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The Future of Smart Homes in the Philippines

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Keyword: Smart Home Systems, Internet of Things (IoT), IoT device

Abstract: Technology continuously helps humans in their daily lives. From increasing productivity, savings in time and resources, and improvement of services, technology has been ingrained and entangled in human's civilization to the point of no return where technology can no longer unlearned and untied to our everyday lives. The emergence of Internet of Things (IoT) underscored the fact that technological advancement can work positively in our lives. This study used data from a construction company in the Philippines that constructs houses and provides service in the installation of Smart Home Systems. The first list consists of the devices that are available for installment shall the homeowner wants to. This data will be used to gauge what are the IoT devices that are available for installation in the Philippines. The second list of data contains of smart home device that the company already installed in the premises of their clients. This will be used to determine which is the most common smart home device being installed in the Philippines. This shows that massive adoption may have begun in the Philippines with the boom of internet connectivity coupled with the increasing middle class who can afford such 'necessary' luxury. In conclusion, recommendations were provided in order for the country to bridge the gap between the present scenario of Smart Home System in the country and the desirable level of adoption of the technology to fully reap its benefits.

1. Introduction

Technology continuously helps humans in their daily lives. From increasing productivity, savings in time and resources, and improvement of services, technology has been ingrained and entangled in human's civilization to the point of no return where technology can no longer unlearned and untied to our everyday lives. The emergence of Internet of Things (IoT) underscored the fact that technological advancement can work positively in our lives. IoT has been used to improved productivity of staff and reduced human labor. Efficient operation management and better use of resources and asset can also be done using this technology. Cost-effective operation, improved work and home safety, and more business opportunities are some other promising advantages of IoT. On the other hand, the technology is network and power dependence and associated to high cost with increase security risks.

Smart Home System using IoT has seen an increase in implementation and integration in the building of homes throughout the world. Smart Home System manages and remote controls your devices from one place which provides convenience. It provides flexibility for new device and

appliance, improved appliance functionality and maximizes the security of the home. Finally, when used extensively, it can provide sizeable energy efficiency and offers home management insight to explore the more technology and appliances that can be connected to the system.

The Philippines has already joined the world in implementation and enjoyment of what technology can offer. However, as a third world country, it is still lacking some aspects of technology compared to the developed countries. The dependence of IoT to network and power will expose the flaw of the country due to its geographical situation as an archipelago which poses challenges that can exacerbate the need to further research on this field on how to fully reap the benefits of such technology. There is also a need to assess at what level can the Smart Home System be adopted without affecting the norms of the Philippine Society. After coming into contact with the technology and their advantage, Filipinos might not be able to or does not want to go back to the low technology homes barely using electricity and manual appliances. But how far can the world go in terms of technological advancement and what is the limit? Will we encounter the ceiling of technological evolution only to find out that we have come to a point of no return where the negative effects of technology have become irreversible. It is imperative to study the present situation of adoption of Smart Homes in the Philippines and find the middle ground between the low technology and the high technology where Smart Home System and its benefits meet harmoniously with the tradition, traits, values, culture, and social fabric of the Philippines.

2. Literature Review

Smart Home Systems use IoT in order to interconnect the devices at home through the internet. The homeowners will now be able to control these devices remotely to their benefit. In the study of Stolojescu-Crisan et. al. [1], access control and surveillance system were implemented in the smart home system using Raspberry Pi boards. The air quality can also be monitored and control using IoT in a Smart Home using sensors and smartphone as remote controller [2]. In this study, the provision of functions that can remotely controlled may change the attitude and behavior of the residents which is an indirect effect of having a Smart Home System. In the study of Marikyan et. al [3], it was found out that the users of Smart Home Systems are motivated to the design, usefulness and practicality of the system rather that its attractiveness. Users are motivated to integrate Smart Home System due to the ease of monitoring and the reduction of energy consumption, support in the daily routine, and operational convenience. Attitudinal beliefs brought by this study shows that the adoption of the technology does not concern users with the risk of the investment might not be justified and data misuse and privacy intrusion might happen while using the technology. Figure 1 shows below the various application of IoT in Smart Home System.

