researchers are investigating RFID home applications, such as energy-management systems, door locks and lighting controls. RFID operates on tags and reader-identification system with a high data transfer rate. Nevertheless, RFID has expensive chips with low bandwidth. The possibility of tag collision within the same zone decreases the accuracy of the RFID scheme.

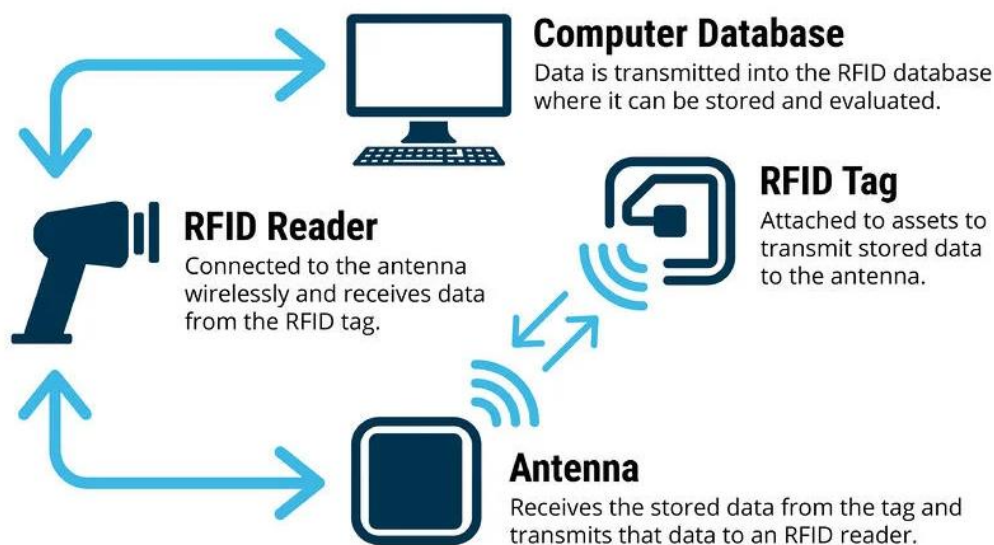


Figure 26: RFID Wireless communication scheme

IoT

This scheme connects home devices, users and grid operators via the internet to monitor and manage smart homes. Consequently, the IoT and cloud computing have proven to be cheap, popular and easy services for smart homes. Moreover, IoT schemes are compatible with many other communication protocols, such as Zigbee and Bluetooth. Internet hacking is the main problem with IoT schemes. System security and privacy are critical challenges for such internet-based schemes.

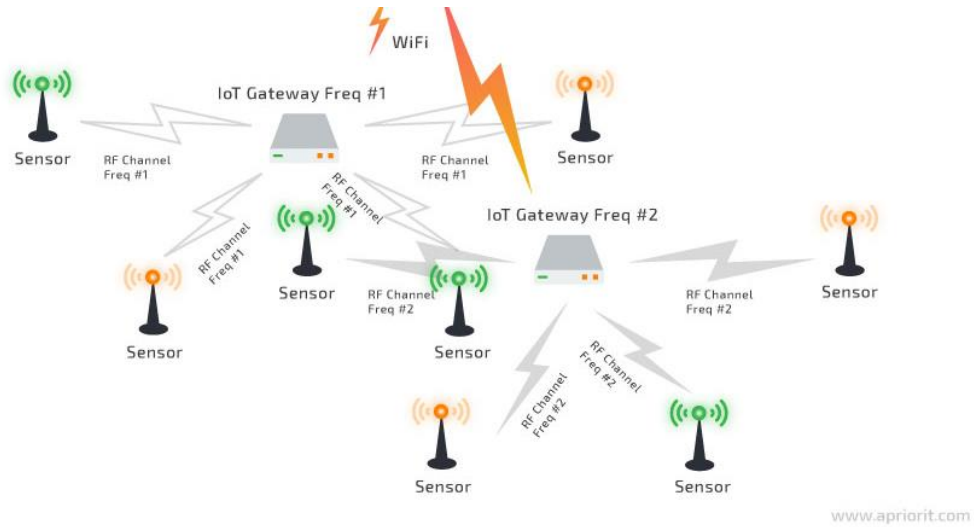


Figure 27: IOT wireless communication scheme

SMART-HOME ENERGY-MANAGEMENT SCHEME (SHEMS)

Today, building energy management systems (BEMS) are utilised within residential, commercial, administration and industrial buildings. Moreover, the integration of variable renewable energy sources with proper ESSs deployed in buildings represents an essential need for reliable, efficient BEMS.