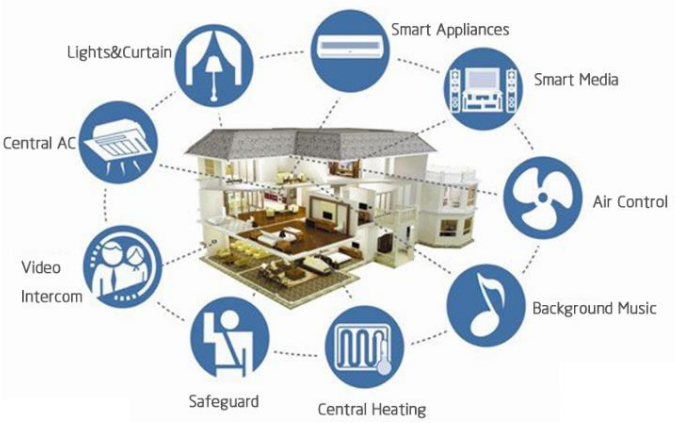

Figure 1: Smart Home Systems Sample Applications. [4]

In a study of Smart Home Technologies in Europe [5], it was determined that not all smart home technologies have the same level of smartness, thus the researchers suggested level of technological smartness in a Smart Home System from a traditional home to a fully smart one. Figure 2 shows Degree of Smartness of Smart Home System.

- Level 0 – It is also called 'dumb', 'basic', 'analog' home without smart home technology.
- Level 1 – Features some technology such as baby monitor and TV, however, residents still need to act in analog way to use the technology which are not interconnected and usually are stand alone.
- Level 2 – This set up provide some appliance interconnected with each other for the convenience of the user. For example, air conditioning and heating system, and entertainment system with Smart TV, internet router, audio sound system, laptop and mobile phone.
- Level 3 – This home with interconnected devices that can perform certain level of automation such as predicting the homeowner's arrival and switching the air conditioning just in time for the homeowner's convenience.
- Level 4 – This is where the feedback loops of the system start to learn and control the action of other devices with higher degree of autonomy to monitor and control the condition of the home based on the preference of the homeowner.
- Level 5 – This can be considered as an artificially intelligent home as it is able to monitor and control parameters among across multiple subsystems such as lighting, heating, gardening, mobility and security. One of the respondents in the study mentioned that in this kind of setting "We will not do anything; these appliances will do everything for us!"
- Level 6 – This level is reached when the Smart Home System can connect beyond the residential premises. Considered as somewhat futuristic, the smart home devices should be able to alert authorities such as the police during intrusion or the Fire Department during the activation of fire and smoke detectors.

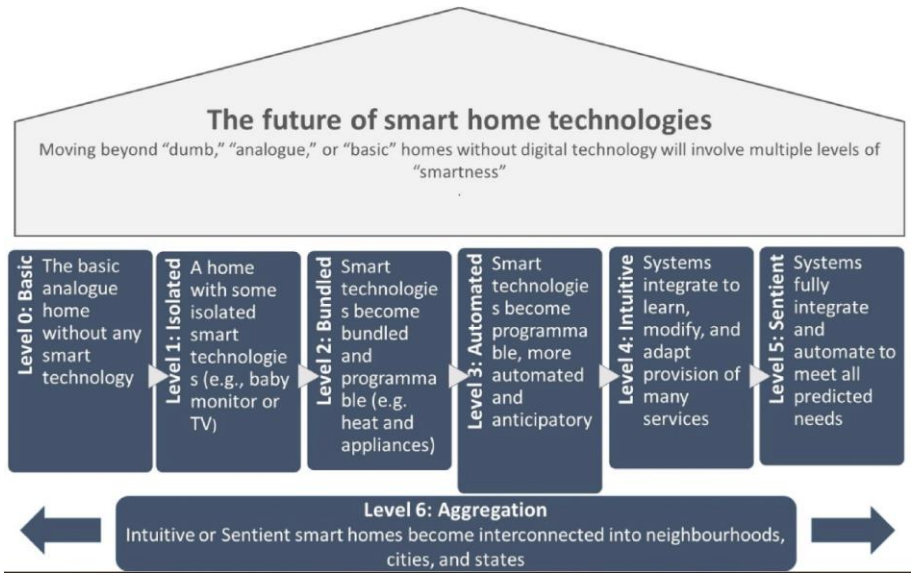

Figure 2: Degree of Smartness of Smart Home System. [5]

In the Philippines, the number of active households in the Smart Home System market is expected to reach 4.1 million users in 2026 [6]. The household penetration will be 8.8% in 2022 and is expected to hit 16.6% by 2026. The average revenue per installed Smart Home System currently is expected to amount to US$105.20 which is a meager amount when the global comparison is considered and reveals that most revenue is generated in the United States at US$31,450.00m in 2022. Figure 3 shows

below that Smart Appliances have become the most popular smart home device group in the Philippines.

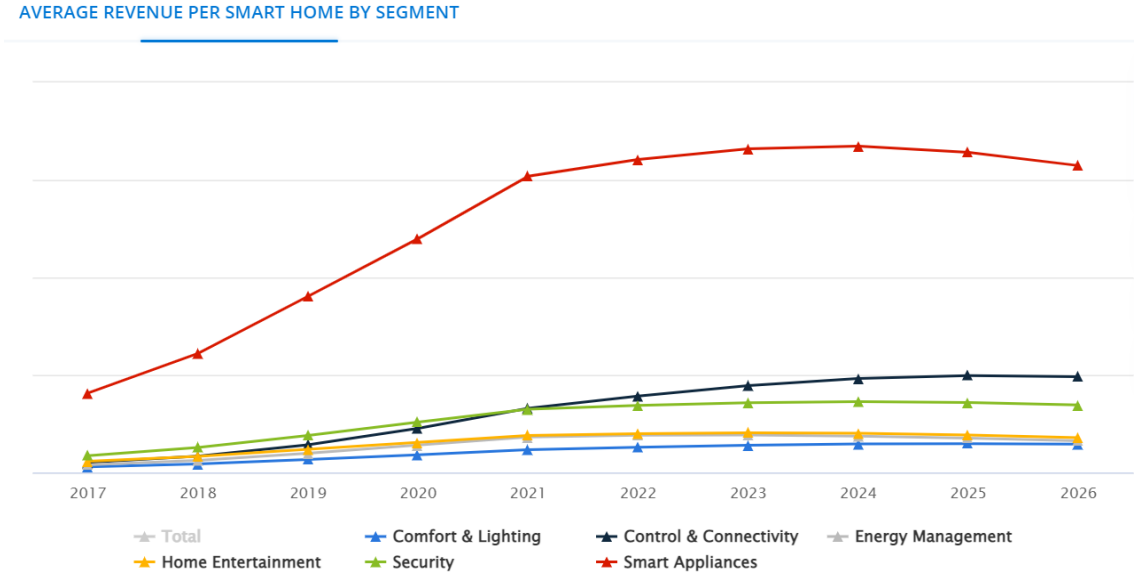

Figure 3: Average Revenue per Smart Home in the Philippines. [6]

Due to the dependence of IoT and Smart Home Systems to network and power infrastructure, it is also essential to look at the present situation of the Philippines on those area. The household electrification level in the Philippines stands at 96.8 percent as of December 2020, from around 93 percent in the previous year. The country aims to reach total electrification in 2022 [7]. Figure 4 shows below that Electrification raise every year in the Philippines.