For small-scale residential buildings or ‘homes’, BEMS should deal with variable uncertain load behaviours according to the home occupants’ desires and requirements, which is known as SMS. Throughout recent decades, many SHEMS have been presented and defined in many research studies.

SMS are defined as services that efficiently monitor and manage electricity generation, storage and consumption in smart houses. A collaborative exchange between smart homes and the utility as a main function of SMS. SMS are defined from the electrical-grid point of view as important tools that provide several benefits such as flattening the load curve, a reduction in peak demand and meeting the demand-side requirements.

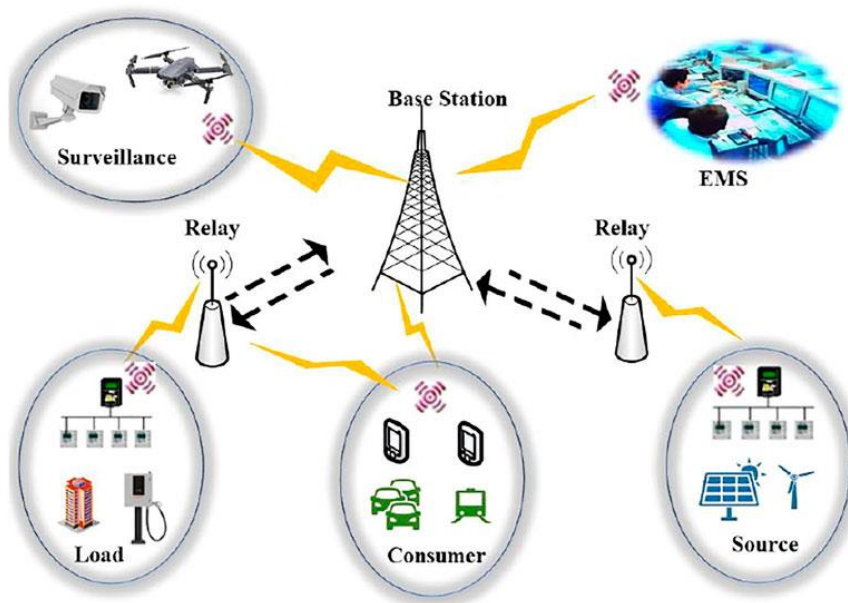


Figure 28: Smart Energy Management system

Functions of SHEMS, the future for Malaysia in Energy Control

Adaptive SHEMS are required to conserve power, especially with the increasing evolution in home loads. SMS should control both home appliances and available energy resources according to the real-time tariff and home user's requirements. Home-management schemes should provide an interface platform between home occupants and the home controller to readjust occasionally the load priority.

The majority of smart-home centres can be summarised as having five (5) main functions, as follows:

- (i) Monitoring: provides home residents with visual instantaneous information about the consumed power of different appliances and the status of several home parameters such as temperature, lights, etc. Furthermore, it can guide users to available alternatives for saving energy according to the existing operating modes of different home appliances.
- (ii) Logging: collects and saves data pertaining to the amount of electricity consumed by each appliance, generated out of energy-conservation states. This functionality includes analysing the demand response for real-time prices.

(iii) Control: both direct and remote-control schemes can be implemented in smart homes. Different home appliances are controlled directly by SHEMS to match the home users' desires, whereas other management functions are controlled remotely via cell phones or laptops, such as logging and controlling the power consumption of interruptible devices.

(iv) Management: the main function of SMS. It concerns the coordination between installed energy sources such as P.V. modules, micro wind turbines, energy storage and home appliances to optimise the total system efficiency and/or increase economic benefits.

(v) Alarms: SHEMS should respond to specific threats or faults by generating proper alarms according to fault locations, types, etc.

Economic analysis

Economic factors affecting home-management systems are classified into two classes. First, sizing costs include expanses of smart-home planning. Second, operating costs consist of bills of consumed energy. These costs depend mainly on the electrical tariff.

Sizing costs

These include capital, maintenance and replacement costs of smart-home infrastructures, such as P.V. systems, wind turbines, batteries/fuel cells and communication systems. In most previous SHEMS, such planning costs usually are not taken into consideration, as management schemes usually concern the daily operating costs only.