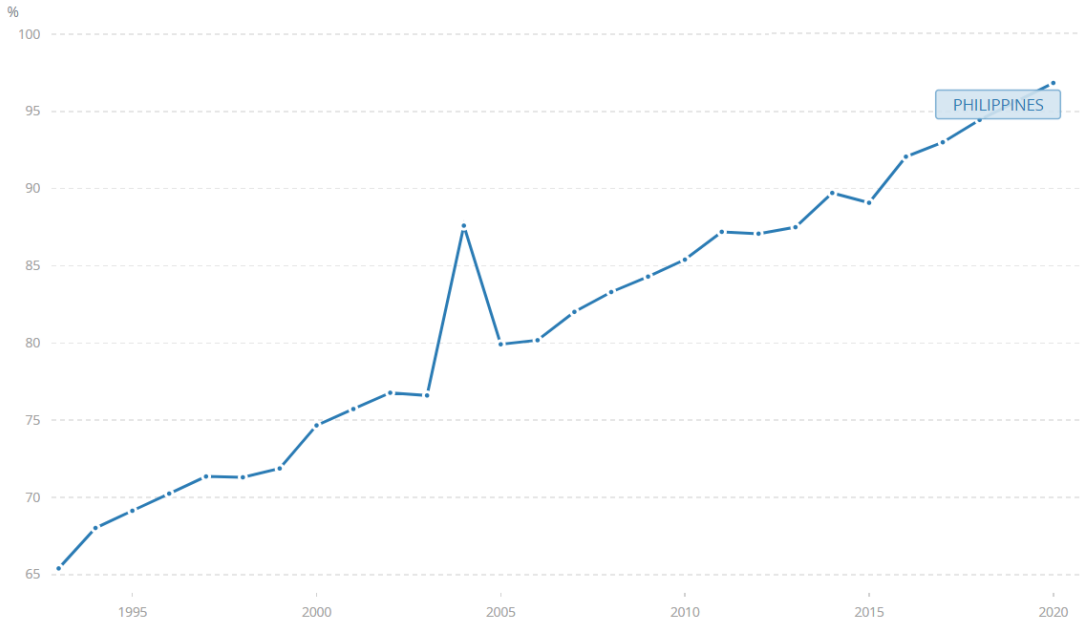

Figure 4: Electrification Rate of the Philippines. [7]

Just like in electrification, the Philippines lags in terms of the percentage of internet users. It was estimated that only 50% of the Philippines population uses internet. Figure 5 shows below that Internet Connectivity Rate raising in recently years in the Philippines.

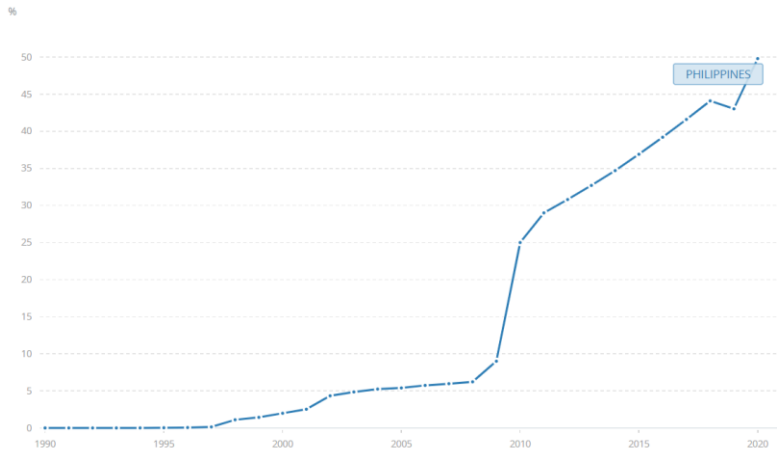

Figure 5: Internet Connectivity Rate of the Philippines. [8]

3. Methodology

This study used data from a construction company in the Philippines that constructs houses and provides service in the installation of Smart Home Systems. The first list consists of the devices that are available for installment shall the homeowner wants to. This data will be used to gauge what are the IoT devices that are available for installation in the Philippines. The second list of data contains of smart home device that the company already installed in the premises of their clients. This will be used to determine which is the most common smart home device being installed in the Philippines. Additionally, the authors searched for relevant papers in Google Scholar, Science Direct and Researchgate to support the information and discussion in this paper. Finally, relevant information regarding government data were presented as reference for the analysis pertaining to the role of government in development and growth of IoT and Smart Home System in particular.

4. Results

Table 1: List of Available Smart Home Devices.

Device	Purpose
No-wash Mop Robot	Cleaning
Air Purifier	Monitoring
Ultra-thin Induction Cooker	Cooking
Smart Air Fryer	Cooking
Smart IH Multi-function Cooking Pot	Cooking
Smart Cat Eye	Monitoring
Smoke Detector	Monitoring
Gas Detector	Monitoring
Smart Home Screen	Display
Smart Door Lock Youth	Access Control
PM2.5 Detector	Monitoring
Security Camera 360 °	Monitoring
Smart Multi-function Cooking	Cooking
Smart Washing Machine	Cleaning
Smart Aircon	HVAC
Refrigerator	Storage
Smart TV	Leisure

Table 1 shows below the list of available Smart Home Devices in the Philippines based on the current offering of the company where the data came from. Out of the 17 devices in the list, monitoring device are most common with 6 instances. Cooking devices and cleaning devices followed at 4 and 2 respectively. Access Control devices, display, HVAC, Storage and Leisure devices all with one.

Table 2 shows the installed Smart Home System devices by the company. The company constructed a house in 2010 and 2011 but there were no smart devices installed. The company installs these devices depending on the desire of the homeowner. This shows that smart home devices are not yet that popular during those times. In 2016, the company started to get request of installations of smart devices. From 2016 to 2019, there were 4 installations all for the security system. This shows that the early adoption of the Smart Home System started to beef up security for homes and that also reflects the immediate concerns of the homeowners. Starting 2019 to 2021, aside from devices, curtain and lighting devices were installed in 5 more clients with the exception one who added smart air condition and access control. The last three clients requested installation of 13 smart devices listed below. This shows that massive adoption may have begun in the Philippines with the boom of internet connectivity coupled with the increasing middle class who can afford such 'necessary' luxury. Again, is it evident that all 12 clients of the company who decide to integrate smart device in their homes all included security systems. With this trend, it is safe to predict and assume that the Smart Home System in the Philippines will become more sophisticated especially that people are not open to using mop-robot and curtain control which might be seen as a simple task that Filipinos are used to do. Thus, the possibility of IoT is limitless as new products and devices are being developed to replace manual tasks from simple to tedious.

Table 2: List of Installed Smart Home Devices.

	Security	Lighting	Curtain	Air Con	Alarm	Rice Cooker	TV	Wash. Machine	Ref	Access	Purifier	Mop-Robot	Switch
Client 1 (2010)													
Client 2 (2011)													
Client 3 (2016)	x												
Client 4 (2017)	x												
Client 5 (2018)	x												
Client 6 (2019)	x												
Client 7 (2019)	x	x	x	x						x			
Client 8 (2021)	x	x	x										
Client 9 (2021)	x	x	x										
Client 10 (2021)	x	x	x										
Client 11 (2021)	x	x	x										
Client 12 (2022)	x	x	x	x	x	x	x	x	x	x	x	x	x
Client 13 (2022)	x	x	x	x	x	x	x	x	x	x	x	x	x
Client 14 (2022)	x	x	x	x	x	x	x	x	x	x	x	x	x

5. Discussion

To foresee the future of Smart Home System of the Philippines, it is imperative that the level of technology is defined to set the demarcation on the limit of technological advancement that will be beneficial to the country.

6. Low Technology

Technological advancement can be grouped and classified into different ways according to the purpose of the technology. For the smart home system, the author proses that the classification of low technology is those home that uses a certain degree of technology for the conform and protection of the homeowner's advantage, but it should not collect data from the user. Basic example of this is that the home should be connected at least to a power grid so the user will be able to use basic appliances for their comfort. For example of these are electric fan, TV, rice cooker, washing machine, refrigerator and so on. Low technology can also include latest entertainment gadgets such as Smart TV, Wireless Fidelity (wifi), routers, speakers, home system and other devices. The demarcation should that these devices are being used by the homeowner and there is no data being collected and processed by machine algorithms.

From the data in Table 1, monitoring devices have the capability to collect data which later will be processed. Other than that, all other smart home devices are for the comfort of the user without collection of data. Monitoring devices are actually designed to monitor a certain data and parameter over the period of time. With this, the Philippines is slowly leaving the low technology area and transitioning into more sophisticated technology. Table 2 also shows that installations of smart devices into the actual homes of the Filipinos are increasing showing the expansion of work and functionalities of these smart devices.