Operating costs

The electricity tariff is the main factor that gives an indication of the value of saving energy, according to the governmental authority; there are many types of tariffs, as follows:

(i) Flat tariffs: the cost of consumed energy is constant regardless of the continuous change in the load. Load-rescheduling schemes do not affect the electricity bills in this scheme. Therefore, homeowners are not encouraged to

rearrange their consumed energy, as they have no economic benefits from managing the consumption of their appliances.

(ii) Block-rate tariffs: in this scheme, the monthly consumed energy price is classified into different categories. Each category has its own flat-rate price. Therefore, the main target of SHEMS is minimising the total monthly consumed energy to avoid the risk of high-priced categories.

(iii) Seasonal tariffs: in this scheme, the total grid-demand load is changed significantly from one season to another. Therefore, the utility grid applies a high flat-rate tariff in high-demand seasons and vice versa. SMS should minimise the total consumption in such high-priced seasons and get the benefit of consumption in low-priced seasons.

(iv) Time-of-use (TOU) tariff: there are two or three predefined categories of tariffs daily in this scheme. First, a high-priced-hours tariff is applied during high demand hours, which is known as a peak-hours tariff. Second, an off-peak-hours tariff is applied during low demand hours with low prices for energy consumption.

Sometimes, three levels of pricing are defined by the utility grid during the day, i.e. off-, middle- and high-peak costs. SHEMS shift interruptible loads with low priority to off-peak hours to minimise the bill.

(v) Super peak TOU: this can be considered as a special case of the previously described TOU tariff but with a short peak-hours period of ~4 hours daily.

(vi) Critical peak pricing (CPP): the utility grid uses this tariff scheme during expected critical events of increasing the gap between generation and power demand. The price is increased exceptionally during these critical events by a constant predefined rate.

(vii) Variable peak pricing: this is a subcategory of the CPP tariff in which the exceptional increase in the tariff is variable. The utility grid informs consumers of the exceptional dynamic price increase according to its initial expectations.

(viii) Real-time pricing (RTP): the price is changing continuously during pre-identified intervals that range from several minutes to an hour. This tariff is the riskiest pricing scheme for homeowners. The electricity bill can increase significantly without a proper management system. SMS should communicate with grid utility and reschedule both home appliances, sources and energy storage continuously to minimise the total bill.

(viii) Peak-time rebates (PTRs): a proper price discount is considered for low-consumption loads during peak hours, which can be refunded later by the grid. Depending on the electricity tariff, SHEMS complexity varies dramatically. In the case of using a flat-rate tariff, the algorithm becomes simpler, as one value is recorded for selling or buying the electricity. Tariffs may be published by the proper authority or predicted according to historical data. Prediction of the dynamic tariff is a main step in any SMS. Many time frames of tariff prediction are proposed that vary from hourly, daily or even a yearly prediction. Many optimisation techniques with various objective functions are proposed to handle different features of both smart-home infrastructures and electricity tariffs, as will be discussed in the following section.

Pre-proposed SHEMS

Different SHEMS may be classified according to four features: operational planning of load-scheduling techniques, system objective functions, optimisation techniques and smart-home model characteristics, as will be discussed in the following subsections.

Load-scheduling techniques

SHEMS concern the generation/load power balance to provide a comfortable lifestyle with the minimum possible costs. Scheduling loads according to their priority and the periods of renewable energy (solar, wind and E.V. state) can help in reducing the overall energy consumption daily. According to data collected by the management system, an initial load schedule is suggested daily to minimise the daily cost of consumed energy.

By using a proper optimal scheduling algorithm, electricity bills can be reduced by shifting loads from high-priced to low-priced intervals. Many techniques have been proposed for home load scheduling, as will be discussed in the following subsections:

(i) Rule-based scheduling: in this algorithm, all home appliances and resources are connected to smart data-collector taps. By processing the collected data, different appliances are scheduled according to their priorities and based on the if/then rule. Also, some high-priority loads are supplied by home renewable sources/storage to maintain their function during predicted peak hours.

(ii) Artificial intelligence (A.I.): many A.I. controllers have been proposed for home load scheduling, such as artificial neural networks (ANNs), fuzzy logic (F.L.) and adaptive neural fuzzy inference systems (ANFISs).