7. High Technology

We can only speculate on how far technology can reach but it is imperative that we set the critical boundaries of the level of our technological needs and the level in which technology might affect humanity negatively. When using IoT in Smart Home Technology, the options are limitless when quenching humanity's thirst for comfort, leisure and efficiency. Science fiction movies is littered with futuristic scenarios and here are some of the products that depicts the complex relationship of high technology with human lives and human homes.

- In the British TV series 'Humans', the fusion of the field of robotics and artificial intelligence made possible the creation of robots as human's assistant that depicts human appearance including their social, cultural, and psychological capabilities. Artificial intelligence and machine learning enables the robots to learn the ways of humans.
- In the movie Ex Machina, a robot developed with artificial intelligence was able to convince a human to help her escape from her creator. Despite being artificial, the robot was capable of thought process while conscious that she is not human.
- In the episode entitled 'Entire History of You' from the series 'Black Mirror', humans have implanted camera in their eyes which they are able to rewind if they wish to. In the episode entitled 'Striking Vipers', two friends are able to feel the character in the video games they are playing. In the episode entitled 'Be Right Back', a lady lost her husband and was able to buy a robot husband in his appearance and slowly learned the ways of the dead husband. In the episode entitled 'Arkangel', a mother signed up her daughter of a monitoring system in which the mother can monitor the vision of her daughter using a tablet.

• In the movie 'The Matrix', robots with artificial intelligence have taken over the world and uses humanities body heat as a power source. While harnessing the energy, the robots put them in trance in which humans dream that they are living in a wonderful world called the matrix.

With all the scenarios offered in these fictional films and TV series, there is a problem in which technology was used overlaps with humanity's values and even natural order of things like in case of death. Technology has gone haywire in which humans are unable to control the technology and their actions, and in return threaten the very existence of humanity. Without setting a boundary with this technological advancement, humanity might be chartering and dangerous territory that might lead to our demise.

8. Middle Ground (Researchers' Stand)

In this study, it is the stand of the authors that the middle ground or middle technology that humanity should maintain are those that are beneficial to them but will not hurt them in the long run. Tables 2 shows the devices being installed in Filipino homes are monitoring systems and smart appliance for the comfort and leisure. It will be desirable if the monitoring systems will be able to alert the authorities in case of emergency. Police will be alerted if the security camera inside the house captures an image of an outsider. Likewise, fire department will be called when the smoke and gas detectors are triggered. In addition to list in Table 2, Filipino homes can also install health related smart devices that can monitor their well-being. For example, tap water can be monitored and checked for unwanted elements and bacteria. A very high but still accepted technology will be able to test and monitor parameters on human's urine and fecal matter to assess the development or emergence of disease and deformities in their bodies. An artificial intelligence might be able to detect a disease and find the cure or medication. The desirable situation will be that the artificial intelligence will just alert the users and stakeholders about the findings, but it will still be the human doctor to decide if this is a valid recommendation of cure. The algorithms will just be a recommending entity in which the decision-making process and responsibilities should remain under the care of humans.

After the presentation of data and its analysis, Table 3 the authors propose the following definition of the classification of technology pertaining to Smart Home System.

Table 3: Classification of Technology in a Smart Home System.

Classification	Description	Sample Devices/Scenario
Low Technology	Classic - Provides entertainment, ease and convenience to the people without collecting any data and trends pertaining to the user	Smart TV, Smart Radio, Cooking Appliances, Smart Refrigerator
Middle Technology	Desirable - Devices able to collect data from the client but the processing is controlled by humans and the application of data processing should not harm the user.	Smart Phone, Wearable Devices, Monitoring Devices that stores data and patterns
High Technology	Haywire - Devices interact with each other with or without the control of humans. Data Processing might endanger humanity.	Doable Technologies from Fictional Movies

9. Technology Clashes with Filipino Culture

With the culture of the Philippines as a family-centered society, it will be interesting to know how far technology can penetrate Filipino's lives and homes. For example, Filipinos usually live with their elderlies. Will it be ok for them to monitor their loved ones over a monitoring device? Likewise with children and working parents, will these monitoring devices replace the usual domestic helpers or day care centers? With the definition of technology for Smart Home System in Table 3 together with the data in Table 2, it is evident that the Philippines is somewhat on the desirable level of technology.

The authors think that there is still time to formulate rules and regulations pertaining to technology before we reach the hypothetical idea of singularity in which technological growth will become out of control and irreversible.

10. Recommendations

With the Philippines still at the desirable level but have not fully achieved the maximum benefits of the technology within that level, the following are the recommendations for the country and its population to adopt and reap the benefits of Smart Home System:

10.1. National Electrification

Since the IoT and Smart Home System is dependent on power, the Philippines will need to fulfill its goal of full electrification in 2022 [7]. The nation is challenged by its geographical setting as an archipelago. However, there are a lot of research done and developed renewable energy resources that can power small island and remote provinces. In Maldives which is an archipelagic country in the Indian Ocean [9], they created floating offshore solar photovoltaics, wave power and offshore wind are modelled on a full hourly resolution in two different scenarios to deal with the need of transportation fuels.[10] In the study of Beartheau, Philippine islands were clustered among the different renewable energy available to them with the aim of 100% electrification. In the study of Gulagi [11], a 100% renewable energy transition pathway for the Philippines was simulated using the LUT Energy System Transition model, a tool developed by the Lappeenranta University of Technology (LUT). The energy sectors power, heat, transport and desalination were realised, and their complex interaction was studied. This proves that renewable energy can be done for the entire Philippine so the possibility of electrifying all inhabited islands is very high.

10.2. National Broadband Network/National Internet through Satellite

Another dependency of IoT and Smart Home System will be the availability of reliable and uninterrupted internet connection. Connectivity is the most crucial factor for IoT. IoT devices rely on networks to communicate with gateways, applications, servers, routers, and other IoT devices. This communication, transmitting and receiving data, enables IoT devices to perform the functions they were designed for. The average download speed of a fixed internet connection in the Philippines was 50.26 Mbps in December 2021 and the average mobile internet connection speed was 19.2 Mbps [12]. The Philippines as the most disaster-prone country in the world will need to design a framework on how to re-install and reconnect the whole country after devastation from typhoons, possible big earthquake, and other disaster of national proportion. The entry of satellite internet in the Philippine [13] could help in regarding that matter however, a national plan on broadband and satellite internet should be formulated so the country will keep on improving in terms of internet speed and its resilience against perennial disasters.

10.3. SIM Card Registration

Legislation regarding the registration of Subscriber Identification Module (SIM) is very important in combatting internet and cybercrimes such as fraud and identity theft. Unfortunately, the last-minute insertion of Senator Franklin Drillon [14] in the SIM Card Registration Act caused it to be vetoed by the President. The senator wants to register not just the SIM Card but also the social media accounts of all citizens and including the registration of social media providers is totally not in line with the essence of the bill and could be seen as intrusion to the private lives of the citizens. This basic law

which has been successfully implemented in other countries will need to be passed by the Congress and signed by the next president which will help the user of mobile data protected from possible intrusion and cybercrimes.

10.4. Cyber Army of the Philippines

The idea of the Philippines having a Cyber Army is first presented by the authors in this paper. Presently, the Philippine Army has a cyber wing called Army Cyber Defense Team [15]. Thorough study should be done to determine if a separate army should be created amidst rising cybercrimes and devices connected in the network. In the study of Aschmann et. al. [16], the cyber army frameworks of the United States, China and India was presented alongside with the proposed cyber army for Africa. For the Philippines to realize the goal of Smart Home System adoption in the entire country, billions of devices will have to be connected to the network and this situation might need an authority to govern and regulate the new norms and realm brought about by this emerging technology.