Objective functions

- (i) Single-objective techniques: in these schemes, only one criterion is minimised or maximised according to the home-user requirements. Several minimisation objective functions were proposed, as follows:
 - lifetime degradation;
 - life-cycle costs;
 - gas emissions;
 - both active and reactive losses.
- (ii) On the other hand, some research defined other single maximising objective functions, such as:
 - net present value.
 - economic profits.
 - increased system reliability: according to many well-known reliability indices, such as loss of power supply probability, loss of load probability and others.
 - generated power.
 - loadability;
- (iii) Multi-objective techniques: homeowners may have several criteria to be optimised together. Multi-objective optimisation (MOO) problems consider many functions simultaneously. MOO finds a proper coordination that moderately satisfies the considered objectives.

Optimisation techniques

Optimisation techniques usually aim to identify the best coordination taking into consideration predefined constraints. Many approaches are available for addressing optimisation problems.

Dynamic tariffs are applied in most smart-home research. E.V. is studied as an energy source in the parking period or vehicle-to-grid (V2G) mode. E.V. in V2G mode reduces the electricity bill in peak hours, whereas ESSs are managed only to reduce the electricity usage from the grid.

DIGITAL ROADMAP FOR SMART HOME

From the above discussion, the following table is recommended for 3 different smart home levels to be adopted in Malaysia.

Basic	Intermediate	Advance
Land-based Phone Line	Wi-Fi	Wi-Fi
<ul style="list-style-type: none"> • Wired Smart Home • Wired CCTV • Home security • NVR (Network Video Recorder) • Central Controller • Phone Line Connection if Intrusion Occur 	<ul style="list-style-type: none"> • Wireless Smart Home • Wireless CCTV • Smart Lock • Smart Switch • Smart Plugs • Smart Lighting • Controller Hubs • Mobile Apps • Wireless Worldwide Connection If Intrusion Occur 	<ul style="list-style-type: none"> • IOT, A.I., • All Intermediate level included • Zigbee, RFID • Smart Electrical Appliances i.e. Washing Machine. Air-Conditioner • Smart Electric Meter • Smart Energy Control • Smart-home energy-management scheme (SHEMS) • Smart Remote Home Automation • Cloud-Based Storage System • Wireless Worldwide Connection If Intrusion Occur

The table above summarises the steps of smart home digitalisation from the Basic Level to the Intermediate Level to the Advanced Level. The following paragraphs explain each level.

Basic Level

This level is the most common practiced so far. The main requirement for this smart home is the land-based phone line. There are many companies that can supply this method of smart home and sensors. Among the disadvantages of this level is that there is hacking around the house and proper finishes are required to properly conceal the wires. If the owners are away, and if intrusion occurs, sensors will be triggered, and intrusion alarm will turn on. The console or the control panel will notify the call centre via the land-based phone line and the call centre will notify the homeowner.

Intermediate Level

For the intermediate level, the most fundamental requirement is internet and stable Wi-Fi connection and mobile smart phone with internet connection and the home can be connected via Wi-Fi from anywhere in the world with internet connection. The home can be equipped with multiple wireless CCTV, be it outdoor or in the home as long as Wi-Fi is reachable. The homeowner can then view the whole house, either outside or inside the house, from anywhere in the world with his smart phone. He can also view whether the automatic gate is closed or open. Wireless motion sensor and lighting can be controlled wirelessly if his motion sensor detects a motion outside the home and alerts him via his smart phone. The homeowner can control the smart door lock, smart switch, smart plugs, and many more wireless smart devices via a control hub using his smart phone. If there is any intrusion, he can be notified instantly, and further action can be taken accordingly.

Advance Level

The fundamental requirement for the Advanced Level is a stable internet connection with Wi-Fi service. This level also enjoys the benefit of that for the intermediate level with more advanced features in the smart system. With the availability of IoT, the smart system can utilise Artificial Intelligence, A.I. In this level also, the energy management system is introduced. The smart meter is installed to measure the import/export of electricity between the national grid and the consumption of the home. In this level also, the homeowner can invest in more smart devices/appliances such as smart fridges, smart washing machines, and smart air conditioning. All these smart home appliances are connected to the home Wi-Fi and can be controlled from anywhere in the world using smart remote home automation as in the smart phone which has an internet connection.

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