10.5. Increase Economic Power

Huge endeavors such as Smart Home System will be a big dream for a developing country such as the Philippines. The country is set to bring down the poverty line in the range of 13 to 15% this year and wipe out poverty in 2040 [17]. Logically speaking, how will the majority of the population afford Smart Home System which might be seen as a luxury when they are barely making ends meet. The Philippines with Gross Domestic Product (GDP) per capita income of US $3430 as of 2020 [18] belongs to the Lower Middle-Income country. The country will need to increase its per capita income by 20% to join the Upper Middle-Income countries with minimum per capita of US$ 4095 and increase 3 times to meet the minimum amount for High Income economy at US$ 12695. To do that, the Philippines will need to mirror the economic miracle of post-WW2 Japan and recently the economic boom of China.

10.6. Research for Low-Cost Materials

Aside from increasing the purchasing power of the population through the improvement of the economy, one viable solution for the affordability of Smart Home System and IoT technology in general is the reduction of the material cost, production cost and its installation. The study of Balta-Ozkan et. al. [20], revealed that aside from security and control, cost is a big disadvantage of IoT and Smart Home System. Various studies have been done to attempt to design and develop low-cost smart home system in Heating, Ventilation and Air Conditioning (HVAC) monitoring [21], home automation system using Arduino-Based components [22], and others that enables the use of smart phone to control the system [23].

10.7. Training of Professionals and Experts for Technology Support

Another issue about this emerging technology is the availability of professionals to support and maintain the technology. In a paper about the long-term viability assessment of a Smart Home System [24], only the IT personnel knows the in-depth of the system. The maintenance cost of the system was also found to be high. The study of Osako et. al. [25], revealed that the cost of maintenance of IoT might be lesser when the economy of scale is considered so there is a big possibility that the production cost of IoT products will decrease with mass adoption, however this will need a lot of expert and professionals to support the installation and maintenance of the system.

10.8. Education and Awareness of the Population

Aside from the economic and technological factors, the acceptance of IoT and Smart Home System by the general population is crucial to its successful implementation. In the study of Park et. al. [26], The negative factor that affects the technology acceptance of the user is the cost, however, the study shows three positive motivators namely: compatibility, connectedness and control. Uses understanding should be compatible with the technology they are going to use from them to have maximum enjoyment and benefit. The robustness and steady connection allow them to consistently use the technology. Finally, people should be able to control the technology depending on their wants and needs. The study of Baudier et. al. [27], revealed that highly educated and digital-savvy people are ready to adopt Smart Home Concepts and thus targeted for marketing and advertisement. This item is intertwined with other items such as increasing economic power will increase the number of middle classes that will be able to afford the technology and adopt them. Increasing IoT conversant professionals will help disseminate information about the benefits of the technology. Finally, electrification and internet connectivity for the whole country will propel the technology into the subconscious of the population as new alternative way of living.

10.9. National Legislative Framework and Standards

In the Three Laws of Robotics suggested by Isaac Asimov [28], the first law says robots should not in any way harm humans, second law says they should obey order from humans unless it violates the first law, and they should protect their existence unless it violates the first and second law. Aside from laws that govern the security of data, there should be a law passed governing IoT that uses Smart Home System, Artificial Intelligence that could be the processor of data from the IoT devices, Cloud technology which can serve as data storage. The IoT Cybersecurity Act of 2020 [29] is a law in the United States mandates the National Institute of Standards and Technology (NIST) and the Office of Management and Budget (OMB) to formulate guidelines in increasing cybersecurity of IoT devices and sets standards on their compliance. The Philippines should be proactive in creating such laws to anticipate the wave of inevitable popularity and adoption of these emerging technologies.

11. Conclusion

The Smart Home System using IoT has slowly gaining popularity and adoption in the Philippines. The authors were able to provide boundaries of the technology and further classified technology into low, middle, and high. Low technology uses appliances and devices that provide a certain level of comfort and efficiency to the homeowner without collecting data from them. Middle technology uses devices that collects data from the homeowners, but the data should be controlled by humans and the processing should not harm the homeowners. High technology is the scenario where in the devices collect and control data on their own which can be borderline unethical and unnatural and might harm humans in the end. Using the data of available and installed devices, the Philippines is at the level of middle technology but still unable to realize the benefits of this emerging technology. Finally, recommendations were provided in order for the country to bridge the gap between the present scenario of Smart Home System in the country and the desirable level of adoption of the technology to fully reap its benefits.

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